

5/1/00-01267

Final

Streamlined Risk Assessments:

**SWMU 28—Area South of CEP 201,
SWMU 32— SWD Area CEP 160/161 Embankment,
SWMU 33—Debris Pile at Seawall—Corner of Sustain Pier,
SWMU 34—SWD Area CEP 156/200, and
SWMU 35—SWD Area CEP 196/Resolute Embankment**

**Naval Station Norfolk
Norfolk, Virginia**



Prepared for

Department of the Navy

Atlantic Division

Naval Facilities Engineering Command

Contract Task Order 0075

May 2000

Under the LANTDIV CLEAN II Program

Contract N62470-95-D-6007

Prepared by

CH2MHILL

Herndon, Virginia

5/1/00-01267

**Final
Streamlined Risk Assessments:
Solid Waste Management Unit (SWMU)
SWMU 28- Area South of CEP 201,
SWMU 32-SWD Area CEP 160/161 Embankment,
SWMU 33- Debris Pile at Seawall- Corner of Sustain Pier,
SWMU 34- SWD Area CEP 156/200,
SWMU 35- SWD Area CEP 196/Resolute Embankment**

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STREAMLINED RISK ASSESSMENT REPORT FOR

SWMUs 28, 32, 33, 34, AND 35

NAVAL STATION NORFOLK

NORFOLK, VIRGINIA

In accordance with the Federal Facilities Agreement for the Naval Station Norfolk, signed February 1999, a desktop evaluation and Streamlined Risk Assessments were completed for SWMU 28- Area South of CEP 201, SWMU 32- SWD Area CEP 160/161 Embankment, SWMU 33- Debris Pile at Seawall Corner of Sustain Pier, SWMU 34- SWD Area CEP 156/200, SWMU 35- SWD Area CEP 196/Resolute Embank at the Naval Station Norfolk. The site Project Managers and members of the Naval Station Norfolk Tier I Partnership determined that no further action is required and the land use will be unrestricted at each site. This evaluation was based on consideration of field sampling data for soil and groundwater, risk screening, and professional judgement. In the event contamination posing an unacceptable risk to human health or the environment is discovered after execution of this site closeout report, the Partnership agrees to remediate the contamination if deemed necessary.

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Introduction

Various Solid Waste Management Units (SWMUs) at the Naval Station, Norfolk (NSN, previously named Naval Base Norfolk) were included in the Baker Environmental Phase I and/or Phase II Relative Risk Ranking (RRR) Study and the CH2M HILL Solid Waste Management Units Supplemental Investigation (CTO 75). In general, the RRR Study evaluation of the SWMUs focused mainly on the surface and subsurface soil, with limited groundwater sampling.

The specific objectives of the supplemental investigation were to: (1) conduct sampling and analysis to fill information gaps; (2) identify and evaluate existing information by a review of the Relative Risk Ranking (RRR) System Data Collection reports; (3) conduct qualitative human health and ecological risk assessments; and (4) determine on a SWMU-specific basis if the site was a candidate for closeout as a No Further Action (NFA) site, or if further investigation or evaluation were warranted.

The following SWMUs were included in the supplemental investigation:

- SWMUs 9 and 10- the LP-200/MAC Terminal Area
- SWMUs 12 and 16 – Disposal and Accumulation Areas near NM 37
- SWMU 14 – Q-50 Satellite Accumulation Area
- SWMU 28 – Area South of CEP 201
- SWMU 32 – SWD Area CEP 160/161 Embankment
- SWMU 33 – Debris Pile at Seawall- Corner of Sustain Pier
- SWMU 34 – SWD Area CEP 156/200
- SWMU 35 – SWD Area CEP 1966/Resolute Embankment
- SWMU 38 – CD Area behind Compost Yard
- SWMU 40 – MCA-603 Pits
- SWMU 41 – Disposal Area, CA-99 Golf Course
- SWMU 42 – CEP 201 Area

The individual SWMUs are shown on Figure 1-1. Samples were collected from various media at each SWMU during the RRR Study and the SWMU supplemental investigation. The analytical results of both investigations were combined and evaluated as one data set for each SWMU to determine the risks associated with the compounds detected on a qualitative screening basis. The screening process used to evaluate each SWMU is outlined in the following section.

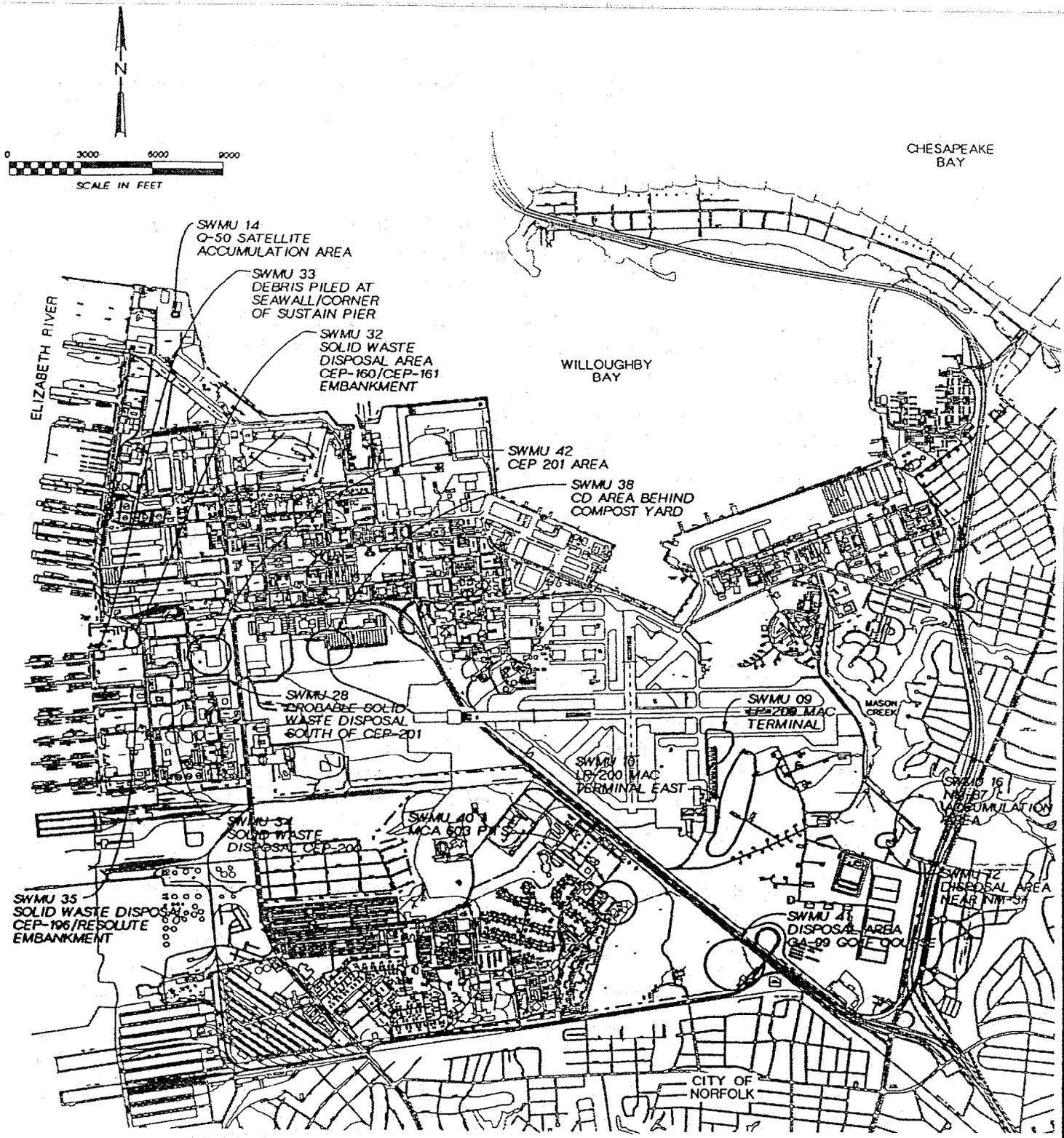


Figure 1-1
SOLID WASTE MANAGEMENT UNITS
INCLUDED IN SWMU INVESTIGATION
Norfolk Naval Base

SWMU Screening Process

An overall screening process outlined in the Federal Facilities Agreement (February 1999) was applied to all of the sites in the Naval Station Norfolk. Through that screening process, sites were categorized as follows (See Figure 1-2 and Figure 1-3 for process outline):

- Installation Restoration (IR) sites. These sites will follow the full CERCLA process. These are the most significant waste disposal sites and are expected to require cleanup or institutional controls.
- Site Screening Areas (SSAs). These sites will go through a site screening process that will either lead to an RI/FS or a decision document.
- Areas of Concern (AOCs). These areas go through a more streamlined process to determine if they should be classified as SSAs, if the area should be closed out with no further action (NFA), or if additional evaluation is required to determine if the area should be classified as an SSA or be closed out.

SWMUs 28, 32, 33, 34, and 35 were categorized as AOCs. Therefore, the screening process for these SWMUs began as follows:

Concentrations of detected chemicals were compared to the following current USEPA screening and regulatory screening criteria for each sample matrix: risk-based concentrations (RBCs) for residential and industrial soil, USEPA tap water RBCs, and drinking water Maximum Contaminant Levels (MCLs) for groundwater. The USEPA Region III Biological Technical Assistance Group (BTAG) screening values for surface water and sediment were used for comparison only and not as screening criteria. The SWMUs were initially categorized based on the comparison to screening and regulatory criteria (comparison criteria).

In addition, the maximum, minimum, arithmetic mean, and median concentrations for the contaminants exceeding the comparison criteria were calculated using the detected concentrations from all samples collected during the RRR Study and the SWMU Supplemental Investigation. Although these values were not used in determining the recommendations for each SWMU, this evaluation was performed to identify the detected range for contaminants exceeding the comparison criteria. These values are presented in Table 1-1.

SWMUs 28, 32, 33, 34, and 35 are AOCs where the available data indicated minimal risk to human health or the environment; however, a more quantitative risk evaluation was warranted before a final risk management decision could be made. A streamlined risk assessment (SRA) process has been applied for each of the SWMUs to determine whether a site can be closed out as an NFA site, or whether the site should be classified as an SSA for further investigation (See Figure 1-4). The results of the SRAs will be combined with the results of the current basewide background study, and final risk management decisions will be made. In the event contamination posing an unacceptable risk to human health or the environment is discovered after execution of a site close-out, the Navy will undertake additional investigation or study to characterize the contamination and associated risk and will take appropriate action under CERCLA if deemed necessary.

**Table 1-1
Statistical Analysis
Basewide Detections**

Frequency of Detection ¹	Analyte	Units	Max ²	Min ²	Mean ²	Median ²
Groundwater						
2 of 55	1,4-Dichlorobenzene	µg/l	1.00	0.30	0.65	0.65
1 of 55	Hexachlorobenzene	µg/l	150.00	150.00	---	---
5 of 55	Chlorobenzene	µg/l	420.00	1.00	99.08	23.50
3 of 55	Chloromethane	µg/l	8.00	4.00	5.67	5.00
5 of 55	Benzene	µg/l	16.00	2.00	7.15	6.45
8 of 55	Methylene Chloride	µg/l	41.00	1.00	6.75	2.00
16 of 55	Bis(2-ethylhexyl)phthalate	µg/l	40.00	1.00	6.89	2.50
8 of 55	Carbazole	µg/l	20.00	2.00	9.00	7.50
2 of 55	Dieldrin	µg/l	0.08	0.06	0.07	0.07
16 of 55	Arsenic	µg/l	48.70	2.60	14.04	5.30
50 of 55	Iron	µg/l	107000.00	81.20	6631.80	1980.00
53 of 55	Manganese	µg/l	9100.00	24.10	564.30	270.50
14 of 55	Thallium	µg/l	4.50	1.70	2.92	3.00
11 of 55	Nickel	µg/l	276.00	8.90	44.22	13.30
21 of 55	Antimony	µg/l	258.00	2.10	18.55	4.10
42 of 55	Barium	µg/l	3310.00	12.60	194.90	62.40
8 of 55	Lead	µg/l	496.00	2.30	114.09	6.55
Surface Soil						
21 of 65	Benzo(a)pyrene	µg/kg	2500.00	39.00	490.45	220.00
9 of 65	Benzo(a)anthracene	µg/kg	5400.00	64.00	769.40	250.00
20 of 65	Benzo(b)fluoranthene	µg/kg	3900.00	38.00	766.41	405.00
5 of 65	Dibenzo(a,h)anthracene	µg/kg	860.00	44.00	239.00	68.00
16 of 65	Indeno(1,2,3-cd)pyrene	µg/kg	2300.00	45.00	359.06	150.00
63 of 65	Arsenic, total	mg/kg	273.00	0.56	24.34	5.90
62 of 65	Iron	mg/kg	77000.00	1250.00	11559.70	8470.00
14 of 65	Antimony, total	mg/kg	55.40	0.36	6.12	1.25
59 of 65	Copper, total	mg/kg	12300.00	1.20	231.96	8.20
62 of 65	Lead, total	mg/kg	1550.00	3.50	98.86	33.50
Subsurface Soil						
13 of 24	Benzo(a)pyrene	µg/kg	680.00	56.00	225.31	180.00
14 of 24	Benzo(b)fluoranthene	µg/kg	900.00	46.00	331.57	245.00
21 of 24	Arsenic, total	mg/kg	40.30	0.95	6.68	4.05
22 of 24	Iron, total	mg/kg	31900.00	3180.00	13289.13	12700.00
Surface Water						
3 of 4	Copper	µg/l	17.10	8.30	13.77	15.90
3 of 4	Lead	µg/l	45.10	9.90	25.07	20.20
3 of 4	Manganese	µg/l	115.00	36.20	77.00	79.80
3 of 4	Zinc	µg/l	533.00	143.00	274.00	146.00
Sediment						
6 of 12	bis(2-Ethylhexyl)phthalate	µg/kg	270000.00	200.00	50828.33	1670.00
7 of 12	Benzo(a)anthracene	µg/kg	1600.00	88.00	424.00	150.00
7 of 12	Chrysene	µg/kg	2600.00	110.00	768.75	360.00
8 of 12	Fluoranthene	µg/kg	2700.00	66.00	880.67	180.00
5 of 12	Phenanthrene	µg/kg	1600.00	130.00	768.00	690.00
8 of 12	Pyrene	µg/kg	4400.00	75.00	842.78	210.00
4 of 12	4,4'-DDC	µg/kg	140.00	7.90	46.38	20.00
6 of 12	4,4'-DDE	µg/kg	240.00	6.80	45.70	10.00
5 of 12	Aroclor-1260	µg/kg	210.00	26.00	67.00	38.00
11 of 12	Cadmium	mg/kg	2.70	0.28	1.38	1.50
12 of 12	Chromium	mg/kg	421.00	12.30	67.52	25.70
12 of 12	Copper	mg/kg	270.00	16.10	69.45	61.00
12 of 12	Lead	mg/kg	637.00	39.20	138.20	64.40
12 of 12	Nickel	mg/kg	36.30	7.90	17.52	16.50
5 of 12	Silver	mg/kg	7.00	3.50	5.40	5.80
12 of 12	Zinc	mg/kg	4080.00	55.50	697.42	192.00

Notes:

- ¹ - Frequency of detection in samples collected during the RRR and SWMU investigations.
- ² - Calculated using the combined RRR and SWMU detects **ONLY**.

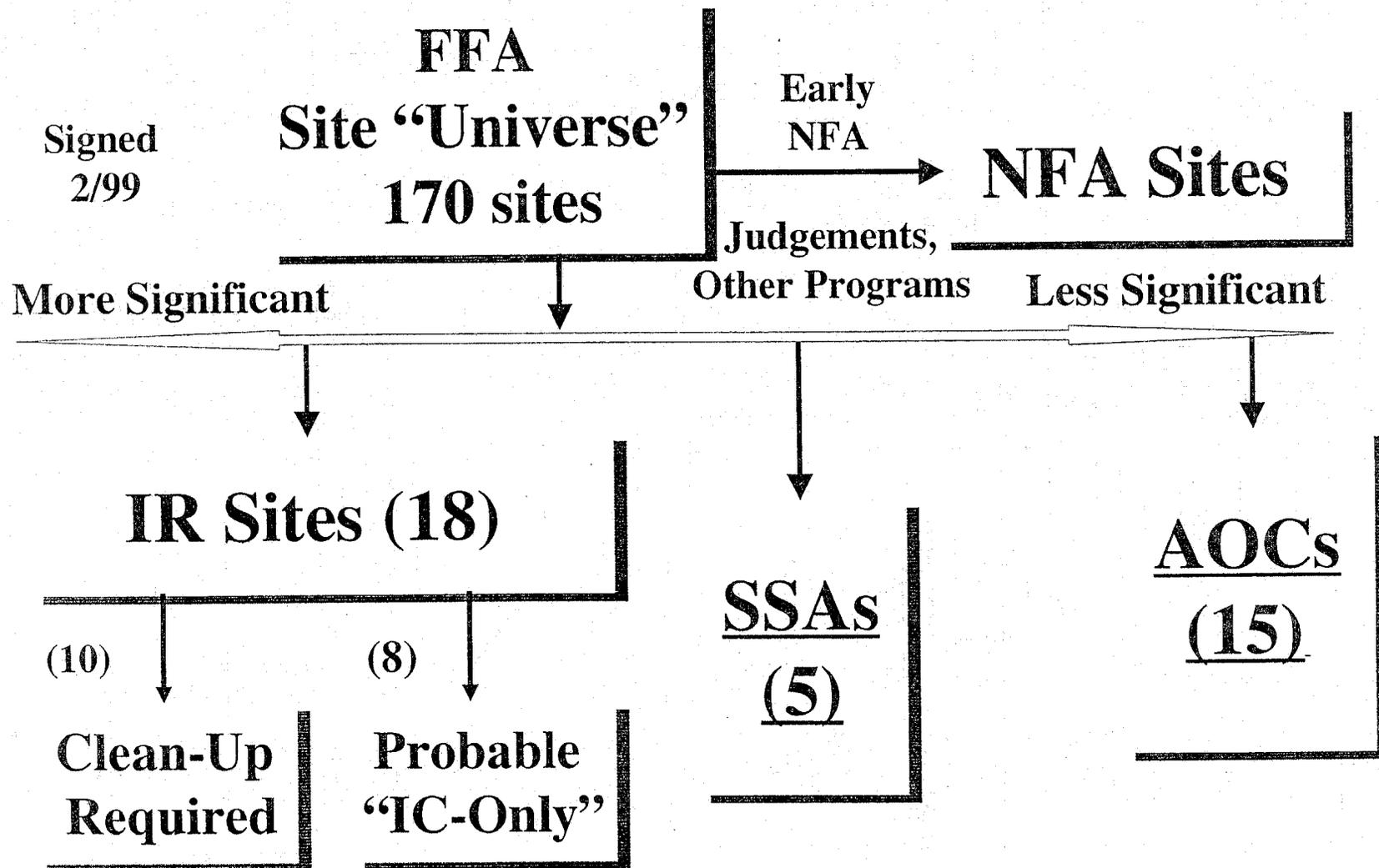


Figure 1-2, Outline of FFA Process

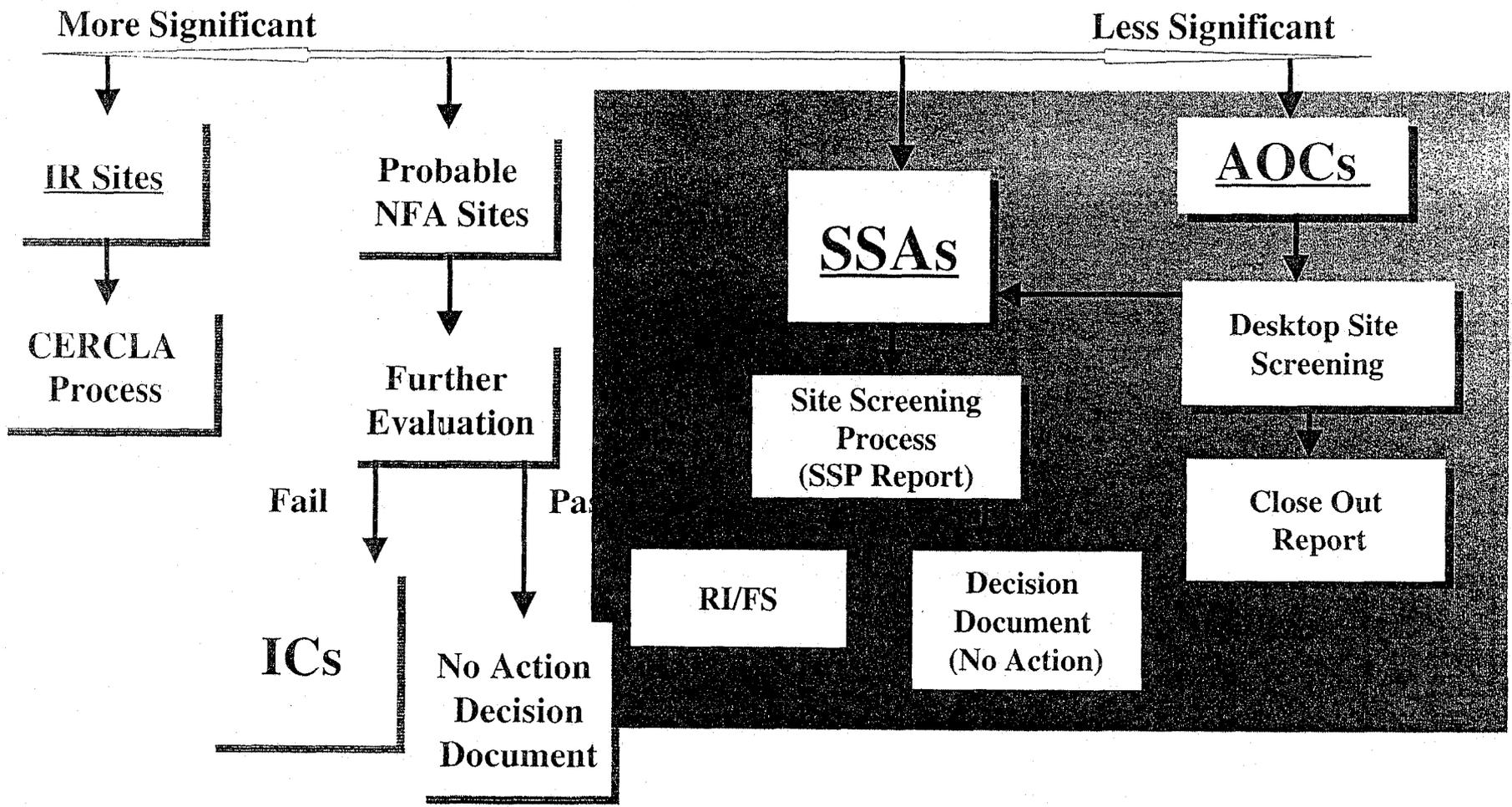


Figure 1-3, Screening Process for SSAs and AOCs

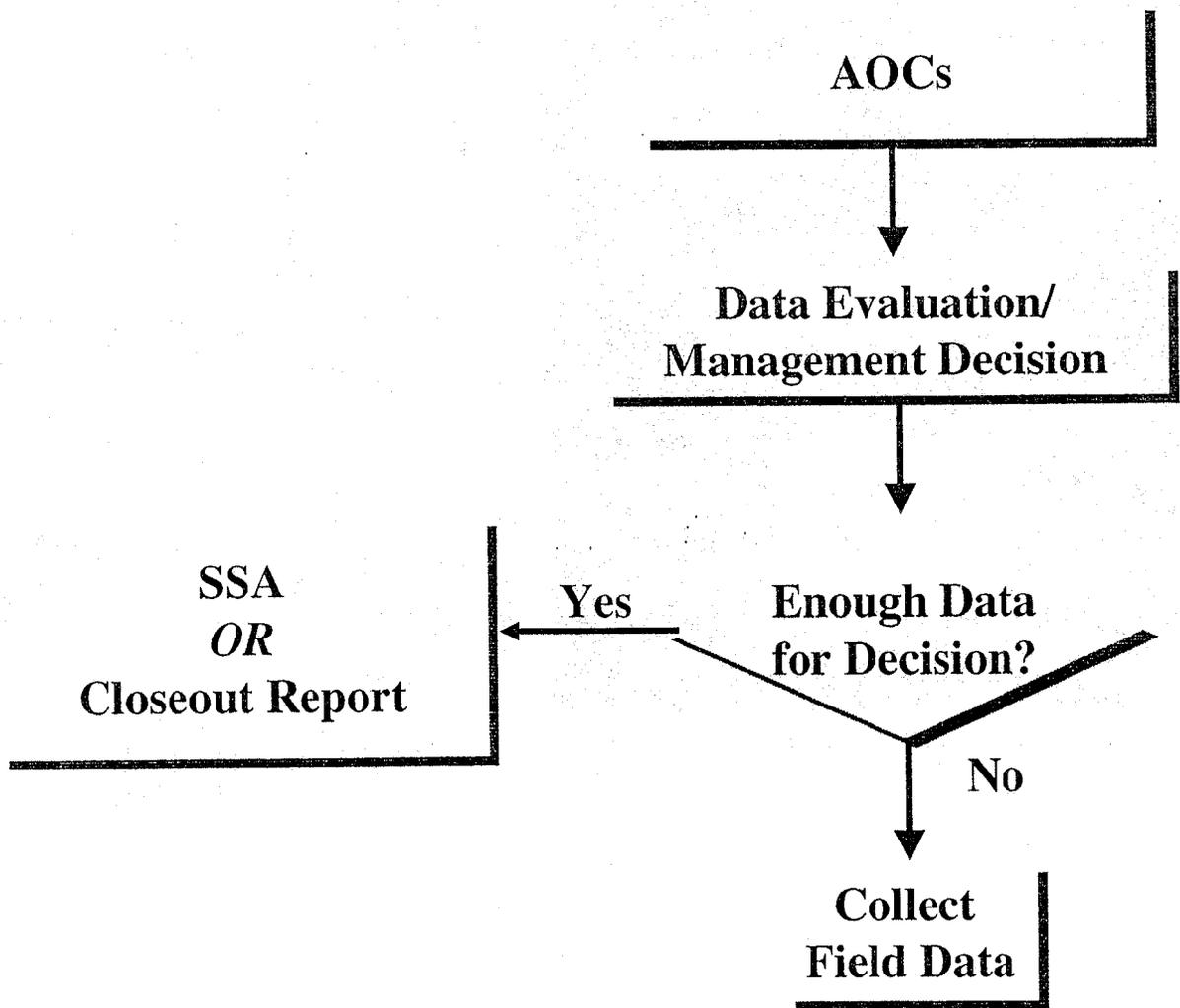


Figure 1-4, Detailed Screening Process for AOCs (Page 1 of 2)

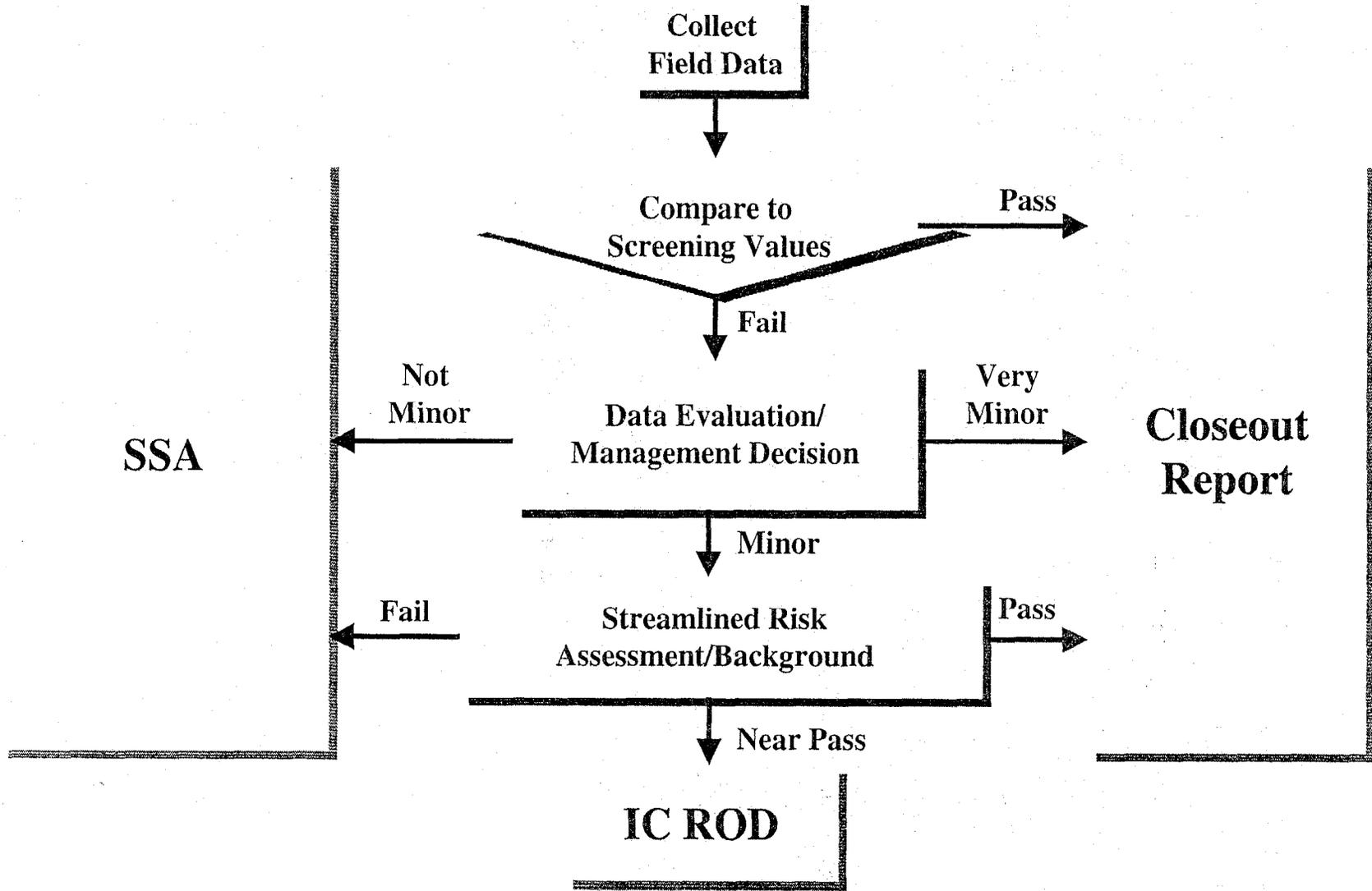


Figure 1-4, Detailed Screening Process for AOCs (Page 2 of 2)

Background Considerations

Background concentrations are important considerations when performing a risk assessment. The Navy has recently initiated a study to establish basewide background concentrations, this investigation is ongoing and a draft of the results were available at the writing of this document (CH2MHILL, May, 2000). Site specific background concentrations were established during the Site 2 – Slag Pile Investigation. Although these concentrations are not interpreted as representative of the basewide background concentrations, the results are being presented for the purpose of comparison. Table 1-2 presents the concentration of compounds detected in the background samples collected during the Site 2 – Slag Pile Investigation. Slag Pile background sampling locations are shown on Figure 1-5.

Report Organization

A separate streamlined risk assessment has been prepared for each of the following SWMUs: 28, 32, 33, 34, and 35. Photographs of each SWMU are included in Appendix A. In the body of each risk assessment, only the screening summary and risk/hazard summary tables are included. Table 1-3 is a conceptual site model summarizing the exposure pathways and receptors evaluated for the SWMUs.

The risk screening summary tables presented for each of the SWMUs were derived from a series of detailed risk calculation and exposure assumption tables. All of the supporting tables are presented in Volume II - *Backup Tables for Streamlined Risk Assessments – SWMUs 28, 32, 33, 34, and 35*. Appendix B presents a list of all tables included in Volume II. Exposure parameters are based on the Human Health Risk Consensus Agreements adopted by the Naval Station Norfolk partnering team and are listed in Appendix C.

Table 1-2
Summary of Detected Compounds
Site 2 - Slag Pile Investigation

Analyte	Units	NBS2-DS01		NBS2-DS02		NBS2-DS03		NBS2-DS04		NBS2-DS05		
		SL01-.5	SL01-1.5	SL02-.5	SL02-1.5	SL03-.5	SL03-1.5	SL04-.5	SL04-1.5	SL05-.5	SL05-.5D	SL05-1.5
Aluminum	mg/kg	7860	1290	6060	3460	4350	3930	10200	3220	8240	8620	12900
Arsenic	mg/kg	1.1J	---	0.99J	---	1.6J	---	2.2J	---	0.98J	1.4J	1.1J
Barium	mg/kg	32.3J	9.4J	30.6J	20J	21.5J	13.6J	45.4J	11.2J	49.2	36.2J	30.7J
Beryllium	mg/kg	---	---	---	---	---	---	0.65J	0.44J	0.28J	---	---
Cadmium	mg/kg	---	---	---	---	---	---	---	---	---	---	---
Calcium	mg/kg	692J	592J	441J	371J	414J	318J	1700	381J	552J	475J	428J
Chromium	mg/kg	9.4	2.4J	7	4.4	5.2	4.2	30.5	3.2	8.3	8.8	14.4
Cobalt	mg/kg	1.3J	0.36J	0.96J	0.5J	0.51J	0.42J	1.9J	0.38J	1.1J	1.1J	1.7J
Copper	mg/kg	20.8	8.2	6.4	5.1J	7.5	3.4J	1380	5.4J	8.6	10.9	11.4
Iron	mg/kg	4670	803	3480	1730	1710	1510	4260	981	3920	4010	6600
Lead	mg/kg	16.7	9.5	10.3	7.5	9.9	3.3	135	9	16	12.1	7.4
Magnesium	mg/kg	594J	143J	445J	248J	275J	275J	779J	226J	587J	625J	676J
Manganese	mg/kg	23.4	5.8	25.3	9.3	8.7	6.8	62.2	5.8	22.2	26.1	15.2
Nickel	mg/kg	4.1J	1.6J	2.9J	1.6J	2J	1.5J	133	1.2J	3.4J	3.8J	4.7J
Potassium	mg/kg	295J	74.4J	224J	126J	133J	124J	361J	128J	309J	348J	450J
Silver	mg/kg	---	---	---	---	---	---	2.5J	---	---	---	---
Sodium	mg/kg	216K	173K	155K	131K	134K	120K	183K	130K	123K	136K	176K
Vanadium	mg/kg	14.9	3.4J	10.9	5.8J	7.6J	6.1J	17.6	4.7J	14.7	15.3	20.1
Zinc	mg/kg	40.9	22.5	25.8	24	42	19.3	275	21	37.1	27.6	23.2
4,4'-DDE	µg/kg	---	---	---	---	---	---	76	---	---	---	---
4,4'-DDT	µg/kg	---	---	---	---	---	---	7.5J	---	---	---	---
bis(2-Ethylhexyl)phthalate	µg/kg	---	---	---	---	---	---	57J	---	---	---	---
Dimethylphthalate	µg/kg	---	---	---	---	100J	---	---	---	---	---	---
Acetone	µg/kg	58J	8.8J	7.6J	6.2J	22J	---	7.7J	---	---	---	---
Methylene Chloride	µg/kg	9.9J	6.4J	12	11J	---	---	---	---	---	---	---
Toluene	µg/kg	5.4J	---	---	---	---	---	---	---	---	---	---

**Table 1-3
Potentially Complete Human Health Exposure Pathways
Conceptual Site Model**

Land Use	Potential Land Use for Consideration in Risk Assessment	Contaminated Media	Potentially Exposed Populations	Exposure Route (Human Health)	Pathway Selected For Evaluation	Rationale
Current and Future						
Industrial	Trespasser	Surface soil	Trespassers - adolescents and adults	Ingestion, dermal contact, and inhalation	Yes	People trespassing on site may incidentally ingest soil, have exposed skin surfaces come into contact with soil, and inhale particulate emissions from soil.
		Sediment*	Trespassers - adolescents and adults	Ingestion and dermal contact	Yes	People trespassing on site may incidentally ingest sediment or have exposed skin surfaces come into contact with sediment.
		Surface water*	Trespassers - adolescents and adults	Ingestion and dermal contact	Yes	People trespassing on site may incidentally ingest surface water or have exposed skin surfaces come into contact with surface water.
	Site worker	Surface soil	Adult worker	Ingestion, dermal contact, and inhalation	Yes	Industrial site workers could incidentally ingest soil, exposed skin surface areas could come into contact with soil, or they may inhale dust from site while working.
Future						
Residential**	Residents	Surface and subsurface soil	Residents - adults and children	Ingestion, dermal contact, and inhalation	Yes	Residents could incidentally ingest soil, exposed skin surface areas could come into contact with soil, and they may the inhale dust from the site.
Industrial	Trespasser	Surface soil	Trespassers - adolescents and adults	Ingestion, dermal contact, and inhalation	Yes	People trespassing on site may incidentally ingest soil, have exposed skin surfaces come into contact with soil, and inhale particulate emissions from soil.
	Site worker	Surface and subsurface soil	Adult worker	Ingestion, dermal contact, and inhalation	Yes	Industrial site workers could incidentally ingest soil, exposed skin surface areas could come into contact with soil, or they may inhale dust from site while working.
	Construction worker	Subsurface Soil	Adult worker	Ingestion, dermal contact, and inhalation	Yes	Adult workers could incidentally ingest soil, exposed skin surface areas could come into contact with soil, and they may the inhale dust from the site during excavation activities.

* Surface water and sediment pathway applicable for SWMU 34 only.

** The residential exposure pathway was evaluated for all sites even where it is highly unlikely that the site will be converted to residential land use

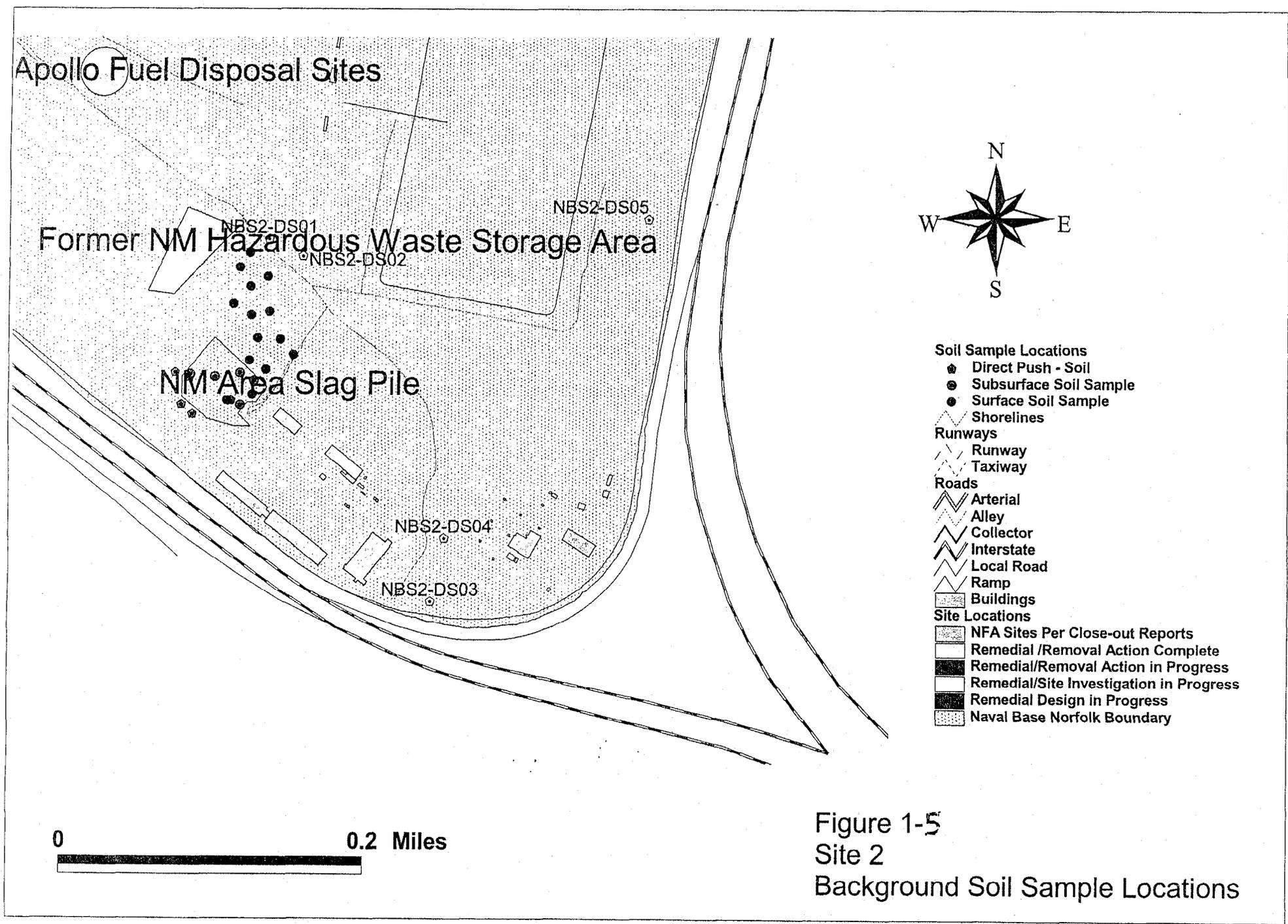


Figure 1-5
 Site 2
 Background Soil Sample Locations

**SWMU 28:
Area South of CEP 201**

Streamlined Risk Assessment

SWMU 28 - Area South of CEP 201

Site Description

SWMU 28 is approximately $\frac{3}{4}$ acre in size and is located within the CEP-201 compound. This SWMU is currently covered by asphalt and is located just south of Building CEP-201. The area is presently used as a storage facility for large objects or equipment awaiting shipment. Tractor-trailers are also parked in the area until they are needed for material transportation. The location of the site is shown in Figure 28-1. Photographs of this SWMU are included in Appendix A.

Data Summary

The analytical results of the RRR Study and SWMU Supplemental Investigation are discussed as one combined data set. Concentrations of detected chemicals were compared to the current USEPA screening criteria (comparison criteria) for each sample matrix: USEPA Region III residential and industrial soil risk-based concentrations (RBCs) for soil, and USEPA Region III tap water RBCs and USEPA drinking water Maximum Contaminant Levels (MCLs) for groundwater. Sample locations are shown in Figure 28-2.

Groundwater

One groundwater sample was collected during the SWMU Supplemental Investigation at SWMU 28. The analytical results were compared to the tap water RBCs and drinking water MCLs. No organic compounds or inorganic constituents were detected at concentrations that exceeded the comparison criteria.

Soil

Two subsurface and two surface soil samples were collected during the RRR Study field activities at SWMU 28. One polynuclear aromatic hydrocarbon (PAH), benzo(a)pyrene, exceeded the residential RBC in surface soil. No other organic compounds were detected above the screening criteria in any soil samples. Arsenic concentrations exceeded the residential and industrial RBCs in both surface and subsurface soil.

Benzo(a)pyrene was detected at an estimated concentration of 120 $\mu\text{g}/\text{kg}$ at sampling location NB33S4. It was not detected at the offsite location and the concentrations at NB33S4 and NB33S3 were both less than the detection limit. Benzo(a)pyrene was not detected in either of the subsurface soil samples. Arsenic concentrations exceeded the residential RBC at all sampling locations. In addition, arsenic concentrations exceeded the industrial RBC at NB33S4 and NB34SD2.

On the basis of these results, it was determined that a more quantitative evaluation of risk was warranted.

Exposure Pathways

It is uncertain to what extent, or for what purpose this site will be used in the future. The site is located in a highly industrialized area of the base and it would be highly unlikely for the site to be converted to residential land use. According to the Naval Base Norfolk 2010 Land Use Plan, future land use at this site is expected to be for industrial or logistics facilities. For purposes of performing the risk characterization, however, exposure to the site soil was evaluated for potential residential, industrial or commercial site worker, construction worker, and trespasser receptors. Assuming no action is taken at the site prior to development, exposure to affected soil could occur as a result of incidental ingestion, dermal contact, and inhalation of volatiles and fugitive dust. The receptors could be exposed to the subsurface soil if future construction work results in disturbance of the soil column.

Groundwater is not currently used as a potable water supply 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). All potable water used in the City limits is supplied by the City of Norfolk. Therefore, there is no potential for direct exposure to groundwater.

Risk Characterization

The screening summary and risk/hazard summary tables included in this SRA are only those relevant to the discussion presented below. The tables presented were derived from a series of risk calculation and exposure assumption tables developed for this SWMU. All tables are presented in Volume II - Backup Tables for Streamlined Risk Assessments - SWMUs 28, 32, 33, 34, and 35. Appendix B presents a list of all tables related to this SRA.

The maximum-reported concentration of each constituent detected in the surface and subsurface soil samples from SWMU 28 were compared to the EPA Region III Risk-Based Concentrations (RBCs) for residential soil. The RBCs for noncarcinogenic constituents were divided by 10 to account for exposure to multiple constituents. Constituents detected at levels exceeding the RBCs were identified as constituents of potential concern (COPCs). This risk-based screening is presented in Table-1 (surface soil) and Table-2 (subsurface soil).

The maximum-reported concentrations of benzo(a)pyrene, arsenic, and iron, in surface soil exceeded the Region III Residential RBCs. Based on the hazard and risk calculations, exposure to surface soil at SWMU 28 would not result in potentially unacceptable risks to potential adult residents, industrial site workers, construction workers, or child and adult trespassers (Table 3). However, there may be a slight noncarcinogenic hazard to future child residents (hazard index of 1.4 compared to EPA's acceptable hazard index of 1.0). This noncarcinogenic hazard is associated with ingestion of arsenic and iron in the surface soil. Neither of the individual hazard quotients for arsenic or iron exceed EPA's acceptable level of 1.0.

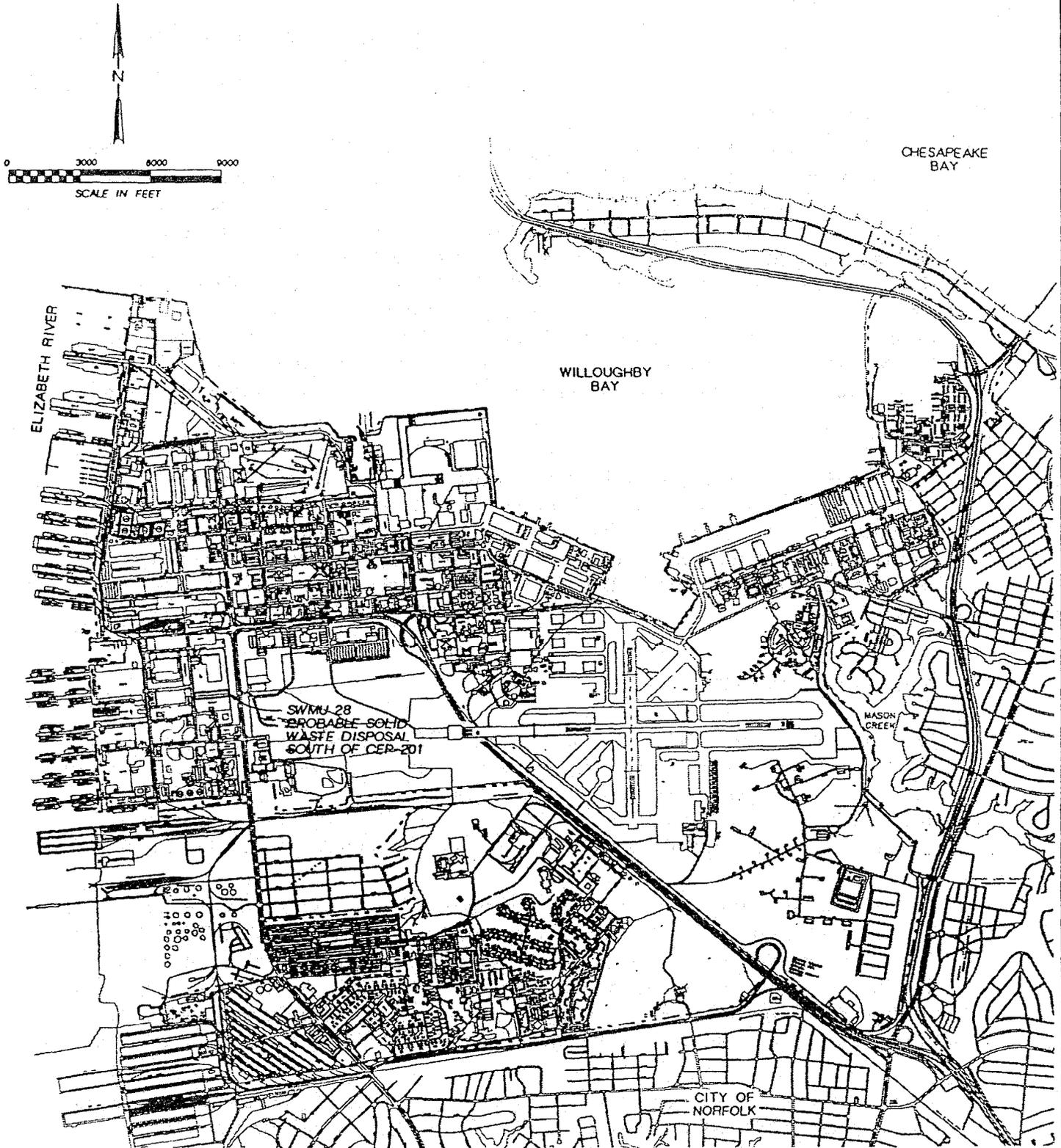
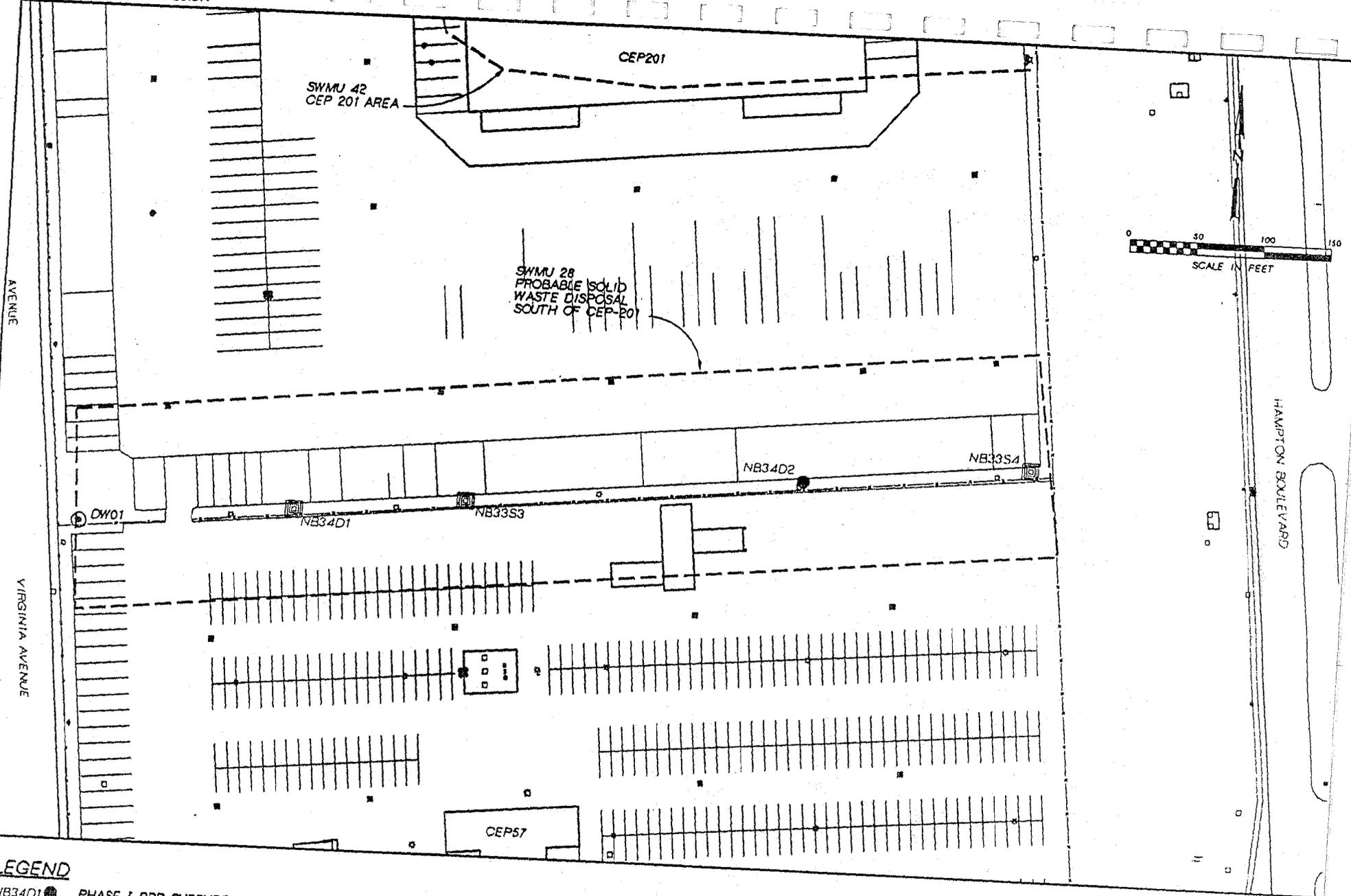


Figure 28-1
 SWMU 28 - PROBABLE SOLID WASTE DISPOSAL
 SOUTH OF CEP-201
 Naval Base, Norfolk



LEGEND

- NB34D1 ● PHASE I RRR SUBSURFACE SOIL SAMPLE LOCATION
- NB33S3 ◻ PHASE II RRR SURFACE SOIL SAMPLE LOCATION
- ⊙ SI GEOPROBE GROUNDWATER SAMPLE LOCATION
- ESTIMATED EXTENT OF WASTE DISPOSAL AREA

Figure 28-2
 SWMU 28 - PROBABLE SOLID WASTE
 AREA CEP-160/161 EMBANKMENT
 SAMPLING LOCATIONS
 Naval Base, Norfolk

The maximum-reported concentrations of aluminum, arsenic, and iron, in subsurface soil exceeded the Region III Residential RBCs. Results of the risk characterization demonstrated a potentially unacceptable noncancer hazard to potential future child residents (hazard index equals 3.1) from subsurface soil ingestion and dermal contact associated with the arsenic and iron detected in the soil. Arsenic is the only constituent with an individual hazard quotient greater than 1.0. There is also a potential carcinogenic risk to the future resident associated with ingestion and dermal contact with arsenic in the subsurface soil ($1.7E-4$ compared with EPA's acceptable carcinogenic risk of $1E-4$). Additionally, there is a potential noncarcinogenic hazard to the future construction worker associated with ingestion and dermal contact of arsenic and iron in the subsurface soil. Neither of these constituents individually pose a hazard above 1.0 to the future construction worker. Risk characterization for the potential future industrial worker and trespasser did not result in unacceptable risks. The results of these comparisons are presented in Table 3.

As noted, the site is located in a highly industrialized area of the base and it would be highly unlikely for the site to be converted to residential land use. In addition, concentrations of arsenic and iron detected in soil at SWMU 28, are within the range of concentrations detected in background soil at Naval Station Norfolk. Final results from the background study will be used to determine if SWMU 28 is suitable for close out as an NFA site, or if institutional controls or other remedial measures are warranted.

**Table I, SWMU 28
Surface Soil Screening
Residential Scenario
SWMU 28**

Chemical	RBC Value¹ (mg/kg)	Maximum Concentration (mg/kg)	Selected as COPC?	Reason for Exclusion
Volatiles				
1,1,1-Trichloroethane	1.6E+02	4.0E-03	NO	Below RBC
Semivolatiles				
Benzo[a]anthracene	8.7E-01	1.2E-01	NO	Below RBC
Benzo[a]pyrene	8.7E-02	1.2E-01	YES	
Benzo[b]fluoranthene	8.7E-01	2.3E-01	NO	Below RBC
Benzo[g,h,i]perylene ²	2.3E+02	1.1E-01	NO	Below RBC
Benzo[k]fluoranthene	8.7E+00	7.1E-02	NO	Below RBC
Bis(2-Ethylhexyl)phthalate	4.6E+01	1.0E-01	NO	Below RBC
Chrysene	8.7E+01	1.7E-01	NO	Below RBC
Fluoranthene	3.1E+02	1.9E-01	NO	Below RBC
Phenanthrene ²	2.3E+02	1.0E-01	NO	Below RBC
Pyrene	2.3E+02	2.8E-01	NO	Below RBC
Pesticides				
Aroclor-1254	3.2E-01	1.5E-01	NO	Below RBC
DDE	1.9E+00	7.2E-03	NO	Below RBC
DDT	1.9E+00	3.4E-03	NO	Below RBC
Inorganics				
Aluminum	7.8E+03	5.2E+03	NO	Below RBC
Arsenic	4.3E-01	1.5E+01	YES	
Barium	5.5E+02	4.0E+01	NO	Below RBC
Beryllium	1.6E+01	4.4E-01	NO	Below RBC
Calcium	NA	7.6E+03	NO	Human Nutrient
Chromium ³	2.3E+01	1.4E+01	NO	Below RBC
Cobalt	4.7E+02	2.6E+00	NO	Below RBC
Copper	3.1E+02	1.5E+01	NO	Below RBC
Iron	2.3E+03	1.2E+04	YES	
Lead ⁴	4.0E+02	3.4E+01	NO	Below RBC
Magnesium	NA	1.1E+03	NO	Human Nutrient
Manganese	1.1E+03	9.9E+01	NO	Below RBC
Nickel	1.6E+02	7.0E+00	NO	Below RBC
Potassium	NA	6.8E+02	NO	Human Nutrient
Sodium	NA	8.8E+01	NO	Below Background
Vanadium	5.5E+01	2.2E+01	NO	Below RBC
Zinc	2.3E+03	1.1E+02	NO	Below RBC

NA = Not Available

Shaded lettering indicates that the compound has been identified as a COPC.

Human nutrient exposure concentrations are not considered to be in the toxic range.

¹ EPA Region III, April, 1999, Residential Ingestion RBC based on hazard index of 0.1 (instead of 1.0 as indicated in the guidance document), and carcinogenic risk of 1x10⁻⁶.

² Pyrene RBC value used.

³ Hexavalent chromium RBC value used.

⁴ Lead action level from *Revised Interim Soil Lead Guidance for CERCLA Site and RCRA Corrective Action Facilities*, EPA, July 1994.

Table 2, SWMU 28
Subsurface Soil Screening
Residential Scenario
SWMU 28

Chemical	RBC Value ¹ (mg/kg)	Maximum Concentration (mg/kg)	Selected as COPC?	Reason for Exclusion
Volatiles				
Chlorobenzene	1.6E+02	1.9E-03	NO	Below RBC
Semivolatiles				
Benzo[b]fluoranthene	8.7E-01	4.6E-02	NO	Below RBC
Chrysene	8.7E+01	6.2E-02	NO	Below RBC
Di-n-butylphthalate	7.8E+02	9.8E-02	NO	Below RBC
Phenanthrene ²	2.3E+02	5.8E-02	NO	Below RBC
Inorganics				
Aluminum	7.8E+03	1.5E+04	YES	
Arsenic	4.3E-01	4.0E+01	YES	
Barium	5.5E+02	4.4E+01	NO	Below RBC
Calcium	NA	1.5E+03	NO	Human Nutrient
Chromium ³	2.3E+01	1.8E+01	NO	Below RBC
Copper	3.1E+02	6.4E+00	NO	Below RBC
Iron	2.3E+03	1.3E+04	YES	
Lead ⁴	4.0E+02	1.1E+01	NO	Below RBC
Magnesium	NA	6.3E+02	NO	Human Nutrient
Manganese	1.1E+03	3.8E+01	NO	Below RBC
Nickel	1.6E+02	4.9E+00	NO	Below RBC
Vanadium	5.5E+01	3.0E+01	NO	Below RBC
Zinc	2.3E+03	3.7E+01	NO	Below RBC

NA = Not Available

Shaded lettering indicates that the compound has been identified as a COPC.

Human nutrient exposure concentrations are not considered to be in the toxic range.

¹ EPA Region III, April, 1999, Residential Ingestion RBC based on hazard index of 0.1 (instead of 1.0 as indicated, in the guidance document) and carcinogenic risk of 1×10^{-6} .

² Pyrene RBC value used.

³ Hexavalent chromium RBC value used.

⁴ Lead action level from *Revised Interim Soil Lead Guidance for CERCLA Site and RCRA Corrective Action Facilities*, EPA, July 1994.

Table 3, SWMU 28
 Risk and Hazard Summary
 SWMU 28, Norfolk Naval Base

Media: Surface Soil

Chemical	Future Residential Adult								Future Residential Child							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)pyrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arsenic	--	6.8E-02	1.2E-01	1.9E-01	--	--	--	--	--	6.4E-01	2.1E-01	8.5E-01	--	--	--	--
Iron	--	5.5E-02	--	5.5E-02	--	--	--	--	--	5.1E-01	--	5.1E-01	--	--	--	--
Totals	--	1.2E-01	1.2E-01	2.4E-01	--	--	--	--	--	1.2E+00	2.1E-01	1.4E+00	--	--	--	--

Chemical	Future Age-Adjusted Resident							
	HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)pyrene	--	--	--	--	4.5E-11	1.4E-06	--	1.4E-06
Arsenic	--	--	--	--	2.7E-08	3.5E-05	2.8E-05	6.3E-05
Iron	--	--	--	--	--	--	--	--
Totals	--	--	--	--	2.7E-08	3.7E-05	2.8E-05	6.4E-05

Chemical	Site Worker								Future Construction Worker							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)pyrene	--	--	--	--	6.6E-12	3.1E-07	--	3.1E-07	--	--	--	--	8.8E-13	5.9E-08	--	5.9E-08
Arsenic	--	4.9E-02	8.6E-02	1.3E-01	4.0E-09	7.9E-06	1.4E-05	2.2E-05	--	2.3E-01	8.6E-02	3.2E-01	5.3E-10	1.5E-06	5.7E-07	2.1E-06
Iron	--	3.9E-02	--	3.9E-02	--	--	--	--	--	1.9E-01	--	1.9E-01	--	--	--	--
Totals	--	8.8E-02	8.6E-02	1.7E-01	4.0E-09	8.2E-06	1.4E-05	2.2E-05	--	4.2E-01	8.6E-02	5.1E-01	5.3E-10	1.6E-06	5.7E-07	2.1E-06

Chemical	Current and Future Trespasser Adult								Current and Future Trespasser Youth							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)pyrene	--	--	--	--	4.9E-12	7.6E-08	--	7.6E-08	--	--	--	--	2.8E-12	4.3E-08	--	4.3E-08
Arsenic	--	1.0E-02	1.8E-02	2.8E-02	3.0E-09	2.0E-06	3.6E-06	5.5E-06	--	1.9E-02	2.3E-02	4.2E-02	1.7E-09	1.1E-06	1.4E-06	2.5E-06
Iron	--	8.1E-03	--	8.1E-03	--	--	--	--	--	1.5E-02	--	1.5E-02	--	--	--	--
Totals	--	1.8E-02	1.8E-02	3.6E-02	3.0E-09	2.0E-06	3.6E-06	5.6E-06	--	3.5E-02	2.3E-02	5.7E-02	1.7E-09	1.2E-06	1.2E-06	2.5E-06

Table 3, SWMU 28
 Risk and Hazard Summary
 SWMU 28, Norfolk Naval Base

Media: Subsurface Soil

Chemical	Future Residential Adult								Future Residential Child							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Aluminum	3.1E-03	2.1E-02	4.0E-02	6.4E-02	--	--	--	--	8.7E-03	1.9E-01	7.1E-02	2.7E-01	--	--	--	--
Arsenic	--	1.8E-01	3.2E-01	5.0E-01	--	--	--	--	--	1.7E+00	5.7E-01	2.3E+00	--	--	--	--
Iron	--	5.9E-02	--	5.9E-02	--	--	--	--	--	5.5E-01	--	5.5E-01	--	--	--	--
Totals	3.1E-03	2.6E-01	3.6E-01	6.3E-01	--	--	--	--	8.7E-03	2.5E+00	6.4E-01	3.1E+00	--	--	--	--

Chemical	Future Age-Adjusted Resident							
	HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Aluminum	--	--	--	--	--	--	--	--
Arsenic	--	--	--	--	7.3E-08	9.4E-05	7.3E-05	1.7E-04
Iron	--	--	--	--	--	--	--	--
Totals	--	--	--	--	7.3E-08	9.4E-05	7.3E-05	1.7E-04

Chemical	Site Worker								Future Construction Worker							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Aluminum	7.4E-04	1.5E-02	2.9E-01	3.0E-01	--	--	--	--	2.5E-03	7.0E-02	2.9E-01	3.6E-01	--	--	--	--
Arsenic	--	1.3E-01	2.3E-01	3.6E-01	1.1E-08	2.1E-05	3.8E-05	5.9E-05	--	6.3E-01	2.3E-01	8.6E-01	1.4E-09	4.0E-06	1.5E-06	5.5E-06
Iron	--	4.2E-02	--	4.2E-02	--	--	--	--	--	2.0E-01	--	2.0E-01	--	--	--	--
Totals	7.4E-04	1.9E-01	5.2E-01	7.1E-01	1.1E-08	2.1E-05	3.8E-05	5.9E-05	2.5E-03	9.0E-01	5.2E-01	1.4E+00	1.4E-09	4.0E-06	1.5E-06	5.5E-06

Chemical	Current and Future Trespasser Adult								Current and Future Trespasser Youth							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Aluminum	4.6E-04	3.1E-03	0.0E+00	3.5E-03	--	--	--	--	8.8E-04	5.8E-03	0.0E+00	6.7E-03	--	--	--	--
Arsenic	--	2.7E-02	4.8E-02	7.5E-02	7.9E-09	5.2E-06	9.5E-06	1.5E-05	--	5.1E-02	6.1E-02	1.1E-01	4.5E-09	3.0E-06	3.6E-06	6.6E-06
Iron	--	8.8E-03	--	8.8E-03	--	--	--	--	--	1.7E-02	--	1.7E-02	--	--	--	--
Totals	4.6E-04	3.9E-02	4.8E-02	8.4E-02	7.9E-09	5.2E-06	9.5E-06	1.5E-05	8.8E-04	7.4E-02	6.1E-02	1.4E-01	4.5E-09	3.0E-06	3.6E-06	6.6E-06

Definitions:

HQ = Hazard Quotient

CR = Cancer Risk

Ing = Ingestion route of exposure

Inh = Inhalation route of exposure

Der = Dermal route of exposure

SWMU 32:
SWD Area CEP-160/161 Embankment

Streamlined Risk Assessment

SWMU 32 – SWD Area CEP-160/161 Embankment

Site Description

SWMU 32 covers approximately 3.6 acres and consists of a gravel parking lot located in the pier area that was formerly used for waste and fill disposal. The site is located in the southwest corner of the intersection of Admiral Taussig Boulevard and Second Street. The site is divided into two sections by a chain-link fence and an aboveground steam line. The western portion of the site is currently used for parking by pier workers. Surface water from the parking lot drains to a drainage ditch located on the southern side of the site. The drainage ditch discharges directly to the Elizabeth River. The location of the site is shown in Figure 32-1. Photographs of this SWMU are included in Appendix A.

Data Summary

The analytical results of the RRR Study and SWMU Supplemental Investigation are discussed as one combined data set. Concentrations of detected chemicals were compared to the following current USEPA screening criteria (comparison criteria) for each sample matrix: USEPA Region III residential and industrial soil risk-based concentrations (RBCs) for soil, and USEPA Region III tap water RBCs and drinking water Maximum Contaminant Levels (MCLs) for groundwater. Sampling locations are shown in Figure 32-2.

Groundwater

Three groundwater samples were collected during the SWMU Supplemental Investigation field activities at SWMU 32. No organic compounds were detected at concentrations exceeding the comparison criteria in any of the groundwater samples. Two inorganic chemicals were detected at concentrations that exceeded the comparison criteria.

Arsenic was detected at two of the three sampling locations at concentrations ranging from 3.8 µg/l to 5.4 µg/l, which exceed the tap water RBC of 0.04 µg/l and the estimated upgradient concentration of < 3 µg/l. In addition, thallium was detected at one sampling location at a concentration of 2.6 µg/l, which is slightly higher than the tap water RBC of 2.56 µg/l and the estimated upgradient concentration of < 2 µg/l.

Soil

Two subsurface soil samples were collected during the RRR Study sampling activities at SWMU 32. One organic compound and one inorganic chemical were detected at concentrations exceeding the comparison criteria.

Benzo(a)pyrene was detected at a concentration of 180 µg/kg at NB29D1, which exceeds the residential RBC of 87.5 µg/kg. Arsenic was detected at both NB29D1 and NB29D2 at concentrations of 4.6 mg/kg and 3.5 mg/kg, respectively. Both arsenic detections exceed the residential RBC of 0.43 mg/kg. In addition, the arsenic concentration at NB29D1 also exceeded the industrial RBC of 3.82 mg/kg.

On the basis of these results, it was determined that a more quantitative evaluation of risk was warranted.

Exposure Pathways

It is uncertain to what extent, or for what purpose this site will be used in the future. The location of this site near the piers indicates that it would be highly unlikely for the site to be converted to residential land use. According to the Naval Base Norfolk 2010 Land Use Plan, future land use at the site is expected to be for industrial or logistics facilities. For purposes of performing the risk characterization, however, exposure to the site soil was evaluated for potential residential, industrial or commercial site worker, construction worker, and trespasser receptors. Assuming no action is taken at the site prior to development, exposure to affected soil could occur as a result of incidental ingestion, dermal contact, and inhalation of volatiles and fugitive dust. The receptors could be exposed to the subsurface soil if future construction work results in disturbance of the soil column.

Groundwater is not currently used as a potable water supply 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. All potable water in the City limits is supplied by the City of Norfolk. Therefore, there is no potential for direct exposure to groundwater.

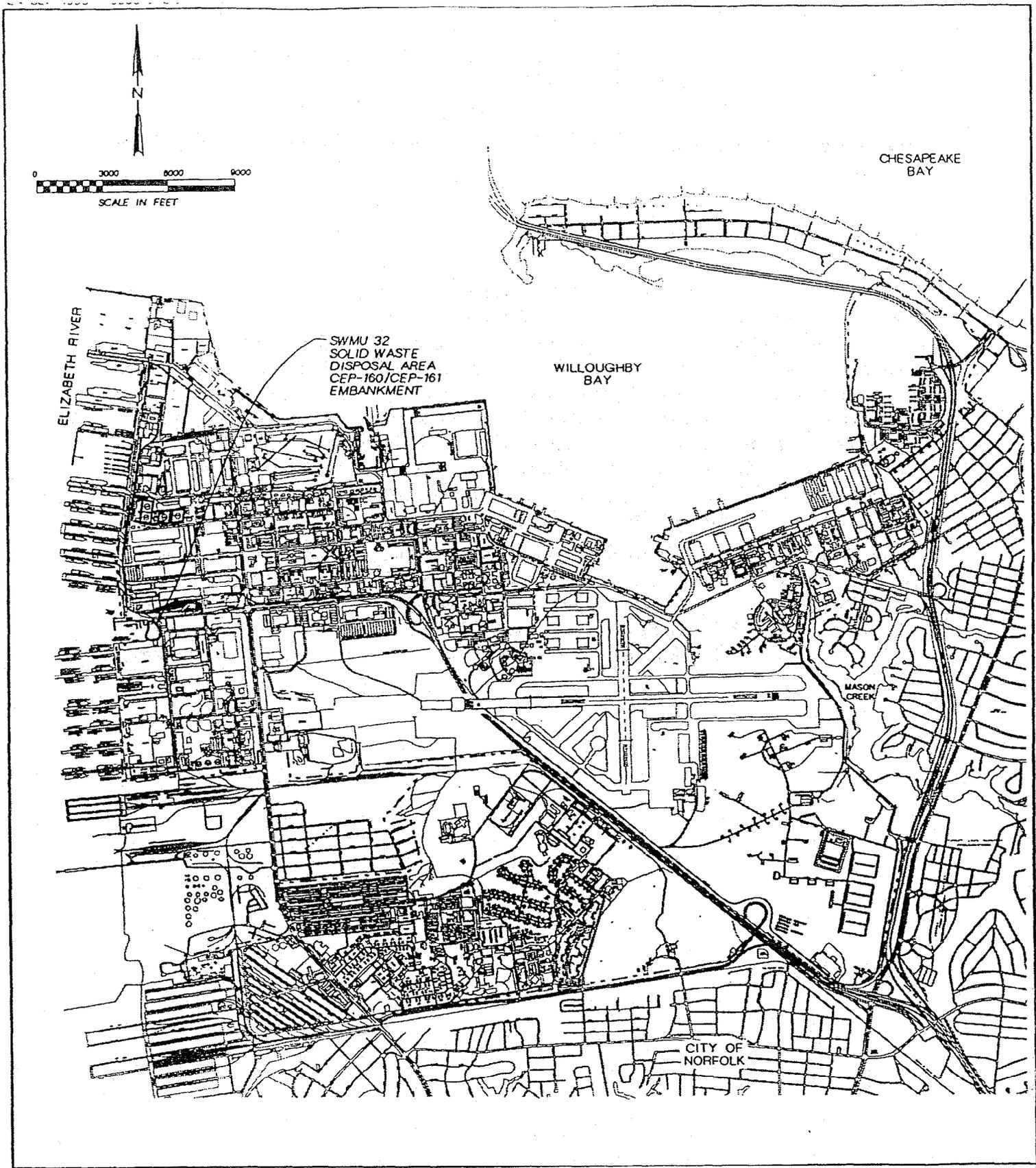
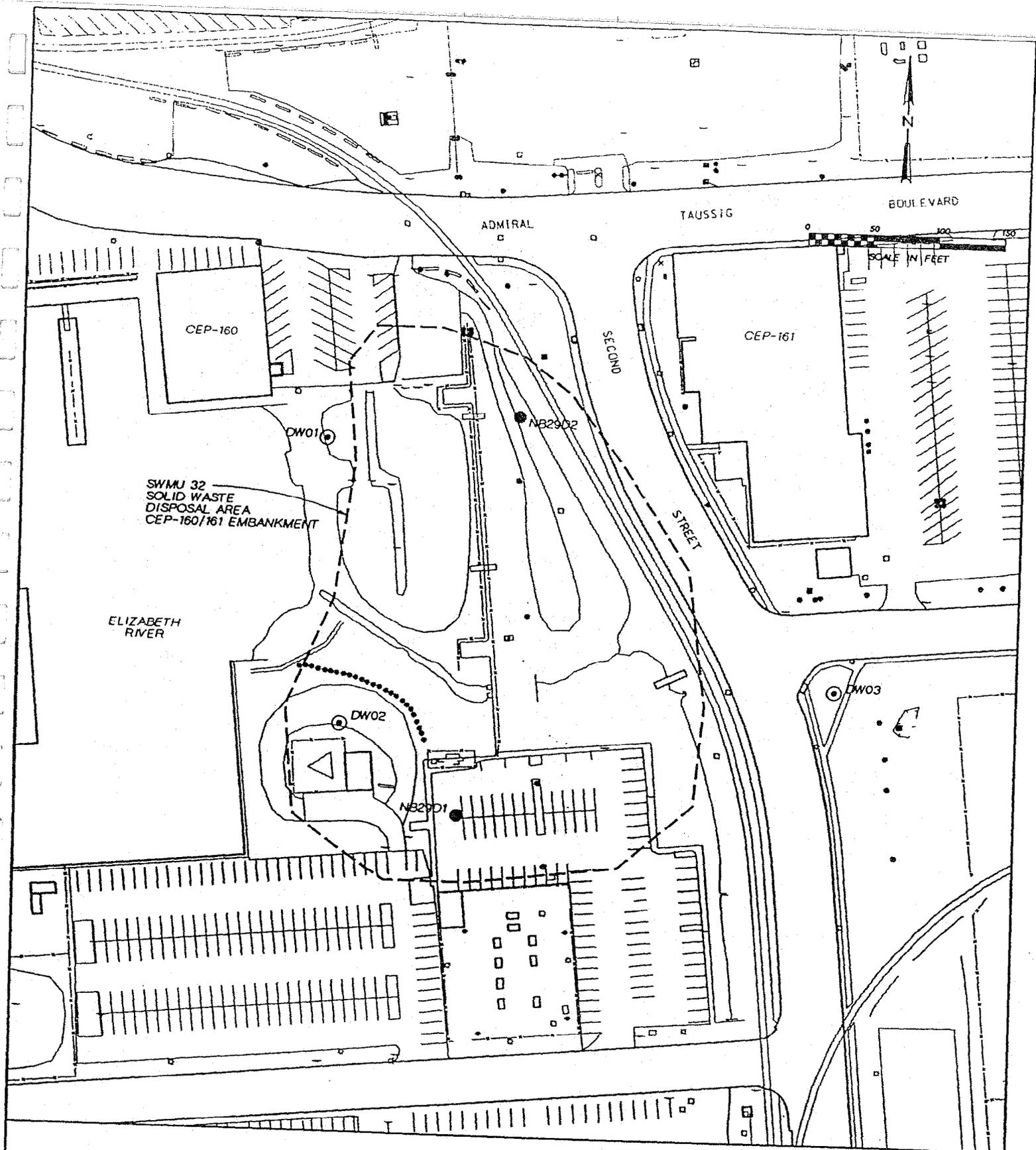


Figure 32-1
 SWMU 32 - PROBABLE SOLID WASTE DISPOSAL AREA
 CEP-160/161 EMBANKMENT
 Naval Base, Norfolk



LEGEND

- NB29D1 ● PHASE I RRR SUBSURFACE SOIL SAMPLE LOCATION
- ⊙ SI GEOPROBE GROUNDWATER SAMPLING LOCATION
- ESTIMATED EXTENT OF WASTE DISPOSAL AREA

Figure 32-2
 SWMU 32 - SOLID WASTE DISPOSAL
 AREA CEP-160/161 EMBANKMENT
 SAMPLING LOCATIONS
 Naval Base, Norfolk

Risk Characterization

The screening summary and risk/hazard summary tables included in this SRA are only those relevant to the discussion presented below. The tables presented were derived from a series of risk calculation and exposure assumption tables developed for this SWMU. All tables are presented in Volume II - Backup Tables for Streamlined Risk Assessments - SWMUs 28, 32, 33, 34, and 35. Appendix B presents a list of all tables related to this SRA.

The maximum-reported concentration of each constituent detected in the subsurface soil samples from SWMU 32 were compared to the EPA Region III Risk-Based Concentrations (RBCs) for residential soil. The RBCs for noncarcinogenic constituents were divided by 10 to account for exposure to multiple constituents. Constituents detected at levels exceeding the RBCs were identified as constituents of potential concern (COPCs). This risk-based screening is presented in Table 1.

The maximum-reported concentrations of benzo(a)pyrene, arsenic, and iron, in subsurface soil exceeded the Region III residential soil RBCs. However, based on the hazard and risk calculations, exposure to soil at SWMU 32 would not result in potentially unacceptable risks to any of the potential receptors (Table 2).

As noted, the location of this site near the piers indicates that it would be highly unlikely for the site to be converted to residential land use. In addition, it is expected that concentrations of arsenic and iron detected in soil at SWMU 32 may be similar to those found in unaffected background soil at Norfolk Naval Base. Further investigation will be conducted as part of the ongoing background study, and more data will be available at the conclusion of the background investigation to make this determination. Based on the results of the risk characterization, which showed no exceedances of risk criteria even under residential exposure scenarios, it is recommended that SWMU 32 be closed out as an NFA site. Results from the background study will be used to determine if SWMU 32 is suitable for close out as an NFA site, or if institutional controls or other remedial measures are warranted.

Table-1
Subsurface Soil Screening
Residential Scenario
SWMU 32

Chemical	RBC Value ¹ (mg/kg)	Maximum Concentration (mg/kg)	Selected as COPC?	Reason for Exclusion
Semivolatiles				
Anthracene	2.3E+03	3.6E-01	NO	Below RBC
Benzo(a)anthracene	8.7E-01	1.8E-01	NO	Below RBC
Benzo(a)pyrene	8.7E-02	1.8E-01	YES	
Benzo(b)fluoranthene	8.7E-01	2.3E-01	NO	Below RBC
Benzo(g,h,i)perylene ²	2.3E+02	8.1E-02	NO	Below RBC
Benzo(k)fluoranthene	8.7E+00	1.3E-01	NO	Below RBC
Chrysene	8.7E+01	2.4E-01	NO	Below RBC
Di-n-butylphthalate	7.8E+02	1.4E+00	NO	Below RBC
Fluoranthene	3.1E+02	4.2E-01	NO	Below RBC
Indeno(1,2,3-cd)pyrene	8.7E-01	8.9E-02	NO	Below RBC
Phenanthrene ²	2.3E+02	3.4E-01	NO	Below RBC
Pyrene	2.3E+02	3.0E-01	NO	Below RBC
Inorganics				
Aluminum	7.8E+03	4.2E+03	NO	Below RBC
Arsenic	4.3E-01	4.6E+00	YES	
Calcium	NA	1.4E+03	NO	Human Nutrient
Chromium ³	2.3E+01	8.6E+00	NO	Below RBC
Copper	3.1E+02	1.2E+01	NO	Below RBC
Iron	2.3E+03	1.2E+04	YES	
Lead ⁴	4.0E+02	2.3E+01	NO	Below RBC
Magnesium	NA	6.4E+02	NO	Human Nutrient
Manganese	1.1E+03	7.2E+01	NO	Below RBC
Nickel	1.6E+02	6.2E+00	NO	Below RBC
Vanadium	5.5E+01	1.4E+01	NO	Below RBC
Zinc	2.3E+03	2.8E+01	NO	Below RBC

NA = Not Available

Shaded lettering indicates that the compound has been identified as a COPC.

Human nutrient exposure concentrations are not considered to be in the toxic range.

¹ EPA Region III, April, 1999, Residential Ingestion RBC based on hazard index of 0.1 (instead of 1.0 as indicated, in the guidance document) and carcinogenic risk of 1x10⁻⁶.

² Pyrene RBC value used.

³ Hexavalent chromium RBC value used.

⁴ Lead action level from *Revised Interim Soil Lead Guidance for CERCLA Site and RCRA Corrective Action Facilities*, EPA, July 1994.

Table 2
Risk and Hazard Summary
SWMU 32, Norfolk Naval Base

Media: Subsurface Soil

Chemical	Receptor 1 (e.g., Future Residential Adult)								Receptor 2 (e.g., Future Residential Child)							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)pyrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arsenic	--	2.1E-02	3.7E-02	5.8E-02	--	--	--	--	--	2.0E-01	6.5E-02	2.6E-01	--	--	--	--
Iron	--	5.5E-02	--	5.5E-02	--	--	--	--	--	5.1E-01	--	5.1E-01	--	--	--	--
Totals	--	7.6E-02	3.7E-02	1.1E-01	--	--	--	--	--	7.1E-01	6.5E-02	7.7E-01	--	--	--	--

Chemical	Receptor 3 (e.g., Future Age-Adjusted Resident)							
	HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)pyrene	--	--	--	--	6.8E-11	2.1E-06	--	2.1E-06
Arsenic	--	--	--	--	8.3E-09	1.1E-05	8.5E-06	1.9E-05
Iron	--	--	--	--	--	--	--	--
Totals	--	--	--	--	8.4E-09	1.3E-05	8.5E-06	2.1E-05

Chemical	Receptor 4 (e.g., Future Site Worker)								Receptor 5 (e.g., Future Construction Worker)							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)pyrene	--	--	--	--	9.9E-12	4.6E-07	--	4.6E-07	--	--	--	--	1.3E-12	8.8E-08	--	8.8E-08
Arsenic	--	1.5E-02	2.6E-02	4.1E-02	1.2E-09	2.4E-06	4.4E-06	6.8E-06	--	7.2E-02	2.6E-02	9.8E-02	1.6E-10	4.6E-07	1.7E-07	6.4E-07
Iron	--	3.9E-02	--	3.9E-02	--	--	--	--	--	1.9E-01	--	1.9E-01	--	--	--	--
Totals	--	5.4E-02	2.6E-02	8.0E-02	1.2E-09	2.9E-06	4.4E-06	7.2E-06	--	2.6E-01	2.6E-02	2.9E-01	1.6E-10	5.5E-07	1.7E-07	7.3E-07

Chemical	Receptor 6 (e.g., Future Trespasser Adult)								Receptor 7 (e.g., Future Trespasser Youth)							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)pyrene	--	--	--	--	7.4E-12	1.1E-07	--	1.1E-07	--	--	--	--	4.2E-12	6.6E-08	--	6.6E-08
Arsenic	--	3.1E-03	5.5E-03	8.6E-03	9.1E-10	6.0E-07	1.1E-06	1.7E-06	--	6.9E-03	7.0E-03	1.3E-02	5.2E-10	3.4E-07	4.2E-07	7.6E-07
Iron	--	8.1E-03	--	8.1E-03	--	--	--	--	--	1.5E-02	--	1.5E-02	--	--	--	--
Totals	--	1.1E-02	5.5E-03	1.7E-02	9.2E-10	7.2E-07	1.1E-06	1.8E-06	--	2.1E-02	7.0E-03	2.8E-02	5.2E-10	4.1E-07	4.2E-07	8.3E-07

Definitions:

HQ = Hazard Quotient

CR = Cancer Risk

Ing = Ingestion route of exposure

Inh = Inhalation route of exposure

Der = Dermal route of exposure

SWMU 33:
Debris Pile at Seawall, Corner of Sustain Pier

Streamlined Risk Assessment

SWMU 33 – Debris Pile at Seawall, Corner of Sustain Pier

Site Description

SWMU 33 covers approximately 1 acre where a former debris pile was located at the floating dry dock USS Sustain. The western side of the site is adjacent to the Elizabeth River while the northern side of the site borders the dry-dock area. A gravel parking lot is south of the dry-dock area. The site extends across both the dry-dock area and the parking lot. A portion of the site is covered with asphalt while the parking area has a gravel surface. A satellite accumulation area (SAA) is also located within the area. Access to the dry-dock portion of the site is restricted. The location of SWMU 33 is shown in Figure 33-1. Photographs of this SWMU are included in Appendix A.

Data Summary

The analytical results of the RRR Study and SWMU Supplemental Investigation are discussed as one combined data set. Concentrations of detected chemicals were compared to the following current USEPA screening criteria (comparison criteria) for each sample matrix: residential and industrial soil risk-based concentrations (RBCs) for soil, and Region III tap water RBCs and federal drinking water Maximum Contaminant Levels (MCLs) for groundwater. Sample locations are shown in Figure 33-2.

Groundwater

Three groundwater samples were collected at SWMU 33 during the Supplemental Investigation field activities. Two organic compounds (carbazole and benzene) and two inorganic chemicals (iron and manganese) were detected at concentrations that exceeded the screening or regulatory criteria (comparison criteria).

Carbazole and benzene concentrations exceeded the tap water RBCs at the estimated upgradient sampling location (NBW33-DW02), but neither compound was detected at any other sampling location at this SWMU. In addition, manganese (1,090 µg/l) and iron (25,800 µg/l) concentrations at sampling location NBW33-DW03 exceeded the tap water RBCs of 730 µg/l and 10,950 µg/l, respectively. Manganese and iron also exceeded the concentrations detected at the estimated upgradient sampling location.

Soil

Two subsurface soil samples were collected during the RRR Study sampling activities at SWMU 33. Benzo(a)pyrene, arsenic, copper, and iron exceeded the residential RBC. Arsenic concentrations also exceeded the industrial RBC.

Benzo(a)pyrene was detected at a concentration of 310 µg/kg at NB30D2, which exceeds the residential RBC of 87.5 µg/kg. Arsenic was detected at both NB30D1 and NB30D2 at concentrations of 1.6 mg/kg and 5.4 mg/kg, respectively. Both arsenic detections exceed the residential RBC of 0.43 mg/kg. In addition, the arsenic concentration at NB30D2 exceeds the industrial RBC of 3.82 mg/kg.

Copper was detected at a concentration of 942 mg/kg at NB30D2 which exceeds the residential RBC of 310 mg/kg and iron was detected at a concentration of 15,800 mg/kg at NB30D2 which exceeds the residential RBC of 2,300 mg/kg.

On the basis of these results, it was determined that a more quantitative evaluation of risk was warranted.

Exposure Pathways

It is uncertain to what extent, or for what purpose this site will be used in the future. The location of this site near the piers indicates that it would be highly unlikely for the site to be converted to residential land use. According to the Naval Base Norfolk 2010 Land Use Plan, future use of this area of the base is for industrial or logistics facilities. For purposes of performing the risk characterization, however, exposure to the site soil was evaluated for potential residential, industrial or commercial site worker, construction worker, and trespasser receptors. Assuming no action is taken at the site prior to development, exposure to affected soil could occur as a result of incidental ingestion, dermal contact, and inhalation of volatiles and fugitive dust. The receptors could be exposed to the subsurface soil if future construction work results in disturbance of the soil column.

Groundwater is not currently used as a potable water supply 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. All potable water in the City limits is supplied by the City of Norfolk. Therefore, there is no potential for direct exposure to groundwater.

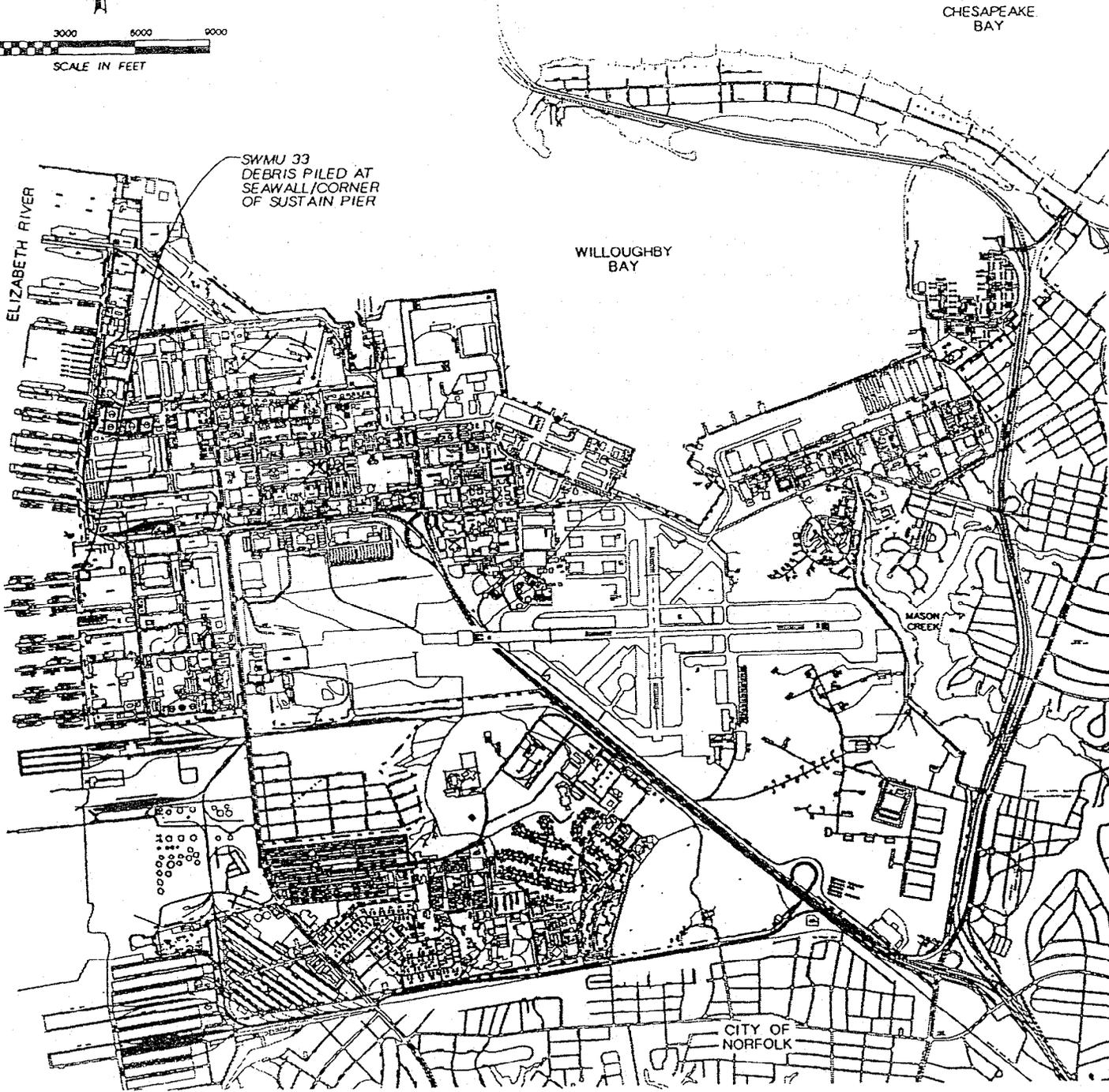
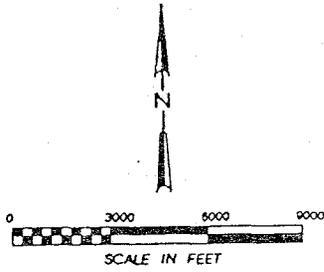
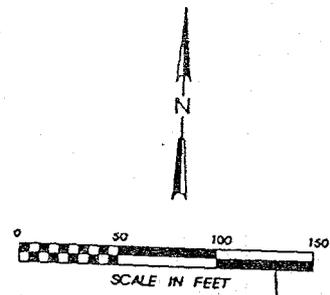


Figure 33-1
SWMU 33 - DEBRIS PILED AT
SEAWALL/CORNER OF SUSTAIN WALL
Naval Base, Norfolk



FLEET LANDING

CEP196

CEP 196 (SUSTAIN PIER)

ELIZABETH RIVER

SWMU 33
DEBRIS PILED AT
SEAWALL/CORNER
OF SUSTAIN PIER

NB30D1

DW03

CEP203

DW01

GRAVEL
PARKING

DW02

GRAVEL
PARKING

NB30D2

LEGEND

- NB30D1 ● PHASE I RRR SUBSURFACE SOIL SAMPLE LOCATION
- ⊙ SI GEOPROBE GROUNDWATER SAMPLING LOCATION
- ESTIMATED EXTENT OF WASTE DISPOSAL AREA

Figure 33-2
SWMU 33 - DEBRIS PILED AT
SEAWALL/CORNER OF SUSTAIN PIER
SAMPLING LOCATIONS
Naval Base, Norfolk

CH2MHILL

Risk Characterization

The screening summary and risk/hazard summary tables included in this SRA are only those relevant to the discussion presented below. The tables presented were derived from a series of risk calculation and exposure assumption tables developed for this SWMU. All tables are presented in Volume II - Backup Tables for Streamlined Risk Assessments - SWMUs 28, 32, 33, 34, and 35. Appendix B presents a list of all tables related to this SRA.

The maximum-reported concentration of each constituent detected in the subsurface soil samples from SWMU 33 were compared to the EPA Region III Risk-Based Concentrations (RBCs) for residential soil. The RBCs for noncarcinogenic constituents were divided by 10 to account for exposure to multiple constituents. Constituents detected at levels exceeding the RBCs were identified as constituents of potential concern (COPCs). This risk-based screening is presented in Table 1.

The maximum-reported concentrations of benzo(a)pyrene, arsenic, copper, and iron, in subsurface soil exceeded the Region III Residential RBCs. Based on the hazard and risk calculations, exposure to subsurface soil at SWMU 33 would not result in unacceptable risks to potential adult residents, industrial site workers, construction workers, or child and adult trespassers (Table 2). However, there may be a slight noncarcinogenic hazard to future child residents (hazard index of 1.3 compared to EPA's acceptable hazard index of 1.0). Based on the anticipated future use of the site in the Naval Base Norfolk 2010 Land Use Plan and on the location of this site, residential use is considered highly improbable. This noncarcinogenic hazard is primarily associated with ingestion of arsenic, copper, and iron in the soil. However, the individual hazard quotients for these constituents do not exceed EPA's acceptable level of 1.0.

It is expected that concentrations of arsenic, copper, and iron detected in soil at SWMU 33 may be similar to those found in unaffected background soil at Norfolk Naval Base. Further investigation will be conducted as part of the ongoing background study, and more data will be available at the conclusion of the background investigation to make this determination. Results from the background study will be used to determine if SWMU 33 is suitable for close out as an NFA site, or if institutional controls or other remedial measures are warranted.

Table-1
Subsurface Soil Screening
Residential Scenario
SWMU 33

Chemical	RBC Value ¹ (mg/kg)	Maximum Concentration (mg/kg)	Selected as COPC?	Reason for Exclusion
Volatiles				
Benzene	2.2E+01	4.4E-03	NO	Below RBC
Methylene chloride	8.5E+01	3.7E-03	NO	Below RBC
Semivolatiles				
Acenaphthene	4.7E+02	7.5E-02	NO	Below RBC
Acenaphthylene ²	1.6E+02	5.2E-02	NO	Below RBC
Anthracene	2.3E+03	1.4E-01	NO	Below RBC
Benzo(a)anthracene	8.7E-01	3.4E-01	NO	Below RBC
Benzo(a)pyrene	8.7E-02	3.1E-01	YES	
Benzo[b]fluoranthene	8.7E-01	5.8E-01	NO	Below RBC
Benzo(g,h,i)perylene ³	2.3E+02	1.3E-01	NO	Below RBC
Benzo(k)fluoranthene	8.7E+00	3.5E-01	NO	Below RBC
Carbazole	3.2E+01	4.7E-02	NO	Below RBC
Chrysene	8.7E+01	7.1E-01	NO	Below RBC
Dibenz(a,h)anthracene	8.7E-02	8.6E-02	NO	Below RBC
Dibenzofuran	3.1E+01	8.1E-02	NO	Below RBC
Fluoranthene	3.1E+02	6.8E-01	NO	Below RBC
Fluorene	3.1E+02	6.1E-02	NO	Below RBC
Indeno(1,2,3-cd)pyrene	8.7E-01	1.4E-01	NO	Below RBC
2-Methylnaphthalene	1.6E+02	8.5E-02	NO	Below RBC
Napthalene	1.6E+02	1.6E-01	NO	Below RBC
Phenanthrene ³	2.3E+02	4.7E-01	NO	Below RBC
Pyrene	2.3E+02	7.7E-01	NO	Below RBC
Inorganics				
Aluminum	7.8E+03	4.9E+03	NO	Below RBC
Arsenic	4.3E-01	5.4E+00	YES	
Barium	5.5E+02	3.6E+01	NO	Below RBC
Calcium	NA	5.2E+04	NO	Human Nutrient
Chromium ⁴	2.3E+01	1.4E+01	NO	Below RBC
Copper	3.1E+02	9.4E+02	YES	
Iron	2.3E+03	1.6E+04	YES	
Lead ⁵	4.0E+02	5.8E+01	NO	Below RBC
Magnesium	NA	1.6E+03	NO	Human Nutrient
Manganese	1.1E+03	1.9E+02	NO	Below RBC
Nickel	1.6E+02	6.6E+00	NO	Below RBC
Potassium	NA	9.7E+02	NO	Human Nutrient
Vanadium	5.5E+01	1.9E+01	NO	Below RBC
Zinc	2.3E+03	5.2E+01	NO	Below RBC

NA = Not Available

Shaded lettering indicates that the compound has been identified as a COPC.

Human nutrient exposure concentrations are not considered to be in the toxic range.

¹ EPA Region III, April, 1999, Residential Ingestion RBC based on hazard index of 0.1 (instead of 1.0 as indicated, in the guidance document) and carcinogenic risk of 1x10⁻⁶.

**Table 2
Risk and Hazard Summary
SWMU 33, Norfolk Naval Base**

Media: **Subsurface Soil**

Chemical	Future Residential Adult								Future Residential Child							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)pyrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arsenic	--	2.5E-02	4.3E-02	6.8E-02	--	--	--	--	--	2.3E-01	7.6E-02	3.1E-01	--	--	--	--
Copper	--	3.2E-02	2.8E-02	6.1E-02	--	--	--	--	--	3.0E-01	5.0E-02	3.5E-01	--	--	--	--
Iron	--	7.2E-02	--	7.2E-02	--	--	--	--	--	6.7E-01	--	6.7E-01	--	--	--	--
Totals	--	1.3E-01	7.2E-02	2.0E-01	--	--	--	--	--	1.2E+00	1.3E-01	1.3E+00	--	--	--	--

Chemical	Future Age-Adjusted Resident							
	HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)pyrene	--	--	--	--	1.2E-10	3.5E-06	--	3.5E-06
Arsenic	--	--	--	--	9.8E-09	1.3E-05	9.9E-06	2.3E-05
Copper	--	--	--	--	--	--	--	--
Iron	--	--	--	--	--	--	--	--
Totals	--	--	--	--	9.8E-09	1.6E-05	9.9E-06	2.6E-05

Chemical	Site Worker								Future Construction Worker							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)pyrene	--	--	--	--	1.7E-11	7.9E-07	--	7.9E-07	--	--	--	--	2.3E-12	1.5E-07	--	1.5E-07
Arsenic	--	1.8E-02	3.1E-02	4.9E-02	1.4E-09	2.8E-06	5.1E-06	8.0E-06	--	8.5E-02	3.1E-02	1.2E-01	1.9E-10	5.4E-07	2.0E-07	7.5E-07
Copper	--	2.3E-02	2.0E-02	4.3E-02	--	--	--	--	--	1.1E-01	2.0E-02	1.3E-01	--	--	--	--
Iron	--	5.2E-02	--	5.2E-02	--	--	--	--	--	2.5E-01	--	2.5E-01	--	--	--	--
Totals	--	9.2E-02	5.1E-02	1.4E-01	1.5E-09	3.6E-06	5.1E-06	8.7E-06	--	4.4E-01	5.1E-02	4.9E-01	1.9E-10	7.0E-07	2.0E-07	9.0E-07

Chemical	Current and Future Trespasser Adult								Current and Future Trespasser Youth							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)pyrene	--	--	--	--	1.3E-11	2.0E-07	--	2.0E-07	--	--	--	--	7.2E-12	1.1E-07	--	1.1E-07
Arsenic	--	3.7E-03	6.4E-03	1.0E-02	1.1E-09	7.1E-07	1.3E-06	2.0E-06	--	6.9E-03	8.2E-03	1.5E-02	6.1E-10	4.0E-07	4.9E-07	8.9E-07
Copper	--	4.8E-03	4.2E-03	9.0E-03	--	--	--	--	--	9.1E-03	5.4E-03	1.4E-02	--	--	--	--
Iron	--	1.1E-02	--	1.1E-02	--	--	--	--	--	2.0E-02	--	2.0E-02	--	--	--	--
Totals	--	1.9E-02	1.1E-02	3.0E-02	1.1E-09	9.0E-07	1.3E-06	2.2E-06	--	3.6E-02	1.4E-02	5.0E-02	6.1E-10	5.1E-07	4.9E-07	1.0E-06

Definitions:

HQ = Hazard Quotient

CR = Cancer Risk

Ing = Ingestion route of exposure

Inh = Inhalation route of exposure

Der = Dermal route of exposure

² Naphthalene RBC value used.

³ Pyrene RBC value used.

⁴ Hexavalent chromium RBC value used.

⁵ Lead action level from *Revised Interim Soil Lead Guidance for CERCLA Site and RCRA Corrective Action Facilities*, EPA, July 1994.

**SWMU 34:
SWD Area CEP 156/200**

Streamlined Risk Assessment

SWMU 34- SWD Area CEP 156/200

Site Description

SWMU 34 is approximately 3.4 acres in size and consists of a grass covered mounded disposal area located between Building CEP-156 to the north and Building CEP-200 to the south. The site extends from Second Street eastward until nearly reaching Virginia Avenue. The crest of the mound is approximately 10 feet above the surrounding ground surface. The location of the site is shown in Figure 34-1. Photographs of this SWMU are included in Appendix A.

Data Summary

The analytical results of the RRR Study and SWMU Supplemental Investigation are discussed as one combined data set. Concentrations of detected chemicals were compared to the following current USEPA screening criteria (comparison criteria) for each sample matrix: residential and industrial soil risk-based concentrations (RBCs) for soil, USEPA tap water RBCs, and drinking water Maximum Contaminant Levels (MCLs) for groundwater. USEPA Region III Biological Technical Assistance Group (BTAG) screening values for surface water and sediment were used for comparison only and not as screening criteria. Sample locations are shown in Figure 34-2.

Groundwater

Three groundwater samples were collected during the Supplemental Investigation field activities at SWMU 34. No organic compounds were detected at concentrations exceeding the comparison criteria in any groundwater samples. However, the concentrations of two inorganic chemicals exceeded the tap water RBCs.

Arsenic was detected at both NBW34-DW02 and NBW34-DW03 at concentrations of 4.1 $\mu\text{g}/\text{l}$ and 11.5 $\mu\text{g}/\text{l}$, respectively. Both of the arsenic detections exceeded the tap water RBC of 0.04 $\mu\text{g}/\text{l}$ and the estimated upgradient concentration of < 3 $\mu\text{g}/\text{l}$. Manganese was also detected at the same two locations at concentrations of 2,300 $\mu\text{g}/\text{l}$ and 1,540 $\mu\text{g}/\text{l}$, which are both higher than the tap water RBC of 730 $\mu\text{g}/\text{l}$ and the estimated upgradient concentration of 609 $\mu\text{g}/\text{l}$.

Soil

Two subsurface soil samples were collected during the RRR Study sampling activities at SWMU 34. One polynuclear aromatic hydrocarbon (PAH), benzo(a)pyrene, exceeded the comparison criteria at sampling location NB31D1. No other organic compounds were detected above the comparison criteria in any soil samples. Two inorganic chemicals, arsenic and iron, were detected at concentrations exceeding the comparison criteria.

Benzo(a)pyrene was detected at a concentration of 260 $\mu\text{g}/\text{kg}$ at NB31D1, which exceeds the residential RBC of 87.5 $\mu\text{g}/\text{kg}$. Arsenic was detected at both NB31D1 and NB31D2 at concentrations of 11.2 mg/kg and 1.2 mg/kg, respectively. Both arsenic detections exceed

the residential RBC of 0.43 mg/kg. In addition, the arsenic concentration at NB31D1 also exceeded the industrial RBC of 3.82 mg/kg. Iron was detected at a concentration of 21,400 mg/kg at NB31D2 which exceeded the residential RBC of 2,300 mg/kg.

Surface Water

Three surface water samples were collected during the RRR Study field activities at SWMU 34. No organic compounds were detected at concentrations that exceeded the comparison criteria in any of the surface water samples. Aluminum, copper, lead, manganese, and zinc were detected at concentrations exceeding the BTAG freshwater values at all sampling locations. The site, an intermittently wet ditch, is located in an industrialized area near the Elizabeth River. The site is likely to have a very low value as a freshwater habitat.

Aluminum, lead, manganese, and zinc were detected at concentrations significantly higher than the BTAG freshwater values and offsite concentrations at all sampling locations. Copper was also detected at concentrations slightly higher than the BTAG values, however the copper concentrations were lower than those detected in the offsite sample.

Sediment

Three sediment samples were collected during the RRR Study field activities at SWMU 34. In all, twelve contaminants were detected at concentrations exceeding the BTAG-sediment values in the sediment samples.

Benzo(a)anthracene, bis(2-ethylhexyl)phthalate, phenanthrene, pyrene, chrysene, fluoranthene, cadmium, chromium, copper, lead, nickel, and zinc concentrations exceeded the BTAG sediment values in at least one sediment sample. In general, the concentrations detected at NB31H5 (upgradient) were higher than the comparison criteria and the concentrations detected at NB31H3 (downgradient), with the exception of chromium. All concentrations were higher than the available data on offsite concentrations.

On the basis of these results, it was determined that a more quantitative evaluation of risk was warranted.

Exposure Pathways

It is uncertain to what extent, or for what purpose this site will be used in the future. The location of this site near the piers indicates that it would be highly unlikely for the site to be converted to residential land use. According to the Naval Base Norfolk 2010 Land Use Plan, expected future use of this site is for industrial or logistics facilities. For purposes of performing the risk characterization, however, exposure to the site soil was evaluated for potential residential, industrial or commercial site worker, construction worker, and trespasser receptors. Assuming no action is taken at the site prior to development, exposure to affected soil could occur as a result of incidental ingestion, dermal contact, and inhalation of volatiles and fugitive dust. The receptors could be exposed to the subsurface soil if future construction work results in disturbance of the soil column.

Groundwater is not currently used as a potable water supply and will not be used as a potable water supply in the reasonable 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. All potable water in the City limits is supplied by the City of Norfolk. Therefore, there is no potential for direct exposure to groundwater.

The potential for exposure to the surface water and sediment at Site 34 is low, and it will remain so. Exposure to surface water and sediment was conservatively evaluated for a current and future trespasser.

Risk Characterization

The screening summary and risk/hazard summary tables included in this SRA are only those relevant to the discussion presented below. The tables presented were derived from a series of risk calculation and exposure assumption tables developed for this SWMU. All tables are presented in Volume II - Backup Tables for Streamlined Risk Assessments - SWMUs 28, 32, 33, 34, and 35. Appendix B presents a list of all tables related to this SRA.

The maximum-reported concentration of each constituent detected in the subsurface soil samples from SWMU 34 were compared to the EPA Region III Risk-Based Concentrations (RBCs) for residential soil. The RBCs for noncarcinogenic constituents were divided by 10 to account for exposure to multiple constituents. Constituents detected at levels exceeding the RBCs were identified as constituents of potential concern (COPCs). This risk-based screening is presented in Table 1.

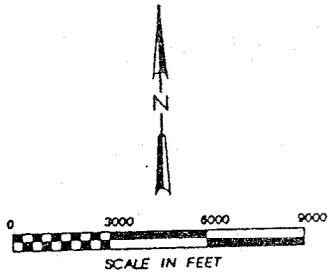
The maximum-reported concentrations of benzo(a)pyrene, arsenic, and iron, in subsurface soil exceeded the Region III Residential RBCs. Based on the hazard and risk calculations, exposure to surface soil at SWMU 34 would not result in unacceptable risks to potential adult residents, industrial site workers, construction workers, or child and adult trespassers (Table 2). However, there may be a slight noncarcinogenic hazard to future child residents (hazard index of 1.5 compared to EPA's acceptable hazard index of 1.0). This noncarcinogenic hazard is primarily associated with ingestion of iron in the soil. However, the individual hazard quotient for iron does not exceed EPA's acceptable level of 1.0.

The concentrations of arsenic and iron detected in soil at SWMU 34 are within the range of those found in the recent background investigation at Norfolk Naval Base. Final results from the background study will be used to determine if SWMU 34 is suitable for close out as an NFA site, or if institutional controls or other remedial measures are warranted.

The maximum-reported concentrations of each constituent detected in the surface water samples collected at SWMU 34 were compared to derived "RBCs", using the equation used to derive the EPA Region III tap water RBC with surface water specific exposure parameters. The risk-based screening is shown in Table 3 (calculation of RBCs) and Table 4 (comparison of site data to the derived RBCs). The maximum-reported concentration of arsenic exceeded the calculated RBC. Based on hazard and risk calculations, exposure to surface water at SWMU 34 by potential trespassers would not result in unacceptable risks (Table 2).

The maximum-reported concentrations of each constituent detected in the sediment samples collected at SWMU 34 were compared to derived RBCs using the equation used to derive the EPA Region III soil RBC with sediment-specific exposure parameters. The risk-based screening is shown in Table 5 (calculation of RBCs) and Table 6 (comparison of site data to derived RBCs). The maximum-reported concentration of arsenic exceeded the calculated

RBC. Based on hazard and risk calculations, exposure to sediment at SWMU 34 by potential trespassers would not result in unacceptable risks (Table 2).



CHESAPEAKE BAY

WILLOUGHBY BAY

ELIZABETH RIVER

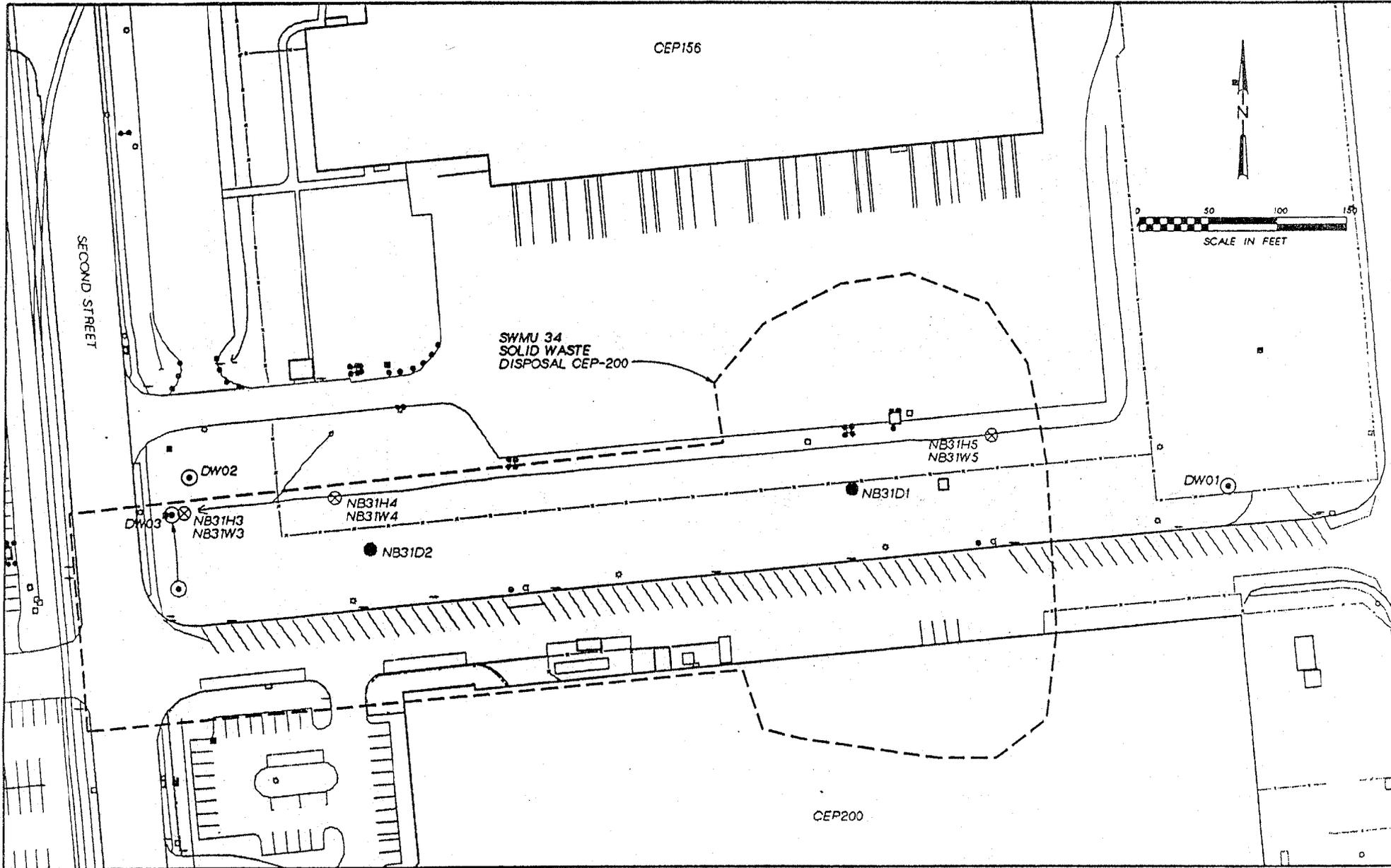
MASON CREEK

SWMU 34
SOLID WASTE
DISPOSAL CEP-200

CITY OF
NORFOLK

Figure 34-1
SWMU 34 - PROBABLE SOLID WASTE DISPOSAL CEP-200
Naval Base, Norfolk

CH2MHILL



LEGEND

- NB31D1 ● PHASE I RRR SUBSURFACE SOIL SAMPLE LOCATION
- NB31H3 ⊗ PHASE II RRR SURFACE WATER AND SEDIMENT SAMPLING LOCATION
- ⊙ SI GEOPROBE GROUNDWATER SAMPLING LOCATION
- ESTIMATED EXTENT OF WASTE DISPOSAL AREA

Figure 34-2
 SWMU 34 - SOLID WASTE DISPOSAL CEP-200
 SAMPLING LOCATIONS
 Naval Base, Norfolk

Table-1
Subsurface Soil Screening
Residential Scenario
SWMU 34

Chemical	RBC Value ¹ (mg/kg)	Maximum Concentration (mg/kg)	Selected as COPC?	Reason for Exclusion
Semivolatiles				
2-methyl-4,6-Dinitrophenol	7.8E-01	2.3E-01	NO	Below RBC
Benzo(a)anthracene	8.7E-01	1.6E-01	NO	Below RBC
Benzo(a)pyrene	8.7E-02	2.6E-01	YES	
Benzo(b)fluoranthene	8.7E-01	3.5E-01	NO	Below RBC
Benzo(k)fluoranthene	8.7E+00	8.6E-02	NO	Below RBC
Chrysene	8.7E+01	3.4E-01	NO	Below RBC
Dibenzofuran	3.1E+01	3.9E-01	NO	Below RBC
Di-n-butylphthalate	7.8E+02	9.7E-02	NO	Below RBC
Fluoranthene	3.1E+02	2.7E-01	NO	Below RBC
Naphthalene	1.6E+02	2.3E-01	NO	Below RBC
Phenanthrene ²	2.3E+02	5.0E-01	NO	Below RBC
Pyrene	2.3E+02	2.1E-01	NO	Below RBC
Inorganics				
Aluminum	7.8E+03	2.9E+03	NO	Below RBC
Arsenic	4.3E-01	1.1E+01	YES	
Barium	5.5E+02	1.6E+02	NO	Below RBC
Beryllium	1.6E+01	1.3E+00	NO	Below RBC
Calcium	NA	4.4E+04	NO	Below RBC
Chromium ³	2.3E+01	8.3E+00	NO	Below RBC
Copper	3.1E+02	5.1E+01	NO	Below RBC
Iron	2.3E+03	2.1E+04	YES	
Lead ⁴	4.0E+02	5.2E+01	NO	Below RBC
Magnesium	NA	2.1E+04	NO	Below RBC
Manganese-Food	1.1E+03	1.7E+02	NO	Below RBC
Nickel	1.6E+02	1.2E+01	NO	Below RBC
Selenium	3.9E+01	1.6E+00	NO	Below RBC
Vanadium	5.5E+01	1.5E+01	NO	Below RBC
Zinc	2.3E+03	5.0E+01	NO	Below RBC

NA = Not Available

Shaded lettering indicates that the compound has been identified as a COPC.

Human nutrient exposure concentrations are not considered to be in the toxic range.

¹ EPA Region III, April, 1999, Residential Ingestion RBC based on hazard index of 0.1 (instead of 1.0 as indicated, in the guidance document) and carcinogenic risk of 1x10⁻⁶.

² Pyrene RBC value used.

³ Hexavalent chromium RBC value used.

⁴ Lead action level from *Revised Interim Soil Lead Guidance for CERCLA Site and RCRA Corrective Action Facilities*, EPA, July 1994.

**Table 2
Risk and Hazard Summary
SWMU 34, Norfolk Naval Base**

Media: Surface Water

Chemical	Current and Future Trespasser Adult								Current and Future Trespasser Adolescent							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Arsenic	--	9.0E-04	6.7E-05	9.6E-04	--	1.7E-07	1.3E-08	1.9E-07	--	1.7E-03	9.9E-05	1.8E-03	--	9.8E-08	5.9E-09	1.0E-07
Totals	--	9.0E-04	6.7E-05	9.6E-04	--	1.7E-07	1.3E-08	1.9E-07	--	1.7E-03	9.9E-05	1.8E-03	--	9.8E-08	5.9E-09	1.0E-07

Media: Sediment

Chemical	Current and Future Trespasser Adult								Current and Future Trespasser Adolescent							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Arsenic	--	5.3E-03	6.3E-03	1.2E-02	--	1.0E-06	1.3E-06	2.3E-06	--	1.0E-02	9.4E-03	2.0E-02	--	5.8E-07	5.8E-07	1.2E-06

Media: Subsurface Soil

Chemical	Future Residential Adult								Future Residential Child							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)pyrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arsenic	--	5.1E-02	9.0E-02	1.4E-01	--	--	--	--	--	4.8E-01	1.6E-01	6.4E-01	--	--	--	--
Iron	--	9.8E-02	--	9.8E-02	--	--	--	--	--	9.1E-01	--	9.1E-01	--	--	--	--
Totals	--	1.5E-01	9.0E-02	2.4E-01	--	--	--	--	--	1.4E+00	1.6E-01	1.5E+00	--	--	--	--

Chemical	Future Age-Adjusted Resident							
	HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)pyrene	--	--	--	--	9.8E-11	3.0E-06	--	3.0E-06
Arsenic	--	--	--	--	2.0E-08	2.6E-05	2.1E-05	4.7E-05
Iron	--	--	--	--	--	--	--	--
Totals	--	--	--	--	2.0E-08	2.9E-05	2.1E-05	5.0E-05

Chemical	Site Worker								Future Construction Worker							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)pyrene	--	--	--	--	1.4E-11	6.6E-07	--	6.6E-07	--	--	--	--	1.9E-12	1.3E-07	--	1.3E-07
Arsenic	--	--	6.4E-02	6.4E-02	3.0E-09	5.9E-06	1.1E-05	1.6E-05	--	1.8E-01	6.4E-02	2.4E-01	4.0E-10	1.1E-06	4.2E-07	1.6E-06
Iron	--	--	--	--	--	--	--	--	--	3.4E-01	--	3.4E-01	--	--	--	--
Totals	--	--	6.4E-02	6.4E-02	3.0E-09	6.5E-06	1.1E-05	1.7E-05	--	5.1E-01	6.4E-02	5.7E-01	4.0E-10	1.3E-06	4.2E-07	1.7E-06

Table 2
 Risk and Hazard Summary
 SWMU 34, Norfolk Naval Base

Chemical	Current and Future Trespasser Adult								Current and Future Trespasser Youth							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)pyrene	--	--	--	--	1.1E-11	1.7E-07	--	1.7E-07	--	--	--	--	6.0E-12	9.4E-08	--	9.4E-08
Arsenic	--	7.6E-03	1.3E-02	2.1E-02	2.2E-09	1.5E-06	2.7E-06	4.1E-06	--	1.4E-02	1.7E-02	3.1E-02	1.3E-09	8.3E-07	1.0E-06	1.9E-06
Iron	--	1.5E-02	--	1.5E-02	--	--	--	--	--	2.7E-02	--	2.7E-02	--	--	--	--
Totals	--	2.2E-02	1.3E-02	3.5E-02	2.2E-09	1.6E-06	2.7E-06	4.3E-06	--	4.2E-02	1.7E-02	5.9E-02	1.3E-09	9.3E-07	1.0E-06	1.9E-06

HQ = Hazard Quotient

CR = Cancer Risk

Ing = Ingestion route of exposure

Inh = Inhalation route of exposure

Der = Dermal route of exposure

Table 3
Risk-Based Concentrations for Noncarcinogenic & Carcinogenic Effects
Surface Water Ingestion
Current and Future Trespasser Adult and Adolescent Scenario
SWMU 34

Chemical	Oral RfD (mg/kg-day)	Adolescent RBC Noncarcinogen (µg/l)	Adult RBC Noncarcinogen (µg/l)	Oral Slope Factor (OSF) (kg-day/mg)	Adolescent RBC Carcinogen (µg/l)	Adult RBC Carcinogen (µg/l)	Lowest Recreational RBC (µg/l)
Inorganic Compounds							
Aluminum	1.0E+00	4.3E+05	8.5E+05	NA			4.3E+05
Antimony	4.0E-04	1.7E+02	3.4E+02	NA			1.7E+02
Arsenic	3.0E-04	1.3E+02	2.6E+02	1.5E+00	4.7E+00	7.9E-02	7.9E-02
Barium	7.0E-02	3.0E+04	6.0E+04	NA			3.0E+04
Calcium	NA			NA			NA
Copper	4.0E-02	1.7E+04	3.4E+04	NA			1.7E+04
Iron	3.0E-01	1.3E+05	2.6E+05	NA			1.3E+05
Lead ¹	NA			NA			NA
Magnesium	NA			NA			NA
Manganese	2.0E-02	8.7E+03	1.7E+04	NA			8.7E+03
Potassium	NA			NA			NA
Sodium	NA			NA			NA
Vanadium	7.0E-03	3.0E+03	6.0E+03	NA			3.0E+03
Zinc	3.0E-01	1.3E+05	2.6E+05	NA			1.3E+05

Noncarcinogen calculations

$$RBC (\mu g/l) = \frac{THI \times BW \times AT \times 365 \text{ days/year} \times 1000 \mu g/mg}{ET \times EF \times ED \times (1/OralRfD) \times IngR}$$

EXPOSURE ASSUMPTIONS FOR NONCARCINOGENS

	Adolescent	Adult
Exposure setting		
THI - Target hazard index (unitless)	0.1	0.1
BW - Body weight (kilograms)	37	70
AT - Averaging time (year)	9	30
ET - Exposure Time (hours/day)	2.6	2.6
EF - Exposure frequency (days/year)	24	23
ED - Exposure duration (year)	9	30
IngR - Ingestion rate (liters/hour)	0.05	0.05

Table 3
Risk-Based Concentrations for Noncarcinogenic & Carcinogenic Effects
Surface Water Ingestion
Current and Future Trespasser Adult and Adolescent Scenario
SWMU 34

Chemical	Oral RfD (mg/kg-day)	Adolescent RBC Noncarcinogen (µg/l)	Adult RBC Noncarcinogen (µg/l)	Oral Slope Factor (OSF) (kg-day/mg)	Adolescent RBC Carcinogen (µg/l)	Adult RBC Carcinogen (µg/l)	Lowest Recreational RBC (µg/l)
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Carcinogen calculations

$$\frac{\text{Risk} * \text{BW} * \text{AT} * 365 \text{ days/year} * 1000 \text{ mg/mg}}{\text{EF} * \text{ED} * \text{OSF} * \text{IngR}}$$

EXPOSURE ASSUMPTIONS FOR CARCINOGENS		
	Adolescent	Adult
Exposure setting		
Risk - Target excess individual lifetime cancer risk (unitless)	1.0E-06	1.0E-06
BW - Body weight (kilograms)	36	70
AT - Averaging time (years)	70	70
ET - Exposure Time (hours/day)	2.6	2.6
EF - Exposure frequency (days/year)	100	100
ED - Exposure duration (year)	10	30
IngR - Ingestion rate (liters/hour)	0.05	0.05

Lead Action Level for tap water is not appropriate for surface water.

NA -- No reference dose or slope factor available.

Table 4
Surface Water Screening
Current and Future Trespasser Adult and Adolescent Scenario
SWMU 34

Chemical	RBC Value (µg/L)	Maximum Concentration (µg/L)	Selected as COPC?	Reason for Exclusion
Aluminum	4.3E+05	1.9E+02	NO	Below RBC
Antimony	1.7E+02	1.5E+01	NO	Below RBC
Arsenic	7.9E-02	2.2E+00	YES	
Barium	3.0E+04	4.6E+01	NO	Below RBC
Calcium	NA	3.3E+04	NO	Human Nutrient
Copper	1.7E+04	1.7E+01	NO	Below RBC
Iron	1.3E+05	1.2E+03	NO	Below RBC
Lead	NA	4.5E+01	NO	Below RBC
Magnesium	NA	2.6E+03	NO	Human Nutrient
Manganese	8.7E+03	1.2E+02	NO	Below RBC
Potassium	NA	2.4E+03	NO	Human Nutrient
Sodium	NA	1.2E+04	NO	Human Nutrient
Vanadium	3.0E+03	7.9E+00	NO	Below RBC
Zinc	1.3E+05	5.3E+02	NO	Below RBC

The RBC values are calculated in Table SW-1.

NA = Not Available

Shaded lettering indicates that the compound has been identified as a COPC.

Human nutrient exposure concentrations are not considered to be in the toxic range.

Table 5
Risk-Based Concentrations for Noncarcinogenic & Carcinogenic Effects
Sediment Ingestion for Adult and Adolescent Trespasser Scenarios
SWMU 34

Chemical	Oral RfD (mg/kg-day)	Adolescent RBC Noncarcinogen (mg/kg)	Adult RBC Noncarcinogen (mg/kg)	Oral Slope Factor (OSF) (kg-day/mg)	Adolescent RBC Carcinogen (mg/kg)	Adult RBC Carcinogen (mg/kg)	Lowest Recreational RBC (mg/kg)
Semivolatile Organic Compounds							
4-Methylphenol	5.0E-03	2.8E+03	5.3E+03	NA			2.8E+03
Benzo(a)anthracene	NA			7.3E-01	6.0E+01	3.4E+01	3.4E+01
Benzo(a)pyrene	NA			7.3E+00	6.0E+00	3.4E+00	3.4E+00
Benzo(b)fluoranthene	NA			7.3E-01	6.0E+01	3.4E+01	3.4E+01
Benzo(g,h,i)perylene ¹	3.0E-02	1.7E+04	3.2E+04	NA			1.7E+04
Benzo(k)fluoranthene	NA			7.3E-02	6.0E+02	3.4E+02	3.4E+02
Bis (2-ethylhexyl)phthalate	2.0E-02	1.1E+04	2.1E+04	1.4E-02	3.1E+03	1.8E+03	1.8E+03
Chrysene	NA			7.3E-03	6.0E+03	3.4E+03	3.4E+03
Fluoranthene	4.0E-02	2.3E+04	4.3E+04	NA			2.3E+04
Phenanthrene ¹	3.0E-02	1.7E+04	3.2E+04	NA			1.7E+04
Pyrene	3.0E-02	1.7E+04	3.2E+04	NA			1.7E+04
Inorganic Compounds							
Aluminum	1.0E+00	5.6E+05	1.1E+06	NA			5.6E+05
Arsenic	3.0E-04	1.7E+02	3.2E+02	1.5E+00	2.9E+01	1.7E+01	1.7E+01
Barium	7.0E-02	3.9E+04	7.5E+04	NA			3.9E+04
Beryllium	2.0E-03	1.1E+03	2.1E+03	NA			1.1E+03
Cadmium	1.0E-03	5.6E+02	1.1E+03	NA			5.6E+02
Calcium	NA			NA			NA
Chromium ²	3.0E-03	1.7E+03	3.2E+03	NA			1.7E+03
Cobalt	6.0E-02	3.4E+04	6.4E+04	NA			3.4E+04
Copper	4.0E-02	2.3E+04	4.3E+04	NA			2.3E+04
Iron	3.0E-01	1.7E+05	3.2E+05	NA			1.7E+05
Lead ³	NA			NA			NA
Magnesium	NA			NA			NA
Manganese	2.0E-02	1.1E+04	2.1E+04	NA			1.1E+04
Mercury	NA			NA			NA
Nickel	2.0E-02	1.1E+04	2.1E+04	NA			1.1E+04
Potassium	NA			NA			NA
Sodium	NA			NA			NA
Vanadium	7.0E-03	3.9E+03	7.5E+03	NA			3.9E+03

Table 5
Risk-Based Concentrations for Noncarcinogenic & Carcinogenic Effects
Sediment Ingestion for Adult and Adolescent Trespasser Scenarios
SWMU 34

Chemical	Oral RfD (mg/kg-day)	Adolescent RBC Noncarcinogen (mg/kg)	Adult RBC Noncarcinogen (mg/kg)	Oral Slope Factor (OSF) (kg-day/mg)	Adolescent RBC Carcinogen (mg/kg)	Adult RBC Carcinogen (mg/kg)	Lowest Recreational RBC (mg/kg)
Zinc	3.0E-01	1.7E+05	3.2E+05	NA			1.7E+05

Noncarcinogenic effects calculations:

$$\text{RBC (mg/kg)} = \frac{\text{THI} * \text{BW} * \text{ATnc} * 365 \text{ days/year} * 1\text{E}+06 \text{ mg/kg}}{\text{EF} * \text{ED} * (1/\text{OralRfD}) * \text{IngR} * \text{FC}}$$

Carcinogen calculations:

$$\text{RBC (mg/kg)} = \frac{\text{Risk} * \text{BW} * \text{ATc} * 365 \text{ days/year} * 1\text{E}+06 \text{ mg/kg}}{\text{EF} * \text{ED} * \text{OSF} * \text{IngR} * \text{FC}}$$

EXPOSURE ASSUMPTIONS

Exposure setting	Adolescent	Adult
THI - Target hazard index (unitless)	0.1	0.1
Risk - Target excess lifetime cancer risk (unitless)	1.0E-06	1.0E-06
BW - Body weight (kilograms)	37	70
ATnc - Averaging time for noncarcinogens (year)	9	30
ATc - Averaging time for carcinogens (year)	70	70
EF - Exposure frequency (days/year)	24	24
ED - Exposure duration (year)	9	30
FC - Fraction of contaminated sediment	1.0	1.0
IngR - Ingestion rate (mg/day)	100	100

NA - No reference dose or slope factor available.

¹ Pyrene value used as a surrogate.

² Hexavalent chromium values used.

³ The soil screening level for lead, 400 mg/kg, not applicable for sediment.

Table 6
Sediment Screening
Recreational Scenario
SWMU 34

Chemical	RBC Value (mg/kg)	Maximum Concentration (mg/kg)	Selected as COPC?	Reason for Exclusion
<i>Semivolatiles</i>				
4-Methylphenol	2.8E+03	2.4E-01	NO	Below RBC
Benzo(a)anthracene	3.4E+01	1.6E+00	NO	Below RBC
Benzo(a)pyrene	3.4E+00	1.2E-01	NO	Below RBC
Benzo(b)fluoranthene	3.4E+01	2.4E-01	NO	Below RBC
Benzo(g,h,i)perylene	1.7E+04	5.4E-01	NO	Below RBC
Benzo(k)fluoranthene	3.4E+02	8.4E-02	NO	Below RBC
Bis(2-ethylhexyl)phthalate	1.8E+03	3.1E+01	NO	Below RBC
Chrysene	3.4E+03	2.6E+00	NO	Below RBC
Fluoranthene	2.3E+04	2.5E+00	NO	Below RBC
Phenanthrene	1.7E+04	1.6E+00	NO	Below RBC
Pyrene	1.7E+04	4.4E+00	NO	Below RBC
<i>Inorganics</i>				
Aluminum	5.6E+05	1.3E+04	NO	Below RBC
Arsenic	1.7E+01	1.7E+01	YES	
Barium	3.9E+04	1.7E+02	NO	Below RBC
Beryllium	1.1E+03	1.2E+00	NO	Below RBC
Cadmium	5.6E+02	1.5E+01	NO	Below RBC
Calcium	NA	3.0E+04	NO	Human Nutrient
Chromium	1.7E+03	4.2E+02	NO	Below RBC
Cobalt	3.4E+04	1.6E+01	NO	Below RBC
Copper	2.3E+04	2.7E+02	NO	Below RBC
Iron	1.7E+05	3.3E+04	NO	Below RBC
Lead	NA	6.4E+02	NO	Qualitative
Magnesium	NA	1.7E+04	NO	Human Nutrient
Manganese	1.1E+04	3.6E+02	NO	Below RBC
Mercury	NA	1.4E-01	NO	Qualitative
Nickel	1.1E+04	3.6E+01	NO	Below RBC
Potassium	NA	1.2E+03	NO	Human Nutrient
Sodium	NA	3.5E+02	NO	Human Nutrient
Vanadium	3.9E+03	1.3E+02	NO	Below RBC
Zinc	1.7E+05	4.1E+03	NO	Below RBC

The RBC values are calculated on Table SED-1.

NA = Not Available

Shaded lettering indicates that the compound has been identified as a COPC.

Human nutrient exposure concentrations are not considered to be in the toxic range.

Qualitative = Discussed in the text under selection of COPC and/or toxicity assessment section.

SWMU 35:
SWD Area CEP 196/Resolute Embankment

Streamlined Risk Assessment

SWMU 35- SWD Area CEP 196/Resolute Embankment

Site Description

SWMU 35 is comprised of approximately 2.6 acres located in an area east of the floating dry-dock USS Resolute. A portion of the site forms a peninsula that extends into the Elizabeth River. The peninsula is grass-covered while the northern portion of the site is within an asphalt parking lot. The areas of the site that border the waterfront are lined with large rocks to prevent erosion. Second Street is immediately east of the site. The location of the site is shown in Figure 35-1. Photographs of this SWMU are included in Appendix A.

Data Summary

The analytical results of the RRR Study and SWMU Supplemental Investigation are discussed as one combined data set. Concentrations of detected chemicals were compared to the following current USEPA screening criteria (comparison criteria) for each sample matrix: residential and industrial soil risk-based concentrations (RBCs) for soil, and USEPA tap water RBCs and drinking water Maximum Contaminant Levels (MCLs) for groundwater. Sampling locations are shown in Figure 35-2.

Groundwater

Three groundwater samples were collected at SWMU 35 during the Supplemental Investigation field activities. Two organic compounds were detected at concentrations that exceeded the comparison criteria at NBW35DW01. In addition, three inorganic chemicals (arsenic, thallium, and iron) were also detected at concentrations exceeding the comparison criteria.

Bis (2-ethylhexyl) phthalate and hexachlorobenzene concentrations exceeded the comparison criteria in the duplicate sample collected at NBW35-DW01. Neither compound was detected in the original sample. Hexachlorobenzene was detected at a concentration of 150 $\mu\text{g}/\text{l}$, which is significantly higher than the tap water RBC of 0.006 $\mu\text{g}/\text{l}$, the drinking water MCL of 1 $\mu\text{g}/\text{l}$, and the estimated upgradient concentration of < 12 $\mu\text{g}/\text{l}$. Bis(2-ethylhexyl)phthalate was detected at a concentration of 40 $\mu\text{g}/\text{l}$, which is higher than the drinking water MCL of 6 $\mu\text{g}/\text{l}$ and the estimated upgradient concentration of 2 $\mu\text{g}/\text{l}$. In addition, arsenic was detected at all onsite-sampling locations at a range of 14.3 $\mu\text{g}/\text{l}$ to 36.8 $\mu\text{g}/\text{l}$. All arsenic detections were higher than the tap water RBC, but were below the estimated upgradient concentration of 43 $\mu\text{g}/\text{l}$. Thallium was detected at concentrations slightly above the tap water RBC at NBW35-DW01 but below the concentrations detected at the estimated upgradient location. Iron exceeded the RBC only at the upgradient sampling location at a concentration of 17,100 $\mu\text{g}/\text{l}$.

Soil

Two subsurface soil samples were collected during the RRR Study sampling activities at SWMU 35. Three polynuclear aromatic hydrocarbons (PAHs) were detected at concentrations that exceeded the residential RBCs. One inorganic chemical was also detected at concentrations above the screening criteria.

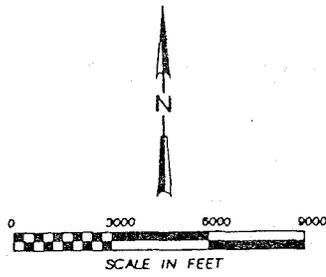
Benzo(a)pyrene was detected at NB32D1 and NB32D2 at concentrations of 680 µg/kg and 200 µg/kg, respectively. These concentrations exceed the residential RBC of 87.50 µg/kg and the industrial RBC of 680 µg/kg. In addition, benzo(a)anthracene (950 µg/kg) and dibenz(a,h)anthracene (120 µg/kg) detections at NB32D1 exceeded the residential RBCs of 875 µg/kg and 87.5 µg/kg, respectively. Arsenic concentrations ranged from 5.7 mg/kg at NB32D1 to 11.8 mg/kg at NB32D2. Arsenic exceeded the residential and industrial RBCs at both sampling locations.

On the basis of these results, it was determined that a more quantitative evaluation of risk was warranted.

Exposure Pathways

It is uncertain to what extent, or for what purpose this site will be used in the future. The location of this site near the piers indicates that it would be highly unlikely for the site to be converted to residential land use. According to Naval Base Norfolk 2010 Land Use Plan, the expected future use for this area of the base is for industrial or logistics facilities. For purposes of performing the risk characterization, however, exposure to the site soil was evaluated for potential residential, industrial or commercial site worker, construction worker, and trespasser receptors. Assuming no action is taken at the site prior to development, exposure to affected soil could occur as a result of incidental ingestion, dermal contact, and inhalation of volatiles and fugitive dust. The receptors could be exposed to the subsurface soil if future construction work results in disturbance of the soil column.

Groundwater is not currently used as a potable water supply and will not be used as a potable water supply in the reasonable 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. All potable water in the City limits is supplied by the City of Norfolk. Therefore, there is no potential for direct exposure to groundwater.



CHESAPEAKE BAY

WILLOUGHBY BAY

ELIZABETH RIVER

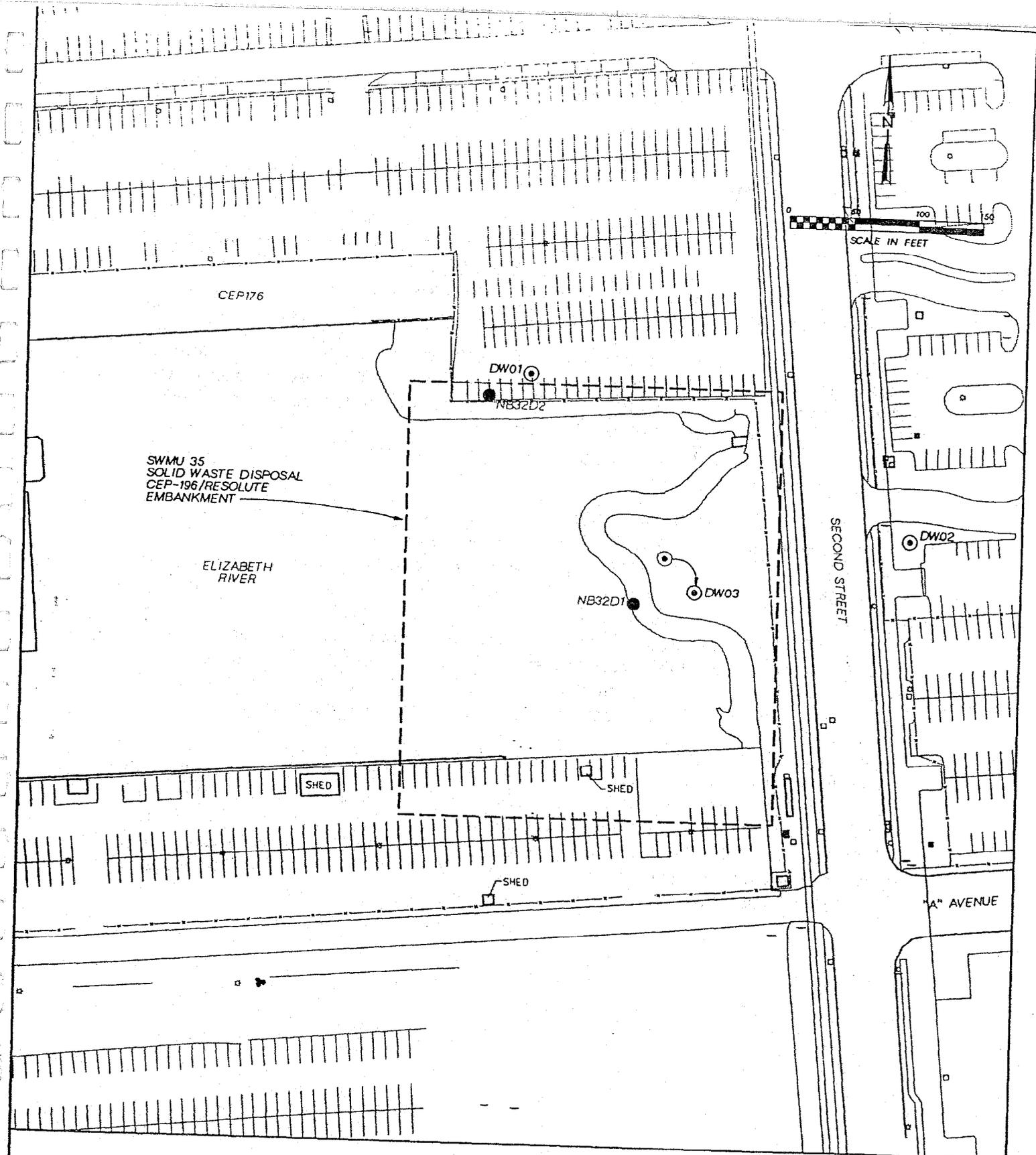
MASON CREEK

SWMU 35
SOLID WASTE DISPOSAL
CEP-196/RESOLUTE
EMBANKMENT

CITY OF
NORFOLK

Figure 35-1
SWMU 35 - PROBABLE SOLID WASTE DISPOSAL
CEP 196/RESOLUTE EMBANKMENT
Naval Base, Norfolk

CH2MHILL



LEGEND

- NB32D1 ● PHASE I RRR SUBSURFACE SOIL SAMPLE LOCATION
- ⊙ SI GEOPROBE GROUNDWATER SAMPLING LOCATION
- ESTIMATED EXTENT OF WASTE DISPOSAL AREA

Figure 35-2
 SWMU 35 - SOLID WASTE DISPOSAL
 CEP-196/RESOLUTE EMBANKMENT
 SAMPLING LOCATIONS
 Naval Base, Norfolk

Risk Characterization

The screening summary and risk/hazard summary tables included in this SRA are only those relevant to the discussion presented below. The tables presented were derived from a series of risk calculation and exposure assumption tables developed for this SWMU. All tables are presented in Volume II - Backup Tables for Streamlined Risk Assessments - SWMUs 28, 32, 33, 34, and 35. Appendix B presents a list of all tables related to this SRA.

The maximum-reported concentration of each constituent detected in the subsurface soil samples from SWMU 35 were compared to the EPA Region 3 Risk-Based Concentrations (RBCs) for residential soil. The RBCs for noncarcinogenic constituents were divided by 10 to account for exposure to multiple constituents. Constituents detected at levels exceeding the RBCs were identified as constituents of potential concern (COPCs). This risk-based screening is presented in Table 1.

The maximum-reported concentrations of benzo(a)anthracene, benzo(a)pyrene, dibenz(a,h)anthracene, arsenic, and iron, in subsurface soil exceeded the Region III Residential RBCs. Based on the hazard and risk calculations, exposure to subsurface soil at SWMU 35 would not result in unacceptable risks to potential adult residents, industrial site workers, construction workers, or child and adult trespassers (Table 2). However, there may be a slight noncarcinogenic hazard to future child residents (hazard index of 1.5 compared to EPA's acceptable hazard index of 1.0). This noncarcinogenic hazard is primarily associated with ingestion of arsenic and iron in the soil. However, the individual hazard quotients for these constituents do not exceed EPA's acceptable level of 1.0.

As noted, the location of this site near the piers indicates that it would be highly unlikely for the site to be converted to residential land use. The Naval Base Norfolk 2010 Land Use Plan indicates that the anticipated future use of this area of the base is for industrial or logistics facilities. In addition, concentrations of arsenic and iron detected in soil at SWMU 35 are within the range of those found in the background soil at Norfolk Naval Base. Results from the background study will be used to determine if SWMU 35 is suitable for close out as an NFA site, or if institutional controls or other remedial measures are warranted.

Table 1
Subsurface Soil Screening
Residential Scenario
SWMU 35

Chemical	RBC Value¹ (mg/kg)	Maximum Concentration (mg/kg)	Selected as COPC?	Reason for Exclusion
Volatiles				
Acetone	7.8E+02	4.1E-02	NO	Below RBC
Methyl ethyl ketone	4.7E+03	5.5E-03	NO	Below RBC
Semivolatiles				
Acenaphthene	4.7E+02	1.2E-01	NO	Below RBC
Acenaphthylene ²	1.6E+02	3.8E-02	NO	Below RBC
Anthracene	2.3E+03	5.0E-01	NO	Below RBC
Benzo(a)anthracene	8.7E-01	9.5E-01	YES	
Benzo(a)pyrene	8.7E-02	6.8E-01	YES	
Benzo[b]fluoranthene	8.7E-01	6.1E-01	NO	Below RBC
Benzo(g,h,i)perylene ³	2.3E+02	2.1E-01	NO	Below RBC
Benzo(k)fluoranthene	8.7E+00	6.2E-01	NO	Below RBC
Carbazole	3.2E+01	8.2E-02	NO	Below RBC
Chrysene	8.7E+01	9.5E-01	NO	Below RBC
Dibenz(a,h)anthracene	8.7E-02	1.2E-01	YES	
Dibenzofuran	3.1E+01	7.4E-02	NO	Below RBC
Di-n-butylphthalate	7.8E+02	8.6E-01	NO	Below RBC
Fluoranthene	3.1E+02	2.4E+00	NO	Below RBC
Fluorene	3.1E+02	1.6E-01	NO	Below RBC
Indeno(1,2,3-cd)pyrene	8.7E-01	2.4E-01	NO	Below RBC
2-Methyl-4,6-Dinitrophenol	7.8E-01	1.7E-01	NO	Below RBC
Napthalene	1.6E+02	9.0E-02	NO	Below RBC
Phenanthrene ³	2.3E+02	1.7E+00	NO	Below RBC
Pyrene	2.3E+02	1.9E+00	NO	Below RBC
Inorganics				
Aluminum	7.8E+03	6.0E+03	NO	Below RBC
Arsenic	4.3E-01	1.2E+01	YES	
Barium	5.5E+02	5.3E+01	NO	Below RBC
Calcium	NA	2.7E+04	NO	Human Nutrient
Chromium ⁴	2.3E+01	1.8E+01	NO	Below RBC
Copper	3.1E+02	7.2E+01	NO	Below RBC
Iron	2.3E+03	2.0E+04	YES	
Lead ⁵	4.0E+02	1.1E+02	NO	Below RBC
Magnesium	NA	1.3E+04	NO	Human Nutrient
Manganese	1.1E+03	1.2E+02	NO	Below RBC
Mercury ⁶	2.3E+00	2.0E-01	NO	Below RBC
Nickel	1.6E+02	1.9E+01	NO	Below RBC
Potassium	NA	5.6E+02	NO	Human Nutrient
Vanadium	5.5E+01	1.6E+01	NO	Below RBC
Zinc	2.3E+03	2.3E+02	NO	Below RBC

NA = Not Available

Shaded lettering indicates that the compound has been identified as a COPC.

Human nutrient exposure concentrations are not considered to be in the toxic range.

¹ EPA Region III, April, 1999. Residential Ingestion RBC based on hazard index of 0.1 (instead of 1.0 as indicated, in the guidance document) and carcinogenic risk of 1x10⁻⁶.

² Naphthalene RBC value used.

³ Pyrene RBC value used.

⁴ Hexavalent chromium RBC value used.

⁵ Lead action level from *Revised Interim Soil Lead Guidance for CERCLA Site and RCRA Corrective Action Facilities*, EPA, July 1994.

⁶ Mercuric chloride RBC value used.

Table 2
Risk and Hazard Summary
SWMU 35, Norfolk Naval Base

Media: Subsurface Soil

Chemical	Future Residential Adult								Future Residential Child							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)anthracene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dibenz(a,h)anthracene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arsenic	--	5.4E-02	9.5E-02	1.5E-01	--	--	--	--	--	5.0E-01	1.7E-01	6.7E-01	--	--	--	--
Iron	--	9.0E-02	--	9.0E-02	--	--	--	--	--	8.4E-01	--	8.4E-01	--	--	--	--
Totals	--	1.4E-01	9.5E-02	2.4E-01	--	--	--	--	--	1.3E+00	1.7E-01	1.5E+00	--	--	--	--

Chemical	Future Age-Adjusted Resident							
	HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)anthracene	--	--	--	--	3.6E-11	1.1E-06	--	1.1E-06
Benzo(a)pyrene	--	--	--	--	2.6E-10	7.8E-06	--	7.8E-06
Dibenz(a,h)anthracene	--	--	--	--	4.5E-11	1.4E-06	--	1.4E-06
Arsenic	--	--	--	--	2.1E-08	2.8E-05	2.2E-05	4.9E-05
Iron	--	--	--	--	--	--	--	--
Totals	--	--	--	--	2.2E-08	3.8E-05	2.2E-05	6.0E-05

Chemical	Site Worker								Future Construction Worker							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)anthracene	--	--	--	--	5.2E-12	2.4E-07	--	2.4E-07	--	--	--	--	7.0E-13	4.7E-08	--	4.7E-08
Benzo(a)pyrene	--	--	--	--	3.7E-11	1.7E-06	--	1.7E-06	--	--	--	--	5.0E-12	3.3E-07	--	3.3E-07
Dibenz(a,h)anthracene	--	--	--	--	6.6E-12	3.1E-07	--	3.1E-07	--	--	--	--	8.8E-13	5.9E-08	--	5.9E-08
Arsenic	--	3.8E-02	6.8E-02	1.1E-01	3.1E-09	6.2E-06	1.1E-05	1.7E-05	--	1.8E-01	6.8E-02	2.6E-01	4.2E-10	1.2E-06	4.5E-07	1.6E-06
Iron	--	6.4E-02	--	6.4E-02	--	--	--	--	--	3.1E-01	--	3.1E-01	--	--	--	--
Totals	--	1.0E-01	6.8E-02	1.7E-01	3.2E-09	8.5E-06	1.1E-05	2.0E-05	--	4.9E-01	6.8E-02	5.8E-01	4.3E-10	1.6E-06	4.5E-07	2.1E-06

Chemical	Current and Future Trespasser Adult								Current and Future Trespasser Youth							
	HQ				CR				HQ				CR			
	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total	Inh	Ing	Der	Total
Benzo(a)anthracene	--	--	--	--	3.9E-12	6.0E-08	--	6.0E-08	--	--	--	--	2.2E-12	3.4E-08	--	3.4E-08
Benzo(a)pyrene	--	--	--	--	2.8E-11	4.3E-07	--	4.3E-07	--	--	--	--	1.6E-11	2.6E-07	--	2.6E-07
Dibenz(a,h)anthracene	--	--	--	--	4.9E-12	7.6E-08	--	7.6E-08	--	--	--	--	2.8E-12	4.3E-08	--	4.3E-08
Arsenic	--	8.0E-03	1.4E-02	2.2E-02	2.3E-09	1.5E-06	2.8E-06	4.3E-06	--	1.5E-02	1.8E-02	3.3E-02	1.3E-09	8.8E-07	1.1E-06	2.0E-06
Iron	--	1.3E-02	--	1.3E-02	--	--	--	--	--	2.5E-02	--	2.5E-02	--	--	--	--
Totals	--	2.1E-02	1.4E-02	3.5E-02	2.4E-09	2.1E-06	2.8E-06	4.9E-06	--	4.0E-02	1.8E-02	5.8E-02	1.3E-09	1.2E-06	1.1E-06	2.3E-06

Definitions:

HQ = Hazard Quotient

CR = Cancer Risk

Ing = Ingestion route of exposure

Inh = Inhalation route of exposure

Der = Dermal route of exposure

References

Baker Environmental Inc., October 1995. Phase I Relative Risk Ranking Study.

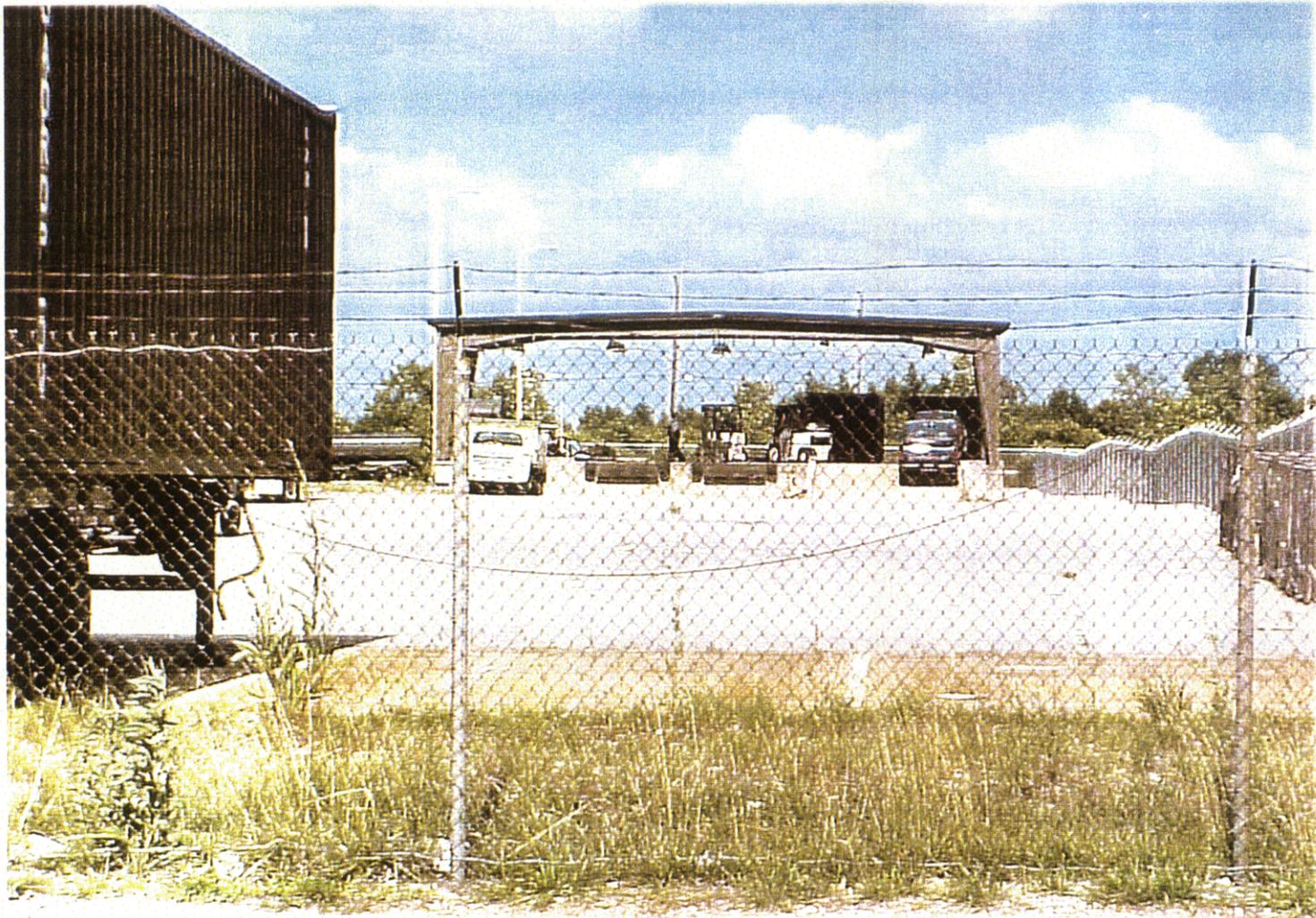
Baker Environmental Inc., September 1996. Phase II Relative Risk Ranking Study.

CH2M HILL, May 2000 Draft Technical Memorandum Naval Station Norfolk Background Soils Evaluation

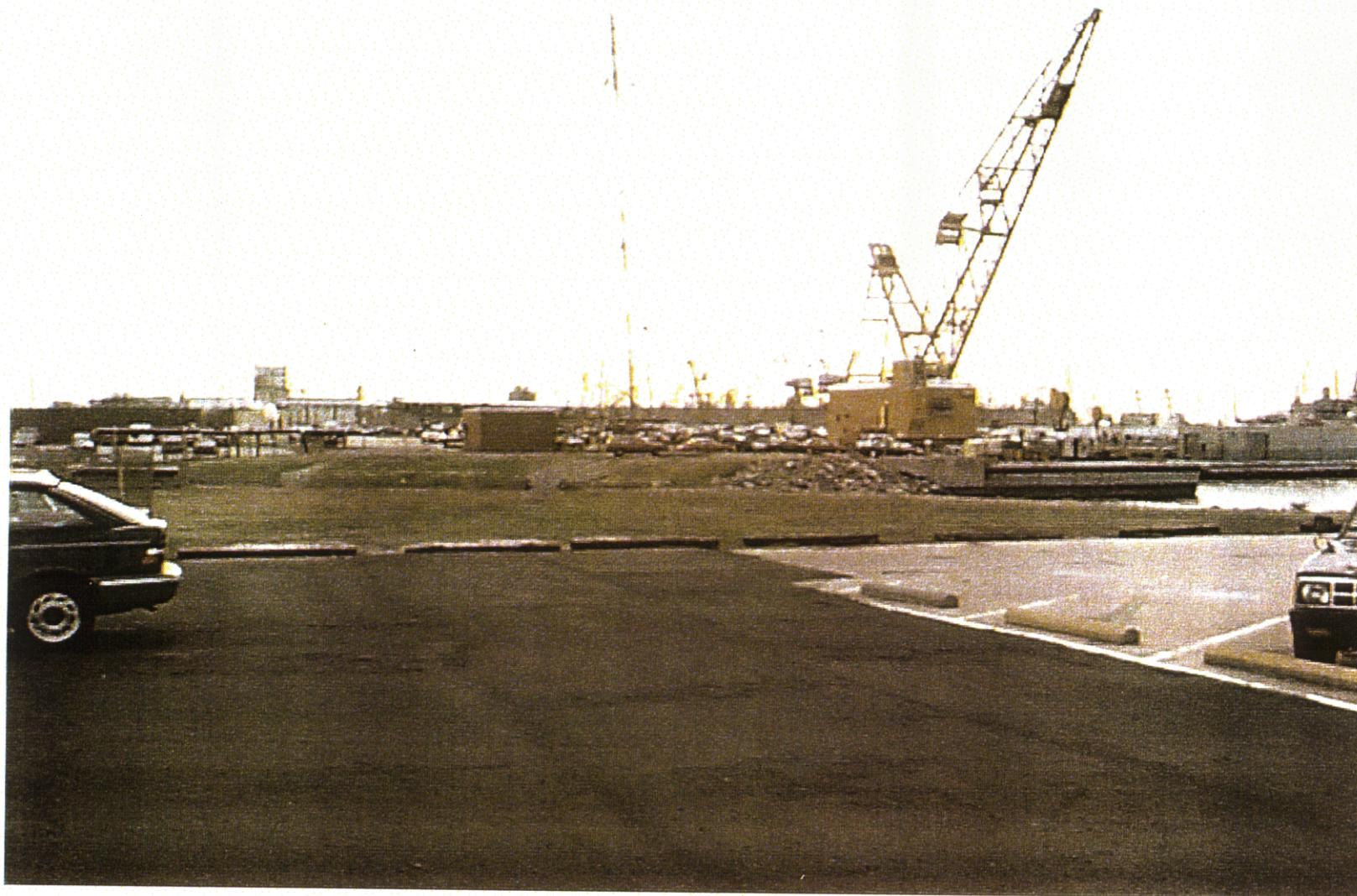
CH2M HILL, October 1998. Draft Report for the SWMU Supplemental Investigation, Naval Base Norfolk.

Naval Base Norfolk 2010 Land Use Plan – Navy Public Works Center Norfolk, August 1995.

**Appendix A:
SWMU Photographs**



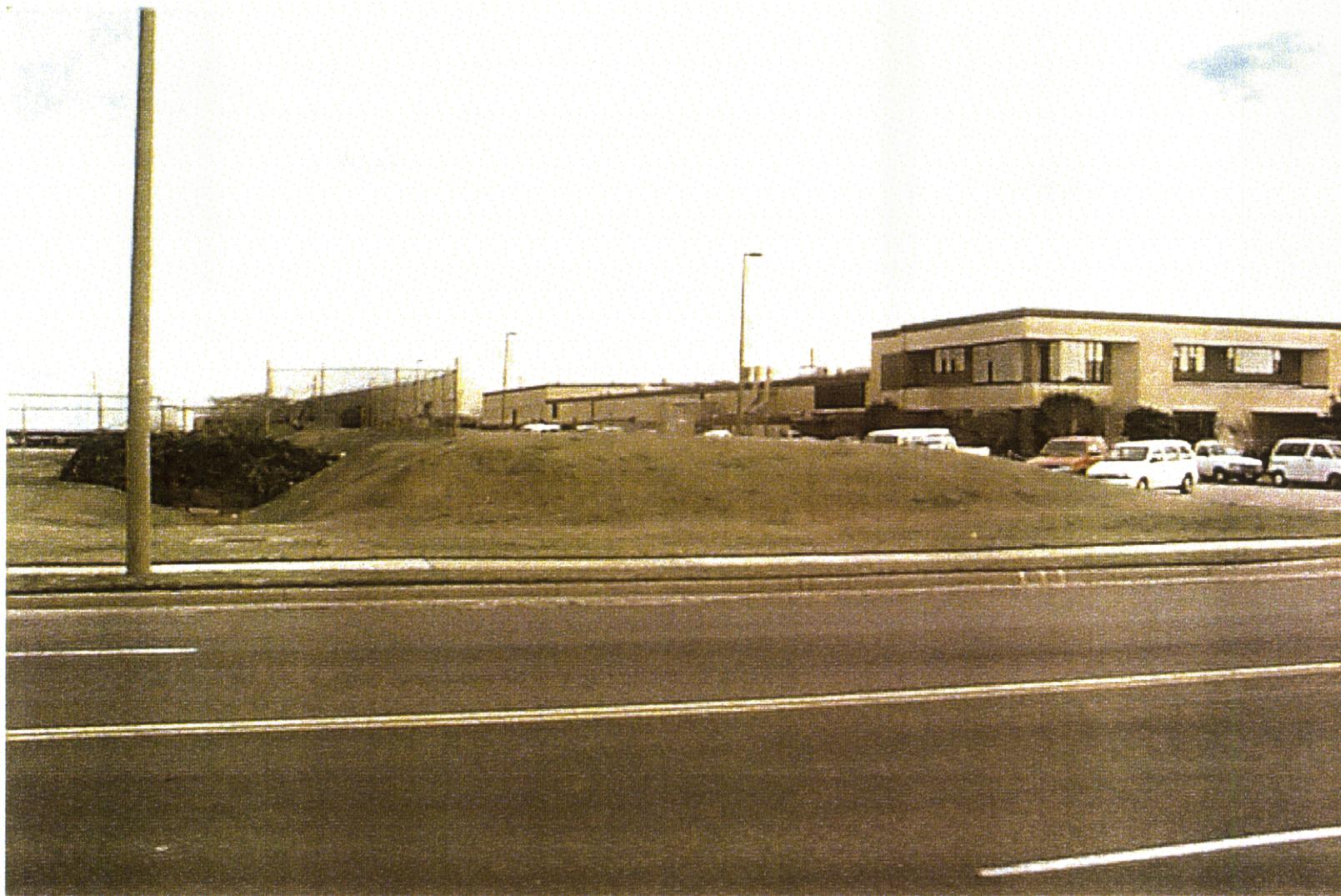
SWMU 28 - Probable Solid Waste Disposal Area South of CEP 201
Photograph taken from Virginia Avenue looking east towards Hampton Boulevard.



SWMU 32 - Solid Waste Disposal Area CEP 160/161
Photograph taken from the east side of CEP 160 looking south.



SWMU 33 - Debris Pile at Seawall Corner of Sustain Pier
Photograph taken from south side of CEP 203 looking northwest towards CEP 196.



SWMU 34 - Solid Waste Disposal Area CEP 156/200
Photograph taken from west side of Second Street looking south towards Virginia Avenue.



SWMU 35 - Solid Waste Disposal Area CEP 196/Resolute Embankment
Photograph taken from northeast corner of SWMU looking south.



SWMU 35 - Solid Waste Disposal Area CEP 196/Resolute Embankment
Photograph Taken from southwest corner of SWMU looking northeast.

Appendix B:
Streamlined Risk Assessment Table Listing

SWMU	Table	Title	Included in SRA	Comments
SWMU 28				
28	SS-1	Surface Soil Screening - Residential Scenario	Y	Table 1 - Surface Soil Screening, Residential Scenario
28	SS-2	Estimated Noncarcinogenic Risk, Surface Soil Inhalation, Future Residential Scenario	N	
28	SS-3	Estimated Carcinogenic Risk, Surface Soil Inhalation, Future Residential Scenario	N	
28	SS-4	Estimated Noncarcinogenic Risk, Surface Soil Ingestion, Future Residential Scenario	N	
28	SS-5	Estimated Carcinogenic Risk, Surface Soil Ingestion, Future Residential Scenario	N	
28	SS-6	Estimated Noncarcinogenic Risk, Dermal Exposure with Surface Soil, Future Residential Scenario	N	
28	SS-7	Estimated Carcinogenic Risk, Dermal Exposure with Surface Soil, Future Residential Scenario	N	
28	SS-8	Estimated Noncarcinogenic Risk, Surface Soil Inhalation, Future Site Worker Scenario	N	
28	SS-9	Estimated Carcinogenic Risk, Surface Soil Inhalation, Future Site Worker Scenario	N	
28	SS-10	Estimated Noncarcinogenic Risk, Surface Soil Ingestion, Future Site Worker Scenario	N	
28	SS-11	Estimated Carcinogenic Risk, Surface Soil Ingestion, Future Site Worker Scenario	N	
28	SS-12	Estimated Noncarcinogenic Risk, Dermal Exposure with Surface Soil, Future Site Worker Scenario	N	
28	SS-13	Estimated Carcinogenic Risk, Dermal Exposure with Surface Soil, Future Site Worker Scenario	N	
28	SS-14	Estimated Noncarcinogenic Risk, Surface Soil Inhalation, Future Construction Worker Scenario	N	
28	SS-15	Estimated Carcinogenic Risk, Surface Soil Inhalation, Future Construction Worker Scenario	N	
28	SS-16	Estimated Noncarcinogenic Risk, Surface Soil Ingestion, Future Construction Worker Scenario	N	
28	SS-17	Estimated Carcinogenic Risk, Surface Soil Ingestion, Future Construction Worker Scenario	N	
28	SS-18	Estimated Noncarcinogenic Risk, Dermal Exposure with Surface Soil, Future Construction Worker Scenario	N	

SWMU	Table	Title	Included in SRA	Comments
28	SS-19	Estimated Carcinogenic Risk, Dermal Exposure with Surface Soil, Future Construction Worker Scenario	N	
28	SS-20	Estimated Noncarcinogenic Risk, Surface Soil Inhalation, Current and Future Trespasser Scenario	N	
28	SS-21	Estimated Carcinogenic Risk, Surface Soil Inhalation, Current and Future Trespasser Scenario	N	
28	SS-22	Estimated Noncarcinogenic Risk, Surface Soil Ingestion, Current and Future Trespasser Scenario	N	
28	SS-23	Estimated Carcinogenic Risk, Surface Soil Ingestion, Current and Future Trespasser Scenario	N	
28	SS-24	Estimated Noncarcinogenic Risk, Dermal Exposure with Surface Soil, Current and Future Trespasser Scenario	N	
28	SS-25	Estimated Carcinogenic Risk, Dermal Exposure with Surface Soil, Current and Future Trespasser Scenario	N	
28	SB-1	Subsurface Soil Screening - Residential Scenario	Y	Table 2 - Subsurface Soil Screening, Residential Scenario
28	SB-2	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Future Residential Scenario	N	
28	SB-3	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Future Residential Scenario	N	
28	SB-4	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Future Residential Scenario	N	
28	SB-5	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Future Residential Scenario	N	
28	SB-6	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Residential Scenario	N	
28	SB-7	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Residential Scenario	N	
28	SB-8	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Future Site Worker Scenario	N	
28	SB-9	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Future Site Worker Scenario	N	
28	SB-10	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Future Site Worker Scenario	N	
28	SB-11	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Future Site Worker Scenario	N	

SWMU	Table	Title	Included in SRA	Comments
28	SB-12	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Site Worker Scenario	N	
28	SB-13	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Site Worker Scenario	N	
28	SB-14	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Future Construction Worker Scenario	N	
28	SB-15	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Future Construction Worker Scenario	N	
28	SB-16	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Future Construction Worker Scenario	N	
28	SB-17	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Future Construction Worker Scenario	N	
28	SB-18	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Construction Worker Scenario	N	
28	SB-19	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Construction Worker Scenario	N	
28	SB-20	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Current and Future Trespasser Scenario	N	
28	SB-21	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Current and Future Trespasser Scenario	N	
28	SB-22	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Current and Future Trespasser Scenario	N	
28	SB-23	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Current and Future Trespasser Scenario	N	
28	SB-24	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Current and Future Trespasser Scenario	N	
28	SB-25	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Current and Future Trespasser Scenario	N	
28	3	Risk and Hazard Summary	Y	Table 3 - Risk and Hazard Summary
SWMU 32				
32	SB-1	Subsurface Soil Screening - Residential Scenario	Y	Table 1 - Subsurface Soil Screening, Residential Scenario
32	SB-2	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Future Residential Scenario	N	
32	SB-3	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Future Residential Scenario	N	

SWMU	Table	Title	Included in SRA	Comments
32	SB-4	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Future Residential Scenario	N	
32	SB-5	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Future Residential Scenario	N	
32	SB-6	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Residential Scenario	N	
32	SB-7	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Residential Scenario	N	
32	SB-8	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Future Site Worker Scenario	N	
32	SB-9	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Future Site Worker Scenario	N	
32	SB-10	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Future Site Worker Scenario	N	
32	SB-11	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Future Site Worker Scenario	N	
32	SB-12	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Site Worker Scenario	N	
32	SB-13	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Site Worker Scenario	N	
32	SB-14	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Future Construction Worker Scenario	N	
32	SB-15	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Future Construction Worker Scenario	N	
32	SB-16	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Future Construction Worker Scenario	N	
32	SB-17	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Future Construction Worker Scenario	N	
32	SB-18	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Construction Worker Scenario	N	
32	SB-19	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Construction Worker Scenario	N	
32	SB-20	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Current and Future Trespasser Scenario	N	
32	SB-21	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Current and Future Trespasser Scenario	N	

SWMU	Table	Title	Included in SRA	Comments
32	SB-22	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Current and Future Trespasser Scenario	N	
32	SB-23	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Current and Future Trespasser Scenario	N	
32	SB-24	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Current and Future Trespasser Scenario	N	
32	SB-25	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Current and Future Trespasser Scenario	N	
32	1	Risk and Hazard Summary	Y	Table 2 - Risk and Hazard Summary
SWMU 33				
33	SB-1	Subsurface Soil Screening - Residential Scenario	Y	Table 1 - Subsurface Soil Screening, Residential Scenario
33	SB-2	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Future Residential Scenario	N	
33	SB-3	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Future Residential Scenario	N	
33	SB-4	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Future Residential Scenario	N	
33	SB-5	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Future Residential Scenario	N	
33	SB-6	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Residential Scenario	N	
33	SB-7	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Residential Scenario	N	
33	SB-8	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Future Site Worker Scenario	N	
33	SB-9	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Future Site Worker Scenario	N	
33	SB-10	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Future Site Worker Scenario	N	
33	SB-11	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Future Site Worker Scenario	N	
33	SB-12	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Site Worker Scenario	N	
33	SB-13	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Site Worker Scenario	N	

SWMU	Table	Title	Included in SRA	Comments
33	SB-14	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Future Construction Worker Scenario	N	
33	SB-15	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Future Construction Worker Scenario	N	
33	SB-16	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Future Construction Worker Scenario	N	
33	SB-17	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Future Construction Worker Scenario	N	
33	SB-18	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Construction Worker Scenario	N	
33	SB-19	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Construction Worker Scenario	N	
33	SB-20	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Current and Future Trespasser Scenario	N	
33	SB-21	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Current and Future Trespasser Scenario	N	
33	SB-22	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Current and Future Trespasser Scenario	N	
33	SB-23	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Current and Future Trespasser Scenario	N	
33	SB-24	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Current and Future Trespasser Scenario	N	
33	SB-25	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Current and Future Trespasser Scenario	N	
33	1	Risk and Hazard Summary	Y	Table 2 - Risk and Hazard Summary
SWMU 34				
34	SB-1	Subsurface Soil Screening - Residential Scenario	Y	Table 1 - Subsurface Soil Screening, Residential Scenario
34	SB-2	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Future Residential Scenario	N	
34	SB-3	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Future Residential Scenario	N	
34	SB-4	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Future Residential Scenario	N	
34	SB-5	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Future Residential Scenario	N	

SWMU	Table	Title	Included in SRA	Comments
34	SB-6	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Residential Scenario	N	
34	SB-7	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Residential Scenario	N	
34	SB-8	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Future Site Worker Scenario	N	
34	SB-9	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Future Site Worker Scenario	N	
34	SB-10	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Future Site Worker Scenario	N	
34	SB-11	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Future Site Worker Scenario	N	
34	SB-12	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Site Worker Scenario	N	
34	SB-13	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Site Worker Scenario	N	
34	SB-14	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Future Construction Worker Scenario	N	
34	SB-15	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Future Construction Worker Scenario	N	
34	SB-16	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Future Construction Worker Scenario	N	
34	SB-17	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Future Construction Worker Scenario	N	
34	SB-18	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Construction Worker Scenario	N	
34	SB-19	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Construction Worker Scenario	N	
34	SB-20	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Current and Future Trespasser Scenario	N	
34	SB-21	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Current and Future Trespasser Scenario	N	
34	SB-22	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Current and Future Trespasser Scenario	N	
34	SB-23	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Current and Future Trespasser Scenario	N	

SWMU	Table	Title	Included in SRA	Comments
34	SB-24	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Current and Future Trespasser Scenario	N	
34	SB-25	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Current and Future Trespasser Scenario	N	
34	SED-1	Risk-Based Concentrations for Noncarcinogenic and Carcinogenic Effects, Sediment Ingestion for Adult and Adolescent Trespasser Scenarios	Y	Table 5 - Risk-Based Concentrations for Noncarcinogenic and Carcinogenic Effects, Sediment Ingestion for Adult and Adolescent Trespasser Scenarios
34	SED-2	Sediment Screening Recreational Scenario	Y	Table 6 - G146 Sediment Screening Recreational Scenario
34	SED-3	Estimated Noncarcinogenic Risk, Sediment Ingestion, Future Adolescent and Adult Trespasser Scenario	N	
34	SED-4	Estimated Carcinogenic Risk, Sediment Ingestion, Future Adolescent and Adult Trespasser Scenario	N	
34	SED-5	Estimated Noncarcinogenic Risk, Dermal Exposure to Sediment, Future Adolescent and Adult Trespasser Scenario	N	
34	SED-6	Estimated Carcinogenic Risk, Dermal Exposure to Sediment, Future Adolescent and Adult Trespasser Scenario	N	
34	SW-1	Risk-Based Concentrations for Noncarcinogenic and Carcinogenic Effects, Surface Water Ingestion, Current and Future Adult and Adolescent Scenario	Y	Table 3 - Risk-Based Concentrations for Noncarcinogenic and Carcinogenic Effects, Surface Water Ingestion, Current and Future Adult and Adolescent Scenario
34	SW-2	Surface Water Screening, Current and Future Trespasser Adult and Adolescent Scenario	Y	Table 4 - Surface Water Screening, Current and Future Trespasser Adult and Adolescent Scenario
34	SW-3	Estimated Noncarcinogenic Risk, Surface Water Ingestion, Current and Future Trespasser Adult and Adolescent Scenario	N	
34	SW-4	Estimated Carcinogenic Risk, Surface Water Ingestion, Current and Future Trespasser Adult and Adolescent Scenario	N	
34	SW-5	Estimated Noncarcinogenic Risk, Surface Water Dermal Exposure, Current and Future Trespasser Adult and Adolescent Scenario	N	
34	SW-6	Estimated Carcinogenic Risk, Surface Water Dermal Exposure, Current and Future Trespasser Adult and Adolescent Scenario	N	
34	1	Risk and Hazard Summary	Y	Table 2 - Risk and Hazard Summary
SWMU 35				
35	SB-1	Subsurface Soil Screening - Residential Scenario	Y	Table 1 - Subsurface Soil Screening, Residential Scenario

SWMU	Table	Title	Included in SRA	Comments
35	SB-2	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Future Residential Scenario	N	
35	SB-3	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Future Residential Scenario	N	
35	SB-4	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Future Residential Scenario	N	
35	SB-5	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Future Residential Scenario	N	
35	SB-6	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Residential Scenario	N	
35	SB-7	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Residential Scenario	N	
35	SB-8	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Future Site Worker Scenario	N	
35	SB-9	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Future Site Worker Scenario	N	
35	SB-10	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Future Site Worker Scenario	N	
35	SB-11	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Future Site Worker Scenario	N	
35	SB-12	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Site Worker Scenario	N	
35	SB-13	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Site Worker Scenario	N	
35	SB-14	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Future Construction Worker Scenario	N	
35	SB-15	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Future Construction Worker Scenario	N	
35	SB-16	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Future Construction Worker Scenario	N	
35	SB-17	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Future Construction Worker Scenario	N	
35	SB-18	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Construction Worker Scenario	N	
35	SB-19	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Future Construction Worker Scenario	N	

SWMU	Table	Title	Included in SRA	Comments
35	SB-20	Estimated Noncarcinogenic Risk, Subsurface Soil Inhalation, Current and Future Trespasser Scenario	N	
35	SB-21	Estimated Carcinogenic Risk, Subsurface Soil Inhalation, Current and Future Trespasser Scenario	N	
35	SB-22	Estimated Noncarcinogenic Risk, Subsurface Soil Ingestion, Current and Future Trespasser Scenario	N	
35	SB-23	Estimated Carcinogenic Risk, Subsurface Soil Ingestion, Current and Future Trespasser Scenario	N	
35	SB-24	Estimated Noncarcinogenic Risk, Dermal Exposure with Subsurface Soil, Current and Future Trespasser Scenario	N	
35	SB-25	Estimated Carcinogenic Risk, Dermal Exposure with Subsurface Soil, Current and Future Trespasser Scenario	N	
35		Risk and Hazard Summary	Y	Table 2 - Risk and Hazard Summary

Appendix C:
Exposure Parameters for Human Health
Risk Assessment

Appendix C
RME Exposure Parameters for Human Health Risk Assessment

	Industrial		Residential		Trespasser	
	Site Worker	Construction Worker	Child (age 1-6)	Adult	Adult	Adolescent (age 9-18)
General Receptor Factors						
Body Weight (kg)	70 ^a	70 ^a	15 ^a	70 ^a	70 ^a	37 ^d
Media-Specific Factors						
Soil						
Ingestion Rate (mg/day)	100 ^a	480 ^a	200 ^a	100 ^a	100 ^a	100 ^a
Inhalation Rate (m ³ /hour)	0.83 ^a	1.7 ^d				
Inhalation Rate (m ³ /day)			12 ^d	20 ^d	20 ^d	20 ^d
Skin Surface Area ¹ (cm ²)	5,300 ^c	5,300 ^c	2,006 ^c	5,300 ^c	5,300 ^c	3,578 ^c
Soil Adherence Factor (mg/cm ² -day)	1 ^c	1 ^c				
Dermal Absorption Factor Solids ²	Chemical Specific		Chemical Specific		Chemical Specific	
Exposure Time (hours/day)	8 ^e	8 ^e				
Exposure Frequency (days/year)	250 ^a	250 ^a	350 ^a	350 ^a	52 ^h	52 ^h
Exposure Duration (years)	25 ^a	1 ^a	6 ^a	24 ^a	24 ^a	9 ^g
Particulate Emission Factor (m ³ /kg)	1.32E+09 ^f	1.32E+09 ^f				
Surface Water - wading						
Ingestion Rate (liters/hour)					0.05 ^b	0.05 ^b
Skin Surface Area ³ (cm ²)					3,595 ^c	2,832 ^c
Permeability Constant (cm/hour)					Chemical Specific ^c	
Exposure Frequency (days/year)					24 ^h	24 ^h
Exposure Time (hours/day)					2.6 ^b	2.6 ^b
Exposure Duration (years)					24 ^a	9 ^g
Sediment-wading						
Ingestion Rate (mg/day)					100 ^a	100 ^a
Skin Surface Area ³ (cm ²)					3,595 ^c	2,832 ^c
Soil Adherence Factor (mg/cm ² -day)					1 ^c	1 ^c
Dermal Absorption Factor Solids ²					Chemical Specific	
Exposure Frequency (days/year)					24 ^h	24 ^h
Exposure Duration (years)					24 ^a	9 ^g

Notes:

1. Worker and trespasser skin surface area includes head, hands, forearms, and lower legs, 25% of total body surface area. Resident wearing shorts, short sleeve shirt, and shoes, 25% of total body surface area.
2. Based on EPA's Risk Assessment Guidance for Superfund Vol. 1: Human Health Evaluation Manual Supplemental Guidance Dermal Risk Assessment Interim Guidance, November 1998. For constituents with no specific values, used default volatile organics value of 20%, semi-volatile organics value of 10%, and Inorganics value of 1%.
3. Skin surface area based on contact while wadding includes lower legs and feet.

Sources:

- a. USEPA, 1991. *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors*.
- b. USEPA, 1989. *Risk Assessment Guidance for Superfund, Volume 1 - Human Health Evaluation Manual (Part A)*. EPA/540/1-89/002.
- c. USEPA, 1992. *Dermal Exposure Assessment: Principles and Applications*. Office of Research and Development. EPA/600/8-91/011B. January 1992.
- d. USEPA, 1997. *Exposure Factors Handbook*. EPA/600/P-95/002Fa.
- e. Professional judgment, assuming worker would work at site 8 hours per day.
- f. USEPA, 1996a. *Soil Screening Guidance: User's Guide*. EPA/540/R-96/018.
- g. Assuming adolescents from 9 to 18 years of age.
- h. Professional judgment, assuming 1 day per week for 52 weeks per year for soil and 1 day per week for one half the year for surface water and sedi
- i. USEPA, 1989. *Risk Assessment Guidance for Superfund, Volume 1 - Human Health Evaluation Manual (Part A)*. EPA/540/1-89/002.