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Final

Remedial Investigation/Human Health Risk Assessment/ Ecological Risk Assessment for SWMU 14, Q-50 Satellite Accumulation Area

Naval Station Norfolk
Norfolk, Virginia

NAVFAC
Naval Facilities Engineering Command

Prepared for

Department of the Navy

Naval Facilities Engineering Command Atlantic

Contract No. N62470-95-D-6007
CTO-0131

August 2004

Prepared by

CH2MHILL

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Contract Task Order Number—0131
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Navy CLEAN II Program

Prepared by

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August 2004

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Executive Summary

Introduction

This report presents the results of the Remedial Investigation (RI), Baseline Human Health Risk Assessment (HHRA), and Baseline Ecological Risk Assessment (ERA) for SWMU 14 at Naval Station Norfolk (NSN) in Norfolk, Virginia. SWMU 14 consisted of a concrete storage pad surrounded by a grass-covered field. The pad served as a less than 90-day hazardous waste accumulation area where wastes generated through various waste streams were processed (sampled, identified, labeled, and packaged) before being shipped to eventual disposal. The original concrete pad for the accumulation area has since been removed. A new pad was installed west of the original location and is used for temporary storage of investigation-derived waste materials.

In addition to the accumulation area, the peninsula at Sewell's Point is a man-made landmass formed from two distinct periods of fill activities. The first landfill activities began in the early 1950s, when the channels were dredged to allow for construction of the northernmost series of piers at the site. The resulting dredge material was used to create much of the land at Sewell's Point. The second period of filling occurred between 1974 and 1978, when the eastern portion of the site was formed from the disposal of construction debris. This landfill was later designated as Site 9, the Q-area Landfill, and reportedly used for the disposal of non-hazardous construction debris. Because Site 9 and SWMU 14 are co-located, both are evaluated as part of this investigation.

Site Physical Characteristics

The material at SWMU 14/Site 9 is divided into two basic classifications: dredge fill and construction debris fill. The dredge fill consists mainly of fine- to medium-grained sand and shell hash that comprises the western half of the Sewell's Point peninsula. Similar material is found below the construction debris fill at a depth of 6 to 14 feet in the eastern portion of the site. The construction debris fill generally consists of black to brown silts and sands with some gravel pockets. Large amounts of metal debris were observed during the test pit and drilling activities. In addition, coal and glass fragments were noted as well as what appeared to be buried wood pilings.

The groundwater elevation data indicates that the water table is relatively flat across the site with a fluctuation of approximately 0.6 ft. The groundwater is at its highest elevation proximal to the current concrete pad at the site. Groundwater flows in a radial pattern from the mound to the east and north towards Willoughby Bay and west towards the Elizabeth River. In addition, a hydraulic divide, located along the western edge of the site, separates the groundwater flow in the east and west. Using slug test data, the range of groundwater flow velocities across the site was calculated to be 56 feet per year to 209 feet per year.

Nature and Extent of Contamination

Contaminants were detected in all media of concern including groundwater, surface soil, subsurface soil, sediment, and surface water.

The groundwater analytical results showed that there were exceedances of the screening criteria (RBCs and MCLs) for VOCs, SVOCs, pesticides, and metals. The concentrations of inorganics exceeded the screening criteria in monitoring wells both within and outside of the fill area.

The analytical results of the surface soil samples indicate exceedances of a VOC, SVOCs, pesticides, PCBs, metals, and dioxins/furans. 1,2-Dichlorobenzene was the only VOC detected above the screening criteria, and only occurred in one sampling location. Dieldrin and methoxyclor, occurring in isolated areas, were the only pesticides detected in exceedance of the screening criteria. The analytical results were compared to the dredge fill background soil levels. Generally, the SVOCs and pesticides, PCBs detected within the landfill at concentrations exceeding the screening values also exceeded the background levels. There were no metals exceeding the screening criteria and the background UTL in surface soil samples collected outside of the landfill. Lead, mercury, thallium, and zinc were in general the most frequently detected analytes exceeding the screening criteria and the background within the site boundary. In addition, there were dioxin/furan exceedances at two of the five surface soil locations analyzed for these parameters.

In subsurface soil samples, SVOCs, pesticide, PCBs, metals, and dioxin/furans were detected at concentrations exceeding the screening criteria. There were no VOC exceedances in subsurface soil. In addition, the concentrations of pesticide, PCB and SVOC exceedances were isolated to those samples collected within the fill area, and generally in the northern and central portions of the site. The site sample concentrations were compared to the dredge fill background soil levels. SVOCs and pesticides/PCBs were detected within the landfill at concentrations that exceeded the RBCs and background levels. Dioxin/furan exceedances concentration exceedances occurred in four sample locations in the eastern central portion of SWMU 14. There were no metals concentrations detected above the background UTL nor the screening criteria in subsurface soil samples collected outside of the fill area. However, there were several inorganic exceedances both north and south of the SWMU 14 boundary.

Five sediment samples were collected in the lagoon south of SWMU 14. SVOC, pesticides, and PCB results did not exceed the RBCs. Arsenic and iron exceeded both human health and ecological screening values. The lagoon may serve as a depositional area for inputs from the two outfalls to the west of SWMU 14 and the bay inlet to the east. As a result, several potential contaminant sources, other than SWMU 14, may be contributing to the lagoon. Results from SD04 and SD02 had the most SVOC, pesticide, and PCB exceedances of the screening values. There were no inorganic exceedances at SD02 and SD03.

Fate and Transport of Contamination

Based on the chemical and physical data collected at SWMU 14, it appears likely that both SWMU 14 and Site 9 were potential sources of contamination. The general contaminant profile fits this contaminant distribution and consists of (1) surficial elevated concentrations

in the vicinity of SWMU 14, (2) laterally widespread surficial and subsurface soil elevated concentrations within the Site 9 fill area, and (3) groundwater concentrations at levels varying from relatively high to relatively low with no readily apparent single source pattern.

Metals, PAHs, pesticides, PCBs, and dioxins/furans are likely to be sorbed with the surface soil particles. Metals can move from surface soil to subsurface soil to groundwater by precipitation-induced leaching. However, PAHs, PCBs, and dioxins/furans are not expected to leach to the subsurface from surface soil, and are expected to remain in close proximity to the release point, sorbed to surface soil particles. Therefore, the only significant release mechanism is airborne or waterborne particles sorbed with PAHs, PCBs, or dioxin/furans. However, the site is vegetated and has little potential for overland flow, which minimizes the risk of transport of surface soil particles.

Due to the shallow depth to groundwater and the site's proximity to the Bay, groundwater flow represents the most significant potential offsite transport mechanism. Based on the conceptual groundwater flow and groundwater flow velocities of 56 to 209 ft per year, it is likely that groundwater discharge occurs to the dredge-fill sediments to the west of the site as well as to Willoughby Bay located to north and east. Constituents that may be transported offsite via groundwater flow include those that are dissolved in groundwater. The concentrations of metals as well as trace levels of VOCs and SVOCs that were observed in the downgradient monitoring wells may indicate possible migration of these contaminants from the Site 9 fill area.

Human Health Risk Assessment

This baseline risk assessment was conducted to evaluate the potential human-health risks associated with the presence of site-related soil, groundwater, surface water, and sediment contamination at NSN SWMU 14. This risk assessment quantifies potential human-health risks at SWMU 14 under current conditions and under potential future use scenarios, if no additional remediation is implemented.

There are no risks or target organ-specific hazards that exceed USEPA target levels for the site worker or trespasser under current site use. The following receptors had total RME noncarcinogenic hazards or carcinogenic risks that exceeded USEPA's target levels:

- Future site worker exposed to subsurface soil
- Future adult resident exposed to subsurface soil and groundwater
- Future child resident exposed to surface soil, subsurface soil, and groundwater
- Future lifetime resident exposed to subsurface soil and groundwater
- Future construction worker exposed to surface soil, subsurface soil, and groundwater
- Future recreational child exposed to surface soil and subsurface soil

The metals detected in the soil are the main contributors to the noncarcinogenic hazard associated with exposure to surface soil (thallium and iron) and subsurface soil (antimony, arsenic, iron, manganese, thallium, and vanadium). The calculated risks are probably site related and not background related. Benzo(a)pyrene is the main contributor to the subsurface soil carcinogenic risk.

The main contributors to the groundwater noncarcinogenic hazard are 4-methylphenol, dibenzofuran, arsenic, iron, manganese, thallium, and vanadium and the main contributors to the carcinogenic risk are n-nitroso-d-n-propylamine, pentachlorophenol, and arsenic.

Ecological Risk Assessment

Six metals (antimony, copper, lead, nickel, thallium, and zinc) and PAHs in surface soil exceeded surface soil screening values or facilitywide background soil concentrations (where available) and were retained as COCs. Copper, lead, and zinc were the inorganics that exceeded both screening values and background concentrations most frequently and at the highest magnitudes. The spatial distribution of the highest screening value exceedances was very similar for these three metals. There are possible risks to lower-trophic-level receptors utilizing some portions of the terrestrial habitats on SWMU 14. However, these risk estimates are likely to be conservative under both existing and projected future land uses because exposures are likely to be limited based upon the nature of the substrate (very coarse sand and gravel), the poor habitat quality (a weedy field that is periodically mowed), and the site's isolated nature (i.e., surrounded by developed areas). Potential risks to upper-trophic-level terrestrial receptors are minimal as no chemical exceeded a LOAEL-based screening value for such receptors. Thus, given the current habitat conditions on the site and the likely future site uses, additional ecological evaluation of the terrestrial portion of SWMU 14 is not currently warranted.

Relatively few chemicals exceeded screening values in lagoon sediment. Arsenic was the only inorganic chemical with a mean HQ greater than or equal to one based upon a detected concentration. While arsenic is identified as a COC in lagoon sediment, arsenic did not exceed screening values in site surface soils or groundwater, suggesting that these low-magnitude sediment exceedances are not site related. Four pesticides (4,4'-DDE, 4,4'-DDT, alpha-chlordane, and gamma-chlordane) and one PCB (Aroclor-1260) exceeded screening values based upon mean detected concentrations. While the mean detected concentrations of five individual PAH compounds exceeded screening values, maximum HQs were less than two and the mean HQ for total PAHs was less than one. This suggests that potential risks related to PAHs are minimal in lagoon sediments. A comparison of sediment concentrations to equilibrium partitioning-based sediment values suggests that potential exposures and risks are very low for all these organic compounds. The lagoon may serve as a depositional area for inputs from the two outfalls to the west and the bay inlet to the east, therefore other contaminant sources may be contributing to the lagoon.

The potential magnitude of contaminant transport via groundwater from SWMU 14 to Willoughby Bay was qualitatively evaluated through a comparison of groundwater concentrations with surface water screening values. Total cyanide, manganese, and 4,4'-DDT had mean HQs exceeding one, based upon detected groundwater concentrations and a dilution factor of 10. Amenable cyanide was not detected in any of the five wells at the same reporting limit as total cyanide. Thus, the cyanide in groundwater is not likely to be present in bioavailable forms and would likely pose a minimal risk to aquatic receptors in Willoughby Bay following discharge. The maximum manganese concentration in groundwater was found in MW19S, which is far removed from the source areas and main groundwater flow direction. This suggests that manganese is likely to be present at background levels in groundwater or is not site-related. Additionally, manganese was not

identified as a potential contaminant of concern (PCOC) in site surface soils. 4,4'-DDT was detected in 4 of 24 groundwater samples from 3 different wells (MW05S, MW07S, and MW15S).

A Watershed Contaminated Source Document (WCSD) is currently being prepared for Willoughby Bay. Once the WCSD results are available, possible future steps of the ERA process (i.e., Steps 3B and 4) for the Bay and lagoon, as related to SWMU 14, will be assessed, as warranted.

Recommendations

The RI sampling has provided adequate data for the characterization and delineation of the contaminants present in the surface soil, subsurface soil, and groundwater at the site. The RI has also provided groundwater-flow direction and velocity data as well as determined the full extent of the Site 9 landfill.

There are no unacceptable human health risks associated with the SWMU 14/Site 9 contaminants under the current land use; however, unacceptable risks associated with exposure to surface soil, subsurface soil, and groundwater are present under most the future scenarios. In addition, there were no unacceptable risks to ecological receptors at the site's terrestrial portion; however, unacceptable ecological risks for sediment and groundwater discharging to surface water are present at the site. Therefore, it is recommended that the ERA process continue to the next phase.

A Feasibility Study (FS) is recommended to address risks associated with potential contaminants of concern at SWMU 14. This study will assess the potential remedial alternatives to be considered in the event that there are changes from the current land use. Presumptive remedies will be considered by the NSN Tier I partnering team.

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Acronyms and Abbreviations

AOC	Area of Concern
AUF	Area Use Factor
AWQC	Ambient Water Quality Criteria
BAF	Bioaccumulation Factor
BCF	Bioconcentration Factor
BERA	Baseline Ecological Risk Assessment
bgs	Below Ground Surface
BOA	Basic Ordering Agreement
BTAG	Biological Technical Assistance Group
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CERCLA	Comprehensive Environmental Response, Compensation, And Liability Act
CLEAN	Comprehensive Long-Term Environmental Action
CNO	Chief of Naval Operations
COC	Constituent of Concern
COPC	Chemical of Potential Concern
CSF	Cancer Slope Factor
CT	Central Tendency
DQO	Data Quality Objective
Eh	Oxidation-Reduction Potential
ELCR	Excess Lifetime Cancer Risk
EM	Electromagnetic
EP	Extraction Procedure
EPA	Environmental Protection Agency
EPC	Exposure Point Concentration
EPIC	Environmental Photographic Interpretation Center
ERA	Ecological Risk Assessment
ERT	Earth Resources Technology
FOD	Frequency of Detection
FOE	Frequency of Exceedance
FSP	Field Sampling Plan
GPR	Ground-Penetrating Radar
GW	Groundwater
HAS	Hollow Stem Auger
HEAST	Health Effects Assessment Summary Table
HI	Hazard Index
HQ	Hazard Quotient
HSDB	Hazardous Substances Data Bank
HSP	Health and Safety Plan

IAS	Initial Assessment Study
IEUBK	Integrated Exposure Uptake Biokinetic
IR	Installation Restoration
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
K_d	Adsorption coefficient
K_{oc}	Adsorption coefficient normalized to total organic carbon
K_{ow}	Octanol-water partition coefficient
LD_{50}	Lethal Dose (50 percent of the population)
LOAEL	Lowest Observed Adverse Effect Level
MCL	Maximum Contaminant Level
MF	Modifying Factor
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
MHz	Megahertz
mlw	Mean low water
mph	Miles per hour
msl	Mean sea level
MW	Monitoring Well
NCEA	National Center for Environmental Assessment
ND	Non Detect
NM	Naval Magazine
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NSN	Naval Station Norfolk
NTU	Nephelometric Turbidity Unit
ORP	Oxidation Reduction Potential
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCOC	Preliminary Chemicals of Concern
PCP	Pentachlorophenol
PEF	Particulate Emissions factor
PPB	Parts Per Billion
ppm	Parts per million
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RBC	Risk Based Concentration
RCRA	Resource Conservation And Recovery Act
RFA	RCRA Facility Assessment
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study

RME	Reasonable Maximum Exposure
RRR	Relative Risk Ranking
SAP	Sampling and Analysis Plan
SB	Soil Boring
SD	Sediment
SERA	Screening Ecological Risk Assessment
SI	Site Investigation
SS	Surface Soil
SVOC	Semivolatile Organic Compound
SW	Surface Water
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCE	Trichloroethylene
TCL	Target Compound List
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbon
UCL	Upper Confidence Limit
UF	Uncertainty Factor
µg/kg	Micrograms Per Kilogram
µg/L	Micrograms Per Liter
USEPA	United States Environmental Protection Agency
VDEQ	Virginia Department of Environmental Quality
VOC	Volatile Organic Compound
VSI	Visual Site Inspection
XRF	X-ray fluorescence

SECTION 1

Introduction

This report presents the procedures and results of the Remedial Investigation (RI) of Solid Waste Management Unit (SWMU) 14, the Q-50 Satellite Accumulation Area at Naval Station Norfolk (NSN), Norfolk, Virginia.

1.1 Purpose and Report Organization

This report presents the results of the Remedial Investigation conducted by CH2M HILL at SWMU 14. It documents the contaminants detected in soil, groundwater, surface water, and sediment as well as present information on the site's physical characteristics. This will facilitate a better understanding of the potential human and ecological exposure to contaminants associated with SWMU 14. It also documents the results of the baseline human health risk and ecological risk assessments for SWMU 14. The specific organization of the report is summarized below.

Section 1 outlines the purpose of the report, provides a site description, and summarizes the results of previous investigations at the site. Section 2 provides information on the approaches, methodology, and practices used during the investigation. Section 3 presents the RI results, includes a characterization of environmental media contamination, and provides information on the site's physical characteristics. Section 4 provides information on contaminant data and physical features that can be used to estimate contaminant fate and transport. Section 5 summarizes the human health risk assessment (HHRA), and Section 6 summarizes the ERA. Section 7 presents the conclusions and recommendations.

1.2 Site Description and History

This subsection contains a brief description of the site-specific information on its environmental setting. The basewide features (physical/chemical information) can be found in the work plans and in the *Site Management Plan FY 2002 Naval Station Norfolk, Norfolk Virginia* (CH2M HILL, February 2002).

As shown in Figure 1-1, SWMU 14 is located in the northeastern corner of Sewell's Point at NSN. The site consisted of a concrete storage pad surrounded by a grass-covered field. The pad served as a less than 90-day hazardous waste accumulation area, where materials generated through various streams were processed (sampled, identified, labeled, and packaged) before being shipped to eventual disposal. SWMU 14 was initially identified from a 1982 Environmental Photographic Interpretation Center (EPIC) aerial photograph (USEPA, September 1994) that showed a drum storage area and scrap metal pile north and east of the concrete pad, respectively. Furthermore, historical plans of the area also showed the presence of stockpiled railroad ties and metal debris northeast of the pad. The site was also cited during the 1992 RCRA Facility Assessment (RFA) (A. T. Kearney, March 1992) site inspection, when areas of stained soil were observed. The original concrete pad for the

accumulation area has since been removed. A new pad was installed west of the original location and is used for temporary storage of investigation-derived waste materials.

In addition to the accumulation area, the peninsula at Sewell's Point is a manmade landmass formed from two distinct periods of fill activities. The first began in the early 1950s, when the channels were dredged to allow for construction of the northernmost series of piers at the site. The resulting dredge material was used to create much of the land at Sewell's Point. The second was between 1974 and 1978, when the site's eastern portion was formed from the disposal of construction debris. This landfill was later designated as Site 9, the Q Area Landfill. Site 9 was initially identified in the Initial Assessment Study (IAS) (Environmental Science and Engineering, February 1983) and reportedly used for the disposal of non-hazardous construction debris. Site 9 was recommended for No Further Action (Baker Environmental, Inc., December 1997); however, because Site 9 and SWMU 14 are co-located, both are evaluated as part of this investigation. Figure 1-2 shows SWMU 14 and the estimated boundary between Site 9 and the dredge-fill area in detail.

1.3 Previous Investigations

Baker Environmental, Inc. completed two Relative Risk Ranking (RRR) studies to evaluate the presence of contamination and potential exposure pathways associated with the SWMUs at NSN. The first study's results are documented in the *Final Relative Risk Ranking System Data Collection Sampling and Analysis Report, Naval Base, Norfolk, Virginia* (Baker Environmental, Inc., January 1996). Samples were collected at SWMUs 9, 10, and 14 during the Phase I RRR study. The second study's results are documented in the *Draft Phase II Relative Risk Ranking System Data Collection Sampling and Analysis Report, Naval Base, Norfolk, Virginia* (Baker Environmental, Inc., December 1996). During the Phase II study, additional sampling was conducted at SWMUs 10 and 14. In addition, a Supplemental Investigation was completed at SWMUs 6, 9, 10, and 14; the results of which are presented in the *Draft Report for the Solid Waste Management Unit Supplemental Investigation Naval Base Norfolk, Norfolk, Virginia* (CH2M HILL, October 1998).

Nine surface soil samples were collected at SWMU 14 during the Phase I and II RRR study. The Phase I soil samples were analyzed for Volatile Organic Compounds (VOCs), Semi Volatile Organic Compounds (SVOCs), metals, and cyanide. Phase II surface soil samples were analyzed for VOCs, SVOCs, pesticides/Polychlorinated Biphenols (PCBs), and metals. One surface water and two sediment samples were also collected in the Phase II RRR Study and analyzed for VOCs, SVOCs, and inorganics. In addition, five groundwater samples were collected and analyzed for VOCs, SVOCs, pesticides/PCBs, and inorganics during the Phase I and II RRR Study.

Groundwater, surface soil, and subsurface soil samples were collected during the Supplemental Investigation activities at SWMU 14 (CH2M HILL, October 1998). Five groundwater samples were collected and analyzed for VOCs, SVOCs, pesticides, PCBs, and metals. Five co-located surface and subsurface soil samples were collected and analyzed for VOCs, SVOCs, pesticides, PCBs, and TAL metals.

1.3.1 Relative Risk Ranking (RRR) and Supplemental Investigation Results

Sampling Locations are shown on Figure 1-3. Appendix A provides a summary of detected compounds. The exceedances are summarized below.

Eighteen constituents were detected at concentrations exceeding the tapwater RBCs in at least one groundwater sample collected at SWMU 14. These constituents included chlorobenzene, benzene, chloromethane, 1,4-dichlorobenzene, vinyl chloride, methylene chloride, pentachlorophenol, benzo(a)anthracene, benzo(b)fluoranthene, bis(2-ethylhexyl)phthalate, carbazole, Aroclor-1248, Aroclor-1254, Aroclor-1260, antimony, arsenic, barium, and iron. In addition, lead concentrations exceeded the Safe Drinking Water Act action levels. Ten constituents were detected at concentrations exceeding the drinking water MCLs in at least one groundwater sample collected at SWMU 14. These constituents included chlorobenzene, benzene, methylene chloride, pentachlorophenol, Aroclor-1248, Aroclor-1254, Aroclor-1260, antimony, barium, and lead. No contaminants exceeded the RBCs or MCLs in upgradient location DW05, indicating that the contaminants may be site-related.

- Nine constituents were detected at concentrations exceeding the residential RBCs and background levels in at least one surface soil sample collected at SWMU 14. These constituents include benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, Aroclor-1248, Aroclor-1254, antimony, and copper. In addition, lead concentrations exceeded the residential soil screening criteria at two locations. Three constituents were detected at concentrations exceeding the residential RBCs in the subsurface soil samples. Benzo(a)pyrene, benzo(b)fluoranthene, and Aroclor-1248 were detected at concentrations exceeding the residential RBCs and background concentrations in at least one location.

- Two sediment samples were collected at SWMU 14 during the Phase II RRR Study field activities. Fifteen constituents were detected at concentrations exceeding the BTAG-Sediment screening values, including acenapthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, N-nitrosodiphenylamine, phenanthrene, pyrene, chromium, copper, lead, and zinc concentrations exceeded the BTAG sediment screening values in at least one sediment sample.

One surface water sample was collected in the SWMU 14 lagoon during the Phase II RRR Study field activities. The analytical results show that the cadmium concentration exceeded the MCL.

The previous investigations identified the presence of PAHs, PCBs, and metals in soils at levels exceeding the RBCs. In addition, seven groundwater samples detected levels of VOCs, SVOCs, metals and PCBs exceeding the RBCs or MCLs. Potential sources of contamination include former locations of railroad ties, scrap metal, and drums as well as the satellite accumulation area. In summary, the initial investigations indicated that there were elevated levels of contaminants at the site; however the full nature and extent of the contamination had not been delineated. Therefore, the RI phase of investigations was initiated to further study the site and evaluate potential risks.

1.3.2 References

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Baker Environmental, Inc. *Final Relative Risk Ranking System Data Collection Sampling and Analysis Report, Naval Base, Norfolk, Virginia.* January 1996.

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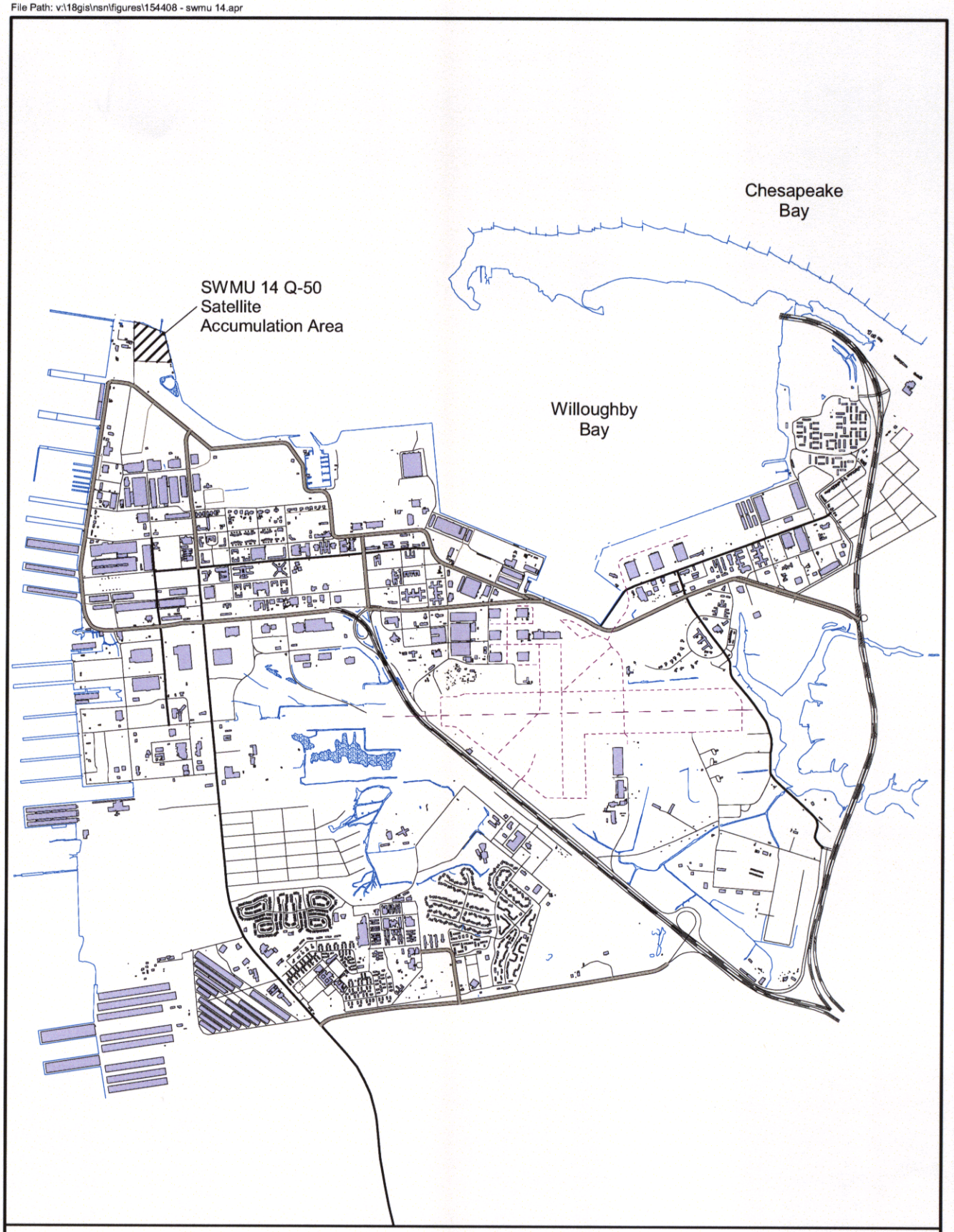

N

0 2000 4000 Feet

Figure 1-1
Site Location
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

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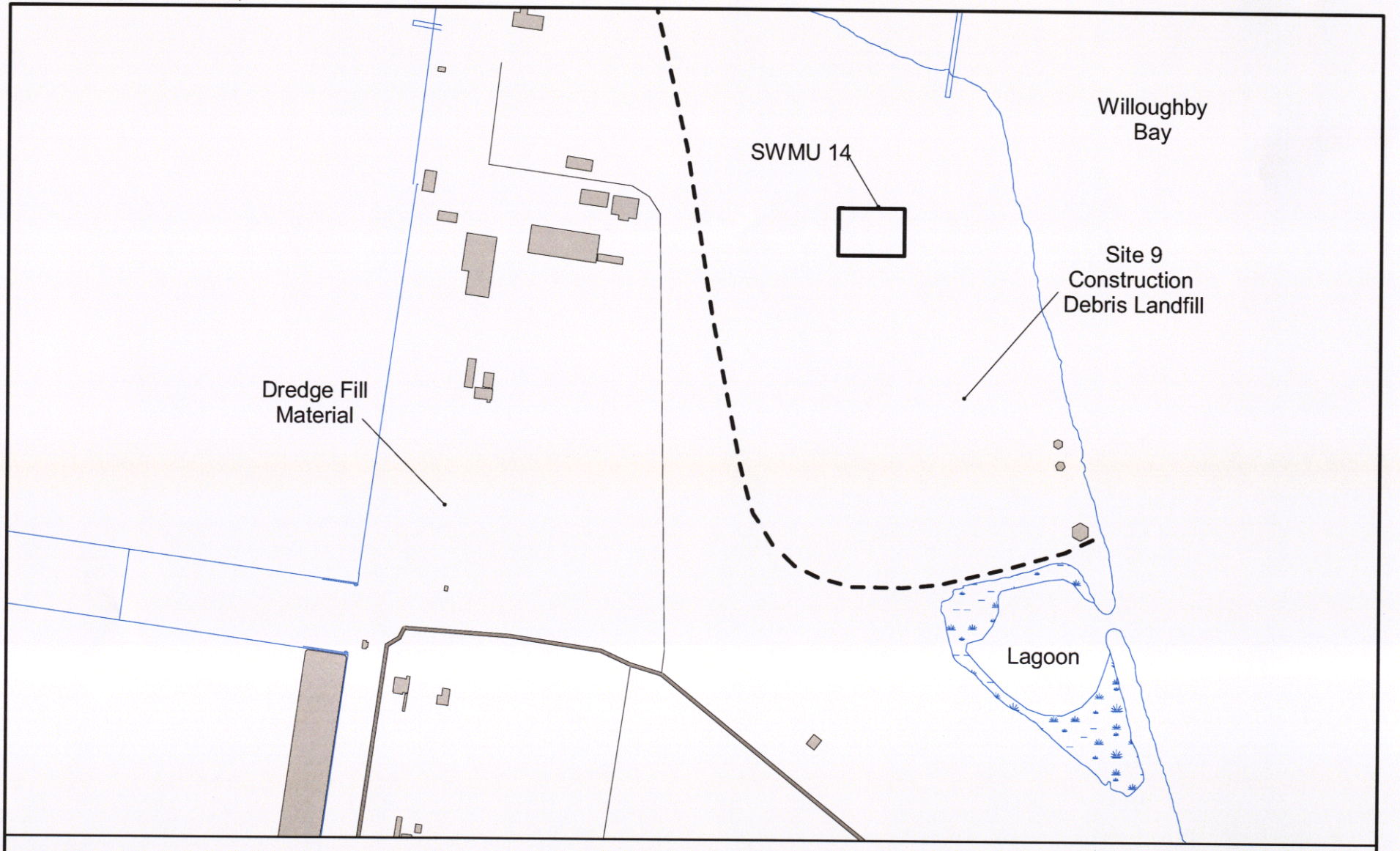

LEGEND

- Shoreline
- Buildings
- SWMUs
- Estimated Landfill Boundary

N

0 200 400 Feet

Figure 1-2
Map of Construction Debris Landfill
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

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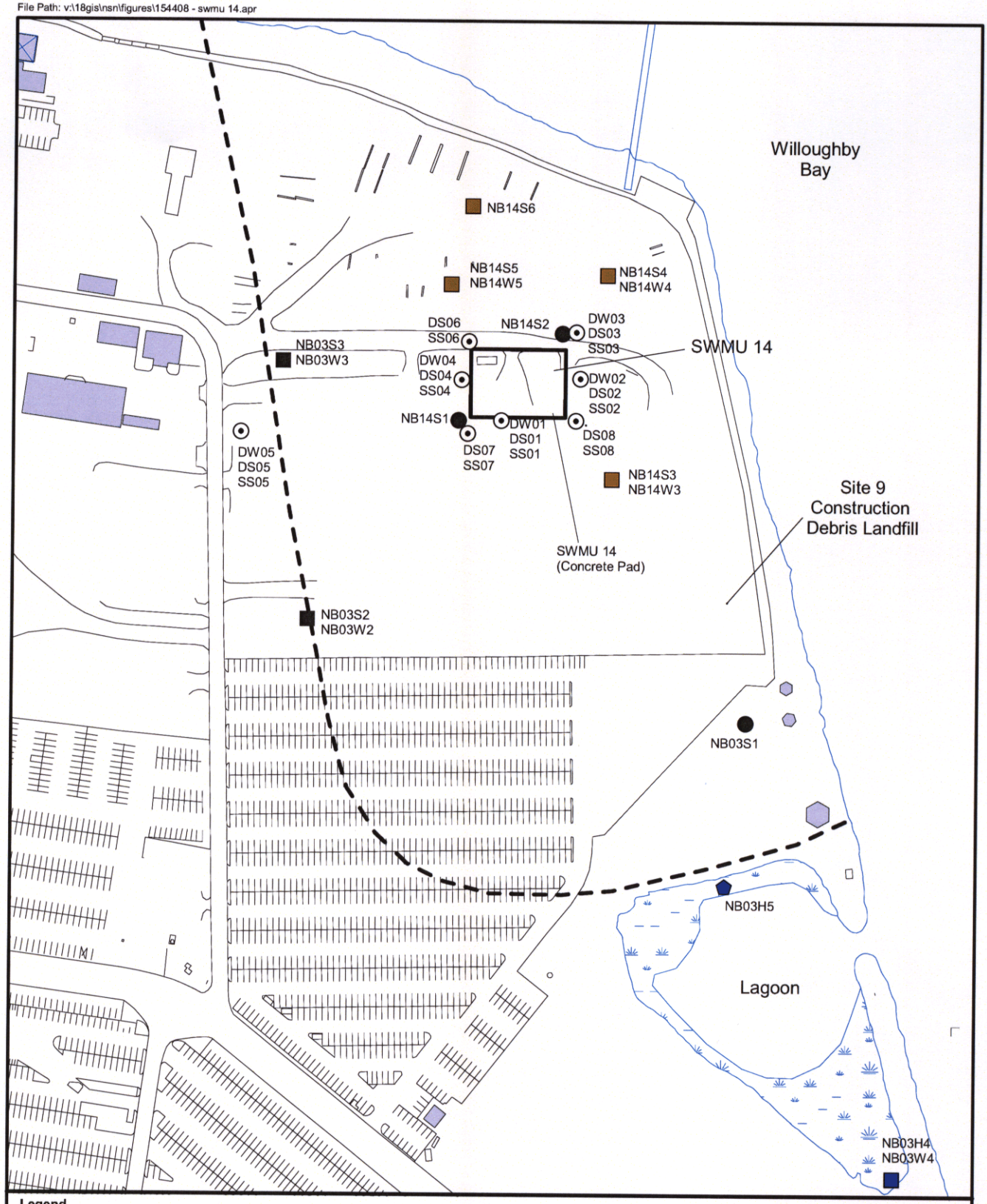

Legend

NB03S2 ● Phase I RRR Surface Soil Sampling Location

NB03S2 NB03W2 ■ Phase I RRR Surface Soil and Groundwater Sampling Location

NB14S6 ■ Phase II RRR Surface Soil Sampling Location

NB14S3 NB14W3 ■ Phase II RRR Surface Soil and Groundwater Sampling Location

DS07 SS07 DW04 DS04 SS04 ⊙ SI Geoprobe Groundwater, Subsurface and Surface Soil Sample Location

NB03H5 ⬟ Phase I Sediment Sample Location

NB03H4 NB03W4 ■ Phase I Sediment and Surface Water Sampling Location

--- Estimated Landfill Boundary

N

0 200 400 Feet

Figure 1-3
SWMU 14 - Q-50 Area
RRR Study / 1998 Supplemental Investigation
Sample Locations
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

CH2MHILL

SECTION 2

Field Investigation Activities

This section documents the field methods used for the SWMU 14 RI and documents the approaches used during the investigation to characterize such features as physiography (topography, drainage, and soil), site geology, and hydrology (surface water and groundwater).

2.1 Investigation Methodology

The following investigations were completed as part of the RI for SWMU 14 at NSN:

- Additional Investigation—RI Phase I (1999)
- Geophysical Survey (2000)
- Supplemental Investigation—RI Phase II (2000)
- Additional Remedial Investigation—RI Phase III (2001)
- Additional Investigation - RI Phase IV (2002)

2.1.1 Additional Investigation Summary (RI Phase I)

The sampling associated with the RI Phase I was proposed based on the results of the RRR studies and the 1998 Supplemental Investigation. The RI Phase I objectives at SWMU 14 were to:

1. characterize the source(s) and downgradient extent of VOCs, SVOCs, PCBs, and metals previously detected in the soil and groundwater
2. evaluate if constituents are potentially reaching ecological receptors in Willoughby Bay
3. characterize the groundwater-flow conditions in the shallow aquifer

The Additional Investigation sampling included:

- Surface and subsurface soil samples were collected at 18 locations (DS01–DS18) to characterize the source and downgradient extent of contaminants previously detected. Figure 2-1 shows the soil boring locations are shown. The surface soil samples were collected between 0 and 6 in. deep and the subsurface samples were collected at 2 to 6 ft below grade. Soil samples were analyzed for Target Analyte List (TAL) metals, Target Compound List (TCL) SVOCs, and TCL pesticides/PCBs. The soil boring logs from the Phase I RI were not available at the time of this report.
- Eight monitoring wells (MW01–MW08) were installed to further characterize the downgradient extent of contaminants detected in the groundwater. The monitoring well data was also utilized to assess if there are potential impacts to ecological receptors in Willoughby Bay. The monitoring wells were installed about 15 ft below ground surface (bgs), using a hollow stem auger (HSA) drill rig with 4¼-in. inner-diameter auger stems. Following well installation and development, groundwater samples were collected and analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, and TAL metals (total and

dissolved). Figure 2-2 shows the monitoring well locations are shown and Appendix B provides boring logs and well construction details.

2.1.2 Geophysical Survey

CH2M HILL conducted a surface geophysical survey at SWMU 14 in June 2000. Earth Resources Technology, Inc. (ERT) of College Park, Maryland, was contracted to perform the geophysical surveys. An electromagnetic survey was initially conducted to establish the extent of the disturbed area and identify buried objects. The survey covered the entire area of the grass field and concrete pad. The survey grid was laid out with a 10-ft interval between east-west survey lines and a 20-ft interval in the north-south direction. Following a review of the data, a ground-penetrating radar survey was performed to assess large anomalies identified in the electromagnetic survey. Appendix C provides the geophysical report.

2.1.3 Supplemental Investigation (RI Phase II)

Based on a review of the available analytical data collected during previous investigations, a supplemental investigation was conducted. The RI Phase II investigation objectives at the SWMU 14 were to:

- further characterize the nature and extent of the contamination,
- establish upgradient concentration values for groundwater, and
- investigate several anomalies detected during the geophysical survey.

The RI Phase II sampling objectives are detailed below.

- Twenty surface and 17 subsurface soil samples (DS19–DS38) were collected to characterize the source and downgradient extent of contamination. The soil-boring locations are shown in Figure 2-1. Each surface and subsurface soil sample was analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, and TAL metals.

- Six monitoring wells were installed and constructed of 2-in. polyvinyl chloride (PVC) well casings and screens. The monitoring well locations are shown on Figure 2-2 and include MW09S and MW11S through MW15S (well MW10S could not be installed due to refusal in the fill material). The wells extended to approximately 15 ft bgs, depending on the depth of the water table. The monitoring wells were installed using a HSA drill rig with 4¼-in. inner-diameter auger stems. Following well installation and development, groundwater samples were collected from seven monitoring wells (six new and one pre-existing) and analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, and TAL metals (total and dissolved). Appendix B provides the well-construction details.

2.1.4 Additional Remedial Investigation (RI Phase III)

A supplemental investigation was conducted, based on a review of the available analytical data collected during previous investigations. The RI Phase III investigation objectives at the SWMU 14 were to:

- Further characterize the nature and extent of soil and groundwater contamination associated with SWMU 14,

- Determine, to the extent possible, the western and southern limits of waste/fill material associated with SWMU 14/Site 9 and establish background levels for soil outside of the fill area as well as groundwater upgradient of the material, and
- Determine the nature of the anomaly encountered at boring location DS19.

The RI Phase III activities are detailed below.

- Eleven soil borings were completed to determine the landfill material's boundary (DS39–DS43 and DS49–DS54). Figure 2-1 shows the soil-boring locations. Nine surface and eight subsurface soil samples were collected from these soil borings to further characterize the source and extent of contamination. Each of the soil samples was analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, and TAL metals. Appendix B provides detailed soil boring logs.
- Four monitoring wells were installed (MW16S–MW19S) and constructed of 2-in. PVC well casings and screens. Figure 2-2 shows the monitoring well locations. The wells extended to approximately 15 ft bgs depending on the depth of the water table. The monitoring wells were installed using a HSA drill rig with 4 ¼-in. inner-diameter auger stems. Following well installation and well development, groundwater samples were collected from all four monitoring wells and analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, and TAL metals (total and dissolved). Appendix B provides well construction details.
- Five surface and subsurface soil samples were collected and analyzed for dioxin and pentachlorophenol. The sample locations (Figure 2-1) include DS44–DS48. These samples were collected near locations with historically high pesticides/PCBs levels.
- An exploratory test pit was conducted at the location of soil boring DS19 (Figure 2-1).

2.1.5 Additional Investigation (2002)

An additional investigation was conducted, based on previous investigations at the site, to evaluate potential impacts on ecological and human receptors. The investigation objectives at SWMU 14 were to:

- Assess possible transport and deposition of material from SWMU 14 to the adjacent lagoon,
- Evaluate a potential lead hotspot identified during the RI sampling, and
- Further evaluate the mobility of contaminants in groundwater and confirm the presence of chloroform.

Sampling locations are shown on Figure 2-3, and the 2002 additional investigation activities are detailed below.

- Five sediment samples (SD01 through SD05) were collected in and near the lagoon. Three of these were collected from the lagoon's interior to assess possible transport and deposition of materials from SWMU 14. The other two were collected at the outfalls to determine the potential impact on the lagoon from sources other than SWMU 14. One was collected adjacent to the southern-area drainage swale that flows into the lagoon.

Another sample was collected at the stormdrain outfall in the lagoon's northern area. The work plan originally scoped the collection of a sediment sample from the stormdrain manhole from the first manhole that was not tidally influenced. However, this sample was not collected due to the absence of accumulated sediment in the manholes. Each sediment sample was analyzed for TCL SVOCs, TCL pesticides/PCBs, TAL metals and cyanide, pH, grain size analysis, and TOC.

- Four surface soil samples (SS09 through SS12) were collected within the site to evaluate a potential lead hotspot identified during the RI sampling and were analyzed for lead only.
- Five groundwater samples were collected from selected monitoring wells (MW05, MW07, MW08, MW15, and MW19) and analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, and TAL metals (total and dissolved), total cyanide, free cyanide, and total dissolved solids (TSS). Groundwater sampling locations were determined based on previous analytical results.

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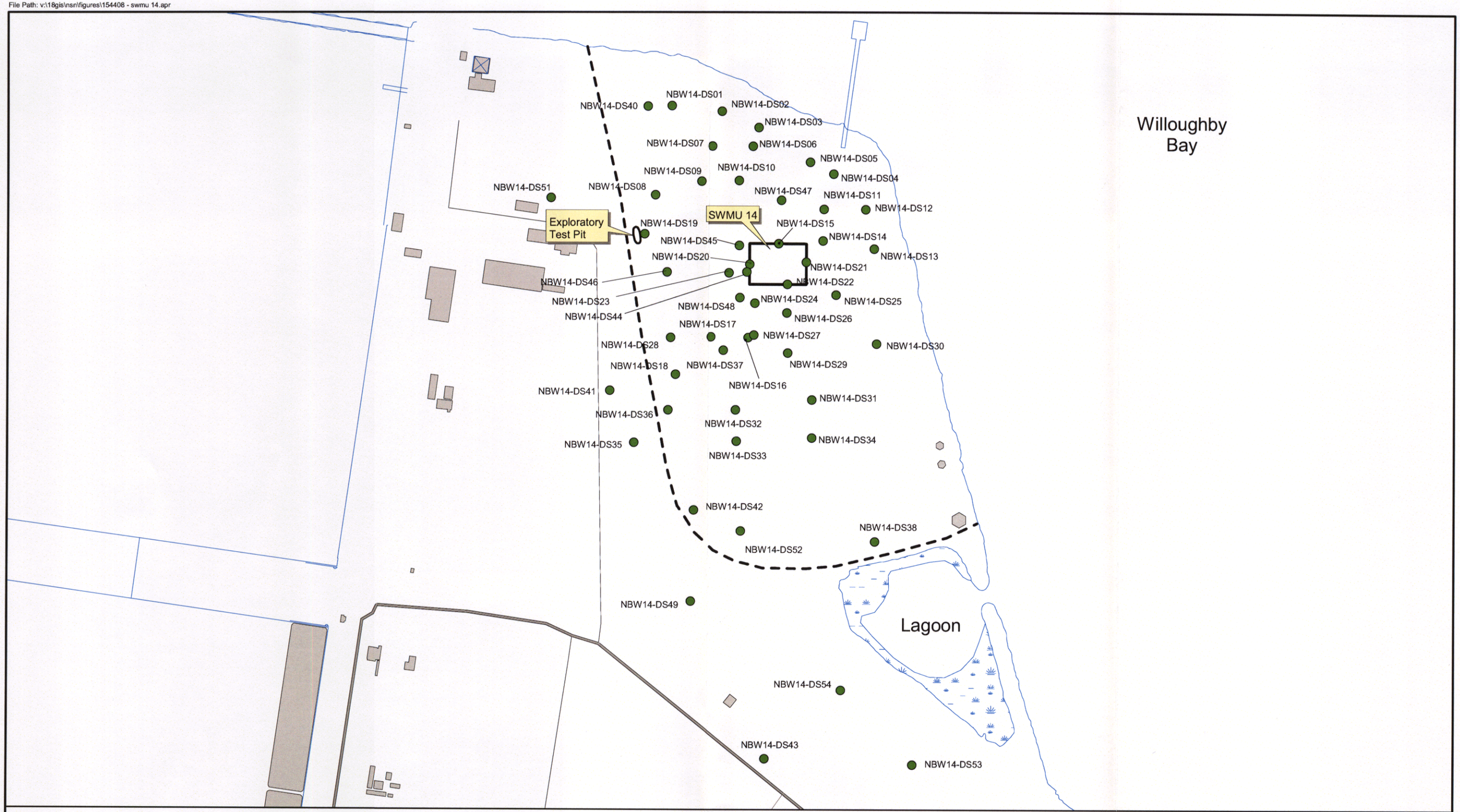

LEGEND

- Soil Borings
- SWMU 14 Satellite Accumulation Area Boundary
- Buildings
- Estimated Q-50 Area / Site 9 Landfill

Figure 2-1
Soil Boring Locations at SWMU 14
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

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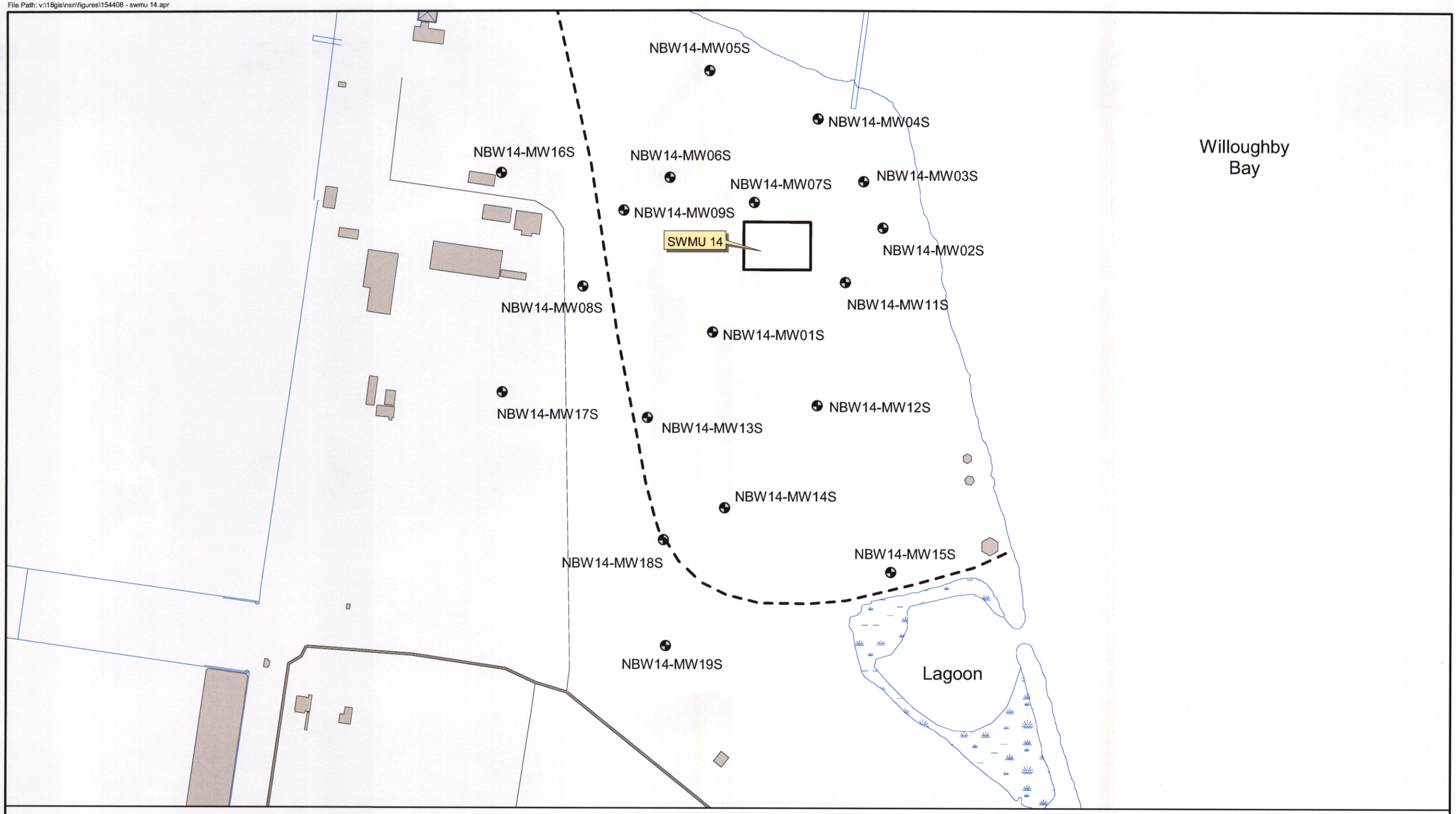

LEGEND

- Monitoring Wells
- SWMU 14 Satellite Accumulation Area Boundary
- Buildings
- Estimated Q-50 Area / Site 9 Landfill

N

0 100 200 Feet

Figure 2-2
Monitoring Well Locations at SWMU 14
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

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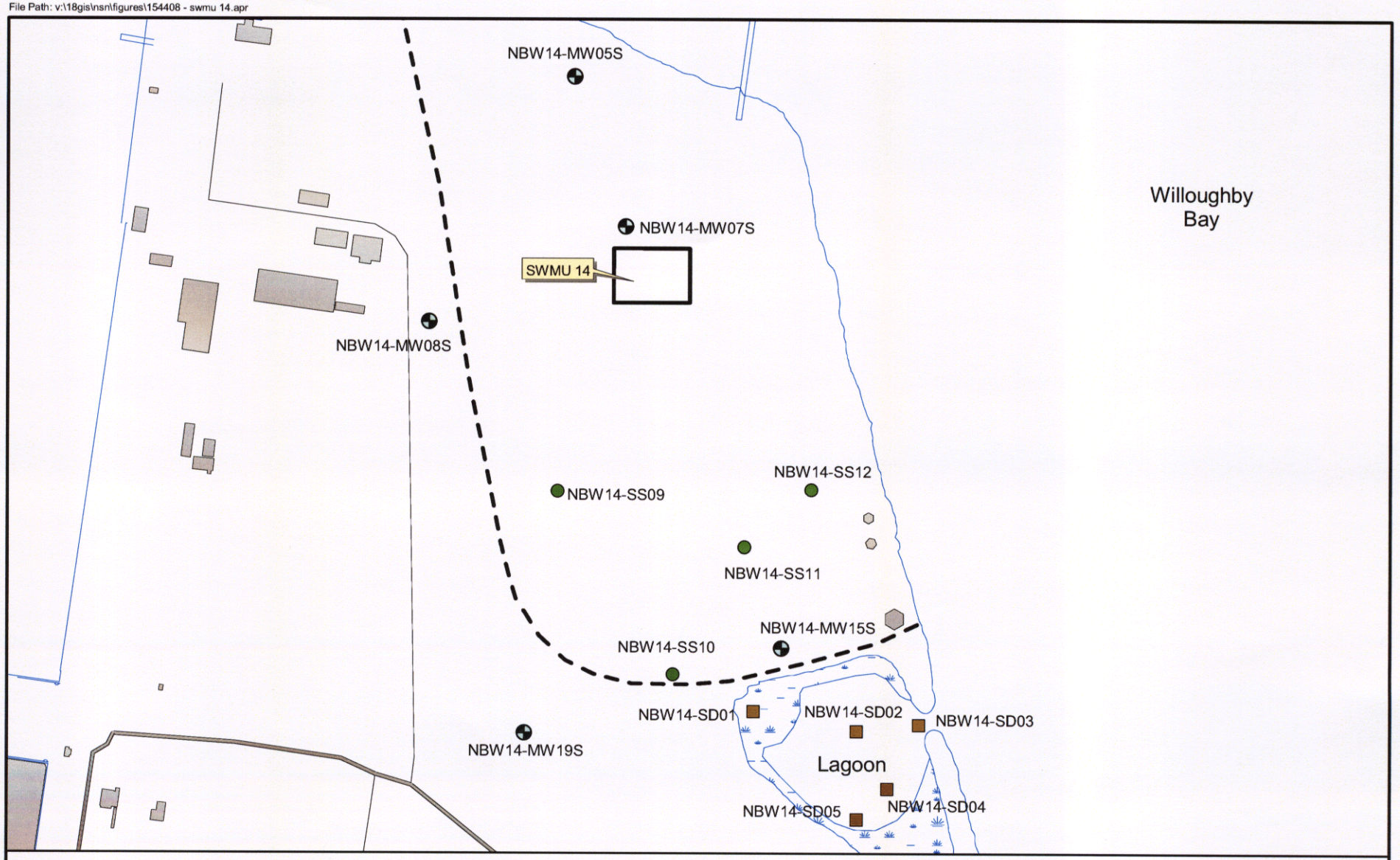

LEGEND

- Groundwater Sample Location
- Surface Soil Sample Location
- Sediment Sample Location
- SWMU 14 Satellite Accumulation Area Boundary
- Buildings
- Estimated Q-50 Area / Site 9 Landfill

N

0 200 400 Feet

Figure 2-3
Additional Sampling Locations Phase IV
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

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SECTION 3

Remedial Investigation Results

This section discusses the physical features of SWMU 14 and the nature and extent of contamination found in groundwater, subsurface soil, and surface soil samples collected during the RI. The discussion is broken down by the site's physical characteristics and sampling media.

3.1 Physiographic Features

The major physiographic features of NSN and surrounding area are described in the following subsections.

3.1.1 Climate

The Hampton Roads Area has a maritime climate characterized by long temperate summers and mild winters. The average annual temperature is 60.7 °F. July is the warmest month, with temperatures averaging 78.7 °F, while January is the coolest, with temperatures averaging 43.1 °F. Precipitation averages 43 inches annually and is evenly distributed throughout the year. A slight increase in precipitation occurs from June to August due to the prevalence of convective thunderstorms. The average annual snowfall is 8.8 inches. Winds are generally in an easterly direction and moderate, ranging from 6 to 8 knots (CH2M HILL, October 1997).

3.1.2 Topography

NSN's topography is nearly level. Surface elevations at the base range from sea level to about 15 ft above mean sea level (msl) in the base's central portion.

3.1.3 Soils

Soils at NSN generally consist of fine sands and silts 20 to 40 ft thick and having low to moderate permeability. Relatively impermeable sediments composed of silt, clay, and sandy clay typically underlie this upper layer of soils. Together, these strata are about approximately 60 ft thick. The average permeability of soils in Norfolk County is less than 2.5 inches per hour (CH2M HILL, October 1997).

The soils at NSN are a complicated distribution of naturally occurring material and dredge-fill material. The native soils are composed of unconsolidated fine sands and silts of low to moderate permeability and are generally underlain by relatively impermeable sediments consisting of silt, clay, and sandy clay. The fill material primarily consists of heterogeneous sediments removed during dredging operations. The composition of the dredge-fill sediments varies from site to site, but it is generally sand, silt, and gravel. Some concrete, stone, and miscellaneous debris were also used as fill material. The complex distribution of the native soils and dredge-fill material and the variable composition of the

fill material must be taken into account when examining soil conditions on NSN (CH2M HILL, October 1997).

3.1.4 Surface Water Resources

Four major surface water features surround the greater Norfolk area including the James and Elizabeth Rivers, Willoughby Bay, and Chesapeake Bay, all of which are tidal. Most surface water on the base flows either to Mason Creek or to the remnants of Bousch Creek. The northernmost channel of Mason Creek traverses the base and empties into Willoughby Bay via a subgrade aqueduct. The main channel of Bousch Creek was filled in and replaced by a network of drainage ditches during the base's development. These narrow drainage channels are interspersed throughout the base's central part. Both Mason Creek and these drainage ditches are tidal throughout the base. Both creeks discharge to Willoughby Bay and ultimately, to the Chesapeake Bay. Some surface water from the base discharges directly into the Elizabeth River (CH2M HILL, October 1997).

3.1.5 Groundwater Resources

NSN is in the outer Atlantic Coastal Plain Physiographic Province, which is characterized by low elevations and gently sloping relief. The base is underlain by more than 2,000 ft of gently dipping sandy sediments, ranging in age from Recent to Lower Cretaceous.

3.1.5.1 Hydrogeology

The uppermost geologic unit is the Columbia Group, composed of Holocene deposits and undifferentiated Pleistocene deposits. The Columbia Group is approximately 60 ft thick. The upper 20 to 40 ft consist of unconsolidated fine sands and silts. These sediments possess low to moderate permeabilities and comprise the unconfined Columbia aquifer. The lower 20 to 40 ft consist of relatively impermeable silt, clay, and sandy clay (CH2M HILL, 1997).

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 underlying Yorktown aquifer. The Yorktown formation is approximately 90 to 100 ft thick in the vicinity of the Base and composed of marine silt and clay and moderately consolidated coarse sand and gravel with abundant shell fragments. The Chesapeake Group is composed of several additional older formations that comprise deeper aquifers and confining units. These overlie the Tertiary Pamunkey Group and Cretaceous stratigraphy.

Two significant shallow aquifer systems in the area are the Columbia aquifer, in the upper 20 to 40 ft of the Columbia Group, and the underlying Yorktown Aquifer. The Columbia aquifer includes the water-table aquifer, is reportedly thin, and consists of discontinuous heterogeneous sand and shell lenses. The water table is usually less than 8 ft deep. The Yorktown Aquifer is semi-confined beneath a clay layer in the upper Yorktown Formation. Water-bearing zones in the Yorktown Aquifer consist of fine to coarse sand, gravel, and shells (CH2M HILL, October 1997).

3.1.5.2 Local Water Usage

Groundwater is not currently used as a potable water supply in the vicinity of NSN. The City of Norfolk Health Department prohibits the use of groundwater for public or private potable water supplies under law ordinance Chapter 46.1, Reference 46.1-5.

3.2 Physical Feature Characterization Results

Understanding of the physical characteristics of SWMU 14 was a primary data-quality objective for the RI. Site physical features of specific interest include the general geology and hydrogeologic characteristics of the site and surrounding areas as well as the areal extent of the Site 9 landfill.

3.2.1 Site Geology and Aerial Extent of the Site 9 Landfill/SWMU 14

The geology of Site 9 is described in detail on the boring logs and well construction diagrams developed during the Phase I, II, and III soil borings and monitoring well installations, and are summarized in Appendix B. An objective of the Phase III RI was also used to determine the extent of the fill material at the site. The characterization of materials at the site is discussed below.

The material at the Sewell's Point peninsula is divided into two basic classifications, dredge fill and construction-debris fill. Figure 1-2 shows the estimated boundary between the two material types. The dredge fill consists mainly of fine- to medium-grained sand and shell hash that comprises the western half of the Sewell's Point peninsula. Similar material is found below the construction debris fill at 6 to 14 ft deep in the site's eastern portion. The eastern section of the peninsula (Site 9 fill area) consists of construction debris fill composed of black to brown silts and sands with some gravel pockets. Large amounts of metal debris were observed during the test pit and drilling activities. In addition, coal and glass fragments were noted as well as what appeared to be buried wood pilings. Figure 3-1 illustrates the cross-sectional view of the borings at SWMU 14. Cross-section A-A1, trending roughly west to east, (Figure 3-2) indicates that the thickness of the landfill material increases significantly from the site's western boundary to the shoreline. The cross-section B-B1, trending south to north, (Figure 3-3) also shows that the landfill material becomes thicker from the site's southern boundary towards the shoreline.

3.2.2 Physical Characteristics of Site 9 Fill Material

A Geometrics Portable Cesium Magnetometer was used during the electromagnetic survey to further characterize the subsurface conditions and determine the presence of buried objects at the site. The electromagnetic data (Figure 3-4) indicate numerous high-intensity magnetic anomalies located throughout the survey area. Such anomalies are typical of buried metallic objects. The anomalies tend to terminate in the southeastern and southwestern corners of the survey area, indicating the possible boundary of the fill material. A Ground Penetrating Radar (GPR) profile was performed, using a Sensors & Software pulse EKKO 1000® radar, on the anomalies located on the eastern side of the concrete slab. However, no specific buried objects were identified, due to their possible oxidation or the close proximity of groundwater. Appendix C includes a copy of the geophysical report showing the locations and results of the surveys.

During the Phase II geophysical survey a large anomaly was detected approximately 50 ft northwest of the existing concrete pad at the site. Soil boring DS19 was completed at the location to determine the nature of the anomaly. During the drilling a metallic object was encountered 5 to 6 ft bgs, and upon examination of the borehole, a petroleum sheen was observed in the groundwater. To further characterize the geophysical anomaly, a 15-ft trench was excavated at the approximate location of DS19 (Figure 2-1). The excavator encountered large metal plates and scrap at 4.5 to 5.5 ft bgs. Therefore, the petroleum sheen observed while drilling was likely derived from the fill material and not the result of a buried tank. Section 4.2.2 includes additional discussion of potential LNAPL in the groundwater.

3.2.3 Hydrogeology

Figure 3-5 shows the plot of the groundwater contours from October 2001. The groundwater-level data indicates that the water table is relatively flat across the site with a fluctuation of approximately 0.6 ft. The groundwater is at its highest elevation near the current concrete pad. Groundwater flows east and north towards Willoughby Bay and west towards the Elizabeth River. In addition, a slight hydraulic divide is located near wells MW07S, MW01S, and MW13S. This divide, located along the site's western edge, separates the groundwater flow to the east and west.

Slug tests were conducted at several of the SWMU 14 monitoring wells in an effort to estimate the hydraulic conductivity of the site's fill materials and calculate groundwater flow velocity across the site. Due to the limited area of influence, the slug test data provide a rough estimate of the water-table aquifer properties near the individual monitoring wells. Appendix D presents the slug test results. The results showed that the hydraulic conductivities at the site ranged from 28 to 106 ft per day. This variation in hydraulic conductivity is characteristic of a site composed of heterogeneous material (i.e., varying types of fill). The groundwater flow velocity at the site was estimated using Darcy's Law divided by the effective porosity:

$$V=Ki/n_e$$

Where:

V = Groundwater velocity (ft/day)

K = average hydraulic conductivity (ft/day)

i = average hydraulic gradient (dimensionless)

n_e = effective porosity (dimensionless)

An average hydraulic gradient of 0.0019 was determined using the groundwater elevations. In addition, based upon the material types at the site an estimated effective porosity of 0.35 was used in the calculation. The results show that the flow velocity across the site ranges from 56 to 209 ft per year.

3.3 Nature and Extent of Contamination

This section discusses the nature and extent of contamination found in soil (surface and subsurface), sediment, and groundwater at SWMU 14 during the RI activities. The discussion is divided into two parts. Section 3.3.1 summarizes the management and evaluation of laboratory analytical data for all media, including surface soil, subsurface soil, groundwater, and sediment. Section 3.3.2 presents the analytical results of the sampling activities.

3.3.1 Data Management

The data management and tracking from the time of field collection to receipt of validated electronic analytical results is of primary importance and reflects their overall quality. Field samples and their corresponding analytical tests were recorded on chain-of-custody forms, which were submitted with the samples to the laboratory. Chain-of-custody entries were checked against the Sampling and Analysis Plan to determine if all designated samples were collected and submitted for the appropriate analyses. On the laboratory's receipt of the samples, a comparison to the field information was made to determine if each sample was analyzed for the correct parameters. In addition, a check was made to ensure that the proper number and types of QA/QC samples were collected for each medium. QA/QC samples included field blanks, equipment blanks, trip blanks, duplicates, MS/MSD samples, and laboratory blanks.

Hardcopies and electronic versions of the analytical data reports for the RI were submitted to a third party for validation. CH2M HILL then formatted the files to automatically download data into the CH2M HILL master Oracle database. Validation procedures established by the Region III Modification to the National Functional Guidelines for Organic (USEPA, 1994) and Inorganic Analyses (USEPA, 1993) were adhered to during the validation process. These steps (third-party validation and electronic data handling) serve to reduce inherent uncertainties associated with data authenticity and usability.

3.3.1.1 Data Comparison

Analytical results for the samples collected from various media during the RI were compared against background values as well as common regulatory, ecological, and human-health based standards or criteria. This comparison was conducted to evaluate the nature and extent of contamination and not to eliminate compounds from further consideration in this document.

The regulatory comparison criteria used are:

- *Surface and subsurface soil* results were screened against background values for dredge fill soil, Region III Risk Based Concentration (RBCs) for residential soil and the ecological screening criteria (surface soil only).
- *Groundwater* results were screened against Federal Maximum Contaminant Levels (MCL) and Region III USEPA RBCs for tap water.

- *Sediment* results were screened against Region III USEPA RBCs (multiplied by 10 for sediment per Region III direction) for residential soil and the ecological screening criteria for sediment.

Brief explanations of the general classes of criteria are provided below.

- **Background UTL-** Background soil constituent concentrations were addressed for Naval Station Norfolk as part of the *Draft Soil Background Investigation Report* (CH2M HILL, September 2000). The investigation's objective was to establish background concentrations of metals, pesticides, and SVOCs in surface and subsurface soil for use in comparison to Installation Restoration Program (IRP) site data to better identify release-related constituents of concern. The background soil samples were collected from dredge fill and native soil to allow for comparison of site data to the corresponding background soil type. Background levels may be attributed to either naturally occurring (those chemicals expected at a site in the absence of human influence) or anthropogenic (chemicals present in the environment due to manmade, non-site-related) sources. Soil data collected at SWMU 14 were compared to Basewide background dredge-fill soil type. Therefore, contaminants that exceeded the established screening criteria in site soil were compared to the dredge-fill background 95-percent upper tolerance limits (UTLs). Additionally, the analytical results for soil were compared to the regulatory screening criteria as discussed below.

- **MCLs for Groundwater**—MCLs are enforceable standards promulgated under the Safe Drinking Water Act for public water supplies consumed by a minimum of 25 persons. The MCLs are designed for the protection of human health, based on laboratory or epidemiological studies. They are designed to prevent adverse human health effects associated with a 70-year lifetime exposure for an average adult (70 kg) consuming 2 liters (L) of water per day. Contaminants exceeding MCLs must be treated/removed from the public water supply prior to its potable use.

- **Region III RBCs for residential soil and tap water (April 2003)**—These criteria, used to evaluate human health are developed using protective default exposure scenarios recommended by USEPA (1991) and the best available reference doses and carcinogenic potency slopes. Exceeding these criteria may result in adverse effects in a human receptor, and might require remedial action by the USEPA or state regulatory agency. Because there are no enforceable regulatory standards for soil in the Commonwealth of Virginia, these criteria are commonly used as a basis of comparison for the nature and extent of soil contamination. They also provide a solely health-based level of comparison for potable water at the point of use. The RBCs based on non-cancer effects were adjusted by using a hazard quotient of 0.1 to account for exposure to multiple constituents.

- Ecological Screening Values—These screening values are based upon USEPA Region III BTAG screening values (USEPA 1995), alternative screening values approved for use at Naval Station Norfolk and additional screening values available from scientific literature. Ecological screening values represent conservative thresholds for adverse ecological effects. When more than one screening value is available for a specific medium and chemical, the lowest were selected. Exceeding these criteria may result in

adverse effects in an ecological receptor and require remedial action by the USEPA or state regulatory agency.

The enforceable regulatory standards are Federal MCLs (used for groundwater comparison). The USEPA Region III RBCs were used in order to evaluate the human health risk associated with detected concentrations in each medium.

The inorganic constituents calcium, magnesium, potassium, and sodium are not typical in waste streams characteristic of the activities conducted at SWMU 14. These common metals are not considered potential site-related compounds and therefore do not warrant detailed attention or discussion. Additionally, there are no human health or ecological screening criteria for these metals.

3.3.2 Data Evaluation and Presentation

Complete data tables, provided in Appendix A, list analytical results for all constituents analyzed for in the samples from the various media (soil, groundwater, and sediment) collected from SWMU 14.

Tables 3-1 through 3-4 show constituents detected in one or more samples for a given matrix. The tables also identify results that exceed selected regulatory, human-health-based criteria, ecologically based criteria, and background concentrations. Shaded cells indicate that the parameter is a possible site contaminant based on exceedance of one or more screening values. Bolded values indicate an exceedance of ecological screening criteria. For soil and groundwater tables, an outlined cell indicates that the parameter exceeded the associated screening values and background 95-percent UTL. This comparison is not done to screen out potential contaminants from further consideration; that step is performed in the human health and ecological risk assessments presented in Sections 7 and 8, respectively. The purpose of the comparison is to focus the subsequent discussions concerning nature and extent on those compounds likely to be site related.

Contaminants were detected in all media of concern including groundwater, surface soil, subsurface soil, and sediment. Concentrations of these contaminants were compared to federal and state screening levels, regulatory standards, guidance, and criteria. This subsection first summarizes the screening levels and regulatory standards, guidance, and criteria used for media evaluation. Then the sampling results for groundwater, surface soil, subsurface soil, and sediment are documented. The results detected from within and outside of the Site 9 boundary are compared to determine potential migration of site constituents. Finally, results of this investigation are compared with those from previous investigations.

A surface water sample was collected during the RRR and is discussed in Section 1.3.1. The surface water data was included in the risk assessments.

This section provides a summary of the distribution of constituents that exceeded screening levels or regulatory standards. This information is documented within the body of the text and summarized in tables for each type of screening level or the regulatory standard for each medium.

3.3.2.1 Results of Groundwater Sampling

Eighteen monitoring wells were sampled during various phases (I, II, III, IV) of the remedial investigation field activities. Samples were analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, and TAL metals (total and dissolved). Samples collected during Phase IV were also analyzed for cyanide (total and free) and TSS.

The groundwater analytical results were compared to the EPA Region III RBC screening levels for tapwater, EPA MCLs for groundwater, and ecological screening values. Table 3-1 lists detected constituents that exceed the screening criteria. Figures 3-6 through 3-9 show the constituents exceeding the screening values.

3.3.2.2 VOCs

Figure 3-6 presents the groundwater VOC analytical results detected above the screening criteria. The analytical results indicate that benzene was detected in exceedance of the RBC tapwater criteria in all but one of the wells (MW12S) in the interior of the fill area, indicating that Site 9 is more likely the source of benzene rather than SWMU 14. The benzene concentrations in four samples also exceeded the MCLs. Vinyl chloride levels in the site's northern half also exceeded the RBC tapwater criteria and MCLs. More sporadic RBC exceedances observed for acetone, TCE, ethylbenzene, 1,4-dichlorobenzene, 1,1,2-trichloroethane, 1,3-dichlorobenzene, 1,2-dichloropropanone, carbon disulfide, chlorobenzene, chloroethane, and chloromethane suggest that Site 9 was the primary source of contamination in groundwater. The chlorobenzene concentration, detected in MW04, also exceeded the MCL.

Low levels of chloroform detected in the groundwater results from MW16S, MW17S, MW18S, and MW19S during Phase III investigation activities were considered to be laboratory contamination since chloroform was not identified as a contaminant in the groundwater samples from the site's interior during any other sampling event. TCE was detected in MW17S west of the Site 9 boundary at a very low estimated concentration of 0.4 μg/L exceeding the tap water RBC during Phase III, but MW17S was not sampled during Phase IV RI activities.

3.3.2.3 SVOCs

Figure 3-7 shows the groundwater SVOC analytical results detected above the screening criteria. With the exception of MW12S, SVOCs exceedances were observed in all of the monitoring wells within the fill area, indicating Site 9 was the primary source of SVOCs. The following SVOCs exceeded only the RBCs: 2-methylnaphathalene, 2,4-dichlorophenol, 1,1-biphenyl, acenaphthene, fluorene, and napthalene. Fluoranthene only exceeded the ecological screening value. 2,4-dimethylphenol, 2-methylphenol, 4-methylphenol, carbazole, dibenzofuran, n-nitroso-di-n-propylamine, and phenanthrene exceeded the RBC and ecological screening values. Pentachlorophenol was the only contaminant that exceeded the RBC, MCLs and ecological screening value. The SVOC exceedances demonstrated that the highest concentrations occurred in isolated pockets along the site's northern boundary, southwest of SWMU 14, and adjacent to the lagoon.

3.3.2.4 Pesticides/PCBs

Figure 3-8 shows the groundwater pesticide/PCB analytical results detected above the screening criteria. No PCB exceedances were observed in the groundwater samples. In addition, only four locations sampled during various phases of the RI activities (MW05S, MW07S, MW12S, and MW15S) demonstrated pesticide exceedances of the RBC or ecological screening value. Compounds that exceeded the ecological screening values included: 4,4'-DDT, endrin, endrin aldehyde, endrin ketone, endosulfan II, alpha-BHC, alpha-chlordane, and gamma-chlordane. Dieldrin, heptachlor epoxide, alpha-BHC, beta-BHC, and gamma-BHC exceeded the RBC. Only heptachlor epoxide and beta-BHC exceeded both the RBC and ecological screening value. The pesticide exceedances occurred in isolated pockets north and south of SWMU 14 along the site's central axis.

3.3.2.5 Metals

Figure 3-9 shows the groundwater metals detected above the screening criteria. At least one inorganic constituent was detected in each location in exceedance of the screening criteria.

- The analytical results show RBC exceedances for total and dissolved antimony, arsenic, barium, thallium, and vanadium. Lead, nickel, and copper exceeded ecological screening values. Total and dissolved cyanide, iron and manganese exceeded both the RBC and ecological screening values.
- Total antimony exceeded the screening criteria at MW04S and MW08S. The estimated concentration at both locations was 1.6 µg/L, just above the RBC threshold value of 1.5 µg/L. Antimony was not detected in the Phase IV sampling at these locations.
- Total and dissolved iron was detected above the RBC and ecological screening criteria in several locations within the Site 9 boundary, but only exceeded the screening value in one location outside of the fill area (MW19S), indicating Site 9 was a likely source of iron contamination.
- Cyanide exceeded the ecological screening value at six groundwater sampling locations. However, the detected cyanide concentrations at MW07S in Phase I, II, and IV were well above both the ecological screening value and the RBC. Cyanide was not detected outside of the fill area, indicating Site 9 was a likely source of cyanide.
- Thallium was detected above the MCL for groundwater and RBC screening criteria in several samples collected in the site's northern portion, and in one location west of Site 9 (MW08S).
- Total and dissolved barium exceeded the RBC at five sampling locations within the fill area. There were no total or dissolved barium exceedances outside of SWMU 14. Barium in MW03S located in the site's northwestern portion also exceeded the MCL for groundwater.
- In general, the highest groundwater metals concentrations were detected at MW07S, located to the north of SWMU 14.
- The distribution of sodium concentrations across the site indicates that the elevated levels are likely due to saltwater intrusion (Table 3-1). The highest sodium concentrations were detected at the monitoring wells near the bay and lagoon with a

range of 1,410,000 µg/L to 4,880,000 µg/L. The wells within the interior and west of the landfill demonstrated significantly lower sodium levels with a range of 67,400 µg/L to 990,000 µg/L.

3.3.2.6 Summary of Exceedances in Groundwater

The groundwater analytical results indicated exceedances of the screening criteria for VOCs, SVOCs, pesticides, and metals. Based on the distribution of these constituents, it appears that Site 9, as well as SWMU 14, was a source of groundwater quality impacts. Although, the groundwater flows radially away from SWMU 14, the groundwater analytical data shows minimum contaminant migration to the west of the Site 9 fill area. However, several of the constituents have been detected in the easternmost wells, indicating the potential for discharge of constituents into Willoughby Bay.

There were no PCB exceedances observed in the groundwater samples. In addition, only four monitoring well locations demonstrated pesticide exceedances of the RBC or ecological screening value. The pesticide exceedances occurred in isolated pockets north and south of SWMU 14 along the site's central axis.

SVOC exceedances were isolated to the samples collected within the debris-fill boundary. SVOC exceedances were observed at almost all interior monitoring wells (with the exception of MW12S). In general, the highest SVOC concentrations occurred in isolated pockets along the site's northern boundary, southwest of SWMU 14, and adjacent to the lagoon.

The concentrations of inorganics exceed the RBCs and ecological screening criteria in monitoring wells both within and outside the Site 9 boundary. The highest levels of inorganics were detected in MW07S, located just north of SWMU 14. The analytical results indicate that there is no overall significant difference in the concentrations of inorganics between the filtered and unfiltered samples. Elevated sodium concentrations in groundwater samples collected along Willoughby Bay are likely attributed to salt water intrusion.

Chloroform was the only exceedance observed in the wells outside the fill area. In addition, chloroform exceedances were not observed in the monitoring wells within the fill area and occurred only in the Phase III samples (in the Phase IV testing of MW19S chloroform was not detected). Therefore, it is likely that chloroform is attributed to laboratory or field collection contamination and is not site related.

Levels of PCBs (specifically Aroclor-1248, Aroclor-1254, and Aroclor-1260) and certain SVOCs (methylene chloride and bis(2-ethylhexyl)phthalate) are significantly lower in the analytical results collected during RI activities. In addition, the RI data show a greater number of metals constituents in exceedance of the screening criteria. These variations in the sampling results can likely be attributed to the limited number of samples collected during the previous investigations in comparison with the relatively larger scale of sampling conducted during the RI.

3.3.3 Results of Surface Soil Sampling

Surface soil samples were collected in all four phases of the remedial investigation field activities. Samples collected during Phase I, Phase II, and Phase III of the remedial investigation were analyzed for SVOCs, pesticides, PCBs, and total metals. Phase II and

Phase III samples were also analyzed for VOCs. Five additional samples(DS44-SD48) collected during the Phase III were analyzed only for dioxin/furans. Phase IV surface soil samples (SS09-SS12) were analyzed for total lead in order to identify a possible lead hotspot in the southern portion of SWMU 14.

The surface soil analytical results were compared to the background UTL for dredge fill soil, EPA Region III residential RBCs, and ecological screening values. Table 3-2 lists the detected constituents. Figures 3-10 through 3-14 illustrate the sample locations and detected constituents exceeding the background UTL and at least one regulatory screening value.

3.3.3.1 VOCs

Surface soil VOC exceedances are shown on Figure 3-10. The only VOC exceedance observed was 1,2-dichlorobenzene in surface soil sample DS33 (270 µg/L) that was above the ecological screening value of 100 µg/L. This location is approximately 400 feet south of SWMU 14 and therefore is not likely attributed to SWMU 14 activities. There were no other VOC exceedances of the screening criteria in surface soil samples collected.

3.3.3.2 SVOCs

Surface soil samples were collected and analyzed for SVOCs in Phase I, II, and III of the RI. Fifteen SVOCs were detected in surface soil samples above the background UTL as well as the regulatory screening criteria, all of which are PAHs. Constituents exceeding the background UTL and the screening criteria include: acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, dibenzofuran, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene. Constituents exceeding the background UTL and the regulatory screening criteria are shown on Figure 3-11.

SVOCs were not detected above the screening values in soil samples collected outside the estimated fill area and in isolated samples in the site's southernmost section. In general, higher concentrations and more numerous constituent exceedances were observed in the site's northern portion. SVOC exceedances were also observed in the site's southwestern portion (DS17, DS18, DS24, DS34, DS36, and DS37). Additionally, isolated exceedances of naphthalene and phenanthrene occurred in various locations throughout the site's middle and northern sections.

3.3.3.3 Pesticides/PCBs

In surface soils, two pesticides and four PCBs were detected above the screening values at various locations within the fill area (Figure 3-12). There were no pesticide/PCB exceedances observed in the soil samples collected outside of the estimated fill area and isolated PCB exceedances to the south of SWMU 14. Dieldrin was detected in DS01 (located in the northeastern portion of the landfill) and DS21 (located along the eastern boundary of SWMU 14) above the background UTL of 12.4 µg/kg and the RBC value of 40µg/kg. Methoxyclor was detected in DS04 (located in the northwestern portion of SWMU 14) above the ecological screening value. Aroclor-1242, Aroclor 1248, Aroclor-1254, and Aroclor-1260 were detected above the screening criteria in various locations within the fill area. Generally, PCB exceedances occurred north of the Site 9 boundary with a few isolated PCB exceedances in the landfill's southern portion. A background UTL for methoxychlor,

Aroclor, 1242, Aroclor 1248, Aroclor 1254, and Aroclor-1260 has not been established for the soil at SWMU 14.

3.3.3.4 Metals

The surface soil metal exceedances are shown on Figure 3-13. Although metals were detected outside the fill area, there were no exceedances of background UTL.

- In general, metal concentrations exceeding the background and regulatory screening criteria occurred in all of the sampling locations in the landfill's northern portion. The exceedances were more isolated in the southern section; however, the highest concentrations of detected constituents, specifically iron and lead, were observed in four sample locations (DS18, DS33, DS34, and DS52) in the southwestern area.
- Elevated lead concentrations were observed in previous RI activities at SWMU 14 in the southern portion of the fill area. Additional surface soil samples were collected during Phase IV sampling activities in order to determine if a hotspot was present. The result from SS10 in the southern portion of SWMU 14 was also elevated, but there was specific trend or pattern correlating to other sampling locations that would suggest a defined hot spot.
- Copper concentrations were elevated in both the site's southern and northern portions. DS07 (9,070 µg/kg) and DS40 (1,210 µg/kg), located in the northern area were detected significantly above the background UTL, ecological screening value, and RBC. Four sampling locations in the landfill's southern portion (DS18 DS33, DS34, and DS52) also had copper results well above the background UTL, ecological screening value, the RBC for residential soil.
- Cadmium was detected above the background and regulatory screening values in several surface soil samples collected at the site. Detected constituents exceeding the screening criteria were located in both the landfill's northern and southern portions. However, there were no specific trends associated with the exceedances. Specifically, the highest cadmium concentrations were located in DS33 (20.3 µg/kg), DS40 (13.7 µg/kg), and DS52 (22.6 µg/kg).
- Aluminum, barium, selenium, and cyanide were detected above the screening criteria in isolated sampling locations. However, aluminum, barium, and selenium exceeded the background UTL and regulatory screening criteria in only one location (DS33). Cyanide exceeded the ecological screening value at DS01 (57.5 µg/kg) collected during Phase I of the RI. A background UTL has not been established for cyanide.
- Vanadium was detected above the background and the regulatory screening criteria in six samples (DS13, DS14, DS30, DS33, DS40, and DS52) collected at SWMU 14. Concentrations ranged from 108 µg/kg to 183 µg/kg with no specific trend. The highest concentration (183µg/kg) was detected in DS52, in the landfill's southwestern portion.
- Thallium was detected above the screening criteria in several surface soil samples collected in the southern portion of Site 9. The highest concentration (41. 6 mg/kg) was detected at DS33, located approximately 450 ft south of the SWMU 14 boundary. Thallium exceeded the screening criteria at only one location north of the SWMU 14 boundary (1.2 mg/kg at DS10). Thallium was not detected during background

investigations for the dredge fill soil, therefore a background screening value has not been established.

- More isolated inorganic constituents including chromium, manganese, mercury, nickel, silver, and zinc were detected in a number of samples above the background and regulatory screening values. Concentrations generally were highest in DS33 and DS52 located in SWMU 14's southern portion as well as DS40 in the northwestern portion.

3.3.3.5 Dioxins and Furans

Five surface soil samples were collected and analyzed for dioxins and furans. Sampling locations and exceedances are shown on Figure 3-14. Background UTLs and ecological screening values were not established for dioxin and furans at SWMU 14. Therefore, the analytical results have been evaluated against the RBC for residential soil alone.

The analytical results indicated dioxins and furans exceeded the RBCs at two surface soil locations (DS44 and DS47) which were collected adjacent to SWMU 14. The compounds that exceeded the RBCs included 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin, 1,2,3,7,8-pentachlorodibenzo-p-dioxin, and 2,3,4,7,8-pentachlorodibenzofuran.

3.3.3.6 Summary of Exceedances in Surface Soil

The analytical results were compared to the dredge-fill background soil levels established in the *Draft Soil Background Investigation Report* (CH2M HILL, September 2000) as well as the RBC residential soil criteria and ecological screening values. Several SVOCs and pesticides/PCBs detected within the landfill at concentrations exceeding the RBCs also exceeded the background levels. 1,2-Dichlorobenzene was the only VOC detected in surface soil sample DS33 above the ecological screening values. Dioxins/furans were detected above the screening criteria in two sampling locations (DS44 and DS47).

A comparison of Phases I, II, III, and IV of the RI data to the previous investigations indicates that, overall, the same groups of contaminants exceed the screening criteria at the site. However, the levels of pesticides/PCBs (specifically Aroclor-1260, and dieldrin) are significantly lower in analytical results collected from RI activities. In addition, the RI data shows that there is a greater number of metals (thallium and manganese) in exceedance of the screening criteria. However, similar SVOC exceedances are observed in both the previous investigations and the RI. These variations in the sampling results can likely be attributed to the limited number of samples collected during the previous investigations in comparison with the relatively larger scale of sampling conducted during the RI.

3.3.4 Results of Subsurface Soil Sampling

The Phase I, II, and III subsurface soil samples were analyzed for TCL VOCs (Phase I and II only), TCL SVOCs, TCL pesticides/PCBs, and TAL metals. In addition, four subsurface soil samples were collected during the Phase III event and analyzed for dioxins/furans.

The subsurface soil analytical results were compared to the background UTL for dredge fill soil, EPA Region III residential RBCs, and ecological screening values. Table 3-3 lists the detected constituents. Figures 3-15 through 3-19 illustrate the sample locations and detected constituents exceeding the background UTL and at least one regulatory screening value.

3.3.4.1 VOCs

There were no subsurface soil VOC exceedances of the residential RBCs.

3.3.4.2 SVOCs

Figure 3-15 shows the subsurface soil SVOC RBC exceedances. No SVOC exceedances were observed in the subsurface soil samples collected outside the estimated fill area. In addition, most of the samples from the landfill interior demonstrated no exceedances of the screening values.

- The subsurface samples from the landfill interior indicate that benzo(a)pyrene levels exceed the RBCs at most sampling locations. However, the concentrations were generally below the background UTL with the exception of the northern and easternmost sampling locations.
- There were isolated pockets of exceedances for benzo(a)anthracene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene northeast, north, and south of the SWMU 14 pad. Sample location DS29 demonstrated the highest concentrations (two orders of magnitude greater than observed throughout the rest of the site) and showed exceedances of benzo(k)fluoranthene, carbazole, and chrysene in addition to constituents that exceeded at the other sampling locations.

3.3.4.3 Pesticides/PCBs

The subsurface soil pesticide/PCB RBC exceedances are shown on Figure 3-16. No pesticide/PCB exceedances were observed in the soil samples collected outside of the estimated fill area. In addition, only one sampling location (DS38) from the landfill interior showed a pesticide exceedance for dieldrin. Furthermore, the samples from the landfill interior show that there were RBC exceedances of aroclor-1242, aroclor-1248, aroclor-1254, and aroclor-1260 observed throughout the site with the highest frequency in the northern portion of the landfill.

3.3.4.4 Metals

Fifteen inorganic constituents exceeded the background UTL and RBC in at least one sampling location. There were no inorganics detected above the background UTL outside of fill area. Figure 3-17 shows the subsurface soil metal RBC.

- The analytical results show that arsenic was detected in exceedance of the RBC in every subsurface soil sample. However, the concentration of arsenic exceeded the background level at only one location (DS01), located within the fill area.
- Antimony, cadmium, chromium, copper, iron, lead, manganese, vanadium, and zinc were detected above the background UTL and RBC at several locations within the site. In general, concentrations were higher in the landfill interior's northern and southwestern portions.
- Additionally, aluminum, barium, beryllium, mercury, nickel, and silver were detected above the background and RBC. However, the exceedances were much less frequent across the site and did not indicate a spatial trend.

- Thallium exceeded the RBC in 21 samples collected at SWMU 14. Subsurface soil samples exceeding the screening criteria were located along the SWMU 14 boundary and in the southern portion of Site 9. Concentrations of thallium were highest in DS33 (45.4 mg/kg). Thallium was not detected in the background investigations, therefore a screening value was not established for dredge fill soil at NSN.

3.3.4.5 Dioxins and Furans

Figure 3-18 shows the subsurface soil dioxin and furan RBC exceedances. The analytical results showed indicated dioxin and furan exceedances at four of the five subsurface soil sampling locations. The following constituents slightly exceeded the adjusted residential soil RBCs: 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin, 1,2,3,4,7,8-hexachlorodibenzofuran, 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin, 1,2,3,6,7,8-hexachlorodibenzofuran, 1,2,3,7,8-pentachlorodibenzo-p-dioxin, 2,3,4,6,7,8-hexachlorodibenzofuran, 2,3,4,7,8-pentachlorodibenzofuran, 2,3,7,8-TCDD, 2,3,7,8-tetrachlorodibenzofuran.

3.3.4.6 Summary of Exceedances in Subsurface Soil

The analytical results of the subsurface soil samples indicate exceedances of the RBC residential soil criteria for SVOCs, pesticides, PCBs, metals, and dioxins/furans. There were no VOC exceedances of the RBCs for subsurface soil. In addition, the exceedances of both the screening values and the background levels were limited to the extent of the fill area. Based on the subsurface soil analytical results and the observations documented in the boring logs, the extent of the Site 9 fill area has been delineated, as illustrated in Figure 1-2.

The analytical results were compared to the dredge-fill background soil levels. SVOCs, pesticides, PCBs, and metals were detected within the landfill at concentrations above the RBCs and background levels.

The results show that arsenic was detected in exceedance of the RBC in every subsurface soil sample. However, only one result exceeded the background UTL (DS01 located within the fill area. Antimony, cadmium, chromium, copper, iron, lead, manganese, vanadium, and zinc were detected above the background UTL and RBC at several locations within the site. In general, concentrations were higher in the landfill interior's northern and southwestern portions of. Aluminum, barium, beryllium, mercury, nickel, and silver were also detected above the background and RBC, however the exceedances were much less frequent across the site and indicated no specific trend. Thallium was detected above the RBC at several locations surrounding SWMU 14 and in the southern portion of Site 9. The analytical results indicated that there were slight exceedances of the adjusted residential soil RBCs for dioxins/furans at four of the five subsurface soil samples collected adjacent to SWMU 14.

3.3.5 Results of Sediment Sampling

Five additional sediment samples were collected during the Additional Investigation activities and analyzed for TCL SVOCs, Pesticide/PCBs, and TAL metals. Table 3-4 lists the detections and exceedances. Figure 3-19 shows the sediment exceedances of the screening criteria.

There were no organic exceedances of the RBCs. Eight PAHs exceeded the ecological screening values in samples SD01, SD02, and SD04 (acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, dibenz(a,h)anthracene, fluorene, phenanthrene, and

pyrene). All PAH values were estimated below the detection limit (as indicated with the J flag) with the exception of pyrene at SD04 (710 µg/kg). Six pesticides/PCBs were detected above the ecological screening value (4,4'-DDE, 4,4'-DDT, arochlor-1260, alpha-chlordane, beta-BHC, and gamma-chlordane).

Inorganic constituents (arsenic, barium, cadmium, copper, cyanide, iron, lead, mercury, nickel, selenium, vanadium, and zinc) exceeded the regulatory screening values. However, arsenic (detected in three of four sampling locations) was the only analyte detected above both the RBC (4.3 µg/kg) and ecological screening value (8 µg/kg).

The analytical results from the lagoon show that SD02 and SD04, located within the interior of the lagoon, consistently demonstrated the highest concentrations of the detected constituents. The lagoon may serve as a depositional area for inputs from the two outfalls to the north and south, as well as, the bay inlet to the east; therefore, other contaminant sources may be contributing to the lagoon.

3.3.6 References

CH2M HILL. *Final Master Work Plan Naval Base, Norfolk, Norfolk, Virginia.* October 1997.

CH2M HILL. *Draft Soil Background Investigation Report, Naval Station Norfolk, Norfolk, Virginia.* September 2000.

USEPA. *Region III Modification to National Functional Guidelines for Data Review.* 1994.

USEPA. *Revised Region III BTAG Screening Levels.* Memorandum from R.S. Davis to Users. August 1995.

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

USEPA. *Region III Risk-Based Concentration (RBC) Table.* Superfund Technical Support Section, Philadelphia, PA. April, 2003.

Table 3-1
Groundwater Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID	MCL-Ground water	Tap Water Adjusted RBC *	Ecological Screening Values	NBW14-MW01S	NBW14-MW02S	NBW14-MW03S	NBW14-MW04S	NBW14-MW05S		NBW14-MW06S
Sample ID				NBW14-MW01S-R01	NBW14-MW02S-R01	NBW14-MW03S-R01	NBW14-MW04S-R01	NBW14-MW05S-R01	NBW14-MW05S-R03	NBW14-MW06S-R01
Sample Date				01/05/00	01/07/00	01/07/00	01/07/00	01/07/00	12/16/02	01/05/00
Chemical Name										
Volatile Organic Compounds (UG/L)										
1,1,2-Trichloroethane	5	0.19	31,200	1 U	1 U	1 U	10 U	5 U	0.5 U	1 U
1,1-Dichloroethane	–	80	320,000	1 U	0.23 J	7.6	10 U	5 U	0.5 U	1 U
1,1-Dichloroethene	7	35	224,000	1 U	1 U	0.14 J	10 U	5 U	0.5 U	1 U
1,2-Dichlorobenzene	600	27	129	1.3	0.19 J	1 U	4.3 J	0.88 J	0.41 J	0.15 J
1,2-Dichloropropane	5	0.16	3,040	1 U	1 U	1 U	10 U	5 U	0.5 U	1 U
1,3-Dichlorobenzene	–	0.55	129	0.29 J	1 U	1 U	1.6 J	5 U	0.5 U	1 U
1,4-Dichlorobenzene	75	0.47	129	17	1 U	1 U	8.4 J	5 U	0.5 U	1 U
2-Butanone	–	190	40,000	5 U	5 UR	5 UR	50 UR	25 UR	1.5 B	5 UR
4-Methyl-2-pentanone	–	14	–	5 U	5 U	5 U	29 J	56	0.46 B	5 U
Acetone	–	61	750	4.7 J	4.1 J	5 UR	50 UR	25 UR	6.5 B	2.2
Benzene	5	0.32	700	25	0.49 J	0.38 J	1.4 J	5	8.1	1.3
Carbon disulfide	–	100	2	1 U	1 U	1 U	10 U	5 U	0.12 J	1 U
Chlorobenzene	100	11	129	15	1 U	1 U	130	30	89	0.43 J
Chloroethane	–	3.6	–	1 U	1 U	10	10 U	5 U	0.5 U	1 U
Chloroform	80	0.063	815	1 U	1 U	1 U	10 U	5 U	0.5 U	1 U
Chloromethane	–	2.1	2,700	1 U	1 U	1 U	10 U	5 U	0.5 U	1 U
Cumene	–	66	–	NA	NA	NA	NA	NA	2.5	NA
Cyclohexane	–	–	–	NA	NA	NA	NA	NA	0.77	NA
Dichlorodifluoromethane(Freon-12)	–	35	6,400	NA	NA	NA	NA	NA	0.5 U	NA
Ethylbenzene	700	3.3	430	12	0.15 J	1 U	2 J	13	14	0.2 J
Methyl-tert-butyl ether (MTBE)	–	0.26	–	NA	NA	NA	NA	NA	0.5 U	NA
Methylcyclohexane	–	630	–	NA	NA	NA	NA	NA	1.2	NA
Methylene chloride	5	4.1	6,400	2 U	2 U	2 U	20 U	10 U	0.22 B	0.32 J
Styrene	100	160	510	1 U	1 U	1 U	10 U	5 U	0.92	1 U
Toluene	1,000	75	1,050	2	1.6	1 U	1.3 J	48	7.4	0.4 J
Trichloroethene	5	0.026	2,000	1 U	1 U	0.21 J	10 U	5 U	0.12 J	1 U
Vinyl chloride	2	0.015	224,000	1 U	1 U	17	10 U	1.3 J	1.1	0.2 J
Xylene, total	10,000	1,200	6,000	24	0.4 J	1 U	2.1 J	86	60	0.95 J
cis-1,2-Dichloroethene	70	6.1	224,000	0.32 J	1 U	3.8	10 U	1.8 J	0.55	0.21 J
trans-1,2-Dichloroethene	100	12	224,000	1 U	1 U	7.6	10 U	5 U	0.29 J	1 U
Semivolatile Organic Compounds (UG/L)										
1,1-Biphenyl	–	30	46	NA	NA	NA	NA	NA	1.5 J	NA
1,2-Dichlorobenzene	600	27	129	10 U	10 U	15	2.9 J	10 U	NA	10 U
1,3-Dichlorobenzene	–	0.55	129	10 U	10 U	14	1.3 J	10 U	NA	10 U
1,4-Dichlorobenzene	75	0.47	129	12	10 U	23	6.6 J	10 U	NA	10 U
2,4,5-Trichlorophenol	–	370	11	25 U	25 U	25 U	2.7 J	25 U	22 U	25 U
2,4,6-Trichlorophenol	–	6.1	12.1	10 U	10 U	10 U	4.1 J	10 U	5.6 U	10 U
2,4-Dichlorophenol	–	11	–	10 U	10 U	10 U	5.5 J	19	4.7 J	4.4 J
2,4-Dimethylphenol	–	73	110	6.1 J	10 U	7.5 J	3.8 J	65	58	52
2-Methylnaphthalene	–	12	300	130	1.1 J	48	41	25	26	3.2 J
2-Methylphenol	–	180	102	2.1 J	10 U	2.8 J	10 U	250	250	80
4-Methylphenol	–	18	50	10 U	1.3 J	2 J	11	9.8 J	5.6 U	8.7 J
Acenaphthene	–	37	710	110	2.9 J	15	5.2 J	4.1 J	3.7 J	2.9 J
Acenaphthylene	–	–	300	1.6 J	10 U	10 U	10 U	10 U	5.6 U	10 U
Anthracene	–	180	300	4.2 J	10 U	10 U	10 U	1.9 J	1.2 J	1 J
Benzaldehyde	–	370	–	NA	NA	NA	NA	NA	5.6 U	NA
Carbazole	–	3.3	10	50	10 U	5.4 J	2.9 J	1.5 J	NA	10 U
Dibenzofuran	–	2.4	10	52	10 U	5.8 J	2.8 J	1.4 J	1.4 J	1 J
Dimethyl phthalate	–	37,000	3.4	10 U	10 U	10 U	10 U	10 U	5.6 U	10 U
Fluoranthene	–	150	16	2.1 J	10 U	10 U	10 U	10 U	5.6 U	10 U
Fluorene	–	24	300	48	1.1 J	6.4 J	2.7 J	2.3 J	2.3 J	1.1 J
Naphthalene	–	0.65	2,300	860	2.9 J	130	66	35	38	2.8 J
Pentachlorophenol	1	0.56	7.9	25 U	25 U	25 U	14 J	25 U	5.6 U	25 U
Phenanthrene	–	18	4.6	41	1.7 J	5.7 J	3.3 J	2 J	2.3 J	1.9 J
Phenol	–	1,100	5,800	1.5 J	1.1 J	10 U	10 U	49	5.6 U	290
Pyrene	–	18	300	1 J	10 U	10 U	10 U	10 U	5.6 U	10 U
bis(2-Ethylhexyl)phthalate	6	4.8	360	10 U	10 U	10 U	2.9 J	10 U	2.7 J	10 U
n-Nitroso-di-n-propylamine	–	0.0096	–	10 U	10 U	10 U	10 U	10 U	5.6 U	10 U
n-Nitrosodiphenylamine	–	14	330,000	12	10 U	10 U	1.1 J	10 U	5.6 U	10 U
Pesticide/Polychlorinated Biphenyls (UG/L)										
4,4'-DDD	–	0.28	0.68	0.15	0.1 U	0.1 U	0.1 U	0.1 U	0.021 UJ	0.1 U
4,4'-DDE	–	0.2	1.4	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.021 J	0.1 U
4,4'-DDT	–	0.2	0.001	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.011 J	0.1 U
Aldrin	–	0.0039	1.3	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.01 UJ	0.05 U
Dieldrin	–	0.0042	0.11	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.021 UJ	0.1 U

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Table 3-1
Groundwater Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID	MCL-Ground water	Tap Water Adjusted RBC *	Ecological Screening Values	NBW14-MW01S	NBW14-MW02S	NBW14-MW03S	NBW14-MW04S	NBW14-MW05S		NBW14-MW06S
Sample ID				NBW14-MW01S-R01	NBW14-MW02S-R01	NBW14-MW03S-R01	NBW14-MW04S-R01	NBW14-MW05S-R01	NBW14-MW05S-R03	NBW14-MW06S-R01
Sample Date				01/05/00	01/07/00	01/07/00	01/07/00	01/07/00	12/16/02	01/05/00
Chemical Name										
Endosulfan I	–	22	0.0087	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.01 UJ	0.05 U
Endosulfan II	–	22	0.0087	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.021 UJ	0.1 U
Endosulfan sulfate	–	22	0.0087	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.021 UJ	0.1 U
Endrin	2	1.1	0.01	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	**0.015 J**	0.1 U
Endrin aldehyde	2	1.1	0.01	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.021 UJ	0.1 U
Endrin ketone	2	1.1	0.01	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.021 UJ	0.1 U
Heptachlor epoxide	0.2	0.0074	0.0036	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.01 UJ	0.05 U
alpha-BHC	–	0.011	0.34	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.01 UJ	0.05 U
alpha-Chlordane	–	0.19	0.004	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	**0.0099 J**	0.05 U
beta-BHC	–	0.037	0.34	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.01 UJ	0.05 U
delta-BHC	–	–	0.34	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.0065 J	0.05 U
gamma-BHC (Lindane)	0.2	0.052	0.16	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.01 UJ	0.05 U
gamma-Chlordane	–	0.19	0.004	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.01 UJ	0.05 U
Total Metals (UG/L)										
Aluminum	–	3,700	87	38.6 B	55.6 B	48 B	96.2 B	92.4 B	86.6 B	42.6 B
Antimony	6	1.5	500	1.4 U	1.4 U	1.4 U	1.8 J	1.4 U	1.2 U	1.4 U
Arsenic	10	0.045	36	3.8 J	3.6 J	2.9 U	2.9 U	21.2	13.9	14
Barium	2,000	260	10,000	160 J	1,510	2,080	941	94.4 J	160 J	27 J
Beryllium	4	7.3	1,500	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.2 U	0.15 U
Cadmium	5	1.8	8.85	3.4 U	3.4 U	3.4 U	3.4 U	3.4 U	0.37 J	3.4 U
Calcium	–	–	–	26,700	84,000	57,000	136,000	14,500	13,700	22,900
Chromium	100	11	50.4	2.8 B	2.2 U	3.8 B	2.2 U	5 B	2.2 J	2.2 U
Cobalt	–	220	23	2.9 U	2.9 U	2.9 U	3.7 B	2.9 U	0.7 U	2.9 U
Copper	1,300	150	3.7	1.2 L	1.2 L	0.8 UL	1.5 L	**4.1 L**	1.5 U	1.8 L
Cyanide	200	73	1	10 U	10 U	10 U	10 U	**12**	**10.9**	11
Iron	–	1,100	1,000	7,950	18,400	18,900	38,300	329	123	209
Lead	15	15	8.5	1.6 U	2.9 B	1.6 U	1.6 U	**13.2**	2.5 L	1.6 U
Magnesium	–	–	–	50,500	236,000	266,000	331,000	27,500	28,200	10,000
Manganese	–	73	10	59.1	480	691	842	**20**	31.1	8.2 J
Nickel	–	73	8.3	**8.8 J**	6.9 U	6.9 U	6.9 U	**9.8 J**	7 J	6.9 U
Potassium	–	–	–	74,700	164,000	192,000	183,000	134,000	194,000 J	60,900
Selenium	50	18	71.1	3 U	3 U	3 U	3 U	3 U	3 UL	3.1 J
Sodium	–	–	–	710,000	3,870,000	4,600,000	4,490,000	1,410,000	1,390,000	731,000
Thallium	2	0.26	2,130	3.8 U	7.5 J	9.3 J	8.2 J	3.8 U	2.4 UL	4.9 J
Vanadium	–	26	10,000	4.2 B	3.2 B	4.4 B	4.3 B	72.4	15.3 J	11.8 B
Zinc	–	1,100	86	9.7 B	34.8 B	10.8 B	80.8	13.6 B	6.1 L	16.7 B
Dissolved Metals (UG/L)										
Antimony	6	1.5	500	1.4 U	2.4	1.4 U	1.4 U	2.6 J	1.2 U	3.4 J
Arsenic	10	0.045	36	6.1	2.9 J	2.9 U	2.9 U	21.2	17.4	11.6
Barium	2,000	260	10,000	158 J	1,670	2,090	845	92.8 J	178 J	24.8 J
Calcium	–	–	–	25,800	81,800	55,400	138,000	14,200	16,200	20,500
Chromium	100	11	50	2.5 B	2.2 U	3.6 B	2.7 B	4.3 B	2.1 J	2.2 U
Cobalt	–	220	23	2.9 U	4.3 B	2.9 U	3.7 B	2.9 U	1 J	2.9 U
Copper	1,300	150	3.1	0.8 UL	0.8 UL	2.4 L	0.8 UL	1.6 L	1.5 U	**23.2 L**
Cyanide	200	73	1	NA	NA	NA	NA	NA	NA	NA
Iron	–	1,100	1,000	7,480	22,000	13,700	55,100	269	109	153
Lead	15	15	8.1	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.2 U	1.6 U
Magnesium	–	–	–	50,100	220,000	252,000	371,000	27,900	34,200	9,760
Manganese	–	73	10	55.9	514	595	864	19.3	36.6	8.6 J
Mercury	2	1.1	0.94	0.024 U	0.024 U	0.024 U	0.047 B	0.024 U	0.1 U	0.035 B
Nickel	–	73	8.2	6.9 U	6.9 U	6.9 U	6.9 U	8.2 J	**8.5 J**	7.9 J
Potassium	–	–	–	74,700	167,000	184,000	201,000	130,000	216,000 J	57,000
Selenium	50	18	71	3 U	3 U	3 U	6 U	3 U	3 UL	3 U
Sodium	–	–	–	670,000	3,720,000	4,430,000	4,880,000	1,410,000	1,550,000	696,000
Thallium	2	0.26	2,130	4.8 J	9.4 J	5.7 J	8.8 J	3.7 U	2.4 UL	5.6 J
Vanadium	–	26	10,000	3.2 B	5.1 B	2.1 U	6.6 B	21.5	33.5 J	8.4 B
Zinc	–	1,100	81	8.3 B	6.1 B	5.2 B	5.3 B	13 B	1.1 UL	12.9 B
Wet Chemistry (MG/L)										
Total dissolved solids (TDS)	–	–	–	NA	NA	NA	NA	NA	4,760	NA

Notes:

NA - Not analyzed
-- Not Available
U - Not detected
B - Blank contamination
J - Estimated
L - Biased low

K - Biased high
R - Unreliable Result
Shaded cells indicate exceedance of human health screening criteria
Bolded text indicates exceedance of ecological screening criteria

Table 3-1
Groundwater Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID	MCL-Ground water	Tap Water Adjusted RBC *	Ecological Screening Values	NBW14-MW07S				NBW14-MW08S		NBW14-MW09S	NBW14-MW11S	NBW14-MW12S	NBW14-MW13S		NBW14-MW14S	NBW14-MW15S		NBW14
Sample ID				NBW14-MW07S-R01	NBW14-MW07S-P-R01	NBW14-MW07S-R02	NBW14-MW07S-R03	NBW14-MW08S-R01	NBW14-MW08S-R03	NBW14-MW09S-R01	NBW14-MW11S-R01	NBW14-MW12S-R01	NBW14-MW13S-R01	NBW14-MW13S-P-R01	NBW14-MW14S-R01	NBW14-MW15S-R01	NBW14-MW15S-R03	NBW14-MW16S-R01
Sample Date				01/05/00	01/05/00	09/27/00	12/16/02	01/04/00	12/16/02	09/26/00	09/27/00	09/27/00	09/26/00	09/26/00	09/27/00	09/27/00	12/16/02	08/24/01
Chemical Name																		
Volatile Organic Compounds (UG/L)																		
1,1,2-Trichloroethane	5	0.19	31,200	1 U	1 U	1 U	0.5 U	1 U	0.5 U	0.279 J	1 U	1 U	1 U	1 U	2 U	1 U	0.5 U	1 U
1,1-Dichloroethane	–	80	320,000	1 U	1 U	1 U	0.14 J	1 U	0.5 U	0.413 J	1 U	1 U	1 U	1 U	2 U	1 U	0.5 U	1 U
1,1-Dichloroethene	7	35	224,000	1 U	1 U	0.153 J	0.5 U	1 U	0.5 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U	0.5 U	1 U
1,2-Dichlorobenzene	600	27	129	1 U	1 U	1 U	0.5 U	1 U	0.5 U	1.25 B	1 U	1 U	1.13	1.05	1.46 J	1 U	0.5 U	1 U
1,2-Dichloropropane	5	0.16	3,040	1 U	1 U	1 U	0.5 U	1 U	0.5 U	0.181 J	1 U	1 U	1 U	1 U	2 U	1 U	0.5 U	1 U
1,3-Dichlorobenzene	–	0.55	129	1 U	1 U	1 U	0.5 U	1 U	0.5 U	1 U	1 U	1 U	1 U	1 U	0.246 J	1 U	0.5 U	1 U
1,4-Dichlorobenzene	75	0.47	129	1 U	1 U	0.202 J	0.23 J	1 U	0.5 U	0.282 J	1 U	1 U	0.181 J	0.269 J	0.003 J	1 U	0.5 U	1 U
2-Butanone	–	190	40,000	6.1 J	5 UR	76.3 J	31	5 UR	0.99 B	5 UR	5 UR	5 UR	5 UR	5 UR	10 UR	5 UR	0.92 B	5 UR
4-Methyl-2-pentanone	–	14	–	10	9.9	78.2	42 B	5 U	5 U	3.29 J	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U
Acetone	–	61	750	13 J	11 J	160 J	49	5 UR	2.9 B	13.0 J	8.19 J	16.7 J	32.9 J	26.3 J	17.5 J	17.1 J	2.2 B	5 UR
Benzene	5	0.32	700	0.35 J	0.36 J	1.07	2	1 U	0.5 U	2.33	0.928 J	0.167 J	5.54	7.41	1.88 J	0.979 J	0.5 U	1 U
Carbon disulfide	–	100	2	0.27 J	1 U	1.04	2.4	1 U	0.5 U	1 U	1 U	0.0944 B	1 U	1 U	2 U	0.129 B	0.5 U	1 U
Chlorobenzene	100	11	129	1 U	1 U	0.392 J	0.36 J	1 U	0.23 J	2.91	1 U	0.238 J	1.99	2.48	34.8	1 U	0.5 U	1 U
Chloroethane	–	3.6	–	1 U	1 U	1 U	0.5 U	1 U	0.5 U	1 U	1 U	1 U	1.01	1.02	2 U	1 U	0.5 U	1 U
Chloroform	80	0.063	815	1 U	1 U	1 U	0.5 U	1 U	0.5 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U	0.5 U	1 U
Chloromethane	–	2.1	2,700	1 U	1 U	1 U	0.5 U	1 U	0.5 U	1 U	2.12	1 U	1 U	1 U	2 U	1 U	0.1 J	0.2 J
Cumene	–	66	–	NA	NA	NA	0.39 J	NA	0.5 U	NA	NA	NA	NA	NA	NA	NA	0.5 U	NA
Cyclohexane	–	–	–	NA	NA	NA	0.5 U	NA	0.5 U	NA	NA	NA	NA	NA	NA	NA	0.5 U	NA
Dichlorodifluoromethane(Freon-12)	–	35	6,400	NA	NA	NA	0.5 U	NA	0.5 U	NA	NA	NA	NA	NA	NA	NA	0.14 J	NA
Ethylbenzene	700	3.3	430	0.2 J	0.2 J	1.2	1.3	1 U	0.5 U	0.453 J	1 U	1 U	0.251 J	0.236 J	0.782 J	2.65	0.14 J	1 U
Methyl-tert-butyl ether (MTBE)	–	0.26	–	NA	NA	NA	0.5 U	NA	0.5 U	NA	NA	NA	NA	NA	NA	NA	0.5 U	NA
Methylcyclohexane	–	630	–	NA	NA	NA	0.5 U	NA	0.5 U	NA	NA	NA	NA	NA	NA	NA	0.5 U	NA
Methylene chloride	5	4.1	6,400	2 U	2 U	0.627 B	0.26 B	2 U	0.16 B	0.919 J	2 U	2 U	2 U	2 U	1.15 B	2 U	0.24 B	2 U
Styrene	100	160	510	1 U	1 U	1 U	0.5 U	1 U	0.5 U	1 U	1 U	1 U	1 U	1 U	0.329 J	1 U	0.5 U	1 U
Toluene	1,000	75	1,050	1.3	1.4	7.01	7.4 B	1 U	0.29 B	0.648 J	1 U	1 U	0.228 J	0.283 J	0.31 B	3.31	0.45 B	1 U
Trichloroethene	5	0.026	2,000	1 U	1 U	0.446 B	0.58	1 U	0.5 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U	0.5 U	1 U
Vinyl chloride	2	0.015	224,000	0.31 J	0.32 J	1 U	2.1	1 U	0.5 U	0.337 J	1 U	1 U	1 U	1 U	2 U	1 U	0.5 U	1 U
Xylene, total	10,000	1,200	6,000	1.6	1.7	9.61	9.9	1 U	0.5 U	1.45	0.122 J	1 U	3.15	2.93	0.998 J	7.88	0.18 B	1 U
cis-1,2-Dichloroethene	70	6.1	224,000	0.34 J	0.37 J	2.07	3.6	1 U	0.5 U	0.561 J	1 U	1 U	0.136 B	1 U	2 U	1 U	0.5 U	0.2 J
trans-1,2-Dichloroethene	100	12	224,000	1 U	1 U	0.151 J	0.15 J	1 U	0.5 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U	0.5 U	1 U
Semivolatile Organic Compounds (UG/L)																		
1,1-Biphenyl	–	30	46	NA	NA	220 U	38 U	NA	5 U	10 U	10 U	10 U	10 U	10 U	10 U	34	2.7 J	11 U
1,2-Dichlorobenzene	600	27	129	100 U	100 U	NA	NA	10 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	–	0.55	129	100 U	100 U	NA	NA	10 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	75	0.47	129	100 U	100 U	NA	NA	10 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,4,5-Trichlorophenol	–	370	11	250 U	250 U	540 U	9.3 J	25 U	20 U	25 U	25 U	25 U	25 U	25 U	26 U	25 U	20 U	28 U
2,4,6-Trichlorophenol	–	6.1	12.1	100 U	100 U	220 U	38 U	10 U	5 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	5 U	11 U
2,4-Dichlorophenol	–	11	–	100 U	100 U	220 U	38 U	10 U	5 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	5 U	11 U
2,4-Dimethylphenol	–	73	110	390	390	290	400	10 U	5 U	27	10 U	10 U	10 U	10 U	10 U	82 J	5 U	11 U
2-Methylnaphthalene	–	12	300	100 U	100 U	220 U	38 U	10 U	5 U	1 J	10 U	10 U	32	33	18	120 J	5 U	11 U
2-Methylphenol	–	180	102	220	220	130 J	210	10 U	5 U	2 J	10 U	10 U	10 U	10 U	10 U	38	5 U	11 U
4-Methylphenol	–	18	50	2,600	2,500	1,700	2,000	10 U	5 U	48	4 J	10 U	1 J	10 U	10 U	96 J	5 U	11 U
Acenaphthene	–	37	710	100 U	100 U	220 U	38 U	10 U	5 U	3 J	1 J	10 U	41	39	56	220 U	31	11 U
Acenaphthylene	–	–	300	100 U	100 U	220 U	38 U	10 U	5 U	10 U	10 U	10 U	1 J	10 U	1 J	11	5 U	11 U
Anthracene	–	180	300	100 U	100 U	220 U	38 U	10 U	5 U	10 U	10 U	10 U	2 J	2 J	3 J	13	1 J	11 U
Benzaldehyde	–	370	–	NA	NA	220 U	38 U	NA	5 U	10 U	10 U	10 U	1 J	10 U	10 U	2 J	5 U	11 U
Carbazole	–	3.3	10	100 U	100 U	220 U	NA	10 U	NA	10 U	10 U	10 U	5 J	8 J	4 J	36 J	NA	11 U
Dibenzofuran	–	2.4	10	100 U	100 U	220 U	38 U	10 U	5 U	1 J	10 U	10 U	17	13	21	30 J	13	11 U
Dimethyl phthalate	–	37,000	3.4	100 U	100 U	220 U	38 U	10 U	5 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	5 U	11 U
Fluoranthene	–	150	16	100 U	100 U	220 U	38 U	10 U	5 U	10 U	10 U	10 U	10 U	1 J	2 J	17	1.8 J	11 U
Fluorene	–	24	300	100 U	100 U	220 U	38 U	10 U	5 U	10 U	10 U	10 U	15	15	19	91 J	12	11 U
Naphthalene	–	0.65	2,300	15 J	15 J	220 U	23 J	10 U	5 U	6 J	1 J	10 U	40	42	14	1,900	30	11 U
Pentachlorophenol	1	0.56	7.9	250 U	250 U	540 U	38 U	25 U	5 U	25 U	25 U	25 U	25 U	25 U	26 U	25 U	5 U	28 U
Phenanthrene	–	18	4.6	100 U	100 U	220 U	38 U	10 U	5 U	10 U	2 J	10 U	11	12	13	140 J	12	11 U
Phenol	–	1,100	5,800	920	880	400	270	10 U	5 U	11	10 U	10 U	10 U	10 U	10 U	51	5 U	11 U
Pyrene	–	18	300	100 U	100 U	220 U	38 U	10 U	5 U	10 U	10 U	10 U	10 U	10 U	10 U	10	0.93 J	11 U
bis(2-Ethylhexyl)phthalate	6	4.8	360	100 U	100 U	220 U	38 U	10 U	5 U	1 B	10 U	2 B	2 B	1 B	10 U	10 U	5 U	11 U
n-Nitroso-di-n-propylamine	–	0.0096	–	100 U	100 U	220 U	45	10 U	5 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	5 U	11 U
n-Nitrosodiphenylamine	–	14	330,000	100 U	100 U	220 U	38 U	10 U	5 U	1 J	10 U	10 U	10 U	4 J	10 U	10 U	5 U	11 U
Pesticide/Polychlorinated Biphenyls (UG/L)																		
4,4'-DDD	–	0.28	0.68	0.1 U	0.1 U	0.1 UJ	0.02 U	0.1 U	0.022 U	0.1 UJ	0.1 UJ	0.1 U	0.1 UJ	0.1 U	0.1 UJ	0.1 UJ	0.02 U	0.12 U
4,4'-DDE	–	0.2	1.4	0.1 U	0.1 U	0.028 J	0.042 K	0.1 U	0.022 U	0.1 UJ	0.1 UJ	0.1 U	0.1 UJ	0.1 U	0.1 UJ	0.1 UJ	0.02 U	0.12 U
4,4'-DDT	–	0.2	0.001	0.1 U	0.1 U	0.1 UJ	0.043 K	0.1 U	0.022 U	0.1 UJ	0.1 UJ	0.1 U	0.1 UJ	0.1 U	0.1 UJ	0.018 L	0.013 J	0.12 U
Aldrin	–	0.0039	1.3	0.05 U	0.05 U	0.051 UJ	0.01 U	0.05 U	0.011 U	0.05 UJ	0.05 UJ	0.05 U	0.05 UJ	0.05 U	0.05 UJ	0.0062	0.01 U	0.059 U
Dieldrin	–	0.0042	0.11	0.1 U	0.1 U	0.1 UJ	0.037 K	0.1 U	0.022 U	0.1 UJ	0.1 UJ	0.1 U	0.1 UJ	0.1 U	0.1 UJ	0.0053 J	0.02 U	0.12 U

Table 3-1
Groundwater Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID	MCL- Ground water	Tap Water Adjusted RBC *	Ecological Screening Values	NBW14-MW07S				NBW14-MW08S		NBW14-MW09S	NBW14-MW11S	NBW14-MW12S	NBW14-MW13S		NBW14-MW14S	NBW14-MW15S		NBW14
Sample ID				NBW14-MW07S-R01	NBW14-MW07S-P-R01	NBW14-MW07S-R02	NBW14-MW07S-R03	NBW14-MW08S-R01	NBW14-MW08S-R03	NBW14-MW09S-R01	NBW14-MW11S-R01	NBW14-MW12S-R01	NBW14-MW13S-R01	NBW14-MW13S-P-R01	NBW14-MW14S-R01	NBW14-MW15S-R01	NBW14-MW15S-R03	NBW14-MW16S-R01
Sample Date				01/05/00	01/05/00	09/27/00	12/16/02	01/04/00	12/16/02	09/26/00	09/27/00	09/27/00	09/26/00	09/26/00	09/27/00	09/27/00	12/16/02	08/24/01
Chemical Name																		
Endosulfan I	--	22	0.0087	0.05 U	0.05 U	0.051 UJ	0.01 U	0.05 U	0.011 U	0.05 UJ	0.05 UJ	0.05 U	0.05 UJ	0.05 U	0.05 UJ	0.0034 L	0.01 U	0.059 U
Endosulfan II	--	22	0.0087	0.1 U	0.1 U	0.1 UJ	0.01 K	0.1 U	0.022 U	0.1 UJ	0.1 UJ	0.1 U	0.1 UJ	0.1 U	0.1 UJ	0.1 UJ	0.02 U	0.12 U
Endosulfan sulfate	--	22	0.0087	0.1 U	0.1 U	0.1 UJ	0.02 U	0.1 U	0.022 U	0.1 UJ	0.1 UJ	0.1 U	0.1 UJ	0.1 U	0.1 UJ	0.0088 L	0.02 U	0.12 U
Endrin	2	1.1	0.01	0.1 U	0.1 U	0.1 UJ	0.02 U	0.1 U	0.022 U	0.1 UJ	0.1 UJ	0.1 U	0.1 UJ	0.1 U	0.1 UJ	0.1 UJ	0.02 U	0.12 U
Endrin aldehyde	2	1.1	0.01	0.1 U	0.1 U	0.1 UJ	0.04 K	0.1 U	0.022 U	0.1 UJ	0.1 UJ	0.1 U	0.1 UJ	0.1 U	0.1 UJ	0.0089 L	0.02 U	0.12 U
Endrin ketone	2	1.1	0.01	0.1 U	0.1 U	0.1 UJ	0.041 K	0.1 U	0.022 U	0.1 UJ	0.1 UJ	0.1 U	0.1 UJ	0.1 U	0.1 UJ	0.1 UJ	0.02 U	0.12 U
Heptachlor epoxide	0.2	0.0074	0.0036	0.05 U	0.05 U	0.051 UJ	0.027 K	0.05 U	0.011 U	0.05 UJ	0.05 UJ	0.012 J	0.05 UJ	0.05 U	0.05 UJ	0.05 UJ	0.01 U	0.059 U
alpha-BHC	--	0.011	0.34	0.05 U	0.05 U	0.051 UJ	0.047 K	0.05 U	0.011 U	0.05 UJ	0.05 UJ	0.05 U	0.05 UJ	0.05 U	0.05 UJ	0.05 UJ	0.0057 J	0.059 U
alpha-Chlordane	--	0.19	0.004	0.05 U	0.05 U	0.051 UJ	0.034 K	0.05 U	0.011 U	0.05 UJ	0.05 UJ	0.05 U	0.05 UJ	0.05 U	0.05 UJ	0.05 UJ	0.01 U	0.059 U
beta-BHC	--	0.037	0.34	0.05 U	0.05 U	0.051 UJ	0.12 K	0.05 U	0.011 U	0.05 UJ	0.05 UJ	0.05 U	0.05 UJ	0.05 U	0.05 UJ	0.05 UJ	0.049 J	0.059 U
delta-BHC	--	--	0.34	0.05 U	0.05 U	0.051 UJ	0.051 K	0.05 U	0.011 U	0.05 UJ	0.05 UJ	0.05 U	0.05 UJ	0.05 U	0.05 UJ	0.05 UJ	0.0093 J	0.059 U
gamma-BHC (Lindane)	0.2	0.052	0.16	0.05 U	0.05 U	0.051 UJ	0.01 U	0.05 U	0.011 U	0.05 UJ	0.05 UJ	0.05 U	0.05 UJ	0.05 U	0.05 UJ	0.075 L	0.01 U	0.059 U
gamma-Chlordane	--	0.19	0.004	0.05 U	0.05 U	0.051 UJ	0.014 K	0.05 U	0.011 U	0.05 UJ	0.05 UJ	0.05 U	0.05 UJ	0.05 U	0.05 UJ	0.05 UJ	0.0057 J	0.059 U
Total Metals (UG/L)																		
Aluminum	--	3,700	87	117 B	129 B	84.9 B	150 B	14.8 U	56.7 U	62.3 J	34.9 U	34.9 U	77.3 J	94.1 B	54 B	56.2 B	56.7 U	46 B
Antimony	6	1.5	500	1.4 U	1.4 U	1.9 U	1.2 U	1.6 J	1.2 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.2 U	1.7 UL
Arsenic	10	0.045	36	23.2	27.1	18.4	16.4	2.9 U	3 U	13.3	4.1 B	9.2 B	8.4 B	5.5 B	18.4	6.4 B	7.3 J	2.7 B
Barium	2,000	260	10,000	76.8 J	80.9 J	135 J	101 J	19.8 J	30.3 J	22.2 J	169 J	29.2 J	470	482	568	269	297	62.8 J
Beryllium	4	7.3	1,500	0.15 U	0.15 U	0.12 B	0.33 J	0.15 U	0.2 U	0.1 U	0.22 B	0.1 U	0.1 U	0.2 B	0.24 B	0.1 U	0.2 U	0.4 U
Cadmium	5	1.8	8.85	3.4 U	3.4 U	0.3 U	0.3 U	3.4 U	0.3 U	0.3 U	0.3 U	0.3 U	0.34 B	0.3 U	0.58 B	0.3 U	0.3 U	0.4 U
Calcium	--	--	--	70,800	74,200	33,100	14,400	172,000	114,000	11,100	159,000	15,800	21,800	21,700	80,300	137,000	114,000	69,100
Chromium	100	11	50.4	2.2 U	2.2 U	2.8 L	3.6 J	2.2 U	0.8 U	1.2 L	1.2 L	1 L	1.4 L	1.4 L	3.2 L	0.5 UL	0.8 U	1 J
Cobalt	--	220	23	2.9 U	2.9 U	2.3 B	1.8 J	2.9 U	0.7 U	0.95 B	1.3 B	1.1 B	1 B	0.87 B	0.71 B	0.5 U	0.7 U	0.7 U
Copper	1,300	150	3.7	1.6 L	3.3 L	1.2 U	1.5 U	0.8 UL	1.5 U	2.6 J	1.2 U	1.2 U	4.9 J	2.7 J	1.2 U	1.2 U	1.5 U	1.6 U
Cyanide	200	73	1	147	145	136	161	10 U	0.5 U	45.5	1.9 L	1.1 L	1 L	1.3 L	2 L	2.2 L	0.61 B	NA
Iron	--	1,100	1,000	182	215	114	188	4.7 B	12.5 U	109	3,430	952	6,580	6,680	7,850	3,170	4,850	10.6 U
Lead	15	15	8.5	1.9 B	1.9 B	2 U	1.5 L	1.6 U	1.2 UL	2 U	2 U	2 U	5.2	6.2	2 U	2 U	1.2 UL	1.8 U
Magnesium	--	--	--	580 J	585 J	1,070 J	1,380 J	28,000	39,700	22,000	190,000	23,500	42,400	42,800	178,000	171,000	75,700	46,700
Manganese	--	73	10	2.5 B	3 B	2.5 J	2.9 J	78.3	113	15.9	321	147	54.2	54.5	208	184	188	235
Nickel	--	73	8.3	30.8 J	26.3 J	25.2 J	20.8 J	6.9 U	1.9 J	7 J	2.2 J	2.9 J	5.8 J	5.5 J	3.3 J	1 J	1 J	2.3 J
Potassium	--	--	--	103,000	109,000	217,000 J	156,000 J	11,700	32,700 J	104,000 J	274,000 J	47,000 J	106,000 J	108,000 J	169,000 J	134,000 J	48,300 J	32,400 J
Selenium	50	18	71.1	4.4 J	5.7	5 U	3 UL	3 U	3 UL	5 U	5 U	5 U	5 U	5 U	5 U	5 U	3 UL	2.8 U
Sodium	--	--	--	1,650,000	1,710,000	2,080,000	1,470,000	67,400	310,000	657,000	3,490,000	583,000	642,000	653,000	1,610,000	1,560,000	450,000	225,000
Thallium	2	0.26	2,130	5.1 J	3.9 J	4.9 U	2.4 UL	5.2 J	2.4 UL	4.9 U	4.9 U	4.9 U	9.2 B	4.9 U	4.9 U	7.9 B	2.4 UL	6.7 B
Vanadium	--	26	10,000	81	81.2	79.9	117	2.1 U	0.7 U	2.8 B	1.5 B	4.2 J	3 B	3 J	1.9 B	3.8 J	1.7 J	0.79 B
Zinc	--	1,100	86	10 B	19.1 B	0.9 UL	6.3 L	6.5 B	1.1 UL	0.9 UL	0.9 UL	0.9 UL	79.4	77.6	0.9 UL	0.9 UL	1.1 UL	0.7 UL
Dissolved Metals (UG/L)																		
Antimony	6	1.5	500	2 J	2.8 J	2.9 L	1.2 U	1.4 U	1.2 U	3.8 L	1.9 UL	1.9 UL	2 L	1.9 UL	1.9 UL	3.3 L	2.9 J	3.3 B
Arsenic	10	0.045	36	23.2	24.2	22.5 B	18.1	4.4 J	3 U	15.8	5.1 B	11.7 B	4.3 B	3.7 B	18.4 B	9.6 B	6.8 J	2.8 U
Barium	2,000	260	10,000	75.1 J	79.7 J	117 J	110 J	20.5 J	31.9 J	24 J	178 J	29.8 J	430	412	553	271	322	56.6 J
Calcium	--	--	--	70,500	75,400	27,800	17,600	175,000	123,000	12,000	158,000	15,900	18,800	18,300	79,500	146,000	130,000	71,500
Chromium	100	11	50	3.1 B	2.2 B	3.5 B	4 J	2.2 U	0.8 U	3.3 B	0.67 B	1.5 B	0.81 B	1.2 B	1.7 B	3.5 B	0.8 U	0.5 U
Cobalt	--	220	23	5.4 B	2.9 U	2.4 B	2 J	2.9 U	0.7 U	0.91 B	0.86 B	1.4 B	1.1 B	0.88 B	1.2 B	1.2 B	0.7 U	0.81 B
Copper	1,300	150	3.1	6.6 L	5.3 L	1.9 J	1.5 U	0.8 U	1.5 U	5.2 J	1.3 J	2.3 J	1.2 U	1.2 U	1.4 J	3.7 J	1.5 U	0.8 U
Cyanide	200	73	1	NA	NA	124 L	NA	NA	NA	50 L	1.9 L	1.2 L	0.8 UL	1 L	1.3 UL	1.8 L	NA	NA
Iron	--	1,100	1,000	135	135	199	126	40.6 B	12.5 U	113	3,700	1,440	5,500	5,420	7,950	4,150	5,660	12.4 U
Lead	15	15	8.1	1.6 U	1.6 U	2 U	1.2 U	1.6 U	1.2 U	2 U	2 U	2 U	11.7	2 U	2 U	2.1 B	1.2 U	1.6 U
Magnesium	--	--	--	566 J	619 J	975 J	1,530 J	29,000	42,700	22,800	181,000	22,900	37,600	36,600	175,000	173,000	73,000	44,700
Manganese	--	73	10	3.9 B	4.1 B	3.5 B	2 J	78.1	118	16.5	321	148	45.5	44.5	209	206	215	230
Mercury	2	1.1	0.94	0.043 B	0.024 U	0.1 J	0.1 U	0.04 B	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Nickel	--	73	8.2	32.5 J	27.7 J	25 J	23.4 J	6.9 U	2.2 J	11.5 J	2.6 B	4.3 B	4.4 B	5.1 B	2.7 B	4.4 B	1.2 J	3.3 U
Potassium	--	--	--	101,000	106,000	207,000 J	169,000 J	11,700	34,900 J	112,000 J	266,000 J	46,200 J	95,800 J	93,600 J	164,000 J	144,000 J	45,500 J	34,300 J
Selenium	50	18	71	4.6 J	3.2 J	5 U	3 UL	3 U	3.3 B	5 U	5 U	5.2	5 U	5 U	5 U	5 U	3 B	3.7 U
Sodium	--	--	--	1,650,000	1,720,000	1,870,000	1,550,000	68,000	324,000	665,000	3,380,000	578,000	611,000	606,000	1,640,000	1,700,000	406,000	242,000 J
Thallium	2	0.26	2,130	4.4 J	5.9 J	4.9 U	3.9 L	5.9 J	2.4 UL	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	2.4 UL	3.5 U
Vanadium	--	26	10,000	75	81.9	79.1	120	2.1 U	0.7 U	3.1 J	1.6 B	5.2 J	2.1 B	1.9 B	2.2 B	7 J	1.8 J	0.57 J
Zinc	--	1,100	81	7 B	10.3 B	2.7 L	5.7 L	2.4 B	1.1 UL	39.7	0.9 UL	1.3 B	30	22.2 L	0.9 UL	17.7 L	1.1 UL	5.8 U
Wet Chemistry (MG/L)																		
Total dissolved solids (TDS)	--	--	--	NA	NA	NA	8,050	NA	1,450	NA	NA	NA	NA	NA	NA	NA	2,010	NA

Notes:
NA - Not analyzed
-- Not Available
U - Not detected
B - Blank contamination
J - Estimated
L - Biased low
K - Biased high
R - Unreliable Result
Shaded cells indicate exceedance of hum
Bolded text indicates exceedance of ec

Table 3-1
Groundwater Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID	MCL-Ground water	Tap Water Adjusted RBC *	Ecological Screening Values	-MW16S	NBW14-MW17S	NBW14-MW18S	NBW14-MW19S		
Sample ID				NBW14-MW16S-P-R01	NBW14-MW17S-R01	NBW14-MW18S-R01	NBW14-MW19S-R01	NBW14-MW19S-R03	NBW14-MW19SP-R03
Sample Date				08/24/01	08/24/01	08/24/01	08/24/01	12/16/02	12/16/02
Chemical Name									
Volatile Organic Compounds (UG/L)									
1,1,2-Trichloroethane	5	0.19	31,200	1 U	1 U	1 U	1 U	0.5 U	0.5 U
1,1-Dichloroethane	–	80	320,000	1 U	1 U	0.3 J	1 U	0.5 U	0.5 U
1,1-Dichloroethene	7	35	224,000	1 U	1 U	1 U	1 U	0.5 U	0.5 U
1,2-Dichlorobenzene	600	27	129	1 U	1 U	1 U	1 U	0.5 U	0.5 U
1,2-Dichloropropane	5	0.16	3,040	1 U	1 U	1 U	1 U	0.5 U	0.5 U
1,3-Dichlorobenzene	–	0.55	129	1 U	1 U	1 U	1 U	0.5 U	0.5 U
1,4-Dichlorobenzene	75	0.47	129	1 U	1 U	1 U	1 U	0.5 U	0.5 U
2-Butanone	–	190	40,000	5 UR	5 UR	5 UR	5 UR	1.4 B	1.6 B
4-Methyl-2-pentanone	–	14	–	5 U	5 U	5 U	5 U	5 U	5 U
Acetone	–	61	750	5 UR	5 UR	5 UR	5 UR	4.1 B	3.7 B
Benzene	5	0.32	700	1 U	1 U	1 U	1 U	0.5 U	0.5 U
Carbon disulfide	–	100	2	1 U	1 U	1 U	1 U	0.5 U	0.5 U
Chlorobenzene	100	11	129	1 U	1 U	3	1 U	0.5 U	0.5 U
Chloroethane	–	3.6	–	1 U	1 U	1 U	1 U	0.5 U	0.5 U
Chloroform	80	0.063	815	1	3	0.8 J	4	0.5 U	0.5 U
Chloromethane	–	2.1	2,700	1 U	1 U	1 U	0.2 J	0.5 U	0.5 U
Cumene	–	66	–	NA	NA	NA	NA	0.5 U	0.5 U
Cyclohexane	–	–	–	NA	NA	NA	NA	0.5 U	0.5 U
Dichlorodifluoromethane(Freon-12)	–	35	6,400	NA	NA	NA	NA	0.5 U	0.5 U
Ethylbenzene	700	3.3	430	1 U	1 U	1 U	1 U	0.5 U	0.5 U
Methyl-tert-butyl ether (MTBE)	–	0.26	–	NA	NA	NA	NA	0.14 J	0.15 J
Methylcyclohexane	–	630	–	NA	NA	NA	NA	0.5 U	0.5 U
Methylene chloride	5	4.1	6,400	2 U	1 B	2 U	2 U	0.16 B	0.5 U
Styrene	100	160	510	1 U	1 U	1 U	1 U	0.5 U	0.5 U
Toluene	1,000	75	1,050	1 U	1 U	1 U	1 U	0.34 B	0.3 B
Trichloroethene	5	0.026	2,000	1 U	0.4 J	1 U	1 U	0.5 U	0.5 U
Vinyl chloride	2	0.016	224,000	1 U	1 U	1 U	1 U	0.5 U	0.5 U
Xylene, total	10,000	1,200	6,000	1 U	1 U	1 U	1 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	70	6.1	224,000	0.2 J	1 U	1 U	1 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	100	12	224,000	1 U	1 U	1 U	1 U	0.5 U	0.5 U
Semivolatile Organic Compounds (UG/L)									
1,1-Biphenyl	–	30	46	11 U	10 U	10 U	11 U	5.6 U	5.3 U
1,2-Dichlorobenzene	600	27	129	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	–	0.55	129	NA	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	75	0.47	129	NA	NA	NA	NA	NA	NA
2,4,5-Trichlorophenol	–	370	11	27 U	25 U	25 U	28 U	22 U	21 U
2,4,6-Trichlorophenol	–	6.1	12.1	11 U	10 U	10 U	11 U	5.6 U	5.3 U
2,4-Dichlorophenol	–	11	–	11 U	10 U	10 U	11 U	5.6 U	5.3 U
2,4-Dimethylphenol	–	73	110	11 U	10 U	10 U	11 U	5.6 U	5.3 U
2-Methylnaphthalene	–	12	300	11 U	10 U	10 U	11 U	5.6 U	5.3 U
2-Methylphenol	–	180	102	11 U	10 U	10 U	11 U	5.6 U	5.3 U
4-Methylphenol	–	18	50	11 U	10 U	10 U	11 U	5.6 U	5.3 U
Acenaphthene	–	37	710	11 U	10 U	10 U	11 U	5.6 U	5.3 U
Acenaphthylene	–	–	300	11 U	10 U	10 U	11 U	5.6 U	5.3 U
Anthracene	–	180	300	11 U	10 U	10 U	11 U	5.6 U	5.3 U
Benzaldehyde	–	370	–	11 U	10 U	10 U	11 U	5.6 U	5.3 U
Carbazole	–	3.3	10	11 U	10 U	10 U	11 U	NA	NA
Dibenzofuran	–	2.4	10	11 U	10 U	10 U	11 U	5.6 U	5.3 U
Dimethyl phthalate	–	37,000	3.4	11 U	3 J	10 U	11 U	5.6 U	5.3 U
Fluoranthene	–	150	16	11 U	10 U	10 U	11 U	5.6 U	5.3 U
Fluorene	–	24	300	11 U	10 U	10 U	11 U	5.6 U	5.3 U
Naphthalene	–	0.65	2,300	11 U	10 U	10 U	11 U	5.6 U	5.3 U
Pentachlorophenol	1	0.56	7.9	27 U	25 U	25 U	28 U	5.6 U	5.3 U
Phenanthrene	–	18	4.6	11 U	10 U	10 U	11 U	5.6 U	5.3 U
Phenol	–	1,100	5,800	11 U	10 U	10 U	11 U	5.6 U	5.3 U
Pyrene	–	18	300	11 U	10 U	10 U	11 U	5.6 U	5.3 U
bis(2-Ethylhexyl)phthalate	6	4.8	360	11 U	10 U	10 U	11 U	5.6 U	1.1 J
n-Nitroso-di-n-propylamine	–	0.0096	–	11 U	10 U	10 U	11 U	5.6 U	5.3 U
n-Nitrosodiphenylamine	–	14	330,000	11 U	10 U	10 U	11 U	5.6 U	5.3 U
Pesticide/Polychlorinated Biphenyls (UG/L)									
4,4'-DDD	–	0.28	0.68	0.11 UL	0.11 U	0.11 U	0.11 U	0.022 U	0.022 U
4,4'-DDE	–	0.2	1.4	0.11 UL	0.11 U	0.11 U	0.11 U	0.022 U	0.022 U
4,4'-DDT	–	0.2	0.001	0.11 UL	0.11 U	0.11 U	0.11 U	0.022 U	0.022 U
Aldrin	–	0.0039	1.3	0.053 UL	0.056 U	0.053 U	0.056 U	0.011 U	0.011 U
Dieldrin	–	0.0042	0.11	0.11 UL	0.11 U	0.11 U	0.11 U	0.022 U	0.022 U

Table 3-1
Groundwater Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID	MCL-Ground water	Tap Water Adjusted RBC *	Ecological Screening Values	MW16S	NBW14-MW17S	NBW14-MW18S	NBW14-MW19S		
Sample ID				NBW14-MW16S-P-R01	NBW14-MW17S-R01	NBW14-MW18S-R01	NBW14-MW19S-R01	NBW14-MW19S-R03	NBW14-MW19SP-R03
Sample Date				08/24/01	08/24/01	08/24/01	08/24/01	12/16/02	12/16/02
Chemical Name									
Endosulfan I	--	22	0.0087	0.053 UL	0.056 U	0.053 U	0.056 U	0.011 U	0.011 U
Endosulfan II	--	22	0.0087	0.11 UL	0.11 U	0.11 U	0.11 U	0.022 U	0.022 U
Endosulfan sulfate	--	22	0.0087	0.11 UL	0.11 U	0.11 U	0.11 U	0.022 U	0.022 U
Endrin	2	1.1	0.01	0.11 UL	0.11 U	0.11 U	0.11 U	0.022 U	0.022 U
Endrin aldehyde	2	1.1	0.01	0.11 UL	0.11 U	0.11 U	0.11 U	0.022 U	0.022 U
Endrin ketone	2	1.1	0.01	0.11 UL	0.11 U	0.11 U	0.11 U	0.022 U	0.022 U
Heptachlor epoxide	0.2	0.0074	0.0036	0.053 UL	0.056 U	0.053 U	0.056 U	0.011 U	0.011 U
alpha-BHC	--	0.011	0.34	0.053 UL	0.056 U	0.053 U	0.056 U	0.011 U	0.011 U
alpha-Chlordane	--	0.19	0.004	0.053 UL	0.056 U	0.053 U	0.056 U	0.011 U	0.011 U
beta-BHC	--	0.037	0.34	0.053 UL	0.056 U	0.053 U	0.056 U	0.011 U	0.011 U
delta-BHC	--	--	0.34	0.053 UL	0.056 U	0.053 U	0.056 U	0.011 U	0.011 U
gamma-BHC (Lindane)	0.2	0.052	0.16	0.053 UL	0.056 U	0.053 U	0.056 U	0.011 U	0.011 U
gamma-Chlordane	--	0.19	0.004	0.053 UL	0.056 U	0.053 U	0.056 U	0.011 U	0.011 U
Total Metals (UG/L)									
Aluminum	--	3,700	87	43.6 U	67.5 B	76.3 B	140 B	56.7 U	56.7 U
Antimony	6	1.5	500	1.7 UL	1.7 UL	1.7 UL	1.7 UL	1.2 U	1.2 U
Arsenic	10	0.045	36	3.5 B	7.7 B	17.5 B	16.6 B	12	13.5
Barium	2,000	260	10,000	62.6 J	80.8 J	162 J	89.9 J	75.6 J	73.2 J
Beryllium	4	7.3	1,500	0.4 U	0.4 U	0.42 B	0.41 B	0.2 U	0.2 U
Cadmium	5	1.8	8.85	0.4 U	0.4 U	0.4 U	0.4 U	0.3 U	0.3 U
Calcium	--	--	--	70,000	58,200	174,000	132,000	131,000	129,000
Chromium	100	11	50.4	1 U	1 U	1 U	1.5 J	0.8 U	0.8 U
Cobalt	--	220	23	0.7 U	0.7 U	2.2 B	0.7 U	0.7 U	0.7 U
Copper	1,300	150	3.7	1.6 U	1.6 U	1.6 U	1.6 U	1.5 U	1.5 U
Cyanide	200	73	1	NA	NA	NA	NA	0.5 U	0.5 U
Iron	--	1,100	1,000	10.6 U	113 B	510	673	5,250	5,090
Lead	15	15	8.5	1.8 U	1.8 U	1.8 U	1.8 U	1.2 UL	1.2 UL
Magnesium	--	--	--	47,200	61,800	113,000	94,500	124,000	121,000
Manganese	--	73	10	238	354	564	883	926	905
Nickel	--	73	8.3	1.6 J	1.4 U	4 J	1.8 J	1 U	1 U
Potassium	--	--	--	32,500 J	50,700 J	76,200 J	69,600 J	103,000 J	98,700 J
Selenium	50	18	71.1	2.8 U	2.8 U	2.8 U	2.8 U	3 UL	3 UL
Sodium	--	--	--	226,000	233,000	922,000	624,000	796,000	765,000
Thallium	2	0.26	2,130	5.2 B	5.4 B	7.7 B	5 B	2.4 UL	2.4 UL
Vanadium	--	26	10,000	0.6 U	1.1 B	1.3 B	0.6 U	0.7 U	0.7 U
Zinc	--	1,100	86	0.7 UL	3.5 L	1.7 L	3.5 L	1.1 UL	1.1 UL
Dissolved Metals (UG/L)									
Antimony	6	1.5	500	2.5 U	4 B	2.8 B	3.1 B	1.2 U	1.2 U
Arsenic	10	0.045	36	2.8 U	3.9 J	9.8 J	8.1 J	12	13.4
Barium	2,000	260	10,000	57.9 J	72.3 J	134 J	91.7 J	81.3 J	79.2 J
Calcium	--	--	--	72,700	52,800	172,000	128,000	147,000	139,000
Chromium	100	11	50	0.5 U	0.5 U	0.5 U	0.5 U	0.8 U	0.8 U
Cobalt	--	220	23	0.6 U	0.6 U	1.4 B	0.99 B	0.7 U	0.7 U
Copper	1,300	150	3.1	0.8 U	0.8 U	0.8 U	0.8 U	1.5 U	1.5 U
Cyanide	200	73	1	NA	NA	NA	NA	NA	NA
Iron	--	1,100	1,000	12.4 U	12.4 U	371	312	5,810	5,768
Lead	15	15	8.1	1.6 U	1.6 U	1.6 U	1.6 U	1.2 U	1.2 U
Magnesium	--	--	--	45,300	63,300	104,000	97,400	135,000	132,000
Manganese	--	73	10	231	347	493	970	999	957
Mercury	2	1.1	0.94	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Nickel	--	73	8.2	3.3 U	3.3 U	3.3 U	3.3 U	1 U	1 J
Potassium	--	--	--	34,700 J	56,400 J	75,500 J	81,500 J	109,000 J	107,000 J
Selenium	50	18	71	3.7 U	3.7 U	3.7 U	3.7 U	4.4 B	3 UL
Sodium	--	--	--	246,000 J	316,000 J	990,000 J	741,000 J	805,000	809,000
Thallium	2	0.26	2,130	3.5 U	3.5 U	3.5 U	5.6 B	2.3 K	2.6 K
Vanadium	--	26	10,000	0.58 J	0.74 J	0.5 U	0.5 U	0.7 U	0.7 U
Zinc	--	1,100	81	5.8 U	5.8 U	5.8 U	5.8 U	1.1 UL	1.1 UL
Wet Chemistry (MG/L)									
Total dissolved solids (TDS)	--	--	--	NA	NA	NA	NA	3,470	3,490

Notes:

NA - Not analyzed
-- Not Available
U - Not detected
B - Blank contamination
J - Estimated
L - Biased low

K - Biased high
R - Unreliable Result
Shaded cells indicate exceedance of MCL
Bolded text indicates exceedance of ec

Table 3-2
Surface Soil Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID	Background	Soil Residential Adjusted RBC *	Ecological Screening Criteria	NBW14-DS01	NBW14-DS02	NBW14-DS03	NBW14-DS04	NBW14-DS05	NBW14-DS06	NBW14-DS07	NBW14-DS08	NBW14-DS09	NBW14-DS10	NBW14-DS11	NBW14-DS12	NBW14-DS13	NBW14-DS14	NBW14-DS15	NBW14-DS16	NBW14-DS17
Sample ID				NBW14-DS01-00	NBW14-DS02-00	NBW14-DS03-00	NBW14-DS04-00	NBW14-DS05-00	NBW14-DS06-00	NBW14-DS07-00	NBW14-DS08-00	NBW14-DS09-00	NBW14-DS10-00	NBW14-DS11-00	NBW14-DS12-00	NBW14-DS13-00	NBW14-DS14-00	NBW14-DS15-00	NBW14-DS16-00	NBW14-DS17-00
Sample Date				09/30/99	09/30/99	09/30/99	09/30/99	09/30/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99
Chemical Name																				
Volatile Organic Compounds (UG/KG)																				
1,1,1-Trichloroethane	–	2,200,000	300	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichlorobenzene	–	700,000	100	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Butanone	–	4,700,000	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acetone	–	780,000	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	–	12,000	100	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbon disulfide	–	780,000	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chlorobenzene	–	160,000	2,400	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloromethane	–	49,000	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyclohexane	–	–	6,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	–	780,000	5,005	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	–	85,000	300	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethene	–	12,000	300	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	–	1,600,000	100	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Trichlorofluoromethane(Freon-11)	–	2,300,000	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Xylene, total	–	16,000,000	100	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Semivolatile Organic Compounds (UG/KG)																				
1,1-Biphenyl	–	390,000	6,800	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	–	160,000	–	3,600 U	62 J	260 L	400 J	79 J	94 J	250 L	190 L	61 L	1,500 U	120 J	62 J	1,800 U	1,900 U	93 J	100 J	68 J
Acenaphthene	–	470,000	2,500	1,200 J	370 U	120 L	750 J	730 U	58 J	160 L	100 L	370 UL	1,500 U	100 J	370 U	280 J	230 J	360 U	360 U	68 J
Acenaphthylene	–	–	100	3,600 U	370 U	120 L	1,800 U	110 J	80 J	230 L	85 L	160 L	1,500 U	320 J	370 U	1,800 U	1,900 U	43 J	360 U	140 J
Anthracene	491	2,300,000	100	1,600 J	44 J	320 L	1,000 J	140 J	160 J	370 L	200 L	110 L	160 J	570 J	61 J	430 J	240 J	79 J	64 J	230 J
Benzo(a)anthracene	490	870	100	3,900 J	100 J	330 L	2,800	310 J	230 J	570 L	390 L	420 L	540 J	910	130 J	600 J	1,000 J	180 J	130 J	660
Benzo(a)pyrene	490	87	100	2,400 J	73 J	360 L	2,200	270 J	180 J	910 L	410 L	450 L	460 J	760	140 J	450 J	860 J	160 J	120 J	750
Benzo(b)fluoranthene	490	870	100	2,600 J	160 J	1,100 L	2,700	790	690	2,400 L	910 L	630 L	780 J	3,000	270 J	640 J	1,100 J	390	280 J	2,100
Benzo(g,h,i)perylene	490	230,000	100	740 J	70 J	78 L	1,100 J	140 J	110 J	240 L	110 L	94 L	450 J	660 J	160 J	240 J	360 J	150 J	92 J	410
Benzo(k)fluoranthene	490	8,700	100	2,100 J	110 J	730 L	2,400	620 J	460	360 UL	480 L	530 L	780 J	1,600	180 J	570 J	1,100 J	270 J	190 J	810
Butylbenzylphthalate	–	1,600,000	–	3,600 U	370 U	370 UL	5,100	89 J	370 U	370 L	360 UL	370 UL	1,500 U	730 U	370 U	1,800 U	1,900 U	46 J	360 U	360 U
Carbazole	–	32,000	2,000	580 J	370 U	130 UL	630 J	100 J	80 J	160 L	84 L	47 L	1,500 U	510 J	370 U	1,800 U	300 J	42 J	360 U	120 J
Chrysene	621	87,000	100	3,300 J	190 J	710 L	2,900	490 J	440	970 L	530 L	480 L	970 J	3,600	250 J	810 J	1,400 J	320 J	240 J	1,200
Di-n-butylphthalate	–	780,000	40,000	3,600 U	370 U	370 UL	1,800 U	100 J	370 U	120 L	530 L	370 UL	1,500 U	730 U	56 J	1,800 U	1,900 U	360 U	360 U	360 U
Di-n-octylphthalate	–	160,000	–	3,600 U	370 U	370 UL	1,800 U	730 U	370 U	360 UL	360 UL	370 UL	1,500 U	730 U	370 U	1,800 U	1,900 U	360 U	360 U	360 U
Dibenz(a,h)anthracene	–	87	100	3,600 U	370 U	58 L	430 J	730 U	60 J	160 L	64 L	57 L	1,500 U	340 J	57 J	1,800 U	1,900 U	64 J	37 J	170 J
Dibenzofuran	–	31,000	14,000	550 J	56 J	210 L	410 J	730 U	84 J	170 L	130 L	40 L	1,500 U	130 J	42 J	200 J	1,900 U	59 J	68 J	61 J
Diethylphthalate	–	6,300,000	13,400	3,600 U	370 U	370 UL	1,800 U	730 U	370 U	360 UL	360 UL	370 UL	1,500 U	730 U	370 U	1,800 U	1,900 U	360 U	360 U	360 U
Fluoranthene	950	310,000	100	10,000	160 J	890 L	6,600	930	640	1,300 L	830 L	720 L	1,400 J	6,800	260 J	2,900	2,400	360	270 J	1,200
Fluorene	401	310,000	1,700	1,200 J	370 U	110 L	680 J	730 U	50 J	160 L	120 L	370 UL	1,500 U	93 J	370 U	440 J	440 J	360 U	360 U	37 J
Indeno(1,2,3-cd)pyrene	660	870	100	3,200 J	89 J	200 L	1,600 J	180 J	160 J	430 L	180 L	170 L	530 J	1,100	170 J	280 J	460 J	180 J	100 J	550
Naphthalene	–	160,000	100	3,600 U	78 J	300 L	500 J	80 J	84 J	260 L	180 L	59 L	1,500 U	110 J	63 J	1,800 U	1,900 U	78 J	95 J	95 J
Phenanthrene	–	230,000	100	9,700	200 J	600 L	5,200	410 J	360 J	800 L	700 L	300 L	500 J	3,200	190 J	2,700	1,100 J	240 J	250 J	530
Phenol	–	2,300,000	1,880	3,600 U	370 U	370 UL	1,800 U	730 U	370 U	110 L	360 UL	370 UL	1,500 U	730 U	370 U	1,800 U	1,900 U	360 U	360 U	360 U
Pyrene	830	230,000	100	6,800 J	150 J	570 L	4,400	650 J	330 J	1,300 L	560 L	510 L	1,200 J	4,800	240 J	1,700 J	1,600 J	270 J	180 J	770
bis(2-Ethylhexyl)phthalate	–	46,000	10,000	3,600 U	110 J	95 L	850 J	830	98 J	2,600 L	230 L	120 L	300 J	180 J	110 J	900 J	990 J	130 J	73 J	130 J
n-Nitrosodiphenylamine	–	130,000	1,090	3,600 U	370 U	44 L	1,800 U	730 U	370 U	38 L	360 UL	370 UL	1,500 U	730 U	370 U	1,800 U	1,900 U	360 U	360 U	360 U
Pesticide/Polychlorinated Biphenyls (UG/KG)																				
4,4'-DDD		2,700	100	120	15 U	4.1 J	47 K	18 U	2.1 J	14 K	30 J	15 J	14 J	18 U	3.4 J	14 J	23 J	3.6 U	3 J	18 U
4,4'-DDE	4	1,900	100	150	15 U	7.5 U	65 K	18 U	3.7 U	11 K	53	20 J	34	18 U	4.1 J	18 U	14 J	3.6 U	3.6 U	18 U
4,4'-DDT	4	1,900	100	13 J	15 U	7.5 U	18 U	18 U	2.1 J	18 U	9.8 J	7.8 J	39	13 J	3.7 U	18 U	19 U	2.4 J	2.2 J	9.7 J
Aldrin	–	38	100	33	7.6 U	3.9 U	9.2 U	9.4 U	1.3 J	18 K	1.9 U	1.9 U	1.9 U	9.4 U	2.4 J	9.3 U	9.6 U	1.8 U	1.8 J	9.3 U
Aroclor-1242	–	320	100	180 U	150 U	75 U	180 U	180 U	37 U	180 U	36 U	37 U	38 U	180 U	37 U	210 J	190 U	36 U	36 U	180 U
Aroclor-1248	–	320	100	180 U	150 U	75 U	180 U	180 U	37 U	180 U	77 J	37 U	38 U	180 U	37 U	180 U	190 U	36 U	36 U	180 U
Aroclor-1254	–	160	100	180 U	150 U	75 U	180 U	180 U	37 U	180 U	36 U	37 U	38 U	180 U	37 U	180 U	190 U	36 U	36 U	180 U
Aroclor-1260	–	320	100	180 U	150 U	75 U	180 U	180 U	100	330 L	220	160	160	1,900	37 U	340	410	170	36 U	180 U
Dieldrin	12.4	40	100	34 J	15 U	15 J	21 K	29 K	7.5 J	30 K	13 J	3.7 U	28	38 J	14 J	18 U	19 U	5.1 J	15	18 U
Endosulfan I	–	47,000	–	9.2 U	7.6 U	3.9 U	9.2 U	9.4 U	1.9 U	9.4 U	1.9 U	1.9 U	1.9 U	9.4 U	1.9 U	9.3 U	9.6 U	1.8 U	1.8 U	9.3 U
Endosulfan II	–	47,000	–	18 U	15 U	7.5 U	18 U	18 U	2.8 J	14 K	5.1	3.5 J	4.4	49	1.9 J	20 J	19 U	4.7 J	3.6 U	18 U
Endosulfan sulfate	–	47,000	–	18 U	15 U	7.5 U	18 U	18 U	4.3 J	13 K	2.7 J	2 J	3.8 U	18 U	3.7 U	18 U	19 U	1.8 J	3.6 U	18 U
Endrin	–	2,300	100	18 U	15 U	7.5 U	18 U	18 U	4.4 J	33 K	11	8.5	7.1 J	85	3.6 J	16 J	15 J	1.8 J	3.6 U	11 J
Endrin aldehyde	–	2,300	100	18 U	12 J	7.5 U	18 U	18 U	3.7 U	35 K	4.4 J	3.4 J	5 J	45 J	9.9 J	28 J	14 J	5.8 J	3.6 U	18 U
Endrin ketone	–	2,300	100	18 U	15 U	7.5 U	45 K	15 K	5.5 J	18 U	3.6 U	3.7 U	2.1 J	18 U	2 J	18 U	19 U	3.6 U	2.7 J	18 U

Table 3-2
Surface Soil Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID / Sample ID / Sample Date	Background	Soil Residential Adjusted RBC *	Ecological Screening Criteria	NBW14-DS01	NBW14-DS02	NBW14-DS03	NBW14-DS04	NBW14-DS05	NBW14-DS06
				NBW14-DS01-00	NBW14-DS02-00	NBW14-DS03-00	NBW14-DS04-00	NBW14-DS05-00	NBW14-DS06-00
				09/30/99	09/30/99	09/30/99	09/30/99	09/30/99	10/01/99
Chemical Name									
Heptachlor	--	140	--	9.2 U	7.6 U	3.9 U	9.2 U	9.4 U	1.9 U
Heptachlor epoxide	--	70	100	9.2 U	7.6 U	3.9 U	9.2 U	9.4 U	1.9 U
Methoxychlor	--	39,000	100	92 U	76 U	39 U	120 K	90 K	17 J
alpha-BHC	--	100	100,000	9.2 U	7.6 U	3.9 U	9.2 U	9.4 U	1.9 U
alpha-Chlordane	--	1,800	100	8.1 J	7.6 U	3.9 U	9.2 U	8.3 K	1.8 J
beta-BHC	--	350	100,000	9.2 U	7.6 U	3.9 U	9.2 U	9.4 U	1.9 U
delta-BHC	--	--	100,000	9.2 U	7.6 U	3.9 U	9.2 U	9.4 U	1.9 U
gamma-BHC (Lindane)	--	490	100	9.2 U	7.6 U	3.9 U	9.2 U	9.4 U	1.9 U
gamma-Chlordane	--	1,800	100	8.9 J	7.6 U	3.9 U	9.2 U	7.7 K	1.1 J
Dioxin/Furans (UG/KG)									
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	--	0.430	--	NA	NA	NA	NA	NA	NA
1,2,3,4,6,7,8-Heptachlorodibenzofuran	--	0.43	--	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8,9-Heptachlorodibenzofuran	--	0.43	--	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	--	0.043	--	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-Hexachlorodibenzofuran	--	0.043	--	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	--	0.043	--	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-Hexachlorodibenzofuran	--	0.043	--	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	--	0.043	--	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-Hexachlorodibenzofuran	--	0.043	--	NA	NA	NA	NA	NA	NA
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	--	0.0085	--	NA	NA	NA	NA	NA	NA
1,2,3,7,8-Pentachlorodibenzofuran	--	0.085	--	NA	NA	NA	NA	NA	NA
2,3,4,6,7,8-Hexachlorodibenzofuran	--	0.043	--	NA	NA	NA	NA	NA	NA
2,3,4,7,8-Pentachlorodibenzofuran	--	0.0085	--	NA	NA	NA	NA	NA	NA
2,3,7,8-TCDD (dioxin)	--	0.0043	--	NA	NA	NA	NA	NA	NA
2,3,7,8-Tetrachlorodibenzofuran	--	0.043	--	NA	NA	NA	NA	NA	NA
Total heptachlorodibenzo-p-dioxin	--	--	--	NA	NA	NA	NA	NA	NA
Total heptachlorodibenzofuran	--	--	--	NA	NA	NA	NA	NA	NA
Total hexachlorodibenzo-p-dioxin	--	--	--	NA	NA	NA	NA	NA	NA
Total hexachlorodibenzofuran	--	--	--	NA	NA	NA	NA	NA	NA
Total octachlorodibenzo-p-dioxin	--	--	--	NA	NA	NA	NA	NA	NA
Total octachlorodibenzofuran	--	--	--	NA	NA	NA	NA	NA	NA
Total pentachlorodibenzo-p-dioxin	--	--	--	NA	NA	NA	NA	NA	NA
Total pentachlorodibenzofuran	--	--	--	NA	NA	NA	NA	NA	NA
Total tetrachlorodibenzo-p-dioxin	--	--	--	NA	NA	NA	NA	NA	NA
Total tetrachlorodibenzofuran	--	--	--	NA	NA	NA	NA	NA	NA
Total Metals (MG/KG)									
Aluminum	22,370	7,800	50	2,470 L	4,050 L	3,850 L	5,270 L	5,140 L	5,250 L
Antimony	1.2	3.1	5	0.94 J	3.5 J	1.6 J	1.8 J	7.1 J	2.1 J
Arsenic	42.2	0.43	60	25.3	27.9	22.5	11.2	11.1	14.1
Barium	67	550	440	33.5 J	67.9	53.7	77.7	213	63.5
Beryllium	2.3	16	10	0.29 B	0.24 B	0.52 B	0.33 B	0.36 B	0.35 B
Cadmium	0.2	3.9	4	0.92 B	0.91 B	1.2 B	0.97 B	7.9	0.85 B
Calcium	16,100	--	--	25,800	16,700	16,400	22,900	26,000	26,400
Chromium	43	23	0.4	8.2	11.8	26	15.5	56.7	15
Cobalt	25	160	100	2.6 B	3.4 J	5.7 J	3.3 J	7.5 J	4.2 J
Copper	31	310	50	20.1	91.7	47.8	78.2	558	57.9
Cyanide	--	160	28	57.5	2.8 U	2.8 U	2.7 U	2.8 U	2.8 U
Iron	96,600	2,300	200	7,760 L	12,600 L	12,900 L	12,500 L	22,900 L	11,300 L
Lead	67	400	50	70.4	315	210	107	415	132
Magnesium	6,590	--	--	996 B	2,450	4,710	3,610	1,580	11,600
Manganese	1,240	160	330	110	118	104	137	231	93.5
Mercury	0.1	2.3	0.1	0.17 B	0.086 B	2.7	0.88	0.37	0.11 B
Nickel	40	160	30	8.5 J	8.3 J	12.8	11.9	63.9	11.2
Potassium	3,690	--	--	488 J	351 B	449 B	608 J	679 J	438 B
Selenium	--	39	2	0.52 U	0.54 U	0.66 J	0.52 U	0.53 U	0.59
Silver	0.52	39	2	0.48 UJ	0.49 U	0.5 UJ	0.48 UJ	1.2 J	0.49 UJ
Sodium	1,370	--	--	444 J	243 J	331 J	1,040 J	565 J	261 J
Thallium	ND	0.56	1	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Vanadium	87	55	2	14.7	19.7	15.7	27.4	39.9	16.1
Zinc	142	2,300	50	91.2	183	143	164	737	162

Station ID / Sample ID / Sample Date	NBW14-DS07	NBW14-DS08	NBW14-DS09	NBW14-DS10	NBW14-DS11	NBW14-DS12
	NBW14-DS07-00	NBW14-DS08-00	NBW14-DS09-00	NBW14-DS10-00	NBW14-DS11-00	NBW14-DS12-00
	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99
Chemical Name						
Heptachlor	9.4 U	1.9 U	1.9 U	1.9 U	9.4 U	1.9 U
Heptachlor epoxide	9.4 U	1.9 U	1.9 U	1.9 U	9.4 U	1.2 J
Methoxychlor	94 U	19 U	19 U	19 U	94 U	19 U
alpha-BHC	9.4 U	1.9 U	1.9 U	1.9 U	9.4 U	1.9 U
alpha-Chlordane	18 K	4	3.4	4.5	32	2.3 J
beta-BHC	9.4 U	1.9 U	1.9 U	1.9 U	9.4 U	1.9 U
delta-BHC	9.4 U	1.9 U	1.9 U	1.9 U	9.4 U	1.9 U
gamma-BHC (Lindane)	9.4 U	1.9 U	1.9 U	1.9 U	9.4 U	1.9 U
gamma-Chlordane	12 K	4.2 J	4.4 J	4.8 J	11 J	1.3 J
Dioxin/Furans (UG/KG)						
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA	NA
1,2,3,4,6,7,8-Heptachlorodibenzofuran	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8,9-Heptachlorodibenzofuran	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-Hexachlorodibenzofuran	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-Hexachlorodibenzofuran	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-Hexachlorodibenzofuran	NA	NA	NA	NA	NA	NA
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA	NA
1,2,3,7,8-Pentachlorodibenzofuran	NA	NA	NA	NA	NA	NA
2,3,4,6,7,8-Hexachlorodibenzofuran	NA	NA	NA	NA	NA	NA
2,3,4,7,8-Pentachlorodibenzofuran	NA	NA	NA	NA	NA	NA
2,3,7,8-TCDD (dioxin)	NA	NA	NA	NA	NA	NA
2,3,7,8-Tetrachlorodibenzofuran	NA	NA	NA	NA	NA	NA
Total heptachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA	NA
Total heptachlorodibenzofuran	NA	NA	NA	NA	NA	NA
Total hexachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA	NA
Total hexachlorodibenzofuran	NA	NA	NA	NA	NA	NA
Total octachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA	NA
Total octachlorodibenzofuran	NA	NA	NA	NA	NA	NA
Total pentachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA	NA
Total pentachlorodibenzofuran	NA	NA	NA	NA	NA	NA
Total tetrachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA	NA
Total tetrachlorodibenzofuran	NA	NA	NA	NA	NA	NA
Total Metals (MG/KG)						
Aluminum	5,490 L	5,110 L	3,300 L	5,210	3,450	3,970
Antimony	42	2.6 J	0.74 J	2.3 J	5.3 J	1.3 J
Arsenic	9.9	7.1	3.9	10.2	14.7	24.2
Barium	264	54.4	69.1	100	53.1	48.9
Beryllium	0.24 B	0.32 B	0.16 B	0.67 B	0.27 B	0.27 B
Cadmium	9.8	3.7	1.6 B	15 J	1.6 J	0.93 J
Calcium	27,000	16,200	8,290	16,600	38,000	23,800
Chromium	63.8	16.9	8	36.9 J	17.5 J	12.5 J
Cobalt	6.4 J	3.3 J	1.2 B	9.8 J	3.6	3.8 J
Copper	9,070	50.8	21.2	193	144	26.5
Cyanide	2.8 U	2.7 U	2.8 U	2.9 U	3.1	2.8 U
Iron	18,700 L	11,400 L	6,530 L	18,300	13,800	10,700
Lead	695	159	163	208 J	126 J	84.2 J
Magnesium	3,100	1,500	513 J	4,060 J	2,460 J	2,060 J
Manganese	1,300	127	54.2	136	147	91.7
Mercury	1.1	0.25	0.066 B	0.53	0.11	0.11 J
Nickel	66.5	11	5 J	60.5 J	20 J	9 J
Potassium	763 J	687 J	332 B	831 J	444 J	599 J
Selenium	0.53 U	0.53 U	0.54 U	0.78 B	0.68 B	0.53 U
Silver	4.7	0.76 J	0.49 UJ	0.92 J	0.49 U	0.49 U
Sodium	474 J	455 J	539 J	284 J	436 J	351 J
Thallium	1.1 U	1.1 U	1.1 U	1.2	1.1 U	1.1 U
Vanadium	38.8	26.3	19.1	27.1	24.1	17.9
Zinc	1,970	167	157	409	239	110

Station ID / Sample ID / Sample Date	NBW14-DS13	NBW14-DS14	NBW14-DS15	NBW14-DS16	NBW14-DS17
	NBW14-DS13-00	NBW14-DS14-00	NBW14-DS15-00	NBW14-DS16-00	NBW14-DS17-00
	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99
Chemical Name					
Heptachlor	9.3 U	9.6 U	1.8 U	1.8 U	9.3 U
Heptachlor epoxide	9.3 U	9.6 U	1.8 U	1.8 U	9.3 U
Methoxychlor	93 U	96 U	18 U	14 J	93 U
alpha-BHC	9.3 U	9.6 U	1.8 U	1.8 U	9.3 U
alpha-Chlordane	15 J	18	1.3 J	1.8 U	18 J
beta-BHC	9.3 U	9.6 U	1.8 U	1.8 U	9.3 U
delta-BHC	9.3 U	9.6 U	1.8 U	1.8 U	9.3 U
gamma-BHC (Lindane)	9.3 U	9.6 U	1.8 U	1.8 U	9.3 U
gamma-Chlordane	23 J	29	1.5 J	1.8 U	31
Dioxin/Furans (UG/KG)					
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA
1,2,3,4,6,7,8-Heptachlorodibenzofuran	NA	NA	NA	NA	NA
1,2,3,4,7,8,9-Heptachlorodibenzofuran	NA	NA	NA	NA	NA
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA
1,2,3,4,7,8-Hexachlorodibenzofuran	NA	NA	NA	NA	NA
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA
1,2,3,6,7,8-Hexachlorodibenzofuran	NA	NA	NA	NA	NA
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA
1,2,3,7,8,9-Hexachlorodibenzofuran	NA	NA	NA	NA	NA
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA
1,2,3,7,8-Pentachlorodibenzofuran	NA	NA	NA	NA	NA
2,3,4,6,7,8-Hexachlorodibenzofuran	NA	NA	NA	NA	NA
2,3,4,7,8-Pentachlorodibenzofuran	NA	NA	NA	NA	NA
2,3,7,8-TCDD (dioxin)	NA	NA	NA	NA	NA
2,3,7,8-Tetrachlorodibenzofuran	NA	NA	NA	NA	NA
Total heptachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA
Total heptachlorodibenzofuran	NA	NA	NA	NA	NA
Total hexachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA
Total hexachlorodibenzofuran	NA	NA	NA	NA	NA
Total octachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA
Total octachlorodibenzofuran	NA	NA	NA	NA	NA
Total pentachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA
Total pentachlorodibenzofuran	NA	NA	NA	NA	NA
Total tetrachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA
Total tetrachlorodibenzofuran	NA	NA	NA	NA	NA
Total Metals (MG/KG)					
Aluminum	3,310	3,320	5,110	2,810	3,910
Antimony	1.9 J	2.3 J	3.1 J	0.9 J	1.9 J
Arsenic	6.7	12.1	11.7	11.4	15.5
Barium	56	56.6	128	38.3 J	57
Beryllium	0.22 B	0.25 B	0.61 B	0.28 B	0.34 B
Cadmium	2.7 J	1.6 J	1.5 J	0.69 UJ	1.8 J
Calcium	33,700	20,200	33,100	14,200	91,100
Chromium	17.9 J	22.7 J	16.1 J	7.4 J	73.6 J
Cobalt	4.8 J	3.7 J	4.3 J	3.1 J	5.1 J
Copper	61.9	59.8	108	16	78.9
Cyanide	2.7 U	2.8 U	2.7 U	2.7 U	2.7 U
Iron	9,810	10,200	13,400	9,160	14,300
Lead	123 J	136 J	134 J	35.3 J	180 J
Magnesium	1,400 J	1,480 J	6,890 J	2,730 J	3,210 J
Manganese	152	155	326	65.7	152
Mercury	0.15	0.27	0.15	0.048 U	0.1 J
Nickel	52.5 J	30.8 J	26.5 J	5.9 J	22.3 J
Potassium	760 J	810 J	786 J	375 J	763 J
Selenium	0.52 U	0.58 B	0.99 B	0.97 B	0.53 U
Silver	0.48 U	0.5 U	0.75 J	0.48 U	0.48 U
Sodium	439 J	415 J	594 J	188 J	838 J
Thallium	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Vanadium	137	108	26.5	15.6	30.4
Zinc	206	209	420	45.3	365

Table 3-2
Surface Soil Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID	Background	Soil Residential Adjusted RBC *	Ecological Screening Criteria	NBW14-DS01	NBW14-DS02	NBW14-DS03	NBW14-DS04	NBW14-DS05	NBW14-DS06	NBW14-DS07	NBW14-DS08	NBW14-DS09	NBW14-DS10	NBW14-DS11	NBW14-DS12	NBW14-DS13	NBW14-DS14	NBW14-DS15	NBW14-DS16	NBW14-DS17
Sample ID				NBW14-DS01-00	NBW14-DS02-00	NBW14-DS03-00	NBW14-DS04-00	NBW14-DS05-00	NBW14-DS06-00	NBW14-DS07-00	NBW14-DS08-00	NBW14-DS09-00	NBW14-DS10-00	NBW14-DS11-00	NBW14-DS12-00	NBW14-DS13-00	NBW14-DS14-00	NBW14-DS15-00	NBW14-DS16-00	NBW14-DS17-00
Sample Date				09/30/99	09/30/99	09/30/99	09/30/99	09/30/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99
Chemical Name																				
Wet Chemistry (MG/KG)																				
% Solids	--	--	--	92.1	89	88.3	92.4	90.4	89	90.6	91	89.3	87.3	90.2	90	91.9	88.2	91.9	92.3	91.2

Notes:

NA - Not analyzed
-- Not Available
U - Not detected
B - Blank contamination
J - Estimated
L - Biased low
UJ - Undetected, estimated limit

UL - Undetected, limit biased low
UR - Undetected, unreliable result
K - Biased high
R - Unreliable Result
Shaded cells indicate exceedance of human health screening criteria
Bolded text indicates exceedance of ecological screening criteria
ND - Not detected

Table 3-2
Surface Soil Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID	Background	Soil Residential Adjusted RBC *	Ecological Screening Criteria	NBW14-DS18		NBW14-DS19	NBW14-DS20	NBW14-DS21	NBW14-DS22	NBW14-DS23	NBW14-DS24		NBW14-DS25		NBW14-DS26		NBW14-DS27	NBW14-DS28	NBW14-DS29	NBW14-DS30
Sample ID				NBW14-DS18-00	NBW14-DS18P-00	NBW14-DS19-00	NBW14-DS20-00	NBW14-DS21-00	NBW14-DS22-00	NBW14-DS23-00	NBW14-DS24-00	NBW14-DS24-P-00	NBW14-DS25-00	NBW14-DS25-P-00	NBW14-DS26-00	NBW14-DS26-P-00	NBW14-DS27-00	NBW14-DS28-00	NBW14-DS29-00	NBW14-DS30-00
Sample Date				10/01/99	10/01/99	09/18/00	09/19/00	09/11/00	09/11/00	09/11/00	09/11/00	09/11/00	09/15/00	09/15/00	09/11/00	09/11/00	09/12/00	09/12/00	09/11/00	09/12/00
Chemical Name																				
Volatile Organic Compounds (UG/KG)																				
1,1,1-Trichloroethane	–	2,200,000	300	NA	NA	11 U	11 U	11 U	11 U	1.28 J	12 U	11 UJ	12 U	11 U	10 UJ	11 U	11 UJ	11 UJ	11 U	11 U
1,2-Dichlorobenzene	–	700,000	100	NA	NA	11 UR	11 UR	11 U	11 UR	11 UJ	12 U	11 UJ	12 U	11 U	10 UR	11 U	11 UJ	11 UJ	11 UR	11 U
2-Butanone	–	4,700,000	–	NA	NA	4.62 J	11 U	11 U	11 UJ	3.74 J	12 U	11 UJ	12 U	11 U	10 UJ	11 U	11 UJ	11 UJ	11 U	11 U
Acetone	–	780,000	–	NA	NA	6.11 J	11 U	11 U	11 UJ	11 UJ	12 U	11 UJ	12 U	11 U	10 UJ	11 U	11 UJ	11 UJ	11 U	4.6 B
Benzene	–	12,000	100	NA	NA	11 U	11 U	11 U	11 U	11 UJ	12 U	11 UJ	12 U	11 U	10 UJ	11 U	11 UJ	11 UJ	11 U	11 U
Carbon disulfide	–	780,000	–	NA	NA	11 U	11 U	11 U	11 UJ	11 UJ	12 U	11 UJ	12 U	11 U	10 UJ	11 U	11 UJ	11 UJ	11 U	11 U
Chlorobenzene	–	160,000	2,400	NA	NA	11 U	11 UR	11 U	11 UR	11 UR	12 UJ	11 UJ	12 U	11 U	10 UR	11 U	11 UJ	11 UJ	11 UR	11 U
Chloromethane	–	49,000	–	NA	NA	11 U	11 U	11 U	11 UJ	11 UJ	12 U	11 UJ	12 U	11 U	10 UJ	11 U	11 UJ	11 UJ	11 U	11 U
Cyclohexane	–	–	6,000	NA	NA	11 U	11 U	11 U	11 U	2.25 J	12 U	11 UJ	12 U	11 U	1.32 J	11 U	11 UJ	11 UJ	11 U	11 U
Ethylbenzene	–	780,000	5,005	NA	NA	11 UR	11 UR	11 U	11 UR	11 UR	12 UJ	11 UJ	12 U	11 U	10 UR	11 U	1.61 J	11 UJ	11 UR	11 U
Methylene chloride	–	85,000	300	NA	NA	29.2 J	10.5 B	3.15 B	10.7 B	78.5 J	2.21 B	2.4 B	1.19 B	1.27 B	24.5 B	1.5 B	8.88 B	12.6 B	21 J	1.11 B
Tetrachloroethene	–	12,000	300	NA	NA	11 UR	11 U	11 U	11 UR	11 UR	12 U	11 UJ	12 U	11 U	10 UR	11 U	2.25 J	11 UJ	11 UR	11 U
Toluene	–	1,600,000	100	NA	NA	3.13 J	3.18 J	10.3 J	19.5 J	12.4 J	12 UJ	1.36 J	2.44 J	11 U	86.7 J	11 U	13.0 J	11.6 J	50.4 J	11 U
Trichlorofluoromethane(Freon-11)	–	2,300,000	–	NA	NA	1.59 J	11 U	11 U	1.46 J	11 UJ	12 U	11 UJ	12 U	11 U	4.53 J	11 U	11 UJ	11 UJ	4.03 J	11 U
Xylene, total	–	16,000,000	100	NA	NA	11 UR	11 UR	11 U	4.71 J	11 UR	12 UJ	11 UJ	12 U	11 U	10 UR	11 U	6.83 J	11 UJ	11 UR	11 U
Semivolatile Organic Compounds (UG/KG)																				
1,1-Biphenyl	–	390,000	6,800	NA	NA	360 U	360 U	380 U	360 U	50 J	350 U	360 U	380 U	360 U	48.3 J	43.6 J	360 U	370 U	44.7 J	1,100 U
2-Methylnaphthalene	–	160,000	–	740 U	770 U	104 J	71.7 J	69.2 J	115 J	210 J	100 J	83.5 J	380 U	360 U	247 J	NA	NA	NA	NA	1,100 U
Acenaphthene	–	470,000	2,500	740 U	770 U	38.2 J	360 U	380 U	360 U	63 J	350 U	87.4 J	380 U	360 U	44.6 J	44.9 J	360 U	45.9 J	50.7 J	1,100 U
Acenaphthylene	–	–	100	740 U	770 U	51.7 J	360 U	41.7 J	58.1 J	370 U	350 U	360 U	380 U	61.0 J	43.5 J	46.2 J	360 U	60.2 J	43.0 J	1,100 U
Anthracene	491	2,300,000	100	99 J	770 U	122 J	64.1 J	74.7 J	156 J	95 J	45 J	128 J	380 U	121 J	90.6 J	86.7 J	58.8 J	144 J	98.0 J	1,100 U
Benzo(a)anthracene	490	870	100	820	160 J	513	101 J	150 J	161 J	170 J	97 J	362 J	102 J	183 J	150 J	145 J	118 J	305 J	171 J	318 J
Benzo(a)pyrene	490	87	100	450 J	140 J	323 J	146 J	169 J	153 J	140 J	79 J	338 J	147 J	265 J	112 J	132 J	36.9 J	376	150 J	280 J
Benzo(b)fluoranthene	490	870	100	1,000	310 J	823 J	395 J	422 J	281 J	370	190 J	422	479 J	458	279 J	280 J	307 J	787 J	321 J	426 J
Benzo(g,h,i)perylene	490	230,000	100	180 J	770 U	165 J	165 J	114 J	102 J	120 J	350 U	151 J	161 J	211 J	70.9 J	97.6 J	70.3 J	231 J	92.2 J	269 J
Benzo(k)fluoranthene	490	8,700	100	860	180 J	882 J	423 J	387 J	225 J	290 J	120 J	385	513 J	339 J	214 J	173 J	280 J	717 J	202 J	397 J
Butylbenzylphthalate	–	1,600,000	–	98 J	770 U	1,031	360 U	380 U	360 U	370 U	350 U	360 U	380 U	360 U	340 U	360 U	360 U	370 U	360 U	1,100 U
Carbazole	–	32,000	2,000	740 U	770 U	54.6 J	360 UJ	380 U	360 U	370 U	350 U	74.7 J	380 UJ	50.2 J	340 U	360 U	360 U	51.5 J	360 U	1,100 U
Chrysene	621	87,000	100	1,000	200 J	898	228 J	245 J	423	330 J	170 J	437	268 J	337 J	263 J	274 J	184 J	410	302 J	498 J
Di-n-butylphthalate	–	780,000	40,000	740 U	770 U	360 U	360 U	401	360 U	370 U	350 U	360 U	380 U	360 U	340 U	360 U	360 U	370 U	360 U	1,100 U
Di-n-octylphthalate	–	160,000	–	170 J	770 U	360 U	360 U	380 U	360 U	370 U	350 U	360 U	380 U	360 U	340 U	360 U	360 U	370 U	360 U	1,100 U
Dibenz(a,h)anthracene	–	87	100	740 U	770 U	54.8 J	65.1 J	71.3 J	75.4 J	56 J	350 U	88.4 J	49.9 J	49.8 J	64.6 J	59.2 J	360 U	135 J	66.8 J	1,100 U
Dibenzofuran	–	31,000	14,000	740 U	770 U	68.0 J	52.4 J	41.5 J	60.4 J	120 J	51 J	59.4 J	380 U	360 U	119 J	97.2 J	62.3 J	62.7 J	104 J	1,100 U
Diethylphthalate	–	6,300,000	13,400	740 U	770 U	360 U	360 U	380 U	360 U	370 U	350 U	360 U	380 U	360 U	340 U	360 U	360 U	370 U	360 U	1,100 U
Fluoranthene	950	310,000	100	1,700	470 J	2,714	190 J	266 J	230 J	370	210 J	975	136 J	321 J	287 J	283 J	197 J	631	360	661 J
Fluorene	401	310,000	1,700	740 U	770 U	37.4 J	360 U	380 U	360 U	370 U	350 U	59.5 J	380 U	360 U	39.8 J	360 U	360 U	38.0 J	360 U	1,100 U
Indeno(1,2,3-cd)pyrene	660	870	100	240 J	770 U	193 J	140 J	153 J	127 J	130 J	66 J	198 J	132 J	203 J	105 J	116 J	84.6 J	286 J	128 J	257 J
Naphthalene	–	160,000	100	740 U	770 U	80.2 J	360 U	67.8 J	120 J	180 J	76 J	114 J	380 U	360 U	234 J	191 J	93.7 J	86.7 J	190 J	1,100 U
Phenanthrene	–	230,000	100	180 J	220 J	765	208 J	209 J	245 J	420	220 J	586	77.3 J	189 J	403	341 J	218 J	516	409	185 J
Phenol	–	2,300,000	1,880	740 U	770 U	360 U	360 U	380 U	360 U	370 U	350 U	360 U	380 U	360 U	340 U	360 U	360 U	370 U	360 U	1,100 U
Pyrene	830	230,000	100	1,300	270 J	2,893	213 J	285 J	237 J	350 J	220 J	846	173 J	373	263 J	283 J	194 J	678 J	308 J	473 J
bis(2-Ethylhexyl)phthalate	–	46,000	10,000	160 J	130 J	122 J	360 U	96.1 J	382	130 J	80 J	103 J	380 U	343 J	46.3 J	37.1 J	116 J	87.3 J	61.4 J	122 B
n-Nitrosodiphenylamine	–	130,000	1,090	740 U	770 U	360 U	360 U	380 U	360 U	49 J	350 U	360 U	380 U	360 U	197 J	360 U	360 U	370 U	360 U	1,100 U
Pesticide/Polychlorinated Biphenyls (UG/KG)																				
4,4'-DDD		2,700	100	2.3 J	7.9 J	3.6 U	2.9 J	3.8 U	2.7 J	3.7 UJ	1.1 J	2.6 J	3.8 U	3.6 U	3.4 U	2.4 J	3.6 U	12 J	5.2 J	5.7 J
4,4'-DDE	4	1,900	100	6 J	21	3.4 J	2 J	17 J	4.1 J	3.7 UJ	1.3 J	2.2 J	6.2 J	1.4 J	4.3	5.2	1.3 J	5.7	2.5 J	3 J
4,4'-DDT	4	1,900	100	2 J	7.7 U	15 J	7.5	3.8 U	6.8 J	5.6 J	2.7 J	4.5 J	3.7 J	3.6 U	5	5.4 J	3.5 J	6.3 J	4.2 J	3.6 U
Aldrin	–	38	100	1.9 U	3.9 U	1.9 U	1.8 U	2.8	1.9 U	1.9 UJ	1.8 U	1.9 U	2 U	1.9 U	1.8 U	1.8 U	1.9 U	1.9 U	1.8 U	1.8 U
Aroclor-1242	–	320	100	37 U	77 U	36 U	36 U	38 U	36 U	37 UJ	35 U	36 U	38 U	36 U	34 U	36 U	36 U	37 U	36 U	36 U
Aroclor-1248	–	320	100	37 U	77 U	36 U	36 U	38 U	36 U	37 UJ	35 U	36 U	38 U	36 U	34 U	36 U	36 U	37 U	36 U	36 U
Aroclor-1254	–	160	100	37 U	77 U	36 U	36 U	38 U	36 U	37 UJ	35 U	36 U	44 J	36 U	34 U	36 U	36 U	37 U	36 U	36 U
Aroclor-1260	–	320	100	37 U	77 U	36 U	36 U	38 U	36 U	37 UJ	35 U	36 U	38 U	36 U	34 U	36 U	36 U	37 U	36 U	150 J
Dieldrin	12.4	40	100	5.1	24	4.9	4.9 J	7.4 J	12 J	8.7 J	6	7.9 J	4	3.6 U	6.3	8.8	3.5	7.4 J	10	2 J
Endosulfan I	–	47,000	–	1.9 U	3.9 U	1.9 U	1.8 U	1.9 U	1.9 U	1.9 UJ	1.8 U	1.9 J	2 U	0.45 J	1.8 U	1.8 U	1.9 J	1.9 U	1.8 U	1.8 U
Endosulfan II	–	47,000	–	3.7 U	7.7 U	3.6 U	3.6 U	3.8 J	3.6 U	3.7 UJ	3.5 U	3.6 U	3.8 U	3.6 U	3.4 J	3.6 U	3.6 U	3.7 U	3.6 U	3.6 U
Endosulfan sulfate	–	47,000	–	3.7 U	7.7 U	1.3 J	1.8 J	14 J	2 J	3.7 UJ	3.5 U	2.6 J	1.8 J	3.6 U	1.2 J	2.4 J	1.4 J	2 J	3.6 U	3.6 U
Endrin	–	2,300	100	3.7 U	7.7 U	3.6 U	3.6 U	11 J	3.6 J	3.7 UJ	3.5 U	4.9 J	3.8 U	3.6 U	1.2 J	4.1 J	3.2 J	3.7	2.2	3.2 J
Endrin aldehyde	–	2,300	100	3.7 U	7.7 U	1.9 J	2.9 J	32 J	3 J	1.4 J	1.2 J	1.8 J	7.6	1.7 J	5.2 J	4.1 J	1.1 J	3.7 U	0.78 J	3.6 U
Endrin ketone	–	2,300	100	3.7 U	7.7 U	4.3 J	2.8 J	3.8 J	3.6 U	3.6 J	1.6 J	4.1 J	1.2 J	3.6 U	2.1 J	3.7 J	3.6 U	3.7 U	1.3 J	3.6 U

Table 3-2
Surface Soil Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID	Background	Soil Residential Adjusted RBC *	Ecological Screening Criteria	NBW14-DS18		NBW14-DS19	NBW14-DS20	NBW14-DS21	NBW14-DS22	NBW14-DS23	NBW14-DS24		NBW14-DS25		NBW14-DS26		NBW14-DS27	NBW14-DS28	NBW14-DS29	NBW14-DS30
Sample ID				NBW14-DS18-00	NBW14-DS18P-00	NBW14-DS19-00	NBW14-DS20-00	NBW14-DS21-00	NBW14-DS22-00	NBW14-DS23-00	NBW14-DS24-00	NBW14-DS24-P-00	NBW14-DS25-00	NBW14-DS25-P-00	NBW14-DS26-00	NBW14-DS26-P-00	NBW14-DS27-00	NBW14-DS28-00	NBW14-DS29-00	NBW14-DS30-00
Sample Date				10/01/99	10/01/99	09/18/00	09/19/00	09/11/00	09/11/00	09/11/00	09/11/00	09/11/00	09/15/00	09/15/00	09/11/00	09/11/00	09/12/00	09/12/00	09/11/00	09/12/00
Chemical Name																				
Heptachlor	–	140	–	1.9 U	3.9 U	1.3 J	1.8 U	16 J	1.3 J	1.9 UJ	1.8 U	1.9 U	2 U	1.9 U	1.3 J	2.1 J	1.9 U	1.9	1.8 U	2.8 J
Heptachlor epoxide	–	70	100	1.9 U	3.9 U	9	1.8 U	1.9 U	1.9 U	1.9 UJ	1.8 U	1.9 U	2 U	1.9 U	1.8 U	1.8 U	1.9 U	1.9	1.8 U	1.8 U
Methoxychlor	–	39,000	100	19 U	39 U	19 U	18 U	23 J	19 U	19 UJ	9.2 J	19 U	20 U	19 U	18 U	18 U	19 U	19 U	18 U	18 U
alpha-BHC	–	100	100,000	1.9 U	3.9 U	1.9 U	1.8 U	15 J	0.7 J	1.9 UJ	1.8 U	1.9 U	2 U	1.9 U	1.8	0.98 J	1.9	0.84 J	1.4 J	0.56 J
alpha-Chlordane	–	1,800	100	0.96 J	3.2 J	16 J	1.8 U	1.9 U	1.9 U	1.8 J	1.8 U	1.9 U	0.83 J	0.91 J	1.8 U	1.8 U	0.94 J	3.8	1.8 U	2.6 J
beta-BHC	–	350	100,000	1.9 U	3.9 U	1.9 U	1.8 U	7 J	0.87 B	1.9 UJ	1.8 U	1.8 B	2 U	1.9 U	1.4 B	1.8 U	1.9 U	1.4 J	1.8 U	1.8 U
delta-BHC	–	–	100,000	1.9 U	3.9 U	1.9 U	1.8 U	1.9 U	1.9 J	1.9 UJ	1.8 U	1.8 J	2 U	1.9 U	1.8 J	1.8	1.9 J	1.9 U	1.8 U	1.8 U
gamma-BHC (Lindane)	–	490	100	1.9 U	3.9 U	1.9 U	1.8 U	1.9 U	1.9 U	1.9 UJ	0.075 J	1.9 U	2 U	1.9 U	1.8 U	2.1 J	1.9 U	1.9 U	1.8 U	1.8 U
gamma-Chlordane	–	1,800	100	1.5 J	3.9 J	13	1.6 J	1.6 J	1.2 J	1.6 J	0.32 J	0.82 J	2 U	1.5 J	1.7 J	1.6 J	1.4 J	2.6 J	0.55 J	5.7 J
Dioxin/Furans (UG/KG)																				
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	–	0.430	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,6,7,8-Heptachlorodibenzofuran	–	0.43	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8,9-Heptachlorodibenzofuran	–	0.43	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	–	0.043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-Hexachlorodibenzofuran	–	0.043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	–	0.043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-Hexachlorodibenzofuran	–	0.043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	–	0.043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-Hexachlorodibenzofuran	–	0.043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	–	0.0085	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8-Pentachlorodibenzofuran	–	0.085	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,4,6,7,8-Hexachlorodibenzofuran	–	0.043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,4,7,8-Pentachlorodibenzofuran	–	0.0085	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,7,8-TCDD (dioxin)	–	0.0043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,7,8-Tetrachlorodibenzofuran	–	0.043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total heptachlorodibenzo-p-dioxin	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total heptachlorodibenzofuran	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total hexachlorodibenzo-p-dioxin	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total hexachlorodibenzofuran	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total octachlorodibenzo-p-dioxin	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total octachlorodibenzofuran	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total pentachlorodibenzo-p-dioxin	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total pentachlorodibenzofuran	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total tetrachlorodibenzo-p-dioxin	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total tetrachlorodibenzofuran	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Metals (MG/KG)																				
Aluminum	22,370	7,800	50	9,120	7,080 L	3,170 L	3,430 L	4,190	3,970	3,220 L	3,700 L	3,970	2,780 L	2,150 L	3,160	3,600	4,160	3,500	3,070	3,390 L
Antimony	1.2	3.1	5	46.8 J	19.2 J	0.82 L	0.39 UL	5.8 L	1.1 B	0.94 B	1 B	0.87 B	2.7 L	0.85 L	1.1 B	0.89 B	0.4 UL	1.6 B	0.94 B	3.2 L
Arsenic	42.2	0.43	60	19.2	12.3 J	13.3	11.6 L	38.2 K	19.4 K	16.8 L	40.7 L	11.3 K	25.3	25.7	14.4 K	13.9 K	9.6 K	15.2 K	12 K	36.7 K
Barium	67	550	440	114	187 J	61.5	48	155	63.5	65.5	52.8	49	49.2	32.2 J	59	51.4	50.4	55	54.2	67
Beryllium	2.3	16	10	0.36 B	0.31 B	0.33 B	0.29 B	0.22 L	0.28 L	0.36 B	0.22 B	0.35 L	0.47 J	0.55 J	0.38 L	0.38 L	0.26 L	0.29 L	0.4 L	0.44 L
Cadmium	0.2	3.9	4	4 J	9.2	0.55 J	0.085 B	1 J	0.38 B	0.48 B	0.18 B	0.34 B	0.42 B	0.58 J	0.33 B	0.32 B	0.59 B	1.3	0.26 B	6.8 J
Calcium	16,100	–	–	113,000	65,500	75,500 J	24,200 J	18,300 J	29,800 J	58,000	21,800	15,300 J	130,000 J	210,000 J	19,800 J	14,400 J	26,300 J	122,000 J	9,250 J	42,500
Chromium	43	23	0.4	35.2 J	40.8 J	13.7	8.4	20.6	9.7	11.1	9.6	8.8	17.8	24.5	8.9	12.1	10.1	16.3	8.1	26.2
Cobalt	25	160	100	6.8 J	12 J	2.8 J	2.6 J	3.5 J	2.3 J	3.5 J	2.6 J	2.7 J	4 J	5.2 J	3.1 J	3 J	2.3 J	3.1 J	2.8 J	5.3 J
Copper	31	310	50	437	5,060	50.3 J	26.1 J	106	32	31.5 L	21.5 L	19	45.7 J	66.3 J	26.5	24.6	28	50	29.1	139
Cyanide	–	160	28	2.8 U	2.9 U	0.044 UL	0.043 UL	0.045 L	0.043 UL	0.046 B	0.078 B	0.052 L	0.044 UL	0.043 UL	0.061 L	0.043 UL	0.042 UL	0.37 L	0.051 L	0.076 L
Iron	96,600	2,300	200	27,300	65,200 L	12,400	9,380	17,200	9,550	13,700 L	10,000	10,600	18,200	24,600	10,400	11,200	10,500	13,800	10,300	24,500
Lead	67	400	50	2,670 J	694	66.4 J	35.5	247	62.1	67.5	44.7	40.5	59.8	50.9	58.8	56	48.6	77.6	49.2	151 K
Magnesium	6,590	–	–	2,520 J	2,190	3,820	2,460	2,190 J	7,070 J	5,450	4,830	2,880 J	2,070	2,030	6,860 J	4,240 J	9,840 J	4,230 J	3,160 J	2,390
Manganese	1,240	160	330	389	673 J	130 L	84.5 L	220	78.5	168 L	84.9 L	80.5	219 L	312 L	76.4	80.7	84	168	57.1	206
Mercury	0.1	2.3	0.1	0.05 U	0.28	0.087 B	0.058 B	0.2 L	0.12 L	0.091 B	0.097 B	0.08 L	0.074 B	0.055 B	0.099 L	0.11 L	0.096 L	0.12 L	0.082 L	0.17
Nickel	40	160	30	34.5 J	101	11	6.6 J	14.5	7.1 J	8.6 J	6.6 J	6.6 J	9.8	12.7	7.8	8.7	7.7 J	14.6	7.4 J	40.4
Potassium	3,690	–	–	590 J	775 J	506 J	446 J	679 J	422 J	1,030 J	447 J	458 J	627 J	689 J	422 J	454 J	650 J	678 J	306 J	647 J
Selenium	–	39	2	0.54 U	0.56 U	1.1 U	1.2	1.2 UL	1 UL	1.1 U	1 U	1 UL	1.1 U	1.1 U	1.1 L	1.1 UL	1.1 UL	1 UL	1.5 L	1 U
Silver	0.52	39	2	2.1 J	14.7	0.13 J	0.12 U	0.14 UL	0.12 UL	0.13 U	0.12 U	0.13 UL	0.14 U	0.13 U	0.12 UL	0.13 UL	0.13 UL	0.32 UL	0.13 UL	0.39 UL
Sodium	1,370	–	–	1,760 J	1,540	926 J	455 B	473 J	229 B	736 J	321 B	204 B	1,580	2,400	167 B	171 B	243 J	1,410	125 B	501 J
Thallium	ND	0.55	1	1.1 U	2.9 B	3.1	3.2 L	8 K	[illegible]	6.2 L	5.8 L	4.3 K	6.1 L	4 L	5 K	4.7 K	4.7 K	4.1 K	[illegible]	[illegible]
Vanadium	87	55	2	83.2	71.5 J	21.5	14.5	24.1	17.1	21.7	15.8	15.2	34.8	44.8	13.5	14.7	13.8	30.8	13.4	133
Zinc	142	2,300	50	682	1,400	106 J	47.9 J	332 K	79.5 K	67.1 L	56.4 L	52 K	146 J	167 J	66.4 K	59.8 K	75.4 K	135 K	41.8 K	273

Table 3-2
Surface Soil Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID	Background	Soil Residential Adjusted RBC *	Ecological Screening Criteria	NBW14-DS18		NBW14-DS19	NBW14-DS20	NBW14-DS21	NBW14-DS22	NBW14-DS23	NBW14-DS24		NBW14-DS25		NBW14-DS26		NBW14-DS27	NBW14-DS28	NBW14-DS29	NBW14-DS30
Sample ID				NBW14-DS18-00	NBW14-DS18P-00	NBW14-DS19-00	NBW14-DS20-00	NBW14-DS21-00	NBW14-DS22-00	NBW14-DS23-00	NBW14-DS24-00	NBW14-DS24-P-00	NBW14-DS25-00	NBW14-DS25-P-00	NBW14-DS26-00	NBW14-DS26-P-00	NBW14-DS27-00	NBW14-DS28-00	NBW14-DS29-00	NBW14-DS30-00
Sample Date				10/01/99	10/01/99	09/18/00	09/19/00	09/11/00	09/11/00	09/11/00	09/11/00	09/11/00	09/15/00	09/15/00	09/11/00	09/11/00	09/12/00	09/12/00	09/11/00	09/12/00
Chemical Name																				
Wet Chemistry (MG/KG)																				
% Solids	--	--	--	89.5	86.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

NA - Not analyzed
-- Not Available
U - Not detected
B - Blank contamination
J - Estimated
L - Biased low
UJ - Undetected, estimated limit

UL - Undetected, limit biased low
UR - Undetected, unreliable result
K - Biased high
R - Unreliable Result
Shaded cells indicate exceedance of human healt
Bolded text indicates exceedance of ecological sc
ND - Not detected

Table 3-2
Surface Soil Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID	Background	Soil Residential Adjusted RBC *	Ecological Screening Criteria	NBW14-DS31	NBW14-DS32	NBW14-DS33	NBW14-DS34	NBW14-DS35	NBW14-DS36	NBW14-DS37	NBW14-DS38	NBW14-DS40	NBW14-DS41	NBW14-DS42	NBW14-DS43	NBW14-DS44	NBW14-DS45	NBW14-DS46	NBW14-DS47	
Sample ID				NBW14-DS31-00	NBW14-DS32-00	NBW14-DS33-00	NBW14-DS34-00	NBW14-DS35-00	NBW14-DS36-00	NBW14-DS37-00	NBW14-DS38-00	NBW14-DS40-00	NBW14-DS41-00	NBW14-DS42-00	NBW14-DS43-00	NBW14-DS44-00	NBW14-DS45-00	NBW14-DS46-00	NBW14-DS47-00	NBW14-DS47-P-00
Sample Date				09/20/00	09/12/00	09/12/00	09/12/00	09/12/00	09/20/00	09/12/00	09/19/00	08/21/01	08/21/01	08/21/01	08/21/01	08/20/01	08/20/01	08/20/01	08/20/01	08/20/01
Chemical Name																				
Volatile Organic Compounds (UG/KG)																				
1,1,1-Trichloroethane	–	2,200,000	300	11 U	11 UJ	33 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA
1,2-Dichlorobenzene	–	700,000	100	11 U	11 UJ	**270**	1.21 J	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA
2-Butanone	–	4,700,000	–	11 U	3.86 B	36.5	2.27 B	4.92 B	11 U	2.24 B	11 U	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA
Acetone	–	780,000	–	11 U	6.48 B	269 J	10.6 B	7.1 B	11 U	5.52 B	11 U	3 B	3 B	3 B	3 B	NA	NA	NA	NA	NA
Benzene	–	12,000	100	11 U	11 UJ	33 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA
Carbon disulfide	–	780,000	–	11 U	11 UJ	5.72 J	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA
Chlorobenzene	–	160,000	2,400	11 U	11 UJ	151	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA
Chloromethane	–	49,000	–	11 U	11 UJ	33 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA
Cyclohexane	–	–	6,000	11 U	11 UJ	33 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA
Ethylbenzene	–	780,000	5,005	1.26 J	11 UJ	33 U	1.35 J	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA
Methylene chloride	–	85,000	300	13.4 B	3.08 B	20.6 J	2.35 B	1.68 B	1.63 B	3.74 B	11 U	2 B	2 B	2 B	2 B	NA	NA	NA	NA	NA
Tetrachloroethene	–	12,000	300	11 U	11 UJ	33 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA
Toluene	–	1,600,000	100	5.7 J	3.43 J	17.3 J	3.49 J	1.42 J	11 U	1.4 J	11 U	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA
Trichlorofluoromethane(Freon-11)	–	2,300,000	–	11 U	11 UJ	33 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA
Xylene, total	–	16,000,000	100	8.18 J	11 UJ	33 U	7.61 J	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA
Semivolatile Organic Compounds (UG/KG)																				
1,1-Biphenyl	–	390,000	6,800	360 U	350 U	430 U	380 U	350 U	350 U	57.0 J	370 U	360 U	360 U	360 U	370 U	NA	NA	NA	NA	NA
2-Methylnaphthalene	–	160,000	–	360 U	NA	NA	NA	350 U	350 U	NA	370 U	67 J	360 U	360 U	370 U	NA	NA	NA	NA	NA
Acenaphthene	–	470,000	2,500	360 U	350 U	430 U	41.9 J	350 U	350 U	87.7 J	370 U	60 J	360 U	360 U	370 U	NA	NA	NA	NA	NA
Acenaphthylene	–	–	100	360 U	350 U	430 U	380 U	350 U	350 U	56.1 J	370 U	69 J	360 U	360 U	370 U	NA	NA	NA	NA	NA
Anthracene	491	2,300,000	100	360 U	350 U	430 U	**115 J**	350 U	51.4 J	**166 J**	370 U	**230 J**	360 U	360 U	370 U	NA	NA	NA	NA	NA
Benzo(a)anthracene	490	870	100	360 U	51.1 J	430 U	**307 J**	350 U	**188 J**	**275 J**	370 U	**590**	360 U	45 J	370 U	NA	NA	NA	NA	NA
Benzo(a)pyrene	490	87	100	44.1 J	61.3 J	430 U	**231 J**	350 U	**196 J**	**206 J**	370 U	**670**	360 U	40 J	370 U	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	490	870	100	65.0 J	**142 J**	430 U	**568 J**	350 U	**412 J**	**483**	370 U	**690**	360 U	37 J	370 U	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	490	230,000	100	50.9 J	36.8 J	430 U	**138 J**	350 U	**110 J**	**143 J**	370 U	**460**	360 U	360 U	370 U	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	490	8,700	100	38.1 J	160 J	430 U	**518 J**	350 U	**354 J**	**338 J**	370 U	**950**	360 U	54 J	370 U	NA	NA	NA	NA	NA
Butylbenzylphthalate	–	1,600,000	–	360 U	350 U	94.7 J	60.2 J	350 U	350 U	370 U	370 U	360 U	360 U	360 U	370 U	NA	NA	NA	NA	NA
Carbazole	–	32,000	2,000	360 UJ	350 U	430 U	58.1 J	350 U	350 UJ	39.8 J	370 UJ	100 J	360 U	360 U	370 U	NA	NA	NA	NA	NA
Chrysene	621	87,000	100	48.2 J	81.6 J	430 U	**382**	350 U	**218 J**	**461**	370 U	**790**	360 U	50 J	370 U	NA	NA	NA	NA	NA
Di-n-butylphthalate	–	780,000	40,000	360 U	350 U	430 U	380 U	350 U	350 U	370 U	370 U	360 U	360 U	360 U	370 U	NA	NA	NA	NA	NA
Di-n-octylphthalate	–	160,000	–	360 U	350 U	430 U	380 U	350 U	350 U	370 U	370 U	360 U	360 U	360 U	370 U	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	–	87	100	360 U	350 U	430 U	70.2 J	350 U	58.4 J	**106 J**	370 U	**230 J**	360 U	360 U	370 U	NA	NA	NA	NA	NA
Dibenzofuran	–	31,000	14,000	360 U	350 U	430 U	380 U	350 U	350 U	**146 J**	370 U	61 J	360 U	360 U	370 U	NA	NA	NA	NA	NA
Diethylphthalate	–	6,300,000	13,400	360 U	350 U	430 U	380 U	350 U	350 U	370 U	370 U	360 U	360 U	360 U	370 U	NA	NA	NA	NA	NA
Fluoranthene	950	310,000	100	360 U	84.9 J	430 U	**773**	350 U	**253 J**	**541**	370 U	**1,600**	360 U	83 J	370 U	NA	NA	NA	NA	NA
Fluorene	401	310,000	1,700	360 U	350 U	430 U	380 U	350 U	350 U	59.1 J	370 U	100 J	360 U	360 U	370 U	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	660	870	100	39.7 J	47.6 J	430 U	**133 J**	350 U	**122 J**	**188 J**	370 U	**580**	360 U	360 U	370 U	NA	NA	NA	NA	NA
Naphthalene	–	160,000	100	360 U	350 U	86.9 J	48.8 J	350 U	350 U	**231 J**	370 U	81 J	360 U	360 U	370 U	NA	NA	NA	NA	NA
Phenanthrene	–	230,000	100	360 U	67.2 J	**430 U**	**389**	350 U	**149 J**	**545**	370 U	**840**	360 U	38 J	370 U	NA	NA	NA	NA	NA
Phenol	–	2,300,000	1,880	360 U	350 U	224 J	380 U	350 U	350 U	370 U	370 U	360 U	360 U	360 U	370 U	NA	NA	NA	NA	NA
Pyrene	830	230,000	100	61.1 J	64.1 J	430 U	**763 J**	350 U	**338 J**	**471 J**	370 U	**1,400**	360 U	79 J	370 U	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	–	46,000	10,000	360 U	42.1 J	530	175 J	350 U	75.9 J	181 J	370 U	290 B	110 B	230 B	130 B	NA	NA	NA	NA	NA
n-Nitrosodiphenylamine	–	130,000	1,090	360 U	350 U	430 U	380 U	350 U	350 U	370 U	370 U	360 U	360 U	360 U	370 U	NA	NA	NA	NA	NA
Pesticide/Polychlorinated Biphenyls (UG/KG)																				
4,4'-DDD		2,700	100	2.2 J	3.5 U	4.3 U	45	3.5 U	2 J	3.7 U	3.7 U	3.6 U	3.6 U	3.6 U	3.7 U	NA	NA	NA	NA	NA
4,4'-DDE	4	1,900	100	8.5 J	2.5 J	6.9 J	63 J	3.5 U	2 J	2.1 J	3.7 U	3.6 U	3.6 U	3.6 U	3.7 U	NA	NA	NA	NA	NA
4,4'-DDT	4	1,900	100	2.3 J	3.5 U	2.2 U	3.6 J	3.5 U	6.6 J	5.7 J	3.7 U	3.6 U	3.6 U	3.6 U	3.7 U	NA	NA	NA	NA	NA
Aldrin	–	38	100	1.9 U	1.8 U	2.2 U	1.9 U	1.8 U	1.8 U	1.9 U	1.9 U	0.95 J	1.9 U	1.8 U	1.9 U	NA	NA	NA	NA	NA
Aroclor-1242	–	320	100	36 U	35 U	43 U	38 U	35 U	35 U	37 U	37 U	36 U	36 U	36 U	37 U	NA	NA	NA	NA	NA
Aroclor-1248	–	320	100	36 U	35 U	43 U	**190**	35 U	35 U	37 U	37 U	36 U	36 U	36 U	37 U	NA	NA	NA	NA	NA
Aroclor-1254	–	160	100	**210**	35 U	**590**	38 U	35 U	35 U	37 U	37 U	**350 J**	36 U	36 U	37 U	NA	NA	NA	NA	NA
Aroclor-1260	–	320	100	36 U	35 U	43 U	38 U	35 U	35 U	37 U	37 U	**190**	7.9 J	36 U	37 U	NA	NA	NA	NA	NA
Dieldrin	12.4	40	100	6 J	2.1 J	8.2	3.3 J	3.5 U	7.3 J	8.7 J	3.7 U	3.6 U	3.6 U	3.6	3.7 U	NA	NA	NA	NA	NA
Endosulfan I	–	47,000	–	1.9 U	1.8 U	1.6 J	1.9 U	1.8 U	1.8 U	0.86 J	1.9 U	1.9 U	1.9 U	1.8 U	1.9 U	NA	NA	NA	NA	NA
Endosulfan II	–	47,000	–	3.6 U	3.5 U	4.3	3.8 U	3.5 U	3.5 U	3.7 U	3.7 U	3.6 U	3.6 U	3.6 U	3.7 U	NA	NA	NA	NA	NA
Endosulfan sulfate	–	47,000	–	1.8 J	3.5 U	7.8	3.1 J	3.5 U	1.5 J	1.9 J	3.7 U	3.6 U	3.6 U	3.6 U	3.7 U	NA	NA	NA	NA	NA
Endrin	–	2,300	100	3.6 U	3.5 U	4.3 U	3.8 U	3.5 U	3.5 U	3.7	3.7 U	3.6 U	3.6 U	3.6 U	3.7 U	NA	NA	NA	NA	NA
Endrin aldehyde	–	2,300	100	4.7	1.7 J	11	3.8 U	3.5 U	1.3 J	1.1 J	3.7 U	3.6 U	3.6 U	3.6 U	3.7 U	NA	NA	NA	NA	NA
Endrin ketone	–	2,300	100	3.6 U	3.5	3.2 J	3.8 U	3.5 U	3.5 U	6.5 J	3.7 U	3.6 U	3.6 U	3.6 U	3.7 U	NA	NA	NA	NA	NA

Table 3-2
Surface Soil Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID	Background	Soil Residential Adjusted RBC *	Ecological Screening Criteria	NBW14-DS31	NBW14-DS32	NBW14-DS33	NBW14-DS34	NBW14-DS35	NBW14-DS36	NBW14-DS37	NBW14-DS38	NBW14-DS40	NBW14-DS41	NBW14-DS42	NBW14-DS43	NBW14-DS44	NBW14-DS45	NBW14-DS46	NBW14-DS47	
Sample ID				NBW14-DS31-00	NBW14-DS32-00	NBW14-DS33-00	NBW14-DS34-00	NBW14-DS35-00	NBW14-DS36-00	NBW14-DS37-00	NBW14-DS38-00	NBW14-DS40-00	NBW14-DS41-00	NBW14-DS42-00	NBW14-DS43-00	NBW14-DS44-00	NBW14-DS45-00	NBW14-DS46-00	NBW14-DS47-00	NBW14-DS47-P-00
Sample Date				09/20/00	09/12/00	09/12/00	09/12/00	09/12/00	09/20/00	09/12/00	09/19/00	08/21/01	08/21/01	08/21/01	08/21/01	08/20/01	08/20/01	08/20/01	08/20/01	08/20/01
Chemical Name																				
Heptachlor	–	140	–	1.9 U	1.8 U	2.2 U	1.9 U	1.8 U	1.8 U	1.9 J	1.9 U	1.9 U	1.9 U	1.8 U	1.9 U	NA	NA	NA	NA	NA
Heptachlor epoxide	–	70	100	1.9 U	1.8 U	2.2 U	1.9 U	1.8 U	1.8 U	1.9 U	1.9 U	1.9 U	1.9 U	1.8 U	1.9 U	NA	NA	NA	NA	NA
Methoxychlor	–	39,000	100	19 U	18 U	22 U	19 U	18 U	18 U	19 U	19 U	19 U	19 U	18 U	19 U	NA	NA	NA	NA	NA
alpha-BHC	–	100	100,000	1.9 U	1.8 J	1.8 J	1.9 U	1.8 U	1.8 U	1.9 U	1.9 U	1.9 U	1.9 U	1.8 U	1.9 U	NA	NA	NA	NA	NA
alpha-Chlordane	–	1,800	100	1.9 U	1.8 U	2.2 U	1.6 J	1.8 U	2.9 J	1.9 U	1.9 U	1.9 U	1.9 U	1.8 U	1.9 U	NA	NA	NA	NA	NA
beta-BHC	–	350	100,000	1.9 U	1.8	3.2 J	1.7	1.8 U	1.8 U	1.7 J	1.9 U	1.9 U	1.9 U	4	1.9 U	NA	NA	NA	NA	NA
delta-BHC	–	–	100,000	1.9 U	1.8 U	2.2 U	1.9 U	1.8 U	1.8 U	1.9 J	1.9 U	1.9 U	1.9 U	1.8 U	1.9 U	NA	NA	NA	NA	NA
gamma-BHC (Lindane)	–	490	100	1.9 U	1.8 U	2.2 U	1.9 U	1.8 U	1.8 U	1.9 U	1.9 U	1.9 U	1.9 U	1.8 U	1.9 U	NA	NA	NA	NA	NA
gamma-Chlordane	–	1,800	100	1.9 U	0.89 J	2.2 U	1.9 U	1.8 U	3 J	0.89 J	1.9 U	1.9 U	1.9 U	1.7 J	1.9 U	NA	NA	NA	NA	NA
Dioxin/Furans (UG/KG)																				
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	–	0.430	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0753	0.151	0.106	0.542	0.461
1,2,3,4,6,7,8-Heptachlorodibenzofuran	–	0.43	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0157	0.0219	0.0121	0.098	0.0745
1,2,3,4,7,8,9-Heptachlorodibenzofuran	–	0.43	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00115 J	0.00174 J	0.00103 J	0.00675	0.00539
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	–	0.043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00356	0.00175 J	0.0012 J	0.0134	0.0102
1,2,3,4,7,8-Hexachlorodibenzofuran	–	0.043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00594	0.00271	0.00226 J	0.0289	0.0188
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	–	0.043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0053	0.00499	0.00322	0.0264	0.0221
1,2,3,6,7,8-Hexachlorodibenzofuran	–	0.043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00604	0.00263	0.00207 J	0.0275	0.0182
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	–	0.043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00441	0.00304	0.00211 J	0.0188	0.014
1,2,3,7,8,9-Hexachlorodibenzofuran	–	0.043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	9.60E-04 J	6.22E-04 J	4.72E-04 J	0.00464	0.00346
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	–	0.0085	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00829	0.00226 J	0.00186 K	0.0208	0.015
1,2,3,7,8-Pentachlorodibenzofuran	–	0.085	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00544	0.00181 J	0.00156 J	0.0199	0.0132
2,3,4,6,7,8-Hexachlorodibenzofuran	–	0.043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.006	0.00287	0.00219 J	0.0242	0.017
2,3,4,7,8-Pentachlorodibenzofuran	–	0.0085	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0105	0.0037	0.00272	0.0284	0.02
2,3,7,8-TCDD (dioxin)	–	0.0043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00187	9.12E-04	6.23E-04	0.00412	0.00306
2,3,7,8-Tetrachlorodibenzofuran	–	0.043	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00429	0.00159	0.00103	0.0132	0.00883
Total heptachlorodibenzo-p-dioxin	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.18	0.355	0.362	2.1	1.77
Total heptachlorodibenzofuran	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.039	0.0741	0.0362	0.229	0.183
Total hexachlorodibenzo-p-dioxin	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0608	0.0494	0.0367	0.383	0.318
Total hexachlorodibenzofuran	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.072	0.0411	0.0275	0.292	0.201
Total octachlorodibenzo-p-dioxin	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.64	2.7	2.28	5.42 J	4.9
Total octachlorodibenzofuran	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0356	0.0843	0.0335	0.158	0.14
Total pentachlorodibenzo-p-dioxin	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0798	0.0215	0.0166	0.291	0.213
Total pentachlorodibenzofuran	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.133	0.0359	0.0291	0.347	0.243
Total tetrachlorodibenzo-p-dioxin	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.064	0.0122	0.0105	0.165	0.138
Total tetrachlorodibenzofuran	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.142	0.033	0.00849	0.256	0.22
Total Metals (MG/KG)																				
Aluminum	22,370	7,800	50	2,480 L	5,300	22,400	12,100	9,700 L	2,990 L	3,780	1,130 L	7,300 L	1,270 L	5,190 L	1,300 L	NA	NA	NA	NA	NA
Antimony	1.2	3.1	5	0.62 L	1.8 B	107 L	18.1 L	1.1 B	0.4 UL	1.2 B	0.4 UL	31.7 L	0.7 B	2.1 B	0.516 UL	NA	NA	NA	NA	NA
Arsenic	42.2	0.43	60	36.8	13 K	7.2 K	8.9 K	1.5 J	9.9	11.8 K	15.2	10.4 J	15.2 J	9 J	17.5 J	NA	NA	NA	NA	NA
Barium	67	550	440	43.4 J	60.4	888	234	151	38.5 J	46.7	18.4 J	200	19.6 J	74.5	15.9 K	NA	NA	NA	NA	NA
Beryllium	2.3	16	10	0.24 B	0.28 L	0.28 L	0.44 L	0.48 L	0.38 B	0.35 L	0.31 B	0.84 J	0.67 J	0.44 B	0.61 J	NA	NA	NA	NA	NA
Cadmium	0.2	3.9	4	0.19 B	0.57 B	20.3	9	0.37 B	1.1	0.26 B	0.064 U	13.7	0.09 B	1.6	0.29 B	NA	NA	NA	NA	NA
Calcium	16,100	–	–	181,000 J	23,300 J	40,300 J	37,000 J	6,240	80,900 J	27,000 J	281,000 J	40,400	1,810	90,700	202,000	NA	NA	NA	NA	NA
Chromium	43	23	0.4	13.3	11.6	182	43.5	18	16.2	8.4	12.9	66.7	16	19.2	19.2	NA	NA	NA	NA	NA
Cobalt	25	160	100	2 J	3.6 J	14.7	7.9 J	8.2 J	3.2 J	2.9 J	2.4 J	10 J	3.2 J	4.1 J	4.2 K	NA	NA	NA	NA	NA
Copper	31	310	50	15.4 J	52.3	2,240	1,170	32.1	50.4 J	22.1	0.99 J	1,210	0.7 L	74.8	0.165 UL	NA	NA	NA	NA	NA
Cyanide	–	160	28	0.044 UL	0.042 UL	0.58 L	0.13 L	0.041 UL	0.042 UL	0.058 L	0.043 UL	0.25 J	0.06 J	0.07 J	0.08 J	NA	NA	NA	NA	NA
Iron	96,600	2,300	200	12,000	15,100	135,000	49,300	18,100	15,700	11,900	15,000	22,200 L	18,300 L	24,200 L	27,600 L	NA	NA	NA	NA	NA
Lead	67	400	50	54.2	58.1	12,000	1,180	33.9 K	121	41.7	4.5	634	4.8	100	4.7 K	NA	NA	NA	NA	NA
Magnesium	6,590	–	–	2,840	3,780 J	7,390 J	3,940 J	6,280	1,390	10,900 J	1,950	2,860	1,310	2,850	1,590	NA	NA	NA	NA	NA
Manganese	1,240	160	330	241 L	151	2,780	609	414	410 L	73.4	244 L	356 K	210 K	925 K	1,237 K	NA	NA	NA	NA	NA
Mercury	0.1	2.3	0.1	0.076 B	0.066 L	0.64 L	1.1 L	0.068 J	0.12 B	0.076 L	0.045 U	0.78	0.046 U	0.15	0.043 U	NA	NA	NA	NA	NA
Nickel	40	160	30	7.9 J	9.7	292	91.9	16.5	10.8	7.5 J	3.4 J	111	4.9 J	18.5	5 K	NA	NA	NA	NA	NA
Potassium	3,690	–	–	438 J	1,160 J	1,220 J	3,990 J	7,110	793 J	406 J	465 J	971 J	590 J	3,060	710 K	NA	NA	NA	NA	NA
Selenium	–	39	2	1.1 U	1.2 L	2.2 L	1.1 UL	1.1 U	1 U	1.4 L	1.1 U	0.92 J	0.742 U	0.77 U	0.764 UL	NA	NA	NA	NA	NA
Silver	0.52	39	2	0.13 U	0.13 UL	15 L	7.4 L	0.13 UL	0.17 J	0.13 UL	0.13 U	4.4	0.14 U	0.93 J	0.145 U	NA	NA	NA	NA	NA
Sodium	1,370	–	–	2,140	378 J	3,130	1,640	278 J	1,140	156 B	2,990	3,710	1,770	939 J	2,010 K	NA	NA	NA	NA	NA
Thallium	ND	0.55	1	3.5 L	7.5 K	41.6 K	18.8 K	10.1	3.9 L	5.2 K	2.1 L	0.751 UL	0.702 UL	0.728 UL	0.723 UL	NA	NA	NA	NA	NA
Vanadium	87	55	2	33.3	25.6	159	69.9	37.5	31.6	13.4	27	135	37.1	37.3	30.6	NA	NA	NA	NA	NA
Zinc	142	2,300	50	64.8 J	106 K	3,930 K	1,790 K	108	287 J	47.2 K	12.6 J	2,420 J	20.1 J	201 J	24.3 K	NA	NA	NA	NA	NA

Table 3-2
Surface Soil Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID	Background	Soil Residential Adjusted RBC *	Ecological Screening Criteria	NBW14-DS31	NBW14-DS32	NBW14-DS33	NBW14-DS34	NBW14-DS35	NBW14-DS36	NBW14-DS37	NBW14-DS38	NBW14-DS40	NBW14-DS41	NBW14-DS42	NBW14-DS43	NBW14-DS44	NBW14-DS45	NBW14-DS46	NBW14-DS47	
Sample ID				NBW14-DS31-00	NBW14-DS32-00	NBW14-DS33-00	NBW14-DS34-00	NBW14-DS35-00	NBW14-DS36-00	NBW14-DS37-00	NBW14-DS38-00	NBW14-DS40-00	NBW14-DS41-00	NBW14-DS42-00	NBW14-DS43-00	NBW14-DS44-00	NBW14-DS45-00	NBW14-DS46-00	NBW14-DS47-00	NBW14-DS47-P-00
Sample Date				09/20/00	09/12/00	09/12/00	09/12/00	09/12/00	09/20/00	09/12/00	09/19/00	08/21/01	08/21/01	08/21/01	08/21/01	08/20/01	08/20/01	08/20/01	08/20/01	08/20/01
Chemical Name																				
Wet Chemistry (MG/KG)																				
% Solids	–	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

NA - Not analyzed
– Not Available
U - Not detected
B - Blank contamination
J - Estimated
L - Biased low
UJ - Undetected, estimated limit

UL - Undetected, limit biased low
UR - Undetected, unreliable result
K - Biased high
R - Unreliable Result
Shaded cells indicate exceedance of human health
Bolded text indicates exceedance of ecological sc
ND - Not detected

Table 3-2
Surface Soil Detections and Exceedances
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Naval Station Norfolk
Norfolk, Virginia

Station ID	Background	Soil Residential Adjusted RBC *	Ecological Screening Criteria	NBW14-DS48	NBW14-DS49		NBW14-DS51	NBW14-DS52	NBW14-DS53	NBW14-DS54		NBW14-SO09		NBW14-SO10	NBW14-SO11	NBW14-SO12
Sample ID				NBW14-DS48-00	NBW14-DS49-00	NBW14-DS49-P-00	NBW14-DS51-00	NBW14-DS52-00	NBW14-DS53-00	NBW14-DS54-00	NBW14-DS54-P-00	NBW14-SS09	NBW14-SS09-P	NBW14-SS10	NBW14-SS11	NBW14-SS12
Sample Date				08/20/01	08/21/01	08/21/01	08/21/01	08/21/01	08/21/01	08/21/01	08/21/01	12/17/02	12/17/02	12/17/02	12/17/02	12/17/02
Chemical Name																
Volatile Organic Compounds (UG/KG)																
1,1,1-Trichloroethane	--	2,200,000	300	NA	11 U	11 U	11 U	12 U	12 U	11 U	11 U	NA	NA	NA	NA	NA
1,2-Dichlorobenzene	--	700,000	100	NA	11 U	11 U	11 U	12 U	12 U	11 U	11 U	NA	NA	NA	NA	NA
2-Butanone	--	4,700,000	--	NA	11 U	11 U	11 U	12 U	12 U	11 U	11 U	NA	NA	NA	NA	NA
Acetone	--	780,000	--	NA	4 B	3 B	3 B	11 B	3 B	2 B	3 B	NA	NA	NA	NA	NA
Benzene	--	12,000	100	NA	11 U	11 U	11 U	12 U	12 U	11 U	11 U	NA	NA	NA	NA	NA
Carbon disulfide	--	780,000	--	NA	11 U	11 U	11 U	12 U	12 U	11 U	11 U	NA	NA	NA	NA	NA
Chlorobenzene	--	160,000	2,400	NA	11 U	11 U	11 U	12 U	12 U	11 U	11 U	NA	NA	NA	NA	NA
Chloromethane	--	49,000	--	NA	1 J	11 U	11 U	12 U	12 U	11 U	11 U	NA	NA	NA	NA	NA
Cyclohexane	--	--	6,000	NA	11 U	11 U	11 U	12 U	12 U	11 U	11 U	NA	NA	NA	NA	NA
Ethylbenzene	--	780,000	5,005	NA	11 U	11 U	11 U	12 U	12 U	11 U	11 U	NA	NA	NA	NA	NA
Methylene chloride	--	85,000	300	NA	2 B	2 B	1 B	1 B	2 B	1 B	1 B	NA	NA	NA	NA	NA
Tetrachloroethene	--	12,000	300	NA	11 U	11 U	11 U	12 U	12 U	11 U	11 U	NA	NA	NA	NA	NA
Toluene	--	1,600,000	100	NA	11 U	11 U	11 U	12 U	12 U	11 U	11 U	NA	NA	NA	NA	NA
Trichlorofluoromethane(Freon-11)	--	2,300,000	--	NA	11 U	11 U	11 U	12 U	12 U	11 U	11 U	NA	NA	NA	NA	NA
Xylene, total	--	16,000,000	100	NA	11 U	11 U	11 U	12 U	12 U	11 U	11 U	NA	NA	NA	NA	NA
Semivolatile Organic Compounds (UG/KG)																
1,1-Biphenyl	--	390,000	6,800	NA	360 U	370 U	360 U	380 U	380 U	350 U	350 U	NA	NA	NA	NA	NA
2-Methylnaphthalene	--	160,000	--	NA	360 U	370 U	360 U	380 U	380 U	350 U	350 U	NA	NA	NA	NA	NA
Acenaphthene	--	470,000	2,500	NA	360 U	370 U	360 U	380 U	380 U	350 U	350 U	NA	NA	NA	NA	NA
Acenaphthylene	--	--	100	NA	360 U	370 U	360 U	380 U	380 U	350 U	350 U	NA	NA	NA	NA	NA
Anthracene	491	2,300,000	100	NA	360 U	370 U	360 U	380 U	380 U	350 U	350 U	NA	NA	NA	NA	NA
Benzo(a)anthracene	490	870	100	NA	360 U	51 J	43 J	70 J	380 U	350 U	350 U	NA	NA	NA	NA	NA
Benzo(a)pyrene	490	87	100	NA	360 U	51 J	48 J	61 J	380 U	350 U	350 U	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	490	870	100	NA	39 J	70 J	81 J	75 J	380 U	36 J	41 J	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	490	230,000	100	NA	360 U	370 U	55 J	42 J	380 U	350 U	16 J	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	490	8,700	100	NA	360 U	76 J	61 J	60 J	380 U	47 J	350 U	NA	NA	NA	NA	NA
Butylbenzylphthalate	--	1,600,000	--	NA	360 U	44 J	360 U	380 U	380 U	350 U	350 U	NA	NA	NA	NA	NA
Carbazole	--	32,000	2,000	NA	360 U	370 U	360 U	380 U	380 U	350 U	350 U	NA	NA	NA	NA	NA
Chrysene	621	87,000	100	NA	36 J	64 J	68 J	100 J	380 U	350 U	350 U	NA	NA	NA	NA	NA
Di-n-butylphthalate	--	780,000	40,000	NA	360 U	370 U	360 U	5,600	380 U	350 U	350 U	NA	NA	NA	NA	NA
Di-n-octylphthalate	--	160,000	--	NA	360 U	370 U	360 U	380 U	380 U	350 U	350 U	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	--	87	100	NA	360 U	370 U	360 U	380 U	380 U	350 U	350 U	NA	NA	NA	NA	NA
Dibenzofuran	--	31,000	14,000	NA	360 U	370 U	360 U	380 U	380 U	350 U	350 U	NA	NA	NA	NA	NA
Diethylphthalate	--	6,300,000	13,400	NA	360 U	370 U	360 U	7,900	380 U	350 U	350 U	NA	NA	NA	NA	NA
Fluoranthene	950	310,000	100	NA	50 J	77 J	70 J	**120 J**	380 U	350 U	350 U	NA	NA	NA	NA	NA
Fluorene	401	310,000	1,700	NA	360 U	370 U	360 U	380 U	380 U	350 U	350 U	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	660	870	100	NA	360 U	44 J	63 J	45 J	380 U	350 U	350 U	NA	NA	NA	NA	NA
Naphthalene	--	160,000	100	NA	360 U	370 U	360 U	380 U	380 U	350 U	350 U	NA	NA	NA	NA	NA
Phenanthrene	--	230,000	100	NA	360 U	370 U	360 U	70 J	380 U	350 U	350 U	NA	NA	NA	NA	NA
Phenol	--	2,300,000	1,880	NA	360 U	370 U	360 U	76 J	380 U	350 U	350 U	NA	NA	NA	NA	NA
Pyrene	830	230,000	100	NA	63 J	89 J	74 J	**150 J**	380 U	350 U	350 U	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	--	46,000	10,000	NA	140 B	130 B	230 B	1,200	55 B	750	460	NA	NA	NA	NA	NA
n-Nitrosodiphenylamine	--	130,000	1,090	NA	360 U	370 U	360 U	380 U	380 U	350 U	350 U	NA	NA	NA	NA	NA
Pesticide/Polychlorinated Biphenyls (UG/KG)																
4,4'-DDD		2,700	100	NA	3.6 U	3.6 U	5.7 J	3.8 U	3.8 U	3.6 U	3.5 U	NA	NA	NA	NA	NA
4,4'-DDE	4	1,900	100	NA	5.1	2.2 J	6.5	1.3 J	4	1.6 J	2.2 J	NA	NA	NA	NA	NA
4,4'-DDT	4	1,900	100	NA	3.6 U	3.6 U	9.3	3.8 U	2.2 J	2 J	3.5 U	NA	NA	NA	NA	NA
Aldrin	--	38	100	NA	1.9 U	1.9 U	1.9 U	2 U	2 U	1.8 U	1.8 U	NA	NA	NA	NA	NA
Aroclor-1242	--	320	100	NA	36 U	36 U	36 U	38 U	38 U	36 U	35 U	NA	NA	NA	NA	NA
Aroclor-1248	--	320	100	NA	36 U	36 U	36 U	38 U	38 U	36 U	35 U	NA	NA	NA	NA	NA
Aroclor-1254	--	160	100	NA	36 U	36 U	36 U	38 U	38 U	36 U	35 U	NA	NA	NA	NA	NA
Aroclor-1260	--	320	100	NA	34 J	47 J	36 U	33 J	38 U	36 U	35 U	NA	NA	NA	NA	NA
Dieldrin	12.4	40	100	NA	3.6 U	3.6 U	10	3.8 U	3.8 U	3.6 U	3.5 U	NA	NA	NA	NA	NA
Endosulfan I	--	47,000	--	NA	1.9 U	1.9 U	1.9 U	2 U	2 U	1.8 U	1.8 U	NA	NA	NA	NA	NA
Endosulfan II	--	47,000	--	NA	3.6 U	3.6 U	3.6 U	3.8 U	3.8 U	3.6 U	3.5 U	NA	NA	NA	NA	NA
Endosulfan sulfate	--	47,000	--	NA	3.6 U	3.6 U	3.6 U	3.8 U	3.8 U	3.6 U	3.5 U	NA	NA	NA	NA	NA
Endrin	--	2,300	100	NA	3.6 U	3.6 U	3.6 U	3.8 U	3.8 U	3.6 U	3.5 U	NA	NA	NA	NA	NA
Endrin aldehyde	--	2,300	100	NA	3.6 U	3.6 U	1.8 J	3.8 U	3.8 U	3.6 U	3.5 U	NA	NA	NA	NA	NA
Endrin ketone	--	2,300	100	NA	3.6 U	3.6 U	3.6 U	3.8 U	3.8 U	3.6 U	3.5 U	NA	NA	NA	NA	NA

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Station ID	Background	Soil Residential Adjusted RBC *	Ecological Screening Criteria	NBW14-DS48	NBW14-DS49		NBW14-DS51	NBW14-DS52	NBW14-DS53	NBW14-DS54		NBW14-SO09		NBW14-SO10	NBW14-SO11	NBW14-SO12
Sample ID				NBW14-DS48-00	NBW14-DS49-00	NBW14-DS49-P-00	NBW14-DS51-00	NBW14-DS52-00	NBW14-DS53-00	NBW14-DS54-00	NBW14-DS54-P-00	NBW14-SS09	NBW14-SS09-P	NBW14-SS10	NBW14-SS11	NBW14-SS12
Sample Date				08/20/01	08/21/01	08/21/01	08/21/01	08/21/01	08/21/01	08/21/01	08/21/01	12/17/02	12/17/02	12/17/02	12/17/02	12/17/02
Chemical Name																
Heptachlor	–	140	–	NA	1.9 U	1.9 U	1.4 J	2 U	2 U	1.8 U	1.8 U	NA	NA	NA	NA	NA
Heptachlor epoxide	–	70	100	NA	1.9 U	1.9 U	11	2 U	2 U	1.8 U	1.8 U	NA	NA	NA	NA	NA
Methoxychlor	–	39,000	100	NA	19 U	19 U	19 U	20 U	20 U	18 U	18 U	NA	NA	NA	NA	NA
alpha-BHC	–	100	100,000	NA	1.9 U	1.9 U	1.9 U	2 U	2 U	1.8 U	1.8 U	NA	NA	NA	NA	NA
alpha-Chlordane	–	1,800	100	NA	1.1 J	1.3 J	63 J	2 U	0.66 J	7.6	1.8 U	NA	NA	NA	NA	NA
beta-BHC	–	350	100,000	NA	1.9 U	1.8 J	1.9 U	3.1 J	1.8 J	1.8 U	1.8 U	NA	NA	NA	NA	NA
delta-BHC	–	–	100,000	NA	1.9 U	1.9 U	1.9 U	2 U	2 U	1.8 U	1.8 U	NA	NA	NA	NA	NA
gamma-BHC (Lindane)	–	490	100	NA	1.9 U	1.9 U	1.9 U	2 U	2 U	1.8 U	1.8 U	NA	NA	NA	NA	NA
gamma-Chlordane	–	1,800	100	NA	0.96 J	0.91 J	51	0.79 J	2 U	1.8 U	1.8 U	NA	NA	NA	NA	NA
Dioxin/Furans (UG/KG)																
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	–	0.430	–	0.0771	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,6,7,8-Heptachlorodibenzofuran	–	0.43	–	0.0113	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8,9-Heptachlorodibenzofuran	–	0.43	–	0.00135 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	–	0.043	–	0.00182 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-Hexachlorodibenzofuran	–	0.043	–	0.00283	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	–	0.043	–	0.00348	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-Hexachlorodibenzofuran	–	0.043	–	0.00285	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	–	0.043	–	0.00244 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-Hexachlorodibenzofuran	–	0.043	–	9.36E-04 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	–	0.0085	–	0.00324	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8-Pentachlorodibenzofuran	–	0.085	–	0.00253 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,4,6,7,8-Hexachlorodibenzofuran	–	0.043	–	0.00269 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,4,7,8-Pentachlorodibenzofuran	–	0.0085	–	0.00421	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,7,8-TCDD (dioxin)	–	0.0043	–	8.70E-04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,7,8-Tetrachlorodibenzofuran	–	0.043	–	0.00159	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total heptachlorodibenzo-p-dioxin	–	–	–	0.18	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total heptachlorodibenzofuran	–	–	–	0.03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total hexachlorodibenzo-p-dioxin	–	–	–	0.029	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total hexachlorodibenzofuran	–	–	–	0.0297	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total octachlorodibenzo-p-dioxin	–	–	–	2.21	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total octachlorodibenzofuran	–	–	–	0.0238	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total pentachlorodibenzo-p-dioxin	–	–	–	0.0236	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total pentachlorodibenzofuran	–	–	–	0.0425	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total tetrachlorodibenzo-p-dioxin	–	–	–	0.0163	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total tetrachlorodibenzofuran	–	–	–	0.042	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Metals (MG/KG)																
Aluminum	22,370	7,800	50	NA	2,610 L	2,950 L	2,659 L	20,500 L	1,920 L	1,390 L	1,450 L	NA	NA	NA	NA	NA
Antimony	1.2	3.1	5	NA	1.2 B	0.55 B	0.7 B	53 L	0.84 B	0.61 B	0.52 B	NA	NA	NA	NA	NA
Arsenic	42.2	0.43	60	NA	6.7 J	10.2 J	6 J	13.2	14.4 J	12.8 J	12 J	NA	NA	NA	NA	NA
Barium	67	550	440	NA	29.2 J	24.5 J	31.6 J	428	19.3 K	16.6 K	16 K	NA	NA	NA	NA	NA
Beryllium	2.3	16	10	NA	0.32 B	0.36 B	0.58 J	0.43 B	0.34 B	0.52 B	0.39 B	NA	NA	NA	NA	NA
Cadmium	0.2	3.9	4	NA	0.85 J	0.69 J	0.64 J	2.6	0.36 B	0.082 U	0.13 B	NA	NA	NA	NA	NA
Calcium	16,100	–	–	NA	54,500	69,000	57,800	25,800	163,000	172,000	176,000	NA	NA	NA	NA	NA
Chromium	43	23	0.4	NA	14.3	16.1	24.3	97.7	15.1	15	14	NA	NA	NA	NA	NA
Cobalt	25	160	100	NA	2.5 J	2.8 J	4.5 J	19.7	2.5 K	3 K	2.6 K	NA	NA	NA	NA	NA
Copper	31	310	50	NA	22.7	18.8	33.5	2,740	3.5 J	0.95 L	1.1 J	NA	NA	NA	NA	NA
Cyanide	–	160	28	NA	0.04 J	0.05 J	0.11 J	0.26 J	0.06 J	0.08 J	0.07 J	NA	NA	NA	NA	NA
Iron	96,600	2,300	200	NA	14,500 L	15,500 L	18,000 L	97,000 L	17,600 L	18,200 L	20,300 L	NA	NA	NA	NA	NA
Lead	67	400	50	NA	64.5	66.3	95.4	2,720	15.7 K	7.3 K	7.8 K	82.2	65.5	2,280	11.4	65.9
Magnesium	6,590	–	–	NA	1,140	1,330	1,380	5,690	1,450	1,320	1,340	NA	NA	NA	NA	NA
Manganese	1,240	160	330	NA	155 K	171 K	233 K	1,350 K	199 K	201 K	202 K	NA	NA	NA	NA	NA
Mercury	0.1	2.3	0.1	NA	0.09 J	0.07 J	0.16	0.71	0.058 U	0.042 U	0.06 J	NA	NA	NA	NA	NA
Nickel	40	160	30	NA	10.2	9.4	8.5	749	4.9 K	5.5 K	5.1 K	NA	NA	NA	NA	NA
Potassium	3,690	–	–	NA	948 J	950 J	928 J	2,730	713 K	564 K	544 K	NA	NA	NA	NA	NA
Selenium	–	39	2	NA	0.792 U	0.802 U	0.762 U	1 J	0.861 UL	0.761 UL	0.763 UL	NA	NA	NA	NA	NA
Silver	0.52	39	2	NA	0.37 J	0.152 U	0.144 U	9.9	0.163 U	0.144 U	0.144 U	NA	NA	NA	NA	NA
Sodium	1,370	–	–	NA	573 J	773 J	937 J	5,780	1,450 K	1,720 K	1,720 K	NA	NA	NA	NA	NA
Thallium	ND	0.55	1	NA	0.749 UL	0.758 UL	0.72 UL	0.812 UL	0.815 UL	0.72 UL	0.721 UL	NA	NA	NA	NA	NA
Vanadium	87	55	2	NA	22.5	27.8	33.5	183	31.1	35.4	33.7	NA	NA	NA	NA	NA
Zinc	142	2,300	50	NA	92.8 J	143 J	354 J	3,500 J	22 K	19.9 K	19.4 K	NA	NA	NA	NA	NA

Table 3-2
Surface Soil Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID	Background	Soil Residential Adjusted RBC *	Ecological Screening Criteria	NBW14-DS48	NBW14-DS49		NBW14-DS51	NBW14-DS52	NBW14-DS53	NBW14-DS54		NBW14-SO09		NBW14-SO10	NBW14-SO11	NBW14-SO12
Sample ID				NBW14-DS48-00	NBW14-DS49-00	NBW14-DS49-P-00	NBW14-DS51-00	NBW14-DS52-00	NBW14-DS53-00	NBW14-DS54-00	NBW14-DS54-P-00	NBW14-SS09	NBW14-SS09-P	NBW14-SS10	NBW14-SS11	NBW14-SS12
Sample Date				08/20/01	08/21/01	08/21/01	08/21/01	08/21/01	08/21/01	08/21/01	08/21/01	12/17/02	12/17/02	12/17/02	12/17/02	12/17/02
Chemical Name																
Wet Chemistry (MG/KG)																
% Solids	--	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

NA - Not analyzed
-- Not Available
U - Not detected
B - Blank contamination
J - Estimated
L - Biased low
UJ - Undetected, estimated limit

UL - Undetected, limit biased low
UR - Undetected, unreliable result
K - Biased high
R - Unreliable Result
Shaded cells indicate exceedance of human health
Bolded text indicates exceedance of ecological sc
ND - Not detected

Table 3-3
Subsurface Soil Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk Virginia

Station ID	Background	Soil Residential Adjusted RBC *	NBW14-DS01	NBW14-DS02	NBW14-DS03	NBW14-DS04	NBW14-DS05		NBW14-DS06	NBW14-DS07	NBW14-DS08	NBW14-DS09	NBW14-DS10		NBW14-DS11	NBW14-DS12	NBW14-DS13	NBW14-DS14		NBW14-DS15	NBW14-DS16
Sample ID			NBW14-DS01-02	NBW14-DS02-02	NBW14-DS03-02	NBW14-DS04-02	NBW14-DS05-02	NBW14-DS05P-02	NBW14-DS06-02	NBW14-DS07-02	NBW14-DS08-02	NBW14-DS09-02	NBW14-DS10-02	NBW14-DS10P-02	NBW14-DS11-02	NBW14-DS12-02	NBW14-DS13-02	NBW14-DS14-02	NBW14-DS14P-02	NBW14-DS15-02	NBW14-DS16-02
Sample Date			09/30/99	09/30/99	09/30/99	09/30/99	09/30/99	09/30/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99
Chemical Name																					
Volatile Organic Compounds (UG/KG)																					
1,2,4-Trichlorobenzene	–	78,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichlorobenzene	–	700,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Butanone	–	4,700,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4-Methyl-2-pentanone	–	630,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acetone	–	780,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	–	12,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbon disulfide	–	780,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloromethane	–	49,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cumene	–	780,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyclohexane	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	–	780,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylcyclohexane	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	–	85,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	–	1,600,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Trichlorofluoromethane(Freon-11)	–	2,300,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Xylene, total	–	16,000,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Semivolatile Organic Compounds (UG/KG)																					
1,1-Biphenyl	–	390,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trichlorobenzene	–	78,000	1,200 U	1,900 U	730 U	1,500 U	740 U	1,800 U	720 U	360 UL	350 U	360 U	350 U	350 U	46 J	760 U	730 U	760 U	1,500 U	750 U	360 U
1,2-Dichlorobenzene	–	700,000	1,200 U	1,900 U	730 U	1,500 U	740 U	1,800 U	720 U	360 UL	350 U	360 U	350 U	350 U	370 U	120 J	730 U	760 U	1,500 U	750 U	360 U
2,4-Dimethylphenol	–	160,000	1,200 U	1,900 U	730 U	1,500 U	740 UR	1,800 UR	720 UR	360 UL	350 U	360 U	350 U	350 U	370 U	760 U	730 UR	760 U	1,500 U	750 U	360 U
2-Methylnaphthalene	–	160,000	200 J	2,700	300 J	170 J	150 J	320 J	720 U	49 L	350 U	360 U	350 U	350 U	96 J	290 J	730 U	4,600	5,100	750 U	120 J
2-Methylphenol	–	390,000	1,200 U	1,900 U	730 U	1,500 U	740 UR	1,800 UR	720 UR	360 UL	350 U	360 U	350 U	350 U	370 U	760 U	730 UR	760 U	1,500 U	750 U	360 U
4-Methylphenol	–	39,000	1,200 U	200 J	730 U	640 J	120 L	1,800 UR	720 UR	360 UL	110 J	360 U	350 U	350 U	370 U	760 U	730 UR	760 U	1,500 U	750 U	360 U
Acenaphthene	–	470,000	440 J	950 J	110 J	640 J	700 J	1,500 J	720 U	53 L	350 U	360 U	350 U	350 U	370 U	1,300	730 U	4,700	8,300	750 U	310 J
Acenaphthylene	–	–	1,200 U	1,900 U	730 U	1,500 U	81 J	1,800 U	970	69 L	350 U	38 J	350 U	350 U	51 J	720 J	730 U	160 J	280 J	750 U	360 U
Anthracene	491	2,300,000	1,200 U	1,900 U	160 J	900 J	580 J	1,400 J	1,100	55 L	51 J	360 U	350 U	350 U	63 J	1,600	730 U	1,500	3,100	750 U	54 J
Benzaldehyde	–	780,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	490	870	1,200 U	1,500 J	250 J	2,600	1,600	2,900	1,800	130 L	67 J	130 J	350 U	350 U	270 J	2,100	190 J	1,800	3,100	650 J	120 J
Benzo(a)pyrene	490	87	1,200 U	1,900 J	230 J	2,100	870	2,200	1,500	160 J	79 J	140 J	350 U	350 U	170 J	2,900	130 J	630	1,500	520 J	100 J
Benzo(b)fluoranthene	490	870	1,200 U	1,600 J	590 J	3,700	2,100	2,700	5,500	280 L	64 J	210 J	46 J	350 U	290 J	5,700	230 J	1,800	2,800	760	240 J
Benzo(g,h,i)perylene	490	230,000	1,200 U	650 J	180 J	620 J	340 J	1,100 J	1,100	42 L	40 J	110 J	46 J	350 U	130 J	1,500	110 J	320 J	490 J	220 J	74 J
Benzo(k)fluoranthene	490	8,700	1,200 U	2,400	290 J	2,800	1,800	2,400	4,000	170 L	76 J	190 J	43 J	350 U	220 J	2,400	230 J	990	1,800	650 J	180 J
Butylbenzylphthalate	–	1,600,000	190 J	1,900 U	730 U	1,300 J	740 U	1,800 U	180 J	360 UL	350 U	360 U	350 U	350 U	370 U	760 U	730 U	760 U	1,500 U	750 U	360 U
Carbazole	–	32,000	1,200 U	1,900 U	730 U	760 J	710 J	1,400 J	1,200	360 UL	350 U	360 U	350 U	350 U	370 U	750 J	730 UR	1,200	2,500	750 U	360 U
Chrysene	621	87,000	1,200 U	2,200	460 J	2,900	1,600	3,000	3,600	190 L	120 J	210 J	44 J	350 U	400	4,500	280 J	2,300	3,800	750	210 J
Di-n-butylphthalate	–	780,000	1,200 U	1,900 U	730 U	1,500 U	740 U	1,800 U	720 U	140 L	350 U	360 U	350 U	350 U	370 U	760 U	730 U	760 U	1,500 U	750 U	360 U
Di-n-octylphthalate	–	160,000	1,200 U	1,900 U	730 U	300 J	740 U	1,800 U	720 U	360 UL	350 U	360 U	350 U	350 U	370 U	760 U	730 U	760 U	220 J	750 U	360 U
Dibenz(a,h)anthracene	–	87	1,200 U	280 J	83 J	320 J	190 J	590 J	360 J	360 UL	350 U	42 J	350 U	350 U	40 J	750 J	730 U	120 J	200 J	79 J	360 U
Dibenzofuran	–	31,000	140 J	320 J	200 J	310 J	410 J	890 J	81 J	360 UL	350 U	360 U	350 U	350 U	370 U	750 J	730 U	2,400	5,300	750 U	98 J
Fluoranthene	950	310,000	290 J	5,200	610 J	6,300	4,700	8,000	5,200	300 L	320 J	230 J	78 J	350 U	540	7,400	550 J	14,000	20,000	1,400	320 J
Fluorene	401	310,000	300 J	1,600 J	84 J	580 J	690 J	1,400 J	720 U	360 UL	350 U	360 U	350 U	350 U	370 U	980	730 U	3,900	7,800	750 U	130 J
Indeno(1,2,3-cd)pyrene	401	870	1,200 U	890 J	220 J	890 J	500 J	1,800 J	1,500	71 L	41 J	110 J	39 J	350 U	140 J	2,400	110 J	420 J	700 J	270 J	86 J
Naphthalene	–	160,000	360 J	1,000 J	320 J	210 J	320 J	1,000 J	720 U	44 L	38 J	360 U	350 U	350 U	100 J	2,000	730 U	9,800	4,700	750 U	180 J
Phenanthrene	660	230,000	470 J	4,400	640 J	3,800	3,400	7,200	630 J	150 L	180 J	100 J	48 J	350 U	240 J	3,800	310 J	18,000	30,000	270 J	290 J
Phenol	–	2,300,000	1,200 U	1,900 U	730 U	2,800	220 L	310 L	720 UR	41 L	53 J	360 U	350 U	350 U	67 J	760 U	730 UR	760 U	1,500 U	750 U	360 U
Pyrene	830	230,000	150 J	3,300	390 J	4,600	3,100	5,100	3,000	250 L	230 J	170 J	66 J	350 U	530	5,900	380 J	5,800	9,300	850	220 J
bis(2-Ethylhexyl)phthalate	–	46,000	3,600	6,300	730 U	6,100	470 J	580 J	230 J	320 L	310 J	80 J	120 J	82 J	580	780	630 J	990	1,000 J	180 J	100 J
Pesticide/Polychlorinated Biphenyls (UG/KG)																					
4,4'-DDD	–	2,700	5.9 U	21 J	4 K	14 K	18 U	20 J	11 K	19 J	15 J	11	9.1	7.7 J	19 U	14 J	15 J	21 J	30 J	4.8 J	2.4 J
4,4'-DDE	4	1,900	3.7 J	22 J	8.6 K	13 K	65 K	42	11 K	29 U	6.7	6.2 J	12	15	19 U	19 U	14 J	19 J	17 J	26	3.6 U
4,4'-DDT	4	1,900	5.9 U	19 U	7.3 U	19 U	18 U	14 U	14 U	70 J	1.7 J	1.9 J	12	14 J	150 J	10 J	18 U	19 J	20 J	3.8 U	2.9 J
Aldrin	–	38	14 J	9.9 U	3.8 U	9.7 U	9.5 U	7.5 U	7.4 U	15 U	3.3 J	1.8	1.7 J	1.8 U	9.7 U	9.7 U	9.4 U	7.3 J	3.8 J	0.99 J	1.1 J
Aroclor-1016	–	550	59 U	190 U	73 U	190 U	180 U	140 U	140 U	290 U	35 U	36 U	35 U	35 U	190 U	190 U	180 U	76 U	77 U	38 U	36 U
Aroclor-1242	–	320	500	570	73 U	190 U	180 U	140 U	140 U	290 U	35 U	36 U	35 U	35 U	190 U	190 U	210	76 U	77 U	210	36 U
Aroclor-1248	–	320	59 U	190 U	73 U	190 U	180 U	140 U	670 J	290 U	150	36 U	35 U	35 U	190 U	190 U	180 U	76 U	77 U	38 U	36 U
Aroclor-1254	–	160	59 U	370	73 U	160 J	180 U	140 U	140 U	290 U	35 U	36 U	35 U	35 U	190 U	190 U	180 U	76 U	77 U	38 U	36 U
Aroclor-1260	–	320	59 U	230 J	73 U	190 U	180 U	210 J	840 K	1,600 J	200	36 U	35 U	60	4,100	2,500	810	530	530	160	36 U
Dieldrin	12.4	40	5.9 U	19 U	12 K	33 K	18 U	18 J	33 K	29 U	3.5 U	6.5	26	27	19	24 J	18 U	7.6 U	7.7 U	3.8 U	7.4 J
Endosulfan I	–	47,000	3 U	9.9 U	3.8 U	9.7 U	9.5 U	7.5 U	7.4 U	15 U	1.8 U	1.8 U	1.8 U	1.8 U	9.7 U	9.7 U	9.4 U	3.9 U	3.9 U	1.9 U	1.8 U
Endosulfan II	–	47,000	5.9 U	19 U	7.3 U	19 U	18 U	14 U	24 K	49 J	4.7 J	3.6 U	3.5 U	3.5 U	110 J	68	15 J	16	16	3.7 J	2.4 J
Endosulfan sulfate	–	47,000	5.9 U	19 U	7.3 U	19 U	18 U	14 U	7.7 K	29 U	3.5 U	3.6 U	3.5 U	3.5 U	19 U	14 J	18 U	8.9 J	7.7 U	2.1 J	3.6 U
Endrin	–	2,300	5.9 U	19 U	7.3 U	19 U	18 U	14 U	34 K	14 J	8.2 J	3.6 U	2 J	3 J	17 J	130 J	12 J	25 J	23 J	9.9	3.6 U
Endrin aldehyde	–	2,300	5.9 U	19 U	7.3 U	19 U	18 U	14 U	25 K	77	7.7	3.6 U	3.5 U	3.5 U	120 J	76 J	18 J	21 J	12 J	3 J	2.4 J
Endrin ketone	–	2,300	5.9 U	19 U	18 K	19 U	51 K	14 U	14 U	29 U	3.5 U	3.6 U	3.6 U	3.5 U	19 U	19 U	18 U	7.6 U	7.7 U	3.8 U	3.9 J
Heptachlor	–	140	3 U	9.9 U	3.8 U	9.7 U	9.5 U	7.5 U	7.4 U	15 U	1.8 U	1.8 U	1.8 U	1.8 U	9.7 U	9.7 U	9.4 U	3.9 U	3.9 U	1.9 U	1.8 U

Table 3-3
Subsurface Soil Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk Virginia

Station ID	Background	Soil Residential Adjusted RBC *	NBW14-DS01	NBW14-DS02	NBW14-DS03	NBW14-DS04	NBW14-DS05		NBW14-DS06	NBW14-DS07	NBW14-DS08	NBW14-DS09	NBW14-DS10		NBW14-DS11	NBW14-DS12	NBW14-DS13	NBW14-DS14		NBW14-DS15	NBW14-DS16
Sample ID			NBW14-DS01-02	NBW14-DS02-02	NBW14-DS03-02	NBW14-DS04-02	NBW14-DS05-02	NBW14-DS05P-02	NBW14-DS06-02	NBW14-DS07-02	NBW14-DS08-02	NBW14-DS09-02	NBW14-DS10-02	NBW14-DS10P-02	NBW14-DS11-02	NBW14-DS12-02	NBW14-DS13-02	NBW14-DS14-02	NBW14-DS14P-02	NBW14-DS15-02	NBW14-DS16-02
Sample Date			09/30/99	09/30/99	09/30/99	09/30/99	09/30/99	09/30/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99	10/01/99
Chemical Name																					
Heptachlor epoxide	--	70	3 U	9.9 U	3.8 U	9.7 U	9.5 U	7.5 U	7.4 U	15 U	1.8 U	1.8 U	1.8 U	1.8 U	9.7 U	9.7 U	9.4 U	3.9 U	3.9 U	1.9 U	1.8 U
Methoxychlor	--	39,000	30 U	99 U	73 K	97 U	160 K	40 J	74 U	150 U	18 U	18 U	18 U	18 U	97 U	97 U	94 U	39 U	20 J	19 U	16 J
alpha-BHC	--	100	3 U	9.9 U	3.8 U	9.7 U	9.5 U	7.5 U	7.4 U	15 U	1.8 U	1.8 U	1.8 U	1.8 U	9.7 U	9.7 U	9.4 U	3.9 U	3.9 U	1.9 U	1.8 U
alpha-Chlordane	--	1,800	2.3 J	8.3 J	3.8 U	9.7 U	9.5 U	7.5 U	13 K	15 U	2.6	1.3 J	1.8 U	1.7 J	6.7	52	9.4 U	31	44	3.7	3.2
beta-BHC	--	350	3 U	9.9 U	3.8 U	9.7 U	9.5 U	7.5 U	7.4 U	15 U	1.8 U	1.8 U	1.8 U	1.8 U	9.7 U	9.7 U	9.4 U	3.9 U	3.9 U	1.9 U	1.8 U
delta-BHC	--	--	3 U	9.9 U	3.8 U	9.7 U	9.5 U	7.5 U	7.4 U	15 U	1.8 U	1.8 U	1.8 U	1.8 U	9.7 U	9.7 U	9.4 U	3.9 U	3.9 U	1.9 U	1.8 U
gamma-BHC (Lindane)	--	490	3 U	9.9 U	3.8 U	9.7 U	9.5 U	7.5 U	7.4 U	15 U	1.8 U	1.8 U	1.8 U	1.8 U	9.7 U	9.7 U	9.4 U	3.9 U	3.9 U	1.9 U	1.8 U
gamma-Chlordane	--	1,800	3 U	9.9 U	3.8 U	9.7 U	9.5 U	7.5 U	11 K	15 U	0.95 J	2.6	1.2 J	1.9 J	9.7 U	14 J	9.4 U	36	52	1.7 J	4.1
Dioxin/Furans (UG/KG)																					
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	--	0.430	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,6,7,8-Heptachlorodibenzofuran	--	0.43	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8,9-Heptachlorodibenzofuran	--	0.43	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	--	0.043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-Hexachlorodibenzofuran	--	0.043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	--	0.043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-Hexachlorodibenzofuran	--	0.043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	--	0.043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-Hexachlorodibenzofuran	--	0.043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	--	0.0085	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8-Pentachlorodibenzofuran	--	0.085	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,4,6,7,8-Hexachlorodibenzofuran	--	0.043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,4,7,8-Pentachlorodibenzofuran	--	0.0085	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,7,8-TCDD (dioxin)	--	0.0043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,7,8-Tetrachlorodibenzofuran	--	0.043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total heptachlorodibenzo-p-dioxin	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total heptachlorodibenzofuran	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total hexachlorodibenzo-p-dioxin	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total hexachlorodibenzofuran	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total octachlorodibenzo-p-dioxin	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total octachlorodibenzofuran	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total pentachlorodibenzo-p-dioxin	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total pentachlorodibenzofuran	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total tetrachlorodibenzo-p-dioxin	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total tetrachlorodibenzofuran	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Metals (MG/KG)																					
Aluminum	22,370	7,800	16,800 L	7,080 L	4,420 L	21,800 L	52,100 L	7,880 L	46,800 L	4,430 L	9,330 L	5,100 L	2,140	3,880	50,900	7,730	12,700	4,660	6,960	7,320	4,270
Antimony	1.2	3.1	14.2 J	41.3	2.2 J	23.1 J	22.8	7.6 J	9.8 J	0.71 J	115	0.39 U	0.39 UJ	0.39 UJ	49.3 J	14.9 J	49.5 J	8.9 J	7.8 J	221 J	1.3 J
Arsenic	42.2	0.43	80.8	15 J	16.6	9.5 J	9.3	6.2	16.5	4.7	18.7	3.2	2.3	3.2	7.7	13.8	11.3	7.9	15.3	9.8	41.8
Barium	67	550	985	293 J	52.3	391 J	333	197	223	23.9 J	333	147	11.1 J	19.4 J	278	158	372	129	126	160	46.7
Beryllium	2.3	16	2.4	0.6 B	0.34 B	0.023 U	0.34 B	0.28 B	0.35 B	0.2 B	1.1	0.21 B	0.083 B	0.16 B	0.18 B	0.23 B	0.22 B	0.32 B	0.38 B	0.39 B	0.37 B
Cadmium	0.2	3.9	2.3 B	15.8	6.8	6.9	8.4	3.7	10.4	0.69 U	20.5	0.69 U	0.68 UJ	0.69 UJ	4.4 J	5.5 J	32.5 J	5.9 J	3.7 J	7.4 J	1.7 J
Calcium	16,100	--	14,100	64,300	14,900	22,300	30,400	34,600	48,700	10,300	25,300	1,290	641	2,950	19,600	18,600	18,700	19,000	22,800	32,300	50,600
Chromium	43	23	32.1 J	89.5 J	53	187 J	134	21.2	69	9.7	82.5	5.1	3.9 J	5.7 J	44.9 J	36.4 J	115 J	30.4 J	35.5 J	35 J	14 J
Cobalt	25	160	8.8 J	16.4 J	6.3 J	13.5 J	9.1 J	3.7 J	8.4 J	2.1 B	8.4 J	0.57 B	0.68 J	1.2 J	11 J	7.6 J	16.3	6.3 J	5.6 J	8 J	4.8 J
Copper	31	310	77.7	1,510	85.7	11,260	568	243	401	6.9	861	11.8	3.8 J	13	694	633	961	294	271	673	55
Cyanide	--	160	4.5 U	2.9 U	2.8 U	2.9 U	2.8 U	2.7 U	2.7 U	2.7 U	9.7	2.7 U	2.7 U	2.7 U	2.8 U	2.9 U	2.8 U	2.9 U	2.9 U	2.9 U	2.7 U
Iron	96,600	2,300	17,200 L	47,700 L	27,900 L	76,900 L	40,100 L	132,600 L	24,300 L	1,250 L	32,700 L	3,970 L	3,100	5,060	40,100	35,400	46,800	19,900	21,400	37,800	34,900
Lead	67	400	70.3	833 J	462	803 J	884	420	471	20.1	1,830	311	7.3 J	19 J	1,220 J	578 J	1,240 J	385 J	328 J	682 J	71.8 J
Magnesium	6,590	--	3,410	10,700	4,130	3,380	3,710	2,640	3,580	656 J	3,850	433 J	364 J	633 J	2,750 J	1,760 J	2,960 J	1,770 J	1,780 J	2,340 J	13,000 J
Manganese	1,240	160	158	592 J	105	671 J	710	958	789	69.7	1,140	24	16.6	31	680	445	681	329	298	492	186
Mercury	0.1	2.3	0.22 B	0.88	2.7	2.8	2.2	0.7	0.52	0.048 U	3.1	0.18 B	0.048 U	0.048 U	0.39	1	0.29	1.8	0.55	0.74	0.12
Nickel	40	160	32	166	18.7	163	171	20.5	71.2	2.9 J	77.6	3.1 J	1.4 UJ	5.4 J	155 J	126 J	166 J	56.5 J	74.9 J	68.4 J	10.3 J
Potassium	3,690	--	3,360	1,070 J	515 J	1,070 J	1,080 J	900 J	856 J	507 J	1,050 J	331 B	290 J	320 J	516 J	712 J	778 J	765 J	858 J	977 J	1,020 J
Selenium	--	39	2.8	0.61 J	0.88 J	0.65 J	0.58 J	0.53 U	0.53 U	0.52 U	0.51 U	0.52 U	0.51 U	0.52 U	0.55 U	1 B	1.4 B	0.55 U	0.82 B	0.55 U	0.52 U
Silver	0.52	39	2.5 J	4.5	1.1 J	54.7	6.7	1.1 J	1.6 J	0.48 UJ	37	0.48 UJ	0.47 U	0.47 U	7.5	36.2	9 J	3	2.1 J	5.2	0.48 U
Sodium	1,370	--	940 J	1,060 J	320 J	2,810	2,760	1,290	694 J	310 J	2,940	585 J	130 J	159 J	850 J	987 J	1,820	926 J	673 J	1,380 J	422 J
Thallium	ND	0.55	2.9 B	1.9 B	1.1 U	3 B	1.1 U	1.1 U	1.1 U	1.1 U	2.3 B	1.1 U	1.1 U	1.1 U	1.1 U	1.2 U	1.4	1.2 U	1.2 U	1.2 J	1.1 U
Vanadium	87	55	175	122 J	17.1	2,430 J	63.4	35.5	55.8	16.4	188	9.1 J	4.6 J	8.5 J	14.9	40.2	49.8	119	90.6	47.5	22.1
Zinc	142	2,300	85.2	2,420	259	1,800	2,930	452	1,110	24.4	3,850	56	11	35	1,350	1,110	2,100	682	596	944	137

Notes:
NA - Not analyzed
-- Not Available
U - Not detected
B - Blank contamination
J - Estimated
ND - Not detected
L - Biased low
K - Biased high
R - Unreliable Result
Shaded cells indicate exceedance of human health screening criteria
Bolded text indicates exceedance of ecological screening criteria

Table 3-3
Subsurface Soil Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk Virginia

Station ID	Background	Soil Residential Adjusted RBC	NBW14-DS17	NBW14-DS18	NBW14-DS19	NBW14-DS20	NBW14-DS21	NBW14-DS24	NBW14-DS26	NBW14-DS27	NBW14-DS28	NBW14-DS29	NBW14-DS30	NBW14-DS31	NBW14-DS32	NBW14-DS33	NBW14-DS34	NBW14-DS35	NBW14-DS36	NBW14-DS37	NBW14-DS38
Sample ID			NBW14-DS17-02	NBW14-DS18-02	NBW14-DS19-06	NBW14-DS20-03	NBW14-DS21-05	NBW14-DS24-05	NBW14-DS26-06	NBW14-DS27-04	NBW14-DS28-03	NBW14-DS29-08	NBW14-DS30-03	NBW14-DS31-04	NBW14-DS32-04	NBW14-DS33-03	NBW14-DS34-05	NBW14-DS35-05	NBW14-DS36-04	NBW14-DS37-06	NBW14-DS38-03
Sample Date			10/01/99	10/01/99	09/18/00	09/19/00	09/12/00	09/11/00	09/11/00	09/12/00	09/12/00	09/12/00	09/12/00	09/20/00	09/12/00	09/12/00	09/12/00	09/12/00	09/20/00	09/12/00	09/19/00
Chemical Name																					
Volatile Organic Compounds (UG/KG)																					
1,2,4-Trichlorobenzene	–	78,000	NA	NA	11 UJ	12 U	11 U	12 U	11 U	29 U	12 U	11 U	12 U	12 U	12 U	12 U	12 U	11 U	1.46 J	12 UR	12 U
1,2-Dichlorobenzene	–	700,000	NA	NA	11 UJ	12 U	11 U	12 U	11 U	7.84 J	12 U	11 U	12 U	12 U	12 U	2.02 J	12 U	11 U	13 UR	12 UR	12 U
2-Butanone	–	4,700,000	NA	NA	11 UJ	4.58 J	61.3	21.0 J	14.5 J	59.0	4.45 B	4.72 B	12 U	12 U	21.9 B	10.8 B	32.7 J	11 U	5.41 J	69.7 J	7.02 J
4-Methyl-2-pentanone	–	630,000	NA	NA	11 UJ	12 U	12.7	12 U	11 U	29 U	12 UJ	11 U	12 U	12 U	12 U	12 U	12 U	11 U	13 UR	12 UR	12 U
Acetone	–	780,000	NA	NA	31.4 J	40.5 J	210 J	134 J	89.1 J	292 J	5.31 B	16.1 B	5.11 B	26.0 J	56.5 J	44.2 B	238 J	3.84 B	39.4 B	236 J	39.6 J
Benzene	–	12,000	NA	NA	11 UJ	12 U	1.51 J	12 U	11 U	29 U	12 U	11 U	12 U	12 U	12 U	12 U	12 U	11 U	1.35 J	43.0	12 U
Carbon disulfide	–	780,000	NA	NA	1.57 J	12 U	8.76 J	2.96 J	1.46 J	6.3 J	12 U	1.89 J	1.26 J	12 U	12 U	12 U	2.15 J	11 U	2.84 J	12.6 J	12 U
Chloromethane	–	49,000	NA	NA	11 UJ	12 U	11 U	12 U	11 U	29 U	12 U	11 U	12 U	12 U	12 U	12 U	12 U	11 U	13 U	12 UJ	12 U
Cumene	–	780,000	NA	NA	12.9 J	12 U	11 U	12 U	14.0	29 U	12 U	11 U	12 U	12 U	12 U	12 U	12 U	11 U	13 UR	12 UR	12 U
Cyclohexane	–	–	NA	NA	11 UJ	12 U	11 U	1.51 J	11 U	29 U	12 U	11 U	12 U	12 U	12 U	12 U	12 U	11 U	13 U	24.2	12 U
Ethylbenzene	–	780,000	NA	NA	3.39 J	12 U	11 U	12 U	3.57 J	29 U	12 UJ	11 U	12 U	12 U	12 U	12 U	12 U	11 U	13 UR	6.05 J	12 U
Methylcyclohexane	–	–	NA	NA	14.1	12 U	11 U	12 U	7.41 J	2.92 J	12 U	11 U	12 U	12 U	12 U	12 U	12 U	11 U	13 U	37.2	12 U
Methylene chloride	–	85,000	NA	NA	2.3 B	3.25 B	17.9	1.87 B	2.01 B	16.1 B	4.39 B	1.6 B	2.19 B	2.03 B	5.83 B	3.27 B	8.68 B	2.15 B	17.8 J	28.2 J	12 U
Toluene	–	1,600,000	NA	NA	6.68 J	1.43 J	3.19 J	12 U	19.5	38.3	11.2 J	2.44 J	1.42 J	12 U	3.78 J	3.79 J	8.31 J	11 U	3.29 J	124 J	12 U
Trichlorofluoromethane(Freon-11)	–	2,300,000	NA	NA	11 UJ	12 U	11 U	12 U	11 U	29 U	12 U	11 U	12 U	12 U	12 U	12 U	12 U	11 U	13 U	4.38 UJ	12 U
Xylene, total	–	16,000,000	NA	NA	41.6 J	3.1 J	11 U	12 U	63.3	29 U	12 UJ	11 U	12 U	12 U	12 U	12 U	12 U	11 U	4.65 J	61.4 UJ	12 U
Semivolatile Organic Compounds (UG/KG)																					
1,1-Biphenyl	–	390,000	NA	NA	60.7 J	390 U	370 U	800 U	55.5 J	380 U	420 U	56,000 U	390 U	410 U	390 U	410 U	400 U	360 U	420 U	135 J	410 U
1,2,4-Trichlorobenzene	–	78,000	370 U	380 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichlorobenzene	–	700,000	370 U	380 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dimethylphenol	–	160,000	370 U	380 U	360 U	390 U	370 U	800 U	380 U	380 U	420 U	56,000 U	390 U	410 U	390 U	410 U	400 U	360 U	63.7 J	160 J	410 U
2-Methylnaphthalene	–	160,000	370 U	380 U	601	390 U	206 J	124 J	NA	NA	420 U	18,410 J	390 U	410 U	NA	79.9 J	NA	NA	420 U	NA	410 U
2-Methylphenol	–	390,000	370 U	380 U	360 U	390 U	370 U	800 U	380 U	380 U	420 U	56,000 U	390 U	410 U	390 U	410 U	400 U	360 U	420 U	44.2 J	410 U
4-Methylphenol	–	39,000	370 U	170 J	360 U	390 U	370 U	800 U	380 U	175 J	420 U	56,000 U	390 U	410 U	390 U	410 U	400 U	360 U	420 U	516	410 U
Acenaphthene	–	470,000	370 U	380 U	64.3 J	390 U	329 J	436 J	116 J	101 J	420 U	41,040 J	147 J	410 U	390 U	45.3 J	400 U	360 U	420 U	109 J	410 U
Acenaphthylene	–	–	370 U	380 U	360 U	390 U	370 U	97.8 J	56.7 J	63.9 J	420 U	56,000 U	44.2 J	410 U	390 U	410 U	400 U	360 U	420 U	129 J	60.4 J
Anthracene	491	2,300,000	61 J	380 U	360 U	390 U	230 J	622 J	109 J	380 U	420 U	92,830	87.3 J	410 U	390 U	410 U	95.7 J	360 U	420 U	89.4 J	410 U
Benzaldehyde	–	780,000	NA	NA	360 U	390 U	370 U	800 U	380 U	142 J	420 U	56,000 U	390 U	410 U	390 U	142 J	400 U	360 U	420 U	410 U	410 U
Benzo(a)anthracene	490	870	240 J	380 U	43.3 J	62.5 J	250 J	1,609	310 J	380 U	60.3 J	137,500	181 J	298 J	390 U	48.0 J	299 J	360 U	54.7 J	268 J	131 J
Benzo(a)pyrene	490	87	190 J	47 J	360 U	80.0 J	201 J	1,670	517	380 U	82.7 J	114,900	223 J	209 J	390 U	410 U	245 J	360 U	51.5 J	238 J	109 J
Benzo(b)fluoranthene	490	870	360 J	380 U	360 U	123 J	230 J	1,931	1,346 J	55.4 J	96.8 J	138,400	508 J	220 J	390 U	50.7 J	262 J	360 U	69.4 J	426 J	328 J
Benzo(g,h,i)perylene	490	230,000	110 J	380 U	360 U	70.3 J	84.8 J	909	144 J	380 U	86.3 J	63,020	159 J	49.9 J	390 U	410 U	116 J	360 U	420 U	245 J	175 J
Benzo(k)fluoranthene	490	8,700	300 J	380 U	360 U	133 J	239 J	1,952	1,221 J	50.5 J	101 J	62,230	528 J	189 J	390 U	43.2 J	225 J	360 U	50.9 J	488 J	361 J
Butylbenzylphthalate	–	1,600,000	370 U	380 U	360 U	390 U	111 J	800 U	380 U	47.7 J	420 U	56,000 U	65.2 J	410 U	390 U	47.0 J	400 U	360 U	420 U	66 J	410 U
Carbazole	–	32,000	370 U	380 U	360 UJ	390 UJ	123 J	391 J	80.5 J	380 U	420 U	49,280 J	42.1 J	410 UJ	390 U	410 U	41.4 J	360 U	420 UJ	410 U	410 UJ
Chrysene	621	87,000	320 J	380 U	57.3 J	88.9 J	360 J	2,068	577	51.3 J	96.1 J	138,800	309 J	444	390 U	110 J	276 J	360 U	88.8 J	402 J	253 J
Di-n-butylphthalate	–	780,000	370 U	380 U	360 U	390 U	370 U	800 U	380 U	380 U	420 U	56,000 U	390 U	410 U	390 U	410 U	400 U	360 U	420 U	410 U	410 U
Di-n-octylphthalate	–	160,000	370 U	380 U	360 U	390 U	370 U	800 U	380 U	380 U	420 U	56,000 U	390 U	410 U	390 U	410 U	400 U	360 U	420 U	410 U	410 U
Dibenz(a,h)anthracene	–	87	370 U	380 U	360 U	390 U	43.3 J	468 J	74.7 J	380 U	420 U	17,220 J	76.6 J	410 U	390 U	410 U	71.1 J	360 U	420 U	41.8 J	410 U
Dibenzofuran	–	31,000	370 U	380 U	64.2 J	390 U	142 J	166 J	52.4 J	380 U	420 U	34,110 J	390 U	410 U	390 U	410 U	400 U	360 U	420 U	333 J	410 U
Fluoranthene	950	310,000	609	79 J	101 J	148 J	1,093	4,908	831	184 J	157 J	307,900	502 J	2,117	390 U	164 J	531	360 U	117 J	629	162 J
Fluorene	401	310,000	370 U	380 U	98.3 J	390 U	249 J	270 J	73.1 J	57.0 J	420 U	55,800 J	58.7 J	410 U	390 U	410 U	49.8 J	360 U	420 U	136 J	410 U
Indeno(1,2,3-cd)pyrene	401	870	130 J	380 U	360 U	46.6 J	87.0 J	1,815	221 J	380 U	65.6 J	52,630	163 J	410 U	390 U	410 U	138 J	360 U	420 U	108 J	123 J
Naphthalene	–	160,000	370 U	380 U	252 J	390 U	488	283 J	189 J	141 J	420 U	51,750 J	390 U	410 U	390 U	77.2 J	400 U	360 U	420 U	1,246	410 U
Phenanthrene	660	230,000	210 J	78 J	268 J	131 J	1,019	2,815	350 J	270 J	104 J	350,900	120 J	99.0 J	43.6 J	133 J	410	360 U	92.4 J	1,393	80.8 J
Phenol	–	2,300,000	370 U	110 J	360 U	390 U	370 U	84.1 J	380 U	384	420 U	56,000 U	390 U	410 U	390 U	410 U	400 U	360 U	420 U	285 J	410 U
Pyrene	830	230,000	370	67 J	106 J	199 J	779 J	4,689 J	832 J	202 J	131 J	265,900	340 J	1,768	390 U	102 J	596 J	360 U	136 J	561	248 J
bis(2-Ethylhexyl)phthalate	–	46,000	140 J	480	360 U	390 U	465 B	393 J	253 J	515	56.8 B	56,000 U	137 B	55.7 J	207 J	1,651 B	52.5 J	360 U	506	434	410 U
Pesticide/Polychlorinated Biphenyls (UG/KG)																					
4,4'-DDD	–	2,700	10	10 J	3 J	9.5	8.3 J	7	12	3.8 U	1.9 J	17	2.7 J	20	4.9	16 J	2.4 J	3.6 U	8.5	34	5.5 J
4,4'-DDE	4	1,900	6.9	21	8	7.7	12	14 J	11 J	17 J	2 J	12 J	2.5 J	17	5.9	9.6 J	1.5 J	3.6 U	2.4 J	13 J	7.7 J
4,4'-DDT	4	1,900	2.5 J	3.8 U	4.9 J	3.9 U	3.7 U	4 U	3.8 U	2 J	4.2 U	7.4 U	3.9 U	4.7	3.9 U	4.1 UL	4 U	3.6 U	4.2 U	4.1 U	6.8 J
Aldrin	–	38	1.9 U	3.8 J	1.9 U	2 U	1.9 U	2 U	2 U	2 U	2.2 U	3.6 J	2 U	2.1 U	2 U	2.1 UL	2 U	1.8 U	2.2 U	2.1 U	1.1 J
Aroclor-1016	–	550	37 U	38 U	150	39 U	37 U	40 U	38 U	38 U	42 U	74 U	39 U	41 U	39 U	41 UL	40 U	36 U	42 U	41 U	41 U
Aroclor-1242	–	320	37 U	38 U	36 U	39 U	37 U	40 U	38 U	38 U	42 U	74 U	39 U	41 U	39 U	500	40 U	36 U	42 U	41 U	41 U
Aroclor-1248	–	320	37 U	270	36 U	39 U	37 U	390 U	38 U	38 U	42 U	74 U	39 U	41 U	39 U	41 UL	40 U	36 U	42 U	250 J	41 U
Aroclor-1254	–	160	37 U	38 U	130	39 U	37 U	110 U	38 U	320	42 U	74 U	39 U	41 U	39 U	41 UL	40 U	36 U	42 U	180	41 U
Aroclor-1260	–	320	37 U	38 U	36 U	39 U	170	40 U	38 U	38 U	42 U	74 U	100 J	41 U	39 U	77 J	40 U	36 U	42 U	41 U	41 U
Dieldrin	12.4	40	3.7 U	33	3.6 U	2.3 J	4 J	3.5 U	3.8 J	4.9 J	4.2 U	16 J	2.3 J	4.1 U	3.9 U	3.4 J	4 U	3.6 U	4.2 U	4.1 J	4.1 U
Endosulfan I	–	47,000	1.9 U	2 U	1.9 U	2 U	1.9 U	2 U	2 U	2	2.2 U	2.1 J	2 U	2.1 U	0.39 J	0.73 J	2 U	1.8 U	2.2 U	2.1	2.1 U
Endosulfan II	–	47,000	3.7 U	3.8 U	3.6 U	3.9 U	3.7 U	2 U	3.8 U	3.8	4.2 U	7.4 U	3.9 U	4.1 U	3.9 U	4.1 UL	4 U	3.6 U	4.2 U	4.1 U	4.1 U
Endosulfan sulfate	–	47,000	3.7 U	3.8 U	5.6 J	3.9 U	3.7 U	2.8 J	2.2 J	3.7 J	4.2 U	2.8 J	3.9 U	1.9 J	3.9	4.1 UL	4 U	3.6 U	4.2 U	4 J	4.1 U
Endrin	–	2,300	3.7 U	3.8 J	3.6 U	3.9 U	4.1 J	4 U	2.8 J	3.8 U	4.2 U	7.4 U	3.3 J	4.1 U	3.9 U	5.8 J	4 U	3.6 U	4.2 U	4.1 U	4.1 U
Endrin aldehyde	–	2,300	2 J	3.8 U	2.5 J	3.9 U	3.7 U	4 U	1.2 J	6.1 J	4.2 U	5.8 J	3.9 U	1.7 J	3.9 U	1.1 J	0.7 J	3.6 U	4.2 U	1.9 J	1.2 J
Endrin ketone	–	2,300	3.7 U	3.8 U	3.6 U	3.9 U	3.7 U	4 U	3.8 U	3.8	4.2 U	744	3.9 U	4.1 U	3.9 U	4.1 UL	4 U	3.6 U	4.2 U	4.1 U	4.1 U
Heptachlor	–	140	1.9 U	2 U	1.9 U	2 U	2 J	2 U	2 U	2	2.2 U	10 J	2 U	2.1 U	2 U	2.1 UL	2 U	1.8 U	2.2 U	0.97 J	2.1 U

Table 3-3
Subsurface Soil Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk Virginia

Station ID	Background	Soil Residential Adjusted RBC *	NBW14-DS17	NBW14-DS18	NBW14-DS19	NBW14-DS20	NBW14-DS21	NBW14-DS24	NBW14-DS26	NBW14-DS27	NBW14-DS28	NBW14-DS29	NBW14-DS30	NBW14-DS31	NBW14-DS32	NBW14-DS33	NBW14-DS34	NBW14-DS35	NBW14-DS36	NBW14-DS37	NBW14-DS38
Sample ID			NBW14-DS17-02	NBW14-DS18-02	NBW14-DS19-06	NBW14-DS20-03	NBW14-DS21-05	NBW14-DS24-05	NBW14-DS26-06	NBW14-DS27-04	NBW14-DS28-03	NBW14-DS29-08	NBW14-DS30-03	NBW14-DS31-04	NBW14-DS32-04	NBW14-DS33-03	NBW14-DS34-05	NBW14-DS35-05	NBW14-DS36-04	NBW14-DS37-06	NBW14-DS38-03
Sample Date			10/01/99	10/01/99	09/18/00	09/19/00	09/12/00	09/11/00	09/11/00	09/12/00	09/12/00	09/12/00	09/12/00	09/20/00	09/12/00	09/12/00	09/12/00	09/12/00	09/20/00	09/12/00	09/19/00
Chemical Name																					
Heptachlor epoxide	–	70	1.9 U	2 U	1.9 U	2 U	1.9 U	2 U	2 U	2 U	2.2 U	3.6 J	2 U	2.1 U	2 U	0.93 J	2 U	1.8 U	2.2 U	2.1 U	2.1 U
Methoxychlor	–	39,000	19 U	20 U	19 U	20 U	19 U	20 U	20 U	20 U	22 U	180	20 U	21 U	20 U	21 UL	20 U	18 U	22 U	21 U	21 U
alpha-BHC	–	100	1.9 U	2 U	1.9 U	2 U	0.93 J	2 U	2 J	2 J	2.2 U	3.8 U	2 U	2.1 U	2 U	0.74 J	2 U	1.8 U	2.2 U	2.1 U	2.1 U
alpha-Chlordane	–	1,800	0.99 J	3.3	1.9 U	0.92 J	3.4 J	4 U	2 U	2 U	2.2 U	3.8 U	0.74 J	2 J	22 J	2.1 UL	2 U	1.8 U	2.2 U	2.1 U	2.9 J
beta-BHC	–	350	1.9 U	2 U	1.9 U	2 U	1.9 U	2 U	2	8.3 J	2.2 U	3.8 U	2.5	2.1 U	1.7 J	5.9 J	2 U	1.8 J	1.3 J	4.3 J	2.1 U
delta-BHC	–	–	1.9 U	2 U	1.9 U	2 U	1.9 U	2 U	2 U	2	2.2 U	3.8 U	2 U	2.1 U	2 U	2.1 UL	2 U	1.8 U	2.2 U	2.1 U	2.1 U
gamma-BHC (Lindane)	–	490	1.9 U	2 U	1.9 U	2 U	1.9 U	2 U	2 J	2 J	2.2 U	3.8 U	2 U	2.1 U	0.65 J	2.1 UL	2 U	1.8 U	0.82 J	2.1 U	2.1 U
gamma-Chlordane	–	1,800	0.97 J	2 U	1.9 U	1.5 J	10	1.7 J	4.9	2 U	2.2 U	180 D	3.1 J	3.9 J	21	1.8 J	2 U	1.8 U	0.78 J	2.1 U	2.1 U
Dioxin/Furans (UG/KG)																					
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	–	0.430	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,6,7,8-Heptachlorodibenzofuran	–	0.43	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8,9-Heptachlorodibenzofuran	–	0.43	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	–	0.043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-Hexachlorodibenzofuran	–	0.043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	–	0.043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-Hexachlorodibenzofuran	–	0.043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	–	0.043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-Hexachlorodibenzofuran	–	0.043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	–	0.0085	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8-Pentachlorodibenzofuran	–	0.085	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,4,6,7,8-Hexachlorodibenzofuran	–	0.043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,4,7,8-Pentachlorodibenzofuran	–	0.0085	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,7,8-TCDD (dioxin)	–	0.0043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,7,8-Tetrachlorodibenzofuran	–	0.043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total heptachlorodibenzo-p-dioxin	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total heptachlorodibenzofuran	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total hexachlorodibenzo-p-dioxin	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total hexachlorodibenzofuran	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total octachlorodibenzo-p-dioxin	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total octachlorodibenzofuran	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total pentachlorodibenzo-p-dioxin	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total pentachlorodibenzofuran	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total tetrachlorodibenzo-p-dioxin	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total tetrachlorodibenzofuran	–	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Metals (MG/KG)																					
Aluminum	22,370	7,800	4,610	13,800	6,670 L	3,860 L	32,500 L	15,700	5,380	18,700	1,300 L	5,170 L	21,900 L	4,580 L	17,000	18,900 L	4,480	1,800	5,180 L	29,400	2,600 L
Antimony	1.2	3.1	7 J	76.1 J	60.6 L	0.52 L	14.6 L	53.5 L	4.3 L	153 L	0.88 B	2.6 B	44.7 L	0.46 UL	49.3 L	55.4 L	0.88 B	0.78 B	0.83 L	40.5 L	0.54 L
Arsenic	42.2	0.43	29.1	9.9	10.9	3.7	8 K	12.5 K	9 K	12 K	5.4 K	5.1 K	8.9 K	6.9	12.1 K	17 K	6 K	14.2 K	3.5	10 K	32.2
Barium	67	550	45.9	410	192	26.6 J	155	409	78.1	461	19.2 J	75.9	389	49.6	457	582	60.1	11.9 J	52	330	36.9 J
Beryllium	2.3	16	0.72 B	0.2 B	0.42 B	0.25 B	0.17 L	0.26 L	0.31 L	0.4 L	0.15 L	1.8	0.33 L	0.31 B	0.36 L	0.25 L	0.29 L	0.62 L	0.24 B	0.41 L	0.36 B
Cadmium	0.2	3.9	3.9 J	39.1 J	17.6	0.2 B	3.3	22	5.4	22.4	0.3 B	1.6	17.2	1.2 J	16.4	11.7	0.87 J	0.25 B	1.2	11.2	0.6 J
Calcium	16,100	–	104,000	19,200	21,200 J	14,300 J	30,900	25,500 J	35,000 J	24,600 J	54,300	33,900	21,000	41,500 J	39,900 J	33,700	2,980 J	110,000 J	5,260 J	53,700 J	96,600 J
Chromium	43	23	330 J	79.5 J	75.7	7.7	37.7	68.3	23.8	126	9.7	32.7	39.6	20.3	83.9	125	11.5	18.7	10	75.3	13
Cobalt	25	160	8.6 J	14.6	13.3	1.8 J	4.1 J	9.2 J	4.6 J	14.4	1.7 J	11.1	8.7 J	2.1 J	9.5 J	14	3.2 J	3.4 J	1.8 J	7.6 J	3.4 J
Copper	31	310	90.2	3,933	793 J	10.7 J	614 J	976	174	2,750	8.9	232	1,720	31.2 J	1,480	1,520	25.2	1.8 B	29.6 J	1,960	33.9 J
Cyanide	–	160	2.8 U	2.9 U	0.12 L	0.046 UL	0.18 L	0.34 L	0.15 L	0.58 L	0.048 UL	0.06 L	0.26 L	0.048 UL	0.57 L	0.51 L	0.047 UL	0.078 L	0.094 L	0.31 L	0.049 UL
Iron	96,600	2,300	41,100	46,100	292,100	7,600	23,500	79,800	225,100	26,000	9,190	16,200	54,700	10,300	108,000	144,000 J	13,000	18,800	8,860	57,000	12,800
Lead	67	400	105 J	2,350 J	604 K	49.2	445 K	1,330	261	4,860	23.4 K	277 K	2,270 K	68.9	2,260	1,560 K	61.3	5.1	79.9	1,810	77.6
Magnesium	6,590	–	2,420 J	5,020 J	2,390	792 J	11,700	3,270 J	2,790 J	5,910 J	978 J	1,440	1,980	1,190 J	2,780 J	2,900	1,530 J	957 J	1,220	3,220 J	4,970
Manganese	1,240	160	433	823 J	808 L	73.8 L	1,090	1,010	278	1,420	123	206	594	109 L	1,220	1,040	88.2	183	82.3 L	761	159 L
Mercury	0.1	2.3	0.2	0.72	0.59	0.15	0.58	0.7 L	0.21 L	0.54 L	0.086 J	0.09	0.4	0.12 B	1.4 L	1	0.11 L	0.047 UL	0.063 B	0.58 L	0.068 B
Nickel	40	160	33.4 J	247 J	107	4.5 J	41.3	103	25.1	314	4.3 J	143	81.8	11.6	164	216	9.7	5.3 J	7.1 J	156	10.8
Potassium	3,690	–	728 J	1,090 J	763 J	435 J	732 J	1,220 J	908 J	1,620 J	281 J	552 J	1,170	539 J	948 J	1,190 J	734 J	538 J	508 J	1,140 J	668 J
Selenium	–	39	0.71 B	1 B	4.1	1.2 U	1.1 U	1.3 L	1.1 UL	1.5 L	1.2 U	1.1 U	1.8 K	1.2 U	3.7 L	2.9 K	1.1 UL	1.2 L	1.2 U	1.5 L	1.2 U
Silver	0.52	39	0.63 J	10.8	13.8	0.14 U	7.6 L	20.9 L	1.6 UL	17.6 L	0.14 UL	0.49 L	14.7 L	0.33 J	15.4 L	24.6 L	0.22 L	0.12 UL	3.5	12.7 L	0.19 J
Sodium	1,370	–	910 J	2,800 J	1,650	383 B	1,390	3,040	1,150	4,240	601 J	1,000 J	2,420	621 B	3,100	2,600	394 J	1,220	506 B	2,930	1,120 J
Thallium	ND	0.55	1.5 J	1.7 J	42.6	3.8 L	9.8	32.4 K	2.1 K	40.4 K	3.7	8.8	23.4	3.2 L	36.6 K	45.4	6.9 K	5 K	3.7 L	19.8 K	1.9 L
Vanadium	87	55	71.4	84.3	149	22.1	56.1	173	44.4	191 J	18.7	330	38.3	24.2	[illegible]	161	16.2	45.5	14.2	108	32.3
Zinc	142	2,300	499	3,710 K	1,600 J	39.6 J	1,130	1,600 K	395 K	8,020 K	38.6	1,330	2,210	112 J	3,250 K	2,620 K	247 K	20.3 K	104 J	1,760 K	100 J

Notes:

NA - Not analyzed
J - Estimated
ND - Not detecte
— Not Available
L - Biased low
U - Not detected
K - Biased high
B - Blank contamination
R - Unreliable Result
Shaded cells indicate exceedance of human health screening criteria
Bolded text indicates exceedance of ecological screening criteria

Table 3-3
Subsurface Soil Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk Virginia

Station ID	Background	Soil Residential Adjusted RBC *	NBW14-DS40	NBW14-DS41	NBW14-DS42	NBW14-DS43	NBW14-DS44	NBW14-DS45	NBW14-DS46	NBW14-DS47	NBW14-DS48	NBW14-DS49	NBW14-DS51	NBW14-DS53	NBW14-DS54
Sample ID			NBW14-DS40-07	NBW14-DS41-05	NBW14-DS42-06	NBW14-DS43-07	NDW14-DS44-06	NDW14-DS45-05	NBW14-DS46-06	NBW14-DS47-04	NBW14-DS48-06	NBW14-DS49-06	NBW14-DS51-07	NBW14-DS53-07	NBW14-DS54-05
Sample Date			08/21/01	08/21/01	08/21/01	08/21/01	08/20/01	08/20/01	08/20/01	08/20/01	08/20/01	08/21/01	08/21/01	08/21/01	08/21/01
Chemical Name															
Volatile Organic Compounds (UG/KG)															
1,2,4-Trichlorobenzene	–	78,000	11 UL	11 U	11 U	11 U	NA	NA	NA	NA	NA	11 U	11 U	12 U	11 U
1,2-Dichlorobenzene	–	700,000	11 UL	11 U	11 U	11 U	NA	NA	NA	NA	NA	11 U	11 U	12 U	11 U
2-Butanone	–	4,700,000	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA	11 U	11 U	12 U	11 U
4-Methyl-2-pentanone	–	630,000	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA	11 U	11 U	12 U	11 U
Acetone	–	780,000	6 B	3 B	4 B	3 B	NA	NA	NA	NA	NA	4 B	3 B	4 B	3 B
Benzene	–	12,000	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA	11 U	11 U	12 U	11 U
Carbon disulfide	–	780,000	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA	11 U	11 U	12 U	11 U
Chloromethane	–	49,000	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA	11 U	11 U	12 U	1 J
Cumene	–	780,000	11 UL	11 U	11 U	11 U	NA	NA	NA	NA	NA	11 U	11 U	12 U	11 U
Cyclohexane	–	–	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA	11 U	11 U	12 U	11 U
Ethylbenzene	–	780,000	11 UL	11 U	11 U	11 U	NA	NA	NA	NA	NA	11 U	11 U	12 U	11 U
Methylcyclohexane	–	–	11 U	11 U	11 U	11 U	NA	NA	NA	NA	NA	11 U	11 U	12 U	11 U
Methylene chloride	–	85,000	5 B	2 B	2 B	1 B	NA	NA	NA	NA	NA	1 B	1 B	2 B	2 B
Toluene	–	1,600,000	2 B	11 U	11 U	11 U	NA	NA	NA	NA	NA	11 U	11 U	12 U	11 U
Trichlorofluoromethane(Freon-11)	–	2,300,000	1 K	11 U	11 U	11 U	NA	NA	NA	NA	NA	11 U	11 U	12 U	11 U
Xylene, total	–	16,000,000	11 UL	11 U	11 U	11 U	NA	NA	NA	NA	NA	11 U	11 U	12 U	11 U
Semivolatile Organic Compounds (UG/KG)															
1,1-Biphenyl	–	390,000	710 U	370 U	360 U	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
1,2,4-Trichlorobenzene	–	78,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichlorobenzene	–	700,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dimethylphenol	–	160,000	710 U	370 U	360 U	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
2-Methylnaphthalene	–	160,000	710 U	370 U	360 U	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
2-Methylphenol	–	390,000	710 U	370 U	360 U	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
4-Methylphenol	–	39,000	710 U	370 U	360 U	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Acenaphthene	–	470,000	710 U	370 U	360 U	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Acenaphthylene	–	–	710 U	370 U	360 U	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Anthracene	491	2,300,000	710 U	370 U	360 U	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Benzaldehyde	–	780,000	710 U	370 U	360 U	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Benzo(a)anthracene	490	870	710 U	370 U	120 J	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Benzo(a)pyrene	490	87	710 U	370 U	120 J	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Benzo(b)fluoranthene	490	870	710 U	370 U	110 J	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Benzo(g,h,i)perylene	490	230,000	710 U	370 U	80 J	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Benzo(k)fluoranthene	490	8,700	710 U	370 U	130 J	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Butylbenzylphthalate	–	1,600,000	710 U	370 U	360 U	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Carbazole	–	32,000	710 U	370 U	360 U	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Chrysene	621	87,000	100 J	370 U	120 J	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Di-n-butylphthalate	–	780,000	710 U	370 U	360 U	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Di-n-octylphthalate	–	160,000	710 U	370 U	360 U	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Dibenz(a,h)anthracene	–	87	710 U	370 U	42 J	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Dibenzofuran	–	31,000	710 U	370 U	360 U	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Fluoranthene	950	310,000	100 J	370 U	180 J	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Fluorene	401	310,000	710 U	370 U	360 U	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Indeno(1,2,3-cd)pyrene	401	870	710 U	370 U	90 J	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Naphthalene	–	160,000	710 U	370 U	360 U	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Phenanthrene	660	230,000	140 J	370 U	99 J	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Phenol	–	2,300,000	710 U	370 U	360 U	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
Pyrene	830	230,000	130 J	370 U	230 J	370 U	NA	NA	NA	NA	NA	360 U	360 U	380 U	360 U
bis(2-Ethylhexyl)phthalate	–	46,000	170 B	320 B	140 B	950	NA	NA	NA	NA	NA	140 B	99 B	440 B	430
Pesticide/Polychlorinated Biphenyls (UG/KG)															
4,4'-DDD	–	2,700	1.7 L	3.7 U	3.6 U	3.7 U	NA	NA	NA	NA	NA	3.6 U	3.6 U	3.8 U	3.6 U
4,4'-DDE	4	1,900	3.6 UL	3.7 U	11	3.7 U	NA	NA	NA	NA	NA	3.6 U	3.6 U	3.8 U	3.6 U
4,4'-DDT	4	1,900	3.6 UL	3.7 U	3.6 U	3.7 U	NA	NA	NA	NA	NA	3.6 U	3.6 U	3.8 U	3.6 U
Aldrin	–	38	1.8 UL	1.9 U	1.9 U	1.9 U	NA	NA	NA	NA	NA	1.9 U	1.8 U	2 U	1.8 U
Aroclor-1016	–	550	36 UL	37 U	36 U	37 U	NA	NA	NA	NA	NA	36 U	36 U	38 U	36 U
Aroclor-1242	–	320	36 UL	37 U	36 U	37 U	NA	NA	NA	NA	NA	36 U	36 U	38 U	36 U
Aroclor-1248	–	320	36 UL	37 U	36 U	37 U	NA	NA	NA	NA	NA	36 U	36 U	38 U	36 U
Aroclor-1254	–	160	36 UL	37 U	36 U	37 U	NA	NA	NA	NA	NA	36 U	36 U	38 U	36 U
Aroclor-1260	–	320	36 UL	37 U	74	37 U	NA	NA	NA	NA	NA	36 U	36 U	38 U	36 U
Dieldrin	12.4	40	3.6 UL	3.7 U	3.6 U	3.7 U	NA	NA	NA	NA	NA	3.6 U	3.6 U	3.8 U	3.6 U
Endosulfan I	–	47,000	1.8 UL	1.9 U	1.9 U	1.9 U	NA	NA	NA	NA	NA	1.9 U	1.8 U	2 U	1.8 U
Endosulfan II	–	47,000	3.6 UL	3.7 U	3.6 U	3.7 U	NA	NA	NA	NA	NA	3.6 U	3.6 U	3.8 U	3.6 U
Endosulfan sulfate	–	47,000	3.6 UL	3.7 U	3.6 U	3.7 U	NA	NA	NA	NA	NA	3.6 U	3.6 U	3.8 U	3.6 U
Endrin	–	2,300	3.6 UL	3.7 U	3.6 U	3.7 U	NA	NA	NA	NA	NA	3.6 U	3.6 U	3.8 U	3.6 U
Endrin aldehyde	–	2,300	3.6 UL	3.7 U	3.6 U	3.7 U	NA	NA	NA	NA	NA	3.6 U	3.6 U	3.8 U	3.6 U
Endrin ketone	–	2,300	3.6 UL	3.7 U	3.6 U	3.7 U	NA	NA	NA	NA	NA	3.6 U	3.6 U	3.8 U	3.6 U
Heptachlor	–	140	1.8 UL	1.9 U	1.9 U	1.9 U	NA	NA	NA	NA	NA	1.9 U	1.8 U	2 U	1.8 U

Table 3-3
Subsurface Soil Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk Virginia

Station ID	Background	Soil Residential Adjusted RBC *	NBW14-DS40	NBW14-DS41	NBW14-DS42	NBW14-DS43	NBW14-DS44	NBW14-DS45	NBW14-DS46	NBW14-DS47	NBW14-DS48	NBW14-DS49	NBW14-DS51	NBW14-DS53	NBW14-DS54
Sample ID			NBW14-DS40-07	NBW14-DS41-05	NBW14-DS42-06	NBW14-DS43-07	NDW14-DS44-08	NDW14-DS45-05	NDW14-DS46-06	NDW14-DS47-04	NDW14-DS48-06	NDW14-DS49-06	NBW14-DS51-07	NBW14-DS53-07	NBW14-DS54-05
Sample Date			08/21/01	08/21/01	08/21/01	08/21/01	08/20/01	08/20/01	08/20/01	08/20/01	08/20/01	08/21/01	08/21/01	08/21/01	08/21/01
Chemical Name															
Heptachlor epoxide	–	70	1.8 UL	1.9 U	1.9 U	1.9 U	NA	NA	NA	NA	NA	1.9 U	1.8 U	2 U	1.8 U
Methoxychlor	–	39,000	18 UL	19 U	19 U	19 U	NA	NA	NA	NA	NA	19 U	18 U	20 U	18 U
alpha-BHC	–	100	1.8 UL	1.9 U	1.9 U	1.9 U	NA	NA	NA	NA	NA	1.9 U	1.8 U	2 U	1.8 U
alpha-Chlordane	–	1,800	3.4 L	1.9 U	1.3 J	1.9 U	NA	NA	NA	NA	NA	1.9 U	1.8 U	2 U	1.8 U
beta-BHC	–	350	1.8 UL	1.9 U	3.6 J	1.9 U	NA	NA	NA	NA	NA	1.9 U	1.8 U	2 U	1.8 U
delta-BHC	–	–	1.8 UL	1.9 U	1.9 U	1.9 U	NA	NA	NA	NA	NA	1.9 U	1.8 U	2 U	1.8 U
gamma-BHC (Lindane)	–	490	1.8 UL	1.9 U	1.9 U	1.9 U	NA	NA	NA	NA	NA	1.9 U	1.8 U	2 U	1.8 U
gamma-Chlordane	–	1,800	5.9 L	1.9 U	1.3 J	1.9 U	NA	NA	NA	NA	NA	1.9 U	1.8 U	2 U	1.8 U
Dioxin/Furans (UG/KG)															
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	–	0.430	NA	NA	NA	NA	0.143	0.139	0.814	0.447	0.445	NA	NA	NA	NA
1,2,3,4,6,7,8-Heptachlorodibenzofuran	–	0.43	NA	NA	NA	NA	0.0081	0.0462	0.295	0.0879	0.0391	NA	NA	NA	NA
1,2,3,4,7,8,9-Heptachlorodibenzofuran	–	0.43	NA	NA	NA	NA	7.24E-04 J	0.00449	0.0279	0.0073	0.00309	NA	NA	NA	NA
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	–	0.043	NA	NA	NA	NA	0.00126 J	0.00712	0.0246	0.0125	0.00471	NA	NA	NA	NA
1,2,3,4,7,8-Hexachlorodibenzofuran	–	0.043	NA	NA	NA	NA	0.00184 J	0.0157	0.0778	0.0245 J	0.00875	NA	NA	NA	NA
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	–	0.043	NA	NA	NA	NA	0.00346	0.012	0.0495	0.0296	0.0124	NA	NA	NA	NA
1,2,3,6,7,8-Hexachlorodibenzofuran	–	0.043	NA	NA	NA	NA	0.00186 J	0.0156	0.0678	0.0253 J	0.00877	NA	NA	NA	NA
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	–	0.043	NA	NA	NA	NA	0.00231 J	0.00864	0.0328	0.018	0.00776	NA	NA	NA	NA
1,2,3,7,8,9-Hexachlorodibenzofuran	–	0.043	NA	NA	NA	NA	4.96E-04 J	0.0041	0.0197	0.00637	0.00219 J	NA	NA	NA	NA
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	–	0.0085	NA	NA	NA	NA	0.00161 J	0.0117	0.0354	0.0196	0.0066	NA	NA	NA	NA
1,2,3,7,8-Pentachlorodibenzofuran	–	0.085	NA	NA	NA	NA	0.00159 J	0.0141	0.0481	0.0197	0.00728	NA	NA	NA	NA
2,3,4,6,7,8-Hexachlorodibenzofuran	–	0.043	NA	NA	NA	NA	0.00219 J	0.0154	0.0824	0.0276	0.00951	NA	NA	NA	NA
2,3,4,7,8-Pentachlorodibenzofuran	–	0.0085	NA	NA	NA	NA	0.00318	0.0191	0.0627	0.0302	0.0105	NA	NA	NA	NA
2,3,7,8-TCDD (dioxin)	–	0.0043	NA	NA	NA	NA	5.07E-04	0.00336	0.00816	0.00458	0.00186	NA	NA	NA	NA
2,3,7,8-Tetrachlorodibenzofuran	–	0.043	NA	NA	NA	NA	0.00164	0.0134	0.0496	0.0156	0.00714	NA	NA	NA	NA
Total heptachlorodibenzo-p-dioxin	–	–	NA	NA	NA	NA	0.33	0.435	1.4	1.16	1.02	NA	NA	NA	NA
Total heptachlorodibenzofuran	–	–	NA	NA	NA	NA	0.0217	0.0798	0.501	0.173	0.0907	NA	NA	NA	NA
Total hexachlorodibenzo-p-dioxin	–	–	NA	NA	NA	NA	0.0514	0.193	0.691	0.387	0.164	NA	NA	NA	NA
Total hexachlorodibenzofuran	–	–	NA	NA	NA	NA	0.0233	0.153	0.713	0.261	0.0982	NA	NA	NA	NA
Total octachlorodibenzo-p-dioxin	–	–	NA	NA	NA	NA	1.55	1.92	3.24	3.39	5.61 J	NA	NA	NA	NA
Total octachlorodibenzofuran	–	–	NA	NA	NA	NA	0.0167	0.0313	0.228	0.0904	0.0513	NA	NA	NA	NA
Total pentachlorodibenzo-p-dioxin	–	–	NA	NA	NA	NA	0.027	0.213	0.762	0.394	0.126	NA	NA	NA	NA
Total pentachlorodibenzofuran	–	–	NA	NA	NA	NA	0.0353	0.231	0.886	0.36	0.123	NA	NA	NA	NA
Total tetrachlorodibenzo-p-dioxin	–	–	NA	NA	NA	NA	0.0165	0.195	0.711	0.363	0.103	NA	NA	NA	NA
Total tetrachlorodibenzofuran	–	–	NA	NA	NA	NA	0.0393	0.322	1.04	0.418	0.162	NA	NA	NA	NA
Total Metals (MG/KG)															
Aluminum	22,370	7,800	2,410 L	2,000 L	3,080 L	1,080 L	NA	NA	NA	NA	NA	1,340 L	1,360 L	2,860 L	1,120 L
Antimony	1.2	3.1	0.6 B	0.85 B	0.62 B	0.54 B	NA	NA	NA	NA	NA	0.62 B	0.532 UL	0.545 UL	0.83 B
Arsenic	42.2	0.43	5.8 L	23.7 J	19.7 J	19.7 J	NA	NA	NA	NA	NA	16.1 J	15.2 J	23.3 J	15.9 J
Barium	67	550	28.2 J	21.5 K	37.1 K	16 K	NA	NA	NA	NA	NA	15.3 K	14.8 K	21.5 K	17.1 K
Beryllium	2.3	16	0.34 B	0.63 J	0.44 B	0.29 B	NA	NA	NA	NA	NA	0.29 B	0.36 B	0.46 B	0.3 B
Cadmium	0.2	3.9	0.42 B	0.18 B	0.65 K	0.09 B	NA	NA	NA	NA	NA	0.11 B	0.085 U	0.18 B	0.1 B
Calcium	16,100	–	2,960	165,000	104,000	245,000	NA	NA	NA	NA	NA	195,000	179,000	216,000	198,000
Chromium	43	23	5.1	20.2	16.1	14.1	NA	NA	NA	NA	NA	16.7	16.4	21.1	15.1
Cobalt	25	160	1.4 J	4.1 K	3.4 K	2.7 K	NA	NA	NA	NA	NA	2 K	2.7 K	2.2 K	1.6 K
Copper	31	310	10.6	6	14.1	0.173 UL	NA	NA	NA	NA	NA	0.168 UL	0.3 L	0.174 UL	0.162 UL
Cyanide	–	160	0.11 J	0.06 J	0.07 J	0.12 J	NA	NA	NA	NA	NA	0.12 J	0.07 J	0.1 J	0.08 J
Iron	96,600	2,300	4,570 L	24,200 L	38,400 L	19,500 L	NA	NA	NA	NA	NA	7,500	17,000 L	17,000 L	12,000 L
Lead	67	400	43.6	14.1 K	39.3 K	3.6 K	NA	NA	NA	NA	NA	3.8 K	4.1 K	4.8 K	3.8 K
Magnesium	6,590	–	1,120	1,370	1,870	2,030	NA	NA	NA	NA	NA	1,440	1,420	1,690	1,590
Manganese	1,240	160	89.4 K	348 K	39 K	200 K	NA	NA	NA	NA	NA	182 K	164 K	135 K	208 K
Mercury	0.1	2.3	0.06 J	0.048 U	0.05 J	0.043 U	NA	NA	NA	NA	NA	0.04 U	0.049 U	0.058 U	0.042 U
Nickel	40	160	4.1 J	6.9 K	6.8 K	3.8 K	NA	NA	NA	NA	NA	3.6 K	4 K	4.4 K	3 K
Potassium	3,690	–	754 J	810 K	938 K	654 K	NA	NA	NA	NA	NA	803 K	697 K	643 K	590 K
Selenium	–	39	0.776 U	0.817 UL	0.756 UL	0.8 UL	NA	NA	NA	NA	NA	0.768 UL	0.787 UL	0.807 UL	0.75 UL
Silver	0.52	39	0.147 U	0.155 U	0.143 U	0.151 U	NA	NA	NA	NA	NA	0.145 U	0.149 U	0.153 U	0.142 U
Sodium	1,370	–	632 J	1,530 K	876 K	2,110 K	NA	NA	NA	NA	NA	1,820 K	1,670 K	2,020 K	1,920 K
Thallium	ND	0.55	0.734 UL	0.773 UL	0.715 UL	0.757 UL	NA	NA	NA	NA	NA	0.726 UL	0.744 UL	0.763 UL	0.71 UL
Vanadium	87	55	17.8	48.3	33.7	27.2	NA	NA	NA	NA	NA	30.5	33.3	54.3	32.9
Zinc	142	2,300	83.8 J	40.4 K	50.1 K	12.6 K	NA	NA	NA	NA	NA	12.7 K	14.3 K	14.8 K	11.5 K

Notes:

NA - Not analyzed
– Not Available
U - Not detected
B - Blank contamination

J - Estimated
L - Biased low
K - Biased high
R - Unreliable Result

ND - Not detecte

Shaded cells indicate exceedance of human health screening criteria

Bolded text indicates exceedance of ecological screening criteria

Table 3-4
Sediment Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID	RBC-Soil Residential Adj X 10 for SD	Ecological Screening Criteria	NBW14-SD01		NBW14-SD02	NBW14-SD03	NBW14-SD04	NBW14-SD05
Sample ID			NBW14-SD01	NBW14-SD01-P	NBW14-SD02	NBW14-SD03	NBW14-SD04	NBW14-SD05
Sample Date			12/19/02	12/19/02	12/19/02	12/19/02	12/19/02	12/19/02
Chemical Name								
Semivolatile Organic Compounds (UG/KG)								
Acenaphthene	4,700,000	16	420 U	430 U	**31 J**	390 U	**24 J**	450 U
Acenaphthylene	--	44	**59 J**	430 U	19 J	390 U	**61 J**	450 U
Anthracene	23,000,000	85	53 J	430 U	**95 J**	26 J	**130 J**	450 U
Benzo(a)anthracene	8,700	261	97 J	15 J	220 J	91 J	**280 J**	450 U
Benzo(a)pyrene	870	430	140 J	20 J	200 J	85 J	330 J	450 U
Benzo(b)fluoranthene	8,700	3,200	200 J	34 J	290 J	130 J	540 J	450 U
Benzo(g,h,i)perylene	2,300,000	670	160 J	430 U	110 J	51 J	200 J	450 U
Benzo(k)fluoranthene	87,000	1,800	120 J	30 J	190 J	130 J	350 J	450 U
Carbazole	320,000	1,800	41 J	430 U	35 J	21 J	54 J	450 U
Chrysene	870,000	384	130 J	30 J	280 J	120 J	380 J	14 J
Di-n-octylphthalate	1,600,000	6,200	27 J	430 U	460 U	390 U	660 U	450 U
Dibenz(a,h)anthracene	870	63	50 J	430 U	48 J	22 J	**79 J**	450 U
Dibenzofuran	310,000	540	420 U	430 U	14 J	390 U	21 J	450 U
Fluoranthene	3,100,000	600	220 J	38 J	470	230 J	540 J	18 J
Fluorene	3,100,000	19	420 U	430 U	**25 J**	390 U	**24 J**	450 U
Indeno(1,2,3-cd)pyrene	8,700	600	170 J	19 J	120 J	58 J	240 J	450 U
Naphthalene	1,600,000	160	11 J	430 U	460 U	390 U	15 J	450 U
Phenanthrene	2,300,000	240	110 J	19 J	**270 J**	110 J	240 J	450 U
Pyrene	2,300,000	665	190 J	41 J	500	210 J	**710**	21 J
bis(2-Ethylhexyl)phthalate	460,000	1,300	240 J	82 B	120 B	42 B	550 J	60 B
Pesticide/Polychlorinated Biphenyls (UG/KG)								
4,4'-DDD	27,000	16	3.4 J	3.9 J	3.6 J	3.9 U	**11**	4.5 U
4,4'-DDE	19,000	2	**3.5 J**	**2.7 J**	**3.3 J**	**2.6 J**	**7.2 J**	4.5 U
4,4'-DDT	19,000	2	**10 J**	**13**	5.4 B	4.3 B	7.3 B	**8.2**
Aroclor-1260	3,200	23	42 U	43 U	**60 J**	14 J	**120**	45 U
Heptachlor	1,400	5	2.2 U	2.2 U	2.4 U	2 U	1.8 J	2.3 U
alpha-Chlordane	18,000	7	**13**	**8.5 J**	**7.7 J**	1 J	**24 J**	2.3 U
beta-BHC	3,500	5	2.2 U	2.2 U	**9.2 J**	2 U	3.4 U	2.3 U
gamma-BHC (Lindane)	4,900	3	2.2 U	2.2 U	2.4 U	2 U	3.4 U	1.2 J
gamma-Chlordane	18,000	7	**13**	**9.3**	**8.9 J**	2 U	**30**	2.3 U
Total Metals (MG/KG)								
Aluminum	78,000	18,000	1,290	1,100	2,250	1,170	13,800	1,660

Table 3-4
Sediment Detections and Exceedances
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

Station ID	RBC-Soil Residential Adj X 10 for SD	Ecological Screening Criteria	NBW14-SD01		NBW14-SD02	NBW14-SD03	NBW14-SD04	NBW14-SD05
Sample ID			NBW14-SD01	NBW14-SD01-P	NBW14-SD02	NBW14-SD03	NBW14-SD04	NBW14-SD05
Sample Date			12/19/02	12/19/02	12/19/02	12/19/02	12/19/02	12/19/02
Chemical Name								
Antimony	31	150	0.29	1.3	0.32	0.28	0.92	0.32
Arsenic	4.3	8	12.9	11.2	2.8	2.1	20.4	17.4
Barium	5,500	48	15.4	19.2	14.5	8	**56.6**	18.4
Beryllium	160	--	0.26	0.16	0.25	0.1	0.96	0.21
Cadmium	39	1	0.13	0.069	0.27	0.072	**2.5**	0.081
Calcium	--	--	229,000	179,000	13,800	43,300	28,800	315,000
Chromium	230	81	12.4	19.3	10.6	4.8	47.9	14.8
Cobalt	1,600	10	1.5	8.7	2.1	0.87	9.1	1.6
Copper	3,100	34	12.6	9.2	10.4	16.1	**67.4**	4
Cyanide	1,600	0.10	**0.13**	0.031	0.035	0.03	**0.19**	0.06
Iron	23,000	220,000	11,300	13,000	6,280	4,480	35,700	11,300
Lead	400	47	13.5	38	17.6	7	**101**	6.7
Magnesium	--	--	2,170	2,110	1,890	1,410	6,510	2,550
Manganese	1,600	260	151	177	54.8	65.6	253	163
Mercury	23	0.15	0.055	0.048	0.063	0.057	**0.34**	0.068
Nickel	1,600	21	5.1	3.6	4	2.4	**27.5**	3.2
Potassium	--	--	599	536	652	420	3,070	815
Selenium	390	1	0.72	0.69	0.8	0.69	**1.2**	0.81
Silver	390	1	0.19	0.18	0.21	0.18	0.69	0.22
Sodium	--	--	3,900	4,270	2,510	2,210	6,330	5,380
Thallium	5.5	--	0.58	0.55	0.64	0.55	0.96	0.65
Vanadium	550	57	26.3	24.6	15.7	7.7	**79.7**	29.3
Zinc	23,000	150	63	56.2	62.3	24.8	**286**	23.3
Wet Chemistry (MG/KG)								
Total organic carbon (TOC)	--	--	28,400 J	79,600 J	51,900 J	7,210 J	44,500 J	53,900 J
pH	--	--	8.47	8.11	8.06	8.47	8.49	7.93

Notes:

NA - Not analyzed
-- Not Available
U - Not detected
B - Blank contamination
J - Estimated
L - Biased low

UJ - Undetected, estimated limit
UL - Undetected, limit biased low
K - Biased high
R - Unreliable Result
Shaded cells indicate exceedance of human health screening criteria
Bolded text indicates exceedance of ecological screening criteria

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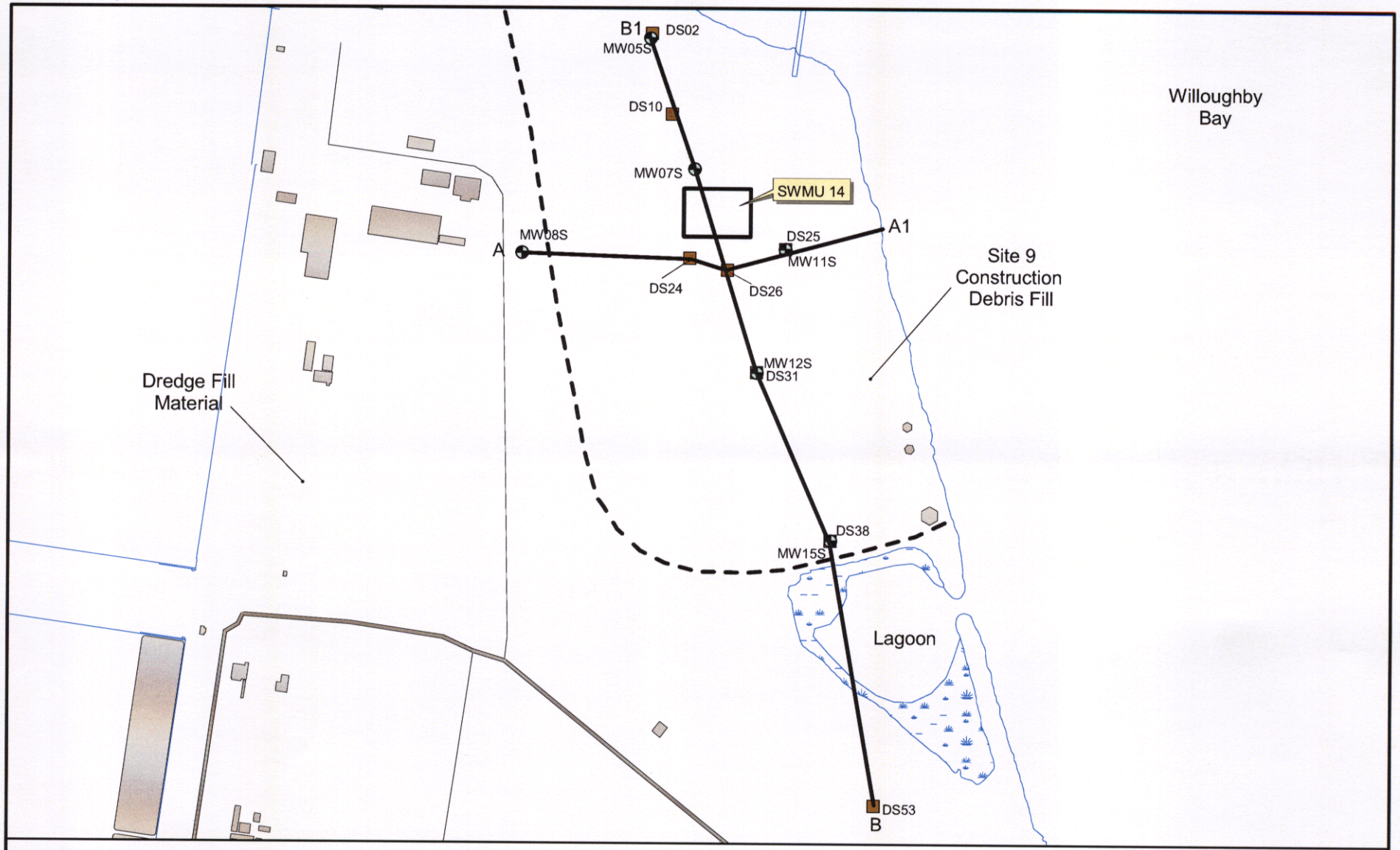

LEGEND

- Direct push
- Monitoring Wells
- Shoreline
- Buildings
- Estimated Landfill Boundary
- A - A1 Cross Section Lines

N

0 200 400 Feet

Figure 3-1
Cross Section Lines For SWMU 14
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

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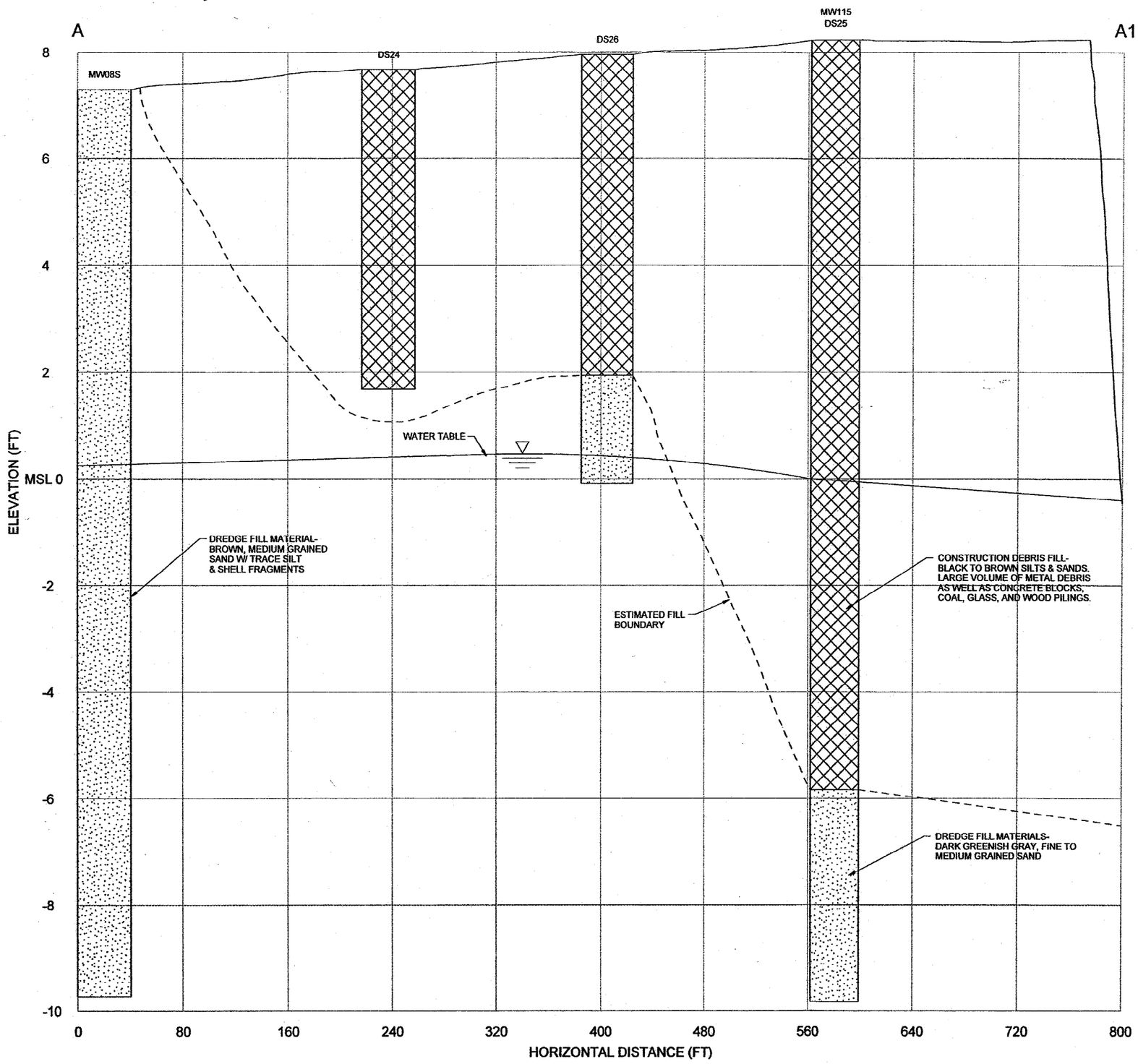
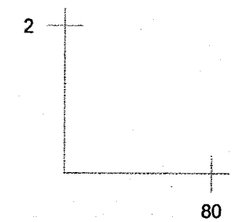


NOTES:

THE ELEVATIONS OF THE SOIL BORINGS ARE ESTIMATED BASED ON THE TOPOGRAPHY OF THE SITE AND THE KNOWN ELEVATIONS OF THE MONITORING WELLS.



VERTICAL SCALE: 1" = 2'-0"
HORIZONTAL SCALE: 1" = 80'-0"

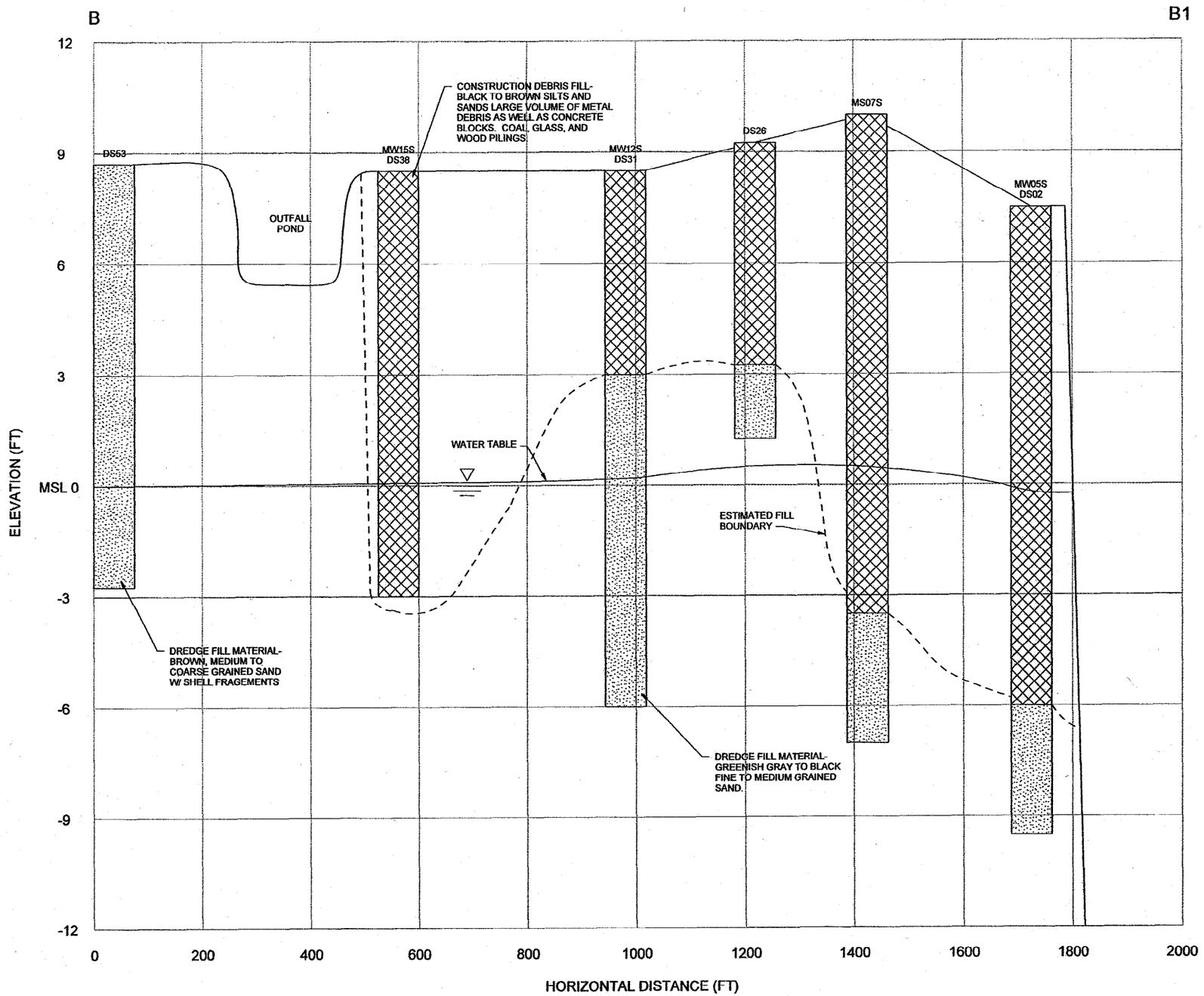
Figure 3-2
CROSS-SECTION A-A1
SWMU-14
Naval Station, Norfolk

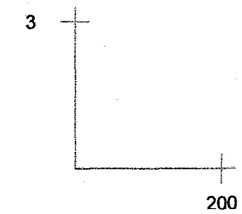
CH2MHILL

4408f078.dgn 07-MAR-2002

NOTE:

THE ELEVATIONS OF THE SOIL BORINGS ARE ESTIMATED BASED ON THE TOPOGRAPHY OF THE SITE AND THE KNOWN ELEVATIONS OF THE MONITORING WELLS.





VERTICAL SCALE: 1" = 3'-0"
HORIZONTAL SCALE: 1" = 200'-0"

Figure 3-3
CROSS-SECTION B-B1
SWMU-14
Naval Station, Norfolk

CH2MHILL

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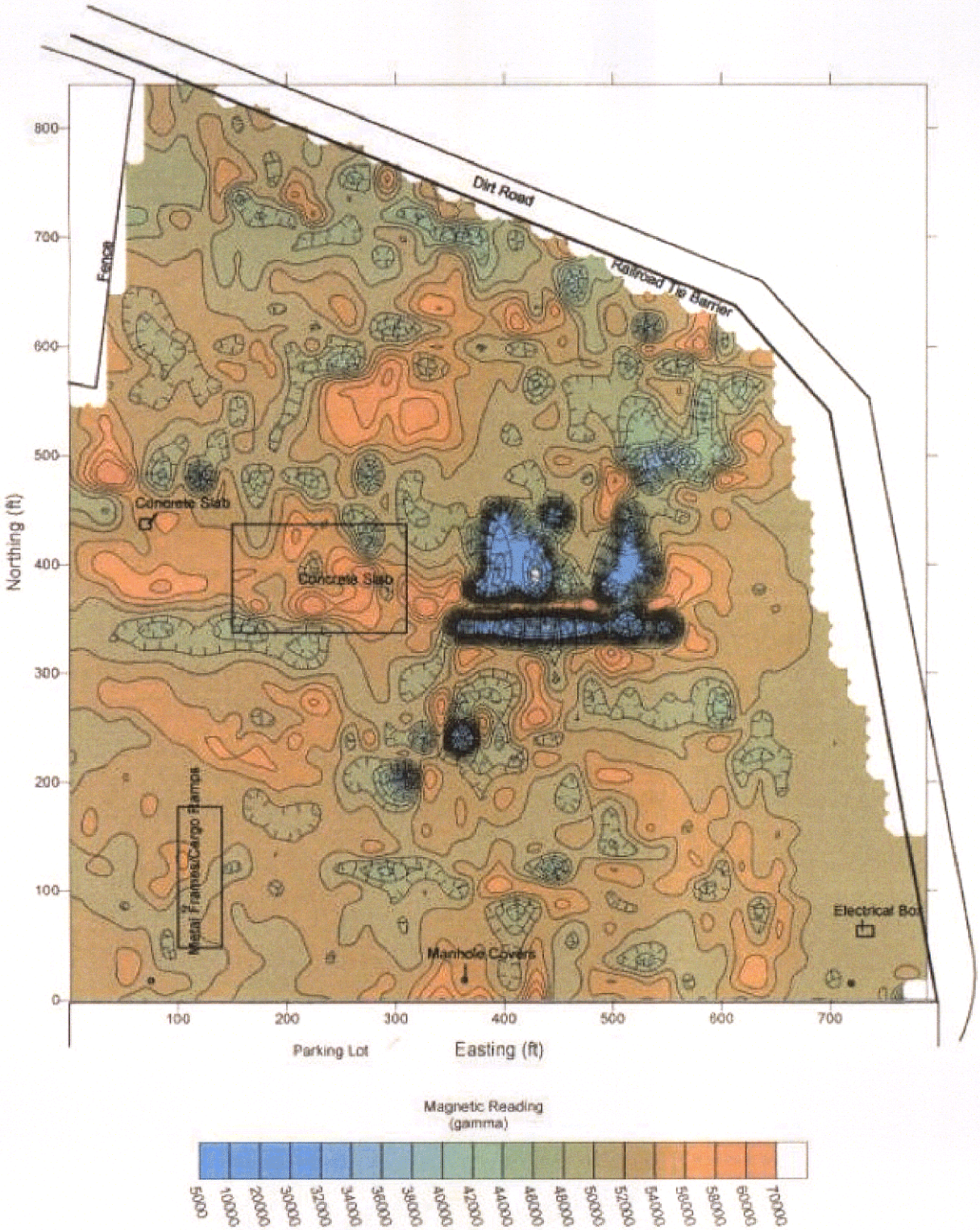

Figure 3-4
Magnetic Contour Map
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

N

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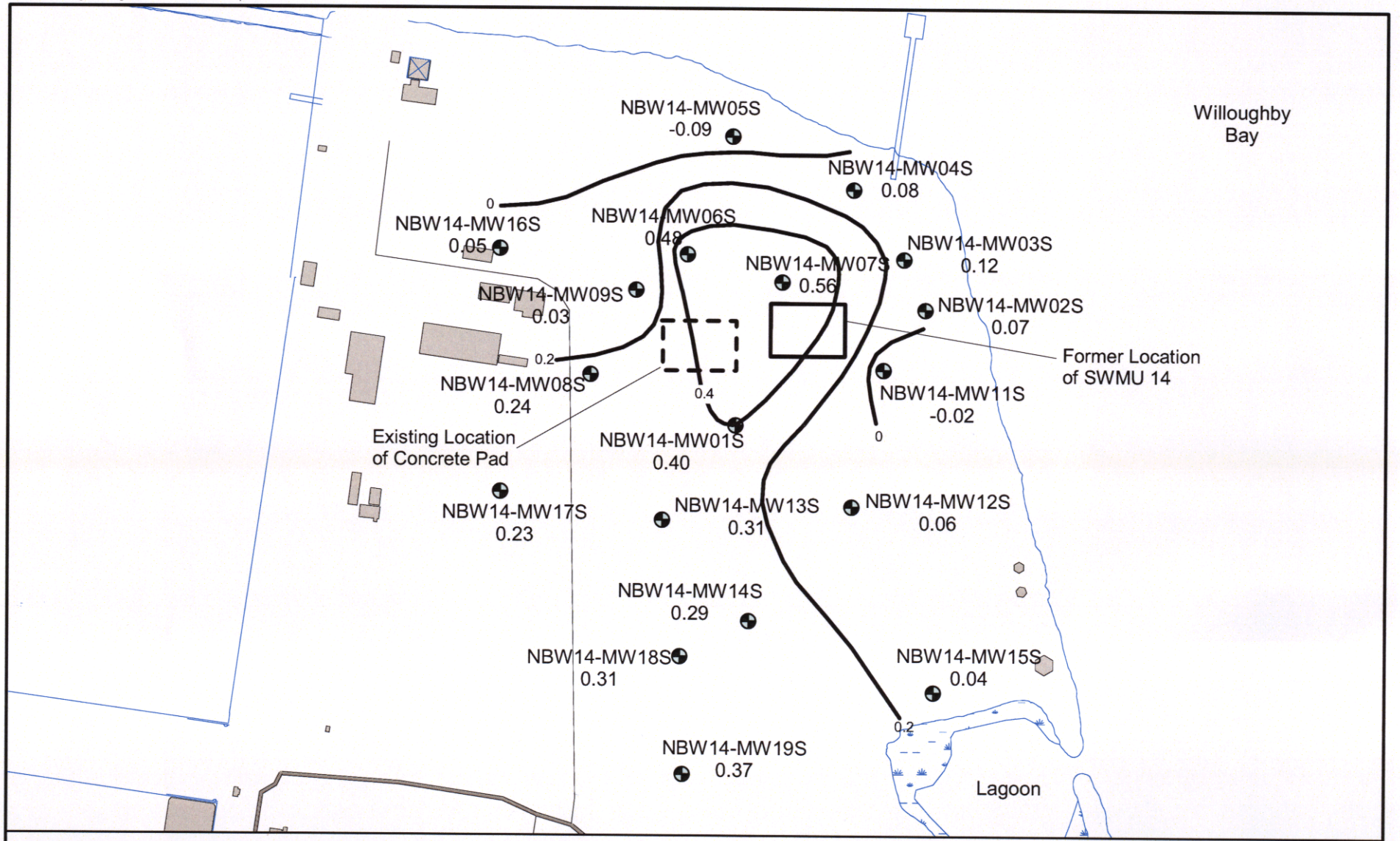

LEGEND

- Groundwater Elevation Contours
- Monitoring Well Locations
- Buildings

N

0 200 400 Feet

Figure 3-5
SWMU 14 Groundwater Elevation Contour Map October, 2001
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

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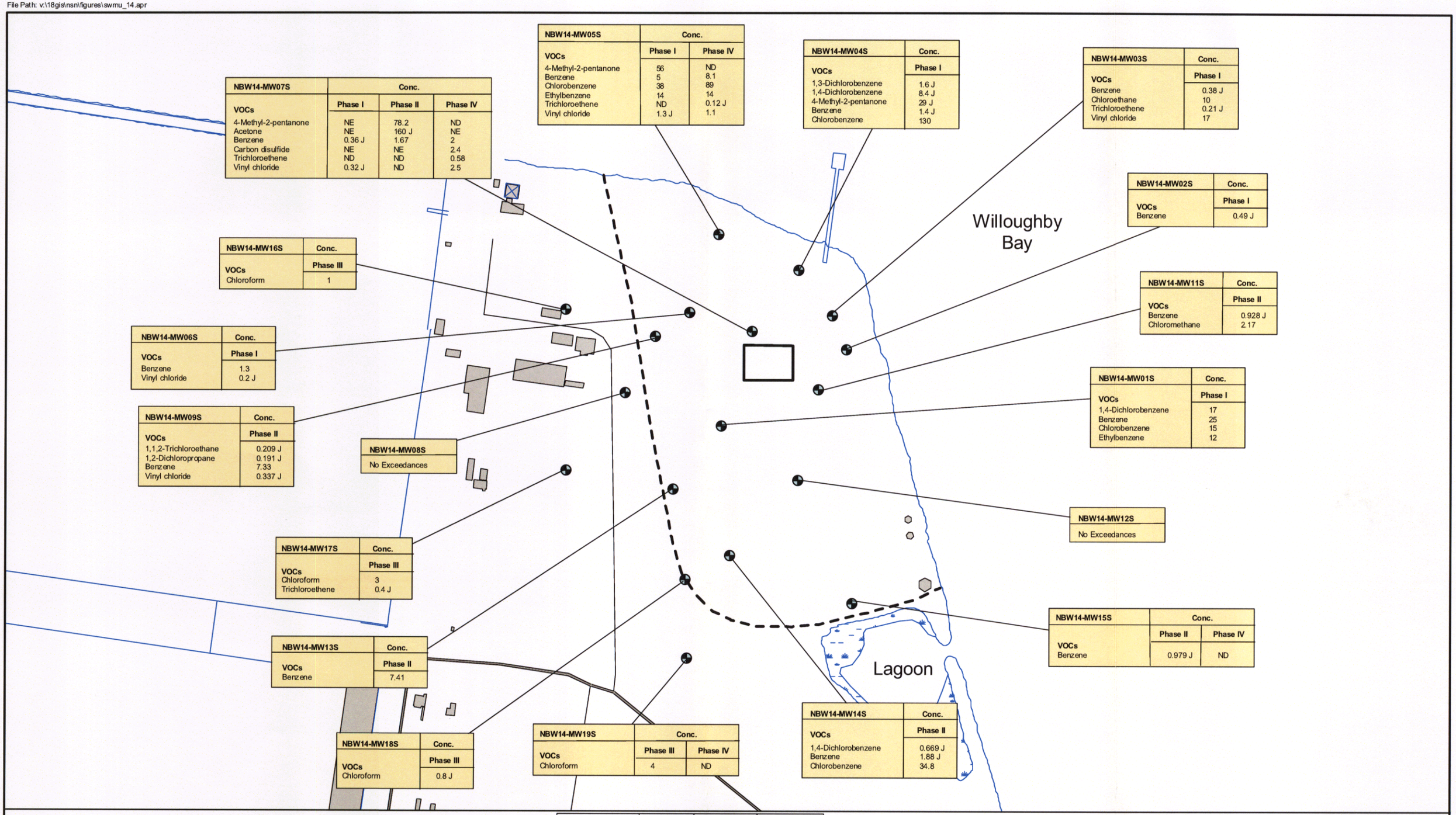

NBW14-MW07S	Conc.		
VOCs	Phase I	Phase II	Phase IV
4-Methyl-2-pentanone	NE	78.2	ND
Acetone	NE	160 J	NE
Benzene	0.36 J	1.67	2
Carbon disulfide	NE	NE	2.4
Trichloroethene	ND	ND	0.58
Vinyl chloride	0.32 J	ND	2.5

NBW14-MW05S	Conc.	
VOCs	Phase I	Phase IV
4-Methyl-2-pentanone	56	ND
Benzene	5	8.1
Chlorobenzene	38	89
Ethylbenzene	14	14
Trichloroethene	ND	0.12 J
Vinyl chloride	1.3 J	1.1

NBW14-MW04S	Conc.
VOCs	Phase I
1,3-Dichlorobenzene	1.6 J
1,4-Dichlorobenzene	8.4 J
4-Methyl-2-pentanone	29 J
Benzene	1.4 J
Chlorobenzene	130

NBW14-MW03S	Conc.
VOCs	Phase I
Benzene	0.38 J
Chloroethane	10
Trichloroethene	0.21 J
Vinyl chloride	17

NBW14-MW02S	Conc.
VOCs	Phase I
Benzene	0.49 J

NBW14-MW16S	Conc.
VOCs	Phase III
Chloroform	1

NBW14-MW11S	Conc.
VOCs	Phase II
Benzene	0.928 J
Chloromethane	2.17

NBW14-MW06S	Conc.
VOCs	Phase I
Benzene	1.3
Vinyl chloride	0.2 J

NBW14-MW01S	Conc.
VOCs	Phase I
1,4-Dichlorobenzene	17
Benzene	25
Chlorobenzene	15
Ethylbenzene	12

NBW14-MW09S	Conc.
VOCs	Phase II
1,1,2-Trichloroethane	0.209 J
1,2-Dichloropropane	0.191 J
Benzene	7.33
Vinyl chloride	0.337 J

NBW14-MW08S
No Exceedances

NBW14-MW12S
No Exceedances

NBW14-MW17S	Conc.
VOCs	Phase III
Chloroform	3
Trichloroethene	0.4 J

NBW14-MW15S	Conc.	
VOCs	Phase II	Phase IV
Benzene	0.979 J	ND

NBW14-MW13S	Conc.
VOCs	Phase II
Benzene	7.41

NBW14-MW14S	Conc.
VOCs	Phase II
1,4-Dichlorobenzene	0.669 J
Benzene	1.88 J
Chlorobenzene	34.8

NBW14-MW18S	Conc.
VOCs	Phase III
Chloroform	0.8 J

NBW14-MW19S	Conc.	
VOCs	Phase III	Phase IV
Chloroform	4	ND

LEGEND

- Groundwater Sample Location
- Shoreline
- Roads
- Buildings
- SWMU Boundary

Note:
Results are in UG/L
ND - not detected
NE - does not exceed screening value
J - value is estimated

Chemical Name	MCL-Groundwater	Tap Water Adjusted RBC	Ecological Screening Value
VOCs			
1,1,2-Trichloroethane	5	0.19	31,200
1,2-Dichloropropane	5	0.16	3,040
1,3-Dichlorobenzene	- -	0.55	129
1,4-Dichlorobenzene	75	0.47	129
4-Methyl-2-pentanone	- -	14	- -
Acetone	- -	61	750
Benzene	5	0.32	700
Carbon disulfide	- -	100	2
Chlorobenzene	100	11	129
Chloroethane	- -	3.6	- -
Chloroform	80	0.063	815
Chloromethane	- -	2.1	2,700
Ethylbenzene	700	3.3	430
Trichloroethene	5	0.026	2,000
Vinyl chloride	2	0.015	224,000

N

0 200 400 Feet

Figure 3-6
VOCs Exceeding Groundwater Screening Values
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

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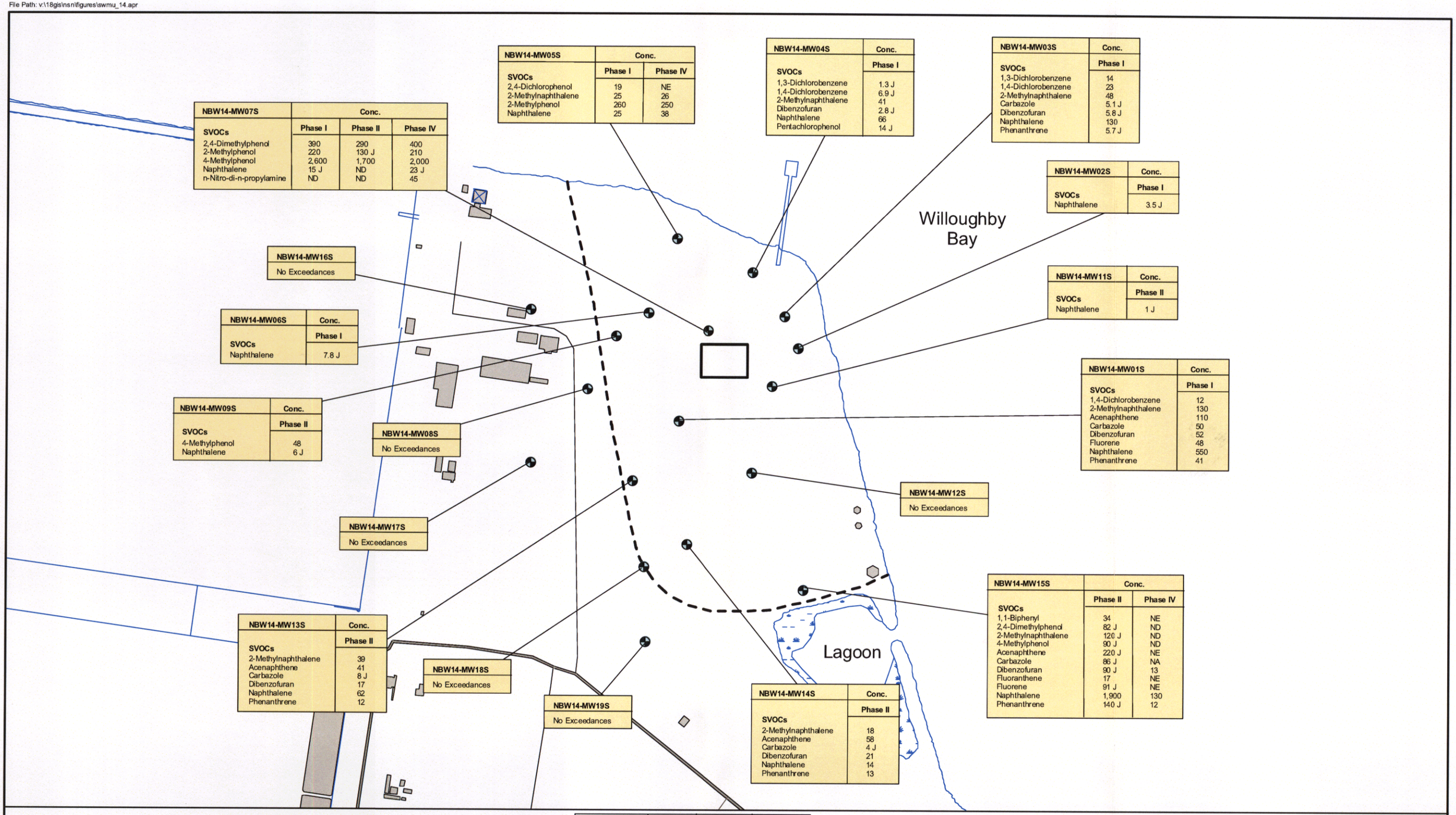

LEGEND

- Groundwater Sample Location
- Shoreline
- Roads
- Buildings
- SWMU Boundary

Notes:
Results are in UG/L.
NE - does not exceed screening value
ND - not detected
NA - not analyzed
J - value is estimated

Chemical Name	MCL-Groundwater	Tap Water Adjusted RBC	Ecological Screening Value
SVOCs			
1,1-Biphenyl	--	30	46
1,3-Dichlorobenzene	--	0.55	129
1,4-Dichlorobenzene	75	0.47	129
2,4-Dichlorophenol	--	11	--
2,4-Dimethylphenol	--	73	110
2-Methylnaphthalene	--	12	300
2-Methylphenol	--	180	102
4-Methylphenol	--	18	50
Acenaphthene	--	37	710
Carbazole	--	3.3	10
Dibenzofuran	--	2.4	10
Fluoranthene	--	150	16
Fluorene	--	24	300
Naphthalene	--	0.65	2,300
Pentachlorophenol	1	0.56	7.9
Phenanthrene	--	18	4.6
n-Nitroso-di-n-propylamine	--	0.0096	--

N

0 200 400 Feet

Figure 3-7
SVOCs Exceeding Groundwater Screening Values
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

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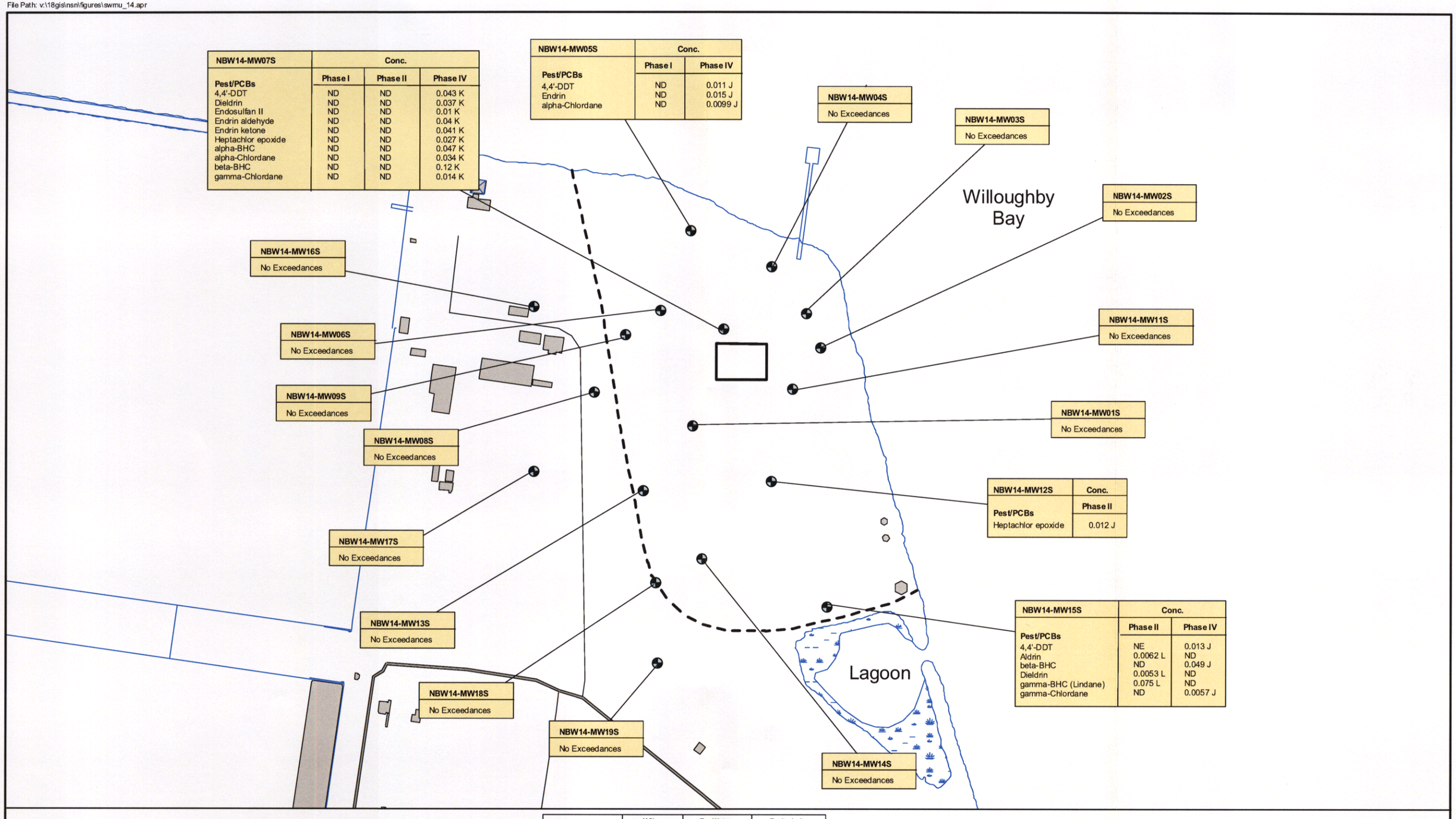

NBW14-MW07S	Conc.		
	Phase I	Phase II	Phase IV
Pest/PCBs			
4,4'-DDT	ND	ND	0.043 K
Dieldrin	ND	ND	0.037 K
Endosulfan II	ND	ND	0.01 K
Endrin aldehyde	ND	ND	0.04 K
Endrin ketone	ND	ND	0.041 K
Heptachlor epoxide	ND	ND	0.027 K
alpha-BHC	ND	ND	0.047 K
alpha-Chlordane	ND	ND	0.034 K
beta-BHC	ND	ND	0.12 K
gamma-Chlordane	ND	ND	0.014 K

NBW14-MW05S	Conc.	
	Phase I	Phase IV
Pest/PCBs		
4,4'-DDT	ND	0.011 J
Endrin	ND	0.015 J
alpha-Chlordane	ND	0.0099 J

NBW14-MW12S	Conc.
	Phase II
Pest/PCBs	
Heptachlor epoxide	0.012 J

NBW14-MW15S	Conc.	
	Phase II	Phase IV
Pest/PCBs		
4,4'-DDT	NE	0.013 J
Aldrin	0.0062 L	ND
beta-BHC	ND	0.049 J
Dieldrin	0.0053 L	ND
gamma-BHC (Lindane)	0.075 L	ND
gamma-Chlordane	ND	0.0057 J

LEGEND

- Groundwater Sample Location
- Shoreline
- Roads
- Buildings
- SWMU Boundary

Notes:
Results are in UG/L
ND - not detected
NE - does not exceed screening value
J - value is estimated
K - value may be biased high
L - value may be biased low

Chemical Name	MCL-Groundwater	Tap Water Adjusted RBC	Ecological Screening Value
Pesticides/PCBs			
4,4'-DDT	--	0.2	0.001
Aldrin	--	0.0039	1.3
Dieldrin	--	0.0042	0.11
Endosulfan II	--	22	0.0087
Endrin aldehyde	2	1.1	0.01
Endrin ketone	2	1.1	0.01
Heptachlor epoxide	0.2	0.0074	0.0036
alpha-BHC	--	0.011	0.34
alpha-Chlordane	--	0.19	0.004
beta-BHC	--	0.037	0.34
gamma-BHC (Lindane)	0.2	0.052	0.16
gamma-Chlordane	--	0.19	0.004

N

0 200 400 Feet

Figure 3-8
Pest/PCBs Exceeding Groundwater Screening Values
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

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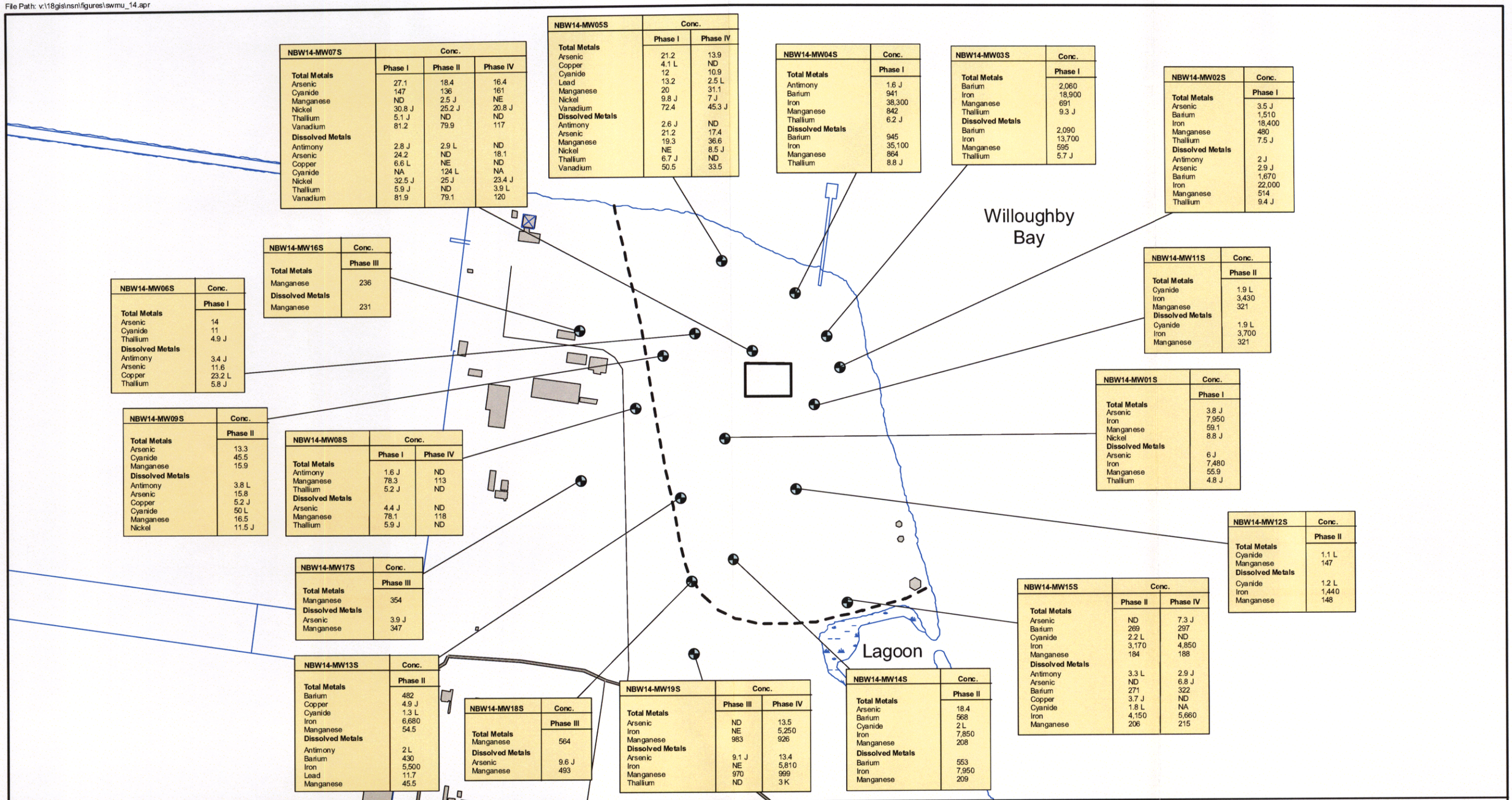

NBW14-MW07S	Conc.		
	Phase I	Phase II	Phase IV
Total Metals			
Arsenic	27.1	18.4	16.4
Cyanide	147	136	161
Manganese	ND	2.5 J	NE
Nickel	30.8 J	25.2 J	20.8 J
Thallium	5.1 J	ND	ND
Vanadium	81.2	79.9	117
Dissolved Metals			
Antimony	2.8 J	2.9 L	ND
Arsenic	24.2	ND	18.1
Copper	6.6 L	NE	ND
Cyanide	NA	124 L	NA
Nickel	32.5 J	25 J	23.4 J
Thallium	5.9 J	ND	3.9 L
Vanadium	81.9	79.1	120

NBW14-MW05S	Conc.	
	Phase I	Phase IV
Total Metals		
Arsenic	21.2	13.9
Copper	4.1 L	ND
Cyanide	12	10.9
Lead	13.2	2.5 L
Manganese	20	31.1
Nickel	9.8 J	7 J
Vanadium	72.4	45.3 J
Dissolved Metals		
Antimony	2.6 J	ND
Arsenic	21.2	17.4
Manganese	19.3	36.6
Nickel	NE	8.5 J
Thallium	6.7 J	ND
Vanadium	50.5	33.5

NBW14-MW04S	Conc.
	Phase I
Total Metals	
Antimony	1.6 J
Barium	941
Iron	38,300
Manganese	842
Thallium	6.2 J
Dissolved Metals	
Barium	945
Iron	35,100
Manganese	864
Thallium	8.8 J

NBW14-MW03S	Conc.
	Phase I
Total Metals	
Barium	2,060
Iron	18,900
Manganese	691
Thallium	9.3 J
Dissolved Metals	
Barium	2,090
Iron	13,700
Manganese	595
Thallium	5.7 J

NBW14-MW02S	Conc.
	Phase I
Total Metals	
Arsenic	3.5 J
Barium	1,510
Iron	18,400
Manganese	480
Thallium	7.5 J
Dissolved Metals	
Antimony	2 J
Arsenic	2.9 J
Barium	1,670
Iron	22,000
Manganese	514
Thallium	9.4 J

NBW14-MW16S	Conc.
	Phase III
Total Metals	
Manganese	236
Dissolved Metals	
Manganese	231

NBW14-MW11S	Conc.
	Phase II
Total Metals	
Cyanide	1.9 L
Iron	3,430
Manganese	321
Dissolved Metals	
Cyanide	1.9 L
Iron	3,700
Manganese	321

NBW14-MW06S	Conc.
	Phase I
Total Metals	
Arsenic	14
Cyanide	11
Thallium	4.9 J
Dissolved Metals	
Antimony	3.4 J
Arsenic	11.6
Copper	23.2 L
Thallium	5.8 J

NBW14-MW01S	Conc.
	Phase I
Total Metals	
Arsenic	3.8 J
Iron	7,950
Manganese	59.1
Nickel	8.8 J
Dissolved Metals	
Arsenic	6 J
Iron	7,480
Manganese	55.9
Thallium	4.8 J

NBW14-MW09S	Conc.
	Phase II
Total Metals	
Arsenic	13.3
Cyanide	45.5
Manganese	15.9
Dissolved Metals	
Antimony	3.8 L
Arsenic	15.8
Copper	5.2 J
Cyanide	50 L
Manganese	16.5
Nickel	11.5 J

NBW14-MW08S	Conc.	
	Phase I	Phase IV
Total Metals		
Antimony	1.6 J	ND
Manganese	78.3	113
Thallium	5.2 J	ND
Dissolved Metals		
Arsenic	4.4 J	ND
Manganese	78.1	118
Thallium	5.9 J	ND

NBW14-MW12S	Conc.
	Phase II
Total Metals	
Cyanide	1.1 L
Manganese	147
Dissolved Metals	
Cyanide	1.2 L
Iron	1,440
Manganese	148

NBW14-MW17S	Conc.
	Phase III
Total Metals	
Manganese	354
Dissolved Metals	
Arsenic	3.9 J
Manganese	347

NBW14-MW15S	Conc.	
	Phase II	Phase IV
Total Metals		
Arsenic	ND	7.3 J
Barium	269	297
Cyanide	2.2 L	ND
Iron	3,170	4,850
Manganese	184	188
Dissolved Metals		
Antimony	3.3 L	2.9 J
Arsenic	ND	6.8 J
Barium	271	322
Copper	3.7 J	ND
Cyanide	1.8 L	NA
Iron	4,150	5,660
Manganese	206	215

NBW14-MW13S	Conc.
	Phase II
Total Metals	
Barium	482
Copper	4.9 J
Cyanide	1.3 L
Iron	6,680
Manganese	54.5
Dissolved Metals	
Antimony	2 L
Barium	430
Iron	5,500
Lead	11.7
Manganese	45.5

NBW14-MW18S	Conc.
	Phase III
Total Metals	
Manganese	564
Dissolved Metals	
Arsenic	9.6 J
Manganese	493

NBW14-MW19S	Conc.	
	Phase III	Phase IV
Total Metals		
Arsenic	ND	13.5
Iron	NE	5,250
Manganese	983	926
Dissolved Metals		
Arsenic	9.1 J	13.4
Iron	NE	5,810
Manganese	970	999
Thallium	ND	3 K

NBW14-MW14S	Conc.
	Phase II
Total Metals	
Arsenic	18.4
Barium	568
Cyanide	2 L
Iron	7,850
Manganese	208
Dissolved Metals	
Barium	553
Iron	7,950
Manganese	209

LEGEND

- Groundwater Sample Location
- Shoreline
- Roads
- Buildings
- SWMU Boundary

Notes:
Results are in UG/L
NA - not analyzed
ND - not detected
NE - does not exceed screening value

Chemical Name	MCL-Groundwater	Tap Water Adjusted RBC	Ecological Screening Value
Total Metals			
Antimony	6	1.5	500
Arsenic	10	0.045	36
Barium	2,000	260	10,000
Copper	1,300	150	3.7
Cyanide	200	73	1
Iron	--	1,100	1,000
Manganese	--	73	10
Nickel	--	73	8.3
Thallium	2	0.26	2,130
Vanadium	--	26	10,000
Dissolved Metals			
Antimony	6	1.5	500
Arsenic	10	0.045	36
Barium	2,000	260	10,000
Copper	1,300	150	3.1
Cyanide	200	73	1
Iron	--	1,100	1,000
Lead	15	15	8.1
Manganese	--	73	10
Nickel	--	73	8.2
Thallium	2	0.26	2,130
Vanadium	--	26	10,000

N

0 200 400 Feet

Figure 3-9
Total and Dissolved Metals Exceeding Groundwater Screening Values
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

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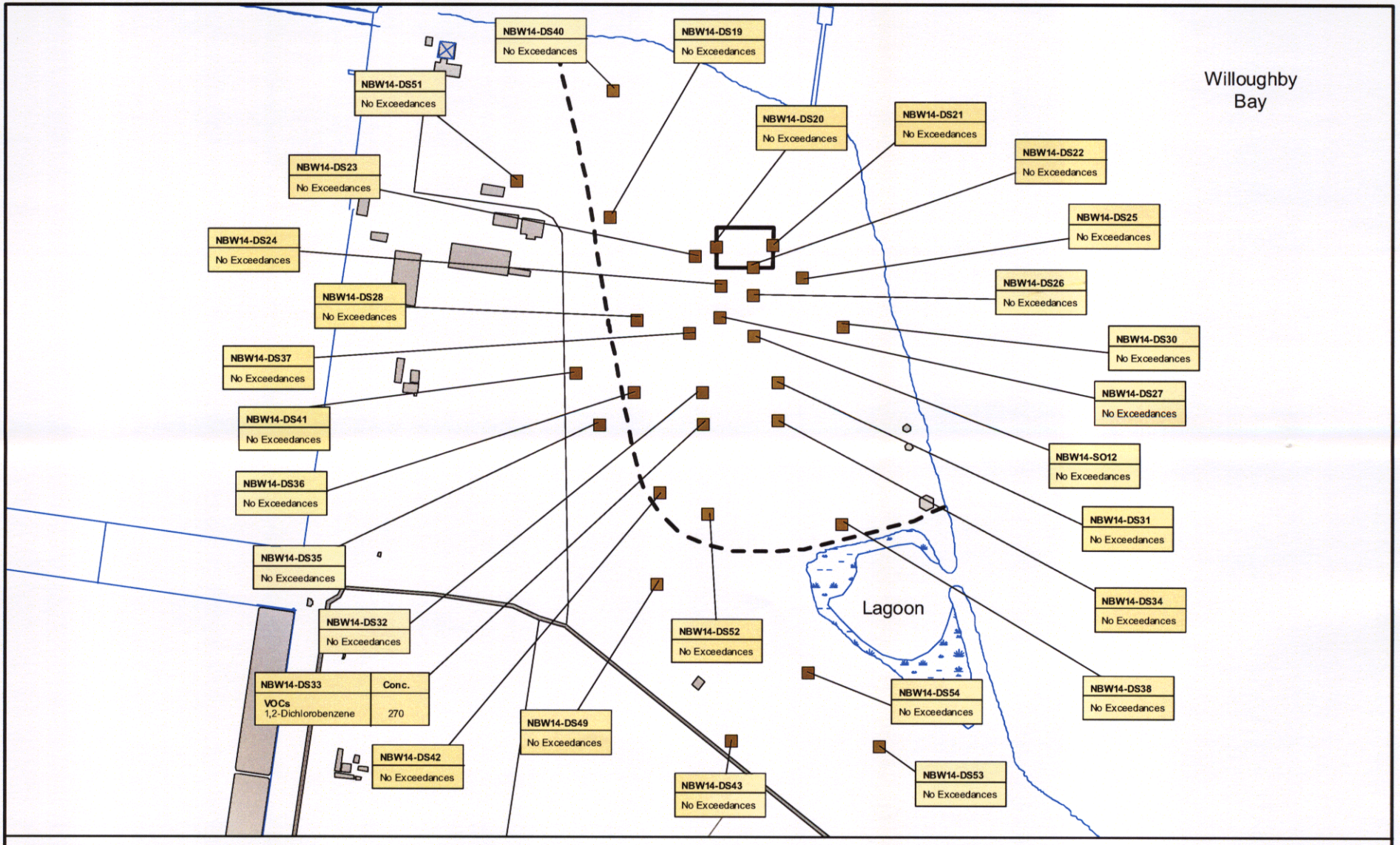

LEGEND

- Surface Soil Sample
- Shoreline
- Roads
- Buildings
- SWMU Boundary

Notes:
VOC samples were not collected during Phase I investigations.
Units are in UG/KG.

N

0 200 400 Feet

Chemical Name	Background	Soil Residential Adjusted RBC	Ecological Screening Value
VOCs			
1,2-Dichlorobenzene	--	700,000	100

Figure 3-10
VOCs Exceeding Surface Soil Screening Values
SWMU 14 Remedial Investigation Report
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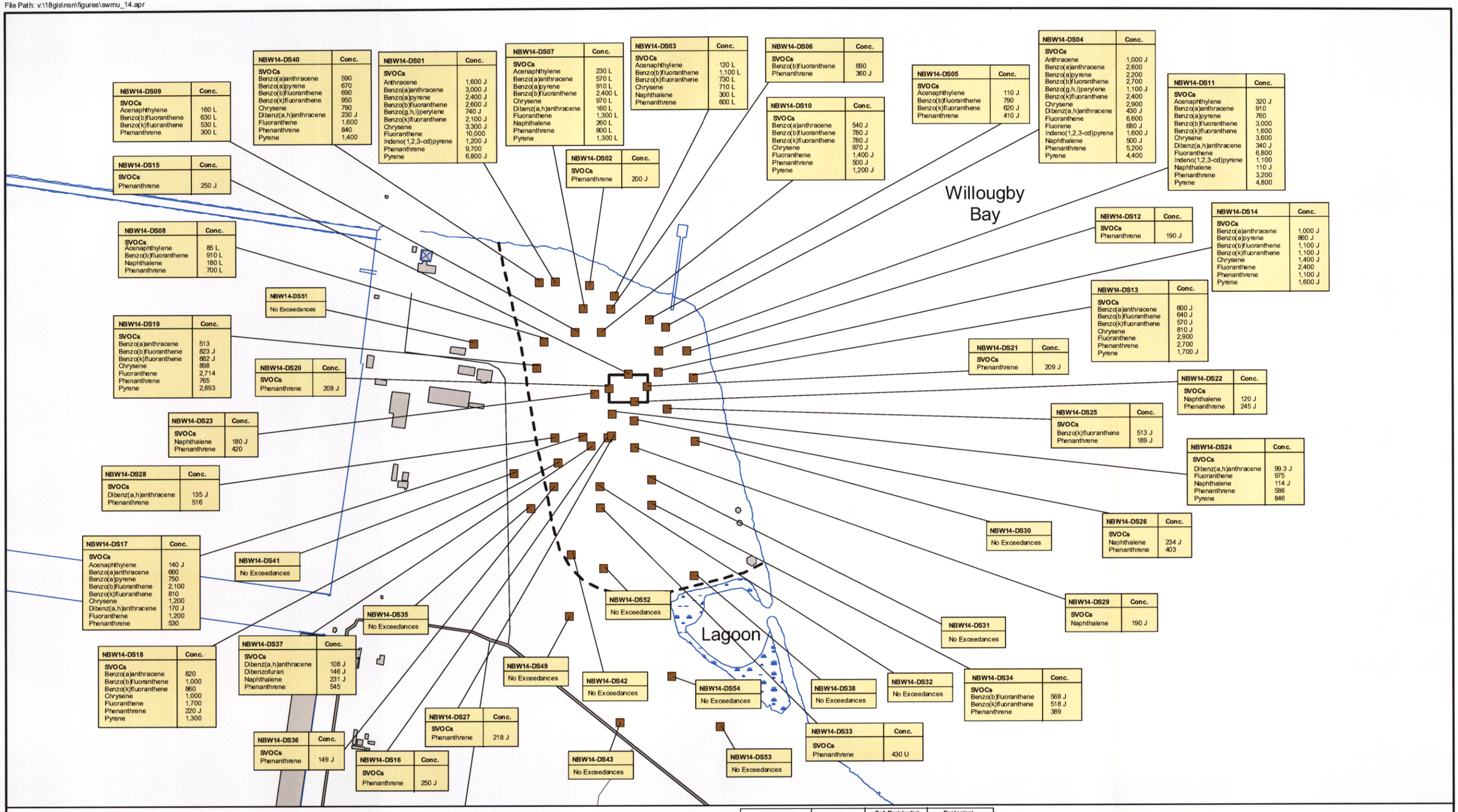

LEGEND

- Surface Soil Sample
- Shoreline
- Roads
- Buildings
- SWMU Boundary

Notes:
Units are in UG/KG.
J - value is estimated
L - value may be biased low

N

0 200 400 Feet

Chemical Name	Background	Soil Residential Adjusted RBC	Ecological Screening Value
SVOCs			
Acenaphthylene	- -	- -	100
Anthracene	491	2,300,000	100
Benzo(a)anthracene	490	870	100
Benzo(a)pyrene	490	87	100
Benzo(b)fluoranthene	490	870	100
Benzo(g,h,i)perylene	490	230,000	100
Benzo(k)fluoranthene	490	8,700	100
Chrysene	621	87,000	100
Dibenz(a,h)anthracene	- -	87	100
Dibenzofuran	- -	31,000	14,000
Fluoranthene	950	310,000	100
Indeno(1,2,3-cd)pyrene	660	870	100
Naphthalene	- -	160,000	100
Phenanthrene	- -	230,000	100
Pyrene	830	230,000	100

Figure 3-11
SVOCs Exceeding Surface Soil Screening Values
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

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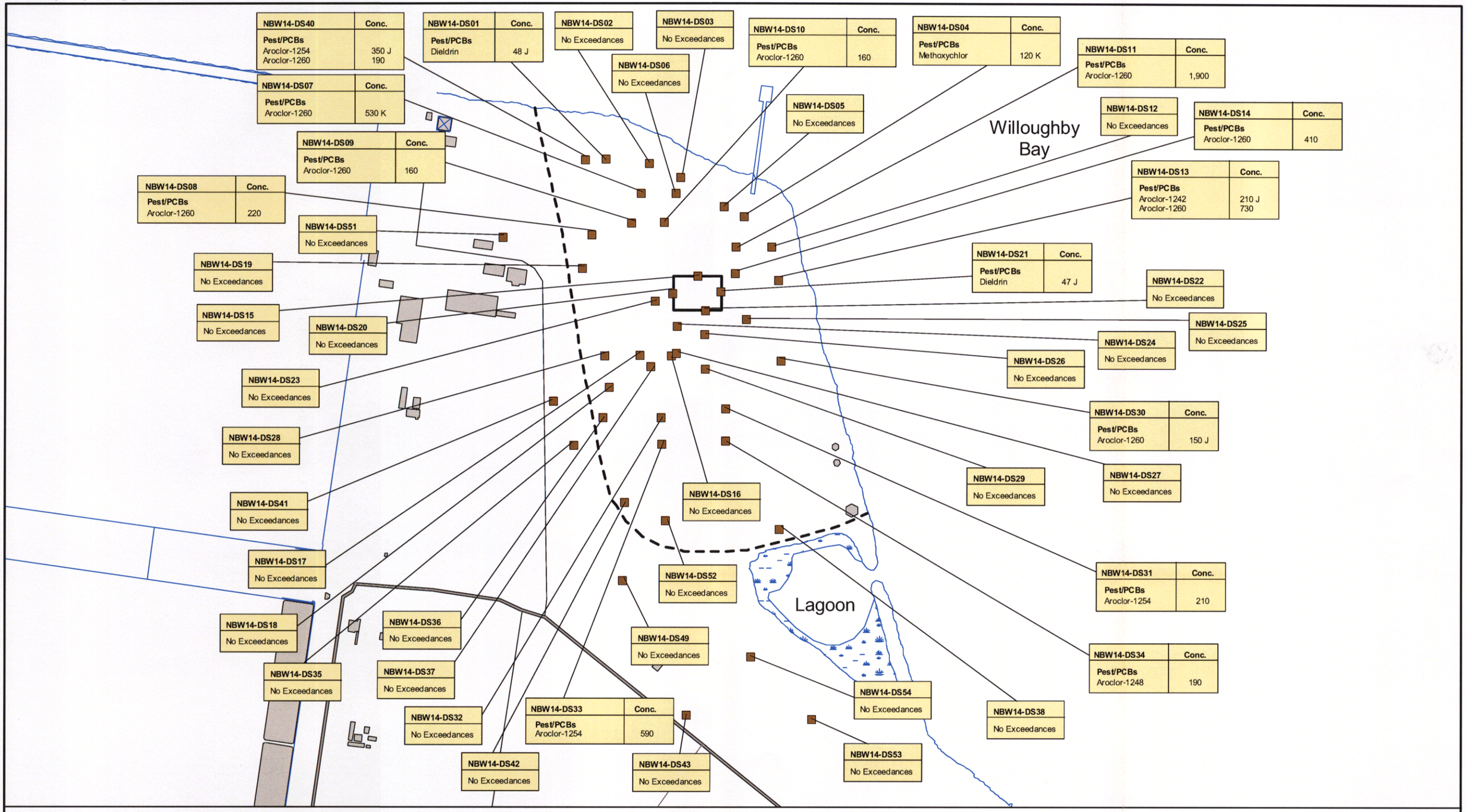

LEGEND

- Surface Soil Sample
- Shoreline
- Roads
- Buildings
- SWMU Boundary

Notes:
Units are in UG/KG.
J - value is estimated
K - value may be biased high

N

0 200 400 Feet

Chemical Name	Background	Soil Residential Adjusted RBC	Ecological Screening Value
Pest/PCBs			
Aroclor-1242	- -	320	100
Aroclor-1248	- -	320	100
Aroclor-1254	- -	160	100
Aroclor-1260	- -	320	100
Dieldrin	12.4	40	100
Methoxychlor	- -	39,000	100

Figure 3-12
Pest / PCBs Exceeding Surface Soil Screening Values
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

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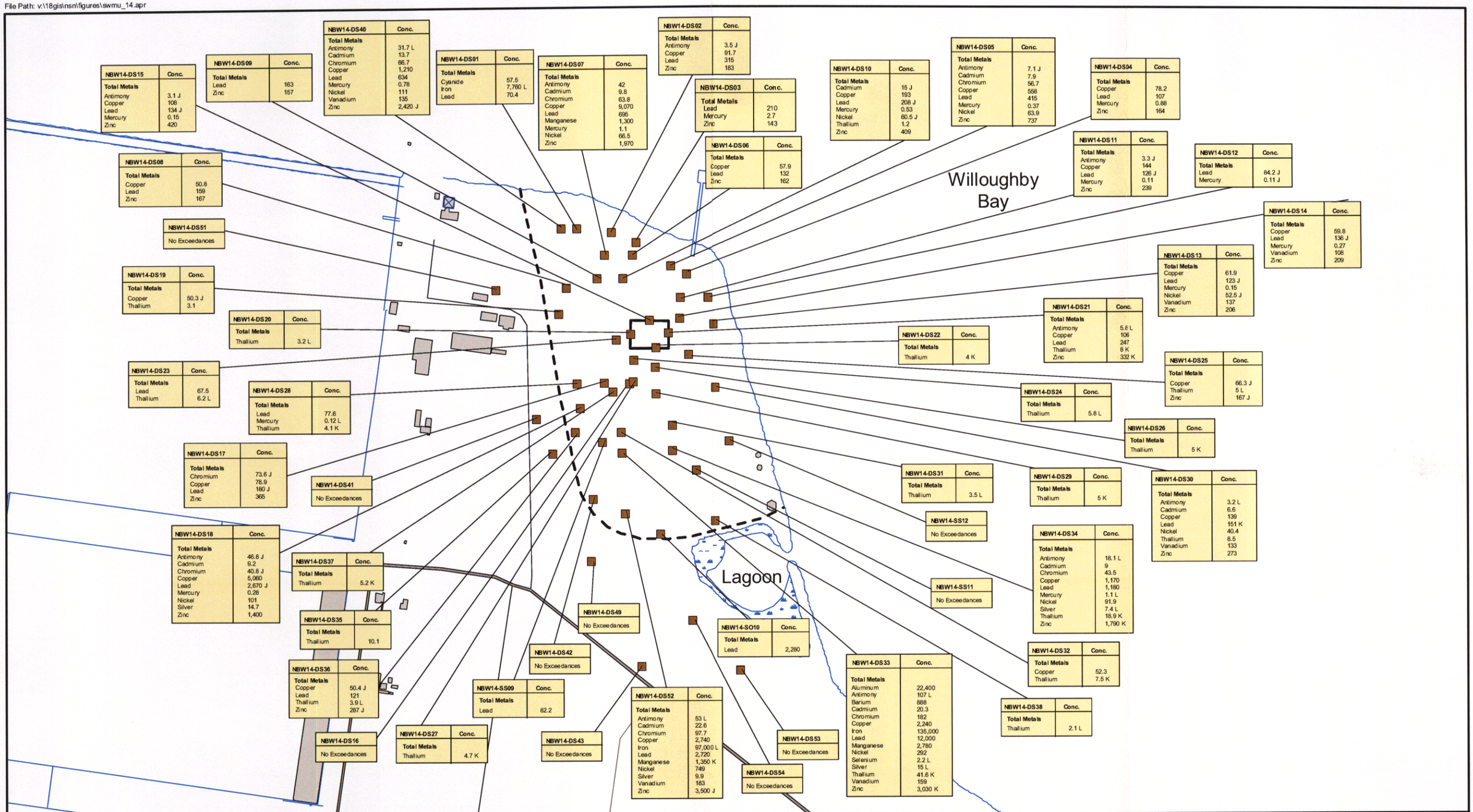

LEGEND

- Surface Soil Sample
- Shoreline
- Roads
- Buildings
- SWMU Boundary

Notes:
SS09 - SS12 were analyzed for Total Lead only.
Units are in MG/KG.
J - value is estimated
L - value may be biased low
K - value may be biased high

N

0 200 400 Feet

Chemical Name	Background	Soil Residential Adjusted RBC	Ecological Screening Value
Total Metals			
Aluminum	22,370	7,800	50
Antimony	1.2	3.1	5
Barium	67	550	440
Cadmium	0.2	3.9	4
Chromium	43	23	0.4
Copper	31	310	50
Cyanide	--	160	28
Iron	95,600	2,300	200
Lead	67	400	50
Manganese	1,240	160	330
Mercury	0.1	2.3	0.1
Nickel	40	160	30
Selenium	--	39	2
Silver	0.52	39	2
Thallium	ND	0.55	1
Vanadium	87	55	2
Zinc	142	2,300	50

Figure 3-13
Total Metals Exceeding Surface Soil Screening Values
SWMU 14 Remedial Investigation
Naval Station Norfolk
Norfolk, Virginia

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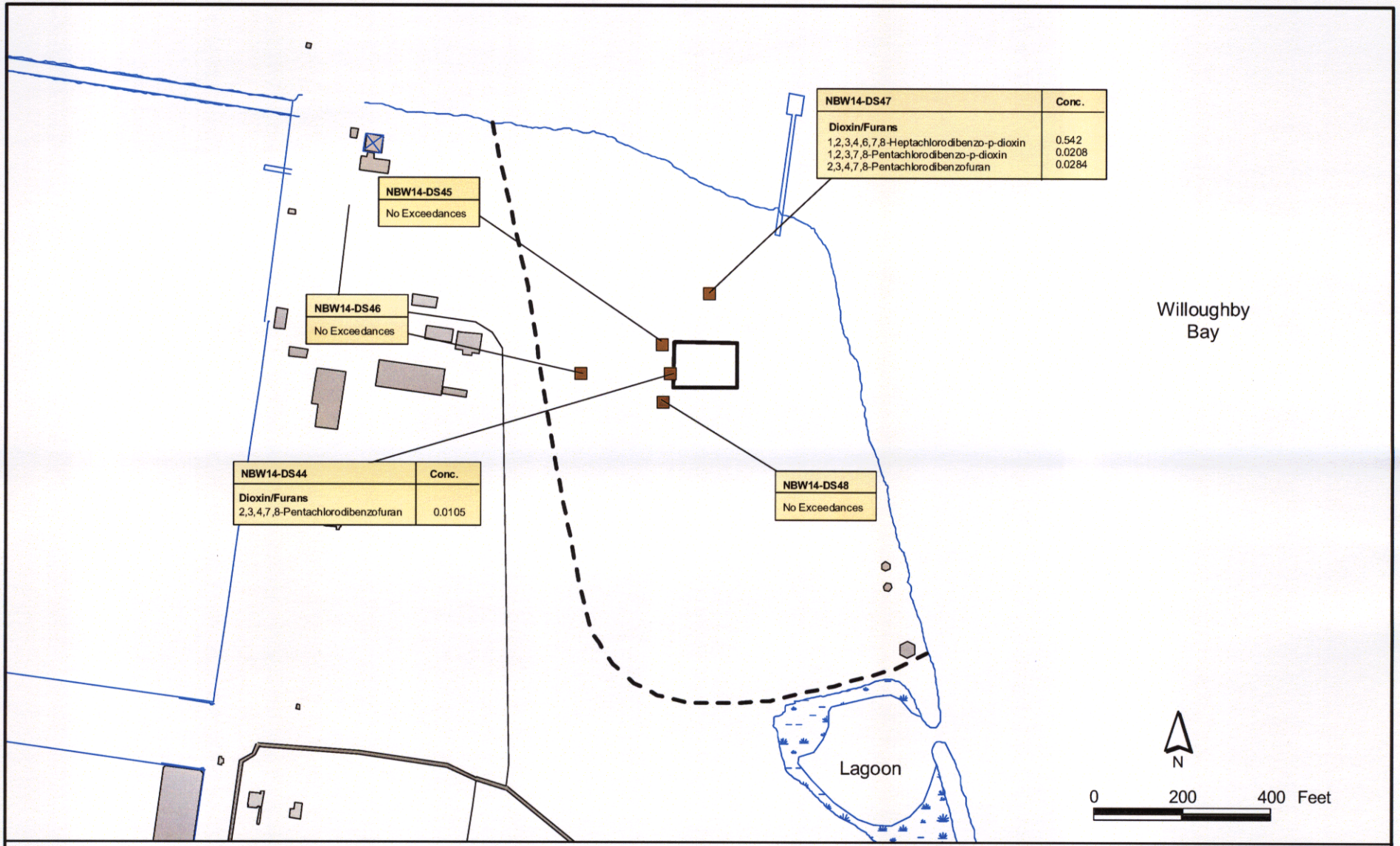
File Path: v:\18gis\nsn\figures\swmu_14.apr



LEGEND

- Surface Soil Sample
- Shoreline
- Roads
- Buildings
- SWMU Boundary

Notes:
Dioxin/Furan samples were collected during Phase III of the Remedial Investigation. Units are in UG/KG.

Chemical Name	Background	Soil Residential Adjusted RBC	Ecological Screening Value
Dioxin/Furans			
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	--	0.430	--
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	--	0.0085	--
2,3,4,7,8-Pentachlorodibenzofuran	--	0.0085	--

Figure 3-14
Dioxin/Furans Exceeding Surface Soil Screening Values
SWMU 14 Remedial Investigation
Naval Station Norfolk
Norfolk, Virginia

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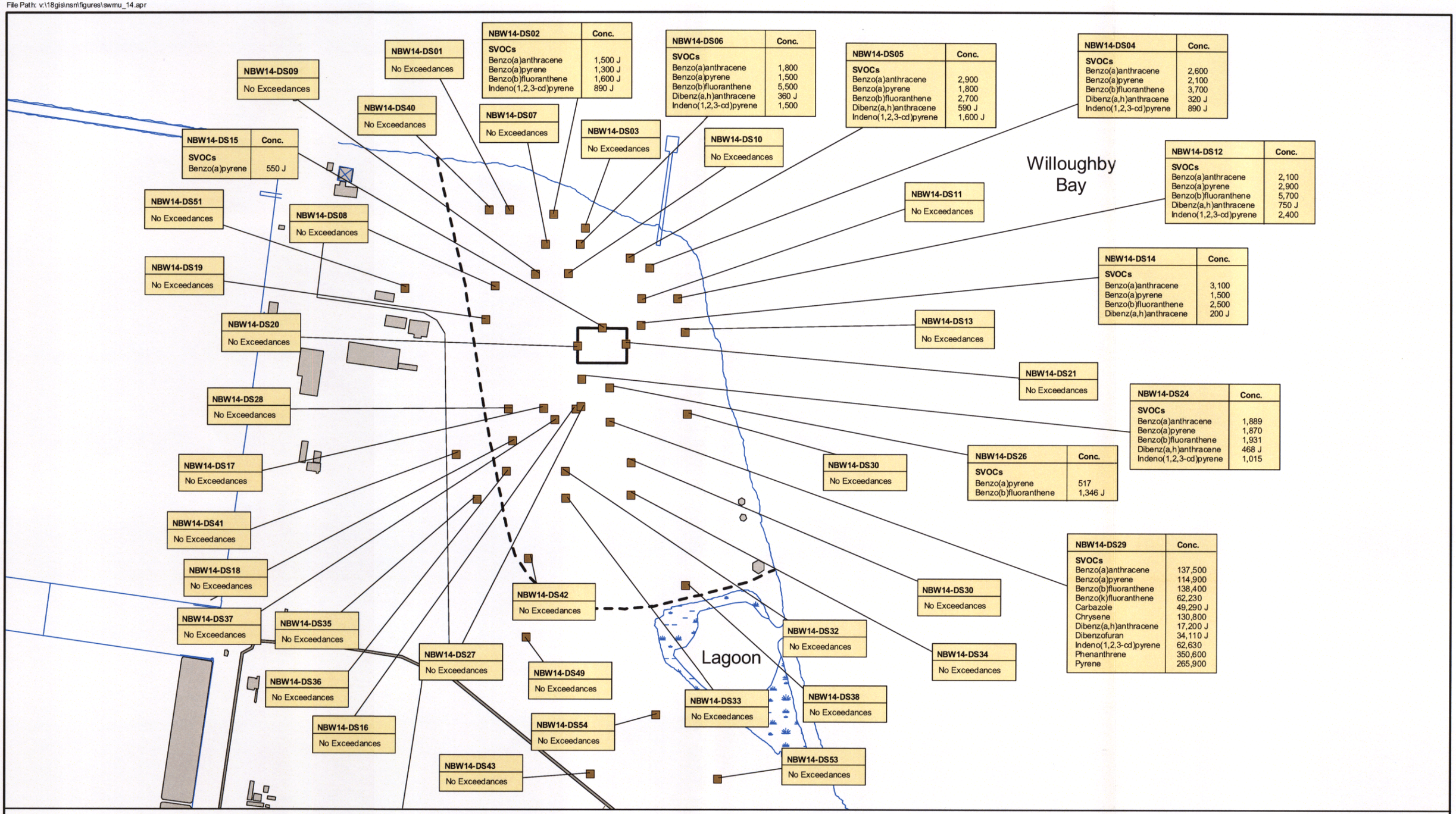

LEGEND

- Subsurface Soil Sample
- Shoreline
- Roads
- Buildings
- SWMU Boundary

Notes:
Units are in UG/KG.
J - value is estimated

N

0 200 400 Feet

Chemical Name	Background	Soil Residential Adjusted RBC
SVOCs		
Benzo(a)anthracene	490	870
Benzo(a)pyrene	490	87
Benzo(b)fluoranthene	490	870
Benzo(k)fluoranthene	490	8,700
Carbazole	--	32,000
Chrysene	621	87,000
Dibenz(a,h)anthracene	--	87
Dibenzofuran	--	31,000
Indeno(1,2,3-cd)pyrene	401	870
Phenanthrene	660	230,000
Pyrene	830	230,000

Figure 3-15
SVOCs Exceeding Subsurface Soil Screening Values
SWMU 14 Remedial Investigation
Naval Station Norfolk
Norfolk, Virginia

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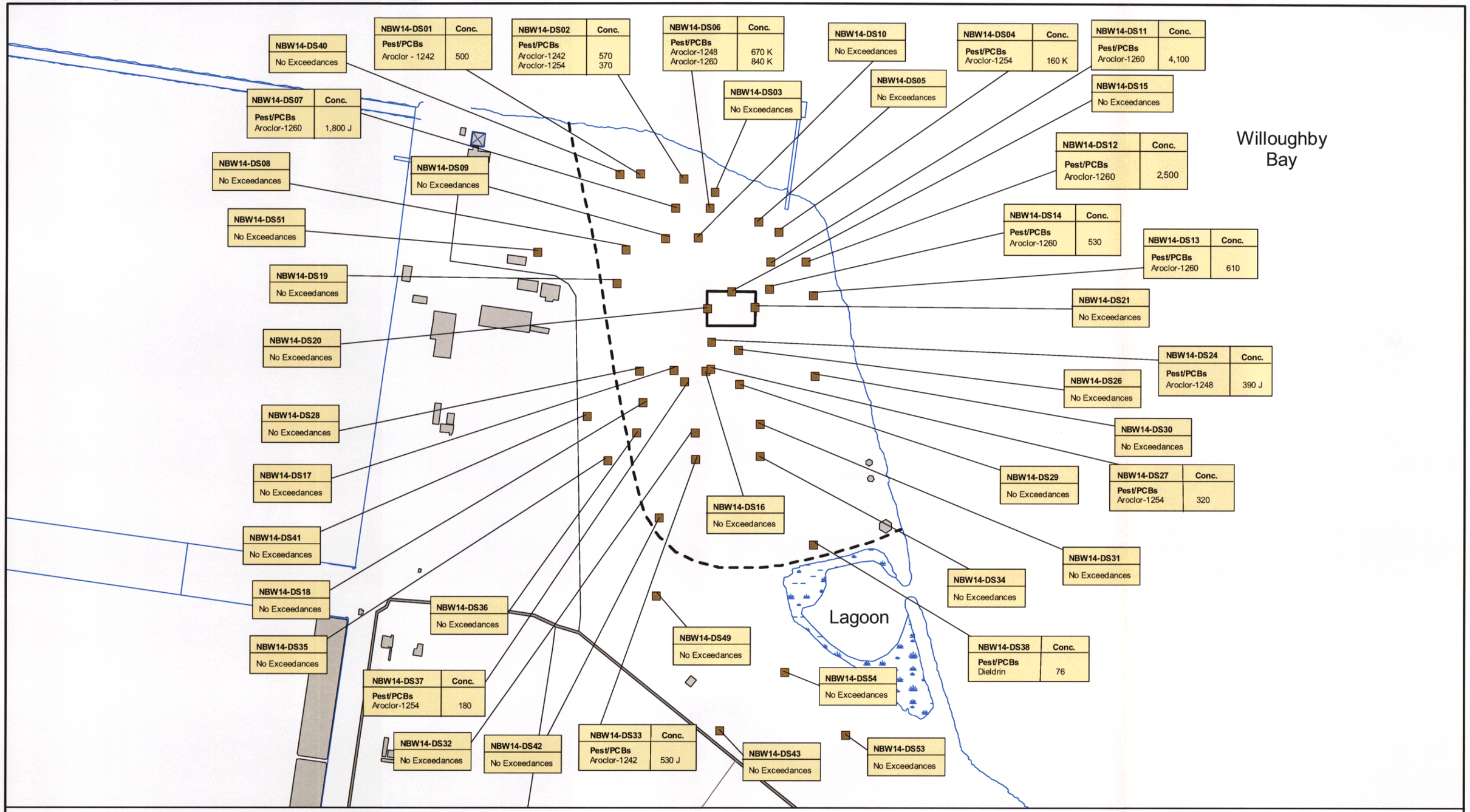

LEGEND

- Subsurface Soil Sample
- Shoreline
- Roads
- Buildings
- SWMU Boundary

Notes:
Units are in UG/KG.
J - vaule is estimated
K - value may be biased high

N

0 200 400 Feet

Chemical Name	Background	Soil Residential Adjusted RBC
Pest/PCBs		
Aroclor-1242	- -	320
Aroclor-1248	- -	320
Aroclor-1254	- -	160
Aroclor-1260	- -	320
Dieldrin	- -	40

Figure 3-16
Pest / PCBs Exceeding Subsurface Soil Screening Values
SWMU 14 Remedial Investigation
Naval Station Norfolk
Norfolk, Virginia

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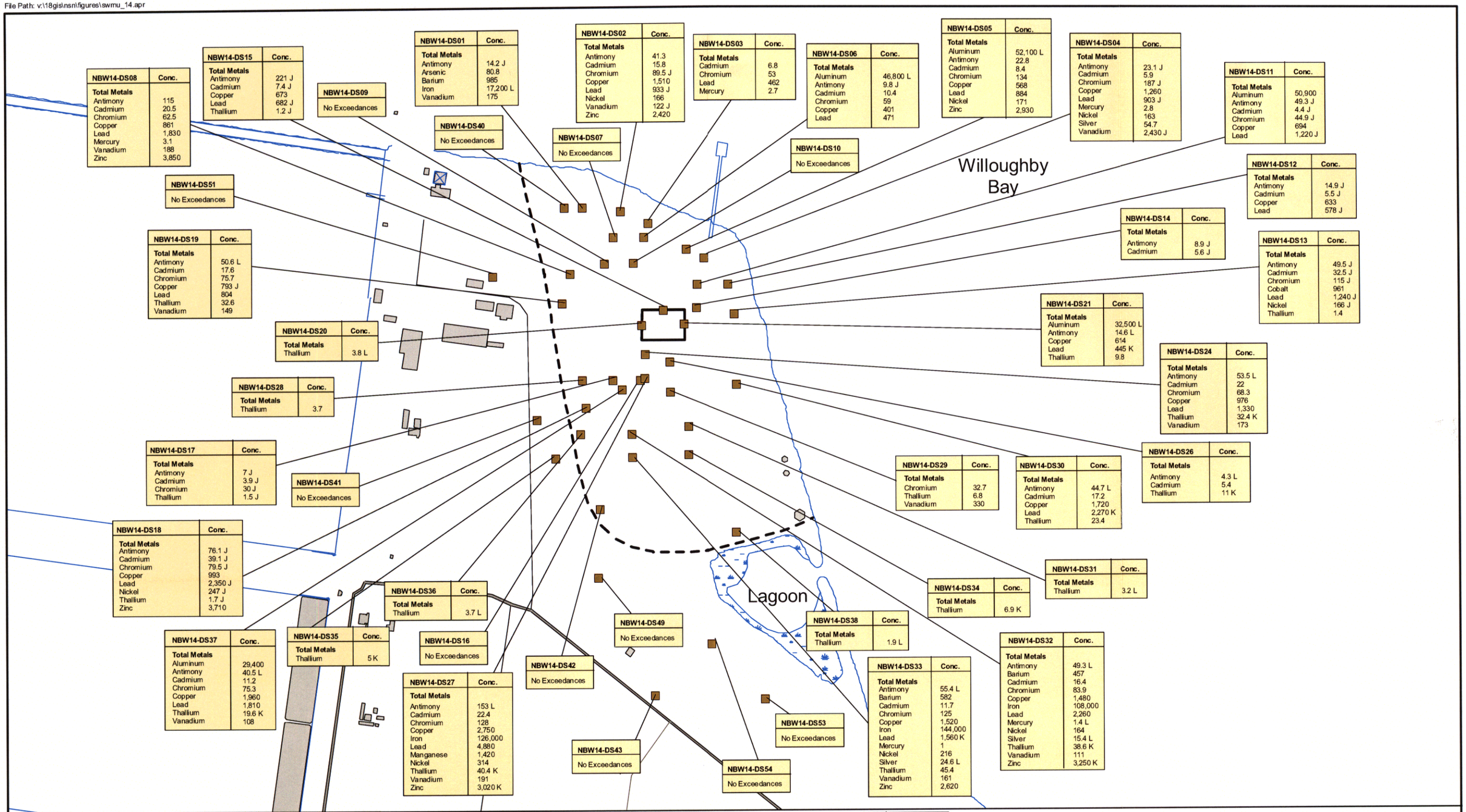

LEGEND

- Subsurface Soil Sample
- Shoreline
- Roads
- Buildings
- SWMU Boundary

Notes:
Units are in MG/KG.
J - value is estimated
L - value may be biased low
K - value may be biased high

N

0 200 400 Feet

Chemical Name	Background	Soil Residential Adjusted RBC
Total Metals		
Aluminum	22,370	7,800
Antimony	1.2	3.1
Arsenic	42.2	0.43
Barium	67	550
Cadmium	0.2	3.9
Chromium	43	23
Copper	31	310
Iron	96,600	2,300
Lead	67	400
Manganese	1,240	160
Mercury	0.1	2.3
Nickel	40	160
Silver	0.52	39
Thallium	ND	0.55
Vanadium	87	55
Zinc	142	2,300

Figure 3-17
Total Metals Exceeding Subsurface Soil Screening Values
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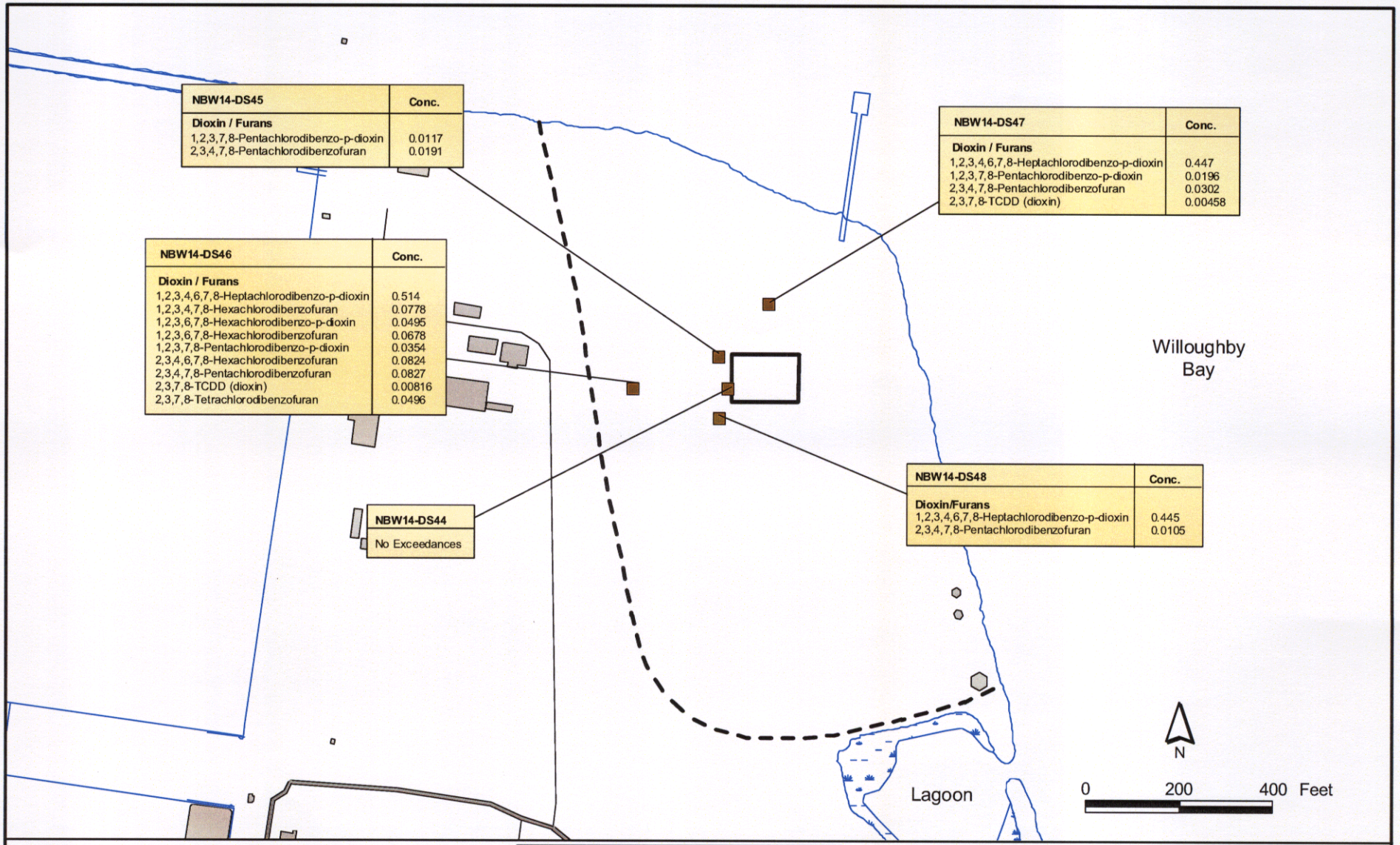

LEGEND

- Subsurface Soil Sample
- Shoreline
- Roads
- Buildings
- SWMU Boundary

Notes:
Dioxin/Furan samples were collected during Phase III of the Remedial Investigation.
Units are in UG/KG.

Chemical Name	Background	Soil Residential Adjusted RBC
Dioxin/Furans		
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	--	0.430
1,2,3,4,7,8-Hexachlorodibenzofuran	--	0.043
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	--	0.043
1,2,3,6,7,8-Hexachlorodibenzofuran	--	0.043
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	--	0.0085
2,3,4,6,7,8-Hexachlorodibenzofuran	--	0.043
2,3,4,7,8-Pentachlorodibenzofuran	--	0.0085
2,3,7,8-TCDD (dioxin)	--	0.0043
2,3,7,8-Tetrachlorodibenzofuran	--	0.043

Figure 3-18
Dioxin/Furans Exceeding Subsurface Soil Screening Values
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

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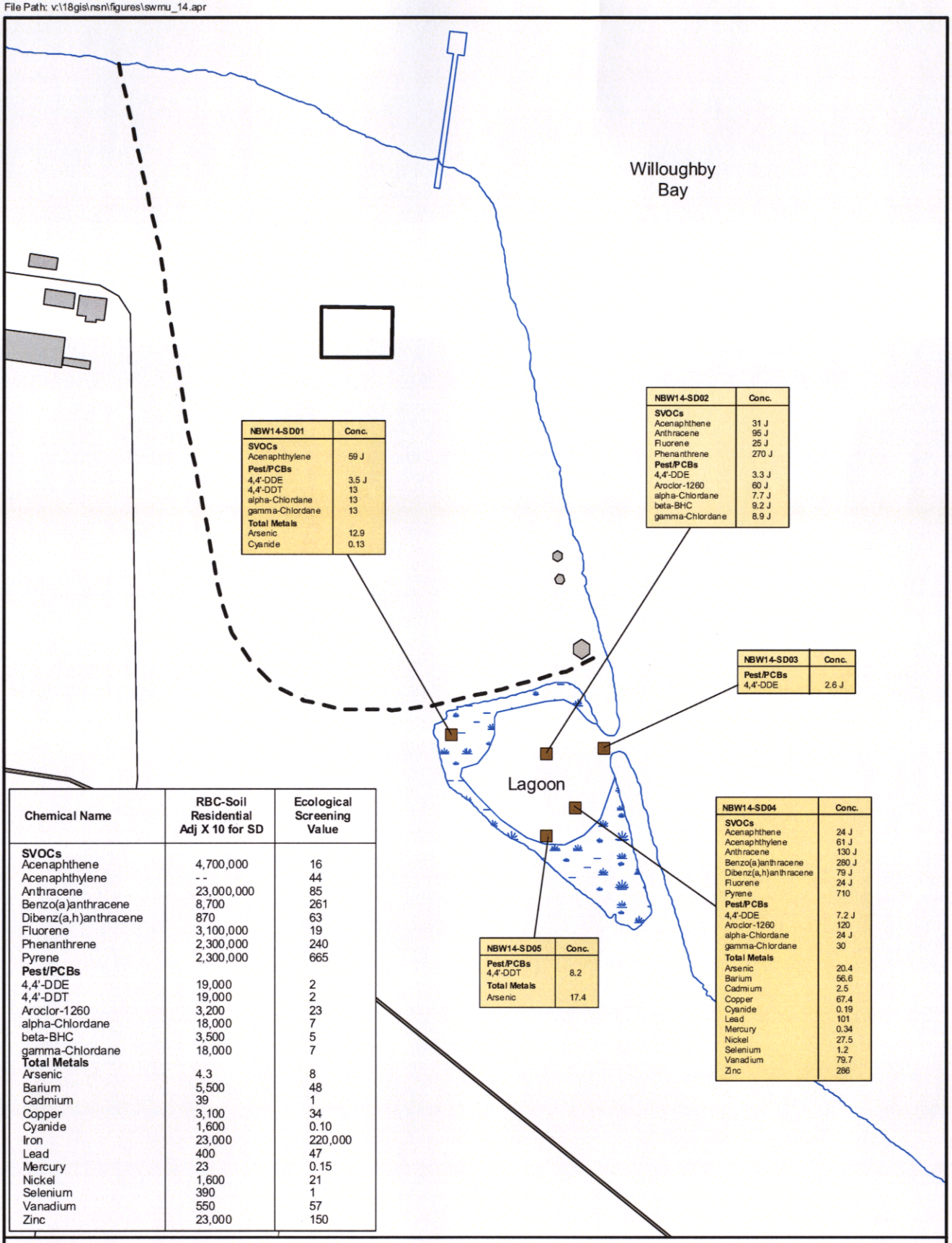

Chemical Name	RBC-Soil Residential Adj X 10 for SD	Ecological Screening Value
SVOCs		
Acenaphthene	4,700,000	16
Acenaphthylene	- -	44
Anthracene	23,000,000	85
Benzo(a)anthracene	8,700	261
Dibenz(a,h)anthracene	870	63
Fluorene	3,100,000	19
Phenanthrene	2,300,000	240
Pyrene	2,300,000	665
Pest/PCBs		
4,4'-DDE	19,000	2
4,4'-DDT	19,000	2
Aroclor-1260	3,200	23
alpha-Chlordane	18,000	7
beta-BHC	3,500	5
gamma-Chlordane	18,000	7
Total Metals		
Arsenic	4.3	8
Barium	5,500	48
Cadmium	39	1
Copper	3,100	34
Cyanide	1,600	0.10
Iron	23,000	220,000
Lead	400	47
Mercury	23	0.15
Nickel	1,600	21
Selenium	390	1
Vanadium	550	57
Zinc	23,000	150

LEGEND

- Sediment Sample
- Shoreline
- Roads
- Buildings
- SWMU Boundary

Notes:
SVOC units are in UG/KG.
Pest/PCB units are in UG/KG.
Total Metal units are in MG/KG.
J - value is estimated

N

0 200 400 Feet

Figure 3-19
Sediment Exceedances of Screening Values
SWMU 14 Remedial Investigation Report
Naval Station Norfolk
Norfolk, Virginia

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SECTION 4

Contaminant Fate and Transport

Environmental fate and transport of constituents that significantly contribute to overall human health and ecological risk were determined based on the screening discussed in Section 3. Section 4.1 and Appendix E present the constituent-specific fate and transport data for these constituents as available from Hazardous Substances Database (National Institutes of Health, 2002) and the specific scientific sources cited therein. Section 4.2 presents a conceptual fate and transport model for SWMU 14 based on this constituent-specific data and the site-specific physical characteristics. Section 4.3 summarizes the potential for offsite migration of site-related constituents.

4.1 Constituent-Specific Fate and Transport

The fate of SWMU 14 constituents is determined by their physical, chemical, and biological interaction with the environment. The mobility and persistence of chemicals in the environment are two key fate and transport characteristics. Mobility is the potential for a chemical to migrate from a site, and persistence is a measure of how long a chemical will remain in the environment. Environmental factors that affect the behavior of the contaminants are pH, concentrations of other contaminants in the media, soil moisture, oxidation-reduction potential (ORP), soil and water chemistry, soil-grain size, organic matter content, and the presence of microorganisms. Constituent-specific fate and transport data for COPCs identified in surface soil, subsurface soil, sediment, and groundwater at SWMU 14 are provided in Appendix E.

4.2 Conceptual Fate and Transport Model for SWMU 14

SWMU 14 consisted of a concrete pad surrounded by a grass-covered field. The pad served as a 90-day hazardous waste accumulation area. In addition, SWMU 14 is located on the Site 9 landfill, a manmade landmass formed from a construction debris landfill (as described in Section 1). Therefore, contaminants could have been introduced to the site via both surficial releases potentially associated with the site's use as an accumulation area, and subsurface deposition of landfilled materials throughout the Site 9 landfill.

The general contaminant profile consisting of 1) surficial contamination in the vicinity of SWMU 14; 2) laterally widespread surface and subsurface soil contamination within the Site 9 fill area; and 3) groundwater contamination at levels varying from relatively high to relatively low with no readily apparent single source pattern, indicates that the contaminant distribution is from several sources.

The fate and transport mechanisms active at the site will, therefore, fall into two general groups:

- **Processes active at the surface**—including volatilization to the atmosphere, uptake by plants, natural erosion of soil and plant material by wind and water, wet and dry deposition, and photolysis.
- **Processes active within the subsurface**—including volatilization to soil gas, percolation through the vadose zone, dissolution/precipitation, sorption/desorption, aqueous geochemical reactions, and groundwater flow.

4.2.1 Contaminant Source Areas

Based on the chemical and physical data collected for SWMU 14, it appears likely that both SWMU 14 and Site 9 were sources of contamination. This assessment is supported by the laterally widespread presence of metals and PAHs in both the surface and subsurface soil samples that does not exhibit a clear pattern of a single source of contaminants originating from either site. In addition, the pattern of sporadically high PAH concentrations within the surface and subsurface soils northwest, northeast, and south of SWMU 14 are more indicative to fill material as opposed to surface releases at SWMU 14. Further, PCBs occur more frequently and at higher concentrations in subsurface soil than in surface soil, which may indicate that PCB-contaminated material was placed at depth during disposal of fill at the site. As discussed in Appendix E, PCBs are not expected to leach from the surface to the subsurface.

4.2.2 Releases from Soil to Groundwater

Metals can move from surface soil to subsurface soil and/or groundwater by precipitation-induced leaching (especially if precipitation is acidic). However, PAHs, PCBs, and dioxins/furans are not expected to readily leach to the subsurface from surface soil, and are expected to remain near their point of release.

Metals in subsurface soil have the potential to leach to groundwater. PAHs, dioxins, and furans in subsurface soil are not expected to leach to groundwater or volatilize to soil gas because of their low mobility. However, naphthalene, which is slightly more mobile in the subsurface than other PAHs at the site, may be leachable. Naphthalene is detected at elevated levels in groundwater samples at the site's southern border near the lagoon. Certain PAHs, including naphthalene, may biodegrade at the site.

As described in Section 3, a petroleum sheen was observed in borehole DS19. However, no measurable amount of LNAPL was observed in monitoring well MW09 (located approximately 5 ft from borehole DS19). In addition, the constituents detected in well MW09 and borehole DS19 do not reflect the presence of free product, indicating that it does not have a significant impact on site contamination.

4.2.3 Releases from Soil to Atmosphere, Surface Water, and Sediment

Metals, PAHs, PCBs, and dioxins/furans are likely to be sorbed with the surface soil particles. Therefore, the only release mechanism to the atmosphere that could be significant is the entrainment of dust in wind. In addition, surface soil particles sorbed with contaminants could be transported offsite by surface runoff or erosion to impact adjacent surface

waters and sediments in the lagoon and Willoughby Bay. However, the site is vegetated and has little relief, minimizing the risk of runoff transport of surface soil particles. The sediment samples collected in the adjacent lagoon detected PAHs, pesticides/PCBs, and metals in exceedance of the screening criteria. In addition, a surface water sample showed an exceedance for cadmium. However, the storm sewer that discharges into the lagoon drains much of the northwestern portion of Naval Station Norfolk. Therefore, it is difficult to determine the sources of the contaminants detected in the sediment and surface water within the lagoon.

4.2.4 Migration of Contaminants in Groundwater

The uppermost aquifer at the site is unconfined with a depth to water of about 6.5 to 9.5 ft bgs. The shallow depth to water and lack of an upper confining unit increase the importance of the groundwater pathway as a transport mechanism. Leaching will be more significant because percolating fluids have decreased downward travel distances, which decreases the ability of the intervening soil to attenuate potential contaminants leached from above.

4.2.4.1 Discussion of Groundwater Field Parameters

Groundwater at the site has a pH range of 7.3 to 9.8 (slightly alkaline to alkaline), which will generally inhibit the leaching of metals that are more soluble in acidic conditions.

Groundwater at the site has an oxidation reduction potential (ORP) range of -119 to 32 millivolts, which indicates reducing to slightly oxidizing conditions (only one groundwater sample had a positive ORP value—MW16S). Other groundwater samples had negative ORP values, indicating that the site's groundwater conditions are largely reducing. Under reducing conditions, certain metal cations (e.g. chromium, iron and zinc) may precipitate from solution to form immobile sulfide deposits, while others (such as arsenic and manganese) will be more mobile due to increased solubility of the reduced oxidation state. This may, in part, explain the relatively high concentrations and frequency of detection of manganese and arsenic (respectively) in certain areas of the site.

The dissolved oxygen range is 0.04 to 9.57 milligrams per liter (μg/L), indicative of reducing conditions to oxidizing conditions. These results do not correspond with the ORP measurements that characterize the site as reducing with only slightly oxidizing conditions. The elevated dissolved oxygen in certain samples may be the result of inaccuracy of the field measurement instruments.

Specific conductance range for groundwater at the site is 1.7 to 20.4 microseimens per centimeter (μS/cm) and shows a very strong correlation (R=0.99) with salinity; conditions that reflect the site's proximity to the saline environment of the bay.

Turbidity range is 0 to 74 Nephelometric Turbidity Units (NTU), which indicates low to moderate potential for colloidal transport. Colloidal transport would increase the mobility of relatively insoluble constituents such as PAHs or PCP.

4.2.4.2 Conceptual Model of Contaminant Transport

As described in Section 3, the groundwater level data indicates that the water table is at its highest elevation at a location just west of SWMU 14. Groundwater from this location flows east, north, and west in a radial pattern.

The most significant pattern of contamination in the groundwater is the prevalence of VOCs and SVOCs across the site. VOC exceedances were not observed in the surface or subsurface soil samples. Benzene exceedances occurred at the majority of the monitoring wells within the fill area, and vinyl chloride exceedances are observed in the site's northern half. Other VOC contaminants at the site tend to be scattered with no apparent pattern. In addition, the concentrations of metals as well as trace levels of VOCs and SVOCs observed in the downgradient monitoring wells may indicate possible migration of these contaminants from the site.

Based on the conceptual groundwater flow and groundwater flow velocities ranging from 56 to 209 ft per year, it is likely that groundwater discharge occurs to the dredge fill material to the west as well as north and east towards Willoughby Bay. Due to the site's close proximity to the bay, the groundwater flow is likely within a groundwater discharge area. As a result, the contaminant migration is likely either lateral to the Bay or upward from the deep groundwater.

4.3 Potential for Migration Offsite

Due to the shallow depth to water and the site's proximity to the Bay, groundwater flow represents the most significant potential offsite transport mechanism. Constituents that could be transported offsite via groundwater flow include those constituents dissolved in groundwater. Dissolved contaminants of concern (COCs) include iron, manganese, arsenic, barium, thallium, naphthalene, 2-methylnaphthalene, 4-methylphenol, pentachlorophenol, and dibenzofuran. However, colloidal transport is expected to be insignificant due to low turbidity values.

Airborne or waterborne surface soil particles with sorbed metals, PAHs, PCBs or dioxins/ furans may represent a secondary, less significant offsite transport mechanism for certain site constituents.

4.4 References

National Institutes of Health. Hazardous Substances Database, http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB. 2002.

SECTION 5

Human Health Risk Assessment

This section presents the results of an assessment of potential human-health risks associated with the presence of potentially site-impacted soil, groundwater, surface water, and sediment at SWMU 14. Analytical results from surface soil, subsurface soil, groundwater, surface water, and sediment were used to examine the potential risks to human health. This baseline human health risk assessment (HHRA), which characterizes the current and potential future human health risks at the SWMU if no additional remediation is implemented, was conducted to assess the potential human health impacts from the site under current conditions, as well as to determine if any further actions are needed to sufficiently protect human health. This risk assessment has been prepared utilizing conservative assumptions, and all feasible exposure pathways have been considered based on current site conditions and current and potential future site usage. The risk assessment incorporates the general methodology described in Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Part A (USEPA, December 1989) and Part D (USEPA, December 2001), USEPA Region III Technical Guidance Manuals for Risk Assessment and Naval Station Norfolk Consensus Agreements (Naval Base Norfolk Partnering Team, 1998).

5.1 Overview of SWMU

SWMU 14 is located in the northeastern corner of Sewell's Point at NSN. The site consisted of a concrete storage pad surrounded by a grass-covered field. The pad served as a 90-day hazardous waste accumulation area where wastes generated through various streams, were processed (sampled, identified, labeled, and packaged) before being shipped to storage and eventual disposal sites. In addition, the peninsula at Sewell's Point is a man-made landmass formed from two distinct periods of fill activities. The first began in the early 1950s, when the channels were dredged to allow for construction of the northernmost series of piers at the site. The resulting dredge material was used to create much of the land at Sewell's Point. The second occurred between 1974 and 1978, when the site's eastern portion was formed from the disposal of construction debris. This landfill was later designated as Site 9, Q-Area Landfill. Site 9 was recommended for No Further Action (Baker Environmental, Inc., December 1997); however, because Site 9 and SWMU 14 are co-located, both sites were evaluated as part of this investigation.

5.2 Scope of Human Health Risk Assessment

The HHRA for SWMU 14 includes the following components:

- **Identification of Chemicals of Potential Concern (COPCs)**—identifies and characterizes the distribution of COPCs found onsite. Chemicals identified in this screening are the focus of the subsequent evaluation in the risk assessment.

- **Exposure Assessment**—identifies potential pathways by which exposure could occur, characterizes the potentially exposed populations (e.g., workers, residents, and trespassers) and estimates exposure magnitude, frequency, and duration.
- **Toxicity Assessment**—identifies the types of adverse health effects associated with exposure to COPCs along with available toxicity factors (e.g., cancer slope factors and reference dose values), and summarizes the relationship between magnitude of exposure and occurrence of adverse health effects. It also identifies related uncertainties (such as the weight-of-evidence of a particular chemical carcinogenicity in humans) associated with these values.
- **Risk Characterization**—integrates the exposure and toxicity assessments results to estimate the potential risks to human health. Both cancer and non-cancer human-health effects are evaluated. Pathways that pose an unacceptable risk based on quantitative risk characterization are identified.
- **Uncertainty Assessment**—identifies sources of uncertainty associated with the data, methodology, and the values used in the risk assessment estimation.

All of the above components were evaluated following Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulations, using USEPA risk assessment guidance (USEPA, December 1989).

5.3 Data Summary

CH2M HILL collected data during three RI phases as described in Section 2. During the investigations, 18 monitoring wells were installed and the samples were analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs and TAL metals (total and dissolved). Fifty-six surface soil, 48 subsurface soil, five sediment, and one surface water sample were collected. Table 5-1 summarizes the samples collected and the corresponding parameters analyzed for each. Sampling efforts were conducted to characterize the source(s) and downgradient extent of contamination.

Figures 2-1 through 2-3 identify the locations of the samples collected at SWMU 14.

5.4 Identification of Chemicals of Potential Concern

The identification of COPCs includes data collection, evaluation, and screening steps. The data collection and evaluation steps involve gathering and reviewing the available site data and identifying a set that is of acceptable quality for use in the risk assessment. This data set is then further screened against concentrations protective of human health to reduce the data set to those chemicals and media of potential concern. The data used for the quantitative risk analysis were all validated prior to use in the risk assessment.

Subsection 5.4.1 discusses the selection of data used for the quantitative risk assessment. The data were selected from the set of validated data determined usable for risk assessment. Subsection 5.4.2 discusses the methodology used to further reduce the risk assessment data set to the constituents and media of primary concern to human health and also identifies the COPCs that were quantitatively assessed in the risk assessment.

5.4.1 Data Evaluation and Selection

Data were collected during the three phases of the RI. Data are available for contaminant levels in soil, groundwater, surface water, and sediment. Detailed results of the sampling and monitoring programs for the sites are presented in Section 3 of this RI Report.

Available data were reviewed to determine their reliability for the quantitative risk assessment. A review of the data identified the following items for data usability and data handling:

- Estimated values flagged with a J qualifier were treated as detected concentrations.
- Data qualified with an R (rejected) were not used in the risk assessment or included in the total count of samples analyzed for a constituent.
- Data qualified with a B (blank contamination) were used in the risk assessment as if they were non-detected, with the blank-related concentrations of each constituent used as the sample quantitation limit (SQL). One-half of the blank-related concentrations were used to calculate exposure point concentrations in the risk assessment.
- For duplicate samples, the higher of the two concentrations was used as the sample concentration.
- One-half the SQL was used as the sample concentration for samples with no detectable contaminant quantities if the contaminant was detected in other samples from that medium. Constituents that were not detected in any samples in a given medium were eliminated from consideration.

5.4.2 Selection of Chemicals of Potential Concern

All of the constituents detected in soil and groundwater were screened following the general approach presented in the Naval Station Norfolk Consensus Agreements (Naval Base Norfolk Partnering Team, 1998) supplemented by the current risk assessment guidance. Surface water and sediment data were screened following standard USEPA Region III procedures, as discussed below. The COPC selection process was conservative to ensure the selection of all appropriate constituents. The maximum-detected concentration of each constituent in each medium was compared to a screening value to select the COPCs. If the maximum concentration of a constituent exceeded the screening value, the constituent was selected as a COPC and retained for the risk evaluation. The COPC screening is presented in Appendix F, Table 2's.

Constituents detected in each media were screened to select the COPCs based on the following procedures:

- **Comparison with Risk-Based Concentrations:** The maximum detected chemical concentrations in groundwater, soil, surface water, and sediment were compared with the risk-based concentrations (RBCs) in USEPA's Region III Updated Risk-Based Concentration Table (USEPA, April 2004). The screening-level RBCs for noncarcinogens were adjusted to reflect a target hazard quotient of 0.1. The screening-level RBCs for carcinogens are based on a target cancer risk of $1x10^{-6}$ and were not adjusted from the values presented in the RBC table.

- Groundwater data were screened using the tap water RBCs. Surface and subsurface soil data were screened against the residential soil ingestion RBCs. Constituents identified as COPCs in soil were also selected as COPCs for the soil-to-air pathway (Appendix G, Table 2.2). Sediment data were screened using a value of 10 times the adjusted residential soil ingestion RBCs, an approach generally accepted by USEPA Region III. Surface water data were screened against a value of 10 times the adjusted tap water RBCs, an approach also generally accepted by USEPA Region III.

  There are no published dose-response values for assessing the risks associated with exposure to lead. USEPA has presented guidance on evaluating lead concentrations in both soil and water. Lead concentrations of less than 0.015 µg/L (15 ppb) in groundwater (the Safe Drinking Water Act action level for lead in potable water) and less than 400 µg/kg in soil are considered adequately protective of human health under residential land-use conditions. Exceedance of these values prompts further evaluation to assess the potential for human-health impacts. The lead soil-screening level was used to screen the soil and sediment data. The lead groundwater-screening level was used to screen the groundwater and surface water data.

- **Comparison with Soil Screening Levels based on Soil to Groundwater Transport for Subsurface Soil:** The maximum detected soil concentrations (subsurface soil) were compared to the current USEPA Region III Soil Screening Levels (SSLs), based on a Dilution and Attenuation Factor (DAF) of 20, to determine if soil is a potential concern based on the transport of constituents from soil to groundwater (USEPA, September 2001). SSLs that are based on noncarcinogenic effects were divided by 10 to account for exposure to multiple constituents. SSLs for carcinogens are based on a target cancer risk of $1x10^{-6}$ and were not adjusted from the values presented in the RBC table. Constituents with a maximum detected concentrations greater than their respective SSL were identified as COPCs for the transport from soil to groundwater pathway, but not for the direct contact with soil pathway.

- **Comparison with Recommended Dietary Allowances:** Constituents that are human nutrients when present at low concentrations (i.e., only slightly elevated above naturally occurring levels), and toxic only at very high doses, were eliminated from the quantitative risk analysis. These constituents are calcium, magnesium, potassium, and sodium. Although iron is also considered an essential nutrient and is toxic at high doses (NAS, 1989), iron was handled the same way as other detected constituents in the HHRA because provisional human health-based screening levels are available for iron. However, the use of provisional toxicity factors increases the uncertainty associated with the quantitative risk evaluation.

The COPCs identified for each medium are shown on Table 5-2 and Appendix F, Table 3s.

5.5 Exposure Assessment

Exposure refers to the potential contact between an individual and a chemical. Exposure assessment has three components:

- Characterization of the exposure setting
- Identification of exposure pathways

- Quantification of exposure

The exposure assessment identifies pathways and routes by which an individual may be exposed to the COPCs and estimates the magnitude, frequency, and duration of potential exposure. The magnitude of exposure is determined by estimating the amount of a constituent available at the exchange boundaries (i.e., the lungs, gastrointestinal tract, and skin). Chemical intakes and associated health risks are only quantified for complete exposure pathways.

5.5.1 Characterization of Exposure Setting

Characterizing an exposure setting consists of two parts: (1) presenting the site's physical characteristics as they relate to exposure, and (2) characterizing human populations on or near the site.

5.5.1.1 Physical Characteristics

Basic site characteristics such as physical setting, climate, groundwater hydrology, and the presence and location of surface water are summarized in Section 3.

5.5.1.2 Potentially Exposed Populations

Potentially exposed populations are identified based on their locations relative to the site, their activity patterns, and the presence of potential sensitive sub-populations.

SWMU 14 is a vacant grass covered lot sometimes used as a temporary parking lot when the adjacent lots are full. The original concrete pad designated as SWMU 14 has been removed; however the existing concrete pad at the site occasionally serves as a temporary (<90 days) storage area for IDW from various site investigations. The only projected future use is to either develop the property for ball fields or pave over the grass field and convert the area into a parking lot. It is highly unlikely that the site will ever be converted to residential land use. For purposes of performing the risk characterization, exposure to the site soil was evaluated for potential residential, recreational, industrial, and commercial site use. Receptors evaluated included child and adult residents, adult industrial workers, adult construction workers, youth and adult trespassers, and child and adult recreational users. Assuming no action is taken at the site prior to development, exposure to affected surface soil could occur as a result of incidental ingestion, dermal contact, or inhalation of fugitive dust. The receptors could also be exposed to the subsurface soil if future construction work results in disturbance of the soil column.

Additionally, future child and adult recreational users may contact the surface water and sediment in the constructed wetland lagoon south of SWMU 14. Exposure to surface water and sediment could occur through incidental ingestion and dermal contact.

Groundwater is not currently used (and will not be used) as a potable water supply in the foreseeable future. The City of Norfolk Health Department prohibits the use of groundwater for public or private potable water supplies under law ordinance Chapter 46.1, Reference 46.1-5. The City of Norfolk supplies all potable water used in the city limits. Therefore, there is no potential direct exposure to groundwater. However, to provide a conservative assessment of the site's groundwater quality at the site and for the purposes of risk characterization, the groundwater was evaluated for future residential potable use.

Exposure to groundwater for residents was evaluated through ingestion of potable water, dermal contact while bathing, and inhalation of VOCs while showering. It is also possible that construction workers may come in contact with the groundwater during construction or excavation activities. Exposure to construction workers could occur as a result of inhalation of volatiles and dermal contact with the groundwater.

5.5.2 Identification of Exposure Pathways

An exposure pathway can be described as a mechanism that moves a COPC from its source to receptors, which may mean an exposed population or an individual. An exposure pathway must be complete or exposure cannot occur. A complete exposure pathway has five elements:

- A source (e.g., chemical residues in soil)
- A mechanism for release and migration of chemical (e.g., leaching)
- An environmental transport medium (e.g., surface water)
- A point or site of potential human contact (exposure point, e.g., drinking water)
- A route of intake (e.g., ingestion of surface water used as a drinking water source)

All five must be present for a pathway to be considered complete.

Contaminant Sources. Contaminant sources at SWMU 14 include potentially contaminated soil due to the use of the site as a 90-day hazardous waste-accumulation area and contaminated fill from disposal activities at the Site 9 landfill. Other sources of contaminants include groundwater, surface water, and sediment that may have been contaminated through leaching from the soil or from historic releases of waste into these media.

Release and Transport Mechanisms. The fate and transport of chemicals in soil and groundwater were qualitatively evaluated for their potential release to the subsurface soil, groundwater, runoff to the surface water bodies, or groundwater release to the surface water. Section 4 includes a detailed description of the fate and transport analysis of the site contamination.

The primary transport mechanism from sources at SWMU 14 is the leaching of contaminants through soil to groundwater, followed by downward-gradient transport in groundwater. COPCs in groundwater were evaluated directly from concentrations detected in the monitoring wells at the site. A mathematical model was used to estimate the concentrations of chemicals volatilizing from groundwater used in showers (hypothetical future land use) and volatilization from groundwater in open excavations.

Fate-and-transport modeling was conducted to determine contaminant concentrations in fugitive dust emissions from soil. Transport modeling for chemical volatilization from soil was not conducted because there were no volatile constituents selected as COPCs for soil.

Direct contact with COPCs in soil, groundwater, surface water, or sediment (i.e., ingestion or dermal contact) does not require fate-and-transport modeling. In these pathways, the receptor is assumed to be exposed at the location of the source of the COPC.

Potential Exposure Points and Exposure Routes. Exposure points are locations where humans could come in contact with contamination They include the inhalation of fugitive

dust at the site, incidental ingestion of (and dermal contact with) soil, groundwater, surface water, and sediment, and inhalation of volatiles from groundwater at SWMU 14.

Potential exposure routes are evaluated for both current and potential future site use. Exposure scenarios and potentially complete pathways of exposure quantitatively evaluated in this risk assessment are presented in Table 5-3. Figure 5-1 summarizes the conceptual site model for SWMU 14.

Current Site Use. As mentioned earlier, SWMU 14 is currently a vacant grass-covered lot sometimes used as a temporary parking lot when the adjacent lots are full. The original concrete pad designated as SWMU 14 has been removed; however the existing pad at the site occasionally serves as a temporary (<90 days) storage area for IDW from various site investigations. Access to the site is not restricted to base personnel. Therefore, the potential current receptors include adolescent and adult trespassers as well as site industrial workers who may contact the surface soil.

- Industrial Workers: inhalation of fugitive dust from surface soil; incidental ingestion of, and dermal contact with surface soil.
- Trespassers (adolescent and adult): incidental ingestion of and dermal contact with surface soil.

Inhalation of fugitive emissions from surface soil is not expected to result in significant exposure to the trespasser due to the short exposure duration at the site, and therefore was not quantitatively evaluated in the risk assessment.

Future Site Use. The projected future use of SWMU 14 is to either develop the property for ball fields or pave over the grass field and convert the area into a parking lot. In addition to the recreational users, industrial workers visitors/trespassers, and construction workers may be exposed to the surface and subsurface soil. These receptors may be exposed to the soil (both surface and subsurface soil) through incidental ingestion, dermal contact, and inhalation of fugitive emissions. As mentioned above, inhalation of fugitive emissions from soil is not expected to result in significant exposure to the trespasser due to the short exposure duration at the site, and was therefore not quantitatively evaluated.

It is highly unlikely that the site will be used for residential purposes in the future; however, the residential receptor was conservatively evaluated in this assessment. Residents could be exposed to contaminants in soil through incidental ingestion, dermal contact, and inhalation of fugitive emissions.

The groundwater beneath the site is not currently used as a potable source. However, exposure to groundwater was hypothetically considered as a complete pathway. The residents could be exposed to groundwater by inhaling VOCs while showering (adults only), ingesting groundwater, and having dermal contact with the groundwater while bathing (child only). The shower-exposure pathway was evaluated for adults, the bath scenario for children.

Exposure to groundwater was also evaluated for an adult construction worker exposed to the shallow groundwater during construction activities. Exposure to the construction worker could occur by dermal contact with groundwater, and inhalation of VOCs during excavation activities.

Potential future recreational site users may contact the surface water and sediment in the lagoon and the surface soil on the site. Exposure to the surface water and sediment could occur through incidental ingestion and dermal contact and exposure to the soil could occur through incidental ingestion and dermal contact.

In summary, the future land use exposure routes include:

- Resident (adult and child): inhalation of fugitive dust from surface and subsurface soil; incidental ingestion of, and dermal contact with the surface and subsurface soil; inhalation of VOCs from groundwater while showering (adults); ingestion of the groundwater; and dermal contact with the groundwater while bathing (child).
- Recreational user (adult and child): incidental ingestion of, and dermal contact with, the surface and subsurface soil; incidental ingestion of, and dermal contact with the surface water and sediment.
- Industrial Worker: inhalation of fugitive dust from surface and subsurface soil; incidental ingestion of, and dermal contact with surface and subsurface soil.
- Trespasser (adolescent and adult): incidental ingestion of, and dermal contact with surface and subsurface soil.
- Construction Worker: inhalation of fugitive dust from surface and subsurface soil; incidental ingestion of, and dermal contact with surface and subsurface soil; inhalation of VOCs from the shallow groundwater; and dermal contact with shallow groundwater.

5.5.3 Quantification of Exposure

Exposure is quantified by estimating the exposure point concentrations and chemical intakes by the receptor. Quantitative dose (intake) estimations were performed for the complete exposure pathways identified for the current and future exposure scenarios and routes. The intake estimates are based on exposure factors presented in Appendix F, Table 4.

5.5.3.1 Exposure Point Concentrations

Exposure point concentrations (EPCs) are estimated chemical concentrations with which a receptor may have contact that are specific to each exposure medium. Exposure point concentrations may be directly monitored (i.e., soil concentration) or estimated using environmental fate and transport models. For this assessment, fate-and-transport modeling was used to estimate constituent concentrations in fugitive dust emissions from soil, in vapors volatilized from groundwater used for showering, and in vapors volatilized from groundwater in an open excavation. Particulate emission from soil was modeled as discussed in USEPA's Soil Screening Guidance (USEPA, April 1996). Volatilization from groundwater while showering was modeled using the Foster and Chrostowski shower model. Volatilization from groundwater in an open excavation was modeled using a two-film volatilization model and USEPA's Screen 3 model, as shown in Table 7.33a.RME Supplement in Appendix F.

The reasonable maximum exposure (RME) EPCs were calculated as the 95 percent upper confidence limit (95% UCL), the 97.5% UCL, or the 99% UCL of the arithmetic mean concentration. The maximum detected concentration was used in place of the appropriate

UCL as the EPC when the calculated UCL was greater than the maximum detected value and when less than five samples were available for the data grouping.

ProUCL, Version 2.1 (USEPA, February 2003), was used to calculate the UCLs and determine the distribution the data fit. The ProUCL model uses the Shapiro-Wilk W-test to determine if the data fit a lognormal or normal distribution for datasets with less than 50 samples. The distribution that the data fit is then used to chose the method that ProUCL uses to calculate the UCL. The recommendations outlined in the ProUCL model documentation were used to select the appropriate UCL. For data that were determined to fit a normal distribution, the student's t-statistic was used to calculate the 95% UCL. For data determined to fit a lognormal distribution, either Land's H-statistic was used to calculate the 95% UCL, or the Chebyshev Theorem using the MVUE of the parameters was used to calculate the 95% UCL or 99% UCL, depending on the standard deviation of the population. For data that fit neither a lognormal or normal distribution, the Chebyshev Theorem using the arithmetic mean and standard deviation was used to calculate the 95% UCL, 97.5% UCL, or 99% UCL, depending on the population standard deviation. For data sets that fit both a lognormal and normal distribution, the methods described above for the distribution with the higher W-value was used to calculate the UCL.

The average concentration was used as the central tendency (CT) EPC. For data that fit a lognormal distribution (based on the discussion above), the average of the log-transformed data was used as the CT EPC. For data that fit a normal distribution, the average of the non-transformed data was used as the CT EPC. For data sets that either fit both a lognormal and normal distribution, or fit neither a lognormal or normal distribution, the distribution with the higher W-value was used to calculate the UCL.

The calculated EPCs are included in Appendix F, Table 3s.

Both unfiltered and filtered analytical results from the metals analysis of the groundwater samples were collected. The unfiltered groundwater data were used in the evaluation for the residential scenario because the concentrations of aluminum, iron, and manganese in the unfiltered samples were not considered to be different from those in the filtered samples (USEPA, August 1992). The unfiltered groundwater results were also used for evaluating potential exposures to the construction worker.

5.5.3.2 Estimation of Chemical Intakes for Individual Pathways

Chemical intake is the amount of the constituent entering the receptor's body. Intakes are generally expressed as follows:

$$I = \frac{C \times CR \times EF \times ED}{BW \times AT} = (mg/kg/day)$$

Where:

I =	intake (mg/kg-day)
C =	chemical concentration at exposure point (µg/L, µg/kg, µg/m^3)
CR=	contact rate, or amount of contaminated medium contacted per unit time or event (L/day, µg/event, m^3/day)
EF=	exposure frequency (days/year)

ED= exposure duration (years)

BW= body weight of exposed individual (kg)

AT= averaging time, or period over which exposure is averaged (days)

The intake equation requires specific exposure parameters for each exposure pathway. Exposure parameters are often assumed values, and their magnitude influences the estimates of potential exposure (and risk). The reliability of the values chosen can also contribute substantially to the uncertainty of the resulting risk estimates. 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 by USEPA guidance and detailed in the consensus agreements. Other assumptions (e.g., for the sediment scenario) required consideration of location-specific information and were determined using professional judgment. Appendix F, Table 4s present the exposure factors used for each exposure scenario evaluated for SWMU 14.

For dermal exposure to groundwater, the non-steady state model or pseudo steady-state model was used to estimate the dermally absorbed dose per event for organic constituents (USEPA, September 2001). If the exposure time (or event time, t_{event}) was shorter than the time to reach steady-state (t^*), the non-steady state model was used. If t_{event} was greater than t^*, the pseudo-steady state model was used. For inorganics, the absorbed dose was calculated using a steady-state approach. For the dermal-contact-with-soil scenario, an absorption factor is required. For the dermal-contact-with-water scenario, skin permeability rates are required. Both the absorption factors and permeability rates used for this evaluation are based on the USEPA's *Risk Assessment Guidance for Superfund, Part E, Supplemental Guidance for Dermal Risk Assessment* (USEPA, September 2001).

For residential exposure to groundwater and soil, lifetime age-adjusted intakes were calculated for carcinogenic constituents. This involved determining age-adjusted factors for ingestion, and dermal contact. These factors were calculated using the equations presented in USEPA Region III table (USEPA, April 2004) for calculating age-adjusted factors and are shown in Appendix F, Table 4s.

5.6 Toxicity Assessment

Toxicity assessment defines the relationship between the magnitude of exposure and possible severity of adverse effects, and weighs the quality of available toxicological evidence. Toxicity assessment generally consists of two steps: hazard identification and dose-response assessment. Hazard identification is the process of determining the potential adverse effects from exposure to the chemical along with the type of health effect involved. Dose-response assessment is the process of quantitatively evaluating the toxicity information and characterizing the relationship between the dose of the contaminant administered or received and the incidence of adverse health effects in the exposed population. Toxicity criteria (e.g., reference doses and slope factors) are derived from the dose-response relationship. USEPA has performed the toxicity assessment step for many chemicals and published the results in the Integrated Risk Information System (IRIS) and Health Effects Assessment Summary Tables (HEAST) databases. Toxicity profiles and

values are also available from the National Center for Environmental Assessment (NCEA). Toxicity values from NCEA were used when information was not available from IRIS and HEAST.

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 are evaluated independently from those having carcinogenic effects. Some chemicals may produce both noncarcinogenic and carcinogenic effects, and are therefore evaluated in both groups. This section discusses noncarcinogenic and carcinogenic effects separately, and concludes with a brief discussion of the toxicological properties of selected COPC.

The primary source of toxicity values is the USEPA's Integrated Risk Information System (IRIS) database, which contains up-to-date information on the potential adverse effects of chemicals on humans as well as dose-response relationships of these effects which are expressed in terms of reference doses (RfDs) and cancer slope factors (CSFs). The IRIS database is the USEPA's preferred source of toxicity information (USEPA, December 2003). In cases where toxicity data was unavailable from IRIS, provisional toxicity data known as the Provisional Peer Reviewed Toxicity Value (PPRTV) developed by the Superfund Technical Support Center (STSC) of the National Center for Environmental Assessment (NCEA), were used. The PPRTV are developed by the STSC only when specific requests for such values are placed with the regional EPA Toxicologist. The third tier of toxicity values, after IRIS and PPRTV was the Health Effects Assessment Summary Tables (HEAST), provisional toxicity values from NCEA, or other USEPA sources (e.g., thallium RfD).

5.6.1 Toxicity Information for Noncarcinogenic Effects

Noncarcinogenic health effects include a variety of toxic effects on body systems, such as renal toxicity (toxicity to the kidneys) to central-nervous-system disorders. Noncarcinogenic health effects can be grouped into two basic toxicity categories: acute and chronic. Acute toxicity can occur after a single exposure (usually at high doses), and the effect is most often seen immediately. Chronic toxicity generally occurs after repeated exposure (usually at low doses) and is seen 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 of exposed human populations, typically in the workplace.

USEPA (December 1989) defines the chronic RfD as an estimate of daily exposure that is likely to be without appreciable risk of deleterious effects during a lifetime of exposure for sensitive subpopulations. Chronic RfDs are specifically developed to be protective for long-term exposure to a compound (for example, 7 years to a lifetime), and consider uncertainty in the toxicological database and sensitive receptors. Chronic RfDs may be overly protective if used to evaluate the potential for adverse health effects resulting from short-term exposure. USEPA's NCEA develops sub-chronic RfDs for short-term exposure (2 weeks to 7 years). Chronic and sub-chronic RfDs are developed for both the inhalation and oral exposures. Sub-chronic RfDs were used for the construction worker scenario because the exposure duration is 1 year.

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 an observed toxic effect is occurring is identified as the "lowest-observed-adverse-effect-level" (LOAEL) and that at which no effect is observed is identified as the "no-observed-adverse-effect-level" (NOAEL). Several uncertainty factors (UFs) may be applied to account for uncertainty. UFs account for uncertain data quality, extrapolation of data from animal studies to human exposures, or the use of sub-chronic studies to develop chronic criteria. These UFs range between 10 and 10,000, and reflect the varying degrees of uncertainty in the toxicity criteria.

USEPA-derived oral and inhalation chronic RfDs, and associated UF and modifying factors (MF) values, available for the COPCs at the SWMU 14 are listed in Tables 5.1 and 5.2 in Appendix F.

Per USEPA guidance, oral toxicity values (RfDs and SFs) were adjusted from administered dose to absorbed dose for evaluating dermal toxicity. The RfD and SF were adjusted using oral absorption factors from USEPA (USEPA, September 2001). The adjusted dermal RfDs and SFs are summarized in Table 5.1 and Table 6.1 in Appendix F, respectively.

5.6.2 Toxicity Information for Carcinogenic Effects

Potential carcinogenic effects quantified as oral cancer-slope factors, inhalation-slope factors, or unit-risk factors that convert estimated exposures directly to incremental lifetime cancer risks. Cancer slope factors (CSFs) are expressed in units of risk per milligram per kilogram (kg) of body weight per day $(\mu g/kg\text{-}day)^{-1}$, and unit risk factors are expressed in units of risk per micrograms per cubic meter $(\mu g/m^3)^{-1}$.

CSFs may be derived from the results of chronic animal bioassays, human epidemiological studies, or both. Animal bioassays are usually conducted at dose levels much higher than likely to be encountered in the environment. This design detects possible adverse effects in the relatively small test populations used in the studies. A number of mathematical models and procedures have been developed to extrapolate from the high doses used in the studies to the low doses typically associated with environmental exposures.

The USEPA-preferred linearized multistage (LMS) model is usually used to estimate the largest linear slope (within the upper 95-percent UCL) at low extrapolated doses consistent with the data. The 95-percent UCL slope of the dose-response curve is subjected to various adjustments, and an inter-species scaling factor is usually applied to derive a cancer-slope factor 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). Dose-response data derived from human epidemiological studies are fitted to dose-time-response curves on an ad hoc basis. In both types of analyses, conservative (e.g., health protective) assumptions are applied and the models are believed to provide rough estimates of the upper limits on potential lifetime risk.

Exposure is averaged over the average adult lifetime of 70 years. The actual risks from exposure to a potential carcinogen are not likely to exceed the estimated risks, and are probably much lower or even zero. USEPA-derived oral and inhalation cancer-slope factors

are listed in Appendix F, Tables 6.1 and 6.2, respectively. The adjusted dermal SFs are summarized in Appendix F, Table 6.1.

In addition to deriving a quantitative estimate of cancer 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.

- 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 with sufficient evidence of carcinogenicity in laboratory animals.
- Group B2 chemicals (probable human carcinogens) are agents for which there is sufficient evidence of carcinogenicity in animals but inadequate evidence in 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.

5.6.3 Chemicals for Which No USEPA Toxicity Values are Available

Most chemicals detected at the site have toxicity factors or appropriate surrogates. In this assessment, lead is the only COPC without available published toxicity factors. Lead is regulated by USEPA based on blood-lead uptake using a physiologically based pharmakokinetic model referred to as the IEUBK model, in the event of excess lead presence at the site. As a screening tool, lead is screened at 400 mg/kg in soil and sediment, and at 15 µg/L in groundwater and surface water.

Residential child exposure to lead was evaluated based on the USEPA's Integrated Exposure/Uptake Biokinetic (IEUBK) model. Lead was detected in surface soil and subsurface soil at concentrations that exceed the screening value. Therefore, lead was retained as a COPC in both the surface and the subsurface soil and risks associated with lead in surface soil and subsurface soil were evaluated using the IEUBK Model for residential scenario.

The average concentration of lead in surface soil was 522 mg/kg and the average concentration of lead in subsurface soil was 672 mg/kg. These concentrations are the average for each data set, respectively, and are the values that were used in the IEUBK model.

Although blood-lead concentrations are not expected to be above 10 µg/dl, exposure to lead in surface soil and subsurface soil could result in more than 5 percent of the population of residential children with blood-lead levels above USEPA's recommended level.

5.7 Risk Characterization

Risk characterization is the process of integrating the previous elements of the risk assessment into quantitative and semi-quantitative expressions of risk. The quantification of risk is then used as an integral component in remedial decision-making and selection of potential remedies or actions.

5.7.1 Noncarcinogenic and Carcinogenic Risk Estimation Methods

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. The noncarcinogenic health impacts from carcinogens are also assessed.

5.7.1.1 Noncarcinogenic Risk Estimation

Noncarcinogenic health risks are estimated by comparing actual or expected exposure levels to threshold concentrations (or RfDs). The expected 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 and represent the same exposure period (i.e., chronic or sub-chronic). The intake and RfD also represent the same exposure route, (i.e., inhalation intakes are divided by the inhalation RfD, oral intakes are divided by the oral RfD, and dermal in takes are divided by an adjusted oral RfD). When HQ exceeds unity (i.e., exposure exceeds the RfD), a certain degree of health risk is indicated. To assess the potential for noncarcinogenic health effects posed by exposure to multiple chemicals a "hazard index" approach is used (USEPA, December 1989). This approach assumes that noncarcinogenic hazards associated with exposure to more than one chemical are additive. Synergistic or antagonistic interactions between chemicals are not accounted for. The hazard index (HI) may exceed unity even if all of the individual HQs are less than one. The chemicals may then be segregated by similar mechanisms of toxicity and toxicological effects, and separate HIs derived based on mechanism and target organs affected.

5.7.1.2 Carcinogenic Risk Estimation

The potential carcinogenic effects due to exposure to site-related contamination is evaluated by estimating excess lifetime cancer risk. Excess lifetime carcinogenic risk is the incremental increase in the probability of developing cancer during one's lifetime in addition to the background probability. For example, the background incidence of cancer in the U.S. population is approximately 30 percent (including both lethal and non-lethal forms). Therefore, a $2x10^{-6}$ excess lifetime carcinogenic risk means that an individual's probability of developing cancer in his or her lifetime changes from approximately 0.300000 to 0.300002. Or, expressed another way, the incidence of cancer *may* increase by two cases for every 1 million people exposed to the carcinogen throughout their lifetimes.

Potential carcinogenic risks associated with exposure to individual carcinogens were calculated using the CSFs from IRIS, PPRTV, NCEA, and HEAST presented in the Toxicity

Assessment section and the intakes calculated in the Exposure Assessment section. Risk is calculated by multiplying the intake by the CSF.

Risk = Intake * CSF

Potential carcinogenic risks associated with residential exposure to vinyl chloride (a COPC for groundwater at SWMU 14) are handled in a different manner than indicated above due to the separate CSFs for vinyl chloride for adult exposure and exposure including early life. The following equation was used to calculate the carcinogenic risks associated with exposure to vinyl chloride for the age-adjusted resident exposed to groundwater.

$$Risk = \frac{C \times IRc \times EF \times EDc \times CSF}{BWc \times AT} + \frac{C \times IRc \times CSF}{BWc} + \frac{C \times IRa \times EF \times EDa \times CSF}{BWa \times AT}$$

Where:

C = chemical concentration in groundwater (µg/L)

IR = intake rate, c-child, a-adult (L/day)

CSF = cancer slope factor (0.72 $(\mu g/kg\text{-}day)^{-1}$)

EF= exposure frequency (days/year)

ED= exposure duration, c-child, a-adult (years)

BW= body weight of exposed individual, c-child, a-adult (kg)

AT= averaging time, or period over which exposure is averaged (70 years x 365 days/year)

The combined risk from exposure to multiple chemicals at a site was evaluated by adding the risks from individual chemicals. Risks were also added across the pathways, if an individual would be exposed through multiple pathways. For example, both the oral and dermal pathways could expose a person contacting the soil onsite.

When a cumulative carcinogenic risk to an individual receptor under the assumed RME exposure conditions at the site exceeds 100 in a million (10^{-4} excess cancer risk), CERCLA generally requires remedial action to reduce risks at the site (USEPA, March 1991). If the cumulative risk is less than 10^{-4}, action generally is not required, but may be warranted if a risk-based, chemical-specific standard for example, maximum contaminant level (MCL) is exceeded. A risk-based remedial decision could be superseded by the presence of noncarcinogenic impact or environmental impact requiring action at the site.

5.7.2 Risk Assessment Results

The results of the risk characterization are presented below. Total risks are summarized by receptor following the media specific discussions. The risk calculation tables are presented in Appendix F, Tables 7s and 8s. A summary of the results by media is shown in Table 5-4 for the RMEs and Table 5-5 for the CTs. CT risks were calculated only when the RME hazards exceeded 1 or the cancer risks exceeded 10^{-4}.

5.7.2.1 Surface Soil Exposure

RME risks estimates for exposure to surface soil were calculated for adult industrial workers and adult and adolescent trespassers under current/future site use and for adult and child residents, construction workers, and adult and child recreational users under future site use. Exposure to surface soil via incidental ingestion, dermal contact, and inhalation of fugitive dust was evaluated. Inhalation of fugitive dust was not evaluated for the trespassers, since they are assumed to spend minimal time at the site.

- **Current Site Worker** (Appendix F, Table 9.1.RME): Based on the hazard and risk calculations, exposure to surface soil at SWMU 14 would result in carcinogenic risk ($3x10^{-5}$) that is within the USEPA target carcinogenic risk (10^{-6} to 10^{-4}) range and total noncarcinogenic hazard that is above USEPA's target HI of one (1.5), although none of the individual constituents contribute an HQ above one. The target organ-specific HIs are below the USEPA's target HI of one.

- **Current Trespasser, Adult** (Appendix F, Table 9.2.RME): Based on the hazard and risk calculations, exposure to surface soil ($5x10^{-6}$) at SWMU 14 would result in carcinogenic risk that is within the USEPA target carcinogenic risk (10^{-6} to 10^{-4}) range and noncarcinogenic hazard (0.21) below USEPA's target HI of one.

- **Current Trespasser, Adolescent** (Appendix F, Table 9.3.RME): Based on the hazard and risk calculations, exposure to surface soil at SWMU 14 would result in a carcinogenic risk ($3x10^{-6}$) that is within the USEPA target carcinogenic risk (10^{-6} to 10^{-4}) range and a noncarcinogenic hazard (0.29) below USEPA's target HI of one.

- **Future Resident, Adult** (Appendix F, Table 9.4.RME): Based on the hazard calculations, exposure to surface soil at SWMU 14 would result in a and noncarcinogenic hazard (1.6) above USEPA's target HI of one, although none of the individual constituents contribute an HQ above one. Similarly, the target organ-specific HIs are all below the USEPA target HI of one.

- **Future Resident, Child** (Appendix F, Table 9.5.RME): Based on the hazard calculations, exposure to surface soil at SWMU 14 would result in a noncarcinogenic hazard (8.5) above the USEPA target HI of one. Iron, thallium, and vanadium are the only constituents that contribute individual HQs greater than one. Because the cumulative RME hazard exceeded one, a CT hazard was calculated (Appendix F, Table 9.16.CT). The CT noncarcinogenic hazard for the child resident (1.5) is greater than USEPA's target hazard index. None of the individual COPCs contribute HQs greater than one. The target organ-specific HIs are all below the USEPA target HI of one.

  The principal assumption associated with the use of the IEUBK model is that a child from age 0 to 6 years is the receptor for potential exposure to lead in surface soil. Appendix F presents the IEUBK results. The IEUBK evaluation resulted in a geometric mean blood concentration of 6.1 micrograms per deciliter (μg/dl) for children 0 to 84 months old as a result of exposure to surface soil, which is below USEPA's recommended level of 10 μg/dl. The IEUBK also estimates the percentage of receptors estimated to have mean blood-lead levels above the acceptable level of 10 μg/dl. Approximately 14.8 percent of this population had a blood-lead level above USEPA's recommended level of 10 μg/dl. These results are above USEPA's threshold level of

5 percent or less of the population with blood-lead concentrations above USEPA's recommended level of 10 μg/dl.

- **Future Lifetime Resident** (Appendix F, Table 9.6.RME): Based on the risk calculations, exposure to surface soil at SWMU 14 would result in carcinogenic risk ($5x10^{-5}$) within the USEPA target carcinogenic risk (10^{-6} to 10^{-4}) range.

- **Future Construction Worker** (Appendix F, Table 9.7.RME): Based on the risk calculations, exposure to surface soil at SWMU 14 would result in carcinogenic risk ($4x10^{-6}$)within the USEPA target carcinogenic risk (10^{-6} to 10^{-4}) range. However, the noncarcinogenic hazard (3.7) exceeds USEPA's target HI. None of the individual COPCs contribute HQs greater than one nor do the cumulative hazards when summed by target organ. Because the cumulative RME hazard exceeded one, a CT hazard was calculated (Appendix, F, Table 9.18.CT). The CT noncarcinogenic hazard for the construction worker (1.3) is greater than USEPA's target HI. None of the individual COPCs contribute HQs greater than one.

- **Future Recreational, Adult** (Appendix F, Table 9.8.RME): Based on the hazard and risk calculations, exposure to surface soil at SWMU 14 would result in carcinogenic risk ($1x10^{-5}$) within the USEPA target (10^{-6} to 10^{-4}) range and noncarcinogenic hazards (0.40) below USEPA's target HI of one.

- **Future Recreational, Child** (Appendix F, Table 9.9.RME): Based on the risk calculations, exposure to surface soil at SWMU 14 would result in carcinogenic risk ($2x10^{-5}$) within the USEPA target carcinogenic risk (10^{-6} to 10^{-4}) range. However, the noncarcinogenic hazard (2.7) exceeds USEPA's target HI. None of the individual COPCs contribute HQs greater than one. Similarly, the target organ-specific HIs are below one. Because the cumulative RME hazard exceeded one, a CT hazard was calculated (Appendix F, Table 9.13.CT). The CT noncarcinogenic HI (0.65) for the recreational child is below the USEPA's target HI.

5.7.2.2 Subsurface Soil Exposure

RME risk estimates for exposure to subsurface soil were calculated for adult industrial workers, adult and adolescent trespassers, adult and child residents, adult and child recreational users, and construction workers under future site use. It was assumed these receptors would be exposed to soil through incidental ingestion, dermal contact, and inhalation of fugitive emissions from soil, the last of which was not evaluated for trespassers since they are assumed to spend minimal time at the site. Fourteen constituents were selected as COPCs based on potential leachability from subsurface soil to groundwater. Nine of the fourteen were also detected in groundwater however, there were no unacceptable risks.

- **Future Site Worker** (Appendix F, Table 9.10.RME) Based on the risk calculations, exposure to subsurface soil at SWMU 14 would result in carcinogenic risk above ($3x10^{-4}$) the USEPA target carcinogenic risk (10^{-6} to 10^{-4}) range. The carcinogenic risk is mainly associated with dermal absorption of benzo(a)pyrene. The noncarcinogenic HI (5.3) exceeds USEPA's target HI. Vanadium is the main contributor and is the only constituent that contributes an HI greater than one. Because the cumulative RME hazard exceeded one, a CT hazard was calculated (Appendix F, Table 9.14CT). The CT

carcinogenic risk ($1x10^{-5}$) is within the USEPA target (10^{-6} to 10^{-4}) range. The CT noncarcinogenic hazard for the site worker (0.46) is below the USEPA's target HI of one.

- **Future Trespasser, Adult** (Appendix F, Table 9.11.RME): Based on the hazard and risk calculations, exposure to subsurface soil at SWMU 14 would result in carcinogenic risk ($4x10^{-5}$) within the USEPA target carcinogenic risk (10^{-6} to 10^{-4}) range and noncarcinogenic HI (0.68) below USEPA's target HI of one.

- **Future Trespasser, Adolescent** (Appendix F, Table 9.12.RME): Based on the hazard and risk calculations, exposure to subsurface soil at SWMU 14 would result in carcinogenic risk ($2x10^{-5}$) within the USEPA target carcinogenic risk (10^{-6} to 10^{-4}) range and noncarcinogenic HI (0.85) below USEPA's target HI of one.

- **Future Resident, Adult** (Appendix F, Table 9.4.RME): Based on the hazard calculations, exposure to subsurface soil at SWMU 14 would result in noncarcinogenic hazard (5.4) that is above USEPA's target HI of one. No individual COPCs contribute an HQ above one to the total HI. Because the cumulative RME hazard exceeded one, a CT hazard was calculated (Appendix F, Table 9.15.CT). The CT noncarcinogenic hazard for the adult resident (0.94) is below USEPA's target HI.

- **Future Resident, Child** (Appendix F, Table 9.5.RME): Based on the hazard calculations, exposure to subsurface soil at SWMU 14 would result in a noncarcinogenic hazard (22) above the USEPA target HI of one. The noncarcinogenic hazard is mainly associated with ingestion of antimony, iron, thallium, and vanadium in the subsurface soil. Because the cumulative RME hazard exceeded one, a CT hazard was calculated. The CT noncarcinogenic hazard for the child resident (2.9) is greater than USEPA's target HI. The target organ-specific HIs are below the USEPA target HI of one.

  The IEUBK evaluation resulted in a geometric mean blood concentration of 7.2 micrograms per deciliter of blood (μg/dl) for children 0 to 84 months old as a result of exposure to subsurface soil, which is below USEPA's recommended level of 10 μg/dl. Approximately 24.1 percent of this population is estimated to have a blood-lead level above 10 μg/dl, which is above USEPA's recommended level of less than 5 percent of the population to exceed 10 μg/dl.

- **Future Lifetime Resident** (Appendix F, Table 9.6.RME): Based on the risk calculations, exposure to subsurface soil at SWMU 14 would result in carcinogenic risk ($6x10^{-4}$) above the USEPA target carcinogenic risk (10^{-6} to 10^{-4}) range. The carcinogenic risk is mainly associated with ingestion and dermal contact with benzo(a)pyrene. Because the cumulative RME risk exceeded 10^{-4}, a CT risk was calculated (Appendix F, Table 9.17.CT). The CT risk for the lifetime resident ($2x10^{-5}$) is within USEPA's risk range.

- **Future Construction Worker** (Appendix F, Table 9.7.RME): Based on the risk calculations, exposure to subsurface soil at SWMU 14 would result in carcinogenic risk ($2x10^{-5}$) within the USEPA target carcinogenic risk (10^{-6} to 10^{-4}) range. The noncarcinogenic hazard (11) exceeds USEPA's target HI. Ingestion of antimony, thallium, and vanadium and dermal contact with vanadium contribute HQs greater than one to the total hazard. Because the cumulative RME hazard exceeded one, a CT hazard was calculated (Appendix F, Table 9.18.CT). The CT noncarcinogenic hazard for the construction worker

(2.6) is greater than USEPA's target HI. None of the individual COPCs contribute HQs greater than one.

- **Future Recreational, Adult** (Appendix F, Table 9.8.RME): Based on the hazard and risk calculations, exposure to subsurface soil at SWMU 14 would result in carcinogenic risk ($8x10^{-5}$) within the USEPA target carcinogenic risk (10^{-6} to 10^{-4}) range and noncarcinogenic hazards that is above USEPA's target HI of one (1.3), although none of the individual constituents contribute an HQ above one.

- **Future Recreational, Child** (Appendix F, Table 9.9.RME): Based on the risk calculations, exposure to subsurface soil at SWMU 14 would result in a carcinogenic risk above ($1x10^{-4}$) the USEPA target carcinogenic risk (10^{-6} to 10^{-4}) range. The carcinogenic risk is mainly associated with the ingestion and dermal absorption of benzo(a)pyrene. The noncarcinogenic hazard (7.6) exceeds USEPA's target HI. Thallium and vanadium are the only constituents that contribute HQs above one. Because the cumulative RME hazard exceeded one, a CT hazard was calculated (Appendix F, Table 9.13.CT). The CT carcinogenic risk ($8.6x10^{-6}$) is within the USEPA's target range. The CT noncarcinogenic hazard (1.4) for the recreational child exceeds USEPA's target HI of one.

5.7.2.3 Groundwater Exposure

Groundwater beneath the site is not currently used as a potable water supply and is not anticipated to be used as such in the future. However, the shallow aquifer groundwater data was evaluated as a worst-case risk estimate for potable groundwater use at the site in a future-residential-exposure scenario.

Risk estimates for exposure to shallow aquifer groundwater were calculated for the hypothetical future child and adult residents. Exposure to the shallow aquifer groundwater by a construction worker during excavation was also evaluated as a potential future exposure scenario. It was assumed that a residential user would ingest the water, have dermal contact while bathing (child only), and inhale volatile constituents while showering (adult only). Future construction workers were evaluated based on exposure via inhalation and the dermal contact. The unfiltered groundwater data was used for evaluating potential exposures to the construction workers and residents.

- **Future Resident, Adult** (Appendix F, Table 9.4.RME): Based on the hazard calculations, exposure to groundwater at SWMU 14 would result in a noncarcinogenic hazard (22) above USEPA's target HI of one. The noncarcinogenic hazard is mainly associated with ingestion of 4-methylphenol, arsenic, iron, manganese, thallium, and vanadium. Because the cumulative RME hazard exceeded one, a CT hazard was calculated (Appendix F, Table 9.15.CT). The CT noncarcinogenic hazard for the adult resident (5.4) is greater than USEPA's target HI. The target organ-specific HIs for effects to skin, liver, central nervous system, and vascular system exceed the USEPA target of one.

- **Future Resident, Child** (Appendix F, Table 9.5.RME): Based on the hazard calculations, exposure to groundwater at SWMU 14 would result in a noncarcinogenic hazard (54) above USEPA's target HI of one. The noncarcinogenic hazard is mainly associated with ingestion of or dermal contact with 4-methylphenol, dibenzofuran, arsenic, iron, manganese, thallium, and vanadium. Because the cumulative RME hazard exceeded one, a CT hazard was calculated (Appendix F, Table 9.16). The CT noncarcinogenic hazard for

the child resident (15) is greater than USEPA's target HI. Several target organ-specific HIs exceed the USEPA target of one (effects to skin, kidney, blood, hair, gastrointestinal, liver, central nervous system, immune system, respiratory system, vascular system, and whole body effects).

- **Future Lifetime Resident** (Appendix F, Table 9.6.RME): Based on the risk calculations, exposure to groundwater at SWMU 14 would result in carcinogenic risk ($7x10^{-3}$) above the USEPA target carcinogenic risk (10^{-6} to 10^{-4}) range. This risk is primarily associated with ingestion of and dermal contact with n-nitroso-d-n-propylamine, pentachlorophenol, and arsenic in groundwater. Because the cumulative RME risk exceeded 10^{-4}, a CT risk was calculated (Appendix F, Table 9.17.CT). The CT risk for the lifetime resident ($2x10^{-3}$) is also above USEPA's risk range.

- **Future Construction Worker** (Appendix F, Table 9.7.RME): Based on the risk calculations, exposure to groundwater at SWMU 14 would result in carcinogenic risk ($2x10^{-5}$) within the USEPA target carcinogenic risk (10^{-6} to 10^{-4}) range. The noncarcinogenic hazard (3.1) exceeds USEPA's target HI. This hazard is mainly associated with dermal contact with dibenzofuran, 4-methylphenol, pentachlorophenol, and vanadium although none of the individual constituents contribute an HI greater than one. Because the cumulative RME hazard exceeded one, a CT hazard was calculated (Appendix F, Table 9.18.CT). The CT noncarcinogenic hazard for the construction worker (2.9) is greater than USEPA's target HI. The target organ-specific HIs are below the USEPA target HI of one.

5.7.2.4 Sediment Exposure

RME risk estimates for exposure to sediment were calculated for adult and child recreational users. It was assumed these receptors would be exposed to sediment through incidental ingestion and dermal contact.

- **Future Recreational, Adult** (Appendix F, Table 9.8.RME): Based on the hazard and risk calculations, exposure to sediment at SWMU 14 would result in carcinogenic risk ($3x10^{-6}$) within the USEPA target carcinogenic risk (10^{-6} to 10^{-4}) range and noncarcinogenic hazard (0.19) that is below USEPA's target HI of one.

- **Future Recreational, Child** (Appendix F, Table 9.9.RME): Based on the hazard and risk calculations, exposure to sediment at SWMU 14 would result in carcinogenic risk ($3x10^{-6}$) within the USEPA target carcinogenic risk (10^{-6} to 10^{-4}) range and noncarcinogenic hazard (0.44) that is below USEPA's target HI of one.

5.7.3 Background Considerations

Background concentrations are important considerations when performing a risk assessment. The Navy investigated basewide background soil concentrations in 2000, and presented the results in *Draft Soil Background Investigation Report*, Naval Station Norfolk, Norfolk, Virginia (CH2MHILL, September, 2000). Non-impacted areas that represent the underlying geologic and hydrogeologic conditions were identified for background sampling locations. Additionally, areas indicative of anthropogenic background conditions were identified, including fill areas composed of dredged sediments and past land use areas where pesticides or PAHs may have been used. Forty-five samples each of surface and subsurface soil were collected as part of the background study.

Statistical analysis using boxplots and the Kruskal-Wallis test showed that metal concentrations in native soils were statistically different from soils within the Golf Course area. Therefore, 95-percent UTLs were calculated for each distinct soil type. The 95-percent UTLs are presented in Appendix F. The 95-percent UTLs can be compared with maximum-detected site concentrations to assess if constituents may be present from background or site-related sources. Table F-6-1 in Appendix F summarizes the background UTLs for each soil type.

The maximum detected concentrations of all of the risk drivers for surface soil exceed the background concentrations. The maximum detected concentrations of all of the risk drivers for subsurface soil exceed the background concentrations.

Background data are not available for the groundwater, surface water, or sediment.

5.8 Uncertainty Associated with Human Health Assessment

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

A discussion of the uncertainties associated with the individual components of the risk assessment is presented in the following sections.

5.8.1 General Uncertainty in COPC Selection

The uncertainty in sampling and possibility of missing a contaminated location is expected to be minimal at this site because of the amount of sampling data available for the site. The quantitative uncertainty associated with the other factors is also minimal, as the data have been fully validated prior to use in the risk assessment.

Comparison of the site data to background data was not used as criterion in selecting the COPCs. Therefore, some constituents that have been retained as COPCs and carried through the risk assessment may be present at concentrations consistent with background conditions at NSN. Section 5.7.4 includes a semi-quantitative comparison of the site soil data to background soil data.

5.8.2 Uncertainty Associated with Exposure Assessment

Most exposure pathways analyzed are assumed, and exposure factors used for quantitation of exposure are conservative and reflect worst-case or upper bound assumptions.

The future soil exposure scenario adds additional conservatism by assuming that the subsurface soil will become surface soil during any future construction activities and that future receptors may contact what is the current surface and current subsurface soil. During many construction projects, clean fill material, such as topsoil, is placed over the soil disturbed during excavation projects. The topsoil material is generally needed to support growth of grass and other landscape plants. This would decrease the possibility of future exposure to both the current surface and subsurface soil after any construction activities.

Elevated lead concentrations were randomly detected at locations across the site in surface and subsurface soil. However, in many cases the elevated concentrations in surface soil are not present in similar concentrations at depth in subsurface soil. Although lead was detected at elevated concentrations, it is uncertain if the use of the average concentrations as the exposure point concentration to represent lead concentrations in soil across the site, since the maximum lead concentration biased the average concentration higher and it is known that concentrations are lower at other locations. The use of the average concentration overstates potential exposures and associated health risks.

Inhalation exposure point concentrations are estimated using the models suggested by USEPA, which assume a continued source of contaminants in the emitting medium and do not account for the depreciation due to volatilization or air-borne dust emission. The inhalation intake estimates also assume that a receptor is always in the downwind direction of the site, while in reality the wind direction changes seasonally.

The percentage of a chemical absorbed through the skin is likely to be affected by many parameters. Some of these include soil loading, soil moisture content, organic content, pH, and presence of other constituents. The availability of a chemical depends on site-specific fate and transport properties of the chemical species available for eventual absorption of skin. Chemical concentrations, specific properties of the chemical, and soil release kinetics all impact the amount of a chemical absorbed. These factors contribute to the uncertainty associated with these estimates and make quantitation of the amount of certain chemicals absorbed from soil difficult.

5.8.3 Uncertainty Associated with Toxicity Assessment

Uncertainty associated with the noncarcinogenic toxicity factors (RfDs) are included in Appendix F and Tables 5.1 and 5.2. The uncertainty associated with CSFs is mostly associated with the low dose extrapolation where carcinogenicity at low doses is assumed to be straight-line responses. This is a conservative assumption, which introduces a high uncertainty into slope factors from this extrapolated area of the dose-response curve. However, most of the experimental studies indicate existence of a threshold for carcinogenicity.

Carcinogenic slope factors developed by the USEPA represent upper bound estimates. Any carcinogenic risks generated in this assessment should be regarded as an upper bound estimate, rather than an accurate representation, of the potential carcinogenic risks. The true carcinogenic risk is likely to be less than the predicted value.

There is uncertainty associated with the derivation of the total dioxin equivalents and the method used to estimate both EPCs and toxicity. The TEF method used to estimate total dioxin equivalents from the seventeen congeners analyzed for in groundwater is based on one biological response (the Ah-receptor) that results in certain toxic effects from exposure to dioxins. While this approach is widely adapted by scientific agencies worldwide, it does limit the basis for toxicity to one set of toxicological responses. While this approach has been described as a "conservative, order of magnitude estimate" of the TCDD dose, recent experimental studies examining both environmental mixtures and laboratory-defined mixtures suggest the TEF method is accurate and may not be as conservative as described (EPA, September 2000). Therefore, the quantitative estimates of dose and risk associated

with exposure to total dioxins should be interpreted carefully and with consideration of the uncertainty and limitations of this method.

Provisional toxicity values were applied in the HHRA for several constituents including aluminum, iron, and others as indicated in Appendix F, Tables 5s and 6s. These values are provisional because the EPA has not agreed upon the exact dose-response information that should be used to estimate toxicity or carcinogenicity to exposed humans. Therefore, additional uncertainty is associated with the quantitative risk estimates for these constituents.

Additional uncertainty is in the prediction of relative sensitivities of different species of animals and the applicability of animal data to humans.

5.8.4 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, susceptibility of exposed receptors, etc.

5.9 Human Health Risk Assessment Summary

This baseline risk assessment was conducted to evaluate the potential human-health risks associated with the presence of site-related soil, groundwater, surface water, and sediment contamination at NSN SWMU 14. This risk assessment quantifies potential human-health risks at SWMU 14 under current conditions and under potential future use scenarios, if no additional remediation is implemented.

Appendix F, Tables 9.1.RME through 9.12.RME summarize the RME total potential risks to each receptor. Appendix F, Tables 9.13.CT through 9.18.CT summarize the CT total potential risks to each receptor that had risks that exceeded an HI of one or a carcinogenic risk of $1x10^{-4}$.

There are no risks or target organ-specific hazards that exceed USEPA target levels for the site worker or trespasser under current site use. The following receptors had total RME noncarcinogenic hazards or carcinogenic risks that exceeded USEPA's target levels:

- Future site worker exposed to subsurface soil
- Future adult resident exposed to subsurface soil and groundwater
- Future child resident exposed to surface soil, subsurface soil, and groundwater
- Future lifetime resident exposed to subsurface soil and groundwater
- Future construction worker exposed to surface soil, subsurface soil, and groundwater
- Future recreational child exposed to surface soil and subsurface soil

Metals detected in the soil are the main contributors to the noncarcinogenic hazard associated with exposure to surface soil (thallium and iron) and subsurface soil (antimony, arsenic, iron, manganese, thallium, and vanadium). There are no carcinogenic risks that exceed USEPA target levels in the surface soil. The main contributor to the carcinogenic risk in subsurface soil is benzo(a)pyrene. A comparison of the maximum detected concentrations and 95-percent UCLs of the metals to the background UTLs does not indicate that the site

metals concentrations are similar to those of background metals. Therefore, based on this comparison, the calculated risks are probably site- and not background related. The main contributor to the subsurface soil carcinogenic risk is benzo(a)pyrene.

The main contributors to the groundwater noncarcinogenic hazard are 4-methylphenol, dibenzofuran, arsenic, iron, manganese, thallium, and vanadium; and the main contributors to the carcinogenic risk are n-nitroso-di-n-propylamine, pentachlorophenol, and arsenic.

Since elevated lead concentrations in soil are randomly distributed across the site independent of depth, EPCs used to evaluate risks are biased high by specific locations that are not indicative of site-wide concentrations. Therefore, risks estimated for residential children from exposure to lead in soil are overstated in this risk assessment.

5.10 References

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Table 5-1
Summary of Data used in Baseline Risk Assessment
SWMU 14
NSN, Norfolk, VA

Medium	Date of Sampling	Sample Locations	Parameters
Groundwater			
	1/5/2000	NBW14-MW01S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	1/7/2000	NBW14-MW02S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	1/7/2000	NBW14-MW03S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	1/7/2000	NBW14-MW04S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	1/7/2000	NBW14-MW05S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	1/5/2000	NBW14-MW06S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	1/5/2000	NBW14-MW07S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	1/5/2000	NBW14-MW07S-P-R01[a]	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	9/27/2000	NBW14-MW07S-R02	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	12/16/2002	NBW14-MW07S-R03	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	1/4/2000	NBW14-MW08S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	12/16/2002	NBW14-MW08S-R03	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	9/26/2000	NBW14-MW09S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	12/16/2002	NBW14-MW05S-R03	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	9/27/2000	NBW14-MW11S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	9/27/2000	NBW14-MW12S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	9/26/2000	NBW14-MW13S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	9/26/2000	NBW14-MW13S-P-R01[b]	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	9/27/2000	NBW14-MW14S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	9/27/2000	NBW14-MW15S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	12/16/2002	NBW14-MW15S-R03	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	8/24/2001	NBW14-MW16S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	8/24/2001	NBW14-MW16S-P-R01[c]	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	8/24/2001	NBW14-MW17S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	8/24/2001	NBW14-MW18S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	8/24/2001	NBW14-MW19S-R01	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	12/16/2002	NBW14-MW19S-R03	VOC, SVOC, Pest/PCBs, inorg, Fmetals
	12/16/2002	NBW14-MW19SP-R03[d]	VOC, SVOC, Pest/PCBs, inorg, Fmetals
Soil			
Surface Soil	9/30/1999	NBW14-DS01-00	SVOC, Pest/PCBs, inorg
	9/30/1999	NBW14-DS02-00	SVOC, Pest/PCBs, inorg
	9/30/1999	NBW14-DS03-00	SVOC, Pest/PCBs, inorg
	9/30/1999	NBW14-DS04-00	SVOC, Pest/PCBs, inorg
	9/30/1999	NBW14-DS05-00	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS06-00	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS07-00	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS08-00	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS09-00	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS10-00	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS11-00	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS12-00	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS13-00	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS14-00	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS15-00	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS16-00	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS17-00	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS18-00	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS18P-00[e]	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS19-00	VOC, SVOC, Pest/PCBs, inorg
	9/19/2000	NBW14-DS20-00	VOC, SVOC, Pest/PCBs, inorg
	9/11/2000	NBW14-DS21-00	VOC, SVOC, Pest/PCBs, inorg
	9/11/2000	NBW14-DS22-00	VOC, SVOC, Pest/PCBs, inorg
	9/11/2000	NBW14-DS23-00	VOC, SVOC, Pest/PCBs, inorg
	9/11/2000	NBW14-DS24-00	VOC, SVOC, Pest/PCBs, inorg
	9/11/2000	NBW14-DS24-P-00[f]	VOC, SVOC, Pest/PCBs, inorg
	9/15/2000	NBW14-DS25-00	VOC, SVOC, Pest/PCBs, inorg
	9/15/2000	NBW14-DS25-P-00[g]	VOC, SVOC, Pest/PCBs, inorg
	9/11/2000	NBW14-DS26-00	VOC, SVOC, Pest/PCBs, inorg
	9/11/2000	NBW14-DS26-P-00[h]	VOC, SVOC, Pest/PCBs, inorg
	9/12/2000	NBW14-DS27-00	VOC, SVOC, Pest/PCBs, inorg

Table 5-1
Summary of Data used in Baseline Risk Assessment
SWMU 14
NSN, Norfolk, VA

Medium	Date of Sampling	Sample Locations	Parameters
Surface Soil (Cont'd)	9/12/2000	NBW14-DS28-00	VOC, SVOC, Pest/PCBs, inorg
	9/11/2000	NBW14-DS29-00	VOC, SVOC, Pest/PCBs, inorg
	9/12/2000	NBW14-DS30-00	VOC, SVOC, Pest/PCBs, inorg
	9/20/2000	NBW14-DS31-00	VOC, SVOC, Pest/PCBs, inorg
	9/12/2000	NBW14-DS32-00	VOC, SVOC, Pest/PCBs, inorg
	9/12/2000	NBW14-DS33-00	VOC, SVOC, Pest/PCBs, inorg
	9/12/2000	NBW14-DS34-00	VOC, SVOC, Pest/PCBs, inorg
	9/12/2000	NBW14-DS35-00	VOC, SVOC, Pest/PCBs, inorg
	9/20/2000	NBW14-DS36-00	VOC, SVOC, Pest/PCBs, inorg
	9/12/2000	NBW14-DS37-00	VOC, SVOC, Pest/PCBs, inorg
	9/19/2000	NBW14-DS38-00	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS40-00	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS41-00	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS42-00	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS43-00	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS44-00	Dioxins,furans
	8/21/2001	NBW14-DS45-00	Dioxins,furans
	8/21/2001	NBW14-DS46-00	Dioxins,furans
	8/21/2001	NBW14-DS47-00	Dioxins,furans
	8/21/2001	NBW14-DS47-P-00[i]	Dioxins,furans
	8/21/2001	NBW14-DS48-00	Dioxins,furans
	8/21/2001	NBW14-DS49-00	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS49-P-00[j]	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS51-00	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS52-00	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS53-00	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS54-00	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS54-P-00[k]	VOC, SVOC, Pest/PCBs, inorg
	12/17/2002	NBW14-SS09	Lead
	12/17/2002	NBW14-SS09-P	Lead
	12/17/2002	NBW14-SS10	Lead
	12/17/2002	NBW14-SS11	Lead
	12/17/2002	NBW14-SS12	Lead
Subsurface Soil	9/30/1999	NBW14-DS01-02	SVOC, Pest/PCBs, inorg
	9/30/1999	NBW14-DS02-02	SVOC, Pest/PCBs, inorg
	9/30/1999	NBW14-DS03-02	SVOC, Pest/PCBs, inorg
	9/30/1999	NBW14-DS04-02	SVOC, Pest/PCBs, inorg
	9/30/1999	NBW14-DS05-02	SVOC, Pest/PCBs, inorg
	9/30/1999	NBW14-DS05P-02[l]	SVOC, Pest/PCBs, inorg
	9/30/1999	NBW14-DS06-02	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS07-02	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS08-02	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS09-02	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS10-02	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS10P-02[m]	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS11-02	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS12-02	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS13-02	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS14-02	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS14P-02[n]	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS15-02	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS16-02	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS17-02	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS18-02	SVOC, Pest/PCBs, inorg
	10/1/1999	NBW14-DS19-06	VOC, SVOC, Pest/PCBs, inorg
	9/18/2000	NBW14-DS20-03	VOC, SVOC, Pest/PCBs, inorg
	9/19/2000	NBW14-DS21-05	VOC, SVOC, Pest/PCBs, inorg
	9/12/2000	NBW14-DS24-05	VOC, SVOC, Pest/PCBs, inorg
	9/11/2000	NBW14-DS26-06	VOC, SVOC, Pest/PCBs, inorg
	9/11/2000	NBW14-DS27-04	VOC, SVOC, Pest/PCBs, inorg
	9/12/2000	NBW14-DS28-03	VOC, SVOC, Pest/PCBs, inorg
	9/12/2000	NBW14-DS29-08	VOC, SVOC, Pest/PCBs, inorg
	9/12/2000	NBW14-DS30-03	VOC, SVOC, Pest/PCBs, inorg
	9/12/2000	NBW14-DS31-04	VOC, SVOC, Pest/PCBs, inorg
	9/20/2000	NBW14-DS32-04	VOC, SVOC, Pest/PCBs, inorg
	9/12/2000	NBW14-DS33-03	VOC, SVOC, Pest/PCBs, inorg

Table 5-1
Summary of Data used in Baseline Risk Assessment
SWMU 14
NSN, Norfolk, VA

Medium	Date of Sampling	Sample Locations	Parameters
	9/12/2000	NBW14-DS34-05	VOC, SVOC, Pest/PCBs, inorg
	9/12/2000	NBW14-DS35-05	VOC, SVOC, Pest/PCBs, inorg
	9/12/2000	NBW14-DS36-04	VOC, SVOC, Pest/PCBs, inorg
	9/20/2000	NBW14-DS37-06	VOC, SVOC, Pest/PCBs, inorg
	9/12/2000	NBW14-DS38-03	VOC, SVOC, Pest/PCBs, inorg
	9/19/2000	NBW14-DS40-07	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS41-05	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS42-06	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS43-07	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS44-08	Dioxins,furans
	8/20/2001	NBW14-DS45-05	Dioxins,furans
	8/20/2001	NBW14-DS46-06	Dioxins,furans
	8/20/2001	NBW14-DS47-04	Dioxins,furans
	8/20/2001	NBW14-DS48-06	Dioxins,furans
	8/20/2001	NBW14-DS49-06	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS51-07	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS53-07	VOC, SVOC, Pest/PCBs, inorg
	8/21/2001	NBW14-DS54-05	VOC, SVOC, Pest/PCBs, inorg
Surface Water			
	9/17/1996	NB03W4	VOC, SVOC, inorg
Sediment			
	12/19/2002	NBW14-SD01	SVOC, Pest/PCBs, inorg
	12/19/2002	NBW14-SD01-P[o]	SVOC, Pest/PCBs, inorg
	12/19/2002	NBW14-SD02	SVOC, Pest/PCBs, inorg
	12/19/2002	NBW14-SD03	SVOC, Pest/PCBs, inorg
	12/19/2002	NBW14-SD04	SVOC, Pest/PCBs, inorg
	12/19/2002	NBW14-SD05	SVOC, Pest/PCBs, inorg

Notes:
VOC - volatile organic constituents
SVOC - semivolatile organic constituents
Pest/PCBs - Pesticides/Polychlorinated Biphenyls
inorg - inorganic constituents including cyanide
Fmetals - dissolved inorganic constituent (groundwater)
a. Duplicate of NBW14-MW07S-R01
b. Duplicate of NBW14-MW13S-R01
c. Duplicate of NBW14-MW16S-R01
d. Duplicate of NBW14-MW19S-R03
e. Duplicate of NBW14-DS18-00
f. Duplicate of NBW14-DS24-00
g. Duplicate of NBW14-DS25-00
h. Duplicate of NBW14-DS26-00
i. Duplicate of NBW14-DS47-00
j. Duplicate of NBW14-DS49-00
k. Duplicate of NBW14-DS54-00
l. Duplicate of NBW14-DS05-02
m. Duplicate of NBW14-DS10-02
n. Duplicate of NBW14-DS14-02
o. Duplicate of NBW14-SD01

Table 5-2
Summary of Chemicals of Potential Concern for the HHRA
SWMU 14
NSN, Norfolk, VA

Groundwater	Surface Soil	Subsurface Soil	Sediment
1,1,2-Trichloroethane	Benzo(a)anthracene	Benzene	Arsenic
1,2-Dichloropropane	Benzo(a)pyrene	Methylene Chloride	Iron
Benzene	Benzo(b)fluoranthene	1,2,4-Trichlorobenzene	Vanadium
Chlorobenzene	Dibenz(a,h)anthracene	2-Methylnapthalene	
Chloroethane	Indeno(1,2,3-cd)pyrene	Acenapthene	
Chloroform	Aroclor-1254	Acenapthylene	
Vinyl chloride	Aroclor-1260	Anthracene	
Xylene, total	Dieldrin	Benzo(a)anthracene	
1,1-Biphenyl	2,3,7,8-TCDD (dioxin equivalent)	Benzo(a)pyrene	
1,4-Dichlorobenzene	Aluminum	Benzo(b)fluoranthene	
2,4-Dichlorophenol	Antimony	Benzo(k)fluoranthene	
2,4-Dimethylphenol	Arsenic	Carbazole	
2-Methylnaphthalene	Barium	Chrysene	
2-Methylphenol	Cadmium	Dibenz(a,h)anthracene	
4-Methylphenol	Chromium	Dibenzofuran	
Acenaphthene	Copper	Fluorene	
Acenaphthylene	Iron	Indeno(1,2,3-cd)pyrene	
Carbazole	Lead	Napthalene	
Dibenzofuran	Manganese	Phenanthrene	
Fluorene	Mercury	Pyrene	
Naphthalene	Nickel	Aroclor-1242	
Pentachlorophenol	Thallium	Aroclor-1248	
Phenanthrene	Vanadium	Aroclor-1254	
n-Nitroso-di-n-propylamine	Zinc	Aroclor-1260	
Aldrin		Aldrin	
Dieldrin		Dieldrin	
Heptachlor epoxide		Endrin Ketone	
alpha-BHC		alpha-BHC	
beta-BHC		beta-BHC	
delta-BHC		2,3,7,8-TCDD (dioxin equivalent)	
gamma-BHC (Lindane)		Aluminum	
Antimony		Antimony	
Arsenic		Arsenic	
Barium		Barium	
Cyanide		Cadmium	
Iron		Chromium	
Manganese		Copper	
Thallium		Iron	
Vanadium		Lead	
		Manganese	
		Mercury	
		Nickel	
		Selenium	
		Silver	
		Thallium	
		Vanadium	
		Zinc	

Table 5-3
Potentially Complete Human Health Exposure Pathways
Conceptual Site Model
SWMU 14
NSN, Norfolk, VA

Land Use	Contaminated Media	Potentially Exposed Populations	Exposure Route (Human Health)	Pathway Selected for Evaluation	Rationale
Current					
Industrial	Surface Soil	Trepassers/Visitors - Adolescents and Adults	Ingestion, dermal contact, and inhalation	Yes	People trespassing on site may incidentally ingest surface soil and have exposed skin surfaces come into contact with surface soil.
	Surface Soil	Adult Worker	Ingestion, dermal contact, and inhalation	Yes	Industrial site workers on site may incidentally ingest surface soil, have exposed skin surfaces come into contact with surface soil, and inhale particulate emissions from surface soil while working.
Future					
Residential	Surface and Subsurface Soil	Residents - Adults and Children	Ingestion, dermal contact, and inhalation	Yes	Residents could incidentally ingest soil, have exposed skin surface areas come into contact with soil, and inhale particulate emissions from the site.
	Groundwater		Ingestion, dermal contact, and inhalation	Yes	Although unlikely, groundwater could be used as a future potable water supply.
Industrial	Surface and Subsurface Soil	Adult Worker	Ingestion, dermal contact, and inhalation	Yes	Industrial site workers on site may incidentally ingest soil, have exposed skin surfaces come into contact with soil, and inhale particulate emissions from soil while working.
	Surface and Subsurface Soil	Construction Worker	Ingestion, dermal contact, and inhalation	Yes	Construction workers could incidentally ingest soil, exposed skin surface areas could come into contact with soil, and they may inhale the particulate emissions from the site during excavation activities.
	Groundwater		Dermal contact and inhalation	Yes	Construction workers could have exposed skin surfaces come into contact with groundwater and inhale volatiles from groundwater during construction or excavation activities.
	Surface and Subsurface Soil	Trepassers/Visitors - Adolescents and Adults	Ingestion and dermal contact	Yes	People trespassing on site may incidentally ingest soil and have exposed skin surfaces come into contact with soil.
Recreational	Surface and Subsurface Soil	Recreational - Adults and Children	Ingestion and dermal contact	Yes	People recreating on site may incidentally ingest soil and have exposed skin surfaces come into contact with soil.
	Surface Water and Sediment		Ingestion and dermal contact	Yes	People recreating on site may incidentally ingest surface water and sediment and have exposed skin surfaces come into contact with surface water and sediment.

Table 5-4
Summary of Media-Specific Risks and Hazards
SWMU 14
Naval Station Norfolk

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $>10^{-4}$	Chemicals with Cancer Risks $>10^{-5}$ and $<10^{-4}$	Chemicals with Cancer Risks $>10^{-6}$ and $<10^{-5}$	Hazard Index	Chemicals with HI>1
Current/Future Site Worker	Surface Soil	Ingestion	1.6E-05			Benzo(a)pyrene, Dibenz(a,h)anthracene, Dioxin equivalents, Arsenic	0.59	
		Dermal Contact	1.4E-05		Arsenic	Benzo(a)pyrene, Dibenz(a,h)anthracene, Dioxin equivalents	0.88	
		Inhalation	3.9E-08				0.0026	
		Total	3.0E-05				1.5	
	All Media	Total	3E-05				1.5	
Current/Future Trespasser - Adult	Surface Soil	Ingestion	4.0E-06			Arsenic	0.12	
		Dermal Contact	1.6E-06				0.086	
		Inhalation	NA				NA	
		Total	5.6E-06				0.21	
	All Media	Total	6E-06				0.21	
Current/Future Trespasser - Adolescent	Surface Soil	Ingestion	2.3E-06			Arsenic	0.23	
		Dermal Contact	3.5E-07				0.061	
		Inhalation	NA				NA	
		Total	2.6E-06				0.29	
	All Media	Total	3E-06				0.29	
Future Resident - Adult	Surface Soil	Ingestion	NA				0.82	
		Dermal Contact	NA				0.77	
		Inhalation	NA				0.011	
		Total	NA				1.6	
	Subsurface Soil	Ingestion	NA				2.0	
		Dermal Contact	NA				3.3	Vanadium
		Inhalation	NA				0.016	
		Total	NA				5.4	
	Groundwater	Ingestion	NA				20	4-Methylphenol, Thallium, Arsenic, Iron, Manganese, Vanadium
		Dermal Contact	NA				0.97	
		Inhalation	NA				0.39	
		Total	NA				22	
	All Media	Total	NA				29	
Future Resident - Child	Surface Soil	Ingestion	NA				7.7	Iron,Thallium
		Dermal Contact	NA				0.81	
		Inhalation	NA				0.030	
		Total	NA				8.5	
	Subsurface Soil	Ingestion	NA				19	Antimony, Iron, Thallium, Vanadium
		Dermal Contact	NA				3.6	Vanadium
		Inhalation	NA				0.044	
		Total	NA				23	
	Groundwater	Ingestion	NA				47	Dibenzofuran, 4-Methylphenol, Arsenic, Iron, Manganese, Thallium,Vanadium
		Dermal Contact	NA				6.3	4-Methylphenol, Dibenzofuran
		Inhalation	NA				NA	
		Total	NA				54	
	All Media	Total	NA				85	

Table 5-4
Summary of Media-Specific Risks and Hazards
SWMU 14
Naval Station Norfolk

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $>10^{-4}$	Chemicals with Cancer Risks $>10^{-5}$ and $<10^{-4}$	Chemicals with Cancer Risks $>10^{-6}$ and $<10^{-5}$	Hazard Index	Chemicals with HI>1
Future Resident - Lifetime	Surface Soil	Ingestion	2.1E-05		Arsenic	Benzo(a)pyrene, Dibenz(a,h)anthracene, Dioxin equivalents	NA	
		Dermal Contact	3.2E-05		Arsenic	Benzo(a)pyrene, Dibenz(a,h)anthracene, Dioxin equivalents	NA	
		Inhalation	6.4E-06			Chromium	NA	
		Total	5.9E-05				NA	
	Subsurface Soil	Ingestion	4.1E-04	Benzo(a)pyrene	Benzo(a)anthracene, Benzo(b)fluoranthene, Dibenz(a,h)anthracene, Dioxin equivalent, Indeno(1,2,3-cd)pyrene, Arsenic	Benzo(k)fluoranthene, Arclor 1260	NA	
		Dermal Contact	1.8E-04	Benzo(a)pyrene	Benzo(a)anthracene, Benzo(b)fluoranthene, Dibenz(a,h)anthracene	Indeno(1,2,3-cd)pyrene, Arclor 1260, Dioxin equivalent, Arsenic	NA	
		Inhalation	9.2E-06			Chromium	NA	
		Total	6.0E-04				NA	
	Groundwater	Ingestion	2.0E-03	Pentachlorophenol, n-Nitroso-di-n-propylamine, Arsenic	Vinyl chloride, Carbazole	1,4-Dichlorobenzne; Dieldrin; Heptachlor epoxide; Benzene; alpha-BHC, Aldrin, beta-BHC	NA	
		Dermal Contact	5.0E-03	n-Nitroso-di-n-propylamine, Pentachlorophenol		Vinyl chloride, 1,4-Dichlorobenzene, carbozole, Dieldrin, Heptachlor epoxide, alpha-BHC	NA	
		Inhalation	--			Chloroform, Vinyl chloride, 1,4-Dichlorobenzene, Benzene	NA	
		Total	7.1E-03				NA	
	All Media	Total	8E-03				NA	
Future Construction Worker	Surface Soil	Ingestion	3.1E-06			Arsenic	2.8	
		Dermal Contact	5.5E-07				0.88	
		Inhalation	3.2E-09				0.0092	
		Total	3.6E-06				3.7	
	Subsurface Soil	Ingestion	1.7E-05			Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Dibenz(a,h)anthracene, Dioxin equivalents, Arsenic	7.0	Antimony, Thallium, Vanadium
		Dermal Contact	1.3E-09				3.8	Vanadium
		Inhalation	4.6E-09				0.0074	
		Total	1.8E-05				11	
	Groundwater	Ingestion	NA				NA	
		Dermal Contact	2.3E-05		Pentachloropheno	N-Nitroso-di-N-propylamine	3.1	
		Inhalation	1.4E-08				0.0082	
		Total	2.3E-05				3.1	
	All Media	Total	4E-05				18	

Table 5-4
Summary of Media-Specific Risks and Hazards
SWMU 14
Naval Station Norfolk

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $>10^{-4}$	Chemicals with Cancer Risks $>10^{-5}$ and $<10^{-4}$	Chemicals with Cancer Risks $>10^{-6}$ and $<10^{-5}$	Hazard Index	Chemicals with HI>1
Future Recreational Adult	Surface Soil	Ingestion	7.7E-06			Dioxin equivalents, Arsenic	0.24	
		Dermal Contact	3.1E-06			Arsenic	0.165	
		Inhalation	1.3E-08				0.00069	
		Total	1.1E-05				0.40	
	Subsurface Soil	Ingestion	4.4E-05		Benzo(a)pyrene	Benzo(a)anthracene, Benzo(b)fluoranthene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, Dioxin equivalents, Arsenic	0.58	
		Dermal Contact	3.9E-05		Benzo(a)pyrene	Benzo(a)anthracene, Benzo(b)fluoranthene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, Arsenic	0.72	
		Inhalation	1.8E-08				0.0010	
		Total	8.3E-05				1.30	
	Sediment	Ingestion	1.2E-06			Arsenic	0.027	
		Dermal Contact	1.8E-06			Arsenic	0.16	
		Inhalation	NA				NA	
		Total	3.0E-06				0.16	
	All Media	Total	1E-04				1.9	
Future Recreational Child	Surface Soil	Ingestion	1.5E-05			Benzo(a)pyrene, Dibenz(a,h)anthracene, Dioxin equivalents, Arsenic	2.2	
		Dermal Contact	1.9E-06				0.48	
		Inhalation	8.3E-09				0.0023	
		Total	1.7E-05				2.7	
	Subsurface Soil	Ingestion	8.5E-05		Benzo(a)pyrene	Benzo(a)anthracene, Benzo(b)fluoranthene, Dibenz(a,h)anthracene, Dioxin equivalents, Arsenic, Indeno(1,2,3-cd)pyrene	5.4	Thallium, Vanadium
		Dermal Contact	2.4E-05		Benzo(a)pyrene	Benzo(a)anthracene, Benzo(b)fluoranthene,Dibenz(a,h)anthracene,	2.1	Vanadium
		Inhalation	1.2E-08				0.0033	
		Total	1.1E-04				7.5	
	Sediment	Ingestion	2.3E-06			Arsenic	0.25	
		Dermal Contact	4.1E-07				0.19	
		Inhalation	NA				NA	
		Total	2.7E-06				0.19	
	All Media	Total	1E-04				10	

Table 5-4
Summary of Media-Specific Risks and Hazards
SWMU 14
Naval Station Norfolk

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $>10^{-4}$	Chemicals with Cancer Risks $>10^{-5}$ and $<10^{-4}$	Chemicals with Cancer Risks $>10^{-6}$ and $<10^{-5}$	Hazard Index	Chemicals with HI>1
Future Site Worker	Surface Soil	Ingestion	1.6E-05			Dibenz(a,h)anthracene, Benzo(a)pyrene, Dioxin equivalents, Arsenic	0.59	
		Dermal Contact	1.4E-05			Dibenz(a,h)anthracene, Benzo(a)pyrene, Dioxin equivalents, Arsenic	0.88	
		Inhalation	3.9E-08				0.0026	
		Total	3.0E-05				1.5	
	Subsurface Soil	Ingestion	9.1E-05		Benzo(a)pyrene	Benzo(a)anthracene, Benzo(b)fluoranthene; Dibenz(a,h)anthracene, Dioxin equivalents, Indeno(1,2,3-cd)pyrene, Arsenic	1.5	
		Dermal Contact	1.7E-04	Benzo(a)pyrene	Benzo(a)anthracene, Benzo(b)fluoranthene; Dibenz(a,h)anthracene	Indeno(1,2,3-cd)pyrene, Dioxin equivalents, Arsenic, Aroclor 1260	3.8	Vanadium
		Inhalation	5.6E-08				0.0037	
		Total	2.7E-04				5.3	
	All Media	Total	3E-04				6.8	
Future Trespasser - Adult	Surface Soil	Ingestion	4.0E-06			Arsenic	0.12	
		Dermal Contact	1.6E-06				0.086	
		Inhalation	NA				NA	
		Total	5.6E-06				0.21	
	Subsurface Soil	Ingestion	2.3E-05		Benzo(a)pyrene	Benzo(a)anthracene, Benzo(b)fluoranthene; Dibenz(a,h)anthracene, Dioxin equivalents, Arsenic	0.30	
		Dermal Contact	2.0E-05		Benzo(a)pyrene	Benzo(a)anthracene, Benzo(b)fluoranthene; Dibenz(a,h)anthracene	0.37	
		Inhalation	NA				NA	
		Total	4.3E-05				0.68	
	All Media	Total	5E-05				0.89	
Future Trespasser - Adolescent	Surface Soil	Ingestion	2.3E-06			Arsenic	0.23	
		Dermal Contact	3.5E-07				0.061	
		Inhalation	NA				NA	
		Total	2.6E-06				0.29	
	Subsurface Soil	Ingestion	1.3E-05			Benzo(a)pyrene, Dibenz(a,h)anthracene, Dioxin equivalents, Arsenic	0.58	
		Dermal Contact	4.5E-06			Benzo(a)pyrene	0.27	
		Inhalation	NA				NA	
		Total	1.7E-05				0.84	
	All Media	Total	2E-05				1.1	

NA - Not applicable, pathway incomplete.

Table 5-5
Summary of Media-Specific Risks and Hazards - Central Tendency
SWMU 14
Naval Station Norfolk, Norfolk, VA

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks >10^{-4}	Chemicals with Cancer Risks >10^{-5} and <10^{-4}	Chemicals with Cancer Risks >10^{-6} and <10^{-5}	Hazard Index	Chemicals with HI>1
Future Resident - Adult	Surface Soil	Ingestion	NA				NA	
		Dermal Contact	NA				NA	
		Inhalation	NA				NA	
		Total	NA				NA	
	Subsurface Soil	Ingestion	NA				0.25	
		Dermal Contact	NA				0.69	
		Inhalation	NA				NA	
		Total	NA				0.94	
	Groundwater	Ingestion	NA				4.7	4-methylphenol
		Dermal Contact	NA				0.65	
		Inhalation	NA				NA	
		Total	NA				5.4	
	All Media	Total	NA				6.3	
Future Resident - Child	Surface Soil	Ingestion	NA				1.2	
		Dermal Contact	NA				0.25	
		Inhalation	NA				NA	
		Total	NA				1.5	
	Subsurface Soil	Ingestion	NA				2.3	
		Dermal Contact	NA				0.61	
		Inhalation	NA				NA	
		Total	NA				2.9	
	Groundwater	Ingestion	NA				11	4-Methylphenol, Arsenic, Thallium, Iron, Manganese
		Dermal Contact	NA				4.2	Dibenzofuran
		Inhalation	NA				NA	
		Total	NA				15	
	All Media	Total	NA				20	
Future Resident - Lifetime	Surface Soil	Ingestion	NA				NA	
		Dermal Contact	NA				NA	
		Inhalation	NA				NA	
		Total	NA				NA	
	Subsurface Soil	Ingestion	1.2E-05			Benzo(a)pyrene, Arsenic, Dioxin equivalents	NA	
		Dermal Contact	8.3E-06			Benzo(a)pyrene	NA	
		Inhalation	NA				NA	
		Total	2.0E-05				NA	
	Groundwater	Ingestion	2.1E-03	n-Nitroso-di-n-propylamine, Arsenic	Vinyl chloride, Pentachlorophenol	Heptachlor epoxide; Benzene; alpha-BHC, Aldrin, Dieldrin, Carbazole	NA	
		Dermal Contact	2.2E-04	Pentachlorophenol	n-Nitroso-di-n-propylamine	Dieldrin	NA	
		Inhalation	NA				NA	
		Total	2.3E-03				NA	
	All Media	Total	2E-03				NA	

Table 5-5
Summary of Media-Specific Risks and Hazards - Central Tendency
SWMU 14
Naval Station Norfolk, Norfolk, VA

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks >10^{-4}	Chemicals with Cancer Risks >10^{-5} and <10^{-4}	Chemicals with Cancer Risks >10^{-6} and <10^{-5}	Hazard Index	Chemicals with HI>1
Future Construction Worker	Surface Soil	Ingestion	NA				1.2	
		Dermal Contact	NA				0.16	
		Inhalation	NA				NA	
		Total	NA				1.3	
	Subsurface Soil	Ingestion	NA				2.2	
		Dermal Contact	NA				0.39	
		Inhalation	NA				NA	
		Total	NA				2.6	
	Groundwater	Ingestion	NA				NA	
		Dermal Contact	NA				2.9	
		Inhalation	NA				NA	
		Total	NA				2.9	
	All Media	Total	NA				6.8	
Future Recreational Child	Surface Soil	Ingestion	NA				0.52	
		Dermal Contact	NA				0.13	
		Inhalation	NA				NA	
		Total	NA				0.65	
	Subsurface Soil	Ingestion	1.8E-06				1.0	
		Dermal Contact	6.8E-06			Benzo(a)pyrene	0.34	
		Inhalation	NA				NA	
		Total	8.6E-06				1.4	
	All Media	Total	9E-06				2.0	
Future Site Worker	Surface Soil	Ingestion	NA				NA	
		Dermal Contact	NA				NA	
		Inhalation	NA				NA	
		Total	NA				NA	
	Subsurface Soil	Ingestion	3.8E-06			Arsenic, Benzo(a)pyrene	0.090	
		Dermal Contact	1.0E-05			Arsenic, Benzo(a)pyrene, Dibenz(a,h)anthracene	0.37	
		Inhalation	NA				NA	
		Total	1.4E-05				0.46	
	All Media	Total	1E-05				0.46	

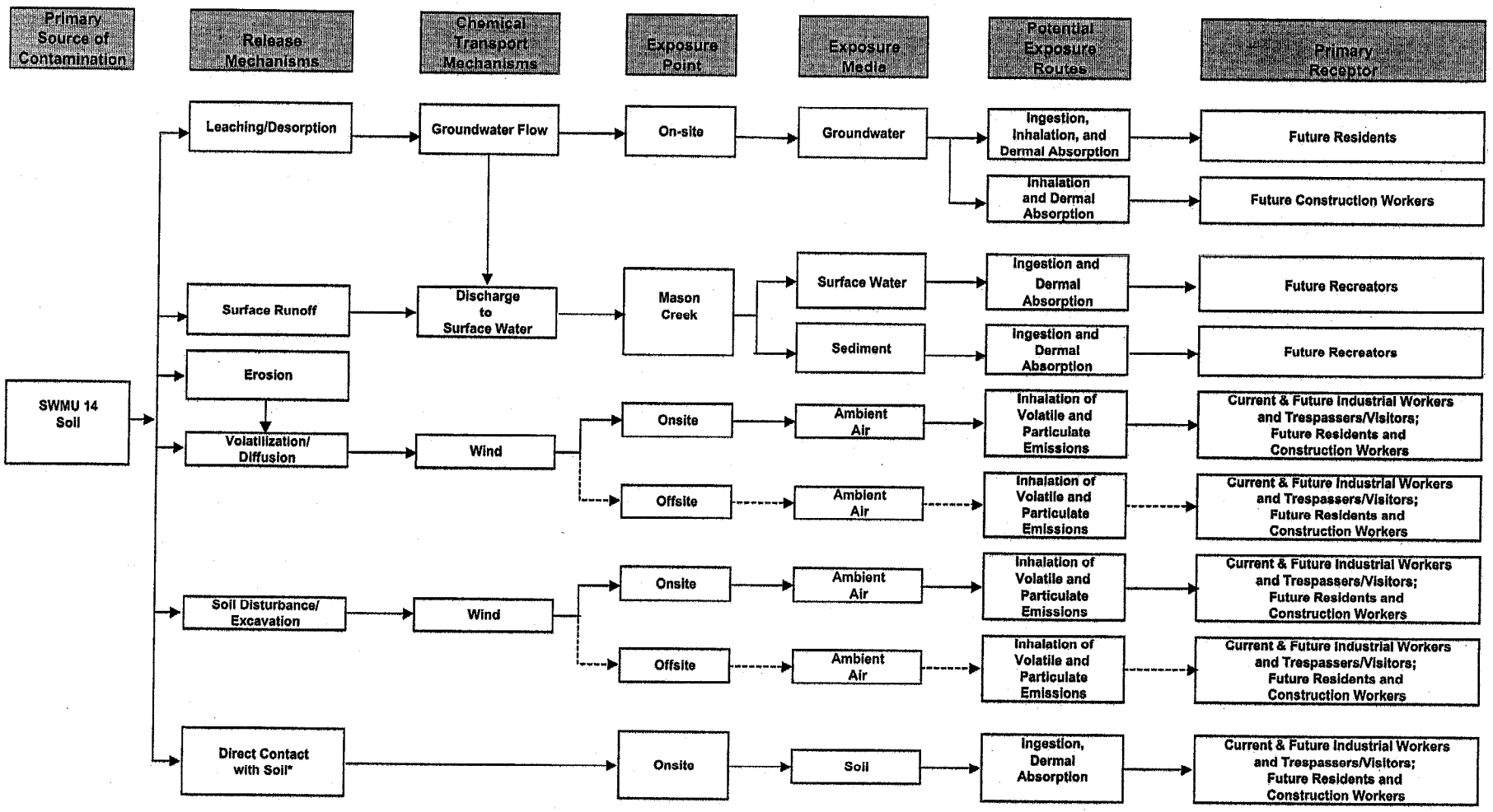
NA - Not applicable, pathway incomplete.

Table 5-6
Summary Table for Risks and Hazards Across Media for All RMEs
SWMU 14
NSN, Norfolk, VA

	Exposure Scenarios								Total Risk for Pathways	Total HI for Pathways	Exposure Scenarios							
	Surface Soil		Subsurface Soil		Groundwater		Sediment				Surface Soil		Subsurface Soil		Groundwater		Sediment	
	Risk	HI	Risk	HI	Risk	HI	Risk	HI			% Risk	% HI	% Risk	% HI	% Risk	% HI	% Risk	% HI
Current Site Worker	3.0E-05	1.5E+00	--	--	--	--	--	--	3.0E-05	1.5E+00	100%	100%	--	--	--	--	--	--
Current Trespasser Adult	5.6E-06	2.1E-01	--	--	--	--	--	--	5.6E-06	2.1E-01	100%	100%	--	--	--	--	--	--
Current Trespasser Adolescent	2.6E-06	2.9E-01	--	--	--	--	--	--	2.6E-06	2.9E-01	100%	100%	--	--	--	--	--	--
Future Site Worker	3.0E-05	2.7E+00	2.7E-04	5.3E+00	--	--	--	--	2.9E-04	8.0E+00	10%	34%	90%	66%	--	--	--	--
Future Resident Adult	NA	1.6E+00	NA	5.4E+00	NA	2.2E+01	--	--	NA	2.9E+01	NA	6%	NA	19%	NA	76%	--	--
Future Resident Child	NA	8.5E+00	NA	2.3E+01	NA	5.4E+01	--	--	NA	8.5E+01	NA	10%	NA	27%	NA	63%	--	--
Future Age-Adjusted Resident	5.9E-05	NA	6.0E-04	NA	7.1E-03	NA	--	--	7.7E-03	NA	1%	NA	8%	NA	91%	NA	--	--
Future Construction Worker	3.6E-06	3.7E+00	1.8E-05	1.1E+01	2.3E-05	3.1E+00	--	--	4.4E-05	1.5E+01	8%	25%	40%	75%	52%	21%	--	--
Future Trespasser Adult	5.6E-06	2.1E-01	4.3E-05	6.8E-01	--	--	--	--	4.9E-05	8.9E-01	12%	23%	88%	77%	--	--	--	--
Future Trespasser Adolescent	2.6E-06	2.9E-01	1.7E-05	8.4E-01	--	--	--	--	2.0E-05	1.1E+00	13%	26%	87%	74%	--	--	--	--
Future Recreational Adult	1.1E-05	4.0E-01	8.3E-05	1.3E+00	--	--	3.0E-06	1.6E-01	9.7E-05	1.9E+00	11%	21%	86%	70%	--	--	3%	9%
Future Recreational Child	1.7E-05	2.7E+00	1.1E-04	7.5E+00	--	--	2.7E-06	1.9E-01	1.3E-04	1.0E+01	13%	26%	85%	72%	--	--	2%	2%

Table 5-7
Summary Table for Risks and Hazards Across Media for All CTs
SWMU 14
NSN, Norfolk, VA

	Exposure Scenarios						Total Risk for Pathways	Total HI for Pathways	Exposure Scenarios					
	Surface Soil		Subsurface Soil		Groundwater				Surface Soil		Subsurface Soil		Groundwater	
	Risk	HI	Risk	HI	Risk	HI			% Risk	% HI	% Risk	% HI	% Risk	% HI
Future Site Worker	NA	--	1.4E-05	--	--	--	**1.4E-05**	--	--	--	NA	NA	--	--
Future Resident Adult	--	--	NA	9.4E-01	NA	5.4E+00	**NA**	**6.3E+00**	--	--	NA	15%	NA	85%
Future Resident Child	NA	1.5E+00	NA	2.9E+00	NA	1.5E+01	**NA**	**2.0E+01**	NA	7%	NA	15%	NA	78%
Future Age-Adjusted Resident	--	--	2.0E-05	NA	2.3E-03	NA	**2.3E-03**	**NA**	--	--	NA	NA	99%	NA
Future Construction Worker	NA	1.3E+00	NA	2.6E+00	NA	2.9E+00	**NA**	**6.8E+00**	NA	20%	NA	39%	NA	42%
Future Recreational Child	NA	6.5E-01	NA	1.4E+00	--	--	**NA**	**2.0E+00**	NA	32%	NA	68%	--	--



Notes:

* Exposure to surface soil for current industrial worker and trespasser/visitor; exposure to combined surface and subsurface soil for future trespasser/visitor, industrial worker, resident, and construction worker.

→ Complete Pathway

⇢ Incomplete Pathway

Figure 5-1

Conceptual Site Model for Potential Human Exposures at SWMU 14, Naval Station Norfolk

SECTION 6

Ecological Risk Assessment

This section contains a screening ecological risk assessment (SERA), Steps 1 and 2 of the ecological risk assessment process, and the first step (Step 3) of a baseline ecological risk assessment (BERA) for SWMU 14 (Q50 Satellite Accumulation Area) on NSN, Norfolk, Virginia. Figure 1-1 shows the location of SWMU 14.

6.1 Introduction

This ERA was conducted in accordance with the *Navy Policy for Conducting Ecological Risk Assessments* (CNO, 1999), the Navy guidance for implementing the Chief of Naval Operations (CNO) ERA policy (NAVFAC, 2001), and the Navy/Tier II ERA approach developed for USEPA Region III. The CNO ERA policy and guidance, which describe a process consisting of eight steps organized into three tiers, are conceptually similar to the eight-step ERA process outlined in USEPA ERA guidance for the Superfund program (USEPA, 1997a). The major differences between the Navy ERA policy/guidance and the USEPA ERA guidance are: (1) the Navy policy and guidance provide clearly defined criteria for exiting the ERA process at specific points, (2) the Navy policy and guidance divide Step 3 (the first step of the baseline ERA) into two distinct sub-steps (Steps 3A and 3B), with a potential exit point after Step 3A, and (3) the Navy policy and guidance incorporate risk management considerations throughout all tiers of the ERA process.

Steps 1 and 2 of the ERA process constitute the SERA, which is conducted using intentionally conservative assumptions. If complete exposure pathways exist at a site and the results of the SERA indicate that risks are possible, the site normally continues on to Step 3, the first step of the BERA. As indicated above, Step 3 is divided into two distinct sub-steps in Navy ERA guidance.

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

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

Step 3A of the Navy policy/guidance (refinement of conservative exposure assumptions) corresponds to the first activity listed above for the USEPA ERA guidance. In Step 3A, a refined evaluation of exposure estimates is conducted using more realistic assumptions and additional methodologies relative to those used in the SERA, which is intended to be a very conservative assessment. Examples of more realistic exposure assumptions include using

central tendency (e.g., arithmetic mean) estimates (rather than maximums) for media concentrations, bioaccumulation factors, and exposure parameters. Examples of additional methodologies include consideration of background concentrations, detection frequency, and bioavailability (CNO, 1999; NAVFAC, 2001).

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

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

6.1.1 Objectives

The SERA objectives are to:

- Determine if potential risks to ecological receptors warrant either: (1) additional assessment beyond the conservative screening steps of the ERA process (unacceptable ecological risks are possible), or (2) the removal of the site from further ecological consideration (no unacceptable ecological risks likely)
- Focus subsequent steps of the ERA process on the specific chemicals, pathways, and receptors of potential concern if unacceptable ecological risks are possible
- Identify any data gaps or areas of unacceptable uncertainty that may require the collection of additional data to support ERA evaluations beyond the screening level

If the site is not screened out in the SERA, the evaluation continues to Step 3. The general objectives of the Step 3 ERA are to:

- Refine the risk estimates from the SERA to determine if risks to ecological receptors from site-related chemicals are likely to occur based upon realistic exposure scenarios
- Focus subsequent data collection activities if potential risks are indicated, uncertainties are unacceptably high, and/or data gaps are identified

At the conclusion of Step 3A, there are three possible decision points:

- **No further action is warranted**—appropriate if the evaluation indicates that sufficient data are available on which to base a conclusion of no unacceptable risk within acceptable uncertainty.
- **Further data are required**—appropriate if the evaluation indicates that the potential for unacceptable risk exists and additional data to refine these estimates (e.g., additional

analytical data, measures of bioavailability) are needed. In this case, the site continues to Steps 3B and 4 of the ERA process.

- **Take remedial action**—appropriate for circumstances where the potential for unacceptable risks was identified but risks could best be addressed through remedial action (e.g., presumptive remedy) rather than additional study.

6.2 Environmental Setting

This section describes the general environmental setting (habitats and biota) of NSN. The description of the environmental setting was extracted largely from the latest Integrated Natural Resources Management Plan (INRMP, 1997) for NSN. The description of the environmental setting at SWMU 14 is included in Section 6.3.1 as part of the screening problem formulation. Sections 1 and 3 contain additional characterization of SWMU 14, including the site's history, is contained in.

6.2.1 Physiographic Features

Section 3 describes major physiographic features of NSN and surrounding area, while those specific to SWMU 14 are described in 3.1 and 6.3.1.

6.2.2 Habitats and Biota

This section briefly describes the habitats and biota at NSN, while Section 6.3.1 describes the likely biota at SWMU 14.

6.2.2.1 Surface Water Bodies

Four major surface water bodies occur on, or directly adjacent to, NSN—the Elizabeth River, which borders the facility on the west; Willoughby Bay, which borders the facility on the north; the remnants of Bousch Creek, located in the facility's center and connect to Willoughby Bay; and Mason Creek, in the facility's eastern portion of the facility and also connects to Willoughby Bay. The River and Bay are both tidal estuaries connected to the Chesapeake Bay, while portions of both creeks are also tidally influenced.

Although some surface water runoff from the NSN's western portion directly to the Elizabeth River, most of the facility lies within the Willoughby Bay watershed. Most surface water runoff on NSN flows either to Mason Creek or to the remnants of Bousch Creek, both of which connect to Willoughby Bay via a system of subsurface pipes and open ditches. One-hundred-and seventy-two outfalls on NSN drain directly (59) or indirectly (113) to Willoughby Bay. Most of these outfalls discharge stormwater runoff not associated with a regulated industrial activity. Some of these outfalls carry stormwater runoff from airfield and vehicle maintenance activities.

The northernmost channel of Mason Creek traverses NSN and empties into Willoughby Bay via a sub-grade aqueduct. The main channel of Bousch Creek, along with most of its bordering vegetated wetlands, was filled in and replaced by a network of drainage ditches and sub-grade pipes during NSN's development. This system of narrow ditches and pipes, which is still called Bousch Creek, is interspersed throughout the central portion of NSN. Bousch Creek empties into Willoughby Bay via a 3,900-ft sub-grade aqueduct. Most of

Mason Creek and the Bousch Creek system on NSN are tidally influenced. The salinity varies by area, point in the tidal cycle, and inputs from surface flow (runoff).

The reported 100-year, static-water flood elevation throughout NSN is +8.5 ft msl. Therefore, portions of NSN adjacent to Willoughby Bay and the Elizabeth River are within the 100-year floodplain. Section 3 describes the regional and site-specific groundwater resources.

6.2.2.2 Habitat Types

During the development of the Sewell's Point Navy Complex, piers and bulkheads engulfed a large portion of the shoreline, hardwood forests and wetlands were developed for the NSN missions, and stands of loblolly pine were planted throughout NSN. There are eight general habitat types currently found on NSN (INRMP, 1997):

- Hardwood forest (approximately 10 acres) consists of live oak, willow oak, and southern red oak and scattered throughout the facility's urban area in small (less than 1 acre) stands.
- Pine forest (157 acres) consists largely of planted loblolly pine stands.
- Mixed forest (143 acres) occurs in stands that range from 0.2 to 56 acres. Age and species composition varies by area. Tree species include sweetgum, black cherry, American holly, willow, willow oak, live oak, white oak, red oak, mulberry, sassafras, black locust, red cedar, and loblolly pine.
- Improved fields (504 acres) are areas of herbaceous vegetation that receive intensive maintenance and include mowed fields, landscaped areas, drill fields, athletic fields, and parade grounds.
- Semi-improved fields (21 acres) are areas that receive periodic recurring maintenance, but not at the rate or intensity applied to improved fields. These fields presently contain many early successional species of introduced herbaceous plants and young red cedar. Fields are mowed at irregular intervals.
- Unimproved fields (187 acres) are defined as those that do not currently receive any recurring maintenance and are dominated by a variety of herbaceous plants and small woody shrubs.
- Wetland areas (316 acres)currently found on NSN include Estuarine Subtidal Unconsolidated Bottom (14.8 acres), Estuarine Intertidal Emergent (2.5 acres), Estuarine Intertidal Unconsolidated Shoreline (0.49 acres), Palustrine Emergent (197.9 acres), Palustrine Forested (0.24 acres), Palustrine Scrub-Shrub/ Emergent (45.8 acres), Palustrine Scrub-Shrub (51.4 acres), and Palustrine Unconsolidated Bottom (borrow pit; 3.0 acres).
- Urban land (3,292 acres) constitutes most of NSN. The degree of urbanization varies from heavily urbanized areas, such as operations areas, to moderately urbanized areas, such as residential and administrative areas. Heavily urbanized areas contain little or no vegetation. Moderately urbanized areas contain maintained lawns along with native and ornamental shrubs and trees.

6.2.2.3 Flora

A detailed inventory of the flora on NSN has not been conducted. However, a list of the plant species that may be found has been compiled as part of the 1997 INRMP. This list is contained in Tables G-1 (general) and G-2 (wetland areas) of Appendix G (all other supporting tables for this ERA are also provided in Appendix G).

6.2.2.4 Fauna

A detailed inventory of fish and wildlife resources at NSN has not been conducted. The U.S. Fish and Wildlife Service (USFWS) developed a list of avian species occurring at NSN as part of their Fish and Wildlife Plan (Audet [1988], as cited in INRMP [1997]). The list includes 317 species of birds, which represent 78 percent of all such species known to occur in Virginia. This list includes resident, wintering, spring and fall migrant, accidental, and hypothetical species that may occur at NSN or its immediate vicinity. Birds expected to be found at NSN are listed in Appendix G, Table G-3. As identified in the 1988 Fish and Wildlife Plan, 36 terrestrial mammal species may be found on NSN (Table G-4, Appendix G). Five marine mammal species may be seen on rare occasions in the waters of the Lower Chesapeake Bay-Hampton Roads vicinity (Table G-4 in Appendix G).

A comprehensive survey of reptiles and amphibians has not been conducted at NSN. The reptilian and amphibian species likely to be found at or adjacent to NSN, as identified in INRMP (1997) include 1 siren, 12 salamanders, 19 toads and frogs, 10 turtles, 4 sea turtles, and 32 lizards and snakes (Table G-5 in Appendix G).

A list of 62 fish species that may use the waters at or surrounding NSN was developed for the 1988 Fish and Wildlife Plan (INRMP, 1997; Table G-6 in Appendix G). Sixteen species of crustaceans and 12 of mollusks have been reported from the lower Elizabeth River. Hampton Roads and the lower James River support large populations of oysters, hard clams, soft-shelled clams, and blue crabs. During the summer, blue crabs are also abundant in Willoughby Bay and Mason Creek (INRMP, 1997).

6.2.2.5 Rare, Threatened, and Endangered Species

There are no legally protected rare, threatened, or endangered plant species confirmed on NSN. However, a small stand of Virginia pinweed (*Lechea maritima* var. *virginica*), a Virginia threatened plant species, was identified on the narrow strip of land immediately north of I-64 (INRMP, 1997). The Willoughby Oak (a single tree) has special historic significance, but the species is not listed as rare, threatened, or endangered.

At the time the INRMP for NSN was prepared (1997), there were six federally endangered, three federally threatened, and three federal candidates for listing that may have been found in NSN's general vicinity. Most of these represent transient birds or marine mammals. Some represent historical records from the Norfolk area. The only threatened or endangered species sighted at or near NSN in recent times are the American peregrine falcon (*Falco peregrinus*) and the West Indian manatee (*Trichechus manatus*). Although confirmed sightings of peregrine falcons have been made at NSN, this species was removed from the federal list on August 25, 1999. In late September 1995, a lone manatee was sighted in the Mason Creek Bridge Road area of Willoughby Bay. This manatee had been observed during the summer as far north as Boston and was evidently heading south at the time of its visit to NSN (INRMP, 1997).

6.3 Screening Ecological Risk Assessment

As discussed in Section 6.1, Steps 1 and 2 of the ERA process constitute the SERA, which is conducted using intentionally conservative assumptions. The principal components of the SERA are problem formulation, exposure estimation, effects evaluation, and risk calculation.

6.3.1 Screening Problem Formulation

Problem formulation establishes the ERA's goals, scope, and focus. As part of problem formulation, the environmental setting of SWMU 14 is characterized in terms of the habitats and biota known or likely to be present. The types and concentrations of chemicals present in ecologically relevant media are also described. A preliminary conceptual model is developed for SWMU 14 that describes potential source areas, potential transport pathways and exposure media, potential exposure pathways and routes, and potential receptors. Assessment endpoints, measurement endpoints, and risk hypotheses are then selected to evaluate those receptors for which complete and potentially significant exposure pathways are likely to exist. The fate, transport, and toxicological properties of the chemicals present at SWMU 14, particularly the potential to bioaccumulate, are also considered during this process.

6.3.1.1 Environmental Setting

SWMU 14 is in the northeastern corner of Sewell's Point (Figure 1-1). The SWMU originally consisted of a concrete storage pad surrounded by a grass-covered field. The pad served as a 90-day hazardous waste accumulation area where wastes generated through various waste streams were processed (sampled, identified, labeled, and packaged) before being shipped offsite for eventual disposal. The original concrete pad has been removed and is not associated with the concrete pad currently at the site. A more detailed description of the site's history can be found in Section 1.2.

The peninsula at Sewell's Point (or the Q-Area) is a manmade landmass formed from two distinct periods of fill activities. The first began in the early 1950s, when channels were dredged to allow for construction of the northernmost series of piers (located along the western side of Sewell's Point). The resulting dredge material was used to create much of the land at the Q-Area. The second occurred between 1974 and 1978, when construction debris was used as fill in the eastern portion of Sewell's Point (Site 9 Landfill), which includes the site (see Figure 1-2). Soils at the site reflect the nature of the fill materials used to create Sewell's Point and are generally very coarse, composed of sand, silt, and gravel. Some concrete, stone, and miscellaneous debris was also used as fill material (see Section 3).

Currently, SWMU 14 consists of a vacant grass-covered lot that is periodically mowed. The grassy area is sometimes used as a temporary parking lot when the adjacent paved lots are full. The concrete pad currently at the site occasionally serves as a temporary (less than 90 days) storage area for IDW from various site investigations. The portion of the site adjacent to Willoughby Bay is used for recreation (jogging trails). A fishing pier is located off the site's northeastern corner. A small picnic area and a volleyball court are located in the Q-Area's extreme southeastern portion. Tentative future uses may include paving over all or part of the field to convert the area into an additional parking lot or constructing ball fields.

South of the grassy field is a small lagoon hydrologically connected to Willoughby Bay by a small inlet/outlet. The approximately 2-acre lagoon consists of a combination of open water areas (in the center of the basin) and vegetated areas (along the shorelines and the southern third of the basin) containing mostly cordgrass (*Spartina alterniflora*). Historically, surface drainage from the site's southernmost portion may have entered the lagoon through sheet flow. Currently, surface water runoff to the lagoon includes stormwater drainage from paved parking areas on Sewell's Point, which enters the lagoon through a regulated outfall located in the basin's northwestern corner of the basin and drainage from ball fields southwest of the lagoon, which enters the basin via a small ditch located in the lagoon's southwestern corner (Figure 6-1). The lagoon is being developed as a wildlife viewing area through the construction of a viewing platform and interpretive signs.

Two tidal major surface water bodies, Willoughby Bay and the Elizabeth River, are in the immediate site vicinity. Precipitation falling on the site is ultimately transported to Willoughby Bay (mostly via groundwater flow), which borders the site on the north and east. West of the site, surface and groundwater flow is west towards the Elizabeth River. Both Willoughby Bay and the Elizabeth River ultimately discharge to the Chesapeake Bay.

Willoughby Bay, a tidal estuary of Chesapeake Bay, abuts the site's northern and eastern site. The shorelines consist of large-diameter riprap. The site, which is very flat, is about 15 to 20 ft above the level of the bay. There are no channelized drainage features connecting the site to the bay. Due to the flat topography, sheet flow from the site to the Bay is likely to be minimal. Groundwater flow is north and east towards the bay.

6.3.1.2 Summary of Analytical Data

The analytical chemistry data used in this ERA for ecologically-relevant media were obtained from several major studies completed to date at NSN—the Relative Risk Ranking System Phase I (1995) and Phase II (1996) studies, the Supplemental Investigation (1998), the RI Phase I (1999), Phase II (2000), and Phase III (2001) studies, and the Additional Investigation (2002). These investigations are described in Sections 1.3 and 2.1.

Table G-7 in Appendix G summarizes the available data (in terms of sources and number of samples), by medium and chemical group, and also identifies the data that were used in the ERA. The rationale for selecting the data to use in the ERA is provided in Section 6.3.2.1. Table G-8 in Appendix G provides a list of the medium-specific samples (station ID, samples ID, and collection date) incorporated into this ERA.

The analytical data used in the ERA are summarized in Appendix G Tables G-9 (lagoon sediment), G-10 (groundwater), and G-11 (surface soil). Sampling locations are shown on Figures 6-1 and 6-2. Appendix A provides the raw analytical data.

6.3.1.3 Preliminary Conceptual Model

Figure 6-3 illustrates a preliminary diagrammatic conceptual model for SWMU 14. Key components of the preliminary conceptual model include the identification of potential source areas, transport pathways, exposure media, exposure routes, and receptors.

Source Areas

Potential source areas at SWMU 14 include the satellite accumulation area (concrete pad) and the area (Site 9 Landfill) where materials (thought to consist mostly of construction

debris) were historically landfilled (Figure 6-1). Potential contamination may be attributable to the hazardous materials that were stored on the pad in the past, from the former drum storage area north of the pad, from the former scrap metal pile north and east of it pad, and from its northeast, where stockpiled railroad ties and metal debris were historically stored (see Section 1.2).

Transport Pathways and Exposure Media

A transport pathway describes the mechanisms whereby chemicals may be transported from a source of contamination to ecologically relevant media. Figure 6-3 shows these transport pathways. Site-related chemicals in surface and subsurface soils may leach to groundwater and then discharge to downgradient water bodies (Willoughby Bay). Historically, when the site was actively used, site-related chemicals in soils may have been transported via surface runoff to adjacent surface water bodies such as the lagoon and Willoughby Bay. Current surface runoff to these water bodies is likely to be minimal, based upon the current site configuration (flat topography and lack of surface drainage structures). Site-related chemicals in surface soil, sediment, and surface water may be taken up and accumulated in the tissues of biota and thus transported to upper-trophic-level receptors via food webs.

Exposure Pathways and Routes

An exposure pathway links a source of contamination with one or more receptors through exposure via one or more media and exposure routes. Exposure, and thus potential risk, can only occur if complete exposure pathways exist. Figure 6-3 shows the potentially complete exposure pathways to ecological receptors at SWMU 14.

Potentially complete exposure pathways to terrestrial receptors utilizing SWMU 14 (grassy field) do exist but are likely to be limited. The coarse nature of the substrate likely limits the presence of soil invertebrates at the site. The site has low habitat quality and diversity, consisting entirely of periodically mowed grass and other herbaceous plants. The site is also isolated from other non-developed areas of NSN; the western portion of Sewell's Point is developed as boat piers and parking areas, and the area south of the site is also completely developed (parking areas and buildings). Thus, terrestrial vertebrates utilizing the site are likely to be limited to birds, such as geese and gulls, which may use the grass field as a resting area.

Potentially complete exposure pathways to aquatic (e.g., benthic invertebrates and fish) and semi-aquatic (e.g., gulls and herons) receptors utilizing adjacent water bodies (lagoon and bay) also exist. Although surface runoff pathways to these water bodies are not likely to be significant at the present time, historical runoff from the site may have entered these water bodies. Groundwater flows north and east from the site towards the Bay (Figure 3-5).

An exposure route describes the specific mechanism(s) by which a receptor is exposed to a chemical present in an environmental medium. Terrestrial plants may be exposed through their root surfaces during water and nutrient uptake to chemicals present in surface soils. Unrooted, floating aquatic plants, and rooted submerged vascular aquatic plants and algae, may be exposed to chemicals directly from the water or (for rooted plants) from sediments.

Animals may be exposed to chemicals through: (1) direct inhalation of gaseous chemicals or of chemicals adhered to airborne particulate matter, (2) incidental ingestion of contaminated

abiotic media (soil or sediment) during feeding activities, (3) the ingestion of contaminated water, (4) the ingestion of contaminated plant and/or animal tissues for chemicals that have entered food webs, and/or (5) dermal contact with contaminated abiotic media. These routes, where applicable, are depicted on Figure 6-3.

Based upon the general fate properties (e.g., relatively high adsorption to solids) of the chemicals commonly present on SWMU 14 (metals, pesticides/PCBs, and PAHs) and the protection offered by hair or feathers, dermal and inhalation exposures for upper-trophic-level receptor species are not considered significant relative to ingestion and are therefore not evaluated in this ERA. Upper-trophic-level receptors considered in this ERA would not likely be exposed to significant airborne sources of chemicals by inhalation because the site is vegetated and little wind erosion of the coarse soils would be expected. Furthermore, the primary chemicals present on the site typically adsorb to soil suggesting that the potential for volatilization and thus exposure via inhalation is limited. Incidental ingestion of soil or sediment during feeding, preening, or grooming activities is, however, considered in the risk estimates. Direct contact is considered for lower-trophic-level receptors (e.g., invertebrates).

Direct ingestion of drinking water is only considered when the salinity is below 15 parts per thousand, the approximate toxic threshold for wildlife receptors (Humphreys, 1988). Since the adjacent lagoon and bay are saline, drinking water exposures are not included in this ERA.

Receptors

Because of the complexity of natural systems, it is generally not possible to directly assess the potential impacts to all ecological receptors at a site. Therefore, specific receptor species or species groups (e.g., great blue heron) are often selected as surrogates to evaluate potential risks to larger portions of the ecological community (guilds; e.g., piscivorous birds) used to represent the assessment endpoints (e.g., survival and reproduction of piscivorous birds). Selection criteria typically include those species that:

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

The following upper-trophic-level receptor species have been chosen for exposure modeling based upon the criteria listed above:

- American robin (*Turdus migratorius*)—terrestrial avian invertivore/omnivore
- Canada goose (*Branta canadensis*)—terrestrial avian herbivore
- Mallard (*Anas platyrhynchos*)—wetland/aquatic avian omnivore
- Great blue heron (*Ardea herodias*)—wetland/aquatic avian piscivore
- Herring gull (*Larus argentatus*)—wetland/aquatic avian piscivore

Upper-trophic-level receptor species quantitatively evaluated in the ERA were limited to birds, which are among the taxonomic groups with the most available data regarding

exposure and toxicological effects. Mammals are not expected to regularly inhabit the area at and surrounding SWMU 14 due to limited access (lack of travel corridors from offsite undeveloped areas) and lack of habitat. Amphibians are typically selected as receptors only when freshwater aquatic or wetland habitats are present on, or in the contaminant transport pathways (as defined in the conceptual model) of a site. Freshwater is defined as surface water salinity less than or equal to 1.0 part per thousand (USEPA, 1996b). These freshwater habitats are not present on or adjacent to SWMU 14. Because of the limited amount of toxicological data available for reptiles, exposures via the food web for this taxonomic group were evaluated using bird receptor species as surrogates.

Lower-trophic-level receptors were evaluated in the ERA based upon those taxonomic groupings for which screening values have been developed; these groupings and screening values are typically used in most ERAs. As such, specific species of aquatic biota (e.g., fish and benthic invertebrates) were not chosen as receptors because of the limited information available for specific species and because aquatic biota were dealt with on a community level via a comparison of surface water and sediment concentrations with medium-specific screening values. Similarly, terrestrial plants and soil invertebrates (earthworms are the standard surrogate although the coarse nature of the soils at the site are likely to limit their presence or abundance) were evaluated using soil screening values developed specifically for these groups.

Endpoints and Risk Hypotheses

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

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

Assessment and measurement endpoints may involve ecological components from any level of biological organization, from individual organisms to the ecosystem itself. Effects on individual organisms are important for some receptors, such as rare and endangered species; population- and community-level effects are typically more relevant to ecosystems.

Population- and community-level effects are usually difficult to evaluate directly without long-term and extensive study. However, measurement endpoint evaluations at the individual level, such as an evaluation of the effects of chemical exposure on reproduction, can be used to predict effects on an assessment endpoint at the population or community level. In addition, use of criteria values designed to protect most (e.g., 95 percent) of the components of a community (e.g., Ambient Water Quality Criteria for the Protection of Aquatic Life) can be useful in evaluating potential community- and/or population-level effects.

Table G-12 in Appendix G shows the preliminary assessment endpoints, risk hypotheses, and measurement endpoints used in the screening portion (Steps 1 and 2) of the ERA. Table G-12 also shows the receptors associated with each endpoint.

6.3.2 Screening Exposure Estimation

Maximum concentrations in lagoon sediment, groundwater, and surface soil were used in the screening portion of the ERA to conservatively estimate potential chemical exposures for the ecological receptors selected to represent the assessment endpoints at SWMU 14. Food web exposures for upper-trophic-level receptor species were determined by estimating the chemical-specific concentrations in each dietary component using uptake and food web models. Incidental ingestion of soil or sediment was also included when calculating the total level of exposure. Maximum sediment or surface soil concentrations were used in all screening food web calculations to provide a conservative assessment.

For conservatism, the maximum reporting limit for chemicals analyzed for but not detected was also compared to medium-specific screening values and (where applicable) used for food web exposure modeling. This was done to determine if reporting limits were less than or equal to chemical concentrations at which potential adverse effects to ecological receptors could occur.

Dioxins and furans detected in surface soil were evaluated as a single group using the toxicity equivalency quotient (TEQ) approach (Van der Berg et al., 1998). The congener-specific avian toxicity equivalency factors (TEFs) used to calculate TEQs are listed in Appendix G, Table G-13.

6.3.2.1 Selection Criteria for Analytical Data

Available analytical data were selected for use in the ERA based upon the following:

- Data must have been validated by a qualified data validator using acceptable data validation methods. Rejected (R) values were not used in the ERA. Unqualified data and data qualified as J, L, or K were treated as detected. Data qualified as U or B were treated as non-detected.
- For samples with duplicate analyses, the higher of the two concentrations was used when both values were detects or when both values were non-detects. In cases where one result was a detection and the other a non-detect, the detected value was used.
- Surface soil or sediment data collected prior to any major physical disturbance (such as capping or paving) that would result in the elimination of realistic exposure pathways

were not used in the ERA nor were surface soil samples that were collected under paved surfaces.

- For surface soil, only samples collected between 0 and 6 in. were used, since this depth range represents the most realistic potential exposures for most of the ecological receptors evaluated in terrestrial habitats. For this reason, the surface soil data from the 1995 and 1996 RRR studies (collected from depths of 0 to 24 inches) were not used in the ERA (Table G-7 in Appendix G).
- For sediment, samples from 0 to 6 inches were used preferentially since this depth range represents the most realistic exposures for sediment-dwelling species. Data from the 1996 RRRS study were not used in the ERA because the complete data set was not available (just detects), the validation status of these data was uncertain, and more recent data from the lagoon were available (Appendix G, Table G-7).
- For groundwater, data from Geoprobe® sampling and from temporary groundwater wells were not considered. Only the more recent data collected as part of the RI and follow-on studies were used in the ERA (Appendix G, Table G-7)
- For groundwater, total (unfiltered) chemical concentrations were used in the screening portion of the ERA for conservatism. Dissolved (filtered) metals data were considered in the refined (Step 3A) evaluation.
- The single lagoon surface water sample collected during the 1996 RRR study was not used in the ERA because it was not likely to be representative of current exposures (due to its age), the complete data set was not available (just detects), and the validation status of this sample was uncertain.

6.3.2.2 Exposure Estimation

Upper-trophic-level receptor exposures (via the food web) to chemicals present in surface soil and sediment were determined by estimating the concentration of each bioaccumulating chemical in each relevant dietary component. Incidental ingestion of soil or sediment was included when calculating the total exposure. Exposure via drinking water was not included since SWMU 14 lacked a potential freshwater drinking source. Since receptors (and their prey) are not exposed directly to groundwater, food web exposures were not calculated based upon groundwater concentrations.

Chemicals with the potential to bioaccumulate were evaluated for exposures via food webs. This list of bioaccumulating chemicals is provided in Appendix G Table G-14 for relevant constituents and is based upon the list provided in Table 4-2 of USEPA (2000).

Dietary items for which tissue concentrations were modeled included terrestrial plants, soil invertebrates, wetland plants, benthic invertebrates, and fish. The tissue calculation methodologies are outlined below. For the screening portion of the ERA, the uptake of chemicals from the abiotic media into these food items was based upon conservative (e.g., maximum or 90th percentile) bioconcentration factors (BCFs) or bioaccumulation factors (BAFs) from the literature. Default factors of 1.0 were used only when data were unavailable for a chemical in the literature.

Screening Exposure Point Concentrations

Maximum media concentrations were used as exposure point concentrations for exposure estimation and food web modeling in the screening portion of the ERA. Exposure point concentrations (concentrations in plant, soil invertebrate, benthic invertebrate, and fish prey items) for terrestrial and aquatic predators were estimated using bioaccumulation models and maximum measured media concentrations. The methodology and models used to derive these estimates are described below.

Terrestrial Plants. Tissue concentrations in the aboveground vegetative portion of terrestrial plants were estimated by multiplying the maximum surface soil concentration for each chemical by chemical-specific soil-to-plant BCFs obtained from the literature. The BCF values used were based upon root uptake from soil and on the ratio between dry-weight soil and dry-weight plant tissue. Literature values based upon the ratio between dry-weight soil and wet-weight plant tissue were converted to a dry-weight basis by dividing the wet-weight BCF by the estimated solids content for plants (15 percent [0.15]] Sample et al., 1997).

For inorganic chemicals without literature-based BCFs, a soil-to-plant BCF of one was assumed. For organic chemicals without literature based BCFs, soil-to-plant BCFs were estimated using the algorithm provided in Travis and Arms (1988):

$$\log B_v = 1.588 - (0.578)(\log K_{ow})$$

where: B_v = Soil-to-plant BCF (unitless; dry-weight basis)
K_{ow} = Octanol-water partitioning coefficient (unitless)

The log K_{ow} values used in the calculations were obtained mostly from USEPA (1995b, 1996a) and are listed in Table G-14. The soil-to-plant BCFs used in the screening portion of the ERA are shown in Table G-15.

Soil Invertebrates. Tissue concentrations in soil invertebrates (earthworms) were estimated by multiplying the maximum surface soil concentration for each chemical by chemical-specific BCFs or BAFs obtained from the literature. BCFs are calculated by dividing the concentration of a chemical in the tissues of an organism by the concentration of that same chemical in the surrounding environmental medium (in this case, soil) without accounting for uptake via the diet. BAFs consider both direct exposure to soil and exposure via the diet. Since earthworms consume soil, BAFs are more appropriate values and were used in the food web models when available. BAFs based upon depurated analyses (soil was purged from the gut of the earthworm prior to analysis) were given preference over undepurated analyses when selecting BAF values because direct ingestion of soil was accounted for separately in the food web model.

The BCF/BAF values used were based upon the ratio between dry-weight soil and dry-weight earthworm tissue. Literature values based upon the ratio between dry-weight soil and wet-weight earthworm tissue were converted to a dry-weight basis by dividing the wet-weight BCF/BAF by the estimated solids content for earthworms (16 percent [0.16], USEPA, 1993). For chemicals without available measured BAFs or BCFs, an earthworm BAF of one was assumed. The soil-to-earthworm BCFs/BAFs used in the screening portion of the ERA are shown in Table G-15.

Wetland Plants. Tissue concentrations in wetland plants were estimated using the same methodologies as described above for terrestrial plants except that maximum sediment (not soil) concentrations were used in the calculation.

Benthic Invertebrates. Tissue concentrations in benthic invertebrates were estimated by multiplying the maximum sediment concentration for each chemical by chemical-specific sediment-to-invertebrate BAFs obtained from the literature. The BAF values used were based upon the ratio between dry-weight sediment and dry-weight invertebrate tissue. BAFs based upon depurated analyses (sediment was purged from the gut of the organism prior to analysis) were given preference over undepurated analyses when selecting BAF values since direct ingestion of sediment was accounted for separately in the food web model.

Literature values based upon the ratio between dry-weight sediment and wet-weight invertebrate tissue were converted to a dry-weight basis by dividing the wet-weight BAF by the estimated solids content for benthic invertebrates (21 percent [0.21], USEPA, 1993). For chemicals without literature-based sediment-to-invertebrate BAFs, a BAF of one was assumed. The sediment-to-invertebrate BAFs used in the screening portion of the ERA are shown in Appendix G, Table G-16.

Fish. Tissue concentrations in whole-body fish were estimated by multiplying the maximum sediment concentration for each chemical by chemical-specific sediment-to-fish BAFs obtained from the literature. The BAF values used were based upon the ratio between dry-weight sediment and dry-weight fish tissue. Literature values based upon the ratio between dry-weight sediment and wet-weight fish tissue were converted to a dry-weight basis by dividing the wet-weight BAF by the estimated solids content for fish (25 percent [0.25]; USEPA, 1993). For chemicals without literature based sediment-to-fish BAFs, a BAF of one was assumed. The sediment-to-fish BAFs used in the screening portion of the ERA are shown in Appendix G, Table G-16.

Dietary Intakes

Dietary intakes for each upper-trophic-level receptor were calculated using the following formula (modified from USEPA [1993]):

$$DI_x = \frac{[[\sum_i (FIR)(FC_{xi})(PDF_i)] + [(FIR)(SC_x)(PDS)] + [(WIR)(WC_x)]]}{BW}$$

where:

DI_x = Dietary intake for chemical x (µg chemical/kg body weight/day)
FIR = Food ingestion rate (kg/day, dry-weight)
FC_{xi} = Concentration of chemical x in food item i (µg/kg, dry-weight)
PDF_i = Proportion of diet composed of food item i (dry-weight basis)
SC_x = Concentration of chemical x in soil/sediment (µg/kg, dry-weight)
PDS = Proportion of diet composed of soil/sediment (dry-weight basis)
WIR = Water ingestion rate (L/day)
WC_x = Concentration of chemical x in water (µg/L)
BW = Body weight (kg, wet-weight)

Receptor-specific values used as inputs to this equation for the screening portion of the ERA are provided in Appendix G Table G-17. Consistent with the conservative approach used for a SERA, the minimum body weight and maximum food ingestion rate from the scientific literature were used for each receptor (the water ingestion rate was set to zero since the site lacked of a freshwater drinking source). It was assumed that chemicals were 100 percent bioavailable to the receptor and it was also assumed that each receptor spent 100 percent of its time on the site (i.e., an area use factor [AUF] of 1.0 was assumed).

6.3.3 Screening Effects Evaluation

The purpose of the screening effects evaluation is to establish chemical exposure levels (screening values) that represent conservative thresholds for adverse ecological effects. One set of screening values is typically developed for each selected assessment endpoint.

6.3.3.1 Medium-Specific Screening Values

Medium-specific screening values were established for each ecologically relevant medium at SWMU 14. Based upon the preliminary conceptual model (Figure 6-3), direct exposure to lagoon surface water, lagoon sediment, and surface soil are potentially complete pathways. Although ecological receptors do not typically have direct exposure to groundwater, surface water screening values were also compared with analytical groundwater data (both with and without dilution factors) in order to provide an initial, conservative evaluation of the potential for significant contaminant transport via groundwater to Willoughby Bay.

The screening values used in the ERA were based upon those of Region III BTAG (USEPA, 1995a) and additional values available from the literature. When more than one screening value was available for a specific medium (e.g., soil fauna and soil flora), the lowest of these values was selected. Screening values were adjusted based upon modifying factors as follows:

- Surface soil screening values based upon Dutch soil standards for certain organic chemicals were adjusted based upon a total organic carbon (TOC) value of 2 percent. This 2 percent value represents the default minimum adjustment value and was used because site-specific TOC data were not available.
- Equilibrium-partitioning based sediment values (used as a measure of bioavailability in Step 3) were adjusted using a mean measured TOC value of 4.74 percent for the lagoon.

The screening values used in the ERA are provided, by medium, in Appendix G Table G-18.

6.3.3.2 Ingestion Screening Values

Ingestion screening values for dietary exposures were derived for each avian receptor species and chemical evaluated in the ERA. Toxicological information from the literature for wildlife species most closely related to the receptor species was used, when available, but was supplemented by laboratory studies of non-wildlife species (e.g., chickens) when necessary. The ingestion screening values are expressed as milligrams of the chemical per kilogram body weight of the receptor per day (µg/kg-BW/day).

Growth and reproduction were emphasized as assessment endpoints since they are the most relevant, ecologically, to maintaining viable populations and because they are

generally the most studied chronic toxicological endpoints for ecological receptors. If several chronic toxicity studies were available from the literature, the most appropriate study was selected for each receptor species based upon study design, study methodology, study duration, study endpoint, and test species. No Observed Adverse Effect Levels (NOAELs) based upon growth and reproduction were utilized, when available, as the primary screening values. When chronic NOAEL values were unavailable, estimates were extrapolated from chronic Lowest Observed Adverse Effect Levels (LOAELs) using an uncertainty factor of 10. Ingestion screening values for birds are provided in Appendix G Table G-19.

6.3.4 Screening Risk Calculation

The screening risk calculation is the final step in a SERA. In this step, the maximum exposure concentrations (abiotic media) or exposure doses (upper-trophic-level receptor species) are compared with the corresponding screening values to derive screening risk estimates. The outcome of this step is a list of Chemicals of Potential Concern (COPCs) for each medium-pathway-receptor combination evaluated or a conclusion of acceptable risk.

6.3.4.1 Selection of Chemicals of Potential Concern (COPCs)

COPCs were selected using the hazard quotient (HQ) method. HQs were calculated by dividing the chemical concentration in the medium being evaluated by the corresponding medium-specific screening value or by dividing the exposure dose by the corresponding ingestion screening value. Chemicals with HQs greater than or equal to one were considered COPCs in the SERA. Detected chemicals for which toxicological data were not available were also retained as COPCs in the SERA.

HQs exceeding one indicate the potential for risk since the chemical concentration or dose (exposure) exceeds the screening value (effect). However, screening values and exposure estimates were derived using intentionally conservative assumptions such that HQs greater than or equal to one do not necessarily indicate that risks are present or impacts are occurring. Rather, it identifies chemical-pathway-receptor combinations requiring further evaluation. HQs that are less than one indicate that risks are very unlikely, enabling a conclusion of no unacceptable risk to be reached with high confidence.

Lagoon Sediment

Maximum sediment concentrations in the lagoon are compared to screening values in Appendix G Table G-20. Based upon this comparison, nine inorganics (arsenic, barium, cadmium, copper, lead, mercury, nickel, vanadium, and zinc) had HQs equaling or exceeding one based upon a detected concentration and were identified as COPCs. Two inorganics (beryllium and cyanide) were identified as COPCs because they were detected but a screening value was not available. One additional inorganic (selenium) exceeded its screening value based upon a maximum reporting limit and was also identified as a COPC.

Five pesticides (4,4'-DDE, 4,4'-DDT, alpha-chlordane, beta-BHC, and gamma-chlordane), one PCB compound (Aroclor-1260), and eight SVOCs (all were PAHs) exceeded screening values based upon detected concentrations and were identified as COPCs. The maximum concentration of total PAHs also exceeded its sediment screening value (Table G-20 in Appendix G). Four pesticides, six PCB compounds, and 12 SVOCs had HQs equaling or exceeding one based upon maximum reporting limits and were also identified as COPCs.

Groundwater

Maximum (undiluted) groundwater concentrations are compared to surface water screening values in Appendix G Table G-21. Based upon this comparison for unfiltered samples, six inorganics (copper, cyanide, iron, lead, manganese, and nickel) had HQs equaling or exceeding one based upon detected maximum concentrations and were identified as COPCs. One other inorganic (silver) had a HQ equaling or exceeding one based upon its maximum reporting limit and was identified as a COPC.

Nine pesticides (4,4'-DDT, endosulfan II, endosulfan sulfate, endrin, endrin aldehyde, endrin ketone, heptachlor epoxide, alpha-chlordane, and gamma-chlordane) had HQs equaling or exceeding one based upon detected concentrations and were identified as COPCs. Three pesticides and seven PCB compounds (Aroclors) had HQs equaling or exceeding one based upon maximum reporting limits and were also identified as COPCs (Table G-21 in Appendix G).

Eight SVOCs (2,4-dimethylphenol, 2-methylphenol, 4-methylphenol, carbazole, dibenzofuran, fluoranthene, pentachlorophenol, and phenanthrene) and two VOCs (carbon disulfide and chlorobenzene) had HQs equaling or exceeding one based upon detected concentrations and were identified as COPCs. Thirteen SVOCs had HQs equaling or exceeding one based upon maximum reporting limits and were also identified as COPCs. Three SVOCs and six VOCs were identified as COPCs because they were detected and screening values were not available (Table G-21 in Appendix G).

Surface Soil

Maximum surface soil concentrations are compared to screening values in Appendix G Table G-22. Based upon this comparison, 17 inorganics had HQs equaling or exceeding one based upon detected maximum concentrations and were identified as COPCs.

Three pesticides (4,4'-DDD, 4,4'-DDE, and methoxychlor) and four PCBs (Aroclors 1242, 1248, 1254, and 1260) had HQs equaling or exceeding one based upon detected maximum concentrations and were identified as COPCs. Three PCB compounds (Aroclors 1016, 1221, and 1232) had HQs equaling or exceeding one based upon maximum reporting limits and were also identified as COPCs.

Sixteen SVOCs (15 PAH compounds, and bis[2-ethylhexyl]phthalate) and one VOC (1,2-dichlorobenzene) had HQs equaling or exceeding one based upon detected maximum concentrations and were identified as COPCs. The maximum concentration of total PAHs also exceeded surface soil screening values. Twelve SVOCs and two VOCs had HQs equaling or exceeding one based upon maximum reporting limits and were also identified as COPCs. Two SVOCs (butylbenzylphthalate and di-n-octylphthalate) and five VOCs (2-butanone, acetone, carbon disulfide, chloromethane, and trichlorofluoromethane) were retained as COPCs because these chemicals were detected but screening values were not available (Table G-22).

Food Web Exposures

Hazard quotients for each upper-trophic-level receptor, based upon maximum exposure doses, are provided in Appendix G Table G-23. Based upon a comparison to NOAELs, nine metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc), one pesticide (4,4'-DDE), two PCBs (Aroclors-1254 and 1260), one SVOC

(hexachlorobenzene), and dioxin/furans had HQs equaling or exceeding one for one or more terrestrial receptors. The exceedance for hexachlorobenzene was based upon the maximum reporting limit. Ingestion screening values were not available for four SVOCs (Table G-23 in Appendix G), none of which was detected in surface soil samples.

Based upon a comparison to NOAELs, four metals (lead, mercury, selenium, and zinc), one PCB (Aroclors-1260), and one SVOC (hexachlorobenzene) had HQs equaling or exceeding one for one or more semi-aquatic receptors. The exceedance for hexachlorobenzene was based upon the maximum reporting limit. Ingestion screening values were not available for four SVOCs (Table G-23 in Appendix G), none of which was detected in lagoon sediment samples.

6.3.5 Screening Risk Conclusions

COPCs were identified in each of the media evaluated. These COPCs are summarized in Appendix G Table G-24.

6.4 Baseline (Step 3) Ecological Risk Assessment

The SERA resulted in a set of COPCs for each medium (Table G-24 in Appendix G). This set of COPCs includes chemicals with HQs exceeding one (based upon maximum exposures) and detected chemicals for which toxicological data (screening values) were not available.

6.4.1 Refinement of Conservative Screening Assumptions

According to Superfund guidance (USEPA, 1997a), Step 3 initiates the problem formulation phase of the BERA. Under Navy policy/guidance (CNO, 1999; NAVFAC, 2001), the BERA begins with a preliminary step (Step 3A) in which the conservative assumptions employed in the SERA are refined and risk estimates are recalculated using the same conceptual model for the site. In addition, the re-evaluation may include consideration of other factors such as background data, the frequency at which chemicals were detected, and chemical-specific bioavailability (CNO, 1999; NAVFAC, 2001).

The assumptions, parameter values, and methods that were modified for the Step 3A evaluation included:

- Risk estimates based upon maximum chemical concentrations were supplemented by risk estimates based upon average (arithmetic mean) chemical concentrations. In addition, BAFs and BCFs were based upon, or modeled from, central tendency estimates (e.g., median or mean) from the literature as opposed to the maximum or high-end (e.g., 90th percentile) estimates used in the SERA for many chemicals. Revised BAF and BCF values used in Step 3A are provided in Appendix G, Tables G-25 and G-26.

  In the BERA, using central tendency estimates (rather than high-end or maximums) for exposure parameters, such as BAFs, provides a more representative estimate of potential exposures and risks to receptor populations (the focus of the assessment endpoints) of upper-trophic-level receptors. Since these upper-trophic-level species are highly mobile, they would be expected to effectively average their exposure over time as they forage within the area defining their home range (which will extend to off-site areas). Average prey concentrations at Step 3A are most appropriately estimated using central tendency

estimates of media concentrations and accumulation factors. For example, the wildlife dietary exposure models contained in the Wildlife Exposure Factors Handbook (USEPA, 1993) specify the calculation of an average daily dose. Increasing the representativeness of the exposure estimates relative to population-level effects is consistent with the intent of the Step 3A evaluation. In cases where adequate spatial sampling coverage exists, mean concentrations are also appropriate for evaluating potential risks to populations of lower-trophic-level receptors because the members of the population are expected to be found throughout a site (where suitable habitat is present), rather than concentrated in one particular area. While effects on individual organisms might be important for some receptors, such as rare and endangered species, population- and community-level effects are typically more relevant to ecosystems. A discussion of the uncertainties associated with the number of available samples and their spatial distribution is contained in Section 6.5.

- Central tendency estimates (e.g., mean, median, or midpoint) for body weight and ingestion rate (Table G-27) were used to develop exposure estimates for upper-trophic-level receptors, rather than the minimum body weights and maximum ingestion rates used in the SERA. Central tendency estimates for these exposure parameters are more relevant for a BERA because they better represent the characteristics of a greater proportion of the individuals in the population. Populations (rather than individual organisms) were emphasized during the development of the assessment endpoints for the ERA.

- The SERA conservatively identified a chemical as a food web COPC if the estimated dose for at least one upper-trophic-level receptor exceeded the NOAEL. The actual dose that is protective of an individual receptor, however, will fall between the NOAEL and the LOAEL. Both the NOAEL and LOAEL were used for comparison in the BERA. However, chemicals were not considered Chemicals of Concern (COCs) following Step 3A unless the exposure dose exceeded the LOAEL because this dose is expected to be protective of the population, which is the assessment endpoint being evaluated.

- Facility-specific background concentrations were also considered in the Step 3A surface soil evaluation.

- The detection frequency for individual chemicals and spatial distribution (including representativeness of sample locations) were considered in the Step 3A evaluation. In general, chemicals that were detected in less than 5 percent of the samples in a medium were not considered COCs in that medium if at least 20 samples were available (USEPA, 1989) and the spatial distribution of chemical concentrations indicated a low potential for receptor exposure. It is unlikely that infrequently detected chemicals represent a risk to receptors at the population level, particularly for groundwater, where dilution upon discharge will further reduce any potential risk. The uncertainties associated with the use of frequency of detection and spatial distribution are discussed in Section 6.5.

- USEPA guidance (USEPA, 1996b) indicates that the dissolved metal fraction should be preferentially used to the total metal fraction in surface water (and by extension in groundwater) screening to evaluate direct exposures of aquatic biota. For conservatism, total metal concentrations were used in the SERA for the groundwater screen. Since high levels of suspended solids and sediment-adsorbed metals could result in overstating

bioavailable groundwater concentrations (and thus potential exposures and risks upon discharge to surface water bodies), filtered metal concentrations (representing the dissolved fraction) in groundwater were also evaluated in the Step 3A portion of the ERA through a comparison to screening values based upon the dissolved metal fraction.

Only complete and significant pathways identified in the SERA were evaluated in Step 3A of the ERA. Similarly, only chemicals and receptors identified in the SERA as requiring further evaluation were addressed in Step 3A. Although many aspects of the estimation of exposure were modified in Step 3A (see above), the screening values (effects) used in Step 3A were the same as the values used in the SERA. Although the same basic conceptual model from the SERA was also used in Step 3A, the endpoints and risk hypotheses from the SERA were modified slightly to better reflect the Step 3A analysis (Table G-28 in Appendix G). Chemicals for which potential risks were still possible following the Step 3A risk characterization were retained as Preliminary Chemicals of Concern (PCOCs) for risk evaluation. Final Chemicals of Concern (COCs) were determined during the risk evaluation (see Section 6.4.3).

6.4.2 Refined (Step 3A) Risk Characterization

Based upon the results of the SERA, the assessment endpoints, measurement endpoints, and risk hypotheses were modified for the Step 3A evaluation (Table G-28). Modifications included eliminating from further consideration those assessment endpoints for which no unacceptable risk was found during the SERA and modifying the measurement endpoints to reflect the assumptions and methods used in the Step 3A evaluation. The results of the refined risk characterization are discussed, by medium, in the following subsections.

6.4.2.1 Lagoon Sediment

The comparison of mean chemical concentrations in lagoon sediment with screening values is presented in Appendix G Table G-29 (maximum concentrations were used if the mean concentration exceeded the maximum). Based upon this comparison, arsenic was the inorganic chemical with a HQ greater than or equal to one based upon a detected concentration. The magnitude of this mean HQ (1.36) was low. Arsenic was also the only detected inorganic that exceeded its screening value in more than one sample. While the mean HQs for the other inorganic COPCs were all less than one, all of the exceedances for these chemicals occurred in sample SD04. This is discussed further in Section 6.4.3. Beryllium and cyanide were detected in sediment but lacked screening values. Beryllium and cyanide were identified, along with arsenic, as PCOCs for risk evaluation.

Four pesticides (4,4'-DDE, 4,4'-DDT, alpha-chlordane, and gamma-chlordane) and one PCB (Aroclor-1260) exceeded screening values based upon mean detected concentrations. Mean HQs ranged from 1.34 (alpha-chlordane) to 3.76 (4,4'-DDT) for the pesticides, while the HQ for Aroclor-1260 was 2.10 (Table G-29 in Appendix G). These five chemicals were identified as PCOCs for risk evaluation. While the mean detected concentrations of five individual PAH compounds exceeded screening values, the mean HQ for total PAHs was less than one.

A number of chemicals were identified as COPCs in the SERA because maximum reporting limits exceeded screening values. Mean HQs (calculated based upon the mean of one-half of the sample reporting limits) for these chemicals were almost always less than four. None of

these undetected chemicals were identified as PCOCs in sediment. This is discussed further in Section 6.5.

6.4.2.2 Groundwater

The comparison of mean chemical concentrations in groundwater with surface water screening values is presented in Appendix G Table G-30 (maximum concentrations were used if the mean concentration exceeded the maximum). This comparison was done first assuming no dilution and again using a dilution factor of 10. In the absence of site-specific dilution factors, Buchman (1999) recommends the use of a dilution factor of 10 to account for the dilution expected during migration and upon discharge of groundwater to surface water.

Based upon this comparison, cyanide, manganese, and 4,4'-DDT had mean HQs equaling or exceeding one based upon detected concentrations and a dilution factor of 10. These three chemicals were identified as PCOCs for risk evaluation.

A number of chemicals were retained as COPCs in the SERA because maximum reporting limits exceeded screening values. Of the COPCs that fall into this category, mean HQs (based upon the mean of one-half of the sample reporting limits) were substantially greater than 10 (the recommended dilution factor) only for benzo(a)pyrene (HQ of 54.7; Table G-30 in Appendix G). There is much uncertainty associated with the screening value for benzo(a)pyrene. The value (0.21 μg/L), which is not well documented, is a BTAG Region III screening value. Buchman (1999) reports an acute marine surface water screening value of 300 μg/L for benzo(a)pyrene. Applying an uncertainty factor of 100 to this value yields an estimated chronic value of 3 μg/L, which is comparable to one-half of the reporting limit (5 μg/L) for 20 of the 24 groundwater samples (the other four samples had elevated detection limits for benzo[a]pyrene of 38, 100, 100, and 220 μg/L). Since benzo(a)pyrene was not actually detected (at a typical reporting limit of 10 μg/L) and groundwater from the site is expected to be significantly diluted when discharged to surface water bodies, it is unlikely that benzo(a)pyrene would constitute a risk to aquatic biota. Thus, none of these undetected chemicals were identified as PCOCs in groundwater. This is discussed further in Section 6.5.

Three SVOCs (2,4-dichlorophenol, benzaldehyde, and n-nitroso-di-n-propylamine) and six VOCs (4-methyl-2-pentanone, chloroethane, cumene, cyclohexane, MTBE, and methylcyclohexane) were detected in groundwater but lacked screening values. These nine chemicals were identified as PCOCs for risk evaluation.

6.4.2.3 Surface Soil

Mean chemical concentrations in surface soil are compared with soil screening values in Appendix G Table G-31 (maximum concentrations were used if the mean concentration exceeded the maximum). Based upon this comparison, eleven inorganic chemicals (aluminum, antimony, chromium, copper, iron, lead, mercury, nickel, thallium, vanadium and zinc) had mean HQs equaling or exceeding one based upon detected concentrations and were identified as PCOCs for risk evaluation. The mean HQs for antimony (1.33) and nickel (1.30) were only marginally greater than one.

Aroclor-1260 and 15 PAHs had mean HQs equaling or exceeding one based upon detected concentrations (Table G-31 in Appendix G) and were identified as PCOCs for risk

evaluation. The mean HQ for total PAHs (1.97) also exceeded one. Two other SVOCs (butylbenzylphthalate and di-n-octylphthalate) and five VOCs (2-butanone, acetone, carbon disulfide, chloromethane, and trichlorofluoromethane) were detected but lacked screening values. These seven chemicals were also identified as PCOCs for risk evaluation.

Seventeen chemicals were identified as COPCs in the SERA because maximum-reporting limits exceeded screening values. Mean HQs (based upon the mean of one-half of the sample reporting limits) were less than one for nine of these chemicals and about three or less for the remaining seven chemicals (Table G-31 in Appendix G). Thus, it is unlikely that these chemicals are present on the site at environmentally meaningful concentrations and none of these undetected chemicals were identified as PCOCs in surface soil. This is discussed further in Section 6.5.

6.4.2.4 Food Web Exposures

Hazard quotients based upon mean exposure doses for each upper-trophic-level receptor species are provided in Appendix G Table G-32. Based upon a comparison to NOAELs, HQs for lead (American robin and Canada goose) and zinc (American robin) exceeded one for terrestrial receptors and HQs for mercury (great blue heron) exceeded one for semi-aquatic receptors. HQs based upon LOAELs were less than one for all terrestrial and semi-aquatic receptors.

6.4.3 Risk Evaluation

This section evaluates the potential for adverse effects associated with the PCOCs identified in Section 6.4.2 and Table G-33 in Appendix G. The goal of this evaluation is to finalize a list of Chemicals of Concern (COCs). Because the refined risk characterization indicated that food web exposures do not pose a significant risk to upper-trophic-level receptors, only potential risks via direct exposure for lower-trophic-level receptors are considered in this section.

6.4.3.1 Terrestrial Habitats

Eleven metals (aluminum, antimony, chromium, copper, iron, lead, mercury, nickel, thallium, vanadium, and zinc) were identified as PCOCs because mean surface soil concentrations exceeded soil-screening values. The mean HQs for antimony (1.33) and nickel (1.30) were only marginally greater than one. To evaluate the potential significance of these exceedances, on-site surface soil concentrations were compared to facilitywide background surface soil concentrations developed as part of the Soil Background Investigation (CH2M HILL, 2000). As part of this background investigation, 95-percent UTL values were developed for a number of metals in surface soils. On-site inorganic surface soil concentrations are compared to these UTLs in Appendix G Table G-34.

Aluminum and iron were consistent with background UTLs for facilitywide dredge-fill soils, and mean concentrations of chromium, mercury, and vanadium were also similar to background soil concentrations (Table G-34 in Appendix G). The remaining six metals were identified as COCs. Copper, lead, and zinc were the inorganics that exceeded both screening values and background concentrations most frequently and with the highest magnitudes. The spatial distribution of the highest screening value exceedances (HQs >5) was very similar for these three metals. There was one cluster of exceedances along the northern site

boundary (DS40, DS07, and DS05) and a second cluster in the site's southwestern portion (DS18, DS33, DS34, and DS52).

The magnitude of the exceedance for Aroclor-1260 (HQ of 1.08) was low and this chemical is unlikely to represent a significant risk, especially on a sitewide basis. The screening value for this chemical (100 µg/kg) was a BTAG Region III value reportedly based upon effects to plants but more likely is based upon Canadian background soil concentrations. USEPA (1999c) reports terrestrial plant and soil invertebrate chronic toxicological values (for Aroclor-1254) of 10,000 and 2,510 µg/kg, respectively. Efroymson et al. (1997a) reports a terrestrial plant screening value (also for Aroclor-1254) of 40,000 µg/kg. The maximum concentration for Aroclor-1260 (1,900 µg/kg) is below these toxicological thresholds.

Fifteen individual PAHs had mean HQs equaling or exceeding one based upon detected concentrations and were identified as PCOCs. However, the screening value for each of these 15 PAHs (100 µg/kg) was a BTAG Region III value reportedly based upon carcinogenic effects in mice treated with benzo(a)pyrene (but more likely based upon Canadian background soil concentrations). Since the objective of this portion of the analysis is to evaluate potential effects to plants and soil invertebrates (exposures via ingestion routes for upper-trophic-level receptors were evaluated separately using more appropriate toxicological endpoints than carcinogenicity), this screening value has limited applicability to this evaluation. Toxicologically based screening values for lower-trophic-level receptors were available for two PAHs (neither of which was identified as a PCOC), including acenaphthene (2,500 µg/kg) and fluorene (1,700 µg/kg). Both of these screening values were substantially higher than 100 µg/kg. This suggests that toxicologically based screening values based upon lower-trophic-level organisms for the 15 PAH PCOCs would likely be higher as well. However, total PAH concentrations (compared to a generic effects-based screening value for total PAHs of 4,100 µg/kg; Table G-18 in Appendix G) did exceed based upon mean concentrations (HQ of 1.97). USEPA (1999c) reports a soil invertebrate screening value for higher molecular weight PAHs (extrapolated to total PAHs) of 25,000 µg/kg based upon toxicity tests conducted using benzo(a)pyrene. Maximum (57,680 µg/kg), but not mean (8,080 µg/kg), total PAH concentrations in site surface soil exceeded this value. Given these factors, and the lack of exceedances from food web modeling, potential risks to terrestrial receptors from exposure to PAHs in surface soils are likely to be limited on a sitewide basis. However, spatially restricted risks are possible, especially along the site's northern i.e., DS01, DS04, and DS11) and the east-central boundaries (area near SS04). For this reason, PAHs are identified as PCOCs.

Butylbenzylphthalate and di-n-octylphthalate were detected but lacked screening values. Soil screening values were available for four other phthalates and ranging from 10,000 to 40,000 µg/kg (Table G-18 in Appendix G). Maximum detected concentrations of both butylbenzylphthalate (5,100 µg/kg) and di-n-octylphthalate (170 µg/kg) were lower than these screening values. In addition, di-n-octylphthalate was detected in only one of 55 samples. Five VOCs (2-butanone, acetone, carbon disulfide, chloromethane, and trichlorofluoromethane) were also detected but lacked screening values. Maximum concentrations for each of these VOCs were less than 300 µg/kg, a typical screening value for other, similar VOCs (Table G-18 in Appendix G). Thus, it is unlikely that these seven chemicals are present in site surface soils at concentrations likely to adversely effect terrestrial fauna.

Although a number of organic (PAHs) and inorganic (particularly copper, lead, and zinc) chemicals exceeded soil screening values and/or background concentrations, the magnitude of potential exposures to these chemicals is expected to be low for terrestrial receptors at the site. Potentially complete exposure pathways to terrestrial receptors utilizing SWMU 14 (grassy field) do exist but are likely to be limited. The coarse nature of the substrate likely limits the presence of soil invertebrates at the site. The site has low habitat quality and diversity, consisting entirely of periodically mowed grass and other herbaceous plants. The site is also isolated from other non-developed areas of NSN; the western portion of Sewell's Point is developed as boat piers and parking areas, and the area south of the site is also completely developed (parking areas and buildings). Thus, terrestrial vertebrates utilizing the site are likely to be mostly limited to avian species, such as geese and gulls that may use the grass field as a resting area. Risks to such avian receptors were low to negligible based upon food web modeling.

6.4.3.2 Aquatic Habitats

Potentially complete exposure pathways to aquatic receptors utilizing adjacent water bodies (lagoon and bay) exist. Although surface water runoff pathways to these water bodies are not likely to be significant at the present time, historical runoff from the site may have entered these water bodies. Groundwater flow from the site is north and east towards the bay (Figure 3-5).

Lagoon

Relatively few chemicals exceeded screening values in lagoon sediment. Arsenic was the only inorganic chemical with a mean HQ greater than or equal to one based upon a detected concentration. The magnitude of this mean HQ (1.36) was low. Arsenic was also the only detected inorganic that exceeded its screening value in more than one sample. While the mean HQs for the other inorganic COPCs (from Step 2) were all less than one, all of the exceedances for these chemicals occurred in sample SD04, although sample-specific HQs were all two or less. The maximum concentration for arsenic also occurred in sample SD04 (HQ of 2.49). While arsenic is identified as a COC in lagoon sediment, arsenic did not exceed screening values in site surface soils or groundwater, suggesting that these low magnitude sediment exceedances are not site related.

Four pesticides (4,4'-DDE, 4,4'-DDT, alpha-chlordane, and gamma-chlordane) and one PCB (Aroclor-1260) exceeded screening values based upon mean detected concentrations. Mean HQs ranged from 1.34 (alpha-chlordane) to 3.76 (4,4'-DDT) for the pesticides, while the HQ for Aroclor-1260 was 2.10. While the mean detected concentrations of five PAH compounds exceeded screening values, maximum HQs were less than two and the mean HQ for total PAHs was less than one. This suggests that potential risks related to PAHs are minimal in lagoon sediments. A comparison of sediment concentrations to equilibrium partitioning-based sediment values, which provide a measure of bioavailability, suggests that potential exposures and risks are very low for all of these organic compounds (Table G-35 in Appendix G). As for metals, the highest concentrations for these organics occurred near the center of the lagoon (samples SD02 and SD04), although the spatial distribution of the pesticides was more widespread across the lagoon. The center of the lagoon may serve as a depositional area for inputs from the two outfalls to the west and the bay inlet to the east, although TOC concentrations in samples SD02 and SD04 (in the center of the lagoon) were

not higher than those in the two samples near the outfalls (SD01 and SD05) but were higher than those from the sample at the bay inlet (SD03).

Beryllium and cyanide were detected in lagoon sediments but lacked screening values. The concentration of beryllium was relatively uniform, as indicated by a coefficient of variation of one. The maximum concentration of beryllium in sediment (0.96 µg/kg) was also below the facility-specific background surface soil concentration for dredge-fill soils (maximum of 2.3 µg/kg and mean of 0.80 µg/kg). Thus, it is likely that beryllium in lagoon sediments is present at background concentrations and does not present an unacceptable risk to ecological receptors. The mean concentration of cyanide (0.08 µg/kg) was less than existing freshwater sediment screening values (0.10; Persaud et al., 1993), suggesting that it too does not present an unacceptable risk to ecological receptors.

Willoughby Bay

Willoughby Bay is located immediately east and north of SWMU 14. Complete transport pathways (current and/or historical) via groundwater link SWMU 14 to the bay based upon proximity and groundwater flow directions.

Cyanide, manganese (dissolved and total), and 4,4'-DDT had mean HQs exceeding one based upon detected concentrations and a dilution factor of 10. Total cyanide was detected in 12 of 20 samples, with a mean diluted HQ of 2.79. Because the screening value for cyanide is based upon free (bioavailable) cyanide, and not total cyanide, the ecological significance of the exceedances is questionable. To address this, five wells were re-sampled in 2002 for amenable (free) cyanide, including MW07, where the maximum concentration of total cyanide was found. Amenable cyanide was not detected in any of the five wells at the same reporting limit as total cyanide. Thus, the cyanide present in groundwater is not likely to be present in bioavailable forms and would likely pose a minimal risk to aquatic receptors in Willoughby Bay following discharge.

There is much uncertainty associated with the marine surface water screening value for manganese. The value (10 µg/L), which is not well documented, is a BTAG Region III screening value for marine fauna. The BTAG Region III screening values for marine flora (200 µg/L) and freshwater fauna (14,500 µg/L) are considerably higher, as is a well-documented freshwater chronic value (120 µg/L) developed by Oak Ridge National Laboratory (Suter and Tsao, 1996) using the USEPA Tier II methodology. The mean HQ for manganese would drop to about two or less (undiluted) and less than one (diluted) based upon a screening value in the 120 to 200 µg/L range. Since no site-specific upgradient wells or facility-specific background wells are available, it is unclear if the observed manganese concentrations are within the range of naturally occurring concentrations in groundwater. However, the maximum manganese concentration in groundwater was found in MW19S, which is far removed from the source areas and the main groundwater flow direction. This suggests that manganese is likely to be present at background levels in groundwater and/or is not site related. Manganese was not identified as a PCOC in site surface soils.

4,4'-DDT was detected in 4 of 24 groundwater samples from 3 different wells (MW05S, MW07S, and MW15S). Most of the detections occurred in the latest round (2002) of groundwater sampling. 4,4'-DDT (and its breakdown products 4,4'-DDD and 4,4'-DDE) was frequently detected in surface soil samples although at concentrations below soil screening values. 4,4'-DDT was thus identified as a COC in groundwater.

Nine other organic chemicals (three SVOCs and six VOCs) were identified as PCOCs based upon their detection in groundwater samples and a lack of screening values. For the SVOCs, n-nitroso-di-n-propylamine was only detected in one of 24 samples (4 percent) and was screened out based upon frequency of detection. Maximum (undiluted) concentrations of 2,4-dichorophenol (19.0 µg/L) and benzaldehyde (2.00 µg/L) were both below freshwater screening values (365 µg/L [USEPA, 1995a] and 22.0 µg/L [AQUIRE 2001], respectively) from the literature, suggesting that they do not represent a potential risk to ecological receptors.

For the VOCs, maximum (undiluted) concentrations of 4-methyl-2-pentanone (78.2 µg/L), cumene (2.50 µg/L), cyclohexane (0.77 µg/L), MTBE (0.15 µg/L), and methylcyclohexane (1.20 µg/L) were each below freshwater screening values (46,000 µg/L [USEPA, 1995a], 41.4 µg/L [AQUIRE 2001], 329 µg/L [AQUIRE 2001], 6,720 µg/L [AQUIRE 2001], and 452 µg/L [AQUIRE 2001], respectively) from the literature, suggesting that they do not represent a potential risk to ecological receptors. Maximum (undiluted) concentrations of chloroethane (10.0 µg/L) were well below screening values for other chlorinated ethanes (which ranged from 940 to 320,000 µg/L; Table G-18 in Appendix G).

6.5 Uncertainties

Uncertainties are present in all risk assessments because of the limitations of the available data and the need to make certain assumptions and extrapolations based upon incomplete information. The uncertainty in this ERA is mainly attributable to the following factors:

- Reporting Limits—Reporting limits for some analytes exceeded applicable screening values in some media; these chemicals were not retained as COCs unless they were detected. In groundwater, mean HQs (based upon the mean of one-half of the sample reporting limits) were substantially greater than 10 (the recommended dilution factor) only for benzo(a)pyrene. There is much uncertainty associated with the screening value for benzo(a)pyrene. The value (0.21 µg/L), which is not well documented, is a BTAG Region III screening value. Buchman (1999) reports an acute marine surface water screening value of 300 µg/L for benzo(a)pyrene. Applying an uncertainty factor of 100 to this value yields an estimated chronic value of 3 µg/L, which is comparable to one-half of the reporting limit (5 µg/L) for 20 of the 24 groundwater samples (the other four samples had elevated detection limits for benzo[a]pyrene of 38, 100, 100, and 220 µg/L). Since benzo(a)pyrene was not actually detected (at a typical reporting limit of 10 µg/L) and groundwater from the site is expected to be significantly diluted when discharged to surface water bodies, it is unlikely that benzo(a)pyrene would constitute a risk to aquatic biota.

  In sediment, mean reporting limits exceeded screening values for a number of chemicals although almost always by a factor of four or less. In surface soil, mean reporting limits for undetected chemicals with screening values were less than four times the screening value, making it unlikely that they are present at ecologically significant concentrations.

- Selection of COCs—Chemicals without available screening values for a medium were not retained as COCs unless they were detected. This was particularly an issue for the surface soil screen (almost all chemicals had water and sediment screening values).

- Use of Freshwater-Based Screening Values—When marine-based water screening values were not available, freshwater-based screening values were used if available. This introduces some uncertainty into the assessment as it assumes that toxicity is similar in freshwater and marine organisms for these chemicals.

- Evaluation of Groundwater—Although ecological receptors are not directly exposed to groundwater, groundwater concentrations were compared to surface water screening values. A dilution factor of 10 (Buchman, 1999) was used in this evaluation since site-specific factors were not available. This introduces some uncertainty into the analysis.

- Evaluation of Soils—The evaluation of chemical contamination in soils was restricted to surface soils from the 0 to 6-inch depth range. Although some ecological receptors may be exposed to deeper soils (e.g., in the 6 to 24-inch depth range), no useable existing soil data were available from this deeper depth range. However, the evaluation of surface soils in the 0 to 6-inch depth range is likely to result in a conservative assessment since releases were at the surface (and thus higher chemical concentrations would be expected in the surface strata except possibly for volatile organic compounds). Also, due to the coarse nature of the substrate on the site, organisms that burrow into the soil are not expected to commonly occur.

- Soil Invertebrate Screening Values—Most soil invertebrate screening values are based upon earthworm data. Due to the coarse nature of the substrate at the site, soil invertebrates are not likely to be common. Terrestrial invertebrates on the site are likely to be limited to organisms such as grasshoppers, which typically have less direct exposure to soils. Also, an invertebrate-eating avian receptor (American robin) was included in the ERA and assumed to consume earthworms (since most soil BAFs are also based upon earthworm data). This is likely to result in a very conservative estimate of risk for this pathway, which is not expected to be important on the site.

- Sediment Screening Values—Most of the sediment screening values used in the ERA do not consider site-specific bioavailability to ecological receptors and are typically based on correlational studies (termed the Screening Level Concentration approach). These factors tend to make the resulting screening values conservative and likely overestimate potential risk.

- Ingestion Screening Values—Data on the toxicity of many chemicals to the receptor species were sparse or lacking, requiring the extrapolation of data from other wildlife species or from laboratory studies with non-wildlife species. This is a typical limitation and extrapolation for ecological risk assessments because so few wildlife species have been tested directly for most chemicals. The uncertainties associated with toxicity extrapolation were minimized through the selection of the most appropriate test species for which suitable toxicity data were available. The factors considered in selecting a test species to represent a receptor species included taxonomic relatedness, trophic level, foraging method, and similarity of diet.

  A second uncertainty related to the derivation of ingestion screening values applies to metals. Most of the toxicological studies on which the ingestion screening values for metals were based used forms of the metal (such as salts) that have high water solubility and high bioavailability to receptors. Since the analytical samples on which site-specific

exposure estimates were based measured total metal, regardless of form, and these highly bioavailable forms are expected to compose only a fraction of the total metal concentration, this is likely to result in an overestimation of potential risks for these chemicals.

A third source of uncertainty associated with the derivation of ingestion screening values concerns the use of uncertainty factors. For example, NOAELs were extrapolated to LOAELs using an uncertainty factor of ten. This approach is likely to be conservative since Dourson and Stara (1983) determined that 96 percent of the chemicals included in a data review had LOAEL/NOAEL ratios of five or less. The use of an uncertainty factor of 10, although potentially conservative, also serves to counter some of the uncertainty associated with interspecies extrapolations, for which a specific uncertainty factor was not used.

- Chemical Mixtures—Information on the ecotoxicological effects of chemical interactions is generally lacking, which required (as is standard for ecological risk assessments) that the chemicals be evaluated on a compound-by-compound basis during the comparison to screening value. This could result in an underestimation of risk (if there are additive or synergistic effects among chemicals) or an overestimation of risks (if there are antagonistic effects among chemicals).

- Receptor Species Selection—Reptiles were selected as receptors in the ERA, but were not evaluated quantitatively even when exposure pathways were likely to be complete. Reptiles were evaluated using other fauna (birds) as surrogates due to the general lack of reptile-specific toxicological data. This represents an uncertainty in the ERA.

  It was also assumed that reptiles were not exposed to significantly higher concentrations of chemicals and were not more sensitive to chemicals than other receptor species evaluated in the ERA. This assumption was a source of uncertainty in the ERA. In addition, there is some uncertainty associated with the use of specific receptor species to represent larger groups of organisms (e.g., guilds).

- Food Web Exposure Modeling—Chemical concentrations in terrestrial and aquatic food items (plants, earthworms, benthic invertebrates, and fish) were modeled from measured media concentrations and were not directly measured. The use of generic, literature-derived exposure models and bioaccumulation factors introduces some uncertainty into the resulting estimates. The values selected and methodology employed were intended to provide a conservative (SERA) or reasonable (Step 3A) estimate of potential food web exposure concentrations.

  Another source of uncertainty is the use of default assumptions for exposure parameters such as BCFs and BAFs. Although BCFs or BAFs for many bioaccumulative chemicals were readily available from the literature and were used in the ERA, the use of a default factor of 1.0 to estimate the concentration of some chemicals in receptor prey items is a source of uncertainty.

  Area use factors were assumed to equal one. This is a conservative assumption since a significant percentage of each upper-trophic-level receptor species time could be spent foraging offsite in non-impacted areas or those where chemical concentrations are expected to be significantly lower.

- Total versus Dissolved Metals—USEPA guidance (USEPA, 1996b) indicates that the dissolved metal fraction should be preferentially used to the total metal fraction in surface water screening (and by extrapolation to groundwater screening). Total (unfiltered) concentrations were used in the SERA for the groundwater screen. High levels of suspended solids and sediment-adsorbed metals would result in overstating bioavailable groundwater concentrations and thus potential exposures and risks. Filtered (dissolved) metals data were considered in the Step 3A screen for groundwater.

- Mean Versus Maximum Media Concentrations—As is typical in an ERA, a finite number of samples of environmental media are used to develop the exposure estimates. The maximum measured concentration provides a conservative estimate for immobile biota or those with a limited home range. The most realistic exposure estimates for mobile species with relatively large home ranges and for species populations (even those that are immobile or have limited home ranges) are those based on the mean chemical concentrations in each medium to which these receptors are exposed. This is reflected in the wildlife dietary exposure models contained in the Wildlife Exposure Factors Handbook (USEPA, 1993), which specify the use of average media concentrations. Given the mobility of the upper-trophic-level receptor species used in the ERA, the use of maximum chemical concentrations (rather than mean concentrations) in the SERA to estimate the exposure via food webs is very conservative. This conservatism was reduced to more realistic levels in the values selected for use in the Step 3A evaluation.

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

- Spatial Distribution of Samples—The number and spatial distribution of surface soil, groundwater, and sediment samples was sufficient to adequately estimate potential ecological risks. There were 55 surface soil and 24 groundwater (from 19 wells) samples spread throughout the 14-acre site. Five sediment samples were collected from the 2-acre lagoon. The number and location of all 2002 samples were scoped jointly by the Navy, other Tier I partnering team members, and the Region III BTAG.

- Frequency of Detection—Frequency of detection was identified as a potential screening criterion when sample size and spatial distribution were adequate. Chemicals that were detected in less than 5 percent of the samples in a medium were not considered COCs in that medium if at least 20 samples were available (USEPA, 1989). It is unlikely that infrequently detected chemicals represent a risk to receptors at the population level. The uncertainties associated with the use of frequency of detection as a screening criterion are low as very few chemicals were screened out based solely upon this criterion.

6.6 Ecological Risk Assessment Conclusions

In surface soil, six metals (antimony, copper, lead, nickel, thallium, and zinc) and PAHs exceeded surface soil screening values and/or facilitywide background soil concentrations (where available) and were retained as COCs (Table G-36 in Appendix G). Copper, lead, and zinc were the inorganics that exceeded both screening values and background concentrations most frequently and with the highest magnitudes. The spatial distribution of the highest screening value exceedances (HQs >5) was very similar for these three metals. There was one cluster of exceedances along the northern site boundary (DS40, DS07, and DS05) and a second cluster in the site's southwestern portion (DS18, DS33, DS34, and DS52). Potential risks to terrestrial receptors from exposure to PAHs in surface soils are likely to be limited on a sitewide basis. However, spatially restricted risks are possible, especially along the site's northern (i.e., DS01, DS04, and DS11) and the east-central site boundaries (area near SS04). Thus, risks to lower-trophic-level receptors utilizing some portions of the terrestrial habitats on SWMU 14 are possible. However, these risk estimates are likely to be conservative under existing and projected future land uses because exposures are likely to be limited based upon the nature of the substrate (very coarse sand and gravel), the poor habitat quality (weedy field that is periodically mowed), and the site's isolated nature (i.e., surrounded by developed areas). Potential risks to upper-trophic-level terrestrial receptors are minimal as no chemical exceeded a LOAEL-based screening value for these receptors even assuming that these receptors would obtain all of their food from the site (an unrealistically conservative assumption given the habitat present on the site). Thus, given the current habitat conditions on the site and the likely future site uses, additional ecological evaluation of the terrestrial portion of SWMU 14 is not warranted at this time.

Relatively few chemicals exceeded screening values in lagoon sediment. Arsenic was the only inorganic chemical with a mean HQ greater than or equal to one based upon a detected concentration. The magnitude of this mean HQ (1.36) was low. Arsenic was also the only detected inorganic that exceeded its screening value in more than one sample. While the mean HQs for the other inorganic COPCs (from Step 2) were all less than one, all of the exceedances for these chemicals occurred in sample SD04, although sample-specific HQs were all two or less. The maximum concentration for arsenic also occurred in sample SD04 (HQ of 2.49). While arsenic is identified as a COC in lagoon sediment, arsenic did not exceed screening values in site surface soils or groundwater, suggesting that these low magnitude sediment exceedances are not site related. Four pesticides (4,4'-DDE, 4,4'-DDT, alpha-chlordane, and gamma-chlordane) and one PCB (Aroclor-1260) exceeded screening values based upon mean detected concentrations. While the mean detected concentrations of five PAH compounds exceeded screening values, maximum HQs were less than two and the mean HQ for total PAHs was less than one. This suggests that potential risks related to PAHs are minimal in lagoon sediments. A comparison of sediment concentrations to equilibrium partitioning-based sediment values, which provide a measure of bioavailability, suggests that potential exposures and risks are very low for all of these organic compounds. As for metals, the highest concentrations for these inorganics occurred near the center of the lagoon (samples SD02 and SD04), although the spatial distribution of the pesticides was more widespread across the lagoon. The center of the lagoon may serve as a depositional area for inputs from the two outfalls to the west and the bay inlet to the east, although TOC concentrations in samples SD02 and SD04 (in the center of the lagoon) were not higher than

those in the two samples near the outfalls (SD01 and SD05) but were higher than those from the sample at the bay inlet (SD03).

The potential magnitude of contaminant transport via groundwater from SWMU 14 to Willoughby Bay was qualitatively evaluated through a comparison of groundwater concentrations with surface water screening values. Total cyanide, manganese, and 4,4'-DDT had mean HQs exceeding one based upon detected groundwater concentrations and a dilution factor of 10. Because the screening value for cyanide is based upon free (bioavailable) cyanide, and not total cyanide, the ecological significance of the exceedances is questionable. To address this, five wells were re-sampled in 2002 for amenable (free) cyanide, including MW07, where the maximum concentration of total cyanide was found. Amenable cyanide was not detected in any of the five wells at the same reporting limit as total cyanide. Thus, the cyanide present in groundwater is not likely to be present in bioavailable forms and would likely pose a minimal risk to aquatic receptors in Willoughby Bay following discharge. Since no site-specific upgradient wells or facility-specific background wells are available, it is unclear if the observed manganese concentrations are within the range of naturally occurring concentrations in groundwater. However, the maximum manganese concentration in groundwater was found in MW19S, which is far removed from the source areas and the main groundwater flow direction. This suggests that manganese is likely to be present at background levels in groundwater and/or is not site related. Manganese was not identified as a PCOC in site surface soils. 4,4'-DDT was detected in four of 24 groundwater samples from three different wells (MW05S, MW07S, and MW15S). Most of the detections occurred in the latest round (2002) of groundwater sampling. 4,4'-DDT (and its breakdown products 4,4'-DDD and 4,4'-DDE) was frequently detected in surface soil samples although at concentrations below soil screening values.

A Watershed Contaminated Source Document (WCSD) is currently being prepared for Willoughby Bay. Once the results of the WCSD are available, possible future steps of the ERA process (i.e., Steps 3B and 4) for the Bay and lagoon, as related to SWMU 14, will be assessed, as warranted.

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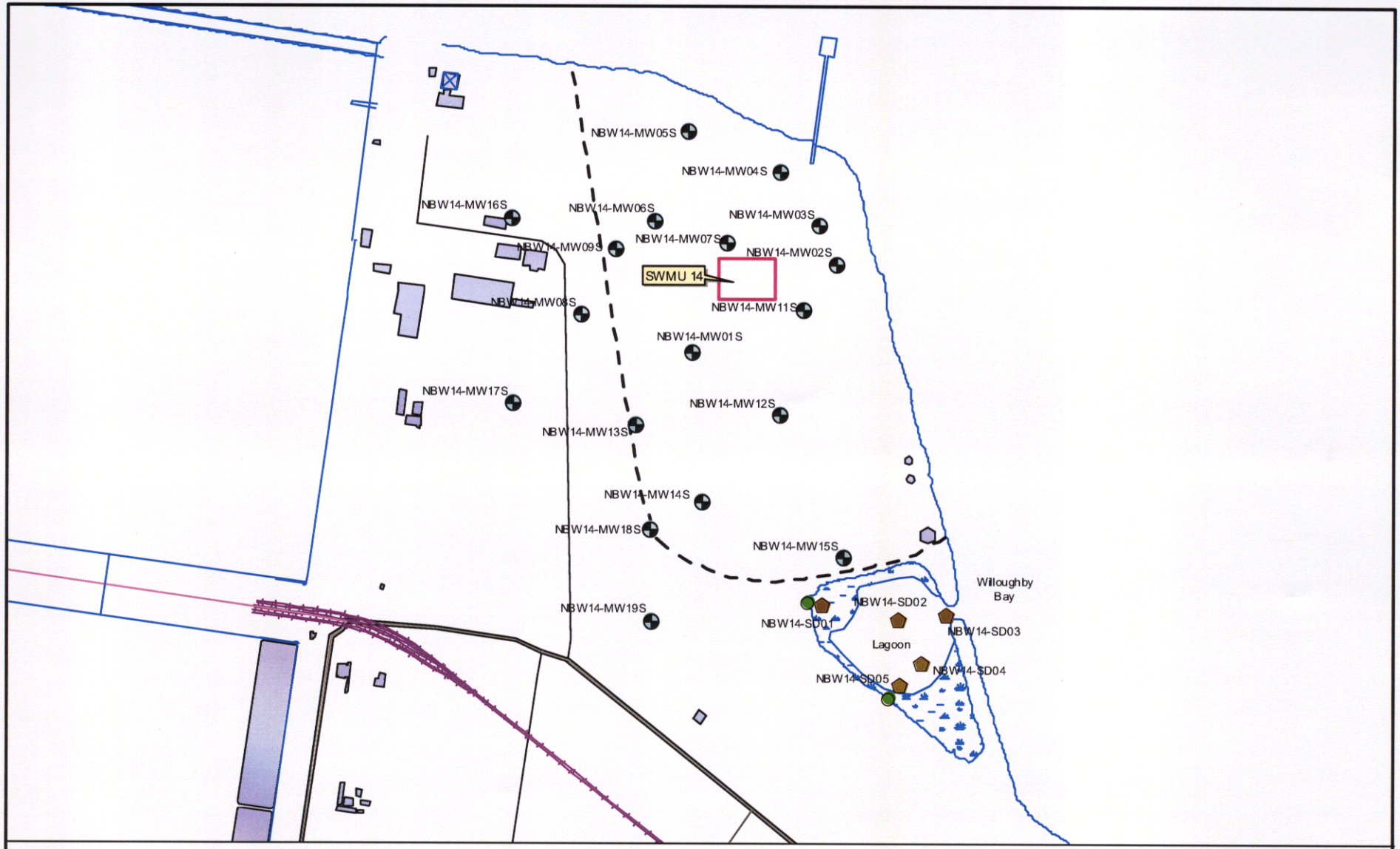

LEGEND

- Sediment Sample Location
- Monitoring Well Location
- SWMU 14 Lagoon Outfalls
- Estimated Q-50 Area / Site 9 Landfill
- Shoreline
- Buildings
- SWMU 14 (Satellite Accumulation Area)

N

0 200 400 Feet

Figure 6-1
Sediment and Groundwater
Sample Locations Used in the ERA
SWMU 14 - Naval Station Norfolk
Norfolk, Virginia

CH2MHILL

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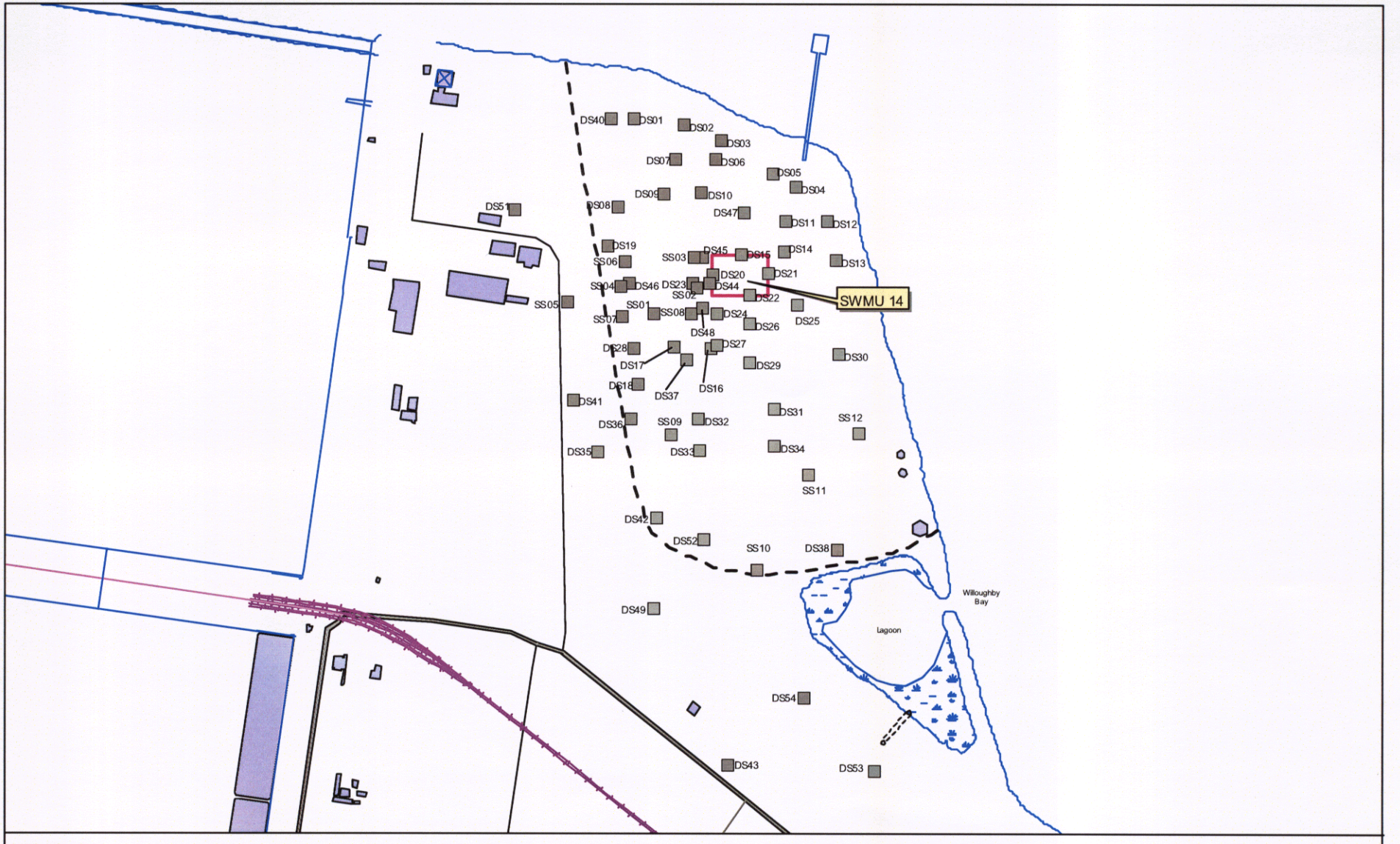

LEGEND

- Surface Soil Samples
- SWMU 14 (Satellite Accumulation Area)
- Shoreline
- Buildings
- Estimated Q-50 Area / Site 9 Landfill

N

0 200 400 Feet

Figure 6-2
Surface Soil Sample Locations Used in the ERA
SWMU 14 - Naval Station Norfolk
Norfolk, Virginia

CH2MHILL

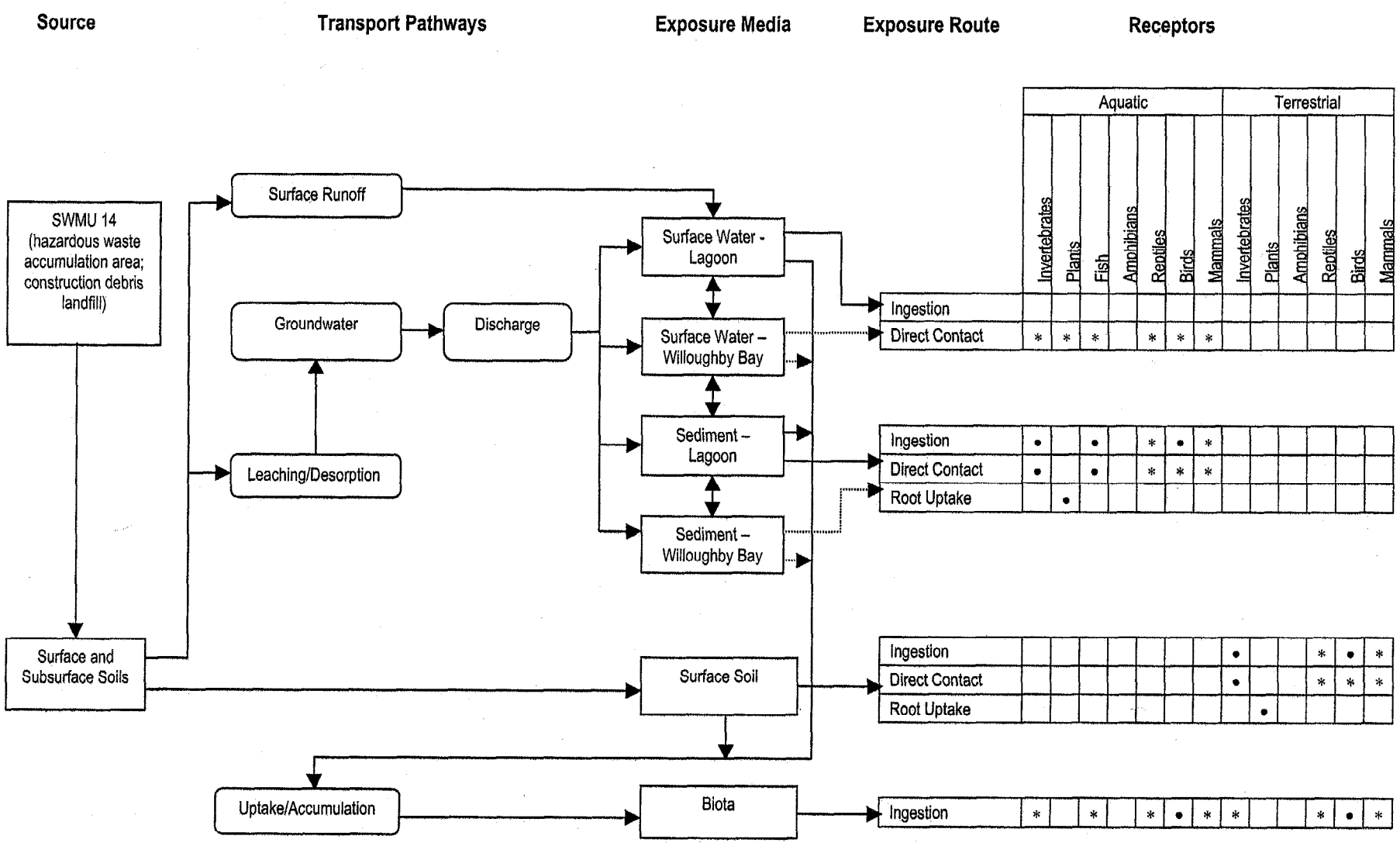

FIGURE 6-3. PRELIMINARY CONCEPTUAL MODEL NAVAL STATION NORFOLK – SWMU 14

SECTION 7

Conclusions and Recommendations

This section presents the conclusions reached by the RI activities and identifies recommendations for completing the next phase in the site remediation process.

7.1 Conclusions

The SWMU 14 RI objectives were to:

- Determine the site's hydrogeologic characteristics, including groundwater flow direction and velocity to define the mobility of contaminants,
- Better define the horizontal and vertical extent of VOCs, SVOCs, pesticides/PCBs, metals, and dioxins/furans in the site's soil and groundwater,
- Assess if SWMU 14 or Site 9 are the source of the contaminants detected in the soil, groundwater, and sediment,
- Delineate the extent of the Site 9 boundary,
- Formulate a baseline risk assessment of possible threats to human health, and
- Conduct a baseline ecological-risk assessment, through step 3B, to determine possible threats to ecological receptors.

7.1.1 Site Physical Characteristics

The material at SWMU 14/Site 9 is divided into two basic classifications: dredge fill and construction debris fill. The dredge fill consists mainly of fine- to medium-grained sand and shell hash that comprises the western half of the Sewell's Point peninsula. Similar material is found below the construction debris fill 6 to 14 ft bgs in the site's eastern portion. The construction debris fill generally consists of black to brown silts and sands with some gravel pockets. Metal debris were observed during the test pit and drilling activities within the boundaries of the Site 9 fill area. In addition, coal and glass fragments were noted as well as apparent buried wood pilings.

The groundwater elevation data indicates that the water table has a very low hydraulic gradient across the site with a fluctuation of approximately 0.6 ft. The groundwater contours show a slight mounding in the water just west of SWMU 14. From this location, groundwater flows in a radial pattern east and north from the mound (towards Willoughby Bay) as well as to the west. Based on slug test data, the range of groundwater flow velocities across the site was estimated to range from 56 to 209 ft per year. Based on the groundwater flow patterns in the vicinity of the site, monitoring well, MW19S can be considered as an upgradient well.

7.2 Nature and Extent of Contamination

Contaminants were detected in all media of concern including groundwater, surface soil, subsurface soil, sediment, and surface water.

The groundwater analytical results showed that there were exceedances of the screening criteria (RBCs and MCLs) for VOCs, SVOCs, pesticides, and metals. However, there were no PCB exceedances observed in the groundwater samples. In addition, the pesticide and SVOC exceedances were isolated to the samples collected within the debris-fill boundary. VOC and SVOC exceedances were observed at almost all interior monitoring wells. However, pesticide exceedances occurred at only four locations as shown in Figure 3-8. The concentrations of inorganics exceeded the screening criteria in monitoring wells in the vicinity of both SWMU 14 and Site 9, indicating both of these areas are potential sources of contamination.

The analytical results of the surface soil samples indicate exceedances of VOCs, SVOCs, pesticides, PCBs, metals, and dioxins/furans. 1,2-Dichlorobenzene was the only VOC detected above the screening criteria, and only occurred in one sampling location. Dieldrin and methoxyclor, occurring in isolated areas, were the only pesticides detected in exceedance of the screening criteria. Dieldrin exceeded the screening value in two samples collected in the northern portion of the site. Methoxychlor exceeded the ecological screening value at DS04. PCB exceedances were more extensive in the northern portion of the site with arochlor 1260 being the predominant PCB contaminant of concern. Generally, the SVOCs and pesticides, PCBs detected within the landfill at concentrations exceeding the screening values also exceeded the background levels. There were no metals exceeding the screening criteria and the background levels in surface soil samples collected outside of the Site 9 boundary. Lead, mercury, and zinc were in general the most frequently detected analytes exceeding the screening criteria and the background within the site boundary. Overall, inorganic exceedances of the screening criteria and the background levels occurred in the northern and southwestern portion of SWU 14. Metals exceedances were less frequent in the southeastern area with the exception of DS30 and DS34. In addition, there were dioxin/furan exceedances at two of the five surface soil locations analyzed for these parameters.

In subsurface soil samples, SVOCs, pesticide, PCBs, metals, and dioxin/furans were detected at concentrations exceeding the screening criteria. There were no VOC exceedances in subsurface soil. In addition, the concentrations of pesticide, PCB and SVOC exceedances were isolated to those samples collected within the Site 9 fill area, and generally in the northern and central portions of the site. The site sample concentrations were compared to the dredge fill background soil levels. SVOCs and pesticides/PCBs were detected within the landfill at concentrations that exceeded the RBCs and background levels. Dioxin/furan concentration exceedances occurred at four sample locations in the eastern central portion of SWMU 14. There were no metals concentrations detected above the background levels nor the screening criteria in subsurface soil samples collected outside of the fill area, indicating that Site 9 and SWMU 14 are likely sources of metal contamination.

Five sediment samples were collected at the SWMU 14 lagoon. SVOC, pesticides, and PCB results did not exceed the RBCs. Arsenic and iron exceeded both human health and ecological screening values. The center of the lagoon may serve as a depositional area for

inputs from the two outfalls to the west and the bay inlet to the east. Results from SD04 and SD02 had the most SVOC, Pesticide, and PCB exceedances of the screening values. There were no inorganic exceedances at SD02 and SD03. A storm drain that discharges into the lagoon extends through much of the northwest portion of the naval base. As a result, the source of these contaminants is not well defined.

7.3 Fate and Transport of Contamination

Based on the chemical and physical data collected at SWMU 14, it appears likely that both SWMU 14 and Site 9 were potential sources of contamination. The general contaminant profile fits this contaminant distribution and consists of (1) surficial elevated concentrations in the vicinity of SWMU 14, (2) laterally widespread surficial and subsurface soil elevated concentrations within the Site 9 fill area, and (3) groundwater concentrations at levels varying from relatively high to relatively low with no readily apparent single source pattern.

Metals, PAHs, pesticides, PCBs, and dioxins/furans are likely to be sorbed with the surface soil particles. Metals can move from surface soil to subsurface soil to groundwater by precipitation-induced leaching. However, PAHs, PCBs, and dioxins/furans are not expected to leach to the subsurface from surface soil, and are expected to be sorbed to surface soil particles and therefore remain in close proximity to their release point. Therefore, the only significant release mechanism is airborne or waterborne particles sorbed with PAHs, PCBs, or dioxin/furans. However, the site is vegetated and has little potential for overland flow, which minimizes the risk of transport of surface soil particles.

Due to the shallow depth to water and the site's proximity to the Bay, groundwater flow represents the most significant potential offsite transport mechanism. Based on the conceptual groundwater flow and groundwater flow velocities of 56 to 209 ft per year, it is likely that groundwater discharge occurs to the dredge-fill sediments to the west of the site as well as to Willoughby Bay located to north and east. Constituents that may be transported offsite via groundwater flow include those that are dissolved in groundwater. The concentrations of metals as well as trace levels of VOCs and SVOCs were observed in the downgradient monitoring wells may indicate possible migration of these contaminants from the site.

7.4 Human Health Risk Assessment

This baseline risk assessment was conducted to evaluate the potential human-health risks associated with the presence of site-related soil, groundwater, surface water, and sediment contamination at NSN SWMU 14. This risk assessment quantifies potential human-health risks at SWMU 14 under current conditions and under potential future use scenarios, if no additional remediation is implemented.

There are no risks or target-organ specific hazards that exceed USEPA target levels for the site worker or trespasser under current site use. The following receptors had total RME noncarcinogenic hazards or carcinogenic risks that exceeded USEPA's target levels:

- Future site worker exposed to subsurface soil

- Future adult resident exposed to subsurface soil and groundwater
- Future child resident exposed to surface soil, subsurface soil, and groundwater
- Future lifetime resident exposed to subsurface soil and groundwater
- Future construction worker exposed to surface soil, subsurface soil, and groundwater
- Future recreational child exposed to surface soil and subsurface soil

The metals detected in the soil are the main contributors to the noncarcinogenic hazard associated with exposure to surface soil (iron and thallium) and subsurface soil (antimony, arsenic, iron, manganese, thallium, and vanadium). A comparison of the maximum detected concentrations and 95-UCLs of the metals to the background UTLs does not indicate that the site metals concentrations are similar to the background metals concentrations. Therefore, based on this comparison, the calculated risks are probably site related and not background related. Benzo(a)pyrene, dioxins, and arsenic are the main contributors to the subsurface soil carcinogenic risk.

The main contributors to the groundwater noncarcinogenic hazard are 2-methylnaphthalene, 4-methylphenol, dibenzofuran, naphthalene, arsenic, iron, manganese, and thallium. The main contributors to the carcinogenic risk are vinyl chloride, n-nitroso-d-n-propylamine, pentachlorophenol, aldrin, and arsenic.

Since elevated lead concentrations in soil are randomly distributed across the site regardless of depth, exposure point concentrations used to evaluate risks are biased high by specific locations not indicative of sitewide concentrations. Therefore, this risk assessment overstates the estimated risks for residential children from exposure to lead in soil.

7.5 Ecological Risk Assessment

Six metals (antimony, copper, lead, nickel, thallium, and zinc) and PAHs in surface soil exceeded surface soil screening values or facilitywide background soil concentrations (where available) and were retained as COCs. Copper, lead, and zinc were the inorganics that exceeded both screening values and background concentrations most frequently and at the highest magnitudes. Site wide, potential risks to terrestrial receptors from exposure to PAHs in surface soils are likely to be limited. There are possible risks to lower-trophic-level receptors utilizing some portions of the terrestrial habitats on SWMU 14. However, these risks are likely to be minimal under both existing and projected future land uses because exposures are likely to be limited based upon the nature of the substrate (very coarse sand and gravel), the poor habitat quality (a weedy field that is periodically mowed), and the site's isolated nature (i.e., surrounded by developed areas). Potential risks to upper-trophic-level terrestrial receptors are minimal as no chemical exceeded a LOAEL-based screening value for such receptors even assuming that they would obtain all of their food from the site (an unrealistically conservative assumption given the habitat present on the site). Thus, given the current habitat conditions on the site and the likely future site uses, additional ecological evaluation of the terrestrial portion of SWMU 14 is not currently warranted.

Relatively few chemicals exceeded screening values in lagoon sediment. Arsenic was the only inorganic chemical with a mean HQ greater than or equal to one based upon a detected concentration. While arsenic is identified as a COC in lagoon sediment, arsenic did not exceed screening values in site surface soils or groundwater, suggesting that these

low-magnitude sediment exceedances are not site related. Four pesticides (4,4'-DDE, 4,4'-DDT, alpha-chlordane, and gamma-chlordane) and one PCB (Aroclor-1260) exceeded screening values based upon mean detected concentrations. While the mean detected concentrations of five individual PAH compounds exceeded screening values, maximum HQs were less than two and the mean HQ for total PAHs was less than one. This suggests that potential risks related to PAHs are minimal in lagoon sediments. A comparison of sediment concentrations to equilibrium partitioning-based sediment values, which provide a measure of bioavailability, suggests that potential exposures and risks are very low for all these organic compounds.

The potential magnitude of contaminant transport via groundwater from SWMU 14 to Willoughby Bay was qualitatively and conservatively evaluated through a comparison of groundwater concentrations with surface water screening values. Total cyanide, manganese, and 4,4'-DDT had mean HQs exceeding one, based upon detected groundwater concentrations and a dilution factor of 10, which is very conservative for this site. Amenable cyanide was not detected in any of the five wells at the same reporting limit as total cyanide. Thus, the cyanide in groundwater is not likely to be present in bioavailable forms and would likely pose a minimal risk to aquatic receptors in Willoughby Bay following discharge. Since no site-specific upgradient wells or facility-specific background wells are available, it is unclear if the observed manganese concentrations are within the range of naturally occurring concentrations in groundwater. However, the maximum manganese concentration in groundwater was found in MW19S, which is far removed from the source areas and main groundwater flow direction. This suggests that manganese is likely to be present at background levels in groundwater or is not site-related. Additionally, manganese was not identified as a potential contaminant of concern (PCOC) in site surface soils. 4,4'-DDT was detected in 4 of 24 groundwater samples from 3 different wells (MW05S, MW07S, and MW15S).

A Watershed Contaminated Source Document (WCSD) is currently being prepared for Willoughby Bay. Once the WCSD results are available, possible future steps of the ERA process (i.e., Steps 3B and 4) for the Bay and lagoon, as related to SWMU 14, will be assessed, as warranted.

7.6 Recommendations

A Feasibility Study (FS) is recommended to address risks associated with potential contaminants of concern at Site 9 and SWMU 14. This study should be evaluated to assess potential remedial alternatives to be considered in the event that there is a change in the use of the site from it's current land use. Presumptive remedies will be considered by the NSN Tier I partnering team.

In addition, it is recommended that the ERA process continue to the next phase, Steps 4 through 7.