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RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION REPORT
ZONE A VOLUME II OF V SECTION 10 TO 13 CNC CHARLESTON SC
8/7/1998
ENSAFE

ZONE A
RCRA FACILITY INVESTIGATION REPORT
NAVBASE CHARLESTON
NORTH CHARLESTON, SOUTH CAROLINA

Volume II of V
Sections 10 to 13

CTO-029
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Release of this document requires prior notification of the Commanding Officer of the Southern Division, Naval Facilities Engineering Command, North Charleston, South Carolina.

10.0 SITE-SPECIFIC EVALUATIONS

This section presents site-specific evaluations which summarize analytical results from samples collected as part of the Zone A RFI at NAVBASE, expected fate and transport of COPCs, human health and ecological risk assessments, and any recommendations for corrective measures. This section is divided into investigatory groups that were established in the *Final Zones A and B RFI Work Plan* (E/A&H, September 1995). Figure 10.0.1 indicates the Zone A sites that were investigated during the RFI. Grid-based sampling is also summarized in this section.

Sampling was conducted in a phased approach presented in Section 2, Volume 1, of the *Final Comprehensive RFI Work Plan* (E/A&H, August 1994). The first round was performed per the *Final Zones A and B RFI Work Plan*. Organic compound analytical results from the first round were compared to the USEPA Region III *Risk-Based Concentration Table, January-June 1996*, June 3, 1996. Inorganic analytical results were compared to RBCs and a background reference concentration, determined as outlined in Section 5 of this report. Based on evaluation of first-round results, some sites required further sampling to identify COPCs, define the nature and extent of any contamination, and provide data collection for a corrective measures study.

Data Evaluation

The following screening tools and data evaluation methods were used to determine COPCs at each site:

- Surface soil analytical results were compared to residential soil ingestion screening values in the USEPA Region III, *Risk-Based Concentration Table*, October 22, 1997. In the site-specific HHRA sections, noncarcinogenic chemicals were adjusted to equate with an HQ of 0.1.

- Groundwater analytical results were compared to the USEPA Region III, *Risk-Based Concentration Table*, October 22, 1997. In the site-specific HHRA sections, noncarcinogenic chemicals were adjusted to equate with a hazard quotient of 0.1.

- Sediment analytical results were compared to ecological reference concentrations in Section 8, Ecological Risk Assessment. Ecological subzones may encompass several AOCs or SWMUs, so site-specific comparisons to ecological risk based screening levels are not appropriate.

- In accordance with USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995, TEFs were used to convert cPAHs to BEQs, which were subsequently summed for each sample and compared to the benzo(a)pyrene RBC of 88 μg/kg for soil. Similarly, TEFs were used to convert dioxins to 2,3,7,8-TCDD equivalents (TEQ), which were compared to the 2,3,7,8-TCDD RBC of 1 μg/kg for soil and 4.5E-7 μg/L for groundwater.

- Duplicate samples were incorporated with their respective primary samples. When either duplicate or primary analytical results had a detection, the detection value was used. When both the duplicate and primary analytical results had detections, an average of the two values was used to compensate for matrix heterogeneity.

Deviations from *Final Zones A and B RFI Work Plan* (E/A&H, September 1995)

Deviations from the proposed sampling in the work plan were required in some cases and are specifically noted in the investigatory group subsections.

Sampling Locations

In total, multimedia sampling was conducted at seven sites within Zone A, along with a grid-based (background) investigation. Table 10.0.1 and Figure 10.0.2 summarize the sample datasets.

Table 10.0.1
Zone A, Summary of Sample Datasets

Site	Soil Borings[a]	Monitoring Wells: Shallow	Monitoring Wells: Intermediate	Monitoring Wells: Deep	Geoprobe Borings[b]	CPT Borings[c]	Sediment	Surface Water
SWMU 1	3	0[d]	0	0	0	0	0	0
SWMU 2	65	6	0	0	0	0	13	0
SWMU 38	14	2[d]	0	1	0	0	0	0
SWMU 39	43	15	5	8	21	29	5	5
SWMU 42/ AOC 505	46	4	0	0	5	0	0	0
SWMU 43	6	1	0	0	3	0	0	0
AOC 506	6	1	0	0	3	0	0	0
Grid Based	16	3	0	3	0	0	0	0
TOTAL	**199**	**32**	**5**	**12**	**32**	**29**	**18**	**5**

Notes:

a = Soil borings installed in Zone A consist of an upper-interval sample (0 to 1 foot) at all locations and a lower-interval sample (3 to 5 feet) at most locations.

b = Geoprobe borings consist of a shallow groundwater sample at all locations and a subsurface soil sample at most locations.

c = CPT borings consist of lithologic data at all locations; a shallow groundwater sample at some locations; and an intermediate groundwater sample at some locations.

d = Shallow well dataset does not include one well from the SWMU 2 set that was used to support the investigation at this site.

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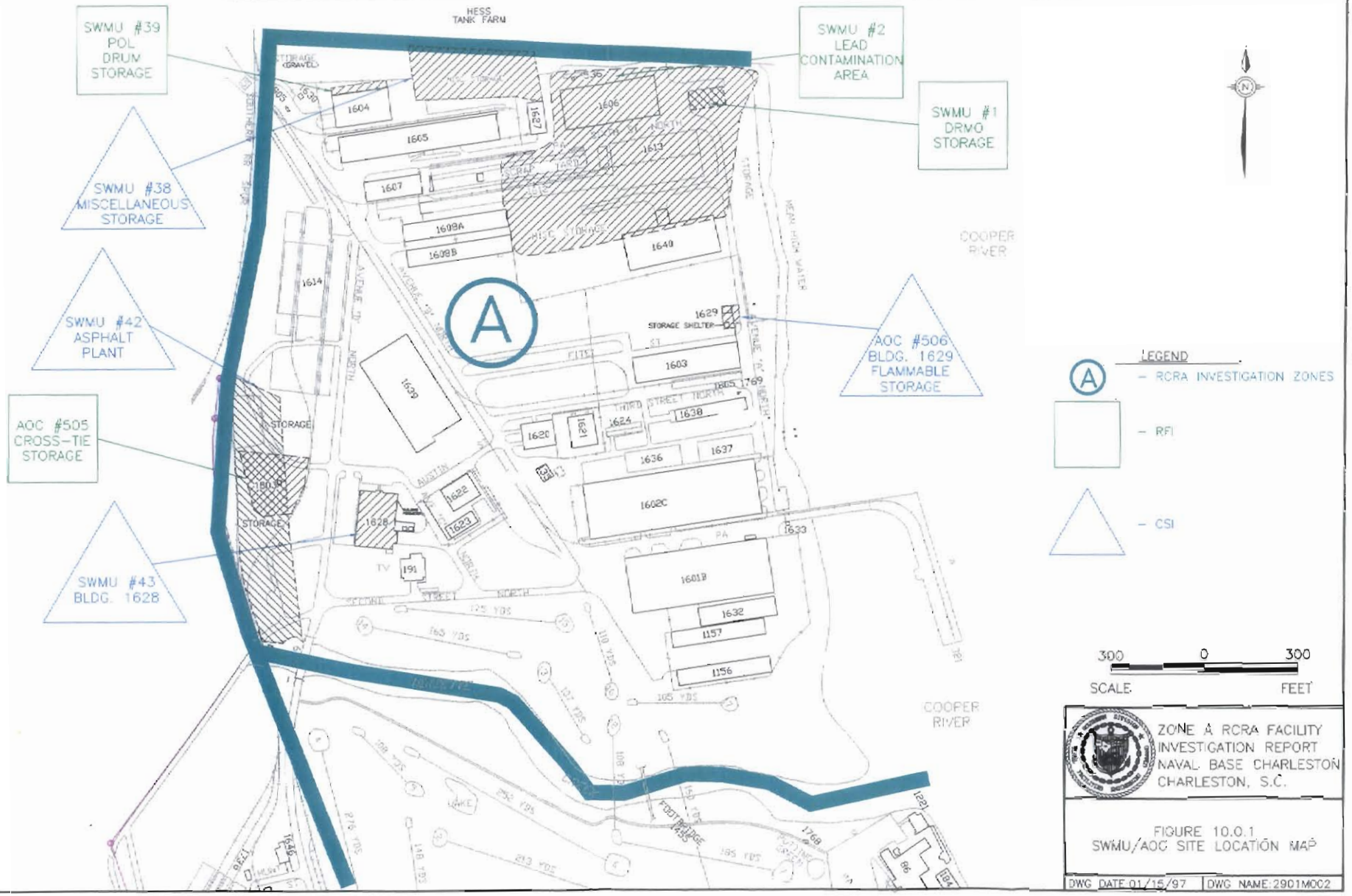

SWMU #39
POL
DRUM
STORAGE
SWMU #38
MISCELLANEOUS
STORAGE
SWMU #42
ASPHALT
PLANT
AOC #505
CROSS-TIE
STORAGE
SWMU #43
BLDG. 1628
SWMU #2
LEAD
CONTAMINATION
AREA
SWMU #1
DRMO
STORAGE
AOC #506
BLDG. 1629
FLAMMABLE
STORAGE
HESS
TANK FARM
COOPER
RIVER
A
LEGEND
A - RCRA INVESTIGATION ZONES
- RFI
- CSI
300 0 300
SCALE FEET
ZONE A RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.
FIGURE 10.0.1
SWMU/AOC SITE LOCATION MAP
DWG DATE 01/15/97
DWG NAME: 2901M002

10.1 SWMU 1, DRMO Storage

SWMU 1 was used by the Defense Reutilization and Marketing Office to store property turned in from local armed forces activities. The property included some products that could not be reutilized by other commands and were consequently classified as waste. Those which were considered hazardous waste were stored until the early 1990s in a covered storage shed formerly known as Building 1617, which no longer exists.

Materials of concern at SWMU 1, identified in the *Final Zones A and B RFI Work Plan*, are VOCs, hydrazine, metals, and characteristic hazardous wastes. Potential receptors include current and future site users involved in invasive activities. The Cooper River is also a potential receptor of contaminated surface water runoff and groundwater discharges.

Soil and groundwater were sampled in accordance with the *Final Zones A and B RFI Work Plan* and as discussed in Section 3 of this report to fulfill RFI objectives for SWMU 1.

10.1.1 Soil Sampling and Analysis

Previous investigations of SWMU 1 culminated in the certification of clean closure for soil of the DRMO Storage Shed. However, documentation is not available to verify that closure certification sampling was conducted in a manner acceptable for risk assessment procedures.

Therefore, additional samples were collected to corroborate the results of the earlier sampling event. In the autumn of 1993, this confirmatory sampling was conducted in the vicinity of SWMU 1. Two soil borings, with two samples each (upper interval and lower interval), were sampled for the complete TCL/TAL list. As outlined in the *Final Zones A and B RFI Work Plan*, one additional soil boring was installed in 1995 at SWMU 1 for the collection of both upper and lower interval samples. All SWMU 1 soil sample locations are shown on Figure 10.1.1.

0 60 feet

LEGEND

- 1995 Boring Location
- 1993 Boring Location

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.11 - SWMU 1

10.1.2 Nature and Extent of Contamination in Soil

Organic compound analytical results for soil are summarized in Table 10.1.2. Inorganic analytical results are summarized in Table 10.1.3. Appendix D is a complete analytical data report for all Zone A samples collected.

Table 10.1.2
SWMU 1
Organic Compounds Detected in Soil

Compound	Sample Interval	Frequency of Detection	Range of Detections (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Volatile Organic Compounds (6 samples collected: 3 upper interval and 3 lower interval)						
Acetone	Upper	1/3	90	NA	7,800,000	0
	Lower	2/3	44 - 110	77	NA	NA
2-butanone (MEK)	Upper	2/3	3.3 - 14	8.6	47,000,000	0
	Lower	1/3	8.6	NA	NA	NA
Carbon disulfide	Upper	0/3	NA	NA	7,800,000	0
	Lower	1/3	2	NA	NA	NA
Chlorobenzene	Upper	1/3	29	NA	1,600,000	0
	Lower	1/3	39	NA	NA	NA
Methylene chloride	Upper	1/3	1.8	NA	85,000	0
	Lower	0/3	NA	NA	NA	NA
Toluene	Upper	1/3	2.9	NA	16,000,000	0
	Lower	1/3	8.9	NA	NA	NA
1,1,1-Trichloroethane	Upper	1/3	2.9	NA	1,600,000	0
	Lower	1/3	8.3	NA	NA	NA
Xylenes (total)	Upper	1/3	2.6	NA	160,000,000	0
	Lower	1/3	5.0	NA	NA	NA

Table 10.1.2
SWMU 1
Organic Compounds Detected in Soil

Compound	Sample Interval	Frequency of Detection	Range of Detections (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Semivolatile Organic Compounds (6 samples collected: 3 upper interval and 3 lower interval)						
BEQ[a]	Upper	1/3	148	NA	88	1
Benzo(a)anthracene	Upper	1/3	120	NA	880	0
	Lower	0/3	NA	NA	NA	NA
Benzo(a)pyrene	Upper	1/3	110	NA	88	1
	Lower	0/3	NA	NA	NA	NA
Benzo(b)fluoranthene	Upper	1/3	150	NA	880	0
	Lower	0/3	NA	NA	NA	NA
Benzo(g,h,i)perylene	Upper	1/3	98	NA	3,100,000[b]	0
	Lower	0/3	NA	NA	NA	NA
Benzo(k)fluoranthene	Upper	1/3	67	NA	8,800	0
	Lower	0/3	NA	NA	NA	NA
Chrysene	Upper	1/3	140	NA	88,000	0
	Lower	0/3	NA	NA	NA	NA
Fluoranthene	Upper	1/3	240	NA	3,100,000	0
	Lower	0/3	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	Upper	1/3	97	NA	880	0
	Lower	0/3	NA	NA	NA	NA
Phenanthrene	Upper	1/3	100	NA	3,100,000[b]	0
	Lower	0/3	NA	NA	NA	NA
Pyrene	Upper	1/3	300	NA	2,300,000	0
	Lower	0/3	NA	NA	NA	NA

Table 10.1.2
SWMU 1
Organic Compounds Detected in Soil

Compound	Sample Interval	Frequency of Detection	Range of Detections (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Pesticides/PCBs (6 samples collected: 3 upper interval and 3 lower interval)						
4,4'-DDE	Upper	1/3	4.1	NA	1,900	0
	Lower	0/3	NA	NA	NA	NA
4,4'-DDT	Upper	1/3	12.0	NA	1,900	0
	Lower	0/3	NA	NA	NA	NA

Notes:
a = Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995.
b = RBC not available for this compound; fluoranthene RBC used as surrogate.
NA = Not applicable

Table 10.1.3
SWMU 1
Inorganics Detected in Soil

Element	Sample Interval	Frequency of Detection	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	Reference Conc. (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding[a]
Inorganic (6 samples collected: 3 upper interval and 3 lower interval)							
Aluminum	Upper	3/3	2,500 - 7,630	4,290	12,800	78,000	0
	Lower	3/3	4,400 - 8,010	6,150	28,240	NA	0
Antimony	Upper	1/3	17.5	NA	**	31	0
	Lower	0/3	NA	NA	**	NA	NA
Arsenic	Upper	1/3	9.4	NA	9.4	0.43	0
	Lower	2/3	1.8 - 5.6	3.7	9.8	NA	0
Barium	Upper	3/3	7.0 - 98.4	38.1	53.0	5,500	0
	Lower	3/3	10.0 - 19.6	14.5	40.0	NA	0
Cadmium	Upper	1/3	1.2	NA	**	39	0
	Lower	0/3	NA	NA	**	NA	NA

Table 10.1.3
SWMU 1
Inorganics Detected in Soil

Element	Sample Interval	Frequency of Detection	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	Reference Conc. (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding[a]
Inorganic (6 samples collected: 3 upper interval and 3 lower interval)							
Calcium	Upper	3/3	2,900 - 38,100	14,700	NA	NA	NA
	Lower	3/3	38,000 - 254,000	143,000	NA	NA	NA
Chromium	Upper	3/3	3.5 - 38.7	15.5	50.4	390	0
	Lower	3/3	8.8 - 53.0	28.2	63.4	NA	0
Cobalt	Upper	1/3	1.9	NA	4.4	4,700	0
	Lower	0/3	NA	NA	1.7	NA	NA
Copper	Upper	2/3	2.0 - 443	222	165	3,100	0
	Lower	3/3	3.5 - 16.8	9.3	33.7	NA	0
Iron	Upper	3/3	490 - 8,470	3,210	NA	NA	NA
	Lower	3/3	4,100 - 5,740	5,010	NA	NA	NA
Lead	Upper	2/3	6.4 - 7.1	6.8	140	400[b]	0
	Lower	3/3	5.4 - 10.4	8.3	22.0	400[b]	0
Magnesium	Upper	2/3	110 - 165	138	NA	NA	NA
	Lower	3/3	840 - 7,040	3,530	NA	NA	NA
Manganese	Upper	3/3	3.1 - 109	38.9	98.1	1,800	0
	Lower	3/3	40 - 83	62	85.5	NA	0
Mercury	Upper	2/3	0.03 - 14.8	7.4	0.30	23	0
	Lower	2/3	0.02 - 0.24	0.13	**	NA	NA
Nickel	Upper	2/3	3.5 - 9.0	6.3	13.6	1,600	0
	Lower	3/3	4.9 - 26.7	15.4	35.0	NA	0
Potassium	Upper	1/3	466	NA	NA	NA	NA
	Lower	3/3	200 - 1,140	600	NA	NA	NA
Selenium	Upper	0/3	NA	NA	1.2	390	0
	Lower	1/3	1.4	NA	1.7	NA	0
Sodium	Upper	2/3	227 - 252	240	NA	NA	NA
	Lower	3/3	230 - 1,000	680	NA	NA	NA

Table 10.1.3
SWMU 1
Inorganics Detected in Soil

Element	Sample Interval	Frequency of Detection	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	Reference Conc. (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding[a]
Inorganic (6 samples collected: 3 upper interval and 3 lower interval)							
Vanadium	Upper	3/3	1.6 - 55	19.6	29.2	550	0
	Lower	3/3	8.5 - 30.2	17.4	77.3	NA	0
Zinc	Upper	3/3	7.1 - 369	242	208	23,000	0
	Lower	3/3	9.4 - 65.3	44.6	165	NA	0

Notes:
a = Number of samples exceeding both RBC and RC in upper interval or number of samples exceeding the reference concentration (RC) in the lower interval.
b = RBC not available for lead. USEPA (1994f) residential soil cleanup level used for comparison (OSWER Directive 9355.4-12).
** = Number of nondetects prevented determination of UTL.

Volatile Organic Compounds in Soil

No VOCs were detected above their respective RBC in upper-interval soil at SWMU 1. Also, none of the lower-interval detections exceeded the respective SSL.

Semivolatile Organic Compounds in Soil

Benzo(a)pyrene was detected above the RBC in one soil sample at SWMU 1, sample number S01SB00201. This location is shown on Figure 10.1.1 earlier in this section. In accordance with recent USEPA cPAH guidance and Section 7 of this report, BEQs were calculated for cPAHs at SWMU 1. BEQs for sample S01SB00201 exceeded the benzo(a)pyrene RBC of 88 μg/kg with a detection of 148 μg/kg. Also, no SVOCs were detected in lower-interval samples.

Pesticides/PCBs

No pesticides or PCBs were detected above their respective RBC at SWMU 1. Also, no pesticides or PCBs were detected in lower-interval samples.

Inorganics in Soil

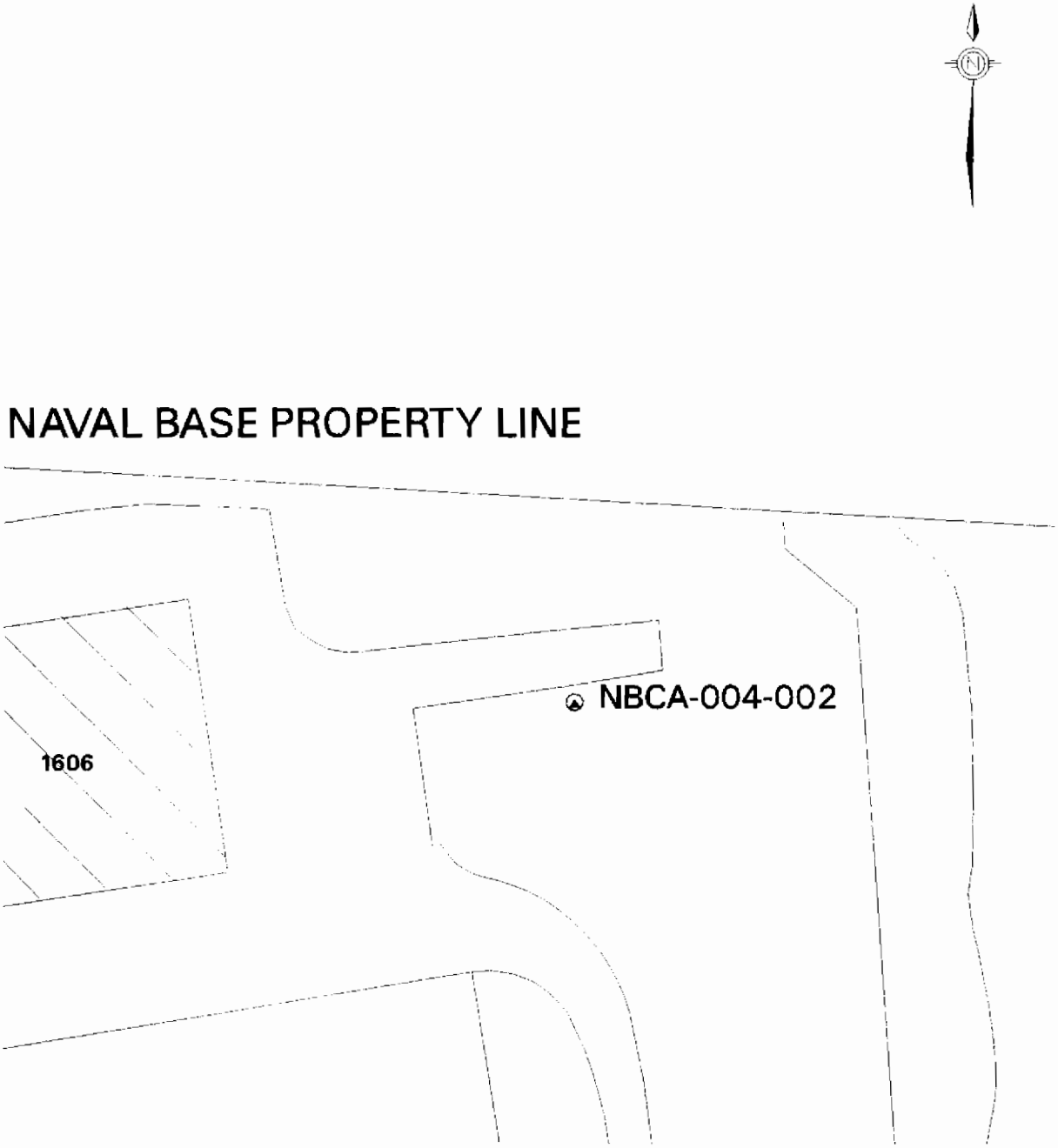
Twenty metals were detected in soil samples collected at SWMU 1. One (arsenic) was detected at concentrations greater than its RBC and equal to its RC (for upper interval only). Also, no lower-interval metals detections exceeded both the RC and SSL.

Arsenic was detected in sample S01SB00201 at a concentration of 9.4 mg/kg, which is greater than the RBC (0.43 mg/kg) and equal to the RC (9.4 mg/kg).

10.1.3 Groundwater Sampling and Analysis

The *Final Zones A and B RFI Work Plan* proposed redeveloping and sampling the one existing shallow monitoring well installed at SWMU 1 during the 1993 investigation at SWMU 2. Figure 10.1.2 illustrates the location of this well, NBCA-002-002. A permit application was submitted in 1996 to SCDHEC to change this monitoring well ID to the current format. For example, this well that was installed as CNSY-02-02 is now NBCA-002-002.

There have been five groundwater sampling events to date at SWMU 1. Table 10.1.4 summarizes this sampling. The first sampling event was conducted after installation of the well in November 1993. The sample was submitted for the standard suite of analyses which includes VOCs, SVOCs, metals, pesticides, PCBs, and cyanide.



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Shallow Monitoring Well

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

After redeveloping the well in September 1995, the first round RFI sample was collected. NBCA-002-002 was again sampled for the standard suite. Because metals were the only constituents detected in this well, second- and third- quarter samples were collected for metals analysis only. The fourth-quarter sample was collected for metals, TDS, sulfate, and chloride.

Second-, third-, and fourth-round samples were collected by the Charleston Environmental and Engineering Remediation Detachment (CEERD) in April, June, and October 1996, respectively.

Table 10.1.4
SWMU 1
Groundwater Sampling Summary

Event	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Nov. 1993	1	1	Standard Suite[a]	Standard Suite[a]	None
Sept. 1995 (1st round)	1	1	Standard Suite[a]	Standard Suite[a]	None
Apr. 1996 (2nd round)	1	1	Metals[b]	Metals[b]	None
Jun. 1996 (3rd round)	1	1	Metals[b]	Metals[b]	None
Oct. 1996 (4th round)	1	1	Metals, TDS, sulfate, chloride	Metals, TDS, sulfate, chloride	None

Notes:
a = VOCs, SVOCs, metals, cyanide, pesticides, and PCBs
b = Second- and third-quarter sampling analyses were based on detections in the first quarter.

This shallow monitoring well was installed at 15 feet bgs in the upper sand aquifer. The well was installed as described in Section 3.3 of this report.

10.1.4 Nature and Extent of Contamination in Groundwater

No organic compounds were detected in any groundwater samples from SWMU 1. Table 10.1.5 summarizes groundwater inorganic analytical results. Appendix D is a complete analytical data report for all samples collected in Zone A, including those collected at SWMU 1.

Volatile Organic Compounds in Groundwater

No VOCs were detected in groundwater at SWMU 1.

Semivolatile Organic Compounds in Groundwater

No SVOCs were detected in groundwater at SWMU 1.

Pesticides and PCBs in Groundwater

No pesticides or PCBs were detected in groundwater at SWMU 1.

Inorganics in Groundwater

Sixteen metals were detected in groundwater samples collected at SWMU 1. One metal (manganese) was detected at concentrations greater than both its RBC and RC.

10.1.5 Fate and Transport for SWMU 1

SWMU 1 was formerly used by the Defense Reutilization and Marketing Office (DRMO) as a storage area for waste material amassed as a result of local armed forces activities. The portion of this waste considered hazardous was stored in a shed formerly known as Building 1617. SWMU 1 was granted clean closure for soils in 1993 based on human health risk-based clean-up goals developed in *Risk Assessment and Development of Risk-based Clean-up Goals for the Charleston Naval Shipyard* (Gradient 1991 and subsequent revisions). Results from the SWMU 1 soil and groundwater samples collected during the Zone A RFI substantiated the 1993 clean closure decision.

Table 10.1.5
SWMU 1
Inorganics Detected in Groundwater

Compound	Nov. 93 Detection (μg/L)	Sep. 95 Detection (μg/L)	Apr. 96 Detection (μg/L)	Jun. 96 Detection (μg/L)	Oct. 96 Detection (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Metals (1 sample collected during each event, 1 duplicate collected)									
Aluminum	ND	50	ND	ND	ND	NA	3,210	37,000	0
Barium	56.6	26.6	ND	27.9	34.1	36.3	104	2,600	0
Cadmium	ND	ND	ND	ND	0.48	NA	**	18	0
Calcium	156,500	93,600	92,600	88,400	108,000	107,800	NA	NA	NA
Chromium	ND	ND	ND	ND	5.2	NA	8.7	180	0
Cobalt	ND	ND	ND	6.3	1.5	3.9	**	2,200	0
Copper	ND	3	ND	ND	4.2	3.6	15.7	1,500	0
Iron	2,940	3,430	2,220	2,520	3,900	3,000	NA	NA	NA
Lead	ND	ND	ND	2.8	ND	NA	4.7	15*	0
Magnesium	87,150	71,100	69,600	65,100	75,200	73,600	NA	NA	NA
Manganese	3,340	3,210	3,350	3,000	3,410	3,260	577	840	5
Nickel	ND	36.4	ND	ND	13	24.7	**	730	0
Potassium	33,200	28,100	25,800	28,400	67,500	36,600	NA	NA	NA
Sodium	504,000	414,000	445,000	434,000	492,000	458,000	NA	NA	NA

Table 10.1.5
SWMU 1
Inorganics Detected in Groundwater

Compound	Nov. 93 Detection (μg/L)	Sep. 95 Detection (μg/L)	Apr. 96 Detection (μg/L)	Jun. 96 Detection (μg/L)	Oct. 96 Detection (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Tin	ND	ND	ND	ND	33.6	NA	**	22,000	0
Zinc	170	228	204	155	242	200	83.2	11,000	0
Other Parameters (Collected only during fourth quarter event)									
Chloride (mg/L)	—	—	—	—	847	NA	NA	NA	NA
Sulfate (mg/L)	—	—	—	—	334	NA	NA	NA	NA
TDS (mg/L)	—	—	—	—	2,150	NA	NA	NA	NA

Notes:
a = Lead does not have an RBC or MCL. Therefore, the USEPA Treatment Technique Action Level (TTAL) of 15 μg/L has been substituted for the RBC.
** = Number of nondetects prevented determination of UTL.
NA = Not applicable.
— = Parameter not sampled.

10.1.5.1 SWMU 1 - Soil to Groundwater Cross-Media Transport

As shown on Table 10.1.6, none of the organic constituents was reported at a concentration exceeding its soil-to-groundwater SSL. As shown on Table 10.1.7, three inorganics — antimony, chromium, and mercury — were identified for further evaluation of soil-to-groundwater migration based on the screening process presented in Section 6. None of these inorganics were detected in SWMU 1 groundwater (including all four quarters) at a concentration above its tap water RBC or background reference concentration. Antimony and mercury were each detected in a single surface soil sample at a concentration exceeding its SSL, but neither was detected in groundwater. Chromium was detected in surface and subsurface soil at concentrations exceeding its SSL, however, it was not reported at concentrations exceeding its background reference concentration in any soil sample. These findings indicate that soil concentrations of antimony, chromium, and mercury do not present a substantial or widespread threat to SWMU 1 groundwater.

10.1.5.2 SWMU 1 — Groundwater to Surface Water Cross-Media Transport

For purposes of fate and transport analysis, analytical results from the samples collected at SWMU 1 during 1993 were not evaluated along with those from the 1995-1996 sampling rounds because of the time-dependence of groundwater concentrations. Tables 10.1.6 and 10.1.7 compare maximum detected groundwater concentrations from four sampling rounds at one shallow well to tap water RBC, saltwater surface water chronic AWQCs, and background reference values for inorganics.

No organic compounds were detected in SWMU 1 groundwater samples. As shown in Table 10.1.7, manganese was detected in SWMU 1 shallow groundwater above both its tap water RBC and its background reference concentration. Additionally, zinc was detected above both its AWQCs and its background reference concentration. Manganese was reported in samples collected from monitoring well NBCA-002-002 in all four quarters at concentrations exceeding both its tap water RBC (840 μg/L) and its background reference value (2,690 μg/L). Zinc was

Table 10.1.6
Organic Compounds Detected in Surface Soil, Subsurface Soil, Sediment, and Shallow Groundwater
Comparison to Cross-media SSLs, Tap Water RBCs, and Saltwater Surface Water Chronic Screening Levels
NAVBASE-Charleston, Zone A: SWMU 1
Charleston, South Carolina

Parameter	Maximum Concentration					Screening Concentration *									
	Surface Soil	Subsurface Soil	Sediment	Shallow GW	Deep GW	Soil to GW	Soil to Air	Tap Water RBC	Saltwater Surf. Wtr. Chronic	Soil Units	Water Units	Leaching Potential	Volatil-ization Potential	Ground-water Migration Concern	Surface Water Migration Concern
Volatile Organic Compounds															
Acetone	90	110	NA	ND	NA	8000	1E+08	3700	NL	UG/KG	UG/L	NO	NO	NO	NO
2-Butanone	14	8.6	NA	ND	NA	3900 c	NDA	1900	NL	UG/KG	UG/L	NO	NO	NO	NO
Carbon disulfide	ND	2	NA	ND	NA	16000	720000	1000	NL	UG/KG	UG/L	NO	NO	NO	NO
Chlorobenzene	29	39	NA	ND	NA	700	130000	39	105	UG/KG	UG/L	NO	NO	NO	NO
Methylene Chloride	1.8	ND	NA	ND	NA	10	13000	4.1	2560	UG/KG	UG/L	NO	NO	NO	NO
Toluene	2.9	8.9	NA	ND	NA	6000	650000	750	37	UG/KG	UG/L	NO	NO	NO	NO
1,1,1-Trichlorethane	2.9	8.3	NA	ND	NA	1000	1200000	540	312	UG/KG	UG/L	NO	NO	NO	NO
Xylene (total)	2.6	5	NA	ND	NA	70000 c	320000	12000	NL	UG/KG	UG/L	NO	NO	NO	NO
Semivolatile Organic Compounds															
Benzo(a)pyrene equivalents															
Benzo(a)anthracene	120	ND	NA	ND	NA	800	NDA	0.092	NL	UG/KG	UG/L	NO	NO	NO	NO
Benzo(a)pyrene	110	ND	NA	ND	NA	4000	NDA	0.0092	NL	UG/KG	UG/L	NO	NO	NO	NO
Benzo(b)fluoranthene	150	ND	NA	ND	NA	2500	NDA	0.092	NL	UG/KG	UG/L	NO	NO	NO	NO
Benzo(k)fluoranthene	67	ND	NA	ND	NA	25000	NDA	0.92	NL	UG/KG	UG/L	NO	NO	NO	NO
Chrysene	140	ND	NA	ND	NA	80000	NDA	9.2	NL	UG/KG	UG/L	NO	NO	NO	NO
Indeno(1,2,3-cd)pyrene	97	ND	NA	ND	NA	7000	NDA	0.092	NL	UG/KG	UG/L	NO	NO	NO	NO
Benzo(g,h,i)perylene	98	ND	NA	ND	NA	120000000 c	NDA	1500	NL	UG/KG	UG/L	NO	NO	NO	NO
Fluoranthene	240	ND	NA	ND	NA	2100000	NDA	1500	1.6	UG/KG	UG/L	NO	NO	NO	NO
Phenanthrene	100	ND	NA	ND	NA	900000 c	NDA	1500	NL	UG/KG	UG/L	NO	NO	NO	NO
Pyrene	300	ND	NA	ND	NA	2100000	NDA	1100	NL	UG/KG	UG/L	NO	NO	NO	NO
Pesticides/PCB Compounds															
4,4'-DDD	8.5	ND	NA	ND	NA	8000	NDA	0.28	0.025	UG/KG	UG/L	NO	NO	NO	NO
4,4'-DDE	140	ND	NA	ND	NA	27000	NDA	0.2	0.14	UG/KG	UG/L	NO	NO	NO	NO
4,4'-DDT	26	ND	NA	ND	NA	16000	1E+09	0.2	0.001	UG/KG	UG/L	NO	NO	NO	NO

Explanations of screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Table 10.1.2.

* Screening Concentrations:
Soil to GW - Generic SSLs based on DAF = 10, adapted from USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or calculated using values from Table 6.2
Soil to Air - From USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or USEPA Region III Risk-Based Concentration Table, June 1996
Tap Water RBC - From USEPA Region III Risk-Based Concentration Table, October 1997
Salt Water Surface Water Chronic - From USEPA Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment, November 1995, Table 2

c - Calculated soil to groundwater SSL value (See Table 6.2)
GW - Groundwater
NA - Not available
ND - Not detected
NDA - No data available
NL - Not listed
RBC - Risk-based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
NG/KG - Nanograms per kilogram
UG/KG - Micrograms per kilogram
PG/L - Picograms per liter
UG/L - Micrograms per liter

Table 10.1.7
Inorganic Chemicals Detected in Surface Soil, Subsurface Soil, Sediment, and Shallow Groundwater
Comparison to Cross-media SSLs, Tap Water RBCs, Saltwater Surface Water Chronic Screening Levels, and Background Reference Values
NAVBASE-Charleston, Zone A: SWMU 1
Charleston, South Carolina

Parameter	Maximum Concentration				Screening Concentration *											
	Surface Soil	Subsurface Soil	Shallow GW	Deep GW	Soil to GW	Soil Background Reference	Soil to Air	Tap Water RBC	GW Background Reference	Saltwater Surf. Wtr. Chronic	Soil Units	Water Units	Leaching Potential	Fugitive Particulate Inhalation Concern	Ground-Water Migration Concern	Surface Water Migration Concern
Inorganic Chemicals																
Aluminum	7630	8010	50	NA	560000 c	28240	NA	37000	3210	NL	MG/KG	UG/L	NO	NO	NO	NO
Antimony	17.5	ND	ND	NA	2.5	ND	NA	15	ND	NL	MG/KG	UG/L	YES	NO	NO	NO
Arsenic	9.4	5.6	ND	NA	15	9.8	750	0.045	11.1	36	MG/KG	UG/L	NO	NO	NO	NO
Barium	98.4	19.6	34.1	NA	820	53	690000	2600	179	NL	MG/KG	UG/L	NO	NO	NO	NO
Cadmium	1.2	ND	0.48	NA	4	ND	1800	18	ND	9.3	MG/KG	UG/L	NO	NO	NO	NO
Chromium (total)	38.7	53	5.2	NA	19	63.4	270	180	8.7	103	MG/KG	UG/L	YES	NO	NO	NO
Cobalt	1.9	ND	6.3	NA	990 c	4.4	NA	2200	12.1	NL	MG/KG	UG/L	NO	NO	NO	NO
Copper	443	16.8	4.2	NA	5600 c	165	NA	1500	15.7	2.9	MG/KG	UG/L	NO	NO	NO	NO
Lead	7.1	10.4	2.8	NA	400	140	400	15	4.7	8.5	MG/KG	UG/L	NO	NO	NO	NO
Manganese	109	83	3410	NA	550 c	98.1	NA	840	2690	NL	MG/KG	UG/L	NO	NO	YES	NO
Mercury	14.8	0.24	ND	NA	1	0.3	10	11	ND	0.2	MG/KG	UG/L	YES	YES	NO	NO
Nickel	9	26.7	36.4	NA	65	35	13000	730	21.1	42	MG/KG	UG/L	NO	NO	NO	NO
Selenium	ND	1.4	ND	NA	2.5	1.7	NA	180	ND	71	MG/KG	UG/L	NO	NO	NO	NO
Vanadium	55	30.2	ND	NA	3000	77.3	NA	260	10.9	NL	MG/KG	UG/L	NO	NO	NO	NO
Tin	ND	ND	33.6	NA	5500 c	ND	NA	22000	NA	NL	MG/KG	UG/L	NO	NO	NO	NO
Zinc	369	65.3	242	NA	6200	208	NA	11000	83.2	86	MG/KG	UG/L	NO	NO	NO	YES

Explanations of screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.1.3 and 10.1.5.

* Screening Concentrations:
Soil to GW - Generic SSLs based on DAF = 10, adapted from USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or calculated using values from Table 6.2
Soil to Air - From USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or USEPA Region III Risk-Based Concentration Table, June 1996
Tap Water RBC - From USEPA Region III Risk-Based Concentration Table, October 1997
Salt Water Surface Water Chronic - From USEPA Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment, November 1995, Table 2
Background reference values for soil are shown for comparison purposes only.
Maximum groundwater concentrations are screened against the greater of tap water RBCs or corresponding background reference values to determine groundwater migration concern.

c - Calculated soil to groundwater SSL value (See Table 6.2)
GW - Groundwater
NA - Not available/Not applicable
ND - Not detected
NL - Not listed
RBC - Risk-based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
UG/L - Micrograms per liter

reported in samples collected from monitoring well NBCA-002-002 in all four quarters at concentrations exceeding both its AWQC (86 μg/L) and its background reference value (83.2 μg/L).

10.1.5.3 SWMU 1 — Soil to Air Cross-Media Transport

As shown on Table 10.1.7, mercury was reported in surface soil at concentrations exceeding its soil-to-air SSL. Mercury was detected in only one surface soil sample (S01SB002 at 14.8 mg/kg) at concentrations marginally exceeding its soil-to-air SSL (10 mg/kg). As a result, mercury was not considered to be a significant contributor via the soil-to-air pathway.

10.1.5.4 SWMU 1 — Fate and Transport Summary

No significant soil-to-groundwater constituent migration was identified for SWMU 1. Zinc was detected in groundwater at concentrations exceeding its saltwater surface water chronic AWQCs.

10.1.6 Human Health Risk Assessment for SWMU 1

10.1.6.1 Site Background and Investigative Approach

SWMU 1 was formerly used by the Defense Reutilization and Marketing Office (DRMO) as a storage area for waste material amassed as a result of local armed forces activities. The portion of this waste considered hazardous was stored in a shed formerly known as Building 1617. SWMU 1 was granted clean closure for soils in 1993 based on human health risk based clean-up goals developed in *Risk Assessment and Development of Risk-based Clean-up Goals for the Charleston Naval Shipyard* (Gradient 1991 and subsequent revisions). Results from the SWMU 1 soil and groundwater samples collected during the Zone A RFI substantiated the 1993 clean closure decision. Section 10.1.1 contains a soil sampling summary and Section 10.1.3 contains a groundwater sampling summary for SWMU 1.

10.1.6.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 of this RFI, BEQ and mercury were identified as COPCs.

Groundwater

Manganese was identified as a shallow groundwater COPC for this site.

10.1.6.3 Exposure Assessment

Exposure Setting

The future use of this SWMU is unknown, although it is in a section of NAVBASE currently slated to become a marine cargo terminal in base reuse plans.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are hypothetical future site residents. Future site resident and worker exposure scenarios were addressed in this risk assessment. The hypothetical future site worker scenario assumed continuous exposure to surface soil conditions and the use of shallow groundwater as a potable water source. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact and the fact that groundwater is not currently used onsite as a source of potable or process water. Therefore, future worker assessment is considered to be protective of current site users. The future site resident scenario was built on the premise that current buildings would be removed and replaced with dwellings. In addition, the future site residents were assumed to use the shallow aquifer onsite as a source of drinking water.

Exposure Pathways

Exposure pathways for the site workers are dermal contact, incidental ingestion of surface soils, and ingestion of shallow groundwater through potable use. The exposure pathways for future residential land use are the same as those for the future site worker. In addition, the hypothetical future site worker scenario assumed continuous exposure to surface soil and groundwater conditions. Uniform exposure was assumed for all sample locations. Table 10.1.8 presents the justification for exposure pathways assessed in this HHRA.

Table 10.1.8
Exposure Pathways Summary — SWMU 1
NAVBASE — Zone A
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
	Current Land Uses		
Current Site Users/Maintenance	Air, Inhalation of gaseous contaminants emanating from soil	No	No COPCs were identified based on screening comparisons summarized in the Fate and Transport Section.
	Air, Inhalation of chemicals entrained in fugitive dust	No	No COPCs were identified based on screening comparisons summarized in the Fate and Transport Section.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No (Qualified)	Shallow groundwater is not currently used as a source of potable or nonresidential water at SWMU 1. Future land use assessment is considered conservatively representative of current receptors.
	Shallow groundwater, Inhalation of volatilized shallow groundwater contaminants	No (Qualified)	Shallow groundwater is not currently used as a source of domestic or process use water at SWMU 1. Future land use assessment is considered conservatively representative of current receptors.
	Soil, Incidental ingestion	No (Qualified)	Future land use assessment is considered to be conservatively representative of current receptors.
	Soil, Dermal contact	No (Qualified)	Future land use assessment is considered conservatively representative of current receptors.

Table 10.1.8
Exposure Pathways Summary — SWMU 1
NAVBASE — Zone A
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
		Future Land Uses	
Future Site Residents (Child and Adult) and Future Site Worker	Air, Inhalation of gaseous contaminants emanating from soil	No	No COPCs were identified based on screening comparisons summarized in the Fate and Transport Section.
	Air, Inhalation of chemicals entrained in fugitive dust	No	No COPCs were identified based on screening comparisons summarized in the Fate and Transport Section.
	Shallow groundwater, Ingestion of contaminants during potable or general use	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	Yes	COPCs were identified subsequent to risk-based screening comparisons.
	Soil, Incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, Dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals, Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina city limits.
	Fruits and vegetables, Ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Exposure Point Concentrations

As discussed in Section 7 of this RFI, UCLs were calculated for datasets consisting of at least 10 samples. Benzo(a)pyrene equivalents and mercury each had only three sample results, and as a result, the maximum concentration was used as the EPC for these constituents.

One shallow monitoring well was installed at this site and sampled once a quarter for four quarters. The maximum manganese concentration was used as the EPC.

Quantification of Exposure

Soil

CDIs for ingestion and dermal contact with soils are shown in Tables 10.1.9 and 10.1.10, respectively.

Groundwater

The CDIs for groundwater ingestion are presented in Table 10.1.11.

10.1.6.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Table 10.1.12 presents toxicological information specific to each COPC identified at SWMU 1. This information was used in the quantification of risk/hazard associated with soil and groundwater contaminants. Brief toxicological profiles for each COPC are provided in the following paragraphs.

Benzo(a)pyrene equivalents include the following list of polynuclear aromatic hydrocarbons:

Benzo(a)anthracene	TEF	0.1
Benzo(b)fluoranthene	TEF	0.1
Dibenz(a,h)anthracene	TEF	1.0
Benzo(k)fluoranthene	TEF	0.01
Benzo(a)pyrene	TEF	1.0
Indeno(1,2,3-cd)pyrene	TEF	0.1
Chrysene	TEF	0.001

Table 10.1.9
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil
SWMU 1
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Fraction Ingested from Contaminated Source *	Exposure Point Concentration (mg/kg)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Future Worker adult H-CDI (mg/kg-day)	Future Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene equivalents	1	0.148	2.03E-07	1.89E-06	2.32E-07	7.24E-08	2.59E-08
Mercury	1	15	2.03E-05	1.89E-04	2.32E-05	7.24E-06	2.59E-06

NOTES:

lwa	Lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI	Chronic Daily Intake in mg/kg-day
H-CDI	CDI for hazard quotient
C-CDI	CDI for excess cancer risk
*	Reflects the estimated fraction of the site impacted by the corresponding COPC.
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day

Table 10.1.10
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil
SWMU 1
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Exposure Point Concentration (mg/kg)	Fraction Contacted from Contaminated Source *	Dermal Absorption Factor (unitless)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Future Worker adult H-CDI (mg/kg-day)	Future Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene equivalents	0.148	1	0.01	8.31E-08	2.74E-07	5.20E-08	5.94E-08	2.12E-08
Mercury	14.8	1	0.001	8.31E-07	2.74E-06	5.20E-07	5.94E-07	2.12E-07

NOTES:

CDI	Chronic Daily Intake in mg/kg-day
H-CDI	CDI for hazard quotient
C-CDI	CDI for excess cancer risk
-	The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
*	Reflects the estimated fraction of the site impacted by the corresponding COPC.
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day

Table 10.1.11
Chronic Daily Intakes (CDI)
Ingestion of COPCs in Shallow Groundwater
SWMU 1
Naval Base Charleston, Zone A
Charleston, SC

Chemical	Exposure Point Concentration (mg/liter)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Future Worker adult H-CDI (mg/kg-day)	Future Worker adult C-CDI (mg/kg-day)
Manganese	3.4	9.34E-02	2.18E-01	5.14E-02	3.34E-02	1.64E-02

NOTES:

lwa Lifetime weighted average
CDI Chronic Daily Intake
H-CDI Non-carcinogenic hazard based Chronic Daily Intake
C-CDI Carcinogenic risk based Chronic Daily Intake
mg/kg-day milligrams per kilogram per day

Table 10.1.12
Toxicological Database Information
for Chemicals of Potential Concern
SWMU 1
NAVBASE Charleston, Zone A

Non-Carcinogenic Toxicity Data

Chemical	Oral Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Inhalation
Benzo(a)pyrene Equivalents	ND				ND	ND				ND
Manganese (food)	0.047	a	NA	neurological effects	1	ND				ND
Manganese (water)	0.023	a	NA	neurological effects	1	1.43E-05	a	M	neurological effects	1000
Mercury	0.0003	b	NA	Autoimmune effects	30	8.6E-05	c			

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d USEPA Region III Screening Tables
e EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
f Withdrawn from IRIS or HEAST
NA Not applicable or not available
ND Not determined due to lack of information

Table 10.1.12 (continued)
Toxicological Database Information
for Chemicals of Potential Concern
SWMU 1
NAVBASE Charleston, Zone

Carcinogenic Toxicity Data

Chemical	Oral Slope Factor [(mg/kg/day)]-1		Inhalation Slope Factor [(mg/kg/day)]-1	Weight of Evidence	Tumor Type
Benzo(a)pyrene Equivalents	7.3	a		B2	mutagen
Manganese (food)	ND		ND	D	
Manganese (water)	ND		ND	D	
Mercury	ND		ND		

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d USEPA Region III Screening Tables
e EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
f Withdrawn from IRIS or HEAST
NA Not applicable or not available
ND Not determined due to lack of information

Some PAHs are toxic to the liver, kidney, and blood. However, the toxic effects of the PAHs above have not been well established. There are no RfDs for the PAHs above due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of benzo(a)pyrene, having an oral SF 7.3 $(mg/kg\text{-}day)^{-1}$. Toxicity Equivalency Factors, also set by USEPA, are multipliers that are applied to the detected concentrations, which are subsequently used to calculate excess cancer risk. These multipliers are discussed further in the exposure and toxicity assessment sections. Most carcinogenic PAHs have been classified as carcinogenic due to animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke). As listed in IRIS, the basis for the benzo(a)pyrene B2 classification is human data specifically linking benzo(a)pyrene to a carcinogenic effect are lacking. There are, however, multiple animal studies in many species demonstrating benzo(a)pyrene to be carcinogenic by numerous routes.

Benzo(a)pyrene has produced positive results in numerous genotoxicity assays. At the June 1992 CRAVE Work Group meeting, a revised risk estimate for benzo(a)pyrene was verified (see Additional Comments for Oral Exposure). This section provides information on two aspects of the carcinogenic risk assessment for the agent in question: the USEPA classification and quantitative estimates of exposure. The classification reflects a weight-of-evidence judgment of the likelihood that the agent is a human carcinogen. The quantitative risk estimates are presented in application of a low-dose extrapolation procedure and presented as the risk per (mg/kg)-day. The unit risk is the quantitative estimate in terms of either risk per $\mu g/L$ drinking water or risk per $\mu g/m^3$ air breathed. The third form in which risk is presented is drinking water or air concentration providing cancer risks of 1 in 10,000 or 1 in 1,000,000. The Carcinogenicity Background Document provides details on the carcinogenicity values found in IRIS. Users are

referred to the Oral Reference Dose and Reference Concentration sections for information on long-term toxic effects other than carcinogenicity.

As listed in IRIS, the basis for the dibenz(a,h)anthracene and benzo(b)fluoranthene B2 classification is no human data and sufficient data from animal bioassays. Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal or subcutaneous injection, and skin painting. As listed in IRIS (search date 6/28/95), the basis for the benzo(a)anthracene B2 classification is no human data and sufficient data from animal bioassays. Benzo(a)anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous or intramuscular injection; and topical application. Benzo(a)anthracene produced mutations in bacteria and in mammalian cells, and transformed mammalian cells in culture. As listed in IRIS (search date 6/28/95) the basis for the benzo(k)fluoranthene B2 classification is no human data and sufficient data from animal bioassays. Benzo(k)fluoranthene produced tumors after lung implantation in mice and when administered with a promoting agent in skin-painting studies. Equivocal results have been found in a lung adenoma assay in mice. Benzo(k)fluoranthene is mutagenic in bacteria. (Klaassen, et al., 1986).

Other PAHs — those not classified by USEPA as carcinogens — are toxic to the liver, kidney and blood. This group of PAHs includes compounds such as *pyrene*, *acenaphthene, acenaphthylene*, *benzo(g,h,i)perylene*, and *phenanthrene*. USEPA determined RfDs for only two of these compounds: pyrene's RfD_o of 0.03 mg/kg-day is also used as a surrogate RfD_o for phenanthrene. The RfD_o for acenaphthene was 0.06 mg/kg-day.

Manganese is an essential nutrient. Chronic exposure to manganese, 0.8 mg/kg-day, causes mental disturbances and various central nervous system effects. Studies have shown that manganese uptake from water is greater than manganese uptake from food, and the elderly appear to be more sensitive than children. The oral RfD is 0.14 mg/kg-day with uncertainty and

modifying factors of 1. When assessing the potential for adverse health effects from nondietary intakes (ingestion of soil or drinking water) of manganese, a modifying factor of 3 is used which gives an oral RfD of 0.047 mg/kg-day. Inhalation of manganese dust causes neurological effects and increased incidence of pneumonia, and an inhalation RfD was set to 0.0000143 mg/kg-day. According to USEPA, manganese can not be classified as to its carcinogenicity. Therefore, the cancer class for manganese is group D. The typical vitamin supplement dose of manganese is 2.5 mg/day (Klaassen, et al, 1986) (Dreisbach, et al, 1987).

Mercury The major source of this element is the degassing of the earth's crust. Target organs of mercury include the kidney, nervous system, fetus, and neonate. In other words, this inorganic can be toxic to a fetus if the mother is exposed during pregnancy. Mercury is toxic to all cells in the body- it binds to enzymes in the cells and disrupts their function, usually causing the cell to be useless or die. Because this inorganic is concentrated in the kidney prior to excretion, the kidney is a major target organ for mercury ingestion. The primary target of mercury vapor is the brain. USEPA has set an inhalation RfD of 8.6E-05 mg/kg-day. Some forms of mercury are drawn towards fats in the body (such as the nervous system), where the form is changed into its toxic form. This causes the nervous disorder known as Minimata disease, overexposure to mercury through ingestion of contaminated fish. The weight of evidence classification for mercury is "D" not classifiable as to human carcinogenicity. USEPA set mercury's oral RfD to 0.0003 mg/kg-day (mercuric chloride). Mercury is liquid at room temperature, and is poorly absorbed in this form if ingested. Typical daily exposure is less than 1 μg/l-day (Klaassen, et al, 1986) (Dreisbach, et al, 1987).

10.1.6.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under both residential and site worker scenarios. For these scenarios, incidental ingestion and dermal contact exposure pathways were evaluated.

For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.1.13 and 10.1.14 present the computed carcinogenic risks and/or HQs associated with incidental ingestion of and dermal contact with site surface soils, respectively.

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime weighted average) for SWMU 1 surface soils is 2E-06. The dermal pathway ILCR is 8E-07. Benzo(a)pyrene equivalents were the primary contributors to both the ingestion and dermal pathways.

The computed hazard indices for the adult resident were 0.07 for the soil ingestion pathway and 0.01 for the dermal contact pathway. The computed hazard indices for the child ingestion and dermal contact pathways were 0.6 and 0.05, respectively. The primary contributor to the hazard index was mercury.

Hypothetical Site Workers

Site worker ILCRs are 2E-7 and 3E-7 for the ingestion and dermal contact pathways, respectively. Benzo(a)pyrene equivalents were the primary contributors for each pathway. Hazard indices for the ingestion and dermal pathways were both projected to be less than 0.1 for the hypothetical site worker scenario.

Groundwater Pathways

Exposure to shallow groundwater onsite was evaluated under both residential and industrial scenarios. The ingestion exposure pathway was evaluated assuming that site groundwater will be used for potable and/or domestic purposes and that an unfiltered well, drawing from the corresponding water-bearing zone, will be installed. For noncarcinogenic contaminants evaluated

Table 10.1.13
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
SWMU 1
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Future Worker adult Hazard Quotient	Future Worker adult ILCR
Benzo(a)pyrene equivalent	NA	7.3	ND	ND	1.7E-06	ND	1.9E-07
Mercury	0.0003	NA	0.068	0.63	ND	0.024	ND
SUM Hazard Index/ILCR			0.07	0.6	2E-06	0.02	2E-07

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk
mg/kg-day milligrams per kilogram per day

Table 10.1.14
'zard Quotients and Incremental Lifetime Cancer Risks
.rmal Contact With Surface Soil
SWMU 1
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Future Worker adult Hazard Quotient	Future Worker adult ILCR
Benzo(a)pyrene equivalent	0.5	NA	14.6	ND	ND	7.6E-07	ND	3.1E-07
Mercury	0.2	6E-05	NA	0.014	0.046	ND	0.0099	ND
SUM Hazard Index/ILCR				0.01	0.05	8E-07	0.01	3E-07

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk
- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)
mg/kg-day milligrams per kilogram per day

relative to future site residents, hazard was computed separately for child and adult receptors. Table 10.1.15 presents the risk and hazard for the ingestion exposure pathways.

Hypothetical Site Residents

The hazard indices for the adult and child resident are 2 and 5, respectively with manganese being the primary contributor to the hazard index.

Hypothetical Site Workers

The hazard index for the ingestion exposure pathway was calculated to be 0.7.

Current Site Workers

Shallow groundwater is not currently used as a potable water source for SWMU 1 or other areas of Zone A. In the absence of a completed exposure pathway, no threat to human health is posed by reported shallow groundwater contamination.

COCs Identified

Chemicals of concern were identified based on cumulative risk and hazard projected for this site, as shown in Table 10.1.16. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a hazard index threshold of 1.0 (unity). In accordance with SCDHEC guidance, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or greater and/or a cumulative hazard index above 1.0, if its individual ILCR exceeds 1E-6 or whose hazard quotient exceeds 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used to provide a more comprehensive evaluation of chemicals contributing to carcinogenic risk or noncarcinogenic hazard during the remedial goal options development process. Table 10.1.16 presents the COCs identified on a medium-specific basis.

Table 10.1.15
Hazard Quotients and Incremental Lifetime Cancer Risks
Shallow Groundwater Ingestion
SWMU 1
Naval Base Charleston, Zone A
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Future Worker adult Hazard Quotient	Future Worker adult ILCR
Manganese	0.047	NA	2.0	4.6	ND	0.71	ND
SUM Hazard Index/ILCR			2	5	ND	0.7	ND

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk
mg/kg-day milligrams per kilogram per day

Table 10.1.16
Summary of Risk and Hazard-Based COCs
SWMU 1
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Medium	Exposure Pathway		Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident Iwa ILCR	Site Worker Hazard Quotient	Site Worker ILCR	Identification of COCs
Surface Soil	Incidental Ingestion	Benzo(a)pyrene equivalents	ND	ND	1.7E-06	ND	1.9E-07	2
		Mercury	0.068	0.63	ND	0.02414	ND	
	Dermal Contact	Benzo(a)pyrene equivalents	ND	ND	7.6E-07	ND	3.1E-07	
		Mercury	0.014	0.046	ND	0.00990	ND	
Surface Soil Pathway Sum			0.1	0.7	2E-06	0.03	5E-07	
Groundwater	Ingestion	Manganese	2.0	4.6	ND	0.71	ND	1
Groundwater Pathway Sum			2	5	ND	0.7	ND	
Sum of All Pathways			2	5	2E-06	0.7	5E-07	

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental lifetime cancer risk
HI indicates hazard index
1- Chemical is a COC by virtue of projected child residence noncarcinogenic hazard.
2- Chemical is a COC by virtue of projected future resident lifetime ILCR.
3- Chemical is a COC by virtue of projected site worker noncarcinogenic hazard.
4- Chemical is a COC by virtue of projected site worker ILCR.

Surface Soils

Hypothetical Site Residents

Benzo(a)pyrene equivalents were identified as the soil pathway COCs based on their contribution to cumulative ILCR projections.

Hypothetical Site Workers

No COCs were identified.

Groundwater

Hypothetical Site Residents (future land use)

Manganese was identified as a shallow groundwater COC based on its contribution to hazard index.

10.1.6.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure.

Residential use of the site would not be expected, based on current site uses and the nature of surrounding buildings. Current reuse plans call for continued commercial/industrial use of Zone A, specifically as a marine cargo terminal. If this area were to be used as a residential site, the buildings and other structures would be demolished, and the surface soil conditions would likely change — the soils would be covered with landscaping soil and/or a house. Consequently, exposure to current surface soil conditions would not be likely under a true future residential scenario. Current site worker's contact with impacted media is much less than is assumed in the

exposure model that is used to assess this pathway. Direct contact to soil is limited due to paved areas and buildings, and groundwater is not currently used as a source of potable or process water. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to current site workers and future site residents.

A basewide system provides drinking and process water to buildings throughout Zone A. This system is slated to remain in operation under the current base reuse plan. As a result, shallow groundwater would not be expected to be used under future site use scenarios. Therefore, the scenario established to project risk/hazard associated with shallow groundwater exposure is highly conservative, and associated pathways are not expected to be completed in the future.

Determination of Exposure Point Concentrations

The maximum soil and groundwater concentrations were used as the exposure point concentrations for this site. The maximum concentration provides a reasonable upper-bound representation of the exposure point concentration.

Groundwater

Groundwater is not currently used as a potable water source at SWMU 1, nor is it used at NAVBASE or in the surrounding area. Municipal water is readily available. As previously mentioned, it is highly unlikely that the site will be developed as a residential area, and it is unlikely that a potable-use well would be installed onsite. It is probable that, if residences were constructed onsite and an unfiltered well were installed, its salinity and dissolved solids would preclude this aquifer from being an acceptable potable water source.

10.1.6.7 Risk Summary

The risk and hazard posed by contaminants at SWMU 1 were assessed for the hypothetical site worker and the hypothetical future site resident under reasonable maximum exposure assumptions.

In surface soils, the incidental ingestion and dermal contact pathways were assessed in this HHRA. The ingestion pathway was evaluated for shallow groundwater based on four quarters of groundwater monitoring data. Table 10.1.17 presents the risk summary for each pathway/receptor group evaluated for SWMU 1.

10.1.6.8 Remedial Goal Options

Soil

Soil RGOs based on the site resident or site workers are presented in Table 10.1.18.

Groundwater

Groundwater RGOs based on site residents are shown in Table 10.1.19.

10.1.7 Corrective Measures Considerations

For SWMU 1, the environmental media investigated were surface soil and shallow groundwater. Based upon the analytical results, there is no evidence of site-related contamination associated with SWMU 1. Benzo(a)pyrene was detected above the RBC in one soil sample at SWMU 1. BEQs for this sample exceeded the benzo(a)pyrene RBC of 88 μg/kg with a detection of 148 μg/kg. The isolated nature of this exceedance is demonstrated by other samples in the vicinity which were nondetect for BEQs. Given these facts, the risk associated with this individual sample is considered acceptable and will not require further evaluation through the CMS process.

Any COCs that may require further evaluation through the CMS process are metals that can be evaluated along with the greater SWMU 2 area of contamination. Therefore, no further action is recommended for SWMU 1, although further action at SWMU 2 could include this area.

Table 10.1.17
Summary of Risk and Hazard
SWMU 1
Naval Base Charleston, Zone A
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.07	0.6	2E-06	0.02	2E-07
	Dermal Contact	0.01	0.05	8E-07	0.01	3E-07
Groundwater	Ingestion	2	5	ND	0.7	ND
Sum of All Pathways		2	5	2E-06	0.7	5E-07

Notes:
ILCR Indicates incremental excess lifetime cancer risk
HI Indicates hazard index
LWA Lifetime weighted average

Table 10.1.18
Remedial Goal Options For Surface Soil
SWMU 1
Naval Base Charleston, Zone A
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	FI/FC Factor	EPC mg/kg	Hazard-Based Remedial Goal Options **3** mg/kg	**1** mg/kg	**0.1** mg/kg	Risk-Based Remedial Goal Options **1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentration mg/kg
Benzo(a)pyrene equivalents	7.3	NA	1	0.1	ND	ND	ND	0.060	0.60	6.0	NA

Worker-Based Remedial Goal Options

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	FI/FC Factor	EPC mg/kg	Hazard-Based Remedial Goal Options **3** mg/kg	**1** mg/kg	**0.1** mg/kg	Risk-Based Remedial Goal Options **1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentration mg/kg
Benzo(a)pyrene equivalents	7.3	NA	1	0.1	ND	ND	ND	0.30	3.0	30	NA

NOTES:

FI/FC Fraction ingested / fraction contaminated
EPC Exposure point concentration
NA Not applicable
ND Not determined
- Remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident or site worker for noncarcinogens
mg/kg-day milligrams per kilogram per day
mg/kg milligrams per kilogram

Table 10.1.19
Remedial Goal Options for Shallow Groundwater
SWMU 1
Naval Base Charleston, Zone A
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Oral SF (mg/kg-day)-1	Oral RfD (mg/kg-day)	EPC mg/l	Hazard-Based Remedial Goal Options **0.1** mg/l	**1.0** mg/l	**3** mg/l	Risk-Based Remedial Goal Options **1E-06** mg/l	**1E-05** mg/l	**1E-04** mg/l	MCL mg/l	Background Concentration mg/l
Manganese	NA	0.047	3.41	0.074	0.74	2.2	ND	ND	ND	NA	0.577

NOTES:

EPC Exposure point concentration
NA Not applicable
ND Not determined
- Remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident for noncarcinogens
mg/kg-day milligrams per kilogram per day
mg/l milligrams per liter

The 1995 soil samples from within the SWMU 1 boundary were analyzed for the standard suite of parameters, which includes: metals, VOCs, SVOCs, cyanide, pesticides, and PCBs at DQO Level III. Table 10.1.1 summarizes soil sampling at SWMU 1.

Table 10.1.1
SWMU 1
Soil Sampling Summary

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
1995 RFI SAMPLING EVENT					
Upper (0' to 1')	1	1	Standard Suite[a]	Standard Suite[a]	None
Lower (3' to 5')	1	1	Standard Suite[a]	Standard Suite[a]	None
1993 SAMPLING EVENT					
Upper (0' to 1')	2	2	Standard Suite[a]	Standard Suite[a]	NA
Lower (3' to 5')	2	2	Standard Suite[a]	Standard Suite[a]	NA

Notes:
a = Standard suite includes VOCs, SVOCs, metals, cyanide, pesticides, and PCBs.
NA = Not applicable.

10.2 SWMU 2, Lead Contamination Area

SWMU 2 consists of salvage bin No. 3 and the adjacent paved ground surface at the DRMO facility. The area was used to store recovered lead from lead-acid submarine batteries from the mid-1960s until 1984. Electrodes and associated internal metallic components were removed from the battery jars in the battery electrode treatment area, SWMU 5 in Zone E. Recovered materials were then placed on a railcar and transferred to the DRMO area for storage and eventual sale to a salvage contractor. Extensive sampling has been conducted at SWMU 2 from 1986 to present, and the site has been designated for an RFI because of the historical lead concentrations in surrounding media. Due to contaminant migration via surface water runoff, the investigation area for SWMU 2 has been expanded to cover a larger area, which also includes SWMU 1 (Section 10.1).

Materials of concern at SWMU 2, identified in the *Final Zones A and B RFI Work Plan*, are lead-acid batteries. Potential receptors include current and future site users involved in invasive activities. The Cooper River is also a potential receptor of contaminated surface water runoff and groundwater discharges.

Soil, sediment, and groundwater were sampled in accordance with the *Final Zones A and B RFI Work Plan* and as discussed in Section 3 of this report to fulfill RFI objectives for SWMU 2.

10.2.1 Soil Sampling and Analysis

Extensive soil, sediment, and groundwater sampling has been conducted to delineate the extent of contamination at SWMU 2 resulting in three datasets for the SWMU 2 vicinity.

1986 Sampling Event

According to the *Final Contamination and Exposure Assessment for the Lead Contamination within the DRMO* (Environmental Science and Engineering, October 1986), 71 samples were

collected from the DRMO site — 35 samples consisted of surficial soil (surface to 6 inches) and the remaining 36 samples were collected at various depth intervals from 10 separate soil borings (total depth of 7.5 feet to 10 feet bgs). Because this sampling was conducted outside of the RFI process and lacks detailed QA/QC documentation, the lead concentrations from these samples can only be used as "screening" data. Figure 10.2.1 indicates the locations of these sample points, and Table 10.2.1 summarizes the lead concentrations detected in these samples.

Table 10.2.1
SWMU 2 — Lead Concentrations
"Screening" Data from 1986 Sampling Event

Sample Location	Depth (feet)	Lead Conc. (mg/kg)	Sample Location	Depth (feet)	Lead Conc. (mg/kg)
SS-1	0 - 0.5	69.2	B1-S	0 - 0.5	4,040
SS-2	0 - 0.5	2.72	B1-1	3.0 - 4.5	3.85
SS-3	0 - 0.5	< 1.3	B1-2	6.0 - 7.5	1.3
SS-4	0 - 0.5	28.5	B1-3	8.5 - 10.0	2.63
SS-5	0 - 0.5	137	B2-S	0 - 0.5	5,000
SS-6	0 - 0.5	< 1.3	B2-1	3.0 - 4.5	101
SS-7	0 - 0.5	20.7	B2-2	6.0 - 7.5	2.13
SS-8	0 - 0.5	6.7	B2-3	8.5 - 10.0	6.98
SS-9	0 - 0.5	8.17	B3-S	0 - 0.5	5,600
SS-10	0 - 0.5	68.7	B3-1	3.0 - 4.5	64.2
SS-11	0 - 0.5	126	B3-2	6.0 - 7.5	24.4
SS-12	0 - 0.5	< 1.3	B3-3	8.5 - 10.0	17.5
SS-13	0 - 0.5	< 1.3	B4-S	0 - 0.5	48,600
SS-14	0 - 0.5	43	B4-1	3.0 - 4.5	1,310
SS-15	0 - 0.5	371	B4-2	6.0 - 7.5	411
SS-16	0 - 0.5	286	B4-3	8.5 - 10.0	2,480
SS-17	0 - 0.5	266	B5-S	0 - 0.5	39,200

Table 10.2.1
SWMU 2 — Lead Concentrations
"Screening" Data from 1986 Sampling Event

Sample Location	Depth (feet)	Lead Conc. (mg/kg)	Sample Location	Depth (feet)	Lead Conc. (mg/kg)
SS-18	0 - 0.5	424	B5-1	3.0 - 4.5	49
SS-19	0 - 0.5	< 1.3	B5-2	6.0 - 7.5	34.1
SS-20	0 - 0.5	40.4	B6-S	0 - 0.5	6,430
SS-21	0 - 0.5	54	B6-1	3.0 - 4.5	14.2
SS-22	0 - 0.5	328	B6-2	6.0 - 7.5	346
SS-23	0 - 0.5	717	B7-S	0 - 0.5	29,500
SS-24	0 - 0.5	488	B7-1	3.0 - 4.5	536
SS-25	0 - 0.5	32.7	B7-2	6.0 - 7.5	1,090
SS-26	0 - 0.5	371,000	B8-S	0 - 0.5	2,780
SS-27	0 - 0.5	10,500	B8-1	3.0 - 4.5	174
SS-28	0 - 0.5	107,000	B8-2	6.0 - 7.5	< 1.3
SS-29	0 - 0.5	1,260	B9-S	0 - 0.5	3,820
SS-30	0 - 0.5	9,320	B9-1	3.0 - 4.5	42.9
SS-31	0 - 0.5	2,810	B9-2	6.0 - 7.5	11.3
SS-32	0 - 0.5	907	B9-3	8.5 - 10.0	39.7
SS-33	0 - 0.5	298	B10-S	0 - 0.5	518
SS-34	0 - 0.5	533	B10-1	3.0 - 4.5	48.1
SS-35	0 - 0.5	411	B10-2	6.0 - 7.5	3.95
			B10-3	8.5 - 10.0	1.62

Notes:
SS = Surficial soil sample collected.
B = Soil boring sampled at multiple intervals.

Ten percent of these locations were resampled during the implementation of the *Zones A and B RFI Work Plan* (E/A&H, September 1995). Table 10.2.2 compares the lead concentrations for the locations that were sampled in 1986 and 1995.

Table 10.2.2
SWMU 2 — Lead Concentrations
Comparison of Resampled Locations

1986 Dataset			1995 Resampling Dataset		
Sample ID	**Depth (feet)**	**Lead (mg/kg)**	**Sample ID**	**Depth (feet)**	**Lead (mg/kg)**
SS-5	0 - 0.5	137	002SB02701	0 - 1.0	6.8
SS-21	0 - 0.5	54	002SB02401	0 - 1.0	3.7
SS-30	0 - 0.5	9,320	002SB01601	0 - 1.0	97.6
SS-32	0 - 0.5	907	002SB01301	0 - 1.0	46.2
B4-S	0 - 0.5	48,600	002SB02301	0 - 1.0	427
B4-1	3.0 - 4.5	1,310	002SB02302	3.0 - 5.0	7.8

Based upon the comparison of the data shown above, the lead concentrations detected in the 1986 sampling event were greater than those in any of the samples collected in 1995. The difference in concentrations further supports the use of the 1986 data as "screening" level data only because the concentrations do not represent the current status of the lead contamination in site soil.

1993 Sampling Event

After Hurricane Hugo impacted the lead distribution onsite in 1989, samples were collected in 1993 to investigate soil and groundwater near this SWMU. Twenty-five soil borings and six shallow monitoring wells were installed. Additionally, 11 sediment samples were collected from the Cooper River and the storm sewer system in the vicinity.

This investigation was conducted by E/A&H and the data are of sufficient quality to be included in the RFI process. In February 1995, a representative portion of the data collected during this event was submitted to USEPA for validation, along with a written description of sample collection procedures. The 1995 sampling included duplicating 10% of the 1993 locations for further QA/QC. Table 10.2.3 compares the lead concentrations for the locations that were sampled in 1993 and 1995.

Table 10.2.3
SWMU 2 — Lead Concentrations
Comparison of Resampled Locations

1993 Dataset			1995 Resampling Dataset		
Sample ID[a]	**Depth (feet)**	**Lead (mg/kg)**	**Sample ID**	**Depth (feet)**	**Lead (mg/kg)**
S01SB00101	0 - 1.0	7.1	001SB00101	0 - 1.0	6.4
S01SB00102	3.0 - 5.0	5.4	001SB00102	3.0 - 5.0	9.2
S02SB00701	0 - 1.0	310	002SB00601	0 - 1.0	36.7
S02SB00702	3.0 - 5.0	23	002SB00602	3.0 - 5.0	45.3
S02SB01301	0 - 1.0	79	002SB02601	0 - 1.0	75.4
S02SB01302	3.0 - 5.0	3.7	002SB02602	3.0 - 5.0	7.0
S02SB01501	0 - 1.0	1,400	002SB00101	0 - 1.0	194
S02M000701	0 - 1.0	47	002M000101	0 - 1.0	15.2
S02M000901	0 - 1.0	26.9	002M000201	0 - 1.0	26.4

Note:
a = 1993 sample identification numbers have been reformatted to fit the 10-character scheme required for inclusion in the analytical database.

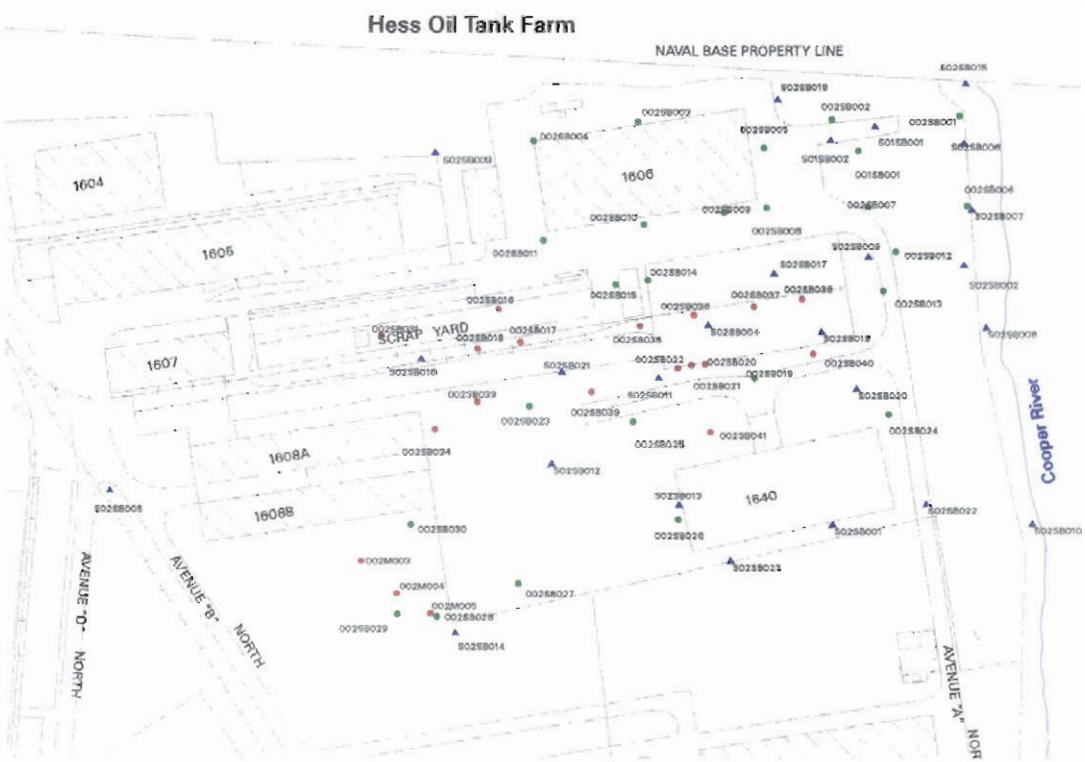
Based upon the comparison of the data shown above, the lead concentrations detected in the 1993 sampling event were similar to those detected in samples collected from the same locations in 1995. Soil samples from both the 1993 event and the 1995 implementation of the *Final Zones A and B RFI Work Plan* for SWMU 2 are shown on Figure 10.2.2.

The 1993 sampling event included 25 soil borings. Twenty-four surface soil samples and 22 lower-interval samples were submitted for metals and cyanide analysis. Three of the 1993 samples were duplicated.

1995 Sampling Event

The *Final Zones A and B RFI Work Plan* proposed collecting 30 soil samples from the upper or surface interval (0' to 1') and 30 from the lower interval (3' to 5') for the SWMU 2 investigation area. As detailed in Section 2.0 of the *Final Zones A and B RFI Work Plan*, the CNSY Radiological Control Office performed detailed radiological surveys at Zone A sites with a low potential for radioactivity. This survey, described in separate work plans and reports, was postponed until after the closure of the DRMO facility. This delayed sampling of six of the proposed boring locations at SWMU 2 (near the former storage bin). Subsequent to the closing of DRMO, the survey was finalized and the samples of the six boring locations were collected (second round event). Additionally, the second-round soil sampling event was expanded to include 10 additional soil borings in areas that exhibited elevated lead concentrations during the 1986 sampling event.

During Zone A second round sampling of the wetland southwest of SWMU 2, three sediment locations and one soil boring (with upper and lower interval samples collected) were sampled for metals analysis. One of these samples, 002M000401, was analyzed for the Appendix IX list of parameters at DQO Level IV to investigate other potential constituents that could have migrated to the wetland. Because this area is no longer a wetland (detailed in Section 10.2.5), data from these samples that was presented as sediment in Section 10.2.5 of the *Draft Zone A RFI Report* have been incorporated as soil into this section in this report.



0 200 feet

LEGEND

- 1995 Boring Location (1st round)
- 1997 Boring Location (2nd round)
- 1993 Boring Location

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.2.2 - SWMU 2
Soil Sample Locations

Therefore, 44 samples were collected from the upper interval onsite. Thirty-five lower-interval samples were collected. Six of the lower-interval samples were not collected due to a water table less than 5 feet bgs; the saturated samples were not submitted for analysis. All 79 of these soil samples were submitted for metals analysis. Six of the first-round samples were duplicated and submitted for Appendix IX analyses at DQO Level IV. Three of the second-round samples were duplicated. Table 10.2.4 summarizes soil sampling for both the 1993 and 1995 investigations at SWMU 2.

Table 10.2.4
SWMU 2
Soil Sampling Summary

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
1995 RFI SAMPLING EVENT					
Upper (0' to 1')	30	44	Metals	Metals	One additional soil sample was collected for wetland characterization. Three other samples collected as "sediments" are now considered soil samples. Ten additional samples were collected for site characterization.
Lower (3' to 5')	30	35	Metals	Metals	High water table prevented collection of six samples, including the additional location for wetland delineation. Saturated samples were not submitted for analysis. Ten additional samples were collected for site characterization.
1993 SAMPLING EVENT					
Upper (0' to 1')	25	24	Metals, CN	Metals, CN	One location was not collected due to concrete obstruction.
Lower (3' to 5')	25	22	Metals, CN	Metals, CN	Three locations were not collected; two due to high water table and one due to auger refusal.

10.2.2 Nature and Extent of Contamination in Soil

Table 10.2.5 summarizes organic analytical results for soil samples collected at SWMU 2. Inorganic analytical results are summarized in Table 10.2.6, including metals samples collected during the SWMU 1 investigation. Appendix D is a complete analytical data report for all Zone A samples collected.

Table 10.2.5
SWMU 2
Organic Compounds Detected in Soil

Compound	Frequency of Detection	Range of Detections (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Volatile Organic Compounds (1 sample collected from former wetland)					
Acetone	1/1	29.0	NA	7,800,000	0
2-butanone (MEK)	1/1	6.0	NA	47,000,000	0
Semivolatile Organic Compounds (1 sample collected from former wetland)					
BEQ[a]	1/1	90.9	NA	88	1
Benzo(a)pyrene	1/1	78	NA	88	0
Benzo(b)fluoranthene	1/1	120	NA	880	0
Benzo(g,h,i)perylene	1/1	73	NA	3,100,000[b]	0
Benzo(k)fluoranthene	1/1	74	NA	8,800	0
Chrysene	1/1	130	NA	88,000	0
Fluoranthene	1/1	170	NA	3,100,000	0
2-Methylnaphthalene	1/1	140	NA	3,100,000	0
Phenanthrene	1/1	150	NA	3,100,000[b]	0
Pyrene	1/1	120	NA	2,300,000	0
Pesticides and PCBs (1 sample collected from former wetland)					
4,4'-DDD	1/1	8.5	NA	2,700	0
4,4'-DDE	1/1	140	NA	1,900	0
4,4'-DDT	1/1	26	NA	1,900	0
Endrin	1/1	12	NA	23,000	0
Aroclor-1260	1/1	500	NA	320	1
Dioxins (1 sample collected from former wetland)					
TCDD TEQ[a]	1/1	0.001208	NA	1	0

Note:

a = Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995.

b = RBC not available for this compound; fluoranthene RBC used as surrogate.

Table 10.2.6
SWMU 2
Inorganics Detected in Soil

Element	Sample Interval	Frequency of Detection	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	Reference Conc. (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding[a]
Inorganics (125 samples collected: 68 upper interval and 57 lower interval, 12 samples duplicated)							
Aluminum	Upper	68/68	1,280 - 40,100	7,500	12,800	78,000	0
	Lower	57/57	2,400 - 95,000	9,470	28,240	NA	1
Antimony	Upper	23/68	0.37 - 470	31.0	**	31	3
	Lower	8/57	0.51 - 13	3.8	**	NA	NA
Arsenic	Upper	62/68	0.93 - 29.4	8.3	9.4	0.43	18
	Lower	54/57	1.1 - 26.5	5.1	9.8	NA	2
Barium	Upper	67/68	3.6 - 260	39.6	53.0	5,500	0
	Lower	57/57	6.8 - 58.0	16.7	40.0	NA	2
Beryllium	Upper	25/68	0.05 - 2.1	0.33	**	0.15	16
	Lower	17/57	0.05 - 0.55	0.23	**	NA	NA
Cadmium	Upper	32/68	0.12 - 7.8	2.7	**	39	0
	Lower	8/57	0.09 - 6.3	1.1	**	NA	NA
Calcium	Upper	68/68	529 - 356,000	43,000	NA	NA	NA
	Lower	57/57	381 - 316,000	66,400	NA	NA	NA
Chromium	Upper	67/68	3.2 - 112	21.3	50.4	390	0
	Lower	57/57	3.9 - 150	25.5	63.4	NA	4
Chromium (hexavalent)	Upper	4/5	0.026 - 0.100	0.053	NA	390	0
	Lower	1/2	0.070	NA	NA	NA	NA
Cobalt	Upper	49/68	0.24 - 66.9	6.2	4.4	4,700	0
	Lower	21/57	0.32 - 2.5	1.1	1.7	NA	4
Copper	Upper	66/68	0.78 - 992	75	165	3,100	0
	Lower	50/57	0.85 - 49.4	7.7	33.7	NA	1
Iron	Upper	68/68	490 - 34,200	10,200	NA	NA	NA
	Lower	57/57	2,700 - 24,200	8,350	NA	NA	NA
Lead	Upper	67/68	1.0 - 89,000	1,620	140	400[b]	16
	Lower	54/57	1.4 - 1,120	35.6	22.0	400[b]	1

Table 10.2.6
SWMU 2
Inorganics Detected in Soil

Element	Sample Interval	Frequency of Detection	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	Reference Conc. (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding[a]
Inorganics (125 samples collected: 68 upper interval and 57 lower interval, 12 samples duplicated)							
Magnesium	Upper	67/68	96.1 - 5,300	1,110	NA	NA	NA
	Lower	57/57	160 - 9,970	2,180	NA	NA	NA
Manganese	Upper	68/68	3.1 - 2,380	96.4	98.1	1,800	1
	Lower	57/57	5.3 - 308	48.0	85.5	NA	6
Mercury	Upper	41/68	0.015 - 15	1.1	0.30	23	0
	Lower	21/57	0.018 - 0.250	0.061	**	NA	NA
Nickel	Upper	59/68	1.0 - 188	12.6	13.6	1,600	0
	Lower	39/57	0.89 - 33.9	12.1	35.0	NA	0
Potassium	Upper	61/68	68.9 - 2,760	444	NA	NA	NA
	Lower	51/57	110 - 1,620	541	NA	NA	NA
Selenium	Upper	28/68	0.43 - 1.7	1.1	1.2	390	0
	Lower	26/57	0.45 - 5.9	1.8	1.7	NA	7
Silver	Upper	5/68	0.36 - 7.8	2.3	**	390	0
	Lower	0/57	NA	NA	**	NA	NA
Sodium	Upper	61/68	72 - 1,110	294	NA	NA	NA
	Lower	51/57	59 - 4,200	512	NA	NA	NA
Thallium	Upper	9/68	0.48 - 2.3	1.2	**	6.3	0
	Lower	7/57	0.43 - 3.3	1.2	**	NA	NA
Tin	Upper	18/68	1.2 - 45.5	8.5	**	47,000	0
	Lower	11/57	1.2 - 10.1	2.7	**	NA	NA
Vanadium	Upper	68/68	1.6 - 114	20.9	29.2	550	0
	Lower	57/57	5.5 - 47.8	22.2	77.3	NA	0
Zinc	Upper	68/68	5.2 - 1,660	210	208	23,000	0
	Lower	57/57	3.0 - 94.1	29.1	165	NA	0

Notes:

a = Number of samples exceeding both RBC and RC in upper interval or number of samples exceeding the reference concentration (RC) in the lower interval.

b = RBC not available for lead. USEPA (1994f) residential soil cleanup level used for comparison (OSWER Directive 9355.4-12).

** = Number of nondetects prevented determination of UTL.

OP Pesticides, Herbicides, and Dioxin

Six Appendix IX duplicate samples collected at SWMU 2 were analyzed for these parameters. Four of these duplicate samples were from upper-interval locations (samples 002CB00101, 002CB00201, 002CB00701, and 002CB01301) and two were from lower-interval locations (samples 002CB01102 and 002CB02402). All of these analytes were reported as nondetect.

Dioxins were also analyzed for and detected in sample 002M000401, collected at the center of the former wetland. The calculated TEQ was below the 2,3,7,8-TCDD RBC of 1 μg/kg.

Volatile Organic Compounds in Soil

Only one of the SWMU 2 soil samples was analyzed for VOCs, sample 002M000401 from the center of the former wetland. Both compounds detected, acetone and 2-butanone, were below the respective RBCs.

Semivolatile Organic Compounds in Soil

Only one of the SWMU 2 soil samples was analyzed for SVOCs, sample 002M000401 from the center of the former wetland. Nine compounds were detected in this sample, including several cPAHs. Although each of the compounds was below its respective RBC, the resulting BEQ calculation (90.9 μg/kg) exceeded the RBC (88 μg/kg).

Pesticides/PCBs in Soil

Only one of the SWMU 2 soil samples was analyzed for pesticides/PCBs, sample 002M000401 from the center of the former wetland. Four pesticides and one PCB were detected in this sample. The PCB detected, Aroclor-1260 at 500 μg/kg, exceeded its RBC (320 μg/kg).

Inorganics in Soil

Twenty-five metals were detected in soil samples collected at SWMU 2. Five were detected at concentrations greater than both their respective RC and RBC (for upper interval only): antimony, arsenic, beryllium, lead, and manganese. Nine were detected in the lower interval at concentrations exceeding the RC: aluminum, arsenic, barium, chromium, cobalt, copper, lead, manganese, and selenium. Also, six elements (antimony, beryllium, cadmium, mercury, thallium, and tin) had lower-interval detections that could not be compared to either an RBC or an RC.

Aluminum exceeded the RC (28,240) in one lower-interval sample, S02SB01602 (95,000 mg/kg). This detection does not exceed the SSL (560,000 mg/kg) for aluminum.

Antimony was detected in three upper-interval samples at concentrations greater than the RBC (31 μg/kg), with detections of 470 mg/kg in sample 002SB03601, 54.4 mg/kg in sample 002SB0201, and 40.0 mg/kg in sample SO2SB01101. Two of the eight subsurface samples (002SB01302 and 002SB03602) exceed the SSL (2.7 mg/kg) for antimony.

Arsenic was detected in 18 upper-interval samples at concentrations greater than both the RBC (0.43 mg/kg) and the RC (9.4 mg/kg). Figure 10.2.3 shows all upper-interval data for arsenic detections at SWMU 2 and Figure 10.2.4 is a contour map for these data. Contouring of this data assumes that homogenous conditions exist in site soil. Also, two lower-interval detections exceeded the RC (9.8 mg/kg) for arsenic, samples 002SB03702 (26.5 mg/kg) and 002SB01802 (13.8 mg/kg). One of these detections also exceeded the SSL (15 mg/kg).

Barium was detected above the RC (40 mg/kg) in two lower-interval samples, 002SB00902 (43.1 mg/kg) and SO2SB02202 (58.0 mg/kg). These concentrations do not exceed the SSL (820 mg/kg) for barium.

Hess Oil Tank Farm

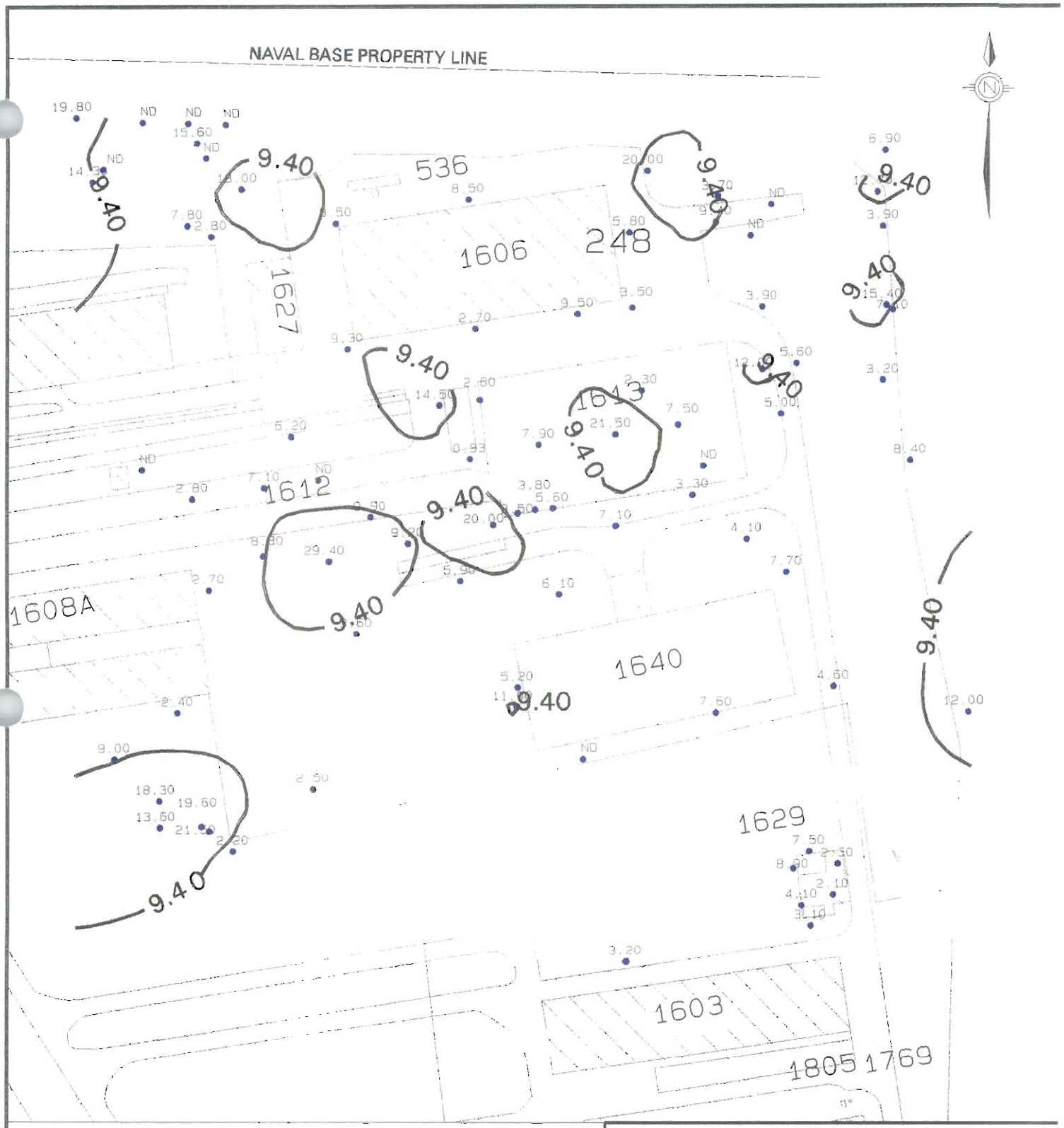
0 200 feet

LEGEND

- 1995/97 Boring Location
- 1993 Boring Location
- 12.3 - Arsenic Concentration Value (ppm)
- Red Indicates Concentration Exceeds the RC (9.4 ppm)

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.2.3 - SWMU 2
Soil Sample Arsenic Results



LEGEND

NOTE: This contour map assumes homogeneous characteristics in soil

- < 9.4 (ppm)
- > 9.4 (ppm)

0 feet 300

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.2.4
SWMU 2
ARSENIC IN
SURFACE SOIL

AML: /home3/projects/charleston_dir/zone_a_dir/contour_dir/soilmap

***Beryllium*'s** RBC (0.15 mg/kg) was exceeded in sixteen upper-interval samples — 002SB00101, 002SB02301, 002SB00601, 002SB00901, 002SB01501, 002SB02001, 002SB03301, 002SB03401, 002SB03501, 002SB03601, 002SB03701, 002SB03901, 002SB04101, 002MO00301, 002MO00401, and 002MO00501 at concentrations ranging from 0.17 mg/kg to 2.1 mg/kg. Also, beryllium was detected in seventeen lower-interval samples at concentrations ranging from 0.05 mg/kg to 0.55 mg/kg. There is no RC for lower-interval beryllium comparison, although these detections were below the SSL for beryllium (32 mg/kg).

Cadmium was detected in eight lower-interval samples at concentrations ranging from 0.09 to 6.3 mg/kg and there is no RC for comparison. One detection exceeded the SSL for cadmium of 4.0 mg/kg, sample S02SB01602.

Chromium exceeded both the RC (63.4 mg/kg) and SSL (19 mg/kg) in five lower-interval samples (002SB00502, 002SB00802, 002SB01902, S02SB02002 and S02SB02302).

Cobalt exceeded the RC (1.7 mg/kg) in four lower-interval samples: SO2SB01002 (1.7 mg/kg), SO2SB02202 (1.9 mg/kg), 002SB01802 (1.8 mg/kg), and 002SB03802 (2.5 mg/kg). These concentrations do not exceed the SSL (990 mg/kg) for cobalt.

Copper exceeded the RC (33.7 mg/kg) in one lower-interval sample, 002SB03702 (49.4 mg/kg). This concentration does not exceed the SSL (5,600 mg/kg) for copper.

Lead is the most widespread contaminant at this site. The comparison to the USEPA residential soil cleanup level of 400 mg/kg was made for both upper- and lower-interval samples. Sixteen upper-interval samples exceeded this concentration. Therefore, upper-interval lead concentrations for all samples are shown on Figure 10.2.5 and Figure 10.2.6 is a contour map for these data.

Contouring of this data assumes that homogenous conditions exist in site soil. The only lower-interval detection that exceeded 400 mg/kg was in sample 002SB03602 (1,120 mg/kg).

Manganese exceeded the RC (98.1 mg/kg) and RBC (1,800 mg/kg) in one upper-interval sample, 002SB03901 at a concentration of 2,380 mg/kg. The RC (85.5 mg/kg) was also exceeded in six lower-interval samples, 002SB01302, 002SB01202, 002SB00702, SO2SB02202, SO2SB00602, and 002SB03902. None of the lower-interval detections exceed the SSL (550 mg/kg) for manganese.

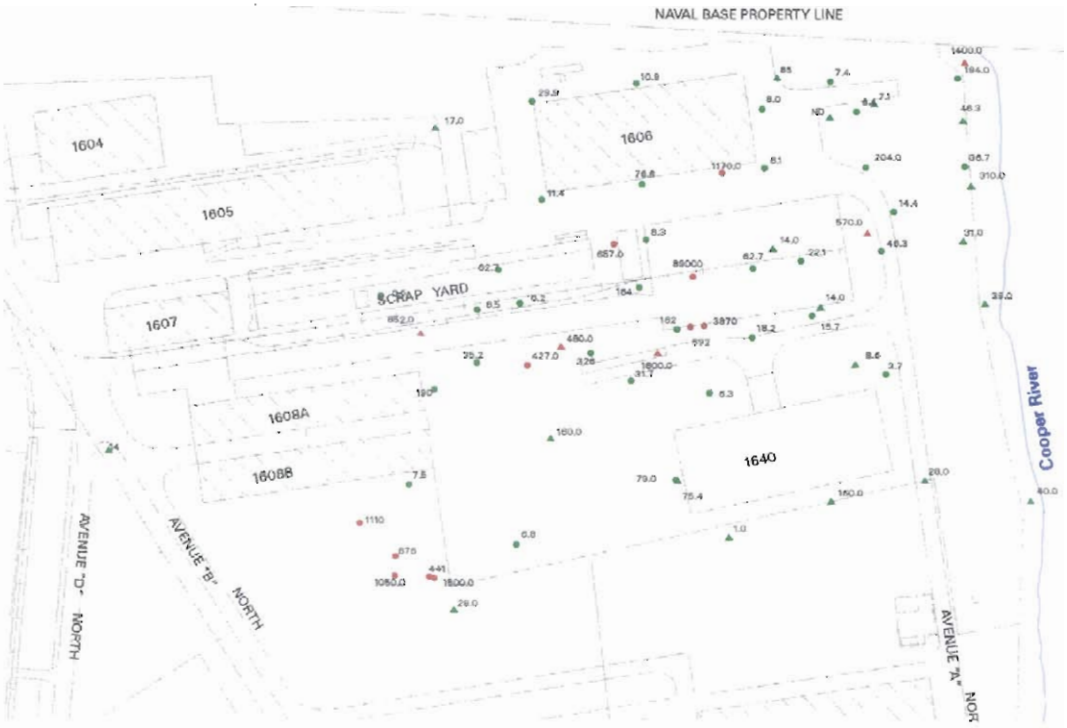
Mercury was detected in 21 lower-interval samples at a maximum of 0.250 mg/kg, but there is no valid RC or RBC for comparison of these data. The SSL for mercury (1 mg/kg) was not exceeded in any of the samples.

Selenium exceeded the RC (1.7 mg/kg) in seven of the lower-interval samples. After comparing this data to the SSL (2.6 mg/kg), four data points are excluded from the exceedance summary. Therefore, three second-interval samples exceeded both the RC and SSL for selenium — 002SB00802 (5.9 mg/kg), 002SB02502 (5.5 mg/kg), and 002SB00502 (5.3 mg/kg).

Thallium was detected in 7 lower-interval samples at concentrations ranging from 0.43 to 3.3 mg/kg. All of these detections exceed the SSL for thallium (0.35 mg/kg).

Tin was detected at concentrations below its RBC in 11 lower-interval samples, and there is no RC for comparison. None of these detections exceed the SSL (5,500 mg/kg) for tin.

Hess Oil Tank Farm



0 200 feet

LEGEND

- • 1995/97 Boring Location
- ▲ 1993 Boring Location
- ▲ 12.3 - Lead Concentration Value (ppm)
- • ▲ Red Indicates Concentration Exceeds USEPA Residential Soil Cleanup Level (400 ppm)

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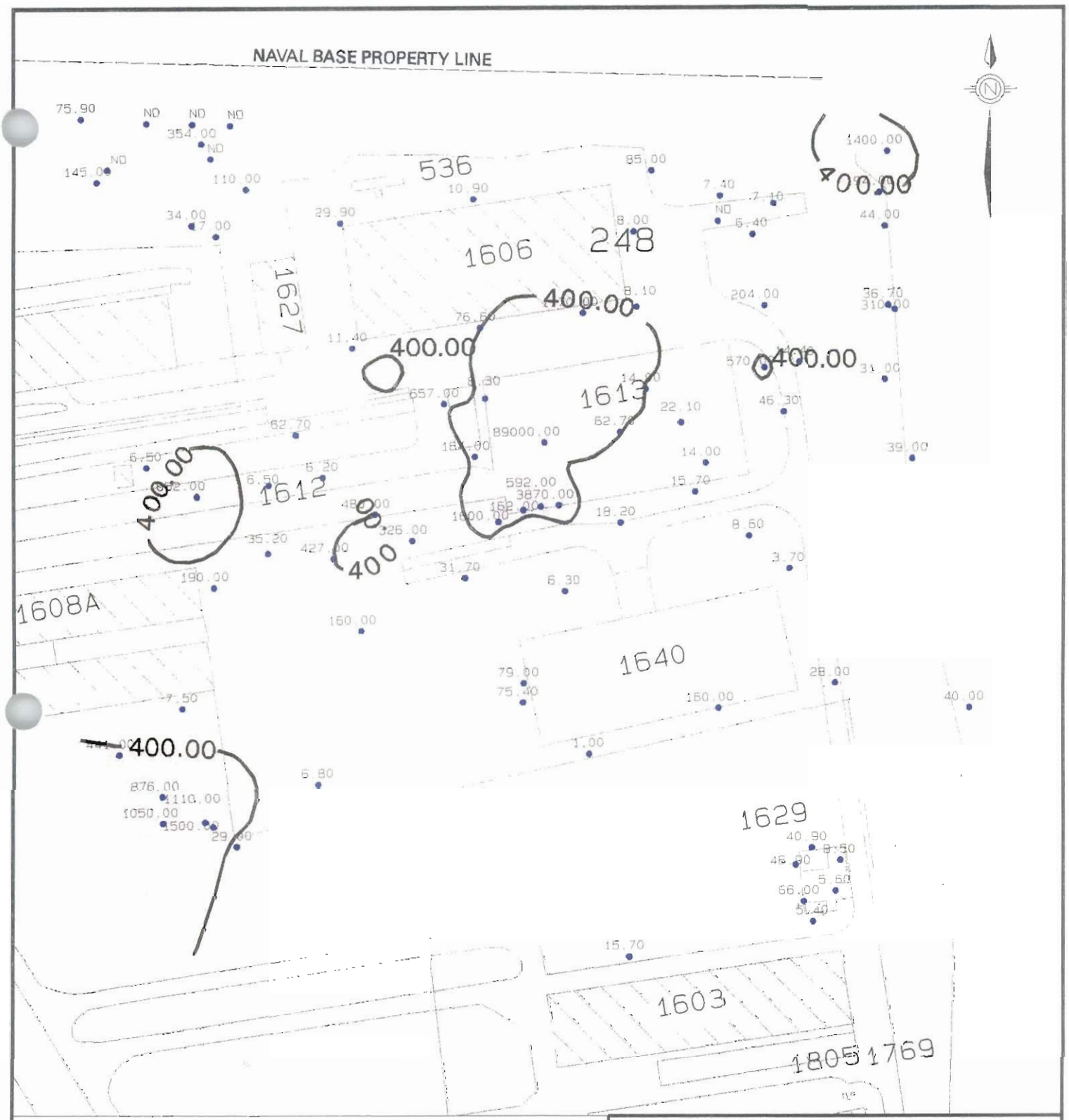
Naval Base Charleston
Charleston, SC

FIGURE 10.2.5 - SWMU 2
Soil Sample Lead Results



LEGEND

NOTE: This contour map assumes homogeneous characteristics in soil

☐ < 400 (ppm)

☐ > 400 (ppm)

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.2.6
SWMU 2
LEAD IN
SURFACE SOIL

10.2.3 Groundwater Sampling and Analysis

The *Final Zones A and B RFI Work Plan* proposed redeveloping and sampling the six existing shallow monitoring wells installed during the 1993 investigation. Figure 10.2.7 illustrates the locations of these wells, consisting of:

- NBCA-002-001
- NBCA-002-002
- NBCA-002-003
- NBCA-002-004
- NBCA-002-005
- NBCA-002-006

A permit application was submitted in 1996 to SCDHEC to change these monitoring well IDs to the current format. For example, the 1993 monitoring well CNSY-02-01 is now NBCA-002-001.

Because these wells are located throughout the northern portion of Zone A, they have been sampled to support investigations at SWMU 2 and other sites. Specifically, NBCA-002-004 was sampled as part of the investigation at SWMU 38 and NBCA-002-006 was sampled as part of the investigation of SWMU 39. All data from these wells will be presented in the applicable site-specific evaluations. The metals data have been incorporated into this section.

There have been five sampling events to date at SWMU 2. Table 10.2.7 summarizes this sampling. The first sampling event was conducted after installation of the wells in November 1993. All six groundwater samples were submitted for metals and cyanide analysis.

After redeveloping the wells in September 1995, the first round of RFI samples was collected. All six wells were sampled for metals to support the SWMU 2 investigation. Second, third, and fourth round samples were collected by the Charleston Environmental and Engineering Remediation Detachment in April, June, and October 1996, respectively. Second- and

third-quarter samples were collected for metals only. Fourth-quarter samples were collected for metals, TDS, sulfate, and chloride. DRMO ceased operations between the third and fourth-quarter sampling events. Sometime during this period, monitoring well NBCA-002-005 was damaged by heavy equipment. Therefore, this well was abandoned in place and unavailable for fourth-quarter sampling.

Table 10.2.7
SWMU 2
Groundwater Sampling Summary

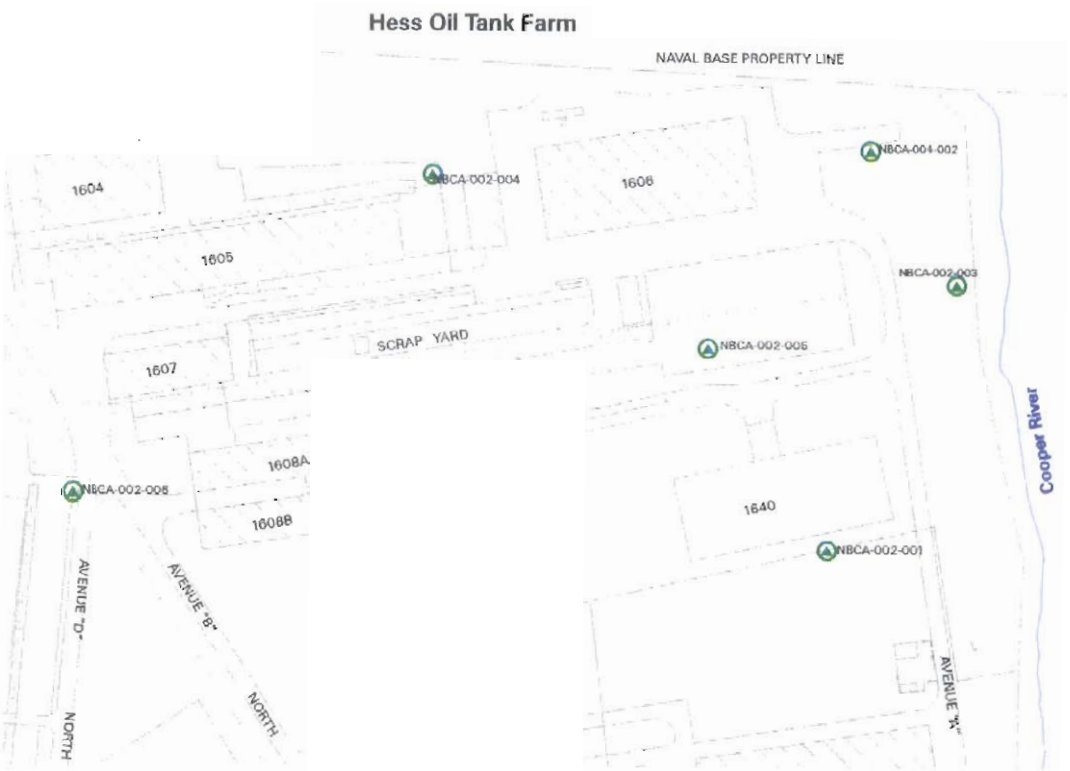
Event	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Nov. 1993	6	6	Metals, cyanide	Metals, cyanide	None
Sep. 1995 (1st rd.)	6	6	Metals	Metals	None
Apr. 1996 (2nd rd.)	6	6	Metals	Metals	None
Jun. 1996 (3rd rd.)	6	6	Metals	Metals	None
Oct. 1996 (4th rd.)	5[a]	5[a]	Metals, TDS, chloride, sulfate	Metals, TDS, chloride, sulfate	None

Notes:
a = NBCA-002-005 was abandoned between the third- and fourth-quarter sampling events.

These six shallow monitoring wells were installed between 13 and 18 feet bgs in the upper sand aquifer. All wells were installed as described in Section 3.3 of this report.

10.2.4 Nature and Extent of Contamination in Groundwater

Table 10.2.8 summarizes groundwater analytical results for SWMU 2. Appendix D is a complete analytical data report for all samples collected in Zone A, including those collected at SWMU 2.



0 200 feet

LEGEND

Shallow Monitoring Well

Zone A RCRA Facility
Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.2.7 - SWMU 2
Groundwater Sample Locations

Table 10.2.8
SWMU 2
Inorganics Detected in Groundwater

Compound	Sampling Event	Frequency of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (6 shallow groundwater samples collected during first four events, 5 samples collected during fifth event))							
Aluminum	Nov. 93	1/6	320,000	NA	3,210	37,000	1
	Sep. 95	6/6	50 - 1,120	374	3,210	37,000	0
	Apr. 96	2/6	816 - 1,280	1,050	3,210	37,000	0
	June 96	2/6	584 - 591	588	3,210	37,000	0
	Oct. 96	1/5	507	NA	3,210	37,000	0
Arsenic	Nov. 93	1/6	59.3	NA	7.4	0.045	1
	Sep. 95	1/6	5.8	NA	7.4	0.045	0
	Apr. 96	0/6	NA	NA	7.4	0.045	0
	June 96	1/6	4.6	NA	7.4	0.045	0
	Oct. 96	2/5	2.2 - 10.3	6.3	7.4	0.045	1
Barium	Nov. 93	5/6	41.0 - 987	247	104	2,600	0
	Sep. 95	6/6	26.6 - 57.2	41.9	104	2,600	0
	Apr. 96	0/6	NA	NA	104	2,600	0
	June 96	6/6	23.6 - 47.2	34.4	104	2,600	0
	Oct. 96	5/5	24.9 - 54.0	39.0	104	2,600	0
Beryllium	Nov. 93	1/6	9.4	NA	**	0.016	1
	Sep. 95	0/6	NA	NA	**	0.016	0
	Apr. 96	0/6	NA	NA	**	0.016	0
	June 96	0/6	NA	NA	**	0.016	0
	Oct. 96	1/5	0.42	NA	**	0.016	1

Table 10.2.8
SWMU 2
Inorganics Detected in Groundwater

Compound	Sampling Event	Frequency of Detection	Range of Detections (µg/L)	Mean of Detections (µg/L)	Reference Conc. (µg/L)	RBC (µg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (6 shallow groundwater samples collected during first four events, 5 samples collected during fifth event))							
Cadmium	Nov. 93	0/6	NA	NA	**	18	0
	Sep. 95	0/6	NA	NA	**	18	0
	Apr. 96	0/6	NA	NA	**	18	0
	June 96	0/6	NA	NA	**	18	0
	Oct. 96	3/5	0.22 - 0.48	0.39	**	18	0
Calcium	Nov. 93	6/6	10,000 - 157,000	76,400	NA	NA	NA
	Sep. 95	6/6	7,540 - 275,000	92,600	NA	NA	NA
	Apr. 96	4/6	48,100 - 101,000	77,500	NA	NA	NA
	June 96	6/6	7,500 - 95,400	52,450	NA	NA	NA
	Oct. 96	5/5	6,260 - 236,000	84,500	NA	NA	NA
Chromium	Nov. 93	1/6	487	NA	8.7	180	1
	Sep. 95	0/6	NA	NA	8.7	180	0
	Apr. 96	0/6	NA	NA	8.7	180	0
	June 96	0/6	NA	NA	8.7	180	0
	Oct. 96	1/5	5.2	NA	8.7	180	0
Cobalt	Nov. 93	1/6	30.1	NA	**	2,200	0
	Sep. 95	0/6	NA	NA	**	2,200	0
	Apr. 96	0/6	NA	NA	**	2,200	0
	June 96	2/6	5.6 - 6.3	5.9	**	2,200	0
	Oct. 96	2/5	1.5 - 2.5	2.0	**	2,200	0

Table 10.2.8
SWMU 2
Inorganics Detected in Groundwater

Compound	Sampling Event	Frequency of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (6 shallow groundwater samples collected during first four events, 5 samples collected during fifth event))							
Copper	Nov. 93	1/6	113	NA	15.7	1,500	0
	Sep. 95	2/6	3.0 - 11.6	7.3	15.7	1,500	0
	Apr. 96	0/6	NA	NA	15.7	1,500	0
	June 96	0/6	NA	NA	15.7	1,500	0
	Oct. 96	5/5	1.7 - 11	5.8	15.7	1,500	0
Iron	Nov. 93	6/6	720 - 139,000	25,600	NA	NA	NA
	Sep. 95	6/6	148 - 12,100	2,900	NA	NA	NA
	Apr. 96	6/6	240 - 15,500	3,440	NA	NA	NA
	June 96	5/6	257 - 15,700	4,140	NA	NA	NA
	Oct. 96	5/5	28 - 11,700	3,280	NA	NA	NA
Lead	Nov. 93	1/6	639	NA	4.7	15[a]	1
	Sep. 95	0/6	NA	NA	4.7	15[a]	0
	Apr. 96	2/6	2.1 - 18.9	10.5	4.7	15[a]	1
	June 96	1/6	2.3	NA	4.7	15[a]	0
	Oct. 96	0/5	NA	NA	4.7	15[a]	0
Magnesium	Nov. 93	6/6	2,500 - 106,000	41,200	NA	NA	NA
	Sep. 95	6/6	2,500 - 74,700	41,500	NA	NA	NA
	Apr. 96	6/6	2,910 - 86,100	38,300	NA	NA	NA
	June 96	6/6	2,490 - 80,700	36,400	NA	NA	NA
	Oct. 96	5/5	2,490 - 75,200	34,800	NA	NA	NA

Table 10.2.8
SWMU 2
Inorganics Detected in Groundwater

Compound	Sampling Event	Frequency of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (6 shallow groundwater samples collected during first four events, 5 samples collected during fifth event))							
Manganese	Nov. 93	6/6	51 - 3,340	735	577	840	1
	Sep. 95	6/6	26.5 - 3,210	668	577	840	1
	Apr. 96	4/6	119 - 3,350	1,060	577	840	1
	June 96	4/6	168 - 3,000	1,370	577	840	2
	Oct. 96	5/5	27 - 3,410	838	577	840	1
Mercury	Nov. 93	1/6	0.46	NA	**	11	0
	Sep. 95	0/6	NA	NA	**	11	0
	Apr. 96	0/6	NA	NA	**	11	0
	June 96	0/6	NA	NA	**	11	0
	Oct. 96	0/5	NA	NA	**	11	0
Nickel	Nov. 93	1/6	78.0	NA	**	730	0
	Sep. 95	1/6	35.4	NA	**	730	0
	Apr. 96	0/6	NA	NA	**	730	0
	June 96	0/6	NA	NA	**	730	0
	Oct. 96	2/5	6.4 - 13	9.7	**	730	0
Potassium	Nov. 93	6/6	1,200 - 83,500	26,300	NA	NA	NA
	Sep. 95	6/6	1,920 - 56,600	23,200	NA	NA	NA
	Apr. 96	5/6	4,000 - 52,400	23,500	NA	NA	NA
	June 96	6/6	2,560 - 60,000	23,200	NA	NA	NA
	Oct. 96	5/5	1,500 - 67,500	30,000	NA	NA	NA

Table 10.2.8
SWMU 2
Inorganics Detected in Groundwater

Compound	Sampling Event	Frequency of Detection	Range of Detections (µg/L)	Mean of Detections (µg/L)	Reference Conc. (µg/L)	RBC (µg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (6 shallow groundwater samples collected during first four events, 5 samples collected during fifth event))							
Silver	Nov. 93	0/6	NA	NA	**	180	0
	Sep. 95	0/6	NA	NA	**	180	0
	Apr. 96	0/6	NA	NA	**	180	0
	June 96	0/6	NA	NA	**	180	0
	Oct. 96	1/5	39.8	NA	**	180	0
Sodium	Nov. 93	6/6	6,900 - 1,020,000	347,000	NA	NA	NA
	Sep. 95	6/6	2,980 - 731,000	246,000	NA	NA	NA
	Apr. 96	4/6	233,000 - 771,000	434,000	NA	NA	NA
	June 96	6/6	3,410 - 763,000	293,000	NA	NA	NA
	Oct. 96	5/5	2,680 - 492,000	167,000	NA	NA	NA
Tin	Nov. 93	0/6	NA	NA	**	22,000	0
	Sep. 95	1/6	40.7	NA	**	22,000	0
	Apr. 96	0/6	NA	NA	**	22,000	0
	June 96	0/6	NA	NA	**	22,000	0
	Oct. 96	1/5	33.6	NA	**	22,000	0
Vanadium	Nov. 93	1/6	479	NA	5.4	260	1
	Sep. 95	1/6	3.2	NA	5.4	260	0
	Apr. 96	0/6	NA	NA	5.4	260	0
	June 96	0/6	NA	NA	5.4	260	0
	Oct. 96	0/5	NA	NA	5.4	260	0

Table 10.2.8
SWMU 2
Inorganics Detected in Groundwater

Compound	Sampling Event	Frequency of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (6 shallow groundwater samples collected during first four events, 5 samples collected during fifth event))							
Zinc	Nov. 93	5/6	21 - 377	190	83.2	11,000	0
	Sep. 95	5/6	9 - 222	98	83.2	11,000	0
	Apr. 96	1/6	204	NA	83.2	11,000	0
	June 96	2/6	58.6 - 155	107	83.2	11,000	0
	Oct. 96	3/5	68.1 - 242	155	83.2	11,000	0
Other Parameters (Collected only during fourth quarter event)							
Chloride (mg/L)	Oct. 96	4/5	23 - 847	276	NA	NA	NA
Sulfate (mg/L)	Oct. 96	4/5	40.4 - 609	279	NA	NA	NA
TDS (mg/L)	Oct. 96	5/5	100 - 2,150	944	NA	NA	NA

Notes:

a = Lead does not have an RBC or MCL. Therefore, the USEPA Treatment Technique Action Level (TTAL) of 15 μg/L has been substituted for the RBC.

NA = Not applicable.

** = Number of nondetects prevented determination of UTL.

Inorganics in Groundwater

Seven elements were detected above the RC and RBC in the 1993 sampling event (1993), all from the same well (NBCA-002-005). These were aluminum, arsenic, beryllium, chromium, lead, manganese, and vanadium. Turbidity measurements were not collected during the 1993 sampling event. During the first-quarter efforts (redeveloping and sampling), this well was noted to be highly turbid and extremely slow in recharging. With the exception of lead, subsequent sampling did not duplicate the exceedances in this well in any of the quarterly sampling events.

Arsenic exceeded the RBC (0.045 μg/L) and RC (7.4 μg/L) in NBCA-002-004 at a concentration of 10.3 μg/L in the fourth quarter event (October 1996).

Beryllium exceeded the RBC (0.016 μg/L) in NBCA-002-006 at a concentration of 0.42 μg/L in the fourth quarter event (October 1996).

Lead, which does not have an RBC or MCL, exceeded the USEPA TTAL in NBCA-002-005 in the 1993 event (639 μg/L) and second round sampling event (18.9 μg/L).

Manganese exceeded the RBC (840 μg/L) in NBCA-002-002 in all four sampling events. It also exceeded the RBC in NBCA-002-001 in the third event.

10.2.5 Sediment Sampling and Analysis

The *Final Zones A and B RFI Work Plan* proposed collection of two sediment samples from the Cooper River for metals analyses as "duplicates" of the 1993 sampling event. The 1993 sediment sampling included the collection of 11 sediment samples; 7 from the Cooper River and 4 from the storm sewer system around DRMO. These samples were submitted for metals and cyanide analyses.

During Zone A second round sampling of the wetland southwest of SWMU 2, three sediment samples were collected for metals analysis. These samples, reported as sediment samples in the *Draft Zone A RFI Report*, are now considered soil samples as the wetland no longer contains surface water. During the course of the RFI investigation at SWMU 2, the wetland area dried out. Apparently, the water source for this region was a leaking underground water line. Once this line was repaired, the wetland vegetation began to wilt.

All sediment sample locations for SWMU 2 are shown on Figure 10.2.8. Table 10.2.9 summarizes the sediment sampling at SWMU 2.

Table 10.2.9
SWMU 2
Sediment Sampling Summary

Samples Proposed	Samples Collected	Analyses Proposed	Analyses Collected	Deviations
1995 RFI SAMPLING EVENT				
2	2	Metals	Metals, organotins	Organotins were added to both samples collected from the Cooper River for site characterization.
1993 SAMPLING EVENT				
11	11[a]	Metals, cyanide	Metals, cyanide	None

Notes:
a = Four of these 11 samples were collected from the DRMO storm sewer system and the other 7 were from the Cooper River.

10.2.6 Nature and Extent of Contamination in Sediment

No sediment samples were analyzed for organic parameters at SWMU 2. Table 10.2.10 summarizes the inorganic analytical results for sediment. Appendix D is the complete analytical report for all samples collected in Zone A. Sediment analytical results were evaluated in Section 8, Ecological Risk Assessment. Therefore, results were not compared to screening levels in this section.

Inorganics in Sediment

Twenty-one metals were detected in sediment samples collected from the DRMO storm sewer and the Cooper River at SWMU 2. These data are presented in Section 8 of this report.

Hess Oil Tank Farm

0 200 feet

LEGEND

- ▲1995 Sampling Event (002M0001)
- •1993 Sampling Event (S02M0012)

Zone A RCRA Facility
Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.2.8 - SWMUs 1 and 2
Sediment Sample Locations

Table 10.2.10
SWMU 2
Inorganics Detected in Sediment (includes both 1993 and 1995 Sampling Events)

Compound	Frequency of Detection	Range of Detections (μg/kg)	Mean (μg/kg)
Inorganics (13 sediment samples collected, 2 duplicates)			
Aluminum	13/13	560 - 14,700	4,780
Antimony	1/13	9.7	na
Arsenic	9/13	2.0 - 18	8.0
Barium	13/13	3.2 - 160	29.7
Beryllium	2/13	0.79 - 2.2	1.5
Cadmium	4/13	1.3 - 8.4	3.3
Calcium	13/13	690 - 150,000	47,900
Chromium	13/13	2.2 - 76.0	19.5
Cobalt	5/13	1.5 - 3.5	2.5
Copper	12/13	3.4 - 290	62
Iron	13/13	1,100 - 17,000	6,970
Lead	13/13	3.7 - 1,000	119
Magnesium	13/13	410 - 4,450	1,770
Manganese	13/13	9.2 - 470	90.8
Mercury	5/13	0.04 - 0.56	0.24
Nickel	6/13	8.3 - 54	23
Potassium	13/13	140 - 1,800	561
Silver	2/13	5.2 - 11.0	8.1
Sodium	13/13	126 - 8,900	2,210
Vanadium	13/13	2.0 - 29.7	12.5
Zinc	13/13	5.8 - 490	121

10.2.7 Fate and Transport Assessment for SWMU 2 (includes SWMU 1)

SWMU 1 was formerly used by the Defense Reutilization and Marketing Office (DRMO) as a storage area for waste material amassed as a result of local armed forces activities. The portion of this waste considered hazardous was stored in a shed formerly known as Building 1617. SWMU 2 was formerly used to store lead recovered from lead-acid submarine batteries. Both SWMU 1 and SWMU 2 were the foci of previous investigations. SWMU 1 was granted clean closure for soils in 1993 based on human health risk-based clean-up goals developed in *Risk Assessment and Development of Risk-based Clean-up Goals for the Charleston Naval Shipyard* (Gradient 1991 and subsequent revisions). Results from the SWMU 1 soil and groundwater samples collected during the Zone A RFI substantiated the 1993 clean closure decision. SWMU 2 lead contamination was investigated in 1986 and again in 1993 in addition to the RFI.

10.2.7.1 SWMU 2 - Soil to Groundwater Cross-Media Transport

Tables 10.2.11 and 10.2.12 compare the maximum detected concentrations of organic and inorganic chemicals reported in soil (68 surface samples and 57 subsurface samples) to the risk-based soil screening levels considered protective of groundwater. As shown on Table 10.2.11, none of the organic constituents was reported at a concentration exceeding its soil-to-groundwater SSL. As shown on Table 10.2.12, ten inorganics — antimony, arsenic, cadmium, chromium, lead, manganese, mercury, nickel, selenium, and thallium — were identified for further evaluation of soil-to-groundwater migration based on the screening process presented in Section 6. Except for lead and manganese, none of these inorganics was detected in SWMU 2 groundwater (including all four quarters) at a concentration above its tap water RBC or background reference concentration. Soil-to-groundwater SSL exceedences were noted in more surface soil samples than subsurface soil samples for antimony (18 surface soil and two subsurface soil samples), arsenic (eight surface soil and one subsurface soil samples), cadmium (seven surface soil and one subsurface soil samples), and lead (16 surface soil and one subsurface soil samples). Soil-to-groundwater exceedences for manganese (one exceedence), nickel (one exceedence), and

ble 10.2.11
Organic Compounds Detected in Surface Soil, Subsurface Soil, Sediment, and Shallow Groundwater
Comparison to Cross-media SSLs, Tap Water RBCs, and Saltwater Surface Water Chronic Screening Levels
NAVBASE-Charleston, Zone A: SWMU 1 and SWMU 2
Charleston, South Carolina

Parameter	Maximum Concentration					Screening Concentration *									
	Surface Soil	Subsurface Soil	Sediment	Shallow GW	Deep GW	Soil to GW	Soil to Air	Tap Water RBC	Saltwater Surf. Wtr. Chronic	Soil Units	Water Units	Leaching Potential	Volatil-ization Potential	Ground-water Migration Concern	Surface Water Migration Concern
Volatile Organic Compounds															
Acetone	90	110	NA	ND	NA	8000	1E+08	3700	NL	UG/KG	UG/L	NO	NO	NO	NO
2-Butanone	14	8.6	NA	ND	NA	3900 c	NDA	1900	NL	UG/KG	UG/L	NO	NO	NO	NO
Carbon disulfide	ND	2	NA	ND	NA	16000	720000	1000	NL	UG/KG	UG/L	NO	NO	NO	NO
Chlorobenzene	29	39	NA	ND	NA	700	130000	39	105	UG/KG	UG/L	NO	NO	NO	NO
Methylene Chloride	1.8	ND	NA	ND	NA	10	13000	4.1	2560	UG/KG	UG/L	NO	NO	NO	NO
Toluene	2.9	8.9	NA	ND	NA	6000	650000	750	37	UG/KG	UG/L	NO	NO	NO	NO
1,1,1-Trichlorethane	2.9	8.3	NA	ND	NA	1000	1200000	540	312	UG/KG	UG/L	NO	NO	NO	NO
Xylene (total)	2.6	5	NA	ND	NA	70000 c	320000	12000	NL	UG/KG	UG/L	NO	NO	NO	NO
Semivolatile Organic Compounds															
Benzo(a)pyrene equivalents															
Benzo(a)anthracene	120	ND	NA	ND	NA	800	NDA	0.092	NL	UG/KG	UG/L	NO	NO	NO	NO
Benzo(a)pyrene	110	ND	NA	ND	NA	4000	NDA	0.0092	NL	UG/KG	UG/L	NO	NO	NO	NO
Benzo(b)fluoranthene	150	ND	NA	ND	NA	2500	NDA	0.092	NL	UG/KG	UG/L	NO	NO	NO	NO
Benzo(k)fluoranthene	74	ND	NA	ND	NA	25000	NDA	0.92	NL	UG/KG	UG/L	NO	NO	NO	NO
Chrysene	140	ND	NA	ND	NA	80000	NDA	9.2	NL	UG/KG	UG/L	NO	NO	NO	NO
Indeno(1,2,3-cd)pyrene	97	ND	NA	ND	NA	7000	NDA	0.092	NL	UG/KG	UG/L	NO	NO	NO	NO
Benzo(g,h,i)perylene	98	ND	NA	ND	NA	120000000 c	NDA	1500	NL	UG/KG	UG/L	NO	NO	NO	NO
Fluoranthene	240	ND	NA	ND	NA	2100000	NDA	1500	1.6	UG/KG	UG/L	NO	NO	NO	NO
2-Methylnaphthalene	140	ND	NA	ND	NA	230000	NDA	1500	NL	UG/KG	UG/L	NO	NO	NO	NO
Phenanthrene	150	ND	NA	ND	NA	900000 c	NDA	1500	NL	UG/KG	UG/L	NO	NO	NO	NO
Pyrene	300	ND	NA	ND	NA	2100000	NDA	1100	NL	UG/KG	UG/L	NO	NO	NO	NO
Pesticides/PCB Compounds															
Aroclor-1260	500	ND	NA	ND	NA	1000	1000	0.034	0.03	UG/KG	UG/L	NO	NO	NO	NO
4,4'-DDD	8.5	ND	NA	ND	NA	8000	NDA	0.28	0.025	UG/KG	UG/L	NO	NO	NO	NO
4,4'-DDE	140	ND	NA	ND	NA	27000	NDA	0.2	0.14	UG/KG	UG/L	NO	NO	NO	NO
4,4'-DDT	26	ND	NA	ND	NA	16000	1E+09	0.2	0.001	UG/KG	UG/L	NO	NO	NO	NO
Endrin	12	ND	NA	ND	NA	500	NDA	11	0.0023	UG/KG	UG/L	NO	NO	NO	NO
Dioxin Compounds															
2,3,7,8-TCDD Equivalents (TEQs)	1.208	ND	NA	NA	NA	1600	NDA	0.45	10	NG/KG	PG/L	NO	NO	NO	NO

Explanations of screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.2.5 and 10.2.11.

* Screening Concentrations:
Soil to GW - Generic SSLs based on DAF = 10, adapted from USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or calculated using values from Table 6.2
Soil to Air - From USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or USEPA Region III Risk-Based Concentration Table, June 1996
Tap Water RBC - From USEPA Region III Risk-Based Concentration Table, October 1997
Salt Water Surface Water Chronic - From USEPA Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment, November 1995, Table 2

c - Calculated soil to groundwater SSL value (See Table 6.2)
GW - Groundwater
NA - Not available
ND - Not detected
NDA - No data available
NL - Not listed
RBC - Risk-based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
NG/KG - Nanograms per kilogram
UG/KG - Micrograms per kilogram
PG/L - Picograms per liter
UG/L - Micrograms per liter

Table 10.2.12
Inorganic Chemicals Detected in Surface Soil, Subsurface Soil, Sediment, and Shallow Groundwater
Comparison to Cross-media SSLs, Tap Water RBCs, Saltwater Surface Water Chronic Screening Levels, and Background Reference Values
NAVBASE-Charleston, Zone A: SWMU 1 and SWMU 2
Charleston, South Carolina

Parameter	Maximum Concentration					Screening Concentration *											
	Surface Soil	Subsurface Soil	Sediment	Shallow GW	Deep GW	Soil to GW	Soil Background Reference	Soil to Air	Tap Water RBC	GW Background Reference	Saltwater Surf. Wtr. Chronic	Soil Units	Water Units	Leaching Potential	Fugitive Particulate Inhalation Concern	Ground-Water Migration Concern	Surface Water Migration Concern
Inorganic Chemicals																	
Aluminum	40100	95000	14700	1280	NA	560000 c	28240	NA	37000	3210	NL	MG/KG	UG/L	NO	NO	NO	NO
Antimony	470	13	9.7	ND	NA	2.5	ND	NA	15	ND	NL	MG/KG	UG/L	YES	NO	NO	NO
Arsenic	29.4	26.5	18	10.3	NA	15	9.8	750	0.045	11.1	36	MG/KG	UG/L	YES	NO	NO	NO
Barium	260	58	160	57.2	NA	800	53	690000	2600	179	NL	MG/KG	UG/L	NO	NO	NO	NO
Beryllium	2.1	0.55	2.2	ND	NA	32	ND	1300	0.016	ND	NL	MG/KG	UG/L	NO	NO	NO	NO
Cadmium	7.8	6.3	8.4	0.48	NA	4	ND	1800	18	ND	9.3	MG/KG	UG/L	YES	NO	NO	NO
Chromium (total)	112	150	76	5.2	NA	19	63.4	270	180	8.7	103	MG/KG	UG/L	YES	NO	NO	NO
Chromium (hexavalent)	0.1	0.07	NA	NA	NA	19	ND	270	180	ND	50	MG/KG	UG/L	NO	NO	NO	NO
Cobalt	66.9	2.5	3.5	6.3	NA	990 c	4.4	NA	2200	12.1	NL	MG/KG	UG/L	NO	NO	NO	NO
Copper	992.5	49.4	290	9.4	NA	5600 c	165	NA	1500	15.7	2.9	MG/KG	UG/L	NO	NO	NO	YES
Cyanide	0.37	ND	ND	ND	NA	20	ND	NA	730	0.05	1	MG/KG	UG/L	NO	NO	NO	NO
Lead	89000	1120	1000	18.9	NA	400	140	400	15	4.7	8.5	MG/KG	UG/L	YES	YES	YES	YES
Manganese	2380	308	470	3410	NA	550 c	98.1	NA	840	2690	NL	MG/KG	UG/L	YES	NO	YES	NO
Mercury	15	0.25	0.56	ND	NA	1	0.3	10	11	ND	0.2	MG/KG	UG/L	YES	YES	NO	NO
Nickel	188	33.9	54	36.4	NA	65	35	13000	730	21.1	42	MG/KG	UG/L	YES	NO	NO	NO
Selenium	1.7	5.9	ND	ND	NA	2.5	1.74	NA	180	ND	71	MG/KG	UG/L	YES	NO	NO	NO
Silver	7.8	ND	11	39.8	NA	17	ND	NA	180	ND	0.23	MG/KG	UG/L	NO	NO	NO	YES
Thallium	4.8	3.3	ND	ND	NA	0.35	ND	NA	2.9	2	21	MG/KG	UG/L	YES	NO	NO	NO
Tin	45.5	10.1	ND	40.7	NA	5500 c	ND	NA	22000	NA	NL	MG/KG	UG/L	NO	NO	NO	NO
Vanadium	114	47.8	29.7	3.2	NA	3000	77.3	NA	260	10.9	NL	MG/KG	UG/L	NO	NO	NO	NO
Zinc	1660	94.1	490	242	NA	6000	208	NA	11000	83.2	86	MG/KG	UG/L	NO	NO	NO	YES

Explanations of screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.2.6 and 10.2.12.

* Screening Concentrations:
Soil to GW - Generic SSLs based on DAF = 10, adapted from USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or calculated using values from Table 6.2
Soil to Air - From USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or USEPA Region III Risk-Based Concentration Table, June 1996
Tap Water RBC - From USEPA Region III Risk-Based Concentration Table, October 1997
Salt Water Surface Water Chronic - From USEPA Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment, November 1995, Table 2
Background reference values for soil are shown for comparison purposes only.
Maximum groundwater concentrations are screened against the greater of tap water RBCs or corresponding background reference values to determine groundwater migration concern.

c - Calculated soil to groundwater SSL value (See Table 6.2)
GW - Groundwater
NA - Not available/Not applicable
ND - Not detected
NL - Not listed
RBC - Risk-based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
UG/L - Micrograms per liter

mercury (five exceedences) were reported from only a few surface soil samples. Exceedences of selenium were found in only three subsurface soil samples. Antimony, mercury, and selenium were not detected in groundwater through four quarters of sampling. Groundwater concentrations of arsenic, cadmium, and nickel were reported below their tap water RBCs or background reference concentrations. Lead was reported in only one groundwater sample (the second-quarter sample from well NBCA-002-005) at a concentration above its TTAL. Manganese was reported in groundwater sampled during all four quarters at concentrations exceeding both its tap water RBC and its background reference concentration. These findings indicate that soil concentrations of antimony, arsenic, cadmium, lead, mercury, nickel, and selenium do not present a substantial or widespread threat to SWMU 2 groundwater. Although manganese was reported in SWMU 2 groundwater at levels exceeding screening concentrations, soil is not a likely source for these concentrations because the only manganese SSL exceedance was in surface soil. Additionally, it is not uncommon to find naturally occurring manganese in groundwater in the esturine environments of NAVBASE.

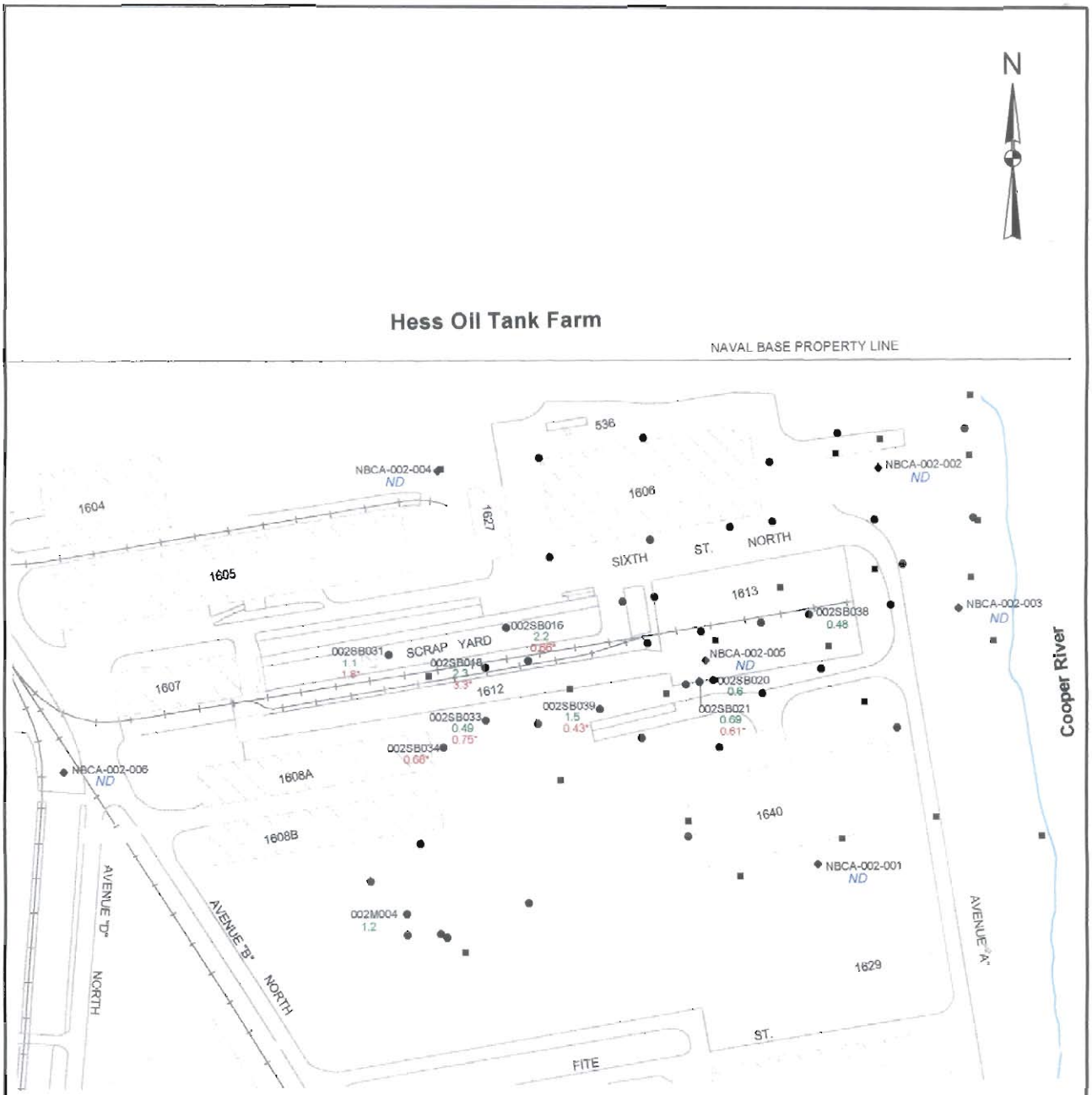
Thallium was reported in nine surface soil samples and seven subsurface soil samples at concentrations exceeding its soil-to-groundwater SSL; however, it was reported as nondetect in groundwater (including all four quarters). Similarly, chromium was reported in 27 surface soil samples and 23 subsurface soil samples but was not detected in groundwater at concentrations exceeding its tap water RBC (including all four quarters). Chromium was screened assuming it to be hexavalent, a more soluble (and toxic) form of chromium. Trivalent chromium is considered by USEPA's Soil Screening Guidance to be highly immobile. Surface and subsurface soil samples analyzed for hexavalent chromium indicate that it comprises a very small percentage of total chromium. As a result, soil concentrations of chromium and thallium do not present a substantial threat to groundwater.

Figures 10.2.9 through 10.2.16 summarize all SSL exceedances and groundwater detections for the ten metals discussed in this section.

10.2.7.2 SWMU 2 — Groundwater to Surface Water Cross-Media Transport

For purposes of fate and transport analysis, sample results from well NBCA-002-006 were removed from the dataset because the well's location falls within the area of SWMU 39 rather than SWMU 2; data from this well are included with the analysis for SWMU 39. In addition, analytical results from the samples collected at SWMU 2 during 1993 were not evaluated along with those from the 1995-1996 sampling rounds because of the time-dependence of groundwater concentrations. Tables 10.2.11 and 10.2.12 compare maximum detected groundwater concentrations from four sampling rounds at five shallow wells to tap water RBCs, saltwater surface water chronic AWQCs, and background reference values for inorganics.

No organic compounds were detected in SWMU 2 groundwater samples. As shown in Table 10.2.12, lead and manganese were detected in SWMU 2 shallow groundwater above both their tap water RBCs and their background reference concentrations. Additionally, copper, lead, silver, and zinc were detected above their AWQCs. Although copper was reported in groundwater at concentrations exceeding its saltwater surface water chronic AWQC, it was not reported at concentrations exceeding its background reference value for groundwater. The maximum groundwater concentration of lead (18.9 μg/L) exceeded its TTAL (15 μg/L), AWQC (8.5 μg/L), and its background reference concentration (4.7 μg/L) in the second-quarter sample collected from monitoring well NBCA-002-005. Manganese was reported in samples collected from monitoring well NBCA-002-002 in all four quarters at concentrations exceeding both its tap water RBC (840 μg/L) and its background reference value (2,690 μg/L). Silver was detected only in the fourth-quarter sample collected from monitoring well NBCA-002-004, where its concentration (39.8 μg/L) exceeded silver's AWQC (0.23 μg/L). Zinc was reported in samples collected from monitoring well NBCA-002-002 in all four quarters at concentrations exceeding both its AWQC (86 μg/L) and its background reference value (83.2 μg/L).



LEGEND

- Shallow Monitoring Well
- 1995 or 1997 Boring Location
- 1993 Boring Location
- 10.0 = Surface Interval SSL Exceedance (mg/kg)
- 10.0* = Subsurface Interval SSL Exceedance (mg/kg)
- 10.0 = Maximum Groundwater Detection (ug/L)
- ND = Not Detected in any Quarterly Sampling Event

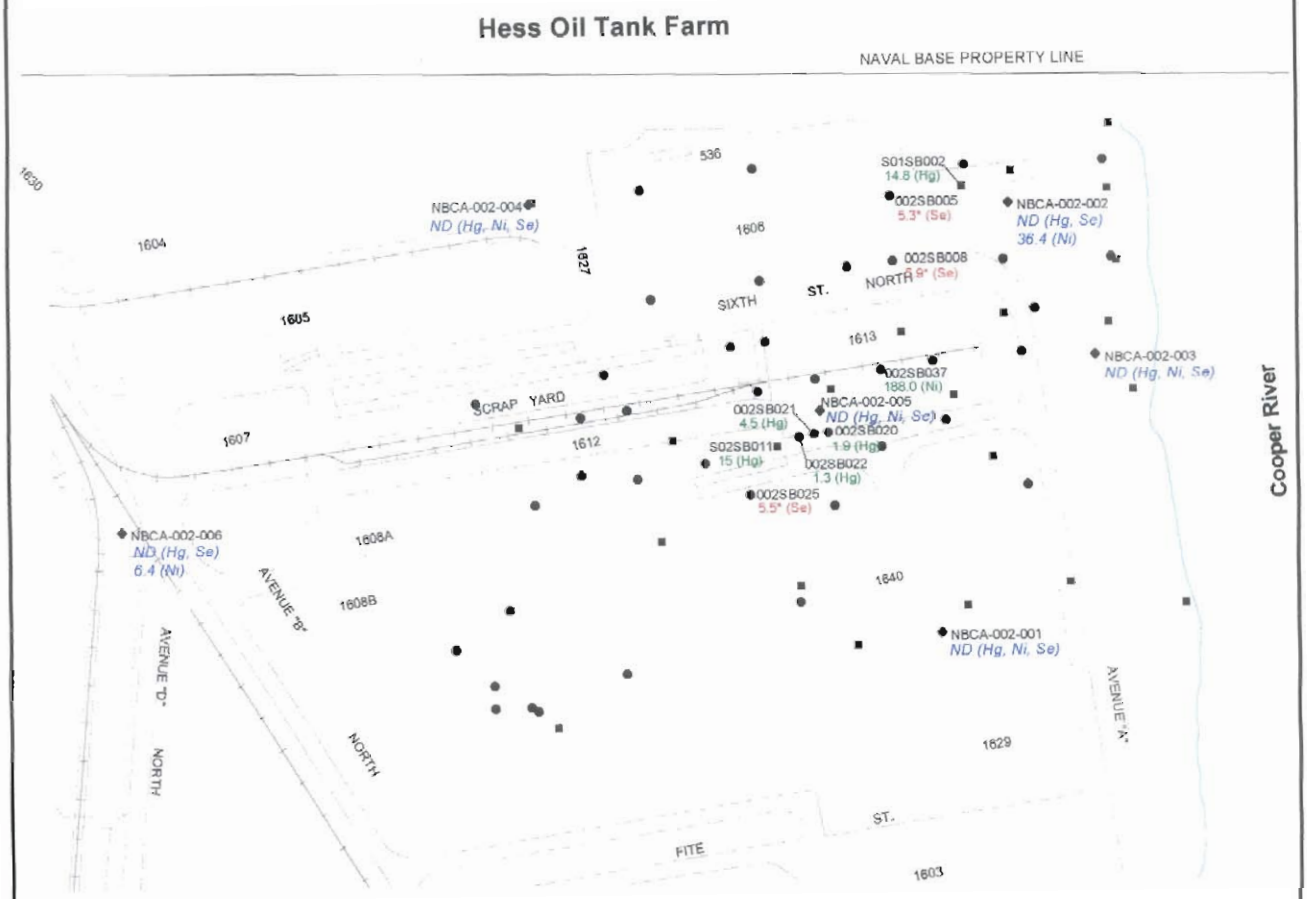
100 0 100 200 Feet

Thallium Comparison Values

SSL = 0.35 mg/kg
Soil Upper RC = None
Soil Lower RC = None
Soil RBC = 6.3 mg/kg
Groundwater RC = None
Tap-Water RBC = 2.9 ug/L

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.2.16 - SWMU 2
THALLIUM SSL SUMMARY



LEGEND

- ◆ Shallow Monitoring Well
- ● 1995 or 1997 Boring Location
- ■ 1993 Boring Location
- 10.0 = Surface Interval SSL Exceedance (mg/kg)
- 10.0* = Subsurface Interval SSL Exceedance (mg/kg)
- 10.0 = Maximum Groundwater Detection (ug/L)
- ND = Not Detected in any Quarterly Sampling Event

98 0 98 196 Feet.

Mercury (Hg) Comparison Values	Nickel (Ni) Comparison Values	Selenium (Se) Comparison Values
SSL = 1 mg/kg	65 mg/kg	2.5 mg/kg
Soil Upper RC = 0.30 mg/kg	13.6 mg/kg	1.2 mg/kg
Soil Lower RC = None	35 mg/kg	1.7 mg/kg
Soil RBC = 23 mg/kg	1600 mg/kg	390 mg/kg
Groundwater RC = None	21.1 ug/L	None
Tap-Water RBC = 11 ug/L	730 ug/L	180 ug/L

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.2.15 - SWMU 2
MERCURY, NICKEL, and SELENIUM
SSL SUMMARY

LEGEND

- Shallow Monitoring Well
- 1995 or 1997 Boring Location
- 1993 Boring Location
- 10.0 = Surface Interval SSL Exceedance (mg/kg)
- 10.0 = Subsurface Interval SSL Exceedance (mg/kg)
- 10.0 = Maximum Groundwater Detection (ug/L)
- ND = Not Detected in any Quarterly Sampling Event

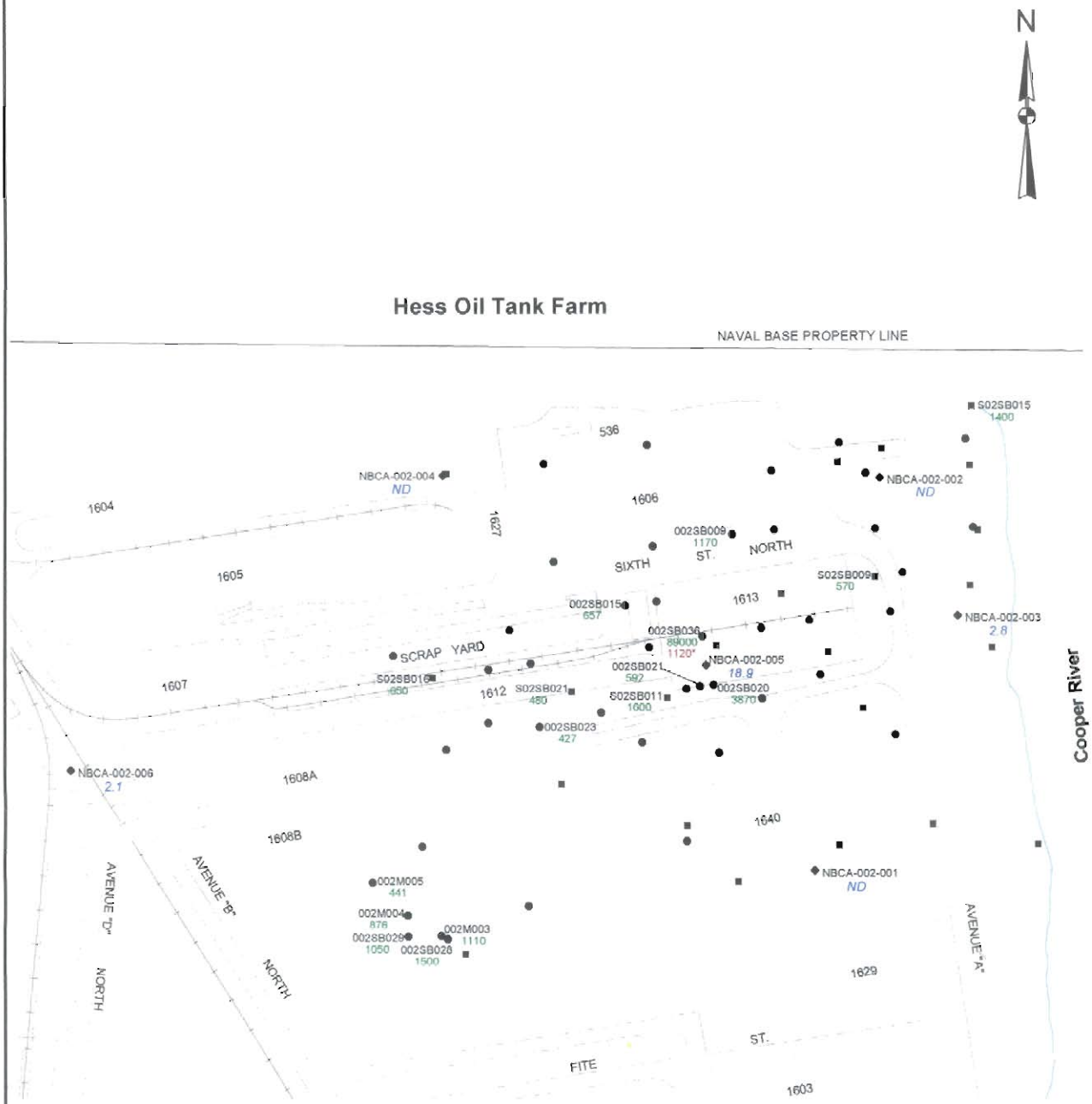
98 0 98 196 Feet

Manganese Comparison Values

SSL = 550 mg/kg
Soil Upper RC = 98.1 mg/kg
Soil Lower RC = 85.5 mg/kg
Soil RBC = 1800 mg/kg
Groundwater RC = 2690 ug/L
Tap-Water RBC = 840 ug/L

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.2.14 - SWMU 2
MANGANESE SSL SUMMARY



LEGEND

- ◆ Shallow Monitoring Well
- ● 1995 or 1997 Boring Location
- ■ 1993 Boring Location
- 10.0 = Surface Interval SSL Exceedance (mg/kg)
- 10.0* = Subsurface Interval SSL Exceedance (mg/kg)
- *10.0* = Maximum Groundwater Detection (ug/L)
- *ND* = Not Detected in any Quarterly Sampling Event

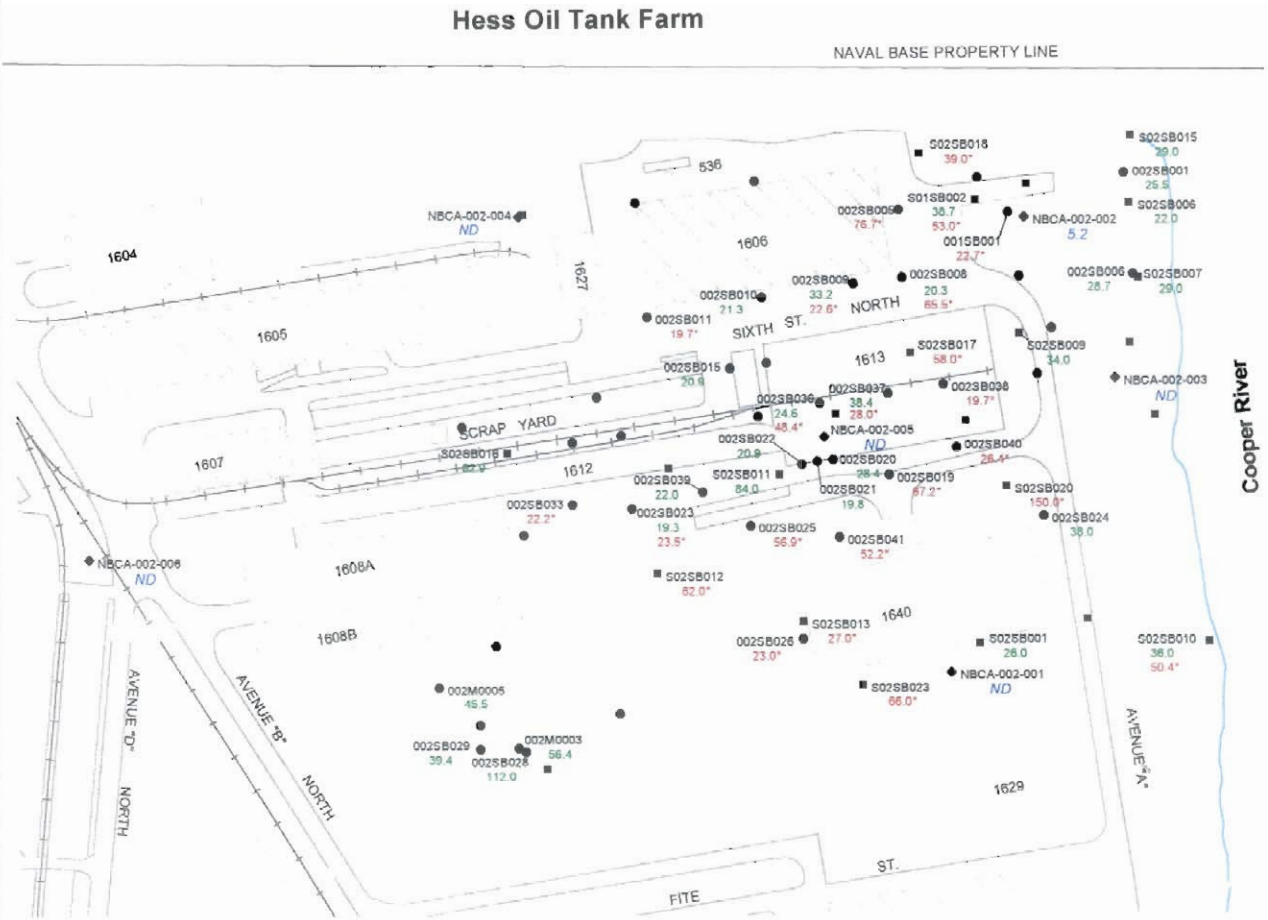
100 0 100 200 Feet

Lead Comparison Values

USEPA Soil Cleanup Level = 400 mg/kg
Soil Upper RC = 140 mg/kg
Soil Lower RC = 22 mg/kg
Groundwater RC = 4.7 ug/L
TTAL = 15 ug/L

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.2.13 - SWMU 2 LEAD SSL SUMMARY



LEGEND

- Shallow Monitoring Well
- 1995 or 1997 Boring Location
- 1993 Boring Location

10.0 = Surface Interval SSL Exceedance (mg/kg)
10.0* = Subsurface Interval SSL Exceedance (mg/kg)
10.0 = Maximum Groundwater Detection (ug/L)
ND = Not Detected in any Quarterly Sampling Event

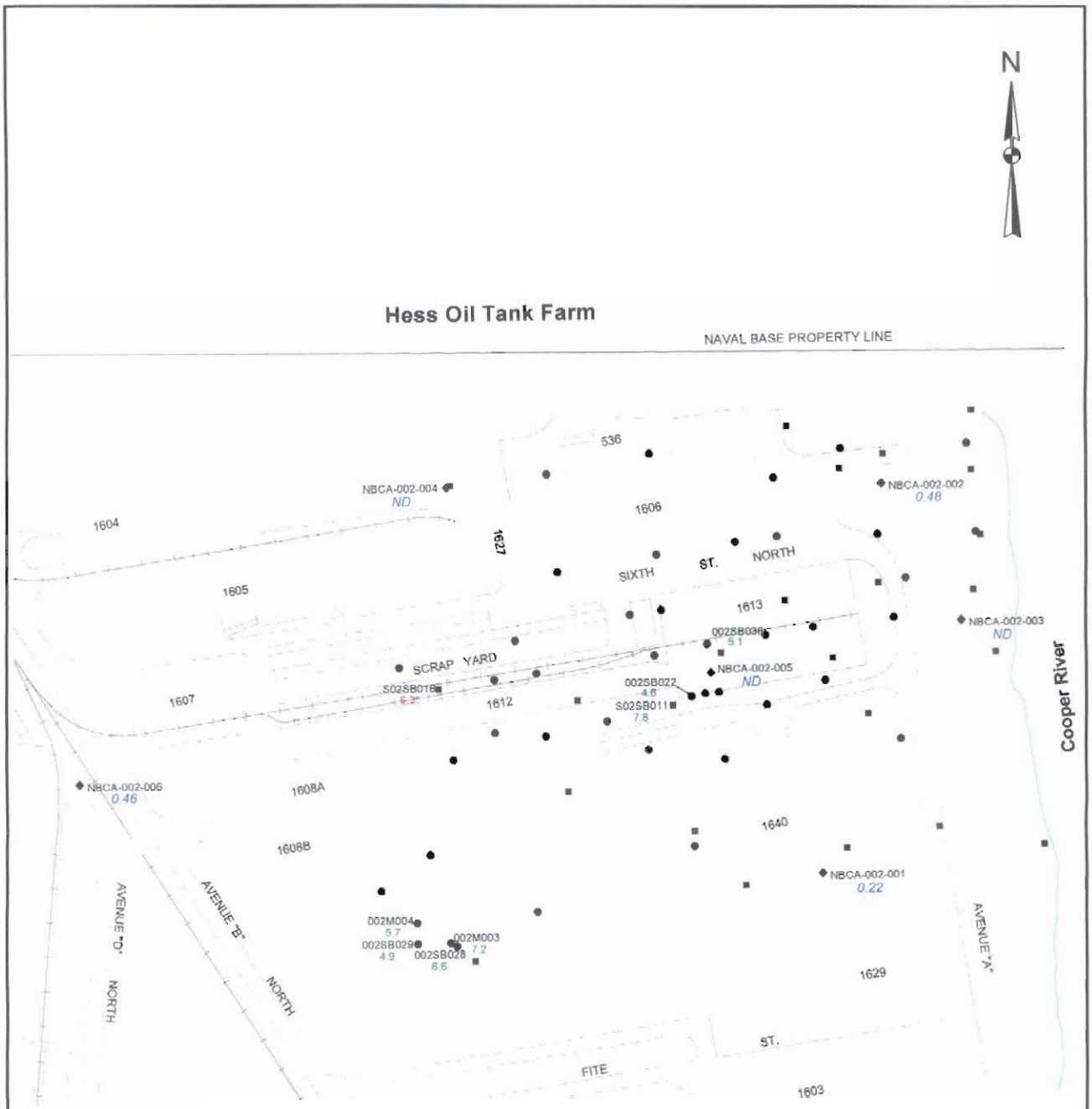
98 0 98 196 Feet

Chromium Comparison Values

SSL = 19 mg/kg
Soil Upper RC = 50.4 mg/kg
Soil Lower RC = 63.4 mg/kg
Soil RBC = 390 mg/kg
Groundwater RC = 8.7 ug/L
Tap-Water RBC = 180 ug/L

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.2.12 - SWMU 2
CHROMIUM SSL SUMMARY



LEGEND

- ◆ Shallow Monitoring Well
- ● 1995 or 1997 Boring Location
- ■ 1993 Boring Location
- 10.0 = Surface Interval SSL Exceedance (mg/kg)
- 10.0* = Subsurface Interval SSL Exceedance (mg/kg)
- 10.0 = Maximum Groundwater Detection (ug/L)
- ND = Not Detected in any Quarterly Sampling Event

98 0 98 196 Feet

Cadmium
Comparison Values

SSL = 4 mg/kg
Soil Upper RC = None
Soil Lower RC = None
Soil RBC = 39 mg/kg
Groundwater RC = None
Tap-Water RBC = 18 ug/L

Zone A RCRA Facility
Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.2.11 - SWMU 2
CADMIUM SSL SUMMARY

LEGEND

- Shallow Monitoring Well
- 1995 or 1997 Boring Location
- 1993 Boring Location
- 10.0 = Surface Interval SSL Exceedance (mg/kg)
- 10.0* = Subsurface Interval SSL Exceedance (mg/kg)
- 10.0 = Maximum Groundwater Detection (ug/L)
- ND = Not Detected in any Quarterly Sampling Event

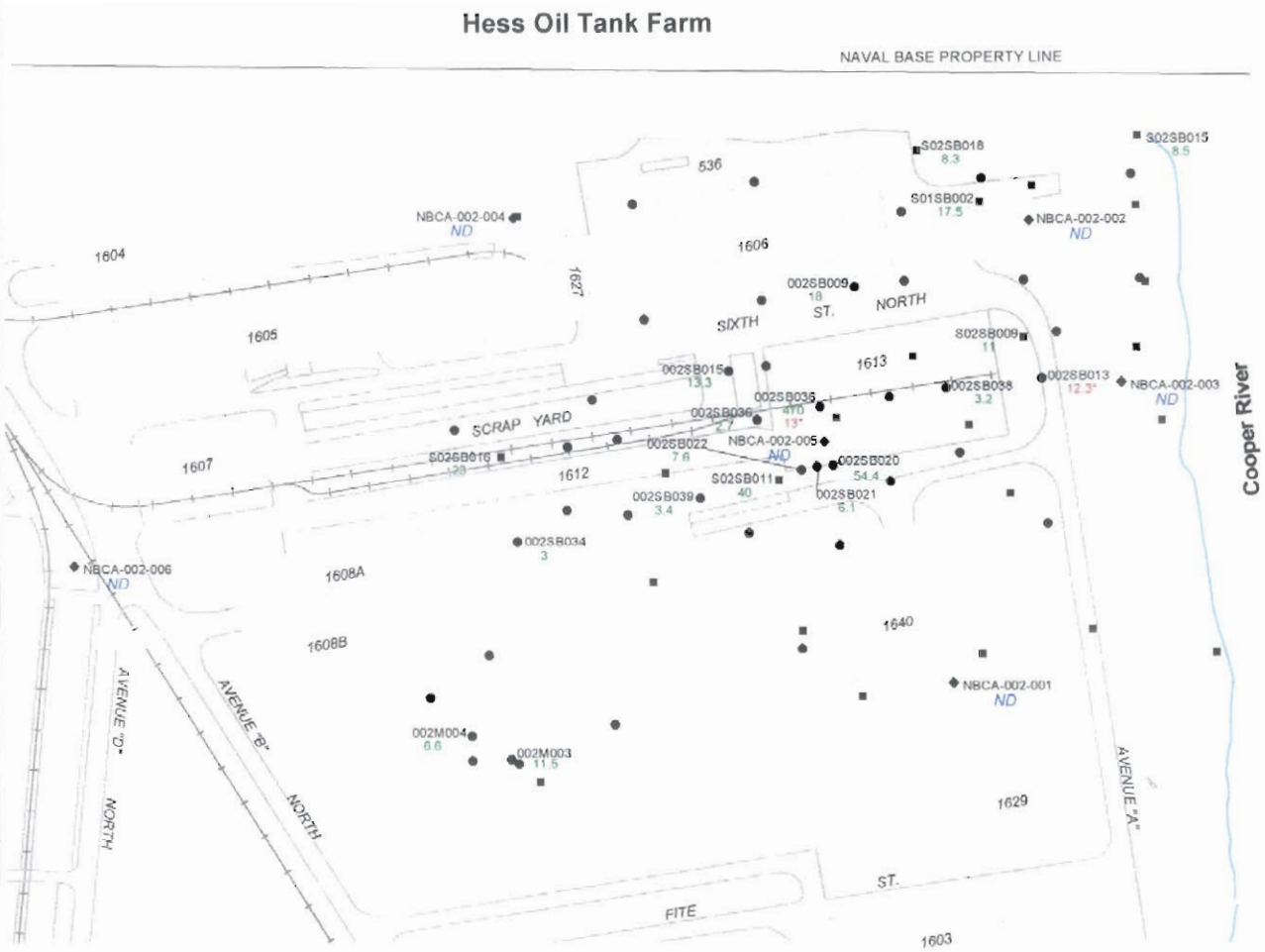
100 0 100 200 Feet

Arsenic
Comparison Values

SSL = 15 mg/kg
Soil Upper RC = 9.4 mg/kg
Soil Lower RC = 9.8 mg/kg
Soil RBC = 0.43 mg/kg
Groundwater RC = 11.1 ug/L
Tap-Water RBC = 0.045 ug/L

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.2.10 - SWMU 2
ARSENIC SSL SUMMARY



LEGEND

- Shallow Monitoring Well
- 1995 or 1997 Boring Location
- 1993 Boring Location
- 10.0 = Surface Interval SSL Exceedance (mg/kg)
- 10.0* = Subsurface Interval SSL Exceedance (mg/kg)
- 10.0 = Maximum Groundwater Detection (ug/L)
- ND = Not Detected in any Quarterly Sampling Event

100 0 100 200 Feet

Antimony Comparison Values

SSL = 2.5 mg/kg
Soil Upper RC = None
Soil Lower RC = None
Soil RBC = 31 mg/kg
Groundwater RC = None
Tap-Water RBC = 15 ug/L

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.2.9 - SWMU 2 ANTIMONY SSL SUMMARY

A travel-time analysis was performed to focus attention on the ability of these constituents to migrate with groundwater. Silver was selected as the subject of the analysis because it was considered the most mobile in the aquifer based on its low K_d value. The closest downgradient surface water body to SWMU 2 is the Cooper River. As summarized in Table 6.4, local groundwater velocity was estimated to be 5.4 feet/year in the shallow aquifer between SWMU 2 and the river. Calculation of horizontal groundwater velocity is explained in Section 2.2.9. In this case, average estimated velocity is based on (1) horizontal hydraulic conductivity of 0.78 feet/day (the geometric mean of the slug-test results from wells NBCA-002-002 and NBCA-002-005), (2) horizontal hydraulic gradient of 0.0038 (based on groundwater elevations taken from Figure 2.8, assuming a surface-water elevation of 0.5 feet for the Cooper River at this location), and (3) effective porosity of 0.20 (based on textural classes of aquifer samples, according to guidance in Table 3-1 of *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance*, USEPA 1989).

Following the potentiometric path dictated by local gradients, groundwater would travel approximately 440 feet from the area around well NBCA-002-005 to the Cooper River at the calculated rate of 5.4 feet/year. Groundwater travel time (advective movement only) is therefore estimated to be 81 years. Based on a K_d of 8.3 L/kg (from the *Soil Screening Guidance: User's Guide*, assuming a default soil pH of 6.8) and mean Zone A soil parameters (total porosity of 40% and a bulk density of 1.57 kg/L), the retardation factor for silver is 34 (Section 6.1.2). If advective travel time for groundwater from SWMU 2 to the Cooper River is 81 years, then travel time for silver via groundwater migration over the same route is 2,800 years. As a result, impacts to the Cooper River resulting from SWMU 2 groundwater are not anticipated to be significant.

10.2.7.3 SWMU 2 — Surface Soil to Sediment Cross-Media Transport

Four sediment samples were collected from catch basins and seven sediment samples were collected from the Cooper River during the 1993 sampling event associated with SWMU 2. Two

sediment samples were collected from the Cooper River during the 1995 RFI. Since most of the SWMU 2 area is covered with asphalt, concrete, or buildings, it is unlikely that SWMU 2 surface soil is a major source for inorganics found in catch basin sediments. However, minor areas of exposed surface soil in the eastern portion of SWMU 2, where the topography forces storm water runoff directly toward the east, are potential sources of sediment in this part of the Cooper River. Fate and transport of contaminants detected in catch-basin sediments will be discussed in the RFI report for Zone L, while fate and transport of contaminants originating in Cooper River sediments will be covered in the RFI report for Zone J.

10.2.7.4 SWMU 2 — Soil to Air Cross-Media Transport

As shown on Table 10.2.12, lead and mercury were reported in surface soil at concentrations exceeding their respective soil-to-air SSLs. Soil concentrations of lead were compared to its residential soil cleanup level and will be further addressed in Section 10.2.8, Human Health Risk Assessment for SWMU 2 using the Lead Model. Mercury was detected in only two surface soil samples (S01SB002 at 14.8 mg/kg and S02SB001 at 15 mg/kg) at concentrations marginally exceeding its soil-to-air SSL (10 mg/kg). As a result, mercury was not considered to be a significant contributor via the soil-to-air pathway. Because much of the "surface soil" at SWMU 2 and other Zone A sites is covered with pavement, the soil-to-air pathway would be limited even at sites where the analytical results for surface soil samples indicate the potential for migration.

10.2.7.5 SWMU 2 — Fate and Transport Summary

Detections of lead and manganese above fate and transport screening levels in both soil and groundwater suggest that soil contamination may be contributing to groundwater contamination. Manganese, however, was detected at concentrations above its soil-to-groundwater SSL in only one surface soil sample and was not considered to be a significant contributor via soil-to-groundwater transport. Lead was evaluated separately and is discussed in Section 10.2.8, Human Health Risk Assessment for SWMU 2 using the Lead Model. Although manganese is present in

groundwater at concentrations exceeding its screening levels, no site source could be determined; hence, groundwater concentrations are likely due to naturally occurring conditions. Copper, lead, silver, and zinc were detected in groundwater at concentrations exceeding their saltwater surface water chronic AWQCs. Travel-time analysis indicates that these four contaminants migrate slowly due to the aquifer's low hydraulic gradient and their tendency to bind to the aquifer matrix. Copper was not present in groundwater at concentrations exceeding its background reference concentration (including all four quarters of sampling), while silver was detected in only a single fourth-quarter sample. Site-related contaminants may have been transported through storm water drainage and sediment deposition into a small field southwest of SWMU 2 that was once a wetland.

10.2.8 Human Health Risk Assessment for SWMU 2 (includes SWMU 1)

10.2.8.1 Site Background and Investigative Approach

SWMU 1 was formerly used by the Defense Reutilization and Marketing Office (DRMO) as a storage area for waste material amassed as a result of local armed forces activities. The portion of this waste considered hazardous was stored in a shed formerly known as Building 1617. SWMU 2 was formerly used to store lead recovered from lead-acid submarine batteries. Both of these SWMUs were the focus of previous investigations. SWMU 1 was granted clean closure for soils in 1993 based on human health risk based clean-up goals developed in *Risk Assessment and Development of Risk-based Clean-up Goals for the Charleston Naval Shipyard* (Gradient 1991 and subsequent revisions). Results from the SWMU 1 soil and groundwater samples collected during the Zone A RFI substantiated the 1993 clean closure decision. SWMU 2 lead contamination was investigated in 1986 and again in 1993. These previous SWMU 2 investigations indicate that lead impacts have increased due to storm water runoff to encompass the SWMU 1 area.

Previous SWMU 2 investigations focused on lead contamination resulting from former storage activities identified in the DRMO area. Soil sampling conducted in 1987 identified lead contamination in the area of the former lead storage bin with the magnitude of lead contamination decreasing with distance (horizontal and vertical) from the source. A 1993 investigation was conducted to assess the effect of Hurricane Hugo on the distribution of lead contamination. Twenty-four surface soil samples and six groundwater samples were collected as part of the 1993 investigation. Comparison of the 1987 data to the 1993 data suggest that Hurricane Hugo had a significant effect on the distribution and concentration of contaminants at SWMU 2. Twenty-eight surface soil samples (three of which were originally collected as sediment in what was a wetland area) and six groundwater samples were collected during the 1995 Zone A RFI. An additional sixteen surface soil samples were collected from the area that was originally off limits due to potential radiological hazards. Three additional quarters of groundwater sampling was conducted from December 1995 through September 1996. Section 10.2.1 contains a soil sampling summary and Section 10.2.3 contains a groundwater sampling summary for SWMU 2.

Tables 10.2.4 and 10.2.7 (excluding the 1993 groundwater sampling event) provide sampling summaries for the surface soil and groundwater considered in the SWMU 2 HHRA. Data from all of the surface soil samples (including metals analyses from samples collected at SWMU 1) were used to assess direct contact soil pathways. Four quarters of groundwater data from all SWMU 2 monitoring wells except for monitoring well NBCA002006 were used to assess the groundwater pathways. Monitoring well NBCA002006 is located in the monitoring well network for SWMU 39 and will be included in the SWMU 39 risk assessment. Monitoring well NBCA002005 was decommissioned prior to the fourth quarter samling event, and as a result, there were only three quarters of groundwater samples collected from this monitoring well.

10.2.8.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 of this RFI and presented in Table 10.2.13, aluminum, antimony, aroclor-1260, arsenic, BEQ, beryllium, cadmium, chromium, lead, manganese, mercury, nickel, thallium and vanadium were identified as COPCs. No inorganic parameter was screened out on the basis of background concentration alone. As a result, Wilcoxon rank sum tests were not necessary.

Groundwater

As shown in Table 10.2.14, arsenic, lead, manganese, and silver were identified as shallow groundwater COPCs for this site. No inorganic parameter was screened out on the basis of background concentration alone. As a result, Wilcoxon rank sum tests were not necessary.

10.2.8.3 Exposure Assessment

Exposure Setting

SWMU 2 was formerly used to store lead recovered from lead-acid submarine batteries. The future use of this SWMU is unknown, although it is in a section of NAVBASE currently slated to become a marine cargo terminal in base reuse plans.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are hypothetical future site residents. Future site resident and worker exposure scenarios were addressed in this risk assessment. The hypothetical future site worker scenario assumed continuous exposure to surface soil conditions and the use of shallow groundwater as a potable water source. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact and the fact that groundwater is not currently used onsite as a source of potable or process water.

Table 10.2.13
Chemicals Present in Site Samples
SWMU 2 - Surface Soil
NAVBASE Charleston
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration RBC	Ref.	Units	Number Exceeding RBC	Ref.
Inorganics													
Aluminum (Al)	*	68	68	1280	40100	7491	NA	NA	7800	12800	mg/kg	22	5
Antimony (Sb)	*	23	68	0.37	470	31	0.34	56.4	3.1	NA	mg/kg	16	
Arsenic (As)	*	62	68	0.93	29.4	8.2	0.88	3	0.43	9.44	mg/kg	62	17
Barium (Ba)		67	68	3.6	260	40	13	13	550	53	mg/kg		11
Beryllium (Be)	*	25	68	0.05	2.1	0.33	0.2	2.4	0.15	NA	mg/kg	16	
Cadmium (Cd)	*	32	68	0.12	7.8	2.7	0.04	1.3	3.9	NA	mg/kg	8	
Calcium (Ca)	N	68	68	529	356000	41492	NA	NA	NA	NA	mg/kg		
Chromium (Cr)	*	67	68	3.2	112	21	23	23	39	50.4	mg/kg	6	4
Chromium (Hexavalent)		4	5	0.026	0.1	0.053	0.049	0.049	39	NA	mg/kg		
Cobalt (Co)		49	68	0.24	66.9	6.2	1.1	1.4	470	4.4	mg/kg		13
Copper (Cu)	*	66	68	0.78	992.5	75	2.6	2.8	310	165	mg/kg		6
Cyaninde (CN)		1	1	0.37	0.37	0.37	NA	NA	160	NA	mg/kg		
Iron (Fe)	N	68	68	490	34200	10234	NA	NA	NA	NA	mg/kg		
Lead (Pb)	*	67	68	1	89000	1617	228	228	400	140	mg/kg	16	25
Magnesium (Mg)	N	67	68	96.1	5300	1114	1420	1420	NA	NA	mg/kg		
Manganese (Mn)	*	68	68	3.1	2380	96	NA	NA	180	98.1	mg/kg	4	12
Mercury (Hg)	*	41	68	0.015	15	1.1	0.01	0.55	2.3	0.3	mg/kg	3	10
Nickel (Ni)	*	59	68	1	188	18	3.1	4.9	160	13.55	mg/kg	1	22
Potassium (K)	N	61	68	68.9	2760	444	100	243	NA	NA	mg/kg		
Selenium (Se)		28	68	0.43	1.7	1.1	0.34	5.7	39	1.2	mg/kg		10
Silver (Ag)		5	68	0.36	7.8	2.3	0.21	3.3	39	NA	mg/kg		
Sodium (Na)	N	61	68	72	1110	290	52	61	NA	NA	mg/kg		
Thallium (Tl)	*	9	68	0.48	2.3	1.2	0.38	5.9	0.63	NA	mg/kg	6	
Tin (Sn)		25	44	1.2	45.5	7.1	0.57	9.6	4700	NA	mg/kg		
Vanadium (V)	*	68	68	1.6	114	21	NA	NA	55	29.24	mg/kg	2	9
Zinc (Zn)		68	68	5.2	1660	210	NA	NA	2300	207.6	mg/kg		18
Carconogenic PAHs													
B(a)P Equiv.	*	1	1	90.87	90.87	91	NA	NA	88	NA	ug/kg	1	
Benzo(a)pyrene		1	1	78	78	78	NA	NA	88	NA	ug/kg		
Benzo(b)fluoranthene		1	1	120	120	120	NA	NA	880	NA	ug/kg		
Benzo(k)fluoranthene		1	1	74	74	74	NA	NA	8800	NA	ug/kg		
Chrysene		1	1	130	130	130	NA	NA	88000	NA	ug/kg		
Semivolatile Organics													
Benzo(g,h,i)perylene		1	1	73	73	73	NA	NA	230000	NA	ug/kg		
Fluoranthene		1	1	170	170	170	NA	NA	310000	NA	ug/kg		
2-Methylnaphthalene		1	1	140	140	140	NA	NA	310000	NA	ug/kg		
Phenanthrene		1	1	150	150	150	NA	NA	230000	NA	ug/kg		
Pyrene		1	1	120	120	120	NA	NA	230000	NA	ug/kg		

Table 10.2.13
Chemicals Present in Site Samples
SWMU 2 - Surface Soil
NAVBASE Charleston
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration RBC	Ref.	Units	Number Exceeding RBC	Ref.
Pesticides/PCBs													
Aroclor-1260	*	1	1	500	500	500	NA	NA	320	NA	ug/kg	1	
4,4'-DDD		1	1	8.5	8.5	8.5	NA	NA	2700	NA	ug/kg		
4,4'-DDE		1	1	140	140	140	NA	NA	1900	NA	ug/kg		
4,4'-DDT		1	1	26	26	26	NA	NA	1900	NA	ug/kg		
Endrin		1	1	12	12	12	NA	NA	23000	NA	ug/kg		
TCDD Equivalents													
Dioxin Equiv.		1	1	1.2082	1.2082	1.2	NA	NA	1000	NA	ng/kg		
Volatile Organics													
Acetone		1	1	29	29	29	NA	NA	780000	NA	ug/kg		
2-Butanone (MEK)		1	1	6	6	6	NA	NA	4700000	NA	ug/kg		

* - Selected as a COPC based on the screening process described in 7.3.4
RBC - Risk-based Concentration based on a target risk of 1E-06 and a target hazard quotient of 0.1.
Ref. - Surface soil background concentration for Zone A.
N - Essential nutrients eliminated from the screening process.
mg/kg - milligrams per kilogram
ug/kg - micrograms per kilogram
ng/kg - nanograms per kilogram

Table 10.2.14
Chemicals Present in Site Samples
SWMU 2 - Shallow Groundwater
NAVBASE Charleston
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration RBC	Ref.	Units	Number Exceeding RBC	Ref.
Inorganics													
Aluminum (Al)		7	19	50	1280	506.5	9.9	192	3700	3120	ug/L		
Arsenic (As)	*	4	19	2.2	10.3	5.7	2	7	0.045	7.4	ug/L	4	1
Barium (Ba)		14	19	23.6	57.2	36.2	22.7	48.9	260	104	ug/L		
Cadmium (Cd)		2	19	0.22	0.48	0.4	0.22	5	1.8	NA	ug/L		
Calcium (Ca)	N	18	19	6260	236000	73727.8	11100	11100	NA	NA	ug/L		
Chromium (Cr)		1	19	5.2	5.2	5.2	2.1	6	18	8.7	ug/L		
Cobalt (Co)		2	19	1.5	6.3	3.9	0.67	7	220	NA	ug/L		
Copper (Cu)		5	19	1.7	9.4	4.2	3	7	150	15.7	ug/L		
Iron (Fe)	N	19	19	113	15700	3936.1	NA	NA	NA	NA	ug/L		
Lead (Pb)	*	2	19	2.8	18.9	10.9	1.4	15	15	4.7	ug/L	1	1
Magnesium (Mg)	N	19	19	13200	86100	45294.7	NA	NA	NA	NA	ug/L		
Manganese (Mn)	*	17	19	26.5	3410	1050.9	28.1	28.3	84	577	ug/L	17	5
Nickel (Ni)		2	19	13	34.6	23.8	0.67	17	73	NA	ug/L		
Potassium (K)	N	19	19	4000	67500	28427.4	NA	NA	NA	NA	ug/L		
Silver (Ag)	*	1	19	39.8	39.8	39.8	1	7	18	NA	ug/L	1	
Sodium (Na)	N	18	19	25500	771000	306455.6	31700	31700	NA	NA	ug/L		
Tin (Sn)		2	19	33.6	40.7	37.2	5.5	37	2200	NA	ug/L		
Vanadium (V)		1	19	3.2	3.2	3.2	0.44	7	26	5.4	ug/L		
Zinc (Zn)		6	20	9	242	149.2	3.1	23.7	1100	83.2	ug/L		4

* - Selected as a COPC based on the screening process described in 7.3.4
RBC - Risk-based Concentration based on a target risk of 1E-06 and a target hazard quotient of 0.1.
Ref. - Shallow groundwater background concentration for Zone A.
N - Essential nutrient
ug/L - micrograms per liter

Therefore, future worker assessment is considered to be protective of current site users. The future site resident scenario was built on the premise that current buildings would be removed and replaced with dwellings. In addition, the future site residents were assumed to use the shallow aquifer onsite as a source of drinking water.

Exposure Pathways

Exposure pathways for the site workers are dermal contact, incidental ingestion of surface soils, and ingestion of shallow groundwater through potable use. The exposure pathways for future residential land use are the same as those for the future site worker. In addition, the hypothetical future site worker scenario assumed continuous exposure to surface soil and groundwater conditions. Uniform exposure was assumed for all sample locations. Table 10.2.15 presents the justification for exposure pathways assessed in this HHRA.

Table 10.2.15
Exposure Pathways Summary — SWMU 2
NAVBASE — Zone A
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
		Current Land Uses	
Current Site Users/Maintenance	Air, Inhalation of gaseous contaminants emanating from soil	No	No COPCs were identified based on screening comparisons summarized in the Fate and Transport Section.
	Air, Inhalation of chemicals entrained in fugitive dust	No	No COPCs were identified based on screening comparisons summarized in the Fate and Transport Section.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No (Qualified)	Shallow groundwater is not currently used as a source of potable or nonresidential water at combined SWMU 2. Future land use assessment is considered conservatively representative of current receptors.
	Shallow groundwater, Inhalation of volatilized shallow groundwater contaminants	No (Qualified)	Shallow groundwater is not currently used as a source of domestic or process use water at combined SWMU 2. Future land use assessment is considered conservatively representative of current receptors.

Table 10.2.15
Exposure Pathways Summary — SWMU 2
NAVBASE — Zone A
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Site Users/Maintenance (Continued)	Soil, Incidental ingestion	No (Qualified)	Future land use assessment is considered to be conservatively representative of current receptors.
	Soil, Dermal contact	No (Qualified)	Future land use assessment is considered conservatively representative of current receptors.
	Future Land Uses		
Future Site Residents (Child and Adult) and Future Site Worker	Air, Inhalation of gaseous contaminants emanating from soil	No	Based on the COPCs identified in this HHRA, this would not be a significant pathway.
	Air, Inhalation of chemicals entrained in fugitive dust	No	No COPCs were identified for this site that would significantly contribute to this pathway.
	Shallow groundwater, Ingestion of contaminants during potable or general use	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	Yes	COPCs were identified subsequent to risk-based screening comparisons.
	Soil, Incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, Dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals, Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina city limits.
	Fruits and vegetables, Ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Exposure Point Concentrations

As discussed in Section 7 of this RFI, UCLs were calculated for datasets consisting of at least 10 samples. UCLs calculated for surface soils are presented in Table 10.2.16. These UCLs were applied as the exposure point concentrations used to estimate the hazard and risk due to exposure to COPCs in SWMU 2 surface soil. Aroclor-1260 and benzo(a)pyrene equivalents each had only one sample result, and as a result, the maximum concentration was used as the EPC for these constituents.

Table 10.2.17 is the statistical analysis for groundwater COPC data. Six shallow monitoring wells were originally installed at this site and sampled once a quarter for four quarters. Monitoring well NBCA-002-005 was abandoned between the third and fourth quarters and thus not sampled in the fourth quarter event. NBCA-002-006 is located in the monitoring well network for SWMU 39 and was not considered in the SWMU 2 HHRA. Current EPA guidance favors the use of the arithmetic mean in the most concentrated area of the plume as the EPC for groundwater COPCs. Groundwater COPCs cannot be associated with a single distinct plume. Instead each of the COPCs were assigned to their own "plume". In each case, a separate plume is defined by the monitoring well which produced the highest concentration for a given COPC. The EPC is calculated as the arithmetic mean of the four quarters of data from the same well. For example, the maximum arsenic detection (0.0103 mg/L) was from monitoring well NBCA-002-004 sampled during the fourth quarter. The first quarter sample from this monitoring well had arsenic at a concentration of 0.0058 mg/L; the third quarter sample from this monitoring well has an arsenic concentration of 0.0046 mg/L; and the second quarter sample was nondetect. The data from first, third and fourth quarter (0.0103, 0.0058, and 0.0064 mg/L) and one half of the SQLs for the nondetected result of the second quarter (0.0035 mg/L) yield an average of 0.0061 mg/L which was used as the EPC for arsenic. This same approach was used for lead, manganese, and silver.

Table 10.2.16
Statistical Analysis of COPCs
Surface Soils at SWMU 2
Naval Base Charleston Zone A
Charleston, South Carolina

COPC	n	Natural Log Transformed mean	SD	H-stat	UCL (mg/kg)	MAX (mg/kg)	EPC (mg/kg)	
Inorganics								
Aluminum	68	8.714	0.648	1.984	8787	40100	8787	UCL Used
Antimony	68	1.484	1.187	2.511	12.8	470	12.8	UCL Used
Arsenic	68	1.671	0.978	2.284	11.27	29.4	11.27	UCL Used
Beryllium	68	-1.567	0.684	2.012	0.31	2.1	0.31	UCL Used
Cadmium	68	-0.298	1.278	2.614	2.53	7.8	2.53	UCL Used
Chromium	68	2.783	0.728	2.049	25.3	112	25.3	UCL Used
Lead	68	4.178	2.076	3.639	1416	89000	1416	UCL Used
Manganese	68	3.672	1.170	2.492	111	2380	111	UCL Used
Mercury	68	-2.384	1.512	2.896	0.49	15	0.49	UCL Used
Nickel	68	2.184	1.113	2.430	23.0	188	23.0	UCL Used
Thallium	68	-0.607	0.687	2.015	0.82	2.3	0.82	UCL Used
Vanadium	68	2.802	0.717	2.040	25.5	114	25.5	UCL Used
Carcinogenic PAHs/PCBs								
Aroclor 1260	1	6.215	NA	NA	NA	0.50	0.50	MAX Used
Benzo(a)pyrene equivalents	1	4.509	NA	NA	NA	0.091	0.091	MAX Used

NOTES:

mean arithmetic mean of the logtransformed data
n number of samples analyzed
SD standard deviation for a sample of data
H-stat "H" statistic from Gilbert 1987; cuboidal interpolation was used to determine the val accordance with USEPA Supplemental Guidance to RAGS, Calculating the Conc
NA not applicable
EPC exposure point concentration
UCL 95 percentile upper confidence level mean
MAX maximum reported concentration

Table 10.2.17
Statistical Analysis of COPCs
Groundwater at SWMU 2
Naval Base Charleston Zone A
Charleston, South Carolina

COPC	Number of Detects	Number of Samples	Natural Log Transformed mean	SD	H-stat	Average in Plume (mg/L)	UCL (mg/L)	MAX (mg/L)	EPC (mg/L)	
Arsenic (As)	4	19	0.554	0.713	2.245	0.0061	0.0033	0.0103	0.0061	Plume
Lead (Pb)	2	19	0.329	0.844	2.410	0.009	0.0032	0.0189	0.009	Plume
Manganese (Mn)	17	19	5.723	1.724	3.795	3.24	6.32	3.41	3.24	Plume
Silver (Ag)	1	19	0.810	0.979	2.595	0.012	0.0066	0.0398	0.012	Plume

NOTES:

mean arithmetic mean of the logtransformed data
n number of samples analyzed
SD standard deviation for a sample of data
H-stat "H" statistic from Gilbert 1987; cuboidal interpolation was used to determine the value in accordance with USEPA Supplemental Guidance to RAGS, Calculating the Concentration Ter
NA not applicable
EPC exposure point concentration
UCL 95 percentile upper confidence level mean
Max maximum reported concentration
Plume defined as the arithmetic mean of the maximum concentration and the results of the remaining thre quarters taken from the same well (one-half the SQL for nondetects)

Quantification of Exposure

Soil

CDIs for ingestion and dermal contact with soils are shown in Tables 10.2.18 and 10.2.19, respectively.

Groundwater

The CDIs for groundwater ingestion are presented in Table 10.2.20.

10.2.8.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Table 10.2.21 presents toxicological information specific to each COPC identified at SWMU 2. This information was used in the quantification of risk/hazard associated with soil and groundwater contaminants. Brief toxicological profiles for each COPC are provided in the following paragraphs.

Aluminum is one of the most abundant metals in the earth's crust, and it is ubiquitous in air and water, as well as soil. This metal is water-soluble, silvery, and ductile, which suggests its usefulness in many processes. Ingestion of aluminum can affect the absorption of other elements within the gastrointestinal tract and can alter intestinal function. Aluminum can potentially interfere with the absorption of essential nutrients and cholesterol absorption. Another effect on the gastrointestinal system is the inhibition of acetylcholine-induced contractions. These contractions are part of the neuro-muscular system controlling bowel muscles. This effect could explain why aluminum-containing antacids often produce constipation. Aluminum dust is moderately flammable and explosive in heat. Inhalation of this dust can cause fibrosis (aluminosis). No data is available on an applicable slope factor or the USEPA cancer group. The National Criteria and Exposure Assessment Regional Support group has provided a provisional RfD of 1 mg/kg-day. The aesthetic-based Secondary Maximum Contaminant Limit (SMCL) for drinking water is 0.05-0.2 μg/l (Klaassen, et al, 1986) (Dreisbach, et al, 1987).

Table 10.2.18
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil
SWMU 2
Naval Base Charleston
Charleston, South Carolina

Chemical	Fraction Ingested from Contaminated Source *	Exposure Point Concentration (mg/kg)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Inorganics							
Aluminum	1	8787	1.20E-02	1.12E-01	1.38E-02	4.30E-03	1.54E-03
Antimony	1	12.8	1.76E-05	1.64E-04	2.01E-05	6.28E-06	2.24E-06
Arsenic	1	11.3	1.54E-05	1.44E-04	1.76E-05	5.51E-06	1.97E-06
Beryllium	1	0.31	4.27E-07	3.99E-06	4.88E-07	1.53E-07	5.45E-08
Cadmium	1	2.53	3.46E-06	3.23E-05	3.95E-06	1.24E-06	4.41E-07
Chromium	1	25.3	3.46E-05	3.23E-04	3.96E-05	1.24E-05	4.42E-06
Manganese	1	111	1.53E-04	1.42E-03	1.74E-04	5.45E-05	1.95E-05
Mercury	1	0.49	6.76E-07	6.31E-06	7.73E-07	2.42E-07	8.63E-08
Nickel	1	23.0	3.15E-05	2.94E-04	3.59E-05	1.12E-05	4.01E-06
Thallium	1	0.82	1.12E-06	1.04E-05	1.28E-06	4.00E-07	1.43E-07
Vanadium	1	25.5	3.49E-05	3.26E-04	3.99E-05	1.25E-05	4.45E-06
Carcinogenic PAHs/PCBs							
Aroclor 1260	1	0.50	6.85E-07	6.39E-06	7.83E-07	2.45E-07	8.74E-08
Benzo(a)pyrene equivalents	1	0.091	1.24E-07	1.16E-06	1.42E-07	4.45E-08	1.59E-08

NOTES:

lwa Lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.2.19
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil
SWMU 2
Naval Base Charleston
Charleston, South Carolina

Chemical	Exposure Point Concentration (mg/kg)	Fraction Contacted from Contaminated Source *	Dermal Absorption Factor (unitless)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Aluminum	8787	1	0.001	4.94E-04	1.63E-03	3.09E-04	3.53E-04	1.26E-04
Antimony	12.8	1	0.001	7.21E-07	2.38E-06	4.51E-07	5.15E-07	1.84E-07
Arsenic	11.3	1	0.001	6.33E-07	2.09E-06	3.96E-07	4.52E-07	1.61E-07
Beryllium	0.31	1	0.001	1.75E-08	5.78E-08	1.10E-08	1.25E-08	4.47E-09
Cadmium	2.53	1	0.001	1.42E-07	4.68E-07	8.88E-08	1.01E-07	3.62E-08
Chromium	25.3	1	0.001	1.42E-06	4.69E-06	8.89E-07	1.01E-06	3.62E-07
Manganese	111	1	0.001	6.25E-06	2.06E-05	3.91E-06	4.47E-06	1.60E-06
Mercury	0.49	1	0.001	2.77E-08	9.15E-08	1.74E-08	1.98E-08	7.07E-09
Nickel	23.0	1	0.001	1.29E-06	4.26E-06	8.07E-07	9.21E-07	3.29E-07
Thallium	0.82	1	0.001	4.59E-08	1.51E-07	2.87E-08	3.28E-08	1.17E-08
Vanadium	25.5	1	0.001	1.43E-06	4.72E-06	8.95E-07	1.02E-06	3.65E-07
Carcinogenic PAHs/PCBs								
Aroclor 1260	0.50	1	0.01	2.81E-07	9.27E-07	1.76E-07	2.01E-07	7.16E-08
Benzo(a)pyrene equivalents	0.091	1	0.01	5.10E-08	1.68E-07	3.19E-08	3.65E-08	1.30E-08

NOTES:

CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.2.20
Chronic Daily Intakes (CDI)
Ingestion of COPCs in Shallow Groundwater
SWMU 2
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Exposure Point Concentration (mg/liter)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Future Worker adult H-CDI (mg/kg-day)	Future Worker adult C-CDI (mg/kg-day)
Arsenic (As)	0.0061	1.66E-04	3.87E-04	9.12E-05	5.92E-05	2.91E-05
Manganese (Mn)	3.2	8.88E-02	2.07E-01	4.88E-02	3.17E-02	1.56E-02
Silver (Ag)	0.012	3.27E-04	7.64E-04	1.80E-04	1.17E-04	5.75E-05

NOTES:

lwa Lifetime weighted average
CDI Chronic Daily Intake
H-CDI Non-carcinogenic hazard based Chronic Daily Intake
C-CDI Carcinogenic risk based Chronic Daily Intake

Table 10.2.21
Toxicological Database Information
for Chemicals of Potential Concern
SWMU 2
NAVBASE Charleston, Zone A
Charleston, South Carolina

Non-Carcinogenic Toxicity Data

Chemical	Oral Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Inhalation
Inorganics										
Aluminum	1	d				ND				
Antimony	0.0004	a	L	Decreased lifespan	1000	ND				
Arsenic	0.0003	a	M	hyperpigmentation	3	ND				
Beryllium	0.005	a	L	microscopic organ changes	100	ND				
Cadmium (food)	0.001	a	H	Proteinuria	10	ND				
Cadmium (water)	0.0005	a	H	Proteinuria	10	ND				
Chromuim (III)	1	a	L	No observable effects	100	ND				
Chromium (VI)	0.005	a	L	No observable effects	500	ND				
Manganese	0.047	a	M	neurological effects	1	1.43E-05	a		Increased incidence of pneumonia	
Mercury	0.0003	b	NA	Autoimune effects	30	8.6E-05	c		Memory disturbances	30
Nickel	0.02	a	M	Decreased body weight	300	ND				
Silver	0.005	a	L	Argyria	3	ND				
Thallium	8E-05	a	L	Increased SGOT	3000	ND				
Vanadium	0.007	b			100	ND				
Carcinogenic PAHs/PCBs										
Aroclor 1260	ND					ND				
Benzo(a)pyrene equivalents	ND					ND				

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
NA Not applicable or not available
ND Not determined due to lack of information

Table 10.1.21
Toxicological Database Information
for Chemicals of Potential Concern
SWMU 2
NAVBASE Charleston, Zone A
Charleston, South Carolina

Carcinogenic Toxicity Data

Chemical	Oral Slope Factor [(mg/kg/day)]-1		Inhalation Slope Factor [(mg/kg/day)]-1		Weight of Evidence	Tumor Type
Aluminum	ND		ND			
Antimony	ND		ND			
Arsenic	1.5	a	15.1	a	A	various
Beryllium	4.3	a	8.4	a	B2	osteosarcoma
Cadmium (food)	ND		6.3	a	B1	Lung cancer
Cadmium (water)	ND		ND			
Chromuim (III)	ND		ND			
Chromium (VI)	ND		42	b	A	Lung cancer
Manganese	ND		ND		D	
Mercury	ND		ND			
Nickel	ND		ND			
Silver	ND		ND			
Thallium	ND		ND			
Vanadium	ND		ND			
Carcinogenic PAHs/PCBs						
Aroclor 1260	2	a	2	a	B2	Liver
Benzo(a)pyrene equivalents	7.3	a	3.1	a	B2	Forestomach

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
e EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
NA Not applicable or not available
ND Not determined due to lack of information

Antimony belongs to the same periodic group as arsenic. This element is absorbed slowly through the gastrointestinal tract, which is the target of this element. Another target is the blood, where antimony concentrates. Antimony is also a common air pollutant from industrial emissions. USEPA has not classified antimony as a carcinogen, and the oral RfD is 0.0004 mg/kg-day (Klaassen, et al, 1986).

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher levels. Exposure to arsenic containing materials has been shown to cause cancer in humans. Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Human milk contains about 3 μg/L arsenic (Klaassen, et al, 1986). USEPA set 0.0003 mg/kg-day as the oral RfD for arsenic based on a NOAEL of 0.0008 mg/kg-day and an uncertainty factor of 3. The uncertainty accounts for insufficiencies in the data base and sensitive human subpopulations. The overall confidence in the oral RfD is medium. Arsenic has been classified as a group A carcinogen with an oral slope factor of 1.5 $(mg/kg\text{-}day)^{-1}$. A inhalation slope factor of 15.1 $(mg/kg\text{-}day)^{-1}$ is calculated by converting the IRIS unit risk to dose units.

Benzo(a)pyrene equivalents include the following list of polynuclear aromatic hydrocarbons:

Benzo(a)anthracene	TEF	0.1
Benzo(b)fluoranthene	TEF	0.1
Dibenz(a,h)anthracene	TEF	1.0
Benzo(k)fluoranthene	TEF	0.01
Benzo(a)pyrene	TEF	1.0
Indeno(1,2,3-cd)pyrene	TEF	0.1
Chrysene	TEF	0.001

Some PAHs are toxic to the liver, kidney, and blood. However, the toxic effects of the PAHs above have not been well established. There are no RfDs for the PAHs above due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of benzo(a)pyrene, having an oral SF 7.3 $(mg/kg\text{-}day)^{-1}$. Toxicity Equivalency Factors, also set by USEPA, are multipliers that are applied to the detected concentrations, which are subsequently used to calculate excess cancer risk. These multipliers are discussed further in the exposure and toxicity assessment sections. Most carcinogenic PAHs have been classified as carcinogenic due to animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke). As listed in IRIS (search data 6/28/95), the basis for the benzo(a)pyrene B2 classification is human data specifically linking benzo(a)pyrene to a carcinogenic effect are lacking. There are, however, multiple animal studies in many species demonstrating benzo(a)pyrene to be carcinogenic by numerous routes.

Benzo(a)pyrene has produced positive results in numerous genotoxicity assays. At the June 1992 CRAVE Work Group meeting, a revised risk estimate for benzo(a)pyrene was verified (see Additional Comments for Oral Exposure). This section provides information on two aspects of the carcinogenic risk assessment for the agent in question: the USEPA classification and quantitative estimates of exposure. The classification reflects a weight-of-evidence judgment of the likelihood that the agent is a human carcinogen. The quantitative risk estimates are presented in application of a low-dose extrapolation procedure and presented as the risk per (mg/kg)-day. The unit risk is the quantitative estimate in terms of either risk per $\mu g/L$ drinking water or risk per $\mu g/m^3$ air breathed. The third form in which risk is presented is drinking water or air concentration providing cancer risks of 1 in 10,000 or 1 in 1,000,000. The Carcinogenicity Background Document provides details on the carcinogenicity values found in IRIS. Users are

referred to the Oral Reference Dose and Reference Concentration sections for information on long-term toxic effects other than carcinogenicity.

As listed in IRIS (search date 6/28/95), the basis for the dibenz(a,h)anthracene and benzo(b)fluoranthene B2 classification is no human data and sufficient data from animal bioassays. Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal or subcutaneous injection, and skin painting. As listed in IRIS (search date 6/28/95), the basis for the benzo(a)anthracene B2 classification is no human data and sufficient data from animal bioassays. Benzo(a)anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous or intramuscular injection; and topical application. Benzo(a)anthracene produced mutations in bacteria and in mammalian cells, and transformed mammalian cells in culture. As listed in IRIS (search date 6/28/95) the basis for the benzo(k)fluoranthene B2 classification is no human data and sufficient data from animal bioassays. Benzo(k)fluoranthene produced tumors after lung implantation in mice and when administered with a promoting agent in skin-painting studies. Equivocal results have been found in a lung adenoma assay in mice. Benzo(k)fluoranthene is mutagenic in bacteria. (Klaassen, et al., 1986).

Other PAHs — those not classified by USEPA as carcinogens — are toxic to the liver, kidney and blood. This group of PAHs includes compounds such as *pyrene*, *acenaphthene, acenaphthylene*, *benzo(g,h,i)perylene*, and *phenanthrene*. USEPA determined RfDs for only two of these compounds: pyrene's RfD_o of 0.03 mg/kg-day is also used as a surrogate RfD_o for phenanthrene. The RfD_o for acenaphthene was 0.06 mg/kg-day.

Beryllium exposure via the inhalation route can cause inflammation of the lungs, a condition known as Acute Beryllium Disease, as a result of short-term exposure to high concentrations. Removal from exposure results in a reversal of the symptoms. Chronic exposure to much lower levels of beryllium or beryllium oxide by inhalation has been reported to cause Chronic Beryllium

Disease, with symptoms including shortness of breath, scarring of the lungs, and berylliosis, which is non-cancerous growths in the lungs of humans. Both forms of Beryllium Disease can be fatal, depending on the severity of the exposure. Additionally, a skin allergy may develop when soluble beryllium compounds come into contact with the skin of sensitized individuals (Gradient, 1991). An oral RfD of 0.005 mg/kg-day has been set for beryllium based on a chronic oral bioassay (rats were the study species) which determined no adverse effect occurs at 0.54 mg/kg-day. An uncertainty factor of 100 is applied to the NOAEL which adjusts for interspecies extrapolation and sensitive subpopulations. Beryllium has been classified by USEPA as a group B2 carcinogen based on animal studies. It has been shown to induce lung cancer via inhalation in rats and monkeys, and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. Human epidemiology studies of beryllium are considered to be inadequate. An inhalation slope factor of 8.4 $(mg/kg\text{-}day)^{-1}$ and an oral slope factor of 4.3 $(mg/kg\text{-}day)^{-1}$ have been set by USEPA.

Cadmium can upset the stomach, leading to vomiting and diarrhea in acute exposure; acute inhalation of cadmium containing dust can irritate the lungs. Chronic exposure to cadmium, either via inhalation or ingestion, has been shown to cause kidney damage (including kidney stones), emphysema, and high blood pressure. Other tissues reportedly injured by cadmium exposure in animals and humans include the lungs, testes, liver, immune system, blood, and the nervous system. An oral RfD of 0.001 mg/kg-day has been determined by USEPA, based on human studies (food) involving chronic exposure in which significant increased protein was found in the urine. A separate oral RfD for water has been determined by USEPA to be 0.0005 mg/kg-day. For inhalation exposure, cadmium has been classified by USEPA as a group B1, or probable human carcinogen, based on limited evidence from epidemiological studies in which an excess risk of lung cancer was observed in cadmium smelter workers. There is sufficient evidence of increased risk of lung cancer in rats and mice exposed to cadmium via inhalation. Seven studies in which cadmium was administered orally to rats and mice have shown no evidence of

carcinogenic response following exposure via this route. An inhalation slope factor of 6.3 $(mg/kg\text{-}day)^{-1}$ has been set for cadmium.

Chromium exists in two stable, natural forms: trivalent (CrIII), and hexavalent (CrVI). Acute exposure to chromium can result in kidney damage following oral exposure, or damage to the nasal mucosa and septum following inhalation exposure. Chronic inhalation exposure to hexavalent chromium has resulted in kidney and respiratory tract damage, as well as excess lung cancer in both animals and humans following occupational exposure. The oral RfD for Cr III is 1.0 mg/kg-day based on a NOEL of 1,468 mg/kg-day, an uncertainty factor of 100, and a modifying factor of 10. The uncertainty factor adjusts for interspecies extrapolation and sensitive human subpopulations, while the modifying factor reflects uncertainties in the corroborative studies. For trivalent chromium, the oral RfD is based on liver toxicity in the rat. The overall confidence for the Cr III oral RfD is low. The oral RfD of Cr VI is 0.005 mg/kg-day based on a NOAEL of 2.4 mg/kg-day and an uncertainty factor of 500. The uncertainty stems from interspecies extrapolation, sensitive human subpopulations, and subchronic to chronic exposure. The toxicity of Cr VI includes unspecified pathological changes observed in rat studies. The overall confidence in the RfD for Cr VI is low. In addition, hexavalent chromium is considered as a group A carcinogen for inhalation exposures, and an oral slope factor of 42 $(mg/kg\text{-}day)^{-1}$ has been established for the hexavalent form. Vitamin supplements contain approximately 0.025 mg of chromium (Gradient, 1991).

Lead has been classified as a group B2 carcinogen by USEPA based on animal data. An RfD or slope factor has been set by USEPA. However, action levels for soil and groundwater have been proposed by USEPA Region IV at 400 mg/kg and 15 μg/L, respectively. An RfD and SF have not been set because of the confusing nature of lead toxicity. Lead accumulates in fat tissue, affects the brain, blood, and mental development of children. RfD's are based on the assumption that a threshold must be exceeded to result in toxic effects (other than carcinogenicity). Once lead

accumulates in the body, other influences cause the actual levels in the blood to fluctuate- sometimes the lead is attached to binding sites, and sometimes lead is free flowing. If an exposed individual has previously been exposed to lead, this individual could lose weight, and set fat-bound lead free. This fluctuation and lack of previous lead exposure data are two of the reasons lead effects are difficult to predict (Klaassen, et al, 1986).

Manganese is an essential nutrient. Chronic exposure to manganese, 0.8 mg/kg-day, causes mental disturbances and various central nervous system effects. Studies have shown that manganese uptake from water is greater than manganese uptake from food, and the elderly appear to be more sensitive than children. The oral RfD is 0.14 mg/kg-day with uncertainty and modifying factors of 1. When assessing the potential for adverse health effects from nondietary intakes (ingestion of soil or drinking water) of manganese, a modifying factor of 3 is used which gives an oral RfD of 0.047 mg/kg-day. Inhalation of manganese dust causes neurological effects and increased incidence of pneumonia, and an inhalation RfD was set to 0.0000143 mg/kg-day. According to USEPA, manganese can not be classified as to its carcinogenicity. Therefore, the cancer class for manganese is group D. The typical vitamin supplement dose of manganese is 2.5 mg/day (Klaassen, et al, 1986) (Dreisbach, et al, 1987).

Mercury The major source of this element is the degassing of the earth's crust. Target organs of mercury include the kidney, nervous system, fetus, and neonate. In other words, this inorganic can be toxic to a fetus if the mother is exposed during pregnancy. Mercury is toxic to all cells in the body- it binds to enzymes in the cells and disrupts their function, usually causing the cell to be useless or die. Because this inorganic is concentrated in the kidney prior to excretion, the kidney is a major target organ for mercury ingestion. The primary target of mercury vapor is the brain. USEPA has set an inhalation RfD of 8.6E-05 mg/kg-day. Some forms of mercury are drawn towards fats in the body (such as the nervous system), where the form is changed into its toxic form. This causes the nervous disorder known as Minimata disease, overexposure to

mercury through ingestion of contaminated fish. The weight of evidence classification for mercury is "D" not classifiable as to human carcinogenicity. USEPA set mercury's oral RfD to 0.0003 mg/kg-day (mercuric chloride). Mercury is liquid at room temperature, and is poorly absorbed in this form if ingested. Typical daily exposure is less than 1 μg/l-day (Klaassen, et al, 1986) (Dreisbach, et al, 1987).

Nickel is an essential nutrient with a five microgram dose typical of supplemental vitamins. USEPA set the oral RfD to 0.02 mg/kg-day. Chronic exposure of rats to nickel caused decreased body and organ weights. For a chronically exposed individual, nickel salts would affect the gastrointestinal system, and would also target the liver and kidney. This element has been shown to be a sensitizer, an element that can produce allergic reactions. Sensitization of skin to nickel dust has been shown to occur in industry (Dreisbach, et al., 1987). As listed in IRIS, the critical effect of this chemical is decreased body and organ weights. The uncertainty factor was 300 and the modifying factor was 1.

PCB Aroclors are a group of chlorinated hydrocarbons (such as aroclor 1260) that accumulate in fat tissue. Occupational exposure (both inhalation and dermal) to PCBs causes eye and lung irritation, loss of appetite, liver enlargement, increased serum liver enzyme levels, rashes and chloracne, and decreased birth weight of infants in heavily exposed worker/mothers. Of the effects listed above, the liver is the primary target organ (Klaassen, et al, 1986) (Dreisbach, et al, 1987). USEPA classified PCB aroclors as group B2 probable human carcinogens, primarily based on animal data. Oral ingestion of PCBs causes liver and stomach tumors in rat studies. The cancer potency of PCB mixtures is determined using a tiered approach. The high risk and persistence tier uses an upper-bound slope factor of 2.0 $(mg/kg\text{-}day)^{-1}$ and is appropriate for food chain exposures, sediment and soil ingestion, dust or aerosol inhalation, and dermal exposure. The low risk and persistence tier uses an upper-bound slope factor of 0.4 $(mg/kg\text{-}day)^{-1}$ and is appropriate for ingestion of water soluble congeners and inhalation of evaporated congeners. The

lowest risk and persistence tier uses an upper-bound slope factor of 0.07 $(mg/kf\text{-}day)^{-1}$ and is appropriate for PCB congener mixtures with congeners having more than four chlorines comprising less than 1/2% of the mixture.

Silver is a shiny grey metal that is naturally occurring. Silver also occurs in compounds such as silver nitrate, silver chloride, silver sulfide, and silver oxide. The most common use of these compounds is photographic development. Silver may enter the body through ingestion, inhalation, or dermal pathways; however, generally, much less silver will be absorbed through the skin than through the lungs or stomach (ATSDR 1990). Chronic exposure to silver causes the skin or other body tissues to take on a grayish or blue-grey color. This is a condition known as argyria, a permanent, but not thought of as medically harmful, condition. Exposure to dust containing silver nitrate and silver oxide may cause breathing problems, lung and throat irritation and stomach pain. An oral reference dose has been determined for silver and its compounds: 0.005 mg/kg-day.

Thallium is readily absorbed through the gut and skin. Primary effects are stomach and bowel disturbances, kidney and liver damage, and neurological disturbances. Thallium was used in the past as a rodenticide and ant killer, and its use for these purposes is now prohibited. This element remains in the body for a relatively long time, and could accumulate if the chronic dose is large. USEPA's oral RfD for Thallium is 0.00008 mg/kg-day (Klaassen, et al, 1986) (Dreisbach, et al, 1987).

Vanadium is not readily absorbed through the skin or through ingestion and is a ubiquitous element. It is also a byproduct of petroleum refining. Vanadium is soluble in fats and oils. Municipal water supplies contain 0.001 to 0.006 mg/l. The target organ is unclear, and the primary focus of toxicological information is inhalation of vanadium dust. Typical vitamin supplements contain approximately 0.010 mg in a daily dose. The oral RfD set by USEPA is 0.007 mg/kg-day (Klaassen, et al, 1986).

10.2.8.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under both residential and site worker scenarios. For these scenarios, incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.2.22 and 10.2.23 present the computed carcinogenic risks and/or HQs associated with incidental ingestion of and dermal contact with site surface soils, respectively. Health effects associated with lead are addressed separately in the "lead toxicity" subsection.

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime weighted average) for SWMU 2 surface soils is 3E-05. The dermal pathway ILCR is 4E-06. Arsenic was the primary contributor to both the ingestion and dermal pathways. Beryllium, Aroclor 1260, and benzo(a)pyrene equivalents were all secondary contributors to the ingestion pathway.

The computed hazard indices for the adult resident were 0.1 for the soil ingestion pathway and 0.03 for the dermal contact pathway. The computed hazard indices for the child ingestion and dermal contact pathways were 1 and 0.09, respectively. The primary contributors to the hazard index were aluminum, antimony, arsenic, and thallium.

Hypothetical Site Workers

Site worker ILCRs are 3E-6 and 2E-6 for the ingestion and dermal contact pathways, respectively. Arsenic was the primary contributor for each pathway. Hazard indices for the ingestion and dermal pathways were both projected to be less than 0.1 for the hypothetical site worker scenario.

Table 10.2.22
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
SWMU 2
Naval Base Charleston

Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Current Worker adult Hazard Quotient	Current Worker adult ILCR
Aluminum	1	NA	0.012	0.11	ND	0.0043	ND
Antimony	0.0004	NA	0.044	0.41	ND	0.016	ND
Arsenic	0.0003	1.5	0.051	0.48	2.6E-05	0.018	3.0E-06
Beryllium	0.005	4.3	0.000085	0.00080	2.1E-06	0.000031	2.3E-07
Cadmium	0.001	NA	0.0035	0.032	ND	0.0012	ND
Chromium	1	NA	0.000035	0.00032	ND	0.000012	ND
Manganese	0.047	NA	0.0032	0.030	ND	0.0012	ND
Mercury	0.0003	NA	0.0023	0.021	ND	0.00081	ND
Nickel	0.02	NA	0.0016	0.015	ND	0.00056	ND
Thallium	8E-05	NA	0.014	0.13	ND	0.0050	ND
Vanadium	0.007	NA	0.0050	0.047	ND	0.0018	ND
Carcinogenic PAHs/PCBs							
Aroclor 1260	NA	2	ND	ND	1.6E-06	ND	1.7E-07
Benzo(a)pyrene equivalents	NA	7.3	ND	ND	1.0E-06	ND	1.2E-07
SUM Hazard Index/ILCR			0.1	1	3E-05	0.05	3E-06

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk

Table 10.2.23
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
SWMU 2
Naval Base Charleston
Charleston, SC

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Current Worker adult Hazard Quotient	Current Worker adult ILCR
Inorganics								
Aluminum	0.2	0.2	NA	0.0025	0.0081	ND	0.0018	ND
Antimony	0.2	8E-05	NA	0.0090	0.030	ND	0.0064	ND
Arsenic	0.2	6E-05	7.5	0.0105	0.035	3.0E-06	0.0075	1.2E-06
Beryllium	0.2	0.001	21.5	0.000018	0.000058	2.4E-07	0.000013	9.6E-08
Cadmium	0.2	0.0002	NA	0.00071	0.0023	ND	0.00051	ND
Chromium	0.2	0.2	NA	0.0000071	0.000023	ND	0.0000051	ND
Manganese	0.2	0.0094	NA	0.00067	0.0022	ND	0.00048	ND
Mercury	0.2	6E-05	NA	0.00046	0.0015	ND	0.00033	ND
Nickel	0.2	0.004	NA	0.00032	0.0011	ND	0.00023	ND
Thallium	0.2	1.6E-05	NA	0.0029	0.009	ND	0.0020	ND
Vanadium	0.2	0.0014	NA	0.00102	0.0034	ND	0.00073	ND
Carcinogenic PAHs/PCBs								
Aroclor 1260	0.5	NA	4	ND	ND	7.0E-07	ND	2.9E-07
Benzo(a)pyrene equivalents	0.5	NA	14.6	ND	ND	4.7E-07	ND	1.9E-07
SUM Hazard Index/ILCR				0.03	0.09	4E-06	0.02	2E-06

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk
- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

Groundwater Pathways

Exposure to shallow groundwater onsite was evaluated under both residential and industrial scenarios. The ingestion exposure pathway was evaluated assuming that site groundwater will be used for potable and/or domestic purposes and that an unfiltered well, drawing from the corresponding water-bearing zone, will be installed. For noncarcinogenic contaminants evaluated relative to future site residents, hazard was computed separately for child and adult receptors. Table 10.2.24 presents the risk and hazard for the ingestion exposure pathways.

Hypothetical Site Residents

The shallow groundwater ingestion ILCR for hypothetical site residents is 2E-4 with contributions from arsenic and beryllium. The hazard indices for the adult and child resident are 3 and 6, respectively with arsenic and manganese being the primary contributors to hazard index.

Hypothetical Site Workers

The shallow groundwater risk estimated for future site workers is 5E-5 for the ingestion exposure pathway with contributions from arsenic and beryllium. The hazard indices for the ingestion exposure pathway was calculated to be 0.9.

Current Site Workers

Shallow groundwater is not currently used as a potable water source for SWMU 2 or other areas of Zone A. In the absence of a completed exposure pathway, no threat to human health is posed by reported shallow groundwater contamination.

Lead Toxicity

Background

Currently, USEPA has not established an SF reference dose for lead. USEPA believes that the available studies in animals and humans do not provide sufficient quantitative information for their

Table 10.2.24
Hazard Quotients and Incremental Lifetime Cancer Risks
Shallow Groundwater Ingestion
SWMU 2
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Future Worker adult Hazard Quotient	Future Worker adult ILCR
Arsenic (As)	0.0003	1.5	0.55	1.3	1.4E-04	0.20	4.4E-05
Manganese (Mn)	0.047	NA	1.9	4.4	ND	0.7	ND
Silver (Ag)	0.005	NA	0.065	0.15	ND	0.023	ND
SUM Hazard Index/ILCR			3	6	1E-04	0.9	4E-05

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk

calculation. Although lead is currently classified as a B2 carcinogen, USEPA considers the noncarcinogenic neurotoxic effects in children to be the critical toxic effect with respect to establishing health-based environmental cleanup objectives. The neurotoxic effects of chronic low-level lead exposure in children may occur at blood levels as low as 10 μg/dL.

In the absence of lead health criteria, USEPA Region IV's Office of Health Assessment sanctions the use of the Lead Uptake/Biokinetics Model (Version 0.99d) (Lead Model) to predict mean blood lead levels in children based on exposure to impacted environmental media. An alternative assessment was also provided using USEPA's *Interim Approach to Assessing Risk Associated with Adult Exposures to Lead in Soil* (December 1996) (Adult Lead Model) to evaluate health impact of lead under the more likely future industrial scenario. These models were used to assess the potential health effects of elevated lead levels reported in surface soil at SWMU 2. The maximum lead concentration reported in surface soil was 89,000 mg/kg at location 002SB036. Figure 10.2.4 shows the distribution of lead concentrations in surface soil at SWMU 2. Lead was detected in 2 of 19 groundwater samples taken from SWMU 2 monitoring wells. The mean concentration (10.9 μg/L) and the mean concentration in the most concentrated area of the plume (9 μg/L) are both below the TTAL of 15 μg/L.

Future Residential Scenario

Lead model default concentrations were used for exposure to air (0.1 Pb grams per cubic meter [g/m^3]) and maternal blood lead level (2.5 μg/dL). In the case of SWMU 2, an area of elevated lead concentration in soil was identified as boring location 002SB036 and the closest sampling locations surrounding this point (locations 002SB020 and 002SB021). The total area encompassed by these locations is approximately one-half acre, and the mean surface soil lead concentration of 31,154 mg/kg was used as the input for soil and house dust. The maximum lead concentration in the plume (Table 10.2.16; 9 μg/L) was used as the input for drinking water. The Lead Model was

run for a child ages 0-7 years using the inputs listed above. Table 10.2.25 presents the lead model output for a child 0 to 7 years old under these exposure conditions.

Figure 10.2.17 shows the probability percentage of blood lead levels for the hypothetical child receptor. Based on this model output using the mean soil lead concentration in the "hot spot", the geometric mean blood concentration is estimated to be 85.7 μg/dL, and the probability of blood lead concentration exceeding 10 μg/dL is 100%. USEPA generally considers that media concentrations resulting in probability percentage estimates of 5% or less sufficiently protect potential child receptors. As shown on Table 10.2.25, lead uptakes resulting from exposure to soil and dust are more than two orders of magnitude higher than uptakes resulting from exposure to groundwater. As a result, surface soil lead would require corrective action under this hypothetical exposure scenario.

Current Commercial/Industrial

USEPA Region IV has developed an interim approach for assessing risk due to adult exposures to lead in soil. The Adult Lead Model considers a woman of child-bearing age and sets a maternal blood lead level which is protective of a developing fetus. This model was used to evaluate the significance of lead in soil at combined SWMUs 1 and 2. The only media of concern under the current industrial scenario is soil since groundwater is not currently used as a source of potable water. Using the default model parameters and the mean soil lead concentration in the "hot spot" (31,154 mg/kg) produces central estimate (PbB_{adult}) of blood lead concentrations in women of child-bearing age of 66 μg/dL.

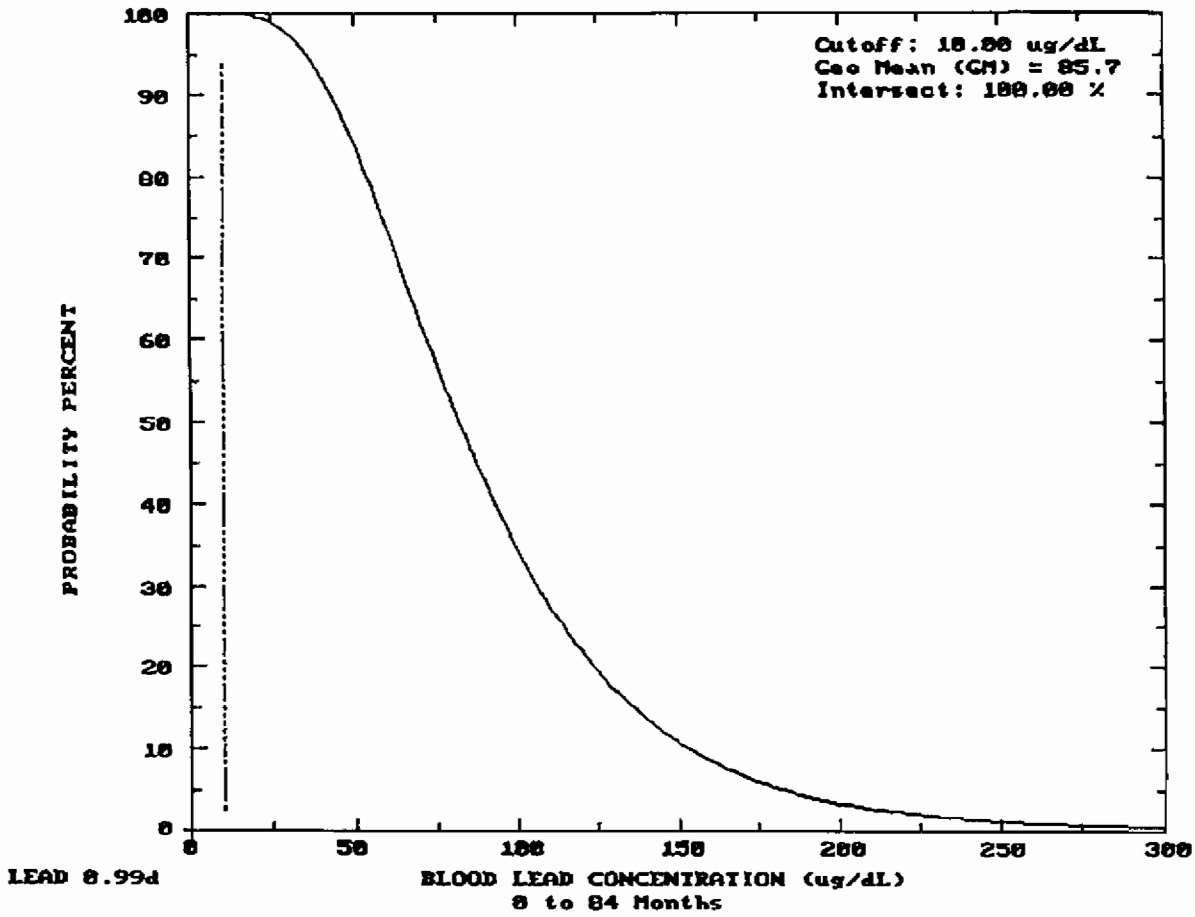


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FIGURE 10.2.17
SWMU 2
LEAD MODEL RESULTS
HYPOTHETICAL CHILD RECEPTOR

DWG DATE: 04/10/98 | DWG NAME: MAPEX

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Table 10.2.25
Lead Model Results
(Future Residential - Child)
NAVBASE - Charleston, SWMU 2
Charleston, South Carolina

LEAD MODEL Version 0.99d

AIR CONCENTRATION: 0.100 μg Pb/m3 DEFAULT
Indoor AIR Pb Conc: 30.0 percent of outdoor.
Other AIR Parameters:

Age	Time Outdoors (hr)	Vent. Rate (m3/day)	Lung Abs. (%)
0-1	1.0	2.0	32.0
1-2	2.0	3.0	32.0
2-3	3.0	5.0	32.0
3-4	4.0	5.0	32.0
4-5	4.0	5.0	32.0
5-6	4.0	7.0	32.0
6-7	4.0	7.0	32.0

DIET: DEFAULT

DRINKING WATER Conc: 9.00 ug Pb/L
WATER Consumption: DEFAULT

SOIL & DUST:
Soil: constant conc.
Dust: constant conc.

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
0-7	31154.0	31154.0

Additional Dust Sources: None DEFAULT

PAINT Intake: 0.00 ug Pb/day DEFAULT

MATERNAL CONTRIBUTION: Infant Model
Maternal Blood Conc: 2.50 ug Pb/dL

CALCULATED BLOOD Pb and Pb UPTAKES:

YEAR	Blood Level (ug/dL)	Total Uptake (ug/day)	Soil+Dust Uptake (ug/day)	Diet Uptake (ug/day)	Water Uptake (ug/day)	Paint Uptake (ug/day)	Air Uptake (ug/day)
0.5-1:	90.4	212.44	211.44	0.74	0.24	0.00	0.02
1-2:	101.8	322.64	321.30	0.74	0.57	0.00	0.03
2-3:	97.1	333.94	332.40	0.85	0.62	0.00	0.06
3-4:	95.1	346.35	344.78	0.85	0.65	0.00	0.07
4-5:	83.4	290.30	288.54	0.93	0.76	0.00	0.07
5-6:	74.3	280.80	278.79	1.05	0.87	0.00	0.09
6-7:	68.5	278.51	276.28	1.22	0.92	0.00	0.09

The target maternal blood lead levels (PbB_T) below which is considered protective of a developing fetus is 4.2 μg/dL. As a result, surface soil lead at combined SWMU 2 would require corrective action under this hypothetical exposure scenario.

$$PbB_{adult} = PbB_0 + \frac{PbS * BKSF * IR_S * AF_S * EF_S}{AT} \qquad PbB_T = \frac{PbB_{fetal95}/R}{GSD_i^{1.645}}$$

Where:

PbB_{adult}	=	Central estimate of blood lead concentrations (μg/dL) in women of child-bearing age that have site exposures to soil lead concentrations. **66 μg/dL**
PbB_T	=	Target for central estimate of blood lead concentration (μg/dL) in women of child-bearing age that have site exposures such that $PbB_{fetal95}$ does not exceed 10 μg/dL. **4.2 μg/dL**
PbB_0	=	Typical blood lead concentration in women of child-bearing age in the absence of exposures to the site that is being assessed. **2.2 μg/dL**
Pb_S	=	Soil lead exposure point concentration. **31,154 μg/g**
BKSF	=	Biokinetic slope factor. **0.4 μg/dL blood lead increase per μg/day uptake**
IR_S	=	Intake rate of soil, including both outdoor soil and indoor soil-derived dust. **0.050 g/day**
AF_S	=	Absolute gastrointestinal absorption fraction for ingested lead in soil and lead in dust derived from soil. **0.15**
EF_S	=	Exposure frequency. **250 days**
AT	=	Averaging time. **365 days**
$PbB_{fetal95}$	=	Goal for the 95th percentile blood lead concentration among fetuses born to women having exposures to the site soil. **10 μg/dL**
GSD_i	=	Estimated value of the individual geometric standard deviation. **1.8**
R	=	Constant of proportionality between fetal blood lead concentration at birth and maternal blood lead concentration. **0.9**

USEPA Region IV has calculated a soil cleanup/screening level for lead of 1,300 mg/kg based on adult exposures. Both the 95% UCL (1,416 mg/kg) and the arithmetic mean (1,617 mg/kg) for SWMU 2 surface soil lead concentrations exceed the USEPA adult cleanup/screening level.

Comparison of the 95% UCL and mean soil concentrations to the adult screening level for lead indicate that action will be necessary with respect to soil.

Future Commercial/Industrial Scenario

In coordination with USEPA Region IV's Office of Health Assessment, a conservative exposure scenario was developed to assess the significance of surface soil lead concentrations at SWMU 2. This scenario involves a child (age 5 to 6) who gains access to the most heavily contaminated area for one day and is maximally exposed. The scenario was based on the proposed future use of the SWMU 2 area. Current base reuse plans indicate that the area will become a marine cargo terminal. The exposure frequency was based on the child accompanying a parent to work at a nearby building on a one-time basis and wandering into SWMU 2.

Exposure to site soil was addressed as an additional exposure relative to typical exposures encountered at the child's place of residence. This additional exposure was presented as an "alternate" source within the constructs of the Lead Model. The only modification made to standard default assumptions in the lead model was raising the drinking water lead concentration to the treatment technique action level (TTAL) of 15 μg/L. Consequently, this is generally consistent with the average in the concentrated area of the plume method used to calculate lead's groundwater EPC (9 μg/L). This change was made to provide a conservative estimate of daily intake from sources unrelated to SWMU 2 (home potable water) although it also approximates water quality that might be expected onsite if the shallow aquifer were used as a potable source.

The assumption was made that this child would ingest 0.1 grams of soil from the most heavily contaminated area. In the case of SWMU 2, the lead hot spot was identified as boring location 002SB036 and the closest sampling locations surrounding this point (locations 002SB020 and 002SB021). The total area encompassed by these locations is approximately one-half acre, and the mean surface soil lead concentration is 31,154 mg/kg. Within the Lead Model, an alternate

source was entered to account for this exposure as previously discussed. The bioavailability of lead ingested from the alternate source (SWMU 2 surface soil) was equal to that of soil lead ingested from the standard residential default source. Assuming a one-time exposure in the most heavily impacted area, the annual alternate source exposure was estimated to be 8.53 μg lead/day. Table 10.2.26 presents the lead model output for a child 5 to 6 years old under these exposure conditions.

Figure 10.2.18 shows the probability percentage of blood lead levels for the hypothetical child receptor. Based on this model output, the geometric mean blood level is estimated to be 4.3 μg/dL, and the probability of blood lead levels in excess of 10 μg/dL is 3.24%. USEPA generally considers media concentrations that result in probability percentage estimates of 5% or less sufficiently protective of potential child receptors. As a result, surface soil lead concentrations at SWMU 2 would not require specific action under the hypothetical exposure scenario.

COCs Identified

Chemicals of concern were identified based on cumulative (all pathway) risk and hazard projected for this site, as shown in Table 10.2.27. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a hazard index threshold of 1.0 (unity). In accordance with SCDHEC guidance, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or greater and/or a cumulative hazard index above 1.0, if its individual ILCR exceeds 1E-6 or whose hazard quotient exceeds 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used to provide a more comprehensive evaluation of chemicals contributing to carcinogenic risk or noncarcinogenic hazard during the remedial goal options development process. Table 10.2.27 presents the COCs identified on a medium-specific basis.

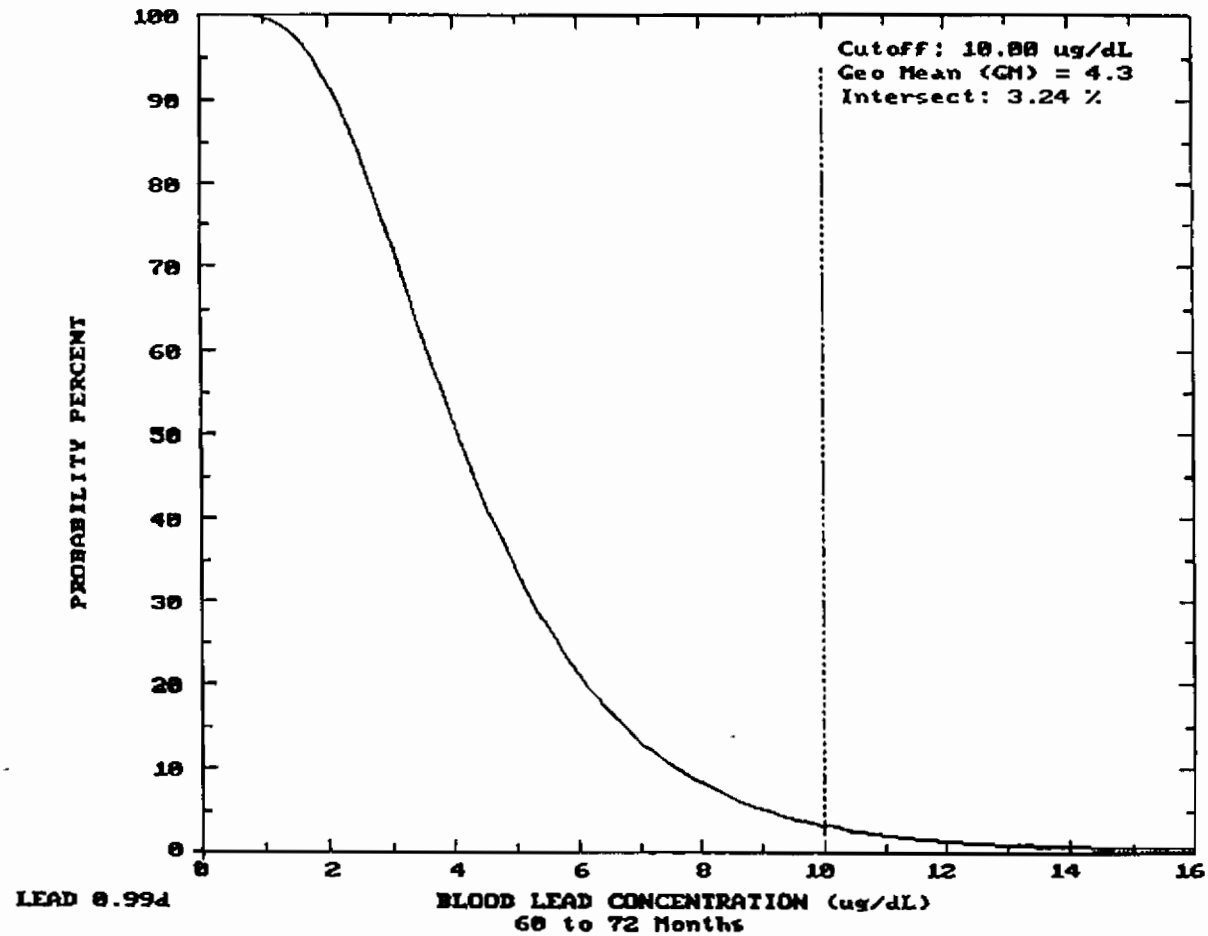

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FIGURE 10.2.18
SWMU 2
LEAD MODEL RESULTS
CHILD ALTERNATE SOURCE SCENARIO

DWG DATE: 04/10/98 | DWG NAME: MAPEX

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Table 10.2.26
Lead Model Results
Future Commercial - Child, Alternative Source Scenario
NAVBASE - Charleston, SWMU 2
Charleston, South Carolina

LEAD MODEL Version 0.99d

AIR CONCENTRATION: 0.100 μg Pb/m3 DEFAULT
Indoor AIR Pb Conc: 30.0 percent of outdoor.
Other AIR Parameters:

Age	Time Outdoors (hr)	Vent. Rate (m3/day)	Lung Abs. (%)
0-1	1.0	2.0	32.0
1-2	2.0	3.0	32.0
2-3	3.0	5.0	32.0
3-4	4.0	5.0	32.0
4-5	4.0	5.0	32.0
5-6	4.0	7.0	32.0
6-7	4.0	7.0	32.0

DIET: DEFAULT

DRINKING WATER Conc: 15.00 μg Pb/L
WATER Consumption: DEFAULT

SOIL & DUST:
Soil: constant conc.
Dust: constant conc.

Age	Soil (μg Pb/g)	House Dust (μg Pb/g)
0-7	200.0	200.0

Additional Dust Sources: None DEFAULT

ALTERNATIVE SOURCE Intake: varied by year as follows:
0-1: 0.00 μg Pb/day
1-2: 0.00 μg Pb/day
2-3: 0.00 μg Pb/day
3-4: 0.00 μg Pb/day
4-5: 0.00 μg Pb/day
5-6: 8.53 μg Pb/day
6-7: 0.00 μg Pb/day

MATERNAL CONTRIBUTION: Infant Model
Maternal Blood Conc: 2.50 μg Pb/dL

CALCULATED BLOOD Pb and Pb UPTAKES:

YEAR	Blood Level (μg/dL)	Total Uptake (μg/day)	Soil+Dust Uptake (μg/day)	Diet Uptake (μg/day)	Water Uptake (μg/day)	Paint Uptake (μg/day)	Air Uptake (μg/day)
0.5-1:	4.6	8.52	4.63	2.51	1.36	0.00	0.02
1-2:	5.4	13.16	7.21	2.57	3.34	0.00	0.03
2-3:	5.1	13.81	7.30	2.93	3.52	0.00	0.06
3-4:	4.9	13.97	7.41	2.85	3.64	0.00	0.07
4-5:	4.3	12.34	5.61	2.81	3.86	0.00	0.07
5-6:	4.3	14.52	5.03	2.95	4.05	2.38	0.09
6-7:	3.7	12.42	4.83	3.31	4.19	0.00	0.09

Table 10.2.27
Summary of Risk and Hazard-based COCs
SWMU 2
NAVBASE - Charleston , Zone A
Charleston, South Carolina

Medium	Exposure Pathway		Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident Iwa ILCR	Site Worker Hazard Quotient	Site Worker ILCR	Identification of COCs
Surface Soil	Incidental Ingestion	**Inorganics**						
		Aluminum	0.012	0.11	ND	0.0043	ND	1
		Antimony	0.044	0.41	ND	0.016	ND	1
		Arsenic	0.051	0.48	2.6E-05	0.018	3.0E-06	1 2 4
		Beryllium	0.000085	0.00080	2.1E-06	0.000031	2.3E-07	2
		Cadmium	0.0035	0.032	ND	0.0012	ND	
		Chromium	0.000035	0.00032	ND	0.000012	ND	
		Lead	ND	ND	ND	ND	ND	*
		Manganese	0.0032	0.030	ND	0.0012	ND	
		Mercury	0.0023	0.021	ND	0.00081	ND	
		Nickel	0.0016	0.015	ND	0.00056	ND	
		Thallium	0.014	0.13	ND	0.0050	ND	1
		Vanadium	0.005	0.047	ND	0.0018	ND	
		Carcinogenic PAHs/PCBs						
		Aroclor 1260	ND	ND	1.6E-06	ND	1.7E-07	2
		Benzo(a)pyrene equivalents	ND	ND	1.0E-06	ND	1.2E-07	2
	Dermal Contact	**Inorganics**						
		Aluminum	0.0025	0.0081	ND	0.0018	ND	
		Antimony	0.0090	0.030	ND	0.0064	ND	
		Arsenic	0.0105	0.035	3.0E-06	0.0075	1.2E-06	2
		Beryllium	0.000018	0.000058	2.4E-07	0.000013	9.6E-08	
		Cadmium	0.00071	0.0023	ND	0.00051	ND	
		Chromium	0.0000071	0.000023	ND	0.0000051	ND	
		Manganese	0.00067	0.0022	ND	0.00048	ND	
		Mercury	0.00046	0.0015	ND	0.00033	ND	
		Nickel	0.00032	0.0011	ND	0.00023	ND	
		Thallium	0.0029	0.0095	ND	0.0020	ND	
		Vanadium	0.00102	0.0034	ND	0.00073	ND	
		Carcinogenic PAHs/PCBs						
		Aroclor 1260	ND	ND	7.0E-07	ND	2.9E-07	
		Benzo(a)pyrene equivalents	ND	ND	4.7E-07	ND	1.9E-07	
Surface Soil Pathway Sum			0.2	1	4E-05	0.07	5E-06	
Groundwater	Ingestion	Arsenic (As)	0.55	1.3	1.4E-04	0.20	4.37E-05	1 2 4
		Manganese (Mn)	1.9	4.4	ND	0.7	ND	1
		Silver (Ag)	0.065	0.15	ND	0.023	ND	1
Groundwater Pathway Sum			3	6	1E-04	1	4E-05	
Sum of All Pathways			3	7	2E-04	1	5E-05	

Notes:
ND Indicates not determined due to the lack of available risk information.
ILCR Indicates incremental excess lifetime cancer risk
HI Indicates hazard index
1- Chemical is a COC by virtue of projected child residence noncarcinogenic hazard.
2- Chemical is a COC by virtue of projected future resident lifetime ILCR.
3- Chemical is a COC by virtue of projected site worker noncarcinogenic hazard.
4- Chemical is a COC by virtue of projected site worker ILCR.
* - Lead identified as a COC based future residential and current commercial exposure scenarios

Surface Soils

Hypothetical Site Residents

Aluminum, antimony, Aroclor 1260, arsenic, benzo(a)pyrene equivalents, beryllium, and thallium were identified as the soil pathway COCs based on their contribution to cumulative ILCR and/or HI projections. Lead was identified as a soil COC based on the Lead Model results.

Hypothetical Site Workers

Arsenic was identified as the a pathway COC based on its contribution to cumulative ILCR projections. Lead was identified as a soil COC based on the results of the Adult Lead Model.

The extent of the COCs identified in surface soil is briefly discussed below. To facilitate this discussion of the extent of COC concentrations, residential soil RBCs were compared to each reported concentration for each COC identified above. Aluminum was detected above its residential RBC (7,800 mg/kg) in 20 of 62 surface soil samples, and was detected above its background concentration (12,800 mg/kg) in only four surface soil samples. Antimony was detected above its residential RBC in 13 of 62 surface soil samples. Arsenic was detected above its residential soil RBC (0.43 mg/kg) in 60 of 62 surface soil samples. However, the background concentration for arsenic was exceeded only 15 times and the mean concentration for SWMU 2 surface soil (7.7 mg/kg) is less than the background concentration (9.44 mg/kg). Beryllium was detected above its residential soil RBC in 12 of 62 surface soil samples. Surface soil concentrations of lead exceeded both the residential soil cleanup level of 400 mg/kg (16 of 68 samples) and the adult (site worker) soil cleanup level of 1,300 mg/kg (5 of 62 samples). Thallium was detected above its residential RBC in only six of 68 surface soil samples. One surface soil sample collected from the former wetland area was analyzed for organic parameters. The concentrations of Aroclor 1260 and benzo(a)pyrene equivalents reported in this sample exceeded their respective residential RBCs. Risk maps are presented in Section 10.2.8.7, Risk Summary, that illustrate the extent of the surface soil COCs.

Groundwater

Hypothetical Site Residents (future land use)

Arsenic, manganese, and silver were identified as shallow groundwater COCs based on their contribution to cumulative risk and/or hazard index.

Hypothetical Site Workers (future land use)

Arsenic was identified as a shallow groundwater COC based on its contribution to cumulative ILCR.

The extent of the COCs identified in shallow groundwater is briefly discussed below. Arsenic was detected in 4 of 19 groundwater samples with the highest concentrations in samples collected from monitoring well NBCA-002-004 during the first, third and fourth quarters. Manganese was detected in 17 of 19 groundwater samples with the highest concentrations in samples collected from monitoring well NBCA-002-002. Silver was detected in only one of 19 groundwater samples; specifically, the fourth quarter sample collected from monitoring well NBCA-002-004.

10.2.8.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure.

Residential use of the site would not be expected, based on current site uses and the nature of surrounding buildings. Current reuse plans call for continued commercial/industrial use of Zone A, specifically as a marine cargo terminal. If this area were to be used as a residential site, the buildings and other structures would be demolished, and the surface soil conditions would

likely change — the soils would be covered with landscaping soil and/or a house. Consequently, exposure to current surface soil conditions would not be likely under a true future residential scenario. Current site worker's contact with impacted media is much less than is assumed in the exposure model that are used to assess this pathway. Direct contact to soil is limited due to paved areas and buildings, and groundwater is not currently used as a source of potable or process water. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to current site workers and future site residents.

A basewide system provides drinking and process water to buildings throughout Zone A. This system is slated to remain in operation under the current base reuse plan. As a result, shallow groundwater would not be expected to be used under future site use scenarios. Therefore, the scenario established to project risk/hazard associated with shallow groundwater exposure is highly conservative, and associated pathways are not expected to be completed in the future.

Determination of Exposure Point Concentrations

The 95% UCL of the mean soil concentrations were used as the exposure point concentrations for this site. In risk assessment, the UCL is recommended for providing a reasonable maximum exposure point concentration. In these cases, the EPC would tend to overestimate risk and hazard. Aroclor 1260 and benzo(a)pyrene equivalents analysis were only conducted on one surface soil sample, and as a result, their concentrations reported in this sample were used as EPCs. Uncertainty is introduced through risk estimates based on the results of only one sample.

EPCs for arsenic, manganese, and silver were calculated by taking their arithmetic mean concentrations of all four quarters of data from the monitoring well which yielded the maximum result. This would tend to overestimate risk and hazard since it does not take into account the dilutional capacity of the surrounding aquifer. Uncertainty is introduced, through this method, by essentially establishing a separate plume for each COPC. Depending on the location of a

hypothetical production well, the risk could be over or underestimated. To address this uncertainty, risk maps are provided which allow the reader to identify areas of the aquifer associated with risk and/or hazard due to the cumulative effect of multiple COCs as well as areas where single COCs contribute nearly all of the risk and/or hazard

Quantification of Risk/Hazard

As indicated by the discussions above, the risk assessment uncertainty is great. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

Of the CPSSs screened and eliminated from formal assessment, none was reported at concentrations close to corresponding RBCs (i.e., within approximately 10% of the RBC). This minimizes the likelihood of potentially significant cumulative risk/hazard based on the eliminated CPSSs.

Central tendency analysis was not formally performed for SWMU 2 surface soil, but a simplified approach was taken to assess the potential influences of CT assumptions. The CT assumption for residential exposure duration is nine years compared to the 30-year assumption for RME. The CT exposure frequency assumption is 234 days/year compared to 350 days/year RME. If all other exposure assumptions remain fixed, application of the CT exposure duration and frequency would result in risk projections approximately 80% below the RME. For the child resident, the CT exposure duration (6 years) falls within the RME exposure duration (9 years). If all other exposure assumptions remain fixed, application of the CT exposure frequency would result in risk projections approximately 34% below the RME. At CT, the residential surface soil pathway related risk (incidental ingestion and dermal contact) would drop from 3E-05 to approximately 6E-6, but would still exceed the 1E-6 point of departure. At CT, the residential (child) surface

soil pathway related hazard index (incidental ingestion and dermal contact) would decrease from 1 to 0.7.

Although the future land use of combined SWMUs 1 and 2 is unknown, both the worker and residential exposure scenarios were assessed in this HHRA. Current base reuse plans call for conversion of the area to a marine cargo terminal. As previously discussed, it is likely that these scenarios would lead to overestimates of risk and/or hazard.

Groundwater

Of the CPSSs screened and eliminated from formal assessment, none was reported at concentrations close to corresponding RBCs (i.e., within approximately 10% of the RBC). This minimizes the likelihood of potentially significant cumulative risk/hazard based on the eliminated CPSSs.

Groundwater is not currently used as a potable water source at SWMU 2, nor is it used at NAVBASE or in the surrounding area. Municipal water is readily available. As previously mentioned, it is highly unlikely that the site will be developed as a residential area, and it is unlikely that a potable-use well would be installed onsite. It is probable that, if residences were constructed onsite and an unfiltered well were installed, its salinity and dissolved solids would preclude this aquifer from being an acceptable potable water source.

Toxicology

Arsenic was a significant contributor to risk estimates based on exposure to SWMU 2 surface soil and groundwater. USEPA has accepted arsenic-related cancer risks of up to 1E-03 because the cancers are squamous cell carcinomas with a low mortality rate (USEPA Region III *Risk-based Concentration Table, January-June 1996*). Cumulative risk for the soil and groundwater pathways due to arsenic did not exceed 1E-03. Aluminum was a contributor to soil-based hazard index

projections. Aluminum is a naturally occurring element and abundant in nature. The RfD for aluminum is a provisional value provided through ECAO which reflects the uncertainty of the level of exposure at which adverse health effects occur.

10.2.8.7 Risk Summary

The risk and hazard posed by contaminants at SWMU 2 were assessed for the hypothetical site worker and the hypothetical future site resident under reasonable maximum exposure assumptions. In surface soils, the incidental ingestion and dermal contact pathways were assessed in this HHRA. The ingestion pathway was evaluated for shallow groundwater based on four quarters of groundwater monitoring data. Table 10.2.28 presents the risk summary for each pathway/receptor group evaluated for SWMU 2.

To add perspective to the SWMU 2 HHRA, point risk and hazard maps are presented below. Point risk maps are based on the unlikely assumption that potential future site residents will be chronically exposed to specific points. Exposure to surface soil conditions is more likely the result of uniform exposure to the soil conditions over the entire site rather than specific points. Risk maps are still useful because they allow the reader to visualize the contribution of risk or hazard index due to individual COCs.

Soil

Figures 10.2.19 and 10.2.20 illustrate point risk and hazard indices for surface soil exposure pathways for SWMU 2 under a residential scenario. Table 10.2.29 provides the contribution of individual COCs to cumulative risk and hazard at each sample location. As shown, concentrations of arsenic and beryllium in surface soil contribute to risk projections above 1E-06 for nearly all of the SWMU 2 surface soil locations. Risk estimates range from 3E-06 (S02SB019) to 8E-05 (002SB023). Contribution to hazard indices above one for the soil pathway was predominantly due to concentrations of aluminum, antimony, and arsenic. Hazard indices above one occurred at 18 of 68 locations ranging from 0.06 (S02SB023) to 17 (002SB036).

Table 10.2.28
Summary of Risk and Hazard for SWMU 2
NAVBASE - Charleston Zone A
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.1	1	3E-05	0.05	3E-06
	Dermal Contact	0.03	0.09	4E-06	0.02	2E-06
Groundwater	Ingestion	3	6	1E-04	1	4E-05
Sum of All Pathways		3	7	2E-04	1	5E-05

Notes:
ND Indicates not determined due to the lack of available risk information.
ILCR Indicates incremental excess lifetime cancer risk
HI Indicates hazard index

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LEGEND

- NO COPCs DETECTED
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

0 feet 400

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE, CHARLESTON
CHARLESTON, S.C.

FIGURE 10.2.19
SWMU 2
SURFACE SOIL POINT RISK
RESIDENTIAL SCENARIO

AML: /home3/projects/charleston_dir/risk_assess/zone_a_dir

LEGEND

- NO COPCs DETECTED
- 0 to 0.1
- 0.1 to 0.5
- 0.5 to 1.0
- 1.0 to 3.0
- > 3.0

0 feet 400

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE, CHARLESTON
CHARLESTON, S.C.

FIGURE 10.2.20
SWMU 2
SURFACE SOIL HAZARD INDEX
RESIDENTIAL SCENARIO

AML: /home3/projects/charleston_dir/risk_assess/zone_a_dir

Table 10.2.29
Point Estimates of Risk and Hazard
Residential Scenario
SWMU 2, Surface Soil
NAVBASE - Charleston
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
001	001	Aluminum (Al)	2730	mg/kg	0.0374	NA
001	001	Antimony (Sb)	ND	mg/kg	NA	NA
001	001	Arsenic (As)	ND	mg/kg	NA	NA
001	001	Beryllium (Be)	ND	mg/kg	NA	NA
001	001	Cadmium (Cd)	ND	mg/kg	NA	NA
001	001	Chromium (Cr)	4.3	mg/kg	0.0118	NA
001	001	Manganese (Mn)	4.5	mg/kg	0.0013	NA
001	001	Mercury (Hg)	ND	mg/kg	NA	NA
001	001	Nickel (Ni)	3.5	mg/kg	0.0024	NA
001	001	Thallium (Tl)	ND	mg/kg	NA	NA
001	001	Vanadium (V)	2.3	mg/kg	0.0045	NA
		Total			0.0574	NA
S01	001	Aluminum (Al)	2500	mg/kg	0.0343	NA
S01	001	Antimony (Sb)	ND	mg/kg	NA	NA
S01	001	Arsenic (As)	ND	mg/kg	NA	NA
S01	001	Beryllium (Be)	ND	mg/kg	NA	NA
S01	001	Cadmium (Cd)	ND	mg/kg	NA	NA
S01	001	Chromium (Cr)	3.5	mg/kg	0.0096	NA
S01	001	Manganese (Mn)	3.1	mg/kg	0.0009	NA
S01	001	Mercury (Hg)	0.03	mg/kg	0.0014	NA
S01	001	Nickel (Ni)	ND	mg/kg	NA	NA
S01	001	Thallium (Tl)	ND	mg/kg	NA	NA
S01	001	Vanadium (V)	1.6	mg/kg	0.0031	NA
		Total			0.0493	NA
S01	002	Aluminum (Al)	7630	mg/kg	0.1046	NA
S01	002	Antimony (Sb)	17.5	mg/kg	0.6034	NA
S01	002	Arsenic (As)	9.4	mg/kg	0.4273	24.74
S01	002	Beryllium (Be)	ND	mg/kg	NA	NA
S01	002	Cadmium (Cd)	1.2	mg/kg	0.0164	NA
S01	002	Chromium (Cr)	38.7	mg/kg	0.1060	NA
S01	002	Manganese (Mn)	109	mg/kg	0.0318	NA
S01	002	Mercury (Hg)	14.8	mg/kg	0.6727	NA
S01	002	Nickel (Ni)	9	mg/kg	0.0062	NA
S01	002	Thallium (Tl)	ND	mg/kg	NA	NA
S01	002	Vanadium (V)	55	mg/kg	0.1078	NA
		Total			2.0763	24.74
002	001	Aluminum (Al)	8225	mg/kg	0.1128	NA
002	001	Antimony (Sb)	ND	mg/kg	NA	NA
002	001	Arsenic (As)	11.3	mg/kg	0.5165	29.52
002	001	Beryllium (Be)	0.3	mg/kg	0.0008	2.25
002	001	Cadmium (Cd)	2.05	mg/kg	0.0279	NA
002	001	Chromium (Cr)	25.45	mg/kg	0.0698	NA
002	001	Manganese (Mn)	134.25	mg/kg	0.0399	NA
002	001	Mercury (Hg)	0.23	mg/kg	0.0105	NA
002	001	Nickel (Ni)	18.25	mg/kg	0.0125	NA
002	001	Thallium (Tl)	ND	mg/kg	NA	NA
002	001	Vanadium (V)	24.95	mg/kg	0.0489	NA
		Total			0.8396	31.76
002	002	Aluminum (Al)	6105	mg/kg	0.0837	NA
002	002	Antimony (Sb)	ND	mg/kg	NA	NA
002	002	Arsenic (As)	3.5	mg/kg	0.1600	9.14
002	002	Beryllium (Be)	ND	mg/kg	NA	NA
002	002	Cadmium (Cd)	ND	mg/kg	NA	NA
002	002	Chromium (Cr)	9.2	mg/kg	0.0252	NA
002	002	Manganese (Mn)	10.45	mg/kg	0.0031	NA
002	002	Mercury (Hg)	ND	mg/kg	NA	NA
002	002	Nickel (Ni)	18.9	mg/kg	0.0130	NA
002	002	Thallium (Tl)	ND	mg/kg	NA	NA
002	002	Vanadium (V)	11.2	mg/kg	0.0219	NA
		Total			0.3069	9.14
002	003	Aluminum (Al)	14000	mg/kg	0.1920	NA

Table 10.2.29
Point Estimates of Risk and Hazard
Residential Scenario
SWMU 2, Surface Soil
NAVBASE - Charleston
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
002	003	Antimony (Sb)	ND	mg/kg	NA	NA
002	003	Arsenic (As)	8.5	mg/kg	0.3885	22.20
002	003	Beryllium (Be)	ND	mg/kg	NA	NA
002	003	Cadmium (Cd)	ND	mg/kg	NA	NA
002	003	Chromium (Cr)	17.9	mg/kg	0.0491	NA
002	003	Manganese (Mn)	23.6	mg/kg	0.0070	NA
002	003	Mercury (Hg)	ND	mg/kg	NA	NA
002	003	Nickel (Ni)	11.2	mg/kg	0.0077	NA
002	003	Thallium (Tl)	ND	mg/kg	NA	NA
002	003	Vanadium (V)	25.4	mg/kg	0.0498	NA
		Total			0.6940	22.20
002	004	Aluminum (Al)	11000	mg/kg	0.1508	NA
002	004	Antimony (Sb)	ND	mg/kg	NA	NA
002	004	Arsenic (As)	8.5	mg/kg	0.3885	22.20
002	004	Beryllium (Be)	ND	mg/kg	NA	NA
002	004	Cadmium (Cd)	ND	mg/kg	NA	NA
002	004	Chromium (Cr)	16.6	mg/kg	0.0455	NA
002	004	Manganese (Mn)	66.8	mg/kg	0.0198	NA
002	004	Mercury (Hg)	ND	mg/kg	NA	NA
002	004	Nickel (Ni)	7.1	mg/kg	0.0049	NA
002	004	Thallium (Tl)	ND	mg/kg	NA	NA
002	004	Vanadium (V)	21.4	mg/kg	0.0419	NA
		Total			0.6515	22.20
002	005	Aluminum (Al)	10200	mg/kg	0.1399	NA
002	005	Antimony (Sb)	ND	mg/kg	NA	NA
002	005	Arsenic (As)	5.8	mg/kg	0.2651	15.15
002	005	Beryllium (Be)	ND	mg/kg	NA	NA
002	005	Cadmium (Cd)	ND	mg/kg	NA	NA
002	005	Chromium (Cr)	12	mg/kg	0.0329	NA
002	005	Manganese (Mn)	14.4	mg/kg	0.0043	NA
002	005	Mercury (Hg)	ND	mg/kg	NA	NA
002	005	Nickel (Ni)	ND	mg/kg	NA	NA
002	005	Thallium (Tl)	ND	mg/kg	NA	NA
002	005	Vanadium (V)	17.3	mg/kg	0.0339	NA
		Total			0.4760	15.15
002	006	Aluminum (Al)	17400	mg/kg	0.2386	NA
002	006	Antimony (Sb)	ND	mg/kg	NA	NA
002	006	Arsenic (As)	15.4	mg/kg	0.7039	40.22
002	006	Beryllium (Be)	0.36	mg/kg	0.0010	2.70
002	006	Cadmium (Cd)	ND	mg/kg	NA	NA
002	006	Chromium (Cr)	28.7	mg/kg	0.0787	NA
002	006	Manganese (Mn)	64.9	mg/kg	0.0193	NA
002	006	Mercury (Hg)	ND	mg/kg	NA	NA
002	006	Nickel (Ni)	15.1	mg/kg	0.0104	NA
002	006	Thallium (Tl)	ND	mg/kg	NA	NA
002	006	Vanadium (V)	35.4	mg/kg	0.0693	NA
		Total			1.1212	42.92
002	007	Aluminum (Al)	5180	mg/kg	0.0710	NA
002	007	Antimony (Sb)	ND	mg/kg	NA	NA
002	007	Arsenic (As)	4.25	mg/kg	0.1943	11.10
002	007	Beryllium (Be)	ND	mg/kg	NA	NA
002	007	Cadmium (Cd)	ND	mg/kg	NA	NA
002	007	Chromium (Cr)	14.85	mg/kg	0.0407	NA
002	007	Manganese (Mn)	86.5	mg/kg	0.0257	NA
002	007	Mercury (Hg)	ND	mg/kg	NA	NA
002	007	Nickel (Ni)	10.75	mg/kg	0.0074	NA
002	007	Thallium (Tl)	ND	mg/kg	NA	NA
002	007	Vanadium (V)	19.3	mg/kg	0.0378	NA
		Total			0.3769	11.10
002	008	Aluminum (Al)	10000	mg/kg	0.1371	NA
002	008	Antimony (Sb)	ND	mg/kg	NA	NA
002	008	Arsenic (As)	3.5	mg/kg	0.1600	9.14

Table 10.2.29
Point Estimates of Risk and Hazard
Residential Scenario
SWMU 2, Surface Soil
NAVBASE - Charleston
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
002	008	Beryllium (Be)	ND	mg/kg	NA	NA
002	008	Cadmium (Cd)	ND	mg/kg	NA	NA
002	008	Chromium (Cr)	20.3	mg/kg	0.0557	NA
002	008	Manganese (Mn)	22.2	mg/kg	0.0066	NA
002	008	Mercury (Hg)	ND	mg/kg	NA	NA
002	008	Nickel (Ni)	10.8	mg/kg	0.0074	NA
002	008	Thallium (Tl)	ND	mg/kg	NA	NA
002	008	Vanadium (V)	18	mg/kg	0.0353	NA
		Total			0.4020	9.14
002	009	Aluminum (Al)	5630	mg/kg	0.0772	NA
002	009	Antimony (Sb)	18	mg/kg	0.6171	NA
002	009	Arsenic (As)	9.5	mg/kg	0.4342	24.81
002	009	Beryllium (Be)	0.45	mg/kg	0.0012	3.37
002	009	Cadmium (Cd)	ND	mg/kg	NA	NA
002	009	Chromium (Cr)	33.2	mg/kg	0.0910	NA
002	009	Manganese (Mn)	98.1	mg/kg	0.0291	NA
002	009	Mercury (Hg)	0.56	mg/kg	0.0256	NA
002	009	Nickel (Ni)	37.2	mg/kg	0.0255	NA
002	009	Thallium (Tl)	ND	mg/kg	NA	NA
002	009	Vanadium (V)	49.2	mg/kg	0.0964	NA
		Total			1.3974	28.18
002	010	Aluminum (Al)	9290	mg/kg	0.1274	NA
002	010	Antimony (Sb)	ND	mg/kg	NA	NA
002	010	Arsenic (As)	2.7	mg/kg	0.1234	7.05
002	010	Beryllium (Be)	ND	mg/kg	NA	NA
002	010	Cadmium (Cd)	ND	mg/kg	NA	NA
002	010	Chromium (Cr)	21.3	mg/kg	0.0584	NA
002	010	Manganese (Mn)	16.4	mg/kg	0.0049	NA
002	010	Mercury (Hg)	0.28	mg/kg	0.0128	NA
002	010	Nickel (Ni)	6	mg/kg	0.0041	NA
002	010	Thallium (Tl)	ND	mg/kg	NA	NA
002	010	Vanadium (V)	19.9	mg/kg	0.0390	NA
		Total			0.3700	7.05
002	011	Aluminum (Al)	12800	mg/kg	0.1755	NA
002	011	Antimony (Sb)	ND	mg/kg	NA	NA
002	011	Arsenic (As)	9.3	mg/kg	0.4251	24.29
002	011	Beryllium (Be)	ND	mg/kg	NA	NA
002	011	Cadmium (Cd)	ND	mg/kg	NA	NA
002	011	Chromium (Cr)	16.7	mg/kg	0.0458	NA
002	011	Manganese (Mn)	19.5	mg/kg	0.0058	NA
002	011	Mercury (Hg)	ND	mg/kg	NA	NA
002	011	Nickel (Ni)	6	mg/kg	0.0041	NA
002	011	Thallium (Tl)	ND	mg/kg	NA	NA
002	011	Vanadium (V)	26.6	mg/kg	0.0521	NA
		Total			0.7084	24.29
002	012	Aluminum (Al)	11600	mg/kg	0.1591	NA
002	012	Antimony (Sb)	ND	mg/kg	NA	NA
002	012	Arsenic (As)	5.6	mg/kg	0.2560	14.63
002	012	Beryllium (Be)	ND	mg/kg	NA	NA
002	012	Cadmium (Cd)	ND	mg/kg	NA	NA
002	012	Chromium (Cr)	13.6	mg/kg	0.0373	NA
002	012	Manganese (Mn)	12.8	mg/kg	0.0038	NA
002	012	Mercury (Hg)	ND	mg/kg	NA	NA
002	012	Nickel (Ni)	4.1	mg/kg	0.0028	NA
002	012	Thallium (Tl)	ND	mg/kg	NA	NA
002	012	Vanadium (V)	20	mg/kg	0.0392	NA
		Total			0.4981	14.63
002	013	Aluminum (Al)	10900	mg/kg	0.1495	NA
002	013	Antimony (Sb)	ND	mg/kg	NA	NA
002	013	Arsenic (As)	5.55	mg/kg	0.2537	14.50
002	013	Beryllium (Be)	ND	mg/kg	NA	NA
002	013	Cadmium (Cd)	ND	mg/kg	NA	NA

Table 10.2.29
Point Estimates of Risk and Hazard
Residential Scenario
SWMU 2, Surface Soil
NAVBASE - Charleston
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
002	013	Chromium (Cr)	15.55	mg/kg	0.0426	NA
002	013	Manganese (Mn)	53.2	mg/kg	0.0158	NA
002	013	Mercury (Hg)	ND	mg/kg	NA	NA
002	013	Nickel (Ni)	6.1	mg/kg	0.0042	NA
002	013	Thallium (Tl)	ND	mg/kg	NA	NA
002	013	Vanadium (V)	22.05	mg/kg	0.0432	NA
		Total			0.5090	14.50
002	014	Aluminum (Al)	9330	mg/kg	0.1279	NA
002	014	Antimony (Sb)	ND	mg/kg	NA	NA
002	014	Arsenic (As)	2.6	mg/kg	0.1188	6.79
002	014	Beryllium (Be)	ND	mg/kg	NA	NA
002	014	Cadmium (Cd)	ND	mg/kg	NA	NA
002	014	Chromium (Cr)	11.8	mg/kg	0.0324	NA
002	014	Manganese (Mn)	24	mg/kg	0.0071	NA
002	014	Mercury (Hg)	ND	mg/kg	NA	NA
002	014	Nickel (Ni)	12.9	mg/kg	0.0088	NA
002	014	Thallium (Tl)	ND	mg/kg	NA	NA
002	014	Vanadium (V)	19	mg/kg	0.0372	NA
		Total			0.3323	6.79
002	015	Aluminum (Al)	3240	mg/kg	0.0444	NA
002	015	Antimony (Sb)	13.3	mg/kg	0.4559	NA
002	015	Arsenic (As)	14.5	mg/kg	0.6628	37.87
002	015	Beryllium (Be)	0.62	mg/kg	0.0017	4.64
002	015	Cadmium (Cd)	ND	mg/kg	NA	NA
002	015	Chromium (Cr)	20.9	mg/kg	0.0573	NA
002	015	Manganese (Mn)	56.6	mg/kg	0.0168	NA
002	015	Mercury (Hg)	0.32	mg/kg	0.0146	NA
002	015	Nickel (Ni)	28.6	mg/kg	0.0196	NA
002	015	Thallium (Tl)	ND	mg/kg	NA	NA
002	015	Vanadium (V)	15.9	mg/kg	0.0311	NA
		Total			1.3043	42.52
002	016	Aluminum (Al)	7320	mg/kg	0.1004	NA
002	016	Antimony (Sb)	2.1	mg/kg	0.0720	NA
002	016	Arsenic (As)	4.9	mg/kg	0.2240	12.80
002	016	Beryllium (Be)	0.09	mg/kg	0.0002	0.67
002	016	Cadmium (Cd)	2.14	mg/kg	0.0291	NA
002	016	Chromium (Cr)	14.1	mg/kg	0.0387	NA
002	016	Manganese (Mn)	36.05	mg/kg	0.0107	NA
002	016	Mercury (Hg)	0.19	mg/kg	0.0087	NA
002	016	Nickel (Ni)	9.85	mg/kg	0.0068	NA
002	016	Thallium (Tl)	2.15	mg/kg	0.3685	NA
002	016	Vanadium (V)	16.6	mg/kg	0.0325	NA
		Total			0.8915	13.47
002	017	Aluminum (Al)	2860	mg/kg	0.0392	NA
002	017	Antimony (Sb)	2	mg/kg	0.0686	NA
002	017	Arsenic (As)	2.1	mg/kg	0.0960	5.49
002	017	Beryllium (Be)	0.05	mg/kg	0.0001	0.37
002	017	Cadmium (Cd)	3.7	mg/kg	0.0503	NA
002	017	Chromium (Cr)	3.2	mg/kg	0.0088	NA
002	017	Manganese (Mn)	7.9	mg/kg	0.0023	NA
002	017	Mercury (Hg)	ND	mg/kg	NA	NA
002	017	Nickel (Ni)	9.5	mg/kg	0.0065	NA
002	017	Thallium (Tl)	ND	mg/kg	NA	NA
002	017	Vanadium (V)	4.5	mg/kg	0.0088	NA
		Total			0.2807	5.86
002	018	Aluminum (Al)	8780	mg/kg	0.1204	NA
002	018	Antimony (Sb)	1.3	mg/kg	0.0446	NA
002	018	Arsenic (As)	7.1	mg/kg	0.3245	18.55
002	018	Beryllium (Be)	0.08	mg/kg	0.0002	0.60
002	018	Cadmium (Cd)	1.9	mg/kg	0.0258	NA
002	018	Chromium (Cr)	10.1	mg/kg	0.0277	NA
002	018	Manganese (Mn)	8.1	mg/kg	0.0024	NA

Table 10.2.29
Point Estimates of Risk and Hazard
Residential Scenario
SWMU 2, Surface Soil
NAVBASE - Charleston
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
002	018	Mercury (Hg)	ND	mg/kg	NA	NA
002	018	Nickel (Ni)	1.3	mg/kg	0.0009	NA
002	018	Thallium (Tl)	2.3	mg/kg	0.3942	NA
002	018	Vanadium (V)	26	mg/kg	0.0509	NA
		Total			0.9917	19.14
002	019	Aluminum (Al)	10100	mg/kg	0.1385	NA
002	019	Antimony (Sb)	ND	mg/kg	NA	NA
002	019	Arsenic (As)	7.1	mg/kg	0.3245	18.55
002	019	Beryllium (Be)	ND	mg/kg	NA	NA
002	019	Cadmium (Cd)	ND	mg/kg	NA	NA
002	019	Chromium (Cr)	12.9	mg/kg	0.0354	NA
002	019	Manganese (Mn)	28.9	mg/kg	0.0086	NA
002	019	Mercury (Hg)	ND	mg/kg	NA	NA
002	019	Nickel (Ni)	9.6	mg/kg	0.0066	NA
002	019	Thallium (Tl)	ND	mg/kg	NA	NA
002	019	Vanadium (V)	20.3	mg/kg	0.0398	NA
		Total			0.5533	18.55
002	020	Aluminum (Al)	7380	mg/kg	0.1012	NA
002	020	Antimony (Sb)	54.4	mg/kg	1.8649	NA
002	020	Arsenic (As)	5.6	mg/kg	0.2560	14.63
002	020	Beryllium (Be)	0.21	mg/kg	0.0006	1.57
002	020	Cadmium (Cd)	3.8	mg/kg	0.0517	NA
002	020	Chromium (Cr)	28.4	mg/kg	0.0779	NA
002	020	Manganese (Mn)	130	mg/kg	0.0386	NA
002	020	Mercury (Hg)	1.9	mg/kg	0.0868	NA
002	020	Nickel (Ni)	13.5	mg/kg	0.0093	NA
002	020	Thallium (Tl)	0.6	mg/kg	0.1028	NA
002	020	Vanadium (V)	15.4	mg/kg	0.0302	NA
		Total			2.6199	16.20
002	021	Aluminum (Al)	6460	mg/kg	0.0886	NA
002	021	Antimony (Sb)	6.1	mg/kg	0.2091	NA
002	021	Arsenic (As)	4.15	mg/kg	0.1897	10.84
002	021	Beryllium (Be)	0.125	mg/kg	0.0003	0.94
002	021	Cadmium (Cd)	0.64	mg/kg	0.0087	NA
002	021	Chromium (Cr)	19.8	mg/kg	0.0543	NA
002	021	Manganese (Mn)	66.75	mg/kg	0.0198	NA
002	021	Mercury (Hg)	4.45	mg/kg	0.2034	NA
002	021	Nickel (Ni)	7.15	mg/kg	0.0049	NA
002	021	Thallium (Tl)	0.69	mg/kg	0.1183	NA
002	021	Vanadium (V)	15.2	mg/kg	0.0298	NA
		Total			0.9269	11.78
002	022	Aluminum (Al)	7050	mg/kg	0.0967	NA
002	022	Antimony (Sb)	7.6	mg/kg	0.2605	NA
002	022	Arsenic (As)	3.5	mg/kg	0.1600	9.14
002	022	Beryllium (Be)	0.13	mg/kg	0.0004	0.97
002	022	Cadmium (Cd)	4.6	mg/kg	0.0626	NA
002	022	Chromium (Cr)	20.9	mg/kg	0.0573	NA
002	022	Manganese (Mn)	66.1	mg/kg	0.0196	NA
002	022	Mercury (Hg)	1.3	mg/kg	0.0594	NA
002	022	Nickel (Ni)	6.1	mg/kg	0.0042	NA
002	022	Thallium (Tl)	ND	mg/kg	NA	NA
002	022	Vanadium (V)	15.4	mg/kg	0.0302	NA
		Total			0.7508	10.12
002	023	Aluminum (Al)	5780	mg/kg	0.0793	NA
002	023	Antimony (Sb)	ND	mg/kg	NA	NA
002	023	Arsenic (As)	29.4	mg/kg	1.3438	76.79
002	023	Beryllium (Be)	0.33	mg/kg	0.0009	2.47
002	023	Cadmium (Cd)	2.1	mg/kg	0.0286	NA
002	023	Chromium (Cr)	19.3	mg/kg	0.0529	NA
002	023	Manganese (Mn)	114	mg/kg	0.0339	NA
002	023	Mercury (Hg)	0.6	mg/kg	0.0274	NA
002	023	Nickel (Ni)	32.9	mg/kg	0.0226	NA

Table 10.2.29
Point Estimates of Risk and Hazard
Residential Scenario
SWMU 2, Surface Soil
NAVBASE - Charleston
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
002	023	Thallium (Tl)	ND	mg/kg	NA	NA
002	023	Vanadium (V)	16.3	mg/kg	0.0319	NA
		Total			1.6212	79.26
002	024	Aluminum (Al)	13300	mg/kg	0.1824	NA
002	024	Antimony (Sb)	ND	mg/kg	NA	NA
002	024	Arsenic (As)	7.7	mg/kg	0.3520	20.11
002	024	Beryllium (Be)	ND	mg/kg	NA	NA
002	024	Cadmium (Cd)	ND	mg/kg	NA	NA
002	024	Chromium (Cr)	38	mg/kg	0.1042	NA
002	024	Manganese (Mn)	53.7	mg/kg	0.0159	NA
002	024	Mercury (Hg)	ND	mg/kg	NA	NA
002	024	Nickel (Ni)	17.4	mg/kg	0.0119	NA
002	024	Thallium (Tl)	ND	mg/kg	NA	NA
002	024	Vanadium (V)	32.5	mg/kg	0.0637	NA
		Total			0.7301	20.11
002	025	Aluminum (Al)	7260	mg/kg	0.0996	NA
002	025	Antimony (Sb)	ND	mg/kg	NA	NA
002	025	Arsenic (As)	5.9	mg/kg	0.2697	15.41
002	025	Beryllium (Be)	ND	mg/kg	NA	NA
002	025	Cadmium (Cd)	ND	mg/kg	NA	NA
002	025	Chromium (Cr)	13.3	mg/kg	0.0365	NA
002	025	Manganese (Mn)	21.9	mg/kg	0.0065	NA
002	025	Mercury (Hg)	ND	mg/kg	NA	NA
002	025	Nickel (Ni)	5.3	mg/kg	0.0036	NA
002	025	Thallium (Tl)	ND	mg/kg	NA	NA
002	025	Vanadium (V)	16	mg/kg	0.0313	NA
		Total			0.4472	15.41
002	026	Aluminum (Al)	8140	mg/kg	0.1116	NA
002	026	Antimony (Sb)	ND	mg/kg	NA	NA
002	026	Arsenic (As)	11	mg/kg	0.5028	28.73
002	026	Beryllium (Be)	ND	mg/kg	NA	NA
002	026	Cadmium (Cd)	ND	mg/kg	NA	NA
002	026	Chromium (Cr)	15.1	mg/kg	0.0414	NA
002	026	Manganese (Mn)	72.6	mg/kg	0.0216	NA
002	026	Mercury (Hg)	ND	mg/kg	NA	NA
002	026	Nickel (Ni)	8.9	mg/kg	0.0061	NA
002	026	Thallium (Tl)	ND	mg/kg	NA	NA
002	026	Vanadium (V)	21.9	mg/kg	0.0429	NA
		Total			0.7264	28.73
002	027	Aluminum (Al)	1280	mg/kg	0.0176	NA
002	027	Antimony (Sb)	ND	mg/kg	NA	NA
002	027	Arsenic (As)	2.5	mg/kg	0.1143	6.53
002	027	Beryllium (Be)	ND	mg/kg	NA	NA
002	027	Cadmium (Cd)	ND	mg/kg	NA	NA
002	027	Chromium (Cr)	6.5	mg/kg	0.0178	NA
002	027	Manganese (Mn)	354	mg/kg	0.1051	NA
002	027	Mercury (Hg)	ND	mg/kg	NA	NA
002	027	Nickel (Ni)	11.3	mg/kg	0.0077	NA
002	027	Thallium (Tl)	ND	mg/kg	NA	NA
002	027	Vanadium (V)	6.1	mg/kg	0.0119	NA
		Total			0.2745	6.53
002	028	Aluminum (Al)	40100	mg/kg	0.5499	NA
002	028	Antimony (Sb)	ND	mg/kg	NA	NA
002	028	Arsenic (As)	21.5	mg/kg	0.9827	56.16
002	028	Beryllium (Be)	ND	mg/kg	NA	NA
002	028	Cadmium (Cd)	6.6	mg/kg	0.0898	NA
002	028	Chromium (Cr)	112	mg/kg	0.3072	NA
002	028	Manganese (Mn)	150	mg/kg	0.0446	NA
002	028	Mercury (Hg)	ND	mg/kg	NA	NA
002	028	Nickel (Ni)	61.7	mg/kg	0.0423	NA
002	028	Thallium (Tl)	ND	mg/kg	NA	NA
002	028	Vanadium (V)	114	mg/kg	0.2233	NA

Table 10.2.29
Point Estimates of Risk and Hazard
Residential Scenario
SWMU 2, Surface Soil
NAVBASE - Charleston
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
		Total			2.2397	56.16
002	029	Aluminum (Al)	12100	mg/kg	0.1659	NA
002	029	Antimony (Sb)	ND	mg/kg	NA	NA
002	029	Arsenic (As)	13.6	mg/kg	0.6216	35.52
002	029	Beryllium (Be)	ND	mg/kg	NA	NA
002	029	Cadmium (Cd)	4.9	mg/kg	0.0666	NA
002	029	Chromium (Cr)	39.4	mg/kg	0.1081	NA
002	029	Manganese (Mn)	32.8	mg/kg	0.0097	NA
002	029	Mercury (Hg)	ND	mg/kg	NA	NA
002	029	Nickel (Ni)	32.3	mg/kg	0.0221	NA
002	029	Thallium (Tl)	ND	mg/kg	NA	NA
002	029	Vanadium (V)	50.8	mg/kg	0.0995	NA
		Total			1.0936	35.52
002	030	Aluminum (Al)	4360	mg/kg	0.0598	NA
002	030	Antimony (Sb)	ND	mg/kg	NA	NA
002	030	Arsenic (As)	2.4	mg/kg	0.1097	6.27
002	030	Beryllium (Be)	0.08	mg/kg	0.0002	0.60
002	030	Cadmium (Cd)	0.12	mg/kg	0.0016	NA
002	030	Chromium (Cr)	6.7	mg/kg	0.0184	NA
002	030	Manganese (Mn)	6.5	mg/kg	0.0019	NA
002	030	Mercury (Hg)	ND	mg/kg	NA	NA
002	030	Nickel (Ni)	1	mg/kg	0.0007	NA
002	030	Thallium (Tl)	ND	mg/kg	NA	NA
002	030	Vanadium (V)	11.4	mg/kg	0.0223	NA
		Total			0.2147	6.87
002	031	Aluminum (Al)	8540	mg/kg	0.1171	NA
002	031	Antimony (Sb)	ND	mg/kg	NA	NA
002	031	Arsenic (As)	3	mg/kg	0.1371	7.84
002	031	Beryllium (Be)	0.07	mg/kg	0.0002	0.52
002	031	Cadmium (Cd)	ND	mg/kg	NA	NA
002	031	Chromium (Cr)	9.3	mg/kg	0.0255	NA
002	031	Manganese (Mn)	8.5	mg/kg	0.0025	NA
002	031	Mercury (Hg)	0.04	mg/kg	0.0018	NA
002	031	Nickel (Ni)	1.6	mg/kg	0.0011	NA
002	031	Thallium (Tl)	1.1	mg/kg	0.1885	NA
002	031	Vanadium (V)	16.2	mg/kg	0.0317	NA
		Total			0.5057	8.36
002	033	Aluminum (Al)	5830	mg/kg	0.0799	NA
002	033	Antimony (Sb)	1.2	mg/kg	0.0411	NA
002	033	Arsenic (As)	8.3	mg/kg	0.3794	21.68
002	033	Beryllium (Be)	0.17	mg/kg	0.0005	1.27
002	033	Cadmium (Cd)	0.4	mg/kg	0.0054	NA
002	033	Chromium (Cr)	11.7	mg/kg	0.0321	NA
002	033	Manganese (Mn)	19.4	mg/kg	0.0058	NA
002	033	Mercury (Hg)	0.08	mg/kg	0.0037	NA
002	033	Nickel (Ni)	3	mg/kg	0.0021	NA
002	033	Thallium (Tl)	0.49	mg/kg	0.0840	NA
002	033	Vanadium (V)	20.2	mg/kg	0.0396	NA
		Total			0.6735	22.95
002	034	Aluminum (Al)	4120	mg/kg	0.0565	NA
002	034	Antimony (Sb)	3	mg/kg	0.1028	NA
002	034	Arsenic (As)	2.7	mg/kg	0.1234	7.05
002	034	Beryllium (Be)	0.2	mg/kg	0.0005	1.50
002	034	Cadmium (Cd)	0.42	mg/kg	0.0057	NA
002	034	Chromium (Cr)	10	mg/kg	0.0274	NA
002	034	Manganese (Mn)	15.4	mg/kg	0.0046	NA
002	034	Mercury (Hg)	0.14	mg/kg	0.0064	NA
002	034	Nickel (Ni)	5.9	mg/kg	0.0040	NA
002	034	Thallium (Tl)	ND	mg/kg	NA	NA
002	034	Vanadium (V)	10.7	mg/kg	0.0210	NA
		Total			0.3524	8.55

Table 10.2.29
Point Estimates of Risk and Hazard
Residential Scenario
SWMU 2, Surface Soil
NAVBASE - Charleston
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
002	035	Aluminum (Al)	5060	mg/kg	0.0694	NA
002	035	Antimony (Sb)	2.7	mg/kg	0.0926	NA
002	035	Arsenic (As)	0.93	mg/kg	0.0425	2.43
002	035	Beryllium (Be)	0.23	mg/kg	0.0006	1.72
002	035	Cadmium (Cd)	0.43	mg/kg	0.0058	NA
002	035	Chromium (Cr)	7.1	mg/kg	0.0195	NA
002	035	Manganese (Mn)	9.2	mg/kg	0.0027	NA
002	035	Mercury (Hg)	0.1	mg/kg	0.0046	NA
002	035	Nickel (Ni)	2.1	mg/kg	0.0014	NA
002	035	Thallium (Tl)	ND	mg/kg	NA	NA
002	035	Vanadium (V)	5.2	mg/kg	0.0102	NA
		Total			0.2493	4.15
002	036	Aluminum (Al)	7540	mg/kg	0.1034	NA
002	036	Antimony (Sb)	470	mg/kg	16.1120	NA
002	036	Arsenic (As)	7.9	mg/kg	0.3611	20.63
002	036	Beryllium (Be)	0.37	mg/kg	0.0010	2.77
002	036	Cadmium (Cd)	5.1	mg/kg	0.0694	NA
002	036	Chromium (Cr)	24.6	mg/kg	0.0675	NA
002	036	Manganese (Mn)	74	mg/kg	0.0220	NA
002	036	Mercury (Hg)	0.32	mg/kg	0.0146	NA
002	036	Nickel (Ni)	38.2	mg/kg	0.0262	NA
002	036	Thallium (Tl)	ND	mg/kg	NA	NA
002	036	Vanadium (V)	16.2	mg/kg	0.0317	NA
		Total			16.8089	23.41
002	037	Aluminum (Al)	6270	mg/kg	0.0860	NA
002	037	Antimony (Sb)	1.5	mg/kg	0.0514	NA
002	037	Arsenic (As)	21.5	mg/kg	0.9827	56.16
002	037	Beryllium (Be)	0.39	mg/kg	0.0011	2.92
002	037	Cadmium (Cd)	1.4	mg/kg	0.0190	NA
002	037	Chromium (Cr)	38.4	mg/kg	0.1053	NA
002	037	Manganese (Mn)	81.8	mg/kg	0.0243	NA
002	037	Mercury (Hg)	ND	mg/kg	NA	NA
002	037	Nickel (Ni)	188	mg/kg	0.1289	NA
002	037	Thallium (Tl)	ND	mg/kg	NA	NA
002	037	Vanadium (V)	21.3	mg/kg	0.0417	NA
		Total			1.4405	59.08
002	038	Aluminum (Al)	6840	mg/kg	0.0938	NA
002	038	Antimony (Sb)	3.15	mg/kg	0.1080	NA
002	038	Arsenic (As)	6.95	mg/kg	0.3177	18.15
002	038	Beryllium (Be)	0.13	mg/kg	0.0004	0.97
002	038	Cadmium (Cd)	1.535	mg/kg	0.0209	NA
002	038	Chromium (Cr)	10.5	mg/kg	0.0288	NA
002	038	Manganese (Mn)	23.45	mg/kg	0.0070	NA
002	038	Mercury (Hg)	0.05	mg/kg	0.0023	NA
002	038	Nickel (Ni)	29.7	mg/kg	0.0204	NA
002	038	Thallium (Tl)	0.48	mg/kg	0.0823	NA
002	038	Vanadium (V)	13.1	mg/kg	0.0257	NA
		Total			0.7070	19.13
002	039	Aluminum (Al)	10700	mg/kg	0.1467	NA
002	039	Antimony (Sb)	3.4	mg/kg	0.1166	NA
002	039	Arsenic (As)	9.2	mg/kg	0.4205	24.03
002	039	Beryllium (Be)	0.27	mg/kg	0.0007	2.02
002	039	Cadmium (Cd)	1.7	mg/kg	0.0231	NA
002	039	Chromium (Cr)	22	mg/kg	0.0603	NA
002	039	Manganese (Mn)	2380	mg/kg	0.7069	NA
002	039	Mercury (Hg)	0.16	mg/kg	0.0073	NA
002	039	Nickel (Ni)	9.7	mg/kg	0.0067	NA
002	039	Thallium (Tl)	1.5	mg/kg	0.2571	NA
002	039	Vanadium (V)	22.6	mg/kg	0.0443	NA
		Total			1.7902	26.05
002	040	Aluminum (Al)	8300	mg/kg	0.1138	NA
002	040	Antimony (Sb)	0.43	mg/kg	0.0147	NA

Table 10.2.29
Point Estimates of Risk and Hazard
Residential Scenario
SWMU 2, Surface Soil
NAVBASE - Charleston
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
002	040	Arsenic (As)	3.3	mg/kg	0.1508	8.62
002	040	Beryllium (Be)	0.11	mg/kg	0.0003	0.82
002	040	Cadmium (Cd)	ND	mg/kg	NA	NA
002	040	Chromium (Cr)	10.6	mg/kg	0.0291	NA
002	040	Manganese (Mn)	8.6	mg/kg	0.0026	NA
002	040	Mercury (Hg)	ND	mg/kg	NA	NA
002	040	Nickel (Ni)	1.6	mg/kg	0.0011	NA
002	040	Thallium (Tl)	ND	mg/kg	NA	NA
002	040	Vanadium (V)	18.5	mg/kg	0.0362	NA
		Total			0.3487	9.44
002	041	Aluminum (Al)	7500	mg/kg	0.1028	NA
002	041	Antimony (Sb)	0.37	mg/kg	0.0127	NA
002	041	Arsenic (As)	6.1	mg/kg	0.2788	15.93
002	041	Beryllium (Be)	0.18	mg/kg	0.0005	1.35
002	041	Cadmium (Cd)	ND	mg/kg	NA	NA
002	041	Chromium (Cr)	12.4	mg/kg	0.0340	NA
002	041	Manganese (Mn)	8.9	mg/kg	0.0026	NA
002	041	Mercury (Hg)	ND	mg/kg	NA	NA
002	041	Nickel (Ni)	2.2	mg/kg	0.0015	NA
002	041	Thallium (Tl)	ND	mg/kg	NA	NA
002	041	Vanadium (V)	22.1	mg/kg	0.0433	NA
		Total			0.4763	17.28
S02	001	Aluminum (Al)	4300	mg/kg	0.0590	NA
S02	001	Antimony (Sb)	ND	mg/kg	NA	NA
S02	001	Arsenic (As)	7.6	mg/kg	0.3474	19.85
S02	001	Beryllium (Be)	ND	mg/kg	NA	NA
S02	001	Cadmium (Cd)	1.7	mg/kg	0.0231	NA
S02	001	Chromium (Cr)	26	mg/kg	0.0713	NA
S02	001	Manganese (Mn)	81	mg/kg	0.0241	NA
S02	001	Mercury (Hg)	0.11	mg/kg	0.0050	NA
S02	001	Nickel (Ni)	23	mg/kg	0.0158	NA
S02	001	Thallium (Tl)	ND	mg/kg	NA	NA
S02	001	Vanadium (V)	38	mg/kg	0.0744	NA
		Total			0.6201	19.85
S02	002	Aluminum (Al)	6100	mg/kg	0.0836	NA
S02	002	Antimony (Sb)	ND	mg/kg	NA	NA
S02	002	Arsenic (As)	3.2	mg/kg	0.1463	8.36
S02	002	Beryllium (Be)	ND	mg/kg	NA	NA
S02	002	Cadmium (Cd)	ND	mg/kg	NA	NA
S02	002	Chromium (Cr)	ND	mg/kg	NA	NA
S02	002	Manganese (Mn)	34	mg/kg	0.0101	NA
S02	002	Mercury (Hg)	0.03	mg/kg	0.0014	NA
S02	002	Nickel (Ni)	13	mg/kg	0.0089	NA
S02	002	Thallium (Tl)	ND	mg/kg	NA	NA
S02	002	Vanadium (V)	19	mg/kg	0.0372	NA
		Total			0.2875	8.36
S02	003	Aluminum (Al)	5600	mg/kg	0.0768	NA
S02	003	Antimony (Sb)	ND	mg/kg	NA	NA
S02	003	Arsenic (As)	2.8	mg/kg	0.1280	7.31
S02	003	Beryllium (Be)	ND	mg/kg	NA	NA
S02	003	Cadmium (Cd)	ND	mg/kg	NA	NA
S02	003	Chromium (Cr)	12	mg/kg	0.0329	NA
S02	003	Manganese (Mn)	32	mg/kg	0.0095	NA
S02	003	Mercury (Hg)	0.03	mg/kg	0.0014	NA
S02	003	Nickel (Ni)	ND	mg/kg	NA	NA
S02	003	Thallium (Tl)	ND	mg/kg	NA	NA
S02	003	Vanadium (V)	22	mg/kg	0.0431	NA
		Total			0.2917	7.31
S02	005	Aluminum (Al)	5400	mg/kg	0.0740	NA
S02	005	Antimony (Sb)	ND	mg/kg	NA	NA
S02	005	Arsenic (As)	2.1	mg/kg	0.0960	5.49
S02	005	Beryllium (Be)	ND	mg/kg	NA	NA

Table 10.2.29
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SWMU 2, Surface Soil
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Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
S02	005	Cadmium (Cd)	ND	mg/kg	NA	NA
S02	005	Chromium (Cr)	4.6	mg/kg	0.0126	NA
S02	005	Manganese (Mn)	31	mg/kg	0.0092	NA
S02	005	Mercury (Hg)	0.05	mg/kg	0.0023	NA
S02	005	Nickel (Ni)	ND	mg/kg	NA	NA
S02	005	Thallium (Tl)	ND	mg/kg	NA	NA
S02	005	Vanadium (V)	6.8	mg/kg	0.0133	NA
		Total			0.2075	5.49
S02	006	Aluminum (Al)	6990	mg/kg	0.0958	NA
S02	006	Antimony (Sb)	ND	mg/kg	NA	NA
S02	006	Arsenic (As)	13.7	mg/kg	0.6262	35.78
S02	006	Beryllium (Be)	ND	mg/kg	NA	NA
S02	006	Cadmium (Cd)	0.8	mg/kg	0.0109	NA
S02	006	Chromium (Cr)	22	mg/kg	0.0603	NA
S02	006	Manganese (Mn)	38.7	mg/kg	0.0115	NA
S02	006	Mercury (Hg)	0.03	mg/kg	0.0014	NA
S02	006	Nickel (Ni)	11.05	mg/kg	0.0076	NA
S02	006	Thallium (Tl)	ND	mg/kg	NA	NA
S02	006	Vanadium (V)	19	mg/kg	0.0372	NA
		Total			0.8509	35.78
S02	007	Aluminum (Al)	5700	mg/kg	0.0782	NA
S02	007	Antimony (Sb)	ND	mg/kg	NA	NA
S02	007	Arsenic (As)	7.1	mg/kg	0.3245	18.55
S02	007	Beryllium (Be)	ND	mg/kg	NA	NA
S02	007	Cadmium (Cd)	4	mg/kg	0.0544	NA
S02	007	Chromium (Cr)	29	mg/kg	0.0795	NA
S02	007	Manganese (Mn)	81	mg/kg	0.0241	NA
S02	007	Mercury (Hg)	0.06	mg/kg	0.0027	NA
S02	007	Nickel (Ni)	18	mg/kg	0.0123	NA
S02	007	Thallium (Tl)	ND	mg/kg	NA	NA
S02	007	Vanadium (V)	20	mg/kg	0.0392	NA
		Total			0.6149	18.55
S02	008	Aluminum (Al)	3000	mg/kg	0.0411	NA
S02	008	Antimony (Sb)	ND	mg/kg	NA	NA
S02	008	Arsenic (As)	8.4	mg/kg	0.3839	21.94
S02	008	Beryllium (Be)	ND	mg/kg	NA	NA
S02	008	Cadmium (Cd)	0.76	mg/kg	0.0103	NA
S02	008	Chromium (Cr)	18	mg/kg	0.0494	NA
S02	008	Manganese (Mn)	140	mg/kg	0.0416	NA
S02	008	Mercury (Hg)	0.03	mg/kg	0.0014	NA
S02	008	Nickel (Ni)	13	mg/kg	0.0089	NA
S02	008	Thallium (Tl)	ND	mg/kg	NA	NA
S02	008	Vanadium (V)	11	mg/kg	0.0215	NA
		Total			0.5582	21.94
S02	009	Aluminum (Al)	2700	mg/kg	0.0370	NA
S02	009	Antimony (Sb)	11	mg/kg	0.3771	NA
S02	009	Arsenic (As)	12	mg/kg	0.5485	31.34
S02	009	Beryllium (Be)	ND	mg/kg	NA	NA
S02	009	Cadmium (Cd)	1.5	mg/kg	0.0204	NA
S02	009	Chromium (Cr)	34	mg/kg	0.0932	NA
S02	009	Manganese (Mn)	46	mg/kg	0.0137	NA
S02	009	Mercury (Hg)	0.11	mg/kg	0.0050	NA
S02	009	Nickel (Ni)	19	mg/kg	0.0130	NA
S02	009	Thallium (Tl)	ND	mg/kg	NA	NA
S02	009	Vanadium (V)	15	mg/kg	0.0294	NA
		Total			1.1374	31.34
S02	010	Aluminum (Al)	8300	mg/kg	0.1138	NA
S02	010	Antimony (Sb)	ND	mg/kg	NA	NA
S02	010	Arsenic (As)	12	mg/kg	0.5485	31.34
S02	010	Beryllium (Be)	ND	mg/kg	NA	NA
S02	010	Cadmium (Cd)	ND	mg/kg	NA	NA
S02	010	Chromium (Cr)	36	mg/kg	0.0987	NA

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S02	010	Manganese (Mn)	48	mg/kg	0.0143	NA
S02	010	Mercury (Hg)	0.04	mg/kg	0.0018	NA
S02	010	Nickel (Ni)	19	mg/kg	0.0130	NA
S02	010	Thallium (Tl)	ND	mg/kg	NA	NA
S02	010	Vanadium (V)	27	mg/kg	0.0529	NA
		Total			0.8430	31.34
S02	011	Aluminum (Al)	4400	mg/kg	0.0603	NA
S02	011	Antimony (Sb)	40	mg/kg	1.3712	NA
S02	011	Arsenic (As)	20	mg/kg	0.9142	52.24
S02	011	Beryllium (Be)	ND	mg/kg	NA	NA
S02	011	Cadmium (Cd)	7.8	mg/kg	0.1061	NA
S02	011	Chromium (Cr)	84	mg/kg	0.2304	NA
S02	011	Manganese (Mn)	250	mg/kg	0.0743	NA
S02	011	Mercury (Hg)	15	mg/kg	0.6856	NA
S02	011	Nickel (Ni)	36	mg/kg	0.0247	NA
S02	011	Thallium (Tl)	ND	mg/kg	NA	NA
S02	011	Vanadium (V)	19	mg/kg	0.0372	NA
		Total			3.5039	52.24
S02	012	Aluminum (Al)	5400	mg/kg	0.0740	NA
S02	012	Antimony (Sb)	ND	mg/kg	NA	NA
S02	012	Arsenic (As)	3.6	mg/kg	0.1645	9.40
S02	012	Beryllium (Be)	ND	mg/kg	NA	NA
S02	012	Cadmium (Cd)	2.8	mg/kg	0.0381	NA
S02	012	Chromium (Cr)	18	mg/kg	0.0494	NA
S02	012	Manganese (Mn)	46	mg/kg	0.0137	NA
S02	012	Mercury (Hg)	0.14	mg/kg	0.0064	NA
S02	012	Nickel (Ni)	13	mg/kg	0.0089	NA
S02	012	Thallium (Tl)	ND	mg/kg	NA	NA
S02	012	Vanadium (V)	19	mg/kg	0.0372	NA
		Total			0.3922	9.40
S02	013	Aluminum (Al)	1800	mg/kg	0.0247	NA
S02	013	Antimony (Sb)	ND	mg/kg	NA	NA
S02	013	Arsenic (As)	5.2	mg/kg	0.2377	13.58
S02	013	Beryllium (Be)	ND	mg/kg	NA	NA
S02	013	Cadmium (Cd)	ND	mg/kg	NA	NA
S02	013	Chromium (Cr)	13	mg/kg	0.0357	NA
S02	013	Manganese (Mn)	350	mg/kg	0.1040	NA
S02	013	Mercury (Hg)	0.21	mg/kg	0.0096	NA
S02	013	Nickel (Ni)	8.8	mg/kg	0.0060	NA
S02	013	Thallium (Tl)	ND	mg/kg	NA	NA
S02	013	Vanadium (V)	6.2	mg/kg	0.0121	NA
		Total			0.4297	13.58
S02	014	Aluminum (Al)	3700	mg/kg	0.0507	NA
S02	014	Antimony (Sb)	ND	mg/kg	NA	NA
S02	014	Arsenic (As)	2.2	mg/kg	0.1006	5.75
S02	014	Beryllium (Be)	ND	mg/kg	NA	NA
S02	014	Cadmium (Cd)	ND	mg/kg	NA	NA
S02	014	Chromium (Cr)	6.7	mg/kg	0.0184	NA
S02	014	Manganese (Mn)	24	mg/kg	0.0071	NA
S02	014	Mercury (Hg)	0.03	mg/kg	0.0014	NA
S02	014	Nickel (Ni)	ND	mg/kg	NA	NA
S02	014	Thallium (Tl)	ND	mg/kg	NA	NA
S02	014	Vanadium (V)	12	mg/kg	0.0235	NA
		Total			0.2017	5.75
S02	015	Aluminum (Al)	3800	mg/kg	0.0521	NA
S02	015	Antimony (Sb)	8.5	mg/kg	0.2914	NA
S02	015	Arsenic (As)	6.9	mg/kg	0.3154	18.02
S02	015	Beryllium (Be)	ND	mg/kg	NA	NA
S02	015	Cadmium (Cd)	3.2	mg/kg	0.0435	NA
S02	015	Chromium (Cr)	29	mg/kg	0.0795	NA
S02	015	Manganese (Mn)	160	mg/kg	0.0475	NA
S02	015	Mercury (Hg)	0.2	mg/kg	0.0091	NA

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Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
S02	015	Nickel (Ni)	29	mg/kg	0.0199	NA
S02	015	Thallium (Tl)	ND	mg/kg	NA	NA
S02	015	Vanadium (V)	17	mg/kg	0.0333	NA
		Total			0.8918	18.02
S02	016	Aluminum	4263.3333	mg/kg	0.0585	NA
S02	016	Antimony	23	mg/kg	0.7885	NA
S02	016	Arsenic	2.7667	mg/kg	0.1265	7.23
S02	016	Beryllium	ND	mg/kg	NA	NA
S02	016	Cadmium	3.4	mg/kg	0.0462	NA
S02	016	Chromium	70.2667	mg/kg	0.1927	NA
S02	016	Manganese	99.6667	mg/kg	0.0296	NA
S02	016	Mercury	0.9267	mg/kg	0.0424	NA
S02	016	Nickel	31.6333	mg/kg	0.0217	NA
S02	016	Thallium	ND	mg/kg	NA	NA
S02	016	Vanadium	18.2	mg/kg	0.0357	NA
		Total			1.3416	7.23
S02	017	Aluminum	7500	mg/kg	0.1028	NA
S02	017	Antimony	ND	mg/kg	NA	NA
S02	017	Arsenic	2.3	mg/kg	0.1051	6.01
S02	017	Beryllium	ND	mg/kg	NA	NA
S02	017	Cadmium	ND	mg/kg	NA	NA
S02	017	Chromium	18	mg/kg	0.0494	NA
S02	017	Manganese	25	mg/kg	0.0074	NA
S02	017	Mercury	0.015	mg/kg	0.0007	NA
S02	017	Nickel	ND	mg/kg	NA	NA
S02	017	Thallium	ND	mg/kg	NA	NA
S02	017	Vanadium	15	mg/kg	0.0294	NA
		Total			0.2948	6.01
S02	018	Aluminum	1500	mg/kg	0.0206	NA
S02	018	Antimony	8.3	mg/kg	0.2845	NA
S02	018	Arsenic	20	mg/kg	0.9142	52.24
S02	018	Beryllium	ND	mg/kg	NA	NA
S02	018	Cadmium	ND	mg/kg	NA	NA
S02	018	Chromium	8.2	mg/kg	0.0225	NA
S02	018	Manganese	55	mg/kg	0.0163	NA
S02	018	Mercury	0.28	mg/kg	0.0128	NA
S02	018	Nickel	9.8	mg/kg	0.0067	NA
S02	018	Thallium	ND	mg/kg	NA	NA
S02	018	Vanadium	9	mg/kg	0.0176	NA
		Total			1.2952	52.24
S02	019	Aluminum	6500	mg/kg	0.0891	NA
S02	019	Antimony	ND	mg/kg	NA	NA
S02	019	Arsenic	1.3	mg/kg	0.0594	3.40
S02	019	Beryllium	ND	mg/kg	NA	NA
S02	019	Cadmium	ND	mg/kg	NA	NA
S02	019	Chromium	9.4	mg/kg	0.0258	NA
S02	019	Manganese	13	mg/kg	0.0039	NA
S02	019	Mercury	0.017	mg/kg	0.0008	NA
S02	019	Nickel	ND	mg/kg	NA	NA
S02	019	Thallium	ND	mg/kg	NA	NA
S02	019	Vanadium	14	mg/kg	0.0274	NA
		Total			0.2064	3.40
S02	020	Aluminum	3400	mg/kg	0.0466	NA
S02	020	Antimony	ND	mg/kg	NA	NA
S02	020	Arsenic	4.1	mg/kg	0.1874	10.71
S02	020	Beryllium	ND	mg/kg	NA	NA
S02	020	Cadmium	ND	mg/kg	NA	NA
S02	020	Chromium	16	mg/kg	0.0439	NA
S02	020	Manganese	81	mg/kg	0.0241	NA
S02	020	Mercury	0.022	mg/kg	0.0010	NA
S02	020	Nickel	8.8	mg/kg	0.0060	NA
S02	020	Thallium	ND	mg/kg	NA	NA

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Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
S02	020	Vanadium	12	mg/kg	0.0235	NA
		Total			0.3325	10.71
S02	021	Aluminum	1300	mg/kg	0.0178	NA
S02	021	Antimony	ND	mg/kg	NA	NA
S02	021	Arsenic	9.9	mg/kg	0.4525	25.86
S02	021	Beryllium	ND	mg/kg	NA	NA
S02	021	Cadmium	1	mg/kg	0.0136	NA
S02	021	Chromium	5	mg/kg	0.0137	NA
S02	021	Manganese	15	mg/kg	0.0045	NA
S02	021	Mercury	0.243	mg/kg	0.0111	NA
S02	021	Nickel	5.8	mg/kg	0.0040	NA
S02	021	Thallium	ND	mg/kg	NA	NA
S02	021	Vanadium	4.9	mg/kg	0.0096	NA
		Total			0.5268	25.86
S02	022	Aluminum	3000	mg/kg	0.0411	NA
S02	022	Antimony	ND	mg/kg	NA	NA
S02	022	Arsenic	4.6	mg/kg	0.2103	12.02
S02	022	Beryllium	ND	mg/kg	NA	NA
S02	022	Cadmium	ND	mg/kg	NA	NA
S02	022	Chromium	7.9	mg/kg	0.0217	NA
S02	022	Manganese	25	mg/kg	0.0074	NA
S02	022	Mercury	0.046	mg/kg	0.0021	NA
S02	022	Nickel	ND	mg/kg	NA	NA
S02	022	Thallium	ND	mg/kg	NA	NA
S02	022	Vanadium	11	mg/kg	0.0215	NA
		Total			0.3041	12.02
S02	023	Aluminum	2800	mg/kg	0.0384	NA
S02	023	Antimony	ND	mg/kg	NA	NA
S02	023	Arsenic	ND	mg/kg	NA	NA
S02	023	Beryllium	ND	mg/kg	NA	NA
S02	023	Cadmium	ND	mg/kg	NA	NA
S02	023	Chromium	5.9	mg/kg	0.0162	NA
S02	023	Manganese	11	mg/kg	0.0033	NA
S02	023	Mercury	ND	mg/kg	NA	NA
S02	023	Nickel	ND	mg/kg	NA	NA
S02	023	Thallium	ND	mg/kg	NA	NA
S02	023	Vanadium	3.1	mg/kg	0.0061	NA
		Total			0.0639	NA
002	M0003	Aluminum	11300	mg/kg	0.1549	NA
002	M0003	Antimony	11.5	mg/kg	0.3942	NA
002	M0003	Arsenic	19.6	mg/kg	0.8959	51.20
002	M0003	Beryllium	0.69	mg/kg	0.0019	5.17
002	M0003	Cadmium	7.2	mg/kg	0.1975	NA
002	M0003	Chromium	56.4	mg/kg	0.1547	NA
002	M0003	Manganese	75.4	mg/kg	0.0220	NA
002	M0003	Mercury	0.23	mg/kg	0.0105	NA
002	M0003	Nickel	29.4	mg/kg	0.0202	NA
002	M0003	Thallium	ND	mg/kg	NA	NA
002	M0003	Vanadium	56.8	mg/kg	0.1113	NA
		Total			1.9630	56.36
002	M0004	Aluminum	3000	mg/kg	0.0411	NA
002	M0004	Antimony	6.6	mg/kg	0.2263	NA
002	M0004	Aroclor 1260	500	ug/kg	NA	2.27
002	M0004	Arsenic	18.3	mg/kg	0.8365	47.80
002	M0004	Benzo(a)pyrene Equivalents	90.87	ug/kg	NA	1.50
002	M0004	Beryllium	0.44	mg/kg	0.0012	5.17
002	M0004	Cadmium	5.7	mg/kg	0.1563	NA
002	M0004	Chromium	17.5	mg/kg	0.0480	NA
002	M0004	Manganese	17.9	mg/kg	0.0052	NA
002	M0004	Mercury	0.13	mg/kg	0.0059	NA
002	M0004	Nickel	22.1	mg/kg	0.0152	NA
002	M0004	Thallium	1.2	mg/kg	0.2057	NA

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Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
002	M0004	Vanadium	31.7	mg/kg	0.0621	NA
		Total			1.6035	56.74
002	M0005	Aluminum	27000	mg/kg	0.3702	NA
002	M0005	Antimony	1.8	mg/kg	0.0617	NA
002	M0005	Arsenic	9	mg/kg	0.4114	23.51
002	M0005	Beryllium	2.1	mg/kg	0.0058	15.72
002	M0005	Cadmium	1.7	mg/kg	0.0466	NA
002	M0005	Chromium	45.5	mg/kg	0.1248	NA
002	M0005	Manganese	172	mg/kg	0.0502	NA
002	M0005	Mercury	0.15	mg/kg	0.0069	NA
002	M0005	Nickel	55	mg/kg	0.0377	NA
002	M0005	Thallium	ND	mg/kg	NA	NA
002	M0005	Vanadium	29.8	mg/kg	0.0584	NA
		Total			1.1736	39.23

Groundwater

Figures 10.2.21 and 10.2.22 illustrate point risk and hazard for SWMU 2 shallow groundwater under a residential scenario. To facilitate the presentation of multiple sampling rounds, the maximum risk and hazard have been plotted. Table 10.2.30 details the individual contributors to risk and hazard at each monitoring well location and for all sampling rounds. Concentrations of arsenic in first quarter groundwater samples collected from monitoring well NBCA-002-004 contribute to risk projections of 1E-04. Arsenic concentrations from third and fourth quarter groundwater samples from this monitoring well equated with risks of 1E-04 and 2E-04, respectively. The second quarter sample was non-detected for arsenic. Manganese is the primary contributor to hazard indices above one. The exceptions are arsenic in the first and fourth quarter samples from monitoring well NBCA-002-004.

10.2.8.8 Remedial Goal Options

Soil

RGOs for carcinogens were based on the lifetime weighted average site resident or site workers as presented in Table 10.2.31 for surface soils. Hazard-based RGOs were calculated based on the hypothetical child resident or site worker, as noted in the table.

Groundwater

Groundwater RGOs based on site residents and site workers are shown in Table 10.2.32.

10.2.9 Corrective Measures Considerations

For SWMU 2, the environmental media investigated were surface soil, subsurface soil, sediment, and shallow groundwater. Based on the analytical results and the risk assessment, COCs requiring further evaluation through the CMS process were identified for surface soil and shallow groundwater. Detections of COCs in the subsurface soil also justify inclusion in the CMS process.

Aluminum, antimony, Aroclor-1260 arsenic, beryllium, BEQ, lead, and thallium were identified as COCs in soil. Arsenic, manganese, and silver were identified as COCs in shallow groundwater.

Potential corrective measures for the impacted medium and respective COCs are in Table 10.2.33. Corrective measures for SWMU 2 are reviewed in more detail in Section 9.

LEGEND

- NO COPCs DETECTED
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

0 feet 600

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE, CHARLESTON
CHARLESTON, S.C.

FIGURE 10.2.21
SWMU 2
SHALLOW GROUNDWATER POINT RISK
RESIDENTIAL SCENARIO

AMU: /home3/projects/charleston_dir/risk_assess/zone_a_dir

LEGEND

- NO COPCs DETECTED
- 0 to 0.1
- 0.1 to 0.5
- 0.5 to 1.0
- 1.0 to 3.0
- > 3.0

0 feet 600

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE, CHARLESTON
CHARLESTON, S.C.

FIGURE 10.2.22
SWMU 2
SHALLOW GROUNDWATER HAZARD INDEX - RESIDENTIAL SCENARIO

AML: /home3/projects/charleston_dir/risk_assess/zone_a_dir

Table 10.2.30
Point Risk Estimates of Risk and Hazard
Residential Scenario
SWMU 2, Groundwater
NAVBASE - Charleston
Charleston, South Carolina

Site	Location	Quarter	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
002	001	01	Arsenic (As)	ND	ug/L	NA	NA
002	001	01	Manganese (Mn)	373	ug/L	1.0361	NA
002	001	01	Silver (Ag)	ND	ug/L	NA	NA
			Total			1.0361	NA
002	002	01	Arsenic (As)	ND	ug/L	NA	NA
002	002	01	Manganese (Mn)	3210	ug/L	8.9167	NA
002	002	01	Silver (Ag)	ND	ug/L	NA	NA
			Total			8.9167	NA
002	003	01	Arsenic (As)	ND	ug/L	NA	NA
002	003	01	Manganese (Mn)	262	ug/L	0.7278	NA
002	003	01	Silver (Ag)	ND	ug/L	NA	NA
			Total			0.7278	NA
002	004	01	Arsenic (As)	5.8	ug/L	1.2340	128.89
002	004	01	Manganese (Mn)	108	ug/L	0.3000	NA
002	004	01	Silver (Ag)	ND	ug/L	NA	NA
			Total			1.5340	128.89
002	005	01	Arsenic (As)	ND	ug/L	NA	NA
002	005	01	Manganese (Mn)	26.5	ug/L	0.0736	NA
002	005	01	Silver (Ag)	ND	ug/L	NA	NA
			Total			0.0736	NA
002	001	02	Arsenic (As)	ND	ug/L	NA	NA
002	001	02	Manganese (Mn)	496	ug/L	1.3786	NA
002	001	02	Silver (Ag)	ND	ug/L	NA	NA
			Total			1.3786	NA
002	002	02	Arsenic (As)	ND	ug/L	NA	NA
002	002	02	Manganese (Mn)	3350	ug/L	9.3111	NA
002	002	02	Silver (Ag)	ND	ug/L	NA	NA
			Total			9.3111	NA
002	003	02	Arsenic (As)	ND	ug/L	NA	NA
002	003	02	Manganese (Mn)	291	ug/L	0.8088	NA
002	003	02	Silver (Ag)	ND	ug/L	NA	NA
			Total			0.8088	NA
002	004	02	Arsenic (As)	ND	ug/L	NA	NA
002	004	02	Manganese (Mn)	119	ug/L	0.3308	NA
002	004	02	Silver (Ag)	ND	ug/L	NA	NA
			Total			0.3308	NA
002	005	02	Arsenic (As)	ND	ug/L	NA	NA
002	005	02	Manganese (Mn)	ND	ug/L	NA	NA
002	005	02	Silver (Ag)	ND	ug/L	NA	NA
			Total			NA	NA
002	001	03	Arsenic (As)	ND	ug/L	NA	NA
002	001	03	Manganese (Mn)	1990	ug/L	5.5311	NA
002	001	03	Silver (Ag)	ND	ug/L	NA	NA
			Total			5.5311	NA
002	002	03	Arsenic (As)	ND	ug/L	NA	NA
002	002	03	Manganese (Mn)	3000	ug/L	8.3383	NA
002	002	03	Silver (Ag)	ND	ug/L	NA	NA
			Total			8.3383	NA
002	003	03	Arsenic (As)	ND	ug/L	NA	NA
002	003	03	Manganese (Mn)	307	ug/L	0.8533	NA
002	003	03	Silver (Ag)	ND	ug/L	NA	NA
			Total			0.8533	NA
002	004	03	Arsenic (As)	4.6	ug/L	0.9802	102.62
002	004	03	Manganese (Mn)	168	ug/L	0.4669	NA

Table 10.2.30
Point Risk Estimates of Risk and Hazard
Residential Scenario
SWMU 2, Groundwater
NAVBASE - Charleston
Charleston, South Carolina

Site	Location	Quarter	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
002	004	03	Silver (Ag)	ND	ug/L	NA	NA
			Total			1.4472	102.62
002	005	03	Arsenic (As)	ND	ug/L	NA	NA
002	005	03	Manganese (Mn)	ND	ug/L	NA	NA
002	005	03	Silver (Ag)	ND	ug/L	NA	NA
			Total			NA	NA
002	001	04	Arsenic (As)	ND	ug/L	NA	NA
002	001	04	Manganese (Mn)	219	ug/L	0.6087	NA
002	001	04	Silver (Ag)	ND	ug/L	NA	NA
			Total			0.6087	NA
002	002	04	Arsenic (As)	ND	ug/L	NA	NA
002	002	04	Manganese (Mn)	3410	ug/L	9.4779	NA
002	002	04	Silver (Ag)	ND	ug/L	NA	NA
			Total			9.4779	NA
002	003	04	Arsenic (As)	2.2	ug/L	0.4688	49.08
002	003	04	Manganese (Mn)	294	ug/L	0.8172	NA
002	003	04	Silver (Ag)	ND	ug/L	NA	NA
			Total			1.2860	49.08
002	004	04	Arsenic (As)	10.3	ug/L	2.1948	229.78
002	004	04	Manganese (Mn)	241	ug/L	0.6698	NA
002	004	04	Silver (Ag)	39.8	ug/L	0.5089	NA
			Total			3.3735	229.78

Table 10.2.31
Remedial Goal Options Surface Soil
SWMU 2
Naval Base Charleston, Zone A
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	EPC mg/kg	Hazard-Based Remedial Goal Options **3** mg/kg	**1** mg/kg	**0.1** mg/kg	Risk-Based Remedial Goal Options **1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentration mg/kg
Aluminum	NA	1	8787	218781	72927	7293	ND	ND	ND	12800
Antimony	NA	0.0004	12.8	88	29	2.9	ND	ND	ND	NA
Arsenic	1.5	0.0003	11.3	66	22	2.2	0.38	3.8	38	9.44
Beryllium	4.3	0.005	0.31	1094	365	36	0.13	1.3	13	NA
Lead*	NA	NA	1416	ND	ND	ND	ND	ND	ND	140
Thallium	NA	8E-05	0.82	18	5.8	0.58	ND	ND	ND	NA
Aroclor 1260	2	NA	0.50	ND	ND	ND	0.22	2.2	22	NA
Benzo(a)pyrene equivalent	7.3	NA	0.09	ND	ND	ND	0.060	0.60	6.0	NA

Worker-Based Remedial Goal Options

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	EPC mg/kg	Hazard-Based Remedial Goal Options **3** mg/kg	**1** mg/kg	**0.1** mg/kg	Risk-Based Remedial Goal Options **1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentration mg/kg
Arsenic	1.5	0.0003	11.3	1305	435	43	2.7	27	271	9.4

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined
- Remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident or site worker for noncarcinogens
* The residential cleanup level for lead is 400 mg/kg, the industrial cleanup level for lead is 1,300 mg/kg

Table 10.2.32
Remedial Goal Options for Shallow Groundwater
SWMU 2
Naval Base Charleston, Zone A
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Oral SF (mg/kg-day)-1	Oral RfD (mg/kg-day)	EPC mg/l	Hazard-Based Remedial Goal Options **0.1** mg/l	**1.0** mg/l	**3** mg/l	Risk-Based Remedial Goal Options **1E-06** mg/l	**1E-05** mg/l	**1E-04** mg/l	MCL mg/l	Background Concentration mg/l
Arsenic	1.5	0.0003	0.0061	0.00047	0.0047	0.014	0.000044	0.00044	0.0044	0.05	0.0074
Manganese	NA	0.047	3.2	0.074	0.74	2.2	ND	ND	ND	NA	0.577
Silver	NA	0.005	0.012	0.0078	0.078	0.23	ND	ND	ND	NA	NA

Worker-Based Remedial Goal Options

Chemical	Oral SF (mg/kg-day)-1	Oral RfD (mg/kg-day)	EPC mg/l	Hazard-Based Remedial Goal Options **0.1** mg/l	**1** mg/l	**3** mg/l	Risk-Based Remedial Goal Options **1E-06** mg/l	**1E-05** mg/l	**1E-04** mg/l	MCL mg/l	Background Concentration mg/l
Arsenic	1.5	0.0003	0.0061	0.0031	0.031	0.092	0.00014	0.0014	0.014	0.05	0.0074
Manganese	NA	0.023	3.2	0.48	4.8	14.4	ND	ND	ND	NA	0.577

NOTES:

EPC Exposure point concentration
NA Not applicable
ND Not determined
- Remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident or site worker for noncarcinogens

Table 10.2.33
Potential Corrective Measures for SWMU 2

Medium	Compounds	Potential Corrective Measures
Soil	Aluminum, antimony, Aroclor-1260, arsenic, beryllium, BEQ, lead, and thallium	a) Institutional controls (deed restrictions, etc.) b) Engineering controls (berms to control overland water flow, etc.) c) Capping d) Hot-spot excavation and disposal/treatment offsite e) Solidification/stabilization (in-situ) f) Vitrification (in-situ) g) Physical separation/acid leaching (ex-situ)
Shallow Groundwater	Arsenic, manganese, and silver	a) Institutional controls (deed restrictions, etc.) b) Containment via barrier wall and hydraulic controls c) Reactive wall d) Groundwater extraction and treatment (metal precipitation, adsorption, filtration, etc.)

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10.3 SWMU 38, Miscellaneous Storage, North of Building 1605

SWMU 38 is the site where a former storage yard was associated with Buildings 1605 and 1604 for approximately 50 years. The gravel storage area, bordered by a chain-link fence, originally belonged to the supply department and later became part of DRMO which used the area for storage of empty drums. The site is north of Building 1605, near the northern boundary of NAVBASE. The Hess Oil, Inc., tank farm is adjacent to this boundary, and the scope of the investigation included assessment of potential petroleum releases from offsite tanks.

The boundary of SWMU 38 was reduced to encompass only the specific area formerly used for storage of empty drums. The remaining area depicted in the RFA was exclusively used for the storage of wooden pallets, boats, and automobiles.

Materials of concern identified in the *Final Zones A and B RFI Work Plan (E/A&H, September 1995)* for SWMU 38 included VOCs, SVOCs, metals, and PCBs. Potential receptors include current and future site users involved in invasive activities.

To fulfill CSI objectives, soil and groundwater were sampled in accordance with the *Final Zones A and B RFI Work Plan* and as described in Section 3 of this report to confirm whether any contamination resulted from onsite activities at SWMU 38.

10.3.1 Soil Sampling and Analysis

Soil was sampled in three rounds at SWMU 38 from the locations shown on Figure 10.3.1. The *Final Zones A and B RFI Work Plan* proposed collection of six soil samples from the upper interval (0 to 1 foot) and six from the lower interval (3 to 5 feet) for the SWMU 38 investigation area. Ten samples were collected from the upper interval and nine were collected from the lower interval. One lower interval sample was not collected due to a water table less than 5 feet bgs; saturated samples were not submitted for analysis. The first round of sampling occurred during

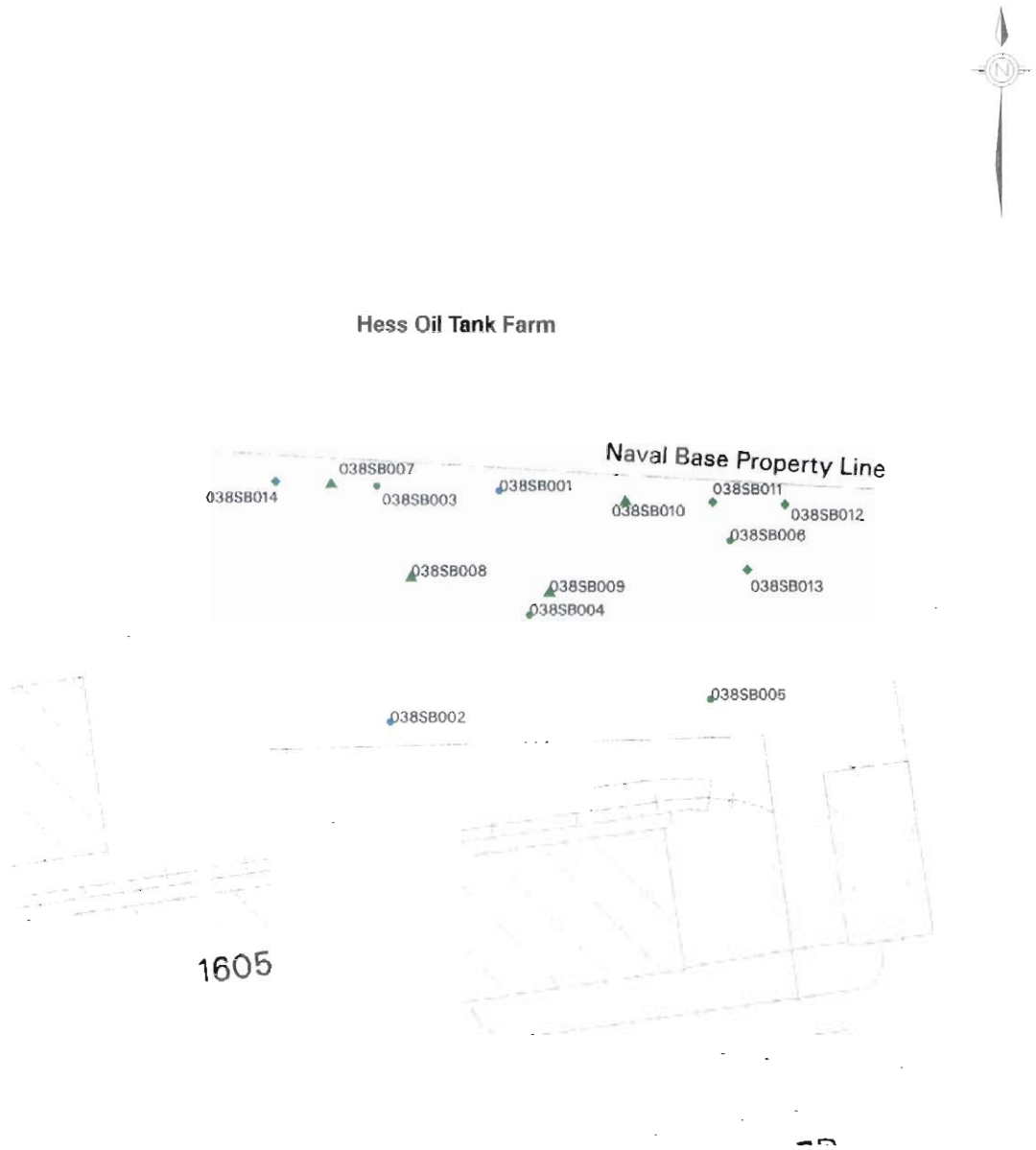
the field investigation for Zone A. Pesticides were detected in several soil samples collected at the site during the first round. As part of the Zones A and B second-round RFI sampling effort, four additional soil borings were sampled at SWMU 38.

First-round samples were submitted for analysis at DQO Level III for VOCs, SVOCs, metals, pesticides, PCBs, and TPH. Two duplicates were collected and submitted for Appendix IX analyses at DQO Level IV. Second-round samples were submitted for pesticides and PCBs at DQO Level III. Table 10.3.1 summarizes first and second-round sampling for SWMU 38.

Table 10.3.1
SWMU 38
First and Second-Round Soil Sampling Summary

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper (0' to 1')	6	10	VOCs, SVOCs, pesticides, PCBs, and metals.	VOCs, SVOCs, pesticides, PCBs, TPH, and metals.[a] Pesticides and PCBs[b]	Four additional samples were collected for site characterization. TPH added for site characterization.
Lower (3' to 5')	6	9	VOCs, SVOCs, pesticides, PCBs, and metals.	VOCs, SVOCs, pesticides, PCBs, TPH, and metals.[a] Pesticides and PCBs[b]	Four additional samples were collected for site characterization. TPH added for site characterization. High water table prevented collection of one sample; as saturated samples were not submitted for analysis.

Notes:
a = First-round samples
b = Second-round samples



0 150 feet

LEGEND

- 1st Round Soil Boring
- 2nd Round Soil Boring
- 3rd Round Soil Boring

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.3.1 - SWMU 38
Soil Sample Locations

Third-round sampling was performed following comparison of first and second-round analytical results to the USEPA Region III *Risk-Based Concentration Table*, March 1995. This comparison showed that two samples (038SB00601 and 038SB00701) contained Aroclor-1260 above its RBC, justifying the collection of four additional upper interval samples for pesticides and PCBs. Table 10.3.2 summarizes the third-round of sampling at SWMU 38.

Table 10.3.2
SWMU 38
Third-Round Soil Sampling Summary

Interval	Samples Collected	Analyses Collected	Justification
Upper	4	Pesticides and PCBs	To delineate the extent of PCBs above RBCs in soil samples 038SB00601 and 038SB00701.

10.3.2 Nature and Extent of Contamination in Soil

Organic compound analytical results for soil are summarized in Table 10.3.3. Inorganic analytical results are summarized in Table 10.3.4. Appendix D is a complete analytical data report for all samples collected in Zone A, including SWMU 38.

Table 10.3.3
SWMU 38
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Volatile Organic Compounds (11 samples collected: 6 upper-interval and 5 lower-interval, 2 samples duplicated for Appendix IX analysis)						
Acetone	Upper	3/6	32.0 - 61.0	44.7	7,800,000	0
	Lower	5/5	15.0 - 200	64.6	NA	NA

Table 10.3.3
SWMU 38
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Volatile Organic Compounds (11 samples collected: 6 upper-interval and 5 lower-interval, 2 samples duplicated for Appendix IX analysis)						
2-Butanone (MEK)	Upper	1/6	9.6	NA	47,000,000	0
	Lower	1/5	32.0	NA	NA	NA
Carbon disulfide	Upper	0/6	NA	NA	7,800,000	0
	Lower	1/5	5.0	NA	NA	NA
cis-1,2-dichloroethene	Upper	0/6	NA	NA	780,000	0
	Lower	1/5	21.0	NA	NA	NA
Toluene	Upper	2/6	1.9 - 4.2	3.1	16,000,000	0
	Lower	0/5	NA	NA	NA	NA
Xylene (total)	Upper	0/6	NA	NA	160,000,000	0
	Lower	1/5	1.5	NA	NA	NA
Semivolatile Organic Compounds (11 samples collected: 6 upper-interval and 5 lower-interval, 2 samples duplicated for Appendix IX analysis)						
BEQ[a]	Upper	1/6	0.15	NA	88	0
	Lower	0/5	NA	NA	NA	NA
bis(2-ethylhexyl)-phthalate (BEHP)	Upper	1/6	210	NA	46,000	0
	Lower	0/5	NA	NA	NA	NA
Butylbenzylphthalate	Upper	1/6	2,300	NA	16,000,000	0
	Lower	0/5	NA	NA	NA	NA
Chrysene	Upper	1/6	150	NA	88,000	0
	Lower	0/5	NA	NA	NA	NA
Di-n-octyl phthalate	Upper	1/6	410	NA	1,600,000	0
	Lower	0/5	NA	NA	NA	NA

Table 10.3.3
SWMU 38
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Pesticides/PCBs (23 samples collected: 14 upper-interval and 9 lower-interval, 3 samples duplicated for Appendix IX analysis)						
Aldrin	Upper	1/14	0.73	NA	38	0
	Lower	0/9	NA	NA	NA	NA
Aroclor-1260	Upper	6/14	18 - 1,300	505	320	4
	Lower	0/9	NA	NA	NA	NA
gamma-BHC (lindane)	Upper	1/14	0.51	NA	1,800	0
	Lower	0/9	NA	NA	NA	NA
alpha-Chlordane	Upper	3/14	1.9 - 8.4	4.1	1,800	0
	Lower	0/9	NA	NA	NA	NA
gamma-Chlordane	Upper	6/14	3.0 - 37	11.8	490	0
	Lower	0/9	NA	NA	NA	NA
4,4'-DDD	Upper	9/14	1.6 - 450,000	50,500	2,700	2
	Lower	3/9	1.8 - 1,800	605	NA	0
4,4'-DDE	Upper	11/14	6.8 - 37,000	3,550	1,900	1
	Lower	2/9	8.2 - 140	74	NA	NA
4,4'-DDT	Upper	11/14	21.0 - 1,000,000	92,000	1,900	2
	Lower	3/9	5.2 - 11,000	3,700	NA	NA
Dieldrin	Upper	1/14	9.6	NA	40	0
	Lower	0/9	NA	NA	NA	NA
Endosulfan II	Upper	1/14	6.3	NA	470,000	0
	Lower	0/9	NA	NA	NA	NA
Endrin	Upper	1/14	14.0	NA	23,000	0
	Lower	0/9	NA	NA	NA	NA

Table 10.3.3
SWMU 38
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Pesticides/PCBs (23 samples collected: 14 upper-interval and 9 lower-interval, 3 samples duplicated for Appendix IX analysis)						
Endrin aldehyde	Upper	1/14	6.6	NA	23,000	0
	Lower	0/9	NA	NA	NA	NA
Heptachlor	Upper	1/14	2.1	NA	140	0
	Lower	2/9	1.6 - 1.7	1.7	NA	NA
Dioxins (2 upper-interval samples collected)						
TCDD TEQ[a]	Upper	2/2	0.00776 - 0.02804	0.014408	1	0
Total Petroleum Hydrocarbons (11 samples collected: 6 upper-interval and 5 lower-interval, 2 samples duplicated for Appendix IX analysis)						
TPH – DRO	Upper	1/6	2,400,000	NA	NA	NA
	Lower	0/5	NA	NA	NA	NA
TPH – GRO	Upper	0/6	NA	NA	NA	NA
	Lower	0/5	NA	NA	NA	NA

Notes:

a = Calculated from the method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995

NA = Not applicable

Table 10.3.4
SWMU 38
Inorganic Detections for Soil

Element	Sample Interval	Freq. of Detections	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	Reference Conc. (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding[a]
Inorganic Analytical Results (11 samples collected: 6 upper-interval and 5 lower-interval, 2 samples duplicated for Appendix IX analysis)							
Aluminum	Upper	6/6	5,880 - 16,600	10,800	12,800	78,000	0
	Lower	5/5	4,470 - 21,600	14,100	28,240	NA	0
Antimony	Upper	0/6	NA	NA	**	31	0
	Lower	1/5	14.8	NA	**	NA	NA
Arsenic	Upper	6/6	7.8 - 19.8	14.7	9.4	0.43	5
	Lower	5/5	1.4 - 11.9	7.3	9.8	NA	1
Barium	Upper	6/6	22.1 - 46.5	34.5	53.0	5,500	0
	Lower	5/5	11.7 - 31.5	21.0	40.0	NA	0
Beryllium	Upper	1/6	0.50	NA	**	0.15	1
	Lower	2/5	0.29 - 0.44	0.37	**	NA	NA
Cadmium	Upper	1/6	1.5	NA	**	39	0
	Lower	0/5	NA	NA	**	NA	0
Calcium	Upper	6/6	8,940 - 137,000	75,600	NA	NA	NA
	Lower	5/5	715 - 177,000	36,900	NA	NA	NA
Chromium	Upper	6/6	12.8 - 37.7	25.7	50.4	390	0
	Lower	4/5	17.7 - 63.4	32.3	63.4	NA	0
Chromium (hexavalent)	Upper	1/2	0.074	NA	NA	390	0
Cobalt	Upper	4/6	1.5 - 4.1	2.8	4.4	4,700	0
	Lower	2/5	1.6 - 2.6	2.1	1.7	NA	1
Copper	Upper	6/6	10.4 - 87.3	31.4	165	3,100	0
	Lower	5/5	0.78 - 16.0	4.9	33.7	NA	0
Iron	Upper	6/6	7,910 - 13,600	10,100	NA	NA	NA
	Lower	5/5	1,570 - 29,300	14,900	NA	NA	NA
Lead	Upper	6/6	16.0 - 218	92	140	400[b]	0
	Lower	5/5	3.0 - 11.6	8.2	22.0	400[b]	0

Table 10.3.4
SWMU 38
Inorganic Detections for Soil

Element	Sample Interval	Freq. of Detections	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	Reference Conc. (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding[a]
Inorganic Analytical Results (11 samples collected: 6 upper-interval and 5 lower-interval, 2 samples duplicated for Appendix IX analysis)							
Magnesium	Upper	6/6	347 - 3,260	2,120	NA	NA	NA
	Lower	5/5	229 - 8,180	2,070	NA	NA	NA
Manganese	Upper	6/6	14.8 - 254	92.1	98.1	1,800	0
	Lower	5/5	8.2 - 223	61.3	85.5	NA	1
Mercury	Upper	3/6	0.15 - 0.31	0.25	0.30	23	0
	Lower	0/5	NA	NA	**	NA	0
Nickel	Upper	6/6	5.7 - 21.6	14.3	13.6	1,600	0
	Lower	4/5	4.8 - 29.0	11.2	35.0	NA	0
Potassium	Upper	2/6	203 - 271	237	NA	NA	NA
	Lower	1/5	1,790	NA	NA	NA	NA
Selenium	Upper	6/6	0.75 - 2.2	1.3	1.2	390	0
	Lower	3/5	0.8 - 4.5	2.2	1.7	NA	1
Sodium	Upper	6/6	237 - 815	482	NA	NA	NA
	Lower	5/5	176 - 1,630	540	NA	NA	NA
Vanadium	Upper	6/6	14.0 - 35.2	24.6	29.2	550	0
	Lower	5/5	1.5 - 47.2	32.0	77.3	NA	0
Zinc	Upper	6/6	16.3 - 221	92.7	208	23,000	0
	Lower	5/5	5.2 - 84.3	23.7	165	NA	0

Notes:

a = Number of samples exceeding both RBC and RC in upper interval or number of samples exceeding the RC in the lower interval.
b = RBC not available for lead. USEPA residential soil cleanup level used for comparison (OSWER Directive 9355.4-12).
** = Number of nondetects prevented determination of UTL.
NA = Not applicable

Volatile Organic Compounds in Soil

Acetone, 2-butanone (MEK), carbon disulfide, cis-1,2-dichloroethene, toluene, and xylene (total) were the only VOCs detected in soil at SWMU 38 and none of the detections were above their respective RBCs. Also, no second-interval detections exceed their SSLs.

Semivolatile Organic Compounds in Soil

Four SVOCs were detected in upper interval soil samples at SWMU 38 and no SVOCs were detected in the lower interval samples. No compounds detected were above their respective RBCs. The calculated BEQs were also below the RBC for benzo(a)pyrene (88μg/kg).

Pesticides/PCBs in Soil

Twelve pesticides were detected in soil samples at SWMU 38. Three of these compounds (DDD, DDE, and DDT) were detected above their respective RBCs in sample 038SB00101. DDD and DDT were also above their RBCs in 038SB00301. Second-round sampling was conducted to determine the extent of pesticide contamination in soil at SWMU 38. None of the 12 other upper interval samples exceeded RBCs for pesticides. Also, no second-interval detections exceed their SSLs.

One PCB, Aroclor-1260, was detected in six upper interval samples at SWMU 38 and four of these detections were greater than the RBC (320 μg/kg). Second and third-round sampling was conducted to define the extent of PCB contamination. All four third-round samples detected Aroclor-1260 and two of these exceeded the RBC. All Aroclor-1260 data are shown on Figure 10.3.2.

Other Organic Compounds in Soil

Dioxins were detected in both of the duplicate samples collected at SWMU 38. The calculated TEQs were below the 2,3,7,8-TCDD RBC of 1 μg/kg.

TPH – Diesel Range Organics were detected in one of six upper interval samples at a concentration of 2,400 mg/kg. TPH was not detected in any of the five lower interval samples analyzed at SWMU 38.

Inorganics in Soil

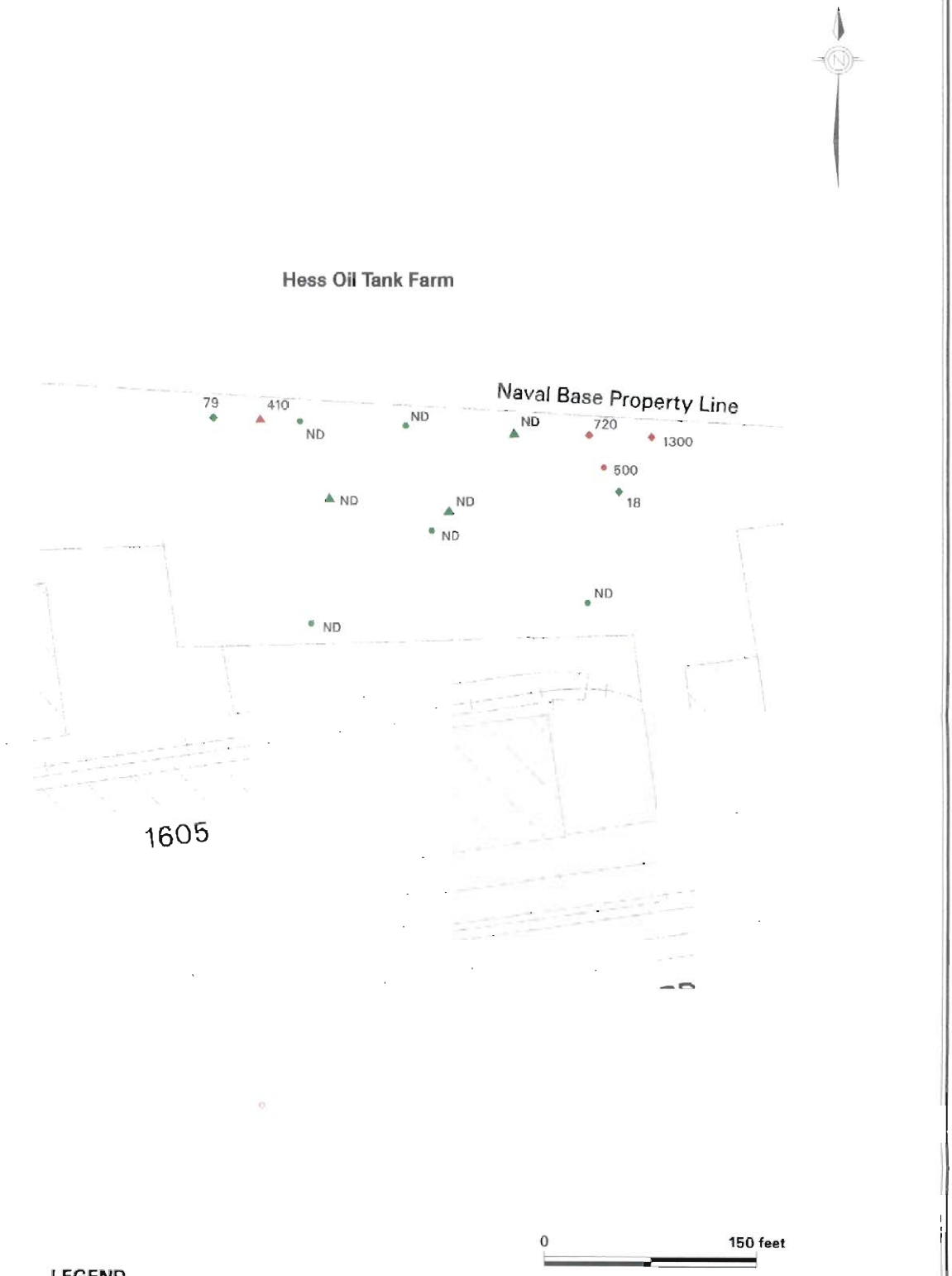
Twenty-two metals were detected in soil at SWMU 38. Based upon the comparisons made in the table, six of these warrant further evaluation: antimony, arsenic, beryllium, cobalt, manganese, and selenium.

Antimony was detected in second-interval sample 038SB00402 (14.8 mg/kg). This concentration exceeds the SSL (2.7 mg/kg) for antimony.

Arsenic was detected in all soil samples at SWMU 38. Five upper interval samples exceeded both the RBC for arsenic as a carcinogen (0.43 mg/kg) and the RC (9.4 mg/kg). The maximum of these detections was 19.8 mg/kg. The only upper interval sample that did not exceed the RC was 038SB00501. Also, one lower interval sample (038SB00102) exhibited an arsenic detection of 11.9 mg/kg, which exceeds the subsurface RC (9.8 mg/kg) for arsenic. However, this concentration is below the SSL for arsenic of 15 mg/kg.

Beryllium exceeded the RBC (0.15 mg/kg) in one upper interval sample, 038SB00301. This detection (0.5 mg/kg) is less than the SSL for beryllium of 32 mg/kg, and it was the only upper interval detection. Both of the lower interval detections of beryllium were also below the SSL.

Cobalt was detected above the RC (1.7 mg/kg) in one of two detections in five lower interval samples. This detection does not exceed the SSL (990 mg/kg) for cobalt.



LEGEND

- 1st Round Soil Boring
- 2nd Round Soil Boring
- 3rd Round Soil Boring
- Concentration Exceeds the RBC for Aroclor-1260 (320ppb)

Note: ND - not detected

All values are in ppb

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.3.2 - SWMU 38
Soil Sample Aroclor-1260 Results

Manganese was detected above the RC (85.5 mg/kg) in one lower interval sample, 038SB00502. This detection does not exceed the SSL (550 mg/kg) for manganese.

Selenium was detected above the RC (1.7 mg/kg) in one lower interval sample, 038SB00502. This detection also exceeds the SSL for selenium of 2.6 mg/kg.

10.3.3 Groundwater Sampling and Analysis

The *Final Zones A and B RFI Work Plan* proposed the installation of one deep and two shallow monitoring wells for SWMU 38. One existing shallow monitoring well (NBCA-002-004) installed in 1993 to investigate SWMU 2 exists within the boundary of the SWMU 38 investigation area. This well was sampled to support both the SWMU 2 and SWMU 38 investigations, and the data have been incorporated into both site-specific discussions.

The well pair is located near the northern NAVBASE property line within SWMU 38 and the other shallow well was installed in the southwest portion of the site. The previously installed well that was sampled is located in the southeast portion of the site. All well locations are shown on Figure 10.3.3.

NBCA-002-004 was redeveloped and sampled in September 1995, as discussed in Section 10.1.3 of this report. After installation and development of the three wells proposed in the *Final Zones A and B RFI Work Plan*, the first-round RFI samples were collected. Groundwater samples were analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and TPH at DQO Level III. Chlorides, sulfate, and TDS samples were collected for the deep well sample 038GW01D01.

Second- , third-, and fourth-quarter analytical parameters for SWMU 38 were based upon detections in the first quarter. Second-round groundwater samples were analyzed at DQO Level III for metals, pesticides, and PCBs. Third- and fourth-round samples were analyzed for

metals, pesticides, PCBs, TDS, chlorides, and sulfate. NBCA-002-004 was not sampled for pesticides and PCBs in the second-, third-, or fourth-round. Second, third, and fourth-round samples were collected by the CEERD in April, June, and October 1996, respectively. Table 10.3.5 summarizes groundwater sampling at SWMU 38.

Table 10.3.5
SWMU 38
Groundwater Sampling Summary

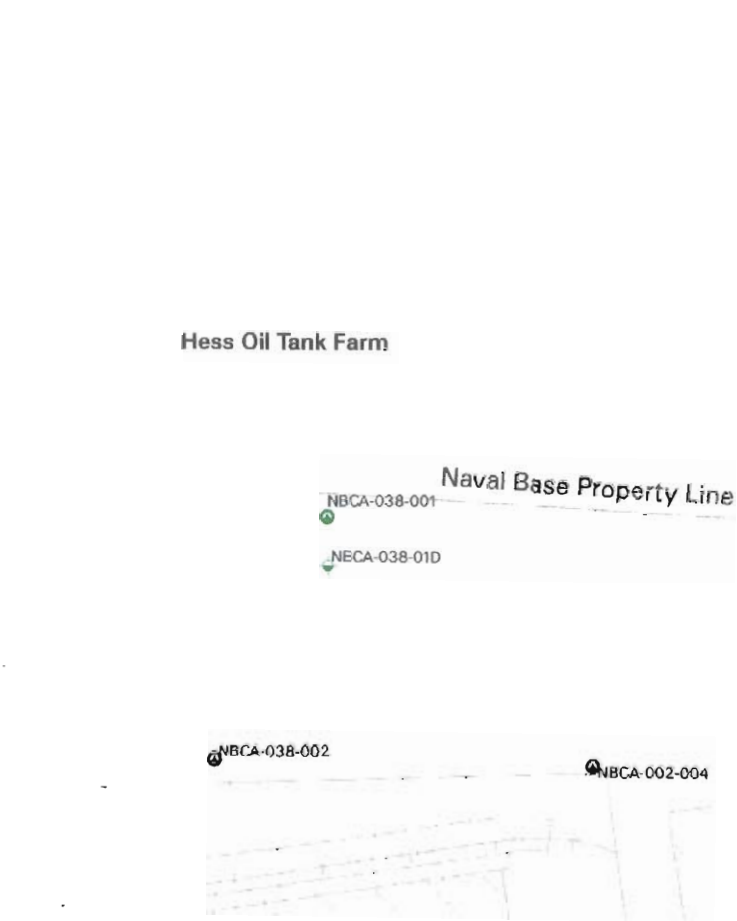
Event	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Sept. - Dec. 1995 (1st round)	4[a]	4[a]	VOCs, SVOCs, metals, pesticides, PCBs, and TPH. TDS, sulfate, chlorides for one deep well.	VOCs, SVOCs, metals, pesticides, PCBs, and TPH. TDS, sulfate, chlorides for one deep well.	None
April 1996 (2nd round)	4[a]	4[a]	Metals, pesticides, and PCBs.[b]	Metals, pesticides, and PCBs.	NBCA-002-004 sampled for metals only.
June 1996 (3rd round)	4[a]	4[a]	Metals, pesticides, PCBs, TDS, sulfate, and chlorides.[c]	Metals, pesticides, PCBs, TDS, sulfate, and chlorides.	NBCA-002-004 sampled for metals only.
October 1996 (4th round)	4[a]	4[a]	Metals, pesticides, PCBs, TDS, sulfate, and chlorides.[c]	Metals, pesticides, PCBs, TDS, sulfate, and chlorides.[c]	NBCA-002-004 sampled for metals, TDS, sulfate, and chlorides.

Notes:

a = Four wells consist of three shallow wells and one deep well sampled in association with the SWMU 38 investigation.

b = Second-round parameters based upon detections from first-round.

c = Third- and fourth-round parameters.



160

0 150 feet

LEGEND

Shallow Monitoring Well

Deep Monitoring Well

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Charleston, SC

FIGURE 10.3.3 - SWMU 38
Monitoring Well Locations

The shallow monitoring wells were installed at 13 feet bgs in the upper sand aquifer, and the deep well was installed at 50 feet bgs in the lower aquifer. All wells were installed as described in Section 3.3 of this report.

10.3.4 Nature and Extent of Contamination in Groundwater

Table 10.3.6 summarizes organic groundwater analytical results and Table 10.3.7 summarizes groundwater inorganic analytical results for SWMU 38. Appendix D is a complete analytical data report for all samples collected in Zone A, including those collected at SWMU 38.

Table 10.3.6
SWMU 38
Organic Compounds Detected in Groundwater

Compound	Sampling Event	Sampling Interval	Frequency of Detection	Range of Detections (µg/L)	Mean of Detections (µg/L)	RBC (µg/L)	Number of Samples Exceeding RBC
Pesticides (3 shallow groundwater samples and 1 deep sample collected during each event[a])							
4,4'-DDD	Dec. 95	Shallow	1/3	3.8	NA	0.28	1
	Apr. 96	Shallow	1/2	4.0	NA	0.28	1
	June 96	Shallow	1/2	2.9	NA	0.28	1
	Oct. 96	Shallow	1/2	3.2	NA	0.28	1
	Dec. 95	Deep	0/1	NA	NA	0.28	0
	Apr. 96	Deep	0/1	NA	NA	0.28	0
	June 96	Deep	0/1	NA	NA	0.28	0
	Oct. 96	Deep	0/1	NA	NA	0.28	0
4,4'-DDE	Dec. 95	Shallow	1/3	0.045	NA	0.20	0
	Apr. 96	Shallow	1/2	0.092	NA	0.20	0
	June 96	Shallow	0/2	NA	NA	0.20	0
	Oct. 96	Shallow	0/2	NA	NA	0.20	0
	Dec. 95	Deep	0/1	NA	NA	0.20	0
	Apr. 96	Deep	0/1	NA	NA	0.20	0
	June 96	Deep	0/1	NA	NA	0.20	0
	Oct. 96	Deep	0/1	NA	NA	0.20	0

Table 10.3.6
SWMU 38
Organic Compounds Detected in Groundwater

Compound	Sampling Event	Sampling Interval	Frequency of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	RBC (μg/L)	Number of Samples Exceeding RBC
4,4'-DDT	Dec. 95	Shallow	1/3	1.5	NA	0.20	1
	Apr. 96	Shallow	1/2	2.6	NA	0.20	1
	June 96	Shallow	1/2	0.23	NA	0.20	1
	Oct. 96	Shallow	0/2	NA	NA	0.20	0
	Dec. 95	Deep	0/1	NA	NA	0.20	0
	Apr. 96	Deep	0/1	NA	NA	0.20	0
	June 96	Deep	0/1	NA	NA	0.20	0
	Oct. 96	Deep	0/1	NA	NA	0.20	0

Note:
a = NBCA-002-004 not sampled in second- and third-quarters.
NA = Not applicable

Table 10.3.7
SWMU 38
Inorganic Analysis Results for Groundwater

Compound	Sampling Event	Sampling Interval	Freq. of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (3 Shallow groundwater samples and 1 deep sample collected during each event)								
Aluminum	Dec. 95	Shallow	3/3	162 - 1,810	843	3,210	37,000	0
	Apr. 96	Shallow	2/3	1,260 - 2,400	1,830	3,210	37,000	0
	June 96	Shallow	0/3	NA	NA	3,210	37,000	0
	Oct. 96	Shallow	0/3	NA	NA	3,210	37,000	0
	Dec. 95	Deep	1/1	57	NA	245	37,000	0
	Apr. 96	Deep	0/1	NA	NA	245	37,000	0
	June 96	Deep	1/1	68.6	NA	245	37,000	0
	Oct. 96	Deep	0/1	NA	NA	245	37,000	0

Table 10.3.7
SWMU 38
Inorganic Analysis Results for Groundwater

Compound	Sampling Event	Sampling Interval	Freq. of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (3 Shallow groundwater samples and 1 deep sample collected during each event)								
Arsenic	Dec. 95	Shallow	2/3	5.8 - 6.0	5.9	7.4	0.045	0
	Apr. 96	Shallow	0/3	NA	NA	7.4	0.045	0
	June 96	Shallow	3/3	3.1 - 12.5	6.7	7.4	0.045	1
	Oct. 96	Shallow	2/3	10.3 - 14.9	12.6	7.4	0.045	2
	Dec. 95	Deep	0/1	NA	NA	11.1	0.045	0
	Apr. 96	Deep	0/1	NA	NA	11.1	0.045	0
	June 96	Deep	0/1	NA	NA	11.1	0.045	0
	Oct. 96	Deep	0/1	NA	NA	11.1	0.045	0
Barium	Dec. 95	Shallow	3/3	21.0 - 40.9	31.3	104	2,600	0
	Apr. 96	Shallow	0/3	NA	NA	104	2,600	0
	June 96	Shallow	3/3	17.5 - 34.4	26.1	104	2,600	0
	Oct. 96	Shallow	3/3	17.5 - 28.5	24.3	104	2,600	0
	Dec. 95	Deep	1/1	22.3	NA	179	2,600	0
	Apr. 96	Deep	0/1	NA	NA	179	2,600	0
	June 96	Deep	1/1	17.5	NA	179	2,600	0
	Oct. 96	Deep	1/1	15.9	NA	179	2,600	0
Calcium	Dec. 95	Shallow	3/3	7,540 - 112,000	60,350	NA	NA	NA
	Apr. 96	Shallow	2/3	54,100 - 99,100	76,600	NA	NA	NA
	June 96	Shallow	3/3	7,500 - 98,000	52,800	NA	NA	NA
	Oct. 96	Shallow	3/3	6,260 - 95,600	52,500	NA	NA	NA
	Dec. 95	Deep	1/1	101,000	NA	NA	NA	NA
	Apr. 96	Deep	1/1	102,000	NA	NA	NA	NA
	June 96	Deep	1/1	97,500	NA	NA	NA	NA
	Oct. 96	Deep	1/1	99,300	NA	NA	NA	NA

Table 10.3.7
SWMU 38
Inorganic Analysis Results for Groundwater

Compound	Sampling Event	Sampling Interval	Freq. of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (3 Shallow groundwater samples and 1 deep sample collected during each event)								
Chromium	Dec. 95	Shallow	2/3	4.2 - 5.6	4.9	8.7	180	0
	Apr. 96	Shallow	0/3	NA	NA	8.7	180	0
	June 96	Shallow	0/3	NA	NA	8.7	180	0
	Oct. 96	Shallow	0/3	NA	NA	8.7	180	0
	Dec. 95	Deep	0/1	NA	NA	7.3	180	0
	Apr. 96	Deep	0/1	NA	NA	7.3	180	0
	June 96	Deep	0/1	NA	NA	7.3	180	0
	Oct. 96	Deep	0/1	NA	NA	7.3	180	0
Cobalt	Dec. 95	Shallow	0/3	NA	NA	**	2,200	0
	Apr. 96	Shallow	0/3	NA	NA	**	2,200	0
	June 96	Shallow	1/3	7.1	NA	**	2,200	0
	Oct. 96	Shallow	0/3	NA	NA	**	2,200	0
	Dec. 95	Deep	0/1	NA	NA	12.1	2,200	0
	Apr. 96	Deep	0/1	NA	NA	12.1	2,200	0
	June 96	Deep	0/1	NA	NA	12.1	2,200	0
	Oct. 96	Deep	0/1	NA	NA	12.1	2,200	0
Copper	Dec. 95	Shallow	2/3	8.5 - 8.8	8.7	15.7	1,500	0
	Apr. 96	Shallow	0/3	NA	NA	15.7	1,500	0
	June 96	Shallow	0/3	NA	NA	15.7	1,500	0
	Oct. 96	Shallow	3/3	1.7 - 7.9	4.5	15.7	1,500	0
	Dec. 95	Deep	0/1	NA	NA	5.8	1,500	0
	Apr. 96	Deep	0/1	NA	NA	5.8	1,500	0
	June 96	Deep	0/1	NA	NA	5.8	1,500	0
	Oct. 96	Deep	1/1	0.9	NA	5.8	1,500	0

Table 10.3.7
SWMU 38
Inorganic Analysis Results for Groundwater

Compound	Sampling Event	Sampling Interval	Freq. of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (3 Shallow groundwater samples and 1 deep sample collected during each event)								
Iron	Dec. 95	Shallow	3/3	1,840 - 16,100	10,000	NA	NA	NA
	Apr. 95	Shallow	3/3	5,990 - 16,200	12,600	NA	NA	NA
	June 96	Shallow	3/3	4,210 - 15,700	11,300	NA	NA	NA
	Oct. 96	Shallow	3/3	645 - 13,600	8,650	NA	NA	NA
	Dec. 95	Deep	1/1	2,710	NA	NA	NA	NA
	Apr. 96	Deep	1/1	3,550	NA	NA	NA	NA
	June 96	Deep	1/1	3,770	NA	NA	NA	NA
	Oct. 96	Deep	1/1	3,660	NA	NA	NA	NA
Lead	Dec. 95	Shallow	0/3	NA	NA	4.7	15*	0
	Apr. 96	Shallow	1/3	2.0	NA	4.7	15*	0
	June 96	Shallow	0/3	NA	NA	4.7	15*	0
	Oct. 96	Shallow	0/3	NA	NA	4.7	15*	0
	Dec. 95	Deep	0/1	NA	NA	**	15*	0
	Apr. 96	Deep	0/1	NA	NA	**	15*	0
	June 96	Deep	0/1	NA	NA	**	15*	0
	Oct. 96	Deep	0/1	NA	NA	**	15*	0
Magnesium	Dec. 95	Shallow	3/3	5,130 - 14,400	9,190	NA	NA	NA
	Apr. 96	Shallow	3/3	6,090 - 17,100	10,100	NA	NA	NA
	June 96	Shallow	3/3	5,550 - 17,200	9,930	NA	NA	NA
	Oct. 96	Shallow	3/3	3,960 - 13,200	8,510	NA	NA	NA
	Dec. 95	Deep	1/1	11,700	NA	NA	NA	NA
	Apr. 96	Deep	1/1	11,100	NA	NA	NA	NA
	June 96	Deep	1/1	11,000	NA	NA	NA	NA
	Oct. 96	Deep	1/1	11,400	NA	NA	NA	NA

Table 10.3.7
SWMU 38
Inorganic Analysis Results for Groundwater

Compound	Sampling Event	Sampling Interval	Freq. of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (3 Shallow groundwater samples and 1 deep sample collected during each event)								
Manganese	Dec. 95	Shallow	3/3	108 - 172	149	577	840	0
	Apr. 96	Shallow	3/3	119 - 187	151	577	840	0
	June 96	Shallow	3/3	141 - 168	154	577	840	0
	Oct. 96	Shallow	3/3	78.7 - 241	159	577	840	0
	Dec. 95	Deep	1/1	666	NA	2,690	840	0
	Apr. 96	Deep	1/1	694	NA	2,690	840	0
	June 96	Deep	1/1	633	NA	2,690	840	0
	Oct. 96	Deep	1/1	714	NA	2,690	840	0
Potassium	Dec. 95	Shallow	3/3	1,340 - 21,800	8,210	NA	NA	NA
	Apr. 96	Shallow	1/3	19,800	NA	NA	NA	NA
	June 96	Shallow	3/3	2,820 - 24,700	10,200	NA	NA	NA
	Oct. 96	Shallow	3/3	2,010 - 38,800	14,300	NA	NA	NA
	Dec. 95	Deep	1/1	3,560	NA	NA	NA	NA
	Apr. 96	Deep	1/1	2,670	NA	NA	NA	NA
	June 96	Deep	1/1	5,080	NA	NA	NA	NA
	Oct. 96	Deep	1/1	6,540	NA	NA	NA	NA
Silver	Dec. 95	Shallow	0/3	NA	NA	**	180	0
	Apr. 96	Shallow	0/3	NA	NA	**	180	0
	June 96	Shallow	0/3	NA	NA	**	180	0
	Oct. 96	Shallow	1/3	39.8	NA	**	180	0
	Dec. 95	Deep	0/1	NA	NA	**	180	0
	Apr. 96	Deep	0/1	NA	NA	**	180	0
	June 96	Deep	0/1	NA	NA	**	180	0
	Oct. 96	Deep	0/1	NA	NA	**	180	0

Table 10.3.7
SWMU 38
Inorganic Analysis Results for Groundwater

Compound	Sampling Event	Sampling Interval	Freq. of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (3 Shallow groundwater samples and 1 deep sample collected during each event)								
Sodium	Dec. 95	Shallow	3/3	43,400 - 268,000	122,000	NA	NA	NA
	Apr. 96	Shallow	1/3	287,000	NA	NA	NA	NA
	June 96	Shallow	3/3	39,000 - 290,000	126,000	NA	NA	NA
	Oct. 96	Shallow	3/3	34,300 - 228,000	103,000	NA	NA	NA
	Dec. 95	Deep	1/1	131,000	NA	NA	NA	NA
	Apr. 96	Deep	0/1	NA	NA	NA	NA	NA
	June 96	Deep	1/1	124,000	NA	NA	NA	NA
	Oct. 96	Deep	1/1	108,000	NA	NA	NA	NA
Thallium	Dec. 95	Shallow	1/3	4.0	NA	**	2.9	1
	Apr. 96	Shallow	0/3	NA	NA	**	2.9	0
	June 96	Shallow	0/3	NA	NA	**	2.9	0
	Oct. 96	Shallow	0/3	NA	NA	**	2.9	0
	Dec. 95	Deep	0/1	NA	NA	2	2.9	0
	Apr. 96	Deep	0/1	NA	NA	2	2.9	0
	June 96	Deep	0/1	NA	NA	2	2.9	0
	Oct. 96	Deep	0/1	NA	NA	2	2.9	0
Zinc	Dec. 95	Shallow	2/3	64.3 - 67.4	65.9	83.2	11,000	0
	Apr. 96	Shallow	0/3	NA	NA	83.2	11,000	0
	June 96	Shallow	0/3	NA	NA	83.2	11,000	0
	Oct. 96	Shallow	0/3	NA	NA	83.2	11,000	0
	Dec. 95	Deep	1/1	3.8	NA	66.2	11,000	0
	Apr. 96	Deep	0/1	NA	NA	66.2	11,000	0
	June 96	Deep	0/1	NA	NA	66.2	11,000	0
	Oct. 96	Deep	0/1	NA	NA	66.2	11,000	0

Table 10.3.7
SWMU 38
Inorganic Analysis Results for Groundwater

Compound	Sampling Event	Sampling Interval	Freq. of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (3 Shallow groundwater samples and 1 deep sample collected during each event)								
Chloride	June 96	Shallow	2/2	36,000 - 62,000	49,000	NA	NA	NA
	Oct. 96	Shallow	3/3	33,000 - 177,000	90,000	NA	NA	NA
	Dec. 95	Deep	1/1	150,000	NA	NA	NA	NA
	June 96	Deep	1/1	160,000	NA	NA	NA	NA
	Oct. 96	Deep	1/1	165,000	NA	NA	NA	NA
Sulfate	June 96	Shallow	1/2	26,000	NA	NA	NA	NA
	Oct. 96	Shallow	1/3	19,800	NA	NA	NA	NA
	Dec. 95	Deep	1/1	15,000	NA	NA	NA	NA
	June 96	Deep	1/1	8,200	NA	NA	NA	NA
	Oct. 96	Deep	0/1	NA	NA	NA	NA	NA
TDS	June 96	Shallow	2/2	360,000 - 540,000	450,000	NA	NA	NA
	Oct. 96	Shallow	3/3	244,000 - 706,000	451,000	NA	NA	NA
	Dec. 95	Deep	1/1	640,000	NA	NA	NA	NA
	June 96	Deep	1/1	200,000	NA	NA	NA	NA
	Oct. 96	Deep	1/1	624,000	NA	NA	NA	NA

Notes:
a = Lead does not have an RBC. Therefore, the USEPA Treatment Technique Action Level (TTAL) of 15 μg/L has been substituted for the RBC.
** = Number of nondetects prevented determination of UTL.

Volatile Organic Compounds in Groundwater

No VOCs were detected in groundwater samples collected at SWMU 38.

Semivolatile Organic Compounds in Groundwater

No SVOCs were detected in groundwater samples collected at SWMU 38.

Pesticides/PCBs in Groundwater

Two pesticides (DDD and DDT) exceeded their RBCs in the same well, NBCA-038-001. DDD exceeded its RBC in all four events and DDT exceeded its RBC in the first three quarters as it was not detected in the fourth-quarter sample. Also, DDE was detected at concentrations below the RBC in this well in two of four events. Pesticide concentrations in soil samples from the boring associated with this well were as follows:

	Upper Interval	Lower Interval
DDD	450,000 μg/kg	1,800 μg/kg
DDE	37,000 μg/kg	140 μg/kg
DDT	1,000,000 μg/kg	11,000 μg/kg

Inorganics in Groundwater

Sixteen metals were detected in groundwater at SWMU 38. Based upon the comparisons made in the table, two of these warrant further evaluation in shallow groundwater, arsenic and thallium. No deep groundwater inorganic detections exceeded the comparison concentrations.

Arsenic detections from third- and fourth-quarter samples exceeded the RBC (0.045 μg/L) and the RC (7.4 μg/L) in the shallow well NBCA-038-001. Also, the fourth quarter detection in shallow well NBCA-002-004 exceeded both the RC and RBC.

Thallium exceeded the RBC (2.9 μg/L) in one shallow well (NBCA-038-002) during the first sampling event.

10.3.5 Fate and Transport Assessment for SWMU 38

SWMU 38 is a former storage yard associated with Buildings 1605 and 1604. The CSI activities focused on the portion of SWMU 38 used to store empty drums. The site is a flat, open area,

predominantly covered with dirt and gravel. Environmental media sampled as part of the SWMU 38 CSI include surface soil, subsurface soil, and shallow and deep groundwater. Potential contaminant migration pathways for SWMU 38 include soil constituents leaching to groundwater, groundwater constituent migration to surface water, constituent migration through surface soil erosion, and emission of VOCs from surface soil to ambient air.

10.3.5.1 SWMU 38 – Soil to Groundwater Cross-Media Transport

Tables 10.3.8 and 10.3.9 compare the maximum detected concentrations of organic and inorganic chemicals reported in soil to risk-based soil screening levels considered protective of groundwater. As shown on Table 10.3.8, five organics — Aroclor-1260, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, and dieldrin — were identified for further evaluation of soil to groundwater migration based on the screening process presented in Section 6. As shown on Table 10.3.9, four inorganics — antimony, arsenic, chromium, and selenium — were identified for further evaluation of soil to groundwater migration. Aroclor-1260, dieldrin, antimony, and selenium were not reported in SWMU 38 groundwater (including all four quarters of sampling).

None of the organic constituents was detected in subsurface soil at a concentration exceeding its soil to groundwater SSL. Concentrations of 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT exceeded their soil to groundwater SSLs in only one surface soil sample (038SB001). The potential for soil to groundwater migration is highlighted for 4,4'-DDD and 4,4'-DDT since their detected concentrations were above both groundwater protection SSLs in soil and tap water RBCs in shallow groundwater. These pesticide compounds are isolated to one monitoring well (NBCA-038-001) and, based on their fate and transport properties, are not anticipated to migrate significantly. Aroclor-1260 (038SB012) and dieldrin (038SB007) were each reported in a single surface soil sample at concentrations exceeding their respective soil to groundwater SSLs.

Table 10.3.8
Organic Compounds Detected in Surface Soil, Subsurface Soil, Sediment, Shallow Groundwater, and Deep Groundwater
Comparison to Cross-media SSLs, Tap Water RBCs, and Saltwater Surface Water Chronic Screening Levels
NAVBASE-Charleston, Zone A: SWMU 38
Charleston, South Carolina

Parameter	Maximum Concentration				Screening Concentration *									
	Surface Soil	Subsurface Soil	Shallow GW	Deep GW	Soil to GW	Soil to Air	Tap Water RBC	Saltwater Surf. Wtr. Chronic	Soil Units	Water Units	Leaching Potential	Volatil-ization Potential	Ground-water Migration Concern	Surface Water Migration Concern
Volatile Organic Compounds														
Acetone	61	200	ND	ND	8000	1E+08	3700	NA	UG/KG	UG/L	NO	NO	NO	NO
2-Butanone	9.6	32	ND	ND	3900 c	NDA	1900	NA	UG/KG	UG/L	NO	NO	NO	NO
Carbon disulfide	ND	5	ND	ND	16000	720000	1000	NA	UG/KG	UG/L	NO	NO	NO	NO
cis-1,2-Dichloroethene	ND	21	ND	ND	200	1200000	61	NA	UG/KG	UG/L	NO	NO	NO	NO
Toluene	4.2	ND	ND	ND	6000	650000	750	37	UG/KG	UG/L	NO	NO	NO	NO
Xylene	ND	1.5	ND	ND	70000 c	320000	12000	NA	UG/KG	UG/L	NO	NO	NO	NO
Semivolatile Organic Compounds														
Benzo(a)pyrene equivalents														
Chrysene	150	ND	ND	ND	80000	NA	9.2	NA	UG/KG	UG/L	NO	NO	NO	NO
Butylbenzylphthalate	2300	ND	ND	ND	8100000	930000	7300	29	UG/KG	UG/L	NO	NO	NO	NO
Di-n-octylphthalate	410	ND	ND	ND	5000000	10000000	730	NA	UG/KG	UG/L	NO	NO	NO	NO
bis(2-Ethylhexyl)phthalate (BEHP)	210	ND	ND	ND	1800000	31000000	4.8	NA	UG/KG	UG/L	NO	NO	NO	NO
Pesticides/PCB Compounds														
Aldrin	0.73	ND	ND	ND	250	3000	0.004	0.13	UG/KG	UG/L	NO	NO	NO	NO
Aroclor-1260	1300	ND	ND	ND	1000	1000	0.034	0.03	UG/KG	UG/L	YES	YES	NO	NO
gamma-BHC (Lindane)	0.51	ND	ND	ND	4.5	NA	0.052	0.016	UG/KG	UG/L	NO	NO	NO	NO
alpha-Chlordane	8.4	ND	ND	ND	5000	20000	0.19	0.004	UG/KG	UG/L	NO	NO	NO	NO
gamma-Chlordane	37	ND	ND	ND	5000	20000	0.19	0.004	UG/KG	UG/L	NO	NO	NO	NO
4,4'-DDD	450000	1800	4	ND	8000	NA	0.28	0.025	UG/KG	UG/L	YES	NO	YES	YES
4,4'-DDE	37000	140	0.092	ND	27000	NA	0.2	0.14	UG/KG	UG/L	YES	NO	NO	NO
4,4'-DDT	1000000	11000	2.6	ND	16000	1E+09	0.2	0.001	UG/KG	UG/L	YES	NO	YES	YES
Dieldrin	9.6	ND	ND	ND	2	1000	0.0042	0.0019	UG/KG	UG/L	YES	NO	NO	NO
Endosulfan II	6.3	ND	ND	ND	9000	NA	220	0.0087	UG/KG	UG/L	NO	NO	NO	NO
Endrin	14	ND	ND	ND	500	NA	11	0.0023	UG/KG	UG/L	NO	NO	NO	NO
Endrin aldehyde	6.6	ND	ND	ND	500	NA	11	NA	UG/KG	UG/L	NO	NO	NO	NO
Heptachlor	2.1	1.7	ND	ND	12000	100	0.0023	0.0036	UG/KG	UG/L	NO	NO	NO	NO
Dioxin Compounds														
Dioxin (TCDD TEQs)	28	NA	NA	NA	1600 c	NA	0.45	10	NG/KG	PG/L	NO	NO	NO	NO
Petroleum Hydrocarbons														
TPH - (Diesel range organics)	2400	ND	ND	ND	NA	NA	NA	NA	MG/KG	UG/L	NO	NO	NO	NO

Explanations of screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.2.3 and 10.2.6.

* Screening Concentrations:
Soil to GW - Generic SSLs based on DAF = 10, adapted from USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or calculated using values from Table
Soil to Air - From USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or USEPA Region III Risk-Based Concentration Table, June 1996
Tap Water RBC - From USEPA Region III Risk-Based Concentration Table, October 1997
Salt Water Surface Water Chronic - From USEPA Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment, November 1995, Table 2

c - Calculated soil to groundwater SSL value (See Table 6.2)
GW - Groundwater
NA - Not available
ND - Not detected
RBC - Risk-based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
NG/KG - Nanograms per kilogram
UG/KG - Micrograms per kilogram
PG/L - Picograms per liter
UG/L - Micrograms per liter

Table 10.3.9
Inorganic Chemicals Detected in Surface Soil, Subsurface Soil, Sediment, Shallow Groundwater,and Deep Groundwater
Comparison to Cross-media SSLs, Tap Water RBCs, Saltwater Surface Water Chronic Screening Levels, and Background Reference Values
NAVBASE-Charleston, Zone A: SWMU 38
Charleston, South Carolina

Parameter	Maximum Concentration				Screening Concentration *											
	Surface Soil	Subsurface Soil	Shallow GW	Deep GW	Soil to GW	Soil Background Reference	Soil to Air	Tap Water RBC	GW Background Reference	Saltwater Surf. Wtr. Chronic	Soil Units	Water Units	Leaching Potential	Fugitive Particulate Inhalation Concern	Ground-Water Migration Concern	Surface Water Migration Concern
Inorganic Chemicals																
Aluminum	16600	21600	2400	68.6	560000 c	28240	NA	37000	3210	NA	MG/KG	UG/L	NO	NO	NO	NO
Antimony	ND	14.8	ND	ND	2.5	ND	NA	15	ND	NA	MG/KG	UG/L	YES	NO	NO	NO
Arsenic	19.8	11.9	14.9	ND	15	9.8	750	0.045	11.1	36	MG/KG	UG/L	YES	NO	YES	NO
Barium	45.5	31.5	40.9	22.3	820	53	690000	2600	179	NA	MG/KG	UG/L	NO	NO	NO	NO
Beryllium	0.5	0.44	ND	ND	32	ND	1300	0.016	ND	NA	MG/KG	UG/L	NO	NO	NO	NO
Cadmium	1.5	ND	ND	ND	4	ND	1800	18	ND	9.3	MG/KG	UG/L	NO	NO	NO	NO
Chromium (total)	37.7	63.4	5.6	ND	19	63.4	270	180	8.7	103	MG/KG	UG/L	YES	NO	NO	NO
Chromium (hexavalent)	0.074	ND	ND	ND	19	ND	270	180	ND	50	MG/KG	UG/L	NO	NO	NO	NO
Cobalt	4.1	2.6	7.1	ND	990 c	4.4	NA	2200	12.1	NA	MG/KG	UG/L	NO	NO	NO	NO
Copper	87.3	16	8.8	0.9	5600 c	165	NA	130000	15.7	2.9	MG/KG	UG/L	NO	NO	NO	YES
Lead	218.3	11.6	2	ND	400	140	400	15	4.7	8.5	MG/KG	UG/L	NO	NO	NO	NO
Manganese	254	223	241	714	550 c	98.1	NA	840	2690	NA	MG/KG	UG/L	NO	NO	NO	NO
Mercury	0.31	ND	ND	ND	1	0.3	10	11	ND	0.2	MG/KG	UG/L	NO	NO	NO	NO
Nickel	21.6	29	ND	ND	65	35	13000	730	21.1	42	MG/KG	UG/L	NO	NO	NO	NO
Selenium	2.2	4.5	ND	ND	2.5	1.74	NA	180	ND	71	MG/KG	UG/L	YES	NO	NO	NO
Silver	ND	ND	39.8	ND	17	ND	NA	180	ND	0.23	MG/KG	UG/L	NO	NO	NO	YES
Thallium	ND	ND	4	ND	0.35	ND	NA	2.9	2	21	MG/KG	UG/L	NO	NO	YES	NO
Vanadium	35.2	47.2	ND	ND	3000	77.3	NA	260	10.9	NA	MG/KG	UG/L	NO	NO	NO	NO
Zinc	220.5	84.3	67.4	3.8	6200	208	NA	11000	83.2	86	MG/KG	UG/L	NO	NO	NO	NO

Explanations of screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.2.4 and 10.2.7.

* Screening Concentrations:
Soil to GW - Generic SSLs based on DAF = 10, adapted from USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or calculated using values from Table 6.2
Soil to Air - From USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or USEPA Region III Risk-Based Concentration Table, June 1996
Tap Water RBC - From USEPA Region III Risk-Based Concentration Table, October 1997
Salt Water Surface Water Chronic - From USEPA Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment, November 1995, Table 2
Background reference values for soil are shown for comparison purposes only.
Maximum groundwater concentrations are screened against the greater of tap water RBCs or corresponding background reference values to determine groundwater migration concern.

c - Calculated soil to groundwater SSL value (See Table 6.2)
GW - Groundwater
NA - Not available/Not applicable
ND - Not detected
RBC - Risk-based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
UG/L - Micrograms per liter

Arsenic exceeded its SSL in surface soil only, antimony and selenium in subsurface soil only, and chromium in both surface and subsurface soil. Arsenic was reported at concentrations equal to or slightly exceeding its SSL in three surface soil samples (038SB001, 038SB002, and 038SB003). Antimony (038SB004) and selenium (038SB005) each were reported in only one subsurface soil sample at concentrations exceeding their SSLs. Antimony was not detected in any surface soil samples. Although chromium was reported in four surface soil samples and three subsurface soil samples at concentrations exceeding its SSL, it was not reported in any soil sample at a concentration exceeding its background reference value. For screening purposes, chromium was conservatively assumed to exist in its soluble hexavalent state. Hexachrome analyses at SWMU 38 and elsewhere in Zone A suggest that chromium in soil exists predominantly in less soluble valence states. These findings suggest that concentrations of inorganic soil constituents do not appreciably threaten SWMU 38 groundwater.

Total petroleum hydrocarbons (diesel range) were detected in surface soil above the UST action level but were not detected in either subsurface soil or shallow groundwater. These findings indicate that soil concentrations of TPH are protective of the shallow aquifer.

10.3.5.2 SWMU 38 — Groundwater to Surface Water Cross-Media Transport

For purposes of fate and transport analysis, sample results from monitoring well NBCA-002-004 were included in the groundwater dataset because the well borders SWMU 38; data from this well are also included with the analysis for SWMU 2. Analytical results from samples collected from well NBCA-002-004 during 1993 were not evaluated along with those from the 1995-1996 sampling rounds because of the time dependence of groundwater concentrations. Tables 10.3.8 and 10.3.9 compare maximum detected groundwater concentrations from four sampling rounds at three shallow wells and one deep well at SWMU 38 to tap water RBCs, saltwater surface water chronic AWQCs, and background reference values for inorganics.

As shown on Table 10.3.8, 4,4'-DDD and 4,4'-DDT were detected in SWMU 38 shallow groundwater above both their tap water RBCs and their saltwater surface water AWQCs. 4,4'-DDD was reported in all four quarterly samples collected from monitoring well NBCA-038-001 at concentrations ranging from 2.9 μg/L to 4 μg/L, which exceeds its tap water RBC (0.28 μg/L) and its saltwater surface water chronic AWQC (0.025 μg/L). 4,4'-DDT was reported in the first three quarterly samples collected from the same well at concentrations ranging from 0.23 μg/L to 2.6 μg/L, which also exceeds its tap water RBC (0.2 μg/L) and its saltwater surface water chronic AWQC (0.001 μg/L). As shown on Table 10.3.9, arsenic and thallium were reported in groundwater above their tap water RBCs while copper and silver were both reported above their saltwater surface water chronic AWQCs. Except for copper, none of these inorganics was reported in deep groundwater. In addition, copper was not reported in any groundwater sample at a concentration exceeding its background reference value. Silver was reported in a single groundwater sample (fourth-quarter sample collected from NBCA-002-004) at a concentration of 39.8 μg/L, which is above its AWQC of 0.23 μg/L. Thallium was reported in a single groundwater sample (first-quarter sample collected from NBCA-038-002) at a concentration of 4 μg/L, which is above its tap water RBC of 2.9 μg/L. Arsenic was reported in two first-quarter samples, two third-quarter samples and two fourth-quarter samples at concentrations above its tap water RBC (0.045 μg/L). However, arsenic was reported at a concentration exceeding its background reference value (7.4 μg/L) in only one third-quarter sample and two fourth-quarter samples.

A travel-time analysis was performed to focus attention on the ability of these constituents to migrate with groundwater. Silver was selected as the subject of the analysis because it has the lowest K_d value of the six chemicals identified as groundwater migration concerns and is therefore considered the most mobile in the aquifer (K_d values for 4,4'-DDD and 4,4'-DDT were calculated by multiplying their K_{oc} values by the default f_{oc} soil value of 0.002). The closest downgradient surface water body to SWMU 38 is the Cooper River. Groundwater travel-time analysis estimates

a groundwater velocity of 7.8 feet/year in the shallow aquifer between SWMU 38 and the river. Following the path dictated by local gradients, groundwater would travel 960 feet to the Cooper River. Groundwater travel time is therefore estimated to be 120 years (Table 6.4). Based on a K_d of 8.3 L/kg and mean Zone A soil parameters (total porosity of 40% and a bulk density of 1.57 kg/L), the retardation factor for silver is 34. Considering this factor, silver's travel time to surface water via groundwater migration increases to 4,080 years with an expected velocity of 2.8 inches/year.

10.3.5.3 SWMU 38 — Soil to Air Cross-Media Transport

As shown on Table 10.3.8, Aroclor-1260 was reported in surface soil at a maximum concentration exceeding its soil to air SSL. As shown on Table 10.3.9, no inorganic constituent exceeded its soil to air SSL. Aroclor was reported in a single surface soil sample at a concentration of 1,300 μg/kg, which is only marginally above its soil to air SSL of 1,000 μg/kg. These findings suggest that the soil to air migration pathway is not expected to be significant at combined SWMU 38.

10.3.5.4 SWMU 38 — Fate and Transport Summary

Figure 10.3.4 illustrates the fate and transport summary for SWMU 38. Detected concentrations of 4,4'-DDD and 4,4'-DDT above fate and transport screening levels in both soil and groundwater suggest that soil contamination may be contributing to localized groundwater contamination. Travel-time analysis indicates that these contaminants are resistant to migration due to a strong affinity for the soil and aquifer matrices. Although the high pesticide concentrations in groundwater may have resulted from their entrainment during monitoring well installation, review of subsequent quarterly groundwater sampling results for SWMU 38 indicates that 4,4'-DDD shallow groundwater concentrations have remained relatively constant over time while 4,4'-DDT shallow groundwater concentrations are diminishing.

10.3.6 Human Health Risk Assessment for SWMU 38

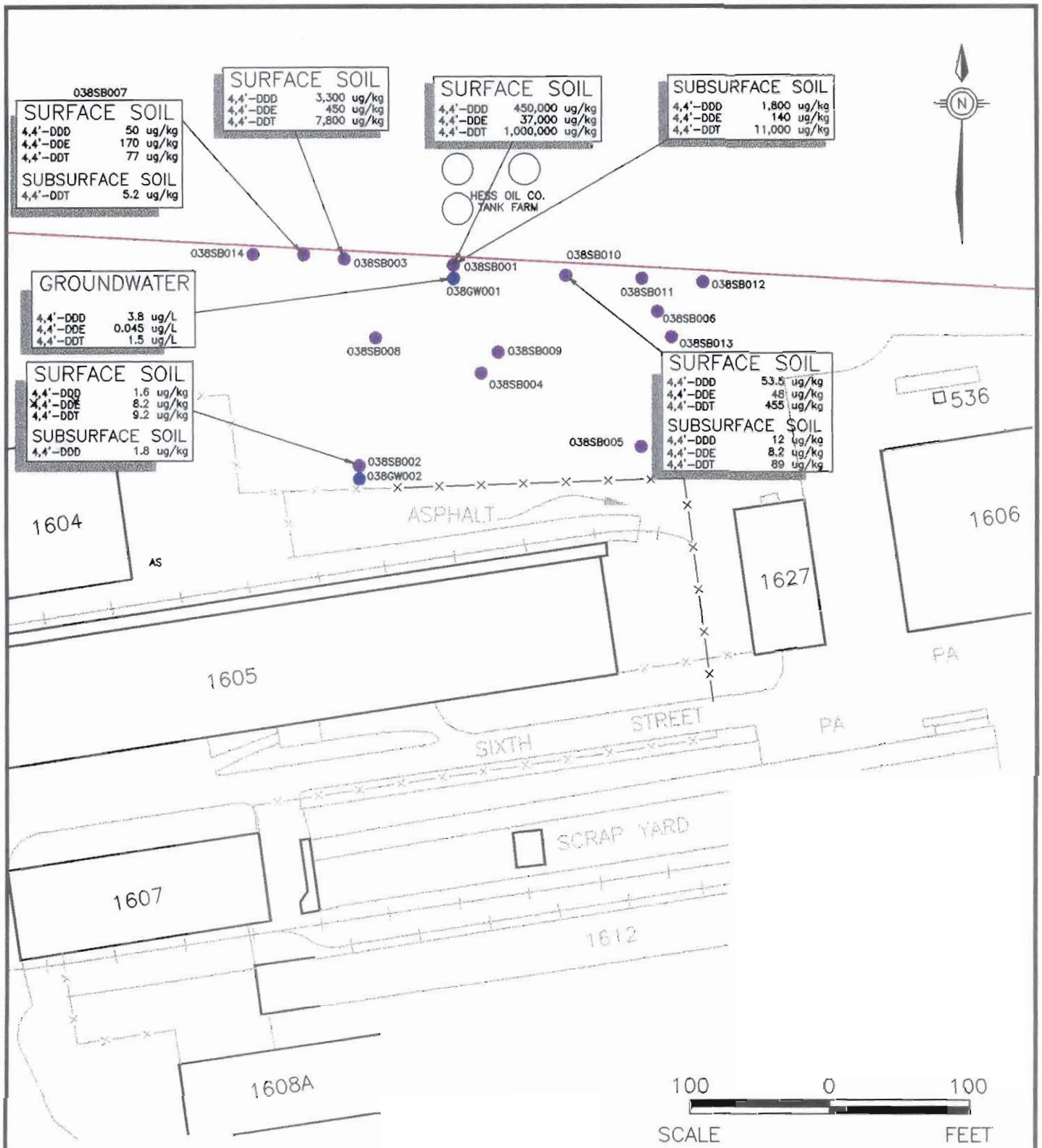
10.3.6.1 Site Background and Investigative Approach

SWMU 38, formerly a storage yard associated with Buildings 1604 and 1605, is located on the northern boundary of Zone A. Materials formerly stored in SWMU 38 include wooden pallets, boats, automobiles, and empty drums. CSI activities focused on the area associated with empty drum storage to determine whether to designate the site NFA or RFI. Six surface soil samples were collected as part of the 1995 CSI activities at SWMU 38. An additional eight surface soil samples were collected during two subsequent sampling rounds. The soil sampling effort for SWMU 38 is provided in Section 10.3.1. All fourteen surface soil samples were used to evaluate soil relative to direct exposure pathways. Indirect exposure pathways associated with subsurface soil were evaluated in Section 10.3.5 (Fate and Transport). Three monitoring wells (two shallow and one deep) were established in the shallow aquifer and four quarterly groundwater samples were collected from each well. Section 10.3.3, presents the quarterly groundwater sampling effort for SWMU 38. All four quarters of data collected from the shallow monitoring wells were used to evaluate the groundwater exposure pathways. Deep groundwater was not considered in this HHRA because there is a physical barrier separating shallow and deep water bearing zones. Additionally, no COPCs were identified in deep groundwater.

10.3.6.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 of this RFI and presented in Table 10.3.10, the focus of this HHRA is on the following COPCs: aluminum, Aroclor-1260, arsenic, beryllium, manganese, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT. Wilcoxon rank sum test analyses did not result in the inclusion of any inorganic parameters that had been screened out on the basis of background concentration comparisons. Total petroleum hydrocarbons (TPH) were identified in one of six samples analyzed. The TPH concentration of 2,400 mg/kg exceeds the



GROUNDWATER PROTECTION SSL
4,4'-DDD – 8,000 ug/kg
4,4'-DDE – 27,000 ug/kg
4,4'-DDT – 16,000 ug/kg

TAP WATER RBC
4,4'-DDD – 0.28 ug/L
4,4'-DDT – 0.2 ug/L
4,4'-DDE – 0.2 ug/L

LEGEND

- SOIL BORING
- MONITORING WELL
- ZONE A BOUNDARY

ZONE A
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, SC

FIGURE 10.3.4
SWMU 38
FATE AND
TRANSPORT SUMMARY

Date: 04/14/98 | DWG Name: 2901C002

Table 10.3.10
Chemicals Present in Site Samples
SWMU 38, Surface Soil
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration RBC	Reference	Units	Number Exceeding RBC	Ref.
Volatile Organics													
Acetone		3	6	32	61	44.7	11	120	780000	NA	ug/kg		
2-Butanone (MEK)		1	6	9.6	9.6	9.6	11	58	4700000	NA	ug/kg		
Toluene		2	6	1.9	4.2	3.1	5.5	7.9	1600000	NA	ug/kg		
Semivolatile Organics													
Benzo(a)pyrene Equiv.		1	1	0.15	0.15	0.15	NA	NA	88	NA	ug/kg		
Chrysene		1	6	150	150	150	720	1000	88000	NA	ug/kg		
bis(2-Ethylhexyl)phthalat		1	6	210	210	210	720	1000	46000	NA	ug/kg		
Butylbenzylphthalate		1	6	2300	2300	2300	720	1000	1600000	NA	ug/kg		
Di-n-octyl phthalate		1	6	410	410	410	720	1000	160000	NA	ug/kg		
Pesticides/PCBs													
Aldrin		1	14	0.73	0.73	0.73	1.4	2.7	38	NA	ug/kg		
Aroclor-1260	*	6	14	18	1300	505	14	90	320	NA	ug/kg	4	
gamma-BHC (Lindane)		1	14	0.51	0.51	0.51	1.4	2.7	490	NA	ug/kg		
alpha-Chlordane		3	14	1.9	8.4	4.1	1.4	2.7	1800	NA	ug/kg		
gamma-Chlordane		6	14	2.95	37	11.8	1.4	2.2	1800	NA	ug/kg		
4,4'-DDD	*	9	14	1.6	450000	50459	2.7	5.3	2700	NA	ug/kg	2	
4,4'-DDE	*	11	14	6.8	37000	3551	3.4	5.3	1900	NA	ug/kg	1	
4,4'-DDT	*	11	14	9.2	1000000	92048	3.4	20	1900	NA	ug/kg	2	
Dieldrin		1	14	9.6	9.6	9.6	2.7	5.3	40	NA	ug/kg		
Endosulfan II		1	14	6.3	6.3	6.3	2.7	5.3	47000	NA	ug/kg		
Endrin		1	14	14	14	14.0	2.7	5.3	2300	NA	ug/kg		
Endrin aldehyde		1	14	6.6	6.6	6.6	2.7	5.3	2300	NA	ug/kg		
Heptachlor		1	14	2.1	2.1	2.1	1.4	2.7	140	NA	ug/kg		
TCDD/TCDF													
Dioxin Equiv.		2	2	0.7759	28.044	14.4	NA	NA	1000	NA	ng/kg		
TPH													
TPH - DRO	*	1	6	2400	2400	2400	33	39	100	NA	mg/kg		
Inorganics													
Aluminum (Al)	*	6	6	5880	16600	10818	NA	NA	7800	12800	mg/kg	5	2
Arsenic (As)	*	6	6	7.8	19.8	14.7	NA	NA	0.43	9.44	mg/kg	6	5
Barium (Ba)		6	6	22.05	46.5	34.5	NA	NA	550	53	mg/kg		
Beryllium (Be)	*	1	6	0.5	0.5	0.50	0.22	0.31	0.15	NA	mg/kg	1	
Cadmium (Cd)		1	6	1.5	1.5	1.50	1.1	1.6	3.9	NA	mg/kg		
Calcium (Ca)	N	6	6	8935	137000	75573	NA	NA	NA	NA	mg/kg		
Chromium (Cr)		6	6	12.8	37.7	25.7	NA	NA	39	50.4	mg/kg		
Chromium (Hexavalent)		1	2	0.074	0.074	0.074	0.024	0.024	39	NA	mg/kg		
Cobalt (Co)		4	6	1.5	4.1	2.8	1.4	1.9	470	4.4	mg/kg		
Copper (Cu)		6	6	10.4	87.25	31.4	NA	NA	310	165	mg/kg		
Iron (Fe)	N	6	6	7910	13600	10108	NA	NA	NA	NA	mg/kg		
Lead (Pb)		6	6	15.95	218.3	92.0	NA	NA	400	140	mg/kg		2

Table 10.3.10
Chemicals Present in Site Samples
SWMU 38, Surface Soil
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration RBC	Reference	Units	Number Exceeding RBC	Ref.
Magnesium (Mg)	N	6	6	346.5	3260	2118	NA	NA	NA	NA	mg/kg		
Manganese (Mn)	*	6	6	14.8	254	92.1	NA	NA	180	98.1	mg/kg	1	3
Mercury (Hg)		3	6	0.15	0.31	0.25	0.11	0.16	2.3	0.3	mg/kg		
Nickel (Ni)		6	6	5.7	21.6	14.3	NA	NA	160	13.55	mg/kg		4
Potassium (K)	N	2	6	203	271	237	403	842	NA	NA	mg/kg		
Selenium (Se)		6	6	0.75	2.2	1.3	NA	NA	39	1.2	mg/kg		3
Sodium (Na)	N	6	6	237	815	482	NA	NA	NA	NA	mg/kg		
Vanadium (V)		6	6	14	35.2	24.6	NA	NA	55	29.24	mg/kg		1
Zinc (Zn)		6	6	16.3	220.5	92.7	NA	NA	2300	207.6	mg/kg		1

* - Identifed as a COPC
N - Essential nutrient
SQL - Sample quantitation limit
RBC - Risk-based concentration
ug/kg - micrograms per kilogram
mg/kg - milligrams per kilogram
ng/kg - nanograms per kilogram

soil action level of 100 mg/kg established for NAVBASE. As established in Section 7, TPH will not be formally assessed in this HHRA.

Groundwater

As shown in Table 10.3.11, the COPCs identified in shallow groundwater for this site are 4,4'-DDD, 4,4'- DDT, arsenic, and thallium. Since 4,4'-DDE was detected in the same samples as 4,4'-DDD and 4,4'-DDT, and is similar in chemical structure, it was also retained as a COPC.

10.3.6.3 Exposure Assessment

Exposure Setting

SWMU 38 is located along the northern boundary of NAVBASE and is currently covered with soil and gravel. The site is within a moderately developed area of NAVBASE and most surrounding parcels are occupied by a commercial fuel farm, warehouse buildings, and parking lots. Current base reuse plans indicate that the SWMU 38 area is slated to be developed as a marine terminal and warehouse storage area. It is likely that the surrounding area will either maintain its current features or be subject to construction/renovation activities.

Potentially Exposed Populations

The most probable exposed populations are current and future site workers. Additional potentially exposed populations are hypothetical future site residents. Future site resident and worker exposure scenarios were addressed in this risk assessment. The hypothetical future site worker scenario assumed continuous exposure to surface soil conditions and the use of shallow groundwater as a potable water source. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact and the fact that groundwater is not currently used onsite as a source of potable or process water. Based on the assumption of chronic exposure for a hypothetical future worker versus a subchronic

Table 10.3.11
Chemicals Present in Site Samples
SWMU 38, Groundwater (all four quarters)
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration RBC	Reference	Units	Number Exceeding RBC	Ref.
Pesticides													
4,4'-DDD	*	4	8	2.9	4	3.47	0.1	0.11	0.28	NA	ug/L	4	
4,4'-DDE		2	8	0.045	0.092	0.069	0.1	0.11	0.2	NA	ug/L		
4,4'-DDT	*	3	8	0.23	2.6	1.44	0.1	0.11	0.2	NA	ug/L	3	
Inorganics													
Aluminum (Al)		4	8	557	2400	1507	41.9	222	3700	3210	ug/L		
Arsenic (As)	*	4	8	3.1	14.9	9.1	2.1	10.4	0.045	7.4	ug/L	4	2
Barium (Ba)		6	8	17.5	40.9	25.3	19.3	33.3	260	104	ug/L		
Calcium (Ca)	N	8	8	52900	112000	78588	NA	NA	NA	NA	ug/L		
Chromium (Cr)		2	8	4.2	5.6	4.9	0.78	6	18	8.7	ug/L		
Cobalt (Co)		1	8	7.1	7.1	7.1	0.67	7	220	NA	ug/L		
Copper (Cu)		4	8	3.9	8.8	7.3	6	7	150	15.7	ug/L		
Iron (Fe)	N	8	8	645	16200	9086	NA	NA	NA	NA	ug/L		
Lead (Pb)		1	8	2	2	2.0	1.4	3	15	4.7	ug/L		
Magnesium (Mg)	N	8	8	3960	8370	6403	NA	NA	NA	NA	ug/L		
Manganese (Mn)		8	8	78.7	187	150	NA	NA	84	577	ug/L	6	
Potassium (K)	N	6	8	1340	3030	2123	1220	1220	NA	NA	ug/L		
Sodium (Na)	N	6	8	34300	54800	44550	40500	49000	NA	NA	ug/L		
Thallium (Tl)	*	1	8	4	4	4.0	3	4	0.29	NA	ug/L	1	
Zinc (Zn)		2	8	64.3	67.4	66	7	25.1	1100	83.2	ug/L		

* - Identifed as a COPC
N - Essential nutrient
SQL - Sample quantitation limit
RBC - Risk-based concentration
ug/L - micrograms per liter

exposure for a hypothetical construction/maintenance worker, exposures that may result from invasive activities, such as construction or utilities maintenance, are expected to be less than exposures for the hypothetical future worker. Therefore, future worker assessment is considered to be protective of both current site use and future construction/maintenance events. The future site resident scenario was developed on the premise that existing buildings and surface coverings would be removed and replaced with dwellings. In addition, the future site residents were assumed to use the shallow aquifer onsite as a source of drinking water.

Exposure Pathways

Exposure pathways for the site workers are dermal contact, incidental ingestion of surface soils, and ingestion of shallow groundwater through potable use. Volatile organic compounds were not detected in shallow groundwater; thus inhalation of volatilized groundwater contaminants was not considered an exposure pathway for SWMU 38. The exposure pathways for future residential land use are the same as those for the future site worker. In addition, the hypothetical future site worker scenario assumed continuous exposure to surface soil and groundwater conditions. Uniform exposure was assumed for all sample locations. Table 10.3.12 presents the justification for exposure pathways assessed in this HHRA.

Exposure Point Concentrations

As discussed in Section 7 of this RFI, UCLs are generally calculated for datasets consisting of at least 10 samples. Only six SWMU 38 surface-soil samples were analyzed for inorganics, SVOCs, and VOCs. For these parameters, no UCL was calculated for surface soil. Instead the maximum concentration was designated as the EPC for each identified surface soil COPC. Fourteen SWMU 38 surface soil samples were analyzed for pesticides and PCBs. The maximum soil concentrations reported for Aroclor-1260, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were exceeded by their 95% UCLs. As a result, maximum concentrations were used as EPCs. The results of the statistical analysis of the SWMU 38 surface soil data are summarized in Table 10.3.13.

Since the maximum concentration was used as the EPC for each COPC, an FI/FC approach is used for estimating the risk and hazard for the soil exposure pathways. It was assumed that a potential receptor would be uniformly exposed to all areas of the site. Where FI/FC terms were applied, the maximum concentration of the COPC represented only a small fraction of the site area (or exposure unit area). The exposure unit area was considered to be approximately one-half acre which is typical of a residential lot. 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were only reported in two surface soil samples (038SB001 and 038SB003) at concentrations above their RBCs. These samples represent an area of approximately 0.1 acres or two tenths of the exposure unit area. The EPCs for 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were adjusted by FI/FC terms of 0.6, 0.8, and 0.8, respectively, and were calculated based on frequency of detection in an effort to maintain a conservative representation of risk and hazard estimates.

Table 10.3.12
Exposure Pathways Summary — SWMU 38
Naval Base Charleston — Zone A
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Site Users/Maintenance	Air, Inhalation of gaseous contaminants emanating from soil	No	Fate and transport screening did not identify any COPCs for this pathway.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Fate and transport screening did not identify any constituents that would significantly contribute to risk via this exposure route.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No	Shallow groundwater is not currently used as a source of potable or process water in Zone A.
	Shallow groundwater, Inhalation of volatilized shallow groundwater contaminants	No	Shallow groundwater is not currently used as a source of potable or process water in Zone A.
	Soil, Incidental ingestion	No (Qualified)	Future land use assessment is considered a conservative representation of current land use.
	Soil, Dermal contact	No (Qualified)	Future land use assessment is considered a conservative representation of current land use.

Table 10.3.12
Exposure Pathways Summary — SWMU 38
Naval Base Charleston — Zone A
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Future Land Uses			
Future Site Residents (Child and Adult) and Future Site Worker	Air, Inhalation of gaseous contaminants emanating from soil	No	Fate and transport screening did not identify any COPCs for this pathway.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Fate and transport screening did not identify any constituents that would significantly contribute to risk via this exposure route.
	Shallow groundwater, Ingestion of contaminants during potable or general use	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	No	No VOC COPCs were identified subsequent to risk-based screening comparisons.
	Soil, Incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, Dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
Future Land Uses			
Future Site Residents (Child and Adult) and Future Site Worker (continued)	Wild game or domestic animals, Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina city limits.
	Fruits and vegetables, Ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Table 10.3.13
Statistical Analysis of COPCs in Surface Soil
SWMU 38
Naval Base Charleston, Zone A
Charleston, South Carolina

COPC	n	Natural Log Transformed mean	SD	H-stat	UCL (mg/kg)	MAX (mg/kg)	EPC (mg/kg)	
Aluminum	6	NA	NA	NA	NA	16600	16600	MAX USED
Aroclor-1260	14	-3.422	2.096	4.894	5.0	1.3	1.3	MAX USED
Arsenic	6	NA	NA	NA	NA	19.8	19.8	MAX USED
Beryllium	6	NA	NA	NA	NA	0.50	0.50	MAX USED
4,4'-DDD	14	-3.459	3.940	8.389	274963	450	450	MAX USED
4,4'-DDE	14	-2.911	2.867	7.206	4333	37	37	MAX USED
4,4'-DDT	14	-1.851	3.736	8.345	963146	1000	1000	MAX USED
Manganese	6	NA	NA	NA	NA	254	254	MAX USED

NOTES:

COPC Chemical of potential concern
mean Arithmetic mean of the logtransformed data
n Number of samples analyzed
SD Standard deviation for a sample of data
H-stat "H" statistic from Gilbert 1987; cuboidal interpolation was used to determine the value in accordance with USEPA Supplemental Guidance to RAGS, Calculating the Concentration Term
NA Not applicable
EPC Exposure point concentration
UCL 95 percentile upper confidence level mean
MAX Maximum reported concentration

Figure 10.3.5 shows the distribution and concentration of surface soil COPCs for SWMU 38. As shown in Figure 10.3.5, 4,4'-DDD and 4,4'-DDT were detected above the residential RBC in two of fourteen surface soil samples (038SB001 and 038SB003), while 4,4'-DDE was detected above the residential RBC in only one of fourteen samples (038SB001). Aroclor-1260 was detected above the residential RBC in four of fourteen surface soil samples. Beryllium was detected in only one of six surface soil samples. Aluminum, arsenic, and manganese were detected in surface soil throughout SWMU 38. Two shallow monitoring wells were installed at this site. As a result, the EPCs were established as the arithmetic mean in the plume for each COPC identified in shallow groundwater as shown on Table 10.3.14. The plume for each COPC in groundwater is represented by the monitoring well containing the maximum reported concentration of each COPC, which in turn was averaged with the other three quarters of data from the same well.

Quantification of Exposure

Soil

CDIs for ingestion and dermal contact with soils are shown in Tables 10.3.15 and 10.3.16, respectively.

Groundwater

The CDIs for groundwater ingestion are presented in Table 10.3.17. No volatile compounds were detected in shallow groundwater; thus inhalation pathway exposures were not a consideration.

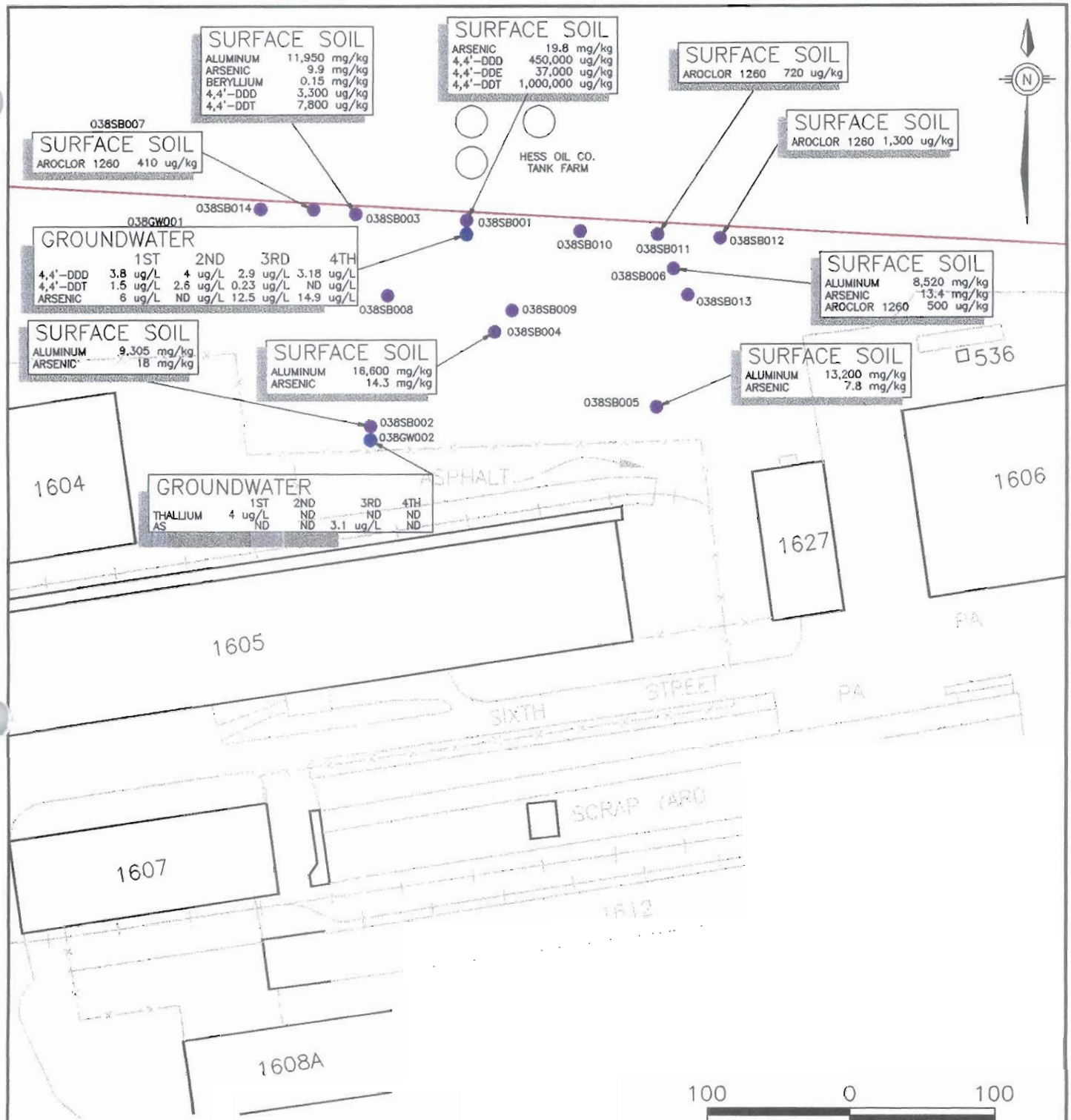
10.3.6.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Table 10.3.18 presents toxicological information specific to each COPC identified at SWMU 38. This information was used in the quantification of risk and hazard associated with soil and groundwater

contaminants. Brief toxicological profiles for each COPC are provided in the following paragraphs.

Aluminum is one of the most abundant metals in the earth's crust (7% aluminum), and it is ubiquitous in air and water, as well as soil. This metal is water-soluble, silvery, and ductile, which suggests its usefulness in many processes. Ingesting aluminum can affect the absorption of other elements within the gastrointestinal tract and can alter intestinal function. Aluminum can potentially interfere with the absorption of essential nutrients and cholesterol. Another effect on the gastrointestinal system is the inhibition of acetylcholine-induced contractions, which are part of the neuro-muscular system controlling bowel muscles. The effect could explain why aluminum-containing antacids often produce constipation. Aluminum dust is moderately flammable and explosive in heat. Inhaling this dust can cause fibrosis (aluminosis) (Klaassen, et al., 1986) (Dreisbach, et al., 1987). No data are available on an applicable SF or the USEPA cancer group. The USEPA Region IV Office of Health Assessment suggested using the provisional oral RfD of 1.0 mg/kg-day. The aesthetic-based Secondary Maximum Contaminant Level for drinking water is 50 to 200 μg/L (USEPA, Office of Water).

Arsenic exposure via the ingestion route darkens and hardens the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen et al., 1986). USEPA set 0.0003 mg/kg-day as the RfD for arsenic based on a no observed adverse effects level (NOAEL) of 0.0008 mg/kg-day in a human exposure study. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher concentrations. Exposure to arsenic-containing materials has been shown to cause cancer in humans. Inhaling these materials can lead to increased lung cancer risk, and ingestion is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the 1.5 $(mg/kg\text{-}day)^{-1}$ oral SF for arsenic. As listed in IRIS, the



100 0 100

SCALE FEET

RESIDENTIAL SOIL RBC
ALUMINUM – 7,800 mg/kg
AROCLOR 1260 – 320 ug/kg
ARSENIC – 0.43 mg/kg
BERYLLIUM – 0.15 mg/kg
4,4'-DDD – 2,700 ug/kg
4,4'-DDE – 1,900 ug/kg
4,4'-DDT – 1,900 ug/kg

TAP WATER RBC
4,4'-DDD – 0.28 ug/L
4,4'-DDT – 0.2 ug/L
4,4'-DDE – 0.2 ug/L
THALLIUM – 2.9 ug/L

GROUNDWATER PROTECTION SSL
ARSENIC – 15 mg/kg
4,4'-DDD – 8,000 ug/kg
4,4'-DDE – 27,000 ug/kg
4,4'-DDT – 16,000 ug/kg

LEGEND

- SOIL BORING
- MONITORING WELL
- ZONE A BOUNDARY

ZONE A
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.3.5
SWMU 38
DISTRIBUTION AND CONCENTRATION
OF COPCs

DWG DATE: 04/13/98 | DWG NAME: 2901B001

Table 10.3.14
Determination of Groundwater EPCs
SWMU 38
Naval Base Charleston, Zone A
Charleston, South Carolina

	Frequency of	Arithmetic Mean in Plume	Maximum Detected Concentration	EPC	
Arsenic	4/8	0.0089	0.0149	0.0089	Plume is represented by Monitoring well NBCA038001
4,4'-DDD	4/8	0.00347	0.004	0.00347	Plume is represented by Monitoring well NBCA038001
4,4'-DDE	2/8	6.1E-05	9.2E-05	6.1E-05	Plume is represented by Monitoring well NBCA038001
4,4'-DDT	3/8	0.0011	0.0026	0.0011	Plume is represented by Monitoring well NBCA038001
Thallium	1/8	0.0021	0.004	0.0021	Plume is represented by Monitoring well NBCA038002

NOTES:

COPC Chemical of potential concern
mean arithmetic mean of four quarter of data from the monitoring well which produced the sample with the highst concentration. (assuming one-half SQL for sample that were non detect)
EPC exposure point concentration
mg/L milligrams per liter

Table 10.3.15
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil
SWMU 38
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Fraction Ingested from Contaminated Source *	Exposure Point Concentration (mg/kg)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Aluminum	1	16600	2.27E-02	2.12E-01	2.60E-02	8.12E-03	2.90E-03
Aroclor-1260	1	1.3	1.78E-06	1.66E-05	2.04E-06	6.36E-07	2.27E-07
Arsenic	1	20	2.71E-05	2.53E-04	3.10E-05	9.69E-06	3.46E-06
Beryllium	1	0.50	6.85E-07	6.39E-06	7.83E-07	2.45E-07	8.74E-08
4,4'-DDD	0.6	450	3.70E-04	3.45E-03	4.23E-04	1.32E-04	4.72E-05
4,4'-DDE	0.8	37	4.05E-05	3.78E-04	4.63E-05	1.45E-05	5.17E-06
4,4'-DDT	0.8	1000	1.10E-03	1.02E-02	1.25E-03	3.91E-04	1.40E-04
Manganese	1	254	3.48E-04	3.25E-03	3.98E-04	1.24E-04	4.44E-05

NOTES:

lwa	Lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI	Chronic Daily Intake in mg/kg-day
H-CDI	CDI for hazard quotient
C-CDI	CDI for excess cancer risk
*	Reflects the estimated fraction of the site impacted by the corresponding COPC.
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day

Table 10.3.16
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil
SWMU 38
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Exposure Point Concentration (mg/kg)	Fraction Contacted from Contaminated Source *	Dermal Absorption Factor (unitless)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Aluminum	16600	1	0.001	9.32E-04	3.08E-03	5.84E-04	6.66E-04	2.38E-04
Aroclor-1260	1.3	1	0.01	7.30E-07	2.41E-06	4.57E-07	5.22E-07	1.86E-07
Arsenic	20	1	0.001	1.11E-06	3.67E-06	6.96E-07	7.94E-07	2.84E-07
Beryllium	0.50	1	0.001	2.81E-08	9.27E-08	1.76E-08	2.01E-08	7.16E-09
4,4'-DDD	450	0.6	0.01	1.52E-04	5.01E-04	9.49E-05	1.08E-04	3.87E-05
4,4'-DDE	37	0.8	0.01	1.66E-05	5.49E-05	1.04E-05	1.19E-05	4.24E-06
4,4'-DDT	1000	0.8	0.01	4.49E-04	1.48E-03	2.81E-04	3.21E-04	1.15E-04
Manganese	254	1	0.01	1.43E-04	4.71E-04	8.93E-05	1.02E-04	3.64E-05

NOTES:

CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
* Reflects the estimated fraction of the site impacted by the corresponding COPC.
mg/kg milligrams per kilogram
mg/kg-day milligrams per kilogram per day

Table 10.3.17
Chronic Daily Intakes (CDI)
Ingestion of COPCs in Shallow Groundwater
SWMU 38
Naval Base Charleston, Zone A
Charleston, SC

Chemical	Exposure Point Concentration (mg/L)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Future Worker adult H-CDI (mg/kg-day)	Future Worker adult C-CDI (mg/kg-day)
Arsenic	0.0089	2.44E-04	5.69E-04	1.34E-04	8.71E-05	4.28E-05
4,4'-DDD	0.0035	9.51E-05	2.22E-04	5.23E-05	3.40E-05	1.67E-05
4,4'-DDE	0.000061	1.67E-06	3.90E-06	9.19E-07	5.97E-07	2.94E-07
4,4'-DDT	0.0011	3.01E-05	7.03E-05	1.66E-05	1.08E-05	5.29E-06
Thallium	0.0021	5.75E-05	1.34E-04	3.16E-05	2.05E-05	1.01E-05

NOTES:

lwa Lifetime weighted average
CDI Chronic Daily Intake
H-CDI Non-carcinogenic hazard based Chronic Daily Intake
C-CDI Carcinogenic risk based Chronic Daily Intake
mg/L milligrams per liter
mg/kg-day milligrams per kilogram per day

Table 10.3.18
Toxicological Database Informatio
for Chemicals of Potential Concern
SWMU 38
NAVBASE Charleston, Zone A

Non-Carcinogenic Toxicity Data

Chemical	Oral Reference Dose (mg/kg-day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg-day)		Confidence Level	Critical Effect	Uncertainty Factor Inhalation
Aluminum	1	c			ND	ND				ND
Arsenic	0.0003	a	M	hyperpigmentation	3	ND				ND
Beryllium	0.005	a	L	microscopic organ changes	100	ND				ND
4,4'-DDD	ND				ND	ND				ND
4,4'-DDE	ND				ND	ND				ND
4,4'-DDT	0.0005	a	M	liver lesions	100	ND				ND
Manganese	0.047	a	NA	neurological effects	1	1.43E-05	a	M	neurological effects	1000
PCB Aroclor-1260	ND				ND	ND				ND
Thallium	8E-05	a		increased SGOT (liver) increased serum LD	3000	ND				ND

Table 10.3.18 is continued on the following page.

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
NA Not applicable or not available
ND Not determined due to lack of information

ble 10.3.18
›xicological Database Informatio
r Chemicals of Potential Concern
VMU 38
AVBASE Charleston, Zone A

Carcinogenic Toxicity Data

hemical	Oral Slope Factor (mg/kg-day)-1		Inhalation Slope Factor (mg/kg-day)-1		Weight of Evidence	Tumor Type
luminum	ND		ND		ND	
rsenic	1.5	a	15.1	a	A	various
eryllium	4.3	a	8.4	a	B2	osteosarcoma
4'-DDD	0.24	a	ND		B2	liver
4'-DDE	0.34	a	ND		B2	liver
4'-DDT	0.34	a	ND		B2	liver
langanese	ND		ND		D	
CB Aroclor-1260	2	a	2	a	B2	hepatocellular carcinoma
hallium	ND		ND		D	

classification is based on sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic. Human milk contains about 3 μg/L arsenic. The RBC for arsenic in tap water is 0.045 μg/L. As listed in IRIS, the critical effect of this chemical is hyperpigmentation, keratosis, and possible vascular complications. The uncertainty factor was 3 and the modifying factor was 1.

Beryllium exposure via the inhalation route can inflame the lungs, a condition known as Acute Beryllium Disease, as a result of short-term exposure to high concentrations. Removal from exposure reverses the symptoms. Chronic exposure to much lower concentrations of beryllium or beryllium oxide by inhalation has been reported to cause chronic beryllium disease, with symptoms including shortness of breath, scarring of the lungs, and berylliosis, which is noncancerous growths in the lungs of humans. Both forms of beryllium disease can be fatal, depending on the severity of the exposure. Additionally, a skin allergy may develop when soluble beryllium compounds come into contact with the skin of sensitized individuals (Gradient, 1991). An oral RfD of 0.005 mg/kg-day has been set for beryllium based on a chronic oral bioassay (rats were the study species) which determined an NOAEL of 0.54 mg/kg-day. Beryllium has been classified by USEPA as a group B2 carcinogen based on animal studies. Human epidemiology studies of beryllium are inadequate. As listed in IRIS, classification is based on beryllium being shown to induce lung cancer via inhalation in rats and monkeys and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. An inhalation SF of 8.4 $(mg/kg\text{-}day)^{-1}$ and an oral SF of 4.3 $(mg/kg\text{-}day)^{-1}$ have been set by USEPA. As listed in IRIS, the critical effect of this chemical is no adverse effect. The uncertainty factor was 100 and the modifying factor was 1. The IRIS RfD in drinking water is 0.005 mg/kg-day.

Manganese is an essential nutrient, but chronic exposure (0.8 mg/kg-day) causes mental disturbances. Studies have shown that manganese uptake from water is greater than manganese uptake from food, and the elderly appear to be more sensitive than children (Klaassen et al., 1986; Dreisbach et al., 1987). USEPA determined the oral RfD to be 0.14 mg/kg-day based on dietary uptake. USEPA recommended using a modifying factor of 3 when estimating intake from soil and water. The oral RfD used is 0.047 mg/kg-day. Inhalation of manganese dust causes neurological effects and increased incidence of pneumonia. An inhalation RfD was set to 0.0000143 mg/kg-day. According to USEPA, manganese cannot be classified as to its carcinogenicity. Therefore, the cancer class for manganese is group D. As listed in IRIS, the classification is based on studies that are inadequate to assess the carcinogenicity of manganese. Manganese is an element considered essential to human health. The typical vitamin supplement dose of manganese is 2.5 mg/day. As listed in IRIS, the critical effects of this chemical in water in the oral summary are Central Nervous System (CNS) effects. The uncertainty factor was 1 and the recommended modifying factor of 3 was used to estimate soil and groundwater intake. As listed in IRIS, the critical effect of this chemical in the inhalation summary is impairment of neuro-behavioral function. For inhalation uptake, the uncertainty factor was 1,000 and the modifying factor was 1. The IRIS reference concentration is 0.00005 mg/m^3.

PCB Aroclors are a group of chlorinated hydrocarbons (such as ***Aroclors-1248, 1254, and 1260***) that accumulate in fat tissue. Occupational exposure (both inhalation and dermal) to PCBs causes eye and lung irritation, loss of appetite, liver enlargement, increased serum liver enzyme levels, rashes and chloracne, and decreased birth weight of infants in heavily exposed worker/mothers. Of the effects listed above, the liver is the primary target organ (Klaassen, et al, 1986) (Dreisbach, et al, 1987). USEPA classified PCB aroclors as group B2 probable human carcinogens, primarily based on animal data. Oral ingestion of PCBs causes liver and stomach tumors in rat studies. The cancer potency of PCB mixtures is determined using a tiered approach. The high risk and persistence tier uses an upper-bound slope factor of 2.0 (mg/kg-day)$^{-1}$ and is appropriate for food

chain exposures, sediment and soil ingestion, dust or aerosol inhalation, and dermal exposure. The low risk and persistence tier uses an upper-bound slope factor of 0.4 $(mg/kg\text{-}day)^{-1}$ and is appropriate for ingestion of water soluble congeners and inhalation of evaporated congeners. The lowest risk and persistence tier uses an upper-bound slope factor of 0.07 $(mg/kg\text{-}day)^{-1}$ and is appropriate for PCB congener mixtures with congeners having more than four chlorines comprising less than 1/2% of the mixture.

4,4'-DDD, a by-product of the pesticide DDT, is a compound typical of halobenzene derivatives. It is soluble in fat, but not in water, and its target organ is the brain. This analog of DDT is the least toxic of the three primary DDT analog (i.e., the least likely to cause cancer). Other DDD effects could include cell death in the liver, fatty change of heart muscles, and kidney damage. If an individual loses body fat, DDD concentrations are not stored at sufficient concentrations to induce toxic effects (Dreisbach, et al., 1987). This compound is listed as a B2 carcinogen, and USEPA set the oral SF for DDD to 0.24 $(mg/kg\text{-}day)^{-1}$.

4,4'-DDE is a compound typical of halobenzene derivatives and is a by-product of the pesticide DDT. It is soluble in fat, but not in water, and its primary target organs are the liver and brain. DDE is the form of DDT which accumulates in organisms and is thought to be responsible for egg shell thinning and other ecological effects. DDE bioconcentrates in aquatic organisms and can significantly alter the ecology of some areas, especially where DDE-containing aquatic species are a critical species in the food chain. (Dreisbach, et al., 1987) (Harte, et al., 1991). This compound is listed as a B2 carcinogen, and USEPA set the oral SF for DDE to 0.34 $(mg/kg\text{-}day)^{-1}$.

4,4'-DDT is a pesticide which is soluble in fat, but not in water. The primary target organ of DDT is the brain. Other DDT effects could include cell death in the liver, fatty change of heart muscles, and kidney damage. In a study mentioned in Dreisbach, et al., workers historically exposed to DDT had up to 648 ppm DDT in their body fat, but no adverse health effects were

observed. If an individual loses body fat, DDT concentrations are not stored at sufficient concentrations to induce toxic effects (Dreisbach, et al., 1987). As listed in IRIS, the critical noncarcinogenic effect of DDT is liver lesions. USEPA determined the oral RfD to be 0.0005 mg/kg-day, with an uncertainty factor of 100 and a modifying factor of 1. Confidence in the RfD is medium. DDT is a class B2 carcinogen based on tumors observed in seven studies in various mouse strains and three studies in rats. DDT is structurally similar to other probable carcinogens, such as DDD and DDE, common degradation products of DDT. USEPA determined the oral slope factor to be 0.34 $(mg/kg\text{-}day)^{-1}$.

Thallium is readily absorbed through the gut and skin. Primary effects are stomach and bowel disturbances, kidney and liver damage, and neurological disturbances. Thallium was used in the past as a rodenticide and ant killer, and its use for these purposes is now prohibited. This element remains in the body for a relatively long time, and could accumulate if the chronic dose is large (Klaassen, et al., 1986) (Dreisbach, et al., 1987). USEPA's oral RfD for thallium is 0.00008 mg/kg-day.

10.3.6.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under both residential and industrial (site worker) scenarios. For these scenarios, the incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.3.19 and 10.3.20 present the computed carcinogenic risks and/or HQs associated with the incidental ingestion of and dermal contact with site surface soils, respectively.

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime weighted average) for SWMU 38 surface soils is 6E-4. The dermal pathway ILCR is 3E-4. Arsenic, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were the primary contributors for each pathway, while Aroclor-1260 and beryllium were secondary contributors. The computed hazard index for the adult and child resident were 2 and 22, respectively, for the soil ingestion pathway. The computed hazard index for the adult and child dermal contact pathways were 2 and 6, respectively. Aluminum, arsenic, and 4,4-DDT were the primary contributors for the ingestion pathway, while 4,4'-DDT was the primary contributor for the dermal pathway.

Hypothetical Site Workers

Site worker ILCRs are 7E-5 and 1E-4 for the ingestion and dermal contact pathways, respectively. Arsenic, 4,4-DDD, 4,4-DDE, and 4,4-DDT were the primary contributors for both pathways. Hazard indices for the ingestion and dermal pathways are 0.8 and 1 for the ingestion and dermal pathways, respectively for the future site-worker scenario. 4,4'-DDT is the primary contributor for both pathways.

Groundwater Pathways (All Four Quarters)

Exposure to shallow groundwater onsite was evaluated under both residential and industrial scenarios. The ingestion exposure pathway was evaluated assuming that site groundwater will be used for potable and/or domestic purposes and that an unfiltered well, drawing from the corresponding water-bearing zone, will be installed. For noncarcinogenic contaminants evaluated relative to future site residents, hazard was computed separately for child and adult receptors. Table 10.3.21 presents the risk and hazard for the exposure pathway.

Table 10.3.19
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
SWMU 38
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Current Worker adult Hazard Quotient	Current Worker adult ILCR
Aluminum	1	NA	0.023	0.21	ND	0.0081	ND
Aroclor-1260	NA	2	ND	ND	4.1E-06	ND	4.5E-07
Arsenic	0.0003	1.5	0.090	0.84	4.6E-05	0.032	5.2E-06
Beryllium	0.005	4.3	0.00014	0.0013	3.4E-06	0.000049	3.8E-07
4,4'-DDD	NA	0.24	ND	ND	1.0E-04	ND	1.1E-05
4,4'-DDE	NA	0.34	ND	ND	1.6E-05	ND	1.8E-06
4,4'-DDT	0.0005	0.34	2.2	20	4.3E-04	0.78	4.8E-05
Manganese	0.047	NA	0.0074	0.069	ND	0.0026	ND
SUM Hazard Index/ILCR			2	22	6E-04	0.8	7E-05

NOTES:

NA	Not available
ND	Not Determined due to lack of available information
lwa	Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR	Incremental Lifetime Cancer Risk
RfD	Reference dose
SF	Slope factor
mg/kg-day	milligrams per kilogram per day

Table 10.3.20
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
SWMU 38
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Current Worker adult Hazard Quotient	Current Worker adult ILCR
Aluminum	0.2	0.2	NA	0.0047	0.015	ND	0.0033	ND
Aroclor-1260	0.5	NA	4	ND	ND	1.8E-06	ND	7.5E-07
Arsenic	0.2	6E-05	7.5	0.019	0.061	5.2E-06	0.013	2.1E-06
Beryllium	0.2	0.001	21.5	0.0000281	0.000093	3.8E-07	0.0000201	1.5E-07
4,4'-DDD	0.5	NA	0.48	ND	ND	4.6E-05	ND	1.9E-05
4,4'-DDE	0.5	NA	0.68	ND	ND	7.1E-06	ND	2.9E-06
4,4'-DDT	0.5	0.00025	0.68	1.8	5.9	1.9E-04	1.3	7.8E-05
Manganese	0.2	0.0094	NA	0.015	0.050	ND	0.011	ND
SUM Hazard Index/ILCR				2	6	3E-04	1	1E-04

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk
\- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)
RfD Reference dose
SF Slope factor
mg/kg-day milligrams per kilogram per day

Table 10.3.21
Hazard Quotients and Incremental Lifetime Cancer Risks
Shallow Groundwater Ingestion
SWMU 38
Naval Base Charleston, Zone A
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Future Worker adult Hazard Quotient	Future Worker adult ILCR
Arsenic	0.0003	1.5	0.81	1.9	2.0E-04	0.29	6.4E-05
4,4'-DDD	NA	0.24	ND	ND	1.3E-05	ND	4.0E-06
4,4'-DDE	NA	0.24	ND	ND	2.2E-07	ND	7.0E-08
4,4'-DDT	0.0005	0.34	0.060	0.14	5.6E-06	0.022	1.8E-06
Thallium	8E-05	NA	0.72	1.7	ND	0.26	ND
SUM Hazard Index/ILCR			2	4	2E-04	1	7E-05

NOTES:

NA	Not available
ND	Not Determined due to lack of available information
lwa	Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR	Incremental Lifetime Cancer Risk
RfD	Reference dose
SF	Slope factor
mg/kg-day	milligrams per kilogram per day

Hypothetical Site Residents

For the groundwater ingestion pathway, the lifetime weighted average ILCR was computed to be 2E-4. Arsenic, 4,4'-DDD and 4,4'-DDT were the primary contributors to risk through the groundwater ingestion exposure route. Hazard indices for the adult and child resident are 2 and 4 for the ingestion pathway. Arsenic and thallium were primary contributors to the hazard index for this exposure route.

Hypothetical Site Workers

For the groundwater ingestion pathway, the ILCR was computed to be 7E-5. Arsenic, 4,4'-DDD and 4,4'-DDT were the primary contributors to risk through the groundwater ingestion pathway. The ingestion pathway hazard index was computed to be 0.6, with arsenic and thallium as the primary contributors.

Current Site Workers

Shallow groundwater is not currently used as a potable water source for SWMU 38, or other areas of Zone A. In the absence of a completed exposure pathway, no threat to human health is posed by reported shallow groundwater contamination.

COCs Identified

Chemicals of concern were identified based on cumulative (all pathway) risk and hazard projected for this site. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a hazard index threshold of 1.0 (unity). In this HHRA, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or greater and/or a cumulative hazard index above 1.0, if its individual ILCR exceeds 1E-6 or its hazard quotient exceeds 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used to provide a more comprehensive evaluation of chemicals

contributing to carcinogenic risk or noncarcinogenic hazard during the remedial goal options development process. Table 10.3.22 provides a summary of COCs identified in each medium based on contribution to cumulative ILCR or hazard index.

Surface Soils

Hypothetical Site Residents (future land use)

Aluminum was identified as a COC based on its contribution to cumulative hazard index. Aroclor-1260, beryllium, 4,4'-DDD and 4,4'-DDE were identified as COCs based on their contribution to cumulative ILCR. Arsenic and 4,4'-DDT were identified as COCs based on their contribution to cumulative ILCR and hazard index.

Hypothetical Site Workers (current land use)

Arsenic, 4,4'-DDD, and 4,4'-DDE were identified as COCs based on their contribution to cumulative ILCR. 4,4'-DDT was identified as COC based on its contribution to cumulative ILCR and hazard index.

Aluminum and arsenic were detected in soil throughout SWMU 38. Aluminum was detected in all six surface soil samples and exceeded the Zone A background concentration in two of six samples. Arsenic was detected in all six surface soil samples and exceeded the Zone A background concentration in five of six samples. 4,4'-DDD was detected in 9 of 14 surface soil samples, while 4,4'-DDE and 4,4'-DDT were detected in eleven of fourteen surface soil samples. The maximum concentrations of all three pesticides were located in the surface soil sample 038SB001 (450, 37, and 1,000 mg/kg, respectively). The next highest concentrations of these pesticides were all located in surface soil sample 038SB003 (3.3, 0.45, and 7.8 mg/kg respectively). These samples were collected from the northern boundary of SWMU 38, along the property line adjoining the Hess Oil tank farm. The two surface soil locations listed above were

Table 10.3.22
Summary of Risk and Hazard-based COCs
SWMU 38
Naval Base Charleston, Zone A
Charleston, South Carolina

Medium	Exposure Pathway		Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident lwa ILCR	Site Worker Hazard Quotient	Site Worker ILCR	Identification of COCs
Surface Soil	Incidental Ingestion	Aluminum	0.023	0.21	ND	0.0081	ND	1
		Aroclor-1260	ND	ND	4.1E-06	ND	4.5E-07	2
		Arsenic	0.090	0.84	4.6E-05	0.032	5.2E-06	1 2 4
		Beryllium	0.000137	0.00128	3.4E-06	0.0000489	3.8E-07	2
		4,4'-DDD	ND	ND	1.0E-04	ND	1.1E-05	2 4
		4,4'-DDE	ND	ND	1.6E-05	ND	1.8E-06	2 4
		4,4'-DDT	2.2	20	4.3E-04	0.78	4.8E-05	1 2 3 4
		Manganese	0.0074	0.069	ND	0.0026	ND	
	Dermal Contact	Aluminum	0.0047	0.015	ND	0.0033	ND	
		Aroclor-1260	ND	ND	1.8E-06	ND	7.5E-07	2
		Arsenic	0.019	0.061	5.2E-06	0.013	2.1E-06	2 4
		Beryllium	0.0000281	0.000093	3.8E-07	0.0000201	1.5E-07	
		4,4'-DDD	ND	ND	4.6E-05	ND	1.9E-05	2 4
		4,4'-DDE	ND	ND	7.1E-06	ND	2.9E-06	2 4
		4,4'-DDT	1.8	5.9	1.9E-04	1.28	7.8E-05	1 2 3 4
		Manganese	0.015	0.050	ND	0.01	ND	
Surface Soil Pathway Sum			4	28	8E-04	2	2E-04	
Shallow Groundwater	Ingestion	Arsenic	0.81	1.9	2.0E-04	0.29	6.4E-05	1 2 4
		4,4'-DDD	ND	ND	1.3E-05	ND	4.0E-06	2 4
		4,4'-DDE	ND	ND	2.2E-07	ND	7.0E-08	
		4,4'-DDT	0.060	0.14	5.6E-06	0.022	1.8E-06	1 2 4
		Thallium	0.72	1.7	ND	0.26	ND	1
Groundwater Pathway Sum			2	4	2E-04	1	7E-05	

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental lifetime cancer risk
HI indicates hazard index
COC indicates chemical of concern
1- Chemical is a COC by virtue of projected child residence noncarcinogenic hazard.
2- Chemical is a COC by virtue of projected future resident lifetime ILCR.
3- Chemical is a COC by virtue of projected site worker noncarcinogenic hazard.
4- Chemical is a COC by virtue of projected site worker ILCR.

the only locations with 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT surface soil concentrations above the residential RBCs. Aroclor-1260 was detected in six of fourteen surface soil samples and was detected above the residential RBC in 4 of 14. The highest Aroclor- 1260 locations are 038SB006 (0.5 mg/kg), 038SB011 (0.72 mg/kg), and 038SB012 (1.3 mg/kg).

Groundwater

Hypothetical Site Residents (future land use)

Thallium was identified as a groundwater COC, based on its contribution to the cumulative hazard index. 4,4'-DDD was identified as a groundwater COC based on its contribution to the cumulative ILCR. Arsenic and 4,4'-DDT were identified as groundwater COCs based on their contribution to cumulative ILCR and hazard index.

Hypothetical Site Workers (current land use)

Arsenic, 4,4'-DDD and 4,4'-DDT were identified as groundwater COCs based on their contribution to ILCR.

Arsenic was detected in the sample collected from the monitoring well NBCA038001 in the first, third, and fourth quarters. Arsenic was also detected in the sample collected from monitoring well NBCA038002 in the third quarter. Arsenic was not detected in either well in the second quarter. Thallium was detected in the first quarter in one of two monitoring wells (NBCA038002) at a concentration of 4 μg/L. Thallium was not detected in shallow groundwater in any subsequent quarter sample. 4,4'-DDD was detected in one shallow monitoring well (NBCA038001) in each of the four quarters. 4,4'-DDT was detected in the same shallow monitoring well (NBCA038001) in each of the first three quarters. Due to their hydrophobic nature, however, 4,4'-DDD and 4,4'-DDT are not expected to migrate with groundwater.

10.3.6.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV and SCDHEC when assessing potential future and current exposure. The exposure assumptions made in the site-worker scenario are highly protective and would tend to overestimate exposure. Although current and future exposure to impacted areas is possible, the frequency and duration of direct contact are likely quite low in comparison to the recommended residential scenario.

Residential use of the site is not expected, based on current site uses and the nature of surrounding buildings. Current base reuse plans call for Zone A to become a marine terminal. If this area were to be used as a residential site, the buildings would be demolished, and the asphalt surface removed. The surface soil conditions would likely change dramatically to accommodate a residential setting. The soils could be covered with landscaping soil, houses, and driveways. Consequently, exposure to current surface soil conditions would not be likely under a true future scenario. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to future site residents.

Shallow groundwater is not currently used at SWMU 38 for potable or industrial purposes. A basewide system provides drinking and process water to buildings throughout Zone A. This system is slated to remain in operation under the current base reuse plan. As a result, shallow groundwater would not be expected to be used under future site use scenarios. Therefore, the scenario established to project risk/hazard associated with shallow groundwater exposure is highly conservative and associated pathways are not expected to be completed in the future.

Determination of Exposure Point Concentrations

Only six surface soil data points were available for aluminum, arsenic, beryllium, and manganese; and the 95% UCL for Aroclor-1260, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT exceeded the maximum detected concentration. As a result, the maximum detected surface soil concentrations were used as EPCs for all COPCs identified for SWMU 38. Since it is unlikely for an individual to be chronically exposed to an isolated maximally contaminated area, a FI/FC term was applied to the EPC to reflect frequency of detection in SWMU 38 surface soil. While the FI/FC term helps to provide a more reasonable estimate of exposure potential, the area of maximum concentration has still been exaggerated, resulting in an overestimation of risk.

Only two groundwater data points were available for arsenic, 4,4'-DDD, 4,4-DDT, and thallium for each quarter of groundwater sampling. As a result, the maximum concentration of each groundwater COPC was applied as the EPC. No FI/FC term was applied to the EPC; as a result, groundwater risk has likely been overestimated.

Frequency of Detection and Spatial Distribution

Soil

4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were each detected in one or two surface soil samples at concentrations in excess of the residential RBCs. These detections are isolated to the northern portion of the site. Aluminum, arsenic, and manganese were detected in all six surface soil samples. Aluminum was detected above the residential RBC in 5 of 6 surface soil samples, arsenic was detected above the residential RBC in 6 of 6 surface soil samples, and manganese was detected above the residential RBC in 1 of 6 surface soil samples. The mean concentrations for aluminum and manganese are below background reference concentrations. Aroclor-1260 was detected above the residential RBC in 4 of 14 surface soil samples. Beryllium was reported in only one of six samples.

Groundwater

4,4'-DDD and 4,4'-DDT were detected in one first quarter shallow groundwater sample (038GW001). Because monitoring well 038GW001 was installed in the same location as soil boring 038SB001 (the soil samples with the highest 4,4'-DDD and 4,4'-DDT concentrations), it has been hypothesized that these groundwater concentrations may be associated with sediment/soil entrained in the borehole annular space during well installation. With respect to 4,4'-DDD and 4,4'-DDT, data from subsequent groundwater sampling are consistent with first quarter results. Turbidity is still a plausible explanation for the 4,4'-DDD and 4,4'-DDT groundwater concentrations. Thallium was detected in one first-round sample from monitoring well NBCA038001 at a concentration of 4 μg/L, but was not detected in subsequent sampling rounds. Arsenic was detected in monitoring well NBCA038001 in the first, third, and fourth quarters of sampling at concentrations of 6.0 μg/L, 12.5 μg/L, and 14.9 μg/L, respectively. Arsenic was also detected in monitoring well NBCA038002 in the third quarter at a concentration of 3.1 μg/L.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

Of the CPSSs screened and eliminated from formal assessment, chromium was reported at a concentration close to its corresponding RBC (i.e., within approximately 10% of the RBC). The use of maximum concentrations for screening comparisons minimizes the likelihood of potentially significant cumulative risk and hazard based on the eliminated CPSS.

Central tendency analysis was not formally performed for SWMU 38 surface soil, but a simplified approach was taken to assess the potential influences of CT assumptions. The CT assumption for residential exposure duration is nine years compared to the 24-year assumption for RME. The CT exposure frequency assumption is 234 days/year compared to 350 days/year RME. If all other exposure assumptions remain fixed, application of the CT exposure duration and frequency would result in risk projections approximately 80% below the RME. For the child resident, the CT exposure duration (6 years) falls within the RME exposure duration (9 years). If all other exposure assumptions remain fixed, application of the CT exposure frequency would result in risk projections approximately 34% below the RME. At CT, the residential surface soil pathway related risk (incidental ingestion and dermal contact) would be approximately 2E-4, but would still exceed the 1E-6 point of departure. At CT, the residential surface soil pathway related hazard index (incidental ingestion and dermal contact) would decrease from 28 to 18.

Although the future land use of SWMU 38 is unknown, both the worker and residential exposure scenarios were assessed in this HHRA. Current base reuse plans call for the development of a marine terminal for Zone A. As previously discussed, it is likely that these scenarios would lead to overestimates of risk and/or hazard.

Groundwater

Of the CPSSs screened and eliminated from formal assessment, 4,4'-DDE was reported at concentrations within approximately 20% of the RBC. 4,4'-DDE would not be a significant contributor to groundwater related risk projections for SWMU 38. Manganese was detected above its corresponding RBC; however, the maximum concentration was below the background concentration. No other inorganic parameters were eliminated from formal assessment based strictly upon comparison to background concentrations.

Groundwater is not currently used as a potable water source at combined SWMU 38, nor is it used at NAVBASE or in the surrounding area. Municipal water is readily available. As previously mentioned, it is highly unlikely that the site will be developed as a residential area and it is

unlikely that a potable-use well would be installed onsite. It is probable that, if residences were constructed onsite and an unfiltered well were installed, the salinity and dissolved solids would preclude this aquifer from being an acceptable potable water source.

Toxicology

Arsenic was a significant contributor to risk estimates based on exposure to SWMU 38 surface soil and groundwater. USEPA has accepted arsenic-related cancer risks of up to 1E-03 because the cancers are squamous cell carcinomas with a low mortality rate (USEPA Region III *Risk-based Concentration Table, January-June 1996*). Arsenic related risk for neither the soil nor groundwater pathways exceeded 1E-03.

10.3.6.7 Risk Summary

The risk and hazard posed by contaminants at SWMU 38 were assessed for the hypothetical site-worker and the hypothetical future site resident under reasonable maximum exposure assumptions. For surface soils, the incidental ingestion and dermal contact pathways were assessed in this HHRA. The ingestion pathway was evaluated for shallow groundwater. Table 10.3.23 provides summaries for each pathway/receptor group evaluated for SWMU 38.

Soil

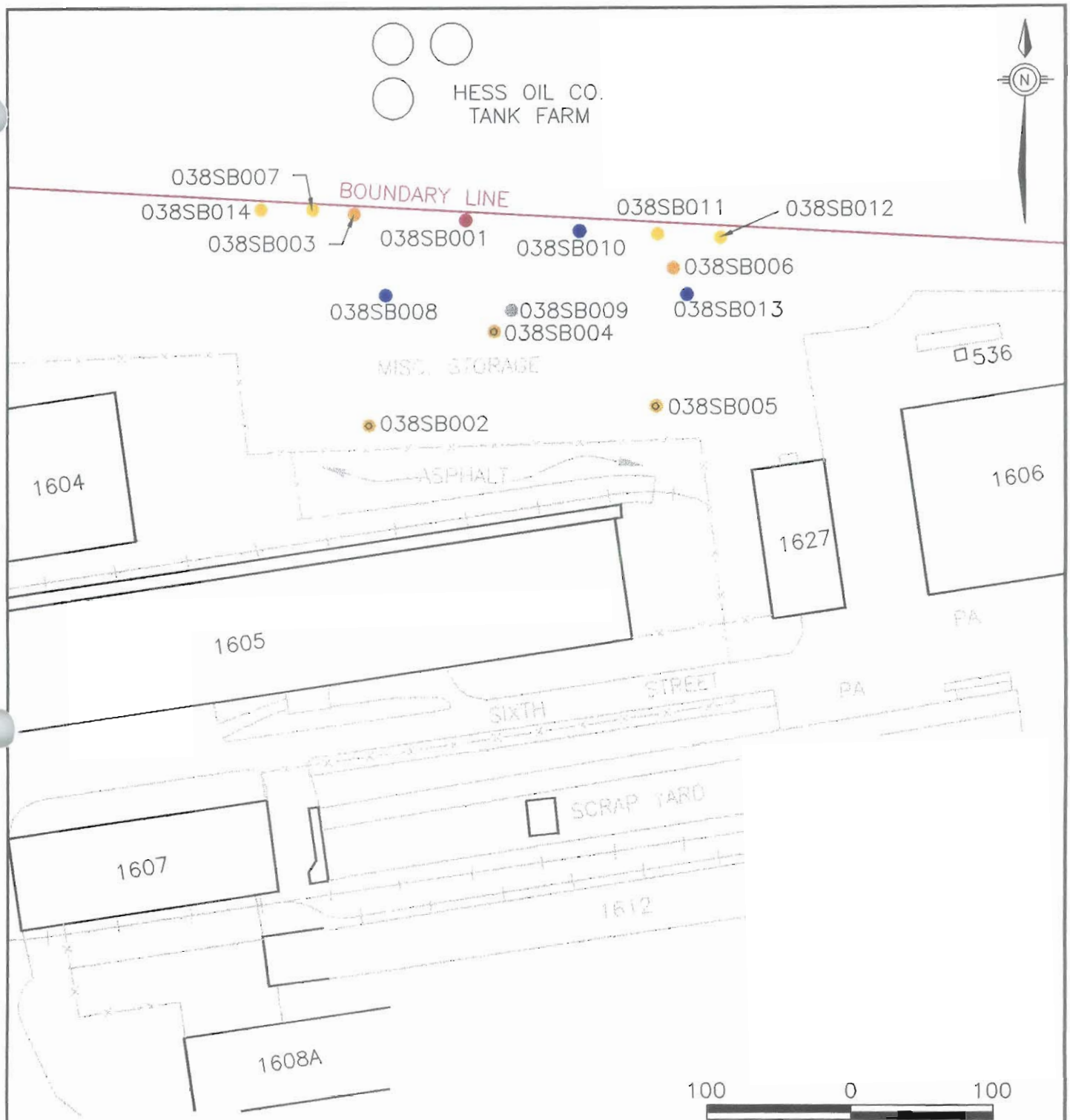
Figures 10.3.6 and 10.3.7 illustrate point risk and hazard indices for SWMU 38 surface soil exposure by potential future site residents. Table 10.3.24 summarizes the risk and hazard contribution of each COPC at each sample location. This point-risk map is based on the unlikely assumption that potential future site resident will be chronically exposed to specific points. Exposure to surface soil conditions is more likely the result of equal exposure to the soil conditions of the entire site (or exposure unit area) rather than specific points. With this in mind, risk maps supplemented by the tables are useful in that they allow the reader to visualize how chemicals driving risk estimates are spatially distributed across the site.

Table 10.3.23
Summary of Risk and Hazard
SWMU 38
Naval Base Charleston, Zone A
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	2	22	6E-04	0.8	7E-05
	Dermal Contact	2	6	3E-04	1	1E-04
Shallow Groundwater	Ingestion	2	4	2E-04	1	7E-05
Sum of All Pathways		6	31	1E-03	3	2E-04

NOTES:

ND Not determined due to the lack of available risk information.
ILCR Incremental lifetime cancer risk
HI Hazard index
LWA Lifetime weighted average



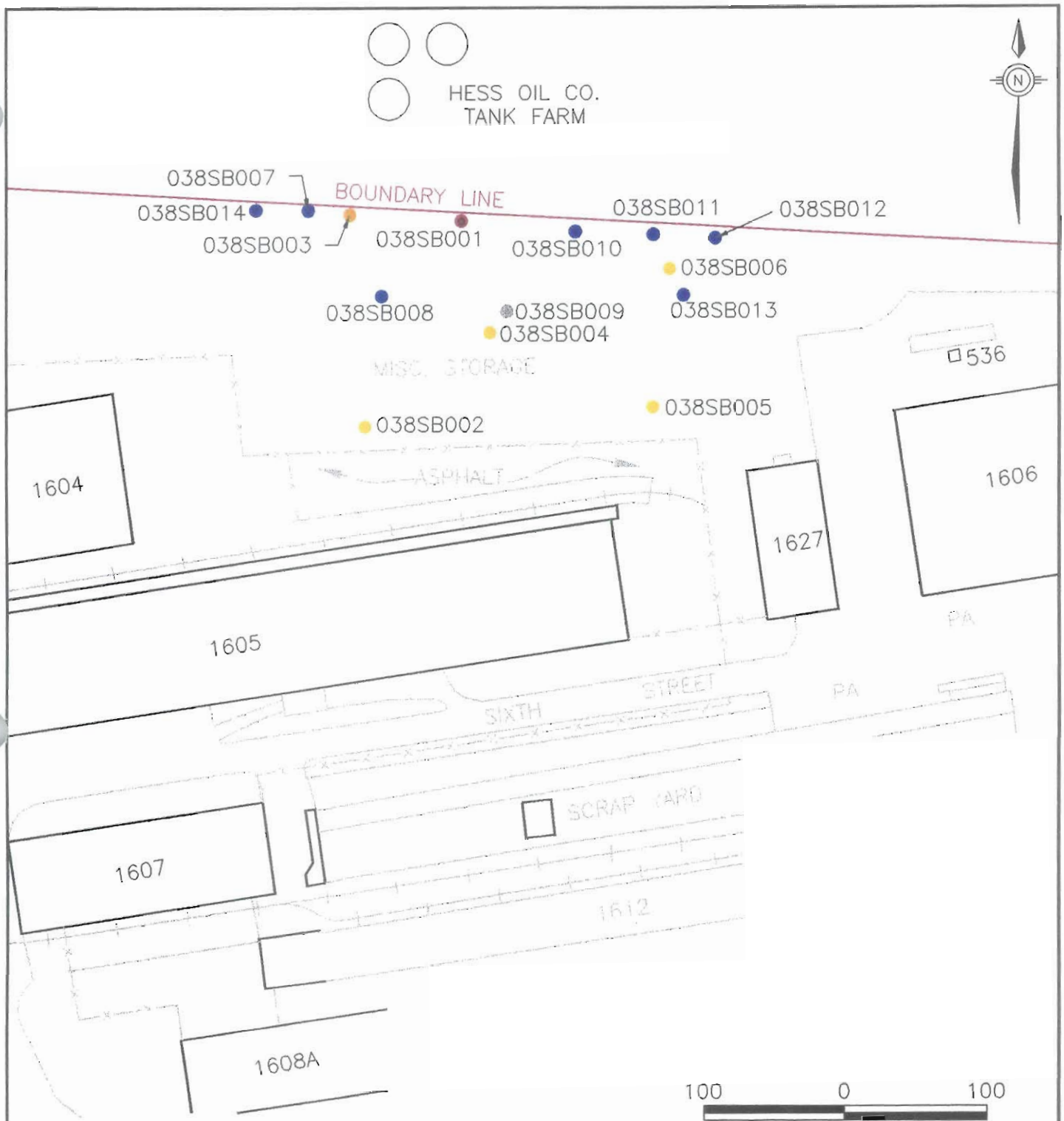
LEGEND

- ○ = 100% OF RISK DUE TO ARSENIC
- ● – NO CARCINOGENIC COPCs DETECTED
- ● – < 1E−6
- ● – 1E−6 TO 1E−5
- ● – 1E−5 TO 1E−4
- ● – > 1E−4
- — – ZONE A BOUNDARY

ZONE A
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.3.6
SWMU 38
SURFACE SOIL POINT RISK
RESIDENTIAL SCENARIO

DWG DATE: 04/13/98 | DWG NAME: 2901B003



100 0 100

SCALE FEET

LEGEND

- ○ = 100% OF HAZARD INDEX DUE TO 4,4'-DDT
- ● – NO NONCARCINOSENIC COPCS DETECTED
- ● – < 0.1
- ● – 0.1 TO 1
- ● – 1 TO 3
- ● – > 3
- ZONE A BOUNDARY

ZONE A
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.3.7
SWMU 38
SURFACE SOIL POINT HAZARD INDEX
RESIDENTIAL SCENARIO

DWG DATE: 04/13/98 | DWG NAME: 2901B004

Table 10.3.24
Point Estimates of Risk and Hazard - Surface Soil
Residential Scenario - SWMU 38
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
038	001	4,4'-DDD	450000	ug/kg	NA	245.0019
038	001	4,4'-DDE	37000	ug/kg	NA	28.5382
038	001	4,4'-DDT	1000000	ug/kg	32.9863	771.3022
038	001	Aluminum (Al)	5880	mg/kg	0.0806	NA
038	001	Aroclor-1260	ND	ug/kg	NA	NA
038	001	Arsenic (As)	19.8	mg/kg	0.9050	51.7176
038	001	Beryllium (Be)	ND	mg/kg	NA	NA
038	001	Manganese (Mn)	130	mg/kg	0.0386	NA
		Total			34.0106	1096.5599
038	002	4,4'-DDD	1.6	ug/kg	NA	0.0009
038	002	4,4'-DDE	8.2	ug/kg	NA	0.0063
038	002	4,4'-DDT	9.2	ug/kg	0.0003	0.0071
038	002	Aluminum (Al)	9305	mg/kg	0.1276	NA
038	002	Aroclor-1260	ND	ug/kg	NA	NA
038	002	Arsenic (As)	17.75	mg/kg	0.8113	46.3630
038	002	Beryllium (Be)	ND	mg/kg	NA	NA
038	002	Manganese (Mn)	14.8	mg/kg	0.0044	NA
		Total			0.9436	46.3773
038	003	4,4'-DDD	3300	ug/kg	NA	1.7967
038	003	4,4'-DDE	450	ug/kg	NA	0.3471
038	003	4,4'-DDT	7800	ug/kg	0.2573	6.0162
038	003	Aluminum (Al)	11400	mg/kg	0.1563	NA
038	003	Aroclor-1260	ND	ug/kg	NA	NA
038	003	Arsenic (As)	15	mg/kg	0.6856	39.1800
038	003	Beryllium (Be)	0.5	mg/kg	0.0014	3.7439
038	003	Manganese (Mn)	254	mg/kg	0.0754	NA
		Total			1.1760	51.0838
038	004	4,4'-DDD	ND	ug/kg	NA	NA
038	004	4,4'-DDE	ND	ug/kg	NA	NA
038	004	4,4'-DDT	ND	ug/kg	NA	NA
038	004	Aluminum (Al)	16600	mg/kg	0.2276	NA
038	004	Aroclor-1260	ND	ug/kg	NA	NA
038	004	Arsenic (As)	14.3	mg/kg	0.6536	37.3516
038	004	Beryllium (Be)	ND	mg/kg	NA	NA
038	004	Manganese (Mn)	29.1	mg/kg	0.0086	NA
		Total			0.8899	37.3516
038	005	4,4'-DDD	ND	ug/kg	NA	NA
038	005	4,4'-DDE	ND	ug/kg	NA	NA
038	005	4,4'-DDT	ND	ug/kg	NA	NA
038	005	Aluminum (Al)	13200	mg/kg	0.1810	NA
038	005	Aroclor-1260	ND	ug/kg	NA	NA
038	005	Arsenic (As)	7.8	mg/kg	0.3565	20.3736
038	005	Beryllium (Be)	ND	mg/kg	NA	NA
038	005	Manganese (Mn)	26.1	mg/kg	0.0078	NA
		Total			0.5453	20.3736
038	006	4,4'-DDD	38.5	ug/kg	NA	0.0210
038	006	4,4'-DDE	85.55	ug/kg	NA	0.0660
038	006	4,4'-DDT	209	ug/kg	0.0069	0.1612
038	006	Aluminum (Al)	8520	mg/kg	0.1168	NA
038	006	Aroclor-1260	500	ug/kg	NA	2.2685
038	006	Arsenic (As)	13.35	mg/kg	0.6102	34.8702
038	006	Beryllium (Be)	ND	mg/kg	NA	NA
038	006	Manganese (Mn)	98.45	mg/kg	0.0292	NA
		Total			0.7632	37.3869

Table 10.3.24
Point Estimates of Risk and Hazard - Surface Soil
Residential Scenario - SWMU 38
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
038	007	4,4'-DDD	50	ug/kg	NA	0.0272
038	007	4,4'-DDE	170	ug/kg	NA	0.1311
038	007	4,4'-DDT	77	ug/kg	0.0025	0.0594
038	007	Aroclor-1260	410	ug/kg	NA	1.8602
		Total			0.0025	2.0779
038	008	4,4'-DDD	ND	ug/kg	NA	NA
038	008	4,4'-DDE	6.8	ug/kg	NA	0.0052
038	008	4,4'-DDT	21	ug/kg	0.0007	0.0162
038	008	Aroclor-1260	ND	ug/kg	NA	NA
		Total			0.0007	0.0214
038	009	4,4'-DDD	ND	ug/kg	NA	NA
038	009	4,4'-DDE	ND	ug/kg	NA	NA
038	009	4,4'-DDT	ND	ug/kg	NA	NA
038	009	Aroclor-1260	ND	ug/kg	NA	NA
		Total			NA	NA
038	010	4,4'-DDD	53.5	ug/kg	NA	0.0291
038	010	4,4'-DDE	48	ug/kg	NA	0.0370
038	010	4,4'-DDT	455	ug/kg	0.0150	0.3509
038	010	Aroclor-1260	ND	ug/kg	NA	NA
		Total			0.0150	0.4171
038	011	4,4'-DDD	210	ug/kg	NA	0.1143
038	011	4,4'-DDE	530	ug/kg	NA	0.4088
038	011	4,4'-DDT	1400	ug/kg	0.0462	1.0798
038	011	Aroclor-1260	720	ug/kg	NA	3.2667
		Total			0.0462	4.8696
038	012	4,4'-DDD	190	ug/kg	NA	0.1034
038	012	4,4'-DDE	170	ug/kg	NA	0.1311
038	012	4,4'-DDT	800	ug/kg	0.0264	0.6170
038	012	Aroclor-1260	1300	ug/kg	NA	5.8982
		Total			0.0264	6.7498
038	013	4,4'-DDD	ND	ug/kg	NA	NA
038	013	4,4'-DDE	12	ug/kg	NA	0.0093
038	013	4,4'-DDT	54	ug/kg	0.0018	0.0417
038	013	Aroclor-1260	18	ug/kg	NA	0.0817
		Total			0.0018	0.1326
038	014	4,4'-DDD	290	ug/kg	NA	0.1579
038	014	4,4'-DDE	580	ug/kg	NA	0.4474
038	014	4,4'-DDT	1700	ug/kg	0.0561	1.3112
038	014	Aroclor-1260	79	ug/kg	NA	0.3584
		Total			0.0561	2.2749

Risk estimates associated with the surface soil pathways exceeded 1E-06 at 10 of 14 sample locations (038SB001, 038SB002, 038SB003, 038SB004, 038SB005, 038SB006, 038SB007, 038SB011, 038SB012, and 038SB014). Arsenic was a primary contributor to risk at each location it was detected (038SB001, 038SB002, 038SB003, 038SB004, 038SB005, and 038SB006). 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were primary contributors to risk at 038SB001, and secondary contributors to risk at 038SB003, 038SB011 and 038SB014. Aroclor-1260 was a primary contributor to risk at 038SB007, 038SB011, and 038SB012, and a secondary contributor to risk at 038SB006 and 038SB014. Beryllium was a secondary contributor to risk at 038SB003. Risk estimates ranged from 2E-08 (038SB008) to 1E-03 (038SB001) with a mean risk of 9E-05.

Hazard index estimates exceeded unity at 2 of 14 surface soil sample locations (038SB001 and 038SB003). 4,4'-DDT is the primary contributor to the hazard index at 038SB001, while arsenic, aluminum, and manganese were secondary contributors. Arsenic was the primary contributor to the hazard index at 038SB003, while 4,4'-DDT, aluminum, beryllium, and manganese were secondary contributors. Hazard index estimates ranged from 0.0007 (038SB008) to 34 (038SB001) with a mean hazard index of 3.

Groundwater

Due to the limited number of monitoring wells, groundwater risk and hazard maps for SWMU 38 were not generated. Table 10.3.25 summarizes the risk and hazard contribution of each COPC at each monitoring well during all four quarters. Risk estimates exceeded 1E-06 in 5 of 8 shallow groundwater samples (NBCA038001-01, NBCA038001-02, NBCA038001-03, NBCA038002-03, and NBCA038001-04). Arsenic was the primary contributor to risk at each location and quarter that it was detected (NBCA038001-01, NBCA038001-03, NBCA038002-03, and NBCA038001-04). 4,4'-DDD was a primary contributor to risk at NBCA038001 in all four quarters. 4,4'-DDT was a primary contributor to risk at NBCA038001 in the first three quarters, but was not detected in the fourth quarter sampling round. No chemicals contributed to risk at NBCA038002 in the first, second, or fourth quarters. Risk estimates ranged from 3E-05 (NBCA038001-02) to 3E-4 (NBCA038001-04) with a mean risk estimate of 1E-04.

Table 10.3.25
Point Estimates of Risk and Hazard - Shallow Groundwater
Residential Scenario - SWMU 38
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Quarter	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
038	001	01	4,4'-DDD	3.8	ug/L	NA	13.5640
038	001	01	4,4'-DDT	1.5	ug/L	0.1918	7.5851
038	001	01	Arsenic (As)	6	ug/L	1.2785	133.8552
038	001	01	Thallium (Tl)	ND	ug/L	NA	NA
			Total			1.4703	155.0043
038	002	01	4,4'-DDD	ND	ug/L	NA	NA
038	002	01	4,4'-DDT	ND	ug/L	NA	NA
038	002	01	Arsenic (As)	ND	ug/L	NA	NA
038	002	01	Thallium (Tl)	4	ug/L	3.1963	NA
			Total			3.1963	NA
038	001	02	4,4'-DDD	4	ug/L	NA	14.2779
038	001	02	4,4'-DDT	2.6	ug/L	0.3324	13.1476
038	001	02	Arsenic (As)	ND	ug/L	NA	NA
038	001	02	Thallium (Tl)	ND	ug/L	NA	NA
			Total			0.3324	27.4254
038	002	02	4,4'-DDD	ND	ug/L	NA	NA
038	002	02	4,4'-DDT	ND	ug/L	NA	NA
038	002	02	Arsenic (As)	ND	ug/L	NA	NA
038	002	02	Thallium (Tl)	ND	ug/L	NA	NA
			Total			NA	NA
038	001	03	4,4'-DDD	2.9	ug/L	NA	10.3515
038	001	03	4,4'-DDT	0.23	ug/L	0.0294	1.1631
038	001	03	Arsenic (As)	12.5	ug/L	2.6636	278.8650
038	001	03	Thallium (Tl)	ND	ug/L	NA	NA
			Total			2.6930	290.3795
038	002	03	4,4'-DDD	ND	ug/L	NA	NA
038	002	03	4,4'-DDT	ND	ug/L	NA	NA
038	002	03	Arsenic (As)	3.1	ug/L	0.6606	69.1585
038	002	03	Thallium (Tl)	ND	ug/L	NA	NA
			Total			0.6606	69.1585
038	001	04	4,4'-DDD	3.18	ug/L	NA	11.3509
038	001	04	4,4'-DDT	ND	ug/L	NA	NA
038	001	04	Arsenic (As)	14.9	ug/L	3.1750	332.4070
038	001	04	Thallium (Tl)	ND	ug/L	NA	NA
			Total			3.1750	343.7580
038	002	04	4,4'-DDD	ND	ug/L	NA	NA
038	002	04	4,4'-DDT	ND	ug/L	NA	NA
038	002	04	Arsenic (As)	ND	ug/L	NA	NA
038	002	04	Thallium (Tl)	ND	ug/L	NA	NA
			Total			NA	NA

Hazard index estimates exceeded unity in 4 of 8 shallow groundwater samples (NBCA038001-01, NBCA038002-01, NBCA038001-03, and NBCA038001-04). No chemicals contributed to hazard estimates at NBCA038002 in the second or fourth quarters. Arsenic was the primary contributor to hazard index estimates at NBCA038001 in the first, third, and fourth quarters. Thallium was the primary contributor to the hazard index at NBCA038002 in the first quarter. 4,4'-DDT was a secondary contributor to hazard index estimates at NBCA038001 in the first and third quarters. Hazard index estimates ranged from 0.3 (NBCA038001-02) to 3 (NBCA038002-01 and NBCA038001-04) with a mean hazard index estimate of 1.

10.3.6.8 Remedial Goal Options

Soil

Surface soil RGOs for carcinogens presented in Table 10.3.26 were based on the lifetime weighted average site resident and adult site-worker, respectively. Hazard-based RGOs were calculated based on either the hypothetical child resident or the adult site-worker, as noted in each of the corresponding tables.

Groundwater

Shallow groundwater RGOs based on site residents and site-workers are shown in Table 10.3.27.

10.3.7 Corrective Measures Considerations

For SWMU 38, the environmental media investigated were surface soil, subsurface soil, shallow groundwater, and deep groundwater. Based on the analytical results and the risk assessment, COCs requiring further evaluation through the CMS process were identified for surface soil and shallow groundwater. Detections of COCs in the subsurface soil also justify inclusion in the CMS process.

DDD, DDE, DDT, Aroclor-1260, arsenic, aluminum, beryllium and TPH were identified as COCs in soil. The CMS for soil should include further defining the area of Aroclor-1260 contamination along the northern NAVBASE property line toward the east.

Table 10.3.26
Remedial Goal Options Surface Soil
SWMU 38
Naval Base Charleston, Zone A
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	FI/FC Factor	EPC mg/kg	Hazard-Based Remedial Goal Options 3 mg/kg	1 mg/kg	0.1 mg/kg	Risk-Based Remedial Goal Options 1E-06 mg/kg	1E-05 mg/kg	1E-04 mg/kg	Background Concentration mg/kg
Aluminum	NA	1	1	16600	218781	72927	7293	ND	ND	ND	12800
Aroclor-1260	2	NA	1	1.3	ND	ND	ND	0.22	2.2	22	NA
Arsenic	1.5	0.0003	1	19.8	66	22	2.2	0.38	3.8	38	9.4
4,4'-DDD	0.24	NA	0.6	450	ND	ND	ND	1.8	18	184	NA
4,4'-DDE	0.34	NA	0.8	37	ND	ND	ND	1.3	13	130	NA
4,4'-DDT	0.34	0.0005	0.8	1000	91	30	3	1.3	13	130	NA

Worker-Based Remedial Goal Options

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	FI/FC Factor	EPC mg/kg	Hazard-Based Remedial Goal Options 3 mg/kg	1 mg/kg	0.1 mg/kg	Risk-Based Remedial Goal Options 1E-06 mg/kg	1E-05 mg/kg	1E-04 mg/kg	Background Concentration mg/kg
Arsenic	1.5	0.0003	1	19.8	1305	435	43	2.7	27	271	9.4
4,4'-DDD	0.24	NA	0.6	450	ND	ND	ND	9	90	903	NA
4,4'-DDE	0.34	NA	0.8	37	ND	ND	ND	6	64	638	NA
4,4'-DDT	0.34	0.0005	0.8	1000	1161	387	39	6	64	638	NA

NOTES:

EPC Exposure point concentration
NA Not applicable
ND Not determined
FI/FC Fraction ingested / fraction contaminated
- Remedial goal options were based on the lifetime weighted average for carcinogens and the child resident or site worker for noncarcinogens
mg/kg milligrams per kilogram
mg/kg-day milligrams per kilogram per day

Table 10.3.27
Remedial Goal Options for Shallow Groundwater
SWMU 38
Naval Base Charleston, Zone A
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Oral Slope Factor (mg/kg-day)-1	Oral Reference Dose (mg/kg-day)	EPC mg/L	Hazard-Based Remedial Goal Options **0.1** mg/L	**1.0** mg/L	**3** mg/L	Risk-Based Remedial Goal Options **1E-06** mg/L	**1E-05** mg/L	**1E-04** mg/L	MCL mg/L	Background Concentration mg/L
Arsenic	1.5	0.0003	0.0089	0.00047	0.0047	0.014	0.000044	0.00044	0.0044	0.05	0.0074
4,4'-DDD	0.24	NA	0.00347	ND	ND	ND	0.00028	0.0028	0.028	NA	NA
4,4'-DDT	0.34	0.0005	0.0011	0.00078	0.0078	0.023	0.00020	0.0020	0.020	NA	NA
Thallium	NA	8E-05	0.0021	0.00013	0.0013	0.0038	ND	ND	ND	0.0005	NA

Worker-Based Remedial Goal Options

Chemical	Oral Slope Factor (mg/kg-day)-1	Oral Reference Dose (mg/kg-day)	EPC mg/L	Hazard-Based Remedial Goal Options **0.1** mg/L	**1** mg/L	**3** mg/L	Risk-Based Remedial Goal Options **1E-06** mg/L	**1E-05** mg/L	**1E-04** mg/L	MCL mg/L	Background Concentration mg/L
Arsenic	1.5	0.0003	0.0089	0.0031	0.031	0.092	0.00014	0.0014	0.014	0.05	0.0074
4,4'-DDD	0.24	NA	0.00347	ND	ND	ND	0.00087	0.0087	0.087	NA	NA
4,4'-DDT	0.34	0.0005	0.0011	0.0051	0.051	0.15	0.00061	0.0061	0.061	NA	NA
Thallium	NA	8E-05	0.0021	0.00082	0.0082	0.025	ND	ND	ND	0.0005	NA

NOTES:

- EPC Exposure point concentration
- MCL Maximum contaminant limit
- NA Not applicable
- ND Not determined
- \- Remedial goal options were based on the lifetime weighted average for carcinogens and the child resident or site worker for noncarcinogens
- mg/L milligrams per liter
- mg/kg-day milligrams per kilogram per day

DDD, DDE, DDT, and arsenic were identified as COCs in shallow groundwater. Potential corrective measures for the impacted medium and respective COCs are in Table 10.3.28. A more detailed review of corrective measures for SWMU 38 is also included in Section 9.

CMS decisions based on this risk assessment should consider that the conclusions of this risk assessment are based upon data collected prior to Interim Measures (IM) activities. In 1997, the CEERD removed pesticide- and PCB-impacted soil as an IM. This removal included sample 038SB00101, which contained the only TPH detection (2,400 ppm) at SWMU 38.

Table 10.3.28
Potential Corrective Measures for SWMU 38

Medium	Compounds	Potential Corrective Measures
Soil	DDD, DDE, DDT, Aroclor-1260, arsenic, aluminum, beryllium, and TPH	a) No Action/Intrinsic Remediation b) No Action/Intrinsic Remediation and Monitoring c) Containment by capping d) Excavation and Landfill, if RCRA-nonhazardous waste e) In-Situ, biological, chemical, and physical treatment f) Ex-Situ, biological, chemical, and physical treatment
Shallow Groundwater	Arsenic and thallium, DDD, DDT	a) No Action/Intrinsic Remediation b) No Action/Intrinsic Remediation and Monitoring c) In-Situ, biological, chemical, and physical treatment d) Ex-Situ, biological, chemical, and physical treatment

10.4 SWMU 39, Former POL Drum Storage Area, Building 1604

SWMU 39 is the site of a former storage area for petroleum, oil, and lubricant (POL) drums north of Building 1604, near the northern boundary of NAVBASE. The Hess Oil, Inc. tank farm is adjacent to this boundary, so the scope of the investigation included assessment of potential petroleum releases from offsite tanks.

Materials of concern identified in the *Zones A and B RFI Work Plan* for SWMU 39 included petroleum, oils, and lubricants (POLs). Potential receptors included current and future site users involved in invasive activities.

To fulfill RFI objectives, soil and groundwater were sampled in accordance with the *Final Zones A and B RFI Work Plan* and as described in Section 3 of this report to confirm whether any contamination resulted from onsite activities at SWMU 39 or from offsite sources.

10.4.1 Soil Sampling and Analysis

Soil was sampled in three rounds from the locations shown on Figure 10.4.1. The *Final Zones A and B RFI Work Plan*, (E/A&H, September 1995) proposed collection of 15 soil samples from the upper interval (0 to 1 foot) and 15 from the lower interval (3 to 5 feet) for the SWMU 39 investigation area. Forty-three samples from the upper interval and 43 from the lower interval were collected. The first round occurred during the field investigation for Zone A. Pesticides, SVOCs, and TPH were detected in several soil samples collected at the site during the first round. As part of the Zones A and B second-round RFI sampling, 25 additional soil borings were sampled at SWMU 39. Due to the presence of VOCs in groundwater at the site, three additional soil borings were sampled under Building 1604 for source investigation (third round).

Also, a Geoprobe investigation was conducted at this site based upon the first-round data (Section 10.4.5). Twenty-one Geoprobe borings were pushed, and a subsurface soil sample

(2 feet to 4 feet) and a shallow groundwater sample (5 feet to 18 feet) were collected from each boring for onsite VOC analysis.

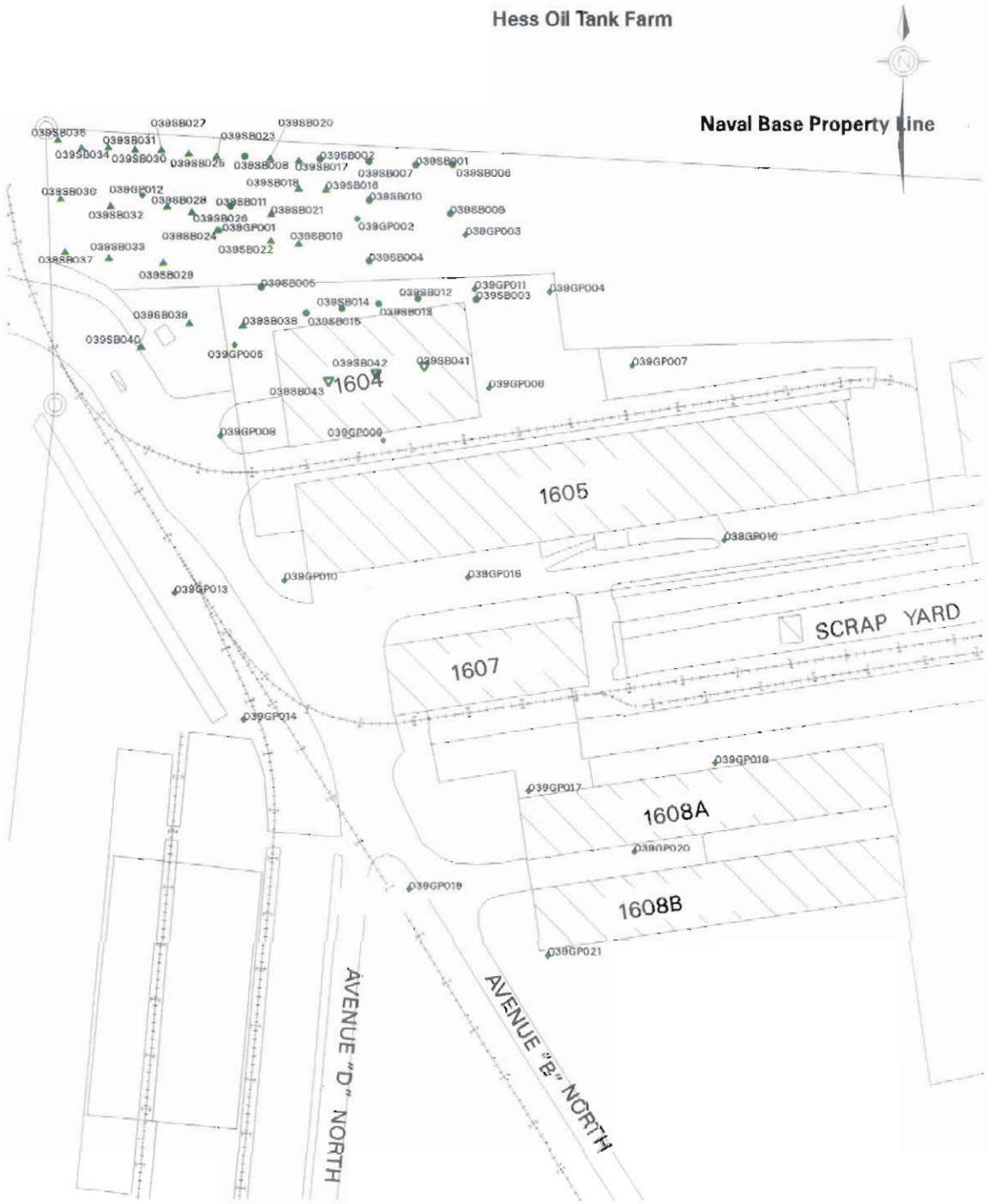
During the installation of NBCA-039-10I, soil with petroleum odor was encountered at 3 feet to 5 feet bgs. A biased sample of this soil was collected for VOC and SVOC analyses. These data are included in the lower-interval dataset.

At SWMU 39, 108 soil samples were collected — 43 from the upper interval, 44 from the lower interval, and 21 from the Geoprobe interval. First-round samples (15 upper interval and 15 lower interval) were submitted for analysis at DQO Level III for VOCs, SVOCs, metals, pesticides, PCBs, and TPH. Two duplicates were collected and submitted for Appendix IX analyses at DQO Level IV.

All second-round samples (25 upper and 25 lower) were analyzed at DQO Level III for TPH, five upper interval second-round samples were also submitted for pesticide and PCB analysis, and four upper interval second-round samples were also analyzed for SVOCs. One duplicate was collected and submitted for Appendix IX analysis at DQO Level IV. The three third-round samples, upper and lower-intervals, were analyzed for VOCs only.

The 21 Geoprobe interval samples were analyzed by the onsite laboratory, Analytical Mobile Services, for VOCs. Five samples were duplicated for offsite VOC analysis by Lockheed Analytical Services. Table 10.4.1 summarizes first, second, third, and Geoprobe rounds of sampling at SWMU 39.

The biased sample, 039SB10I02, was analyzed at DQO Level III for VOCs and SVOCs.



LEGEND

- 1st Round Soil Borings
- 2nd Round Soil Borings
- 3rd Round Soil Borings
- Geoprobe Borings

0 200 feet

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.4.1 - SWMU 39
Soil Sample Locations

Table 10.4.1
SWMU 39
Soil Sampling Summary

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper (0' to 1')	15	43	VOCs, SVOCs, pesticides, PCBs, TPH, and metals.	VOCs, SVOCs, pesticides, PCBs, TPH, and metals for first-round samples. TPH for all 25, SVOCs for 4, and pesticides and PCBs for 5 second-round samples. VOCs for all three third-round samples.	Twenty-five additional samples were collected for site characterization. Three additional samples were collected for source investigation.
Lower (3' to 5')	15	44	VOCs, SVOCs, pesticides, PCBs, TPH, and metals.	VOCs, SVOCs, pesticides, PCBs, TPH, and metals for first-round samples. TPH for all 25 second round samples. VOCs for all three third-round samples.	Twenty-five additional samples were collected for site characterization. Three additional samples were collected for source investigation. One additional biased sample was collected to investigate petroleum odor.
Geoprobe (2' to 4')	21	21	VOCs	VOCs	None[a]

Note:
[a] = These samples were collected during the Geoprobe investigation and analyzed by an onsite laboratory; five were duplicated for offsite confirmation analysis.

10.4.2 Nature and Extent of Contamination in Soil

Organic compound analytical results for soil are summarized in Table 10.4.2. Inorganic analytical results are summarized in Table 10.4.3. Appendix D is a complete analytical data report for all samples collected in Zone A, including SWMU 39.

Volatile Organic Compounds in Soil

No VOCs were detected above their respective RBCs in upper-interval soil samples collected at SWMU 39. Also, no VOCs were detected in the biased lower-interval sample collected from NBCA-039-10I. Five compounds exceeded their SSLs in lower-interval samples, consisting of: benzene, 1,2-dichloroethane, ethylbenzene, trichloroethene, and 1,3,5-trimethylbenzene.

Benzene has an SSL of 17 μg/kg and both lower-interval detections exceeded this concentration. The exceedances were in samples 039SB00802 (990 μg/kg) and 039SB01102 (61 μg/kg).

1,2-dichloroethane has an SSL of 12 μg/kg and the only lower-interval detection exceeded this concentration. The exceedance was in sample 039SB01102 (25 μg/kg).

Ethylbenzene has an SSL of 6,700 μg/kg and one of two lower-interval detections exceeded this concentration. The exceedance was in sample 039SB00802 (22,000 μg/kg).

Trichloroethene has an SSL of 28 μg/kg and although none of three lower-interval detections exceeded this concentration, two of four geoprobe-interval detections exceeded the SSL. The exceedances were in samples 039SP00801 (123 μg/kg) and 039SP00901 (907 μg/kg).

1,3,5-trimethylbenzene has an SSL of 260 μg/kg and although this compound was not detected in any lower-interval samples, one of two geoprobe-interval detections exceeded the SSL. The exceedance was in sample 039SP00901 (580 μg/kg).

Table 10.4.2
SWMU 39
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Volatile Organic Compounds (58 samples collected: 18 upper interval, 19 lower interval, and 21 Geoprobe[a] interval, 7 samples duplicated)						
Acetone	Upper	12/18	11 - 74	32	7,800,000	0
	Lower	13/19	8.7 - 140	38	NA	NA
	Geoprobe[a]	5/21	4.1 - 3,500	907	NA	NA
Benzene	Upper	0/18	NA	NA	22,000	0
	Lower	2/19	61 - 990	526	NA	NA
	Geoprobe	1/21	4.9	NA	NA	NA
2-butanone (MEK)	Upper	3/18	3.6 - 11	7.0	47,000,000	0
	Lower	5/19	2.3 - 5.0	4.0	NA	NA
	Geoprobe	1/21	3.3	NA	NA	NA
n-butylbenzene	Upper	0/18	NA	NA	780,000	0
	Lower	0/19	NA	NA	NA	NA
	Geoprobe	3/21	19.3 - 125	59.6	NA	NA
sec-butylbenzene	Upper	0/18	NA	NA	780,000	0
	Lower	0/19	NA	NA	NA	NA
	Geoprobe	3/21	18.9 - 118	57.8	NA	NA
tert-butylbenzene	Upper	0/18	NA	NA	780,000	0
	Lower	0/19	NA	NA	NA	NA
	Geoprobe	2/21	6.3 - 25.8	16.1	NA	NA
Carbon disulfide	Upper	1/18	1.2	NA	7,800,000	0
	Lower	1/19	1.8	NA	NA	NA
	Geoprobe	0/21	NA	NA	NA	NA

Table 10.4.2
SWMU 39
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Volatile Organic Compounds (58 samples collected: 18 upper interval, 19 lower interval, and 21 Geoprobe[a] interval, 7 samples duplicated)						
1,2-dichlorobenzene	Upper	1/18	1.2	NA	7,000,000	0
	Lower	0/19	NA	NA	NA	NA
	Geoprobe	0/21	NA	NA	NA	NA
1,2-dichloroethane	Upper	1/18	1.2	NA	7,000	0
	Lower	1/19	25.0	NA	NA	NA
	Geoprobe	0/21	NA	NA	NA	NA
cis-1,2-dichloroethene	Upper	2/18	10 - 200	105	780,000	0
	Lower	5/19	2.0 - 51	18	NA	NA
	Geoprobe	3/21	12.6 - 67	32.3	NA	NA
trans-1,2-dichloroethene	Upper	1/18	4.1	NA	1,600,000	0
	Lower	1/19	4.5	NA	NA	NA
	Geoprobe	0/21	NA	NA	NA	NA
Ethylbenzene	Upper	2/18	1.9 - 150	76	7,800,000	0
	Lower	2/19	92 - 22,000	11,000	NA	NA
	Geoprobe	2/21	121 - 1,174	648	NA	NA
2-Hexanone	Upper	1/18	1.8	NA	3,100,000	NA
	Lower	0/19	NA	NA	NA	NA
	Geoprobe	0/21	NA	NA	NA	NA
Isopropylbenzene	Upper	0/18	NA	NA	NA	NA
	Lower	0/19	NA	NA	NA	NA
	Geoprobe	3/21	10.4 - 209	83.3	NA	NA

Table 10.4.2
SWMU 39
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Volatile Organic Compounds (58 samples collected: 18 upper interval, 19 lower interval, and 21 Geoprobe[a] interval, 7 samples duplicated)						
4-isopropyltoluene	Upper	0/18	NA	NA	NA	NA
	Lower	0/19	NA	NA	NA	NA
	Geoprobe	2/21	93 - 805	449	NA	NA
Methylene chloride	Upper	1/18	1.2	NA	85,000	0
	Lower	0/19	NA	NA	NA	NA
	Geoprobe	0/21	NA	NA	NA	NA
4-methyl-2-pentanone (MIBK)	Upper	0/18	NA	NA	6,300,000	0
	Lower	2/19	3.2 - 4.0	3.6	NA	NA
	Geoprobe	0/21	NA	NA	NA	NA
Naphthalene[b]	Geoprobe	4/21	23.4 - 570	192	NA	NA
n-propylbenzene	Upper	0/19	NA	NA	780,000	NA
	Lower	0/19	NA	NA	NA	NA
	Geoprobe	3/21	27.7 - 314	128	NA	NA
Tetrachloroethene	Upper	1/18	170	NA	12,000	0
	Lower	0/19	NA	NA	NA	NA
	Geoprobe	2/21	21.4 - 22.0	21.7	NA	NA
Toluene	Upper	5/18	1.5 - 2.3	1.9	16,000,000	0
	Lower	0/19	NA	NA	NA	NA
	Geoprobe	1/21	56.2	NA	NA	NA
1,2,4-trichlorobenzene	Upper	1/18	1.7	NA	780,000	0
	Lower	0/19	NA	NA	NA	NA
	Geoprobe	0/21	NA	NA	NA	NA

Table 10.4.2
SWMU 39
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Volatile Organic Compounds (58 samples collected: 18 upper interval, 19 lower interval, and 21 Geoprobe[a] interval, 7 samples duplicated)						
1,1,1-trichloroethane	Upper	0/18	NA	NA	1,600,000	0
	Lower	1/19	160	NA	NA	NA
	Geoprobe	0/21	NA	NA	NA	NA
Trichloroethene	Upper	2/18	3 - 37	20	58,000	0
	Lower	3/19	1.0 - 2.3	1.6	NA	NA
	Geoprobe	4/21	3.2 - 907	260	NA	NA
1,2,4-trimethyl-benzene	Upper	0/18	NA	NA	3,900,000	0
	Lower	0/19	NA	NA	NA	NA
	Geoprobe	2/21	71.3 - 727	399	NA	NA
1,3,5-trimethyl-benzene	Upper	0/18	NA	NA	3,900,000	0
	Lower	0/19	NA	NA	NA	NA
	Geoprobe	2/21	14 - 580	297	NA	NA
m,p-xylene	Upper	0/18	NA	NA	160,000,000	0
	Lower	0/19	NA	NA	NA	NA
	Geoprobe	2/21	276 - 1,359	818	NA	NA
o-xylene	Upper	0/18	NA	NA	160,000,000	0
	Lower	2/19	63 - 1,600	830	NA	NA
	Geoprobe	2/21	10.1 - 253	132	NA	NA
Xylene (total)	Upper	2/18	1.8 - 300	151	160,000,000	0
	Lower	3/19	1.3 - 48,000	19,100	NA	NA
	Geoprobe	0/21	NA	NA	NA	NA

Table 10.4.2
SWMU 39
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Semivolatile Organic Compounds (35 samples collected: 19 upper interval and 16 lower interval, 2 samples duplicated for Appendix IX analysis)						
BEQ[c]	Upper	3/19	15.2 - 5,780	1,950	88	1
	Lower	1/16	0.15	NA	NA	NA
Acenaphthene	Upper	1/19	300	NA	4,700,000	0
	Lower	2/16	2,800 - 4,300	3,550	NA	NA
Acenaphthylene	Upper	1/19	730	NA	4,700,000	0
	Lower	0/16	NA	NA	NA	NA
Anthracene	Upper	1/19	1,100	NA	23,000,000	0
	Lower	2/16	1,100 - 1,500	1,300	NA	NA
Benzo(a)anthracene	Upper	3/19	46 - 4,000	1,400	880	1
	Lower	0/16	NA	NA	NA	NA
Benzo(a)pyrene	Upper	1/19	3,500	NA	88	1
	Lower	0/16	NA	NA	NA	NA
Benzo(b)-fluoranthene	Upper	2/19	49 - 6,200	3,120	880	1
	Lower	0/16	NA	NA	NA	NA
Benzo(g,h,i)-perylene	Upper	1/19	2,900	NA	3,100,000[d]	0
	Lower	0/16	NA	NA	NA	NA
Benzo(k)-fluoranthene	Upper	2/19	39 - 3,800	1,920	8,800	0
	Lower	0/16	NA	NA	NA	NA
bis(2-ethylhexyl)-phthalate	Upper	4/19	82 - 6,200	1,820	46,000	0
	Lower	0/16	NA	NA	NA	NA
Butylbenzyl-phthalate	Upper	1/19	44	NA	16,000,000	0
	Lower	0/16	NA	NA	NA	NA

Table 10.4.2
SWMU 39
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Semivolatile Organic Compounds (35 samples collected: 19 upper interval and 16 lower interval, 2 samples duplicated for Appendix IX analysis)						
Carbazole	Upper	1/19	960	NA	32,000	0
	Lower	0/16	NA	NA	NA	NA
Chrysene	Upper	3/19	67 - 6,900	2,380	88,000	0
	Lower	1/16	150	NA	NA	NA
Dibenz(a,h)-anthracene	Upper	1/19	950	NA	88	1
	Lower	0/16	NA	NA	NA	NA
Dibenzofuran	Upper	0/19	NA	NA	310,000	0
	Lower	2/16	4,800 - 6,700	5,750	NA	NA
di-n-octylphthalate	Upper	1/19	49	NA	1,600,000	0
	Lower	0/16	NA	NA	NA	NA
Fluoranthene	Upper	2/19	86 - 350	218	3,100,000	0
	Lower	1/16	380	NA	NA	NA
Fluorene	Upper	1/19	320	NA	3,100,000	0
	Lower	3/16	730 - 10,000	6,040	NA	NA
Indeno(1,2,3-cd)-pyrene	Upper	1/19	2,700	NA	880	1
	Lower	0/16	NA	NA	NA	NA
2-Methylnaphthalene	Upper	3/19	230 - 1,700	890	3,100,000	0
	Lower	1/16	23,000	NA	NA	NA
Naphthalene	Upper	2/19	91 - 1,100	600	3,100,000	0
	Lower	1/16	8,000	NA	NA	NA
Phenanthrene	Upper	4/19	78 - 6,500	1,770	3,100,000[a]	0
	Lower	3/16	590 - 14,000	8,900	NA	NA

Table 10.4.2
SWMU 39
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Semivolatile Organic Compounds (35 samples collected: 19 upper interval and 16 lower interval, 2 samples duplicated for Appendix IX analysis)						
Pyrene	Upper	3/19	78 - 11,000	3,790	2,300,000	0
	Lower	2/16	890 - 1,200	1,050	NA	NA
Pesticides/PCBs (35 samples collected: 20 upper interval and 15 lower interval, 3 samples duplicated for Appendix IX analysis)						
Aroclor-1260	Upper	4/20	26 - 1,100	391	320	2
	Lower	0/15	NA	NA	NA	NA
alpha-chlordane	Upper	2/20	1.8 - 10.0	5.9	1,800	0
	Lower	0/15	NA	NA	NA	NA
gamma-chlordane	Upper	1/20	24.0	NA	1,800	0
	Lower	0/15	NA	NA	NA	NA
4,4'-DDD	Upper	5/20	3.6 - 22.0	11.6	2,700	0
	Lower	1/15	4.5	NA	NA	NA
4,4'-DDE	Upper	7/20	1.1 - 53.0	15.1	1,900	0
	Lower	0/15	NA	NA	NA	NA
4,4'-DDT	Upper	8/20	3.6 - 26.0	13.0	1,900	0
	Lower	1/15	520	NA	NA	NA
Dieldrin	Upper	1/20	13.0	NA	40	0
	Lower	0/15	NA	NA	NA	NA
Endrin aldehyde	Upper	2/20	6.7 - 13.0	9.9	23,000	0
	Lower	0/15	NA	NA	NA	NA
Heptachlor	Upper	1/20	2.0	NA	140	0
	Lower	0/15	NA	NA	NA	NA

Table 10.4.2
SWMU 39
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Dioxins (2 Appendix IX Duplicate samples collected)						
TCDD TEQ[c]	Upper	2/2	0.00376 - 0.00764	0.00250	1	0
Total Petroleum Hydrocarbons (80 samples collected, 40 upper interval and 40 lower interval, samples duplicated for Appendix IX analysis)						
TPH — DRO	Upper	3/40	48,000 - 1,300,000	500,000	NA	NA
	Lower	2/40	14,000,000 - 19,000,000	16,500,000	NA	NA
TPH — GRO	Upper	18/40	11.3 - 380,000	30,600	NA	NA
	Lower	20/40	7.16 - 9,500,000	100,000	NA	NA

Notes:
a = Geoprobe interval samples from Geoprobe investigation were collected from 2' to 4' bgs.
b = SVOC detected during onsite VOC analysis due to short retention time.
c = Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995
d = RBC not available for this compound; fluoranthene RBC used as surrogate.
NA = Not applicable

Table 10.4.3
SWMU 39
Inorganics Detected in Soil

Element	Sample Interval	Frequency of Detections	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	Reference Conc. (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding[a]
Inorganics (30 samples collected: 15 upper interval and 15 lower interval, 2 samples duplicated for Appendix IX analysis)							
Aluminum	Upper	15/15	4,750 - 16,000	8,340	12,800	78,000	0
	Lower	15/15	1,340 - 9,890	6,370	28,240	NA	0
Arsenic	Upper	15/15	1.4 - 17.9	4.9	9.4	0.43	1
	Lower	8/15	1.1 - 5.1	2.1	9.8	NA	0

Table 10.4.3
SWMU 39
Inorganics Detected in Soil

Element	Sample Interval	Frequency of Detections	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	Reference Conc. (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding[a]
Inorganics (30 samples collected: 15 upper interval and 15 lower interval, 2 samples duplicated for Appendix IX analysis)							
Barium	Upper	15/15	10.7 - 41.7	23.5	53.0	5,500	0
	Lower	15/15	3.2 - 23.7	15.6	40.0	NA	0
Beryllium	Upper	2/15	0.24 - 0.45	0.35	**	0.15	2
	Lower	0/15	NA	NA	**	NA	NA
Calcium	Upper	15/15	1,870 - 136,000	27,700	NA	NA	NA
	Lower	15/15	226 - 4,290	1,270	NA	NA	NA
Chromium	Upper	15/15	7.3 - 24.1	13.8	50.4	390	0
	Lower	15/15	2.1 - 18.1	9.5	63.4	NA	0
Cobalt	Upper	13/15	1.4 - 3.5	2.5	4.4	4,700	0
	Lower	10/15	1.5 - 2.5	1.9	1.7	NA	7
Copper	Upper	15/15	1.5 - 32.2	9.6	165	3,100	0
	Lower	13/15	0.88 - 6.1	2.4	33.7	NA	0
Iron	Upper	15/15	4,250 - 16,300	8,370	NA	NA	NA
	Lower	15/15	1,210 - 9,900	4,730	NA	NA	NA
Lead	Upper	15/15	4.0 - 108	24.4	140	400[b]	0
	Lower	15/15	1.7 - 5.6	3.7	22.0	400[b]	0
Magnesium	Upper	15/15	286 - 1,800	891	NA	NA	NA
	Lower	15/15	111 - 830	446	NA	NA	NA
Manganese	Upper	15/15	11.2 - 191	55.0	98.1	1,800	0
	Lower	15/15	3.6 - 27.0	9.8	85.5	NA	0
Mercury	Upper	7/15	0.15 - 2.8	1.3	0.30	23.0	0
	Lower	4/15	1.4 - 2.0	1.7	**	NA	NA
Nickel	Upper	12/15	3.9 - 9.8	6.2	13.6	1,600	0
	Lower	3/15	3.6 - 4.4	4.1	35.0	NA	0
Potassium	Upper	11/15	198 - 813	398	NA	NA	NA
	Lower	6/15	147 - 398	265	NA	NA	NA

Table 10.4.3
SWMU 39
Inorganics Detected in Soil

Element	Sample Interval	Frequency of Detections	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	Reference Conc. (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding[a]
Inorganics (30 samples collected: 15 upper interval and 15 lower interval, 2 samples duplicated for Appendix IX analysis)							
Selenium	Upper	3/15	0.68 - 0.90	0.77	1.2	390	0
	Lower	0/15	NA	NA	1.7	NA	0
Sodium	Upper	15/15	184 - 349	231	NA	NA	NA
	Lower	15/15	183 - 243	214	NA	NA	NA
Vanadium	Upper	15/15	7.50 - 31.4	14.5	29.2	550	0
	Lower	15/15	2.0 - 18.9	9.1	77.3	NA	0
Zinc	Upper	15/15	4.90 - 268	43.1	208	23,000	0
	Lower	15/15	3.40 - 48.1	14.0	165	NA	0

Notes:
[a] = Number of samples exceeding both RBC and RC in upper interval or number of samples exceeding the RC in the lower interval.
[b] = RBC not available for lead. USEPA residential soil cleanup level used for this comparison (OSWER Directive 9355.4-12).
** = Number of nondetects prevented determination of UTL.

Semivolatile Organic Compounds in Soil

Of the 22 SVOCs detected in soil samples at SWMU 39, five were detected in upper interval samples above the respective RBCs: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. All of these RBC exceedances were in one upper-interval sample (039SB00501) and the resulting BEQ calculation also exceeded the RBC. This sample justified analyzing four of the second-round samples for SVOCs to determine the extent of contamination. None of the other samples (including second-round) at SWMU 39 had concentrations that exceeded the respective RBCs for SVOCs.

No subsurface SVOC detections at SWMU 39 exceeded their respective SSLs, including the four compounds (fluorene, 2-methylnaphthalene, naphthalene, and phenanthrene) that were detected in the biased lower-interval sample collected from NBCA-039-10I.

Pesticides/PCBs in Soil

Eight pesticides and one PCB were detected in soil samples collected at SWMU 39. The only RBC exceedance was for the PCB, Aroclor-1260, in two of the upper-interval samples: 039SB01701 (340 μg/kg) and 039SB00201 (1,100 μg/kg), located along the northern NAVBASE property line.

This data justified analyzing five of the second-round samples for pesticides and PCBs to determine the extent of contamination. Only two of the other 17 upper interval samples exhibited Aroclor-1260 detections, samples 039SB00801 (26 μg/kg) and 039SB00701 (98 μg/kg).

No subsurface pesticide or PCB detections at SWMU 39 exceeded their respective SSLs.

Other Organic Compounds in Soil

Dioxins were detected in both duplicate samples collected at SWMU 39. The calculated TEQs were below the 2,3,7,8-TCDD RBC of 1 μg/kg.

TPH detections at SWMU 39 were widespread. Although many of the boreholes exhibited physical evidence of contamination (i.e., strong odor and discoloration), only two of 40 upper-interval samples and three of 40 lower-interval samples were detected at concentrations greater than 100,000 μg/kg. Risk associated with individual TPH constituents (i.e., BTEX, naphthalene, and PAHs) will be addressed in the HHRA for SWMU 39. Spatial distribution of TPH in SWMU 39 soil is shown in Figure 10.4.2.

Inorganics in Soil

Nineteen metals were detected in soil samples collected at SWMU 39. Based upon the comparisons made in Table 10.4.3, four warrant further evaluation: arsenic, beryllium, cobalt, and mercury.

Arsenic was detected at 17.9 mg/kg in sample 039SB00601. This was the only upper-interval detection that exceeded both the RC (9.4 mg/kg) and the RBC (0.43 mg/kg). This detection also exceeds the SSL (15 mg/kg).

Beryllium exceeded the RBC (0.15 mg/kg) in two upper-interval samples, 039SB00601 and 039SB01001 at 0.45 mg/kg and 0.24 mg/kg, respectively. The SSL for beryllium is 32 mg/kg.

Cobalt was detected above the RC (1.7 mg/kg) in seven lower-interval samples. The range of these detections was 1.8 mg/kg to 2.5 mg/kg, which does not exceed cobalt's SSL (990 mg/kg).

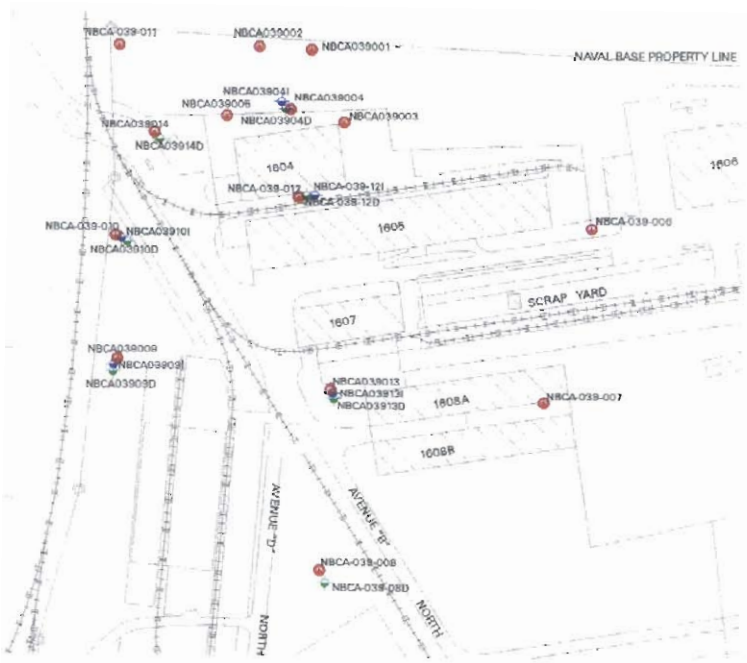
Mercury was detected in four lower-interval samples at a concentration range of 1.4 mg/kg to 2.0 mg/kg. All of these detections exceed the SSL (1 mg/kg) for mercury.

10.4.3 Groundwater Sampling and Analysis

The *Final Zones A and B RFI Work Plan* proposed the installation of one deep and five shallow monitoring wells associated with SWMU 39. The initial well pair (NBCA-039-004 and NBCA-039-04D) is located in the approximate center of the investigation area. The other four initial shallow wells are located between Building 1604 and the northern NAVBASE property line.

Due to VOC detections, the groundwater investigation at SWMU 39 expanded to include: a geoprobe investigation, a cone penetrometer technology (CPT) investigation, installation of 15 shallow monitoring wells, 5 intermediate monitoring wells, and 8 deep monitoring wells. Also, a total of 12 groundwater "sampling events" have been conducted. All well locations are shown on Figure 10.4.3.

Hess Oil Tank Farm



0 400 feet

LEGEND

- Shallow Monitoring Well
- Intermediate Monitoring Well
- Deep Monitoring Well

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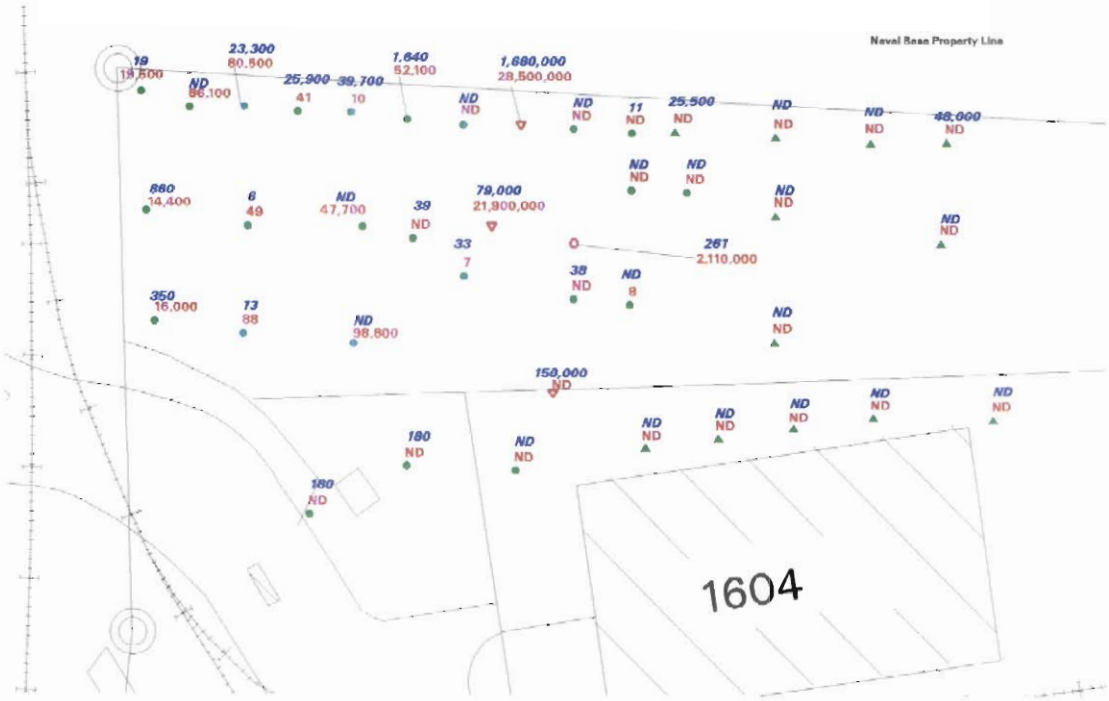
Naval Base Charleston
Charleston, SC

FIGURE 10.4.3 - SWMU 39
Monitoring Well Locations

Hess Oil Tank Farm



LEGEND

- ▲ 1st Round Soil Borings
- ● 2nd Round Soil Borings

● Surface - TPH concentration (ppb)
Subsurface - TPH concentration (ppb)

▽ ○ TPH Concentration (Surface and/or Subsurface) Exceeds 100,000 ppb

Note: ND - Not Detected

0 100 feet

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Charleston, SC

FIGURE 10.4.2 - SWMU 39
TPH Detections in Soil

In order to facilitate the presentation of the logical progression of events that transpired during the groundwater investigation at SWMU 39, a timeline summarizing significant events is provided in Table 10.4.4.

Table 10.4.4
SWMU 39 Groundwater Investigation
Timeline of Events

Date	Event	# of wells installed			# of wells sampled			Comments
		S	I	D	S	I	D	
Oct. 95	MW Installation (Round 1)	5	0	1	0	0	0	Initial wells installed per RFI Work Plan
Dec. 95	GW Sampling	0	0	0	5	0	1	First quarter sampling event
Apr. 96	GW Sampling	0	0	0	5	0	0	"Interim" sampling event to verify VOC detections prior to geoprobe investigation.
Apr. 96	GW Sampling	0	0	0	5	0	1	Second quarter sampling event
Jun. 96	Geoprobe Invest.	21[a]	0	0	28[a]	0	1	Data identified a suspected plume of chlorinated solvent contamination in the vicinity of Bldgs. 1604,1605, & 1607.
Jun. 96	GW Sampling	0	0	0	5	0	1	Third quarter sampling event.
Jul. 96	MW Installation (Round 2)	7	1	2	0	0	0	Based upon the geoprobe investigation, wells were installed to further delineate the suspected plume.
Aug. 96	GW Sampling	0	0	0	7	1	2	"Interim" sampling of Round 2 wells for VOCs.
Sept. 96	CPT Invest.	0	0	29[b]	13[b]	8[b]	0	Investigation both on and off base to further define stratigraphy and sample the offbase region for VOCs.
Sept. 96	MW Installation (Round 3)	0	4	3	0	0	0	Based upon the CPT investigation, additional intermediate and deep wells were installed for vertical delineation.
Sept. 96	GW Sampling	0	0	0	0	4	3	"Interim" sampling of Round 3 wells for VOCs.
Oct. 96	GW Sampling	0	0	0	12	1	3	Fourth quarter event for initial wells, first quarter event for Round 2 wells.
Nov. 96	GW Sampling	0	0	0	0	4	3	First quarter event for Round 3 wells.
Jan. 97	MW Installation (Round 4)	3	0	2	0	0	0	Final data gaps, both horizontal and vertical.

Table 10.4.4
SWMU 39 Groundwater Investigation
Timeline of Events

Date	Event	# of wells installed			# of wells sampled			Comments
		S	I	D	S	I	D	
Feb. 97	GW Sampling	0	0	0	3	0	2	First quarter event for Round 4 wells.
Mar. 97	GW Sampling	0	0	0	7	4	7	Second quarter event for Round 3 and 4 wells.
Jul. 97	GW Sampling	0	0	0	10	5	7	Third quarter event for Round 2, 3, and 4 wells.
Oct. 97	GW Sampling	0	0	0	10	5	7	Fourth quarter event for Round 2, 3, and 4 wells.

Notes:
S = Shallow monitoring well
I = Intermediate monitoring well
D = Deep monitoring well
a = During the geoprobe investigation, 21 borings were installed for collection of a shallow groundwater sample. Seven samples from monitoring wells were also collected for analysis by the onsite laboratory during this investigation.
b = During the CPT investigation, 13 borings were pushed onbase to further define the stratigraphic relationship between the shallow aquifer and the discontinuous clay layers that overlie the intermediate sand unit. Also, 16 borings were pushed in the neighborhood streets offbase. In 13 of these locations, shallow groundwater samples were collected; and in 8 of these locations, intermediate groundwater samples were collected.

After installation and development of the initial six monitoring wells, the first-round RFI samples were collected. Groundwater samples were analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and TPH at DQO Level III. Chlorides, sulfate, and TDS analyses were performed on the deep well sample, 039GW04D01. One shallow groundwater sample was duplicated for Appendix IX analyses at DQO Level IV. Subsequent analytical parameters for SWMU 39 were based upon prior detections and existing data gaps.

The shallow monitoring wells bottom of screen were installed from 12 to 15 feet bgs in the upper sand aquifer, the intermediate wells from 15.5 to 33.5 feet bgs in the intermediate sand unit, and the deep wells from 19 to 54.5 feet bgs in the lower sand aquifer. Site-specific geologic conditions are presented in Section 10.4.8 of this report. All wells were installed as described in Section 3.3 of this report.

10.4.4 Nature and Extent of Contamination in Groundwater

Due to the number of installation and sampling events, groundwater data for SWMU 39 has been uniquely formatted for presentation. There are fifteen locations of individual wells, well pairs, or well clusters. Tables 10.4.5 through 10.4.19 include summaries for both organic and inorganic groundwater analytical results for all samples collected at each of these locations. Appendix D is a complete analytical data report for all samples collected in Zone A, including those collected at SWMU 39.

Table 10.4.5
SWMU 39 - Compounds Detected in Groundwater
Individual Well NBCA-039-001

Compound	Event "01"	Event "11"	Event "02"	Event "03"	Event "04"	RBC	RC	# of Samples Exceeding RC and RBC
VOCs (μg/L)								
Benzene	25	36	47	35	110	0.36	NA	5
2-butanone (MEK)	3.3	<DL	<DL	<DL	<DL	1,900	NA	0
Ethylbenzene	10	7	9	10	34	1,300	NA	0
Toluene	<DL	2	3.9	2.2	4	750	NA	0
xylene (m+p)	<DL	59	68	81	<DL	12,000	NA	0
o-xylene	1.3	<DL	1.8	2.1	<DL	12,000	NA	0
xylene (total)	91	<DL	<DL	<DL	72	12,000	NA	0
SVOCs (μg/L)								
2-methylnaphthalene	<DL	—	5	<DL	4	1,500	NA	0
bis(2-ethylhexyl)-phthalate	<DL	—	<DL	13	<DL	4.8	NA	1
Metals (μg/L)								
Aluminum	197	—	<DL	117	<DL	37,000	3,210	0
Arsenic	43.8	—	34.6	39.1	36.7	0.045	7.4	4
Barium	36.7	—	<DL	27.6	30.6	2,600	104	0
Calcium	64,600	—	61,500	55,500	63,600	NA	NA	NA
Copper	<DL	—	<DL	<DL	2.1	1,500	15.7	0
Iron	36,600	—	31,900	28,300	31,200	NA	NA	NA
Magnesium	7,560	—	7,410	6,710	7,670	NA	NA	NA

Table 10.4.5
SWMU 39 - Compounds Detected in Groundwater
Individual Well NBCA-039-001

Compound	Event "01"	Event "11"	Event "02"	Event "03"	Event "04"	RBC	RC	# of Samples Exceeding RC and RBC
Manganese	904	—	932	794	969	840	577	3
Potassium	3,260	—	2,170	3,170	4,460	NA	NA	NA
Sodium	19,000	—	<DL	17,700	20,500	NA	NA	NA
Zinc	<DL	—	<DL	12.8	<DL	11,000	83.2	0
Other Parameters								
Chloride (mg/L)	—	—	—	7.8	<DL	NA	NA	NA
Sulfate (mg/L)	—	—	—	<DL	<DL	NA	NA	NA
TDS (mg/L)	—	—	—	70	256	NA	NA	NA
Hexavalent chromium (mg/L)	—	—	<DL	<DL	—	0.18	NA	0
TCDD TEQ [a] (pg/L)	—	—	—	—	1.47	0.43	NA	1
Pesticides	<DL	—	—	—	—	NA	NA	0
PCBs	<DL	—	—	—	—	NA	NA	0
TPH	<DL	—	—	—	—	NA	NA	NA

Notes:

a	=	Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995.
NA	=	Not applicable
<DL	=	Below detection limit
01	=	First-quarter sampling event (12/95)
11	=	Interim sampling event (4/96)
02	=	Second-quarter sampling event (4/96)
03	=	Third-quarter sampling event (6/96)
04	=	Fourth-quarter sampling event (10/96)
—	=	Parameter not sampled.

Table 10.4.6
SWMU 39 – Compounds Detected in Groundwater
Individual Well NBCA-039-002

Compound	Event "01"	Event "11"	Event "02"	Event "03"	Event "04"	RBC	RC	# of Samples Exceeding RC and RBC
VOCs (μg/L)								
All compounds	<DL	<DL	<DL	<DL	<DL	NA	NA	0
SVOCs (μg/L)								
All compounds	<DL	–	<DL	<DL	<DL	NA	NA	0
Metals (μg/L)								
Aluminum	2,490	–	1,280	6,610	462	37,000	3,210	0
Arsenic	33.1	–	40.7	48.1	43.6	0.045	7.4	4
Barium	44.2	–	<DL	36.5	34.1	2,600	104	0
Calcium	70,000	–	59,900	52,700	52,800	NA	NA	NA
Chromium	8.3	–	<DL	<DL	<DL	180	8.7	0
Cobalt	8.7	–	<DL	9.5	3.4	2,200	**	0
Copper	9.8	–	<DL	<DL	1.2	1,500	15.7	0
Iron	9,330	–	8,700	7,250	7,880	NA	NA	NA
Lead	3.6	–	<DL	4.2	<DL	15.0 *	4.7	0
Magnesium	3,740	–	2,950	2,510	2,740	NA	NA	NA
Manganese	1,240	–	1,120	1,070	1,100	840	577	4
Potassium	1,920	–	<DL	3,170	2,170	NA	NA	NA
Sodium	18,500	–	<DL	14,600	13,800	NA	NA	NA
Vanadium	5.6	–	<DL	<DL	<DL	260	5.4	0
Zinc	66.1	–	<DL	6.5	<DL	11,000	83.2	0
Other Parameters								
Chloride (mg/L)	–	–	–	9.6	15	NA	NA	NA
Sulfate (mg/L)	–	–	–	22	18.4	NA	NA	NA
TDS (mg/L)	–	–	–	730	192	NA	NA	NA
Hexavalent chromium (mg/L)	–	–	<DL	<DL	–	0.18	NA	0

Table 10.4.6
SWMU 39 - Compounds Detected in Groundwater
Individual Well NBCA-039-002

Compound	Event "01"	Event "11"	Event "02"	Event "03"	Event "04"	RBC	RC	# of Samples Exceeding RC and RBC
TCDD TEQ [b] (pg/L)	—	—	—	—	0.11	0.43	NA	0
Pesticides	<DL	—	—	—	—	NA	NA	0
PCBs	<DL	—	—	—	—	NA	NA	0
TPH	<DL	—	—	—	—	NA	NA	NA

Notes:

a	=	Lead does not have an RBC or MCL. Therefore, the USEPA Treatment Technique Action Level of 15 μg/L has been substituted for the RBC.
b	=	Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995.
**	=	Number of non-detects prevented determination of UTL.
NA	=	Not applicable
<DL	=	Below detection limit
01	=	First-quarter sampling event (12/95)
11	=	Interim sampling event (4/96)
02	=	Second-quarter sampling event (4/96)
03	=	Third-quarter sampling event (6/96)
04	=	Fourth-quarter sampling event (10/96)
—	=	Parameter not sampled.

Table 10.4.7
SWMU 39 - Compounds Detected in Groundwater
Individual Well NBCA-039-003

Compound	Event "01"	Event "11"	Event "02"	Event "03"	Event "04"	RBC	RC	# of Samples Exceeding RC and RBC
VOCs (μg/L)								
Tetrachloroethene	16	7	9.2	11.5	8	1.1	NA	5
Trichloroethene	41	44	49	91	30	1.6	NA	5
cis-1,2-dichloroethene	4.8	3	3	6.5	3	61	NA	0
1,1-dichloroethene	<DL	<DL	<DL	1.1	<DL	0.044	NA	1
1,1,2,2-tetrachloroethane	<DL	<DL	<DL	1.4	<DL	0.052	NA	1
Dibromochloromethane	<DL	<DL	5.5	<DL	<DL	730[a]	NA	0
1,2-dibromo-3-chloropropane	<DL	<DL	<DL	3	<DL	0.048	NA	1

Table 10.4.7
SWMU 39 - Compounds Detected in Groundwater
Individual Well NBCA-039-003

Compound	Event "01"	Event "11"	Event "02"	Event "03"	Event "04"	RBC	RC	# of Samples Exceeding RC and RBC
2-hexanone	<DL	<DL	<DL	4.4	<DL	1,500	NA	0
4-methyl-2-pentanone (MIBK)	<DL	<DL	<DL	3.3	<DL	2,900	NA	0
SVOCs (μg/L)								
bis(2-ethylhexyl)-phthalate	<DL	—	<DL	<DL	2	4.8	NA	0
Metals (μg/L)								
Aluminum	707	—	1,940	217	87.8	37,000	3,210	0
Arsenic	<DL	—	<DL	3.3	<DL	0.045	7.4	0
Barium	26.7	—	<DL	23.2	23.9	2,600	104	0
Calcium	61,100	—	57,700	50,500	57,500	NA	NA	NA
Chromium	<DL	—	6.9	<DL	<DL	180	8.7	0
Cobalt	<DL	—	<DL	4.3	<DL	2,200	**	0
Copper	<DL	—	7.7	<DL	7.2	1,500	15.7	0
Iron	1,390	—	3,400	656	108	NA	NA	NA
Magnesium	3,820	—	3,830	4,050	3,420	NA	NA	NA
Manganese	52.7	—	58.7	64.7	48.4	840	577	0
Potassium	1,320	—	1,590	2,430	2,115	NA	NA	NA
Silver	<DL	—	<DL	<DL	1.1	180	**	0
Sodium	20,600	—	<DL	20,200	18,900	NA	NA	NA
Vanadium	4.1	—	7.0	<DL	0.83	260	5.4	0
Zinc	<DL	—	<DL	5.3	<DL	11,000	83.2	0
Other Parameters								
Chloride (mg/L)	13	—	—	15	12	NA	NA	NA
Sulfate (mg/L)	18	—	—	20	11.1	NA	NA	NA
TDS (mg/L)	240	—	—	440	212	NA	NA	NA
Hexavalent chromium (mg/L)	0.032	—	0.01	<DL	—	0.18	NA	0
TCDD TEQ[b] (pg/L)	<DL	—	0.14	<DL	0.37	0.43	NA	0

Table 10.4.7
SWMU 39 - Compounds Detected in Groundwater
Individual Well NBCA-039-003

Compound	Event "01"	Event "11"	Event "02"	Event "03"	Event "04"	RBC	RC	# of Samples Exceeding RC and RBC
Pesticides	<DL	—	—	—	—	NA	NA	0
PCBs	<DL	—	—	—	—	NA	NA	0
TPH	<DL	—	—	—	—	NA	NA	NA
Cyanide (μg/L)	—	—	<DL	—	—	180	NA	0

Notes:

a	=	Calculated according to the USEPA Region III, *Risk-Based Concentration Table, January-June 1996*, June 3, 1996 using a reference dose of 0.2 mg/kg-day in accordance with IRIS.
b	=	Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995.
**	=	Number of non-detects prevented determination of UTL.
NA	=	Not applicable
<DL	=	Below detection limit
01	=	First-quarter sampling event (12/95)
11	=	Interim sampling event (4/96)
02	=	Second-quarter sampling event (4/96)
03	=	Third-quarter sampling event (6/96)
04	=	Fourth-quarter sampling event (10/96)
—	=	Parameter not sampled.

Table 10.4.8
SWMU 39 - Compounds Detected in Groundwater
Well Cluster NBCA-039-004, NBCA-039-04I, and NBCA-039-04D

	NBCA-039-004							NBCA-039-04I						NBCA-039-04D					
Compound	Event "01"	Event "11"	Event "02"	Event "03"	Event "04"	RC	# of Samples Exceeding RC and RBC	Event "A1"	Event "01"	Event "05"	Event "06"	RBC	# of Samples Exceeding RBC	Event "01"	Event "02"	Event "03"	Event "04"	RC	# of Samples Exceeding RC and RBC
VOCs (μg/L)																			
etrachloroethene	<DL	1	3.8	1.7	<DL	NA	2	<DL	<DL	<DL	<DL	1.1	0	<DL	<DL	<DL	<DL	NA	0
richloroethene	<DL	1	2.3	1.6	<DL	NA	2	<DL	<DL	<DL	<DL	1.6	0	<DL	<DL	<DL	<DL	NA	0
is-1,2-ichloroethene	<DL	1	2.3	1.2	<DL	NA	0	<DL	<DL	<DL	<DL	61	0	<DL	<DL	<DL	<DL	NA	0
,2-dichloroethane	<DL	<DL	<DL	<DL	<DL	NA	0	<DL	<DL	1	<DL	0.12	1	<DL	<DL	<DL	<DL	NA	0
,1,1-ichloroethane	<DL	<DL	<DL	1.3	<DL	NA	0	<DL	<DL	<DL	<DL	540	0	<DL	<DL	<DL	<DL	NA	0
-butanone	3.2	<DL	<DL	<DL	<DL	NA	0	<DL	<DL	<DL	<DL	1,900	0	<DL	<DL	<DL	<DL	NA	0
arbon disulfide	<DL	<DL	<DL	4.6	<DL	NA	0	<DL	<DL	<DL	<DL	1,000	0	<DL	<DL	<DL	<DL	NA	0
hloroform	<DL	<DL	<DL	<DL	<DL	NA	0	8	<DL	<DL	<DL	0.15	1	<DL	<DL	<DL	<DL	NA	0
-hexanone	2	<DL	<DL	<DL	<DL	NA		<DL	<DL	<DL	<DL	1,500	0	<DL	<DL	<DL	<DL	NA	0
oluene	<DL	<DL	<DL	<DL	<DL	NA	0	2	7	<DL	<DL	750	0	<DL	<DL	<DL	<DL	NA	0
VOCs (μg/L)																			
ll compounds	<DL	—	<DL	<DL	<DL	NA	0	—	<DL	<DL	<DL	NA	0	<DL	<DL	<DL	<DL	NA	0
etals (μg/L)																			
luminum	144	—	<DL	<DL	<DL	3,210	0	—	—	—	<DL	37,000	0	67.4	<DL	<DL	<DL	245	0

Table 10.4.8
SWMU 39 – Compounds Detected in Groundwater
Well Cluster NBCA-039-004, NBCA-039-04I, and NBCA-039-04D

	NBCA-039-004							NBCA-039-04I						NBCA-039-04D					
Compound	Event "01"	Event "11"	Event "02"	Event "03"	Event "04"	RC	# of Samples Exceeding RC and RBC	Event "A1"	Event "01"	Event "05"	Event "06"	RBC	# of Samples Exceeding RBC	Event "01"	Event "02"	Event "03"	Event "04"	RC	# of Samples Exceeding RC and RBC
Arsenic	42.6	–	51.4	46.3	48.4	7.4	4	–	–	–	40	0.045	1	<DL	<DL	<DL	<DL	11.1	0
Barium	56.1	–	<DL	57.5	59.6	104	0	–	–	–	33.6	2,600	0	<DL	<DL	<DL	4.1	179	0
Cadmium	<DL	–	<DL	<DL	<DL	**	0	–	–	–	<DL	18	0	<DL	<DL	3.0	<DL	**	0
Calcium	57,000	–	54,700	52,300	51,400	NA	NA	–	–	–	67,600	NA	NA	53,500	54,800	50,700	51,000	NA	NA
Copper	<DL	–	<DL	<DL	4.2	15.7	0	–	–	–	<DL	1,500	0	<DL	<DL	<DL	4.3	5.8	0
Iron	13,200	–	16,600	13,500	12,700	NA	NA	–	–	–	785	NA	NA	395	264	219	168	NA	NA
Magnesium	3,340	–	3,520	3,720	3,180	NA	NA	–	–	–	2,670	NA	NA	3,540	4,060	3,790	3,900	NA	NA
Manganese	2,020	–	1,880	1,910	1,810	577	4	–	–	–	41.9	840	0	91.5	106	96.9	103	2,690	0
Mercury	<DL	–	<DL	<DL	<DL	**	0	–	–	–	0.17	11	0	<DL	<DL	<DL	<DL	**	0
Nickel	<DL	–	<DL	<DL	<DL	**	0	–	–	–	1.1	730	0	<DL	<DL	<DL	<DL	21.1	0
Potassium	1,460	–	<DL	<DL	1,950	NA	NA	–	–	–	1,670	NA	NA	649	<DL	<DL	1,440	NA	NA
Silver	<DL	–	<DL	<DL	<DL	**	0	–	–	–	<DL	180	0	<DL	<DL	<DL	5.2	**	0
Sodium	14,900	–	<DL	13,800	15,200	NA	NA	–	–	–	16,400	NA	NA	12,400	<DL	9,510	9,770	NA	NA
Tin	<DL	–	<DL	<DL	<DL	**	0	–	–	–	<DL	22,000	0	<DL	<DL	16.9	<DL	**	0
Zinc	<DL	–	<DL	4.9	<DL	83.2	0	–	–	–	94.4	11,000	0	<DL	<DL	<DL	<DL	66.2	0

Table 10.4.8
SWMU 39 - Compounds Detected in Groundwater
Well Cluster NBCA-039-004, NBCA-039-04I, and NBCA-039-04D

	NBCA-039-004							NBCA-039-04I						NBCA-039-04D					
Compound	Event "01"	Event "11"	Event "02"	Event "03"	Event "04"	RC	# of Samples Exceeding RC and RBC	Event "A1"	Event "01"	Event "05"	Event "06"	RBC	# of Samples Exceeding RBC	Event "01"	Event "02"	Event "03"	Event "04"	RC	# of Samples Exceeding RC and RBC
Other Parameters																			
Chloride (mg/L)	–	–	–	11	9	NA	NA	–	–	–	–	NA	NA	16	–	15	15	NA	NA
Sulfate (mg/L)	–	–	–	11	10.8	NA	NA	–	–	–	–	NA	NA	11	–	<DL	<DL	NA	NA
TDS (mg/L)	–	–	–	480	200	NA	NA	–	–	–	–	NA	NA	200	–	420	230	NA	NA
Hexavalent chromium (mg/L)	–	–	<DL	<DL	–	NA	0	–	–	–	–	0.18	NA	–	<DL	<DL	–	NA	0
TCDD TEQ * (pg/L)	–	–	–	0.42	0.58	NA	1	–	–	–	–	0.43	NA	–	–	0.42	0.04	NA	0
Pesticides	<DL	–	–	–	–	NA	0	–	–	–	–	NA	NA	<DL	–	–	–	NA	0
PCBs	<DL	–	–	–	–	NA	0	–	–	–	–	NA	NA	<DL	–	–	–	NA	0
TPH	<DL	–	–	–	–	NA	0	–	–	–	–	NA	NA	<DL	–	–	–	NA	0

otes:

	=	Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995.
	=	Number of non-detects prevented determination of UTL.
A	=	Not applicable
DL	=	Below detection limit
	=	First-quarter sampling event (12/95), shallow and deep well.
	=	Interim sampling event (4/96), shallow well
	=	Second-quarter sampling event (4/96), shallow and deep well.
	=	Third-quarter sampling event (6/96), shallow and deep well.
	=	Fourth-quarter sampling event (10/96), shallow and deep well.
	=	Interim sampling event (9/96), intermediate well.
	=	First-quarter sampling event (11/96), intermediate well.
	=	Third-quarter sampling event (7/97), intermediate well. No second-quarter sample collected.
	=	Fourth-quarter sampling event (7/97), intermediate well.
	=	Parameter not sampled.

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Table 10.4.9
SWMU 39 - Compounds Detected in Groundwater
Individual Well NBCA-039-005

Compound	Event "01"	Event "11"	Event "02"	Event "03"	Event "04"	RBC	RC	# of Samples Exceeding RC and RBC
VOCs (μg/L)								
Vinyl chloride	1.9	<DL	<DL	5.8	<DL	0.019	NA	2
1,1-dichloroethane	1.1	<DL	<DL	2	<DL	810	NA	0
Benzene	90	71	100	170	78	0.36	NA	5
Ethylbenzene	1.4	1	3	1.1	<DL	1,300	NA	0
Toluene	<DL	<DL	1.7	1.3	<DL	750	NA	0
xylene (m+p)	<DL	2	11	4.5	<DL	12,000	NA	0
o-xylene	<DL	<DL	1.5	1.9	<DL	12,000	NA	0
SVOCs (μg/L)								
Acenaphthene	<DL	—	<DL	<DL	2	2,200	NA	0
Anthracene	<DL	—	<DL	2.2	<DL	11,000	NA	0
bis(2-ethylhexyl) phthalate	13	—	<DL	5.1	<DL	4.8	NA	2
Dibenzofuran	4.6	—	4.1	3.5	4	150	NA	0
Fluorene	4	—	3.9	2.7	4	1,500	NA	0
2-methylnaphthalene	13	—	23	14	3	1,500	NA	0
Naphthalene	9.1	—	64	35	<DL	1,500	NA	0
Phenanthrene	3	—	2.8	2.1	3	1,100*	NA	0
Metals (μg/L)								
Aluminum	1,380	—	760	287	<DL	37,000	3,210	0
Arsenic	61.3	—	66.8	74.9	77.7	0.045	7.4	4
Barium	50.6	—	<DL	43.9	46.9	2,600	104	0
Calcium	76,000	—	69,100	62,500	61,100	NA	NA	NA
Chromium	5.8	—	<DL	<DL	<DL	180	8.7	0
Copper	10.8	—	<DL	<DL	2	1,500	15.7	0
Iron	54,400	—	57,200	50,500	47,100	NA	NA	NA
Magnesium	5,360	—	4,440	3,750	3,970	NA	NA	NA
Manganese	2,050	—	2,040	1,890	1,840	840	577	4

Table 10.4.9
SWMU 39 - Compounds Detected in Groundwater
Individual Well NBCA-039-005

Compound	Event "01"	Event "11"	Event "02"	Event "03"	Event "04"	RBC	RC	# of Samples Exceeding RC and RBC
Potassium	1,390	—	1,620	<DL	1,850	NA	NA	NA
Sodium	18,900	—	<DL	14,200	15,400	NA	NA	NA
Zinc	65.2	—	<DL	3.6	<DL	11,000	83.2	0
Other Parameters								
Chloride (mg/L)	—	—	—	8.5	9	NA	NA	NA
Sulfate (mg/L)	—	—	—	<DL	<DL	NA	NA	NA
TDS (mg/L)	—	—	—	280	218	NA	NA	NA
Hexavalent chromium (mg/L)	—	—	<DL	<DL	—	0.18	NA	0
TCDD TEQ [b] (pg/L)	—	—	—	0.50	0.21	0.43	NA	1
Pesticides	<DL	—	—	—	<DL	NA	NA	0
PCBs	<DL	—	—	—	<DL	NA	NA	0
TPH — DRO (mg/L)	<DL	—	—	—	0.5	NA	NA	NA
TPH — GRO (mg/L)	<DL	—	—	—	3.5	NA	NA	NA
Cyanide (μg/L)	—	—	—	—	<DL	180	NA	0

Notes:

a	=	Phenanthrene does not have an RBC. Pyrene RBC used as surrogate.
b	=	Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995.
NA	=	Not applicable
<DL	=	Below detection limit
01	=	First-quarter sampling event (12/95)
11	=	Interim sampling event (4/96)
02	=	Second-quarter sampling event (4/96)
03	=	Third-quarter sampling event (6/96)
04	=	Fourth-quarter sampling event (10/96)
—	=	Parameter not sampled.

Table 10.4.10
SWMU 39 - Compounds Detected in Groundwater
Individual Well NBCA-039-006

Compound	Event "0A"	Event "04"	Event "05"	Event "06"	RBC	RC	# of Samples Exceeding RC and RBC
VOCs (μg/L)							
Chlorobenzene	1.5	<DL	3	4	39	NA	0
SVOCs (μg/L)							
Benzoic acid	—	<DL	<DL	1	150,000	NA	0
Bis(2-ethylhexyl)phthalate	—	<DL	<DL	2	4.8	NA	0
Diethylphthalate	—	<DL	1	<DL	29,000	NA	0
Metals (μg/L)							
Aluminum	—	1,340	—	<DL	37,000	3,210	0
Arsenic	—	<DL	—	5.6	0.045	7.4	0
Barium	—	70.5	—	83.9	2,600	104	0
Cadmium	—	<DL	—	0.97	18	**	0
Calcium	—	35,300	—	40,000	NA	NA	NA
Chromium	—	2.2	—	<DL	180	8.7	0
Iron	—	9,870	—	20,500	NA	NA	NA
Lead	—	2.9	—	<DL	15.0 [a]	4.7	0
Magnesium	—	21,700	—	29,100	NA	NA	NA
Manganese	—	47.3	—	62.8	840	577	0
Mercury	—	<DL	—	1	11	**	0
Nickel	—	<DL	—	0.83	730	**	0
Potassium	—	42,000	—	30,600	NA	NA	NA
Sodium	—	255,000	—	347,000	NA	NA	NA
Vanadium	—	2.9	—	<DL	260	5.4	0

Table 10.4.10
SWMU 39 - Compounds Detected in Groundwater
Individual Well NBCA-039-006

Compound	Event "0A"	Event "04"	Event "05"	Event "06"	RBC	RC	# of Samples Exceeding RC and RBC
Other Parameters							
Chloride (mg/L)	—	342	—	—	NA	NA	NA
Sulfate (mg/L)	—	<DL	—	—	NA	NA	NA
TDS (mg/L)	—	916	—	—	NA	NA	NA
TCDD TEQ [b] (pg/L)	—	0.03	—	—	0.43	NA	0

Notes:

a	=	Lead does not have an RBC or MCL. Therefore, the USEPA Treatment Technique Action Level of 15 μg/L has been substituted for the RBC.
b	=	Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995.
**	=	Number of non-detects prevented determination of UTL.
NA	=	Not applicable
<DL	=	Below detection limit
0A	=	Interim sampling event (8/96)
04	=	First-quarter sampling event (10/96) for this well that was conducted during the fourth-quarter sampling event.
05	=	Third-quarter sampling event (7/97) for this well. No second-quarter sample collected.
06	=	Fourth-quarter sampling event (10/97) for this well.
—	=	Parameter not sampled.

Table 10.4.11
SWMU 39 - Compounds Detected in Groundwater
Individual Well NBCA-039-007

Compound	Event "0A"	Event "04"	Event "05"	Event "06"	RBC	RC	# of Samples Exceeding RC and RBC
VOCs (μg/L)							
1,1-dichloroethene	1.2	<DL	<DL	<DL	0.044	NA	1
SVOCs (μg/L)							
All compounds	—	<DL	<DL	<DL	NA	NA	0
Metals (μg/L)							
Aluminum	—	<DL	—	72.2	37,000	3,210	0
Arsenic	—	3.3	—	9.6	0.045	7.4	1

Table 10.4.11
SWMU 39 - Compounds Detected in Groundwater
Individual Well NBCA-039-007

Compound	Event "0A"	Event "04"	Event "05"	Event "06"	RBC	RC	# of Samples Exceeding RC and RBC
Barium	—	65.5	—	62.1	2,600	104	0
Cadmium	—	<DL	—	0.59	18	**	0
Calcium	—	107,000	—	103,000	NA	NA	NA
Iron	—	5,090	—	12,200	NA	NA	NA
Magnesium	—	25,800	—	21,400	NA	NA	NA
Manganese	—	41.5	—	58.4	840	577	0
Mercury	—	<DL	—	0.3	11	**	0
Nickel	—	<DL	—	0.87	730	**	0
Potassium	—	24,600	—	12,200	NA	NA	NA
Sodium	—	136,000	—	54,800	NA	NA	NA
Other Parameters							
Chloride (mg/L)	—	173	—	—	NA	NA	NA
Sulfate (mg/L)	—	<DL	—	—	NA	NA	NA
TDS (mg/L)	—	744	—	—	NA	NA	NA
TCDD TEQ [a] (pg/L)	—	0.28	—	—	0.43	NA	0

Notes:

a	=	Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995.
**	=	Number of non-detects prevented determination of UTL.
NA	=	Not applicable
<DL	=	Below detection limit
0A	=	Interim sampling event (8/96)
04	=	First-quarter sampling event (10/96) for this well that was conducted during the fourth-quarter sampling event.
05	=	Third-quarter sampling event (7/97) for this well. No second-quarter sample collected.
06	=	Fourth-quarter sampling event (10/97) for this well.
—	=	Parameter not sampled.

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Table 10.4.12
SWMU 39 – Compounds Detected in Groundwater
Well Pair NBCA-039-008 and NBCA-039-08D

	NBCA-039-008								NBCA-039-08D						
Compound	**Event "0A"**	**Event "04"**	**Event "A2"**	**Event "05"**	**Event "06"**	**RBC**	**RC**	**# of Samples Exceeding RC and RBC**	**Event "0A"**	**Event "04"**	**Event "A2"**	**Event "05"**	**Event "06"**	**RC**	**# of Samples Exceeding RC and RBC**
VOCs (μg/L)															
Acetone	<DL	<DL	<DL	<DL	<DL	3,700	NA	0	<DL	13	<DL	<DL	<DL	NA	0
2-butanone	<DL	<DL	<DL	<DL	<DL	1,900	NA	0	<DL	<DL	18	<DL	<DL	NA	0
Carbon disulfide	<DL	<DL	<DL	<DL	<DL	1,000	NA	0	10	<DL	<DL	<DL	<DL	NA	0
SVOCs (μg/L)															
Acenaphthene	—	2	<DL	<DL	<DL	2,200	NA	0	—	<DL	<DL	<DL	<DL	NA	0
Dibenzofuran	—	<DL	<DL	<DL	<DL	150	NA	0	—	5	2	3	<DL	NA	0
Di-n-butylphthalate	—	<DL	<DL	<DL	<DL	3,700	NA	0	—	<DL	<DL	1	<DL	NA	0
Fluorene	—	<DL	<DL	<DL	6	1,500	NA	0	—	<DL	<DL	<DL	6	NA	0
2-methylnaphthalene	—	5	<DL	<DL	5	1,500	NA	0	—	<DL	<DL	<DL	5	NA	0
Naphthalene	—	110	13	4	<DL	1,500	NA	0	—	7	2	2	4	NA	0
Metals (μg/L)															
Aluminum	—	<DL	28.6	—	2,430	37,000	3,210	0	—	<DL	138	—	187	245	0
Arsenic	—	9.3	<DL	—	17.3	0.045	7.4	2	—	14.3	17.2	—	13.1	11.1	3

Table 10.4.12
SWMU 39 – Compounds Detected in Groundwater
Well Pair NBCA-039-008 and NBCA-039-08D

	NBCA-039-008								NBCA-039-08D						
Compound	Event "0A"	Event "04"	Event "A2"	Event "05"	Event "06"	RBC	RC	# of Samples Exceeding RC and RBC	Event "0A"	Event "04"	Event "A2"	Event "05"	Event "06"	RC	# of Samples Exceeding RC and RBC
Barium	—	45	50.8	—	51.6	2,600	104	0	—	36	20.6	—	16.8	179	0
Beryllium	—	<DL	<DL	—	<DL	0.016	**	0	—	<DL	0.23	—	0.26	**	2
Cadmium	—	<DL	<DL	—	1	18	**	0	—	<DL	<DL	—	0.63	**	0
Calcium	—	120,000	255,000	—	109,000	NA	NA	NA	—	39,700	27,300	—	239,000	NA	NA
Chromium	—	2.1	<DL	—	2.9	180	8.7	0	—	5.4	<DL	—	1.1	7.3	0
Cobalt	—	<DL	<DL	—	1.2	2,200	**	0	—	69.3	83.8	—	88.5	12.1	0
Iron	—	8,720	11,400	—	22,200	NA	NA	NA	—	18,600	15,500	—	13,400	NA	NA
Magnesium	—	53,200	77,100	—	51,700	NA	NA	NA	—	34,100	25,400	—	22,000	NA	NA
Manganese	—	257	532	—	156	840	577	0	—	2,180	2,200	—	2,020	2,690	0
Mercury	—	<DL	<DL	—	0.24	11	**	0	—	<DL	<DL	—	0.88	**	0
Nickel	—	<DL	<DL	—	3.4	730	**	0	—	5.6	11	—	11.5	21.1	0
Potassium	—	53,400	27,800	—	29,700	NA	NA	NA	—	9,930	3,420	—	2,730	NA	NA
Sodium	—	233,000	135,000	—	96,300	NA	NA	NA	—	82,800	22,100	—	12,700	NA	NA
Vanadium	—	2.5	2.5	—	3.8	260	5.4	0	—	2.9	<DL	—	<DL	10.9	0
Zinc	—	<DL	<DL	—	<DL	11,000	83.2	0	—	<DL	299	—	332	66.2	0

Table 10.4.12
SWMU 39 – Compounds Detected in Groundwater
Well Pair NBCA-039-008 and NBCA-039-08D

	NBCA-039-008								NBCA-039-08D						
Compound	**Event "0A"**	**Event "04"**	**Event "A2"**	**Event "05"**	**Event "06"**	**RBC**	**RC**	**# of Samples Exceeding RC and RBC**	**Event "0A"**	**Event "04"**	**Event "A2"**	**Event "05"**	**Event "06"**	**RC**	**# of Samples Exceeding RC and RBC**
Other Parameters															
Chloride (mg/L)	—	<DL	64.5	—	—	NA	NA	NA	—	140	23.3	—	—	NA	NA
Sulfate (mg/L)	—	580	502	—	—	NA	NA	NA	—	1,700	158	—	—	NA	NA
TDS (mg/L)	—	1,190	1,580	—	—	NA	NA	NA	—	592	348	—	—	NA	NA
TCDD TEQ[a] (pg/L)	—	0.05	0.06	—	—	0.43	NA	0	—	0.18	0.05	—	—	NA	0
TPH	—	—	<DL	—	—	NA	NA	NA	—	—	<DL	—	—	NA	NA

Notes:

a	=	Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995.
**	=	Number of non-detects prevented determination of UTL.
NA	=	Not applicable
<DL	=	Below detection limit
0A	=	Interim sampling event (8/96)
04	=	First-quarter sampling event (10/96) for these wells that was conducted during the fourth-quarter sampling event.
A2	=	Second-quarter sampling event (3/97) for these wells.
05	=	Third-quarter sampling event (7/97) for these wells.
06	=	Fourth-quarter sampling event (10/97) for these wells.
—	=	Parameter not sampled.

Table 10.4.13
SWMU 39 - Compounds Detected in Groundwater
Well Cluster NBCA-039-009, NBCA-039-09I, and NBCA-039-09D

	NBCA-039-009								NBCA-039-09I						NBCA-039-09D						
Compound	Event "0A"	Event "04"	Event "A2"	Event "05"	Event "06"	RBC	RC	# of Samples > RC and RBC	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	# of Samples > RBC	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	RC	# of Samples > RC and RBC
VOCs (μg/L)																					
Trichloroethene	1.7	2	2	1	2	1.6	NA	4	<DL	<DL	<DL	<DL	<DL	0	<DL	<DL	<DL	<DL	<DL	NA	0
cis-1,2-dichloroethene	39	38	28	44	38	61	NA	0	2	<DL	4	5	6	0	<DL	<DL	<DL	<DL	<DL	NA	0
1,1-dichloroethene	1.1	<DL	<DL	<DL	<DL	0.044	NA	1	<DL	<DL	<DL	<DL	<DL	0	<DL	<DL	<DL	<DL	<DL	NA	0
Vinyl chloride	6.2	6	5	10	9	0.019	NA	5	<DL	<DL	<DL	<DL	<DL	0	<DL	<DL	<DL	<DL	<DL	NA	0
1,1-dichloroethane	1.1	<DL	<DL	<DL	<DL	810	NA	0	<DL	<DL	<DL	<DL	<DL	0	<DL	<DL	<DL	<DL	<DL	NA	0
Acetone	<DL	<DL	<DL	<DL	<DL	3,700	NA	0	9	<DL	<DL	<DL	<DL	0	11	<DL	<DL	<DL	<DL	NA	0
Methylene chloride	<DL	<DL	<DL	<DL	<DL	4.1	NA	0	4	<DL	<DL	<DL	<DL	0	3	<DL	<DL	<DL	<DL	NA	0
Toluene	<DL	<DL	<DL	<DL	<DL	750	NA	0	6	<DL	<DL	<DL	<DL	0	4	4	<DL	<DL	<DL	NA	0
SVOCs (μg/L)																					
Di-n-butyl phthalate	–	<DL	<DL	3	<DL	3,700	NA	0	–	<DL	<DL	<DL	<DL	0	–	<DL	<DL	<DL	<DL	NA	0

Table 10.4.13
SWMU 39 - Compounds Detected in Groundwater
Well Cluster NBCA-039-009, NBCA-039-09I, and NBCA-039-09D

	NBCA-039-009								NBCA-039-09I						NBCA-039-09D						
Compound	Event "0A"	Event "04"	Event "A2"	Event "05"	Event "06"	RBC	RC	# of Samples > RC and RBC	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	# of Samples > RBC	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	RC	# of Samples > RC and RBC
Metals (μg/L)																					
Aluminum	–	<DL	28	–	<DL	37,000	3,210	0	–	–	<DL	–	<DL	0	–	–	18	–	<DL	245	0
Antimony	–	<DL	2.4	–	<DL	15	**	0	–	–	<DL	–	<DL	0	–	–	<DL	–	<DL	**	0
Arsenic	–	25.1	17.8	–	35.5	0.045	7.4	3	–	–	<DL	–	3.6	1	–	–	<DL	–	<DL	11.1	0
Barium	–	27	35.6	–	22.7	2,600	104	0	–	–	5.6	–	6.0	0	–	–	4.9	–	4.5	179	0
Cadmium	–	<DL	<DL	–	0.61	18	**	0	–	–	<DL	–	<DL	0	–	–	<DL	–	<DL	**	0
Calcium	–	45,900	48,600	–	39,900	NA	NA	NA	–	–	65,100	–	65,800	NA	–	–	42,400	–	47,100	NA	NA
Chromium	–	<DL	<DL	–	<DL	180	8.3	0	–	–	<DL	–	1.7	0	–	–	<DL	–	<DL	7.3	0
Cobalt	–	<DL	3.1	–	6	2,200	**	0	–	–	<DL	–	<DL	0	–	–	<DL	–	<DL	12	0
Iron	–	9,840	7,780	–	12,200	NA	NA	NA	–	–	2,320	–	2,430	NA	–	–	213	–	171	NA	NA
Magnesium	–	8,070	7,460	–	6,800	NA	NA	NA	–	–	6,200	–	6,080	NA	–	–	5,540	–	6,200	NA	NA
Manganese	–	981	769	–	958	840	577	2	–	–	350	–	348	0	–	–	119	–	110	2,690	0
Mercury	–	<DL	<DL	–	0.18	11	**	0	–	–	<DL	–	0.43	0	–	–	<DL	–	<DL	**	0
Nickel	–	<DL	<DL	–	<DL	730	**	0	–	–	<DL	–	1.3	0	–	–	<DL	–	<DL	21.1	0
Potassium	–	1,180	1,140	–	<DL	NA	NA	NA	–	–	1,700	–	1,490	NA	–	–	2,230	–	2,290	NA	NA

Table 10.4.13
SWMU 39 - Compounds Detected in Groundwater
Well Cluster NBCA-039-009, NBCA-039-09I, and NBCA-039-09D

	NBCA-039-009								NBCA-039-09I						NBCA-039-09D						
Compound	Event "0A"	Event "04"	Event "A2"	Event "05"	Event "06"	RBC	RC	# of Samples > RC and RBC	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	# of Samples > RBC	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	RC	# of Samples > RC and RBC
Sodium	–	<DL	11,100	–	10,600	NA	NA	NA	–	–	24,200	–	21,200	NA	–	–	49,800	–	25,300	NA	NA
Vanadium	–	<DL	1.2	–	<DL	260	5.4	0	–	–	<DL	–	<DL	0	–	–	<DL	–	<DL	10.9	0
Other Parameters																					
Chloride (mg/L)	–	<DL	5.3	–	–	NA	NA	NA	–	12	9.7	–	–	NA	–	–	19	–	–	NA	NA
Sulfate (mg/L)	–	<DL	5.9	–	–	NA	NA	NA	–	<DL	3	–	–	NA	–	–	2.4	–	–	NA	NA
TDS (mg/L)	–	<DL	212	–	–	NA	NA	NA	–	–	328	–	–	NA	–	–	212	–	–	NA	NA
TCDD TEQ * (pg/L)	–	0.03	0.09	–	–	0.43	NA	0	–	–	0.04	–	–	0	–	–	0.04	–	–	NA	0
TPH – GRO (µg/L)	–	–	6.3	–	–	NA	NA	NA	–	–	<DL	–	–	NA	–	–	<DL	–	–	NA	NA

otes:

	=	Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995.
	=	Number of non-detects prevented determination of UTL.
A	=	Not applicable
DL	=	Below detection limit
A	=	Interim sampling event (8/96) for this shallow well.
	=	First-quarter sampling event (10/96) for this shallow well that was conducted during the fourth-quarter sampling event.
1	=	Interim sampling event (9/96), intermediate and deep wells.
	=	First-quarter sampling event (11/96), intermediate and deep wells.
2	=	Second-quarter sampling event (3/97) for all three wells.
	=	Third-quarter sampling event (7/97) for all three wells.
	=	Fourth-quarter sampling event (10/97) for all three wells.
	=	Parameter not sampled.

Table 10.4.14
SWMU 39 - Compounds Detected in Groundwater
Well Cluster NBCA-039-010, NBCA-039-10I, and NBCA-039-10D

	NBCA-039-010								NBCA-039-10I							NBCA-039-10D							
Compound	Event "0A"	Event "04"	Event "A2"	Event "05"	Event "06"	RBC	RC	# > RC and RBC	Event "B1"	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	# > RBC	Event "B1"	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	RC	# > RC and RBC
VOCs (µg/L)																							
cis-1,2-dichloroethene	<DL	<DL	<DL	<DL	<DL	61	NA	0	<DL	60	48	42	44	29	0	<DL	6	7	8	12	11	NA	0
Vinyl chloride	<DL	<DL	<DL	<DL	<DL	0.019	NA	0	<DL	8	10	7	8	6	5	<DL	<DL	<DL	<DL	<DL	5	NA	1
1,1,1-trichloroethane	1.1	<DL	<DL	<DL	<DL	540	NA	0	<DL	<DL	<DL	<DL	<DL	<DL	0	<DL	<DL	<DL	<DL	<DL	<DL	NA	0
Toluene	<DL	<DL	<DL	<DL	<DL	750	NA	0	<DL	4	<DL	<DL	<DL	<DL	0	<DL	<DL	<DL	<DL	<DL	<DL	NA	0
SVOCs (µg/L)																							
Acenaphthene	–	<DL	2	<DL	<DL	2,200	NA	0	–	–	<DL	<DL	<DL	<DL	0	–	–	<DL	<DL	<DL	<DL	NA	0
Benzyl alcohol	–	<DL	<DL	1	<DL	11,000	NA	0	–	–	<DL	<DL	<DL	<DL	0	–	–	<DL	<DL	<DL	<DL	NA	0
Dibenzofuran	–	<DL	2	1	<DL	150	NA	0	–	–	<DL	<DL	<DL	<DL	0	–	–	<DL	<DL	<DL	<DL	NA	0
Di-n-butyl phthalate	–	<DL	<DL	3	<DL	3,700	NA	0	–	–	<DL	<DL	2	4	0	–	–	<DL	<DL	3	<DL	NA	0
Fluorene	–	<DL	<DL	<DL	6	1,500	NA	0	–	–	<DL	<DL	<DL	<DL	0	–	–	<DL	<DL	<DL	<DL	NA	0
2-methyl naphthalene	–	<DL	<DL	<DL	3	1,500	NA	0	–	–	<DL	<DL	<DL	<DL	0	–	–	<DL	<DL	<DL	<DL	NA	0
Naphthalene	–	4	<DL	5	5	1,500	NA	0	–	–	<DL	<DL	<DL	<DL	0	–	–	<DL	<DL	<DL	<DL	NA	0
Phenol	–	<DL	<DL	8	<DL	22,000	NA	0	–	–	<DL	<DL	2	<DL	0	–	–	<DL	<DL	<DL	<DL	NA	0

Table 10.4.14
SWMU 39 – Compounds Detected in Groundwater
Well Cluster NBCA-039-010, NBCA-039-10I, and NBCA-039-10D

	NBCA-039-010								NBCA-039-10I							NBCA-039-10D							
Compound	Event "0A"	Event "04"	Event "A2"	Event "05"	Event "06"	RBC	RC	# > RC and RBC	Event "B1"	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	# > RBC	Event "B1"	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	RC	# > RC and RBC
Metals (μg/L)																							
Aluminum	–	<DL	778	–	235	37,000	3,210	0	–	–	–	35.3	–	<DL	0	–	–	–	16	–	<DL	245	0
Arsenic	–	<DL	63.3	–	5.0	0.045	7.4	1	–	–	–	25.6	–	26.5	2	–	–	–	<DL	–	<DL	11.1	0
Barium	–	31.5	24.5	–	42.7	2,600	104	0	–	–	–	23.4	–	23.2	0	–	–	–	12.3	–	11.1	179	0
Cadmium	–	<DL	<DL	–	0.41	18	**	0	–	–	–	<DL	–	0.37	0	–	–	–	<DL	–	<DL	**	0
Calcium	–	19,200	19,800	–	23,100	NA	NA	NA	–	–	–	48,600	–	47,800	NA	–	–	–	60,300	–	60,200	NA	NA
Cobalt	–	<DL	0.96	–	<DL	2,200	**	0	–	–	–	17.1	–	15.9	0	–	–	–	<DL	–	<DL	12	0
Copper	–	<DL	2.2	–	<DL	1,500	15.7	0	–	–	–	<DL	–	<DL	0	–	–	–	<DL	–	<DL	5.8	0
Iron	–	6,780	36,700	–	2,390	NA	NA	NA	–	–	–	9,050	–	8,350	NA	–	–	–	663	–	635	NA	NA
Magnesium	–	6,130	8,470	–	7,240	NA	NA	NA	–	–	–	6,440	–	6,450	NA	–	–	–	2,670	–	2,720	NA	NA
Manganese	–	21.3	97.2	–	5.6	840	577	0	–	–	–	3,100	–	2,990	2	–	–	–	72.9	–	76.9	2,690	0
Mercury	–	<DL	<DL	–	<DL	11	**	0	–	–	–	<DL	–	0.21	0	–	–	–	<DL	–	<DL	**	0
Potassium	–	985	696	–	918	NA	NA	NA	–	–	–	938	–	849	NA	–	–	–	926	–	782	NA	NA
Sodium	–	<DL	5,750	–	2,970	NA	NA	NA	–	–	–	9,830	–	9,020	NA	–	–	–	14,000	–	12,100	NA	NA
Vanadium	–	0.51	2.2	–	<DL	260	5.4	0	–	–	–	<DL	–	<DL	0	–	–	–	<DL	–	<DL	10.9	0
Zinc	–	<DL	7.7	–	<DL	11,000	83.2	0	–	–	–	<DL	–	<DL	0	–	–	–	<DL	–	8.1	66.2	0

Table 10.4.14
SWMU 39 - Compounds Detected in Groundwater
Well Cluster NBCA-039-010, NBCA-039-10I, and NBCA-039-10D

	NBCA-039-010								NBCA-039-10I							NBCA-039-10D							
Compound	Event "0A"	Event "04"	Event "A2"	Event "05"	Event "06"	RBC	RC	# > RC and RBC	Event "B1"	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	# > RBC	Event "B1"	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	RC	# > RC and RBC
Other Parameters																							
Chloride (mg/L)	—	<DL	2.8	—	—	NA	NA	NA	—	—	<DL	5.2	—	—	NA	—	—	7	7.8	—	—	NA	NA
Sulfate (mg/L)	—	11.5	2.4	—	—	NA	NA	NA	—	—	<DL	0.65	—	—	NA	—	—	21.9	18	—	—	NA	NA
TDS (mg/L)	—	<DL	92	—	—	NA	NA	NA	—	—	—	172	—	—	NA	—	—	—	208	—	—	NA	NA
TCDD TEQ * (pg/L)	—	0.04	3.10	—	—	0.43	NA	1	—	—	—	0.06	—	—	0	—	—	—	0.07	—	—	NA	0
TPH	—	—	<DL	—	—	NA	NA	NA	—	—	—	<DL	—	—	NA	—	—	—	<DL	—	—	NA	NA

otes:

	=	Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995.
	=	Number of non-detects prevented determination of UTL.
A	=	Not applicable
DL	=	Below detection limit
	=	Interim sampling event (8/96) for this shallow well.
	=	First-quarter sampling event (10/96) for this shallow well that was conducted during the fourth-quarter sampling event.
	=	Interim sampling event (9/96), intermediate and deep wells.
	=	Interim sampling event (9/96), intermediate and deep wells.
	=	First-quarter sampling event (11/96), intermediate and deep wells.
	=	Second-quarter sampling event (3/97) for all three wells.
	=	Third-quarter sampling event (7/97) for all three wells.
	=	Fourth-quarter sampling event (10/97) for all three wells.
	=	Parameter not sampled.

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Table 10.4.15
SWMU 39 - Compounds Detected in Groundwater
Individual Well NBCA-039-011

Compound	Event "0A"	Event "04"	Event "05"	Event "06"	RBC	RC	# of Samples Exceeding RC and RBC
VOCs (μg/L)							
1,1,1-trichloroethane	1	<DL	<DL	<DL	540	NA	0
1,1-dichloroethene	1.4	<DL	<DL	<DL	0.044	NA	1
1,2-dichloroethane	1.6	4	<DL	<DL	0.12	NA	2
Chlorobenzene	<DL	<DL	<DL	2	39	NA	0
Benzene	620	190	140	150	0.36	NA	4
Ethylbenzene	190	170	160	140	1,300	NA	0
Toluene	140	24	10	11	750	NA	0
o-xylene	33	35	<DL	<DL	12,000	NA	0
Xylene (m+p)	380	<DL	<DL	<DL	12,000	NA	0
Xylene (total)	<DL	300	560	380	12,000	NA	0
Acetone	<DL	34	<DL	<DL	3,700	NA	0
2-butanone (MEK)	6.3	<DL	<DL	<DL	1,900	NA	0
2-hexanone	<DL	7	<DL	<DL	1,500	NA	0
4-methyl-2-pentanone (MIBK)	2.1	<DL	<DL	<DL	2,900	NA	0
SVOCs (μg/L)							
Acenaphthene	—	3	2	<DL	2,200	NA	0
Anthracene	—	5	<DL	<DL	11,000	NA	0
Benzoic acid	—	<DL	8	<DL	150,000	NA	0
Bis(2-ethylhexyl)phthalate (BEHP)	—	8	<DL	<DL	4.8	NA	1
Butylbenzylphthalate	—	<DL	2	<DL	7,300	NA	0
Dibenzofuran	—	9	6	<DL	150	NA	0
Diethylphthalate	—	11	<DL	<DL	29,000	NA	0

Table 10.4.15
SWMU 39 - Compounds Detected in Groundwater
Individual Well NBCA-039-011

Compound	Event "0A"	Event "04"	Event "05"	Event "06"	RBC	RC	# of Samples Exceeding RC and RBC
2,4-dimethylphenol	—	11	3	<DL	730	NA	0
Fluorene	—	8	6	8	1,500	NA	0
2-methylnaphthalene	—	260	210	95	1,500	NA	0
2-methylphenol	—	<DL	2	1	1,800	NA	0
4-methylphenol	—	15	10	22	180	NA	0
Naphthalene	—	420	300	120	1,500	NA	0
n-nitrosodiphenylamine	—	2	<DL	<DL	14	NA	0
Pentachlorophenol	—	<DL	2	<DL	0.56	NA	1
Phenanthrene	—	8	5	6	1,100[a]	NA	0
Metals (μg/L)							
Aluminum	—	137	—	239	37,000	3,210	0
Arsenic	—	2.5	—	5.2	0.045	7.4	0
Barium	—	9.0	—	6.6	2,600	104	0
Cadmium	—	<DL	—	1.2	18	**	0
Calcium	—	11,500	—	9,930	NA	NA	NA
Chromium	—	<DL	—	2.2	180	8.7	0
Iron	—	28,400	—	27,300	NA	NA	NA
Magnesium	—	2,930	—	2,700	NA	NA	NA
Manganese	—	37.3	—	24.6	840	577	0
Mercury	—	<DL	—	0.21	11	**	0
Potassium	—	1,990	—	1,210	NA	NA	NA
Sodium	—	<DL	—	7,570	NA	NA	NA
Vanadium	—	1.6	—	1.5	260	5.4	0

Table 10.4.15
SWMU 39 - Compounds Detected in Groundwater
Individual Well NBCA-039-011

Compound	Event "0A"	Event "04"	Event "05"	Event "06"	RBC	RC	# of Samples Exceeding RC and RBC
Other Parameters							
Chloride (mg/L)	—	<DL	—	—	NA	NA	NA
Sulfate (mg/L)	—	<DL	—	—	NA	NA	NA
TDS (mg/L)	—	<DL	—	—	NA	NA	NA
TCDD TEQ [b] (pg/L)	—	0.35	—	—	0.43	NA	0

Notes:

a	=	Phenanthrene does not have an RBC. Pyrene RBC used as surrogate.
b	=	Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995.
**	=	Number of non-detects prevented determination of UTL.
NA	=	Not applicable
<DL	=	Below detection limit
0A	=	Interim sampling event (8/96)
04	=	First-quarter sampling event (10/96) for this well that was conducted during the fourth-quarter sampling event.
05	=	Third-quarter sampling event (7/97) for this well. No second-quarter sample collected.
06	=	Fourth-quarter sampling event (10/97) for this well.
—	=	Parameter not sampled.

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Table 10.4.16
SWMU 39 - Compounds Detected in Groundwater
Well Cluster NBCA-039-012, NBCA-039-12I, and NBCA-039-12D

	NBCA-039-012								NBCA-039-12I						NBCA-039-12D						
Compound	Event "0A"	Event "04"	Event "A2"	Event "05"	Event "06"	RBC	RC	# of Samples > RC and RBC	Event "0A"	Event "04"	Event "A2"	Event "05"	Event "06"	# of Samples > RBC	Event "0A"	Event "04"	Event "A2"	Event "05"	Event "06"	RC	# of Samples > RC and RBC
VOCs (μg/L)																					
Trichloroethene	72	92	110	94	90	1.6	NA	5	110	120	100	110	120	5	<DL	<DL	<DL	<DL	<DL	NA	0
cis-1,2-dichloroethene	140	130	170	160	120	61	NA	5	190	240	140	330	320	5	<DL	<DL	<DL	<DL	<DL	NA	0
trans-1,2-dichloroethene	4	<DL	<DL	<DL	<DL	120	NA	0	1.7	<DL	<DL	<DL	<DL	0	<DL	<DL	<DL	<DL	<DL	NA	0
1,1-dichloroethene	2.9	3	3	3	2	0.044	NA	5	5	5	4	5	6	5	<DL	<DL	<DL	<DL	<DL	NA	0
Vinyl chloride	3.9	3	4	<DL	2	0.019	NA	4	<DL	<DL	<DL	<DL	2	1	<DL	<DL	<DL	<DL	<DL	NA	0
1,1,1-trichloroethane	<DL	<DL	<DL	<DL	<DL	540	NA	0	10	<DL	<DL	<DL	<DL	0	<DL	<DL	<DL	<DL	<DL	NA	0
1,1-dichloroethane	1.7	<DL	<DL	<DL	<DL	810	NA	0	2	<DL	<DL	<DL	<DL	0	<DL	<DL	<DL	<DL	<DL	NA	0
Benzene	<DL	<DL	<DL	<DL	<DL	0.36	NA	0	1.3	<DL	<DL	1	1	3	<DL	<DL	<DL	<DL	<DL	NA	0
Methylene chloride	<DL	<DL	<DL	<DL	<DL	4.1	NA	0	2.8	<DL	<DL	<DL	<DL	0	<DL	<DL	<DL	<DL	<DL	NA	0
Toluene	<DL	<DL	<DL	<DL	<DL	750	NA	0	1.2	<DL	<DL	<DL	<DL	0	<DL	<DL	<DL	<DL	<DL	NA	0

Table 10.4.16
SWMU 39 – Compounds Detected in Groundwater
Well Cluster NBCA-039-012, NBCA-039-12I, and NBCA-039-12D

	NBCA-039-012								NBCA-039-12I						NBCA-039-12D						
Compound	Event "0A"	Event "04"	Event "A2"	Event "05"	Event "06"	RBC	RC	# of Samples > RC and RBC	Event "0A"	Event "04"	Event "A2"	Event "05"	Event "06"	# of Samples > RBC	Event "0A"	Event "04"	Event "A2"	Event "05"	Event "06"	RC	# of Samples > RC and RBC
SVOCs (μg/L)																					
Benzyl alcohol	–	<DL	<DL	<DL	<DL	11,000	NA	0	–	<DL	<DL	2	<DL	0	–	<DL	<DL	<DL	<DL	NA	0
Di-n-butyl-phthalate	–	<DL	<DL	2	<DL	3,700	NA	0	–	<DL	<DL	2	<DL	0	–	<DL	<DL	2	<DL	NA	0
Phenol	–	<DL	<DL	3	<DL	22,000	NA	0	–	<DL	<DL	7	<DL	0	–	<DL	<DL	3	<DL	NA	0
Metals (μg/L)																					
Aluminum	–	<DL	17	–	158	37,000	3,210	0	–	<DL	17.3	–	<DL	0	–	<DL	21.3	–	103	245	0
Arsenic	–	107	95.9	–	109	0.045	7.4	3	–	2.2	<DL	–	4.0	2	–	<DL	<DL	–	<DL	11.1	0
Barium	–	67.5	63.1	–	70.8	2,600	104	0	–	7.3	8.9	–	9.6	0	–	27.8	22.5	–	43.5	179	0
Calcium	–	56,500	55,900	–	52,300	NA	NA	NA	–	78,500	74,500	–	75,600	NA	–	47,800	42,300	–	17,600	NA	NA
Chromium	–	1.8	<DL	–	<DL	180	8.7	0	–	<DL	<DL	–	<DL	0	–	2.2	<DL	–	<DL	7.3	0
Cobalt	–	50.9	48.2	–	71.2	2,200	**	0	–	<DL	<DL	–	<DL	0	–	<DL	<DL	–	<DL	12	0
Iron	–	20,800	30,000	–	22,400	NA	NA	NA	–	489	614	–	616	NA	–	931	<DL	–	<DL	NA	NA
Lead	–	<DL	<DL	–	<DL	15.0*	4.7	0	–	<DL	<DL	–	<DL	0	–	2.2	<DL	–	<DL	**	0
Magnesium	–	4,320	4,170	–	4,620	NA	NA	NA	–	4,620	4,410	–	4,340	NA	–	5,960	5,150	–	2,080	NA	NA
Manganese	–	2,230	2,680	–	2,080	840	577	3	–	460	507	–	535	0	–	45.3	9.1	–	<DL	2,690	0
Mercury	–	<DL	<DL	–	0.12	11	**	0	–	<DL	<DL	–	<DL	0	–	<DL	<DL	–	<DL	**	0

Table 10.4.16
SWMU 39 – Compounds Detected in Groundwater
Well Cluster NBCA-039-012, NBCA-039-12I, and NBCA-039-12D

	NBCA-039-012								NBCA-039-12I						NBCA-039-12D						
Compound	Event "0A"	Event "04"	Event "A2"	Event "05"	Event "06"	RBC	RC	# of Samples > RC and RBC	Event "0A"	Event "04"	Event "A2"	Event "05"	Event "06"	# of Samples > RBC	Event "0A"	Event "04"	Event "A2"	Event "05"	Event "06"	RC	# of Samples > RC and RBC
Nickel	–	<DL	<DL	–	3.5	730	**	0	–	<DL	<DL	–	<DL	0	–	<DL	<DL	–	<DL	21.1	0
Potassium	–	1,930	1,190	–	1,490	NA	NA	NA	–	1,850	1,560	–	2,100	NA	–	1,850	3,450	–	30,200	NA	NA
Silver	–	1.5	<DL	–	<DL	180	**	0	–	1.1	<DL	–	<DL	0	–	<DL	<DL	–	<DL	**	0
Sodium	–	<DL	14,200	–	<DL	NA	NA	NA	–	<DL	20,100	–	<DL	NA	–	<DL	30,300	–	<DL	NA	NA
Vanadium	–	0.62	<DL	–	<DL	260	5.4	0	–	<DL	<DL	–	<DL	0	–	<DL	<DL	–	<DL	10.9	0
Other Parameters																					
Chloride (mg/L)	–	<DL	9.8	–		NA	NA	NA	–	<DL	14.3	–	–	NA	–	<DL	34.5	–	–	NA	NA
Sulfate (mg/L)	–	<DL	5.5	–	–	NA	NA	NA	–	20.1	18.2	–	–	NA	–	62.6	17.1	–	–	NA	NA
TDS (mg/L)	–	<DL	224	–	–	NA	NA	NA	–	288	280	–	–	NA	–	252	244	–	–	NA	NA
TCDD TEQ [b] (pg/L)	–	0.02	0.04	–	–	0.43	NA	0	–	0.01	0.04	–	–	0	–	0.29	0.01	–	–	NA	0
TPH	–	–	<DL	–	–	NA	NA	NA	–	–	<DL	–	–	NA	–	–	<DL	–	–	NA	NA

otes:

	=	Lead does not have an RBC or MCL. Therefore, the USEPA Treatment Technique Action Level of 15 μg/L has been substituted for the RBC.
	=	Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995.
*	=	Number of non-detects prevented determination of UTL.
A	=	Not applicable
DL	=	Below detection limit
A	=	Interim sampling event (8/96) for all three wells.
	=	First-quarter sampling event (10/96) for all three wells that was conducted during the fourth-quarter sampling event.
2	=	Second-quarter sampling event (3/97) for all three wells.
	=	Third-quarter sampling event (7/97) for all three wells.
	=	Fourth-quarter sampling event (10/97) for all three wells.
	=	Parameter not sampled.

Table 10.4.17
SWMU 39 – Compounds Detected in Groundwater
Well Cluster NBCA-039-013, NBCA-039-13I, and NBCA-039-13D

	NBCA-039-013							NBCA-039-13I						NBCA-039-13D						
Compound	Event "01"	Event "A2"	Event "05"	Event "06"	RBC	RC	# of Samples > RC and RBC	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	# of Samples > RBC	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	RC	# of Samples > RC and RBC
VOCs (μg/L)																				
Tetrachloroethene	25	30	19	9	1.1	NA	4	64	110	85	110	100	5	19	33	48	54	43	NA	5
Trichloroethene	6	7	4	3	1.6	NA	4	20	22	41	43	22	5	45	56	79	84	70	NA	5
cis-1,2-dichloroethene	32	34	26	22	61	NA	0	82	69	120	140	88	5	59	70	180	180	160	NA	4
1,1-dichloroethene	<DL	<DL	<DL	<DL	0.044	NA	0	2	<DL	2	3	2	4	1	<DL	3	4	4	NA	4
Vinyl chloride	<DL	<DL	<DL	<DL	0.019	NA	0	8	9	7	10	9	5	<DL	<DL	7	8	7	NA	3
1,1-dichloroethane	<DL	<DL	<DL	<DL	810	NA	0	2	<DL	<DL	<DL	<DL	0	<DL	<DL	<DL	<DL	3	NA	0
Acetone	<DL	<DL	<DL	<DL	3,700	NA	0	<DL	<DL	<DL	<DL	<DL	0	6	<DL	<DL	<DL	<DL	NA	0
Methylene chloride	<DL	<DL	<DL	<DL	4.1	NA	0	<DL	<DL	<DL	<DL	<DL	0	3	<DL	<DL	<DL	<DL	NA	0
Chloroform	<DL	<DL	<DL	<DL	0.15	NA	0	<DL	<DL	<DL	<DL	<DL	0	3	7	<DL	<DL	<DL	NA	2
SVOCs (μg/L)																				
Benzyl alcohol	<DL	<DL	<DL	<DL	11,000	NA	0	–	<DL	<DL	1	<DL	0	–	<DL	<DL	<DL	<DL	NA	0
Diethylphthalate	<DL	<DL	1	<DL	29,000	NA	0	–	<DL	<DL	<DL	<DL	0	–	<DL	<DL	<DL	<DL	NA	0
Naphthalene	<DL	<DL	<DL	<DL	1,500	NA	0	–	<DL	<DL	<DL	3	0	–	<DL	<DL	<DL	<DL	NA	0
Phenol	<DL	<DL	<DL	<DL	22,000	NA	0	–	<DL	<DL	<DL	2	0	–	<DL	<DL	<DL	<DL	NA	0

Table 10.4.17
SWMU 39 - Compounds Detected in Groundwater
Well Cluster NBCA-039-013, NBCA-039-13I, and NBCA-039-13D

	NBCA-039-013							NBCA-039-13I						NBCA-039-13D						
Compound	Event "01"	Event "A2"	Event "05"	Event "06"	RBC	RC	# of Samples > RC and RBC	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	# of Samples > RBC	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	RC	# of Samples > RC and RBC
Metals (μg/L)																				
Aluminum	11,100	421	–	4,370	37,000	3,210	0	–	–	56.3	–	<DL	0	–	–	28.8	–	<DL	245	0
Arsenic	14.4	<DL	–	5	0.045	7.4	1	–	–	<DL	–	2.6	1	–	–	<DL	–	2.1	11.1	0
Barium	51.3	10.9	–	25.8	2,600	104	0	–	–	18.6	–	<DL	0	–	–	16	–	11	179	0
Beryllium	<DL	<DL	–	0.4	0.016	**	1	–	–	<DL	–	<DL	0	–	–	<DL	–	<DL	**	0
Cadmium	0.53	1	–	1.1	18	**	0	–	–	<DL	–	<DL	0	–	–	<DL	–	<DL	**	0
Calcium	19,100	13,700	–	13,000	NA	NA	NA	–	–	29,000	–	<DL	NA	–	–	59,900	–	43,500	NA	NA
Chromium	21.5	<DL	–	8.9	180	8.7	0	–	–	<DL	–	1	0	–	–	<DL	–	<DL	7.3	0
Cobalt	7.4	1.1	–	10.8	2,200	**	0	–	–	1.3	–	<DL	0	–	–	<DL	–	<DL	12	0
Copper	11.9	2	–	10.9	1,500	15.7	0	–	–	<DL	–	<DL	0	–	–	<DL	–	<DL	5.8	0
Iron	18,300	550	–	6,800	NA	NA	NA	–	–	568	–	<DL	NA	–	–	36.6	–	66.8	NA	NA
Lead	16.5	<DL	–	<DL	15.0*	4.7	1	–	–	<DL	–	<DL	0	–	–	<DL	–	<DL	**	0
Magnesium	5,430	3,620	–	3,230	NA	NA	NA	–	–	4,470	–	<DL	NA	–	–	11,900	–	13,000	NA	NA
Manganese	135	16.1	–	157	840	577	0	–	–	586	–	<DL	0	–	–	51.2	–	42.3	2,690	0
Mercury	<DL	<DL	–	0.17	11	**	0	–	–	<DL	–	0.2	0	–	–	<DL	–	0.11	**	0
Nickel	10.3	<DL	–	5.9	730	**	0	–	–	<DL	–	<DL	0	–	–	<DL	–	<DL	21.1	0
Potassium	2,560	1,560	–	1,630	NA	NA	NA	–	–	1,490	–	<DL	NA	–	–	2,960	–	2,830	NA	NA

Table 10.4.17
SWMU 39 - Compounds Detected in Groundwater
Well Cluster NBCA-039-013, NBCA-039-13I, and NBCA-039-13D

	NBCA-039-013							NBCA-039-13I						NBCA-039-13D						
Compound	Event "01"	Event "A2"	Event "05"	Event "06"	RBC	RC	# of Samples > RC and RBC	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	# of Samples > RBC	Event "A1"	Event "01"	Event "A2"	Event "05"	Event "06"	RC	# of Samples > RC and RBC
Sodium	13,100	10,600	–	9,020	NA	NA	NA	–	–	17,100	–	<DL	NA	–	–	33,300	–	27,800	NA	NA
Vanadium	32.6	<DL	–	12.1	260	5.4	0	–	–	<DL	–	<DL	0	–	–	2.4	–	<DL	10.9	0
Zinc	104	85	–	90.8	11,000	83.2	0	–	–	<DL	–	<DL	0	–	–	<DL	–	<DL	68.2	0
Other Parameters																				
Chloride (mg/L)	–	5.4	–	–	NA	NA	NA	–	<DL	8.6	–	–	NA	–	21	15.8	–	–	NA	NA
Sulfate (mg/L)	–	39.7	–	–	NA	NA	NA	–	36.6	23.5	–	–	NA	–	42.7	34	–	–	NA	NA
TDS (mg/L)	–	108	–	–	NA	NA	NA	–	–	144	–	–	NA	–	–	320	–	–	NA	NA
TCDD TEQ [b] (pg/L)	–	0.09	–	–	0.43	NA	0	–	–	0.06	–	–	0	–	–	0.10	–	–	NA	0
TPH	–	<DL	–	–	NA	NA	NA	–	–	<DL	–	–	NA	–	–	<DL	–	–	NA	NA
Cyanide (μg/L)	<DL	–	–	–	180	NA	0	–	–	–	–	–	NA	–	–	–	–	–	NA	NA
Pesticides	<DL	–	–	–	NA	NA	0	–	–	–	–	–	NA	–	–	–	–	–	NA	NA

otes:

	=	Lead does not have an RBC or MCL. Therefore, the USEPA Treatment Technique Action Level of 15 μg/L has been substituted for the RBC.
	=	Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995.
	=	Number of non-detects prevented determination of UTL.
A	=	Not applicable
DL	=	Below detection limit
1	=	Interim sampling event (9/96) for intermediate and deep wells.
	=	First-quarter sampling event (11/96) for intermediate and deep wells and (2/97) for shallow well.
2	=	Second-quarter sampling event (3/97) for all three wells.
3	=	Third-quarter sampling event (7/97) for all three wells.
5	=	Fourth-quarter sampling event (10/97) for all three wells.
	=	Parameter not sampled.

Table 10.4.18
SWMU 39 - Compounds Detected in Groundwater
Well Pair NBCA-039-014 and NBCA-039-14D

	NBCA-039-014							NBCA-039-14D					
Compound	Event "01"	Event "A2"	Event "05"	Event "06"	RBC	RC	# of Samples Exceeding RC and RBC	Event "01"	Event "A2"	Event "05"	Event "06"	RC	# of Samples Exceeding RC and RBC
VOCs (μg/L)													
Acetone	10	<DL	<DL	<DL	3,700	NA	0	<DL	<DL	<DL	<DL	NA	0
Benzene	8	23	6	3	0.36	NA	4	<DL	<DL	<DL	<DL	NA	0
Methylene chloride	5	<DL	<DL	<DL	4.1	NA	1	<DL	<DL	<DL	<DL	NA	0
SVOCs (μg/L)													
Benzoic acid	<DL	<DL	<DL	1	150,000	NA	0	<DL	<DL	<DL	<DL	NA	0
Dibenzofuran	2	<DL	2	<DL	150	NA	0	<DL	<DL	<DL	<DL	NA	0
Diethylphthalate	<DL	<DL	<DL	<DL	29,000	NA	0	<DL	<DL	2	<DL	NA	0
Fluorene	1	<DL	2	6	1,500	NA	0	<DL	<DL	<DL	<DL	NA	0
2-methylnaphthalene	11	<DL	2	6	1,500	NA	0	<DL	<DL	<DL	<DL	NA	0
Naphthalene	5	<DL	<DL	<DL	1,500	NA	0	<DL	<DL	<DL	<DL	NA	0
Phenanthrene	1	<DL	<DL	1	1,100[a]	NA	0	<DL	<DL	<DL	<DL	NA	0
Phenol	<DL	<DL	<DL	4	22,000	NA	0	<DL	<DL	<DL	<DL	NA	0
Metals (μg/L)													
Aluminum	408	<DL	–	594	37,000	3,210	0	46	<DL	–	<DL	245	0
Arsenic	23	23.8	–	33.1	0.045	7.4	3	<DL	<DL	–	2.3	11.1	0

Table 10.4.18
SWMU 39 - Compounds Detected in Groundwater
Well Pair NBCA-039-014 and NBCA-039-14D

	NBCA-039-014							NBCA-039-14D					
Compound	Event "01"	Event "A2"	Event "05"	Event "06"	RBC	RC	# of Samples Exceeding RC and RBC	Event "01"	Event "A2"	Event "05"	Event "06"	RC	# of Samples Exceeding RC and RBC
Barium	42.3	46.3	—	47.9	2,600	104	0	16.4	13	—	12.5	179	0
Cadmium	<DL	<DL	—	1.6	18	**	0	<DL	<DL	—	<DL	**	0
Calcium	51,500	48,900	—	50,700	NA	NA	NA	51,800	49,200	—	50,500	NA	NA
Copper	<DL	6.5	—	<DL	1,500	15.7	0	<DL	<DL	—	<DL	5.8	0
Iron	32,900	33,300	—	33,100	NA	NA	NA	127	362	—	526	NA	NA
Lead	3	<DL	—	<DL	15.0[b]	4.7	0	<DL	<DL	—	<DL	**	0
Magnesium	2,940	2,800	—	3,020	NA	NA	NA	2,230	1,990	—	2,000	NA	NA
Manganese	67.7	66	—	84.7	840	577	0	36.5	34	—	32.1	2,690	0
Mercury	<DL	<DL	—	0.16	11	**	0	<DL	<DL	—	0.16	**	0
Potassium	1,680	1,390	—	1,170	NA	NA	NA	<DL	947	—	<DL	NA	NA
Selenium	<DL	2.9	—	<DL	180	**	0	<DL	2.2	—	<DL	**	0
Sodium	13,200	13,900	—	11,700	NA	NA	NA	16,200	13,000	—	12,900	NA	NA
Vanadium	1.3	<DL	—	<DL	260	5.4	0	0.86	<DL	—	<DL	10.9	0
Other Parameters													
Chloride (mg/L)	—	<DL	—	—	NA	NA	NA	—	6	—	—	NA	NA
Sulfate (mg/L)	—	<DL	—	—	NA	NA	NA	—	33.3	—	—	NA	NA

Table 10.4.18
SWMU 39 - Compounds Detected in Groundwater
Well Pair NBCA-039-014 and NBCA-039-14D

	NBCA-039-014							NBCA-039-14D					
Compound	**Event "01"**	**Event "A2"**	**Event "05"**	**Event "06"**	**RBC**	**RC**	**# of Samples Exceeding RC and RBC**	**Event "01"**	**Event "A2"**	**Event "05"**	**Event "06"**	**RC**	**# of Samples Exceeding RC and RBC**
Cyanide (µg/L)	<DL	<DL	–	–	180	NA	0	<DL	<DL	–	–	NA	0
Pesticides	<DL	<DL	–	–	NA	NA	0	<DL	<DL	–	–	NA	0

Notes:

a	=	Phenanthrene does not have an RBC. Pyrene RBC used as surrogate.
b	=	Lead does not have an RBC or MCL. Therefore, the USEPA Treatment Technique Action Level of 15 µg/L has been substituted for the RBC.
**	=	Number of non-detects prevented determination of UTL.
NA	=	Not applicable
<DL	=	Below detection limit
01	=	First-quarter sampling event (2/97) for both wells.
A2	=	Second-quarter sampling event (3/97) for both wells.
05	=	Third-quarter sampling event (7/97) for both wells.
06	=	Fourth-quarter sampling event (10/97) for both wells.
–	=	Parameter not sampled.

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Table 10.4.19
SWMU 39 – Compounds Detected in Groundwater
Well Pair NBCA-039-015 and NBCA-039-15D

	NBCA-039-015							NBCA-039-15D					
Compound	Event "01"	Event "A2"	Event "05"	Event "06"	RBC	RC	# of Samples Exceeding RC and RBC	Event "01"	Event "A2"	Event "05"	Event "06"	RC	# of Samples Exceeding RC and RBC
VOCs (μg/L)													
All compounds	<DL	<DL	<DL	<DL	NA	NA	0	<DL	<DL	<DL	<DL	NA	0
SVOCs (μg/L)													
Benzoic acid	<DL	<DL	<DL	2	150,000	NA	0	<DL	<DL	<DL	<DL	NA	0
Dibenz(a,h)anthracene	<DL	<DL	<DL	<DL	0.0092	NA	0	<DL	1	<DL	<DL	NA	1
Diethylphthalate	<DL	<DL	<DL	1	29,000	NA	0	<DL	<DL	<DL	<DL	NA	0
Metals (μg/L)													
Aluminum	104	201	--	84	37,000	3,210	0	411	<DL	--	<DL	245	0
Arsenic	5.1	<DL	--	5.5	0.045	7.4	0	<DL	<DL	--	<DL	11.1	0
Barium	731	820	--	792	2,600	104	0	12.8	11.6	--	9	188	0
Beryllium	<DL	<DL	--	0.22	0.016	**	1	<DL	<DL	--	<DL	**	0
Calcium	96,200	99,100	--	91,000	NA	NA	NA	48,500	45,800	--	49,600	NA	NA
Chromium	2.4	33.1	--	1.7	180	8.7	0	1.1	<DL	--	<DL	7.3	0
Copper	<DL	7.9	--	<DL	1,500	15.7	0	<DL	4.3	--	<DL	5.8	0
Iron	8,930	8,010	--	3,730	NA	NA	NA	567	409	--	558	NA	NA
Magnesium	275,000	320,000	--	272,000	NA	NA	NA	15,100	13,700	--	15,300	NA	NA
Manganese	129	131	--	130	840	577	0	145	140	--	161	2,690	0

Table 10.4.19
SWMU 39 - Compounds Detected in Groundwater
Well Pair NBCA-039-015 and NBCA-039-15D

	NBCA-039-015							NBCA-039-15D					
Compound	**Event "01"**	**Event "A2"**	**Event "05"**	**Event "06"**	**RBC**	**RC**	**# of Samples Exceeding RC and RBC**	**Event "01"**	**Event "A2"**	**Event "05"**	**Event "06"**	**RC**	**# of Samples Exceeding RC and RBC**
Mercury	<DL	<DL	–	0.19	11	**	0	<DL	<DL	–	0.11	**	0
Nickel	1.1	<DL	–	0.82	730	**	0	1.4	<DL	–	<DL	21.1	0
Potassium	100,000	180,000	–	106,000	NA	NA	NA	9,180	12,000	–	8,270	NA	NA
Silver	<DL	9.8	–	<DL	180	**	0	<DL	<DL	–	<DL	**	0
Sodium	2,830,000	2,590,000	–	2,410,000	NA	NA	NA	120,000	102,000	–	120,000	NA	NA
Tin	<DL	60.1	–	<DL	22,000	**	0	<DL	<DL	–	<DL	**	0
Vanadium	0.54	<DL	–	<DL	260	5.4	0	1.3	<DL	–	<DL	10.9	0
Other Parameters													
Chloride (mg/L)	–	5,490	–	–	NA	NA	NA	–	190	–	–	NA	NA
Sulfate (mg/L)	–	<DL	–	–	NA	NA	NA	–	53.5	–	–	NA	NA
Cyanide (µg/L)	24.7	30	–	–	180	NA	0	<DL	<DL	–	–	NA	0
Pesticides	<DL	<DL	–	–	NA	NA	0	<DL	<DL	–	–	NA	0

Notes:

**	=	Number of non-detects prevented determination of UTL.
NA	=	Not applicable
<DL	=	Below detection limit
01	=	First-quarter sampling event (2/97) for both wells.
A2	=	Second-quarter sampling event (3/97) for both wells.
05	=	Third-quarter sampling event (7/97) for both wells.
06	=	Fourth-quarter sampling event (10/97) for both wells.
–	=	Parameter not sampled.

Volatile Organic Compounds in Groundwater

Of the VOCs detected in groundwater at SWMU 39, eleven compounds exceeded their respective RBCs, consisting of: ten in the shallow aquifer, eight in the intermediate aquifer, and six in the deep aquifer. Table 10.4.20 summarizes RBC exceedances in groundwater at SWMU 39.

Semivolatile Organic Compounds in Groundwater

Of the SVOCs detected in groundwater at SWMU 39, three compounds exceeded their respective RBCs, consisting of: two (bis(2-ethylhexyl)phthalate and pentachlorophenol) in the shallow aquifer, none in the intermediate aquifer, and one (dibenz(a,h)anthracene) in the deep aquifer. This data is also summarized in Table 10.4.20.

Other Organic Compounds in Groundwater

All dioxins detected in groundwater at SWMU 39 were below the calculated TEQ RBC of 4.0 E-07 during first and second quarter sampling. Subsequent sampling events resulted in four detections that exceeded the RBC in the shallow aquifer. This data is also summarized in Table 10.4.20.

Inorganics in Groundwater

Of the metals detected in groundwater at SWMU 39, four elements exceeded both their RBCs and RCs in the shallow aquifer (arsenic, beryllium, lead, and manganese), two (manganese and arsenic) in the intermediate aquifer, and two (arsenic and beryllium) in the deep aquifer.

Data Mapping

Based upon the groundwater RBC exceedances at SWMU 39, a total of nine figures summarizing data are included. It is critical to note that the wells were installed in four separate rounds, and groundwater sampling was also conducted in multiple rounds. Therefore, the data presented on the figures are the maximum detected at each well location in the events that the well was sampled.

Groundwater data for chlorinated solvents (maximum detected) are summarized on Figures 10.4.4, 10.4.5, and 10.4.6 for shallow, intermediate, and deep aquifers, respectively.

BTEX data (maximum detected) are summarized on Figures 10.4.7, 10.4.8, and 10.4.9 for shallow, intermediate, and deep aquifers, respectively.

Manganese and arsenic data (maximum detected) are summarized on Figures 10.4.10, 10.4.11, and 10.4.12 for shallow, intermediate, and deep aquifers, respectively.

Table 10.4.20
SWMU 39 - RBC Exceedance Summary

	Shallow MW														Intermediate MW					Deep MW			
Compound	039-001	039-002	039-003	039-004	039-005	039-007	039-008	039-009	039-010	039-011	039-012	039-013	039-014	039-015	039-04I	039-09I	039-10I	039-12I	039-13I	039-08D	039-10D	039-13D	039-15D
VOCs																							
Tetrachloroethene	0/5	0/5	**5/5**	**2/5**	0/5	0/4	0/5	0/5	0/5	0/4	0/5	**4/4**	0/4	0/4	0/4	0/5	0/6	0/5	**5/5**	0/5	0/6	**5/5**	0/4
Trichloroethene	0/5	0/5	**5/5**	**2/5**	0/5	0/4	0/5	**4/5**	0/5	0/4	**5/5**	**4/4**	0/4	0/4	0/4	0/5	0/6	**5/5**	**5/5**	0/5	0/6	**5/5**	0/4
cis-1,2-dichloroethene	0/5	0/5	0/5	0/5	0/5	0/4	0/5	0/5	0/5	0/4	**5/5**	0/4	0/4	0/4	0/4	0/5	0/6	**5/5**	**5/5**	0/5	0/6	**4/5**	0/4
1,1-dichloroethene	0/5	0/5	**1/5**	0/5	0/5	**1/4**	0/5	**1/5**	0/5	**1/4**	**5/5**	0/4	0/4	0/4	0/4	0/5	0/6	**5/5**	**4/5**	0/5	0/6	**4/5**	0/4
Vinyl chloride	0/5	0/5	0/5	0/5	**2/5**	0/4	0/5	**5/5**	0/5	0/4	**4/5**	0/4	0/4	0/4	0/4	0/5	**5/6**	**1/5**	**5/5**	0/5	**1/6**	**3/5**	0/4
1,1,2,2-tetrachloroethane	0/5	0/5	**1/5**	0/5	0/5	0/4	0/5	0/5	0/5	0/4	0/5	0/4	0/4	0/4	0/4	0/5	0/6	0/5	0/5	0/5	0/6	0/5	0/4
1,2-dichloroethane	0/5	0/5	0/5	0/5	0/5	0/4	0/5	0/5	0/5	**2/4**	0/5	0/4	0/4	0/4	**1/4**	0/5	0/6	0/5	0/5	0/5	0/6	0/5	0/4
Chloroform	0/5	0/5	0/5	0/5	0/5	0/4	0/5	0/5	0/5	0/4	0/5	0/4	0/4	0/4	**1/4**	0/5	0/6	0/5	0/5	0/5	0/6	**2/5**	0/4
Methylene chloride	0/5	0/5	0/5	0/5	0/5	0/4	0/5	0/5	0/5	0/4	0/5	0/4	**1/4**	0/4	0/4	0/5	0/6	0/5	0/5	0/5	0/6	0/5	0/4
Benzene	**5/5**	0/5	0/5	0/5	**5/5**	0/4	0/5	0/5	0/5	**4/4**	0/5	0/4	**4/4**	0/4	0/4	0/5	0/6	**3/5**	0/5	0/5	0/6	0/5	0/4
1,2-dibromo-3-chloropropane	0/5	0/5	**1/5**	0/5	0/5	0/4	0/5	0/5	0/5	0/4	0/5	0/4	0/4	0/4	0/4	0/5	0/6	0/5	0/5	0/5	0/6	0/5	0/4

Table 10.4.20
SWMU 39 - RBC Exceedance Summary

Compound	Shallow MW														Intermediate MW					Deep MW			
	039-001	039-002	039-003	039-004	039-005	039-007	039-008	039-009	039-010	039-011	039-012	039-013	039-014	039-015	039-04I	039-09I	039-10I	039-12I	039-13I	039-08D	039-10D	039-13D	039-15D
VOCs																							
is(2-ethylhexyl)phthalate	1/4	0/4	0/4	0/4	2/4	0/3	0/4	0/4	0/4	1/3	0/4	0/4	0/4	0/4	0/3	0/4	0/4	0/4	0/4	0/4	0/4	0/4	0/4
Dibenz(a,h)anthracene	0/4	0/4	0/4	0/4	0/4	0/3	0/4	0/4	0/4	0/3	0/4	0/4	0/4	0/4	0/3	0/4	0/4	0/4	0/4	0/4	0/4	0/4	1/4
Pentachlorophenol	0/4	0/4	0/4	0/4	0/4	0/3	0/4	0/4	0/4	1/3	0/4	0/4	0/4	0/4	0/3	0/4	0/4	0/4	0/4	0/4	0/4	0/4	0/4
Metals																							
Arsenic	4/4	4/4	0/4	4/4	4/4	½	2/3	3/3	1/3	0/2	3/3	1/3	3/3	0/3	1/1	½	2/2	2/3	½	3/3	0/2	0/2	0/3
Beryllium	0/4	0/4	0/4	0/4	0/4	0/2	0/3	0/3	0/3	0/2	0/3	1/3	0/3	1/3	0/1	0/2	0/2	0/3	0/2	2/3	0/2	0/2	0/3
Lead	0/4	0/4	0/4	0/4	0/4	0/2	0/3	0/3	0/3	0/2	0/3	1/3	0/3	0/3	0/1	0/2	0/2	0/3	0/2	0/3	0/2	0/2	0/3
Manganese	3/4	4/4	0/4	4/4	4/4	0/2	0/3	2/3	0/3	0/2	3/3	0/3	0/3	0/3	0/1	0/2	2/2	0/3	0/2	0/3	0/2	0/2	0/3
Other Parameters																							
Dioxin (TCDD TEQ)	1/1	0/1	0/4	½	½	0/1	0/2	0/2	½	0/1	0/2	0/1	—	—	—	0/1	0/1	0/2	0/1	0/2	0/1	0/1	—

tes:
/ = Number of exceedances/number of samples.
= No dioxin samples collected at this well.
e following shallow well did not have any compounds exceeding the risk-based concentrations: NBCA-039-006.
e following deep wells did not have any compounds exceeding the risk-based concentrations: NBCA-039-04D, NBCA-039-09D, NBCA-039-12D, and NBCA-039-14D.

Hess Oil Tank Farm

LEGEND

Intermediate Monitoring Well
As = Arsenic (RBC = 0.045 ppb)
Mn = Manganese (RBC = 840 ppb)

0 400 feet

* ALL CONCENTRATIONS SHOWN ARE IN PARTS PER BILLION

ND = NOT DETECTED

ONE OR BOTH EXCEEDS ITS RBC AND RC

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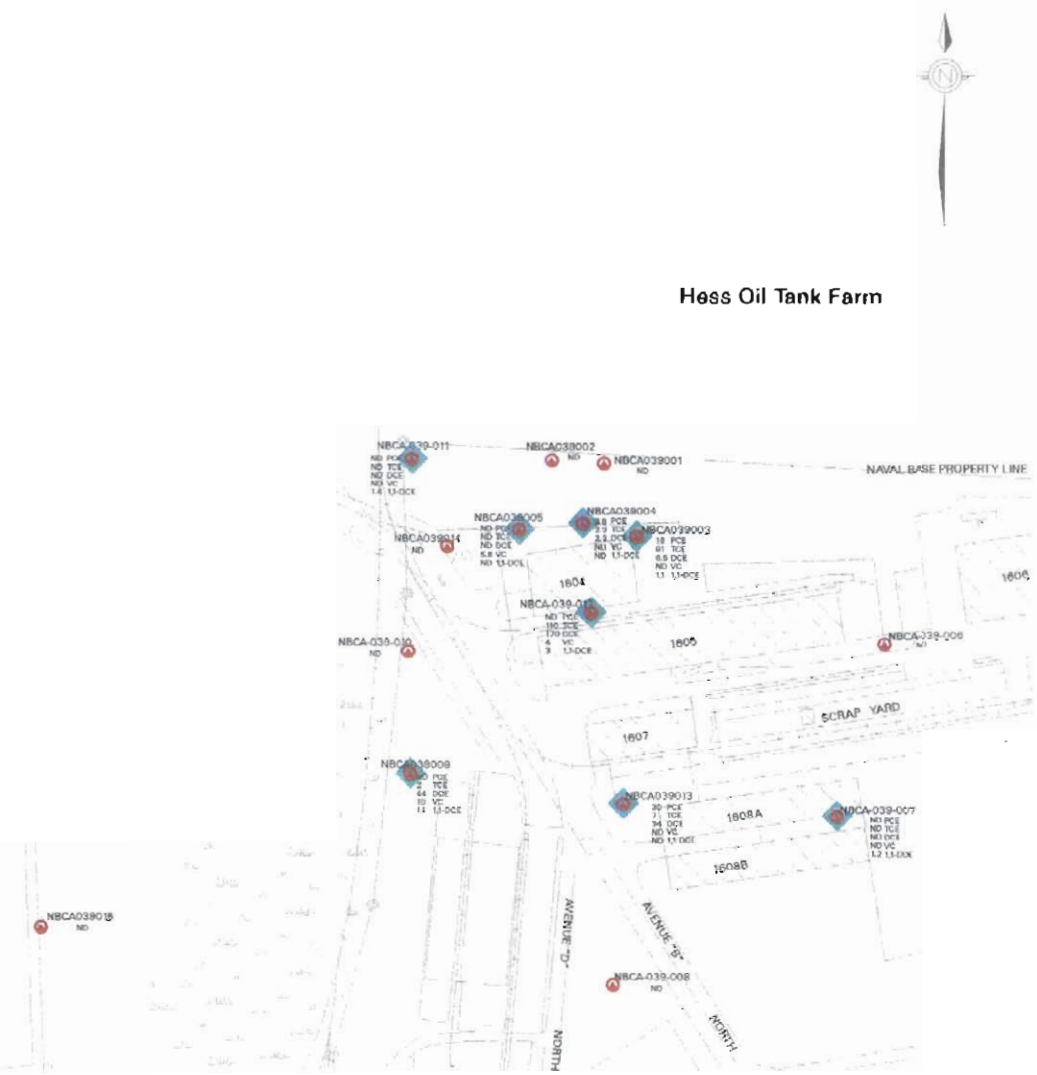
FIGURE 10.4.11 - SWMU 39
Arsenic and Manganese Maximum
Detections in Intermediate Groundwater



LEGEND

- Shallow Monitoring Well

PCE = Tetrachloroethene (RBC = 1.1 ppb)
TCE = Trichloroethene (RBC = 1.6 ppb)
DCE = cis - 1,2-dichloroethene (RBC = 61 ppb)
VC = Vinyl Chloride (RBC = 0.019 ppb)
1,1-DCE = 1,1-dichloroethene (RBC = 0.044 ppb)

* ALL CONCENTRATIONS SHOWN ARE IN PARTS PER BILLION

ND = NOT DETECTED

ONE OR MORE OF THESE COMPOUNDS EXCEEDS ITS RBC

0 400 feet

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FIGURE 10.4.4 - SWMU 39
Chlorinated Solvent Maximum Detections in Shallow Groundwater

Hess Oil Tank Farm

LEGEND

0 400 feet

- Intermediate Monitoring Well

PCE = Tetrachloroethene (RBC = 1.1 ppb)
TCE = Trichloroethene (RBC = 1.6 ppb)
DCE = cis - 1,2-dichloroethene (RBC = 61 ppb)
VC = Vinyl Chloride (RBC = 0.019 ppb)
1,1-DCE = 1,1-dichloroethene (RBC = 0.044 ppb)

* ALL CONCENTRATIONS SHOWN ARE IN PARTS PER BILLION

ND = NOT DETECTED

ONE OR MORE OF THESE COMPOUNDS EXCEEDS ITS RBC

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FIGURE 10.4.5 - SWMU 39
Chlorinated Solvent Maximum Detections in Intermediate Groundwater

Hess Oil Tank Farm

LEGEND

0 400 feet

Deep Monitoring Well
PCE = Tetrachloroethene (RBC = 1.1 ppb)
TCE = Trichloroethene (RBC = 1.6 ppb)
DCE = cis - 1,2-dichloroethene (RBC = 61 ppb)
VC = Vinyl Chloride (RBC = 0.019 ppb)
1,1-DCE = 1,1-dichloroethene (RBC = 0.044 ppb)

* ALL CONCENTRATIONS SHOWN ARE IN PARTS PER BILLION

ND = NOT DETECTED

ONE OR MORE OF THESE COMPOUNDS EXCEEDS ITS RBC

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Charleston, SC

FIGURE 10.4.6 - SWMU 39
Chlorinated Solvent Maximum Detections in Deep Groundwater

Hess Oil Tank Farm

LEGEND

- Shallow Monitoring Well
- B = Benzene
- T = Toluene
- E = Ethylbenzene
- X = Xylene (total)

* ALL CONCENTRATIONS SHOWN ARE IN PARTS PER BILLION

ND = NOT DETECTED

BENZENE EXCEEDS ITS RBC

0 400 feet

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Charleston, SC

FIGURE 10.4.7 - SWMU 39
BTEX Maximum Detections in Shallow Groundwater

Hess Oil Tank Farm

LEGEND

- Intermediate Monitoring Well
- B = Benzene
- T = Toluene
- E = Ethylbenzene
- X = Xylene (total)

* ALL CONCENTRATIONS SHOWN ARE IN PARTS PER BILLION

ND = NOT DETECTED

BENZENE EXCEEDS ITS RBC

0 400 feet

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FIGURE 10.4.8 - SWMU 39
BTEX Maximum Detections
in Intermediate Groundwater

Hess Oil Tank Farm

LEGEND

- Deep Monitoring Well
- B = Benzene
- T = Toluene
- E = Ethylbenzene
- X = Xylene (total)

* ALL CONCENTRATIONS SHOWN ARE IN PARTS PER BILLION

ND = NOT DETECTED

0 400 feet

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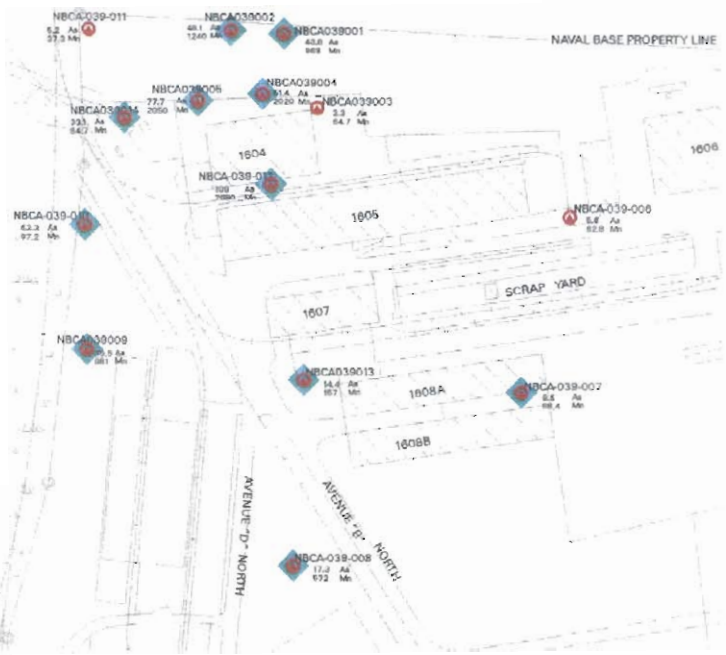
FIGURE 10.4.9 - SWMU 39
BTEX Maximum Detections
in Deep Groundwater

Hess Oil Tank Farm



LEGEND

Shallow Monitoring Well
As = Arsenic (RC = 7.4 ppb)
Mn = Manganese (RBC = 840 ppb)

0 400 feet

* ALL CONCENTRATIONS SHOWN ARE IN PARTS PER BILLION

ND = NOT DETECTED

ONE OR BOTH EXCEEDS ITS RBC AND RC

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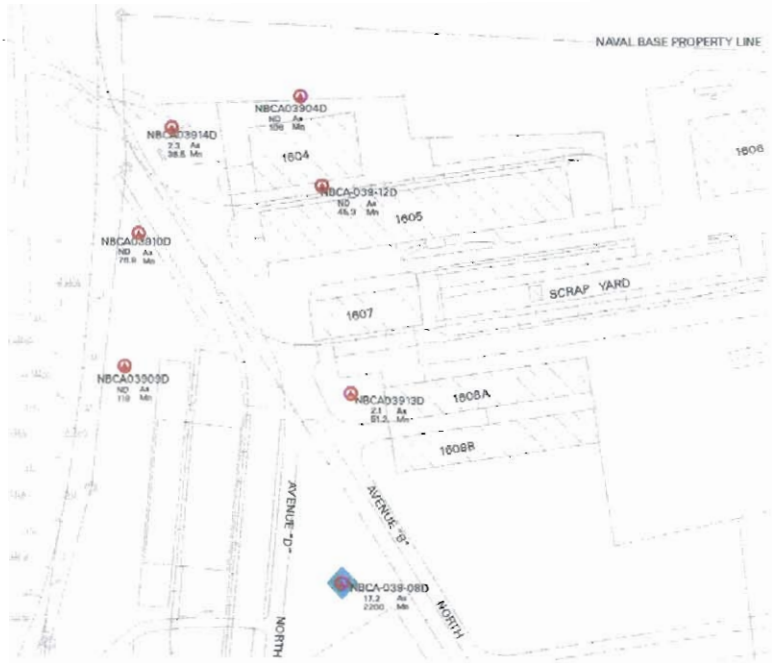
Charleston, SC

FIGURE 10.4.10 - SWMU 39
Arsenic and Manganese Maximum Detections in Shallow Groundwater

Hess Oil Tank Farm



LEGEND

Deep Monitoring Well
As = Arsenic (RC = 11.1 ppb)
Mn = Manganese (RC = 2690 ppb)

0 400 feet

* ALL CONCENTRATIONS SHOWN ARE IN PARTS PER BILLION

ND = NOT DETECTED

ONE OR BOTH EXCEEDS ITS RBC AND RC

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FIGURE 10.4.12 - SWMU 39
Arsenic and Manganese Maximum Detections in Deep Groundwater

Data Contouring

VOCs that exceeded the RBCs in more than one well at SWMU 39 were considered for contouring. This presentation of data included using data from adjacent sites' well samples and CPT data for samples collected off NAVBASE to assist with plume delineation. Two estimated contour lines are depicted, where applicable, the "zero" or non-detect boundary and the maximum contaminant level (MCL). Six VOCs were considered for contouring in each groundwater interval (shallow, intermediate, and deep): tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (DCE), vinyl chloride (VC), 1,1-dichloroethene (1,1-DCE), and benzene. Table 10.4.21 summarizes the datasets available for contouring. Contaminants with only one detection were not contoured.

Table 10.4.21
SWMU 39 Contour Map Summary

	Shallow Aquifer			Intermediate Aquifer			Deep Aquifer		
Compound	# of hits [a]	# of points [b]	Map (Y/N)	# of hits [a]	# of points [c]	Map (Y/N)	# of hits [a]	# of points [d]	Map (Y/N)
PCE	4	36	Yes, Fig. 10.4.13	1	13	No	1	9	No
TCE	6	36	Yes, Fig. 10.4.14	2	13	Yes, Fig. 10.4.19	1	9	No
DCE	5	36	Yes, Fig.10.4.15	4	13	Yes, Fig. 10.4.20	2	9	Yes, Fig. 10.4.24
VC	3	36	Yes, Fig. 10.4.16	2	13	Yes, Fig. 10.4.21	2	9	Yes, Fig. 10.4.25
1,1-DCE	6	36	Yes, Fig. 10.4.17	2	13	Yes, Fig. 10.4.22	1	9	No
Benzene	6	36	Yes, Fig. 10.4.18	2	13	Yes, Fig. 10.4.23	0	9	No

Notes:

a = Maximum detection for parameter per location was used for contouring, where applicable

b = 36 shallow locations consist of: 15 shallow wells (SWMU 39), 13 shallow CPT samples (SWMU 39), 4 shallow wells (SWMU 42/AOC 505), 2 shallow wells (SWMU 38), and 2 shallow wells (SWMU 2).

c = 13 intermediate locations consist of: 5 intermediate wells (SWMU 39) and 8 intermediate CPT samples (SWMU 39).

d = 9 deep locations consist of: 8 deep wells (SWMU 39) and 1 deep well (SWMU 38).

Dense Nonaqueous Phase Liquids (DNAPLs) were encountered at monitoring well NBCA-039-005 during the first round. No DNAPL layer was noted during subsequent sampling of this well. During the first round, a sample of the DNAPL was bailed from the well for characterization analyses. Due to the difficulties in obtaining significant quantities by bailings, this sample was placed into seven 40-ml VOA vials because other containers would have been too large. The laboratory mistakenly analyzed each of the vials for VOCs instead of combining their contents and performing the requested characterization analyses. Table 10.4.22 lists the VOCs and their average concentrations.

Table 10.4.22
Monitoring Well NBCA-039-005
DNAPL VOC Constituents

Compound	Concentration (μg/L)
Benzene	114
Bromomethane	2.5
2-butanone (MEK)	5.3
cis-1,2-dichloroethene	1.7
1,1-dichloroethane	2.3
Ethylbenzene	2.9
2-hexanone	4.8
o-Xylene	1.1
1,1,2,2-tetrachloroethane	1.5
Vinyl chloride	3.7
Xylene	2.1

Additionally, an LNAPL was observed in NBCA-039-011. The well was installed on July 10, 1996. Development of the well was initiated on July 29, 1997. During the initial development it was recorded that approximately 1 foot of LNAPL was observed in the development pump suction line. On January 22, 1997 water level measurements were taken in SWMU 39 wells and a 0.37 foot thickness of LNAPL was measured in well NBCA-039-011 using an oil-water interface probe. The well was sampled again during the week of August 3, 1997. No measurable LNAPL was observed at that time.

LEGEND

Approximate extent of PCE based upon computer generated contours

- ND
- ND - MCL (5 ppb)
- > MCL (5 ppb)

0 feet 700

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CHARLESTON, S.C.

FIGURE 10.4.13
SWMU 39
PCE IN
SHALLOW GROUNDWATER

AML

LEGEND

Approximate extent of TCE based upon computer generated contours

- ND
- ND - MCL (5 ppb)
- > MCL (5 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
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CHARLESTON, S.C.

FIGURE 10.4.14
SWMU 39
TCE IN
SHALLOW GROUNDWATER

AML: /home2/projects/charleston_de/zone_a_dir/contour_dir/

LEGEND

Approximate extent of CIS-1,2-DCE based upon computer generated contours

ND

ND - MCL (70 ppb)

> MCL (70 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.4.15
SWMU 39
CIS-1,2-DCE IN
SHALLOW GROUNDWATER

AML: /home3/projects/charleston dir/zone a dir/contour dir/

LEGEND

Approximate extent of VINYL CHLORIDE based upon computer generated contours

- ND
- ND - MCL (2 ppb)
- > MCL (2 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.4.16
SWMU 39
VINYL CHLORIDE IN SHALLOW GROUNDWATER

AML: /home3/projects/charleston_dir/zone_a_dir/contour_dir/

LEGEND

Approximate extent of 1,1-DCE based upon computer generated contours

- ND
- ND - MCL (7 ppb)
- > MCL (7 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.4.17
SWMU 39
1,1-DCE IN
SHALLOW GROUNDWATER

AML: /home3/projects/charleston_dir/zone_a_dir/contour_dir/

LEGEND

Approximate extent of BENZENE based upon computer generated contours

- ND
- ND - MCL (5 ppb)
- > MCL (5 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.4.18
SWMU 39
BENZENE IN
SHALLOW GROUNDWATER

AML: /home3/projects/charleston_de/zone_a_dir/contour dir/

LEGEND

Approximate extent of TCE based upon computer generated contours

ND

ND - MCL (5 ppb)

> MCL (5 ppb)

0 feet 700

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CHARLESTON, S.C.

FIGURE 10.4.19
SWMU 39
TCE IN
INTERMEDIATE GROUNDWATER

AML: /home3/projects/charleston_dir/zone_a_dir/contour_dir/

LEGEND

Approximate extent of CIS-1,2-DCE based upon computer generated contours

- ND
- ND - MCL (70 ppb)
- > MCL (70 ppb)

0 feet 700

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CHARLESTON, S.C.

FIGURE 10.4.20
SWMU 39
CIS-1,2-DCE IN
INTERMEDIATE GROUNDWATER

LEGEND

Approximate extent of VINYL CHLORIDE based upon computer generated contours

- ND
- ND - MCL (2 ppb)
- > MCL (2 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
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CHARLESTON, S.C.

FIGURE 10.4.21
SWMU 39
VINYL CHLORIDE IN
INTERMEDIATE GROUNDWATER

AML: /home3/projects/charleston_dir/zone_a_dir/contour dir/

LEGEND

Approximate extent of 1,1-DCE based upon computer generated contours

- ND
- ND - MCL (7 ppb)
- > MCL (7 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.4.22
SWMU 39
1,1-DCE IN
INTERMEDIATE GROUNDWATER

AML: /home3/projects/charleston_dir/zone_a_dir/contour_dir/

LEGEND

Approximate extent of BENZENE based upon computer generated contours

ND

ND - MCL (5 ppb)

> MCL (5 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.4.23
SWMU 39
BENZENE IN
INTERMEDIATE GROUNDWATER

AML: /home3/projects/charleston dir/zone a dir/contour.dgn

LEGEND

Approximate extent of CIS-1,2-DCE based upon computer generated contours

- ND
- ND - MCL (70 ppb)
- > MCL (70 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.4.24
SWMU 39
CIS-1,2-DCE IN
DEEP GROUNDWATER

AMIL: /home3/projects/charleston_dir/zone_a_dir/contour_dir/

LEGEND

Approximate extent of VINYL CHLORIDE based upon computer generated contours

- ND
- ND - MCL (2 ppb)
- > MCL (2 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
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CHARLESTON, S.C.

FIGURE 10.4.25
SWMU 39
VINYL CHLORIDE IN DEEP GROUNDWATER

10.4.5 Summary of Geoprobe Investigation at SWMU 39

The Geoprobe investigation was conducted at SWMU 39 between Monday, June 17, 1996, and Friday, June 21, 1996. The constituents of concern that warranted this investigation were chlorinated solvents, including: tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (DCE), and vinyl chloride.

The sampling strategy for the Geoprobe sampling was outlined in the NAVBASE project team meeting on February 28, 1996. It was included in the *Zones A and B - Second Round RFI Sampling* (E/A&H, March 1996) memorandum that detailed all second-round sampling planned for both Zones A and B. Sampling was conducted in accordance with Section 6.1.3 included in Revision No. 01 of the *Final Comprehensive Sampling and Analysis Plan* (CSAP) dated December 1, 1995.

This Geoprobe investigation was originally scheduled for March 1996. At that time, the investigation included SWMU 39, SWMU 42/AOC 505, and SWMU 43 because only the first quarter of data had been received. The "interim" sampling was conducted to verify the chlorinated solvent detections from the initial sampling event prior to BCT approval of the Geoprobe investigation. When the data were received, the proposed Geoprobe investigation was scaled back to include only SWMU 39 and SWMU 43 (Anderson to Bergstrand letter dated May 22, 1996).

Field Investigation

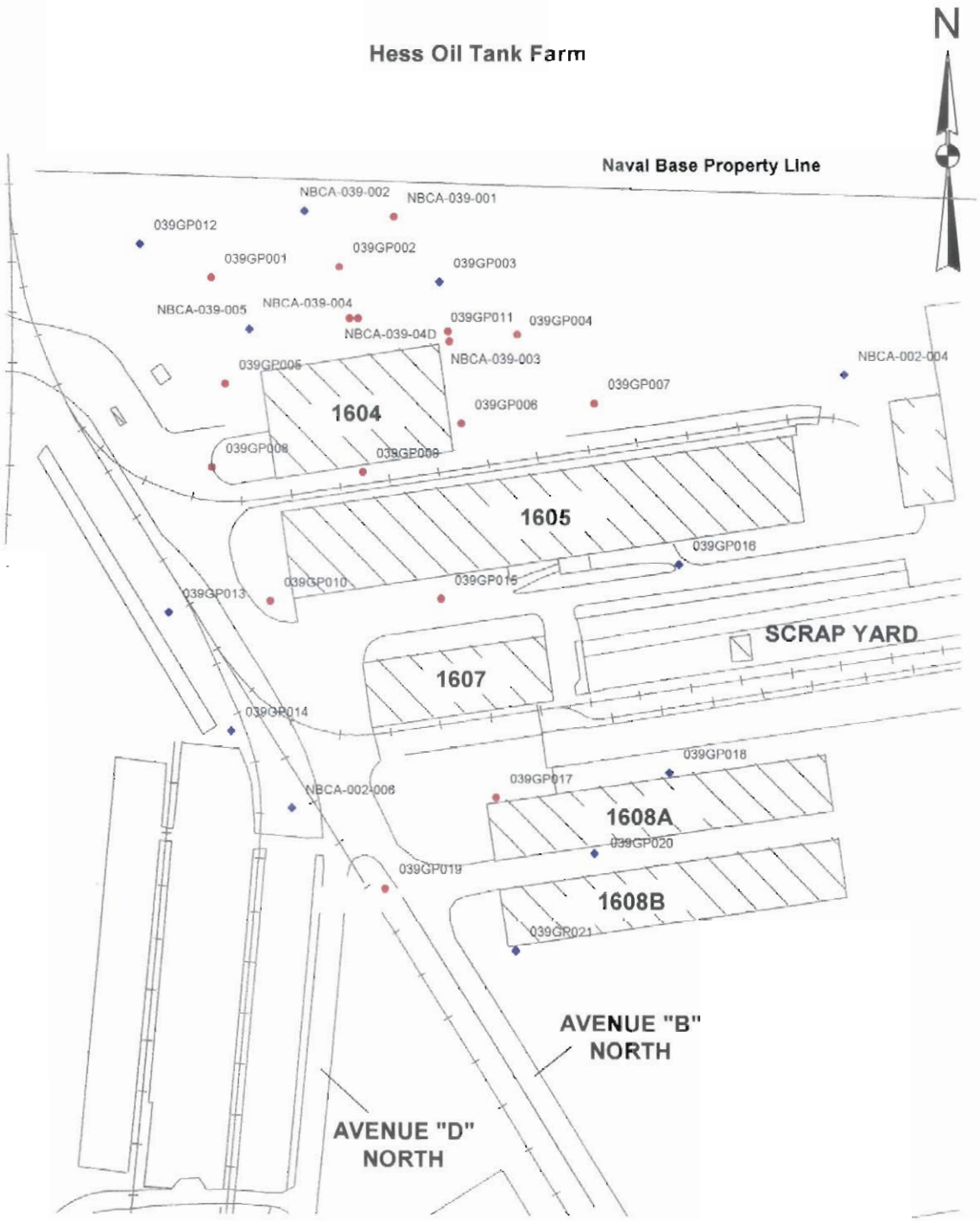
Soil samples were collected from a subsurface interval (2' to 4' bgs) and groundwater samples were collected from the shallow aquifer (5' to 18' bgs) at each location. The samples were analyzed at an onsite laboratory with a GC/MS (Method 5030/8260); 25% were duplicated for offsite laboratory confirmation analyses. After sampling, each borehole was abandoned using bentonite pellets. A sample was also collected from eight existing monitoring wells for onsite analyses. The wells were not triple-volume purged prior to sampling because of the "screening"

quality of the data being generated by the onsite laboratory. For these samples, groundwater was simply extracted from the wells using Teflon tubing.

On Tuesday, June 18, 1996, the Geoprobe investigation began at this site. Eleven borings were installed, and subsurface soil and groundwater samples were collected. Based upon the results of these groundwater samples, 10 additional locations were sampled over the following two days. These locations are shown on Figure 10.4.26. The depth of the top of the 2-foot screen at which groundwater was collected for each sample is indicated by the last two digits of the 10-digit alphanumeric code. For example, 039GP00107 was Geoprobe boring 1 at SWMU 39 and the sampling interval was 7 feet to 9 feet bgs.

Eight monitoring wells were resampled to support this investigation, including: five shallow wells at SWMU 39, one deep well at SWMU 39, NBCA-002-004, and NBCA-002-006. With the exception of shallow well NBCA-039-001, all monitoring well data was consistent with earlier analytical results. DCE was detected in NBCA-039-001 for the first time during this investigation. Table 10.4.23 summarizes all Geoprobe groundwater data analyzed onsite during this investigation.

For additional QA/QC of the data generated by the onsite laboratory, five duplicate samples were analyzed by Lockheed Analytical Services. Duplicate groundwater samples from borings GP007, GP009, GP015, GP018, and GP019 were collected with the last two characters designated as LH for "Lockheed" (e.g., sample 039GP007LH in Table 10.4.24 is the duplicate for sample 039GP00705 in Table 10.4.23). This data was consistent with the onsite data for the duplicate samples in that chlorinated solvents were either detected or not detected in both samples by each laboratory. This offsite laboratory data is summarized in Table 10.4.24.



100 0 100 200 Feet

LEGEND

- Chlorinated solvents not detected during Geoprobe event
- Chlorinated solvents detected during Geoprobe event

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FIGURE 10.4.26 - SWMU 39
Geoprobe Sample Locations

Table 10.4.25
Summary of CPT Boring Locations

Location	CPT Depth (feet)	Shallow GW Interval	Shallow GW Sample ID	Intermediate GW Interval	Intermediate GW Sample ID
039GP036	NA	9.5-11.5	039GP03611	NA	NC
039GP037	0-45	8.9-10.9	039GP03711	17-19	039GP03719
ZONE A LOCATIONS (No groundwater samples collected)					
039CP001	0-34	NA	NC	NA	NC
039CP002	0-61	NA	NC	NA	NC
039CP003	0-34	NA	NC	NA	NC
039CP004	0-34	NA	NC	NA	NC
039CP005	0-50	NA	NC	NA	NC
039CP006	0-41	NA	NC	NA	NC
039CP007	0-68	NA	NC	NA	NC
039CP008	0-55	NA	NC	NA	NC
039CP009	0-60	NA	NC	NA	NC
039CP010	0-60	NA	NC	NA	NC
039CP011	0-58	NA	NC	NA	NC
039CP012	0-60	NA	NC	NA	NC
039CP013	0-57	NA	NC	NA	NC

Notes:
NA = Not applicable.
NC = No sample collected.

Table 10.4.26
Summary of CPT Groundwater Analyses

Sample Location	PCE (μg/L)	TCE (μg/L)	Total DCE (μg/L)	Vinyl Chloride (μg/L)	Other
CPT GROUNDWATER SAMPLES					
039GP02211	< 5	< 5	< 5	< 10	Toluene 5.4
039GP02223	< 5	< 5	< 5	< 10	<DL
039GP02312	< 5	< 5	< 5	< 10	Chloroform 8.2
039GP02326	< 5	< 5	< 5	< 10	<DL
039GP02412	< 5	< 5	< 5	< 10	<DL
039GP02426	< 5	< 5	< 5	< 10	Chloroform 6.6
039GP02510	< 5	< 5	< 5	< 10	Carbon Disulfide 28.5, Toluene 1.1J, Benzene 3.6J, xylene (tot) 10.5
039GP02520	< 5	< 5	< 5	< 10	Carbon Disulfide 23.7, Benzene 3.2J, xylene (tot) 8.2
039GP02611	< 5	< 5	< 5	< 10	<DL
039GP02711	< 5	< 5	< 5	< 10	Chloroform 3.2J, Toluene 1.1J
039GP02910	< 5	< 5	< 5	< 10	Toluene 1.5J

Table 10.4.26
Summary of CPT Groundwater Analyses

Sample Location	PCE (μg/L)	TCE (μg/L)	Total DCE (μg/L)	Vinyl Chloride (μg/L)	Other
039GP03127	< 5	< 5	< 5	< 10	<DL
039GP03211	< 5	< 5	< 5	< 10	Toluene 1.8J, Carbon Disulfide 2.9J
039GP03311	< 5	< 5	< 5	< 10	<DL
039GP03325	< 5	< 5	< 5	< 10	Carbon Disulfide 1.2J
039GP03411	< 5	< 5	< 5	< 10	<DL
039GP03511	< 5	< 5	< 5	< 10	<DL
039GP03530	< 5	< 5	< 5	< 10	<DL
039GP03611	< 5	< 5	<5	< 10	<DL
039GP03711	< 5	< 5	< 5	< 10	Benzene 2.5J, 2-Hexanone 1.9J
039GP03719	< 5	< 5	< 5	< 10	<DL

Notes:
J = Estimated concentration less than the method detection limit but greater than the instrument detection limit.

As Table 10.4.26 indicates, there were no chlorinated solvent detections above the respective method detection limits in any of the groundwater samples collected beyond NAVBASE property. There were detections of chemicals most likely associated with the diesel fuel contamination evident in monitoring well NBCA-039-011; however, these detections were primarily limited to the sampling locations along Virginia Avenue with only one detection along O'Hear Avenue and were typically only found in shallow groundwater except at location 039CP025 where traces were detected at 20 feet below ground surface.

10.4.7 Sediment/Surface Water Sampling and Analysis

During the extensive groundwater investigation conducted at SWMU 39, five locations were selected for the collection of VOC samples for both sediment and surface water, and one duplicate sample was collected from both media. This sampling was conducted in response to a RAB member's concern over the potential for contaminated groundwater to impact the adjoining marsh. All of these locations are shown on Figure 10.4.29.

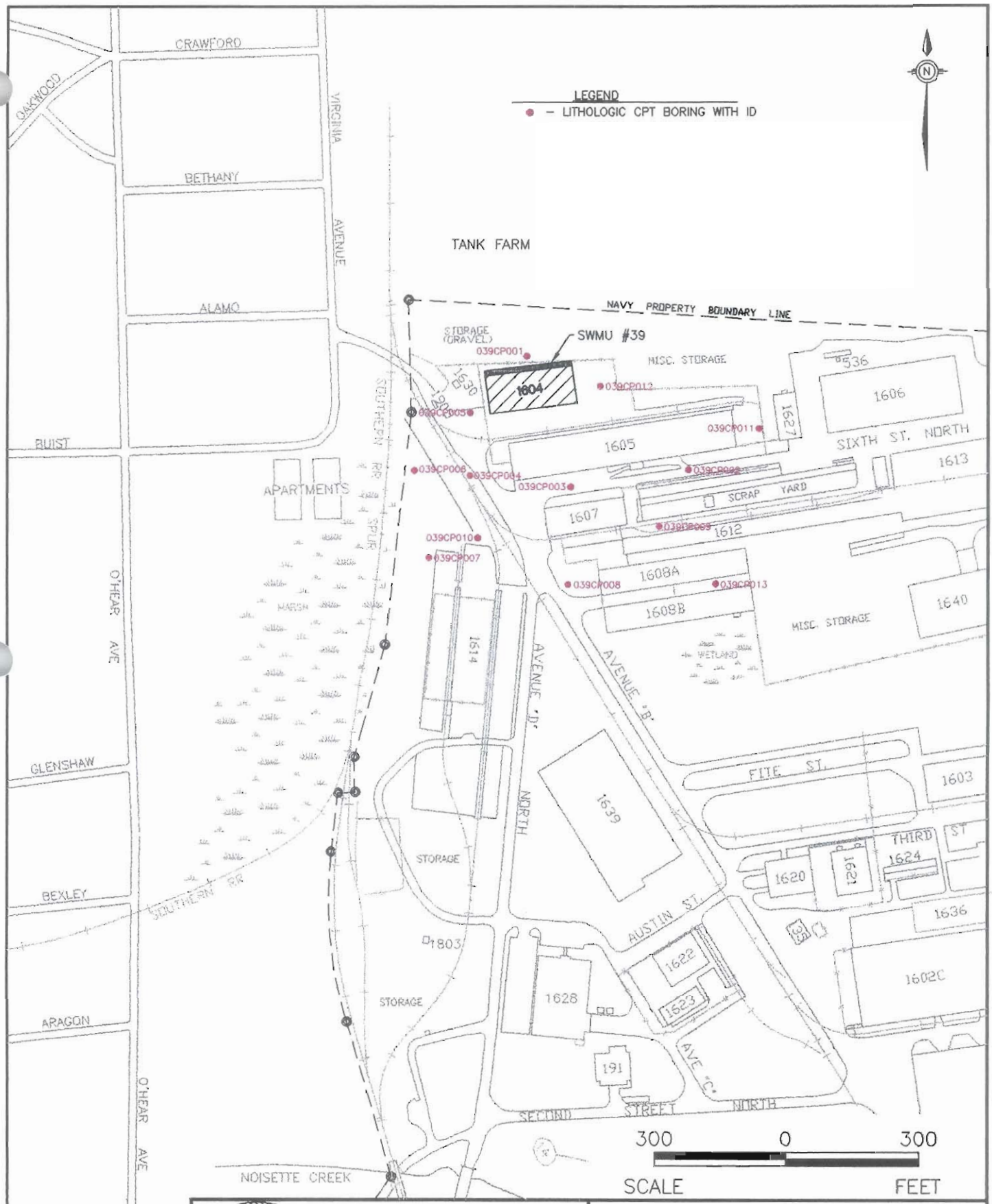

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FIGURE 10.4.27
SWMU 39
CPT LOCATIONS

DWG DATE: 04/03/98 | DWG NAME: 2901S004

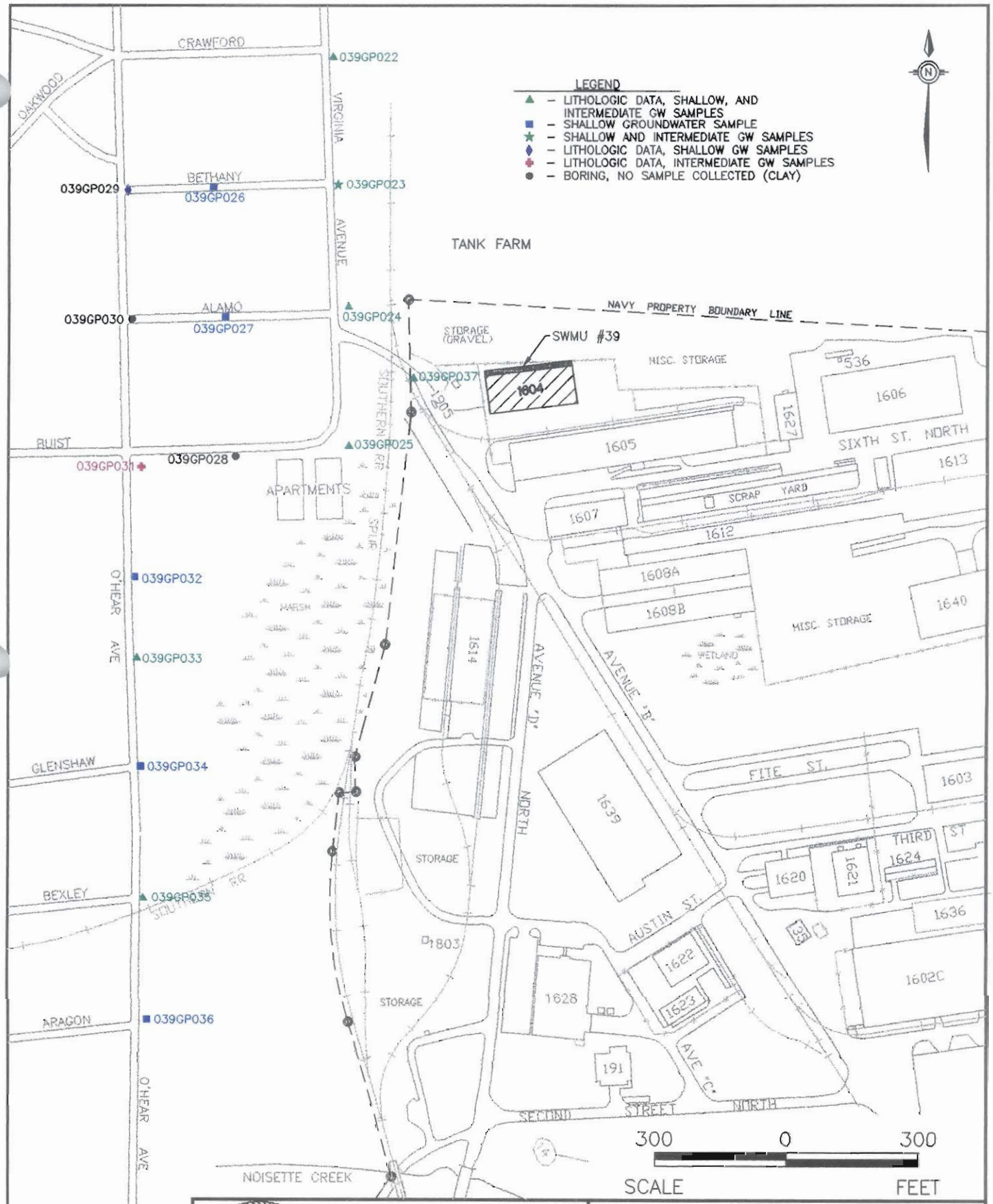

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FIGURE 10.4.28
SWMU 39
OFF-BASE SAMPLE LOCATIONS

DWG DATE: 04/06/98 | DWG NAME: 2901S001

Table 10.4.23
SWMU 39 - Geoprobe Groundwater Data Summary
Analytical Results from Onsite Laboratory

	Results (μg/L)				
Sample Location	**PCE**	**TCE**	**DCE**	**Vinyl Chloride**	**Other**
Geoprobe Borings (21 groundwater samples collected)					
039GP00107	< 2	4.7	5.0	< 5	< DL
039GP00207	1.9J	5.3	38.0	29.0	< DL
039GP00309	< 2	< 2	< 2	< 5	< DL
039GP00405	57.0	3.5	1.8J	< 5	1,2,4-trimethylbenzene 2.4
039GP00505	< 2	< 2	124	18.3	1,1-dichloroethane 18.7 benzene 9.6
039GP00609	3.5	12.7	132	16.4	1,2,4-trimethylbenzene 2.4 toluene 3.0 1,1,2,2-tetrachloroethane 4.4
039GP00705	< 2	< 2	3.3	< 5	1,2,4-trimethylbenzene 1.8J
039GP00805	< 2	< 2	499	110	naphthalene 451
039GP00907	< 2	141	509	12.2	1,2,4-trimethylbenzene 2.4 benzene 4.5 trans-1,2-dichloroethane 5.8 1,1-dichloroethane 12.0
039GP01012	< 2	2.3	35.3	< 5	1,2,4-trimethylbenzene 1.9J
039GP01106	1.5J	9.2	6.3	< 5	1,2,4-trimethylbenzene 2.3
039GP01202	< 2	< 2	< 2	< 5	< DL
Geoprobe Borings (21 groundwater samples collected)					
039GP01309	< 2	< 2	< 2	< 5	< DL
039GP01409	< 2	< 2	< 2	< 5	< DL
039GP01508	< 2	19	41	< 5	< DL
039GP01612	< 2	< 2	< 2	< 5	< DL
039GP01712	23	6.0	26	< 5	< DL
039GP01808	< 2	< 2	< 2	< 5	< DL
039GP01912	1.6J	< 2	< 2	< 5	< DL
039GP02012	< 2	< 2	< 2	< 5	< DL
039GP02116	< 2	< 2	< 2	< 5	< DL

Table 10.4.23
SWMU 39 - Geoprobe Groundwater Data Summary
Analytical Results from Onsite Laboratory

	Results (μg/L)				
Sample Location	**PCE**	**TCE**	**DCE**	**Vinyl Chloride**	**Other**
Existing Monitoring Wells (6 groundwater samples collected during geoprobe event)					
NBCA-002-004	< 2	< 2	< 2	< 5	< DL
NBCA-002-006	< 2	< 2	< 2	< 5	< DL
NBCA-039-001	< 2	< 2	2.9	< 5	benzene 24.2 n-propylbenzene 4.2 ethylbenzene 3.0 sec-butylbenzene 3.5 m,p-xylene 68.0 n-butylbenzene 3.5 isopropylbenzene 6.8
NBCA-039-002	< 2	< 2	< 2	< 5	< DL
NBCA-039-003	13.2	68.1	12.9	< 5	< DL
NBCA-039-004	< 2	< 2	1.4J	< 5	< DL
NBCA-039-04D	< 2	< 2	< 2	< 5	< DL
NBCA-039-005	< 2	< 2	< 2	< 5	benzene 92 n-propylbenzene 4.6 naphthalene 174 n-butylbenzene 3.2 ispropylbenzene 8.0

Note:
J = Indicates estimated concentration.

Table 10.4.24
SWMU 39 — Geoprobe Groundwater Data Summary
Analytical Results from Offsite Laboratory (μg/L)

Constituent	039GP007LH	039GP009LH	039GP015LH	039GP018LH	039GP019LH
Acetone	<DL	<DL	<DL	6.5	6.3
Benzene	<DL	8.6	1.3	<DL	<DL
1,1-dichloroethane	<DL	16	6.7	<DL	<DL
1,1-dichloroethene	<DL	16	6.7	<DL	<DL
cis-1,2-dichloroethene	3.7	570	280	<DL	<DL

Table 10.4.24
SWMU 39 — Geoprobe Groundwater Data Summary
Analytical Results from Offsite Laboratory (μg/L)

Constituent	039GP007LH	039GP009LH	039GP015LH	039GP018LH	039GP019LH
trans-1,2-dichloroethene	<DL	7.5	4.2	<DL	<DL
1,1,2,2-tetrachloroethane	<DL	1	<DL	<DL	<DL
Trichloroethene	<DL	240	91	<DL	<DL
Toluene*	3.5	2.2	1.8	2.0	1.8
Vinyl chloride	<DL	13	6.8	<DL	<DL
Xylene (m+p)	2.5	<DL	<DL	<DL	<DL

Note:
<DL = Below detection limit.

Analysis of the data collected during the Geoprobe investigation identified a suspected plume of chlorinated solvent contamination in the general vicinity of Buildings 1604, 1605, and 1607. The boundary of the plume was approximated by the following Geoprobe and monitoring well sampling locations: NBCA-002-004, 039-GP016, 039-GP-018, 039-GP020, 039-GP021, 039-GP019, NBCA-002-006, 039-GP014, and 039-GP013 (see Figure 10.4.26).

10.4.6 CPT Investigation

The on-base portion of the CPT direct push investigation occurred between September 13-15, 1996 and the off-base portion of the investigation took place between September 25-30, 1996; both are included in SCDHEC permit HW-96-0081 dated September 16, 1996.

Thirteen (13) cone penetrometer borings were pushed in the vicinity of SWMU 39 in Zone A. The purpose of these borings was to further define the stratigraphic relationship between the shallow aquifer and the discontinuous clay layers that often overlie an intermediate sand unit. These borings were pushed to a maximum depth of 68 feet below ground surface and were designated as NBCA\039CP001 through NBCA\039CP013.

Sixteen (16) borings were pushed in the neighborhood streets in the vicinity of the Virginia Avenue entrance to NAVBASE. In eight (8) of these locations, a cone penetrometer was used to collect stratigraphic information and to locate water-bearing zones to obtain groundwater samples. Groundwater samples were taken from the shallow subsurface (less than fifteen feet below ground surface) at thirteen (13) locations and from depths between 20-30 feet below ground surface at eight (8) locations. Sample designation was a continuation of the Zone A Geoprobe investigation in July 1996; the off base sample designations begin with NBCA\039GP022 and continue through NBCA\039GP037.

Figure 10.4.27 and Figure 10.4.28 are maps detailing the locations and designations of all CPT sample points on and off NAVBASE, respectively. Table 10.4.25 summarizes the sample designations and depths for data collection for each location. Table 10.4.26 summarizes the chemical data for the groundwater samples from the borings. Cone penetrometer logs for these locations are included as Appendix G.

Table 10.4.25
Summary of CPT Boring Locations

Location	CPT Depth (feet)	Shallow GW Interval	Shallow GW Sample ID	Intermediate GW Interval	Intermediate GW Sample ID
OFF-BASE INVESTIGATION					
039GP022	0-31	9.5-11.5	039GP02211	21-23	039GP02223
039GP023	NA	10-12	039GP02312	24-26	039GP02326
039GP024	0-61	10-12	039GP02412	24-26	039GP02426
039GP025	0-57	9-10	039GP02510	18-20	039GP02520
039GP026	NA	9-11	039GP02611	NA	NC
039GP027	NA	8.9-10.7	039GP02711	NA	NC
039GP028	NA	DRY	NC	NA	NC
039GP029	0-28	8-10	039GP02910	NA	NC
039GP030	NA	DRY	NC	NA	NC
039GP031	0-61	DRY	NC	25-27	039GP03127
039GP032	NA	9.4-11.2	039GP03211	NA	NC
039GP033	0-45	8.9-10.7	039GP03311	22.9-24.7	039GP03325
039GP034	NA	9.4-11.2	039GP03411	NA	NC
039GP035	0-45	9.5-11.5	039GP03511	28-30	039GP03530

LEGEND

- ▲ Sediment/Surface Water Sample Locations
- ← Approximate Direction of Surface Water Flow
- ## Methylene Chloride Detected in Sediments (ppb)

0 200 feet

Zone A RCRA Facility Investigation Report
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FIGURE 10.4.29 - SWMU 39 - Sediment Surface Water Sample Locations

10.4.8 Nature and Extent of Contamination in Sediment/Surface Water

Table 10.4.27 summarizes the analytical results for sediment/surface water at SWMU 39. Appendix D is the complete analytical report for all samples collected in Zone A. The only compound detected in these sediment samples, methylene chloride at 86 μg/kg in 039M0004 and 55 μg/kg in 039M0005, was infrequently detected in SWMU 39 groundwater samples. Also, the few detections in SWMU 39 groundwater were at much lower concentrations than the two sediment detections. Based upon this data, the marsh does not appear to be impacted by contaminated groundwater from SWMU 39.

Table 10.4.27
SWMU 39
VOCs Detected in Sediment/Surface Water

Compound	Media	Frequency of Detection	Range of Detections (μg/kg)	Mean of Detections (μg/kg)
Volatile Organic Compounds (5 Sediment Samples Collected, 1 duplicate; 5 Surface Water Samples Collected, 1 duplicate)				
Methylene chloride	Sediment	2/5	55 - 86	71
	Surface Water	0/5	NA	NA
All other VOCs	Sediment	0/5	NA	NA
	Surface Water	0/5	NA	NA

10.4.9 SWMU 39 Geologic Investigation

10.4.9.1 Monitoring Wells

A total of 28 monitoring wells (15 shallow, 5 intermediate, and 8 deep) were drilled at SWMU 39 during the RFI (Figure 10.4.3). Four separate drilling events took place in an effort to define the dissolved VOC contaminant plume associated with the site. All shallow wells were installed using hollow stem auger techniques. Intermediate and deep wells were installed using either mud rotary or rotasonic drilling methods. Well construction data and water level data for the SWMU 39 wells are presented in Table 10.4.28. Drilling and well construction logs may be found in Appendix A.

Table 10.4.28
SWMU 39
Monitoring Well Construction Data

Monitoring Well ID	Date Installed	TOC Elevation (msl)	Ground Elevation (msl)	Drilled Depths (bgs)			Depth to Groundwater (below TOC)*	Groundwater Elevation (msl)*
				TOS	BOS	BOW		
NBCA-039-001	10/3/95	13.47	11.1	3.1	12.6	13.1	5.22	8.25
NBCA-039-002	10/4/95	14.35	12.1	2.6	12.1	12.6	6.9	7.45
NBCA-039-003	10/4/95	8.64	8.8	2.8	12.3	12.6	3.07	5.57
NBCA-039-004	10/5/95	11.72	9.4	3.0	12.5	13.0	5.72	6.00
NBCA-039-04I	9/15/96	8.98	9.8	21.7	30.7	31.5	2.74	6.24
NBCA-039-04D	11/16/95	9.77	9.9	44.6	54.0	54.5	7.88	1.89
NBCA-039-005	10/5/95	12.67	10.2	3.0	12.5	13.0	6.73	5.94
NBCA-039-006	7/15/96	8.64	9.0	3.0	12.5	13.0	5.42	3.22
NBCA-039-007	7/10/96	8.24	8.5	4.5	14.0	14.5	2.78	5.46
NBCA-039-008	7/16/96	9.76	7.6	4.0	13.5	14.0	6.98	2.78
NBCA-039-08D	7/17/96	9.73	7.6	40.1	49.6	50.1	8.65	1.08
NBCA-039-009	7/15/96	9.41	7.4	3.0	12.5	13.0	5.15	4.26
NBCA-039-09I	9/17/96	9.13	7.1	23.2	33.0	33.5	5.42	3.71
NBCA-039-09D	9/17/96	9.06	6.9	35.7	45.5	46.0	7.42	1.64
NBCA-039-010	7/10/96	13.41	11.2	3.2	12.7	13.2	4.69	4.69
NBCA-039-10I	9/16/96	13.17	10.9	15.7	25.4	26.0	8.36	4.81
NBCA-039-10D	9/18/96	13.05	10.9	36.7	40.7	41.5	10.90	2.15
NBCA-039-011	7/10/96	14.85	12.7	3.3	12.8	13.3	6.55	8.65
NBCA-039-012	7/16/96	8.33	8.6	2.6	12.1	12.6	3.03	5.30
NBCA-039-12I	7/22/96	8.50	8.7	22.0	31.5	32.0	3.29	5.21
NBCA-039-12D	7/22/96	8.32	8.7	46.3	55.8	56.3	6.68	1.64
NBCA-039-013	1/6/97	10.37	8.4	3.5	13.0	13.5	6.98	3.39
NBCA-039-13I	9/18/96	10.21	8.1	19.0	23.2	24.0	8.87	1.34
NBCA-039-13D	9/18/96	10.12	8.2	41.7	51.5	52.0	8.89	1.23
NBCA-039-014	1/7/97	13.27	13.9	2.5	12.0	12.5	6.86	6.41
NBCA-039-14D	1/14/97	13.11	13.7	18.9	23.7	24.2	5.93	7.18
NBCA-039-015	1/7/97	6.10	7.0	4.5	14.0	14.5	3.98	2.12
NBCA-039-15D	1/14/97	6.53	7.2	24.1	33.6	34.1	6.31	0.22

Notes:

msl	=	mean sea level
bgs	=	below ground surface
TOC	=	Top of well casing
TOS	=	Top of screened interval
BOS	=	Bottom of screened interval
BOW	=	Bottom of well (end cap)
*	=	Groundwater level data from January 22, 1997 presented. Since depths to groundwater vary seasonally and diurnally, these depths should only be considered approximate.

10.4.9.2 Cone Penetrometer Borings

The CPT study presented previously in Section 10.4.6 focused on delineating the extent of clay and sand deposits at SWMU 39. In order to calibrate the CPT data with deep well boring log data, a CPT boring was advanced in close proximity to deep well 039-04D to permit correlation of the CPT instrument responses with each known lithology at the deep well. Subsequent CPT borings could then be used to differentiate permeable from impermeable units in the subsurface. Due to the close proximity of several CPT locations with deep well borings, a reliable comparison of depth control could be made. The CPT data is regarded as being more accurate and was used as the primary source of depth control for the major geologic features in SWMU 39. The CPT data logs are provided in Appendix G.

For the remainder of this section, CPT boring locations will be referred to interchangeably with deep well boring locations. CPT locations are easily identified by the "CP" or "GP" after the "039" in their identifier. Specific monitoring wells are identified by a three digit alphanumeric sequence following "039" that indicate its location and relative depth (shallow, intermediate, or deep well). For example, the shallow, intermediate, and deep wells at location 4 at SWMU 39 are identified as 039-004, 039-04I, and 039-04D, respectively.

10.4.10 SWMU 39 Geology

10.4.10.1 Introduction

The geology at SWMU 39 has been some of the most complicated encountered during the RFI at NAVBASE. Since the chemical properties of the dissolved solvent VOCs detected in groundwater at SWMU 39 suggest that sorption potential is low and migration with the aqueous phase is high, the following discussion will focus on the extent and distribution of the primary geologic units influencing groundwater movement. Understanding the basic geologic and hydrogeologic framework will aid in assessing the present location of the dissolved solvent plume and its possible migration pathways in the future.

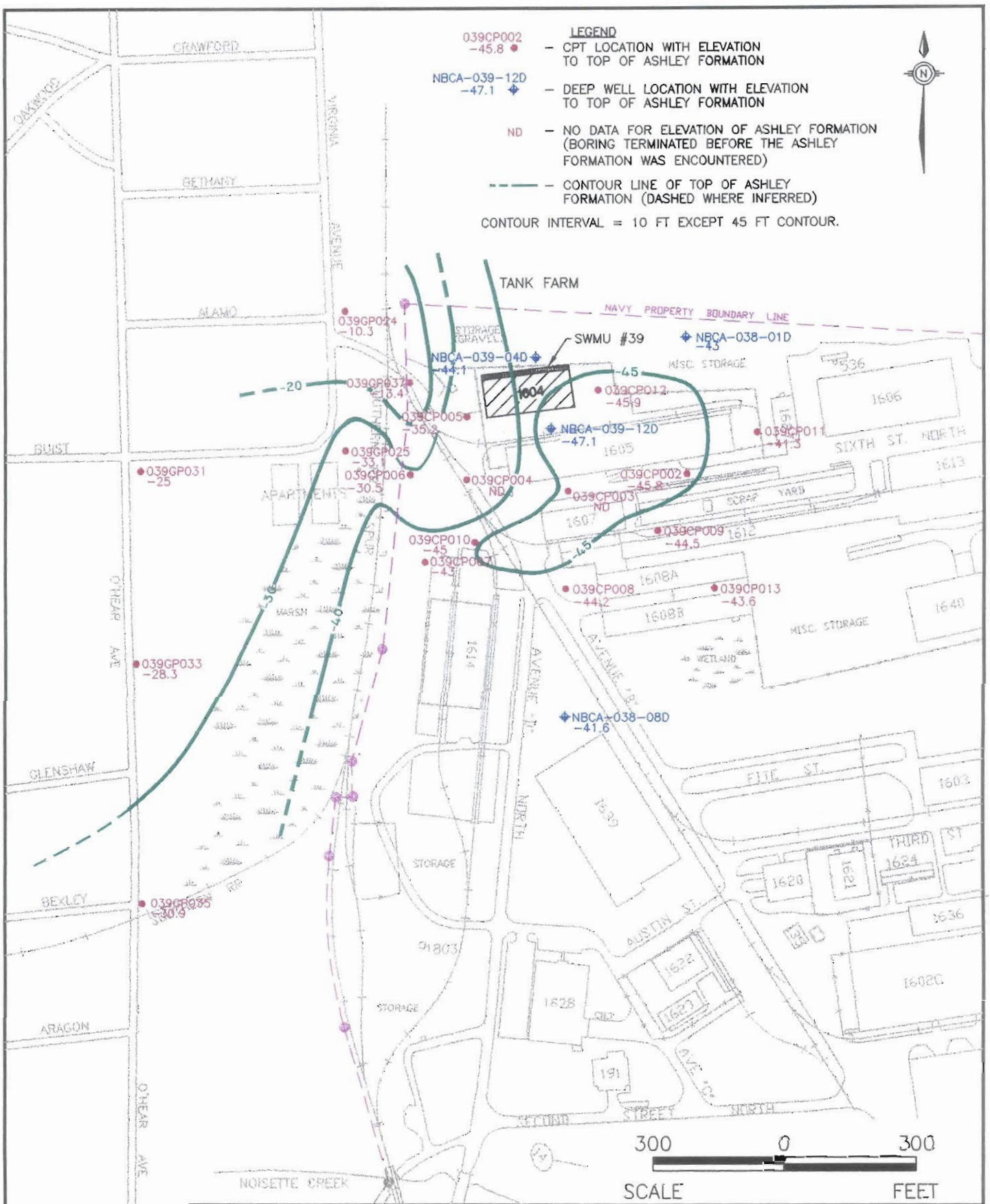
The geologic relationships encountered at SWMU 39 are similar to those presented previously in Section 2.1 for all of Zone A. The oldest geologic unit is the Tertiary-age Ashley Formation (Ta) which varies in depth between 21-56 feet bgs at SWMU 39. Overlying the Ashley throughout most of SWMU 39 is a Quaternary-age sand deposit (Qs) that is often separated from the shallow subsurface by discontinuous layers of compacted Quaternary-age dewatered marsh clay (Qdm). Periodic rising and falling of sea level during Quaternary time have eroded portions of this clay unit and introduced younger Quaternary-age sand (Qs); Quaternary-age clay (Qc); Quaternary-age interbedded clay, sand, and silt (Qcs); younger, softer Quaternary-age marsh clay (Qm); and Quaternary peat (Qp). These units have been identified and described in Section 2.1 with one exception: the Quaternary clayey and silty sand (Qc) unit introduced in Section 2.1.4 has been divided into the Quaternary-age clay (Qc) unit and the Quaternary-age interbedded clay, sand, and silt (Qcs) unit for the geologic discussion specific to SWMU 39.

Five lithologic cross-sections were constructed across SWMU 39 (Figure 10.4.30). Well boring log data was used in places where no CPT data existed (e.g., NBCA-039-12D) and to place the approximate locations of well screens.

10.4.10.2 Lithologic Distribution

Ashley Formation (Ta)

As stated previously in Section 2.1.3.1, the Ashley Formation has undergone extensive erosion due to several sea level transgression-regression (rise and fall) sequences after its deposition. As a result, it is not uncommon to find occasional undulations across its upper contact. This aspect of the Ashley is plainly evident in reviewing cross-sections F-F' and H-H' in Figure 10.4.30 and the elevation contour map of the top of the unit (Figure 10.4.31). The highest Ta elevation at SWMU 39 is -10.3 ft msl at 039GP037 in the NW portion of Zone A. To the east and south, Ta elevations abruptly decrease, forming a depression at an elevation of at least -47.1 ft msl at 039-12D. This SW-NE trending depression is best demonstrated by the dashed -45 ft elevation contour in Figure 10.4.31. Undulations along the northwestern edge of this depression are evident



ZONE A
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INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.4.31
TOP OF ASHLEY FORMATION
AT SWMU 39

DWG DATE: 04/06/98 | DWG NAME: 2901S005

from the contour pattern along the western NAVBASE boundary just south of the elevation high at 039GP037.

The relief of the Ashley becomes more gentle along the central to southwest portion of SWMU 39. Higher elevations were encountered in the eastern to southeastern portion of Zone A (Figure 2.7). Little relief of the top of the Ashley Formation is seen along cross-section E-E' (Figure 10.4.30) west of the NAVBASE boundary, as the unit gently slopes to the south approximately 5 feet over a horizontal distance of approximately 1,000 feet along O'Hear Avenue. Consequently, it appears that the depression and the high relief forming its northwestern edge are the major features regarding the Ashley Formation's surface at SWMU 39.

Marsh Clay (Qm)

Although marsh clay deposits have been found in abundance throughout NAVBASE, they are less pervasive in the vicinity of SWMU 39. The most extensive Qm deposits encountered were those shown in cross-section E-E' (Figure 10.4.30). The Qm deposit varies in thickness from approximately 9.3 ft at 039GP029 to approximately 21.7 ft at 039GP035. Boring logs from 039-015 and 039-15D reveal these deposits to be intermixed with peat and interbedded with sand lenses ranging in thickness from 1-12 inches. The Qm separates a deeper Qs unit that overlies the Ashley Formation and shallow Qs and Qc units that are interbedded in the vicinity of 039GP033.

Quaternary marsh clay was encountered within the northern portion of SWMU 39 (Figure 10.4.30; cross-sections G-G' and F-F'). An interval of Qm nearly 5 feet thick was found at 039CP037 along cross-section F-F' and lies at an elevation that correlates with the Qm encountered at 039-04D and 039-12D along cross-section E-E'. Drilling data from 039-04D, 039-12D, and 039-14D reveal the Qm deposit to be soft to firm and thinly interbedded with 1-4 inch thick sand and shell hash lenses. However, the CPT response at 039CP003 to the south reflected a stiff clay that more closely resembled the Qdm signature. These data suggest that the

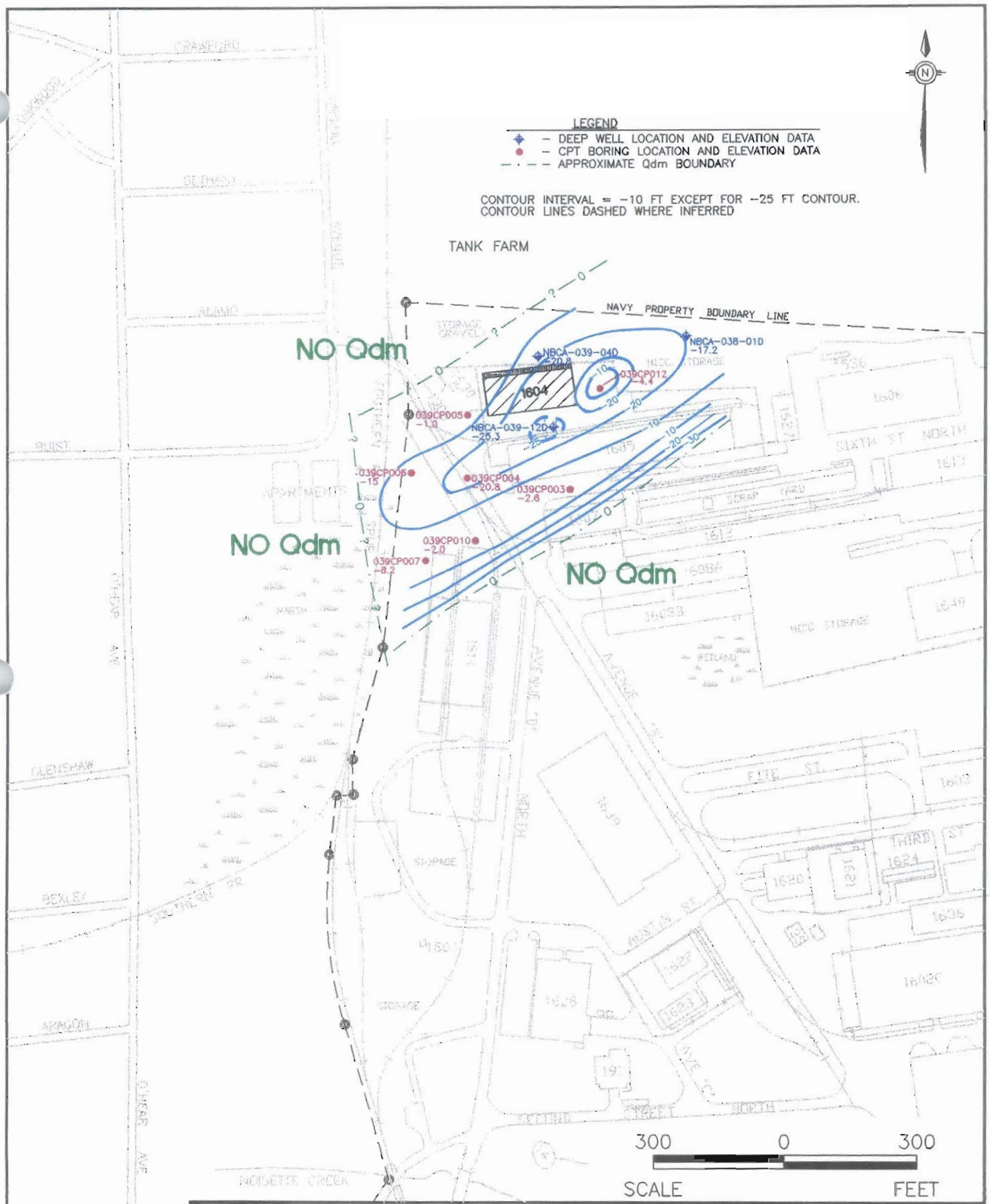
younger Qm deposit lies unconformably adjacent to the older Qdm in the area between deep well 039-12D and 039CP003.

Dewatered Marsh Clay (Qdm)

The dewatered marsh clay (Qdm) is an older, more compacted and stiffer form of the younger marsh clay unit (Qm). The Qdm is typically found either lying unconformably over the Ta or overlying Qs deposits that in turn cover the Ta. An example of both these stratigraphic relationships is evident in cross-section F-F' at locations 039CP006 and 039CP007 (Figure 10.4.30).

Quaternary dewatered marsh clay elevation and thickness maps are presented in Figures 10.4.32 and 10.4.33, respectively. These maps demonstrate the extent of Qdm deposits and indicate that the unit is primarily confined to elevational lows of the Ashley Formation. Based on the cross-sections, boring logs and CPT logs, areas with and without Qdm deposits in the subsurface were delineated by the Qdm boundaries shown trending NE to SW across SWMU 39. A western Qdm boundary was inferred trending north to south since no Qdm deposits were found west of NAVBASE property (Figure 10.4.30; cross-section E-E').

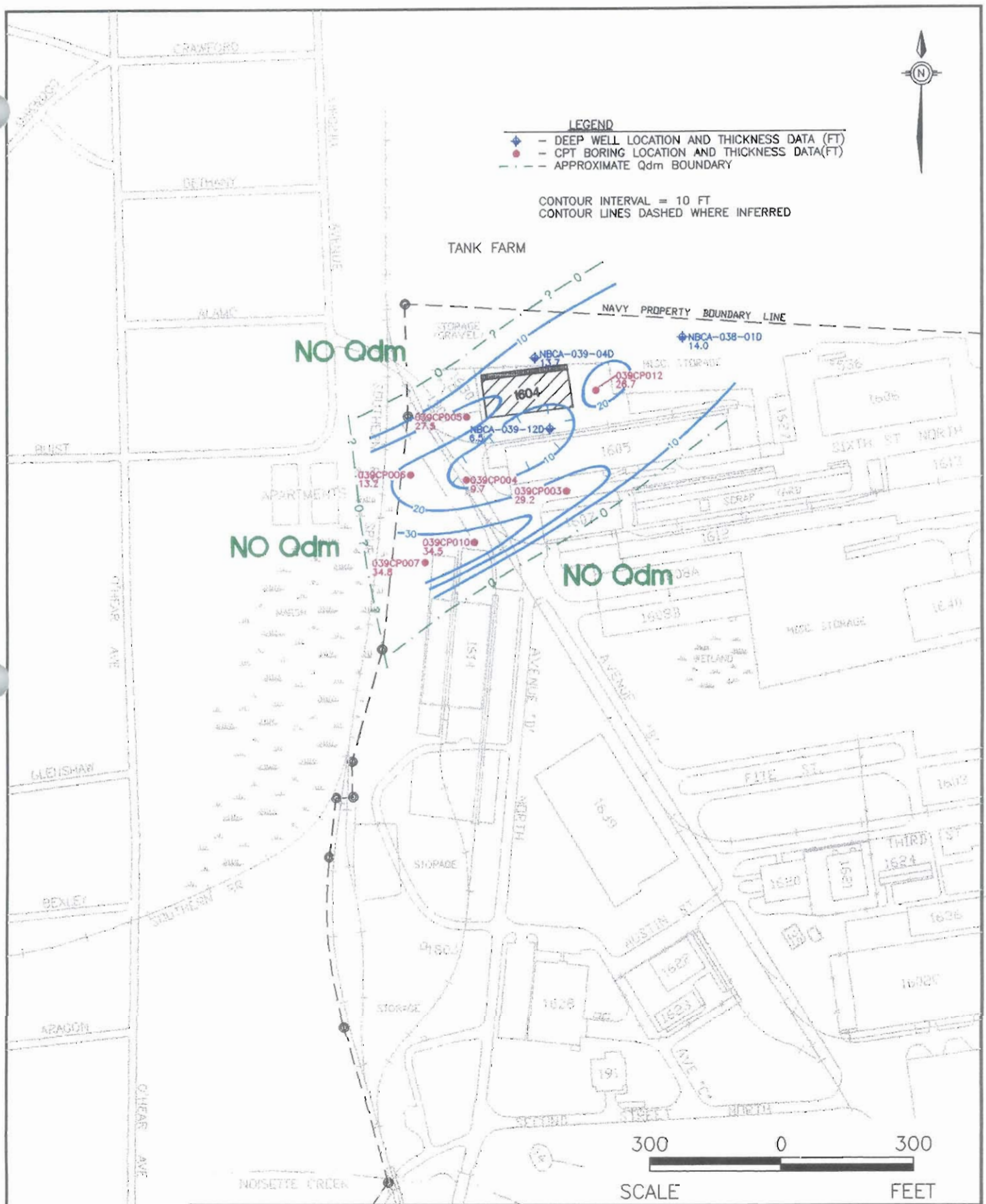
As shown in Figure 10.4.32, the Qdm deposits rise in elevation sharply from approximately -30 ft msl in the south to a high point of -2.0 ft msl to the north at 039CP010, creating a narrow NE-SW trending "ridge." Dewatered marsh clay deposits 34.8 and 34.5 feet thick at 039CP007 and 039CP010, respectively, mark the southwestern extent of the ridge. Successive erosional events appear to have removed much of this deposit south of SWMU 39 as indicated by the



ZONE A
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.4.32
ELEVATION OF TOP OF DEWATERED
MARSH CLAY (Qdm) AT
SWMU 39

DWG DATE: 04/10/98 | DWG NAME: 2901S002



ZONE A
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INVESTIGATION REPORT
NAVAL BASE CHARLESTON
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FIGURE 10.4.33
THICKNESS OF DEWATERED
MARSH CLAY (Qdm) AT
SWMU 39

DWG DATE: 04/03/98 | DWG NAME: 2901S003

bowl-shaped depression or pocket in Figures 10.4.32 and 10.4.33. Northeast of the ridge, the Qdm unit decreases in elevation and thickness at 039-12D of -25.3 ft msl and 6.5 ft, respectively. Northeast of the depression, a 20-foot increase in elevation and thickness of Qdm deposits formed a knob-like feature northeast of the depression that was not as severely eroded as Qdm deposits that once existed in the vicinity of the depression.

The northern and northwestern extent of the Qdm deposits within the Qdm boundaries are difficult to accurately define due to limited data. However, the absence of any Qdm sediments west of 039GP037 indicates that the unit has been truncated by erosion. The Qdm unit was not encountered south of 039CP003 (Figure 10.4.30; cross-sections G-G' and I-I'). The Qdm in this area was likely removed by a highly erosive event.

Quaternary Sand (Qs)

The Quaternary sand (Qs) deposits at SWMU 39 are a grouping of several depositional episodes that occurred at this locale. In general, Qs deposits within the Qdm boundary area (Figures 10.4.32 and 10.4.33) are thinner, discontinuous, and intermixed with deposits of marsh clay (Qm), interbedded clay and sand (Qcs), and inorganic clay (Qc). Within the Qdm boundary, Qs ranges in thickness from only 6 ft at 039CP007 to 20 ft at 039CP004 (Figure 10.4.30; cross-section F-F'). These Qs thicknesses correlate with areas in which the Qdm thicknesses decreases from 34.8 ft and 9.7 ft, respectively.

South to southeast of the Qdm boundaries, Qs deposition is much more pervasive and becomes the dominant lithology. A 44-foot thick Qs deposit was encountered at 039CP009 (Figure 10.4.30; cross-section I-I'). This Qs development continues to the south beyond 039-08D towards GDA-02D where it remains approximately 30 feet thick (Figure 2.4). The fact that the Qs deposits lie unconformably on the Ta south of the Qdm boundary suggests a high energy environment subsequent to the Qdm depositional period, eroding away all but Qdm remnant encountered at SWMU 39.

Quaternary interbedded clay, sand, and silt (Qcs)

The Qcs unit is primarily limited to the upper 15-20 feet of the shallow subsurface. The most abundant Qcs deposits are south and east of 039CP003 (Figure 10.4.30; cross-sections G-G', H-H', and I-I'). Minor development of the Qcs is evident northwest of 039CP003 at 039GP037 and 039CP006 (cross-section F-F'). The stratigraphic unit as a whole is highly variable in composition, reflecting the individual but distinct sand, clay, and silt bodies encountered throughout the shallow subsurface.

Quaternary clay (Qc)

The majority of the Qc deposits encountered were discontinuous and localized in near surface occurrences west and south of SWMU 39. The most prolific Qc deposit was found west of NAVBASE property in the upper 15 ft of the shallow subsurface (Figure 10.4.30; cross-section E-E'). Because of their close proximity to land surface, it is often difficult to differentiate Qc deposits from fill materials.

10.4.11 SWMU 39 Hydrogeology

10.4.11.1 Three-layered Aquifer System

The general hydrogeologic role of the above units in Zone A was previously discussed in Section 2.2.2. These roles will be briefly summarized here in regards to the aquifer system at SWMU 39. The Ashley Formation is the lower confining unit as it has been for the entire RFI at NAVBASE. The discontinuous Qm and Qdm deposits behave as aquitards within the surficial aquifer, separating it into three localized flow zones: the upper aquifer, the intermediate aquifer, and the lower aquifer. While the flow zones may be comprised primarily of the Qs, Qcs, Qp, and Qc units, groundwater will preferentially flow through the more permeable Qs and Qcs deposits with minor flow potential through the less permeable Qc and Qp deposits. Each of these aquifers will be discussed separately.

Upper Aquifer

As described in Section 2.2.4.1, the upper flow zone is considered an unconfined aquifer or water table aquifer. The upper flow zone at SWMU 39 typically consists of Qs and Qcs deposits and may include Qc, Qm, Qp, and fill materials within the interval.

The bottom boundary of this upper flow zone varies greatly in the vicinity of SWMU 39. Deposits of Qdm or Qm lie beneath the upper flow zone at 039-04D, 039-12D, and 039CP003 (Figure 10.4.30; cross-section G-G'). In general, it is believed that these clay deposits are impermeable enough to restrict downward groundwater flow. Based on the January 1997 water levels at 039-004 and 039-012 (Table 10.4.28), the upper flow zone at these locations have a saturated thickness between 11.4 and 8.6 ft, respectively.

In other locales, the bottom boundary of the upper flow zone is ambiguous because a shallow basal aquitard is either "leaky" or not present. At locations 039CP002 and 039CP011 (Figure 10.4.30; cross-section I-I'), 2-5 ft thick deposits of Qcs lie beneath the upper flow zone. Depending upon the hydraulic connection between the interbedded sand lenses within the Qcs unit, the upper flow zone in this locale may or may not be isolated from the deeper flow zones. At the southernmost SWMU 39 well location (039-08D), no intervening aquitard is present (cross-section G-G').

Intermediate Aquifer

The localized presence of the Qdm and to a lesser extent the Qm deposits at SWMU 39 has created an intermediate flow zone between the upper and lower flow zones. The best example of this intermediate flow zone is seen at locations 039-04D and 039-12D (Figure 10.4.30; cross-section G-G'). At these locations the intermediate flow zone may locally behave as a semi-confined to confined aquifer due to the presence of the Qm and Qdm aquitards forming its boundaries. The January 1997 water levels in 039-04I and 039-12I (Table 10.4.28) were found to be above the bottom of the overlying aquitard contact, a typical characteristic for confined conditions.

To the west of cross-section G-G' at location 039-14D (Figure 10.4.30; cross-section F-F'), the intermediate aquifer consists of Qcs deposits and lies unconformably on the Ashley Formation. These Qcs deposits are in turn confined by an overlying interval of Qm deposits that pinch out to the south. Beyond the southern limit of the confining Qm unit, the intermediate aquifer appears to co-mingle with the overlying upper aquifer of Qs deposits.

The intermediate flow zone at 039CP008 is also not well-defined (Figure 10.4.30; cross-section I-I'). The Qs unit being monitored by 039-13I co-mingles with the Qs deposits to the south. The hydraulic connection between the Qs and the overlying Qcs is also unclear since the Qcs deposits are highly variable in composition. Any hydraulic connection of the interbedded sand lenses would provide a migration pathway from the upper aquifer to the intermediate aquifer, similar to a "leaky" aquitard condition. However, January 1997 water levels in 039-013 and 039-13I (Table 10.4.28) differed by more than 2 feet, suggesting that the intermediate and upper flow zones behave independently.

The intermediate flow zone is no longer considered a separate aquifer to the south and east of 039CP008 as it merges into the thick Qs deposits (Figure 10.4.30; cross-sections G-G' and I-I'). West of cross-section G-G' at 039CP007 in cross-section F-F', the intermediate flow zone is not present. Monitoring well 039-09I is screened at an interval in the Qdm deposits that is very thinly interbedded with sand lenses that are not part of the intermediate flow zone; however, they could possibly be hydraulically connected with the extensive Qs development to the south.

Lower Aquifer

The lower aquifer at SWMU 39 primarily consists of Qs deposits that overlie the Ashley Formation. Semi-confined to confined conditions appear to exist in the lower aquifer sand at areas lying within the Qdm boundaries (Figures 10.4.32 and 10.4.33). The Qdm unit behaves as an aquitard at deep well locations 039-04D, 039-12D, 039-10D, and 039-13D, which is

supported by the significant variation between water levels in the deep and corresponding shallow and/or intermediate wells at these locations (Table 10.4.28).

At location 039-08D the lower aquifer and intermediate aquifer co-mingle because of the lack of an aquitard, behaving as one flow zone. The range in groundwater elevation between the shallow and deep well at this location is only 1.70 ft, the smallest disparity between shallow and deep water level elevations of all SWMU 39 wells.

10.4.11.2 SWMU 39 Groundwater Flow

A zone-wide groundwater level measurement event of all Zone A monitoring wells was conducted on January 22, 1997 (Table 10.4.28). This event was timed irrespective of any tidal events due to the limited interaction seen during previous events on February 13 and August 7, 1996 (Figures 2.8 through 2.11). Groundwater elevation maps for the shallow wells, intermediate wells, and deep wells are presented in Figures 10.4.34, 10.4.35, and 10.4.36, respectively.

Groundwater flow lines and flow divides have been added to help illustrate the complex groundwater flow evident within Zone A.

Upper Aquifer

Groundwater flow directions in the upper flow zone in the vicinity of SWMU 39 are primarily dictated by the groundwater flow divides labeled "A", "B", and "C" on Figure 10.4.34. Groundwater divide "A" is oriented north-south at SWMU 39; divide "B" trends north-south in the vicinity of the wetland to the southeast of SWMU 39; divide "C" has a SW-NE trend in the west-central portion of Zone A.

In general, groundwater flows southwest to southeast across SWMU 39 from the northwest corner of the zone where the hydraulic gradient is the greatest. A recharge zone in the central portion

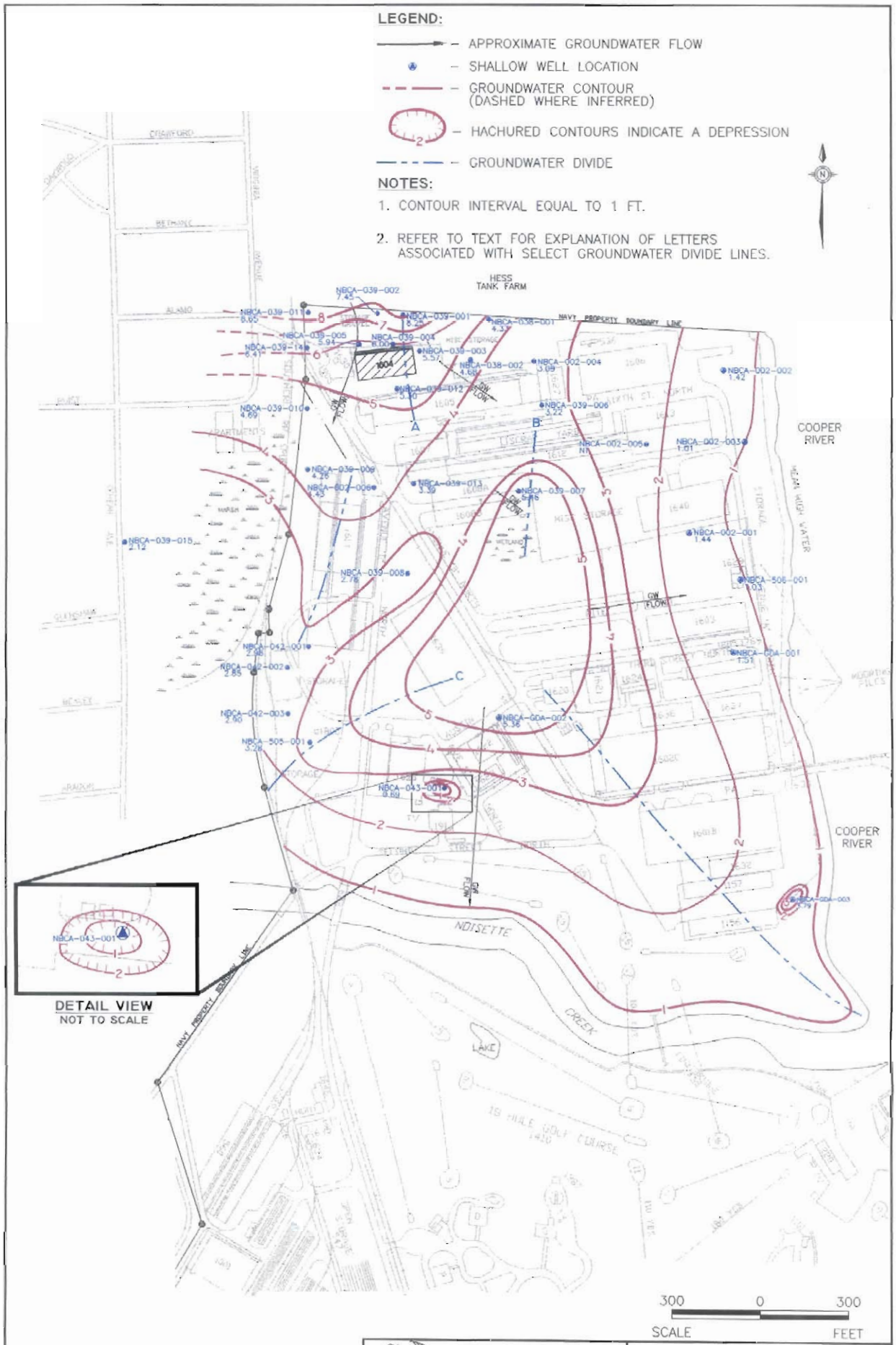
of Zone A behaves as a hydraulic barrier between groundwater in the vicinity of SWMU 39 and the Cooper River. Groundwater in areas east of divide "A" flows towards the Cooper River. Groundwater in areas west of divide "A" flows south to southwest towards the western boundary of Zone A as dictated by the recharge zone and shown by divides "B" and "C". However, the orientation of divide "B" allows groundwater to flow from the recharge zone north to northwest towards the southern extent of the dissolved solvent plume associated with SWMU 39 near 039CP008. Eventually, groundwater in the vicinity of 039CP008 is influenced by the overall trend of south to southwesterly movement towards the western boundary of NAVBASE.

Intermediate Aquifer

Groundwater flow in the intermediate flow zone trends south to southeast (Figure 10.4.35). The lowest head value of all intermediate wells was measured at 039-13I and possibly reflects the hydraulic connection between the Qs deposit at this location and the extensive Qs deposits to the south at location 039-08D. It is important to recognize that flow in the intermediate zone is subject to the discontinuities of the sand deposits within the aquifer and that contaminants found in the intermediate zone will preferentially flow through the most permeable units present.

Lower Aquifer

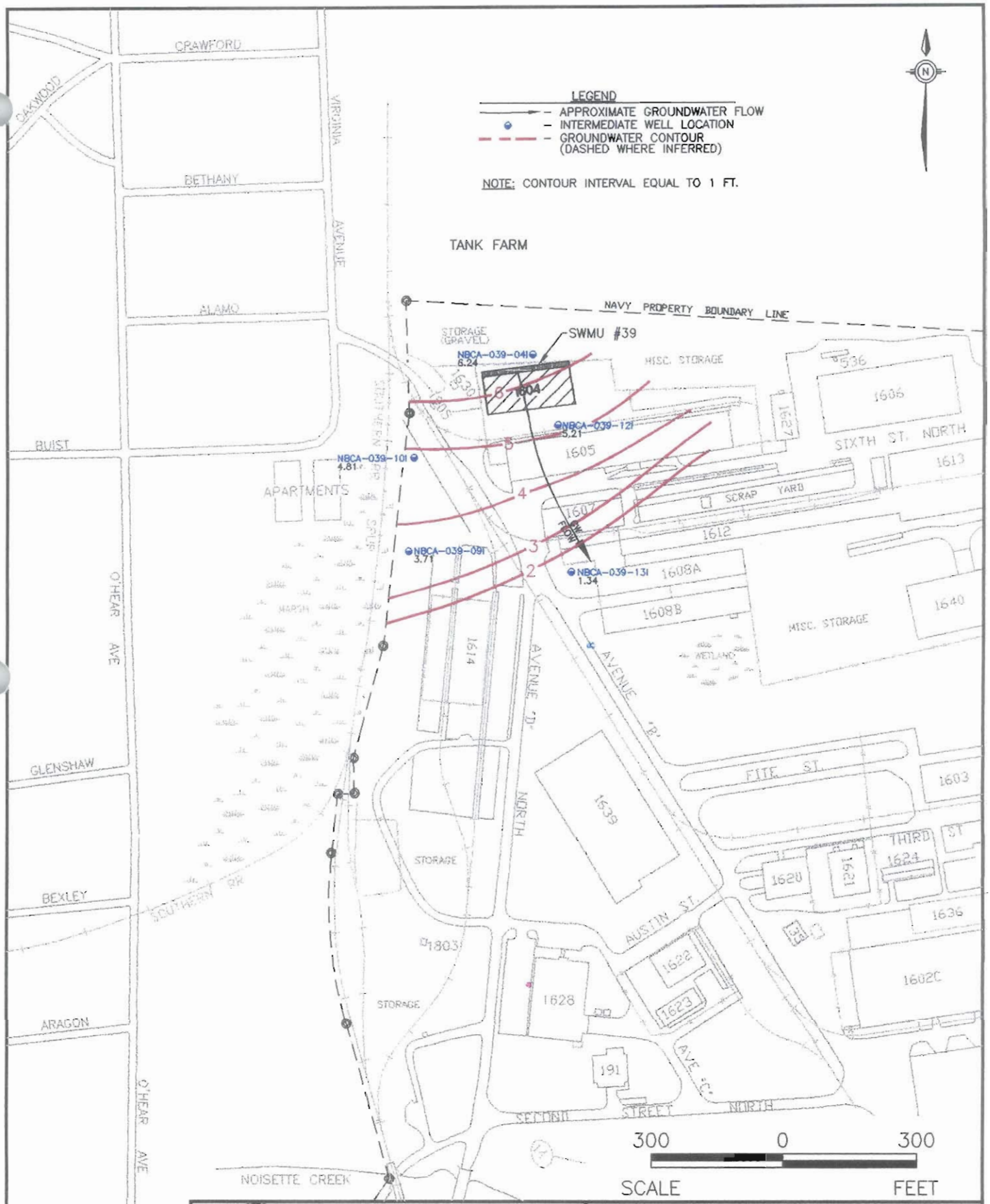
Groundwater flow along the top of the Ashley Formation generally reflects a more subtle, lower relief trend than that of the upper and intermediate aquifers. A pattern similar to that shown in Figures 2.10 and 2.11 is seen in Figure 10.4.36 with the exception of the large groundwater high or mound located at 039-14D. Groundwater flows in a general southeastern trend across the majority of Zone A towards the Cooper River and Noisette Creek. The abrupt increase in hydraulic head at 039-14D is most likely associated with the rapid rise in elevation of the Ashley Formation at that location and shown previously in cross-section F-F' (Figure 10.4.30) and Figure 10.4.31.



ZONE A
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.4.34
GROUNDWATER ELEVATION CONTOURS
SWMU 39 SHALLOW WELLS
JANUARY 22, 1997

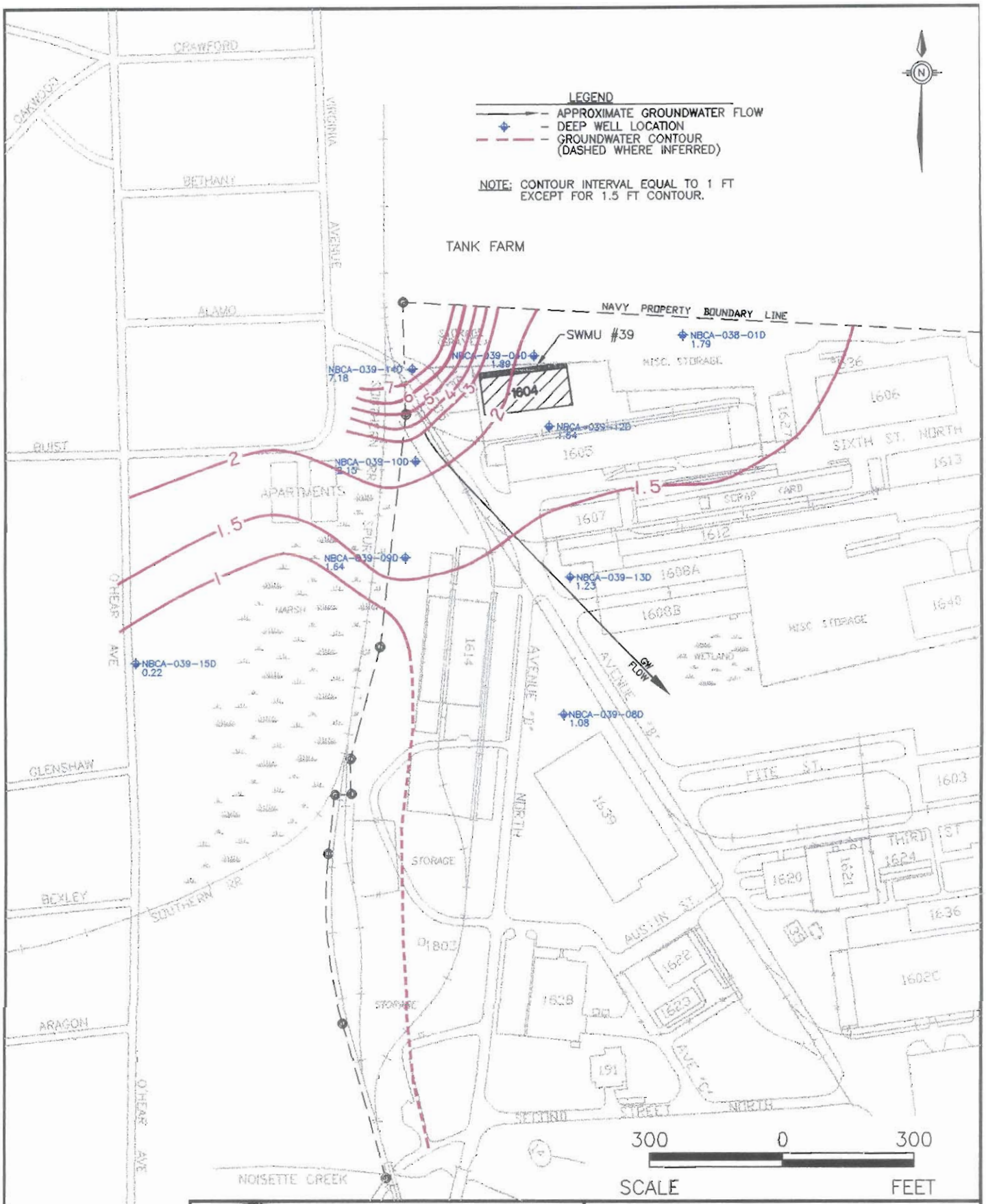
DWG DATE: 04/03/98 | DWG NAME: 2901S006



ZONE A
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.4.35
GROUNDWATER ELEVATION CONTOURS
SWMU 39 INTERMEDIATE WELLS
JANUARY 22, 1997

DWG DATE: 04/03/98 | DWG NAME: 2901S007



ZONE A
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.4.36
GROUNDWATER ELEVATION CONTOURS
SWMU 39 DEEP WELLS
JANUARY 22, 1997

DWG DATE: 04/03/98 | DWG NAME: 2901S008

10.4.11.3 Horizontal Hydraulic Gradients

The horizontal hydraulic gradient was estimated between a few locations in the upper and intermediate aquifers using the same procedure previously specified in Section 2.2.7. Since none of the SWMU 39 wells lie directly within groundwater flowpaths from each other, the gradient was estimated along segments of the generalized groundwater flowpath arrows shown on Figures 10.4.34 and 10.4.35. Due to the presence of the groundwater high at 039-14D in the lower aquifer and the limited hydraulic head data, no horizontal hydraulic gradients were calculated for the lower aquifer.

Upper Aquifer

Two locations on either side of groundwater divide "A" were chosen for horizontal hydraulic gradient calculations (Figure 10.4.34). Between the intersection of the groundwater flowpath west of the divide with the 8-foot elevation contour and the 6-foot elevation contour to the south, the gradient was estimated as 2 ft (elevation)/~125 ft (distance), or 0.016 ft/ft. Between the intersection of the groundwater flowpath east of divide "A" and the 6-foot elevation contour and the 4-foot elevation contour to the southeast, the gradient was estimated as 2 ft/~225 ft, or 0.009 ft/ft. Thus, the horizontal hydraulic gradient is roughly twice as great to the west-southwest of SWMU 39 as it is to the east-southeast.

Intermediate Aquifer

The horizontal hydraulic gradient was estimated along the groundwater flowpath in Figure 10.4.35 between its intersection with the 6-foot elevation contour and the 2-foot elevation contour. It was estimated at 4 ft/~390 ft, or 0.010 ft/ft.

10.4.11.4 Vertical Gradients

Vertical gradients were calculated from the January 1997 water level measurement data following the procedure specified in Section 2.2.6. Positive vertical gradients indicate the potential for

downward vertical flow whereas negative vertical gradients indicate the potential for upward vertical flow. The vertical gradient was calculated between the shallow and intermediate pair, and intermediate and deep pair when possible at each well cluster (Table 10.4.29).

Table 10.4.29
Vertical Hydraulic Gradients

Well Pairs	Vertical Distance (ft)	Groundwater Elevation Difference (ft)	Vertical Hydraulic Gradient (ft/ft)
039-004 and -04I	18.5	-0.24	-0.0130
039-04I and -04D	23.0	4.35	0.1891
039-008 and -08D	36.1	1.70	0.0471
039-009 and -09I	20.5	0.55	0.0268
039-09I and -09D	12.5	2.07	0.1656
039-010 and -10I	12.8	-0.12	-0.0094
039-10I and -10D	15.5	2.66	0.1716
039-012 and -12I	19.4	0.09	0.0046
039-12I and -12D	24.3	3.57	0.1469
039-013 and -13I	10.5	2.05	0.1952
039-13I and -13D	28.0	0.11	0.0039
039-014 and -14D	11.7	-0.77	-0.0658
039-015 and -15D	19.6	1.90	0.0969

All vertical hydraulic gradients were downward with the exception of upward vertical gradients between wells 039-004 and 04I, 039-010 and 10I, and 039-014 and 14D. The highest magnitude of the upward potential vertical gradients was measured at wells 039-014 and 14D and reflects the large increase in hydraulic head at the deep well related to the abrupt rise in the Ashley Formation elevation. It should be noted, however, that the magnitude of the downward vertical gradient between wells 039-04I and 04D and 039-10I and 10D are 14 to 19 times greater, respectively, than the smaller upward vertical gradients between the shallow and intermediate wells at the same locations.

10.4.11.5 Horizontal Hydraulic Conductivity (K_h)

Slug Tests

Slug tests were performed on five shallow, five intermediate, and four deep wells at SWMU 39 in the manner previously described in Section 2.28. Multiple tests were conducted on several wells in an effort to better quantify the horizontal hydraulic conductivity (K_h) at those locations. The tests were analyzed using the software package AQUIFERTEST 2.51 (Waterloo Hydrogeologic, Inc). Test results are provided in Appendix C. All wells were treated as fully penetrating the aquifer since a slug test imparts a lower total stress on the system as compared to that of a pumping or specific capacity test. This tends to over predict aquifer K_h values by 20-30%.

The results of the slug test analyses are presented in Table 10.4.30. The geometric means of all test results at each well were calculated as the average value for that location. Each well was grouped by lithology based on the unit within the screened interval that was most likely to respond to the slug test stress. Tests that were corrupted or nonsensical were not analyzed.

Table 10.4.30
Slug Test Horizontal Hydraulic Conductivity Results in feet/day

Well ID	Test	Falling Head K_h	Rising Head K_h	Geomean	Lith. Type
Shallow Wells					
NBCA-039-006	1	0.48	1.0	0.69	Qc
NBCA-039-007	1	0.12	0.15	0.13	Qc/Qp
NBCA-039-009	1	10.4	3.7	6.2	FILL
NBCA-039-010	1	4.2	2.8	3.4	Qc
NBCA-039-012	1A	14.7	11.8	12.9	Qs
	1B	not used	12.4		
Intermediate Wells					
NBCA-039-04I	1	16.4	18.3	17.3	Qs
NBCA-039-09I	1	0.13	0.17	0.15	Qdm
NBCA-039-10I	1	7.2	7.2	7.2	Qcs

Table 10.4.30
Slug Test Horizontal Hydraulic Conductivity Results in feet/day

Well ID	Test	Falling Head K_h	Rising Head K_h	Geomean	Lith. Type
NBCA-039-12I	1A	0.37	0.33		Qs
	1B	not used	0.34	0.35	
	1C	0.34	0.35		
NBCA-039-13I	1A	16.9	18.1		Qs
	1B	16.6	18.7	18.1	
	1C	18.6	19.7		
Deep Wells					
NBCA-039-09D	1	0.41	0.34	0.37	Qdm
NBCA-039-10D	1	4.3	2.0	2.9	Qs
NBCA-039-12D	1A	7.5	7.9		Qs
	1B	7.0	7.2	7.0	
	1C	5.8	not used		
NBCA-039-13D	1A	25.6	not used		Qs
	1B	19.0	20.3	19.9	
	1C	18.5	17.3		

The greatest number of tests were conducted in the Qs deposits, which showed the greatest range in horizontal hydraulic conductivity (K_h) values between 0.35 and 19.9 feet/day. The geometric mean of its Qs slug test data is a K_h of 5.0 feet/day. The two tests on Qdm deposits resulted in a closer range of K_h values between 0.15 and 0.37 feet/day and a geometric mean of 0.23 feet/day. The K_h values of the two Qc (not including the Qc/Qp location) tests ranged between 0.69 and 3.4 feet/day, with a geometric mean of 1.5 feet/day. The K_h value for Qc is higher than expected and clearly indicates it has more permeable components probably in the form of sand lenses that make it a viable migratory pathway in certain locales. Variations among lithologic types may reflect any of the following local-scale heterogeneities: interbedded clay, silt, or sand lenses, partings, or laminations; grain size distribution and sorting; and interactions or contributions from other lithologies within the screened interval.

10.4.11.6 SWMU 39 Contaminant Migration and Distribution

The RBC exceedance summary data table (Table 10.4.20) was used to make qualitative comparisons of dissolved chlorinated VOC contamination within the aquifer system. No specific compounds within the TCE degradation pathway nor site-specific chlorinated VOC groundwater concentrations were considered for this brief discussion. Migration of the dissolved solvent VOCs will be discussed in the context of advection only, thus ignoring the effects of diffusion, dispersion, and retardation.

Upper Aquifer

Chlorinated VOCs were detected in eight of fifteen shallow wells at SWMU 39. Four of these eight wells (039-003, 004, 005 and 012) are the closest wells located to SWMU 39 and its suspected source area at Building 1604. Three well locations (039-007, 009, and 013) are located downgradient. The eighth well location is 039-011 and is located upgradient in the NW corner of Zone A.

Advection of the VOCs would occur preferentially through the units of greatest permeability in the upper aquifer as dictated by the horizontal hydraulic gradient and horizontal hydraulic conductivity. However, hydraulic conductivities vary greatly within the upper aquifer due to the highly variable nature of its composition. For these reasons the chlorinated VOC detections in the shallow Qs unit located in the near vicinity of Building 1604 and monitored by 039-004 and 039-012 are not unexpected (Figure 10.4.30; cross-section G-G'). Further downgradient lateral migration through the Qs unit moved the chlorinated VOCs into the Qcs being monitored by 039-013. The low permeability Qp deposits have hindered shallow lateral migration in the vicinity of 039-008.

In some locations, vertical migration of the contaminants would be restricted by underlying aquitards, while at others the contaminants could freely migrate deeper into the subsurface.

Vertical flow of groundwater is primarily downward except in the vicinity of well pairs at locations 039-004 and 04I, 039-010 and 10I, and 039-014 and 14D where an upward potential exists. These localized upward gradients are relative to the upper aquifer and reflect the competency of aquitards, where present, and are orders of magnitude less than the downward vertical gradients between the intermediate and deep wells at the same locations.

Intermediate Aquifer

Four of five intermediate wells have chlorinated VOC detections (none at 039-09I). Five were detected above RBCs at 039-13I and four at 039-12I during the three sampling quarters. Only one VOC was detected above RBCs during the second and fourth sampling quarters at locations 039 04I and 039-10I, respectively. Thus, the northern and western fringes of the intermediate flow zone appear to have less contamination than the central and southern portions in this zone.

Since lateral migration of chlorinated VOCs from 039-12I to 039-13I (cross-section G-G') would be hindered by the 29 foot thick Qdm deposit, the VOCs at 039-13I probably migrated from the upgradient source area between 039-004 and 039-012 through the Qs and Qcs deposits between 039CP003 and 039-13I. The Qcs K_h value from Table 10.4.30 is certainly high enough to justify the Qcs as a migration pathway. The hydraulic connection between the interbedded sand lenses within the Qcs and larger sand bodies in the vicinity would greatly influence the migration pathway potential of the Qcs.

Chlorinated VOCs detected at 039-10I probably migrated southwest from the suspected source area through the laterally continuous Qs unit southwest of the Qdm elevation high at 039CP005. Since the shallow Qs is monitored by both 039-010 and 039-10I (Figure 10.4.30; cross-section F-F') and no chlorinated VOCs were detected in 039-010, the VOCs must have migrated downwards into the underlying Qcs that is also being monitored by 039-10I before reaching this well cluster location.

Southeastward lateral chlorinated VOC migration from the suspected source area is not likely due to approximately 27 feet of Qdm encountered at 39CP012 (Appendix G).

Vertical migration from the intermediate zone is generally downward based on the vertical gradient magnitudes presented in Table 10.4.29.

Lower Aquifer

The only SWMU 39 deep well with chlorinated VOC detections was 039-13D. Downward vertical migration through the highly permeable Qs unit of the VOCs from the upper and intermediate flow zones account for these detections. Hydraulic conductivities in the lower aquifer tend to be the greatest of those measured, especially among the Qs deposits (geomean of 7.4 feet/day from deep well Qs results). It can be expected that these chlorinated VOCs will continue to migrate downgradient towards 039-08D as dictated by the lower aquifer's hydraulic gradient (Figure 10.4.36). However, no VOCs have been detected at 039-08D to date.

Those locations that underlie the Qdm aquitard at SWMU 39 (039-04D, 09D, 10D, and 12D) are free of chlorinated VOC contamination as a result of restricted vertical migration through the unit.

10.4.12 Fate and Transport Assessment for SWMU 39

SWMU 39 was formerly a storage area for petroleum, oil, and lubricant drums located north of Building 1604. Currently, the portion of the site adjacent to the north side of Building 1604 is asphalt-paved and the section of the site that continues north to the property boundary is covered with gravel. Environmental media sampled as part of the SWMU 39 RFI include surface soil, subsurface soil, shallow groundwater, intermediate groundwater, and deep groundwater. The confining layer that was considered to separate the shallow and deep aquifers for other zones is less apparent at SWMU 39. As a result, shallow, intermediate, and deep groundwater have been combined for the screening phase of this assessment. For purposes of fate and transport analysis,

geoprobe sample data and interim groundwater sample data were only used qualitatively. Geoprobe sampling was conducted to facilitate on-site decisions regarding monitoring well installation and delineating plumes. Interim sampling was conducted without developing the monitoring wells prior to sampling. Quantitative screening comparisons were conducted using the all data from quarterly sampling events. Potential constituent migration pathways for SWMU 39 include constituents leaching from soil to groundwater, groundwater constituent migration to surface water or to the NAVBASE property line, constituent migration through surface soil erosion, and emission of volatile constituents from surface soil to ambient air.

10.4.12.1 SWMU 39 - Soil to Groundwater Cross Media Transport

Tables 10.4.31 and 10.4.32 compare the maximum detected concentrations of organic and inorganic chemicals reported in soil to risk-based soil screening levels considered protective of groundwater. As shown on Table 10.4.31, twelve organics — Aroclor-1260, benzene, benzo(a)anthracene, benzo(b)fluoranthene, carbazole, dibenz(a,h)anthracene, 1,2-dichloroethane, dieldrin, ethylbenzene, indeno(1,2,3-cd)pyrene, tetrachloroethene, and trichloroethene — were identified for further evaluation of soil to groundwater migration based on the screening process presented in Section 6. As shown on Table 10.4.32, three inorganics —arsenic, chromium, and mercury — were identified for further evaluation of soil to groundwater migration. Total petroleum hydrocarbons (diesel range and gasoline range) were detected in surface soil and subsurface soil above 100 mg/kg. Aroclor-1260, benzo(a)anthracene, benzo(b)fluoranthene, carbazole, dibenzo(a,h,)anthracene, dieldrin, indeno(1,2,3-cd)pyrene, and mercury were not reported in SWMU 39 groundwater (including all rounds sampling).

Table 10.4.31
Organic Chemicals Detected in Surface Soil, Subsurface Soil, Sediment, and Shallow, Intermediate, and Deep Groundwater
Comparison to Cross-media SSLs, Tap Water RBCs, and Background UTLs
NAVBASE-Charleston, Zone A, SWMU 39
Charleston, South Carolina

Parameter	Maximum Concentration						Screening Concentration *									
	Surface Soil	Subsurface Soil	Sediment	Shallow GW	Inter-mediate GW	Deep GW	Soil to GW	Soil to Air	Tap Water RBC	Saltwater Surf. Wtr. Chronic	Soil Units	Water Units	Leaching Potential	Volatil-ization Potential	Ground-water Migration Concern	Surface Water Migration Concern
Volatile Organics																
Acetone	74	140	ND	34	ND	13	290	100000000	3700	NDA	UG/KG	UG/L	NO	NO	NO	NO
Benzene	ND	990	ND	190	1	ND	15	800	0.36	109	UG/KG	UG/L	YES	YES	YES	YES
2-Butanone	11	5	ND	3.3	ND	18	3900 c	NDA	1900	NDA	UG/KG	UG/L	NO	NO	NO	NO
Carbon disulfide	1.2	1.8	ND	4.6	ND	ND	16000	720000	1000	NDA	UG/KG	UG/L	NO	NO	NO	NO
Chlorobenzene	ND	ND	ND	4	ND	ND	700	130000	39	105	UG/KG	UG/L	NO	NO	NO	NO
Chloroform	ND	ND	ND	ND	ND	7	300	300	0.15	815	UG/KG	UG/L	NO	NO	YES	NO
Chloromethane	ND	ND	ND	2	ND	ND	3.4 c	1300000	1.4	NDA	UG/KG	UG/L	NO	NO	YES	NO
Dibromochloromethane	ND	ND	ND	5.5	ND	ND	NDA	NDA	0.17	NDA	UG/KG	UG/L	NO	NO	YES	NO
1,2-Dibromo-3-chloropropane	ND	ND	ND	3	ND	ND	NDA	NDA	0.048	NDA	UG/KG	UG/L	NO	NO	YES	NO
1,2-Dichlorobenzene	1.2	ND	ND	ND	ND	ND	8500	560000	64	NDA	UG/KG	UG/L	NO	NO	NO	NO
1,1-Dichloroethane	ND	ND	ND	2	ND	3	12000	1300000	810	NDA	UG/KG	UG/L	NO	NO	NO	NO
1,2-Dichloroethane	1.2	25	ND	4	1	ND	10	400	0.12	1130	UG/KG	UG/L	YES	NO	YES	NO
1,1-Dichloroethene	ND	ND	ND	3	6	4	30	70	0.044	2240	UG/KG	UG/L	NO	NO	YES	NO
cis-1,2-Dichloroethene	200	51	ND	170	240	180	200	1200000	61	NDA	UG/KG	UG/L	NO	NO	YES	NO
trans-1,2-Dichloroethene	4.1	4.5	ND	ND	ND	ND	350	3100000	120	NDA	UG/KG	UG/L	NO	NO	NO	NO
1,2-Dichloroethene (total)	10	20	ND	160	330	180	200	1200000	55	NDA	UG/KG	UG/L	NO	NO	YES	NO
Ethylbenzene	150	22000	ND	165	ND	ND	6500	400000	1300	4.3	UG/KG	UG/L	YES	NO	NO	YES
2-Hexanone	1.8	ND	ND	7	ND	ND	3700 c	NDA	1500	NDA	UG/KG	UG/L	NO	NO	NO	NO
Methylene chloride	1.2	ND	86	2	ND	ND	10	13000	4.1	2560	UG/KG	UG/L	NO	NO	NO	NO
4-Methyl-2-Pentanone	ND	4	ND	3.3	ND	ND	6700	NDA	2900	NDA	UG/KG	UG/L	NO	NO	NO	NO
1,1,2,2-Tetrachloroethane	ND	ND	ND	1.4	ND	ND	1.5	600	0.052	90.2	UG/KG	UG/L	NO	NO	YES	NO
Tetrachloroethene	170	ND	ND	30	110	54	30	11000	1.1	45	UG/KG	UG/L	YES	NO	YES	YES
Toluene	1.5	ND	ND	24	7	4	600	650000	750	37	UG/KG	UG/L	NO	NO	NO	NO
1,1,1-Trichloroethane	ND	160	ND	1.3	ND	ND	1000	1200000	540	312	UG/KG	UG/L	NO	NO	NO	NO
Trichloroethene	37	2.3	ND	110	120	84	30	5000	1.6	NDA	UG/KG	UG/L	YES	NO	YES	NO
Vinyl chloride	ND	ND	ND	10	10	8	7	30	0.019	NDA	UG/KG	UG/L	NO	NO	YES	NO
m&p-Xylene	300	48000	ND	91	ND	ND	100000	420000	12000	NDA	UG/KG	UG/L	NO	NO	NO	NO
o-Xylene	ND	1600	ND	35	ND	ND	95000	410000	12000	NDA	UG/KG	UG/L	NO	NO	NO	NO
Xylene (total)	NA	NA	ND	560	ND	ND	95000	410000	12000	NDA	UG/KG	UG/L	NO	NO	NO	NO
Semivolatile Organics																
Acenaphthene	300	4300	ND	3	ND	ND	290000	NDA	2200	9.7	UG/KG	UG/L	NO	NO	NO	NO
Acenaphthylene	730	ND	ND	ND	ND	ND	96000 c	NDA	NDA	NDA	UG/KG	UG/L	NO	NO	NO	NO
Anthracene	1100	1500	ND	5	ND	ND	6500000 c	NDA	11000	NDA	UG/KG	UG/L	NO	NO	NO	NO
Azobenzene	ND	ND	ND	6	ND	ND	NDA	NDA	0.61	NDA	UG/KG	UG/L	NO	NO	YES	NO
Benzoic acid	ND	ND	ND	8	ND	ND	200000	NDA	150000	NDA	UG/KG	UG/L	NO	NO	NO	NO

able 10.4.31
rganic Chemicals Detected in Surface Soil, Subsurface Soil, Sediment, and Shallow, Intermediate, and Deep Groundwater
omparison to Cross-media SSLs, Tap Water RBCs, and Background UTLs
IAVBASE-Charleston, Zone A, SWMU 39
harleston, South Carolina

Parameter	Maximum Concentration						Screening Concentration *									
	Surface Soil	Subsurface Soil	Sediment	Shallow GW	Inter-mediate GW	Deep GW	Soil to GW	Soil to Air	Tap Water RBC	Saltwater Surf. Wtr. Chronic	Soil Units	Water Units	Leaching Potential	Volatil-ization Potential	Ground-water Migration Concern	Surface Water Migration Concern
Benzo(a)pyrene Equivalents																
Benzo(a)anthracene	4000	ND	ND	ND	ND	ND	800	NDA	0.092	NDA	UG/KG	UG/L	YES	NO	NO	NO
Benzo(a)pyrene	3500	ND	ND	ND	ND	ND	4000	NDA	0.0092	NDA	UG/KG	UG/L	NO	NO	NO	NO
Benzo(b)fluoranthene	6200	ND	ND	ND	ND	ND	2500	NDA	0.092	NDA	UG/KG	UG/L	YES	NO	NO	NO
Benzo(k)fluoranthene	3800	ND	ND	ND	ND	ND	25000	NDA	0.92	NDA	UG/KG	UG/L	NO	NO	NO	NO
Chrysene	6900	150	ND	ND	ND	ND	80000	NDA	9.2	NDA	UG/KG	UG/L	NO	NO	NO	NO
Dibenz(a,h)anthracene	950	ND	ND	ND	ND	ND	800	NDA	0.0092	NDA	UG/KG	UG/L	YES	NO	NO	NO
Indeno(1,2,3-cd)pyrene	2700	ND	ND	ND	ND	ND	700	NDA	0.092	NDA	UG/KG	UG/L	YES	NO	NO	NO
Benzo(g,h,i)perylene	2900	ND	ND	ND	ND	ND	120000000 c	NDA	NDA	NDA	UG/KG	UG/L	NO	NO	NO	NO
Benzyl alcohol	ND	ND	ND	1	1	2	NDA	NDA	11000	NDA	UG/KG	UG/L	NO	NO	NO	NO
Butylbenzylphthalate	44	ND	ND	2	ND	ND	930000	930000	7300	29.4	UG/KG	UG/L	NO	NO	NO	NO
Carbazole	960	ND	ND	ND	ND	ND	300	NA	3.4	NDA	UG/KG	UG/L	YES	NO	NO	NO
Dibenzofuran	ND	6700	ND	9	ND	5	42000 c	120000	150	NDA	UG/KG	UG/L	NO	NO	NO	NO
Di-n-butylphthalate	ND	ND	ND	6	4	3	2300000	2300000	3700	3.4	UG/KG	UG/L	NO	NO	NO	YES
Diethylphthalate	ND	ND	ND	11	ND	2	240000	2000000	29000	NDA	UG/KG	UG/L	NO	NO	NO	NO
2,4-Dimethylphenol	ND	ND	ND	10.5	ND	ND	4000	NDA	730	NDA	UG/KG	UG/L	NO	NO	NO	NO
Di-n-octyl phthalate	49	ND	ND	ND	ND	ND	10000000	10000000	730	NDA	UG/KG	UG/L	NO	NO	NO	NO
bis(2-Ethylhexyl)phthalate	6200	ND	ND	20	ND	6	1800000	31000000	4.8	NDA	UG/KG	UG/L	NO	NO	YES	NO
Fluoranthene	350	380	ND	ND	ND	ND	2200000	NDA	1500	1.6	UG/KG	UG/L	NO	NO	NO	NO
Fluorene	320	10000	ND	8	ND	6	280000	NDA	1500	NDA	UG/KG	UG/L	NO	NO	NO	NO
2-Methylnaphthalene	1700	ND	ND	255	ND	5	42000	NDA	1500	23.5	UG/KG	UG/L	NO	NO	NO	YES
2-Methylphenol	ND	ND	ND	2	ND	ND	7500	NDA	1800	NDA	UG/KG	UG/L	NO	NO	NO	NO
4-Methylphenol	ND	ND	ND	22	ND	ND	670 c	NDA	180	NDA	UG/KG	UG/L	NO	NO	NO	NO
Naphthalene	1100	ND	ND	420	3	7	42000	NDA	1500	23.5	UG/KG	UG/L	NO	NO	NO	YES
N-Nitrosodiphenylamine	ND	ND	ND	2	ND	ND	600	NDA	14	33000	UG/KG	UG/L	NO	NO	NO	NO
Pentachlorophenol	ND	ND	ND	2	ND	ND	15	NDA	0.56	7.9	UG/KG	UG/L	NO	NO	YES	NO
Phenanthrene	6500	14000	ND	8	ND	ND	900000 c	NDA	1100	NDA	UG/KG	UG/L	NO	NO	NO	NO
Phenol	ND	ND	ND	8	3	7	50000	NDA	22000	NDA	UG/KG	UG/L	NO	NO	NO	NO
Pyrene	11000	1200	ND	ND	ND	ND	2100000	NDA	1100	NDA	UG/KG	UG/L	NO	NO	NO	NO
1,2,4-Trichlorobenzene	1.7	ND	ND	ND	ND	ND	2500	3200000	190	4.5	UG/KG	UG/L	NO	NO	NO	NO
Petroleum																
Gasoline	39650	2110000	ND	3500	ND	ND	NDA	NDA	NDA	NDA	UG/KG	UG/L	NO	NO	NO	NO
TPH - Diesel Range	1300	19000	ND	500	ND	ND	NDA	NDA	NDA	NDA	MG/KG	UG/L	NO	NO	NO	NO
TPH - Gasoline Range	380	9500	ND	NA	ND	ND	NDA	NDA	NDA	NDA	MG/KG	UG/L	NO	NO	NO	NO

Table 10.4.31
Organic Chemicals Detected in Surface Soil, Subsurface Soil, Sediment, and Shallow, Intermediate, and Deep Groundwater
Comparison to Cross-media SSLs, Tap Water RBCs, and Background UTLs
NAVBASE-Charleston, Zone A, SWMU 39
Charleston, South Carolina

Parameter	Maximum Concentration						Screening Concentration *									
	Surface Soil	Subsurface Soil	Sediment	Shallow GW	Inter-mediate GW	Deep GW	Soil to GW	Soil to Air	Tap Water RBC	Saltwater Surf. Wtr. Chronic	Soil Units	Water Units	Leaching Potential	Volatil-ization Potential	Ground-water Migration Concern	Surface Water Migration Concern
Pesticides/PCBs																
Aroclor-1260	1100	ND	ND	ND	ND	ND	1000	1000	0.034	0.03	UG/KG	UG/L	YES	YES	NO	NO
alpha-Chlordane	10	ND	ND	ND	ND	ND	5000	20000	0.19	0.004	UG/KG	UG/L	NO	NO	NO	NO
gamma-Chlordane	24	ND	ND	ND	ND	ND	5000	20000	0.19	0.004	UG/KG	UG/L	NO	NO	NO	NO
4,4'-DDD	22	4.5	ND	ND	ND	ND	8000	NDA	0.28	0.025	UG/KG	UG/L	NO	NO	NO	NO
4,4'-DDE	53	ND	ND	ND	ND	ND	27000	NDA	0.2	0.14	UG/KG	UG/L	NO	NO	NO	NO
4,4'-DDT	26	520	ND	ND	ND	ND	16000	1000000	0.2	0.001	UG/KG	UG/L	NO	NO	NO	NO
Dieldrin	13	ND	ND	ND	ND	ND	2	1000	0.0042	0.0019	UG/KG	UG/L	YES	NO	NO	NO
Endrin aldehyde	13	ND	ND	ND	ND	ND	500 c	NDA	NDA	NDA	UG/KG	UG/L	NO	NO	NO	NO
Heptachlor	2	ND	ND	ND	ND	ND	12000	100	0.0023	0.0036	UG/KG	UG/L	NO	NO	NO	NO
TCDD Equivalents																
Dioxin Equiv.	3.2	ND	ND	3.1	0.06	0.42	1600	NDA	0.45	10	NG/KG	PG/L	NO	NO	YES	NO

Explanations of screening procedures appear in Section 6.2.

Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Table 10.4.2 for soil. Groundwater detections and comparisons appear in tables 10.4.5 through 10.4.19.

* Screening Concentrations:
Soil to GW - Generic SSLs based on DAF = 10, adapted from USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or calculated using values from Table 6.2
Soil to Air - From USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or USEPA Region III Risk-Based Concentration Table, June 1996
Tap Water RBC - From USEPA Region III Risk-Based Concentration Table, October 1997
Salt Water Surface Water Chronic - From USEPA Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment, November 1995, Table 2

c - Calculated soil to groundwater SSL value (See Table 6.2)
GW - Groundwater
NA - Not available
ND - Not detected

RBC - Risk-based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
NG/KG - Nanograms per kilogram

UG/KG - Micrograms per kilogram
PG/L - Picograms per liter
UG/L - Micrograms per liter

Table 10.4.32
Inorganic Chemicals Detected in Surface Soil, Subsurface Soil, Shallow Groundwater, and Deep Groundwater
Comparison to Cross-media SSLs, Tap Water RBCs, Saltwater Surface Water Chronic Screening Levels, and Background Reference Values
NAVBASE-Charleston, Zone A: SWMU 39
Charleston, South Carolina

Parameter	Maximum Concentration					Screening Concentration *											
	Surface Soil	Subsurface Soil	Shallow GW	Intermediate GW	Deep GW	Soil to GW	Soil Background Reference	Soil to Air	Tap Water RBC	GW Background Reference	Saltwater Surf. Wtr Chronic	Soil Units	Water Units	Leaching Potential	Fugitive Particulate Inhalation Concern	Ground-Water Migration Concern	Surface Water Migration Concern
Inorganic Chemicals																	
Aluminum (Al)	16000	9890	11100	56.3	411	560000 c	28240	NA	37000	3210	NA	MG/KG	UG/L	NO	NO	NO	NO
Antimony (Sb)	ND	ND	2.4	ND	ND	2.5	ND	NA	15	ND	NA	MG/KG	UG/L	NO	NO	NO	NO
Arsenic (As)	17.9	5.1	109	40	17.2	15	9.8	750	0.045	11.1	36	MG/KG	UG/L	YES	NO	YES	YES
Barium (Ba)	41.7	23.7	820	23.4	36	820	53	690000	2600	179	NA	MG/KG	UG/L	NO	NO	NO	NO
Beryllium (Be)	0.45	ND	1.2	ND	0.23	32	ND	1300	0.016	ND	NA	MG/KG	UG/L	NO	NO	YES	NO
Cadmium (Cd)	ND	ND	1.6	0.37	0.63	4	ND	1800	18	ND	9.3	MG/KG	UG/L	NO	NO	NO	NO
Chromium (Cr)	24.1	18.1	33.1	ND	5.4	19	63.4	270	37000	8.7	103	MG/KG	UG/L	YES	NO	NO	NO
Chromium (Hexavalent)	ND	ND	0.032	ND	ND	19	ND	270	180	ND	50	MG/KG	UG/L	NO	NO	NO	NO
Cobalt (Co)	3.5	2.5	50.9	17.1	83.8	990 c	4.4	NA	2200	12.1	NA	MG/KG	UG/L	NO	NO	NO	NO
Copper (Cu)	32.2	6.1	11.9	ND	4.3	5600 c	165	NA	1500	15.7	2.9	MG/KG	UG/L	NO	NO	NO	YES
Lead (Pb)	108	5.6	16.5	ND	2.2	400	140	400	15	4.7	8.5	MG/KG	UG/L	NO	NO	YES	YES
Manganese (Mn)	191	27	2680	3100	2200	550 c	98.1	NA	840	2690	NA	MG/KG	UG/L	NO	NO	YES	NO
Mercury (Hg)	2.8	2	ND	ND	ND	1	0.3	10	11	ND	0.2	MG/KG	UG/L	YES	NO	NO	NO
Nickel (Ni)	9.8	4.4	10.3	ND	11	65	35	13000	730	21.1	42	MG/KG	UG/L	NO	NO	NO	NO
Selenium (Se)	0.895	ND	2.9	ND	2.2	2.5	1.7	NA	180	ND	71	MG/KG	UG/L	NO	NO	NO	NO
Vanadium (V)	31.4	18.9	32.6	ND	2.9	3000	77.3	NA	260	10.9	NA	MG/KG	UG/L	NO	NO	NO	NO
Zinc (Zn)	268	48.1	104	ND	299	6200	208	NA	11000	83.2	86	MG/KG	UG/L	NO	NO	NO	YES

Explanations of screening procedures appear in Section 6.2.

Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Table 10.4.3 for soil. Groundwater detections and comparisons appear in tables 10.4.5 through 10.4.19.

* Screening Concentrations:
Soil to GW - Generic SSLs based on DAF = 10, adapted from USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or calculated using values from Table 6.2
Soil to Air - From USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or USEPA Region III Risk-Based Concentration Table, June 1996
Tap Water RBC - From USEPA Region III Risk-Based Concentration Table, October 1997
Salt Water Surface Water Chronic - From USEPA Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment, November 1995, Table 2
Background reference values for soil are shown for comparison purposes only.
Maximum groundwater concentrations are screened against the greater of tap water RBCs or corresponding background reference values to determine groundwater migration concern.

c - Calculated soil to groundwater SSL value (See Table 6.2)
GW - Groundwater
NA - Not available/Not applicable
ND - Not detected
RBC - Risk based concentration
SSL - Soil screening level
MG/KG - M ams per kilogram
UG/L - Mic ms per liter

Aroclor-1260, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, carbazole, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, and dieldrin were not reported in any subsurface soil or groundwater samples. These findings indicate that soil concentrations of these chemicals are not significant in terms of soil-to-groundwater migration. First round soil samples, collected in the area north of Building 1604, were analyzed for the standard suite of analytes. Based on first round soil sampling, there is some indication that concentrations of BTEX/petroleum-related chemicals, such as benzene and ethylbenzene, detected in the subsurface soil sample 039SB006 are contributing to elevated concentrations in groundwater in this area. It is conceivable that concentrations of TPH and BTEX/petroleum-related chemicals are related. Since most second round soil samples, collected northwest of Building 1604, were only analyzed for TPH it is possible that the area of BTEX/petroleum-related chemicals may extend westward contributing to groundwater concentrations of related compounds in the northwest corner of the site.

Concentrations of chlorinated VOCs (1,2-dichloroethane, tetrachloroethene, and trichloroethene) were detected in surface and subsurface soil samples 039SB011 and 039SB014. The Geoprobe subsurface soil investigation summarized on Table 10.4.2 and on Figure 10.4.26, revealed the highest concentrations of chlorinated VOCs just to the south of Building 1604. These findings indicate that concentrations of chlorinated VOCs in soil in the vicinity of Building 1604 may be a source of groundwater impacts in this area.

Arsenic was reported in a single surface soil sample (039SB006) at a concentration above its SSL (15 mg/kg). The mean detected concentration in surface soil (4.9 mg/kg) and subsurface soil (2.1 mg/kg) are below the arsenic background reference concentrations of 9.4 mg/kg for surface soil and 9.8 mg/kg for subsurface soil. Although chromium was reported in four surface soil samples at concentrations exceeding its SSL, it was not reported in any soil sample at a concentration exceeding its background reference value. For screening purposes, chromium was conservatively assumed to exist in its soluble hexavalent state. Hexachrome analyses at SWMU 39

and elsewhere in Zone A suggest that chromium in soil exists predominantly in less soluble valence states. Mercury was reported in 5 surface soil samples and 4 subsurface soil samples at a concentration above its SSL. Mercury was not, however, detected in groundwater through all rounds of sampling at this site. These findings indicate that with the exception of mercury, inorganic soil concentrations do not present a widespread threat in terms of soil to groundwater migration. Soil concentrations of mercury indicate a potential for impacts to groundwater, however, current groundwater data do not support that this migration is occurring.

10.4.12.2 SWMU 39 - Groundwater to Surface Water Cross Media Transport

As shown on Tables 10.4.31 and 10.4.32, arsenic, azobenzene, benzene, beryllium, chloroform, chloromethane, dibromochloromethane, 1,2-dibromo-3-chloropropane, 1,1-dichloroethene, 1,2-dichloroethane, cis-1,2-dichloroethene, 1,2-dichloroethene (total), dioxin equivalents, bis(2-ethylhexyl)phthalate, lead, manganese, pentachlorophenol, 1,1,2,2-tetrachloroethane, tetrachloroethene, trichloroethene, and vinyl chloride were detected in SWMU 39 groundwater above corresponding tap water RBCs (organics) and corresponding background reference concentrations (inorganics). Additionally, arsenic, benzene, copper, ethylbenzene, lead, tetrachloroethene, di-n-butylphthalate, 2-methylnaphthalene, naphthalene, and zinc, were reported in groundwater at concentrations above their corresponding saltwater surface water AWQCs.

The highest concentrations of petroleum-related chemicals (azobenzene, benzene, ethylbenzene, 2-methylnaphthalene, and naphthalene) were reported in groundwater samples collected from monitoring wells NBCA-039-011, NBCA-039-001, NBCA-039-005, and NBCA-039-014. The highest concentrations of chlorinated VOCs were reported in groundwater samples collected from monitoring wells NBCA-039-003, NBCA-039-004, NBCA-039-009, NBCA-039-012, NBCA-039-12I, NBCA-039-013, NBCA-039-13I, and NBCA-039-13D. Figures 10.4.18 and 10.4.23, represent benzene plumes for shallow and intermediate groundwater, respectively. Figures 10.4.13 through 10.4.17, 10.4.19 through 10.4.22, and 10.4.25, represent chlorinated

VOC plumes in shallow, intermediate, and deep groundwater. Because some of the chlorinated VOCs were reported so infrequently at concentrations above RBCs, plume maps were not provided. Chloroform (NBCA-039-13D), chloromethane (NBCA-039-011), dibromochloropropane (NBCA-039-003), 1,2-dichloro-3-chloropropane (NBCA-039-003), and 1,1,2,2-tetrachloroethane (NBCA-039-003) were reported in a single groundwater sample each. Pentachlorophenol, bis(2-ethylhexyl)phthalate, and dioxin equivalents could not be associated with a distinct plume. Pentachlorophenol was reported in a single groundwater sample (NBCA-039-011) at a concentration exceeding its tap water RBC. Bis(2-ethylhexyl)phthalate was reported in six groundwater samples at concentrations exceeding its tap water RBC (NBCA-039-001, -005, -011, -013, -014, and -15D). Dioxin equivalents were reported in 34 groundwater samples collected from locations across the site.

Arsenic and manganese are widespread in the surficial aquifer, however, manganese was reported at concentrations exceeding its background reference concentration in only two samples. Beryllium was reported in six groundwater samples (NBCA-039-08D twice, -013 twice, -015 twice) at concentrations above its tap water RBC. Lead was detected in a single groundwater sample (NBCA-039-013) at a concentration above its TTAL and its AWQC. Although copper was reported at concentrations above its AWQC in 10 groundwater samples, it did not exceed its background reference concentration in any sample. Zinc was reported in groundwater at concentrations exceeding its AWQC in five samples (NBCA-039-04I, -08D twice, -013 twice).

A discussion of the groundwater migration pathways for SWMU 39 is provided in Section 10.4.11, SWMU 39 Hydrogeology. Groundwater migration pathways are described as following a south-southeasterly path to a divide located in the south central portion of the SWMU 39 monitoring well array. At this divide, groundwater would either follow a southwesterly path toward SWMU 42 or an easterly path toward the Cooper River. Based on the locations of the contaminant detections, the majority of the SWMU 39 groundwater contamination

would tend to favor the southwesterly path toward SWMU 42. The exception would be the petroleum-related VOCs identified in monitoring well NBCA-039-001 which may favor the easterly path toward the as yet impacted monitoring well NBCA-039-006.

10.4.12.3 SWMU 39 - Soil-to-Air Cross Media Transport

Table 10.4.32 lists the volatile organic compounds detected in surface soil samples collected at SWMU 39 along with corresponding soil-to-air volatilization screening levels. Aroclor 1260 and benzene were detected in SWMU 39 soil at concentrations exceeding their corresponding soil-to-air volatilization screening levels. Aroclor 1260 was reported in a single surface soil sample (039SB00201) at a concentration of 1,100 ug/kg which exceeds its soil to air SSL of 1,000 ug/kg. Benzene was reported in a single subsurface soil sample (039SB00802) at a concentration of 990 ug/kg which exceeds its soil to air SSL of 800 ug/kg. These isolated exceedances of screening values do not indicate a substantial threat via the soil-to-air pathway. Additional discussion regarding this pathway is provided in Section 10.4.13, Human Health Risk Assessment.

10.4.12.4 SWMU 39 - Fate and Transport Summary

Soil-to-Groundwater

Concentrations of benzene and ethylbenzene were reported in subsurface soil samples 039SB008, 039SB011, and 039SP012, collected along the northern portion of SWMU 39, and in subsurface soil samples 039SP008 and 039SP009 collected just south of Building 1604. Total petroleum hydrocarbons (diesel range and gasoline range) were reported in subsurface soil samples collected west of 039SB008 and 039SB0011 and along the northern boundary of the site. These soil impacts correlate with observed petroleum-related contamination seen in monitoring wells NBCA-039-011, NBCA-039-001, NBCA-039-005, and NBCA-039-014.

Elevated concentrations of chlorinated VOCs (1,1-dichloroethene, cis-1,2-dichloroethene, tetrachloroethene, 1,1,1-trichloroethane, and trichloroethene) were detected in surface and subsurface soil samples 039SB011 and 039SB014 and in geoprobe subsurface soil samples 039SP004, 039SP005, 039SP006, 039SP008, and 039SP009. Although these soil impacts correlate with observed chlorinated VOC contamination seen in monitoring wells NBCA-039-003, NBCA-039-004, NBCA-039-005, NBCA-039-012, and NBCA-039-12I, a soil source has not at this time been definitively determined.

Groundwater migration pathways are described as following a south-southeasterly path to a divide located in the south central portion of the SWMU 39 groundwater investigation area. At this divide, groundwater would either follow a southwesterly path toward SWMU 42 or an easterly path toward the Cooper River. The majority of the empirical evidence indicates that the southwesterly path predominates. This would account for the observed chlorinated VOCs detected in groundwater samples collected from monitoring wells NBCA-039-10I, NBCA-039-10D, NBCA-039-013, NBCA-039-13I, and NBCA-039-13D. The petroleum-related VOCs identified in monitoring well NBCA-039-001 may favor the easterly path toward monitoring well NBCA-039-006, although petroleum-related VOCs have yet to be identified at this monitoring well location.

10.4.13 Human Health Risk Assessment for SWMU 39

10.4.13.1 Site Background and Investigative Approach

SWMU 39 was formerly a storage area for petroleum, oil, and lubricant drums north of Building 1604. Currently the portion of the site adjacent to the north side of Building 1604 is asphalt-paved and the section of the site that continues north to the property boundary is covered with gravel.

Section 10.4.1 provides details of the soil sampling effort and Table 10.4.1 provides a soil sampling summary for the SWMU 39 RFI. A total of 43 soil samples were collected from the upper interval as part of the RFI activities. All 43 samples were analyzed for TPH, 15 were analyzed for TAL metals, 18 were analyzed for VOCs, 19 were analyzed for SVOCs, and 20 were analyzed for pesticides/PCBs. TPH analyses were not quantitatively considered in the HHRA since a toxicological database is not available for this broad category of constituents.

Section 10.4.3 provides details of the groundwater sampling effort and Table 10.4.4 provides a timeline of the groundwater investigation for the SWMU 39 RFI. As shown, the groundwater investigation at SWMU 39 consisted of multiple monitoring well investigations, geoprobe investigations, and CPT investigations. Only data from the monitoring well investigation were used in the quantitative HHRA. A total of 15 shallow, five intermediate, and eight deep monitoring wells were sampled over multiple sampling events. Groundwater data generated during the quarterly sampling of SWMU 39 monitoring wells were considered sufficient to characterize groundwater pathways in the risk assessment. Data from interim sampling, geoprobe investigations, and CPT investigations were used to select monitoring well locations and delineate plumes. Data from a total of 108 groundwater samples were used to assess the groundwater pathway.

10.4.13.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 of this RFI and presented in Table 10.4.33, the focus of this HHRA is on the following COPCs: aluminum, Aroclor-1260, arsenic, benzo(a)pyrene equivalents, beryllium, manganese, and mercury. Wilcoxon rank sum test analyses did not result in the inclusion of any inorganic parameters that had been screened out on the basis of upper tolerance limit and risk-based concentration comparisons. Total petroleum

Table 10.4.33
Chemicals Present in Site Samples
SWMU 39 - Surface Soil
NAVBASE Charleston
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration RBC	Ref.	Units	Number Exceeding RBC	Ref.
Volatile Organics													
Acetone		12	18	11	74	32.0	12	430	780000	NA	ug/kg		
2-Butanone		3	18	3.6	11	7.0	6	12	4700000	NA	ug/kg		
Carbon disulfide		1	18	1.2	1.2	1.2	5.4	6.1	780000	NA	ug/kg		
1,2-Dichlorobenzene		1	19	1.2	1.2	1.2	5.4	380	700000	NA	ug/kg		
1,2-Dichloroethane		1	18	1.2	1.2	1.2	5.4	6.1	7000	NA	ug/kg		
cis-1,2-Dichloroethene		1	15	200	200	200.0	5.4	6.1	78000	NA	ug/kg		
trans-1,2-Dichloroethene		1	15	4.1	4.1	4.1	5.4	6.1	160000	NA	ug/kg		
1,2-Dichloroethene (total)		1	5	10	10	10.0	5.5	6	70000	NA	ug/kg		
Ethylbenzene		2	18	1.9	150	76.0	5.4	6.1	780000	NA	ug/kg		
2-Hexanone		1	18	1.8	1.8	1.8	5.4	12	630000	NA	ug/kg		
Methylene chloride		1	18	1.2	1.2	1.2	5.4	12	8500	NA	ug/kg		
Tetrachloroethene		1	18	170	170	170.0	5.4	6.1	12000	NA	ug/kg		
Toluene		5	18	1.5	2.3	1.9	5.4	6.1	1600000	NA	ug/kg		
Trichloroethene		2	18	3	37	20.0	5.4	6.1	58000	NA	ug/kg		
m+p Xylene		3	15	1.4	300	101.1	5.4	6.1	16000	NA	ug/kg		
Carcinogenic PAHs													
Benzo(a)pyrene Equiv.	*	3	19	9.957	5784.9	1936.7	NA	NA	88	NA	ug/kg	1	
Benzo(a)anthracene	*	3	19	46	4000	1398.7	350	810	880	NA	ug/kg	1	
Benzo(a)pyrene	*	1	19	3500	3500	3500.0	350	810	88	NA	ug/kg	1	
Benzo(b)fluoranthene	*	2	19	49	6200	3124.5	350	810	880	NA	ug/kg	1	
Benzo(k)fluoranthene		2	19	39	3800	1919.5	350	810	8800	NA	ug/kg		
Chrysene		3	19	67	6900	2379.0	350	810	88000	NA	ug/kg		
Dibenz(a,h)anthracene	*	1	19	950	950	950.0	350	810	88	NA	ug/kg	1	
Indeno(1,2,3-cd)pyrene	*	1	19	2700	2700	2700.0	350	810	880	NA	ug/kg	1	
Semivolatile Organics													
Acenaphthene		1	19	300	300	300.0	350	810	470000	NA	ug/kg		
Acenaphthylene		1	19	730	730	730.0	350	810	230000	NA	ug/kg		
Anthracene		1	19	1100	1100	1100.0	350	810	2300000	NA	ug/kg		
Benzo(g,h,i)perylene		1	19	2900	2900	2900.0	350	810	230000	NA	ug/kg		
Butylbenzylphthalate		1	19	44	44	44.0	350	810	1600000	NA	ug/kg		
Carbazole		1	19	960	960	960.0	350	810	32000	NA	ug/kg		
Di-n-octyl phthalate		1	19	49	49	49.0	350	810	160000	NA	ug/kg		
bis(2-Ethylhexyl)phthalate		4	19	82	6200	1815.5	360	810	46000	NA	ug/kg		
Fluoranthene		2	19	86	350	218.0	350	15000	310000	NA	ug/kg		
Fluorene		1	19	320	320	320.0	350	810	310000	NA	ug/kg		
2-Methylnaphthalene		3	19	230	1700	886.7	350	810	310000	NA	ug/kg		
Naphthalene		2	19	91	1100	595.5	350	810	310000	NA	ug/kg		
Phenanthrene		4	19	78	6500	1769.5	350	800	230000	NA	ug/kg		
Pyrene		3	19	78	11000	3789.3	350	810	230000	NA	ug/kg		
1,2,4-Trichlorobenzene		1	19	1.7	1.7	1.7	5.5	810	78000	NA	ug/kg		
Pesticides/PCBs													
Aroclor-1260	*	4	20	26	1100	391.0	14	76	320	NA	ug/kg	2	
alpha-Chlordane		2	20	1.8	10	5.9	1.4	9.4	1800	NA	ug/kg		
gamma-Chlordane		1	20	24	24	24.0	1.4	9.4	1800	NA	ug/kg		
4,4'-DDD		5	20	3.55	22	11.6	2.6	18	2700	NA	ug/kg		
4,4'-DDE		7	20	1.1	53	15.1	2.6	18	1900	NA	ug/kg		
4,4'-DDT		8	20	3.6	26	13.0	2.8	18	1900	NA	ug/kg		

Table 10.4.33
Chemicals Present in Site Samples
SWMU 39 - Surface Soil
NAVBASE Charleston
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration RBC	Ref.	Units	Number Exceeding RBC	Ref.
Dieldrin		1	20	13	13	13.0	2.8	18	40	NA	ug/kg		
Endrin aldehyde		2	20	6.7	13	9.9	2.6	18	2300	NA	ug/kg		
Heptachlor		1	20	2	2	2.0	1.4	9.4	140	NA	ug/kg		
TCDD Equivalents													
Dioxin Equiv.		2	2	1.7637	3.2278	2.5	NA	NA	1000	NA	ng/kg		
Total Petroleum Hydrocarbons													
TPH - Diesel Range Organics	*	3	15	48	1300	499.3	30	36	100	NA	mg/kg	2	
TPH - Gasoline Range Organics	*	2	15	79	380	229.5	30	36	100	NA	mg/kg	1	
Inorganics													
Aluminum (Al)	*	15	15	4750	16000	8335.3	NA	NA	7800	12800	mg/kg	7	2
Arsenic (As)	*	15	15	1.4	17.9	4.9	NA	NA	0.43	9.44	mg/kg	15	1
Barium (Ba)		15	15	10.7	41.7	23.5	NA	NA	550	53	mg/kg		
Beryllium (Be)	*	2	15	0.24	0.45	0.3	0.21	0.24	0.15	NA	mg/kg	2	
Calcium (Ca)	N	15	15	1870	136000	27728.3	NA	NA	NA	NA	mg/kg		
Chromium (Cr)		15	15	7.3	24.1	13.8	NA	NA	39	50.4	mg/kg		
Chromium (Hexavalent)		0	2	ND	ND	ND	0.023	0.023	39	NA	mg/kg		
Cobalt (Co)		13	15	1.4	3.5	2.5	1.4	1.4	470	4.4	mg/kg		
Copper (Cu)		15	15	1.5	32.2	9.6	NA	NA	310	165	mg/kg		
Iron (Fe)	N	15	15	4250	16300	8365.7	NA	NA	NA	NA	mg/kg		
Lead (Pb)		15	15	4	108	24.4	NA	NA	400	140	mg/kg		
Magnesium (Mg)	N	15	15	286	1800	891.2	NA	NA	NA	NA	mg/kg		
Manganese (Mn)	*	15	15	11.2	191	55.0	NA	NA	180	98.1	mg/kg	1	4
Mercury (Hg)	*	7	15	0.15	2.8	1.3	0.11	0.12	2.3	0.3	mg/kg	1	5
Nickel (Ni)		12	15	3.9	9.8	6.2	3.2	4	160	13.55	mg/kg		
Potassium (K)	N	12	15	198	813	398.4	256	561	NA	NA	mg/kg		
Selenium (Se)		3	15	0.68	0.895	0.77	0.63	0.74	39	1.2	mg/kg		
Sodium (Na)	N	15	15	184	349	230.5	NA	NA	NA	NA	mg/kg		
Vanadium (V)		15	15	7.5	31.4	14.5	NA	NA	55	29.24	mg/kg		1
Zinc (Zn)		15	15	4.9	268	43.1	NA	NA	2300	207.6	mg/kg		1

* - Selected as a COPC based on the screening process described in 7.3.4
RBC - Risk-based Concentration based on a target risk of 1E-06 and a target hazard quotient of 0.1.
Ref. - Surface soil background concentration for Zone A.
N - Essential nutrients eliminated from the screening process.
mg/kg - milligrams per kilogram

hydrocarbons (TPH) were detected in surface soil above the action level of 100 mg/kg established for NAVBASE. In order to conduct a quantitative risk assessment for TPH, it is necessary to have more detail on the individual chemicals. In the absence of such data, no quantitative risk assessment for TPH can be supported.

Groundwater

As shown in Table 10.4.34, the COPCs identified in shallow groundwater for this site include aluminum, antimony, arsenic, azobenzene, barium, benzene, beryllium, bis(2-ethylhexyl)phthalate, chlorobenzene, chloroform, chloromethane, chromium, dibromochloromethane, 1,2-dibromo-3-chloropropane, 1,1-dichloroethene, 1,2-dichloroethane, 1,2-dichloroethene (total), cis-1,2-dichloroethene, dioxin equivalents, ethylbenzene, lead, manganese, 2-methylnaphthalene, 4-methylphenol, naphthalene, pentachlorophenol, 1,1,2,2-tetrachloroethane, tetrachloroethene, thallium, trichloroethene, vanadium, vinyl chloride, and m&p-xylene. Wilcoxon rank sum test analyses did not result in the inclusion of any inorganic parameters that had been screened out on the basis of background reference concentration comparisons.

Several COPCs that were identified through the conservative screening process were eliminated from further consideration in the HHRA due to a low frequency of detection. These included antimony (1 of 79), azobenzene (1 of 27), dibromochloromethane (1 of 108), 1,2-dibromo-3-chloropropane (1 of 5), and pentachlorophenol (1 of 108). It is recognized by RAGS that parameters can be misidentified even under careful quality control. To address this, RAGS allows parameters to be eliminated from consideration in the risk assessment if they are detected at a frequency of less than 5 percent assuming there is no reason to believe that the parameter is present at concentrations below the detection limit or that the parameter is present in other site media. The range of quantitation limits provided on Table 10.4.34 represent the values that the

Table 10.4.34
Chemicals Present in Site Samples
SWMU 39, Groundwater
NAVBASE - Charleston
Charleston, South Carolina

		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration RBC	Reference	Units	Number Exceeding RBC	Ref.
Inorganics													
Aluminum (Al)	*	44	79	16	11100	910	8	1060	3700	3210	ug/L	2	2
Antimony (Sb)	*	1	79	2.4	2.4	2.4	1.6	51	1.5	NA	ug/L	1	
Arsenic (As)	*	51	79	2.1	109	31	2	8.3	0.045	11.1	ug/L	51	34
Barium (Ba)	*	70	79	4.1	820	63	0.3	58.6	260	179	ug/L	4	4
Beryllium (Be)	*	6	79	0.215	1.2	0.44	0.11	1.1	0.016	NA	ug/L	6	
Cadmium (Cd)		12	79	0.37	1.6	0.83	0.22	5	18	NA	ug/L		
Calcium (Ca)	N	78	79	9930	255000	56341	43	43	NA	NA	ug/L		
Chromium (Cr)	*	19	79	1	33.1	5.9	0.78	8.1	18	8.7	ug/L	2	3
Chromium (Hexavalent)	*	2	13	0.01	0.032	0.021	0.003	0.003	0.018	NA	mg/L	1	
Cobalt (Co)		20	79	0.96	88.5	25	0.67	7	220	12.1	ug/L		8
Copper (Cu)		20	79	1.2	11.9	5.3	0.89	13.8	150	15.7	ug/L		
Cyanide (CN)		2	12	24.7	30	27	2	10	73	0.05	ug/L		2
Iron (Fe)	N	76	79	36.6	57200	12383	20	147	NA	NA	ug/L		
Lead (Pb)	*	6	79	2.2	16.5	5.4	0.89	8.1	15	4.7	ug/L	1	1
Magnesium (Mg)	N	78	79	1990	320000	20073	43	43	NA	NA	ug/L		
Manganese (Mn)	*	77	79	5.6	3100	682	0.3	7.5	84	2690	ug/L	54	2
Mercury		17	79	0.11	1	0.28	0.08	0.2	1.1	NA	ug/L		
Nickel (Ni)		14	79	0.815	11.5	4.2	0.67	14	73	21.1	ug/L		
Potassium (K)	N	69	79	649	180000	11235	55	1600	NA	NA	ug/L		
Selenium (Se)		2	79	2.2	2.9	2.6	2.1	10.6	18	NA	ug/L		
Silver (Ag)		5	79	1.1	9.8	3.7	1	7	18	NA	ug/L		
Sodium (Na)	N	63	79	2970	2830000	163347	19	36300	NA	NA	ug/L		
Thallium (Tl)	*	3	79	3.7	7.4	5.2	2.7	30	0.29	NA	ug/L	3	
Tin (Sn)		1	73	60.1	60.1	60	2.6	58.4	2200	NA	ug/L		
Vanadium (V)	*	22	79	0.51	32.6	4.1	0.4	7	26	10.9	ug/L	1	1
Zinc (Zn)		14	79	7.7	322	88	2.7	318	1100	83.2	ug/L		6
Semivolatile Organics													
Acenaphthene		5	108	2	3	2.2	10	12	220	NA	ug/L		
Anthracene		2	108	2.2	5	3.6	10	12	1100	NA	ug/L		
Azobenzene	*	1	27	6	6	6.0	10	11	0.61	NA	ug/L	1	
Benzoic acid		4	108	1	8	2.9	10	62	15000	NA	ug/L		
Benzyl alcohol		3	108	1	2	1.3	10	23	11000	NA	ug/L		
Butylbenzylphthalate		1	108	2	2	2.0	10	12	730	NA	ug/L		
Dibenzofuran		13	108	1	9	3.7	10	12	15	NA	ug/L		
Di-n-butylphthalate		13	108	1	6	3.2	10	12	370	NA	ug/L		
Diethylphthalate		5	108	1	11	3.2	10	12	2900	NA	ug/L		
2,4-Dimethylphenol		2	108	3	10.5	6.8	10	12	73	NA	ug/L		
bis(2-Ethylhexyl)phthalate	*	8	108	2	20	8.3	10	12	4.8	NA	ug/L	6	
Fluorene		11	108	2	8	4.8	10	12	150	NA	ug/L		
2-Methylnaphthalene	*	16	108	2	255	41.3	10	12	150	NA	ug/L	2	
2-Methylphenol		2	108	1	2	1.5	10	12	180	NA	ug/L		
4-Methylphenol	*	3	108	10	22	15.5	10	12	18	NA	ug/L	1	
Naphthalene	*	18	108	2	420	63.4	10	12	150	NA	ug/L	2	
N-Nitrosodiphenylamine		1	108	2	2	2.0	10	12	14	NA	ug/L		
Pentachlorophenol	*	1	108	2	2	2.0	25	62	0.56	NA	ug/L	1	
Phenanthrene		9	108	1	8	3.5	10	12	110	NA	ug/L		
Phenol		7	108	2	8	4.0	10	12	2200	NA	ug/L		

Table 10.4.34
Chemicals Present in Site Samples
SWMU 39, Groundwater
NAVBASE - Charleston
Charleston, South Carolina

		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration RBC	Reference	Units	Number Exceeding RBC	Ref.
Volatile Organics													
Acetone		4	108	7	34	17	10	340	370	NA	ug/L		
Benzene	*	17	108	1	190	69	5	5	0.36	NA	ug/L	17	
2-Butanone		3	108	3.2	18	8.2	10	10	190	NA	ug/L		
Carbon disulfide		1	108	4.6	4.6	4.6	5	5	100	NA	ug/L		
Chlorobenzene	*	2	108	3	4	3.5	5	5	3.9	NA	ug/L	1	
Chloroform	*	1	108	7	7	7.0	5	5.1	0.15	NA	ug/L	1	
Chloromethane	*	1	108	2	2	2.0	10	10	1.4	NA	ug/L	1	
Dibromochloromethane	*	1	108	5.5	5.5	5.5	5	5	0.17	NA	ug/L	1	
1,2-Dibromo-3-Chloropropane	*	1	5	3	3	3.0	5	10	0.048	NA	ug/L	1	
1,1-Dichloroethane		3	108	1.1	3	2.0	5	5	81	NA	ug/L		
1,2-Dichloroethane	*	2	108	1	4	2.5	5	5	0.12	NA	ug/L	2	
1,1-Dichloroethene	*	15	108	1.05	6	3.3	5	5	0.044	NA	ug/L	15	
cis-1,2-Dichloroethene	*	22	59	1.2	240	61	5	5	6.1	NA	ug/L	16	
1,2-Dichloroethene (total)	*	18	68	5	330	98	5	5	5.5	NA	ug/L	17	
Ethylbenzene	*	10	108	1.1	165	53	5	5	130	NA	ug/L	3	
2-Hexanone		3	108	2	7	4.5	10	10	290	NA	ug/L		
Methylene chloride		1	108	2	2	2.0	5	5	4.1	NA	ug/L		
4-Methyl-2-Pentanone		1	108	3.3	3.3	3.3	10	10	290	NA	ug/L		
1,1,2,2-Tetrachloroethane	*	1	108	1.4	1.4	1.4	5	5	0.052	NA	ug/L	1	
Tetrachloroethene	*	18	108	1.7	110	40	5	5	1.1	NA	ug/L	18	
Toluene		10	108	1.3	24	6.9	5	5	75	NA	ug/L		
1,1,1-Trichloroethane		1	108	1.3	1.3	1.3	5	5	79	NA	ug/L		
Trichloroethene	*	30	108	1	120	50	5	5	1.6	NA	ug/L	28	
Vinyl chloride	*	22	108	1.9	10	6.4	5	10	0.019	NA	ug/L	22	
m+p Xylene	*	5	18	4.5	91	51	5	5	52	NA	ug/L	3	
o-Xylene		6	20	1.3	35	7.3	5	5	140	NA	ug/L		
Xylene (Total)		4	90	72	560	327	5	5	1200	NA	ug/L		
TPH													
Diesel		1	19	500	500	500	25	25	NA	NA	ug/L		
Gasoline		2	19	6.3	3500	1753	10	10	NA	NA	ug/L		
TCDD Equivalents													
Dioxin Equiv.	*	34	34	0.0072	3.1	0.28	NA	NA	0.43	NA	pg/L	4	

* - Selected as a COPC based on the screening process described in Section 7.3.4
RBC - Risk-based Concentration based on target risk of 1E-06 and a target hazard quotient of 0.1
Ref. - The greater of the shallow or deep groundwater background reference concentration for Zone A
N - Essential nutrients eliminated from the screening process
ug/L - microgram per liter
mg/L - milligram per liter
pg/L - picogram per liter

laboratory is required to report. In general, the analytical instrumentation can detect chemicals at concentrations lower than the quantitation limit provided on the table. When chemicals are reported at concentrations lower than their quantitation limit the concentration is flagged with a "J" by the validator. Dibromochloromethane, 1,2-dibromo-3-chloropropane, and pentachlorophenol were not detected in any other media sampled at SWMU 39 nor are they consistent with the other more frequently detected COPCs. The isolated occurrence of these parameters indicates that their overall contribution to the groundwater pathway risk/hazard would be minimal in relation to the more frequently detected COPCs. Azobenzene, 1,2-dibromo-3-chloropropane are on the Appendix IX list of analytical parameters. Neither were reported in subsequent groundwater samples collected from the monitoring well for which they were originally reported. To address this and any other uncertainty associated with the removal of these COPCs from the formal HHRA, they have been included in the point risk and hazard analysis provided in Section 10.4.13.7. Chromium was addressed in the risk assessment assuming that it was present in groundwater in its hexavalent state. This is due to the fact that hexavalent chromium was reported in groundwater at concentrations above its RBC.

10.4.13.3 Exposure Assessment

Exposure Setting

SWMU 39 is located in the northwest corner of NAVBASE and is currently covered by either buildings, asphalt, or gravel. The site is located within a moderately developed industrial area of NAVBASE and most surrounding parcels are also occupied by warehouse buildings and/or service roads. A Hess Oil tank farm occupies an adjoining parcel of land to the north of the site. Current base reuse plans indicate that the area surrounding SWMU 39 is slated to be developed as a marine terminal and warehouse storage. The surrounding area will likely maintain current features and/or entail additional building construction.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are hypothetical future site residents. Future site resident and worker exposure scenarios were addressed in this risk assessment. The hypothetical future site worker scenario assumed continuous exposure to surface soil conditions and the use of groundwater as a potable water source. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact and the fact that groundwater is not currently used onsite as a source of potable or process water. Therefore, future worker assessment is considered to be protective of current site users. The future site resident scenario was built on the premise that existing buildings would be removed and replaced with dwellings. In addition, the future site residents were assumed to use the aquifer onsite as a source of drinking water.

Exposure Pathways

Exposure pathways for the site workers are dermal contact and incidental ingestion of surface soils, and ingestion of groundwater through potable use. The exposure pathways for future residential land use are the same as those for the future site worker. In addition, inhalation of volatile organic compounds through the use of groundwater is considered for both future site residents and future site workers. Uniform exposure was assumed for all sample locations. Table 10.4.35 presents the justification for exposure pathways assessed in this HHRA.

Table 10.4.35
Exposure Pathways Summary — SWMU 39
NAVBASE — Zone A
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Site Users/Maintenance	Air, Inhalation of gaseous contaminants emanating from soil	No	Soil to air screening did not identify any COPCs for this exposure route.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Soil to air screening did not identify any COPCs for this exposure route.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No (Qualified)	Shallow groundwater is not currently used as a source of potable or non-residential water at SWMU 39. Future land use assessment is considered to be conservatively representative of current receptors.
	Shallow groundwater, Inhalation of volatilized shallow groundwater contaminants	No (Qualified)	Shallow groundwater is not currently used as a source of potable or non-residential water at SWMU 39. Future land use assessment is considered to be conservatively representative of current receptors.
	Soil, Incidental ingestion	No (Qualified)	Future land use assessment is considered to be conservatively representative of current receptors.
	Soil, Dermal contact	No (Qualified)	Future land use assessment is considered to be conservatively representative of current receptors.
Future Land Uses			
Future Site Residents (Child and Adult) and Future Site Worker	Air, Inhalation of gaseous contaminants emanating from soil	No	Soil to air screening did not identify any COPCs for this exposure route.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Soil to air screening did not identify any COPCs for this exposure route.
	Shallow groundwater, Ingestion of contaminants during potable or general use	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.

Table 10.4.35
Exposure Pathways Summary — SWMU 39
NAVBASE — Zone A
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Future Site Residents (Child and Adult) and Future Site Worker (Continued)	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	Yes	COPCs were identified subsequent to risk-based screening comparisons.
	Soil, Incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, Dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals, Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina city limits.
	Fruits and vegetables, Ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Exposure Point Concentrations

As discussed in Section 7 of this RFI, UCLs are generally calculated for datasets consisting of at least 10 samples. Table 10.4.36 summarizes the 95% UCLs calculated for the COPCs identified for surface soil. The UCL was used to estimate risk/hazard resulting from exposure to surface soil for all COPCs except mercury. Since the UCL calculated for mercury was greater than the maximum detected concentration, the maximum concentration was assigned as its EPC.

Table 10.4.37 summarizes the determination of the groundwater EPC. Current EPA guidance favors the use of the arithmetic mean in the most concentrated area of the plume as the EPC for groundwater COPCs. The most concentrated area of the plume is defined separately for each COPC as summarized on Table 10.4.37. The EPC is calculated as the arithmetic mean of all

Table 10.4.36
Statistical Analysis of COPCs in Surface Soil
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

COPC	n	Natural Log Transformed mean	SD	H-stat	UCL (mg/kg)	MAX (mg/kg)	EPC (mg/kg)	
Aluminum	15	8.958	0.380	1.951	10181	16000	10181	UCL Used
Aroclor 1260	20	2.937	1.466	3.307	0.17	1.1	0.17	UCL Used
Arsenic	15	1.390	0.610	2.194	6.9	17.9	6.9	UCL Used
Benzo(a)pyrene equivalent	19	6.704	0.569	2.085	1.3	5.8	1.3	UCL Used
Beryllium	15	-2.038	0.396	1.965	0.17	0.45	0.17	UCL Used
Manganese	15	3.631	0.898	2.586	105	191	105	UCL Used
Mercury	15	-1.602	1.601	3.801	3.7	2.8	2.8	MAX Used

NOTES:

mean Arithmetic mean of the logtransformed data
n Number of samples analyzed
SD Standard deviation for a sample of data
H-stat "H" statistic from Gilbert 1987; cuboidal interpolation was used to determine accordance with USEPA Supplemental Guidance to RAGS, Calculating t
NA Not applicable
EPC Exposure point concentration
UCL 95 percentile upper confidence level mean
MAX Maximum reported concentration

Table 10.4.37
Determination of Groundwater EPCs
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

	Detection Frequency	Log Transformed mean	st.dev.	H-stat	95% UCL mg/L	Maximum Conc. mg/L	Average Conc. in Plume** mg/L	EPC (mg/L)	EPC Rationale
Aluminum (Al)	44/79	4.365	1.950	3.467	1.1	11	NA	1.1	No distinct plume was identified
Arsenic (As)	51/79	1.947	1.598	3.006	0.043	0.11	NA	0.043	No distinct plume was identified
Barium (Ba)	70/79	3.174	1.198	2.523	0.069	0.82	NA	0.069	No distinct plume was identified
Benzene	17/108	NA	NA	NA	NA	0.19	0.103	0.103	Plume defined by monitoring wells 1,5,11
Beryllium (Be)	6/79	-1.920	0.846	2.156	0.00026	0.0012	NA	0.00026	No distinct plume was identified
Chlorobenzene	2/108	NA	NA	NA	NA	0.0040	0.0032	0.0032	Plume defined by monitoring well 6
Chloroform	1/108	NA	NA	NA	NA	0.0070	0.0036	0.0036	Plume defined by monitoring well 13D
Chloromethane	1/108	NA	NA	NA	NA	0.0020	0.0013	0.0013	Plume defined by monitoring well 11
Chromium (Cr)	19/79	0.199	1.024	2.332	0.0027	0.033	NA	0.0027	No distinct plume was identified
1,2-Dichloroethane	2/108	NA	NA	NA	NA	0.0040	0.0030	0.0030	Plume defined by monitoring well 11
1,1-Dichloroethene	15/108	NA	NA	NA	NA	0.0060	0.0034	0.0034	Plume defined by monitoring wells 12,12I,13I,13D
cis-1,2-Dichloroethene	22/59	NA	NA	NA	NA	0.24	0.14	0.14	Plume defined by monitoring wells 12,12I,13I,13D
1,2-Dichloroethene (total)	18/68	NA	NA	NA	NA	0.33	0.13	0.13	Plume defined by monitoring wells 12,12I,13I,13D
Dioxin Equiv.	34/34	-2.281	1.354	2.853	5.01E-10	0.0031	NA	5.01E-10	No distinct plume was identified
Ethylbenzene	10/108	NA	NA	NA	NA	0.17	0.049	0.049	Plume defined by monitoring wells 1,5,11
bis(2-Ethylhexyl)phthalate	8/108	1.649	0.224	1.728	0.0055	0.020	NA	0.0055	No distinct plume was identified
Lead (Pb)	6/79	-0.270	0.695	2.021	0.0011	0.017	NA	0.0011	No distinct plume was identified
Manganese (Mn)	77/79	5.308	1.874	3.366	2.4	3.1	NA	2.4	No distinct plume was identified
2-Methylnaphthalene	16/108	NA	NA	NA	NA	0.26	0.19	0.19	Plume defined by monitoring well 11
4-Methylphenol	3/108	NA	NA	NA	NA	0.022	0.016	0.016	Plume defined by monitoring well 11
Naphthalene	18/108	NA	NA	NA	NA	0.42	0.29	0.29	Plume defined by monitoring well 11
1,1,2,2-Tetrachloroethane	1/108	NA	NA	NA	NA	0.0014	0.0022	0.0022	Plume defined by monitoring well 3
Tetrachloroethene	18/108	NA	NA	NA	NA	0.11	0.016	0.016	Plume defined by monitoring wells 13,13I,13D
Thallium (Tl)	3/79	0.762	0.376	1.800	0.0025	0.0074	NA	0.0025	No distinct plume was identified
Trichloroethene	30/108	NA	NA	NA	NA	0.12	0.0058	0.0058	Plume defined by monitoring wells 3,12,12I,13I,13D
Vanadium (V)	22/79	0.034	1.016	2.324	0.0023	0.033	NA	0.0023	No distinct plume was identified
Vinyl chloride	22/108	NA	NA	NA	NA	0.01	0.0058	0.0058	Plume defined by monitoring wells
m+p Xylene	5/18	NA	NA	NA	NA	0.091	0.043	0.043	Plume defined by monitoring wells 1,5

No distinct plume was identified", EPC was set equal to the 95% UCL concentration calculated for all groundwater data

** - Arithmetic mean of available quarterly data produced from samples collected in plume
(one-half SQL substituted for nondetects)

rounds of data from each monitoring well in the "most concentrated area" for each COPCs respective plume. One-half of the SQL was used for nondetected results. Figures 10.4.13 through 10.4.25 are plume maps for benzene, 1,1-dichloroethene, cis-1,2-dichloroethene, tetrachloroethene, trichloroethene, and vinyl chloride. Not all of the COPCs identified for groundwater had sufficient spatial extent to support presentation on a figure. Additionally, many of the COPCs either could not be assigned to a distinct plume or were detected throughout the site. As a result, the EPCs for aluminum, arsenic, barium, beryllium, chromium, dioxin, bis(2-ethylhexyl)phthalate, lead, manganese, thallium, and vanadium, were set equal to their 95% UCLs.

Quantification of Exposure

Soil

CDIs for ingestion and dermal contact with soils are shown in Tables 10.4.38 and 10.4.39, respectively.

Groundwater

The CDIs for groundwater ingestion are presented in Table 10.4.40. The CDIs for inhalation of volatile organic compounds is assumed to be approximately equal to the CDI for ingestion as indicated in the *Technical Memorandum Guidance on Estimating Exposure to VOCs While Showering* (USEPA/ORD, July 10, 1991).

10.4.13.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Table 10.4.41 presents toxicological information specific to each COPC identified at SWMU 39. This information was used in the quantification of risk/hazard associated with soil and groundwater contaminants. Brief toxicological profiles for each COPC are provided in the following paragraphs.

Table 10.4.38
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil (0-1')
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Chemical	Fraction Ingested from Contaminated Source *	Exposure Point Concentration (mg/kg)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Aluminum	1	10181	1.39E-02	1.30E-01	1.59E-02	4.98E-03	1.78E-03
Aroclor 1260	1	0.17	2.30E-07	2.15E-06	2.63E-07	8.22E-08	2.93E-08
Arsenic	1	6.9	9.47E-06	8.84E-05	1.08E-05	3.38E-06	1.21E-06
Benzo(a)pyrene equivalent	1	1.3	1.74E-06	1.62E-05	1.99E-06	6.21E-07	2.22E-07
Beryllium	1	0.17	2.38E-07	2.22E-06	2.72E-07	8.49E-08	3.03E-08
Manganese	1	105	1.44E-04	1.34E-03	1.65E-04	5.14E-05	1.84E-05
Mercury	0.5	2.8	1.92E-06	1.79E-05	2.19E-06	6.85E-07	2.45E-07

NOTES:

lwa Lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.4.39
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil (0-1')
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Chemical	Exposure Point Concentration (mg/kg)	Fraction Contacted from Contaminated Source *	Dermal Absorption Factor (unitless)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Aluminum	10181	1	0.001	5.72E-04	1.89E-03	3.58E-04	4.08E-04	1.46E-04
Aroclor 1260	0.17	1	0.01	9.43E-08	3.11E-07	5.90E-08	6.74E-08	2.41E-08
Arsenic	6.9	1	0.001	3.88E-07	1.28E-06	2.43E-07	2.77E-07	9.91E-08
Benzo(a)pyrene equivalent	1.3	1	0.01	7.12E-07	2.35E-06	4.46E-07	5.09E-07	1.82E-07
Beryllium	0.17	1	0.001	9.74E-09	3.22E-08	6.10E-09	6.96E-09	2.49E-09
Manganese	105	1	0.001	5.90E-06	1.95E-05	3.69E-06	4.22E-06	1.51E-06
Mercury	2.8	0.5	0.001	7.86E-08	2.60E-07	4.92E-08	5.62E-08	2.01E-08

NOTES:

CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.4.40
Chronic Daily Intakes (CDI)
Ingestion of COPCs in Groundwater
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Chemical	Exposure Point Concentration (mg/liter)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Future Worker adult H-CDI (mg/kg-day)	Future Worker adult C-CDI (mg/kg-day)
Aluminum (Al)	1.1	3.10E-02	7.24E-02	1.71E-02	1.11E-02	3.96E-03
Arsenic (As)	0.043	1.19E-03	2.77E-03	6.52E-04	4.24E-04	1.51E-04
Barium (Ba)	0.069	1.89E-03	4.41E-03	1.04E-03	6.75E-04	2.41E-04
Benzene	0.10	2.83E-03	6.60E-03	1.55E-03	1.01E-03	3.61E-04
Beryllium (Be)	0.00026	7.06E-06	1.65E-05	3.88E-06	2.52E-06	9.01E-07
Chlorobenzene	0.0032	8.68E-05	2.02E-04	4.77E-05	3.10E-05	1.11E-05
Chloroform	0.0036	9.93E-05	2.32E-04	5.46E-05	3.55E-05	1.27E-05
Chloromethane	0.0013	3.65E-05	8.52E-05	2.01E-05	1.30E-05	4.66E-06
Chromium (Cr)	0.0027	7.40E-05	1.73E-04	4.07E-05	2.64E-05	9.44E-06
1,2-Dichloroethane	0.0030	8.22E-05	1.92E-04	4.52E-05	2.94E-05	1.05E-05
1,1-Dichloroethene	0.0034	9.25E-05	2.16E-04	5.09E-05	3.30E-05	1.18E-05
cis-1,2-Dichloroethene	0.140	3.83E-03	8.94E-03	2.11E-03	1.37E-03	4.89E-04
1,2-Dichloroethene (total)	0.126	3.44E-03	8.03E-03	1.89E-03	1.23E-03	4.39E-04
Dioxin Equiv.	5.0E-10	1.37E-11	3.20E-11	7.55E-12	4.90E-12	1.75E-12
Ethylbenzene	0.049	1.33E-03	3.11E-03	7.34E-04	4.77E-04	1.70E-04
bis(2-Ethylhexyl)phthalate	0.0055	1.52E-04	3.54E-04	8.34E-05	5.42E-05	1.93E-05
Lead (Pb)	0.0011	3.12E-05	7.28E-05	1.72E-05	1.11E-05	3.98E-06
Manganese (Mn)	2.4	6.54E-02	1.53E-01	3.60E-02	2.34E-02	8.35E-03
2-Methylnaphthalene	0.187	5.11E-03	1.19E-02	2.81E-03	1.83E-03	6.52E-04
4-Methylphenol	0.016	4.25E-04	9.91E-04	2.34E-04	1.52E-04	5.42E-05
Naphthalene	0.290	7.95E-03	1.85E-02	4.37E-03	2.84E-03	1.01E-03
1,1,2,2-Tetrachloroethane	0.0022	6.10E-05	1.42E-04	3.35E-05	2.18E-05	7.78E-06
Tetrachloroethene	0.016	4.32E-04	1.01E-03	2.37E-04	1.54E-04	5.50E-05
Thallium (Tl)	0.0025	6.80E-05	1.59E-04	3.74E-05	2.43E-05	8.68E-06
Trichloroethene	0.0058	1.59E-04	3.71E-04	8.76E-05	5.69E-05	2.03E-05
Vanadium (V)	0.0023	6.21E-05	1.45E-04	3.41E-05	2.22E-05	7.92E-06
Vinyl chloride	0.0058	1.59E-04	3.71E-04	8.76E-05	5.69E-05	2.03E-05
m+p Xylene	0.043	1.18E-03	2.75E-03	6.48E-04	4.21E-04	1.50E-04

NOTES:

lwa Lifetime weighted average
CDI Chronic Daily Intake
H-CDI Noncarcinogenic hazard based Chronic Daily Intake
C-CDI Carcinogenic risk based Chronic Daily Intake

Table 10.4.41
Toxicological Database Information
for Chemicals of Potential Concern
SWMU 39
NAVBASE Charleston, Zone A

Non-Carcinogenic Toxicity Data

Chemical	Oral Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Inhalation
Aluminum	1	d				ND				
Arsenic	0.0003	a	M	hyperpigmentation	3	ND				
Benzo(a)pyrene Equivalents	ND					ND				
Barium	0.07	a	M	Increased blood pressure	3	ND				
Benzene	ND					0.00171	d			
Beryllium	0.005	a	L	microscopic organ changes	100	ND				
Chromium (trivalent)	1	a	L	No observable effects	100	ND				
Chromium (hexavalent)	0.005	a	L	No observable effects	500	ND				
1,1-Dichloroethene	0.009	a	M	liver lesions	1000	ND				
cis-1,2-Dichloroethene	0.01	b				ND				
Dioxin equivalents	ND					ND				
Ethylbenzene	0.1	a	L	Liver and kidney toxicity	1000	0.286	c	L	Developmental toxicity	300
bis(2-Ethylhexyl)phthalate	0.02	a	M	Increased relative liver weight	1000	ND				
Lead	ND					ND				
Manganese (food)	0.047	a		neurological effects	1	ND				
Manganese (water)	0.023	a		neurological effects	1	1.43E-05	a	M	neurological effects	1000
Mercury	0.0003	b		Autoimune effects	30	8.6E-05	c	NA		
2-Methylnaphthalene	0.04	e								
Naphthalene	0.04	f								
PCB Aroclor-1260	ND					ND				
Tetrachloroethene	0.01	a	M	Hepatotoxicity	1000	ND				
Thallium	8E-05	a	L	Increased SGOT	3000	ND				
Trichloroethene	0.006	d				ND				
Vanadium	0.007	a		unclear	100	ND				
Vinyl chloride	ND					ND				
m&p-Xylene	2	a	M	Hyperactivity and decreased body weight	100	ND				

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
e Withdrawn from IRIS or HEAST
g RfD for naphthalene cross assigned to 2-methylnaphthalene
ND Not determined due to lack of information

Table 10.4.41 (continued)
Toxicological Database Information
for Chemicals of Potential Concern
SWMU 39
NAVBASE Charleston, Zone

Carcinogenic Toxicity Data

Chemical	Oral Slope Factor [(mg/kg/day)]-1		Inhalation Slope Factor [(mg/kg/day)]-1		Weight of Evidence	Tumor Type
Aluminum	ND		ND		D	
Arsenic	1.5	a	15.1	a	A	various
Benzo(a)pyrene Equivalents	7.3	a	ND		B2	mutagen
Barium	ND		ND			
Benzene	0.029	a	0.029	b	A	Leukemia
Beryllium	4.3	a	8.4	a	B2	osteosarcoma
Chromium (trivalent)	ND		ND			
Chromium (hexavalent)	ND		41	b	A	Lung cancer
1,1-Dichloroethene	0.6	a	0.175	a	C	kidney adenosarcoma
cis-1,2-Dichloroethene	ND		ND			
Dioxin equivalents	150000	b	150000	b	B2	respiratory system and liver tumors
Ethylbenzene	ND		ND			
bis(2-Ethylhexyl)phthalate	0.014	a	ND		B2	Hepatocellular carcinomas and adenomas
Lead	ND		ND			
Manganese (food)	ND		ND		D	
Manganese (water)	ND		ND		D	
Mercury	ND		ND			
2-Methylnaphthalene	ND		ND			
Naphthalene	ND		ND			
PCB Aroclor-1260	2	a	ND		B2	hepatocellular carcinoma
Tetrachloroethene	0.052	d	0.00203	d	B2	hepatotoxicity
Thallium	ND		ND			
Trichloroethene	ND		0.006	d	B2	forestomach tumors in mice
Vanadium	ND		ND		D	
Vinyl chloride	1.9	b	0.3	b	A	Lung and liver tumors
m&p-Xylene	ND		ND		D	

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
ND Not determined due to lack of information

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Aluminum is one of the most abundant metals in the earth's crust (7% aluminum), and it is ubiquitous in air and water, as well as soil. This metal is water-soluble, silvery, and ductile, which suggests its usefulness in many processes. Ingesting aluminum can affect the absorption of other elements within the gastrointestinal tract and can alter intestinal function. Aluminum can potentially interfere with the absorption of essential nutrients and cholesterol. Another effect on the gastrointestinal system is the inhibition of acetylcholine-induced contractions, which are part of the neuromuscular system controlling bowel muscles. The effect could explain why aluminum-containing antacids often produce constipation. Aluminum dust is moderately flammable and explosive in heat. Inhaling this dust can cause fibrosis (aluminosis) (Klaassen, et al., 1986) (Dreisbach, et al., 1987). No data are available on an applicable SF or the USEPA cancer group. The USEPA Region IV Office of Health Assessment suggested using the provisional oral RfD of 1.0 mg/kg-day. The aesthetic-based SMCL for drinking water is 50 to 200 μg/L (USEPA, Office of Water).

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen, et al., 1986). USEPA set 0.3 μg/kg-day as the RfD for arsenic based on a NOAEL of 0.8 μg/kg-day in a human exposure study. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher levels. Exposure to arsenic-containing materials has been shown to cause cancer in humans. Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the 1.5 $(\text{mg/kg-day})^{-1}$ SF for arsenic. As listed in IRIS, the basis for the classification is sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic

arsenic. Human milk contains about 3 μg/L arsenic. The RBC for arsenic in tap water is 0.038 μg/L. As listed in IRIS, the critical effect of this chemical is hyperpigmentation, keratosis, and possible vascular complications. The uncertainty factor was determined to be 3 and the modifying factor was determined to be 1.

Barium is used in various alloys, paints, soap, and manufacture processes. Barium sulfate is used to aid x-ray diagnosis. This element is relatively abundant in nature and is found in plant and animal tissue. Brazil nuts contain 3 to 4 mg per gram nuts. The fatal absorbed dose of barium is approximately 1000 mg (for humans). Assuming an absorption efficiency of five percent for barium, 20,000 mg ingested barium could be fatal. Major toxic effects of this element are muscle stimulation, central nervous system effects, and effects on the heart. The major critical effect is increased blood pressure. USEPA determined the oral RfD and inhalation RfD to be 0.07 and 1.43E-4 mg/kg-day, respectively (Dreisbach, et al, 1987) (Klaassen, et al, 1986), based on a medium confidence level. The oral uncertainty factor for barium is 3 and the oral modifying factor is 1. Barium has been issued a carcinogenic weight-of-evidence classification of "D".

Benzene is a volatile organic chemical which has been associated with leukemia. This chemical has been used as a solvent in coal tar naphtha, rubber, and plastic cement. USEPA lists benzene as a group A carcinogen. In large doses, benzene depresses the central nervous system, and chronic exposure depresses bone marrow. The oral SF for benzene was set by USEPA as 2.9E-2 $(mg/kg\text{-}day)^{-1}$, and an oral RfD has not been set. Occupational inhalation exposure to benzene is acceptable by OSHA at levels of 3.25 mg/m^3 or 1 ppm in air (Dreisbach, et al, 1987) (NIOSH, 1990).

Benzo(a)pyrene equivalents include the following list of polynuclear aromatic hydrocarbons:

Benzo(a)anthracene	TEF	0.1
Benzo(b)fluoranthene	TEF	0.1
Dibenz(a,h)anthracene	TEF	1.0
Benzo(k)fluoranthene	TEF	0.01
Benzo(a)pyrene	TEF	1.0
Indeno(1,2,3-cd)pyrene	TEF	0.1
Chrysene	TEF	0.001

Some PAHs are toxic to the liver, kidney, and blood. However, the toxic effects of the PAHs above have not been well established. There are no RfDs for the PAHs above due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of benzo(a)pyrene, having an oral SF 7.3 $(mg/kg\text{-}day)^{-1}$. Toxicity Equivalency Factors, also set by USEPA, are multipliers that are applied to the detected concentrations, which are subsequently used to calculate excess cancer risk. These multipliers are discussed further in the exposure and toxicity assessment sections. Most carcinogenic PAHs have been classified as carcinogenic due to animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke). As listed in IRIS, the basis for the benzo(a)pyrene B2 classification is human data specifically linking benzo(a)pyrene to a carcinogenic effect are lacking. There are, however, multiple animal studies in many species demonstrating benzo(a)pyrene to be carcinogenic by numerous routes.

Benzo(a)pyrene has produced positive results in numerous genotoxicity assays. At the June 1992 Carcinogen Risk Assessment Verification Endeavor (CRAVE) Work Group meeting, a revised

risk estimate for benzo(a)pyrene was verified (see Additional Comments for Oral Exposure). This section provides information on two aspects of the carcinogenic risk assessment for the agent in question: the USEPA classification and quantitative estimates of exposure. The classification reflects a weight-of-evidence judgment of the likelihood that the agent is a human carcinogen. The quantitative risk estimates are presented in application of a low-dose extrapolation procedure and presented as the risk per (mg/kg)-day. The unit risk is the quantitative estimate in terms of either risk per μg/L drinking water or risk per $\mu g/m^3$ air breathed. The third form in which risk is presented is drinking water or air concentration providing cancer risks of 1 in 10,000 or 1 in 1,000,000. The Carcinogenicity Background Document provides details on the carcinogenicity values found in IRIS. Users are referred to the Oral Reference Dose and Reference Concentration sections for information on long-term toxic effects other than carcinogenicity.

As listed in IRIS, the basis for the dibenz(a,h)anthracene and benzo(b)fluoranthene B2 classification is no human data and sufficient data from animal bioassays. Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal or subcutaneous injection, and skin painting. As listed in IRIS, the basis for the benzo(a)anthracene B2 classification is no human data and sufficient data from animal bioassays. Benzo(a)anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous or intramuscular injection; and topical application. Benzo(a)anthracene produced mutations in bacteria and in mammalian cells, and transformed mammalian cells in culture. As listed in IRIS the basis for the benzo(k)fluoranthene B2 classification is no human data and sufficient data from animal bioassays. Benzo(k)fluoranthene produced tumors after lung implantation in mice and when administered with a promoting agent in skin-painting studies. Equivocal results have been found in a lung adenoma assay in mice. Benzo(k)fluoranthene is mutagenic in bacteria. (Klaassen, et al., 1986).

Other PAHs — those not classified by USEPA as carcinogens — are toxic to the liver, kidney and blood. This group of PAHs includes compounds such as *pyrene*, *acenaphthene, acenaphthylene*,

benzo(g,h,i)perylene, and *phenanthrene*. USEPA determined RfDs for only two of these compounds: pyrene's RfD_o of 0.03 mg/kg-day is also used as a surrogate RfD_o for phenanthrene. The RfD_o for acenaphthene was 0.06 mg/kg-day.

Beryllium exposure via the inhalation route can cause inflammation of the lungs, a condition known as acute beryllium disease, as a result of short-term exposure to high concentrations. Removal from exposure results in a reversal of the symptoms. Chronic exposure to much lower levels of beryllium or beryllium oxide by inhalation has been reported to cause chronic beryllium disease, with symptoms including shortness of breath, scarring of the lungs, and berylliosis, which is noncancerous growths in the human lungs. Both forms of beryllium disease can be fatal, depending on the severity of the exposure. Additionally, a skin allergy may develop when soluble beryllium compounds contact the skin of sensitized individuals. An oral RfD of 0.0054 mg/kg-day has been set for beryllium, based on a chronic oral bioassay (rats were the study species) which determined that no adverse effect occurs at 0.54 mg/kg-day. Beryllium has been classified by USEPA as a group B2 carcinogen based on animal studies. It has been shown to induce lung cancer via inhalation in rats and monkeys, and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. Human epidemiology studies of beryllium are considered to be inadequate. As listed in IRIS, the basis for the classification is that beryllium has been shown to induce lung cancer via inhalation in rats and monkeys and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. Human epidemiology studies are considered inadequate. An inhalation slope factor of 8.4 $(mg/kg\text{-}day)^{-1}$ and an oral SF of 4.3 $(mg/kg\text{-}day)^{-1}$ have been set by USEPA. As listed in IRIS, the critical effect of this chemical is no adverse effect. The uncertainty factor was 100 and the modifying factor was 1. The IRIS RfD in drinking water is 0.005 mg/kg-day.

1,1-Dichloroethene is a volatile organic compound, primarily toxic to the liver, central nervous system, and kidneys. The mucous membrane, skin, lung, and cornea (irritation) are also affected.

1,1-Dichloroethene is more toxic than 1,2-Dichloroethene; this chlorinated compound is a USEPA group C carcinogen. The RfD_o is 0.009 mg/kg-day, and the SF_o and SF_i are 0.6 and 0.175 $(mg/kg\text{-}day)^{-1}$, respectively (Dreisbach, et al., 1987).

1,2-Dichloroethane is used as a solvent in the rubber, plastic, and insecticide industries. This compound is also used as a gasoline additive and in some rubber and plastic cements used in various hobbies. Municipal water supplies commonly detect dichloroethane as a contaminant if the municipal water treatment facility uses chlorine in its water purification processes. Detected concentrations range from 0.2 to 6 μg/l (Klaasen, et al, 1986), and the MCL is 5 μg/l . The fatal adult dose is approximately 5 ml of 1,2-dichloroethane, and the time weighted average exposure limit is 1 ppm for inhalation exposure. The inhalation exposure limit is below the odor threshold, 3 ppm.

Fatty liver, liver cell damage, and kidney damage are the primary non-cancer toxic effects caused by dichloroethane. Because this compound is chemically transformed into a toxic metabolite by enzymes in the liver (biotransformation); toxic effects can be greatly enhanced (synergism) when the liver's enzymes are induced. Enzyme inducers such as ketones and alcohols can lead to synergistic toxic effects. An additional, secondary effect evident in canine studies is the clouding of corneal eye tissue. This effect was indirect, apparently occurring following biotransformation by liver enzymes, and was not caused by direct eye exposure to dichloroethane. USEPA determined the inhalation reference dose to be 0.00286 mg/kg-day. No reference dose is currently available for the ingestion exposure pathway.

This compound can react with DNA, which indicates a potential to cause cancer. Studies indicate this compound is a carcinogen if ingested (Klaasen, et al), but the reference data do not indicate inhaling this compound would cause cancer. USEPA has classified dichloroethane as a B2 carcinogen and determined the slope factor to be 0.091 $(mg/kg\text{-}day)^{-1}$ for both ingestion and

inhalation exposure. As listed in IRIS, the basis for the classification is the induction of several tumor types in rats and mice treated by gavage and lung papillomas in mice after topical application.

cis-1,2-Dichloroethene is a halogenated hydrocarbon associated with toxicity to the mucous membrane, skin, lung, cornea (irritation), and liver. There is no USEPA carcinogenicity listing for this compound. However, the RfDo has been set to 0.01 mg/kg-day by USEPA. The critical effect of this chemical is decreased hemoglobin. The uncertainty factor was determined to be 3000.

Chlorinated Dibenzodioxin/Dibenzofurans are a general grouping of many congeners or chemicals within the same chemical family. This family of chemicals is considered a byproduct the combustion process, especially if certain precursor compounds (e.g. PCBs, chlorinated benzenes). Chlorinated dibenzodioxin/dibenzofurans are potent carcinogens that target the liver. Because of their persistence in the environment, dioxin compounds, have accumulated in soil and sediment, and have moved up the food chain. It has been determined that only certain congeners are capable of producing the most severe toxic effects associated with exposure to dioxin. The toxicity of this subset of chlorinated dibenzodioxins/dibenzofurans is measured relative to the 2,3,7,8-tetrachlorodibenzodioxin congener (2,3,7,8-TCDD). In order to simplify the estimation of risk due to exposure to dioxin, the concentration of each toxic congener is adjusted by multiplying by its toxic equivalency factor (TEF). The following is a list of 2,3,7,8-TCDD congeners and TEFs:

2,3,7,8-TCDD	1.0
2,3,7,8-PeCDD	0.5
2,3,7,8-HxCDD	0.1
2,3,7,8-HpCDD	0.01

OCDD	0.001
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.05
2,3,4,7,8-PeCDF	0.5
2,3,7,8-HxCDF	0.1
2,3,7,8-HpCDF	0.01
OCDF	0.001

The numbers 2,3,7,8 correspond to the positioning of chlorine atoms on the molecular structure while the T, Pe, Hx, Hp, and O stand for the total number (4, 5, 6, 7, and 8, respectively) of chlorine atoms in the molecular structure. The result of this procedure provides one concentration representative of all toxic dioxin congeners for each sample, which is compared to toxicity criteria for 2,3,7,8-tetrachlorodibenzodioxin. HEAST lists an oral slope factor of 156,000 $(mg/kg\text{-}day)^{-1}$ and an inhalation slope factor of 116,000 $(mg/kg\text{-}day)^{-1}$.

Chlorobenzene is a volatile organic that has been shown to cause histopathologic changes in the liver when ingested. Chlorobenzene has also been shown to cause irritation to the mucous membrane, skin, cornea, and lungs; it has also been shown to cause kidney damage and central nervous system effects. USEPA set the oral RfD and inhalation RfD to 0.02 and 0.00571 mg/kg-day, respectively, with an uncertainty factor of 1,000 (Dreisbach et al., 1987). Chlorobenzene has been classified as group "D" by USEPA's weight-of-evidence classification (IRIS).

Chloroform, a halogenated hydrocarbon, has been used as a fumigant and an additive to suppress the fire hazard of carbon disulfide, as well as having a low capacity for insect control. Volatile and gaseous anesthetics such as chloroform are sometimes used to produce general anesthesia. This contaminant is the primary chlorinated hydrocarbon produced during chlorination of drinking

water, and is commonly present at low concentrations in most drinking water supplies. This compound depresses all CNS function in descending order from the cortex to the medulla. Additional target organs include the liver, heart, and kidney. Chloroform exposure to the heart sensitizes the muscle to arrhythmias, as do many halogenated hydrocarbons. This action could interfere with digitalis glycosides or a pacemaker in the form of premature or uncontrolled beats. Chloroform is a class B2 carcinogen, and USEPA set the oral SF and inhalation SF to 0.0061 and 0.0805 $(mg/kg\text{-}day)^{-1}$, respectively. The oral RfD is 0.01 mg/kg-day (Dreisbach et al., 1987).

Chloromethane is a clear, colorless gas that has a faintly sweet, nonirritating odor at high levels in the air. A naturally occurring chemical, it is made in large amounts in the oceans and is produced by some plants and rotting wood and when such materials as grass, wood, charcoal, and coal burn. Chloromethane is also produced industrially, but most of it is destroyed during use. It is used mainly in the production of other chemicals such as silicones (72%), agricultural chemicals (8%), quaternary mines, and butyl rubber.

Case reports of humans exposed acutely to high concentrations of chloromethane have described severe neurological effects, sometimes followed by death. Effects on the cardiovascular system, liver, and kidney have also been described in the case reports of humans exposed for brief periods or for more prolonged periods occupationally (Gummart, 1961; McNally, 1946; Spevak et al., 1976). Numerous acute inhalation studies have identified the liver and kidney as target organs in rats and mice, the spleen in mice and dogs, and the testes and epididymides as target organs in rats. These studies have shown that species differences in susceptibility exist and that generally animals are more susceptible to relatively low exposures given continuously than to relatively high exposures given intermittently (ATSDR, 1990). USEPA has ranked chloromethane as a group C carcinogen (USEPA, 1993). Chloromethane has an oral SF as well as an inhalation SF that are 1.3E-02 and 6.3E-03, respectively (HEAST, 1996).

Chromium exists in two stable, natural forms: trivalent (CrIII) and hexavalent (CrVI). Acute exposure to chromium can result in kidney damage following oral exposure or damage to the nasal mucosa and septum following inhalation exposure. Chronic inhalation exposure to hexavalent chromium has resulted in kidney and respiratory tract damage, as well as excess lung cancer in both animals and humans following occupational exposure. Only hexavalent chromium is believed to be carcinogenic by inhalation (IRIS). Oral RfD values for trivalent and hexavalent forms of chromium are 1.0 and 5E-3 (mg/kg-day), respectively. For trivalent chromium, the RfD is based on liver toxicity in the rat. For the hexavalent form, the RfD is based on unspecified pathological changes observed in rat studies. In addition, hexavalent chromium is considered a group A carcinogen for inhalation exposures, and an oral SF of 42 $(mg/kg\text{-}day)^{-1}$ has been established for the hexavalent form. Vitamin supplements contain approximately 0.025 mg of chromium. As listed in IRIS, no critical effects were observed for chromium (III). The uncertainty factor was 100 and the modifying factor was 10. As listed in IRIS, no critical effects were observed for chromium (VI). The uncertainty factor was 500 and the modifying factor was 1.

Ethylbenzene is used as a solvent and is a petroleum fuel constituent. Chronic exposure to ethyl benzene can cause dizziness, weight loss, weakness and/or numbness in the limbs, anemia, and nervousness, and the target organ is the central nervous system. As listed in IRIS, the basis for the D classification is nonclassifiable due to lack of animal bioassays and human studies. This compound is a volatile organic, and USEPA determined the RfDo to be 0.1 mg/kg-day, and the RfDi was set to 0.286 mg/kg-day. As listed in IRIS, the critical effect of this chemical is liver and kidney toxicity. The uncertainty factor was determined to be 1000 and the modifying factor was determined to be 1. (Dreisbach, et al, 1987).

bis(2-Ethylhexyl)phthalate, otherwise known as BEHP, is a plasticizer used in virtually every major product category. Phthalate esters are ubiquitously distributed in the environment. Although the toxicity of this compound is relatively low, it is a carcinogen. Reproductive effects

are also possible (indicated in animal studies) due to chronic exposure to BEHP. This compound is classified as a B2 carcinogen, and USEPA set the RfDo and SFo to 0.02 mg/kg-day and 0.014 $(mg/kg\text{-}day)^{-1}$, respectively (Klaassen, et al, 1986).

Lead has been classified as a group B2 carcinogen by USEPA based on animal data. No RfD or SF has been set by USEPA. However, an action level for soil protective of child residents has been proposed by USEPA Region IV: 400 mg/kg. USEPA's OSWER has recommended a 1,000 mg/kg cleanup standard for industrial properties. USEPA's Office of Water has established a treatment technique action level of 15 μg/L. As listed in IRIS, the classification is base on sufficient animal evidence. Ten rat bioassays and one mouse assay have shown statistically significant increases in renal tumors with dietary and subcutaneous exposure to several soluble lead salts. Animal assays provide reproducible results in several laboratories, in multiple rat strains with some evidence of multiple tumor sites. Short-term studies show that lead affects gene expression. Human evidence is inadequate. An RfD and SF have not been set because of the confounding nature of lead toxicity. Lead can accumulate in bone marrow, and effects have been observed in the CNS, blood, and mental development of children. RfDs are based on the assumption that a threshold must be exceeded to result in toxic effects (other than carcinogenicity). Once lead accumulates in the body, other influences cause the actual levels in the blood to fluctuate - sometimes the lead is attached to binding sites; sometimes lead is free flowing. If an exposed individual has previously been exposed to lead, this individual could lose weight and set fat-bound lead free. This fluctuation and lack of previous lead exposure data are two of the reasons lead effects are difficult to predict (Klaassen et al., 1986).

Manganese is an essential nutrient. Chronic exposure to manganese, 0.8 mg/kg-day, causes mental disturbances and various central nervous system effects. Studies have shown that manganese uptake from water is greater than manganese uptake from food, and the elderly appear to be more sensitive than children. The oral RfD is 0.14 mg/kg-day with uncertainty and

modifying factors of 1. When assessing the potential for adverse health effects from nondietary intakes (ingestion of soil or drinking water) of manganese, a modifying factor of 3 is used which gives an oral RfD of 0.047 mg/kg-day. An additional consideration for increased uptake of manganese in infants and fasted individuals further reduces the oral RfD for water ingestion to 0.023 mg/kg-day. Inhalation of manganese dust causes neurological effects and increased incidence of pneumonia, and an inhalation RfD was set to 0.0000143 mg/kg-day. According to USEPA, manganese can not be classified as to its carcinogenicity. Therefore, the cancer class for manganese is group D. The typical vitamin supplement dose of manganese is 2.5 mg/day (Klaassen, et al, 1986) (Dreisbach, et al, 1987).

Mercury The major source of this element is the degassing of the earth's crust. Target organs of mercury include the kidney, nervous system, fetus, and neonate. In other words, this can be toxic to a fetus if the mother is exposed during pregnancy. Mercury is toxic to all cells in the body- it binds to enzymes in the cells and disrupts their function, usually causing the cell to be useless or die. Because this inorganic is concentrated in the kidney prior to excretion, the kidney is a major target organ for mercury ingestion. The primary target of mercury vapor is the brain. Some forms of mercury are drawn towards fats in the body (such as the nervous system), where it is changed into its toxic form. This causes the nervous disorder known as Minimata disease, which results from overexposure to mercury through ingestion of contaminated fish. USEPA set mercury's RfD to 0.0003 mg/kg-day (inorganic form). Mercury is liquid at room temperature, and is poorly absorbed in this form if ingested. Typical daily exposure is less than 1 μg/l-day (Klaassen, et al, 1986) (Dreisbach, et al, 1987).

4-Methylphenol is also known as p-cresol. Effects associated with acute exposure to cresols in humans include irritation and burning of skin, eyes, mouth, and throat, abdominal pain and vomiting, hemolytic anemia, kidney damage, facial paralysis, coma, and death. Exposure levels associated with human deaths have not been reliably reported, however, crude estimates based on

accidental or intentional ingestion of cresol, the lethal oral exposure level for humans appeared to be at or above 2 g/kg (Chan et al., 1971). Autopsies of people who died following cresol exposure revealed gross lesions in the lungs, pancreas, liver, and kidneys, although these data cannot be considered reliable indicators of target organ effects. Studies in animals have shown that cresols can be lethal when exposure is through the inhalation, oral, or dermal routes. 4-Methylphenol is classified "C" in USEPA's weight of evidence. An oral RfD of 5.0E-03 mg/kg-day has been issued for 4-methylphenol (HEAST, 1996).

Naphthalene, is obtained from coal tar and is used as moth repellant and as a synthetic intermediate. The primary effect of naphthalene is on the kidneys due to this compound's effect on the blood. Naphthalene was determined to be a USEPA class D carcinogen (i.e., is not classified due to insufficient data). As listed in IRIS, the basis for the classification is no human data and inadequate data from animal bioassays. Subsequent to the verification of this cancer assessment in 1990, the National Toxicology Program completed a two-year cancer bioassay (1991); its results suggest that naphthalene may be more appropriately classified as a possible human carcinogen (Group C under current EPA guidelines). The NTP concluded, "Under the conditions of these 2-year studies, there are no evidence of carcinogenic activity of naphthalene in male B6C3F1 mice exposed by inhalation to concentrations of 10 or 30 ppm for 6 hours daily, 5 days per week, for 103 weeks. There was some evidence of carcinogenic activity of naphthalene in female B6C3F1 mice, as indicated by the increased incidences of pulmonary alveolar/bronchiolar adenomas." USEPA determined the RfDo to be 0.04 mg/kg-day, which was withdrawn from IRIS/HEAST (Dreisbach, et al, 1987). Toxicological data for naphthalene was used as surrogate information for ***2-methylnaphthalene***.

PCB Aroclors are a group of chlorinated hydrocarbons (such as Aroclor-1260) that accumulate in fat tissue. Occupational exposure (both inhalation and dermal) to PCBs causes eye and lung irritation, loss of appetite, liver enlargement, increased serum liver enzyme levels, rashes and

chloracne, and decreased birth weight of infants in heavily exposed worker/mothers. Of the effects listed above, the liver is the primary target organ (Klaassen, et al, 1986) (Dreisbach, et al, 1987). USEPA classified PCB aroclors as group B2 probable human carcinogens, primarily based on animal data. Oral ingestion of PCBs causes liver and stomach tumors in rat studies. The cancer potency of PCB mixtures is determined using a tiered approach. The high risk and persistence tier uses an upper-bound slope factor of 2.0 $(mg/kg\text{-}day)^{-1}$ and is appropriate for food chain exposures, sediment and soil ingestion, dust or aerosol inhalation, and dermal exposure. The low risk and persistence tier uses an upper-bound slope factor of 0.4 $(mg/kg\text{-}day)^{-1}$ and is appropriate for ingestion of water soluble congeners and inhalation of evaporated congeners. The lowest risk and persistence tier uses an upper-bound slope factor of 0.07 $(mg/kf\text{-}day)^{-1}$ and is appropriate for PCB congener mixtures with congeners having more than four chlorines comprising less than 1/2% of the mixture.

1,1,2,2-Tetrachloroethane is volatile organic compound used in industry and is a contaminant in many other solvents. The target organs of this solvent are the central nervous system, the liver, and the kidneys. Chronic exposure causes congestion of the target organs, intoxication, tremors, and the alteration of nerve functions. The effect on the liver can lead to jaundice. Acute exposure to this compound causes long-lasting narcosis with delayed onset. Additional effects are irritation of the mucous membranes, nausea, and headaches which can progress to coma. Simultaneous exposure to alcohols or ketones can exacerbate the toxic effects of this compound. The exposure limit for inhalation is 1 ppm. In addition to the noncarcinogenic effects of tetrachloroethane, it is listed as a class A-B carcinogen by USEPA. As listed in IRIS, the basis for the C classification is increased incidence of hepatocellular carcinomas in mice. The USEPA set the SF_o and SF_i to 0.2 and 0.203 $(mg/kg\text{-}day)^{-1}$, respectively (Dreisbach, et al., 1987).

Tetrachloroethene (PCE) has been used as a solvent in industry and occurs as a volatile contaminant in other chlorinated hydrocarbons. Tetrachloroethene exposure can result in

long-lasting narcosis with delayed onset and damage to the liver and kidneys. The principal manifestations of over-exposure to this halogenated hydrocarbon are jaundice and oliguria, and irritation of the eyes and nose, followed by headaches, nausea and coma. Cyanosis and central nervous system depression progressing to coma appear one to four hours after the short-term exposure. Liver and kidney damage after apparent recovery or after repeated exposures causes acute symptoms such as nausea, vomiting, abdominal pain, jaundice, oliguria and uremia. PCE exposure via the inhalation and/or skin absorption exposure pathways could result in headaches, tremor, dizziness, peripheral paresthesia, hypesthesia, or anesthesia. PCE is a carcinogen, but is currently under review by USEPA; it is currently classified as a B2-C carcinogen. The RfD_o has been set to 0.01 mg/kg-day, and the SF_o and SF_i have been set to 0.052 and 0.00203 $(mg/kg\text{-}day)^{-1}$, respectively, by USEPA. As listed in IRIS, the critical effect of this chemical is hepatotoxicity in mice, weight gain in rats. The uncertainty factor was determined to be 1000 and the modifying factor was determined to be 1. (Dreisbach, et al., 1987).

Thallium is readily absorbed through the gut and skin. Primary effects are stomach and bowel disturbances, kidney and liver damage, and neurological disturbances. Thallium was used in the past as a rodenticide and ant killer, and its use for these purposes is now prohibited. This element remains in the body for a relatively long time, and could accumulate if the chronic dose is large. USEPA's oral RfD for thallium is 0.00008 mg/kg-day (Klaassen, et al, 1986) (Dreisbach, et al, 1987).

Trichloroethene (TCE) is a mobile, volatile liquid which has the characteristic odor of chloroform. Inhalation, intravenous and subcutaneous routes are all viable exposure pathways for this compound. TCE is a strong skin and eye irritant that is relatively less toxic if ingested. Inhalation of high concentrations causes narcosis and anesthesia. This compound targets the liver and other organs. TCE is a B2 carcinogen, and the Sf_o and SF_i have been set by USEPA to 0.011

and 0.006 (mg/kg-day)$^{-1}$, respectively. USEPA also set the RfDo to 0.006 mg/kg-day (Dreisbach, et al., 1987).

Vanadium is not readily absorbed through the skin or oral ingestion and is a ubiquitous element. It is also a by-product of petroleum refining. Vanadium is soluble in fats and oils (Klaassen et al., 1986). Municipal water supplies contain 0.001 to 0.006 mg/L. The target organ is unclear, and the primary focus of toxicological information is inhalation of vanadium dust. Typical vitamin supplements contain approximately 0.010 mg in a daily dose. The oral RfD set by USEPA is 0.007 mg/kg-day.

Vinyl chloride is a volatile organic that can cause Raynaud's Phenomenon or white finger disease. It has been shown to cause angiosarcoma, a cancer. It has been also been associated with reproductive dysfunction in men and women. The primary target organs for non-carcinogenic effects are the liver, kidney, and nervous system. This compound inhibits one of the main metabolic pathways of the body (a group of enzymes), and can influence the toxicity of other compounds because of this effect. Due to the carcinogenicity of this compound, USEPA classified vinyl chloride as a class A carcinogen and set the SFi and SFo to 0.3 and 1.9 (mg/kg-day)$^{-1}$, respectively (Klaassen, et al, 1986) (Dreisbach, et al, 1987).

m&p-Xylene is widely used in industry and consumer products. This volatile organic compound is used as a building block for other solvents, plastics, and pharmaceuticals. Xylene is also used as a base for various pesticides, and is commonly found in paint, paint remover, nail polish, air fresheners, degreasing cleaners, lacquers, glues, and pens. Xylene targets the respiratory tract and the central nervous system, and the effects can be enhanced by the ingestion of ethyl alcohol. Xylene has not been determined to be a carcinogen by USEPA, having a USEPA Classification of D. The critical effect of xylene in study organisms is hyperactivity, decreased body weight, and increased mortality. USEPA determined the oral RfD to be 2 mg/kg-day. As listed in IRIS,

the uncertainty factor was determined to be 100 and the modifying factor was determined to be 1. (Harte, et al, 1991).

10.4.13.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under both residential and industrial (site worker) scenarios. For these scenarios, the incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.4.42 and 10.4.43 present the computed carcinogenic risks and/or HQs associated with the incidental ingestion of and dermal contact with site surface soils, respectively.

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime weighted average) for SWMU 39 surface soils is 3E-5. The dermal pathway ILCR is 9E-6. Arsenic, benzo(a)pyrene equivalents, and beryllium were the primary contributors for the ingestion pathway, and arsenic and benzo(a)pyrene equivalents were the primary contributors to the dermal pathway.

The computed hazard index for the adult and child resident were 0.06 and 0.5 respectively for the soil ingestion pathway. The computed hazard index for the adult and child dermal contact pathways were 0.01 and 0.04, respectively.

Hypothetical Site Workers

Site worker ILCR is 4E-6 for both the ingestion and dermal contact pathways. Arsenic and benzo(a)pyrene equivalents were the primary contributors for the ingestion pathway and benzo(a)pyrene equivalents were the primary contributors to the dermal pathway. Hazard indices for the ingestion and dermal pathways were 0.007 and 0.008, respectively.

Table 10.4.42
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Current Worker adult Hazard Quotient	Current Worker adult ILCR
Aluminum	1	NA	0.014	0.13	ND	0.0018	ND
Aroclor 1260	NA	2	ND	ND	5.3E-07	ND	5.9E-08
Arsenic	0.0003	1.5	0.032	0.29	1.6E-05	0.0040	1.8E-06
Benzo(a)pyrene equivalent	NA	7.3	ND	ND	1.4E-05	ND	1.6E-06
Beryllium	0.005	4.3	0.000048	0.00044	1.2E-06	0.0000061	1.3E-07
Manganese	0.047	NA	0.0031	0.029	ND	0.00039	ND
Mercury	0.0003	NA	0.0064	0.060	ND	0.00082	ND
SUM Hazard Index/ILCR			0.06	0.5	3E-05	0.007	4E-06

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk

Table 10.4.43
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Current Worker adult Hazard Quotient	Current Worker adult ILCR
Aluminum	0.2	0.2	NA	0.0029	0.0094	ND	0.0020	ND
Aroclor 1260	0.5	NA	4	ND	ND	2.4E-07	ND	9.6E-08
Arsenic	0.2	6E-05	7.5	0.0065	0.021	1.8E-06	0.0046	7.4E-07
Benzo(a)pyrene equivalent	0.5	NA	14.6	ND	ND	6.5E-06	ND	2.7E-06
Beryllium	0.2	0.001	21.5	0.000010	0.000032	1.3E-07	0.0000070	5.3E-08
Manganese	0.2	0.0094	NA	0.00063	0.0021	ND	0.00045	ND
Mercury	0.2	6E-05	NA	0.0013	0.0043	ND	0.00094	ND
SUM Hazard Index/ILCR				0.01	0.04	9E-06	0.008	4E-06

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk
- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

Groundwater Pathways

Exposure to shallow groundwater onsite was evaluated under both residential and industrial scenarios. The groundwater exposure pathways were evaluated assuming that site groundwater will be used for potable and/or domestic purposes and that an unfiltered well, drawing from the corresponding water bearing zone, will be installed. For noncarcinogenic contaminants evaluated relative to future site residents, hazard was computed separately for child and adult receptors. Tables 10.4.44 and 10.4.45 present the risk and hazard for the exposure pathways.

Hypothetical Site Residents

For the ingestion and inhalation pathway, the lifetime weighted average ILCRs were computed to be 1E-3 and 1E-4, respectively. For the ingestion pathway the primary contributors were arsenic, benzene, beryllium, 1,1-dichloroethene, tetrachloroethene, and vinyl chloride, with secondary contribution from 1,2-dichloroethane, dioxin equivalents, bis(2-ethylhexyl)phthalate, and 1,1,2,2-tetrachloroethane. For the inhalation pathway, the primary contributors are benzene, chloroform, 1,2-dichloroethane, 1,1-dichloroethene, 1,1,2,2-tetrachloroethane, and vinyl chloride.

Hazard indices for the adult and child resident are 10 and 23, respectively, for the ingestion pathway and 3 and 6, respectively, for the inhalation pathway. The primary contributors to the ingestion pathway are arsenic, benzene, manganese, and thallium. The primary contributors to the inhalation pathway include benzene, cis-1,2-dichloroethene, and 1,2-dichloroethene (total).

Hypothetical Site Workers

For the ingestion pathway, the ILCR was computed to be 3E-04. The primary contributors to the ingestion pathway include arsenic and vinyl chloride with secondary contribution from benzene, beryllium, 1,1-dichloroethene, 1,1,2,2-tetrachloroethane, and tetrachloroethene. The inhalation pathway ILCR was computed to be 2E-05 with contribution primarily from benzene, chloroform, 1,1-dichloroethene, 1,1,2,2-tetrachloroethane, and vinyl chloride.

Table 10.4.44
Hazard Quotients and Incremental Lifetime Cancer Risks
Groundwater Ingestion
SWMU 39
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Future Worker adult Hazard Quotient	Future Worker adult ILCR
Aluminum (Al)	1	NA	0.031	0.072	ND	0.011	ND
Arsenic (As)	0.0003	1.5	4.0	9.2	9.8E-04	1.4	2.3E-04
Barium (Ba)	0.07	NA	0.027	0.063	ND	0.0096	ND
Benzene	0.003	0.029	0.94	2.2	4.5E-05	0.34	1.0E-05
Beryllium (Be)	0.005	4.3	0.0014	0.0033	1.7E-05	0.00050	3.9E-06
Chlorobenzene	0.02	NA	0.0043	0.010	ND	0.0015	ND
Chloroform	0.01	0.0061	0.0099	0.023	3.3E-07	0.0035	7.7E-08
Chloromethane	NA	0.013	ND	ND	2.6E-07	ND	6.1E-08
Chromium (Cr)	0.005	NA	0.015	0.03	ND	0.0053	ND
1,2-Dichloroethane	NA	0.091	ND	ND	4.1E-06	ND	9.5E-07
1,1-Dichloroethene	0.009	0.6	0.010	0.024	3.1E-05	0.0037	7.1E-06
cis-1,2-Dichloroethene	0.01	NA	0.38	0.89	ND	0.14	ND
1,2-Dichloroethene (total)	0.009	NA	0.38	0.89	ND	0.14	ND
Dioxin Equiv.	NA	156000	ND	ND	1.2E-06	ND	2.7E-07
Ethylbenzene	0.1	NA	0.013	0.031	ND	0.0048	ND
bis(2-Ethylhexyl)phthalate	0.02	0.014	0.0076	0.018	1.2E-06	0.0027	2.7E-07
Lead (Pb)	NA	NA	ND	ND	ND	ND	ND
Manganese (Mn)	0.023	NA	2.8	6.6	ND	1.0	ND
2-Methylnaphthalene	0.04	NA	0.13	0.30	ND	0.046	ND
4-Methylphenol	0.005	NA	0.085	0.20	ND	0.030	ND
Naphthalene	0.04	NA	0.20	0.46	ND	0.071	ND
1,1,2,2-Tetrachloroethane	NA	0.2	ND	ND	6.7E-06	ND	1.6E-06
Tetrachloroethene	0.01	0.052	0.043	0.10	1.2E-05	0.015	2.9E-06
Thallium (Tl)	8E-05	NA	0.9	2.0	ND	0.30	ND
Trichloroethene	0.006	0.011	0.027	0.062	9.6E-07	0.0095	2.2E-07
Vanadium (V)	0.007	NA	0.009	0.021	ND	0.0032	ND
Vinyl chloride	NA	1.9	ND	ND	1.7E-04	ND	3.9E-05
m+p Xylene	2	NA	0.00059	0.0014	ND	0.00021	ND
SUM Hazard Index/ILCR			10	23	1E-03	4	3E-04

NA Not available
ND Not Determined due to lack of available information
lwa Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk

Table 10.4.45
Hazard Quotients and Incremental Lifetime Cancer Risks
Inhalation of Contaminatin in Groundwater Due to Domestic Use
SWMU 39
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Inhalation Rf Used (mg/kg-day)	Inhalation SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Future Worker adult Hazard Quotient	Future Worker adult ILCR
Benzene	0.00171	0.029	1.7	3.9	4.5E-05	0.59	1.0E-05
Chlorobenzene	0.00571	NA	0.015	0.035	ND	0.0054	ND
Chloroform	0.01	0.0805	0.0099	0.023	4.4E-06	0.0035	1.0E-06
Chloromethane	NA	0.0063	ND	ND	1.3E-07	ND	2.9E-08
1,2-Dichloroethane	0.00286	0.091	0.029	0.067	4.1E-06	0.010	9.5E-07
1,1-Dichloroethene	0.009	0.175	0.010	0.024	8.9E-06	0.0037	2.1E-06
cis-1,2-Dichloroethene	0.01	NA	0.38	0.89	ND	0.14	ND
1,2-Dichloroethene (total)	0.009	NA	0.38	0.89	ND	0.14	ND
Ethylbenzene	0.286	NA	0.0047	0.011	ND	0.0017	ND
1,1,2,2-Tetrachloroethane	NA	0.203	ND	ND	6.8E-06	ND	1.6E-06
Tetrachloroethene	0.01	0.00203	0.043	0.10	4.8E-07	0.015	1.1E-07
Trichloroethene	0.006	0.006	0.027	0.062	5.3E-07	0.0095	1.2E-07
Vinyl chloride	NA	0.3	ND	ND	2.6E-05	ND	6.1E-06
m+p Xylene	0.00857	NA	0.14	0.32	ND	0.049	ND
SUM Hazard Index/ILCR			3	6	1E-04	1	2E-05

NA Not available
ND Not Determined due to lack of available information
lwa Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk

The ingestion and inhalation pathway hazard indices were computed to be 4 and 1, respectively. The primary contributors to the ingestion pathway include arsenic and manganese. The primary contributors to the inhalation pathway include benzene, cis-1,2-dichloroethene, and 1,2-dichloroethene (total).

Lead Toxicity

The mean detected lead concentration for SWMU 39 was calculated to be 0.0054 mg/L and the 95% UCL lead concentration was calculated to be 0.0011 mg/L. Only one groundwater sample out of 57 samples analyzed had a concentration (0.0165 mg/L) above the TTAL for lead (0.015 mg/L). Because the mean falls below the TTAL, chronic exposures are not expected to pose a significant health threat to potential future child residents.

Current Site Workers

Shallow groundwater is not currently used as a potable water source for SWMU 39, or other areas of Zone A. In the absence of a completed exposure pathway, no threat to human health is posed by reported shallow groundwater contamination.

COCs Identified

Chemicals of concern were identified based on cumulative (all pathway) risk and hazard projected for this site. USEPA has established a generally acceptable risk range of 1E-04 to 1E-06, and a hazard index threshold of 1.0 (unity). As recommended by SCDHEC, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-06 or greater and/or a cumulative hazard index above 1.0, and whose individual ILCR exceeds 1E-06 or whose hazard quotient exceeds 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-04 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used in order to provide a more comprehensive evaluation of chemicals contributing to carcinogenic risk or noncarcinogenic hazard

during the remedial goal options development process. Table 10.4.46 provides a summary of COCs identified in each medium based on contribution to cumulative ILCR or hazard index.

Surface Soils

Hypothetical Site Residents

Aluminum was identified as a COC based on its contribution to cumulative hazard index. Benzo(a)pyrene equivalents and beryllium were identified as COCs based on their contribution to cumulative ILCR. Arsenic was identified as a COC based on its contribution to ILCR and hazard index.

Hypothetical Site Workers

Arsenic and benzo(a)pyrene equivalents were identified as COCs based on their contribution to cumulative ILCR.

Groundwater

Hypothetical Site Residents

Manganese, cis-1,2-dichloroethene, 1,2-dichloroethene (total), 2-methylnaphthalene, naphthalene, and thallium were identified as groundwater COCs based on their contribution to cumulative hazard index. Beryllium, bis(2-ethylhexyl)phthalate, chloroform, 1,2-dichloroethane, 1,1-dichloroethene, dioxin equivalents, 1,1,2,2-tetrachloroethane, and vinyl chloride were identified as COCs based on their contribution to cumulative ILCR. Arsenic, benzene, and tetrachloroethene were identified as COCs based on their contribution to ILCR and hazard index.

Hypothetical Site Workers

Manganese, cis-1,2-dichloroethene, 1,2-dichloroethene (total), and thallium were identified as groundwater COCs for this scenario based on their contribution to hazard index. Beryllium, chloroform, 1,1-dichloroethene, 1,1,2,2-tetrachloroethane, tetrachloroethene, and vinyl chloride

Table 10.4.46
Summary of Risk and Hazard-based COCs
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Medium	Exposure Pathway		Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident lwa ILCR	Site Worker Hazard Quotient	Site Worker ILCR	Identification of COCs
Surface Soil	Incidental Ingestion	Aluminum	0.014	0.13	ND	0.0018	ND	1
		Aroclor 1260	ND	ND	5.3E-07	ND	5.9E-08	
		Arsenic	0.032	0.29	1.6E-05	0.0040	1.8E-06	1 2 4
		Benzo(a)pyrene equivalents	ND	ND	1.4E-05	ND	1.6E-06	2 4
		Beryllium	0.000048	0.00044	1.2E-06	0.0000061	1.3E-07	2
		Manganese	0.0031	0.029	ND	0.00039	ND	
		Mercury	0.006	0.06	ND	0.0008	ND	
	Dermal Contact	Aluminum	0.0029	0.0094	ND	0.0020	ND	
		Aroclor 1260	ND	ND	2.4E-07	ND	9.6E-08	
		Arsenic	0.0065	0.021	1.8E-06	0.0046	7.4E-07	2
		Benzo(a)pyrene equivalents	ND	ND	6.5E-06	ND	2.7E-06	2 4
		Beryllium	0.000010	0.000032	1.3E-07	0.0000070	5.3E-08	
		Manganese	0.00063	0.0021	ND	0.00045	ND	
		Mercury	0.0013	0.0043	ND	0.00094	ND	
Surface Soil Pathway Sum			0.07	0.6	4E-05	0.02	7E-06	
Groundwater Pathways	Ingestion	Aluminum (Al)	0.031	0.072	ND	0.011	ND	
		Arsenic (As)	4.0	9.2	9.8E-04	1.4	2.3E-04	1 2 3 4
		Barium (Ba)	0.027	0.063	ND	0.0096	ND	
		Benzene	0.94	2.2	4.5E-05	0.34	1.0E-05	1 2 3 4
		Beryllium (Be)	0.0014	0.0033	1.7E-05	0.00050	3.9E-06	2 4
		Chlorobenzene	0.0043	0.0101	ND	0.0015	ND	
		Chloroform	0.0099	0.023	3.3E-07	0.0035	7.7E-08	
		Chloromethane	ND	ND	2.6E-07	ND	6.1E-08	
		Chromium (Cr)	0.015	0.035	ND	0.0053	ND	
		1,2-Dichloroethane	ND	ND	4.1E-06	ND	9.5E-07	2
		1,1-Dichloroethene	0.010	0.024	3.1E-05	0.0037	7.1E-06	2 4
		cis-1,2-Dichloroethene	0.38	0.89	ND	0.14	ND	1 3
		1,2-Dichloroethene (total)	0.38	0.89	ND	0.14	ND	1 3
		Dioxin Equiv.	ND	ND	1.2E-06	ND	2.7E-07	2
		Ethylbenzene	0.013	0.031	ND	0.0048	ND	
		bis(2-Ethylhexyl)phthalate	0.0076	0.018	1.2E-06	0.0027	2.7E-07	2
		Lead (Pb)	ND	ND	ND	ND	ND	
		Manganese (Mn)	2.8	6.6	ND	1.0	ND	1 3
		2-Methylnaphthalene	0.13	0.30	ND	0.046	ND	1
		4-Methylphenol	0.085	0.20	ND	0.030	ND	1
		Naphthalene	0.20	0.46	ND	0.071	ND	1
		1,1,2,2-Tetrachloroethane	ND	ND	6.7E-06	ND	1.6E-06	2 4
		Tetrachloroethene	0.043	0.10	1.2E-05	0.015	2.9E-06	1 2 4
		Thallium (Tl)	0.85	2.0	ND	0.30	ND	1 3
		Trichloroethene	0.027	0.062	9.6E-07	0.0095	2.2E-07	
		Vanadium (V)	0.0089	0.021	ND	0.0032	ND	
		Vinyl chloride	ND	ND	1.7E-04	ND	3.9E-05	2 4
		m+p Xylene	0.00059	0.0014	ND	0.00021	ND	
	Inhalation	Benzene	1.65	3.9	4.5E-05	0.59	1.0E-05	1 2 3 4
		Chlorobenzene	0.015	0.035	ND	0.0054	ND	
		Chloroform	0.0099	0.023	0.0	0.0035	1.0E-06	2 4
		Chloromethane	ND	ND	0.0	ND	2.9E-08	
		1,2-Dichloroethane	0.029	0.067	4.1E-06	0.010	9.5E-07	2
		1,1-Dichloroethene	0.0103	0.024	8.9E-06	0.0037	2.1E-06	2 4
		cis-1,2-Dichloroethene	0.38	0.89	ND	0.14	ND	1 3
		1,2-Dichloroethene (total)	0.38	0.89	ND	0.14	ND	1 3
		Ethylbenzene	0.0047	0.011	ND	0.0017	ND	
		1,1,2,2-Tetrachloroethane	ND	ND	6.8E-06	ND	1.6E-06	2 4
		Tetrachloroethene	0.043	0.10	4.8E-07	0.015	1.1E-07	1
		Trichloroethene	0.027	0.062	5.3E-07	0.0095	1.2E-07	
		Vinyl chloride	ND	ND	2.6E-05	ND	6.1E-06	2 4
		m+p Xylene	0.14	0.32	ND	0.049	ND	1
Groundwater Pathway Sum			13	30	1E-03	5	3E-04	
Sum of All Pathways			13	30	1E-03	5	3E-04	

Notes:
ND Indicates not determined due to the lack of available risk information.
NA Not applicable
ILCR Indicates incremental excess lifetime cancer risk
HI Indicates hazard index
1- Chemical is a COC by virtue of projected child residence non-carcinogenic hazard.
2- Chemical is a COC by virtue of projected future resident lifetime ILCR.
3- Chemical is a COC by virtue of projected site worker non-carcinogenic hazard.
4- Chemical is a COC by virtue of projected site worker ILCR.

were identified as COCs based on their contribution to ILCR. Arsenic and benzene were identified as COCs based on their contribution to cumulative ILCR and hazard index.

10.4.13.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure. Current site workers are not exposed to site groundwater, nor is site groundwater used as a source of water for any purpose at this time.

Residential use of the site is not expected, based on current site uses and the nature of surrounding buildings. Current base reuse plans call for Zone A to become a marine terminal. If this area were to be used as a residential site, the buildings would be demolished, asphalt surfaces removed, and the surface soil conditions would likely change dramatically. Consequently, exposure to current surface soil conditions would not be likely under a true future residential scenario. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to current site workers and future site residents.

Shallow groundwater is not currently used at SWMU 39 for potable or industrial purposes. A basewide system provides drinking and process water to buildings throughout Zone A. This system is slated to remain in operation under the current base reuse plan. As a result, shallow groundwater would not be expected to be used under future site use scenarios. Therefore, the scenario established to project risk/hazard associated with shallow groundwater exposure is highly conservative, and associated pathways are not expected to be completed in the future.

Determination of Exposure Point Concentrations

A 95% UCL or maximum concentrations were applied as EPCs used to estimate risk and hazard for each soil COPC. As a result, it is unlikely that the EPC is exceeded by the true mean soil concentration for any soil COPC.

EPCs for the groundwater pathways were set equal to the arithmetic mean in the most concentrated area of the plume. The mean concentration was calculated using data generated from all sampling rounds of monitoring wells in the most concentrated area of the plume with substitution of one-half of the SQL for nondetects. Each COPC was assigned to it own plume based on its own "most concentrated area". COPCs that could not be assigned to a distinct plume used a 95% UCL concentration as an EPC. Assigning COPCs to different plumes and the use of 95% UCLs could either overestimate or underestimate the EPC, depending on the location of the hypothetical production well that would be used to provided domestic use water.

Frequency of Detection and Spatial Distribution

Aluminum and arsenic were present in surface soil throughout SWMU 39. Aluminum exceeded the background reference concentration in only two samples and arsenic exceeded its background reference concentration in only one sample. Beryllium was detected in 2 of 15 surface soil samples with the concentration in both exceeding the RBC. There was no valid background reference concentration available for beryllium, although the maximum beryllium concentration for SWMU 39 would not have exceeded the approved background reference concentrations calculated for Zones B, E, and H. Benzo(a)pyrene equivalents were detected in 3 of 19 surface soil samples and above the RBC in only 1 of 19.

Antimony, azobenzene, dibromochloromethane, 1,2-dibromo-3-chloropropane and pentachlorophenol were eliminated from further consideration in the HHRA due to a low frequency of detection (one detection out of 79 to 108 samples). Elimination of these COPCs from

the formal HHRA would cause an underestimation of risk/hazard, however, only in extremely isolated areas. To address this uncertainty, these COPCs are included in the risk maps provided in Section 10.4.13.7, Risk Summary.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

Of the organic CPSSs screened and eliminated from formal assessment, none was reported at a concentration within approximately 10% of the RBC. No inorganic CPSSs whose concentration exceeded their corresponding RBCs were eliminated based on their corresponding reference concentrations.

Central tendency analysis was not formally performed for SWMU 39 surface soil, but a simplified approach was taken to assess the potential influences of CT assumptions. The central tendency assumption for residential exposure duration is 9 years compared to the 30 year assumption for RME. The CT exposure frequency assumption is 234 days/year compared to 350 days/year RME. In addition, CT ingestion rate assumptions are one-half those applied for RME. If all other exposure assumptions remain fixed, application of the CT exposure duration and frequency, as well as ingestion rate would result in risk projections approximately 80 percent below the RME.

At CT, the residential surface soil pathway related risk (incidental ingestion and dermal contact) would drop from 1E-03 to approximately 2E-4 but would still exceed the 1E-6 point of departure.

Although the future land use of SWMU 39 is unknown, both the worker and residential exposure scenarios were assessed in this HHRA. Current base reuse plans call for development of Zone A into a marine terminal area. As previously discussed, it is likely that these scenarios would lead to overestimates of risk and/or hazard.

Groundwater

Of the organic CPSSs screened and eliminated from formal assessment, none was reported at a concentration within approximately 10% of the RBC. No inorganic parameters were eliminated from formal assessment based strictly upon comparison to background reference concentrations.

Groundwater is not currently used as a potable water source at SWMU 39, nor is it used at NAVBASE or in the surrounding area. Municipal water is readily available. As previously mentioned, it is highly unlikely that the site will be developed as a residential area, and it is unlikely that a potable-use well would be installed onsite. It is probable that, if residences were constructed onsite and an unfiltered well were installed, the salinity and dissolved solids would preclude this aquifer from being an acceptable potable water source.

10.4.13.7 Risk Summary

The risk and hazard posed by contaminants at SWMU 39 were assessed for the hypothetical site worker and the hypothetical future site resident under reasonable maximum exposure assumptions. For surface soils, the incidental ingestion and dermal contact pathways were assessed in this HHRA. The ingestion and inhalation pathways were evaluated for shallow groundwater. Table 10.4.47 presents the risk summary for each pathway/receptor group evaluated for SWMU 39.

To add perspective to the SWMU 39 HHRA, point risk and hazard maps are presented below. Point risk maps are based on the unlikely assumption that potential future site residents will be

Table 10.4.47
Summary of Risk and Hazard
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.06	0.5	3E-05	0.007	4E-06
	Dermal Contact	0.01	0.04	9E-06	0.008	4E-06
Groundwater	Ingestion	10	23	1E-03	4	3E-04
	Inhalation of VOCs	3	6	1E-04	1.0	2E-05
Sum of All Pathways		13	30	1E-03	5	3E-04

Notes:
ND Indicates not determined due to the lack of available risk information.
ILCR Indicates incremental lifetime cancer risk
HI Indicates hazard index

chronically exposed to specific points. Exposure to surface soil conditions is more likely the result of uniform exposure to the soil conditions over the entire site rather than specific points. Risk maps are still useful because they allow the reader to visualize the contribution of risk or hazard index due to individual COCs.

Soil

Figures 10.4.37 and 10.4.38 illustrate point risk and hazard indices for exposure to SWMU 39 surface soil under a residential scenario. Table 10.4.48 provides the contribution of individual COCs to cumulative risk and hazard at each sample location. As shown, concentrations of arsenic in surface soil are responsible for risk projections above 1E-06 for nearly all of the SWMU 39 surface soil locations. The exceptions are beryllium at locations 039SB006 and 039SB010, Aroclor-1260 at locations 039SB002 and 039SB017, and benzo(a)pyrene equivalents at location 039SB005. Risk estimates range from 1E-04 (039SB005) to 2E-07 (039SB024). Contributions to hazard indices above one for the soil pathway were predominantly due to concentrations of aluminum, arsenic, and manganese. A point specific hazard index above one occurred at location 039SB006 only.

Groundwater

Figures 10.4.39 and 10.4.40 illustrate point risk and hazard for SWMU 39 groundwater under a residential scenario. To provide a graphical presentation of multiple sampling events, the maximum total hazard and maximum total risk for each monitoring well location was plotted. Table 10.4.49 details the individual contributors to risk and hazard at each monitoring well location and for all sampling rounds. Concentrations of arsenic in groundwater samples collected throughout SWMU 39 contribute to risk projections ranging from 5E-05 to 2E-03. The highest arsenic-related risk estimates were associated with samples collected from monitoring well NBCA-039-012. The concentrations of benzene in groundwater samples collected from monitoring wells NBCA-039-001, NBCA-039-005, NBCA-039-011, and NBCA-039-014 equate with risk ranging from 1E-06 to 2E-04.

Concentrations of chlorinated VOCs in groundwater samples collected from NBCA-039-003, NBCA-039-004, NBCA-039-005, NBCA-039-009, NBCA-039-10I, NBCA-039-012, NBCA-039-12I, NBCA-039-013, NBCA-039-13I, and NBCA-039-13D equate with risk projections ranging from 2E-06 to 8E-04.

Concentrations of arsenic and manganese are the primary contributors to hazard indices above one. The exceptions are benzene in groundwater samples collected from monitoring wells NBCA-039-001 and NBCA-039-005, chlorinated VOCs in monitoring wells NBCA-039-003, NBCA-039-012, NBCA-039-12I, NBCA-039-13I, and NBCA-039-13D, and petroleum-related chemicals in groundwater samples collected from monitoring well NBCA-039-011. Groundwater samples collected from monitoring wells NBCA-039-013, NBCA-039-014, and NBCA-039-015 had concentrations of aluminum, barium, thallium, and vanadium that contributed to a hazard index above one at these locations.

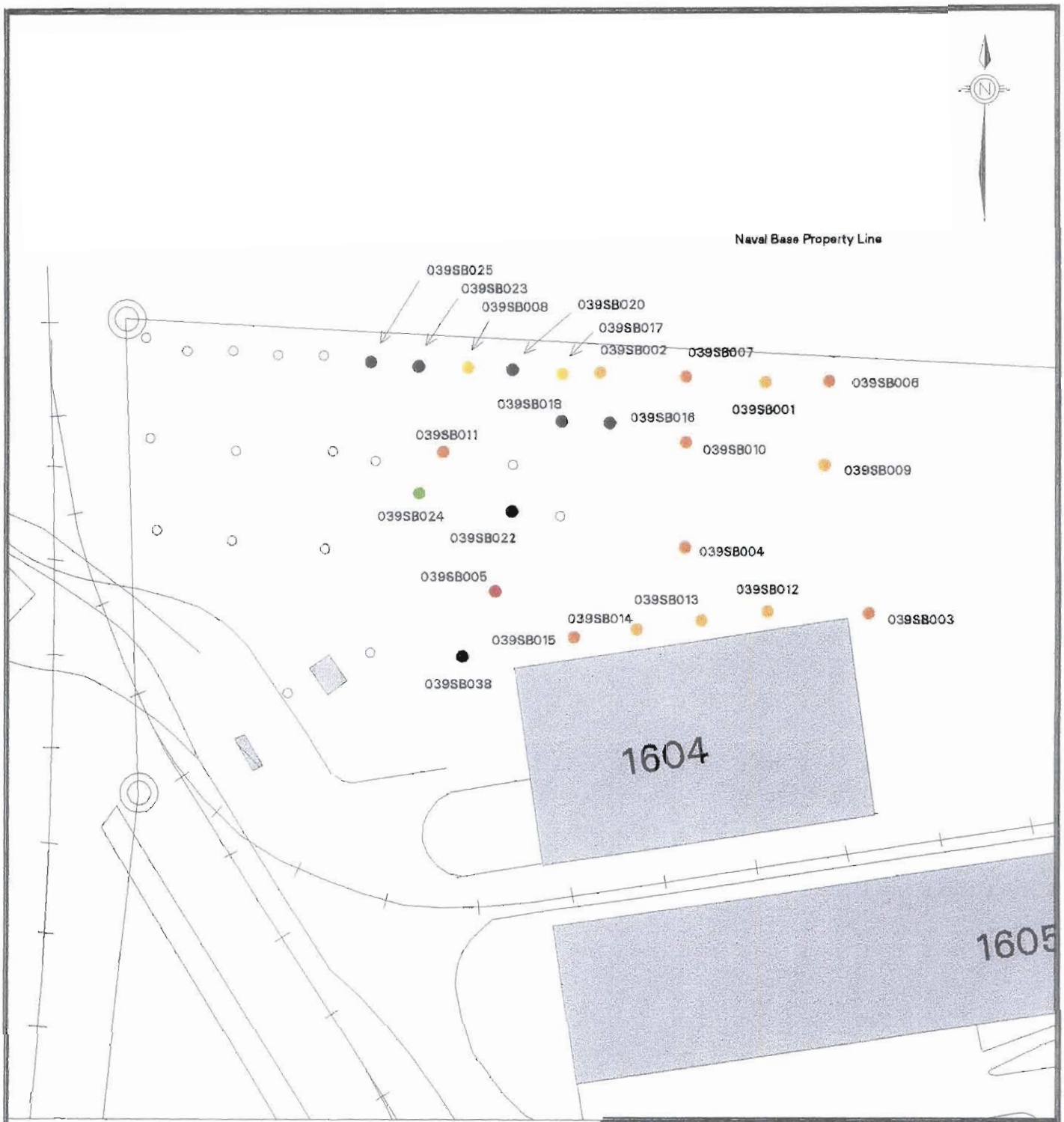
10.4.13.8 Remedial Goal Options

Soil

Surface soil RGOs for carcinogens presented in Table 10.4.50 were based on the lifetime weighted average site resident and adult site worker, respectively. Hazard-based RGOs were calculated based on either the hypothetical child resident or the adult site worker, as noted in each of the corresponding tables.

Groundwater

Shallow groundwater RGOs based on site residents and site workers are shown in Table 10.4.51.

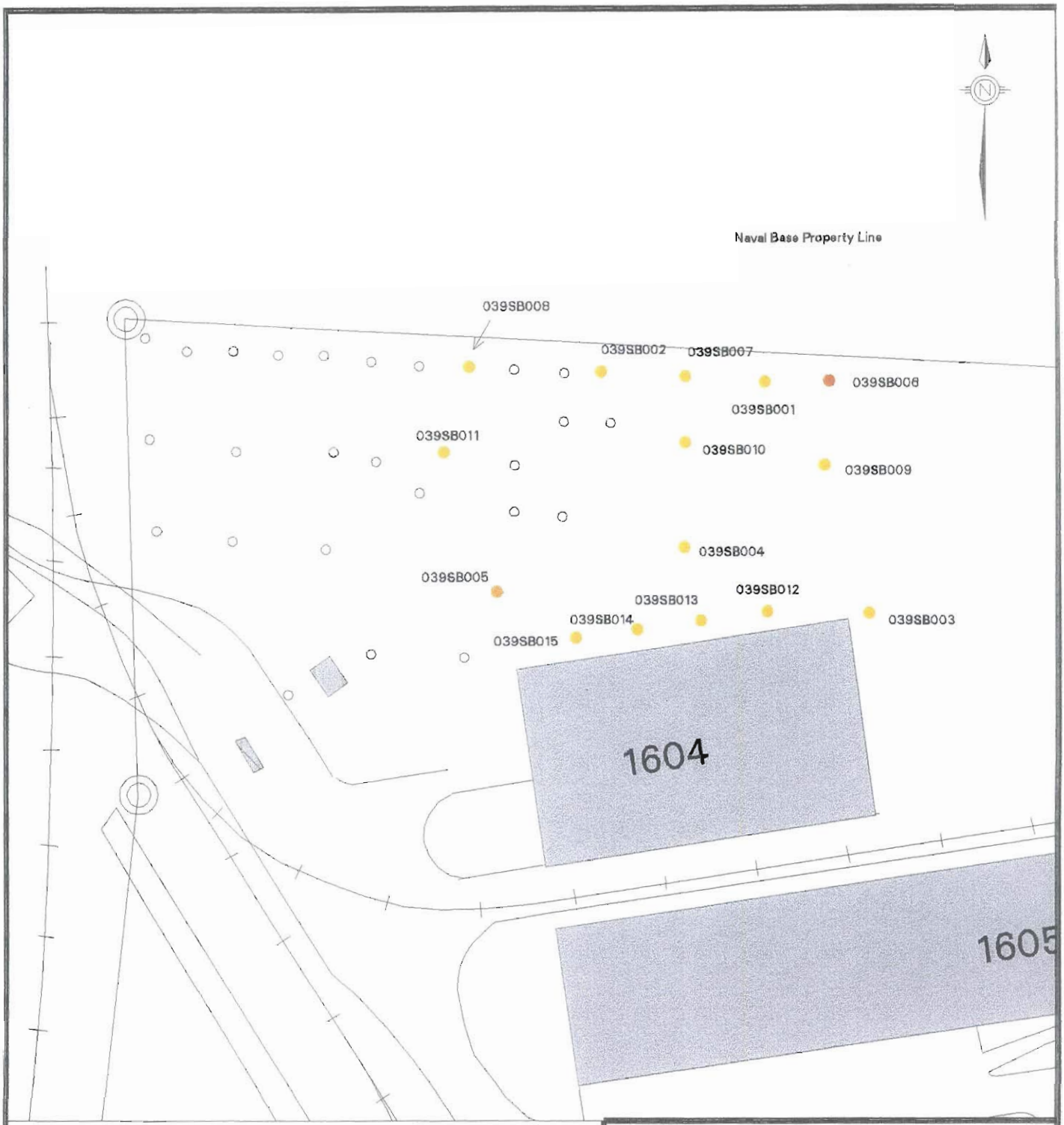


NOT APPLICABLE FOR RISK CALCULATION
NO COPCs DETECTED
< 1E-6
1E-6 to 5E-6
5E-6 to 1E-5
1E-5 to 1E-4
> 1E-4

0 feet 140

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE, CHARLESTON
CHARLESTON, S.C.

FIGURE 10.4.37
POINT RISK SUMMARY
FOR SURFACE SOIL
SWMU 39



NOT APPLICABLE FOR HAZARD CALCULATION
NO COPCs DETECTED
0 to 0.1
0.1 to 0.5
0.5 to 1.0
1.0 to 3.0
> 3.0

0 feet 140

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE, CHARLESTON
CHARLESTON, S.C.

FIGURE 10.4.38
HAZARD INDEX SUMMARY
FOR SURFACE SOIL
SWMU 39

AML: /home3/projects/charleston_dir/risk_assess/zone_a_dir/main_39

Table 10.4.48
Point Estimates of Risk and Hazard - Surface Soil
Residential Scenario
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Inedx	Risk (E-06)
039	001	Aluminum (Al)	5490	mg/kg	0.0753	NA
039	001	Aroclor-1260	ND	ug/kg	NA	NA
039	001	Arsenic (As)	2.3	mg/kg	0.1051	6.0076
039	001	B(a)P Equiv.	ND	ug/kg	NA	NA
039	001	Beryllium (Be)	ND	mg/kg	NA	NA
039	001	Manganese (Mn)	107	mg/kg	0.0638	NA
039	001	Mercury (Hg)	ND	mg/kg	NA	NA
		Total			0.2442	6.0076
039	002	Aluminum (Al)	5210	mg/kg	0.0714	NA
039	002	Aroclor-1260	1100	ug/kg	NA	4.9908
039	002	Arsenic (As)	1.9	mg/kg	0.0868	4.9628
039	002	B(a)P Equiv.	ND	ug/kg	NA	NA
039	002	Beryllium (Be)	ND	mg/kg	NA	NA
039	002	Manganese (Mn)	36.5	mg/kg	0.0218	NA
039	002	Mercury (Hg)	ND	mg/kg	NA	NA
		Total			0.1800	9.9536
039	003	Aluminum (Al)	12500	mg/kg	0.1714	NA
039	003	Aroclor-1260	ND	ug/kg	NA	NA
039	003	Arsenic (As)	4.7	mg/kg	0.2148	12.2764
039	003	B(a)P Equiv.	ND	ug/kg	NA	NA
039	003	Beryllium (Be)	ND	mg/kg	NA	NA
039	003	Manganese (Mn)	27.45	mg/kg	0.0164	NA
039	003	Mercury (Hg)	ND	mg/kg	NA	NA
		Total			0.4026	12.2764
039	004	Aluminum (Al)	5630	mg/kg	0.0772	NA
039	004	Aroclor-1260	ND	ug/kg	NA	NA
039	004	Arsenic (As)	5	mg/kg	0.2285	13.0600
039	004	B(a)P Equiv.	ND	ug/kg	NA	NA
039	004	Beryllium (Be)	ND	mg/kg	NA	NA
039	004	Manganese (Mn)	35.8	mg/kg	0.0213	NA
039	004	Mercury (Hg)	0.19	mg/kg	0.0087	NA
		Total			0.3358	13.0600
039	005	Aluminum (Al)	4750	mg/kg	0.0651	NA
039	005	Aroclor-1260	ND	ug/kg	NA	NA
039	005	Arsenic (As)	7.3	mg/kg	0.3337	19.0676
039	005	B(a)P Equiv.	5784.9	ug/kg	NA	95.7998
039	005	Beryllium (Be)	ND	mg/kg	NA	NA
039	005	Manganese (Mn)	107	mg/kg	0.0638	NA
039	005	Mercury (Hg)	2.8	mg/kg	0.1280	NA
		Total			0.5906	114.8674
039	006	Aluminum (Al)	16000	mg/kg	0.2194	NA
039	006	Aroclor-1260	ND	ug/kg	NA	NA
039	006	Arsenic (As)	17.9	mg/kg	0.8182	46.7548
039	006	B(a)P Equiv.	ND	ug/kg	NA	NA
039	006	Beryllium (Be)	0.45	mg/kg	0.0012	3.3695
039	006	Manganese (Mn)	191	mg/kg	0.1139	NA
039	006	Mercury (Hg)	0.15	mg/kg	0.0069	NA
		Total			1.1595	50.1243
039	007	Aluminum (Al)	5590	mg/kg	0.0767	NA
039	007	Aroclor-1260	98	ug/kg	NA	0.4446
039	007	Arsenic (As)	3.9	mg/kg	0.1783	10.1868
039	007	B(a)P Equiv.	ND	ug/kg	NA	NA
039	007	Beryllium (Be)	ND	mg/kg	NA	NA
039	007	Manganese (Mn)	110	mg/kg	0.0656	NA
039	007	Mercury (Hg)	1.5	mg/kg	0.0686	NA
		Total			0.3891	10.6314
039	008	Aluminum (Al)	7610	mg/kg	0.1044	NA
039	008	Aroclor-1260	26	ug/kg	NA	0.1180
039	008	Arsenic (As)	1.4	mg/kg	0.0640	3.6568
039	008	B(a)P Equiv.	ND	ug/kg	NA	NA
039	008	Beryllium (Be)	ND	mg/kg	NA	NA
039	008	Manganese (Mn)	13.2	mg/kg	0.0079	NA
039	008	Mercury (Hg)	1.7	mg/kg	0.0777	NA
		Total			0.2539	3.7748

Table 10.4.48
Point Estimates of Risk and Hazard - Surface Soil
Residential Scenario
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Inedx	Risk (E-06)
039	009	Aluminum (Al)	11200	mg/kg	0.1536	NA
039	009	Aroclor-1260	ND	ug/kg	NA	NA
039	009	Arsenic (As)	3.6	mg/kg	0.1645	9.4032
039	009	B(a)P Equiv.	ND	ug/kg	NA	NA
039	009	Beryllium (Be)	ND	mg/kg	NA	NA
039	009	Manganese (Mn)	26.2	mg/kg	0.0156	NA
039	009	Mercury (Hg)	1.3	mg/kg	0.0594	NA
		Total			0.3932	9.4032
039	010	Aluminum (Al)	8160	mg/kg	0.1119	NA
039	010	Aroclor-1260	ND	ug/kg	NA	NA
039	010	Arsenic (As)	6.5	mg/kg	0.2971	16.9780
039	010	B(a)P Equiv.	ND	ug/kg	NA	NA
039	010	Beryllium (Be)	0.24	mg/kg	0.0007	1.7971
039	010	Manganese (Mn)	56.5	mg/kg	0.0337	NA
039	010	Mercury (Hg)	ND	mg/kg	NA	NA
		Total			0.4433	18.7751
039	011	Aluminum (Al)	6750	mg/kg	0.0926	NA
039	011	Aroclor-1260	ND	ug/kg	NA	NA
039	011	Arsenic (As)	5	mg/kg	0.2285	13.0600
039	011	B(a)P Equiv.	15.17	ug/kg	NA	0.2512
039	011	Beryllium (Be)	ND	mg/kg	NA	NA
039	011	Manganese (Mn)	50.9	mg/kg	0.0303	NA
039	011	Mercury (Hg)	1.4	mg/kg	0.0640	NA
		Total			0.4154	13.3112
039	012	Aluminum (Al)	9370	mg/kg	0.1285	NA
039	012	Aroclor-1260	ND	ug/kg	NA	NA
039	012	Arsenic (As)	3.8	mg/kg	0.1737	9.9256
039	012	B(a)P Equiv.	ND	ug/kg	NA	NA
039	012	Beryllium (Be)	ND	mg/kg	NA	NA
039	012	Manganese (Mn)	11.2	mg/kg	0.0067	NA
039	012	Mercury (Hg)	ND	mg/kg	NA	NA
		Total			0.3089	9.9256
039	013	Aluminum (Al)	12800	mg/kg	0.1755	NA
039	013	Aroclor-1260	ND	ug/kg	NA	NA
039	013	Arsenic (As)	3.7	mg/kg	0.1691	9.6644
039	013	B(a)P Equiv.	ND	ug/kg	NA	NA
039	013	Beryllium (Be)	ND	mg/kg	NA	NA
039	013	Manganese (Mn)	17.4	mg/kg	0.0104	NA
039	013	Mercury (Hg)	ND	mg/kg	NA	NA
		Total			0.3550	9.6644
039	014	Aluminum (Al)	8230	mg/kg	0.1129	NA
039	014	Aroclor-1260	ND	ug/kg	NA	NA
039	014	Arsenic (As)	2.4	mg/kg	0.1097	6.2688
039	014	B(a)P Equiv.	ND	ug/kg	NA	NA
039	014	Beryllium (Be)	ND	mg/kg	NA	NA
039	014	Manganese (Mn)	23.75	mg/kg	0.0142	NA
039	014	Mercury (Hg)	ND	mg/kg	NA	NA
		Total			0.2367	6.2688
039	015	Aluminum (Al)	5740	mg/kg	0.0787	NA
039	015	Aroclor-1260	ND	ug/kg	NA	NA
039	015	Arsenic (As)	3.9	mg/kg	0.1783	10.1868
039	015	B(a)P Equiv.	ND	ug/kg	NA	NA
039	015	Beryllium (Be)	ND	mg/kg	NA	NA
039	015	Manganese (Mn)	11.3	mg/kg	0.0067	NA
039	015	Mercury (Hg)	ND	mg/kg	NA	NA
		Total			0.2637	10.1868
039	016	Aroclor-1260	ND	ug/kg	NA	NA
		Total			NA	NA
039	017	Aroclor-1260	340	ug/kg	NA	1.5426
		Total			NA	1.5426

Table 10.4.48
Point Estimates of Risk and Hazard - Surface Soil
Residential Scenario
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Inedx	Risk (E-06)
039	018	Aroclor-1260	ND	ug/kg	NA	NA
		Total			NA	NA
039	020	Aroclor-1260	ND	ug/kg	NA	NA
		Total			NA	NA
039	022	B(a)P Equiv.	ND	ug/kg	NA	NA
		Total			NA	NA
039	023	B(a)P Equiv.	ND	ug/kg	NA	NA
		Total			NA	NA
039	024	B(a)P Equiv.	9.957	ug/kg	NA	0.1649
		Total			NA	0.1649
039	025	Aroclor-1260	ND	ug/kg	NA	NA
		Total			NA	NA
039	038	B(a)P Equiv.	ND	ug/kg	NA	NA
		Total			NA	NA

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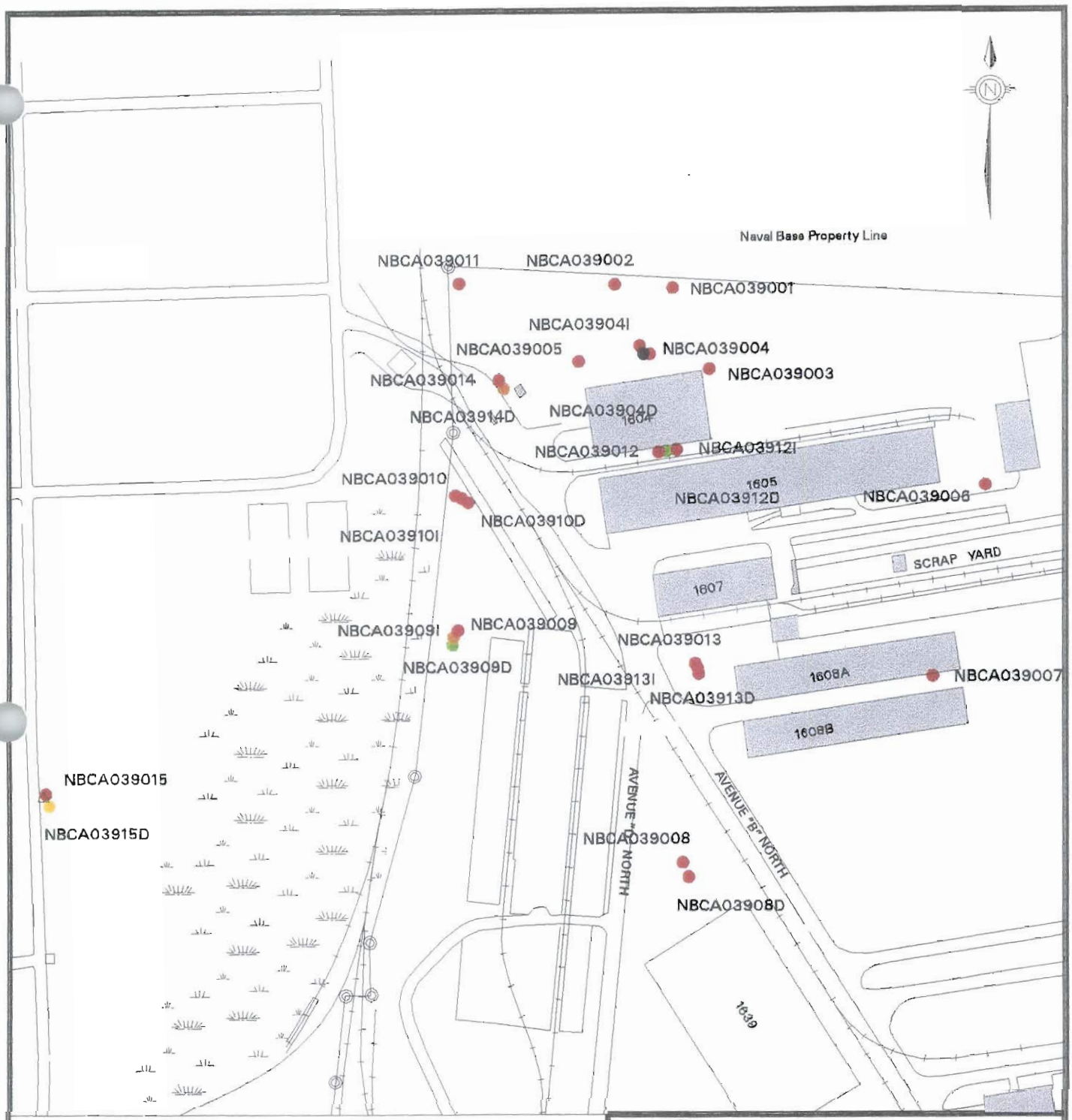


LEGEND

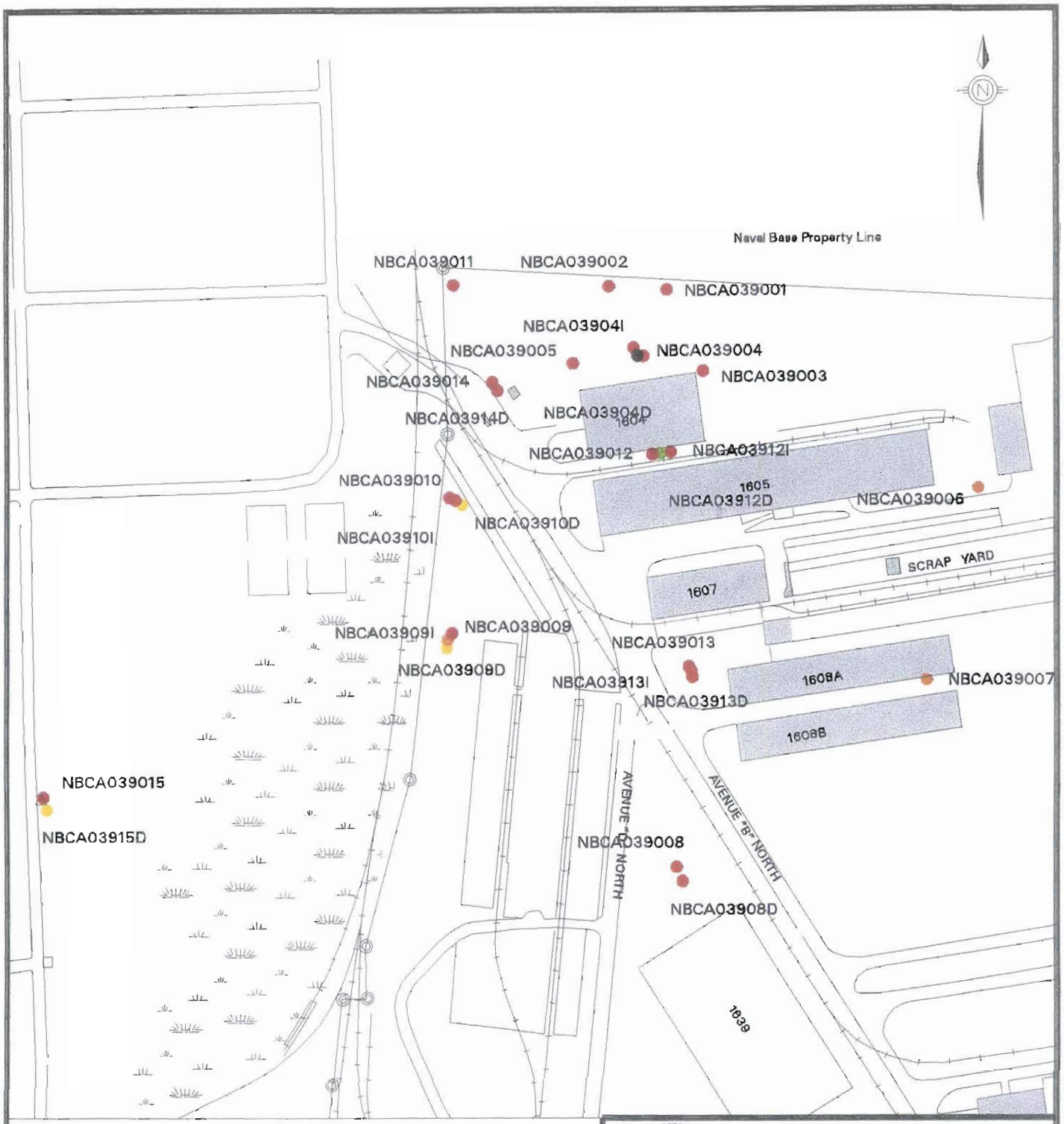
- NO COPCs DETECTED
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

0 feet 400

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE, CHARLESTON
CHARLESTON, S.C.

FIGURE 10.4.39
POINT RISK SUMMARY
FOR GROUNDWATER
SWMU 39

AML: /home3/projects/charleston_dir/risk_assess/zone_a_dir/main_39l



LEGEND

- NO COPCs DETECTED
- 0 to 0.1
- 0.1 to 0.5
- 0.5 to 1.0
- 1.0 to 3.0
- > 3.0

0 feet 400

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE, CHARLESTON
CHARLESTON, S.C.

FIGURE 10.4.40
HAZARD INDEX SUMMARY
FOR GROUNDWATER
SWMU 39

AML: /home3/projects/charleston_dir/risk_assess/zone_a_dir/main_39

Table 10.4.49
Point Estimates of Risk and Hazard - Groundwater
Residential Scenario
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Event	Parameter	Concentration	Units	Hazard Quotient	Risk (E-06)
039	001	01	Aluminum (Al)	197	ug/L	0.0126	NA
039	001	01	Arsenic (As)	43.8	ug/L	9.3333	977.14
039	001	01	Barium (Ba)	36.7	ug/L	0.0335	NA
039	001	01	Benzene	25	ug/L	1.8692	21.57
039	001	01	Ethylbenzene	10	ug/L	0.0086	NA
039	001	01	Manganese (Mn)	904	ug/L	2.5126	NA
			Total			13.7699	998.71
039	001	02	2-Methylnaphthalene	5	ug/L	0.0080	NA
039	001	02	Arsenic (As)	34.6	ug/L	7.3729	771.90
039	001	02	Benzene	47	ug/L	3.5141	40.54
039	001	02	Ethylbenzene	9	ug/L	0.0078	NA
039	001	02	Manganese (Mn)	932	ug/L	2.5904	NA
			Total			13.4932	812.44
039	001	03	Arsenic (As)	39.1	ug/L	8.3318	872.29
039	001	03	Barium (Ba)	27.6	ug/L	0.0252	NA
039	001	03	Benzene	35	ug/L	2.6169	30.19
039	001	03	Ethylbenzene	10	ug/L	0.0086	NA
039	001	03	Manganese (Mn)	794	ug/L	2.2069	NA
039	001	03	bis(2-Ethylhexyl)phthalate (BEHP)	13	ug/L	0.0416	2.71
			Total			13.2310	905.19
039	001	04	2-Methylnaphthalene	4	ug/L	0.0064	NA
039	001	04	Arsenic (As)	36.7	ug/L	7.8204	818.75
039	001	04	Barium (Ba)	30.6	ug/L	0.0279	NA
039	001	04	Benzene	110	ug/L	8.2245	94.89
039	001	04	Dioxin Equiv.	1.4674	pg/L	NA	3.51
039	001	04	Ethylbenzene	34	ug/L	0.0293	NA
039	001	04	Manganese (Mn)	969	ug/L	2.6933	NA
			Total			18.8019	917.15
039	002	01	Aluminum (Al)	2490	ug/L	0.1592	NA
039	002	01	Arsenic (As)	33.1	ug/L	7.0533	738.43
039	002	01	Barium (Ba)	44.2	ug/L	0.0404	NA
039	002	01	Chromium (Cr)	8.3	ug/L	0.1061	NA
039	002	01	Lead (Pb)	3.6	ug/L	NA	NA
039	002	01	Manganese (Mn)	1240	ug/L	3.4465	NA
039	002	01	Vanadium (V)	5.6	ug/L	0.0511	NA
			Total			10.8566	738.43
039	002	02	Aluminum (Al)	1280	ug/L	0.0818	NA
039	002	02	Arsenic (As)	40.7	ug/L	8.6728	907.98
039	002	02	Manganese (Mn)	1120	ug/L	3.1130	NA
			Total			11.8675	907.98
039	002	03	Aluminum (Al)	6610	ug/L	0.4226	NA
039	002	03	Arsenic (As)	48.1	ug/L	10.2496	1073.07
039	002	03	Barium (Ba)	36.5	ug/L	0.0333	NA
039	002	03	Lead (Pb)	4.2	ug/L	NA	NA
039	002	03	Manganese (Mn)	1070	ug/L	2.9740	NA
			Total			13.6795	1073.07
039	002	04	Aluminum (Al)	462	ug/L	0.0295	NA
039	002	04	Arsenic (As)	43.6	ug/L	9.2907	972.68
039	002	04	Barium (Ba)	34.1	ug/L	0.0311	NA
039	002	04	Dioxin Equiv.	0.1131	pg/L	NA	0.27
039	002	04	Manganese (Mn)	1100	ug/L	3.0574	NA
			Total			12.4088	972.95
039	003	01	Aluminum (Al)	707	ug/L	0.0452	NA
039	003	01	Barium (Ba)	26.65	ug/L	0.0243	NA
039	003	01	Manganese (Mn)	52.65	ug/L	0.1463	NA
039	003	01	Tetrachloroethene	15.5	ug/L	0.1982	12.46
039	003	01	Trichloroethene	41	ug/L	0.8737	10.37
039	003	01	Vanadium (V)	4.1	ug/L	0.0374	NA
039	003	01	cis-1,2-Dichloroethene	4.8	ug/L	0.0614	NA
			Total			1.3865	22.82
039	003	02	Aluminum (Al)	1940	ug/L	0.1240	NA
039	003	02	Chromium (Cr)	6.9	ug/L	0.0882	NA

Table 10.4.49
Point Estimates of Risk and Hazard - Groundwater
Residential Scenario
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Event	Parameter	Concentration	Units	Hazard Quotient	Risk (E-06)
039	003	02	Dibromochloromethane	5.5	ug/L	0.0352	13.74
039	003	02	Dioxin Equiv.	0.138	pg/L	NA	0.33
039	003	02	Manganese (Mn)	58.65	ug/L	0.1630	NA
039	003	02	Tetrachloroethene	9.15	ug/L	0.1170	7.35
039	003	02	Trichloroethene	48.5	ug/L	1.0335	12.26
039	003	02	Vanadium (V)	7	ug/L	0.0639	NA
039	003	02	cis-1,2-Dichloroethene	2.95	ug/L	0.0377	NA
			Total			1.6625	33.69
039	003	03	1,1,2,2-Tetrachloroethane	1.4	ug/L	NA	8.39
039	003	03	1,1-Dichloroethene	1.05	ug/L	0.0149	12.10
039	003	03	1,2-Dibromo-3-Chloropropane	3	ug/L	6.7292	62.57
039	003	03	Arsenic (As)	3.25	ug/L	0.6925	72.50
039	003	03	Barium (Ba)	23.2	ug/L	0.0212	NA
039	003	03	Manganese (Mn)	64.65	ug/L	0.1797	NA
039	003	03	Tetrachloroethene	11.5	ug/L	0.1470	9.24
039	003	03	Trichloroethene	91	ug/L	1.9391	23.01
039	003	03	cis-1,2-Dichloroethene	6.5	ug/L	0.0831	NA
			Total			9.8067	187.82
039	003	04	Aluminum (Al)	87.8	ug/L	0.0056	NA
039	003	04	Barium (Ba)	23.85	ug/L	0.0218	NA
039	003	04	Dioxin Equiv.	0.3654	pg/L	NA	0.88
039	003	04	Manganese (Mn)	48.4	ug/L	0.1345	NA
039	003	04	Tetrachloroethene	7.5	ug/L	0.0959	6.03
039	003	04	Trichloroethene	30	ug/L	0.6393	7.59
039	003	04	Vanadium (V)	0.83	ug/L	0.0076	NA
039	003	04	bis(2-Ethylhexyl)phthalate (BEHP)	2	ug/L	0.0064	0.42
039	003	04	cis-1,2-Dichloroethene	3	ug/L	0.0384	NA
			Total			0.9494	14.90
039	004	01	Aluminum (Al)	144	ug/L	0.0092	NA
039	004	01	Arsenic (As)	42.6	ug/L	9.0776	950.37
039	004	01	Barium (Ba)	56.1	ug/L	0.0512	NA
039	004	01	Manganese (Mn)	2020	ug/L	5.6145	NA
			Total			14.7525	950.37
039	004	02	Arsenic (As)	51.4	ug/L	10.9528	1146.69
039	004	02	Manganese (Mn)	1880	ug/L	5.2253	NA
039	004	02	Tetrachloroethene	3.8	ug/L	0.0486	3.05
039	004	02	Trichloroethene	2.3	ug/L	0.0490	0.58
039	004	02	cis-1,2-Dichloroethene	2.3	ug/L	0.0294	NA
			Total			16.3051	1150.33
039	004	03	Arsenic (As)	46.3	ug/L	9.8661	1032.92
039	004	03	Barium (Ba)	57.5	ug/L	0.0525	NA
039	004	03	Dioxin Equiv.	0.42	pg/L	NA	1.01
039	004	03	Manganese (Mn)	1910	ug/L	5.3087	NA
039	004	03	Tetrachloroethene	1.7	ug/L	0.0217	1.37
039	004	03	Trichloroethene	1.6	ug/L	0.0341	0.40
039	004	03	cis-1,2-Dichloroethene	1.2	ug/L	0.0153	NA
			Total			15.2985	1035.69
039	004	04	Arsenic (As)	48.4	ug/L	10.3135	1079.77
039	004	04	Barium (Ba)	59.6	ug/L	0.0544	NA
039	004	04	Dioxin Equiv.	0.5811	pg/L	NA	1.39
039	004	04	Manganese (Mn)	1810	ug/L	5.0308	NA
			Total			15.3987	1081.16
039	04I	01	No COPCs detected				
039	04I	05	1,2-Dichloroethane	1	ug/L	NA	NA
			Total			NA	NA
039	04I	06	Arsenic (As)	40	ug/L	8.5581	911.64
039	04I	06	Barium (Ba)	33.6	ug/L	0.0307	NA
039	04I	06	Manganese (Mn)	41.9	ug/L	0.1152	NA
			Total			8.7040	911.64
039	04D	01	No COPCs detected				

Table 10.4.49
Point Estimates of Risk and Hazard - Groundwater
Residential Scenario
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Event	Parameter	Concentration	Units	Hazard Quotient	Risk (E-06)
039	04D	02	No COPCs detected				
039	04D	03	No COPCs detected				
039	04D	04	No COPCs detected				
039	005	01	2-Methylnaphthalene	13	ug/L	0.0208	NA
039	005	01	Aluminum (Al)	1380	ug/L	0.0882	NA
039	005	01	Arsenic (As)	61.3	ug/L	13.0624	1367.55
039	005	01	Barium (Ba)	50.6	ug/L	0.0462	NA
039	005	01	Benzene	90	ug/L	6.7292	77.64
039	005	01	Chromium (Cr)	5.8	ug/L	0.0742	NA
039	005	01	Ethylbenzene	1.4	ug/L	0.0012	NA
039	005	01	Manganese (Mn)	2050	ug/L	5.6978	NA
039	005	01	Naphthalene	9.1	ug/L	0.0145	NA
039	005	01	Vinyl chloride	1.9	ug/L	NA	62.17
			Total			25.7345	1507.36
039	005	02	2-Methylnaphthalene	23	ug/L	0.0368	NA
039	005	02	Aluminum (Al)	760	ug/L	0.0486	NA
039	005	02	Arsenic (As)	66.8	ug/L	14.2344	1490.25
039	005	02	Benzene	100	ug/L	7.4768	86.26
039	005	02	Ethylbenzene	3	ug/L	0.0026	NA
039	005	02	Manganese (Mn)	2040	ug/L	5.6700	NA
039	005	02	Naphthalene	64	ug/L	0.1023	NA
			Total			27.5715	1576.52
039	005	03	2-Methylnaphthalene	14	ug/L	0.0224	NA
039	005	03	Aluminum (Al)	287	ug/L	0.0183	NA
039	005	03	Arsenic (As)	74.9	ug/L	15.9604	1670.96
039	005	03	Barium (Ba)	43.9	ug/L	0.0401	NA
039	005	03	Benzene	170	ug/L	12.7106	146.65
039	005	03	Dioxin Equiv.	0.5035	pg/L	NA	1.21
039	005	03	Ethylbenzene	1.1	ug/L	0.0009	NA
039	005	03	Manganese (Mn)	1890	ug/L	5.2531	NA
039	005	03	Naphthalene	35	ug/L	0.0559	NA
039	005	03	Vinyl chloride	5.8	ug/L	NA	189.78
039	005	03	bis(2-Ethylhexyl)phthalate (BEHP)	5.1	ug/L	0.0163	1.06
			Total			34.0782	2009.65
039	005	04	2-Methylnaphthalene	3	ug/L	0.0048	NA
039	005	04	Arsenic (As)	77.7	ug/L	16.5571	1733.42
039	005	04	Barium (Ba)	46.9	ug/L	0.0428	NA
039	005	04	Benzene	78	ug/L	5.8319	67.28
039	005	04	Dioxin Equiv.	0.2144	pg/L	NA	0.51
039	005	04	Manganese (Mn)	1840	ug/L	5.1142	NA
			Total			27.5508	1801.22
039	006	04	Aluminum (Al)	1340	ug/L	0.0857	NA
039	006	04	Barium (Ba)	70.5	ug/L	0.0644	NA
039	006	04	Chromium (Cr)	2.2	ug/L	0.0281	NA
039	006	04	Dioxin Equiv.	0.0312	pg/L	NA	0.007
039	006	04	Lead (Pb)	2.9	ug/L	NA	NA
039	006	04	Manganese (Mn)	47.3	ug/L	0.1315	NA
039	006	04	Vanadium (V)	2.9	ug/L	0.0265	NA
			Total			0.3361	0.01
039	006	05	Chlorobenzene	3	ug/L	0.0423	NA
			Total			0.0423	NA
039	006	06	Arsenic (As)	5.6	ug/L	1.1933	124.93
039	006	06	Barium (Ba)	83.9	ug/L	0.0766	NA
039	006	06	Chlorobenzene	4	ug/L	0.0564	NA
039	006	06	Manganese (Mn)	62.8	ug/L	0.1745	NA
039	006	06	bis(2-Ethylhexyl)phthalate (BEHP)	2	ug/L	0.0064	0.42
			Total			1.5072	125.35

Table 10.4.49
Point Estimates of Risk and Hazard - Groundwater
Residential Scenario
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Event	Parameter	Concentration	Units	Hazard Quotient	Risk (E-06)
039	007	04	Arsenic (As)	3.3	ug/L	0.7032	73.62
039	007	04	Barium (Ba)	65.5	ug/L	0.0598	NA
039	007	04	Dioxin Equiv.	0.2845	pg/L	NA	0.76
039	007	04	Manganese (Mn)	41.5	ug/L	0.1153	NA
			Total			0.8784	74.38
039	007	05	No COPCs detected				
039	007	06	Aluminum (Al)	72.2	ug/L	0.0046	NA
039	007	06	Arsenic (As)	9.6	ug/L	2.0457	214.17
039	007	06	Barium (Ba)	62.1	ug/L	0.0567	NA
039	007	06	Manganese (Mn)	58.4	ug/L	0.1623	NA
						2.2692	214.17
039	008	04	2-Methylnaphthalene	5	ug/L	0.0080	NA
039	008	04	Arsenic (As)	9.3	ug/L	1.9817	207.48
039	008	04	Barium (Ba)	45	ug/L	0.0411	NA
039	008	04	Chromium (Cr)	2.1	ug/L	0.0268	NA
039	008	04	Dioxin Equiv.	0.0487	pg/L	NA	0.12
039	008	04	Manganese (Mn)	257	ug/L	0.7143	NA
039	008	04	Naphthalene	110	ug/L	0.1758	NA
039	008	04	Vanadium (V)	2.5	ug/L	0.0228	NA
			Total			2.9706	207.59
039	008	A2	Aluminum (Al)	28.6	ug/L	0.0018	NA
039	008	A2	Barium (Ba)	50.8	ug/L	0.0464	NA
039	008	A2	Dioxin Equiv.	0.06	pg/L	NA	0.14
039	008	A2	Manganese (Mn)	532	ug/L	1.4786	NA
039	008	A2	Naphthalene	13	ug/L	0.0208	NA
039	008	A2	Vanadium (V)	2.5	ug/L	0.0228	NA
			Total			1.5704	0.14
039	008	05	Naphthalene	4	ug/L	0.0064	NA
			Total			0.0064	NA
039	008	06	2-Methylnaphthalene	5	ug/L	0.0138	NA
039	008	06	Aluminum (Al)	2430	ug/L	0.1592	NA
039	008	06	Arsenic (As)	17.3	ug/L	3.7014	394.28
039	008	06	Barium (Ba)	51.6	ug/L	0.0471	NA
039	008	06	Chromium (Cr)	2.9	ug/L	0.0376	NA
039	008	06	Manganese (Mn)	156	ug/L	0.4290	NA
039	008	06	Vanadium (V)	3.8	ug/L	0.0347	NA
			Total			4.4227	394.28
039	08D	04	Arsenic (As)	14.3	ug/L	3.0472	319.02
			Total			3.0472	319.02
039	08D	A2	Aluminum (Al)	18	ug/L	0.0012	NA
039	08D	A2	Arsenic (As)	17.2	ug/L	3.6800	392.01
039	08D	A2	Barium (Ba)	20.6	ug/L	0.0188	NA
039	08D	A2	Beryllium (Be)	0.23	ug/L	0.0029	15.04
039	08D	A2	Dioxin Equiv.	0.05	ug/L	NA	0.12
039	08D	A2	Manganese (Mn)	2200	ug/L	6.0500	NA
039	08D	A2	Naphthalene	2	ug/L	0.0032	NA
			Total			9.7561	407.16
039	08D	05	Naphthalene	2	ug/L	0.0032	NA
			Total			0.0032	NA
039	08D	06	2-Methylnaphthalene	5	ug/L	0.0079	NA
039	08D	06	Aluminum (Al)	187	ug/L	0.0122	NA
039	08D	06	Arsenic (As)	13.1	ug/L	2.8028	298.56
039	08D	06	Barium (Ba)	16.8	ug/L	0.0153	NA
039	08D	06	Beryllium (Be)	0.26	ug/L	0.0033	17.00
039	08D	06	Chromium (Cr)	1.1	ug/L	0.0143	NA
039	08D	06	Manganese (Mn)	2020	ug/L	5.5550	NA
039	08D	06	Naphthalene	4	ug/L	0.0063	NA
			Total			8.4093	315.56
039	009	04	Arsenic (As)	25.1	ug/L	5.3486	559.96
039	009	04	Barium (Ba)	27	ug/L	0.0247	NA

Table 10.4.49
Point Estimates of Risk and Hazard - Groundwater
Residential Scenario
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Event	Parameter	Concentration	Units	Hazard Quotient	Risk (E-06)
039	009	04	Dioxin Equiv.	0.0296	pg/L	NA	0.007
039	009	04	Manganese (Mn)	981	ug/L	2.7266	NA
039	009	04	Trichloroethene	2	ug/L	0.0426	0.51
039	009	04	Vinyl chloride	6	ug/L	NA	196.32
039	009	04	cis-1,2-Dichloroethene	38	ug/L	0.4858	NA
			Total			8.6283	756.79
039	009	A2	Aluminum (Al)	28	ug/L	0.0018	NA
039	009	A2	Arsenic (As)	17.8	ug/L	3.7930	397.10
039	009	A2	Barium (Ba)	35.6	ug/L	0.0326	NA
039	009	A2	Dioxin Equiv.	0.09	pg/L	NA	0.22
039	009	A2	Manganese (Mn)	769	ug/L	2.1374	NA
039	009	A2	Trichloroethene	2	ug/L	0.0426	0.51
039	009	A2	Vinyl chloride	5	ug/L	NA	163.60
039	009	A2	Vanadium (V)	1.2	ug/L	0.0109	NA
039	009	A2	cis-1,2-Dichloroethene	28	ug/L	0.3580	NA
			Total			6.3762	561.43
039	009	05	1,2-Dichloroethene (total)	44	ug/L	1.9668	119.13
039	009	05	Trichloroethene	1	ug/L	0.0213	0.26
039	009	05	Vinyl chloride	10	ug/L	NA	327.20
			Total			1.9881	446.59
039	009	06	1,2-Dichloroethene	38	ug/L	1.6986	102.89
039	009	06	Arsenic (As)	35.5	ug/L	7.5647	791.97
039	009	06	Barium (Ba)	22.7	ug/L	0.0208	NA
039	009	06	Manganese (Mn)	958	ug/L	2.6627	NA
039	009	06	Trichloroethene	2	ug/L	0.0426	0.51
039	009	06	Vinyl chloride	9	ug/L	NA	294.48
			Total			11.9894	1189.84
039	09I	01	No COPCs detected				
039	09I	A2	Barium (Ba)	5.6	ug/L	0.0051	NA
039	09I	A2	Dioxin Equiv.	0.04	pug/L	NA	0.096
039	09I	A2	Manganese (Mn)	350	ug/L	0.9625	NA
039	09I	A2	cis-1,2-Dichloroethene	4	ug/L	0.0509	NA
			Total			1.0185	0.10
039	09I	05	1,2-Dichloroethene (total)	5	ug/L	0.0636	NA
			Total			0.0636	NA
039	09I	06	1,2-Dichloroethene (total)	6	ug/L	0.0763	NA
039	09I	06	Arsenic (As)	3.6	ug/L	0.7702	82.05
039	09I	06	Barium (Ba)	6	ug/L	0.0055	NA
039	09I	06	Chromium (Cr)	1.7	ug/L	0.0220	NA
039	09I	06	Manganese (Mn)	348	ug/L	0.9570	NA
			Total			1.8310	82.05
039	09D	01	No COPCs detected				
039	09D	A2	Aluminum (Al)	18	ug/L	0.0012	NA
039	09D	A2	Barium (Ba)	4.9	ug/L	0.0045	NA
039	09D	A2	Dioxin Equiv.	0.04	pg/L	NA	0.096
039	09D	A2	Manganese (Mn)	119	ug/L	0.3273	NA
			Total			0.3329	0.10
039	09D	05	No COPCs detected				
039	09D	06	Barium (Ba)	4.5	ug/L	0.0041	NA
039	09D	06	Manganese (Mn)	110	ug/L	0.3025	NA
			Total			0.3066	NA
039	010	04	Barium (Ba)	31.5	ug/L	0.0288	NA
039	010	04	Dioxin Equiv.	0.0394	pg/L	NA	0.01
039	010	04	Manganese (Mn)	21.3	ug/L	0.0592	NA
039	010	04	Naphthalene	4	ug/L	0.0064	NA
039	010	04	Vanadium (V)	0.51	ug/L	0.0047	NA
			Total			0.0990	0.01
039	010	A2	Aluminum (Al)	778	ug/L	0.0500	NA

Table 10.4.49
Point Estimates of Risk and Hazard - Groundwater
Residential Scenario
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Event	Parameter	Concentration	Units	Hazard Quotient	Risk (E-06)	
039	010	A2	Arsenic (As)	63.3	ug/L	13.4886	1411.68	
039	010	A2	Barium (Ba)	24.5	ug/L	0.0224	NA	
039	010	A2	Dioxin Equiv.	3.1	pg/L	NA	7.43	
039	010	A2	Manganese (Mn)	97.2	ug/L	0.2702	NA	
039	010	A2	Vanadium (V)	2.2	ug/L	0.0207	NA	
			Total			13.8519	1419.10	
039	010	05	Naphthalene	4.5	ug/L	0.0072	NA	
			Total			0.0072	NA	
039	010	06	2-Methylnaphthalene	5	ug/L	0.0080	NA	
039	010	06	Aluminum (Al)	235.3	ug/L	0.0149	NA	
039	010	06	Barium (Ba)	42.7	ug/L	0.0390	NA	
039	010	06	Manganese (Mn)	5.6	ug/L	0.0156	NA	
039	010	06	Naphthalene	5	ug/L	0.0080	NA	
			Total			0.0855	NA	
039	10I	01	Vinyl chloride	10	ug/L	NA	327.20	
039	10I	01	cis-1,2-Dichloroethene	48	ug/L	0.6137	NA	
			Total			0.6137	327.20	
039	10I	A2	Aluminum (Al)	35.3	ug/L	0.0023	NA	
039	10I	A2	Arsenic (As)	25.6	ug/L	5.4772	583.45	
039	10I	A2	Barium (Ba)	23.4	ug/L	0.0214	NA	
039	10I	A2	Dioxin Equiv.	0.06	pg/L	0.0000	0.14	
039	10I	A2	Manganese (Mn)	3100	ug/L	8.5250	NA	
039	10I	A2	Vinyl chloride	7	ug/L	NA	236.55	
039	10I	A2	cis-1,2-Dichloroethene	42	ug/L	0.5340	NA	
			Total			14.5599	820.14	
039	10I	05	1,2-Dichloroethene (total)	44	ug/L	0.5594	NA	
039	10I	05	Vinyl chloride	8	ug/L	NA	270.34	
			Total			0.5594	270.34	
039	10I	06	1,2-Dichloroethene (total)	29	ug/L	0.3687	NA	
039	10I	06	Arsenic (As)	26.5	ug/L	5.6698	603.96	0.213954
039	10I	06	Barium (Ba)	23.2	ug/L	0.0212	NA	
039	10I	06	Manganese (Mn)	2990	ug/L	8.2225	NA	
039	10I	06	Vinyl chloride	6	ug/L	NA	202.76	
			Total			14.2822	806.72	
039	10D	01	cis-1,2-Dichloroethene	7	ug/L	0.0890	NA	
			Total			0.0890	NA	
039	10D	A2	Aluminum (Al)	16	ug/L	0.0010	NA	
039	10D	A2	Barium (Ba)	12.3	ug/L	0.0112	NA	
039	10D	A2	Dioxin Equiv.	0.07	pg/L	NA	0.17	
039	10D	A2	Manganese (Mn)	72.9	ug/L	0.2005	NA	
039	10D	A2	cis-1,2-Dichloroethene	8	ug/L	0.1017	NA	
			Total			0.3145	0.17	
039	10D	05	No COPCs detected					
039	10D	06	1,2-Dichloroethene (total)	11	ug/L	0.1399	NA	
039	10D	06	Barium (Ba)	11.1	ug/L	0.0101	NA	
039	10D	06	Manganese (Mn)	76.9	ug/L	0.2115	NA	
039	10D	06	Vinyl chloride	3	ug/L	NA	101.38	
			Total			0.3615	101.38	
039	011	04	1,2-Dichloroethane	4	ug/L	0.1788	10.83	
039	011	04	2-Methylnaphthalene	255	ug/L	0.4075	NA	
039	011	04	Aluminum (Al)	137	ug/L	0.0088	NA	
039	011	04	Arsenic (As)	2.5	ug/L	0.5327	55.77	
039	011	04	Azobenzene	6	ug/L	NA	9.82	
039	011	04	Barium (Ba)	9	ug/L	0.0082	NA	
039	011	04	Benzene	190	ug/L	14.2060	163.90	
039	011	04	Dioxin Equiv.	0.35386	pg/L	NA	0.85	
039	011	04	Ethylbenzene	165	ug/L	0.1424	NA	
039	011	04	Manganese (Mn)	37.3	ug/L	0.1037	NA	
039	011	04	Naphthalene	420	ug/L	0.6712	NA	
039	011	04	Vanadium (V)	1.56	ug/L	0.0142	NA	

Table 10.4.49
Point Estimates of Risk and Hazard - Groundwater
Residential Scenario
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Event	Parameter	Concentration	Units	Hazard Quotient	Risk (E-06)
039	011	04	bis(2-Ethylhexyl)phthalate (BEHP)	8	ug/L	0.0256	1.67
			Total			16.2991	242.83
039	011	05	2-Methylnaphthalene	210	ug/L	0.3316	NA
039	011	05	4-Methylphenol	10	ug/L	0.0556	NA
039	011	05	Benzene	140	ug/L	10.6019	61.16
039	011	05	Ethylbenzene	160	ug/L	0.1371	NA
039	011	05	Naphthalene	300	ug/L	0.4737	NA
039	011	05	Pentachlorophenol	2	ug/L	NA	3.57
			Total			11.5999	64.74
039	011	06	2-Methylnaphthalene	95	ug/L	0.1500	NA
039	011	06	4-Methylphenol	22	ug/L	0.1222	NA
039	011	06	Aluminum (Al)	239	ug/L	0.0157	NA
039	011	06	Barium (Ba)	6.6	ug/L	0.0060	NA
039	011	06	Benzene	150	ug/L	11.3592	65.53
039	011	06	Chlormethane	2	ug/L	NA	0.60
039	011	06	Chromium (Cr)	2.2	ug/L	0.0285	NA
039	011	06	Ethylbenzene	140	ug/L	0.1200	NA
039	011	06	Manganese (Mn)	24.6	ug/L	0.0677	NA
039	011	06	Naphthalene	150	ug/L	0.2368	NA
039	011	06	Vanadium (V)	1.5	ug/L	0.0137	NA
			Total			12.1198	66.13
039	012	04	1,1-Dichloroethene	3	ug/L	0.0426	34.58
039	012	04	Arsenic (As)	107	ug/L	22.8006	2387.08
039	012	04	Barium (Ba)	67.5	ug/L	0.0616	NA
039	012	04	Chromium (Cr)	1.8	ug/L	0.0230	NA
039	012	04	Dioxin Equiv.	0.0178	pg/L	NA	0.043
039	012	04	Manganese (Mn)	2230	ug/L	6.1981	NA
039	012	04	Trichloroethene	92	ug/L	1.9604	23.26
039	012	04	Vanadium (V)	0.62	ug/L	0.0057	NA
039	012	04	Vinyl chloride	3	ug/L	NA	98.16
039	012	04	cis-1,2-Dichloroethene	130	ug/L	1.6621	NA
			Total			32.7542	2543.13
039	012	A2	1,1-Dichloroethene	3	ug/L	0.0424	35.21
039	012	A2	Aluminum (Al)	17	ug/L	0.0011	NA
039	012	A2	Arsenic (As)	95.9	ug/L	20.5181	2185.66
039	012	A2	Barium (Ba)	63.1	ug/L	0.0576	NA
039	012	A2	Dioxin Equiv.	0.04	pg/L	NA	0.096
039	012	A2	Manganese (Mn)	2680	ug/L	7.3700	NA
039	012	A2	Trichloroethene	110	ug/L	2.3517	28.26
039	012	A2	Vinyl chloride	4	ug/L	NA	135.17
039	012	A2	cis-1,2-Dichloroethene	170	ug/L	2.1614	NA
			Total			32.5023	2384.39
039	012	05	1,1-Dichloroethene	3	ug/L	0.0424	35.21
039	012	05	1,2-Dichloroethene (total)	160	ug/L	2.0342	NA
039	012	05	Trichloroethene	94	ug/L	2.0096	24.15
			Total			4.0862	59.35
039	012	06	1,1-Dichloroethene	2	ug/L	0.0282	23.47
039	012	06	1,2-Dichloroethene (total)	120	ug/L	1.5257	NA
039	012	06	Aluminum (Al)	158	ug/L	0.0103	NA
039	012	06	Arsenic (As)	109	ug/L	23.3209	2484.22
039	012	06	Barium (Ba)	70.8	ug/L	0.0646	NA
039	012	06	Manganese (Mn)	2080	ug/L	5.7200	NA
039	012	06	Trichloroethene	90	ug/L	1.9241	23.12
039	012	06	Vinyl chloride	2	ug/L	NA	67.59
			Total			32.5939	2598.40
039	12I	04	1,1-Dichloroethene	5	ug/L	0.0710	57.63
039	12I	04	Arsenic (As)	2.2	ug/L	0.4688	49.08
039	12I	04	Barium (Ba)	7.3	ug/L	0.0067	NA
039	12I	04	Dioxin Equiv.	0.00724	pg/L	NA	0.017
039	12I	04	Manganese (Mn)	460	ug/L	1.2785	NA
039	12I	04	Trichloroethene	120	ug/L	2.5571	30.34
039	12I	04	cis-1,2-Dichloroethene	240	ug/L	3.0685	NA
			Total			7.4506	137.07

Table 10.4.49
Point Estimates of Risk and Hazard - Groundwater
Residential Scenario
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Event	Parameter	Concentration	Units	Hazard Quotient	Risk (E-06)
039	12I	A2	1,1-Dichloroethene	4	ug/L	0.0565	46.94
039	12I	A2	Aluminum (Al)	17.3	ug/L	0.0011	NA
039	12I	A2	Barium (Ba)	8.9	ug/L	0.0081	NA
039	12I	A2	Dioxin Equiv.	0.04	pg/L	NA	0.096
039	12I	A2	Manganese (Mn)	507	ug/L	1.3943	NA
039	12I	A2	Trichloroethene	100	ug/L	2.1379	25.69
039	12I	A2	cis-1,2-Dichloroethene	140	ug/L	1.7800	NA
			Total			5.3778	72.73
039	12I	05	1,1-Dichloroethene	5	ug/L	0.0706	58.68
039	12I	05	1,2-Dichloroethene (total)	330	ug/L	4.1956	NA
039	12I	05	Benzene	1	ug/L	0.0757	0.44
039	12I	05	Trichloroethene	110	ug/L	2.3517	28.26
			Total			6.6936	87.37
039	12I	06	1,1-Dichloroethene	6	ug/L	0.0847	70.41
039	12I	06	1,2-Dichloroethene (total)	320	ug/L	4.0685	NA
039	12I	06	Arsenic (As)	4	ug/L	0.8558	91.16
039	12I	06	Barium (Ba)	9.6	ug/L	0.0088	NA
039	12I	06	Benzene	1	ug/L	0.0757	0.44
039	12I	06	Manganese (Mn)	535	ug/L	1.4713	NA
039	12I	06	Trichloroethene	120	ug/L	2.5655	30.83
039	12I	06	Vinyl chloride	2	ug/L	NA	67.59
			Total			9.1302	260.42
039	12D	04	No COPCs detected				
039	12D	A2	Aluminum (Al)	21.3	ug/L	0.0014	NA
039	12D	A2	Barium (Ba)	22.5	ug/L	0.0205	NA
039	12D	A2	Dioxin Equiv.	0.01	ug/L	NA	0.12
039	12D	A2	Manganese (Mn)	9.1	ug/L	0.0250	NA
			Total			0.0470	0.12
039	12D	05	No COPCs detected				
039	12D	06	Aluminum (Al)	103	ug/L	0.0067	NA
039	12D	06	Barium (Ba)	43.5	ug/L	0.0397	NA
			Total			0.0465	NA
039	013	01	1,2-Dichloroethene (total)	32	ug/L		
039	013	01	Aluminum (Al)	11100	ug/L	0.7096	NA
039	013	01	Arsenic (As)	14.4	ug/L	3.0685	321.25
039	013	01	Barium (Ba)	51.3	ug/L	0.0468	NA
039	013	01	Beryllium (Be)	1.2	ug/L	0.0153	76.74
039	013	01	Chromium (Cr)	21.5	ug/L	0.2749	NA
039	013	01	Lead (Pb)	16.5	ug/L	NA	NA
039	013	01	Manganese (Mn)	135	ug/L	0.3752	NA
039	013	01	Tetrachloroethene	25	ug/L	0.3196	20.09
039	013	01	Thallium (Tl)	4.6	ug/L	3.6758	NA
039	013	01	Trichloroethene	6	ug/L	0.1279	1.52
039	013	01	Vanadium (V)	32.6	ug/L	0.2977	NA
039	013	01	bis(2-Ethylhexyl)phthalate (BEHP)	20	ug/L	0.0639	4.16
			Total			8.9753	423.77
039	013	A2	Aluminum (Al)	421	ug/L	0.0276	NA
039	013	A2	Barium (Ba)	10.9	ug/L	0.0100	NA
039	013	A2	Dioxin Equiv.	0.09	pg/L	NA	0.22
039	013	A2	Manganese (Mn)	16.1	ug/L	0.0443	NA
039	013	A2	Tetrachloroethene	30	ug/L	0.3750	23.40
039	013	A2	Trichloroethene	7	ug/L	0.1497	1.80
039	013	A2	cis-1,2-Dichloroethene	34	ug/L	0.4323	NA
			Total			10.5035	454.86
039	013	05	1,2-Dichloroethene (total)	36	ug/L	0.4577	NA
039	013	05	Tetrachloroethene	19	ug/L	0.2375	14.82
039	013	05	Trichloroethene	4	ug/L	0.0855	1.03
			Total			0.7807	15.85
039	013	06	1,2-Dichloroethene (total)	22	ug/L	0.2797	NA
039	013	06	Aluminum (Al)	4370	ug/L	0.2862	NA
039	013	06	Barium (Ba)	25.8	ug/L	0.0236	NA

Table 10.4.49
Point Estimates of Risk and Hazard - Groundwater
Residential Scenario
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Event	Parameter	Concentration	Units	Hazard Quotient	Risk (E-06)
039	013	06	Beryllium (Be)	0.4	ug/L	0.0051	26.15
039	013	06	Chromium (Cr)	8.9	ug/L	0.1154	NA
039	013	06	Manganese (Mn)	157	ug/L	0.4318	NA
039	013	06	Tetrachloroethene	9	ug/L	0.1125	7.02
039	013	06	Trichloroethene	3	ug/L	0.0641	0.77
039	013	06	Vanadium (V)	12.1	ug/L	0.1105	NA
			Total			1.4288	33.94
039	13I	01	Tetrachloroethene	110	ug/L	1.4064	88.39
039	13I	01	Trichloroethene	22	ug/L	0.4688	5.56
039	13I	01	Vinyl chloride	9	ug/L	NA	294.48
039	13I	01	cis-1,2-Dichloroethene	69	ug/L	0.8822	NA
			Total			2.7574	388.44
039	13I	A2	1,1-Dichloroethene	2	ug/L	0.0282	23.47
039	13I	A2	Aluminum (Al)	56.3	ug/L	0.0037	NA
039	13I	A2	Barium (Ba)	18.6	ug/L	0.0170	NA
039	13I	A2	Dioxin Equiv.	0.06	pg/L	NA	0.14
039	13I	A2	Manganese (Mn)	586	ug/L	1.6115	NA
039	13I	A2	Tetrachloroethene	85	ug/L	1.0625	66.30
039	13I	A2	Trichloroethene	41	ug/L	0.8765	10.53
039	13I	A2	Vinyl chloride	7	ug/L	NA	236.55
039	13I	A2	cis-1,2-Dichloroethene	120	ug/L	1.5257	NA
			Total			5.1251	337.00
039	13I	05	1,1-Dichloroethene	3	ug/L	0.0424	35.21
039	13I	05	1,2-Dichloroethene (total)	140	ug/L	1.7800	NA
039	13I	05	Tetrachloroethene	110	ug/L	1.3750	85.80
039	13I	05	Trichloroethene	43	ug/L	0.9193	11.05
039	13I	05	Vinyl chloride	10	ug/L	NA	337.93
			Total			4.1166	469.98
039	13I	06	1,1-Dichloroethene	2	ug/L	0.0282	23.47
039	13I	06	1,2-Dichloroethene (total)	88	ug/L	1.1188	NA
039	13I	06	Arsenic (As)	2.6	ug/L	0.5563	59.26
039	13I	06	Chromium (Cr)	1	ug/L	0.0130	NA
039	13I	06	Naphthalene	3	ug/L	0.0047	NA
039	13I	06	Tetrachloroethene	100	ug/L	1.2500	78.00
039	13I	06	Trichloroethene	22	ug/L	0.4703	5.65
039	13I	06	Vinyl chloride	9	ug/L	NA	304.14
			Total			3.4414	470.52
039	13D	01	Chloroform	7	ug/L	0.0895	9.02
039	13D	01	Tetrachloroethene	33	ug/L	0.4219	26.52
039	13D	01	Trichloroethene	56	ug/L	1.1933	14.16
039	13D	01	cis-1,2-Dichloroethene	70	ug/L	0.8950	NA
			Total			2.5997	49.69
039	13D	A2	1,1-Dichloroethene	3	ug/L	0.0424	35.21
039	13D	A2	Aluminum (Al)	28.8	ug/L	0.0019	NA
039	13D	A2	Barium (Ba)	16	ug/L	0.0146	NA
039	13D	A2	Dioxin Equiv.	0.1	pg/L	NA	0.24
039	13D	A2	Manganese (Mn)	51.2	ug/L	0.1408	NA
039	13D	A2	Tetrachloroethene	48	ug/L	0.6000	37.44
039	13D	A2	Trichloroethene	79	ug/L	1.6889	20.30
039	13D	A2	Vanadium (V)	2.4	ug/L	0.0219	NA
039	13D	A2	Vinyl chloride	7	ug/L	NA	236.55
039	13D	A2	cis-1,2-Dichloroethene	180	ug/L	2.2885	NA
			Total			4.7990	329.73
039	13D	05	1,1-Dichloroethene	4	ug/L	0.0565	46.94
039	13D	05	1,2-Dichloroethene (total)	180	ug/L	2.2885	NA
039	13D	05	Tetrachloroethene	54	ug/L	0.6750	42.12
039	13D	05	Trichloroethene	84	ug/L	1.7958	21.58
039	13D	05	Vinyl chloride	8	ug/L	0.0000	270.34
			Total			4.8158	380.98
039	13D	06	1,1-Dichloroethene	4	ug/L	0.0565	46.94
039	13D	06	1,2-Dichloroethene (total)	160	ug/L	2.0342	NA
039	13D	06	Arsenic (As)	2.1	ug/L	0.4493	47.86
039	13D	06	Barium (Ba)	11	ug/L	0.0100	NA

Table 10.4.49
Point Estimates of Risk and Hazard - Groundwater
Residential Scenario
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Event	Parameter	Concentration	Units	Hazard Quotient	Risk (E-06)
039	13D	06	Manganese (Mn)	42.3	ug/L	0.1163	NA
039	13D	06	Tetrachloroethene	43	ug/L	0.5375	33.54
039	13D	06	Trichloroethene	70	ug/L	1.4965	17.98
039	13D	06	Vinyl chloride	7	ug/L	NA	236.55
			Total			4.7004	382.88
039	014	01	2-Methylnaphthalene	11	ug/L	0.0176	NA
039	014	01	Aluminum (Al)	408	ug/L	0.0261	NA
039	014	01	Arsenic (As)	23	ug/L	4.9011	513.11
039	014	01	Barium (Ba)	42.3	ug/L	0.0386	NA
039	014	01	Benzene	8	ug/L	0.5981	6.90
039	014	01	Lead (Pb)	3	ug/L	NA	NA
039	014	01	Manganese (Mn)	67.7	ug/L	0.1882	NA
039	014	01	Naphthalene	5	ug/L	0.0080	NA
039	014	01	Thallium (Tl)	7.4	ug/L	5.9132	NA
039	014	01	Vanadium (V)	1.3	ug/L	0.0119	NA
039	014	01	bis(2-Ethylhexyl)phthalate (BEHP)	10	ug/L	0.0320	2.08
			Total			11.7347	522.09
039	014	A2	Arsenic (As)	23.8	ug/L	5.0921	542.43
039	014	A2	Barium (Ba)	46.3	ug/L	0.0423	NA
039	014	A2	Benzene	23	ug/L	1.7417	10.05
039	014	A2	Manganese (Mn)	66	ug/L	0.1815	NA
			Total			7.0576	552.47
039	014	05	2-Methylnaphthalene	2	ug/L	0.0032	NA
039	014	05	Benzene	6	ug/L	0.4544	2.62
			Total			0.4575	2.62
039	014	06	2-Methylnaphthalene	6	ug/L	0.0095	NA
039	014	06	Aluminum (Al)	394	ug/L	0.0258	NA
039	014	06	Arsenic (As)	33.1	ug/L	7.0819	754.38
039	014	06	Barium (Ba)	47.9	ug/L	0.0437	NA
039	014	06	Benzene	3	ug/L	0.2272	1.31
039	014	06	Manganese (Mn)	84.7	ug/L	0.2329	NA
			Total			7.6210	755.69
039	14D	01	Aluminum (Al)	46	ug/L	0.0030	NA
039	14D	01	Barium (Ba)	16.4	ug/L	0.0150	NA
039	14D	01	Manganese (Mn)	36.5	ug/L	0.1004	NA
039	14D	01	Vanadium (V)	0.86	ug/L	0.0079	NA
			Total			7.7472	NA
039	14D	A2	Barium (Ba)	13	ug/L	0.0119	NA
039	14D	A2	Manganese (Mn)	34	ug/L	0.0935	NA
			Total			7.9608	NA
039	14D	05	No COPCs detected				
039	14D	06	Arsenic (As)	2.3	ug/L	0.4921	52.42
039	14D	06	Barium (Ba)	12.5	ug/L	0.0114	NA
039	14D	06	Manganese (Mn)	32.1	ug/L	0.0883	NA
			Total			0.5918	52.42
039	015	01	Aluminum (Al)	104	ug/L	0.0066	NA
039	015	01	Arsenic (As)	5.1	ug/L	1.0868	113.78
039	015	01	Barium (Ba)	731	ug/L	0.6676	NA
039	015	01	Beryllium (Be)	0.32	ug/L	0.0041	20.46
039	015	01	Chromium (Cr)	2.4	ug/L	0.0307	NA
039	015	01	Manganese (Mn)	129	ug/L	0.3585	NA
039	015	01	Thallium (Tl)	3.7	ug/L	2.9566	NA
039	015	01	Vanadium (V)	0.54	ug/L	0.0049	NA
			Total			5.1159	134.24
039	015	A2	Aluminum (Al)	201	ug/L	0.0132	NA
039	015	A2	Barium (Ba)	820	ug/L	0.7487	NA
039	015	A2	Chromium (Cr)	33.1	ug/L	0.4291	NA
039	015	A2	Manganese (Mn)	131	ug/L	0.3603	NA
			Total			1.5512	NA

Table 10.4.49
Point Estimates of Risk and Hazard - Groundwater
Residential Scenario
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Event	Parameter	Concentration	Units	Hazard Quotient	Risk (E-06)
039	015	05	No COPCs detected				
039	015	06	Aluminum (Al)	84	ug/L	0.0055	NA
039	015	06	Arsenic (As)	5.45	ug/L	1.1660	124.21
039	015	06	Barium (Ba)	791.5	ug/L	0.7227	NA
039	015	06	Beryllium (Be)	0.215	ug/L	0.0027	14.06
039	015	06	Chromium (Cr)	1.65	ug/L	0.0214	NA
039	015	06	Manganese (Mn)	129.5	ug/L	0.3561	NA
			Total			2.2745	138.27
039	15D	01	Aluminum (Al)	411	ug/L	0.0269	NA
039	15D	01	Barium (Ba)	12.8	ug/L	0.0117	NA
039	15D	01	Chromium (Cr)	1.1	ug/L	0.0143	NA
039	15D	01	Manganese (Mn)	145	ug/L	0.3988	NA
039	15D	01	Vanadium (V)	1.3	ug/L	0.0119	NA
039	15D	01	bis(2-Ethylhexyl)phthalate (BEHP)	6	ug/L	0.0192	1.25
			Total			0.4827	1.25
039	15D	A2	Barium (Ba)	11.6	ug/L	0.0106	NA
039	15D	A2	Manganese (Mn)	140	ug/L	0.3850	NA
			Total			0.3956	NA
039	15D	05	No COPCs detected				
039	15D	06	Barium (Ba)	9	ug/L	0.0082	NA
039	15D	06	Manganese (Mn)	161	ug/L	0.4428	NA
			Total			0.4510	NA

Table 10.4.50
Remedial Goal Options Surface Soil
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	EPC mg/kg	Hazard-Based Remedial Goal Options 3 mg/kg	1 mg/kg	0.1 mg/kg	Risk-Based Remedial Goal Options 1E-06 mg/kg	1E-05 mg/kg	1E-04 mg/kg	Background Concentration mg/kg
Aluminum	NA	1	10181	218781	72927	7293	ND	ND	ND	12786
Arsenic	1.5	0.0003	6.9	66	22	2.2	0.38	3.8	38	9.4
Benzo(a)pyrene equivalents	7.3	NA	1.3	ND	ND	ND	0.060	0.60	6.0	NA
Beryllium	4.3	0.005	0.17	1094	365	36.5	0.13	1.3	13	NA

Worker-Based Remedial Goal Options

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	EPC mg/kg	Hazard-Based Remedial Goal Options 3 mg/kg	1 mg/kg	0.1 mg/kg	Risk-Based Remedial Goal Options 1E-06 mg/kg	1E-05 mg/kg	1E-04 mg/kg	Background Concentration mg/kg
Arsenic	1.5	0.0003	6.9	2398	799	80	2.7	27	271	9.4
Benzo(a)pyrene equivalents	7.3	NA	1.3	ND	ND	ND	0.30	3.0	30	NA

NOTES:

EPC Exposure point concentration
NA Not applicable
ND Not determined
- Remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident or site worker for noncarcinogens

Table 10.4.51
Remedial Goal Options Groundwater
SWMU 39
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Oral SF (mg/kg-day)-1	Oral RfD (mg/kg-day)	EPC mg/l	Hazard-Based Remedial Goal Options 0.1 mg/l	1.0 mg/l	3 mg/l	Risk-Based Remedial Goal Options 1E-06 mg/l	1E-05 mg/l	1E-04 mg/l	Background Concentration mg/l	MCL mg/l
Arsenic	1.5	0.0003	0.043	0.00047	0.0047	0.014	0.000044	0.00044	0.0044	0.0111	0.05
Benzene	0.029	0.003	0.10	0.0017	0.017	0.051	0.0011	0.011	0.11	NA	0.005
Beryllium	4.3	0.005	0.00026	0.0078	0.078	0.23	0.000015	0.00015	0.0015	NA	0.004
Chloroform	0.0061	0.01	0.0036	0.0078	0.078	0.23	0.00077	0.0077	0.077	NA	NA
1,2-Dichloroethane	NA	0.005	0.003	0.0078	0.078	0.23	ND	ND	ND	0.0087	NA
1,1-Dichloroethene	0.6	0.009	0.0034	0.0070	0.070	0.21	0.000086	0.00086	0.0086	NA	0.007
cis-1,2-Dichloroethene	NA	0.01	0.140	0.0078	0.078	0.23	ND	ND	ND	NA	0.07
1,2-Dichloroethene (total)	NA	0.009	0.126	0.0070	0.070	0.21	ND	ND	ND	NA	NA
Dioxin equivalents	156000	NA	0.0000	ND	ND	ND	4.3E-10	4.3E-09	4.3E-08	NA	NA
bis(2-Ethylhexyl)phthalate	0.014	0.02	0.0055	0.031	0.31	0.94	0.0047	0.047	0.47	NA	0.006
Manganese	NA	0.023	2.39	0.036	0.36	1.079	ND	ND	ND	2.69	NA
2-Methylnaphthalene	NA	0.04	0.19	0.063	0.63	1.877	ND	ND	ND	NA	NA
Naphthalene	NA	0.04	0.29	0.063	0.63	1.877	ND	ND	ND	NA	NA
1,1,2,2-Tetrachloroethane	0.2	NA	0.002	ND	ND	ND	0.00016	0.0016	0.016	NA	NA
Tetrachloroethene	0.052	0.01	0.016	0.0078	0.078	0.23	0.0012	0.012	0.12	NA	0.005
Thallium	NA	8E-05	0.00	0.00013	0.0013	0.0038	ND	ND	ND	NA	NA
Vinyl chloride	1.9	NA	0.006	ND	ND	ND	0.000030	0.00030	0.0030	NA	0.002
m+p-Xylene	NA	2	0.043	0.013	0.13	0.40	ND	ND	ND	NA	10

Worker-Based Remedial Goal Options

Chemical	Oral SF (mg/kg-day)-1	Oral RfD (mg/kg-day)	EPC mg/l	Hazard-Based Remedial Goal Options 0.1 mg/l	1.0 mg/l	3 mg/l	Risk-Based Remedial Goal Options 1E-06 mg/l	1E-05 mg/l	1E-04 mg/l	Background Concentration mg/l	MCL mg/l
Arsenic	1.5	0.0003	0.043	0.0031	0.031	0.092	0.00019	0.0019	0.019	0.0111	0.05
Benzene	0.029	0.003	0.10	0.011	0.11	0.33	0.0049	0.049	0.49	NA	0.005
Beryllium	4.3	0.005	0.00026	0.051	0.51	1.5	0.000067	0.00067	0.0067	NA	0.004
Chloroform	0.0061	0.01	0.0036	0.035	0.35	1.1	0.0019	0.019	0.19	NA	NA
1,1-Dichloroethene	0.6	0.009	0.0034	0.048	0.48	1.4	0.0031	0.031	0.31	NA	0.007
cis-1,2-Dichloroethene	NA	0.01	0.14	0.051	0.51	1.5	ND	ND	ND	NA	0.007
1,2-Dichloroethene (total)	NA	0.009	0.13	0.046	0.46	1.4	ND	ND	ND	NA	NA
Manganese	NA	0.023	2.4	0.24	2.4	7.1	ND	ND	ND	2.69	NA
1,1,2,2-Tetrachloroethane	0.2	NA	0.002	ND	ND	ND	0.00071	0.0071	0.071	NA	NA
Tetrachloroethene	0.052	0.01	0.016	0.051	0.51	1.5	0.0053	0.053	0.53	NA	0.005
Thallium	NA	8E-05	0.0025	0.00082	0.0082	0.025	ND	ND	ND	NA	NA
Vinyl chloride	1.9	NA	0.0058	ND	ND	ND	0.00013	0.0013	0.013	NA	0.002

NOTES:

EPC Exposure point concentration
NA Not applicable
ND Not determined
- Remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident or site worker for noncarcinogens

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10.4.9 Corrective Measures Considerations

For SWMU 39, the environmental media investigated were surface soil, subsurface soil, sediment, surface water, and groundwater (shallow, intermediate, and deep). Based on the analytical results and the risk assessment, COCs requiring further evaluation through the CMS process were identified for surface soil and groundwater. Detections of COCs in the subsurface soil also justify inclusion in the CMS process. TPH contamination is suspected to have originated offbase and is being investigated separately by SCDHEC.

Aluminum, arsenic, BEQs, and beryllium, were identified as COCs in soil. Arsenic, benzene, beryllium, bis(2-ethylhexyl)phthalate, chloroform, 1,1-dichloroethene, 1,2-dichloroethane, 1,2-dichloroethene (total), cis-1,2-dichloroethene, dioxin equivalents, manganese, 2-methylnaphthalene, naphthalene, 1,1,2,2-tetrachloroethane, tetrachloroethene, thallium, and vinyl chloride were identified as COCs in groundwater.

Potential corrective measures for the impacted media and respective COCs are in Table 10.4.52. Corrective measures for SWMU 39 are reviewed in more detail in Section 9.

Table 10.4.52
Potential Corrective Measures for SWMU 39

Medium	Compounds	Potential Corrective Measures
Soil	Aluminum, arsenic, BEQs, and beryllium	a) Institutional controls (deed restrictions, etc.) b) Engineering Controls (berms to control overland water flow, etc.) c) Capping d) Hot-spot excavation and disposal/treatment offsite e) Solidification/stabilization (in-situ) f) Vitrification (in-situ) g) Physical separation/acid leaching (ex-situ)
Groundwater	Arsenic, benzene, beryllium, bis(2-ethylhexyl)phthalate, chloroform, 1,1-dichloroethene, 1,2-dichloroethane, 1,2-dichloroethene (total), cis-1,2-dichloroethene, dioxin equivalents, manganese, 2-methylnaphthalene, naphthalene, 1,1,2,2-tetrachloroethane, tetrachloroethene, thallium, and vinyl chloride	a) Institutional controls (deed restrictions, etc.) b) Natural attenuation c) Containment via barrier wall and hydraulic controls d) Reactive wall e) GW extraction and treatment (metal precipitation, adsorption, filtration, oxidation/reduction, UV/ozone oxidation and UV reduction, air stripping, etc.)

10.5 SWMU 42, Former Asphalt Plant Tanks/Boiler Plant and AOC 505, Creosote Cross-Tie/Railroad Ballast Storage Area

SWMU 42 consists of a former asphalt plant site and its associated tanks. The unit operated from 1947 until 1962, and has since been demolished. Because the facility was taken out of service in the early 1960s, little information is available regarding dimensions, design features, operating practices, or waste disposal methods. The site currently contains a concrete rack once used to support asphalt-related aboveground storage tanks (ASTs). The unpaved surrounding area contains rock and asphalt debris.

AOC 505 consists of Building 1803, the former golf course maintenance shop, and a nearby area which was used to store creosote cross-ties and removed railroad ballast during the 1960s and 1970s. Pesticides used at the golf course were handled in Building 1803. The site is currently a graveled area containing asphalt rubble, traces of tar, and other debris. Operations were discontinued at this unit in the 1970s, and little information is available regarding the unit's design features, specific dates of operation, or operating practices.

These overlapping sites are in Zone A's southwest portion, and are bounded by a railroad spur to the west, Noisette Creek to the south, and the railroad storage yard surrounding Building 1614 to the north. The east side of the sites roughly follows a rail spur and divides an open area to the Noisette Creek bridge on Avenue D. Although SWMU 42 was designated for a CSI and AOC 505 an RFI, the investigation of these sites has been conducted simultaneously.

Materials of concern identified in the *Zones A and B RFI Work Plan* (E/A&H, September 1995) for SWMU 42 include VOCs, metals, phenolic compounds, PAHs, petroleum hydrocarbons, and PCBs, and for AOC 505 include VOCs, metals, phenolic compounds, PAHs, chlorinated pesticides and herbicides, and petroleum hydrocarbons. Potential receptors include current and

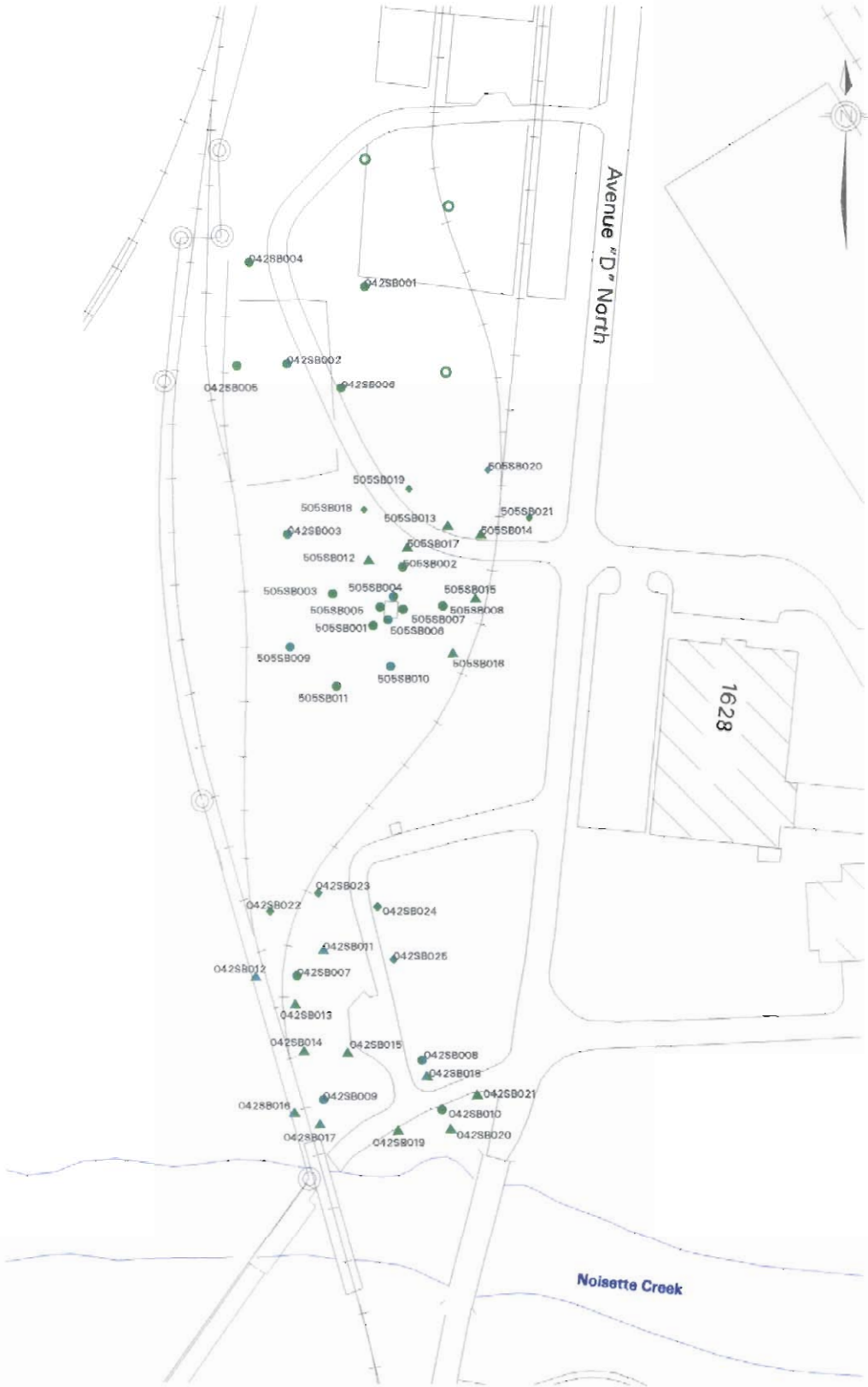
future site users involved in invasive activities. Noisette Creek, to the south, creates the potential for exposure to biological receptors other than humans.

To fulfill CSI and RFI objectives for these sites, soil and groundwater were sampled in accordance with the *Final Zones A and B RFI Work Plan* and as described in Section 3 of this report to confirm whether any contamination resulted from onsite activities at SWMU 42/AOC 505.

10.5.1 Soil Sampling and Analysis

Soil was sampled in three rounds and during a Geoprobe investigation at SWMU 42/AOC 505 locations shown on Figure 10.5.1. The *Final Zones A and B RFI Work Plan* proposed collection of 21 soil samples from the upper interval (0 to 1 foot) and 21 from the lower interval (3 to 5 feet). A total of twenty-one samples were collected from the upper interval and 17 were collected from the lower interval. Four lower-interval samples were not collected due to a water table less than 5 feet bgs; saturated samples were not submitted for analysis. The first round occurred during the Zone A field investigation. Several compounds were detected in soil samples collected at the site during the first round. As part of the Zones A and B second-round RFI sampling, 17 additional soil borings were sampled; six at AOC 505 to delineate the extent of Aroclor-1260 and BEQs, and 11 at SWMU 42 to delineate the extent of BEQs and lead. All 17 of the upper-interval and 16 of the lower-interval second-round samples were collected. One lower-interval location could not be sampled due to auger refusal as a subsurface layer of gravel/debris could not be penetrated.

First-round samples were submitted for analysis at DQO Level III for VOCs, SVOCs, metals, cyanide, pesticides, herbicides, and PCBs. Two duplicates were collected and submitted for Appendix IX analyses at DQO Level IV. SWMU 42 second-round samples were submitted for SVOCs and metals at DQO Level III, and two duplicates were collected at DQO Level IV.



LEGEND

- 1st Round Soil Borings
- 2nd Round Soil Borings
- 3rd Round Soil Borings
- Geoprobe Soil Borings

0 125 feet

Zone A RCRA Facility
Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.5.1 - SWMU 42 and AOC 505
Soil Sample Locations

AOC 505 second-round samples were submitted for SVOCs, pesticides, and PCBs at DQO Level III, with one duplicate collected at DQO Level IV. Also, a Geoprobe investigation was conducted at SWMU 42 based upon the groundwater data from first-quarter groundwater sampling (Section 10.5.3). A groundwater sample and a subsurface soil sample (2' to 4') were collected from each of three Geoprobe borings at the site.

Therefore, three additional soil samples were collected from the Geoprobe interval and analyzed by the onsite laboratory, Analytical Mobile Services, for VOCs using a GC/MS (Method 5030/8260). One sample was duplicated for VOC analysis by Lockheed Analytical Services. Table 10.5.1 summarizes first and second-round sampling for SWMU 42/AOC 505.

Table 10.5.1
SWMU 42/AOC 505
First- and Second-Round Soil Sampling Summary

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper (0' to 1')	21	38	VOCs, SVOCs, metals, herbicides, pesticides, PCBs, and cyanide.	VOCs, SVOCs, metals, herbicides, pesticides, PCBs, and cyanide.[a] SVOCs and metals for 11 second-round samples. SVOCs, pesticides, and PCBs for six second-round samples.	17 additional samples were collected for site characterization.[b]

Table 10.5.1
SWMU 42/AOC 505
First- and Second-Round Soil Sampling Summary

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Lower (3' to 5')	21	33	VOCs, SVOCs, metals, herbicides, pesticides, PCBs, and cyanide.	VOCs, SVOCs, metals, herbicides, pesticides, PCBs, and cyanide.[a] SVOCs and metals for 11 second-round samples. SVOCs, pesticides, and PCBs for five second-round samples.	17 additional samples were collected for site characterization. One not sampled due to auger refusal.[b] High water table prevented collection of 4 samples, as saturated samples were not submitted for analysis.
Geoprobe (2' to 4')	3	3	VOCs	VOCs	None[c]

Notes:
a = First-round samples
b = Second-round samples
c = These samples were collected during the Geoprobe investigation and analyzed by an onsite laboratory; one was duplicated for offsite confirmation analysis.

Third-round soil samples were collected after comparison of first- and second-round analytical results to the USEPA Region III *Risk-Based Concentration Table*, June 1996. This comparison showed that several site samples contained BEQs above the RBC, justifying the collection of eight additional upper-interval and two lower-interval samples for SVOCs. Table 10.5.2 summarizes the third round of sampling at SWMU 42/AOC 505.

Table 10.5.2
SWMU 42/AOC 505
Third-Round Soil Sampling Summary

Interval	Samples Collected	Analyses Performed	Justification
Upper	8[a]	SVOCs	To delineate the extent of BEQs above the RBC in soil.
Lower	2[b]	SVOCs	To delineate the extent of BEQs in subsurface soil.

Notes:
a = Four samples from SWMU 42, four from AOC 505, one duplicate collected from each group.
b = Both samples from AOC 505

10.5.2 Nature and Extent of Contamination in Soil

Organic and inorganic compound analytical results for soil are summarized in Table 10.5.3 and Table 10.5.4. Appendix D is a complete analytical data report for all Zone A samples, including SWMU 42 and AOC 505.

Table 10.5.3
SWMU 42/AOC 505
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (µg/kg)	Mean of Detections (µg/kg)	RBC (µg/kg)	Number of Samples Exceeding RBC
Volatile Organic Compounds (41 samples collected: 21 upper interval, 17 lower interval, and 3 Geoprobe[a] interval samples collected. 2 samples duplicated for Appendix IX analysis)						
Acetone	Upper	1/21	10	NA	7,800,000	0
	Lower	7/17	12 - 55	29	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA

Table 10.5.3
SWMU 42/AOC 505
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Volatile Organic Compounds (41 samples collected: 21 upper interval, 17 lower interval, and 3 Geoprobe[a] interval samples collected. 2 samples duplicated for Appendix IX analysis)						
2-Butanone (MEK)	Upper	0/21	NA	NA	47,000,000	0
	Lower	3/17	1.3 - 16	6.6	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA
Carbon disulfide	Upper	1/21	88	NA	7,800,000	0
	Lower	1/17	2.3	NA	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA
2-hexanone	Upper	0/21	NA	NA	3,100,000	NA
	Lower	1/17	1.2	NA	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA
Methylene chloride	Upper	0/21	NA	NA	85,000	0
	Lower	1/17	2.9	NA	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA
Tetrachloroethene	Upper	1/21	1.3	NA	12,000	0
	Lower	1/17	2.3	NA	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA
Toluene	Upper	4/21	1.3 - 2.0	1.6	16,000,000	0
	Lower	0/17	NA	NA	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA
Trichloroethene	Upper	4/21	1.7 - 5.4	3.0	58,000	0
	Lower	0/17	NA	NA	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA

Table 10.5.3
SWMU 42/AOC 505
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Semivolatile Organic Compounds (81 samples collected: 46 upper interval and 35 lower interval, 9 samples duplicated for Appendix IX analysis)						
BEQ[b]	Upper	28/46	0.12 - 7,353	890	88	22
	Lower	6/35	0.16 - 3,226	1,140	NA	NA
Acenaphthene	Upper	1/46	720	NA	4,700,000	0
	Lower	1/35	120	NA	NA	NA
Acenaphthylene	Upper	6/46	41 - 200	135	4,700,000	0
	Lower	2/35	160 - 485	320	NA	NA
Anthracene	Upper	8/46	67 - 1,400	420	23,000,000	0
	Lower	2/35	310 - 470	390	NA	NA
bis(2-ethylhexyl)-phthalate (BEHP)	Upper	6/46	46 - 99	73	46,000	0
	Lower	4/35	89 - 220	140	NA	NA
Benzo(a)anthracene	Upper	23/46	38 - 5,000	650	880	3
	Lower	5/35	78 - 1,350	700	NA	NA
Benzo(a)pyrene	Upper	24/46	57 - 5,500	680	88	22
	Lower	5/35	88 - 1,900	840	NA	NA
Benzo(b)fluoranthene	Upper	23/46	45 - 5,800	1,010	880	9
	Lower	5/35	91 - 1,750	810	NA	NA
Benzo(g,h,i)perylene	Upper	23/46	61 - 1,800	470	3,100,000[c]	0
	Lower	5/35	72 - 1,850	710	NA	NA
Benzo(k)fluoranthene	Upper	23/46	77 - 5,400	800	8,800	0
	Lower	5/35	90 - 1,600	800	NA	NA
Butylbenzylphthalate	Upper	2/46	160 - 390	280	16,000,000	0
	Lower	0/35	NA	NA	NA	NA

Table 10.5.3
SWMU 42/AOC 505
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Semivolatile Organic Compounds (81 samples collected: 46 upper interval and 35 lower interval, 9 samples duplicated for Appendix IX analysis)						
Carbazole	Upper	3/46	290 - 1,100	610	32,000	0
	Lower	1/35	290	NA	NA	NA
4-chloro-3-methyl-phenol	Upper	1/46	78	NA	NA	NA
	Lower	1/35	86	NA	NA	NA
2-chlorophenol	Upper	0/46	NA	NA	390,000	0
	Lower	1/35	110	NA	NA	NA
Chrysene	Upper	28/46	65 - 5,100	770	88,000	0
	Lower	6/35	91 - 1,700	710	NA	NA
Dibenz(a,h)-anthracene	Upper	14/46	57 - 560	240	88	10
	Lower	4/35	100 - 810	380	NA	NA
Dibenzofuran	Upper	2/46	45 - 460	250	310,000	0
	Lower	2/35	96 - 130	110	NA	NA
di-n-butylphthalate	Upper	4/46	58 - 200	120	7,800,000	0
	Lower	0/35	NA	NA	NA	NA
di-n-octylphthalate	Upper	1/46	49	NA	1,600,000	0
	Lower	0/35	NA	NA	NA	NA
Fluoranthene	Upper	23/46	85 - 9,400	1,400	3,100,000	0
	Lower	6/35	120 - 2,500	1,200	NA	NA
Fluorene	Upper	1/46	780	NA	3,100,000	0
	Lower	1/35	250	NA	NA	NA
Indeno(1,2,3-cd)-pyrene	Upper	23/46	58 - 1,900	440	880	3
	Lower	5/35	65 - 1,750	640	NA	NA

Table 10.5.3
SWMU 42/AOC 505
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Semivolatile Organic Compounds (81 samples collected: 46 upper interval and 35 lower interval, 9 samples duplicated for Appendix IX analysis)						
2-methylnaphthalene	Upper	2/46	38 - 43	41	3,100,000	0
	Lower	3/35	114 - 390	230	NA	NA
3-methylphenol (m-cresol)	Upper	0/46	NA	NA	3,900,000	0
	Lower	1/35	71	NA	NA	NA
4-methylphenol (P-cresol)	Upper	0/46	NA	NA	390,000	0
	Lower	1/35	53	NA	NA	NA
Napthalene	Upper	1/46	480	NA	3,100,000	0
	Lower	3/35	200 - 300	240	NA	NA
N-Nitrosodiphenyl-amine	Upper	1/46	43	NA	130,000	0
	Lower	0/35	NA	NA	NA	NA
Phenanthrene	Upper	18/46	110 - 5,200	630	3,100,000	0
	Lower	6/35	85 - 1,450	520	NA	NA
Phenol	Upper	1/46	78	NA	47,000,000	0
	Lower	1/35	100	NA	NA	NA
Pyrene	Upper	27/46	50 - 6,900	1,050	2,300,000	0
	Lower	7/35	120 - 2,300	920	NA	NA
Pesticides/PCBs (49 samples collected: 27 upper interval and 22 lower interval, 9 samples duplicated for Appendix IX analysis)						
Aldrin	Upper	0/27	NA	NA	38	0
	Lower	1/22	2.4	NA	NA	NA
Aroclor-1260	Upper	5/27	83 - 1,800	630	320	1
	Lower	2/22	26 - 59	43	NA	NA
alpha-chlordane	Upper	5/27	2.0 - 17.0	6.1	1,800	0
	Lower	0/22	NA	NA	NA	NA

Table 10.5.3
SWMU 42/AOC 505
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Pesticides/PCBs (49 samples collected: 27 upper interval and 22 lower interval, 9 samples duplicated for Appendix IX analysis)						
gamma-chlordane	Upper	3/27	3.4 - 17	8.4	1,800	0
	Lower	0/22	NA	NA	NA	NA
4,4'-DDD	Upper	7/27	9.0 - 700	230	2,700	0
	Lower	2/22	1.7 - 3.8	2.8	NA	NA
4,4'-DDE	Upper	16/27	12 - 2,500	200	1,900	1
	Lower	1/22	1.2	NA	NA	NA
4,4'-DDT	Upper	14/27	6.9 - 2,300	210	1,900	1
	Lower	4/22	4.3 - 19.4	9.4	NA	NA
Endosulfan sulfate	Upper	0/27	NA	NA	470,000[d]	0
	Lower	1/22	10	NA	NA	NA
Endrin	Upper	1/27	3.8	NA	23,000	0
	Lower	1/22	4.4	NA	NA	NA
Endrin ketone	Upper	0/3	NA	NA	23,000[e]	0
	Lower	1/6	45	NA	NA	NA
Heptachlor epoxide	Upper	0/27	NA	NA	70	0
	Lower	1/22	6	NA	NA	NA
Dioxins (2 samples collected, 1 upper interval and 1 lower interval)						
TCDD TEQ[b]	Upper	1/1	0.00155	NA	1	0
	Lower	1/1	0.00042	NA	1	0

Notes:
a = Geoprobe interval samples were collected from 2' to 4' bgs.
b = Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995
c = RBC not available for this compound; fluoranthene RBC used as surrogate.
d = RBC not available for this compound; endosulfan RBC used as surrogate.
e = RBC not available for this compound; endrin RBC used as surrogate.
NA = Not applicable

Table 10.5.4
SWMU 42/AOC 505
Inorganics Detected in Soil

Element	Sample Interval	Freq. of Detections	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	Reference Conc. (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding[a]
Inorganics (60 samples collected: 32 upper interval and 28 lower interval, 4 samples duplicated for Appendix IX analysis)							
Aluminum	Upper	32/32	1,200 - 9,700	5,080	12,800	78,000	0
	Lower	28/28	1,710 - 23,900	8,110	28,240	NA	0
Antimony	Upper	8/32	0.36 - 1.5	0.82	**	31	0
	Lower	5/28	0.36 - 13.6	3.35	**	NA	NA
Arsenic	Upper	31/32	1.1 - 62.0	12.5	9.4	0.43	12
	Lower	24/28	1.2 - 21.4	6.2	9.8	NA	4
Barium	Upper	32/32	6.7 - 160	28	53.0	5,500	0
	Lower	28/28	4.0 - 108	24	40.0	NA	3
Beryllium	Upper	14/32	0.09 - 0.38	0.22	**	0.15	11
	Lower	15/28	0.11 - 0.34	0.19	**	NA	NA
Cadmium	Upper	9/32	0.05 - 0.32	0.18	**	39	0
	Lower	4/28	0.05 - 0.41	0.25	**	NA	NA
Calcium	Upper	32/32	267 - 54,500	7,450	NA	NA	NA
	Lower	28/28	179 - 2,890	1,150	NA	NA	NA
Chromium	Upper	32/32	2.6 - 29.2	10.4	50.4	390	0
	Lower	28/28	2.1 - 36.1	12.0	63.4	NA	0
Chromium (hexavalent)	Lower	1/1	0.12	NA	NA	390	0
Cobalt	Upper	18/32	0.26 - 16.6	2.2	4.4	4,700	0
	Lower	14/28	0.21 - 2.3	0.94	1.7	NA	2
Copper	Upper	32/32	1.70 - 192	25.4	165	3,100	0
	Lower	26/28	0.73 - 39.5	5.1	33.7	NA	1
Iron	Upper	32/32	1,760 - 47,500	6,840	NA	NA	NA
	Lower	28/28	1,500 - 36,700	10,100	NA	NA	NA
Lead	Upper	32/32	4.2 - 1,180	120	140	400[b]	2
	Lower	28/28	2.2 - 216	29.7	22.0	400[b]	0

Table 10.5.4
SWMU 42/AOC 505
Inorganics Detected in Soil

Element	Sample Interval	Freq. of Detections	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	Reference Conc. (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding[a]
Inorganics (60 samples collected: 32 upper interval and 28 lower interval, 4 samples duplicated for Appendix IX analysis)							
Magnesium	Upper	32/32	99.8 - 894	356	NA	NA	NA
	Lower	28/28	130 - 1,420	475	NA	NA	NA
Manganese	Upper	32/32	10.2 - 311	58.6	98.1	1,800	0
	Lower	28/28	5.2 - 186	28.0	85.5	NA	1
Mercury	Upper	10/32	0.07 - 0.35	0.17	0.30	23	0
	Lower	3/28	0.05 - 0.23	0.12	**	NA	NA
Nickel	Upper	21/32	0.86 - 20.0	6.4	13.6	1,600	0
	Lower	17/28	0.62 - 6.7	2.8	35.0	NA	0
Potassium	Upper	29/32	128 - 952	342	NA	NA	NA
	Lower	24/28	131 - 965	527	NA	NA	NA
Selenium	Upper	9/32	0.35 - 1.2	0.7	1.2	390	0
	Lower	6/28	0.49 - 1.9	1.0	1.7	NA	1
Sodium	Upper	28/32	59.2 - 433	196	NA	NA	NA
	Lower	28/28	57.5 - 796	198	NA	NA	NA
Thallium	Upper	1/32	0.42	NA	**	6.3	0
	Lower	1/28	0.48	NA	**	NA	NA
Tin	Upper	15/32	0.79 - 28.5	7.5	**	47,000	0
	Lower	8/28	0.57 - 10.1	4.6	**	NA	NA
Vanadium	Upper	32/32	3.90 - 39.9	11.7	29.2	550	0
	Lower	28/28	2.60 - 52.1	15.6	77.3	NA	0
Zinc	Upper	32/32	8.30 - 303	66.2	208	23,000	0
	Lower	28/28	2.40 - 364	34.1	165	NA	1

Notes:
a = Number of samples exceeding both RBC and RC in upper interval or number of samples exceeding the RC in the lower interval.
b = RBC not available for lead. USEPA residential soil cleanup level used for comparison (OSWER Directive 9355.4-12).
** = Number of nondetects prevented determination of UTL.
NA = Not applicable

Volatile Organic Compounds in Soil

Eight VOCs were detected in soil samples collected at SWMU 42/AOC 505. None of these detections exceeded their RBCs. Also, none of the detections exceeded their SSLs.

Semivolatile Organic Compounds in Soil

Twenty-nine SVOCs were detected in soil samples collected at SWMU 42/AOC 505. The five compounds detected in soil above their respective RBCs were benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. Because all of the RBC exceedances were cPAH compounds, the BEQ calculation summarizes these samples. BEQs exceeded the benzo(a)pyrene RBC (88 μg/kg) in 22 of the surface soil samples; the data are shown on Figure 10.5.2.

BEQs were detected in six second-interval soil samples: 042SB01302 (477 μg/kg), 042SB01702 (2,297 μg/kg), 042SB01902 (112 μg/kg), 505SB00402 (731 μg/kg), 505SB01702 (3,226 μg/kg), and 505SB00502 (0.16 μg/kg).

Four compounds exceeded their SSLs in upper-interval soil samples: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and carbazole. All of these, with the exception of carbazole, contribute to BEQ, which also exceeded the SSL for benzo(a)pyrene in upper-interval samples.

Two compounds exceeded their SSLs in lower-interval soil samples: benzo(a)anthracene (730 μg/kg) and dibenz(a,h)anthracene (700 μg/kg). Benzo(a)anthracene was detected at 1,300 μg/kg and 1,350 μg/kg in samples 042SB01702 and 505SB01702, respectively. Dibenz(a,h)anthracene was detected at 810 μg/kg in sample 505SB01702.

Pesticides/PCBs in Soil

Eleven pesticides were detected in soil samples at SWMU 42/AOC 505. Two of these compounds (DDE and DDT) were detected above the respective RBCs in sample 042SB01001.

One PCB, Aroclor-1260, was detected in five upper-interval samples at SWMU 42/AOC 505. Only one sample, 505SB00801 (1,800 μg/kg) exceeds the RBC (320 μg/kg). All of the detections are near Building 1803. Second-round sampling was conducted to define the extent of PCB contamination at the site. All second-round samples were nondetect for Aroclor-1260.

Aroclor-1260 also exceeded its SSL (1,000 μg/kg) in sample 505SB00801. This was the only pesticide or PCB SSL exceedance. The lower-interval sample (505SB00802), with a detection of 59 μg/kg, did not exceed the SSL.

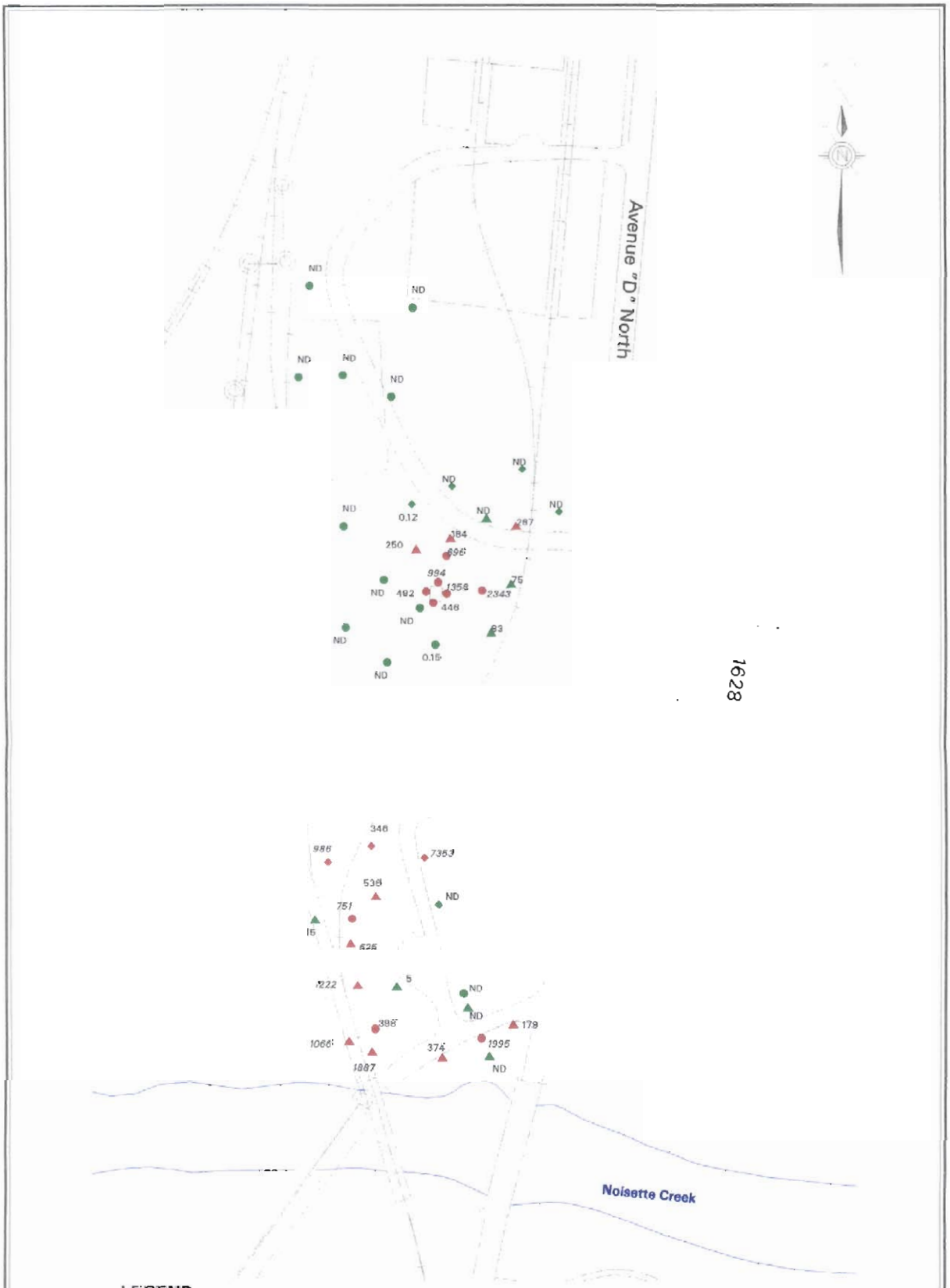
Other Organic Compounds in Soil

Dioxins were detected in one sample from each interval at SWMU 42/AOC 505. The calculated TEQs were below the 2,3,7,8-TCDD RBC of 1 μg/kg.

Inorganics in Soil

Twenty-four metals were detected in soil at SWMU 42/AOC 505. Based upon the comparisons made in the table, 14 of these warrant further evaluation: antimony, arsenic, barium, beryllium, cadmium, cobalt, copper, lead, manganese, mercury, selenium, thallium, tin, and zinc.

Antimony's five second interval detections, ranging from 0.36 mg/kg to 13.6 mg/kg, do not have an RC or RBC for comparison. The largest of these detections, sample 505SB00101, exceeds the SSL (2.7 mg/kg). All other antimony detections were below the SSL.



Zone A RCRA Facility Investigation Report
Naval Base Charleston, Charleston, SC

FIGURE 10.5.2 - SWMU 42 and AOC 505 Upper Interval BEQ Detections in Soil

1628

Arsenic was detected in the majority of soil samples at SWMU 42/AOC 505. Twelve upper-interval samples exceeded both the RBC for arsenic as a carcinogen (0.43 mg/kg) and the RC (9.4 mg/kg). The maximum of these detections was 62.0 mg/kg. Also, four lower-interval samples were detected above the RC for arsenic. However, only one (042SB01702) exceeded the SSL for arsenic of 15 mg/kg.

Barium exceeded the RC (40 mg/kg) in three second-interval samples: 042SB01402, 042SB07102, and 505SB00402. None of these detections exceeded the SSL for barium (820 mg/kg).

Beryllium exceeded the RBC (0.15 mg/kg) in 11 upper-interval samples. All detections (maximum of 0.38 mg/kg) were less than the SSL for beryllium of 32 mg/kg. All 15 of the lower-interval beryllium detections were also below the SSL.

Cadmium's four lower-interval detections do not have an RC or RBC for comparison. All of these detections were below the SSL for cadmium of 4 mg/kg.

Cobalt was detected above the RC (1.7 mg/kg) in two lower-interval samples. Neither of these detections exceeded the SSL for cobalt (990 mg/kg).

Copper was detected above the RC (33.7 mg/kg) in one lower-interval sample. These detection does not exceed the SSL for copper (5,600 mg/kg).

Lead exceeded the USEPA residential soil cleanup guidance level of 400 mg/kg in two upper-interval samples, 505SB00601 (491 mg/kg) and 042SB00901 (1,180 mg/kg). Second-round sampling was conducted in the southern portion of SWMU 42 to define the extent of lead contamination. None of the lower- interval lead detections exceeded 400 mg/kg.

Manganese exceeded the RC (85.5 mg/kg) in one lower-interval sample, 505SB00702. This detection did not exceed the SSL for manganese (550 mg/kg).

Mercury detections in three lower-interval samples have no RC or RBC for comparison. These detections (maximum 0.23 mg/kg) were below the SSL for mercury of 1 mg/kg.

Selenium exceeded the RC (1.7 mg/kg) in one lower interval sample, 042SB00202. This detection does not exceed the SSL for selenium of 2.6 mg/kg.

Thallium was detected in one upper- and one lower-interval sample at SWMU 42/AOC 505. The upper interval sample was below the RBC, and the lower-interval detection (0.48 mg/kg) does not have an RC or RBC for comparison. The SSL for thallium (0.35 mg/kg) was exceeded in this sample, 042SB01402.

Tin's eight lower-interval detections do not have an RC or RBC for comparison. All detections were below the SSL for tin (5,500 mg/kg).

Zinc exceeded the RC (165 mg/kg) in one lower-interval sample, 042SB01402. This detection does not exceed the SSL for zinc of 6,800 mg/kg.

10.5.3 Groundwater Sampling and Analysis

The *Final Zones A and B RFI Work Plan* proposed the installation of four shallow monitoring wells at SWMU 42/AOC 505. Three are in the northern portion of SWMU 42 and the other is near Building 1803 in the AOC 505 investigation area.

Groundwater at SWMU 42/AOC 505 was also investigated during the Zone A Geoprobe investigation. A subsurface soil sample (2' to 4') and a shallow aquifer groundwater sample were

collected from each of three borings. Also, a shallow and deep groundwater sample were collected from two additional Geoprobe borings. All groundwater sampling locations for SWMU 42/AOC 505 are shown on Figure 10.5.31. The Geoprobe investigation will be discussed in greater detail after the presentation of monitoring well data in this section.

After installation and development of all four wells proposed in the *Final Zones A and B RFI Work Plan*, the first-round RFI samples were collected. Groundwater samples were collected for VOCs, SVOCs, metals, cyanide, herbicides, pesticides, and PCBs at DQO Level III. Because chlorinated compounds were detected in the first-round samples, the Geoprobe investigation was proposed. Prior to conducting the geoprobe investigation, an interim round of samples was collected from all four wells for VOC analysis at DQO Level III. These samples were collected on April 3, 1996.

Sampling parameters for the second, third, and fourth-quarter (round) sampling events were reduced to VOCs and metals at DQO Level III based upon first-quarter detections. Second, third, and fourth-round samples were collected by the CEERD in April, June, and October 1996, respectively. Table 10.5.5 summarizes groundwater sampling at SWMU 42/AOC 505.

The shallow monitoring wells were installed at 13 feet bgs in the upper sand aquifer. All wells were installed as described in Section 3.3 of this report.

10.5.4 Nature and Extent of Contamination in Groundwater

Tables 10.5.6 and 10.5.7 summarizes organic and inorganic groundwater analytical results for SWMU 42/AOC 505. Appendix D is a complete analytical data report for all Zone A samples, including those collected at SWMU 42/AOC 505.

Table 10.5.5
SWMU 42/AOC 505
Groundwater Sampling Summary

Event	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Dec. 1995 (1st round)	4[a]	4[a]	VOCs, SVOCs, metals, cyanide, herbicides, PCBs, and pesticides.	VOCs, SVOCs, metals, cyanide, herbicides, PCBs, and pesticides.	None
April 3, 1996 (Interim round)	4[a]	4[a]	VOCs[b]	VOCs[b]	None
April 24, 1996 (2nd round)	4[a]	4[a]	VOCs and metals[c]	VOCs and metals[c]	None
June 1996 (3rd round)	4[a]	4[a]	VOCs and metals[c]	VOCs and metals[c]	None
October 1996 (4th round)	4[a]	4[a]	VOCs and metals[c]	VOCs and metals[c]	None

Notes:
a = Four wells consist of three shallow wells at SWMU 42 and one shallow well at AOC 505.
b = Interim analyses consisted of VOCs only to confirm chlorinated solvent detections prior to implementation of the Geoprobe investigation.
c = Second- and third-round parameters were based upon detections in the first-round sampling.

Table 10.5.6
SWMU 42/AOC 505
Organic Compounds Detected in Groundwater

Compound	Sampling Event	Sampling Interval	Frequency of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	RBC (μg/L)	Number of Samples Exceeding RBC
Volatile Organic Compounds (4 shallow groundwater samples collected during each event)							
Carbon disulfide	Dec. 95	Shallow	0/4	NA	NA	1,000	0
	03 Apr. 96	Shallow	0/4	NA	NA	1,000	0
	24 Apr. 96	Shallow	0/4	NA	NA	1,000	0
	June 96	Shallow	1/4	1.6	NA	1,000	0
	Oct. 96	Shallow	0/4	NA	NA	1,000	0

Table 10.5.6
SWMU 42/AOC 505
Organic Compounds Detected in Groundwater

Compound	Sampling Event	Sampling Interval	Frequency of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	RBC (μg/L)	Number of Samples Exceeding RBC
Volatile Organic Compounds (4 shallow groundwater samples collected during each event)							
Chlorobenzene	Dec. 95	Shallow	1/4	1.3	NA	39	0
	03 Apr. 96	Shallow	0/4	NA	NA	39	0
	24 Apr. 96	Shallow	0/4	NA	NA	39	0
	June 96	Shallow	0/4	NA	NA	39	0
	Oct. 96	Shallow	0/4	NA	NA	39	0
Chloromethane	Dec. 95	Shallow	1/4	7.8	NA	1.4	1
	03 Apr. 96	Shallow	0/4	NA	NA	1.4	0
	24 Apr. 96	Shallow	0/4	NA	NA	1.4	0
	June 96	Shallow	0/4	NA	NA	1.4	0
	Oct. 96	Shallow	0/4	NA	NA	1.4	0
1,2-dichloro-benzene	Dec. 95	Shallow	1/4	1.8	NA	64	0
	03 Apr. 96	Shallow	0/4	NA	NA	64	0
	24 Apr. 96	Shallow	0/4	NA	NA	64	0
	June 96	Shallow	0/4	NA	NA	64	0
	Oct. 96	Shallow	0/4	NA	NA	64	0
1,3-dichloro-benzene	Dec. 95	Shallow	1/4	1.8	NA	540	0
	03 Apr. 96	Shallow	0/4	NA	NA	540	0
	24 Apr. 96	Shallow	0/4	NA	NA	540	0
	June 96	Shallow	0/4	NA	NA	540	0
	Oct. 96	Shallow	0/4	NA	NA	540	0

Table 10.5.6
SWMU 42/AOC 505
Organic Compounds Detected in Groundwater

Compound	Sampling Event	Sampling Interval	Frequency of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	RBC (μg/L)	Number of Samples Exceeding RBC
Volatile Organic Compounds (4 shallow groundwater samples collected during each event)							
1,4-dichloro-benzene	Dec. 95	Shallow	1/4	2.0	NA	0.44	1
	03 Apr. 96	Shallow	0/4	NA	NA	0.44	0
	24 Apr. 96	Shallow	0/4	NA	NA	0.44	0
	June 96	Shallow	0/4	NA	NA	0.44	0
	Oct. 96	Shallow	0/4	NA	NA	0.44	0
1,1-dichloro-ethene	Dec. 95	Shallow	1/4	1.0	NA	0.044	1
	03 Apr. 96	Shallow	0/4	NA	NA	0.044	0
	24 Apr. 96	Shallow	0/4	NA	NA	0.044	0
	June 96	Shallow	0/4	NA	NA	0.044	0
	Oct. 96	Shallow	0/4	NA	NA	0.044	0
Ethylbenzene	Dec. 95	Shallow	1/4	1.2	NA	1,300	0
	03 Apr. 96	Shallow	0/4	NA	NA	1,300	0
	24 Apr. 96	Shallow	0/4	NA	NA	1,300	0
	June 96	Shallow	0/4	NA	NA	1,300	0
	Oct. 96	Shallow	0/4	NA	NA	1,300	0
1,1,2,2-tetra-chloroethane	Dec. 95	Shallow	1/4	1.5	NA	0.052	1
	03 Apr. 96	Shallow	0/4	NA	NA	0.052	0
	24 Apr. 96	Shallow	0/4	NA	NA	0.052	0
	June 96	Shallow	0/4	NA	NA	0.052	0
	Oct. 96	Shallow	0/4	NA	NA	0.052	0

Table 10.5.6
SWMU 42/AOC 505
Organic Compounds Detected in Groundwater

Compound	Sampling Event	Sampling Interval	Frequency of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	RBC (μg/L)	Number of Samples Exceeding RBC
Volatile Organic Compounds (4 shallow groundwater samples collected during each event)							
tetrachloro-ethene	Dec. 95	Shallow	1/4	5.9	NA	1.1	1
	03 Apr. 96	Shallow	0/4	NA	NA	1.1	0
	24 Apr. 96	Shallow	1/4	1.5	NA	1.1	1
	June 96	Shallow	1/4	1.4	NA	1.1	1
	Oct. 96	Shallow	0/4	NA	NA	1.1	0
trichloroethene	Dec. 95	Shallow	0/4	NA	NA	1.6	0
	03 Apr. 96	Shallow	0/4	NA	NA	1.6	0
	24 Apr. 96	Shallow	1/4	1.4	NA	1.6	0
	June 96	Shallow	1/4	1.6	NA	1.6	0
	Oct. 96	Shallow	0/4	NA	NA	1.6	0
o-xylene	Dec. 95	Shallow	1/4	1.4	NA	12,000	0
	03 Apr. 96	Shallow	0/4	NA	NA	12,000	0
	24 Apr. 96	Shallow	0/4	NA	NA	12,000	0
	June 96	Shallow	0/4	NA	NA	12,000	0
	Oct. 96	Shallow	0/4	NA	NA	12,000	0
Xylene (m+p)	Dec. 95	Shallow	1/4	3.5	NA	12,000	0
	03 Apr. 96	Shallow	0/4	NA	NA	12,000	0
	24 Apr. 96	Shallow	0/4	NA	NA	12,000	0
	June 96	Shallow	0/4	NA	NA	12,000	0
	Oct. 96	Shallow	0/4	NA	NA	12,000	0

Note:
NA = Not applicable

Table 10.5.7
SWMU 42/AOC 505
Inorganics Detected in Groundwater

Compound	Sampling Event	Sampling Interval	Freq. of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (4 shallow groundwater samples collected during each event)								
Aluminum	Dec. 95	Shallow	4/4	229 - 2,020	890	3,210	37,000	0
	Apr. 96	Shallow	3/4	1,230 - 27,200	10,100	3,210	37,000	0
	June 96	Shallow	4/4	77 - 6,760	1,880	3,210	37,000	0
	Oct. 96	Shallow	1/4	364	NA	3,210	37,000	0
Arsenic	Dec. 95	Shallow	0/4	NA	NA	7.4	0.045	0
	Apr. 96	Shallow	0/4	NA	NA	7.4	0.045	0
	June 96	Shallow	1/4	9.0	NA	7.4	0.045	1
	Oct. 96	Shallow	2/4	2.9 - 6.4	4.6	7.4	0.045	0
Barium	Dec. 95	Shallow	3/4	14.9 - 53.6	34.7	104	2,600	0
	Apr. 96	Shallow	0/4	NA	NA	104	2,600	0
	June 96	Shallow	4/4	9.5 - 41.7	22.3	104	2,600	0
	Oct. 96	Shallow	4/4	9.6 - 30.9	17.2	104	2,600	0
Cadmium	Dec. 95	Shallow	0/4	NA	NA	**	18	0
	Apr. 96	Shallow	0/4	NA	NA	**	18	0
	June 96	Shallow	0/4	NA	NA	**	18	0
	Oct. 96	Shallow	1/4	0.29	NA	**	18	0
Calcium	Dec. 95	Shallow	4/4	15,700 - 78,800	52,300	NA	NA	NA
	Apr. 96	Shallow	3/4	27,400 - 13,400	89,100	NA	NA	NA
	June 96	Shallow	4/4	10,800 - 117,000	66,800	NA	NA	NA
	Oct. 96	Shallow	4/4	8,630 - 108,000	41,400	NA	NA	NA
Chromium	Dec. 95	Shallow	1/4	4.9	NA	8.7	180	0
	Apr. 96	Shallow	2/4	6.4 - 45.9	26.2	8.7	180	0
	June 96	Shallow	1/4	9.7	NA	8.7	180	0
	Oct. 96	Shallow	0/4	NA	NA	8.7	180	0

Table 10.5.7
SWMU 42/AOC 505
Inorganics Detected in Groundwater

Compound	Sampling Event	Sampling Interval	Freq. of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (4 shallow groundwater samples collected during each event)								
Cobalt	Dec. 95	Shallow	1/4	25.0	NA	**	2,200	0
	Apr. 96	Shallow	2/4	12.7 - 20.9	16.8	**	2,200	0
	June 96	Shallow	1/4	14.0	NA	**	2,200	0
	Oct. 96	Shallow	1/4	12.1	NA	**	2,200	0
Copper	Dec. 95	Shallow	2/4	7.5 - 9.9	8.7	15.7	1,500	0
	Apr. 96	Shallow	1/4	12.2	NA	15.7	1,500	0
	June 96	Shallow	2/4	6.7 - 7.1	6.9	15.7	1,500	0
	Oct. 96	Shallow	2/4	2.0 - 5.5	3.7	15.7	1,500	0
Iron	Dec. 95	Shallow	4/4	260 - 25,800	9,800	NA	NA	NA
	Apr. 95	Shallow	4/4	2,570 - 32,300	18,600	NA	NA	NA
	June 96	Shallow	4/4	2,260 - 32,100	12,500	NA	NA	NA
	Oct. 96	Shallow	4/4	192 - 28,000	8,130	NA	NA	NA
Lead	Dec. 95	Shallow	0/4	NA	NA	4.7	15[a]	0
	Apr. 96	Shallow	2/4	2.1 - 7.6	4.9	4.7	15[a]	0
	June 96	Shallow	2/4	2.2 - 2.5	2.4	4.7	15[a]	0
	Oct. 96	Shallow	1/4	1.6	NA	4.7	15[a]	0
Magnesium	Dec. 95	Shallow	4/4	4,900 - 23,400	11,100	NA	NA	NA
	Apr. 96	Shallow	4/4	3,800 - 43,900	16,100	NA	NA	NA
	June 96	Shallow	4/4	3,370 - 35,200	13,500	NA	NA	NA
	Oct. 96	Shallow	4/4	2,790 - 9,370	6,350	NA	NA	NA
Manganese	Dec. 95	Shallow	4/4	232 - 827	444	577	840	0
	Apr. 96	Shallow	4/4	281 - 692	492	577	840	0
	June 96	Shallow	4/4	287 - 656	451	577	840	0
	Oct. 96	Shallow	4/4	18.6 - 533	273	577	840	0

Table 10.5.7
SWMU 42/AOC 505
Inorganics Detected in Groundwater

Compound	Sampling Event	Sampling Interval	Freq. of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (4 shallow groundwater samples collected during each event)								
Nickel	Dec. 95	Shallow	0/4	NA	NA	**	730	0
	Apr. 96	Shallow	0/4	NA	NA	**	730	0
	June 96	Shallow	0/4	NA	NA	**	730	0
	Oct. 96	Shallow	1/4	0.9	NA	**	730	0
Potassium	Dec. 95	Shallow	4/4	2,250 - 9,300	6,750	NA	NA	NA
	Apr. 96	Shallow	4/4	3,140 - 11,800	6,550	NA	NA	NA
	June 96	Shallow	4/4	3,950 - 10,800	6,620	NA	NA	NA
	Oct. 96	Shallow	4/4	4,600 - 12,700	8,910	NA	NA	NA
Selenium	Dec. 95	Shallow	0/4	NA	NA	**	180	0
	Apr. 96	Shallow	0/4	NA	NA	**	180	0
	June 96	Shallow	0/4	NA	NA	**	180	0
	Oct. 96	Shallow	1/4	3.1	NA	**	180	0
Silver	Dec. 95	Shallow	0/4	NA	NA	**	180	0
	Apr. 96	Shallow	0/4	NA	NA	**	180	0
	June 96	Shallow	0/4	NA	NA	**	180	0
	Oct. 96	Shallow	1/4	111	NA	**	180	0
Sodium	Dec. 95	Shallow	4/4	9,280 - 109,000	60,900	NA	NA	NA
	Apr. 96	Shallow	0/4	NA	NA	NA	NA	NA
	June 96	Shallow	4/4	11,300 - 108,000	77,300	NA	NA	NA
	Oct. 96	Shallow	3/4	19,900 - 80,300	59,000	NA	NA	NA
Tin	Dec. 95	Shallow	0/4	NA	NA	**	22,000	0
	Apr. 96	Shallow	0/4	NA	NA	**	22,000	0
	June 96	Shallow	0/4	NA	NA	**	22,000	0
	Oct. 96	Shallow	2/4	23.3 - 51.4	37.3	**	22,000	0

Table 10.5.7
SWMU 42/AOC 505
Inorganics Detected in Groundwater

Compound	Sampling Event	Sampling Interval	Freq. of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (4 shallow groundwater samples collected during each event)								
Vanadium	Dec. 95	Shallow	0/4	NA	NA	5.4	260	0
	Apr. 96	Shallow	1/4	61.0	NA	5.4	260	0
	June 96	Shallow	1/4	9.0	NA	5.4	260	0
	Oct. 96	Shallow	1/4	1.5	NA	5.4	260	0
Zinc	Dec. 95	Shallow	2/4	66.5 - 99.6	83.1	83.2	11,000	0
	Apr. 96	Shallow	0/4	NA	NA	83.2	11,000	0
	June 96	Shallow	1/4	25.6	NA	83.2	11,000	0
	Oct. 96	Shallow	0/4	NA	Na	83.2	11,000	0

Notes:
a = Lead does not have an RBC. Therefore, the USEPA Treatment Technique Action Level (TTAL) of 15 μg/L has been substituted for the RBC.
** = Number of nondetects prevented determination of UTL.

Volatile Organic Compounds in Groundwater

Thirteen VOCs were detected in groundwater samples collected at SWMU 42/AOC 505; six exceeded their RBCs in one or more samples. The first-round sample from monitoring well NBCA-505-001 contained 3 of these exceedances – 1,4-dichlorobenzene, 1,1-dichloroethene, and 1,1,2,2-tetrachloroethane. These compounds were not detected in any other samples from this monitoring well or any other monitoring wells at this site. Similarly, chloromethane exceeded its RBC in its only site detection, the first-quarter sample from monitoring well NBCA-042-001.

Tetrachloroethene (PCE) and trichloroethene (TCE) were only detected in monitoring well NBCA-042-001. PCE was detected in three samples (first-, second-, and third-quarter) and each

of these detections exceeded the RBC (1.1 μg/L). TCE was detected in second- and third-quarter samples only, with the third-quarter detection equaling the RBC (1.6 μg/L).

The PCE and TCE detections at the north end of this site justified pushing five Geoprobe borings (see previous Figure 10.5.3) to better define the extent of solvent contamination in groundwater. The Geoprobe samples for onsite VOC analysis were assigned the following identification numbers:

- Boring 042-GP-001 – Sample ID 042GP00109
- Boring 042-GP-002 – Sample ID 042GP00202
- Boring 042-GP-003 – Sample ID 042GP00306
- Boring 042-GP-004 – Sample ID's 042GP00401 (shallow) and 042GP00402 (deep)
- Boring 042-GP-005 – Sample ID's 042GP00501 (shallow) and 042GP00502 (deep)

For the first three Geoprobe borings, the last two digits were used to designate the depth of the top of the 2-foot screen used for sample collection. No VOCs were detected in any of the samples analyzed by the onsite laboratory, including a sample collected from monitoring well NBCA-042-001. The monitoring well was not purged before collecting the sample for onsite analysis.

The duplicate for offsite analysis came from Sample 042GP00306. It was designated 042GP003LH and submitted to Lockheed Analytical Services for analysis. Toluene (2.6 μg/L) was the only VOC detected in this sample. For the last two Geoprobe borings, the last two digits were used to designate the groundwater interval (-01 for shallow and -02 for deep). No VOCs were detected in any of these samples.

LEGEND

- Shallow Monitoring Wells
- Geoprobe Locations

0 125 feet

Zone A RCRA Facility
Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.5.3 - SWMU 42 and AOC 505
Groundwater Sample Locations

Based upon this Geoprobe investigation, there are no data gaps related to the extent of chlorinated solvent contamination in groundwater at SWMU 42/AOC 505. These detections, however, have been included in the presentation (mapping) of the chlorinated solvent plume at SWMU 39.

Semivolatile Organic Compounds in Groundwater

No SVOCs were detected in groundwater samples collected at SWMU 42/AOC 505.

Herbicides and Pesticides/PCBs in Groundwater

None of these compounds were detected in groundwater samples collected at SWMU 42/AOC 505.

Inorganics in Groundwater

Twenty metals were detected in shallow groundwater at SWMU 42/AOC 505. Arsenic in the third-quarter sample from NBCA-505-001 was the only detection (9.0 μg/L) exceeding both its RC (7.4 μg/L) and RBC (0.045 μg/L). However, the arsenic detection did not exceed the RC (11.1 μg/L) for the deep portion of the surficial aquifer.

10.5.5 Fate and Transport Assessment for SWMU 42 and AOC 505

Due to their proximity, SWMU 42 and AOC 505 are discussed concurrently (as "combined SWMU 42") for fate and transport assessment. Potential contaminant migration pathways for combined SWMU 42 include soil constituents leaching to groundwater, groundwater constituent migration to surface water, constituent migration through surface soil erosion, and emission of VOCs from surface soil to ambient air. Environmental media sampled as part of the combined SWMU 42 CSI/RFI and considered in the fate and transport assessment are surface soil, subsurface soil, and shallow groundwater.

10.5.5.1 SWMU 42 — Soil to Groundwater Cross-Media Transport

Tables 10.5.8 and 10.5.9 compare the maximum detected concentrations of organic and inorganic chemicals reported in soil to risk-based soil screening levels considered protective of groundwater. As shown on Table 10.5.8, six organics — benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, carbazole, and Aroclor-1260 — were identified for further evaluation of soil to groundwater migration based on the screening process presented in Section 6. None of these organic constituents were reported in combined SWMU 42 groundwater. As shown in Table 10.5.9, five inorganics — antimony, arsenic, chromium (total), lead, and thallium — were identified for further evaluation of soil to groundwater migration. Antimony and thallium were not reported in groundwater samples collected from combined SWMU 42.

One organic, PCE, exceeded its MCL in well NBCA-042-001, but was not further evaluated for soil to groundwater migration because only two soil samples (505SB00501 and 505SB00702) detected PCE. The detections did not exceed the SSL and are near Building 1803, approximately 300 feet south of NBCA-042-001. Furthermore, PCE was not detected in groundwater samples from well NBCA-505-001 which is downgradient and near soil borings SB005 and SB007.

Of the six organics retained for further evaluation of soil to groundwater migration, only benzo(a)anthracene and dibenzo(a,h)anthracene were reported in subsurface soil at concentrations exceeding their corresponding soil to groundwater SSL. Benzo(a)anthracene exceeded its soil to groundwater SSL in five surface soil samples (042SB010, 042SB017, 042SB024, 505SB007, and 505SB008) and in two subsurface soil samples (042SB017 and 505SB017). Dibenzo(a,h)anthracene exceeded its soil to groundwater SSL in one subsurface soil sample only (505SB017). Benzo(a)pyrene exceeded its soil to groundwater SSL in one surface soil sample (042SB024). Benzo(b)fluoranthene and carbazole exceeded their respective soil to groundwater SSLs in the same two surface soil samples (042SB010 and 042SB024). Aroclor-1260 exceeded its soil to groundwater SSL in one surface soil sample (505SB008). With the exceptions of dibenzo(a,h)anthracene and Aroclor-1260, the maximum concentrations of each chemical exceeding its soil to groundwater SSL were detected in the same surface soil sample (042SB024).

Table 10.5.8
Organic Compounds Detected in Surface Soil, Subsurface Soil, Shallow Groundwater, and Deep Groundwater
Comparison to Cross-media SSLs, Tap Water RBCs, and Saltwater Surface Water Chronic Screening Levels
NAVBASE-Charleston, Zone A: SWMU 42 and AOC 505
Charleston, South Carolina

Parameter	Maximum Concentration				Screening Concentration *									
	Surface Soil	Subsurface Soil	Shallow GW	Deep GW	Soil to GW	Soil to Air	Tap Water RBC	Saltwater Surf. Wtr. Chronic	Soil Units	Water Units	Leaching Potential	Volatil-ization Potential	Ground-Water Migration Concern	Surface Water Migration Concern
Volatile Organic Compounds														
Acetone	10	55	ND	NA	8000	100000000	3700	NA	ug/kg	ug/L	NO	NO	NO	NO
2-Butanone	ND	16	ND	NA	3900 c	NA	1900	NA	ug/kg	ug/L	NO	NO	NO	NO
Carbon disulfide	88	2.3	1.6	NA	16000	720000	1000	NA	ug/kg	ug/L	NO	NO	NO	NO
Chlorobenzene	ND	ND	1.3	NA	700	130000	39	105	ug/kg	ug/L	NO	NO	NO	NO
Chloromethane	ND	ND	7.8	NA	3.4 c	63	1.4	NA	ug/kg	ug/L	NO	NO	YES	NO
1,1-Dichloroethene	ND	ND	1	NA	30	70	0.044	NA	ug/kg	ug/L	NO	NO	YES	NO
Ethylbenzene	ND	ND	1.2	NA	6500	400000	1300	4.3	ug/kg	ug/L	NO	NO	NO	NO
2-Hexanone	ND	1.2	ND	NA	3700 c	NA	1500	NA	ug/kg	ug/L	NO	NO	NO	NO
Methylene chloride	ND	2.9	ND	NA	10	13000	4.1	2600	ug/kg	ug/L	NO	NO	NO	NO
1,1,2,2-Tetrachloroethane	ND	ND	1.5	NA	1.5	600	0.052	90	ug/kg	ug/L	NO	NO	YES	NO
Tetrachloroethene	1.3	2.3	5.9	NA	30	11000	1.1	45	ug/kg	ug/L	NO	NO	YES	NO
Trichloroethene	ND	ND	1.6	NA	30	5000	1.6	NA	ug/kg	ug/L	NO	NO	NO	NO
Xylene	ND	ND	3.5	NA	70000 c	320000	12000	NA	ug/kg	ug/L	NO	NO	NO	NO
o-Xylene	ND	ND	1.4	NA	95000	410000	12000	NA	ug/kg	ug/L	NO	NO	NO	NO
Semivolatile Organic Compounds														
Acenaphthene	720	120	ND	NA	290000	NA	2200	9.7	ug/kg	ug/L	NO	NO	NO	NO
Acenaphthylene	200	485	ND	NA	96000 c	NA	1500	NA	ug/kg	ug/L	NO	NO	NO	NO
Anthracene	490	470	ND	NA	5900000	NA	11000	NA	ug/kg	ug/L	NO	NO	NO	NO
Benzo(g,h,i)perylene	1800	1850	ND	NA	1.2E+08 c	NA	1500	NA	ug/kg	ug/L	NO	NO	NO	NO
Benzo(a)pyrene equivalents														
Benzo(a)anthracene	5000	1350	ND	NA	800	NA	0.092	NA	ug/kg	ug/L	YES	NO	NO	NO
Benzo(a)pyrene	5500	1900	ND	NA	4000	NA	0.0092	NA	ug/kg	ug/L	YES	NO	NO	NO
Benzo(b)fluoranthene	5800	1750	ND	NA	2500	NA	0.092	NA	ug/kg	ug/L	YES	NO	NO	NO
Benzo(k)fluoranthene	5400	1600	ND	NA	25000	NA	0.92	NA	ug/kg	ug/L	NO	NO	NO	NO
Chrysene	5100	1700	ND	NA	80000	NA	9.2	NA	ug/kg	ug/L	NO	NO	NO	NO
Dibenzo(a,h)anthracene	560	805	ND	NA	800	NA	0.0092	NA	ug/kg	ug/L	YES	NO	NO	NO
Indeno(1,2,3-cd)pyrene	1900	1750	ND	NA	7000	NA	0.092	NA	ug/kg	ug/L	NO	NO	NO	NO
Butylbenzylphthalate	390	ND	ND	NA	8100000	930000	7300	29	ug/kg	ug/L	NO	NO	NO	NO
Carbazole	1100	290	ND	NA	300	NA	3.4	NA	ug/kg	ug/L	YES	NO	NO	NO
4-Chloro-3-methylphenol	78	86	ND	NA	4300 c	NA	NA	NA	ug/kg	ug/L	NO	NO	NO	NO
2-Chlorophenol	ND	110	ND	NA	2000	53000000	180	NA	ug/kg	ug/L	NO	NO	NO	NO
Dibenzofuran	460	130	ND	NA	42000 c	120000	150	NA	ug/kg	ug/L	NO	NO	NO	NO
Di-n-butylphthlate	200	ND	ND	NA	2700000	2300000	3700	3.4	ug/kg	ug/L	NO	NO	NO	NO
1,2-Dichlorobenzene	ND	ND	1.8	NA	8500	560000	64	20	ug/kg	ug/L	NO	NO	NO	NO
1,3-Dichlorobenzene	ND	ND	1.8	NA	8700 c	NA	540	29	ug/kg	ug/L	NO	NO	NO	NO
1,4-Dichlorobenzene	ND	ND	2	NA	1000	1E+09	0.44	20	ug/kg	ug/L	NO	NO	YES	NO
Di-n-octylphthalate	49	ND	ND	NA	1.2E+09	10000000	730	NA	ug/kg	ug/L	NO	NO	NO	NO
bis(2-Ethylhexyl)phthalate	99	220	ND	NA	1800000	31000000	4.8	NA	ug/kg	ug/L	NO	NO	NO	NO
Fluoranthene	9400	2500	ND	NA	2100000	NA	1500	1.6	ug/kg	ug/L	NO	NO	NO	NO
Fluorene	780	245	ND	NA	280000	NA	1500	NA	ug/kg	ug/L	NO	NO	NO	NO
2-Methylnaphthalene	43	390	ND	NA	230000 c	NA	1500	NA	ug/kg	ug/L	NO	NO	NO	NO
3-Methylphenol	ND	71	ND	NA	6700 c	NA	1800	NA	ug/kg	ug/L	NO	NO	NO	NO
4-Methylphenol (p-cresol)	ND	53	ND	NA	670 c	NA	180	NA	ug/kg	ug/L	NO	NO	NO	NO

Table 10.5.8
Organic Compounds Detected in Surface Soil, Subsurface Soil, Shallow Groundwater, and Deep Groundwater
Comparison to Cross-media SSLs, Tap Water RBCs, and Saltwater Surface Water Chronic Screening Levels
NAVBASE-Charleston, Zone A: SWMU 42 and AOC 505
Charleston, South Carolina

Parameter	Maximum Concentration				Screening Concentration *									
	Surface Soil	Subsurface Soil	Shallow GW	Deep GW	Soil to GW	Soil to Air	Tap Water RBC	Saltwater Surf. Wtr. Chronic	Soil Units	Water Units	Leaching Potential	Volatil-ization Potential	Ground-Water Migration Concern	Surface Water Migration Concern
Naphthalene	480	300	ND	NA	42000	NA	1500	24	UG/KG	UG/L	NO	NO	NO	NO
N-Nitrosodiphenylamine	43	ND	ND	NA	600	NA	0.0096	NA	UG/KG	UG/L	NO	NO	NO	NO
Phenanthrene	5200	1450	ND	NA	900000 c	NA	1500	NA	UG/KG	UG/L	NO	NO	NO	NO
Phenol	78	100	ND	NA	50000	NA	22000	58	UG/KG	UG/L	NO	NO	NO	NO
Pyrene	6900	2300	ND	NA	2100000	NA	1100	NA	UG/KG	UG/L	NO	NO	NO	NO
Pesticides/PCB Compounds														
Aldrin	ND	2.4	ND	NA	250	3000	0.004	0.13	UG/KG	UG/L	NO	NO	NO	NO
Aroclor-1260	1800	59	ND	NA	1000	1000	0.034	0.03	UG/KG	UG/L	YES	YES	NO	NO
alpha-Chlordane	17	ND	ND	NA	5000	20000	0.19	0.004	UG/KG	UG/L	NO	NO	NO	NO
gamma-Chlordane	17	ND	ND	NA	5000	20000	0.19	0.004	UG/KG	UG/L	NO	NO	NO	NO
4,4'-DDD	700	3.8	ND	NA	8000	NA	0.28	0.025	UG/KG	UG/L	NO	NO	NO	NO
4,4'-DDE	2500	1.2	ND	NA	27000	NA	0.2	0.14	UG/KG	UG/L	NO	NO	NO	NO
4,4'-DDT	2300	19.4	ND	NA	16000	1E+09	0.2	0.001	UG/KG	UG/L	NO	NO	NO	NO
Endosulfan sulfate	ND	10	ND	NA	9000	NA	220	0.0087	UG/KG	UG/L	NO	NO	NO	NO
Endrin	3.8	4.4	ND	NA	500	NA	11	0.0023	UG/KG	UG/L	NO	NO	NO	NO
Endrin ketone	ND	45	ND	NA	500	NA	11	NA	UG/KG	UG/L	NO	NO	NO	NO
Heptachlor epoxide	ND	6	ND	NA	350	5000	0.0012	0.0036	UG/KG	UG/L	NO	NO	NO	NO
Dioxin Compounds														
Dioxin (TCDD TEQ)	1.549	0.421	ND	NA	1600 c	NA	0.45	10	NG/KG	PG/L	NO	NO	NO	NO

Explanations of screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.5.3 and 10.5.6.

* Screening Concentrations:
Soil to GW - Generic SSLs based on DAF = 10, adapted from USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or calculated using values from T
Soil to Air - From USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or USEPA Region III Risk-Based Concentration Table, June 1996
Tap Water RBC - From USEPA Region III Risk-Based Concentration Table, October 1997
Salt Water Surface Water Chronic - From USEPA Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment, November 1995, Table 2

c - Calculated soil to groundwater SSL value (See Table 6.2)
GW - Groundwater
NA - Not available
ND - Not detected
RBC - Risk-based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
NG/KG - Nanograms per kilogram
UG/KG - Micrograms per kilogram
PG/L - Picograms per liter
UG/L - Micrograms per liter

Table 10.5.9
Inorganic Chemicals Detected in Surface Soil, Subsurface Soil, Shallow Groundwater, and Deep Groundwater
Comparison to Cross-media SSLs, Tap Water RBCs, Saltwater Surface Water Chronic Screening Levels, and Background Reference Values
NAVBASE-Charleston, Zone A: SWMU 42 and AOC 505
Charleston, South Carolina

Parameter	Maximum Concentration				Screening Concentration *											
	Surface Soil	Subsurface Soil	Shallow GW	Deep GW	Soil to GW	Soil Background Reference	Soil to Air	Tap Water RBC	GW Background Reference	Saltwater Surf. Wtr. Chronic	Soil Units	Water Units	Leaching Potential	Fugitive Particulate Inhalation Concern	Ground-Water Migration Concern	Surface Water Migration Concern
Inorganic Chemicals																
Aluminum	9700	23900	27200	NA	560000 c	28240	NA	37000	3210	NA	MG/KG	UG/L	NO	NO	NO	NO
Antimony	1.5	13.6	ND	NA	2.5	ND	NA	15	ND	NA	MG/KG	UG/L	YES	NO	NO	NO
Arsenic	62	21.4	9	NA	15	9.8	750	0.045	11.1	36	MG/KG	UG/L	YES	NO	NO	NO
Barium	160	108	53.6	NA	820	53	690000	2600	179	NA	MG/KG	UG/L	NO	NO	NO	NO
Beryllium	0.38	0.34	ND	NA	32	ND	1300	0.016	ND	NA	MG/KG	UG/L	NO	NO	NO	NO
Cadmium	0.032	0.41	0.29	NA	4	ND	1800	18	ND	9.3	MG/KG	UG/L	NO	NO	NO	NO
Chromium (total)	29.2	36.1	45.9	NA	19	63.4	270	180	8.7	103	MG/KG	UG/L	YES	NO	NO	NO
Chromium (hexavalent)	ND	0.12	ND	NA	19	ND	270	180	ND	50	MG/KG	UG/L	NO	NO	NO	NO
Cobalt	16.6	2.3	25	NA	990 c	4.4	NA	2200	12.1	NA	MG/KG	UG/L	NO	NO	NO	NO
Copper	192	39.5	12.2	NA	5600 c	165	NA	130000	15.7	2.9	MG/KG	UG/L	NO	NO	NO	YES
Lead	1180	216	7.6	NA	400	140	400	15	4.7	8.5	MG/KG	UG/L	YES	YES	NO	NO
Manganese	311	186	827	NA	550 c	98.1	NA	840	2690	NA	MG/KG	UG/L	NO	NO	NO	NO
Mercury	0.35	0.23	ND	NA	1	0.3	10	11	ND	0.2	MG/KG	UG/L	NO	NO	NO	NO
Nickel	20	6.7	0.9	NA	65	35	13000	730	21.1	42	MG/KG	UG/L	NO	NO	NO	NO
Selenium	1.2	1.9	3.1	NA	2.5	1.7	NA	180	ND	71	MG/KG	UG/L	NO	NO	NO	NO
Silver	ND	ND	111	NA	17	ND	NA	180	ND	0.23	MG/KG	UG/L	NO	NO	NO	YES
Thallium	0.42	0.48	ND	NA	0.35	ND	NA	2.9	2	21	MG/KG	UG/L	YES	NO	NO	NO
Tin	28.5	10.1	51.4	NA	5500 c	ND	NA	22000	ND	NA	MG/KG	UG/L	NO	NO	NO	NO
Vanadium	39.9	52.1	61	NA	3000	77.3	NA	260	10.9	NA	MG/KG	UG/L	NO	NO	NO	NO
Zinc	303	364	99.6	NA	6200	208	NA	11000	83.2	86	MG/KG	UG/L	NO	NO	NO	YES

Explanations of screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.5.4 and 10.5.7.

* Screening Concentrations:
Soil to GW - Generic SSLs based on DAF = 10, adapted from USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or calculated using values from Table 6.2
Soil to Air - From USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or USEPA Region III Risk-Based Concentration Table, June 1996
Tap Water RBC - From USEPA Region III Risk-Based Concentration Table, October 1997
Salt Water Surface Water Chronic - From USEPA Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment, November 1995, Table 2
Background reference values for soil are shown for comparison purposes only.
Maximum groundwater concentrations are screened against the greater of tap water RBCs or corresponding background reference values to determine groundwater migration concern.

c - Calculated soil to groundwater SSL value (See Table 6.2)
GW - Groundwater
NA - Not available/Not applicable
ND - Not detected
RBC - Risk based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
UG/L - Micrograms per liter

Antimony exceeded its soil to groundwater SSL in one subsurface soil sample (505SB001), but was not detected in any surface soil samples. Arsenic exceeded its groundwater protection SSL in eight surface soil samples (042SB014, 042SB016, 042SB017, 042SB020, 042SB021, 505SB002, 505SB007, and 505SB010) and in one subsurface soil sample (042SB017). Lead exceeded its soil to groundwater SSL in two surface soil samples (042SB009 and 505SB005). Thallium exceeded its soil to groundwater SSL in one surface soil sample (042SB011) and one subsurface soil sample (042SB014). Chromium was detected at concentrations exceeding its soil to groundwater SSL at three surface soil sample locations (042SB010, 042SB017, and 505SB008) and at five subsurface soil sample locations (042SB001, 042SB002, 042SB004, 042SB005, and 042SB011). Chromium, however, was not reported in any soil sample at a concentration exceeding its background reference value. For screening purposes chromium was conservatively assumed to exist in its soluble hexavalent state. Hexachrome analyses at combined SWMU 42 and elsewhere in Zone A suggest that chromium in soil exists predominantly in less soluble valence states.

Antimony and thallium were not detected in groundwater through four quarters of groundwater sampling. Chromium and lead were not detected in groundwater at concentrations above their respective tap water RBCs through four quarters of groundwater sampling. Generally, combined SWMU 42 soil concentrations of antimony, chromium, and lead are consistent with background concentrations. Except for arsenic, combined SWMU 42 inorganic soil concentrations do not indicate a significant soil- to-groundwater migration concern.

Of the organic parameters identified as combined SWMU 42 soil-to-groundwater migration concerns, the PAH compounds benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene most frequently exceeded the SSLs. Subsurface soil concentrations of these PAH compounds are lower than surface soil concentrations such that only benzo(a)anthracene and dibenz(a,h)anthracene exceed the SSLs at depth. The extent of subsurface soil PAH contamination is much smaller in area than

in surface soil. Additionally, these PAH compounds were not present in the combined SWMU 42 shallow aquifer, although generally the quantitation limits for these PAHs are higher than their tap water RBCs.

Aroclor-1260 and carbazole exceeded the SSLs infrequently so that a widespread threat to the shallow aquifer is not indicated. Additionally, neither of these organic constituents were detected in shallow groundwater, although the quantitation limit for Aroclor-1260 in groundwater is generally higher than its tap water RBC. These findings indicate that, although isolated leaching from soil has the potential to occur, combined SWMU 42 soil concentrations do not present an imminent or widespread threat to the shallow aquifer.

10.5.5.2 SWMU 42 — Groundwater to Surface Water Cross-Media Transport

Tables 10.5.8 and 10.5.9 also compare maximum detected shallow groundwater concentrations from four sampling rounds at combined SWMU 42 to tap water RBCs, saltwater surface water chronic AWQCs, and background reference values for inorganics.

As shown on Table 10.5.8, five organic constituents — chloromethane, 1,1-dichloroethene, 1,1,2,2-tetrachloroethane, tetrachloroethene, and 1,4-dichlorobenzene — were detected in shallow groundwater above corresponding tap water RBCs. Tetrachloroethene was reported at monitoring well location NBCA505001 in the first three quarters of sampling at concentrations of 5.9 μg/L, 1.5 μg/L, and 1.4 μg/L, respectively; each of these concentrations exceeds the tap water RBC for tetrachloroethene (1.1 μg/L). Chloromethane exceeded its tap water RBC in the first quarter groundwater sample collected from monitoring well NBCA042001, but was not reported in subsequent sampling rounds. 1,1-Dichloroethene, 1,1-tetrachloroethane, and 1,4-dichlorobenzene were each reported at a concentration slightly exceeding their respective tap water RBCs in the first quarter of groundwater sampling collected from NBCA505001. None of these chemicals were reported in subsequent sampling rounds. None of the organic constituents which exceeded

their tap water RBCs were reported at concentrations exceeding saltwater surface water chronic screening levels.

As shown on Table 10.5.9, arsenic was the only inorganic that was detected in groundwater samples that exceeded its tap water RBC (0.045 μg/L). However, the maximum reported groundwater concentration of arsenic (9 μg/L) was between the corresponding background reference values for arsenic in the shallow (7.4 μg/L) and deep (11.1 μg/L) portions of the surficial aquifer. Copper, silver, and zinc each exceeded their corresponding saltwater surface water chronic screening value. Copper was reported at concentrations exceeding its saltwater surface water chronic screening value at two locations in first quarter groundwater samples (NBCA042002 and NBCA505001), one location in second quarter groundwater samples (NBCA042003), two locations in third quarter groundwater samples (NBCA042003 and NBCA505001) and one location in fourth quarter groundwater samples (NBCA042001). The maximum concentration of copper (12.2 μg/L) did not, however, exceed either the tap water RBC for copper (130,000 μg/L), or the background reference value for copper (15.7 μg/L). Silver was reported at a concentration exceeding its saltwater surface water chronic screening level at one location in the fourth quarter of groundwater sampling (NBCA042003). The maximum reported concentration of silver in groundwater (111 μg/L) did not exceed its tap water RBC (180 μg/L). A background reference value was not available for silver in groundwater. Silver was not detected in surface soil or subsurface soil, nor was it detected in any other groundwater sample. Zinc was reported at a concentration exceeding its saltwater surface water chronic screening level in one shallow groundwater sample in the first quarter (NBCA042002). Zinc was not detected at a concentration exceeding its saltwater surface water chronic screening value in any subsequent sampling rounds. The maximum reported concentration of zinc in groundwater (99.6 μg/L) did not exceed the tap water RBC for zinc (11,000 μg/L).

10.5.5.3 SWMU 42 — Soil-to-Air Cross-Media Transport

Tables 10.5.8 and 10.5.9 also list the organic compounds detected in surface soil samples from combined SWMU 42, along with corresponding soil-to-air volatilization screening levels. Aroclor-1260 and lead are the only chemicals that exceeded their corresponding soil-to-air volatilization screening levels. Aroclor-1260 was reported in a single surface soil sample at a concentration of 1,800 μg/kg, which is only marginally above its soil-to-air SSL of 1,000 μg/kg. Lead was reported at concentrations exceeding its soil-to-air SSL (140 mg/kg) in 8 surface soil samples (042SB009, 042SB010, 042SB011, 042SB013, 042SB014, 042SB020, 505SB005, and 505SB008). Only two of these samples yielded lead concentrations exceeding its action level of 400 mg/kg (042SB009 - 1,180 mg/kg and 505SB005 - 491 mg/kg). The maximum surface soil concentration of no volatile organic compound exceeded its corresponding soil-to-air volatilization screening level. These findings suggest that the soil-to-air migration pathway would not be expected to be significant at combined SWMU 42.

10.5.5.4 SWMU 42 — Fate and Transport Summary

PAHs and arsenic were the primary chemicals exceeding soil-to-groundwater SSLs. PAHs were reported at their highest concentrations in the surface soil sample collected from 042SB024, indicating a potential hot spot. However, PAHs were not reported in groundwater samples at combined SWMU 42, suggesting that the PAHs are not migrating to groundwater. Arsenic was reported in groundwater samples, but not at a concentration exceeding its background reference value. Therefore, arsenic in soil is not expected to be a significant source of soil-to-groundwater contamination. Inorganics exceeding saltwater surface water chronic screening values were generally consistent with background reference values, and are not expected to be significant at combined SWMU 42. Aroclor-1260 and lead were the only chemicals exceeding soil-to-air screening values, but are not expected to be significant at combined SWMU 42. Aroclor-1260 was only detected above its soil-to-air SSL once, and only marginally exceeded the SSL. Although the maximum concentration of lead was nearly 3 times the soil-to-air SSL, all other reported lead

concentrations were generally consistent with its soil-to-air SSL and soil-to-groundwater SSL of 400 mg/kg.

10.5.6 Human Health Risk Assessment for SWMU 42 (includes AOC 505)

10.5.6.1 Site Background and Investigative Approach

SWMU 42 was formerly an asphalt plant and AOC 505 was formerly the golf course maintenance shop. Primary concerns include potential impacts from aboveground storage tanks associated with the former asphalt plant, potential releases resulting from the storage of creosote-covered cross-ties and railroad ballasts, and potential releases of pesticides from the golf course maintenance shop. The aboveground storage tanks and the maintenance building remain on this site, which is currently used as a contractor staging and drum storage area. Gravel and asphalt debris cover the exposed portion of the grounds.

Twenty-one soil samples were collected from the upper interval as part of the original RFI. An additional seventeen surface soil samples were collected during second-round sampling to fill benzo(a)pyrene equivalents, PCBs, and lead data gaps. Eight third round surface soil samples were collected and analyzed for SVOCs. Groundwater samples were collected from four wells completed in the shallow aquifer.

10.5.6.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 of this RFI and presented in Table 10.5.10, the focus of this HHRA is on the following COPCs: Aroclor-1260, arsenic, benzo(a)pyrene equivalents, beryllium, 4,4'-DDE, 4,4'-DDT, lead, and manganese. 4,4'-DDD was added to the list of COPCs based on its chemical and toxicological similarities to 4,4'-DDE and 4,4'-DDT. Wilcoxon rank sum test analyses did not result in the inclusion of any inorganic parameters that had otherwise been screened out on the basis of background concentrations.

Table 10.5.10
Chemicals Present in Site Samples
SWMU 42/AOC 505 Surface Soil
NAVBASE-Charleston, Zone A
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration RBC	Reference	Units	Number Exceeding RBC	Ref.
Volatile Organics													
Acetone		1	21	10	10	10	11	16	780000	NA	ug/kg		
Carbon disulfide		1	21	88	88	88	5.3	7.9	780000	NA	ug/kg		
Tetrachloroethene		1	21	1.3	1.3	1.3	5.3	7.9	12000	NA	ug/kg		
Toluene		4	21	1.3	2	1.6	5.3	7.9	1600000	NA	ug/kg		
Trichloroethene		4	21	1.7	5.4	3	5.3	7.9	58000	NA	ug/kg		
Semivolatile Organics													
Acenaphthene		1	46	720	720	720	370	1000	470000	NA	ug/kg		
Acenaphthylene		6	46	41	200	135	370	1000	230000	NA	ug/kg		
Anthracene		8	46	67	1400	418	370	950	2300000	NA	ug/kg		
Benzo(g,h,i)perylene		23	46	61	1800	473	370	920	230000	NA	ug/kg		
Benzo(a)pyrene Equiv.	*	29	46	0.12	7389.1	857	NA	NA	88	NA	ug/kg	22	
Benzo(a)anthracene	*	23	46	38	5000	651	370	920	880	NA	ug/kg	3	
Benzo(a)pyrene	*	24	46	57	5500	685	370	920	88	NA	ug/kg	22	
Benzo(b)fluoranthene	*	23	46	45	5800	1011	380	920	880	NA	ug/kg	9	
Benzo(k)fluoranthene		23	46	77	5400	797	370	1000	8800	NA	ug/kg		
Chrysene		28	46	65	5100	771	370	920	88000	NA	ug/kg		
Dibenz(a,h)anthracene	*	14	46	57	560	242	370	950	88	NA	ug/kg	10	
Indeno(1,2,3-cd)pyrene	*	23	46	58	1900	439	370	920	880	NA	ug/kg	3	
Butylbenzylphthalate		2	46	160	390	275	370	1000	1600000	NA	ug/kg		
Carbazole		3	46	290	1100	607	370	980	32000	NA	ug/kg		
4-Chloro-3-methylphenol		1	46	78	78	78	370	2000	39000	NA	ug/kg		
Dibenzofuran		2	46	45	460	253	370	1000	31000	NA	ug/kg		
Di-n-butylphthalate		4	46	58	200	117	370	1000	780000	NA	ug/kg		
Di-n-octyl phthalate		1	46	49	49	49	370	1000	160000	NA	ug/kg		
bis(2-Ethylhexyl)phthalate		6	46	46	99	73	370	1000	46000	NA	ug/kg		
Fluoranthene		23	46	85	9400	1372	370	920	310000	NA	ug/kg		
Fluorene		1	46	780	780	780	370	1000	310000	NA	ug/kg		
2-Methylnaphthalene		2	46	38	43	41	370	1000	310000	NA	ug/kg		
Naphthalene		1	46	480	480	480	370	1000	310000	NA	ug/kg		
N-Nitrosodiphenylamine		1	46	43	43	43	370	1000	130000	NA	ug/kg		
Phenanthrene		18	46	110	5200	632	370	920	230000	NA	ug/kg		
Phenol		1	46	78	78	78	370	1000	4700000	NA	ug/kg		
Pyrene		27	46	50	6900	1054	370	920	230000	NA	ug/kg		
Pesticides/PCBs													
Aroclor-1260	*	5	27	83	1800	629	14	810	83	NA	ug/kg	5	
alpha-Chlordane		5	27	2	17	6.1	1.5	16	1800	NA	ug/kg		
gamma-Chlordane		3	27	3.4	17	8.4	1.5	16	1800	NA	ug/kg		
4,4'-DDD		7	27	9	700	226	3.6	5	2700	NA	ug/kg		
4,4'-DDE	*	16	27	12	2500	195	3.6	4.6	1900	NA	ug/kg	1	
4,4'-DDT	*	14	27	6.9	2300	207	2.8	5	1900	NA	ug/kg	1	
Endrin		1	27	3.8	3.8	3.8	2.8	30	2300	NA	ug/kg		
TCDD Equivalents													
Dioxin		1	1	1.5494	1.5494	1.5494	NA	NA	1000	NA	ng/kg		
Inorganics													
Aluminum (Al)		32	32	1200	9700	5075	NA	NA	7800	12800	mg/kg	5	
Antimony (Sb)		8	32	0.36	1.5	0.82	0.34	15.9	3.1	NA	mg/kg		
Arsenic (As)	*	31	32	1.1	62	13	0.93	0.93	0.43	9.44	mg/kg	31	12

Table 10.5.10
Chemicals Present in Site Samples
SWMU 42/AOC 505 Surface Soil
NAVBASE-Charleston, Zone A
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration RBC	Screening Concentration Reference	Units	Number Exceeding RBC	Number Exceeding Ref.
Barium (Ba)		32	32	6.7	160	28	NA	NA	550	53	mg/kg		2
Beryllium (Be)	*	14	32	0.09	0.38	0.22	0.21	0.29	0.15	NA	mg/kg	11	
Cadmium (Cd)		9	32	0.05	0.32	0.18	0.05	1.6	3.9	NA	mg/kg		
Calcium (Ca)	N	32	32	267	54500	7448	NA	NA	NA	NA	mg/kg		
Chromium (Cr)		32	32	2.6	29.2	10	NA	NA	39	50.4	mg/kg		
Cobalt (Co)		18	32	0.26	16.6	2.2	1.3	1.8	470	4.4	mg/kg		1
Copper (Cu)		32	32	1.7	192	25	NA	NA	27000	165	mg/kg		1
Iron (Fe)	N	32	32	1760	47500	6843	NA	NA	NA	NA	mg/kg		
Lead (Pb)	*	32	32	4.2	1180	120	NA	NA	400	140	mg/kg	2	8
Magnesium (Mg)	N	32	32	99.8	894	356	NA	NA	NA	NA	mg/kg		
Manganese (Mn)	*	32	32	10.2	311	59	NA	NA	180	98.1	mg/kg	2	2
Mercury (Hg)		10	32	0.07	0.35	0.17	0.04	0.14	2.3	0.3	mg/kg		
Nickel (Ni)		21	32	0.86	20	6.4	3	3.9	160	13.55	mg/kg		2
Potassium (K)	N	29	32	128	952	342	119	142	NA	NA	mg/kg		
Selenium (Se)		9	32	0.35	1.2	0.73	0.33	0.85	39	1.2	mg/kg		
Sodium (Na)	N	28	32	59.2	433	196	50.7	54.8	NA	NA	mg/kg		
Thallium (Tl)		1	32	0.42	0.42	0.42	0.37	1.2	0.63	NA	mg/kg		
Tin (Sn)		15	32	0.79	28.5	7.5	0.58	10.3	4700	NA	mg/kg		
Vanadium (V)		32	32	3.9	39.9	12	NA	NA	55	29.24	mg/kg		1
Zinc (Zn)		32	32	8.3	303	66	NA	NA	2300	207.6	mg/kg		2

* - Identified as a COPC
N - Essential nutrient
SQL - Sample quantitation limit
RBC - Risk-based concentration
ug/kg - micrograms per kilogram
mg/kg - milligrams per kilogram
ng/kg - nanograms per kilogram
NA - Not applicable or not available

Groundwater

As shown in Table 10.5.11, the COPCs identified in at least one of the four quarters of shallow groundwater sampling for this site were aluminum, arsenic, chloromethane, chromium, 1,4-dichlorobenzene, 1,1-dichloroethene, manganese, silver, 1,1,2,2-tetrachloroethane, tetrachloroethene, and vanadium. Trichloroethene was detected at a concentration equal to its RBC and was added to the list of COPCs based on its chemical similarity to tetrachloroethene and 1,1,2,2-tetrachloroethane.

10.5.6.3 Exposure Assessment

Exposure Setting

SWMU 42 is a former asphalt plant with aboveground storage tanks related to the plant's past activities. AOC 505 is a former golf course maintenance shop that has also been used to store cross-ties and railroad ballasts. Surrounding land associated with combined SWMU 42 is currently used as a contractor staging area, and the railroad storage area is currently used for drum storage. The future use of this combined SWMU/AOC is unknown, although it is in a section of NAVBASE currently slated to become a marine cargo terminal in base reuse plans.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are hypothetical future site residents. Future site resident and worker exposure scenarios were addressed in this risk assessment. The hypothetical future site worker scenario assumed continuous exposure to surface soil conditions and the use of shallow groundwater as a potable water source. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact and the fact that groundwater is not currently used onsite as a source of potable or process water. Therefore, future worker assessment is considered to be protective of current site users. The future site resident scenario was built on the premise that current buildings would be removed and

Table 10.5.11
Chemicals Present in Site Samples
SWMU 42/AOC 505 Shallow Groundwater
NAVBASE-Charleston, Zone A
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration RBC	Reference	Number Exceeding RBC	Ref.
Volatile Organics												
Acetone		1	16	6.6	6.6	6.6	10	10	370	NA		
Carbon disulfide		1	16	1.6	1.6	1.6	5	5	100	NA		
Chlorobenzene		1	16	1.3	1.3	1.3	5	5	3.9	NA		
Chloromethane	*	1	16	7.8	7.8	7.8	5	10	1.4	NA	1	
1,1-Dichloroethene	*	1	16	1	1	1	5	5	0.044	NA	1	
Ethylbenzene		1	16	1.2	1.2	1.2	5	5	130	NA		
1,1,2,2-Tetrachloroethane	*	1	16	1.5	1.5	1.5	5	5	0.052	NA	1	
Tetrachloroethene	*	3	16	1.4	5.9	2.9	5	5	1.1	NA	3	
Trichloroethene		2	16	1.4	1.6	1.5	5	5.9	1.6	NA		
Xylene		1	16	3.5	3.5	3.5	5	5	1200	NA		
o-Xylene		1	16	1.4	1.4	1.4	5	5	52	NA		
Semivolatile Organics												
1,2-Dichlorobenzene		1	12	1.8	1.8	1.8	5	5	27	NA		
1,3-Dichlorobenzene		1	12	1.8	1.8	1.8	5	5	54	NA		
1,4-Dichlorobenzene	*	1	12	2	2	2	5	5	0.44	NA	1	
Inorganics												
Aluminum	*	12	16	77	27200	3490	132	325	3700	3210	2	2
Arsenic	*	3	16	2.9	9	6.1	2.1	11.7	0.045	7.4	3	1
Barium		11	16	9.5	53.6	24	10.1	111	260	104		
Cadmium		1	16	0.29	0.29	0.29	0.22	5	1.8	NA		
Calcium	N	15	16	8630	134000	62069	11800	11800	NA	NA		
Chromium	*	4	16	4.9	45.9	16.7	0.78	6	18	8.7	1	2
Cobalt		5	16	12.1	25	16.9	0.67	7	220	NA		
Copper		7	16	2	12.2	7.3	0.89	7	150	15.7		
Iron	N	16	16	192	32300	12263	NA	NA	NA	NA		
Lead		5	16	1.6	7.6	3.2	1.4	3	15	4.7		
Magnesium	N	16	16	2790	43900	11758	NA	NA	NA	NA		
Manganese	*	16	16	18.6	827	415	NA	NA	84	577	15	4
Nickel		1	16	0.9	0.9	0.90	0.67	14	73	NA		
Potassium	N	16	16	2250	12700	7206	NA	NA	NA	NA		
Selenium		1	16	3.1	3.1	3.1	2.1	3	18	NA		
Silver	*	1	16	111	111	111	1	7	18	NA	1	
Sodium	N	11	16	9280	109000	66380	10000	113000	NA	NA		
Tin		2	12	23.3	51.4	37.4	5.5	54.8	2200	NA		
Vanadium	*	3	16	1.5	61	23.8	0.59	7	26	5.4	1	2
Zinc		3	16	25.6	99.6	63.9	3	66.3	1100	83.2		

* - Identified as a COPC
N - Essential nutrient
SQL - Sample quantitation limit
RBC - Risk-based concentration
ug/L - micrograms per liter
mg/kg - milligrams per liter
NA - Not applicable or not available

replaced with dwellings. In addition, the future site residents were assumed to use the shallow aquifer onsite as a source of drinking water.

Exposure Pathways

Exposure pathways for the site workers are dermal contact, incidental ingestion of surface soils, and ingestion of shallow groundwater through potable use. Volatile organic compounds were detected in the shallow aquifer; thus, inhalation of volatilized groundwater contaminants was also considered a viable exposure pathway. The exposure pathways for future residential land use are the same as those for the future site worker. In addition, the hypothetical future site worker scenario assumed continuous exposure to surface soil and groundwater conditions. Uniform exposure was assumed for all sample locations. Table 10.5.12 presents the justification for exposure pathways assessed in this HHRA.

Exposure Point Concentrations

As discussed in Section 7 of this RFI, UCLs were calculated for datasets consisting of at least 10 samples. UCLs calculated for surface soils are presented in Table 10.5.13. These UCLs were applied as the exposure point concentrations used to estimate the hazard and risk due to exposure to COPCs in combined SWMU 42 surface soil. Since the 95% UCL for benzo(a)pyrene equivalents exceeded the maximum concentration, the maximum concentration was used to estimate soil-related exposure. Since it is improbable for a potential receptor to be chronically exposed to the area of maximum concentration, an FI/FC term of 0.6 was used to adjust the EPC for benzo(a)pyrene equivalents based on frequency of detection. Because the statistical approach or 95% UCL failed to produce a reasonable upper-bound estimate of the mean concentration, the FI/FC is used to average a potential receptors contact between contaminated media and uncontaminated media.

Table 10.5.12
Exposure Pathways Summary — SWMU 42/AOC 505
NAVBASE — Zone A
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
		Current Land Uses	
Current Site Users/Maintenance	Air, Inhalation of gaseous contaminants emanating from soil	No	Based on the COPCs identified in this HHRA for combined SWMU 42, no significant VOC concentrations were identified at this site.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Soil-to-air screening did not identify any constituents that would significantly contribute to risk via this route.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No (Qualified)	Shallow groundwater is not currently used as a source of potable or nonresidential water at combined SWMU 42. Future land use assessment is considered protective of current receptors.
	Shallow groundwater, Inhalation of volatilized shallow groundwater contaminants	No (Qualified)	Shallow groundwater is not currently used as a source of potable or nonresidential water at combined SWMU 42. Future land use assessment is considered protective of current receptors.
	Soil, Incidental ingestion	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
	Soil, Dermal contact	No (Qualified)	Future land use assessment is considered protective of current receptors.
		Future Land Uses	
Future Site Residents (Child and Adult) and Future Site Worker	Air, Inhalation of gaseous contaminants emanating from soil	No	Based on the COPCs identified in this HHRA for combined SWMU 42, no significant VOC concentrations were identified at this site.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Soil to air screening did not identify any constituents that would significantly contribute to risk via this route.
	Shallow groundwater, Ingestion of contaminants during potable or general use	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	Yes	COPCs were identified subsequent to risk-based screening comparisons.

Table 10.5.12
Exposure Pathways Summary — SWMU 42/AOC 505
NAVBASE — Zone A
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
	Soil, Incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, Dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals, Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina city limits.
	Fruits and vegetables, Ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Table 10.5.13
Statistical Analysis of COPCs
Surface Soils at SWMU 42 and AOC 505
Naval Base Charleston Zone A
Charleston, South Carolina

COPC	n	Natural Log Transformed mean	SD	H-stat	UCL (mg/kg)	MAX (mg/kg)	EPC (mg/kg)	
Aroclor 1260	27	2.679	1.635	3.376	0.16	1.8	0.16	UCL Used
Arsenic	32	1.878	1.171	2.631	23	62	23	UCL Used
Benzo(a)pyrene equivalents	46	4.819	2.351	4.104	8.3	7.4	7.4	MAX Used
Beryllium	32	-1.901	0.381	1.842	0.18	0.38	0.18	UCL Used
4,4'-DDE	27	2.480	1.873	3.743	0.27	2.5	0.27	UCL Used
4,4'-DDT	27	2.083	2.019	3.974	0.30	2.3	0.30	UCL Used
Lead	32	3.655	1.567	3.420	438	1180	438	UCL Used
Manganese	32	3.683	0.839	2.240	79	311	79	UCL Used

NOTES:

mean Arithmetic mean of the logtransformed data
n Number of samples analyzed
SD Standard deviation for a sample of data
H-stat "H" statistic from Gilbert 1987; cuboidal interpolation was used to determine the value in accordance with USEPA Supplemental Guidance to RAGS, Calculating the Concentration Term
NA Not applicable
EPC Exposure point concentration
UCL 95 percentile upper confidence level mean
MAX Maximum reported concentration
mg/kg milligrams per kilogram

Table 10.5.14 is the statistical analysis for groundwater COPC data. Four shallow monitoring wells were installed at this site and sampled once a quarter for four quarters. Current EPA guidance favors the use of the arithmetic mean in the most concentrated area of the plume as the EPC for groundwater COPCs. Aluminum and manganese were detected in all four quarters and in most of the monitoring wells at combined SWMU 42. A clear plume cannot be identified for aluminum and manganese, rather these inorganic constituents seem to be widespread in the shallow aquifer of Zone A. As a result, a 95% UCL was calculated for both which was then compared to their maximum concentrations. Since the 95% UCL exceeded the maximum concentration for manganese, the maximum concentration was used as the EPC. The 95% UCL was used as the EPC for aluminum. The remainder of the groundwater COPCs cannot be associated with a single distinct plume. Instead, each of the remaining COPCs, arsenic, chloromethane, chromium, 1,1-dichloroethene, 1,4-dichlorobenzene, silver, 1,1,2,2-tetrachloroethane, tetrachloroethene, trichloroethene, and vanadium, were assigned to its own "plume". In each case, a separate plume is defined by the monitoring well which produced the highest concentration for a given COPC. The EPC is calculated as the arithmetic mean of the four quarters of data from the same well. For example, the maximum arsenic detection (0.009 mg/L) was from monitoring well NBCA505W001 sampled during the third quarter. The fourth quarter sample from this monitoring well had an arsenic concentration of 0.0064 mg/L; the first and second quarter samples were nondetected. The data from third and fourth quarter (0.009 and 0.0064 mg/L) and one half of the SQLs for the nondetected results of the first and second quarters (0.002 and 0.0026 mg/L) yield an average of 0.005 mg/L, which was used as the EPC for arsenic. 1,1-Dichloroethene, 1,4-dichlorobenzene, and 1,1,2,2-tetrachloroethane were only detected in first quarter samples from NBCA505W001 at concentrations below one-half of their SQLs. Similarly, trichloroethene was detected in monitoring well NBCA042001 at concentrations below one-half its SQL during the first and second quarters and was not detected in the third and fourth quarters. As a result, the only detected concentration was used as the EPC for these COPCs.

Table 10.5.14
Statistical Analysis of COPCs
Groundwater at SWMU 42/AOC 505
Naval Base Charleston Zone A
Charleston, South Carolina

COPC	Number of Detects	Number of Samples	Natural Log Transformed mean	SD	H-stat	Average in Plume (mg/L)	UCL (mg/L)	MAX (mg/L)	EPC (mg/L)	
Aluminum	12	16	6.310	1.642	3.822	NA	10.7	27.2	10.7	UCL
Arsenic	3	16	0.752	0.675	2.256	0.005	0.0040	0.0090	0.005	Plume
Chloromethane	1	16	1.161	0.388	1.947	0.0044	0.0042	0.0078	0.0044	Plume
Chromium	4	16	0.893	1.230	3.09	0.0146	0.014	0.0459	0.0146	Plume
1,1-Dichloroethene	1	16	0.859	0.229	1.823	NA	0.0027	0.0010	0.0010	Max
1,4-Dichlorobenzene	1	12	0.898	0.064	NA	NA	NA	0.0020	0.0020	Max
Manganese	16	16	5.808	0.877	2.53	NA	0.87	0.827	0.827	Max
Silver	1	16	0.854	1.258	3.137	0.04	0.014	0.111	0.04	Plume
1,1,2,2-Tetrachloroethane	1	16	0.884	0.128	1.761	NA	0.0026	0.0015	0.0015	Max
Tetrachloroethene	3	16	0.902	0.298	1.872	0.0028	0.0030	0.0059	0.0028	Plume
Trichloroethene	2	16	0.863	0.186	1.795	NA	0.0026	0.0016	0.0016	Max
Vanadium	3	16	0.880	1.212	3.061	0.018	0.013	0.061	0.018	Plume

NOTES:

mean arithmetic mean of the logtransformed data
n number of samples analyzed
SD standard deviation for a sample of data
H-stat "H" statistic from Gilbert 1987; cuboidal interpolation was used to determine the value in accordance with USEPA Supplemental Guidance to RAGS, Calculating the Concentration Term
NA not applicable
EPC exposure point concentration
UCL 95 percentile upper confidence level mean
Max maximum reported concentration
Plume defined as the arithmetic mean of the maximum concentration and the results of the remaining three quarters taken from the same well (one-half the SQL for nondetects)
mg/L milligrams per liter

Quantification of Exposure

Soil

CDIs for ingestion and dermal contact with soils are shown in Tables 10.5.15 and 10.5.16, respectively.

Groundwater

The CDIs for groundwater ingestion are presented in Table 10.5.17. The CDI for inhalation of volatile constituents during use of groundwater is assumed to be equal to the CDI estimated for groundwater ingestion.

10.5.6.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Table 10.5.18 presents toxicological information specific to each COPC identified at combined SWMU 42. This information was used in the quantification of risk/hazard associated with soil and groundwater contaminants. Brief toxicological profiles for each COPC are provided in the following paragraphs.

Aluminum is one of the most abundant metals in the earth's crust (7% aluminum), and it is ubiquitous in air and water, as well as soil. This metal is water-soluble, silvery, and ductile, which suggests its usefulness in many processes. Ingesting aluminum can affect the absorption of other elements within the gastrointestinal tract and can alter intestinal function. Aluminum can potentially interfere with the absorption of essential nutrients and cholesterol. Another effect on the gastrointestinal system is the inhibition of acetylcholine-induced contractions, which are part of the neuromuscular system controlling bowel muscles. The effect could explain why aluminum-containing antacids often produce constipation. Aluminum dust is moderately flammable and explosive in heat. Inhaling this dust can cause fibrosis (aluminosis) (Klaassen, et al., 1986) (Dreisbach, et al., 1987). No data are available on an applicable SF or the USEPA cancer group.

Table 10.5.15
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil (0-1')
SWMU 42 and AOC 505
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Fraction Ingested from Contaminated Source *	Exposure Point Concentration (mg/kg)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Aroclor 1260	1	0.16	2.24E-07	2.09E-06	2.56E-07	8.01E-08	2.86E-08
Arsenic	1	23	3.09E-05	2.89E-04	3.53E-05	1.10E-05	3.94E-06
Benzo(a)pyrene equivalents	0.6	7.4	6.07E-06	5.67E-05	6.94E-06	2.17E-06	7.75E-07
Beryllium	1	0.18	2.50E-07	2.33E-06	2.85E-07	8.92E-08	3.19E-08
4,4'-DDE	1	0.27	3.74E-07	3.49E-06	4.27E-07	1.33E-07	4.77E-08
4,4'-DDT	1	0.30	4.07E-07	3.80E-06	4.65E-07	1.45E-07	5.19E-08
Manganese	1	79	1.09E-04	1.01E-03	1.24E-04	3.88E-05	1.39E-05

NOTES:

lwa	Lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI	Chronic Daily Intake in mg/kg-day
H-CDI	CDI for hazard quotient
C-CDI	CDI for excess cancer risk
*	Reflects the estimated fraction of the site impacted by the corresponding COPC.
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day

Table 10.5.16
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil (0-1')
SWMU 42 and AOC 505
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Exposure Point Concentration (mg/kg)	Fraction Contacted from Contaminated Source *	Dermal Absorption Factor (unitless)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Aroclor 1260	0.16	1	0.01	9.20E-08	3.04E-07	5.76E-08	6.57E-08	2.35E-08
Arsenic	23	1	0.001	1.27E-06	4.18E-06	7.93E-07	9.06E-07	3.23E-07
Benzo(a)pyrene equivalents	7.4	0.6	0.01	2.49E-06	8.22E-06	1.56E-06	1.78E-06	6.35E-07
Beryllium	0.18	1	0.001	1.02E-08	3.38E-08	6.41E-09	7.31E-09	2.61E-09
4,4'-DDE	0.27	1	0.01	1.53E-07	5.06E-07	9.59E-08	1.09E-07	3.91E-08
4,4'-DDT	0.30	1	0.01	1.67E-07	5.50E-07	1.04E-07	1.19E-07	4.25E-08
Manganese	79	1	0.001	4.45E-06	1.47E-05	2.79E-06	3.18E-06	1.14E-06

NOTES:

CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
* Reflects the estimated fraction of the site impacted by the corresponding COPC.
mg/kg milligrams per kilogram
mg/kg-day milligrams per kilogram per day

Table 10.5.17
Chronic Daily Intakes (CDI)
Ingestion of COPCs in Shallow Groundwater
SWMU 42 and AOC 505
Naval Base Charleston, Zone A
Charleston, SC

Chemical	Exposure Point Concentration (mg/liter)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Future Worker adult H-CDI (mg/kg-day)	Future Worker adult C-CDI (mg/kg-day)
Aluminum	10.7	2.93E-01	6.84E-01	1.61E-01	1.05E-01	5.15E-02
Arsenic	0.0050	1.37E-04	3.20E-04	7.53E-05	4.89E-05	2.41E-05
Chloromethane	0.0044	1.21E-04	2.81E-04	6.63E-05	4.31E-05	2.12E-05
Chromium	0.015	4.00E-04	9.33E-04	2.20E-04	1.43E-04	7.03E-05
1,1-Dichloroethene	0.0010	2.74E-05	6.39E-05	1.51E-05	9.78E-06	4.81E-06
1,4-Dichlorobenzene	0.0020	5.48E-05	1.28E-04	3.01E-05	1.96E-05	9.63E-06
Manganese	0.83	2.27E-02	5.29E-02	1.25E-02	8.09E-03	3.98E-03
Silver	0.04	1.10E-03	2.56E-03	6.03E-04	3.91E-04	1.93E-04
1,1,2,2-Tetrachloroethane	0.0015	4.11E-05	9.59E-05	2.26E-05	1.47E-05	7.22E-06
Tetrachloroethene	0.0028	7.67E-05	1.79E-04	4.22E-05	2.74E-05	1.35E-05
Trichloroethene	0.0016	4.38E-05	1.02E-04	2.41E-05	1.57E-05	7.70E-06
Vanadium	0.018	4.93E-04	1.15E-03	2.71E-04	1.76E-04	8.66E-05

NOTES:

lwa Lifetime weighted average
CDI Chronic Daily Intake
H-CDI Non-carcinogenic hazard based Chronic Daily Intake
C-CDI Carcinogenic risk based Chronic Daily Intake
mg/kg-day milligrams per kilogram per day

Table 10.5.18
Toxicological Database Information
for Chemicals of Potential Concern
SWMU 42/AOC 505
NAVBASE Charleston, Zone A

Non-Carcinogenic Toxicity Data

Chemical	Oral Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Inhalation
Aluminum	1	e								
Arsenic	0.0003	a	M	hyperpigmentation	3	ND				ND
Benzo(a)pyrene Equivalents	ND				ND	ND				ND
Beryllium	0.005	a	L	microscopic organ changes	100	ND				ND
Chloromethane	0.257		H	hepatotoxicity	300	0.257		H	hepatotoxicity	ND
1,1-Dichloroethene	0.009	a	M	liver lesions	1000	ND				ND
1,4-Dichlorobenzene	ND				ND	0.229	a	M	increased liver weight	100
4,4'-DDD	ND				ND	ND				ND
4,4'-DDE	ND				ND	ND				ND
4,4'-DDT	0.0005	a	M	liver lesions	100	ND				ND
Manganese (food)	0.047	a	NA	neurological effects	1	ND				ND
Manganese (water)	0.023	a	NA	neurological effects	1	1.43E-05	a	M	neurological effects	1000
PCB Aroclor-1260	ND				ND	ND				ND
1,1,2,2-Tetrachloroethane	ND				ND	ND				ND
Tetrachloroethene	0.01	a			1000	ND				ND
Trichloroethene	0.006	e	NA	NA	NA	ND				ND
Vanadium	0.007	a		unclear	100	ND				ND

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d USEPA Region III Screening Tables
e EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
f Withdrawn from IRIS or HEAST
NA Not applicable or not available
ND Not determined due to lack of information

Table 10.5.18 (continued)
Toxicological Database Information
for Chemicals of Potential Concern
SWMU 42/AOC 505
NAVBASE Charleston, Zone

Carcinogenic Toxicity Data

Chemical	Oral Slope Factor [(mg/kg/day)]-1		Inhalation Slope Factor [(mg/kg/day)]-1		Weight of Evidence	Tumor Type
Aluminum	ND		ND		D	
Arsenic	1.5	a	15.1	a	A	various
Benzo(a)pyrene Equivalents	7.3	a			B2	mutagen
Beryllium	4.3	a	8.4	a	B2	osteosarcoma
Chloromethane	0.012	b	0.0063	b	C	kidney tumors
1,1-Dichloroethene	0.6	a	0.175	a	C	kidney adenosarcoma
1,4-Dichlorobenzene	0.024	b	ND		B2	NA
4,4'-DDD	0.024	a	ND		B2	liver
4,4'-DDE	0.34	a	ND		B2	liver
4,4'-DDT	0.34	a	ND		B2	liver
Manganese (food)	ND		ND		D	
Manganese (water)	ND		ND		D	
PCB Aroclor-1260	2		ND		B2	hepatocellular carcinoma
1,1,2,2-Tetrachloroethane	0.2	a	0.203	a	A	central nervous system, liver, and kidney
Tetrachloroethene	0.052	e	0.00203	e	B2	hepatotoxicity
Trichloroethene	ND		0.006		B2	forestomach tumors in mice
Vanadium	ND		ND		D	

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d USEPA Region III Screening Tables
e EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
f Withdrawn from IRIS or HEAST
NA Not applicable or not available
ND Not determined due to lack of information

The USEPA Region IV Office of Health Assessment suggested using the provisional oral RfD of 1.0 mg/kg-day. The aesthetic-based SMCL for drinking water is 50 to 200 μg/L (USEPA, Office of Water).

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen, et al., 1986). USEPA set 0.3 μg/kg-day as the RfD for arsenic based on a NOAEL of 0.8 μg/kg-day in a human exposure study. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher levels. Exposure to arsenic-containing materials has been shown to cause cancer in humans. Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the 1.5 $(mg/kg\text{-}day)^{-1}$ SF for arsenic. As listed in IRIS (search date 9/1/95), the basis for the classification is sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic. Human milk contains about 3 μg/L arsenic. The RBC for arsenic in tap water is 0.038 μg/L. As listed in IRIS (search date 9/1/95), the critical effect of this chemical is hyperpigmentation, keratosis, and possible vascular complications. The uncertainty factor was determined to be 3 and the modifying factor was determined to be 1.

Benzo(a)pyrene equivalents include the following list of polynuclear aromatic hydrocarbons:

Benzo(a)anthracene	TEF	0.1
Benzo(b)fluoranthene	TEF	0.1
Dibenz(a,h)anthracene	TEF	1.0
Benzo(k)fluoranthene	TEF	0.01

Benzo(a)pyrene	TEF	1.0
Indeno(1,2,3-cd)pyrene	TEF	0.1
Chrysene	TEF	0.001

Some PAHs are toxic to the liver, kidney, and blood. However, the toxic effects of the PAHs above have not been well established. There are no RfDs for the PAHs above due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of benzo(a)pyrene, having an oral SF 7.3 (mg/kg-day)^{1}. Toxicity Equivalency Factors, also set by USEPA, are multipliers that are applied to the detected concentrations, which are subsequently used to calculate excess cancer risk. These multipliers are discussed further in the exposure and toxicity assessment sections. Most carcinogenic PAHs have been classified as carcinogenic due to animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke). As listed in IRIS (search data 6/28/95), the basis for the benzo(a)pyrene B2 classification is human data specifically linking benzo(a)pyrene to a carcinogenic effect are lacking. There are, however, multiple animal studies in many species demonstrating benzo(a)pyrene to be carcinogenic by numerous routes.

Benzo(a)pyrene has produced positive results in numerous genotoxicity assays. At the June 1992 CRAVE Work Group meeting, a revised risk estimate for benzo(a)pyrene was verified (see Additional Comments for Oral Exposure). This section provides information on two aspects of the carcinogenic risk assessment for the agent in question: the USEPA classification and quantitative estimates of exposure. The classification reflects a weight-of-evidence judgment of the likelihood that the agent is a human carcinogen. The quantitative risk estimates are presented in application of a low-dose extrapolation procedure and presented as the risk per (mg/kg)-day. The unit risk is the quantitative estimate in terms of either risk per μg/L drinking water or risk per

$\mu g/m^3$ air breathed. The third form in which risk is presented is drinking water or air concentration providing cancer risks of 1 in 10,000 or 1 in 1,000,000. The Carcinogenicity Background Document provides details on the carcinogenicity values found in IRIS. Users are referred to the Oral Reference Dose and Reference Concentration sections for information on long-term toxic effects other than carcinogenicity.

As listed in IRIS (search date 6/28/95), the basis for the dibenz(a,h)anthracene and benzo(b)fluoranthene B2 classification is no human data and sufficient data from animal bioassays. Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal or subcutaneous injection, and skin painting. As listed in IRIS (search date 6/28/95), the basis for the benzo(a)anthracene B2 classification is no human data and sufficient data from animal bioassays. Benzo(a)anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous or intramuscular injection; and topical application. Benzo(a)anthracene produced mutations in bacteria and in mammalian cells, and transformed mammalian cells in culture. As listed in IRIS (search date 6/28/95) the basis for the benzo(k)fluoranthene B2 classification is no human data and sufficient data from animal bioassays. Benzo(k)fluoranthene produced tumors after lung implantation in mice and when administered with a promoting agent in skin-painting studies. Equivocal results have been found in a lung adenoma assay in mice. Benzo(k)fluoranthene is mutagenic in bacteria. (Klaassen, et al., 1986).

Other PAHs — those not classified by USEPA as carcinogens — are toxic to the liver, kidney and blood. This group of PAHs includes compounds such as *pyrene*, *acenaphthene, acenaphthylene*, *benzo(g,h,i)perylene*, and *phenanthrene*. USEPA determined RfDs for only two of these compounds: pyrene's RfD_o of 0.03 mg/kg-day is also used as a surrogate RfD_o for phenanthrene. The RfD_o for acenaphthene was 0.06 mg/kg-day.

Beryllium exposure via the inhalation route can cause inflammation of the lungs, a condition known as acute beryllium disease, as a result of short-term exposure to high concentrations. Removal from exposure results in a reversal of the symptoms. Chronic exposure to much lower levels of beryllium or beryllium oxide by inhalation has been reported to cause chronic beryllium disease, with symptoms including shortness of breath, scarring of the lungs, and berylliosis, which is noncancerous growths in the human lungs. Both forms of beryllium disease can be fatal, depending on the severity of the exposure. Additionally, a skin allergy may develop when soluble beryllium compounds contact the skin of sensitized individuals (Gradient, 1991). An oral RfD of 0.0054 mg/kg-day has been set for beryllium, based on a chronic oral bioassay (rats were the study species) which determined that no adverse effect occurs at 0.54 mg/kg-day. Beryllium has been classified by USEPA as a group B2 carcinogen based on animal studies. It has been shown to induce lung cancer via inhalation in rats and monkeys, and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. Human epidemiology studies of beryllium are considered to be inadequate. As listed in IRIS (search date 6/28/95), the basis for the classification is that beryllium has been shown to induce lung cancer via inhalation in rats and monkeys and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. Human epidemiology studies are considered inadequate. An inhalation slope factor of 8.4 $(mg/kg\text{-}day)^{-1}$ and an oral SF of 4.3 $(mg/kg\text{-}day)^{-1}$ have been set by USEPA. As listed in IRIS (search date 6/28/95), the critical effect of this chemical is no adverse effect. The uncertainty factor was 100 and the modifying factor was 1. The IRIS RfD in drinking water is 0.005 mg/kg-day.

Chloromethane is a colorless gas having an ethereal odor and sweet taste. It is slightly soluble in water and volatile. Acute poisoning is characterized by the narcotic effect. In addition, repeated exposure to low concentrations causes damage to the central nervous system and less frequently to the liver, kidneys, bone marrow and cardiovascular system. Hemorrhages into the lungs, intestinal tract have also been reported. In exposures to high concentrations, dizziness, drowsiness, in coordination, confusion, nausea and vomiting, abdominal pains, hiccoughs,

diplopia and dimness of vision are followed by delirium, convulsions and coma, and death may be immediate. Death may occur several days later from degenerative changes in the heart, liver and especially the kidneys.

Chromium exists in two stable, natural forms: trivalent (CrIII), and hexavalent (CrVI). Acute exposure to chromium can result in kidney damage following oral exposure or damage to the nasal mucosa and septum following inhalation exposure. Chronic inhalation exposure to hexavalent chromium has resulted in kidney and respiratory tract damage, as well as excess lung cancer in both animals and humans following occupational exposure. Only hexavalent chromium is believed to be carcinogenic by inhalation (Gradient, 1991). Oral RfD values for both forms of chromium are 1.0 and 5E-3 (mg/kg-day). For trivalent chromium, the RfD is based on liver toxicity in rats. For the hexavalent form, the RfD is based on unspecified pathological changes observed in rat studies. In addition, hexavalent chromium is considered a group A carcinogen for inhalation exposures, and a SF_o of 42 $(mg/kg\text{-}day)^{-1}$ has been established for the hexavalent form. Vitamin supplements contain approximately 0.025 mg of chromium. As listed in IRIS (search date 6/28/95), no critical effects were observed for chromium (III). The uncertainty factor was determined to be 100 and the modifying factor was determined to be 10. As listed in IRIS (search date 6/28/95), no critical effects were observed for chromium (VI). The uncertainty factor was determined to be 500 and the modifying factor was determined to be 1.

4,4'-DDD, a by-product of the pesticide DDT, is a compound typical of halobenzene derivatives. It is soluble in fat, but not in water, and its target organ is the brain. This analog of DDT is the least toxic of the three primary DDT analogs (i.e., the least likely to cause cancer). Other DDD effects could include cell death in the liver, fatty change of heart muscles, and kidney damage. If an individual loses body fat, DDD concentrations are not stored at sufficient concentrations to induce toxic effects (Dreisbach, et al, 1987). This compound is listed as a B2 carcinogen, and USEPA set the Sf_o for DDD to 0.24 $(mg/kg\text{-}day)^{-1}$.

4,4'-DDE is a compound typical of halobenzene derivatives and is a by-product of the pesticide DDT. It is soluble in fat, but not in water, and its primary target organs are the liver and brain. DDE is the form of DDT which accumulates in organisms and is thought to be responsible for egg shell thinning and other ecological effects. DDE bioconcentrates in aquatic organisms and can significantly alter the ecology of some areas, especially where DDE-containing aquatic species are a critical species in the food chain. (Dreisbach, et al., 1987) (Harte, et al., 1991). This compound is listed as a B2 carcinogen, and USEPA set the SF_o for DDE to 0.34 $(mg/kg\text{-}day)^{-1}$.

4,4'-DDT is a pesticide which is soluble in fat, but not in water. The primary target organ of DDT is the brain. Other DDT effects could include cell death in the liver, fatty change of heart muscles, and kidney damage. In a study mentioned in Dreisbach, et al., workers historically exposed to DDT had up to 648 ppm DDD in their body fat and no adverse health effects were observed. If an individual loses body fat, DDT concentrations are not stored at sufficient concentrations to induce toxic effects (Dreisbach, et al., 1987). As listed in IRIS (search date 1/15/96), the critical noncarcinogenic effect of DDT is liver lesions. USEPA determined the oral RfD to be 0.0005 mg/kg-day, with an uncertainty factor of 100 and a modifying factor of 1.0. Confidence in the RfD is medium. DDT is a class B2 carcinogen, based on tumors observed in seven studies in various mouse strains and three studies in rats. DDT is structurally similar to other probable carcinogens, such as DDD and DDE. USEPA determined the slope factor to be 0.34 $(mg/kg\text{-}day)^{-1}$.

1,4-Dichlorobenzene is a CLP SVOC; however, it was evaluated for the inhalation pathway as a volatile due to its Henry's law Constant. This compound affects the CNS, causes liver and kidney damage, and irritation of the mucous membranes, skin, and eyes (Dreisbach, et al., 1987). This compound is classified by USEPA as a B2 carcinogen, with a SF_o of 0.024 $(mg/kg\text{-}day)^{-1}$. The RfD_i was set to 0.229 mg/kg/day. As listed in IRIS (search date 6/29/95), the critical effect

of this chemical is increased liver weights in P1 males. The uncertainty factor was determined to be 100 and the modifying factor was determined to be 1. The IRIS RfC is 0.8 mg/m^3.

1,1-Dichloroethene is a volatile organic compound, primarily toxic to the liver, central nervous system, and kidneys. The mucous membrane, skin, lung, and cornea (irritation) are also affected. 1,1-Dichloroethene is more toxic than 1,2-Dichloroethene; this chlorinated compound is a USEPA group C carcinogen. The RfD_o is 0.009 mg/kg-day, and the SF_o and Sf_i are 0.6 and 0.175 $(mg/kg\text{-}day)^{-1}$, respectively (Dreisbach, et al., 1987).

Lead has been classified as a group B2 carcinogen by USEPA, based on animal data. No RfD or SF has been set by USEPA. However, an action level for soil protective of child residents has been proposed by USEPA Region IV, 400 mg/kg. USEPA's OSWER has recommended a 1,300 mg/kg cleanup standard for industrial properties. USEPA's Office of Water has established a treatment technique action level of 15 $\mu g/L$. As listed in IRIS (search date 10/17/95), the basis for classification is sufficient animal evidence. Ten rat bioassays and one mouse assay have shown statistically significant increases in renal tumors with dietary and subcutaneous exposure to several soluble lead salts. Animal assays provide reproducible results in several laboratories in multiple rat strains with some evidence of multiple tumor sites. Short- term studies show that lead affects gene expression. Human evidence is inadequate. An RfD and SF have not been set because of the confounding nature of lead toxicity. Lead can accumulate in bone marrow and effects have been observed in the CNS, blood, and mental development of children. RfDs are based on the assumption that a threshold must be exceeded to result in toxic effects (other than carcinogenicity). Once lead accumulates in the body, other influences cause the actual levels in the blood to fluctuate – sometimes the lead is attached to binding sites; sometimes lead is free flowing. If an exposed individual has previously been exposed to lead, this individual could lose weight and set fat-bound lead free. This fluctuation and lack of previous lead exposure data are two of the reasons lead effects are difficult to predict (Klaassen, et al., 1986).

Manganese is an essential nutrient. Chronic exposure to manganese, 0.8 mg/kg-day, causes mental disturbances and various central nervous system effects. Studies have shown that manganese uptake from water is greater than manganese uptake from food, and the elderly appear to be more sensitive than children. The oral RfD is 0.14 mg/kg-day with uncertainty and modifying factors of 1. When assessing the potential for adverse health effects from nondietary intakes (ingestion of soil or drinking water) of manganese, a modifying factor of 3 is used which gives an oral RfD of 0.047 mg/kg-day. An additional consideration for increased uptake of manganese in infants and fasted individuals further reduces the oral RfD for water ingestion to 0.023 mg/kg-day. Inhalation of manganese dust causes neurological effects and increased incidence of pneumonia, and an inhalation RfD was set to 0.0000143 mg/kg-day. According to USEPA, manganese can not be classified as to its carcinogenicity. Therefore, the cancer class for manganese is group D. The typical vitamin supplement dose of manganese is 2.5 mg/day (Klaassen, et al, 1986) (Dreisbach, et al, 1987).

PCB Aroclors are a group of chlorinated hydrocarbons (such as Aroclor-1260) that accumulate in fat tissue. Occupational exposure (both inhalation and dermal) to PCBs causes eye and lung irritation, loss of appetite, liver enlargement, increased serum liver enzyme levels, rashes and chloracne, and decreased birth weight of infants in heavily exposed worker/mothers. Of the effects listed above, the liver is the primary target organ (Klaassen, et al, 1986) (Dreisbach, et al, 1987). USEPA classified PCB aroclors as group B2 probable human carcinogens, primarily based on animal data. Oral ingestion of PCBs causes liver and stomach tumors in rat studies. The cancer potency of PCB mixtures is determined using a tiered approach. The high risk and persistence tier uses an upper-bound slope factor of 2.0 $(mg/kg\text{-}day)^{-1}$ and is appropriate for food chain exposures, sediment and soil ingestion, dust or aerosol inhalation, and dermal exposure. The low risk and persistence tier uses an upper-bound slope factor of 0.4 $(mg/kg\text{-}day)^{-1}$ and is appropriate for ingestion of water soluble congeners and inhalation of evaporated congeners. The lowest risk and persistence tier uses an upper-bound slope factor of 0.07 $(mg/kf\text{-}day)^{-1}$ and is

appropriate for PCB congener mixtures with congeners having more than four chlorides comprising less than 1/2% of the mixture.

Silver is a shiny grey metal that is naturally occurring. Silver also occurs in compounds such as silver nitrate, silver chloride, silver sulfide, and silver oxide. The most common use of these compounds is photographic development. Silver may enter the body through ingestion, inhalation, or dermal pathways; however, generally, much less silver will be absorbed through the skin than through the lungs or stomach (ATSDR 1990). Chronic exposure to silver causes the skin or other body tissues to take on a grayish or blue-grey color. This is a condition known as argyria, a permanent, but not thought of as medically harmful, condition. Exposure to dust containing silver nitrate and silver oxide may cause breathing problems, lung and throat irritation and stomach pain. An oral reference dose has been determined for silver and its compounds: 0.005 mg/kg-day.

1,1,2,2-Tetrachloroethane is a volatile organic compound used in industry and is a contaminant in many other solvents. The target organs of this solvent are the central nervous system, the liver, and the kidneys. Chronic exposure causes congestion of the target organs, intoxication, tremors, and the alteration of nerve functions. The effect on the liver can lead to jaundice. Acute exposure to this compound causes long-lasting narcosis with delayed onset. Additional effects are irritation of the mucous membranes, nausea, and headaches which can progress to coma. Simultaneous exposure to alcohols or ketones can exacerbate the toxic effects of this compound. The exposure limit for inhalation is 1 ppm. In addition to the noncarcinogenic effects of tetrachloroethane, it is listed as a class A-B carcinogen by USEPA. As listed in IRIS (search date 11/22/95), the basis for the C classification is increased incidence of hepatocellular carcinomas in mice. The USEPA set the SF_o and SF_i to 0.2 and 0.203 $(mg/kg\text{-}day)^{-1}$, respectively (Dreisbach, et al., 1987).

Tetrachloroethene (PCE) has been used as a solvent in industry and occurs as a volatile contaminant in other chlorinated hydrocarbons. Tetrachloroethene exposure can result in long-lasting narcosis with delayed onset and damage to the liver and kidneys. The principal manifestations of over-exposure to this halogenated hydrocarbon are jaundice and oliguria, and irritation of the eyes and nose, followed by headaches, nausea and coma. Cyanosis and central nervous system depression progressing to coma appear one to four hours after the short-term exposure. Liver and kidney damage after apparent recovery or after repeated exposures causes acute symptoms such as nausea, vomiting, abdominal pain, jaundice, oliguria and uremia. PCE exposure via the inhalation and/or skin absorption exposure pathways could result in headaches, tremor, dizziness, peripheral paresthesia, hypesthesia, or anesthesia. PCE is a carcinogen, but is currently under review by USEPA; it is currently classified as a B2-C carcinogen. The RfD_o has been set to 0.01 mg/kg-day, and the SF_o and SF_i have been set to 0.052 and 0.00203 $(mg/kg\text{-}day)^{-1}$, respectively, by USEPA. As listed in IRIS (search date 11/22/95), the critical effect of this chemical is hepatotoxicity in mice, weight gain in rats. The uncertainty factor was determined to be 1000 and the modifying factor was determined to be 1. (Dreisbach, et al., 1987).

Trichloroethene (TCE) is a mobile, volatile liquid which has the characteristic odor of chloroform. Inhalation, intravenous and subcutaneous routes are all viable exposure pathways for this compound. TCE is a strong skin and eye irritant that is relatively less toxic if ingested. Inhalation of high concentrations causes narcosis and anesthesia. This compound targets the liver and other organs. TCE is a B2 carcinogen, and the Sf_o and SF_i have been set by USEPA to 0.011 and 0.006 $(mg/kg\text{-}day)^{-1}$, respectively. USEPA also set the RfDo to 0.006 mg/kg-day (Dreisbach, et al., 1987).

Vanadium is not readily absorbed through the skin or oral ingestion and is ubiquitous. It is also a byproduct of petroleum refining. Vanadium is soluble in fats and oils (Klaassen, et al., 1986).

Municipal water supplies contain 0.001 to 0.006 mg/L. The target organ is unclear, and the primary focus of toxicological information is inhalation of vanadium dust. Typical vitamin supplements contain approximately 0.010 mg in a daily dose. The RfD_o set by USEPA is 0.007 mg/kg-day.

10.5.6.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under both residential and industrial (site worker) scenarios. For these scenarios, incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.5.19 and 10.5.20 present the computed carcinogenic risks and/or HQs associated with incidental ingestion of and dermal contact with site surface soils, respectively.

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime weighted average) for combined SWMU 42 surface soils is 1E-4. The dermal pathway ILCR is 3E-5. Arsenic, benzo(a)pyrene equivalents, and beryllium were the primary contributors to the ingestion pathway and arsenic and benzo(a)pyrene equivalents were the primary contributors to the dermal pathway.

The computed hazard indices for the adult resident were 0.1 for the soil ingestion pathway and 0.02 for the dermal contact pathway. The computed hazard indices for the child ingestion and dermal contact pathways were 1 and 0.07, respectively. The primary contributor to the hazard index was arsenic.

Hypothetical Site Workers

Site worker ILCRs are 1E-5 for both the ingestion and dermal contact pathways. Arsenic and benzo(a)pyrene equivalents were the primary contributors for each pathway. Hazard indices for the ingestion and dermal pathways were projected to be 0.04 and 0.02, respectively, for the hypothetical site worker scenario.

Lead Toxicity

At combined SWMU 42, two surface soil samples (042SB009; 1180 mg/kg and 505SB005; 491 mg/kg) contained lead at concentrations exceeding the residential cleanup goal of 400 mg/kg. The mean lead concentration at combined SWMU 42 was calculated to be 120 mg/kg. Because the mean falls below the residential soil cleanup goal, chronic exposures are not expected to pose a significant health threat to potential future child residents.

Groundwater Pathways

Exposure to shallow groundwater onsite was evaluated under both residential and industrial scenarios. The ingestion exposure pathway was evaluated assuming that site groundwater will be used for potable and/or domestic purposes and that an unfiltered well, drawing from the corresponding water-bearing zone, will be installed. For noncarcinogenic contaminants evaluated relative to future site residents, hazard was computed separately for child and adult receptors. Tables 10.5.21 and 10.5.22 present the risk and hazard for the ingestion and inhalation exposure pathways, respectively.

Hypothetical Site Residents

The shallow groundwater ingestion ILCR for hypothetical site residents is 1E-4 with contributions from arsenic, 1,1-dichloroethene, and tetrachloroethene. The inhalation pathway ILCR is 9E-6 with contributions from 1,1-dichloroethene and 1,1,2,2-tetrachloroethane. For the ingestion

Table 10.5.19
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
SWMU 42 and AOC 505
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Current Worker adult Hazard Quotient	Current Worker adult ILCR
Aroclor 1260	NA	2	ND	ND	5.1E-07	ND	5.7E-08
Arsenic	0.0003	1.5	0.10	0.96	5.3E-05	0.037	5.9E-06
Benzo(a)pyrene equivalent	NA	7.3	ND	ND	5.1E-05	ND	5.7E-06
Beryllium	0.005	4.3	0.000050	0.00047	1.2E-06	0.000016	1.4E-07
4,4'-DDE	NA	0.34	ND	ND	1.5E-07	ND	1.6E-08
4,4'-DDT	0.0005	0.34	0.00081	0.0076	1.6E-07	0.00029	1.8E-08
Manganese	0.047	NA	0.0023	0.022	ND	0.00083	ND
SUM Hazard Index/ILCR			0.1	1	1E-04	0.04	1E-05

NOTES:

NA	Not available
ND	Not Determined due to lack of available information
lwa	Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR	Incremental Lifetime Cancer Risk
mg/kg-day	milligrams per kilogram per day

Table 10.5.20
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
SWMU 42 and AOC 505
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Current Worker adult Hazard Quotient	Current Worker adult ILCR
Aroclor 1260	0.5	NA	4	ND	ND	2.3E-07	ND	9.4E-08
Arsenic	0.2	6E-05	7.5	0.021	0.070	6.0E-06	0.015	2.4E-06
Benzo(a)pyrene equivalent	0.5	NA	14.6	ND	ND	2.3E-05	ND	9.3E-06
Beryllium	0.2	0.001	21.5	0.000010	0.000034	1.4E-07	0.0000073	5.6E-08
4,4'-DDE	0.5	NA	0.68	ND	ND	6.5E-08	ND	2.7E-08
4,4'-DDT	0.5	0.00025	0.68	0.00067	0.0022	7.1E-08	0.00048	2.9E-08
Manganese	0.2	0.0094	NA	0.00047	0.00156	ND	0.00034	ND
SUM Hazard Index/ILCR				0.02	0.07	3E-05	0.02	1E-05

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk
\- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)
mg/kg-day milligrams per kilogram per day

Table 10.5.21
Hazard Quotients and Incremental Lifetime Cancer Risks
Shallow Groundwater Ingestion
SWMU 42 and AOC 505
Naval Base Charleston, Zone A
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Future Worker adult Hazard Quotient	Future Worker adult ILCR
Aluminum	1	NA	0.29	0.68	ND	0.10	ND
Arsenic	0.0003	1.5	0.46	1.1	1.1E-04	0.16	3.6E-05
Chloromethane	NA	0.013	ND	ND	8.6E-07	ND	2.8E-07
Chromium	0.005	NA	0.080	0.19	ND	0.029	ND
1,1-Dichloroethene	0.009	0.6	0.0030	0.0071	9.0E-06	0.0011	2.9E-06
1,4-Dichlorobenzene	NA	0.024	ND	ND	7.2E-07	ND	2.3E-07
Manganese	0.023	NA	0.99	2.3	ND	0.35	ND
Silver	0.005	NA	0.22	0.5	ND	0.078	ND
1,1,2,2-Tetrachloroethane	NA	0.2	ND	ND	4.5E-06	ND	1.4E-06
Tetrachloroethene	0.01	0.052	0.0077	0.018	2.2E-06	0.0027	7.0E-07
Trichloroethene	0.006	0.011	0.0073	0.017	2.7E-07	0.0026	8.5E-08
Vanadium	0.007	NA	0.070	0.16	ND	0.025	ND
SUM Hazard Index/ILCR			2	5	1E-04	0.8	4E-05

NOTES:

NA	Not available
ND	Not Determined due to lack of available information
lwa	Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR	Incremental Lifetime Cancer Risk
mg/kg-day	milligrams per kilogram per day

Table 10.5.22
Hazard Quotients and Incremental Lifetime Cancer Risks
Inhalation of Contaminants in Shallow Groundwater due to Domestic Use
SWMU 42 and AOC 505
Naval Base Charleston, Zone A
Charleston, SC

Chemical	Inhalation Rf Used (mg/kg-day)	Inhalation SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Future Worker adult Hazard Quotient	Future Worker adult ILCR
Chloromethane	NA	0.0063	ND	ND	4.2E-07	ND	1.3E-07
1,1-Dichloroethene	0.009	0.175	0.0030	0.0071	2.6E-06	0.0011	8.4E-07
1,4-Dichlorobenzene	0.229	0.024	0.00024	0.00056	7.2E-07	0.000085	2.3E-07
1,1,2,2-Tetrachloroethane	NA	0.203	ND	ND	4.6E-06	ND	1.5E-06
Tetrachloroethene	0.01	0.00203	0.008	0.018	8.6E-08	0.0027	2.7E-08
Trichloroethene	0.006	0.006	0.0073	0.017	1.4E-07	0.0026	4.6E-08
SUM Hazard Index/ILCR			0.02	0.04	9E-06	0.007	3E-06

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk
mg/kg-day milligrams per kilogram per day

aluminum, arsenic, manganese, silver, and vanadium being the primary contributors to hazard index. Inhalation pathway hazard indices are 0.02 and 0.04 for adult and child receptors, respectively.

Hypothetical Site Workers

The shallow groundwater risk estimated for future site workers is 4E-5 for the ingestion exposure pathway with contributions from arsenic and 1,1-dichloroethene. The estimated risk to future site workers through the inhalation pathway is 3E-06 with 1,1,2,2-tetrachloroethane as the primary contributor. The hazard indices for the ingestion and inhalation exposure pathways were calculated to be 0.8 and 0.007, respectively.

Current Site Workers

Shallow groundwater is not currently used as a potable water source for SWMU 42 and AOC 505 or other areas of Zone A. In the absence of a completed exposure pathway, no threat to human health is posed by reported shallow groundwater contamination.

COCs Identified

Chemicals of concern were identified based on cumulative (all pathway) risk and hazard projected for this site, as shown in Table 10.5.23. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a hazard index threshold of 1.0 (unity). In this HHRA, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or greater and/or a cumulative hazard index above 1.0, if its individual ILCR exceeds 1E-6 or whose hazard quotient exceeds 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used to provide a more comprehensive evaluation of chemicals contributing to carcinogenic risk or noncarcinogenic hazard

Table 10.5.23
Summary of Risk and Hazard-based COCs
SWMU 42 and AOC 505
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Medium	Exposure Pathway		Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident lwa ILCR	Site Worker Hazard Quotient	Site Worker ILCR	Identification of COCs		
Surface Soil	Incidental Ingestion	Aroclor 1260	ND	ND	5.1E-07	ND	5.7E-08			
		Arsenic	0.10	0.96	5.3E-05	0.037	5.9E-06	1	2	4
		Benzo(a)pyrene equivalents	ND	ND	5.1E-05	ND	5.7E-06		2	4
		Beryllium	0.000050	0.00047	1.2E-06	0.000016	1.4E-07		2	
		4,4'-DDE	ND	ND	1.5E-07	ND	1.6E-08			
		4,4'-DDT	0.00081	0.0076	1.6E-07	0.00029	1.8E-08			
		Manganese	0.0023	0.022	ND	0.00083	ND			
	Dermal Contact	Aroclor 1260	ND	ND	2.3E-07	ND	9.4E-08			
		Arsenic	0.021	0.070	6.0E-06	0.015	2.4E-06		2	4
		Benzo(a)pyrene equivalents	ND	ND	2.3E-05	ND	9.3E-06		2	4
		Beryllium	0.000010	0.000034	1.4E-07	0.0000073	5.6E-08			
		4,4'-DDE	ND	ND	6.5E-08	ND	2.7E-08			
		4,4'-DDT	0.00067	0.0022	7.1E-08	0.00048	2.9E-08			
		Manganese	0.00047	0.0016	ND	0.00034	ND			
Surface Soil Pathway Sum			0.1	1	1E-04	0.05	2E-05			
Groundwater	Ingestion	Aluminum	0.29	0.68	ND	0.10	ND	1		
		Arsenic	0.46	1.1	1.1E-04	0.16	3.6E-05	1	2	4
		Chloromethane	ND	ND	8.6E-07	ND	2.8E-07			
		Chromium	0.080	0.19	ND	0.029	ND	1		
		1,1-Dichloroethene	0.0030	0.0071	9.0E-06	0.0011	2.9E-06		2	4
		1,4-Dichlorobenzene	ND	ND	7.2E-07	ND	2.3E-07			
		Manganese	0.99	2.3	ND	0.35	ND	1		
		Silver	0.22	0.51	ND	0.078	ND	1		
		1,1,2,2-Tetrachloroethane	ND	ND	4.5E-06	ND	1.4E-06		2	4
		Tetrachloroethene	0.0077	0.018	2.2E-06	0.0027	7.0E-07		2	
		Trichloroethene	0.0073	0.017	2.7E-07	0.0026	8.5E-08			
		Vanadium	0.070	0.16	ND	0.025	ND	1		
	Inhalation	First Quarter								
		Chloromethane	ND	ND	4.2E-07	ND	1.3E-07			
		1,1-Dichloroethene	0.0030	0.0071	2.6E-06	0.0011	8.4E-07		2	
		1,4-Dichlorobenzene	0.00024	0.00056	7.2E-07	0.000085	2.3E-07			
		1,1,2,2-Tetrachloroethane	ND	ND	4.6E-06	ND	1.5E-06		2	4
		Tetrachloroethene	0.0077	0.018	8.6E-08	0.0027	2.7E-08			
		Trichloroethene	0.0073	0.017	1.4E-07	0.0026	4.6E-08			
Groundwater Pathway Sum			2	5	1E-04	0.8	4E-05			
Sum of All Pathways			2	6	3E-04	0.8	7E-05			

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental lifetime cancer risk
HI indicates hazard index
1- Chemical is a COC by virtue of projected child residence noncarcinogenic hazard.
2- Chemical is a COC by virtue of projected future resident lifetime ILCR.
3- Chemical is a COC by virtue of projected site worker noncarcinogenic hazard.
4- Chemical is a COC by virtue of projected site worker ILCR.

during the remedial goal options development process. Table 10.5.24 presents the COCs identified on a medium-specific basis.

Surface Soils

Hypothetical Site Residents (future land use)

Arsenic, benzo(a)pyrene equivalents, and beryllium were identified as the soil pathway COCs based on their contribution to cumulative ILCR projections.

Hypothetical Site Workers (current land use)

Arsenic and benzo(a)pyrene equivalents were identified as the soil pathway COCs based on their contribution to cumulative ILCR projections.

The extent of the COCs identified in surface soil is briefly discussed below. To facilitate this discussion of the extent of COC concentrations, residential soil RBCs were compared to each reported concentration for each COC identified above. Arsenic was detected above the residential soil RBC (0.43 mg/kg) in 31 of 32 surface soil samples. However, the background concentration for arsenic was exceeded only 12 times and the mean concentration for combined SWMU 42 surface soil (12.5 mg/kg) was only slightly higher than the background (9 mg/kg). Beryllium was only detected above the residential soil RBC in 11 of 32 surface soil samples. Benzo(a)pyrene equivalents were detected above the residential RBC in 22 of 46 surface soil samples collected in the combined SWMU 42 area. This frequency is consistent with asphalt and tar debris scattered throughout the area.

Groundwater

Hypothetical Site Residents (future land use)

Aluminum, chromium, manganese, silver, and vanadium were identified as shallow groundwater COCs based on their contribution to cumulative hazard index. 1,1-Dichloroethene, 1,1,2,2-

Table 10.5.24
Summary of Risk and Hazard
SWMU 42 and AOC 505
Naval Base Charleston, Zone A
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.1	1	1E-04	0.04	1E-05
	Dermal Contact	0.02	0.07	3E-05	0.02	1E-05
Groundwater	Ingestion	2	5	1E-04	0.8	4E-05
	Inhalation	0.02	0.04	9E-06	0.007	3E-06
Sum of All Pathways		2	6	3E-04	0.8	1E-04

Notes:
ILCR Indicates incremental excess lifetime cancer risk
HI Indicates hazard index
LWA Lifetime weighted average

tetrachloroethane, and tetrachloroethene were identified as shallow groundwater COCs based on their contribution to cumulative ILCR. Arsenic was identified as a COC based in its contribution to both HI and ILCR.

Hypothetical Site Workers (future land use)

Arsenic, 1,1-dichloroethene, and 1,1,2,2-tetrachloroethane were identified as shallow groundwater COCs based on their contribution to cumulative ILCR.

The extent of the COCs identified in first-quarter shallow groundwater is briefly discussed below. Each of the identified shallow groundwater COCs was detected in one well during first-quarter sampling. Arsenic was detected in monitoring well NBCA505001 during the third and fourth quarter, and was detected in monitoring well NBCA042002 during the fourth quarter. 1,1-Dichloroethene and 1,1,2,2-tetrachloroethene were detected in monitoring well NBCA505001 during the first quarter only.

10.5.6.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure.

Residential use of the site would not be expected, based on current site uses and the nature of surrounding buildings. Current reuse plans call for continued commercial/industrial use of Zone A, specifically as a marine cargo terminal. If this area were to be used as a residential site, the buildings and other features would be demolished, and the surface soil conditions would likely change — the soils would be covered with landscaping soil and/or a house. Consequently,

exposure to current surface soil conditions would not be likely under a true future residential scenario. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to current site workers and future site residents.

Shallow groundwater is not currently used at combined SWMU 42 for potable or industrial purposes. A basewide system provides drinking and process water to buildings throughout Zone A. This system is slated to remain in operation under the current base reuse plan. As a result, shallow groundwater would not be expected to be used under future site use scenarios. Therefore, the scenario established to project risk/hazard associated with shallow groundwater exposure is highly conservative, and associated pathways are not expected to be completed in the future.

Determination of Exposure Point Concentrations

The 95% UCLs of the mean soil concentrations were used as the exposure point concentrations for this site. In these cases, the EPC would tend to overestimate risk and hazard. The maximum concentration of benzo(a)pyrene equivalents was used as the EPC because the 95% UCL was greater than the maximum concentration. Therefore, a FI/FC term was applied to account for the fraction of the exposure area which is contaminated with benzo(a)pyrene equivalents in soil. Use of the FI/FC term in association with the maximum concentration in effect distributes the maximum concentration to areas which are known to have lower concentrations. This would tend to cause an overestimation of risk and hazard. Conversely, FI/FC assumes that no contamination exists in areas where limitations in analytical methodology may not have been able to detect contamination. This would tend to underestimate risk and hazard.

Maximum detected concentrations in groundwater were used as the EPCs for 1,1-dichloroethene, 1,4-dichlorobenzene, manganese, and 1,1,2,2-tetrachloroethane. This would tend to overestimate groundwater risk and hazard for these constituents. This is especially true for 1,1-dichloroethene,

1,4-dichlorobenzene, and 1,1,2,2-tetrachloroethene which were only detected in monitoring well NBCA505001 during the first quarter and were not detected in any of the three subsequent quarters. EPCs for arsenic, chloromethane, chromium, silver, tetrachloroethene, and vanadium were calculated by taking their arithmetic mean concentrations of all four quarters of data from the monitoring well which yielded the maximum concentration. This would tend to overestimate risk and hazard since it does not take into account the dilutional effect of groundwater which has a much lower concentration. Uncertainty is introduced, through this method, by essentially establishing a separate plume for each COPC. Dependent on the location of a hypothetical production well, the risk could be over or underestimated. To address this uncertainty, risk maps are provided which will allow the reader to identify areas of the aquifer associated with risk and/or hazard due to the cumulative effect of multiple COCs, as well as areas where single COCs contribute nearly all of the risk and/or hazard.

Frequency of Detection and Spatial Distribution

Arsenic was detected above its RBC in 31 of 32 surface soil samples, and was detected in 12 of 32 surface soil samples at concentrations above its background reference concentration. Beryllium was detected above its RBC in 11 of 32 surface soil samples; its mean concentration of 0.22 mg/kg was only slightly above its RBC (0.15 mg/kg). Benzo(a)pyrene equivalents were detected above their RBCs in 22 of 46 surface soil samples.

1,1-Dichloroethene and 1,1,2,2-tetrachloroethane were only detected in the first quarter sample collected from monitoring well NBCA505001 and were not detected in any other monitoring well or sampling round. Similarly, silver was only detected in the fourth quarter sample collected from monitor well NBCA042003. Aluminum and manganese were detected in all four quarters of groundwater sampling. Aluminum was detected at a mean concentration for all four quarters of 3,490 μg/L which is below its RBC. Manganese was detected at a mean concentration for all four quarters of 415 μg/L which is below its background reference concentration. Tetrachloroethene

was detected in the first, second, and third quarter sample collected from monitoring well NBCA042001 at concentrations above its RBC. Chromium and vanadium were detected above their RBCs in the second quarter sample collected from monitoring well NBCA042003; the mean concentration for chromium over all four quarters was 16.7 µg/L which is below its RBC, and the mean concentration for vanadium over all four quarters was 23.6 µg/L which is below its RBC. Arsenic was detected above its RBC in the third and fourth quarter sampling rounds. The mean concentration of arsenic over all four quarters is above its RBC but well below its MCL.

Quantification of Risk/Hazard

As indicated by the discussions above, the risk assessment uncertainty is great. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

Of the organic CPSSs screened and eliminated from formal assessment, none was reported at concentrations close to corresponding RBCs (i.e., within approximately 10% of the RBC). This minimizes the likelihood of potentially significant cumulative risk/hazard based on the eliminated CPSSs. 4,4'-DDD was added to the list of COPCs based on chemical and toxicological similarities to 4,4'-DDE. Concentrations of aluminum exceeded its corresponding RBC, but did not exceed the corresponding background concentrations. Therefore, aluminum was eliminated from formal assessment, based on comparisons to reference concentrations.

Although the future land use of combined SWMU 42 is unknown, both the worker and residential exposure scenarios were assessed in this HHRA. Current base reuse plans call for conversion of the area to a marine cargo terminal. As previously discussed, it is likely that these scenarios would lead to overestimates of risk and/or hazard.

Groundwater

Of the CPSS screened and eliminated from formal assessment, chlorobenzene was reported in one of four first quarter monitoring wells at a concentration approaching the RBC and was not detected in any of the subsequent quarters. Use of maximum concentrations for screening comparisons minimizes the potential of significant cumulative risk/hazard based on eliminated CPSS.

Groundwater is not currently used as a potable water source at combined SWMU 42, nor is it used at NAVBASE or in the surrounding area. Municipal water is readily available. As previously mentioned, it is highly unlikely that the site will be developed as a residential area, and it is unlikely that a potable-use well would be installed onsite. It is probable that, if residences were constructed onsite and an unfiltered well were installed, its salinity and dissolved solids would preclude this aquifer from being an acceptable potable water source.

Toxicology

Arsenic was a significant contributor to risk estimates based on exposure to combined SWMU 42 surface soil and groundwater. USEPA has accepted arsenic-related cancer risks of up to 1E-03 because the cancers are squamous cell carcinomas with a low mortality rate (USEPA Region III *Risk-based Concentration Table, January-June 1996*). Cumulative risk for the soil and groundwater pathways due to arsenic did not exceed 1E-03. Aluminum and chromium were significant contributors to groundwater-based hazard index projections. Aluminum is a naturally occurring element and abundant in nature. Chromium is present in predominantly two valence states. All chromium data were assumed to be present in the more toxic chromium VI valence state. Realistically, chromium is present in a balance between chromium III and chromium VI. The RfD for chromium VI is 0.005 mg/kg-day as opposed to 1 mg/kg-day for chromium III. As a result, hazard indices based on exposures to these inorganic elements in combined SWMU 42 groundwater are considered overestimations.

10.5.6.7 Risk Summary

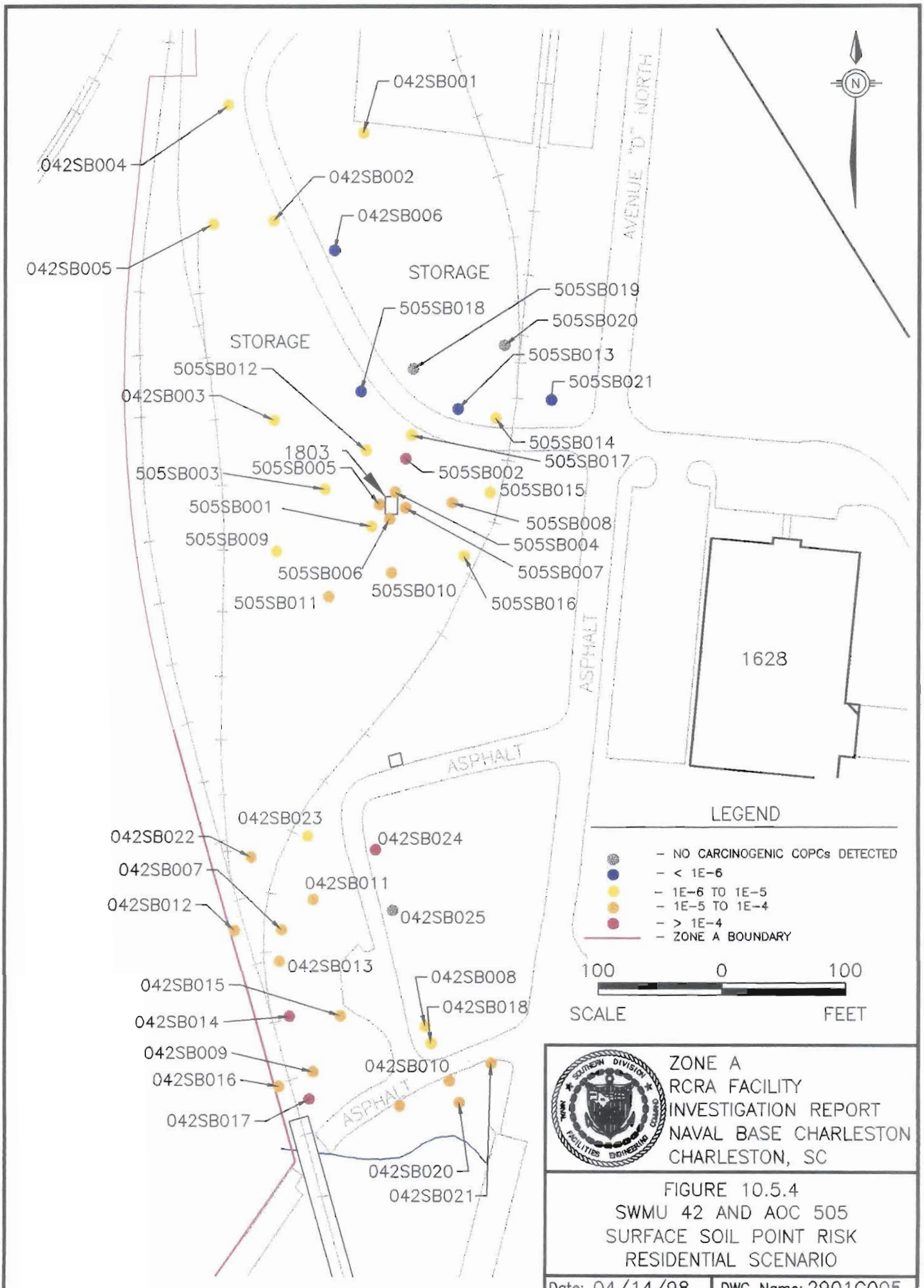
The risk and hazard posed by contaminants at combined SWMU 42 were assessed for the hypothetical site worker and the hypothetical future site resident under reasonable maximum exposure assumptions. In surface soils, the incidental ingestion and dermal contact pathways were assessed in this HHRA. Ingestion and inhalation were evaluated for shallow groundwater based on four quarters of groundwater monitoring data. Table 10.5.24 presents the risk summary for each pathway/receptor group evaluated for combined SWMU 42.

Soil

Figures 10.5.4 and 10.5.5 illustrate point risk and hazard indices for exposure to combined SWMU 42 surface soil under a residential scenario. Table 10.5.25 provides the contribution of individual COCs to cumulative risk and hazard at each sample location. The point risk map is based on the unlikely assumption that the potential future site resident will be chronically exposed to specific points. Exposure to surface soil conditions is more likely the result of equal exposure to the soil conditions over the entire site rather than specific points. Risk maps are still useful because they allow the reader to visualize the contribution to risk or hazard index of individual COCs. As shown, concentrations of arsenic and benzo(a)pyrene equivalents in surface soil contribute to risk projections above 1E-06 for most of combined SWMU 42. Concentrations of beryllium in surface soil contribute to risk projections above 1E-06 in the SWMU 42 area only. Arsenic in surface soil is the only contributor to hazard indices above one for combined SWMU 42.

Groundwater

Figures 10.5.6 and 10.5.7 illustrate point risk and hazard for SWMU 42/AOC 505 shallow groundwater under a residential scenario. To facilitate the presentation of multiple sampling rounds, the maximum risk and hazard have been plotted. Table 10.5.26 details the individual contributors to risk and hazard at each monitoring well location and for all sampling rounds. Concentrations of the chlorinated solvents, chloromethane, 1,4-dichlorobenzene, 1,1-dichloroethene, 1,1,2,2-tetrachloroethane, and tetrachloroethene in first quarter groundwater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042SB006
042SB005
STORAGE
505SB019
505SB018
505SB020
STORAGE
505SB013
505SB012
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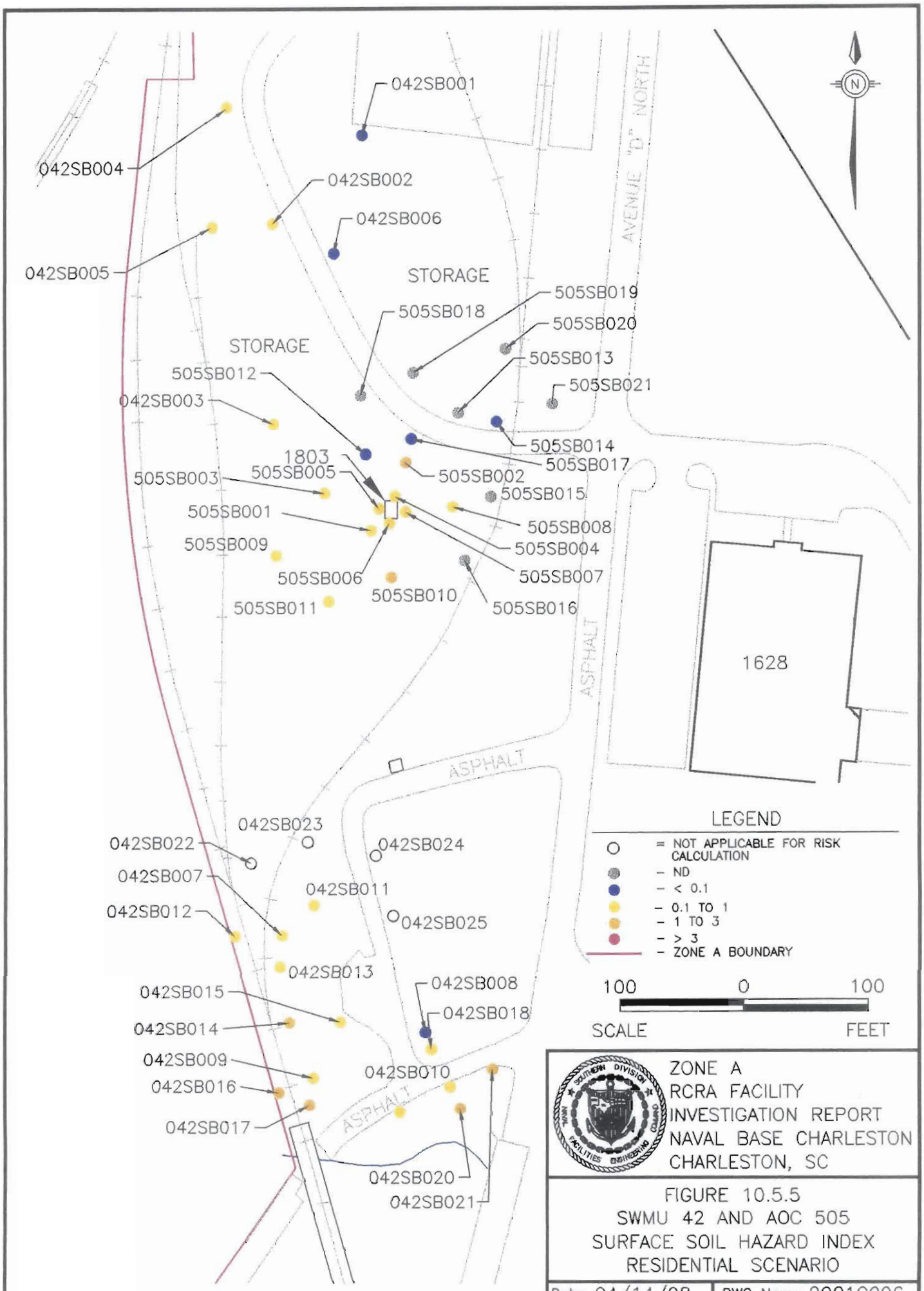
042SB003
505SB014
1803
505SB017
505SB005
505SB002
505SB003
505SB015
505SB001
505SB008
505SB009
505SB004
505SB006
505SB007
505SB010
505SB011
505SB016
AVENUE "D" NORTH
ASPHALT
1628
ASPHALT
042SB023
042SB022
042SB024
042SB007
042SB011
042SB012
042SB025
042SB013
042SB015
042SB008
042SB018
042SB014
042SB009
042SB010
042SB016
ASPHALT
042SB017
042SB020
042SB021
N
LEGEND
– NO CARCINOGENIC COPCs DETECTED
– < 1E-6
– 1E-6 TO 1E-5
– 1E-5 TO 1E-4
– > 1E-4
– ZONE A BOUNDARY
100 0 100
SCALE FEET
ZONE A
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, SC
FIGURE 10.5.4
SWMU 42 AND AOC 505
SURFACE SOIL POINT RISK
RESIDENTIAL SCENARIO
Date: 04/14/98
DWG Name: 29016005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042SB004
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STORAGE
505SB019
505SB018
505SB020
STORAGE
505SB013
505SB012
505SB021
042SB003
505SB014
1803
505SB017
505SB005
505SB002
505SB003
505SB015
505SB001
505SB008
505SB009
505SB004
505SB006
505SB007
505SB010
505SB011
505SB016
AVENUE "D" NORTH
ASPHALT
1628
ASPHALT
042SB023
042SB022
042SB024
042SB007
042SB011
042SB012
042SB025
042SB013
042SB015
042SB008
042SB018
042SB014
042SB009
042SB010
042SB016
ASPHALT
042SB017
042SB020
042SB021
N
LEGEND
= NOT APPLICABLE FOR RISK CALCULATION
– ND
– < 0.1
– 0.1 TO 1
– 1 TO 3
– > 3
– ZONE A BOUNDARY
100
0
100
SCALE
FEET
ZONE A
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, SC
FIGURE 10.5.5
SWMU 42 AND AOC 505
SURFACE SOIL HAZARD INDEX
RESIDENTIAL SCENARIO
Date: 04/14/98
DWG Name: 2901C006

Table 10.5.25
Point Estimates of Risk and Hazard - Surface Soil
Residential Scenario
SWMU 42/AOC 505
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
042	001	4,4'-DDE	ND	ug/kg	NA	NA
042	001	4,4'-DDT	ND	ug/kg	NA	NA
042	001	Aroclor-1260	ND	ug/kg	NA	NA
042	001	Arsenic (As)	1.5	mg/kg	0.0686	3.9180
042	001	B(a)P Equiv.	ND	ug/kg	NA	NA
042	001	Beryllium (Be)	ND	mg/kg	NA	NA
042	001	Lead (Pb)	14.4	mg/kg	NA	NA
042	001	Manganese (Mn)	13.9	mg/kg	0.0041	NA
		Total			0.0727	3.9180
042	002	4,4'-DDE	ND	ug/kg	NA	NA
042	002	4,4'-DDT	ND	ug/kg	NA	NA
042	002	Aroclor-1260	ND	ug/kg	NA	NA
042	002	Arsenic (As)	2.3	mg/kg	0.1051	6.0076
042	002	B(a)P Equiv.	ND	ug/kg	NA	NA
042	002	Beryllium (Be)	0.27	mg/kg	0.0007	2.0217
042	002	Lead (Pb)	4.2	mg/kg	NA	NA
042	002	Manganese (Mn)	18.9	mg/kg	0.0056	NA
		Total			0.1115	8.0293
042	003	4,4'-DDE	ND	ug/kg	NA	NA
042	003	4,4'-DDT	ND	ug/kg	NA	NA
042	003	Aroclor-1260	ND	ug/kg	NA	NA
042	003	Arsenic (As)	2	mg/kg	0.0914	5.2240
042	003	B(a)P Equiv.	ND	ug/kg	NA	NA
042	003	Beryllium (Be)	0.37	mg/kg	0.0010	2.7705
042	003	Lead (Pb)	9.4	mg/kg	NA	NA
042	003	Manganese (Mn)	44.2	mg/kg	0.0131	NA
		Total			0.1056	7.9945
042	004	4,4'-DDE	ND	ug/kg	NA	NA
042	004	4,4'-DDT	6.9	ug/kg	0.0002	0.0053
042	004	Aroclor-1260	ND	ug/kg	NA	NA
042	004	Arsenic (As)	2.1	mg/kg	0.0960	5.4852
042	004	B(a)P Equiv.	ND	ug/kg	NA	NA
042	004	Beryllium (Be)	ND	mg/kg	NA	NA
042	004	Lead (Pb)	14.15	mg/kg	NA	NA
042	004	Manganese (Mn)	28.15	mg/kg	0.0084	NA
		Total			0.1046	5.4905
042	005	4,4'-DDE	ND	ug/kg	NA	NA
042	005	4,4'-DDT	ND	ug/kg	NA	NA
042	005	Aroclor-1260	ND	ug/kg	NA	NA
042	005	Arsenic (As)	2.1	mg/kg	0.0960	5.4852
042	005	B(a)P Equiv.	ND	ug/kg	NA	NA
042	005	Beryllium (Be)	ND	mg/kg	NA	NA
042	005	Lead (Pb)	30.7	mg/kg	NA	NA
042	005	Manganese (Mn)	34.7	mg/kg	0.0103	NA
		Total			0.1063	5.4852
042	006	4,4'-DDE	ND	ug/kg	NA	NA
042	006	4,4'-DDT	7.2	ug/kg	0.0002	0.0056
042	006	Aroclor-1260	ND	ug/kg	NA	NA
042	006	Arsenic (As)	ND	mg/kg	NA	NA
042	006	B(a)P Equiv.	ND	ug/kg	NA	NA
042	006	Beryllium (Be)	ND	mg/kg	NA	NA
042	006	Lead (Pb)	23	mg/kg	NA	NA
042	006	Manganese (Mn)	61.6	mg/kg	0.0183	NA
		Total			0.0185	0.0056
042	007	4,4'-DDE	69	ug/kg	NA	0.0532
042	007	4,4'-DDT	47	ug/kg	0.0016	0.0363
042	007	Aroclor-1260	ND	ug/kg	NA	NA
042	007	Arsenic (As)	5.5	mg/kg	0.2514	14.3660
042	007	B(a)P Equiv.	753.51	ug/kg	NA	12.4784

Table 10.5.25
Point Estimates of Risk and Hazard - Surface Soil
Residential Scenario
SWMU 42/AOC 505
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
042	007	Beryllium (Be)	ND	mg/kg	NA	NA
042	007	Lead (Pb)	96	mg/kg	NA	NA
042	007	Manganese (Mn)	59.1	mg/kg	0.0176	NA
		Total			0.2705	26.9338
042	008	4,4'-DDE	ND	ug/kg	NA	NA
042	008	4,4'-DDT	19	ug/kg	0.0006	0.0147
042	008	Aroclor-1260	ND	ug/kg	NA	NA
042	008	Arsenic (As)	1.1	mg/kg	0.0503	2.8732
042	008	B(a)P Equiv.	ND	ug/kg	NA	NA
042	008	Beryllium (Be)	ND	mg/kg	NA	NA
042	008	Lead (Pb)	7.1	mg/kg	NA	NA
042	008	Manganese (Mn)	21.1	mg/kg	0.0063	NA
		Total			0.0572	2.8879
042	009	4,4'-DDE	72	ug/kg	NA	0.0555
042	009	4,4'-DDT	62	ug/kg	0.0020	0.0478
042	009	Aroclor-1260	ND	ug/kg	NA	NA
042	009	Arsenic (As)	6.1	mg/kg	0.2788	15.9332
042	009	B(a)P Equiv.	399.3	ug/kg	NA	6.6125
042	009	Beryllium (Be)	ND	mg/kg	NA	NA
042	009	Lead (Pb)	1180	mg/kg	NA	NA
042	009	Manganese (Mn)	60.4	mg/kg	0.0179	NA
		Total			0.2988	22.6491
042	010	4,4'-DDE	2500	ug/kg	NA	1.9283
042	010	4,4'-DDT	2300	ug/kg	0.0759	1.7740
042	010	Aroclor-1260	ND	ug/kg	NA	NA
042	010	Arsenic (As)	12.3	mg/kg	0.5622	32.1276
042	010	B(a)P Equiv.	1887.4	ug/kg	NA	31.2559
042	010	Beryllium (Be)	0.38	mg/kg	0.0010	2.8453
042	010	Lead (Pb)	339	mg/kg	NA	NA
042	010	Manganese (Mn)	73.7	mg/kg	0.0219	NA
		Total			0.6610	69.9311
042	011	Arsenic (As)	3.2	mg/kg	0.1463	8.3584
042	011	B(a)P Equiv.	537.2	ug/kg	NA	8.8962
042	011	Beryllium (Be)	0.19	mg/kg	0.0005	1.4227
042	011	Lead (Pb)	162	mg/kg	NA	NA
042	011	Manganese (Mn)	53.8	mg/kg	0.0160	NA
		Total			0.1628	18.6773
042	012	Arsenic (As)	4.8	mg/kg	0.2194	12.5376
042	012	B(a)P Equiv.	15.086	ug/kg	NA	0.2498
042	012	Beryllium (Be)	0.28	mg/kg	0.0008	2.0966
042	012	Lead (Pb)	7.2	mg/kg	NA	NA
042	012	Manganese (Mn)	10.2	mg/kg	0.0030	NA
		Total			0.2232	14.8840
042	013	Arsenic (As)	9.5	mg/kg	0.4342	24.8140
042	013	B(a)P Equiv.	626.81	ug/kg	NA	10.3802
042	013	Beryllium (Be)	0.19	mg/kg	0.0005	1.4227
042	013	Lead (Pb)	167	mg/kg	NA	NA
042	013	Manganese (Mn)	47.8	mg/kg	0.0142	NA
		Total			0.4489	36.6168
042	014	Arsenic (As)	30.3	mg/kg	1.3849	79.1436
042	014	B(a)P Equiv.	1227.2	ug/kg	NA	20.3228
042	014	Beryllium (Be)	0.27	mg/kg	0.0007	2.0217
042	014	Lead (Pb)	173	mg/kg	NA	NA
042	014	Manganese (Mn)	308	mg/kg	0.0915	NA
		Total			1.4772	101.4881
042	015	Arsenic (As)	4.55	mg/kg	0.2080	11.8846
042	015	B(a)P Equiv.	4.5	ug/kg	NA	0.0745

Table 10.5.25
Point Estimates of Risk and Hazard - Surface Soil
Residential Scenario
SWMU 42/AOC 505
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
042	015	Beryllium (Be)	0.16	mg/kg	0.0004	1.1980
042	015	Lead (Pb)	28.1	mg/kg	NA	NA
042	015	Manganese (Mn)	26.9	mg/kg	0.0080	NA
		Total			0.2164	13.1572
042	016	Arsenic (As)	28.2	mg/kg	1.2890	73.6584
042	016	B(a)P Equiv.	1067.08	ug/kg	NA	17.6712
042	016	Beryllium (Be)	0.17	mg/kg	0.0005	1.2729
042	016	Lead (Pb)	39.2	mg/kg	NA	NA
042	016	Manganese (Mn)	20	mg/kg	0.0059	NA
		Total			1.2954	92.6025
042	017	Arsenic (As)	38.6	mg/kg	1.7643	100.8232
042	017	B(a)P Equiv.	1882.95	ug/kg	NA	31.1822
042	017	Beryllium (Be)	0.23	mg/kg	0.0006	1.7222
042	017	Lead (Pb)	86.5	mg/kg	NA	NA
042	017	Manganese (Mn)	81.5	mg/kg	0.0242	NA
		Total			1.7892	133.7277
042	018	Arsenic (As)	2.6	mg/kg	0.1188	6.7912
042	018	B(a)P Equiv.	ND	ug/kg	NA	NA
042	018	Beryllium (Be)	0.13	mg/kg	0.0004	0.9734
042	018	Lead (Pb)	44	mg/kg	NA	NA
042	018	Manganese (Mn)	18.5	mg/kg	0.0055	NA
		Total			0.1247	7.7646
042	019	Arsenic (As)	6.3	mg/kg	0.2880	16.4556
042	019	B(a)P Equiv.	374.74	ug/kg	NA	6.2058
042	019	Beryllium (Be)	0.17	mg/kg	0.0005	1.2729
042	019	Lead (Pb)	128	mg/kg	NA	NA
042	019	Manganese (Mn)	68.4	mg/kg	0.0203	NA
		Total			0.3087	23.9343
042	020	Arsenic (As)	31.6	mg/kg	1.4444	82.5392
042	020	B(a)P Equiv.	ND	ug/kg	NA	NA
042	020	Beryllium (Be)	0.09	mg/kg	0.0002	0.6739
042	020	Lead (Pb)	153	mg/kg	NA	NA
042	020	Manganese (Mn)	10.2	mg/kg	0.0030	NA
		Total			1.4476	83.2131
042	021	Arsenic (As)	25.4	mg/kg	1.1610	66.3448
042	021	B(a)P Equiv.	124.051	ug/kg	NA	2.0543
042	021	Beryllium (Be)	0.13	mg/kg	0.0004	0.9734
042	021	Lead (Pb)	34.4	mg/kg	NA	NA
042	021	Manganese (Mn)	15.1	mg/kg	0.0045	NA
		Total			1.1658	69.3726
042	022	B(a)P Equiv.	1019.84	ug/kg	NA	16.8889
		Total			NA	16.8889
042	023	B(a)P Equiv.	350.645	ug/kg	NA	5.8068
		Total			NA	5.8068
042	024	B(a)P Equiv.	7389.1	ug/kg	NA	122.3658
		Total			NA	122.3658
042	025	B(a)P Equiv.	ND	ug/kg	NA	NA
		Total			NA	NA
505	001	4,4'-DDE	ND	ug/kg	NA	NA
505	001	4,4'-DDT	ND	ug/kg	NA	NA
505	001	Aroclor-1260	ND	ug/kg	NA	NA
505	001	Arsenic (As)	2.9	mg/kg	0.1326	7.5748
505	001	B(a)P Equiv.	ND	ug/kg	NA	NA
505	001	Beryllium (Be)	ND	mg/kg	NA	NA

Table 10.5.25
Point Estimates of Risk and Hazard - Surface Soil
Residential Scenario
SWMU 42/AOC 505
NAVBASE - Charleston, Zone A
Charleston, South Carolina

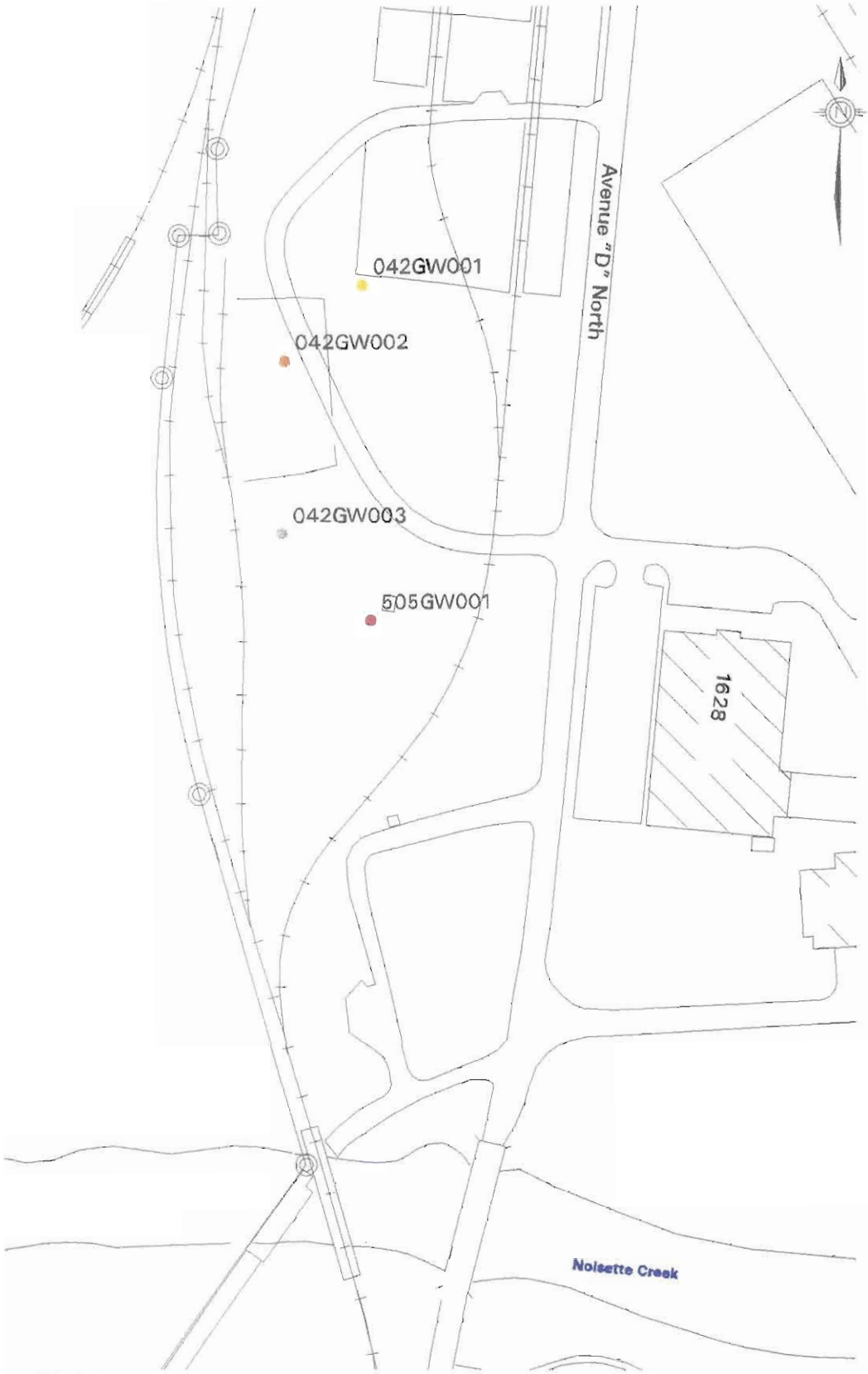
Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
505	001	Lead (Pb)	5.9	mg/kg	NA	NA
505	001	Manganese (Mn)	16.6	mg/kg	0.0049	NA
		Total			0.1375	7.5748
505	002	4,4'-DDE	39	ug/kg	NA	0.0301
505	002	4,4'-DDT	ND	ug/kg	NA	NA
505	002	Aroclor-1260	270	ug/kg	NA	1.2250
505	002	Arsenic (As)	62	mg/kg	2.8339	161.9441
505	002	B(a)P Equiv.	698.42	ug/kg	NA	11.5661
505	002	Beryllium (Be)	ND	mg/kg	NA	NA
505	002	Lead (Pb)	73.5	mg/kg	NA	NA
505	002	Manganese (Mn)	54.5	mg/kg	0.0162	NA
		Total			2.8501	174.7652
505	003	4,4'-DDE	34	ug/kg	NA	0.0262
505	003	4,4'-DDT	170	ug/kg	0.0056	0.1311
505	003	Aroclor-1260	ND	ug/kg	NA	NA
505	003	Arsenic (As)	3.3	mg/kg	0.1508	8.6196
505	003	B(a)P Equiv.	ND	ug/kg	NA	NA
505	003	Beryllium (Be)	ND	mg/kg	NA	NA
505	003	Lead (Pb)	43.6	mg/kg	NA	NA
505	003	Manganese (Mn)	56.1	mg/kg	0.0167	NA
		Total			0.1731	8.7769
505	004	4,4'-DDE	20	ug/kg	NA	0.0154
505	004	4,4'-DDT	ND	ug/kg	NA	NA
505	004	Aroclor-1260	ND	ug/kg	NA	NA
505	004	Arsenic (As)	6.6	mg/kg	0.3017	17.2392
505	004	B(a)P Equiv.	995.87	ug/kg	NA	16.4919
505	004	Beryllium (Be)	ND	mg/kg	NA	NA
505	004	Lead (Pb)	125	mg/kg	NA	NA
505	004	Manganese (Mn)	36.8	mg/kg	0.0109	NA
		Total			0.3126	33.7466
505	005	4,4'-DDE	ND	ug/kg	NA	NA
505	005	4,4'-DDT	ND	ug/kg	NA	NA
505	005	Aroclor-1260	83	ug/kg	NA	0.3766
505	005	Arsenic (As)	8.6	mg/kg	0.3931	22.4632
505	005	B(a)P Equiv.	483.62	ug/kg	NA	8.0089
505	005	Beryllium (Be)	ND	mg/kg	NA	NA
505	005	Lead (Pb)	491	mg/kg	NA	NA
505	005	Manganese (Mn)	69.1	mg/kg	0.0205	NA
		Total			0.4136	30.8487
505	006	4,4'-DDE	12	ug/kg	NA	0.0093
505	006	4,4'-DDT	37	ug/kg	0.0012	0.0285
505	006	Aroclor-1260	210	ug/kg	NA	0.9528
505	006	Arsenic (As)	7	mg/kg	0.3200	18.2840
505	006	B(a)P Equiv.	448.35	ug/kg	NA	7.4248
505	006	Beryllium (Be)	ND	mg/kg	NA	NA
505	006	Lead (Pb)	26	mg/kg	NA	NA
505	006	Manganese (Mn)	311	mg/kg	0.0924	NA
		Total			0.4135	26.6994
505	007	4,4'-DDE	45	ug/kg	NA	0.0347
505	007	4,4'-DDT	ND	ug/kg	NA	NA
505	007	Aroclor-1260	780	ug/kg	NA	3.5389
505	007	Arsenic (As)	18.2	mg/kg	0.8319	47.5384
505	007	B(a)P Equiv.	1365.9	ug/kg	NA	22.6197
505	007	Beryllium (Be)	ND	mg/kg	NA	NA
505	007	Lead (Pb)	94.9	mg/kg	NA	NA
505	007	Manganese (Mn)	67.1	mg/kg	0.0199	NA
		Total			0.8518	73.7318
505	008	4,4'-DDE	54	ug/kg	NA	0.0417

Table 10.5.25
Point Estimates of Risk and Hazard - Surface Soil
Residential Scenario
SWMU 42/AOC 505
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
505	008	4,4'-DDT	ND	ug/kg	NA	NA
505	008	Aroclor-1260	1800	ug/kg	NA	8.1667
505	008	Arsenic (As)	12.9	mg/kg	0.5896	33.6948
505	008	B(a)P Equiv.	2348.8	ug/kg	NA	38.8969
505	008	Beryllium (Be)	ND	mg/kg	NA	NA
505	008	Lead (Pb)	195	mg/kg	NA	NA
505	008	Manganese (Mn)	90.7	mg/kg	0.0269	NA
		Total			0.6166	80.8001
505	009	4,4'-DDE	ND	ug/kg	NA	NA
505	009	4,4'-DDT	8.1	ug/kg	0.0003	0.0062
505	009	Aroclor-1260	ND	ug/kg	NA	NA
505	009	Arsenic (As)	3.6	mg/kg	0.1645	9.4032
505	009	B(a)P Equiv.	ND	ug/kg	NA	NA
505	009	Beryllium (Be)	ND	mg/kg	NA	NA
505	009	Lead (Pb)	15.4	mg/kg	NA	NA
505	009	Manganese (Mn)	46.1	mg/kg	0.0137	NA
		Total			0.1785	9.4095
505	010	4,4'-DDE	ND	ug/kg	NA	NA
505	010	4,4'-DDT	43	ug/kg	0.0014	0.0332
505	010	Aroclor-1260	ND	ug/kg	NA	NA
505	010	Arsenic (As)	33.1	mg/kg	1.5129	86.4572
505	010	B(a)P Equiv.	0.15	ug/kg	NA	0.0025
505	010	Beryllium (Be)	ND	mg/kg	NA	NA
505	010	Lead (Pb)	26.5	mg/kg	NA	NA
505	010	Manganese (Mn)	39	mg/kg	0.0116	NA
		Total			1.5259	86.4929
505	011	4,4'-DDE	76	ug/kg	NA	0.0586
505	011	4,4'-DDT	65	ug/kg	0.0021	0.0501
505	011	Aroclor-1260	ND	ug/kg	NA	NA
505	011	Arsenic (As)	10.3	mg/kg	0.4708	26.9036
505	011	B(a)P Equiv.	ND	ug/kg	NA	NA
505	011	Beryllium (Be)	ND	mg/kg	NA	NA
505	011	Lead (Pb)	6.1	mg/kg	NA	NA
505	011	Manganese (Mn)	13	mg/kg	0.0039	NA
		Total			0.4768	27.0124
505	012	4,4'-DDE	20	ug/kg	NA	0.0154
505	012	4,4'-DDT	21	ug/kg	0.0007	0.0162
505	012	Aroclor-1260	ND	ug/kg	NA	NA
505	012	B(a)P Equiv.	251.81	ug/kg	NA	4.1701
		Total			0.0007	4.2017
505	013	4,4'-DDE	15	ug/kg	NA	0.0116
505	013	4,4'-DDT	ND	ug/kg	NA	NA
505	013	Aroclor-1260	ND	ug/kg	NA	NA
505	013	B(a)P Equiv.	ND	ug/kg	NA	NA
		Total			NA	0.0116
505	014	4,4'-DDE	79	ug/kg	NA	0.0609
505	014	4,4'-DDT	21	ug/kg	0.0007	0.0162
505	014	Aroclor-1260	ND	ug/kg	NA	NA
505	014	B(a)P Equiv.	267.97	ug/kg	NA	4.4377
		Total			0.0007	4.5148
505	015	4,4'-DDE	12	ug/kg	NA	0.0093
505	015	4,4'-DDT	ND	ug/kg	NA	NA
505	015	Aroclor-1260	ND	ug/kg	NA	NA
505	015	B(a)P Equiv.	74.635	ug/kg	NA	1.2360
		Total			NA	1.2452
505	016	4,4'-DDE	14	ug/kg	NA	0.0108
505	016	4,4'-DDT	ND	ug/kg	NA	NA

Table 10.5.25
Point Estimates of Risk and Hazard - Surface Soil
Residential Scenario
SWMU 42/AOC 505
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
505	016	Aroclor-1260	ND	ug/kg	NA	NA
505	016	B(a)P Equiv.	84.096	ug/kg	NA	1.3927
		Total			NA	1.4035
505	017	4,4'-DDE	64	ug/kg	NA	0.0494
505	017	4,4'-DDT	84	ug/kg	0.0028	0.0648
505	017	Aroclor-1260	ND	ug/kg	NA	NA
505	017	B(a)P Equiv.	184.35	ug/kg	NA	3.0529
		Total			0.0028	3.1670
505	018	B(a)P Equiv.	0.12	ug/kg	NA	0.0020
		Total			NA	0.0020
505	019	B(a)P Equiv.	ND	ug/kg	NA	NA
		Total			NA	NA
505	020	B(a)P Equiv.	ND	ug/kg	NA	NA
		Total			NA	NA
505	021	B(a)P Equiv.	0.12	ug/kg	NA	0.0020
		Total			NA	0.0020



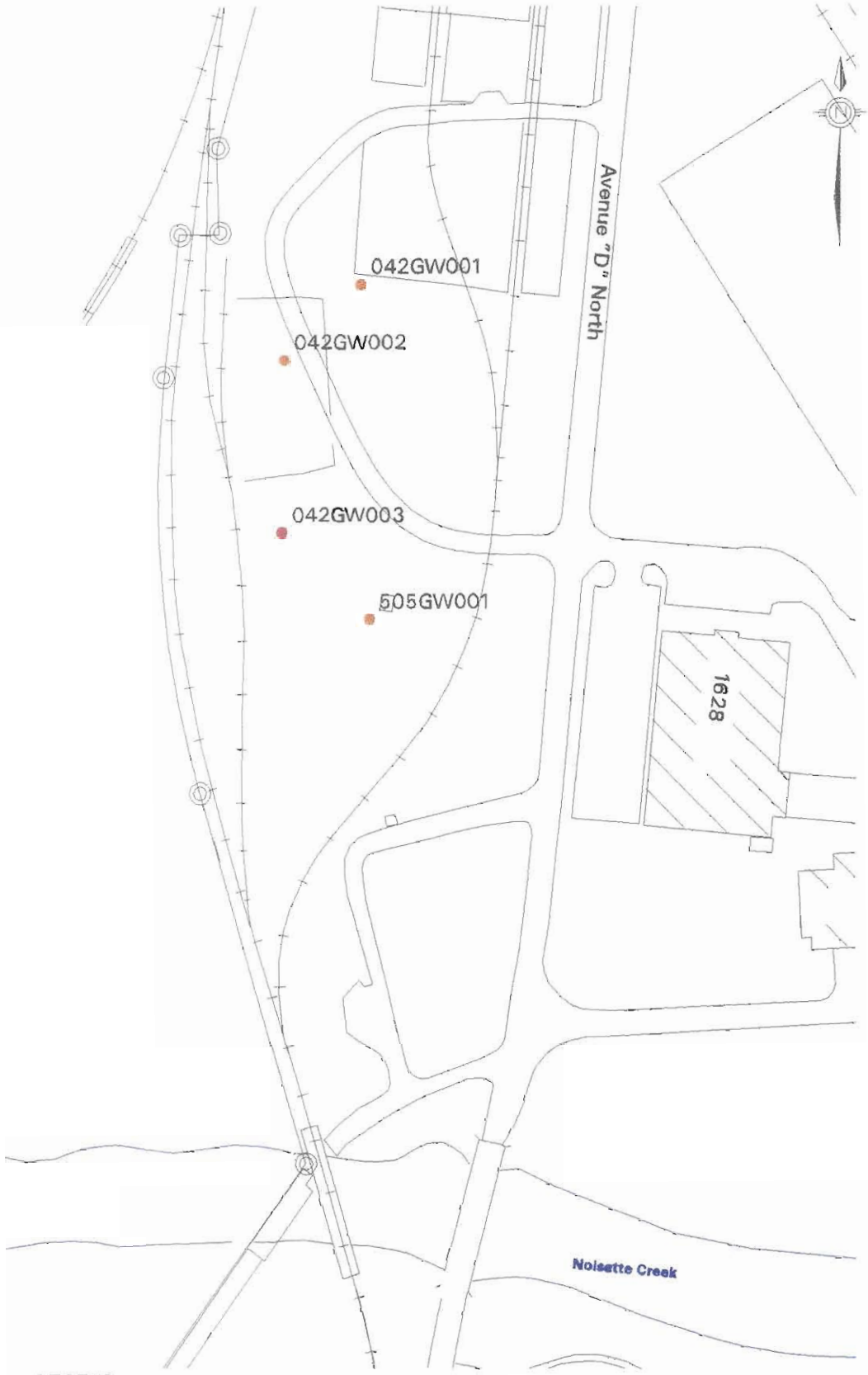
LEGEND

- ND
- < 1E-06
- 1E-06 to 1E-05
- 1E-05 to 1E-04
- > 1E-04

0 125 feet

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.5.6 - SWMU 42 and AOC 505 Groundwater Point Risk - Residential Scenario



LEGEND

- ND
- < 0.1
- 0.1 to 1
- 1 to 3
- > 3

0 125 feet

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.5.7 SWMU 42 and AOC 505

Table 10.5.26
Point Estimates of Risk and Hazard - Shallow Groundwater
Residential Scenario
SWMU 42/AOC 505
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Quarter	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
042	001	01	1,1,2,2-Tetrachloroethane	ND	ug/L	NA	NA
042	001	01	1,1-Dichloroethene	ND	ug/L	NA	NA
042	001	01	1,4-Dichlorobenzene	ND	ug/L	NA	NA
042	001	01	Aluminum (Al)	649	ug/L	0.0415	NA
042	001	01	Arsenic (As)	ND	ug/L	NA	NA
042	001	01	Chloromethane	7.8	ug/L	NA	2.2390
042	001	01	Chromium (Cr)	ND	ug/L	NA	NA
042	001	01	Manganese (Mn)	353	ug/L	0.9811	NA
042	001	01	Silver (Ag)	ND	ug/L	NA	NA
042	001	01	Tetrachloroethene	5.9	ug/L	0.0754	4.7411
042	001	01	Trichloroethene	ND	ug/L	NA	NA
042	001	01	Vanadium (V)	ND	ug/L	NA	NA
			Total			1.0981	6.9801
042	002	01	1,1,2,2-Tetrachloroethane	ND	ug/L	NA	NA
042	002	01	1,1-Dichloroethene	ND	ug/L	NA	NA
042	002	01	1,4-Dichlorobenzene	ND	ug/L	NA	NA
042	002	01	Aluminum (Al)	2020	ug/L	0.1291	NA
042	002	01	Arsenic (As)	ND	ug/L	NA	NA
042	002	01	Chloromethane	ND	ug/L	NA	NA
042	002	01	Chromium (Cr)	4.9	ug/L	0.0626	NA
042	002	01	Manganese (Mn)	827	ug/L	2.2986	NA
042	002	01	Silver (Ag)	ND	ug/L	NA	NA
042	002	01	Tetrachloroethene	ND	ug/L	NA	NA
042	002	01	Trichloroethene	ND	ug/L	NA	NA
042	002	01	Vanadium (V)	ND	ug/L	NA	NA
			Total			2.4904	NA
042	003	01	1,1,2,2-Tetrachloroethane	ND	ug/L	NA	NA
042	003	01	1,1-Dichloroethene	ND	ug/L	NA	NA
042	003	01	1,4-Dichlorobenzene	ND	ug/L	NA	NA
042	003	01	Aluminum (Al)	229	ug/L	0.0146	NA
042	003	01	Arsenic (As)	ND	ug/L	NA	NA
042	003	01	Chloromethane	ND	ug/L	NA	NA
042	003	01	Chromium (Cr)	ND	ug/L	NA	NA
042	003	01	Manganese (Mn)	365	ug/L	1.0145	NA
042	003	01	Silver (Ag)	ND	ug/L	NA	NA
042	003	01	Tetrachloroethene	ND	ug/L	NA	NA
042	003	01	Trichloroethene	ND	ug/L	NA	NA
042	003	01	Vanadium (V)	ND	ug/L	NA	NA
			Total			1.0291	NA
505	001	01	1,1,2,2-Tetrachloroethane	1.5	ug/L	NA	8.9906
505	001	01	1,1-Dichloroethene	1	ug/L	0.0142	11.5264
505	001	01	1,4-Dichlorobenzene	2	ug/L	0.0011	1.4278
505	001	01	Aluminum (Al)	675	ug/L	0.0432	NA
505	001	01	Arsenic (As)	ND	ug/L	NA	NA
505	001	01	Chloromethane	ND	ug/L	NA	NA
505	001	01	Chromium (Cr)	ND	ug/L	NA	NA
505	001	01	Manganese (Mn)	232	ug/L	0.6448	NA
505	001	01	Silver (Ag)	ND	ug/L	NA	NA
505	001	01	Tetrachloroethene	ND	ug/L	NA	NA
505	001	01	Trichloroethene	ND	ug/L	NA	NA
505	001	01	Vanadium (V)	ND	ug/L	NA	NA
			Total			0.7033	21.9448
042	001	02	1,1,2,2-Tetrachloroethane	ND	ug/L	NA	NA
042	001	02	1,1-Dichloroethene	ND	ug/L	NA	NA
042	001	02	1,4-Dichlorobenzene	ND	ug/L	NA	NA
042	001	02	Aluminum (Al)	1230	ug/L	0.0786	NA
042	001	02	Arsenic (As)	ND	ug/L	NA	NA
042	001	02	Chloromethane	ND	ug/L	NA	NA
042	001	02	Chromium (Cr)	ND	ug/L	NA	NA
042	001	02	Manganese (Mn)	306	ug/L	0.8505	NA

Table 10.5.26
Point Estimates of Risk and Hazard - Shallow Groundwater
Residential Scenario
SWMU 42/AOC 505
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Quarter	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
042	001	02	Silver (Ag)	ND	ug/L	NA	NA
042	001	02	Tetrachloroethene	1.5	ug/L	0.0192	1.2054
042	001	02	Trichloroethene	1.4	ug/L	0.0298	0.3540
042	001	02	Vanadium (V)	ND	ug/L	NA	NA
			Total			0.9781	1.5593
042	002	02	1,1,2,2-Tetrachloroethane	ND	ug/L	NA	NA
042	002	02	1,1-Dichloroethene	ND	ug/L	NA	NA
042	002	02	1,4-Dichlorobenzene	ND	ug/L	NA	NA
042	002	02	Aluminum (Al)	ND	ug/L	NA	NA
042	002	02	Arsenic (As)	ND	ug/L	NA	NA
042	002	02	Chloromethane	ND	ug/L	NA	NA
042	002	02	Chromium (Cr)	ND	ug/L	NA	NA
042	002	02	Manganese (Mn)	690	ug/L	1.9178	NA
042	002	02	Silver (Ag)	ND	ug/L	NA	NA
042	002	02	Tetrachloroethene	ND	ug/L	NA	NA
042	002	02	Trichloroethene	ND	ug/L	NA	NA
042	002	02	Vanadium (V)	ND	ug/L	NA	NA
			Total			1.9178	NA
042	003	02	1,1,2,2-Tetrachloroethane	ND	ug/L	NA	NA
042	003	02	1,1-Dichloroethene	ND	ug/L	NA	NA
042	003	02	1,4-Dichlorobenzene	ND	ug/L	NA	NA
042	003	02	Aluminum (Al)	27200	ug/L	1.7388	NA
042	003	02	Arsenic (As)	ND	ug/L	NA	NA
042	003	02	Chloromethane	ND	ug/L	NA	NA
042	003	02	Chromium (Cr)	45.9	ug/L	0.5868	NA
042	003	02	Manganese (Mn)	692	ug/L	1.9234	NA
042	003	02	Silver (Ag)	ND	ug/L	NA	NA
042	003	02	Tetrachloroethene	ND	ug/L	NA	NA
042	003	02	Trichloroethene	ND	ug/L	NA	NA
042	003	02	Vanadium (V)	61	ug/L	0.5571	NA
			Total			4.8061	NA
505	001	02	1,1,2,2-Tetrachloroethane	ND	ug/L	NA	NA
505	001	02	1,1-Dichloroethene	ND	ug/L	NA	NA
505	001	02	1,4-Dichlorobenzene	ND	ug/L	NA	NA
505	001	02	Aluminum (Al)	1930	ug/L	0.1234	NA
505	001	02	Arsenic (As)	ND	ug/L	NA	NA
505	001	02	Chloromethane	ND	ug/L	NA	NA
505	001	02	Chromium (Cr)	6.4	ug/L	0.0818	NA
505	001	02	Manganese (Mn)	281	ug/L	0.7810	NA
505	001	02	Silver (Ag)	ND	ug/L	NA	NA
505	001	02	Tetrachloroethene	ND	ug/L	NA	NA
505	001	02	Trichloroethene	ND	ug/L	NA	NA
505	001	02	Vanadium (V)	ND	ug/L	NA	NA
			Total			0.9862	NA
042	001	03	1,1,2,2-Tetrachloroethane	ND	ug/L	NA	NA
042	001	03	1,1-Dichloroethene	ND	ug/L	NA	NA
042	001	03	1,4-Dichlorobenzene	ND	ug/L	NA	NA
042	001	03	Aluminum (Al)	477	ug/L	0.0305	NA
042	001	03	Arsenic (As)	ND	ug/L	NA	NA
042	001	03	Chloromethane	ND	ug/L	NA	NA
042	001	03	Chromium (Cr)	ND	ug/L	NA	NA
042	001	03	Manganese (Mn)	313	ug/L	0.8700	NA
042	001	03	Silver (Ag)	ND	ug/L	NA	NA
042	001	03	Tetrachloroethene	1.4	ug/L	0.0179	1.1250
042	001	03	Trichloroethene	1.6	ug/L	0.0341	0.4045
042	001	03	Vanadium (V)	ND	ug/L	NA	NA
			Total			0.9524	1.5295
042	002	03	1,1,2,2-Tetrachloroethane	ND	ug/L	NA	NA
042	002	03	1,1-Dichloroethene	ND	ug/L	NA	NA
042	002	03	1,4-Dichlorobenzene	ND	ug/L	NA	NA

Table 10.5.26
Point Estimates of Risk and Hazard - Shallow Groundwater
Residential Scenario
SWMU 42/AOC 505
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Quarter	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
042	002	03	Aluminum (Al)	77	ug/L	0.0049	NA
042	002	03	Arsenic (As)	ND	ug/L	NA	NA
042	002	03	Chloromethane	ND	ug/L	NA	NA
042	002	03	Chromium (Cr)	ND	ug/L	NA	NA
042	002	03	Manganese (Mn)	656	ug/L	1.8233	NA
042	002	03	Silver (Ag)	ND	ug/L	NA	NA
042	002	03	Tetrachloroethene	ND	ug/L	NA	NA
042	002	03	Trichloroethene	ND	ug/L	NA	NA
042	002	03	Vanadium (V)	ND	ug/L	NA	NA
			Total			1.8282	NA
042	003	03	1,1,2,2-Tetrachloroethane	ND	ug/L	NA	NA
042	003	03	1,1-Dichloroethene	ND	ug/L	NA	NA
042	003	03	1,4-Dichlorobenzene	ND	ug/L	NA	NA
042	003	03	Aluminum (Al)	6760	ug/L	0.4321	NA
042	003	03	Arsenic (As)	ND	ug/L	NA	NA
042	003	03	Chloromethane	ND	ug/L	NA	NA
042	003	03	Chromium (Cr)	9.7	ug/L	0.1240	NA
042	003	03	Manganese (Mn)	549	ug/L	1.5259	NA
042	003	03	Silver (Ag)	ND	ug/L	NA	NA
042	003	03	Tetrachloroethene	ND	ug/L	NA	NA
042	003	03	Trichloroethene	ND	ug/L	NA	NA
042	003	03	Vanadium (V)	9	ug/L	0.0822	NA
			Total			2.1643	NA
505	001	03	1,1,2,2-Tetrachloroethane	ND	ug/L	NA	NA
505	001	03	1,1-Dichloroethene	ND	ug/L	NA	NA
505	001	03	1,4-Dichlorobenzene	ND	ug/L	NA	NA
505	001	03	Aluminum (Al)	272	ug/L	0.0174	NA
505	001	03	Arsenic (As)	9	ug/L	1.9178	200.7828
505	001	03	Chloromethane	ND	ug/L	NA	NA
505	001	03	Chromium (Cr)	ND	ug/L	NA	NA
505	001	03	Manganese (Mn)	287	ug/L	0.7977	NA
505	001	03	Silver (Ag)	ND	ug/L	NA	NA
505	001	03	Tetrachloroethene	ND	ug/L	NA	NA
505	001	03	Trichloroethene	ND	ug/L	NA	NA
505	001	03	Vanadium (V)	ND	ug/L	NA	NA
			Total			2.7329	200.7828
042	001	04	1,1,2,2-Tetrachloroethane	ND	ug/L	NA	NA
042	001	04	1,1-Dichloroethene	ND	ug/L	NA	NA
042	001	04	Aluminum (Al)	364	ug/L	0.0233	NA
042	001	04	Arsenic (As)	ND	ug/L	NA	NA
042	001	04	Chloromethane	ND	ug/L	NA	NA
042	001	04	Chromium (Cr)	ND	ug/L	NA	NA
042	001	04	Manganese (Mn)	218	ug/L	0.6059	NA
042	001	04	Silver (Ag)	ND	ug/L	NA	NA
042	001	04	Tetrachloroethene	ND	ug/L	NA	NA
042	001	04	Trichloroethene	ND	ug/L	NA	NA
042	001	04	Vanadium (V)	ND	ug/L	NA	NA
			Total			0.6292	NA
042	002	04	1,1,2,2-Tetrachloroethane	ND	ug/L	NA	NA
042	002	04	1,1-Dichloroethene	ND	ug/L	NA	NA
042	002	04	Aluminum (Al)	ND	ug/L	NA	NA
042	002	04	Arsenic (As)	2.9	ug/L	0.6180	64.6967
042	002	04	Chloromethane	ND	ug/L	NA	NA
042	002	04	Chromium (Cr)	ND	ug/L	NA	NA
042	002	04	Manganese (Mn)	533	ug/L	1.4814	NA
042	002	04	Silver (Ag)	ND	ug/L	NA	NA
042	002	04	Tetrachloroethene	ND	ug/L	NA	NA
042	002	04	Trichloroethene	ND	ug/L	NA	NA
042	002	04	Vanadium (V)	ND	ug/L	NA	NA
			Total			2.0994	64.6967

Table 10.5.26
Point Estimates of Risk and Hazard - Shallow Groundwater
Residential Scenario
SWMU 42/AOC 505
NAVBASE - Charleston, Zone A
Charleston, South Carolina

Site	Location	Quarter	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
042	003	04	1,1,2,2-Tetrachloroethane	ND	ug/L	NA	NA
042	003	04	1,1-Dichloroethene	ND	ug/L	NA	NA
042	003	04	Aluminum (Al)	ND	ug/L	NA	NA
042	003	04	Arsenic (As)	ND	ug/L	NA	NA
042	003	04	Chloromethane	ND	ug/L	NA	NA
042	003	04	Chromium (Cr)	ND	ug/L	NA	NA
042	003	04	Manganese (Mn)	18.6	ug/L	0.0517	NA
042	003	04	Silver (Ag)	111	ug/L	1.4192	NA
042	003	04	Tetrachloroethene	ND	ug/L	NA	NA
042	003	04	Trichloroethene	ND	ug/L	NA	NA
042	003	04	Vanadium (V)	ND	ug/L	NA	NA
			Total			1.4709	NA
505	001	04	1,1,2,2-Tetrachloroethane	ND	ug/L	NA	NA
505	001	04	1,1-Dichloroethene	ND	ug/L	NA	NA
505	001	04	Aluminum (Al)	ND	ug/L	NA	NA
505	001	04	Arsenic (As)	6.4	ug/L	1.3638	142.7789
505	001	04	Chloromethane	ND	ug/L	NA	NA
505	001	04	Chromium (Cr)	ND	ug/L	NA	NA
505	001	04	Manganese (Mn)	323	ug/L	0.8978	NA
505	001	04	Silver (Ag)	ND	ug/L	NA	NA
505	001	04	Tetrachloroethene	ND	ug/L	NA	NA
505	001	04	Trichloroethene	ND	ug/L	NA	NA
505	001	04	Vanadium (V)	1.5	ug/L	0.0137	NA
			Total			2.2752	142.7789

samples collected from monitoring wells NBCA042001 and NBCA505001 contribute to risk projections above 1E-06. Of these, only tetrachloroethene was detected in any subsequent sampling rounds. Concentrations of arsenic in groundwater, although not detected in the first two quarters, contribute to risk projection above 1E-06 in the third and fourth quarters. Manganese in groundwater is the primary contributor to hazard indices above one. The exceptions are aluminum in the second quarter sample from monitoring well NBCA042003, and silver in the fourth quarter sample from monitoring well NBCA042003.

10.5.6.8 Remedial Goal Options

Soil

RGOs for carcinogens were based on the lifetime weighted average for site resident and site workers and are presented in Table 10.5.27 for surface soils. Hazard-based RGOs were calculated based on the hypothetical child resident or the site worker, as noted in the corresponding table.

Groundwater

Groundwater RGOs based on site residents and site workers are shown in Table 10.5.28.

10.5.7 Corrective Measures Considerations

For SWMU 42/AOC 505, the environmental media investigated were surface soil, subsurface soil, and shallow groundwater. Based on the analytical results and the risk assessment, COCs requiring further evaluation through the CMS process were identified for surface soil and shallow groundwater. Detections of COCs in the subsurface soil also justify inclusion in the CMS process.

Arsenic, beryllium, and BEQs were identified as COCs in soil. The CMS for soil should further delineate the BEQ area of contamination, identified as a data gap in the southern to middle portion of the combined investigation area. Aluminum, arsenic, chromium, silver, vanadium, PCE, 1,1,2,2-TCA, 1,1-DCE, and manganese were identified as COCs in shallow groundwater.

Table 10.5.27
Remedial Goal Options Surface Soil
SWMU 42 and AOC 505
Naval Base Charleston, Zone A
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	FI/FC Factor	EPC mg/kg	Hazard-Based Remedial Goal Options 3 mg/kg	1 mg/kg	0.1 mg/kg	Risk-Based Remedial Goal Options 1E-06 mg/kg	1E-05 mg/kg	1E-04 mg/kg	Background Concentration mg/kg
Arsenic	1.5	0.0003	1	23	66	22	2.2	0.38	3.8	38	9.44
Benzo(a)pyrene equivalents	7.3	NA	0.6	7.4	ND	ND	ND	0.060	0.60	6.0	NA
Beryllium	4.3	0.005	1	0.18	8091	2697	270	0.13	1.3	13	NA

Worker-Based Remedial Goal Options

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	FI/FC Factor	EPC mg/kg	Hazard-Based Remedial Goal Options 3 mg/kg	1 mg/kg	0.1 mg/kg	Risk-Based Remedial Goal Options 1E-06 mg/kg	1E-05 mg/kg	1E-04 mg/kg	Background Concentration mg/kg
Arsenic	1.5	0.0003	1	23	1305	435	43	2.7	27	271	9.44
Benzo(a)pyrene equivalents	7.3	NA	0.6	7.4	ND	ND	ND	0.30	3.0	30	NA

NOTES:

FI/FC	Fraction ingested / fraction contaminated
EPC	Exposure point concentration
NA	Not applicable
ND	Not determined
-	Remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident or site worker for noncarcinogens
mg/kg-day	milligrams per kilogram per day
mg/kg	milligrams per kilogram

Table 10.5.28
Remedial Goal Options for Shallow Groundwater
SWMU 42 and AOC 505
Naval Base Charleston, Zone A
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Oral SF (mg/kg-day)-1	Oral RfD (mg/kg-day)	EPC mg/l	Hazard-Based Remedial Goal Options 0.1 mg/l	1.0 mg/l	3 mg/l	Risk-Based Remedial Goal Options 1E-06 mg/l	1E-05 mg/l	1E-04 mg/l	MCL mg/l	Background Concentration mg/l
Aluminum	NA	1	10.7	1.6	16	47	ND	ND	ND	NA	3.21
Arsenic	1.5	0.0003	0.0050	0.00047	0.0047	0.014	0.000044	0.00044	0.0044	0.05	0.0074
Chromium	NA	0.005	0.0146	0.0078	0.078	0.23	ND	ND	ND	0.1	0.0087
1,1-Dichloroethene	0.6	0.009	0.0010	0.0070	0.070	0.21	0.000086	0.00086	0.0086	0.007	NA
Manganese	NA	0.023	0.827	0.036	0.36	1.1	ND	ND	ND	NA	0.577
Silver	NA	0.005	0.04	0.0078	0.078	0.23	ND	ND	ND	NA	NA
1,1,2,2-Tetrachloroethane	0.2	NA	0.0015	ERR	ERR	ERR	0.00016	0.0016	0.016	NA	NA
Tetrachloroethene	0.052	0.01	0.0028	0.0078	0.078	0.23	0.0012	0.012	0.12	0.005	NA
Vanadium	NA	0.007	0.018	0.011	0.11	0.33	ND	ND	ND	NA	0.0054

Worker-Based Remedial Goal Options

Chemical	Oral SF (mg/kg-day)-1	Oral RfD (mg/kg-day)	EPC mg/l	Hazard-Based Remedial Goal Options 0.1 mg/l	1 mg/l	3 mg/l	Risk-Based Remedial Goal Options 1E-06 mg/l	1E-05 mg/l	1E-04 mg/l	MCL mg/l	Background Concentration mg/l
Arsenic	1.5	0.0003	0.0050	0.0031	0.031	0.092	0.00014	0.0014	0.014	0.05	0.0074
1,1-Dichloroethene	0.6	0.009	0.0010	0.046	0.46	1.4	0.00027	0.0027	0.027	0.007	NA
1,1,2,2-Tetrachloroethane	0.2	NA	0.0015	ERR	ERR	ERR	0.0005	0.005	0.05	NA	NA

NOTES:

EPC Exposure point concentration
NA Not applicable
ND Not determined
\- Remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident or site worker for noncarcinogens
mg/kg-day milligrams per kilogram per day
mg/l milligrams per liter

Potential corrective measures for the impacted medium and respective COCs are in Table 10.5.29. Corrective measures for SWMU 42/AOC 505 are reviewed in more detail in Section 9.

Table 10.5.29
Potential Corrective Measures for SWMU 42/AOC 505

Medium	Compounds	Potential Corrective Measures
Soil	Arsenic, beryllium, and BEQs	a) No Action/Intrinsic Remediation b) No Action/Intrinsic Remediation and Monitoring c) Containment by capping d) Excavation and Landfill, if RCRA-nonhazardous waste e) In-Situ, biological, chemical, and physical treatment f) Ex-Situ, biological, chemical, and physical treatment
Shallow Groundwater	Aluminum, arsenic, chromium, silver, vanadium, PCE, 1,1,2,2-TCA, 1,1-DCE, and manganese	a) No Action/Intrinsic Remediation b) No Action/Intrinsic Remediation and Monitoring c) In-Situ, biological and chemical treatment d) Ex-Situ, biological, chemical, and physical treatment

The RFI process has identified PCE as a groundwater COC at SWMU 42/AOC 505. Because no site-related source for this compound was identified, the SWMU 39 plume could be the source of this PCE contamination. This is why the SWMU 39 contour maps included SWMU 42/AOC 505 monitoring wells. It is also noteworthy that quarterly sampling indicates decreasing PCE detections, with non-detect in the most recent event.

10.6 SWMU 43, Publications and Printing Plant, Building 1628

SWMU 43 is Building 1628, the Publications and Printing Plant, which operated from 1979 to 1996. A darkroom and hazardous materials locker were on the ground floor of the building. Prior to the installation of the lockers, hazardous materials were stored in two areas outside of the main building. These areas were the focus of sampling efforts for this site.

Materials of concern identified in the *Zones A and B RFI Work Plan* (E/A&H, September 1995) for SWMU 43 are silver-containing developing solutions, lead, chromium, acetic acid, ferric chloride, and potassium hydroxide. Potential receptors include current and future site users involved in invasive activities. Also, Noisette Creek is approximately 200 feet south of the site and biological receptors other than humans may be exposed to materials of concern. Potential surface water and sediment contamination in Noisette Creek will be characterized in the Zone J RFI Work Plan.

To fulfill CSI objectives, soil was sampled in accordance with the *Final Zones A and B RFI Work Plan* and as described in Section 3 of this report to confirm whether any contamination resulted from onsite activities at SWMU 43.

10.6.1 Soil Sampling and Analysis

Surface and subsurface soil was sampled in two rounds at SWMU 43 from the locations shown on Figure 10.6.1. The *Final Zones A and B RFI Work Plan* proposed collecting six soil samples from the upper interval (0 to 1 foot) and six from the lower interval (3 to 5 feet) for the SWMU 43 investigation area. However, two of the lower-interval samples (043SB00202 and 043SB00302) were not collected due to a water table less than 5 feet bgs; saturated samples were not submitted for analysis.

Also, a Geoprobe investigation was conducted at this site based upon the first-round data (Section 10.6.3). Three Geoprobe borings were pushed, and groundwater samples were collected from them. During the installation of each of these borings, a subsurface soil sample (2' to 4') was collected.

Therefore, 13 soil samples were collected – six from the upper interval, four from the lower interval, and three from the Geoprobe interval. The upper and lower-interval soil samples were submitted for VOCs, SVOCs, metals, and pH analyses at DQO Level III. One sample was collected as a duplicate and submitted for Appendix IX analyses at DQO Level IV.

The three Geoprobe interval samples were analyzed by the onsite laboratory, Analytical Mobile Services, for VOCs using a GC/MS (Method 5030/8260). One of these samples was duplicated for VOC analysis by Lockheed Analytical Services. Table 10.6.1 summarizes the samples collected at SWMU 43.

Table 10.6.1
SWMU 43
Soil Sampling Summary

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper (0' to 1')	6	6	VOCs, SVOCs, metals, and pH	VOCs, SVOCs, metals, and pH	None
Lower (3' to 5')	6	4	VOCs, SVOCs, metals, and pH	VOCs, SVOCs, metals, and pH	High water table prevented collection of 2 samples, as saturated samples were not submitted for analysis.
Geoprobe (2' to 4')	3	3	VOCs	VOCs	None[a]

Note:
a = These samples were collected during the Geoprobe investigation and analyzed by an onsite laboratory; one was duplicated for offsite confirmation analysis.

LEGEND

- Soil Boring
- Geoprobe Boring

0 25 feet

Note: The location and dimensions of the storage sheds are approximate

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.6.1 - SWMU 43
Soil Sample Locations

10.6.2 Nature and Extent of Contamination in Soil

Data from the pH analysis for the upper and lower interval soil samples are summarized in Table 10.6.2. Organic compound analytical results for soil are summarized in Table 10.6.3 and inorganic analytical results are summarized in Table 10.6.4. Appendix D is a complete analytical data report for all samples collected in Zone A.

Table 10.6.2
SWMU 43
pH Data

Upper Interval		Lower Interval*	
Sample ID	**pH**	**Sample ID**	**pH**
043SB00101	8.2	043SB00102	7.2
043SB00201	8.1	043SB00202	NA
043SB00301	8.2	043SB00302	NA
043SB00401	7.8	043SB00402	7.4
043SB00501	8.0	043SB00502	7.2
043SB00601	8.0	043SB00602	8.0
AVG.	8.0	AVG.	7.4

Notes:
NA = Not applicable because saturated samples were not submitted for analyses.
* = Soil samples collected during the Geoprobe investigation were not analyzed for pH.

Table 10.6.3
SWMU 43
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Volatile Organic Compounds (13 samples collected: 6 upper interval, 4 lower interval, and 3 Geoprobe[a] interval, 1 sample duplicated)						
Acetone	Upper	3/6	9.0 - 63.0	34.0	7,800,000	0
	Lower	3/4	50.0 - 1,600	647	NA	NA
	Geoprobe	1/3	12.0	NA	NA	NA
Bromomethane	Upper	0/6	NA	NA	110,000	0
	Lower	1/4	3.4	NA	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA
2-Butanone	Upper	0/6	NA	NA	47,000,000	0
	Lower	3/4	8.8 - 190	70	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA
Carbon disulfide	Upper	0/6	NA	NA	7,800,000	0
	Lower	1/4	5.9	NA	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA
cis-1,2-dichloroethene	Upper	0/6	NA	NA	780,000	0
	Lower	2/4	2.6 - 79.0	40.8	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA
Methylene chloride	Upper	1/6	15.0	NA	85,000	0
	Lower	1/6	100	NA	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA
4-methyl-2-pentanone (MIBK)	Upper	0/6	NA	NA	6,300,000	0
	Lower	1/4	6.8	NA	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA

Table 10.6.3
SWMU 43
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Volatile Organic Compounds (13 samples collected: 6 upper interval, 4 lower interval, and 3 Geoprobe[a] interval, 1 sample duplicated)						
Tetrachloroethene	Upper	1/6	1.7	NA	12,000	0
	Lower	1/4	11.0	NA	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA
Toluene	Upper	0/6	NA	NA	16,000,000	0
	Lower	2/4	2.3 - 3.3	2.8	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA
trans-1,2-dichloroethene	Upper	0/6	NA	NA	1,600,000	0
	Lower	1/4	6.3	NA	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA
Trichloroethene	Upper	0/6	NA	NA	58,000	0
	Lower	2/4	2.9 - 14.0	8.5	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA
Trichlorofluoromethane	Upper	0/6	NA	NA	23,000,000	0
	Lower	1/4	25.0	NA	NA	NA
	Geoprobe	0/3	NA	NA	NA	NA

Notes:
a = Third-interval samples from Geoprobe investigation were collected from 2' to 4' bgs.
NA = Not applicable

Table 10.6.4
SWMU 43
Inorganics Detected in Soil

Element	Sample Interval	Frequency of Detections	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	Reference Conc. (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding[a]
Inorganics (10 samples collected: 6 upper interval and 4 lower interval, 1 sample duplicated for Appendix IX analysis)							
Aluminum	Upper	6/6	3,700 - 7,890	5,570	12,800	78,000	0
	Lower	4/4	8,740 - 11,300	9,990	28,240	NA	0
Arsenic	Upper	6/6	1.7 - 3.7	2.8	9.4	0.43	0
	Lower	4/4	4.1 - 6.6	5.1	9.8	NA	0
Barium	Upper	6/6	4.3 - 17.3	11.7	53.0	5,500	0
	Lower	4/4	12.7 - 21.4	16.6	40.0	NA	0
Calcium	Upper	6/6	3,370 - 36,300	14,900	NA	NA	NA
	Lower	4/4	2,230 - 36,800	16,200	NA	NA	NA
Chromium	Upper	6/6	7.0 - 13.0	10.2	50.4	390	0
	Lower	4/4	13.7 - 27.0	17.8	63.4	NA	0
Cobalt	Upper	2/6	1.8 - 2.9	2.4	4.4	4,700	0
	Lower	0/4	NA	NA	1.7	NA	0
Copper	Upper	6/6	1.6 - 10.8	6.0	165	3,100	0
	Lower	4/4	3.0 - 12.2	8.0	33.7	NA	0
Iron	Upper	6/6	3,540 - 8,900	6,040	NA	NA	NA
	Lower	4/4	7,600 - 12,200	9,170	NA	NA	NA
Lead	Upper	6/6	1.8 - 55.4	20.0	140	400[b]	0
	Lower	4/4	7.1 - 27.0	18.6	22.0	400[b]	0
Magnesium	Upper	6/6	354 - 894	495	NA	NA	NA
	Lower	4/4	393 - 2,650	1,470	NA	NA	NA
Manganese	Upper	6/6	13.0 - 63.8	25.5	98.1	1,800	0
	Lower	4/4	10.5 - 41.7	31.0	85.5	NA	0
Nickel	Upper	5/6	3.6 - 8.3	5.2	13.6	1,600	0
	Lower	4/4	4.9 - 11.5	8.5	35.0	NA	0
Potassium	Upper	4/6	189 - 243	208	NA	NA	NA
	Lower	4/4	285 - 727	477	NA	NA	NA

Table 10.6.4
SWMU 43
Inorganics Detected in Soil

Element	Sample Interval	Frequency of Detections	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	Reference Conc. (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding[a]
Inorganics (10 samples collected: 6 upper interval and 4 lower interval, 1 sample duplicated for Appendix IX analysis)							
Selenium	Upper	1/6	0.76	NA	1.2	390	0
	Lower	0/4	NA	NA	1.7	NA	0
Sodium	Upper	6/6	210 - 284	253	NA	NA	NA
	Lower	4/4	265 - 631	442	NA	NA	NA
Tin	Upper	5/6	9.4 - 15.0	10.9	**	47,000	0
	Lower	1/4	28.1	NA	**	NA	NA
Vanadium	Upper	6/6	7.2 - 15.5	11.6	29.2	550	0
	Lower	4/4	16.1 - 23.0	19.2	77.3	NA	0
Zinc	Upper	6/6	7.4 - 47.3	23.8	208	23,000	0
	Lower	4/4	9.3 - 32.1	24.1	165	NA	0

Notes:
a = Number of samples exceeding both RBC and RC in upper interval or number of samples exceeding the RC in the lower interval.
b = RBC not available for lead. USEPA residential soil cleanup level used for comparison (OSWER Directive 9355.4-12).
** = Number of nondetects prevented determination of UTL.
NA = Not applicable.

Volatile Organic Compounds in Soil

No VOCs detected at SWMU 43 exceeded their RBCs. Acetone, methylene chloride, and tetrachloroethene were the only VOCs detected in the upper interval; 12 compounds were detected in the lower interval, and one compound (acetone) was detected in the Geoprobe interval.

All VOC detections at SWMU 43 were below their respective SSLs, with the exception of methylene chloride. Methylene chloride exceeded its SSL (9.5 μg/kg) in two samples: surface sample 043SB00102 (100 μg/kg) and subsurface sample 043SB00602 (15 μg/kg).

Semivolatile Organic Compounds in Soil

No SVOCs were detected in any soil samples at SWMU 43.

Inorganics in Soil

Eighteen metals were detected in soil samples collected at SWMU 43. None of the detections exceeded both their respective RC and RBC. However, the subsurface tin detection does not have an RC or RBC for comparison. This detection does not exceed the SSL (5,500 mg/kg) for tin.

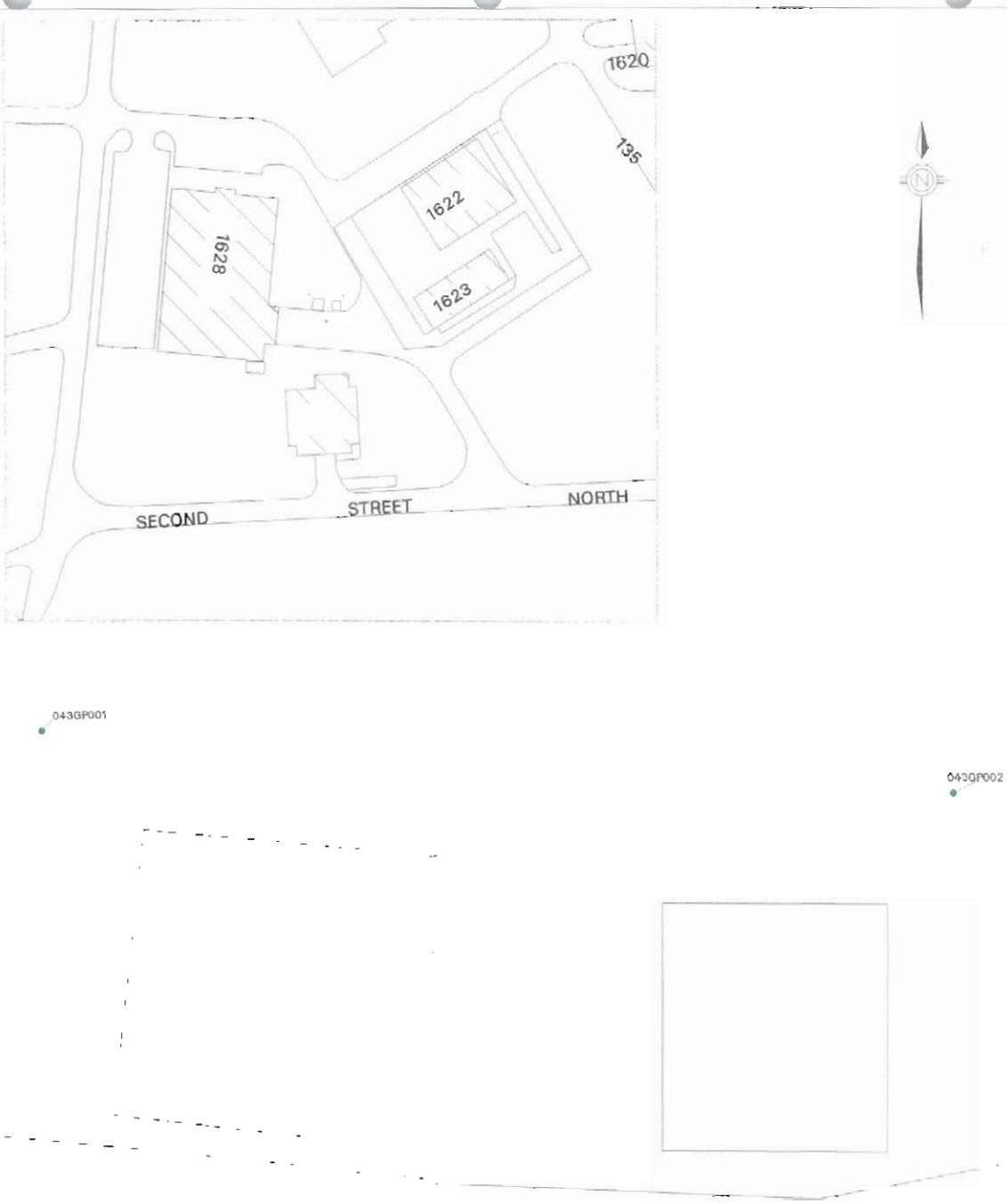
10.6.3 Groundwater Sampling and Analysis

The *Final Zones A and B RFI Work Plan* did not propose the installation of monitoring wells as part of the CSI for SWMU 43. As discussed at the NAVBASE project team meeting in February 1996 and detailed in the *Zones A & B - Second Round RFI Sampling*, (E/A&H, March 1996) memorandum, a Geoprobe investigation was implemented at several sites within Zone A.

In SWMU 43 soil samples (Section 10.6.2), chlorinated solvents were detected in both the surface and subsurface interval. Because no groundwater sampling was conducted at SWMU 43, the Geoprobe investigation included three borings at SWMU 43 to determine if migration of contamination has occurred onsite. These locations are indicated on Figure 10.6.2.

Sampling was performed in accordance with Section 6.1.3 included in Revision No. 01 of the *Final Comprehensive Sampling and Analysis Plan* dated December 1, 1995. Although this plan had not received final regulatory approval at the time of sampling, the applicable sections did not receive comments requiring modifications.

Three groundwater samples were collected from the shallow aquifer, one at each location. The approximate depth was 5 to 10 feet below ground surface. Each sample was rapidly analyzed for VOCs by an onsite laboratory, and a duplicate from Geoprobe boring 043GP002 was sent to an offsite lab for confirmation.



LEGEND

- Geoprobe Locations
- Shallow Monitoring Well Location

Note: The location and dimensions of the storage sheds are approximate

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.6.2 - SWMU 43
Groundwater Sample Locations

According to SCDHEC policy, Geoprobe data is insufficient for making a No Further Action determination. Therefore, one shallow monitoring well was installed at the downgradient side of the site to provide a reproducible groundwater sampling location for site closure. This well location is also shown on Figure 10.6.2.

Sampling parameters for the monitoring well were expanded to include more than VOCs. The well was sampled by the CEERD for four quarters: February, March, June, and October 1997. Table 10.6.5 summarizes all groundwater sampling at SWMU 43.

The monitoring well was installed as described in Section 3.3 of this report at 12 feet bgs in the upper sand aquifer.

Table 10.6.5
SWMU 43
Groundwater Sampling Summary

Event	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Geoprobe	3[a]	3[a]	VOCs	VOCs	None
Feb. 97 (1st round)	1[b]	1[b]	VOCs	VOCs, SVOCs, metals, cyanide, and pests/PCBs.	Additional analyses performed.
March 1997 (2nd round)	1[b]	1[b]	VOCs	VOCs, SVOCs, metals, cyanide, and pests/PCBs.	Additional analyses performed.
July 1997 (3rd round)	1[b]	1[b]	VOCs	VOCs, and SVOCs.	Additional analyses performed.
October 1997 (4th round)	1[b]	1[b]	VOCs	VOCs, SVOCs, and metals.	Additional analyses performed.

Notes:
a = Three geoprobe samples were collected from the shallow aquifer.
b = One shallow monitoring well was installed downgradient of the site to confirm geoprobe analytical results.

10.6.4 Nature and Extent of Contamination in Groundwater

Tables 10.6.6 and 10.6.7 summarize organic and inorganic groundwater analytical results for SWMU 43, respectively. Appendix D is a complete analytical data report for all Zone A samples, including those collected at SWMU 43.

Table 10.6.6
SWMU 43
Organic Compounds Detected in Groundwater

Compound	Sampling Event	Sampling Interval	Frequency of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	RBC (μg/L)	Number of Samples Exceeding RBC
Volatile Organic Compounds (3 shallow groundwater samples collected during Geoprobe event; 1 during other events)							
Acetone	Geoprobe	Shallow	1/3	8.2	NA	3,700	0
	Feb. 97	Shallow	0/1	NA	NA	3,700	0
	Mar. 97	Shallow	0/1	NA	NA	3,700	0
	July 97	Shallow	0/1	NA	NA	3,700	0
	Oct. 97	Shallow	0/1	NA	NA	3,700	0
Toluene	Geoprobe	Shallow	1/3	4.0	NA	750	0
	Feb. 97	Shallow	0/1	NA	NA	750	0
	Mar. 97	Shallow	0/1	NA	NA	750	0
	July 97	Shallow	0/1	NA	NA	750	0
	Oct. 97	Shallow	0/1	NA	NA	750	0
Semivolatile Organic Compounds (1 shallow groundwater sample collected during well sampling events)							
Fluorene	Feb. 97	Shallow	0/1	NA	NA	1,500	0
	Mar. 97	Shallow	0/1	NA	NA	1,500	0
	July 97	Shallow	0/1	NA	NA	1,500	0
	Oct. 97	Shallow	1/1	6	NA	1,500	0

Note:
NA = Not applicable

Table 10.6.7
SWMU 43
Inorganics Detected in Groundwater

Compound	Sampling Event	Sampling Interval	Freq. of Detection	Range of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (1 shallow groundwater sample collected during three of the events)							
Aluminum	Feb. 97	Shallow	1/1	1,380	3,210	37,000	0
	Mar. 97	Shallow	0/1	NA	3,210	37,000	0
	Oct. 97	Shallow	1/1	760	3,210	37,000	0
Arsenic	Feb. 97	Shallow	1/1	18.3	7.4	0.045	1
	Mar. 97	Shallow	1/1	21.2	7.4	0.045	1
	Oct. 97	Shallow	1/1	25.2	7.4	0.045	1
Barium	Feb. 97	Shallow	1/1	64.7	104	2,600	0
	Mar. 97	Shallow	1/1	62.5	104	2,600	0
	Oct. 97	Shallow	1/1	73.0	104	2,600	0
Cadmium	Feb. 97	Shallow	0/1	NA	**	18	0
	Mar. 97	Shallow	0/1	NA	**	18	0
	Oct. 97	Shallow	1/1	0.66	**	18	0
Calcium	Feb. 97	Shallow	1/1	112,000	NA	NA	NA
	Mar. 97	Shallow	1/1	107,000	NA	NA	NA
	Oct. 97	Shallow	1/1	110,000	NA	NA	NA
Chromium	Feb. 97	Shallow	1/1	1.2	8.7	180	0
	Mar. 97	Shallow	0/1	NA	8.7	180	0
	Oct. 97	Shallow	0/1	NA	8.7	180	0
Copper	Feb. 97	Shallow	0/1	NA	15.7	1,500	0
	Mar. 97	Shallow	1/1	3.9	15.7	1,500	0
	Oct. 97	Shallow	1/1	10	15.7	1,500	0
Iron	Feb. 97	Shallow	1/1	21,600	NA	NA	NA
	Mar. 97	Shallow	1/1	18,200	NA	NA	NA
	Oct. 97	Shallow	1/1	18,200	NA	NA	NA

Table 10.6.7
SWMU 43
Inorganics Detected in Groundwater

Compound	Sampling Event	Sampling Interval	Freq. of Detection	Range of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding both RC and RBC
Inorganics (1 shallow groundwater sample collected during three of the events)							
Magnesium	Feb. 97	Shallow	1/1	35,800	NA	NA	NA
	Mar. 97	Shallow	1/1	28,200	NA	NA	NA
	Oct. 97	Shallow	1/1	24,400	NA	NA	NA
Manganese	Feb. 97	Shallow	1/1	80.0	577	840	0
	Mar. 97	Shallow	1/1	66.1	577	840	0
	Oct. 97	Shallow	1/1	160	577	840	0
Nickel	Feb. 97	Shallow	0/1	NA	**	730	0
	Mar. 97	Shallow	0/1	NA	**	730	0
	Oct. 97	Shallow	1/1	1	**	730	0
Potassium	Feb. 97	Shallow	1/1	15,800	NA	NA	NA
	Mar. 97	Shallow	1/1	18,800	NA	NA	NA
	Oct. 97	Shallow	1/1	13,600	NA	NA	NA
Selenium	Feb. 97	Shallow	1/1	3.1	**	180	0
	Mar. 97	Shallow	1/1	3.2	**	180	0
	Oct. 97	Shallow	0/1	NA	**	180	0
Sodium	Feb. 97	Shallow	1/1	54,400	NA	NA	NA
	Mar. 97	Shallow	1/1	48,600	NA	NA	NA
	Oct. 97	Shallow	1/1	41,400	NA	NA	NA
Vanadium	Feb. 97	Shallow	1/1	2.8	5.4	260	0
	Mar. 97	Shallow	1/1	1.4	5.4	260	0
	Oct. 97	Shallow	1/1	1.5	5.4	260	0

Notes:
NA = Not Applicable.
** = Number of nondetects prevented determination of UTL.

Volatile Organic Compounds in Groundwater

Only two VOCs were detected in groundwater samples collected at SWMU 43 (acetone and toluene). Both detections were in the geoprobe duplicate sample (043GP002<H) that was analyzed offsite and neither exceeded its RBC.

Semivolatile Organic Compounds in Groundwater

Fluorene was the only SVOC detected in groundwater samples collected at SWMU 43. This detection occurred in the fourth-quarter sampling event, although it did not exceed the RBC for fluorene.

Inorganics in Groundwater

Fifteen metals were detected in groundwater samples collected from the monitoring well at SWMU 43. Of these detections, arsenic, in all three samples, was the only compound that exceeded both its RC (7.4 μg/L) and RBC (0.045 μg/L).

10.6.5 Fate and Transport Assessment for SWMU 43

The CSI focused on two hazardous materials storage areas outside Building 1628. Environmental media sampled as part of the CSI at SWMU 43 include surface soil, subsurface soil and shallow groundwater. Potential contaminant migration pathways for SWMU 43 include soil constituents leaching to groundwater, groundwater constituent migration to surface water, and emission of VOCs from surface soil to ambient air.

10.6.5.1 SWMU 43 — Soil to Groundwater Cross-Media Transport

Tables 10.6.8 and 10.6.9 compare the maximum detected concentrations of organic and inorganic chemicals reported in soil to risk-based soil screening levels considered protective of groundwater. As shown on Table 10.6.8, methylene chloride was identified for further evaluation of soil to groundwater migration based on the screening process presented in Section 6. As shown on

Table 10.6.9, chromium was identified for further evaluation of soil to groundwater migration. Methylene chloride was reported in one subsurface soil sample (043SB00102) at a concentration of 100 μg/kg which exceeds its SSL of 10 μg/kg. Methylene chloride was not reported in any SWMU 43 groundwater sample (including all four quarters). Although chromium was reported in a single subsurface soil sample at concentrations exceeding its SSL, it was not reported in any soil sample at a concentration exceeding its background reference value. For screening purposes, chromium was conservatively assumed to exist in its soluble hexavalent state. Hexachrome analyses for Zone A suggest that chromium in soil exists predominantly in less soluble valence states. Additionally, chromium was not reported in groundwater at concentrations exceeding its tapwater RBC, background reference concentration, or saltwater surface water chronic AWQC (including four quarters of groundwater sampling). These findings suggest that concentrations of chemical constituents reported in SWMU 43 soil do not appreciably threaten groundwater.

10.6.5.2 SWMU 43 — Groundwater to Surface Water Cross-Media Transport

Tables 10.6.8 and 10.6.9 compare maximum detected groundwater concentrations from four sampling rounds at one shallow well for SWMU 43 to tap water RBCs, saltwater surface water chronic AWQCs, and background reference values for inorganics.

As shown on Table 10.6.8, no organic constituents were reported in SWMU 43 shallow groundwater above both its tap water RBC or saltwater surface water AWQC. As shown on Table 10.6.9, copper was reported in groundwater at concentrations of 10 μg/L and 3.9 μg/L, which exceed its AWQC of 2.9 μg/L. However, copper was not reported in any groundwater sample at a concentration exceeding its background reference value.

Table 10.6.8
Organic Compounds Detected in Surface Soil, Subsurface Soil, and Shallow Groundwater
Comparison to Cross-media SSLs, Tap Water RBCs, and Saltwater Surface Water Chronic Screening Levels
NAVBASE-Charleston, Zone A: SWMU 43
Charleston, South Carolina

Parameter	Maximum Concentration				Screening Concentration *									
	Surface Soil	Subsurface Soil	Shallow GW	Deep GW	Soil to GW	Soil to Air	Tap water RBC	Saltwater Surf. Wtr. Chronic	Soil Units	Water Units	Leaching Potential	Volatil-ization Potential	Ground-water Migration Concern	Surface Water Migration Concern
Volatile Organic Compounds														
Acetone	63	1600	ND	NA	8000	1E+08	3700	NDA	UG/KG	UG/L	NO	NO	NO	NO
Bromomethane	ND	3.4	ND	NA	21 c	2000	8.7	NDA	UG/KG	UG/L	NO	NO	NO	NO
2-Butanone	ND	190	ND	NA	3900 c	NDA	1900	NDA	UG/KG	UG/L	NO	NO	NO	NO
Carbon disulfide	ND	5.9	ND	NA	16000	720000	1000	NDA	UG/KG	UG/L	NO	NO	NO	NO
cis-1,2-Dichloroethene	ND	79	ND	NA	200	1200000	61	NDA	UG/KG	UG/L	NO	NO	NO	NO
trans-1,2-Dichloroethene	ND	6.3	ND	NA	350	3100000	120	NDA	UG/KG	UG/L	NO	NO	NO	NO
4-Methyl-2-pentanone	ND	6.8	ND	NA	6700 c	NDA	2900	NDA	UG/KG	UG/L	NO	NO	NO	NO
Methylene chloride	15	100	ND	NA	10	13000	4.1	2560	UG/KG	UG/L	YES	NO	NO	NO
Tetrachloroethene	1.7	11	ND	NA	30	11000	1.1	45	UG/KG	UG/L	NO	NO	NO	NO
Toluene	ND	3.3	ND	NA	6000	650000	750	37	UG/KG	UG/L	NO	NO	NO	NO
Trichloroethene	ND	14	ND	NA	30	5000	1.6	NDA	UG/KG	UG/L	NO	NO	NO	NO
Trichlorofluoromethane	ND	25	ND	NA	10000 c	790000	1300	NDA	UG/KG	UG/L	NO	NO	NO	NO
Semivolatile Organic Compounds														
Fluorene	ND	ND	6	NA	280000	NDA	1500	NDA	UG/KG	UG/L	NO	NO	NO	NO

Explanations of screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.6.3 and 10.6.6.

* Screening Concentrations:
Soil to GW - Generic SSLs based on DAF = 10, adapted from USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or calculated using values from Ta
Soil to Air - From USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or USEPA Region III Risk-Based Concentration Table, June 1996
Tap Water RBC - From USEPA Region III Risk-Based Concentration Table, October 1997
Salt Water Surface Water Chronic - From USEPA Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment, November 1995, Table 2

c - Calculated soil to groundwater SSL value (See Table 6.2)
GW - Groundwater
NA - Not available
ND - Not detected
NDA - No data available
RBC - Risk-based concentration
SSL - Soil screening level
UG/KG - Micrograms per kilogram
UG/L - Micrograms per liter

Table 10.6.9
Inorganic Chemicals Detected in Surface Soil, Subsurface Soil, and Shallow Groundwater
Comparison to Cross-media SSLs, Tap Water RBCs, Saltwater Surface Water Chronic Screening Levels, and Background Reference Values
NAVBASE-Charleston, Zone A: SWMU 43
Charleston, South Carolina

Parameter	Maximum Concentration				Screening Concentration *											
	Surface Soil	Subsurfac Soil	Shallow GW	Deep GW	Soil to GW	Soil Background Reference	Soil to Air	Tap water RBC	GW Background Reference	Saltwater Surf. Wtr. Chronic	Soil Units	Water Units	Leaching Potential	Fugitive Particulate Inhalation Concern	Ground-water Migration Concern	Surface Water Migration Concern
Inorganic Chemicals																
Aluminum	7890	11300	1380	NA	560000 c	28240	NA	37000	3210	NA	MG/KG	UG/L	NO	NO	NO	NO
Arsenic	3.7	6.6	25.2	NA	15	9.8	750	0.045	11.1	36	MG/KG	UG/L	NO	NO	YES	NO
Barium	17.3	21.4	73	NA	820	53	690000	2600	179	NA	MG/KG	UG/L	NO	NO	NO	NO
Chromium (total)	13	27	1.2	NA	19	63.4	270	180	8.7	50	MG/KG	UG/L	YES	NO	NO	NO
Cadmium	ND	ND	0.66	NA	4	NA	1800	18	ND	9.3	MG/KG	UG/L	NO	NO	NO	NO
Cobalt	2.9	ND	ND	NA	990 c	4.4	NA	2200	12.1	NA	MG/KG	UG/L	NO	NO	NO	NO
Copper	10.8	12.2	10	NA	5600 c	165	NA	1500	15.7	2.9	MG/KG	UG/L	NO	NO	NO	YES
Lead	55.4	27	ND	NA	400	140	NA	15	4.7	8.5	MG/KG	UG/L	NO	NO	NO	NO
Manganese	63.8	41.7	80	NA	550 c	98.1	NA	840	2690	NA	MG/KG	UG/L	NO	NO	NO	NO
Nickel	8.3	11.5	1	NA	65	35	13000	730	21.1	8.3	MG/KG	UG/L	NO	NO	NO	NO
Selenium	0.76	ND	3.2	NA	2.5	1.74	NA	180	ND	71	MG/KG	UG/L	NO	NO	NO	NO
Tin	15	28.1	ND	NA	5500 c	ND	NA	22000	ND	NA	MG/KG	UG/L	NO	NO	NO	NO
Vanadium	15.5	23	2.8	NA	3000	77.3	NA	260	10.9	NA	MG/KG	UG/L	NO	NO	NO	NO
Zinc	47.3	32.1	ND	NA	6000	208	NA	11000	83.2	86	MG/KG	UG/L	NO	NO	NO	NO

Explanations of screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.6.4 and 10.6.7.

* Screening Concentrations:
Soil to GW - Generic SSLs based on DAF = 10, adapted from USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or calculated using values from Table
Soil to Air - From USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or USEPA Region III Risk-Based Concentration Table, June 1996
Tap Water RBC - From USEPA Region III Risk-Based Concentration Table, October 1997
Salt Water Surface Water Chronic - From USEPA Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment, November 1995, Table 2
Background reference values for soil are shown for comparison purposes only.
Maximum groundwater concentrations are screened against the greater of tap water RBCs or corresponding background reference values to determine groundwater migration concern.

c - Calculated soil to groundwater SSL value (See Table 6.2)
GW - Groundwater
NA - Not available/Not applicable
ND - Not detected
RBC - Risk-based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
UG/L - Micrograms per liter

10.6.5.3 SWMU 43 – Soil-to-Air Cross-Media Transport

Tables 10.6.8 and 10.6.9 list the organic and inorganic compounds detected in surface soil samples from SWMU 43, along with corresponding soil-to-air volatilization screening levels. The maximum surface soil concentration of no constituent exceeded its corresponding soil-to-air volatilization screening level. As a result, the soil-to-air migration pathway is not expected to be significant at SWMU 43.

10.6.6 Human Health Risk Assessment for SWMU 43

10.6.6.1 Site Background and Investigative Approach

SWMU 43 includes Building 1628, the publication and printing plant, and the area surrounding Building 1628. SWMU 43 was investigated to assess the impact of hazardous materials storage in areas outside Building 1628.

Six soil samples were collected from the upper interval. Section 10.6.1 presents a summary of the soil sampling effort for SWMU 43. One monitoring well was installed and sampled subsequent to the CSI sampling effort at SWMU 43. Data from all four sampling rounds were considered in the HHRA.

10.6.6.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 of this RFI and presented in Table 10.6.10, no surface soil COPCs were identified for SWMU 43. Wilcoxon rank sum test analysis did not support the inclusion of any inorganic parameters that had been screened out based on individual sample comparisons to background UTLs.

Groundwater

One monitoring well was installed into the shallow aquifer at SWMU 43 to confirm that VOCs were not present in groundwater. Incidentally, arsenic was detected at concentrations above its tap water RBCs in the groundwater sample. Arsenic was detected at a concentrations of 18.3 g/L, 21.2 g/L, and 25.2 g/L, for the first-, second-, and fourth-quarter samples, respectively. All three rounds reported groundwater concentrations of arsenic above its RBC (0.045 μg/L) and its background reference (7.4 μg/L). Groundwater concentrations of arsenic did not, however exceed its MCL of 50 μg/L. As a result, arsenic was not considered further in the SWMU 43 HHRA.

10.6.7 Corrective Measures Considerations

No COCs were identified at SWMU 43; therefore, no corrective measures evaluation was necessary.

Table 10.6.10
Chemicals Present in Site Samples
SWMU 43, Surface Soil
NAVBASE-Charleston, Zone A
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration RBC	Reference	Units	Number Exceeding RBC	Ref.
Volatile Organics													
Acetone		3	6	9	63	34	12	12	780000	NA	ug/kg		
Methylene chloride		1	6	15	15	15	6	6.3	85000	NA	ug/kg		
Tetrachloroethene		1	6	1.7	1.7	1.7	5.9	6.3	12000	NA	ug/kg		
Inorganics													
Aluminum (Al)		6	6	3700	7890	5568	NA	NA	7800	12800	mg/kg	1	
Arsenic (As)		6	6	1.7	3.7	2.8	NA	NA	0.43	9.44	mg/kg	6	
Barium (Ba)		6	6	4.3	17.3	11.7	NA	NA	550	53	mg/kg		
Calcium (Ca)	N	6	6	3370	36300	14905	NA	NA	NA	NA	mg/kg		
Chromium (Cr)		6	6	7	13	10.2	NA	NA	39	50.4	mg/kg		
Cobalt (Co)		2	6	1.8	2.9	2.4	1.4	1.4	470	4.4	mg/kg		
Copper (Cu)		6	6	1.6	10.8	6.0	NA	NA	310	165	mg/kg		
Iron (Fe)	N	6	6	3540	8900	6037	NA	NA	NA	NA	mg/kg		
Lead (Pb)		6	6	1.8	55.4	20.0	NA	NA	400	140	mg/kg		
Magnesium (Mg)	N	6	6	354	894	495	NA	NA	NA	NA	mg/kg		
Manganese (Mn)		6	6	13	63.8	25.5	NA	NA	180	98.1	mg/kg		
Nickel (Ni)		5	6	3.6	8.3	5.2	3.4	3.4	160	13.55	mg/kg		
Potassium (K)	N	4	6	189	243	208	124	133	NA	NA	mg/kg		
Selenium (Se)		1	6	0.76	0.76	0.76	0.71	0.75	39	1.2	mg/kg		
Sodium (Na)	N	6	6	210	284	253	NA	NA	NA	NA	mg/kg		
Tin (Sn)		5	6	9.4	15	10.9	8.7	8.7	4700	NA	mg/kg		
Vanadium (V)		6	6	7.2	15.5	11.6	NA	NA	55	29.24	mg/kg		
Zinc (Zn)		6	6	7.4	47.3	23.8	NA	NA	2300	207.6	mg/kg		

N - Essential nutrient
ug/kg - micrograms per kilogram
mg/kg - milligrams per kilogram

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10.7 AOC 506, Building 1629, Flammable Storage Shelter

AOC 506 is Building 1629, a structure used since 1942 for storage of flammable material returned to Building 1603, the DRMO Material Turn-In Site. AOC 506 consists of a 21-foot by 30-foot concrete pad enclosed with a chain-link fence and covered by a metal roof. There is a second storage shelter to the south of Building 1629. During the field investigation, several pallets of drums were staged beneath this structure. No containment structures are associated with this unit.

Materials of concern identified in the *Zones A and B RFI Work Plan* (E/A&H, September 1995) for AOC 506 are solvents, paints, fuels, and other unknown flammable materials. Potential receptors are current and future site users involved in invasive activities. Also, the Cooper River is approximately 200 feet east of the site and the potential exists for exposure to biological receptors other than humans.

To fulfill CSI objectives, soil and groundwater were sampled in accordance with the *Final Zones A and B RFI Work Plan* and as described in Section 3 of this report to confirm whether any contamination resulted from onsite activities at AOC 506.

10.7.1 Soil Sampling and Analysis

Surface and subsurface soil was sampled in one round at AOC 506 at the locations shown on Figure 10.7.5. The *Final Zones A and B RFI Work Plan* proposed collecting five soil samples from the upper interval (0 to 1 foot) and five from the lower interval (3 to 5 feet). One additional boring was added during the field investigation to investigate soils near the second storage shelter that was also used for drum storage.

Therefore, 12 soil samples in all were collected — six upper interval and six lower interval — and submitted for VOC, SVOC, and metal analyses at DQO Level III. One duplicate sample was collected and submitted for Appendix IX analyses at DQO Level IV. Table 10.7.1 summarizes all soil samples collected at AOC 506.

Table 10.7.1
AOC 506
Soil Sampling Summary

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper (0' to 1')	5	6	VOCs, SVOCs, and metals	VOCs, SVOCs, and metals	An additional sample was collected for characterization of the second drum storage area.
Lower (3' to 5')	5	6	VOCs, SVOCs, and metals	VOCs, SVOCs, and metals	An additional sample was collected for characterization of the second drum storage area.

10.7.2 Nature and Extent of Contamination in Soil

Organic and inorganic compound analytical results for soil are summarized in Tables 10.7.2 and 10.7.3. Appendix D is a complete analytical data report for all samples collected in Zone A, including those from AOC 506.

Table 10.7.2
AOC 506
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (µg/kg)	Mean of Detections (µg/kg)	RBC (µg/kg)	Number of Samples Exceeding RBC
Volatile Organic Compounds (12 samples collected: 6 upper interval and 6 lower interval, 1 sample duplicated for Appendix IX analysis)						
Acetone	Upper	3/6	15.0 - 60.0	36.3	7,800,000	0
	Lower	2/6	7.7 - 56.0	31.9	NA	NA
2-Butanone (MEK)	Upper	0/6	NA	NA	47,000,000	0
	Lower	1/6	4.8	NA	NA	NA
Carbon disulfide	Upper	0/6	NA	NA	7,800,000	0
	Lower	1/6	3.6	NA	NA	NA
Methylene chloride	Upper	0/6	NA	NA	85,000	0
	Lower	1/6	1.2	NA	NA	NA

Table 10.7.2
AOC 506
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Volatile Organic Compounds (12 samples collected: 6 upper interval and 6 lower interval, 1 sample duplicated for Appendix IX analysis)						
Toluene	Upper	2/6	1.3 - 1.7	1.5	16,000,000	0
	Lower	4/6	2.4 - 9.2	4.8	NA	NA
Semivolatile Organic Compounds (12 samples collected: 6 upper interval and 6 lower interval, 1 sample duplicated for Appendix IX analysis)						
BEQ[a]	Upper	0/6	NA	NA	88	0
	Lower	3/6	210 - 8,377	3,008	NA	NA
Acenaphthene	Upper	0/6	NA	NA	4,700,000	0
	Lower	1/6	600	NA	NA	NA
Acenaphthylene	Upper	0/6	NA	NA	4,700,000	0
	Lower	1/6	970	NA	NA	NA
Anthracene	Upper	0/6	NA	NA	23,000,000	0
	Lower	1/6	1,800	NA	NA	NA
Benzo(a)anthracene	Upper	0/6	NA	NA	880	0
	Lower	2/6	300 - 5,700	3,000	NA	NA
Benzo(a)pyrene	Upper	0/6	NA	NA	88	0
	Lower	3/6	210 - 5,400	1,980	NA	NA
Benzo(b)-fluoranthene	Upper	0/6	NA	NA	880	0
	Lower	2/6	370 - 8,000	4,190	NA	NA
Benzo(g,h,i)perylene	Upper	0/6	NA	NA	3,100,000[b]	0
	Lower	2/6	270 - 3,100	1,690	NA	NA
Benzo(k)-fluoranthene	Upper	0/6	NA	NA	8,800	0
	Lower	1/6	390	NA	NA	NA

Table 10.7.2
AOC 506
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Semivolatile Organic Compounds (12 samples collected: 6 upper interval and 6 lower interval, 1 sample duplicated for Appendix IX analysis)						
Carbazole	Upper	0/6	NA	NA	32,000	0
	Lower	1/6	1,200	NA	NA	NA
Chrysene	Upper	0/6	NA	NA	88,000	0
	Lower	3/6	250 - 6,500	2,390	NA	NA
Dibenzofuran	Upper	0/6	NA	NA	310,000	0
	Lower	1/6	1,200	NA	NA	NA
Dibenz(a,h)-anthracene	Upper	0/6	NA	NA	88	0
	Lower	1/6	1,300	NA	NA	NA
Fluoranthene	Upper	0/6	NA	NA	3,100,000	0
	Lower	2/6	350 - 750	550	NA	NA
Fluorene	Upper	0/6	NA	NA	3,100,000	0
	Lower	1/6	1,800	NA	NA	NA
Indeno(1,2,3-cd)-pyrene	Upper	0/6	NA	NA	880	0
	Lower	2/6	250 - 3,000	1,620	NA	NA
2-methylnaphthalene	Upper	0/6	NA	NA	3,100,000[c]	0
	Lower	1/6	580	NA	NA	NA
Naphthalene	Upper	0/6	NA	NA	3,100,000	0
	Lower	2/6	350 - 550	450	NA	NA
Phenanthrene	Upper	0/6	NA	NA	3,100,000[b]	0
	Lower	2/6	530 - 11,000	5,760	NA	NA
Pyrene	Upper	0/6	NA	NA	2,300,000	0
	Lower	1/6	690	NA	NA	NA

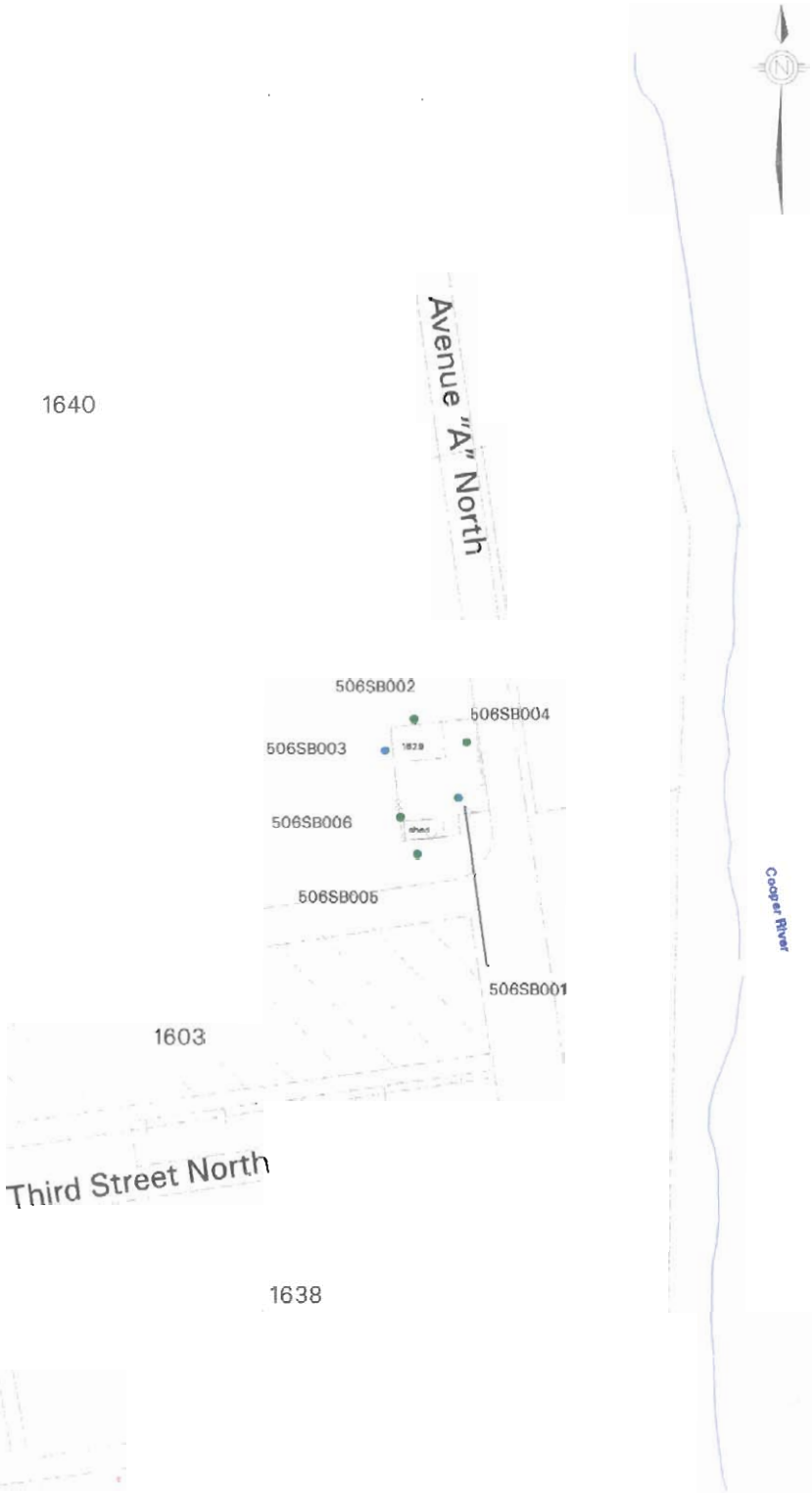
Notes:

a = Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, Bulletin No. 2, November 1995.

b = RBC not available for this compound; fluoranthene RBC used as surrogate.

c = RBC not available for this compound; naphthalene RBC used as surrogate.

NA = Not applicable



LEGEND

- Soil Boring

0 200 feet

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.7.1 - AOC 506
Soil Sample Locations

Table 10.7.3
AOC 506
Inorganics Detected in Soil

Element	Sample Interval	Frequency of Detections	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	Reference Conc. (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding[a]
Inorganics (12 samples collected: 6 upper interval and 6 lower interval, 1 sample duplicated for Appendix IX analysis)							
Aluminum	Upper	6/6	5,010 - 11,000	8,050	12,800	78,000	0
	Lower	6/6	5,160 - 11,100	8,700	28,240	NA	0
Arsenic	Upper	6/6	2.1 - 8.9	4.7	9.4	0.43	0
	Lower	6/6	2.0 - 5.8	3.6	9.8	NA	0
Barium	Upper	6/6	16.9 - 665	131	53.0	5,500	0
	Lower	6/6	18.7 - 33.1	25.8	40.0	NA	0
Cadmium	Upper	1/6	1.2	NA	**	39	0
	Lower	0/6	NA	NA	**	NA	0
Calcium	Upper	6/6	1,110 - 12,000	5,120	NA	NA	NA
	Lower	6/6	2,580 - 115,000	61,600	NA	NA	NA
Chromium	Upper	6/6	8.9 - 30.1	14.6	50.4	390	0
	Lower	6/6	6.8 - 29.1	18.2	63.4	NA	0
Cobalt	Upper	4/6	1.5 - 17.7	6.2	4.4	4,700	0
	Lower	2/6	1.7 - 2.8	2.3	1.7	NA	2
Copper	Upper	6/6	1.9 - 48.9	15.7	165	3,100	0
	Lower	6/6	3.2 - 11.0	7.8	33.7	NA	0
Iron	Upper	6/6	5,290 - 9,220	7,060	NA	NA	NA
	Lower	6/6	4,520 - 8,340	5,840	NA	NA	NA
Lead	Upper	6/6	5.4 - 66.0	28.9	140	400[b]	0
	Lower	6/6	7.5 - 72.6	23.0	22.0	400[b]	0
Magnesium	Upper	6/6	325 - 1,110	531	NA	NA	NA
	Lower	6/6	403 - 2,950	1,570	NA	NA	NA
Manganese	Upper	6/6	11.8 - 63.7	32.4	98.1	1,800	0
	Lower	6/6	13.2 - 157	72.4	85.5	NA	2
Mercury	Upper	2/6	0.98 - 1.30	1.14	0.30	23	0
	Lower	0/6	NA	NA	**	NA	0

Table 10.7.3
AOC 506
Inorganics Detected in Soil

Element	Sample Interval	Frequency of Detections	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	Reference Conc. (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding[a]
Inorganics (12 samples collected: 6 upper interval and 6 lower interval, 1 sample duplicated for Appendix IX analysis)							
Nickel	Upper	5/6	3.9 - 9.9	7.5	13.6	1,600	0
	Lower	6/6	4.9 - 12.4	8.5	35.0	NA	0
Potassium	Upper	6/6	172 - 376	287	NA	NA	NA
	Lower	6/6	282 - 658	474	NA	NA	NA
Selenium	Upper	0/6	NA	NA	1.2	390	0
	Lower	2/6	0.95 - 1.00	0.98	1.7	NA	0
Sodium	Upper	6/6	208 - 244	228	NA	NA	NA
	Lower	6/6	218 - 882	505	NA	NA	NA
Tin	Upper	0/6	NA	NA	**	47,000	0
	Lower	1/6	14.7	NA	**	NA	NA
Vanadium	Upper	6/6	12.2 - 17.0	14.4	29.2	550	0
	Lower	6/6	6.8 - 20.8	13.8	77.3	NA	0
Zinc	Upper	6/6	6.8 - 281	73.0	208	23,000	0
	Lower	6/6	10.2 - 38.2	29.2	165	NA	0

Notes:
a = Number of samples exceeding both RBC and RC in upper interval or number of samples exceeding the RC in the lower interval.
b = RBC not available for lead. USEPA residential soil cleanup level used for comparison (OSWER Directive 9355.4-12).
** = Number of nondetects prevented determination of UTL.
NA = Not applicable

Volatile Organic Compounds in Soil

Acetone, 2-butanone, carbon disulfide, methylene chloride, and toluene were the only VOCs detected in soil at AOC 506; and no detections were above their respective RBCs. Also, no VOC detections exceeded their respective SSLs.

Semivolatile Organic Compounds in Soil

No SVOCs were detected in any of the first-interval samples at AOC 506. Nineteen SVOCs were detected in the second-interval samples. Five exceeded their SSL: benzo(a)anthracene (730 μg/kg), benzo(a)pyrene (4,100 μg/kg), benzo(b)fluoranthene (2,300 μg/kg), carbazole (240 μg/kg), and dibenz(a,h)anthracene (700 μg/kg). Also, the resulting BEQ calculation exceeds the SSL for benzo(a)pyrene.

All of the exceedances were in one second-interval sample, 506SB00102. The concentrations detected in this sample were benzo(a)anthracene (5,700 μg/kg), benzo(a)pyrene (5,400 μg/kg), benzo(b)fluoranthene (8,000 μg/kg), carbazole (1,200 μg/kg), and dibenz(a,h)anthracene (1,300 μg/kg). The only other second-interval samples in which cPAHs were detected were 506SB00202 and 506SB00402, but these detections were below the respective SSLs.

Inorganics in Soil

Twenty metals were detected in soil at AOC 506. Three warrant further evaluation: cobalt, manganese, and tin.

Cobalt was detected above the RC (1.7 mg/kg) in both of the detections in six lower-interval samples. These detections do not exceed the SSL (990 mg/kg) for cobalt.

Manganese was detected above the RC (85.5 mg/kg) in two second-interval samples – 506SB00102 and 506SB00202. This detection does not exceed the SSL (550 mg/kg) for manganese.

Tin does not have an RC or RBC for comparison of the second-interval detection. This detection does not exceed the SSL (5,500 mg/kg) for tin.

10.7.3 Groundwater Sampling and Analysis

The *Final Zones A and B RFI Work Plan* proposed one shallow monitoring well associated with AOC 506. This well was installed in a biased location (the middle of the storage area) to confirm whether a release to groundwater has occurred from this site. This location is shown on Figure 10.7.2.

After installation and development, the first-round RFI sample was collected. Groundwater samples were collected for VOCs, SVOCs, and metals at DQO Level III. Second- and third-quarter analytical parameters for AOC 506 were based upon the detections in the first quarter. These samples were analyzed for VOCs and metals at DQO Level III. The second and third-round samples were collected by the CEERD in April and June 1996, respectively.

Based upon a review of AOC 506 data, BEQ detections in subsurface soil exceed SSLs. First-quarter sampling of the monitoring well onsite did not indicate the presence of any SVOCs in groundwater and SVOCs were dropped from the list of parameters during subsequent sampling events. As an additional measure to confirm that groundwater at AOC 506 has not been impacted, the fourth-quarter sampling event conducted by the CEERD in October 1996 included SVOC analysis.

Also, a geoprobe investigation was conducted in June 1997 at AOC 506 to further assess previous VOC detections in groundwater. Three geoprobe borings were installed and two intervals were sampled in each, shallow and deep. Table 10.7.4 summarizes groundwater sampling at AOC 506.

The shallow monitoring well, NBCA-506-001, was installed at 13 feet bgs in the upper sand aquifer. It was installed as described in Section 3.3 of this report.

LEGEND

- Shallow Monitoring Well
- Geoprobe Borings

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.7.2 - AOC 506
Groundwater Sample Locations

Table 10.7.4
AOC 506
Groundwater Sampling Summary

Event	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
December 1995 (1st round)	1	1	VOCs, SVOCs, and metals	VOCs, SVOCs, and metals	None
April 1996 (2nd round)	1	1	VOCs and metals[a]	VOCs and metals	None
June 1996 (3rd round)	1	1	VOCs and metals[a]	VOCs and metals	None
October 1996 (4th round)	1	1	VOCs, SVOCs, and metals[b]	VOCs, SVOCs, and metals[b]	None
June 1997 (Geoprobe)	6[c]	6[c]	VOCs	VOCs	None

Note:
a = Second- and third-round parameters were based upon detections from first round samples.
b = SVOCs added to fourth-quarter sampling event.
c = Geoprobe investigation included the collection of two samples (shallow and deep) from three borings.

10.7.4 Nature and Extent of Contamination in Groundwater

Table 10.7.5 summarizes organic groundwater analytical results and Table 10.7.6 summarizes groundwater inorganic analytical results for AOC 506. Appendix D is a complete analytical data report for all samples collected in Zone A, including those collected at AOC 506.

Volatile Organic Compounds in Groundwater

Three VOCs — carbon disulfide, 1,1-dichloroethane, and trichlorofluoromethane — were detected in groundwater at AOC 506. No detections exceeded their respective RBC concentration.

Semivolatile Organic Compounds in Groundwater

No SVOCs were detected in AOC 506 groundwater.

Table 10.7.5
AOC 506
Organic Compounds Detected in Groundwater

Compound	Sampling Event	Sampling Interval	Freq. of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	RBC (μg/L)	Number of Samples Exceeding RBC
Volatile Organics (1 shallow groundwater sample collected quarterly; 3 shallow and 3 deep groundwater samples collected during the Geoprobe event)							
Carbon disulfide	Dec. 95	Shallow	0/1	NA	NA	1,000	0
	Apr. 96	Shallow	0/1	NA	NA	1,000	0
	June 96	Shallow	1/1	1.6	NA	1,000	0
	Oct. 96	Shallow	0/1	NA	NA	1,000	0
	June 97	Shallow	0/3	NA	NA	1,000	0
	June 97	Deep	0/3	NA	NA	1,000	0
1,1-dichloroethane	Dec. 95	Shallow	1/1	3.5	NA	810	0
	Apr. 96	Shallow	1/1	4.2	NA	810	0
	June 96	Shallow	1/1	5.1	NA	810	0
	Oct. 96	Shallow	0/1	NA	NA	810	0
	June 97	Shallow	1/3	5.0	NA	810	0
	June 97	Deep	0/3	NA	NA	810	0
Trichlorofluoro-methane	Dec. 95	Shallow	1/1	21.0	NA	1,300	0
	Apr. 96	Shallow	1/1	33.0	NA	1,300	0
	June 96	Shallow	1/1	28.0	NA	1,300	0
	Oct. 96	Shallow	0/1	NA	NA	1,300	0
	June 97	Shallow	0/3	NA	NA	1,300	0
	June 97	Deep	0/3	NA	NA	1,300	0

Note:
NA = Not applicable

Table 10.7.6
AOC 506
Inorganics Detected in Shallow Groundwater

Compound	Sampling Event	Frequency of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding Both RC and RBC
Inorganics (1 shallow groundwater sample collected during each event)							
Aluminum	Dec. 95	1/1	3,020	NA	3,210	37,000	0
	Apr. 96	1/1	3,190	NA	3,210	37,000	0
	June 96	1/1	1,840	NA	3,210	37,000	0
	Oct. 96	0/1	NA	NA	3,210	37,000	0
Barium	Dec.. 95	1/1	35.4	NA	104	2,600	0
	Apr. 96	0/1	NA	NA	104	2,600	0
	June 96	1/1	46.0	NA	104	2,600	0
	Oct. 96	1/1	97.0	NA	104	2,600	0
Calcium	Dec. 95	1/1	38,900	NA	NA	NA	NA
	Apr. 96	1/1	47,200	NA	NA	NA	NA
	June 96	1/1	40,000	NA	NA	NA	NA
	Oct. 96	1/1	84,600	NA	NA	NA	NA
Chromium	Dec. 95	1/1	9.7	NA	8.7	180	0
	Apr. 96	1/1	7.1	NA	8.7	180	0
	June 96	0/1	NA	NA	8.7	180	0
	Oct. 96	0/1	NA	NA	8.7	180	0
Copper	Dec. 95	1/1	14.4	NA	15.7	1,500	0
	Apr. 96	1/1	8.9	NA	15.7	1,500	0
	June 96	1/1	7.8	NA	15.7	1,500	0
	Oct. 96	0/1	NA	NA	15.7	1,500	0
Iron	Dec. 95	1/1	3,710	NA	NA	NA	NA
	Apr. 96	1/1	2,800	NA	NA	NA	NA
	June 96	1/1	1,850	NA	NA	NA	NA
	Oct. 96	1/1	112	NA	NA	NA	NA

Table 10.7.6
AOC 506
Inorganics Detected in Shallow Groundwater

Compound	Sampling Event	Frequency of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding Both RC and RBC
Inorganics (1 shallow groundwater sample collected during each event)							
Magnesium	Dec. 95	1/1	23,900	NA	NA	NA	NA
	Apr. 96	1/1	18,000	NA	NA	NA	NA
	June 96	1/1	16,900	NA	NA	NA	NA
	Oct. 96	1/1	16,600	NA	NA	NA	NA
Manganese	Dec. 95	1/1	85.7	NA	577	840	0
	Apr. 96	0/1	NA	NA	577	840	0
	June 96	1/1	36.2	NA	577	840	0
	Oct. 96	1/1	16.6	NA	577	840	0
Nickel	Dec. 95	1/1	16.7	NA	**	730	0
	Apr. 96	0/1	NA	NA	**	730	0
	June 96	0/1	NA	NA	**	730	0
	Oct. 96	0/1	NA	NA	**	730	0
Potassium	Dec. 95	1/1	6,870	NA	NA	NA	NA
	Apr. 96	1/1	5,450	NA	NA	NA	NA
	June 96	1/1	5,790	NA	NA	NA	NA
	Oct. 96	1/1	9,200	NA	NA	NA	NA
Selenium	Dec. 95	1/1	3.0	NA	**	180	0
	Apr. 96	1/1	5.6	NA	**	180	0
	June 96	1/1	3.8	NA	**	180	0
	Oct. 96	0/1	NA	NA	**	180	0
Sodium	Dec. 95	1/1	63,400	NA	NA	NA	NA
	Apr. 96	0/1	NA	NA	NA	NA	NA
	June 96	1/1	55,900	NA	NA	NA	NA
	Oct. 96	0/1	NA	NA	NA	NA	NA

Table 10.7.6
AOC 506
Inorganics Detected in Shallow Groundwater

Compound	Sampling Event	Frequency of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	Reference Conc. (μg/L)	RBC (μg/L)	Number of Samples Exceeding Both RC and RBC
Inorganics (1 shallow groundwater sample collected during each event)							
Vanadium	Dec. 95	1/1	6.2	NA	5.4	260	0
	Apr. 96	1/1	8.9	NA	5.4	260	0
	June 96	0/1	NA	NA	5.4	260	0
	Oct. 96	1/1	0.76	NA	5.4	260	0
Zinc	Dec. 95	1/1	137	NA	83.2	11,000	0
	Apr. 96	0/1	NA	NA	83.2	11,000	0
	June 96	0/1	NA	NA	83.2	11,000	0
	Oct. 96	0/1	NA	NA	83.2	11,000	0

Notes:
** = Number of nondetects prevented determination of UTL.
NA = Not applicable.

Inorganics in Groundwater

Fourteen metals were detected in groundwater samples collected at AOC 506. No detections exceeded both their RC and RBC.

10.7.5 Fate and Transport Assessment for AOC 506

AOC 506 consists of a concrete pad enclosed with a chain-link fence and covered by a metal roof. Environmental media sampled as part of the AOC 506 CSI include surface soil, subsurface soil, and groundwater. Potential contaminant migration pathways for AOC 506 include soil constituents leaching to groundwater, groundwater constituent migration to surface water, and emission of VOCs from surface soil to ambient air.

10.7.5.1 AOC 506 — Soil to Groundwater Cross-Media Transport

Tables 10.7.7 and 10.7.8 compare the maximum detected concentrations of organic and inorganic chemicals reported in soil to risk-based soil screening levels considered protective of groundwater. As shown on Table 10.7.7, five organics — benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, carbazole, and dibenzo(a,h)anthracene — were identified for further evaluation of soil to groundwater migration based on the screening process presented in Section 6. None of these organic chemicals were reported in shallow groundwater (including four rounds of groundwater sampling). As shown on Table 10.7.8, two inorganics — chromium and mercury — were identified for further evaluation of soil to groundwater migration. Chromium was detected in groundwater at a concentration less than its groundwater screening values; mercury was not detected in groundwater (including four rounds of groundwater sampling).

All of the organic exceedences were reported in a single subsurface soil sample (506SB00102). Soil concentrations reported for these organic chemicals are not likely to present a widespread threat to AOC 506 groundwater based on their limited areal extent at concentrations above their SSLs. Mercury was reported in a single surface soil sample (506SB00201) at a concentration of 1.3 mg/kg which marginally exceeds its SSL of 1 mg/kg. Although chromium was reported in one surface soil sample and four subsurface soil samples at concentrations exceeding its SSL, it was not reported in any soil sample at a concentration exceeding its background reference value. For screening purposes, chromium was conservatively assumed to exist in its soluble hexavalent state. Hexachrome analyses at AOC 506 and elsewhere in Zone A suggest that chromium in soil exists predominantly in less soluble valence states. These findings suggest that concentrations of inorganic soil constituents do not appreciably threaten AOC 506 groundwater.

10.7.5.2 AOC 506 — Groundwater to Surface Water Cross-Media Transport

As shown on Table 10.7.7, no organic constituents were detected in AOC 506 shallow groundwater above tap water RBCs or surface water saltwater AWQCs. Therefore, it has been

Table 10.7.7
Organic Compounds Detected in Surface Soil, Subsurface Soil, and Shallow Groundwater
Comparison to Cross-media SSLs, Tap Water RBCs, and Saltwater Surface Water Chronic Screening Levels
NAVBASE-Charleston, Zone A: AOC 506
Charleston, South Carolina

Parameter	Maximum Concentration				Screening Concentration *				Soil Units	Water Units	Leaching Potential	Volatil-ization Potential	Ground-Water Migration Concern	Surface Water Migration Concern
	Surface Soil	Subsurface Soil	Shallow GW	Deep GW	Soil to GW	Soil to Air	Tap Water RBC	Saltwater Surf. Wtr. Chronic						
Volatile Organic Compounds														
Acetone	60	56	ND	NA	8000	1E+08	3700	NDA	UG/KG	UG/L	NO	NO	NO	NO
2-Butanone	ND	4.75	ND	NA	3900 c	NDA	1900	NDA	UG/KG	UG/L	NO	NO	NO	NO
Carbon disulfide	ND	3.6	1.6	NA	16000	720000	1000	NDA	UG/KG	UG/L	NO	NO	NO	NO
1,1-Dichloroethane	ND	ND	5.1	NA	12000	1300000	810	NDA	UG/KG	UG/L	NO	NO	NO	NO
Methylene chloride	ND	1.2	ND	NA	10	13000	4.1	2560	UG/KG	UG/L	NO	NO	NO	NO
Toluene	1.7	9.2	ND	NA	6000	650000	750	37	UG/KG	UG/L	NO	NO	NO	NO
Trichlorofluoromethane	ND	ND	33	NA	10000 c	790000	1300	NDA	UG/KG	UG/L	NO	NO	NO	NO
Semivolatile Organic Compounds														
Acenaphthene	ND	600	ND	NA	290000	NDA	2200	9.7	UG/KG	UG/L	NO	NO	NO	NO
Acenaphthylene	ND	970	ND	NA	96000 c	NDA	1500	NDA	UG/KG	UG/L	NO	NO	NO	NO
Anthracene	ND	1800	ND	NA	5900000	NDA	11000	NDA	UG/KG	UG/L	NO	NO	NO	NO
Benzo(g,h,i)perylene	ND	3100	ND	NA	1.2E+08 c	NDA	1500	NDA	UG/KG	UG/L	NO	NO	NO	NO
Benzo(a)pyrene equivalents														
Benzo(a)anthracene	ND	5700	ND	NA	800	NDA	0.092	NDA	UG/KG	UG/L	YES	NO	NO	NO
Benzo(a)pyrene	ND	5400	ND	NA	4000	NDA	0.0092	NDA	UG/KG	UG/L	YES	NO	NO	NO
Benzo(b)fluoranthene	ND	8000	ND	NA	2500	NDA	0.092	NDA	UG/KG	UG/L	YES	NO	NO	NO
Benzo(k)fluoranthene	ND	390	ND	NA	25000	NDA	0.92	NDA	UG/KG	UG/L	NO	NO	NO	NO
Chrysene	ND	6500	ND	NA	80000	NDA	9.2	NDA	UG/KG	UG/L	NO	NO	NO	NO
Dibenzo(a,h)anthracene	ND	1300	ND	NA	800	NDA	0.0092	NDA	UG/KG	UG/L	YES	NO	NO	NO
Indeno(1,2,3-cd)pyrene	ND	3000	ND	NA	7000	NDA	0.092	NDA	UG/KG	UG/L	NO	NO	NO	NO
Carbazole	ND	1200	ND	NA	300	NDA	3.4	NDA	UG/KG	UG/L	YES	NO	NO	NO
Dibenzofuran	ND	1200	ND	NA	42000 c	120000	150	NDA	UG/KG	UG/L	NO	NO	NO	NO
Fluoranthene	ND	750	ND	NA	2200000	NDA	1500	1.6	UG/KG	UG/L	NO	NO	NO	NO
Fluorene	ND	1800	ND	NA	280000	NDA	1500	NDA	UG/KG	UG/L	NO	NO	NO	NO
2-Methylnaphthalene	ND	580	ND	NA	230000 c	NDA	1500	NDA	UG/KG	UG/L	NO	NO	NO	NO
Naphthalene	ND	550	ND	NA	42000	NDA	1500	23.5	UG/KG	UG/L	NO	NO	NO	NO
Phenanthrene	ND	11000	ND	NA	900000 c	NDA	1500	NDA	UG/KG	UG/L	NO	NO	NO	NO
Pyrene	ND	690	ND	NA	2100000	NDA	1100	NDA	UG/KG	UG/L	NO	NO	NO	NO

Explanations of screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Table 10.7.2 and 10.7.5.

* Screening Concentrations:
Soil to GW - Generic SSLs based on DAF = 10, adapted from USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or calculated using values from Table 6.2
Soil to Air - From USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or USEPA Region III Risk-Based Concentration Table, June 1996
Tap Water RBC - From USEPA Region III Risk-Based Concentration Table, October 1997
Salt Water Surface Water Chronic - From USEPA Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment, November 1995, Table 2

c - Calculated soil to groundwater SSL value (See Table 6.2)
GW - Groundwater
NA - Not applicable
ND - Not detected
NDA - No data available
RBC - Risk-based concentration
SSL - Soil screening level
UG/KG - Micrograms per kilogram
UG/L - Micrograms per liter

Table 10.7.8
Inorganic Chemicals Detected in Surface Soil, Subsurface Soil, and Shallow Groundwater
Comparison to Cross-media SSLs, Tap Water RBCs, Saltwater Surface Water Chronic Screening Levels, and Background Reference Values
NAVBASE-Charleston, Zone A: AOC 506
Charleston, South Carolina

Parameter	Maximum Concentration				Screening Concentration *											
	Surface Soil	Subsurfac Soil	Shallow GW	Deep GW	Soil to GW	Soil Background Reference	Soil to Air	Tap Water RBC	GW Background Reference	Saltwater Surf. Wtr. Chronic	Soil Units	Water Units	Leaching Potential	Fugitive Particulate Inhalation Concern	Ground-Water Migration Concern	Surface Water Migration Concern
Inorganic Chemicals																
Aluminum	11000	11100	3190	NA	560000 c	28240	NA	37000	3210	NA	MG/KG	UG/L	NO	NO	NO	NO
Arsenic	8.9	5.8	ND	NA	15	9.8	750	0.045	11.1	36	MG/KG	UG/L	NO	NO	NO	NO
Barium	665	33.1	97	NA	820	53	690000	2600	179	NA	MG/KG	UG/L	NO	NO	NO	NO
Cadmium	1.2	ND	ND	NA	4	ND	1800	18	ND	9.3	MG/KG	UG/L	NO	NO	NO	NO
Chromium (total)	30.1	29.1	9.7	NA	19	63.4	270	180	8.7	50	MG/KG	UG/L	YES	NO	NO	NO
Cobalt	17.7	2.8	ND	NA	990 c	4.4	NA	2200	12.1	NA	MG/KG	UG/L	NO	NO	NO	NO
Copper	48.9	11	14.4	NA	5600 c	165	NA	1500	15.7	2.9	MG/KG	UG/L	NO	NO	NO	YES
Lead	66	72.6	ND	NA	400	140	400	15	4.7	8.5	MG/KG	UG/L	NO	NO	NO	NO
Manganese	63.7	157	85.7	NA	550 c	98.1	NA	840	2690	NA	MG/KG	UG/L	NO	NO	NO	NO
Mercury	1.3	ND	ND	NA	1 c	0.3	10	11	ND	0.25	MG/KG	UG/L	YES	NO	NO	NO
Nickel	9.9	12.4	16.7	NA	65	35	13000	730	21.1	8.3	MG/KG	UG/L	NO	NO	NO	YES
Selenium	ND	1	5.6	NA	2.5	1.74	NA	180	ND	71	MG/KG	UG/L	NO	NO	NO	NO
Tin	ND	14.7	ND	NA	5500 c	ND	NA	22000	ND	NA	MG/KG	UG/L	NO	NO	NO	NO
Vanadium	17	20.8	8.9	NA	3000	77.3	NA	260	10.9	NA	MG/KG	UG/L	NO	NO	NO	NO
Zinc	281	38.2	137	NA	6200	208	NA	11000	83.2	86	MG/KG	UG/L	NO	NO	NO	YES

Explanations of screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Table 10.7.3 and 10.7.6.

* Screening Concentrations:
Soil to GW - Generic SSLs based on DAF = 10, adapted from USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or calculated using values from Table 6.2
Soil to Air - From USEPA Soil Screening Guidance: Technical Background Document, May 1996 (first preference), or USEPA Region III Risk-Based Concentration Table, June 1996
Tap Water RBC - From USEPA Region III Risk-Based Concentration Table, October 1997
Salt Water Surface Water Chronic - From USEPA Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment, November 1995, Table 2
Background reference values for soil are shown for comparison purposes only.
Maximum groundwater concentrations are screened against the greater of tap water RBCs or corresponding background reference values to determine groundwater migration concern.

c - Calculated soil to groundwater SSL value (See Table 6.2)
GW - Groundwater
NA - Not available/Not applicable
ND - Not detected
RBC - Risk-based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
UG/L - Micrograms per liter

concluded that groundwater does not present a significant migration pathway with respect to organic constituents for AOC 506. As shown on Table 10.7.8, copper, nickel, and zinc were reported at a concentrations exceeding their surface water saltwater chronic AWQCs. Neither copper nor nickel were reported in groundwater samples at concentrations exceeding their background reference concentrations (including four quarters of sampling). Although zinc was reported in a single shallow groundwater sample collected during the first quarter at a concentrations exceeding its AWQC and its background reference concentration, results for the next three quarters were nondetect for zinc. These findings indicate that groundwater concentrations of zinc do not appreciably threaten ecological receptors as a result of groundwater to surface water migration.

10.7.5.3 AOC 506 — Soil-to-Air Cross-Media Transport

As shown on Tables 10.7.7 and 10.7.8, no organic or inorganic constituent exceeded its corresponding soil to air SSL. As a result, the soil-to-air migration pathway is not expected to be significant at AOC 506.

10.7.6 Human Health Risk Assessment for AOC 506

10.7.6.1 Site Background and Investigative Approach

AOC 506 is Building 1629, a structure used since 1942 for storage of flammable material returned to Building 1603, the DRMO Material Turn-In Site. Materials of concern for AOC 506 are solvents, paints, fuels, and other unknown flammable materials. Six soil samples were collected from the upper interval. Section 10.7.1 provides a summary of the soil sampling effort for AOC 506. All of the surface soil samples were considered to evaluate the soil pathways in the HHRA. Groundwater samples were collected from one shallow monitoring well over four quarters. Section 10.7.3 provides a summary of the groundwater effort for AOC 506. Only groundwater data resulting from samples collected from the permanent monitoring well were used to quantitatively evaluate groundwater pathways in the HHRA.

10.7.6.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 of this RFI and presented in Table 10.7.9, barium was the only COPC identified in surface soil. Wilcoxon rank sum test analyses did not result in the inclusion of any inorganic parameters that had been screened out on the basis of background reference concentration comparisons.

Groundwater

As shown in Table 10.7.10, no COPCs were identified in shallow groundwater for this site. Wilcoxon rank sum test analyses did not result in the inclusion of any inorganic parameters that had been screened out on the basis of background reference concentration comparisons.

10.7.6.3 Exposure Assessment

Exposure Setting

The majority of AOC 506 is currently covered by structures and a concrete pad. Soil is exposed in areas immediately surrounding the concrete pad. AOC 506 is in a moderately developed area of NAVBASE and most surrounding land is grass-covered. Current base reuse plans indicate that Zone A is slated for development as a marine cargo terminal, in which case AOC 506 will likely maintain current features and/or be subject to construction and/or demolition activities.

Potentially Exposed Populations

The most probable exposed populations are current and future site workers. Additional potentially exposed populations are hypothetical future site residents. Future site resident and worker exposure scenarios were addressed in this risk assessment. The hypothetical future site worker scenario assumed continuous exposure to surface soil conditions and the use of shallow groundwater as a potable water source. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact and

Table 10.7.9
Chemicals Present in Site Samples
AOC 506, Surface Soil
NAVBASE-Charleston, Zone A
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration RBC	Reference	Units	Number Exceeding RBC	Ref.
Volatile Organics													
Acetone		3	6	15	60	36.3	11	12	780000	NA	ug/kg		
Toluene		2	6	1.3	1.7	1.5	5.4	6	1600000	NA	ug/kg		
Inorganics													
Aluminum (Al)		6	6	5010	11000	8050	NA	NA	7800	12800	mg/kg	3	
Arsenic (As)		6	6	2.1	8.9	4.67	NA	NA	0.43	9.44	mg/kg	6	
Barium (Ba)	*	6	6	16.9	665	131	NA	NA	550	53	mg/kg	1	1
Cadmium (Cd)		1	6	1.2	1.2	1.2	1.1	1.2	3.9	NA	mg/kg		
Calcium (Ca)	N	6	6	1110	12000	5120	NA	NA	NA	NA	mg/kg		
Chromium (Cr)		6	6	8.9	30.1	14.6	NA	NA	39	50.4	mg/kg		
Cobalt (Co)		4	6	1.5	17.7	6.18	1.3	1.4	470	4.4	mg/kg		1
Copper (Cu)		6	6	1.9	48.9	15.7	NA	NA	310	165	mg/kg		
Iron (Fe)	N	6	6	5290	9220	7055	NA	NA	NA	NA	mg/kg		
Lead (Pb)		6	6	5.4	66	28.9	NA	NA	400	140	mg/kg		
Magnesium (Mg)	N	6	6	325	1110	531	NA	NA	NA	NA	mg/kg		
Manganese (Mn)		6	6	11.8	63.7	32.4	NA	NA	180	98.1	mg/kg		
Mercury (Hg)		2	6	0.98	1.3	1.14	0.1	0.12	2.3	0.3	mg/kg		
Nickel (Ni)		5	6	3.9	9.9	7.46	3.1	3.1	160	13.55	mg/kg		
Potassium (K)	N	6	6	172	376	287	NA	NA	NA	NA	mg/kg		
Sodium (Na)	N	6	6	208	244	228	NA	NA	NA	NA	mg/kg		
Vanadium (V)		6	6	12.2	17	14.4	NA	NA	55	29.24	mg/kg		
Zinc (Zn)		6	6	6.8	281	73	NA	NA	2300	207.6	mg/kg		1

* - Identified as a COPC
N - Essential nutrient
ug/kg - micrograms per kilogram
mg/kg - milligrams per kilogram

Table 10.7.10
Chemicals Present in Site Samples
AOC 506, Shallow Groundwater (Four Quarters)
NAVBASE-Charleston, Zone A
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration RBC	Reference	Units	Number Exceeding RBC	Ref.
Volatile Organics													
Carbon disulfide		1	4	1.6	1.6	1.6	5	5	100	NA	ug/L		
1,1-Dichloroethane		3	4	3.5	5.1	4.27	5	5	81	NA	ug/L		
Trichlorofluoromethane		3	3	21	33	27.3	NA	NA	130	NA	ug/L		
Inorganics													
Aluminum (Al)		3	4	1840	3190	2683	118	118	3700	3210	ug/L		
Barium (Ba)		3	4	35.4	97	59.5	51.8	51.8	260	104	ug/L		
Calcium (Ca)	N	4	4	38900	84600	52675	NA	NA	NA	NA	ug/L		
Chromium (Cr)		2	4	7.1	9.7	8.4	0.78	6	18	8.7	ug/L		1
Copper (Cu)		3	4	7.8	14.4	10.4	2.7	2.7	150	15.7	ug/L		
Iron (Fe)	N	4	4	112	3710	2118	NA	NA	NA	NA	ug/L		
Magnesium (Mg)	N	4	4	16600	23900	18850	NA	NA	NA	NA	ug/L		
Manganese (Mn)		3	4	16.6	85.7	46.2	30	30	84	577	ug/L	1	
Nickel (Ni)		1	4	16.7	16.7	16.7	0.67	13	73	NA	ug/L		
Potassium (K)	N	4	4	5450	9200.6	6828	NA	NA	NA	NA	ug/L		
Selenium (Se)		3	4	3	5.6	4.13	9.8	9.8	18	NA	ug/L		
Sodium (Na)	N	2	4	55900	63400	59650	27800	49900	NA	NA	ug/L		
Vanadium (V)		3	4	0.76	8.9	5.29	6	6	26	5.4	ug/L		2
Zinc (Zn)		1	4	137	137	137	14.4	25.7	1100	83.2	ug/L		1

N - Essential nutrient
ug/L - micrograms per liter

the fact that groundwater is not currently used onsite as a source of potable or process water. Therefore, future worker assessment is considered to be protective of current site users. The future site resident scenario was developed on the premise that current buildings and surface coverings would be removed and replaced with dwellings. In addition, the future site residents were assumed to use the shallow aquifer onsite as a drinking water source.

Exposure Pathways

Exposure pathways for site workers are dermal contact and incidental ingestion of surface soils. Since no COPCs were identified in shallow groundwater, exposure through potable use or inhalation of VOCs while showering is not considered significant. The exposure pathways for future residential land use are the same as those for the future site worker. In addition, the hypothetical future site worker scenario assumed continuous exposure to surface soils. Uniform exposure was assumed for all sample locations. Table 10.7.11 presents the justification for exposure pathways assessed in this HHRA.

Table 10.7.11
Exposure Pathways Summary — AOC 506
NAVBASE — Zone A
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
		Current Land Uses	
Current Site Users/Maintenance	Air, Inhalation of gaseous contaminants emanating from soil	No	No COPCs were identified for this pathway based on fate and transport screening comparisons. The site area is covered by buildings and a concrete pad.
	Air, Inhalation of chemicals entrained in fugitive dust	No	No COPCs were identified for this pathway based on fate and transport screening comparisons. The site area is covered by buildings and a concrete pad which limits fugitive dust generation.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No	Shallow groundwater is not currently used as a source of potable or nonresidential water at AOC 506.

Table 10.7.11
Exposure Pathways Summary — AOC 506
NAVBASE — Zone A
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Site Users/Maintenance (Continued)	Shallow groundwater, Inhalation of volatilized shallow groundwater contaminants	No	Shallow groundwater is not currently used as a source of potable or non-residential water at AOC 506.
	Soil, Incidental ingestion	No (Qualified)	Future land use assessment is considered to be conservatively representative of current receptors.
	Soil, Dermal contact	No (Qualified)	Future land use assessment is considered to be conservatively representative of current receptors.
	Future Land Uses		
Future Site Residents (Child and Adult) and Future Site Worker	Air, Inhalation of gaseous contaminants emanating from soil	No	No COPCs were identified for this pathway based on fate and transport screening comparisons. The site area is covered by buildings and a concrete pad.
	Air, Inhalation of chemicals entrained in fugitive dust	No	No COPCs were identified for this pathway based on fate and transport screening comparisons. The site area is covered by buildings and a concrete pad, limiting fugitive dust generation.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No	No COPCs were identified in AOC 506 shallow groundwater.
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	No	No COPCs were identified in AOC 506 shallow groundwater.
Future Site Residents (Child and Adult) and Future Site Worker	Soil, Incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, Dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals: Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, SC, city limits.
	Fruits and vegetables: Ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Exposure Point Concentrations

As discussed in Section 7 of this RFI, UCLs are generally calculated for datasets consisting of at least 10 samples. Only six surface soil samples were analyzed for AOC 506. As a result, the maximum detected barium concentration was assigned as the EPC to estimate exposure. Barium was detected in all six surface soil samples. Five of the surface soil samples have barium concentrations well below the residential RBC and background UTL. Only sample 506SB00601 (665 mg/kg) had a barium concentration exceeding the residential RBC and background UTL.

Quantification of Exposure

Soil

CDIs for ingestion and dermal contact with surface soils are shown in Tables 10.7.12 and 10.7.13, respectively.

10.7.6.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Table 10.7.14 presents toxicological information specific to barium, the COPC identified at AOC 506. This information was used in the quantification of risk/hazard associated with soil exposure. A brief toxicological profile for barium is provided in the following paragraph.

Barium is used in various alloys, paints, soap, and manufacturing processes. Barium sulfate is used to aid x-ray diagnosis. This element is relatively abundant in nature and is found in plant and animal tissue (Dreisbach, et al., 1987; Klaassen, et al., 1986). Brazil nuts contain 3 to 4 mg per gram of nut. The fatal absorbed dose of barium is approximately 1000 mg (for humans). Assuming an absorption efficiency of 5% for barium, 20,000 mg ingested barium could be fatal (approximately 333 Brazil nuts, assuming 15 g/nut). Major toxic effects of this element are muscle stimulation, central nervous system effects, and effects on the heart. USEPA determined the oral RfD and inhalation RfD to be 0.07 and 1.43E-4 mg/kg-day, respectively. As listed in

Table 10.7.12
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil (0-1')
AOC 506
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Fraction Ingested from Contaminated Source *	Exposure Point Concentration (mg/kg)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Barium	1	665	9.11E-04	8.50E-03	1.04E-03	3.25E-04	1.16E-04

NOTES:

lwa Lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.7.13
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil (0-1')
AOC 506
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Exposure Point Concentration (mg/kg)	Fraction Contacted from Contaminated Source *	Dermal Absorption Factor (unitless)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Barium	665	1	0.001	3.73E-05	1.23E-04	2.34E-05	2.67E-05	9.53E-06

NOTES:

CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic constituents
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.7.14
Toxicological Database Information
for Chemicals of Potential Concern
AOC 506
NAVBASE Charleston, Zone A
Charleston, South Carolina

	Non-Carcinogenic Toxicity Data											Carcinogenic Toxicity Data			
emical	Oral Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Inhalation	Chemical	Oral Slope Factor [(mg/kg/day)]-1	Inhalation Factor [(mg/kg/day)]-1	Weight of Evidence	Tumor Type
ium	0.07	a	M	increased blood pressure	ND	0.000143	b	NA		ND	Barium	ND	ND	D	NA

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
NA Not applicable or not available
ND Not determined due to lack of information

IRIS, the critical effect of this chemical is increased blood pressure. The uncertainty factor was determined to be 3 and the modifying factor was determined to be 1.

10.7.6.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under both residential and industrial (site worker) scenarios. For these scenarios, the incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.7.15 and 10.7.16 present the computed carcinogenic risks and/or HQs associated with the incidental ingestion of and dermal contact with site surface soils, respectively.

Hypothetical Site Residents

The ingestion ILCR could not be estimated in the absence of a cancer potency slope factor for barium. The computed hazard indices for the adult resident are 0.01 and 0.003 for the soil ingestion and dermal contact pathways, respectively. The computed hazard indices for the child ingestion and dermal contact pathways are 0.1 and 0.009, respectively.

Hypothetical Site Workers

The ingestion ILCR could not be estimated in the absence of a cancer potency slope factor for barium. Hazard indices for the ingestion and dermal pathways are 0.005 and 0.002 for the ingestion and dermal pathways, respectively.

COCs Identified

As shown on Table 10.7.17, no chemicals of concern were identified based on cumulative (all pathway) risk and hazard projected for this site. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a hazard index threshold of 1.0 (unity). In this HHRA,

Table 10.7.15
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
AOC 506
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Current Worker adult Hazard Quotient	Current Worker adult ILCR
Barium	0.07	NA	0.013	0.12	ND	0.0046	ND
SUM Hazard Index/ILCR			0.01	0.1	ND	0.005	ND

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk

Table 10.7.16
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
AOC 506
Naval Base Charleston, Zone A
Charleston, South Carolina

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident lwa ILCR	Current Worker adult Hazard Quotient	Current Worker adult ILCR
Barium	0.2	0.014	NA	0.0027	0.0088	ND	0.0019	ND
SUM Hazard Index/ILCR				0.003	0.009	ND	0.002	ND

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa Lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk
- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

Table 10.7.17
Summary of Risk and Hazard-based COCs
AOC 506
NAVBASE - Charleston
Charleston, South Carolina

Medium	Exposure Pathway		Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident lwa ILCR	Site Worker Hazard Quotient	ILCR	Identification of COCs
Surface Soil	Incidental Ingestion	Barium	0.013	0.12	ND	0.0046	ND	
	Dermal Contact	Barium	0.0027	0.0088	ND	0.0019	ND	
Surface Soil Pathway Sum			0.02	0.1	ND	0.007	ND	
Sum of All Pathways			0.02	0.1	ND	0.007	ND	

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index
1- Chemical is a COC by virtue of projected child residence noncarcinogenic hazard.
2- Chemical is a COC by virtue of projected future resident lifetime ILCR.
3- Chemical is a COC by virtue of projected site worker noncarcinogenic hazard.
4- Chemical is a COC by virtue of projected site worker ILCR.

a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or greater and/or a cumulative hazard index above 1.0 if its individual ILCR exceeds 1E-6 or its hazard quotient exceeds 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used to provide a more comprehensive evaluation of chemicals contributing to carcinogenic risk or noncarcinogenic hazard during the remedial goal options development process.

10.7.6.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site-worker scenario are highly protective and would tend to overestimate exposure.

Residential use of the site is not expected, based on current site uses and the nature of surrounding buildings. Current base reuse plans indicate that AOC 506 will likely maintain current features. If this area were to be used as a residential site, the buildings would be demolished and the concrete surface removed. The surface soil conditions would likely change dramatically, since the area could be covered with landscaping soil, and/or a house. Consequently, exposure to current surface soil conditions would not be likely under a true future residential scenario. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to current site workers and future site residents.

Shallow groundwater is not currently used at AOC 506 for potable or industrial purposes. A basewide system provides drinking and process water to buildings throughout Zone A. This system is slated to remain in operation under the current base reuse plan. As a result, shallow

groundwater would not be expected to be used under future site use scenarios. Therefore, the screening performed to identify COPCs associated with shallow groundwater exposure is highly conservative, and associated pathways are not expected to be completed in the future.

Determination of Exposure Point Concentrations

Due to the nature of observed surface soil impacts (limited extent, single detection above residential RBC and background UTL), the maximum barium concentration was applied as the EPC. Considering that the remaining five surface soil samples were below both the residential RBC and the background UTL, the use of the maximum detected concentration as the EPC is considered highly conservative.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

Of the CPSS screened and eliminated from formal assessment, aluminum and arsenic were reported at concentrations exceeding their corresponding RBCs. This increases the likelihood of potentially cumulative risk/hazard based on the eliminated CPSS. These inorganic parameters did not exceed their corresponding background concentrations.

Groundwater

Of the CPSS screened and eliminated from formal assessment, only manganese was reported at a concentration exceeding its corresponding RBC. Although elimination of manganese from the

formal risk assessment may tend to underestimate risk, manganese was not detected above the background concentration for Zone A shallow groundwater.

Groundwater is not currently used as a potable water source at AOC 506, nor is it used for this purpose at NAVBASE or in the surrounding area. Municipal water is readily available. As previously mentioned, it is unlikely that the site will be developed as a residential area, and it is unlikely that a potable-use well would be installed onsite. It is probable that, if residences were constructed onsite and an unfiltered well were installed, the salinity and dissolved solids would preclude this aquifer from being an acceptable potable water source.

10.7.6.7 Risk Summary

The risk and hazard posed by contaminants at AOC 506 were assessed for the hypothetical site worker and the hypothetical future site resident under reasonable maximum exposure assumptions. For surface soils, the incidental ingestion and dermal contact pathways were assessed in this HHRA. Table 10.7.18 summarizes risk for each pathway/receptor group evaluated for AOC 506. No COCs were identified for AOC 506.

10.7.7 Corrective Measures Considerations

For AOC 506, the environmental media investigated were surface soil, subsurface soil, and shallow groundwater. Based on the analytical results and the risk assessment, no COCs were identified for surface soil and shallow groundwater. However, BEQ contamination in subsurface soil at AOC 506 warrants further evaluation through the CMS process. Potential corrective measures for this impacted medium are in Table 10.7.19. Corrective measures for AOC 506 are reviewed in more detail in Section 9.

Table 10.7.18
Summary of Risk and Hazard
AOC 506
Naval Base Charleston, Zone A
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.01	0.1	ND	0.005	ND
	Dermal Contact	0.003	0.009	ND	0.002	ND
Sum of All Pathways		0.02	0.1	ND	0.007	ND

NOTES:

ND Not determined due to the lack of available risk information.
ILCR Incremental lifetime cancer risk
HI Hazard index

Table 10.7.19
Potential Corrective Measures for
AOC 506

Medium	Compounds	Potential Corrective Measures
Soil (subsurface only)	BEQs	a) No Action/Intrinsic Remediation b) No Action/Intrinsic Remediation and Monitoring c) Containment by capping d) In-Situ, biological, chemical, and physical treatment e) Ex-Situ, biological, chemical, and physical treatment

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10.8 Grid-Based Sampling

To characterize background conditions across Zone A, as required by the *Final Zones A and B RFI Work Plan* (E/A&H, September 1995), systematic grid-based soil and groundwater sampling was performed.

10.8.1 Soil Sampling and Analysis

The *Final Zones A and B RFI Work Plan* proposed 14 upper interval soil samples and 14 lower interval samples. Sixteen upper-interval (0 to 1 foot) and 12 lower-interval (3 to 5 feet) samples were collected.

As detailed in Section 2 of the *Final Zones A and B RFI Work Plan*, the CNSY Radiological Control Office conducted detailed radiological surveys at Zone A sites with a low potential for radioactivity. This survey, described in separate work plans and reports, prevented the collection of samples at one of the Zone A grid-based boring locations (GDASB004). One additional lower interval sample (GDASB01002) was not collected due to a water table less than 5 feet bgs; saturated samples were not submitted for analysis.

During the outlier evaluation performed as part of the Zone A background determination, the project team agreed by consensus that the surface soil arsenic concentration of 30.1 ppm at GDASB006 warranted further consideration. Additional samples were collected around this location to determine if the arsenic concentration was an isolated anomaly. Three surface soil samples were collected within a 10-foot radius of GDASB006 for arsenic analysis. The results were 6.4, 7.2, and 15.3 ppm. This data has been incorporated into the Zone A background dataset. All other samples collected from the locations shown in Figure 10.8.1 were analyzed for the standard suite of parameters: VOCs, SVOCs, metals, cyanide, pesticides, and PCBs. Table 10.8.1 summarizes soil sampling and analysis of the grid-based locations.

Table 10.8.1
Grid-Based
Soil Sampling Summary

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Collected	Deviations
Upper	14	16	Standard Suite[a] for 13 samples, arsenic only for 3 samples.	Standard Suite[a] for 13 samples, arsenic only for 3 samples.	One location was not sampled due to radiological potential. Three samples collected to assess arsenic around sample GDASB00601.
Lower	14	12	Standard Suite[a]	Standard Suite[a]	One location was not sampled due to radiological potential. One lower-interval sample was not collected due to a water table less than 5 feet bgs.

Note:
a = VOCs, SVOCs, metals, cyanide, pesticides, and PCBs

10.8.2 Nature and Extent of Chemicals in Soil

Organic compound analytical results for soil are summarized in Table 10.8.2. Inorganic analytical results for soil are summarized in Table 10.8.3. Appendix D is a complete analytical data report for all samples collected in Zone A.

Volatile Organic Compounds in Soil

Acetone, 2-butanone (MEK), carbon disulfide, toluene, and trichloroethene were detected in grid-based soil samples. None of these detections exceeded the respective RBCs or SSLs.

Hess Oil Tank Farm

LEGEND

- Soil Boring

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.8.1 - Grid-Based Soil Sample Locations

Table 10.8.2
Grid-Based Locations
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Volatile Organic Compounds (25 samples collected: 13 upper interval and 12 lower interval, 4 samples duplicated)						
Acetone	Upper	3/13	10 - 128	52	7,800,000	0
	Lower	5/12	12 - 260	65	NA	NA
2-Butanone (MEK)	Upper	2/13	1.4 - 7.8	4.6	47,000,000	0
	Lower	1/12	12	NA	NA	NA
Carbon disulfide	Upper	1/13	1.8	NA	7,800,000	0
	Lower	2/12	2.7 - 19	11	NA	NA
Toluene	Upper	1/13	1.7	NA	16,000,000	0
	Lower	1/12	1.3	NA	NA	NA
Trichloroethene	Upper	8/13	1.2 - 2.7	1.9	58,000	0
	Lower	1/12	2.4	NA	NA	NA
Semivolatile Organic Compounds (25 samples collected: 13 upper interval and 12 lower interval, 4 samples duplicated)						
BEQ*	Upper	5/13	0.19 - 1,385	564	88	4
	Lower	1/12	0.16	NA	NA	NA
Benzo(a)anthracene	Upper	4/13	250 - 660	420	880	0
	Lower	0/12	NA	NA	NA	NA
Benzo(a)pyrene	Upper	4/13	325 - 830	490	88	4
	Lower	0/12	NA	NA	NA	NA
Benzo(b)fluoranthene	Upper	4/13	390 - 1,800	770	880	1
	Lower	0/12	NA	NA	NA	NA
Benzo(g,h,i)perylene	Upper	4/13	230 - 650	360	2,300,000	0
	Lower	0/12	NA	NA	NA	NA

Table 10.8.2
Grid-Based Locations
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Semivolatile Organic Compounds (25 samples collected: 13 upper interval and 12 lower interval, 4 samples duplicated)						
Benzo(k)fluoranthene	Upper	4/13	390 - 1,100	590	8,800	0
	Lower	0/12	NA	NA	NA	NA
Bis(2-ethylhexyl)-phthalate (BEHP)	Upper	1/13	290	NA	46,000	0
	Lower	0/12	NA	NA	NA	NA
Chrysene	Upper	5/13	190 - 980	470	88,000	0
	Lower	1/12	160	NA	NA	NA
Dibenz(a,h)-anthracene	Upper	1/13	230	NA	88	1
	Lower	0/12	NA	NA	NA	NA
Fluoranthene	Upper	4/13	250 - 870	580	3,100,000	0
	Lower	1/12	330	NA	NA	NA
Indeno(1,2,3-cd)-pyrene	Upper	4/13	210 - 670	340	880	0
	Lower	0/12	NA	NA	NA	NA
Phenanthrene	Upper	3/13	180 - 400	260	2,300,000	0
	Lower	2/12	200 - 460	330	NA	NA
Pyrene	Upper	4/13	360 - 1,300	760	2,300,000	0
	Lower	0/12	NA	NA	NA	NA
Pesticides/PCBs (25 samples collected: 13 upper interval and 12 lower interval, 4 samples duplicated)						
Aroclor-1260	Upper	2/13	54 - 86	70	320	0
	Lower	0/12	NA	NA	NA	NA
4,4'-DDD	Upper	7/13	5.8 - 62	28	2,700	0
	Lower	2/12	0.6 - 1.4	1.0	NA	NA

Table 10.8.2
Grid-Based Locations
Organic Compounds Detected in Soil

Compound	Sampling Interval	Frequency of Detection	Range of Detection (μg/kg)	Mean of Detections (μg/kg)	RBC (μg/kg)	Number of Samples Exceeding RBC
Pesticides/PCBs (25 samples collected: 13 upper interval and 12 lower interval, 4 samples duplicated)						
4,4'-DDE	Upper	9/13	2.4 - 170	66	1,900	0
	Lower	0/12	NA	NA	NA	NA
4,4'-DDT	Upper	6/13	5.7 - 70	32	1,900	0
	Lower	3/12	2.7 - 4.9	4.1	NA	NA
Alpha-BHC	Upper	1/13	8.7	NA	100	0
	Lower	0/12	NA	NA	NA	NA
Beta-BHC	Upper	2/13	3.1 - 31	17	350	0
	Lower	0/12	NA	NA	NA	NA
Delta-BHC	Upper	1/13	4.7	NA	350	0
	Lower	0/12	NA	NA	NA	NA
Alpha-chlordane	Upper	5/13	1.1 - 71	17	1,800	0
	Lower	1/12	2.1	NA	NA	NA
Gamma-chlordane	Upper	5/13	2.1 - 53	16	1,800	0
	Lower	0/12	NA	NA	NA	NA
Heptachlor epoxide	Upper	4/13	1.9 - 27	9.2	70	0
	Lower	0/12	NA	NA	NA	NA
Duplicate samples (4 samples collected for Appendix IX analysis, 3 upper interval and 1 lower interval)						
Dioxin (TCDD TEQ[a])	Upper	3/3	0.00122 - 0.00709	0.00345	1	0
	Lower	1/1	0.00067	NA	NA	NA

Notes:

a = Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Human Health Risk Assessment*, Bulletin 2, November 1995

NA = Not applicable

Table 10.8.3
Grid-Based Locations
Inorganics Detected in Soil

Element	Sample Interval	Freq. of Detections	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding RBC
Inorganics (28 samples collected: 16 upper interval and 12 lower interval, 4 samples duplicated)						
Aluminum	Upper	13/13	3,640 - 11,200	7,370	78,000	0
	Lower	12/12	3,850 - 17,500	9,130	NA	NA
Arsenic	Upper	16/16	1.7 - 30.1	7.0	0.43	2
	Lower	11/12	1.1 - 6.9	4.2	NA	NA
Barium	Upper	13/13	6.5 - 46.5	22.7	5,500	0
	Lower	12/12	5.7 - 31.0	16.5	NA	NA
Beryllium	Upper	1/13	0.32	NA	0.15	1
	Lower	0/12	NA	NA	NA	NA
Cadmium	Upper	1/13	2.8	NA	39	0
	Lower	0/12	NA	NA	NA	NA
Calcium	Upper	13/13	797 - 65,300	17,200	NA	NA
	Lower	12/12	491 - 262,000	59,100	NA	NA
Chromium	Upper	13/13	5.7 - 32.9	15.7	390	0
	Lower	12/12	6.3 - 63.4	25.2	NA	NA
Cobalt	Upper	5/13	1.6 - 4.4	2.6	4,700	0
	Lower	3/12	1.6 - 1.7	1.6	NA	NA
Copper	Upper	13/13	2.2 - 70.9	18.3	3,100	0
	Lower	12/12	1.1 - 12.9	5.2	NA	NA
Iron	Upper	13/13	1,530 - 13,700	7,230	NA	NA
	Lower	12/12	2,550 - 37,400	10,100	NA	NA

Table 10.8.3
Grid-Based Locations
Inorganics Detected in Soil

Element	Sample Interval	Freq. of Detections	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding RBC
Inorganics (28 samples collected: 16 upper interval and 12 lower interval, 4 samples duplicated)						
Lead	Upper	13/13	4.1 - 93.1	36.3	400 [a]	0
	Lower	12/12	2.4 - 25.6	8.5	400 [a]	0
Magnesium	Upper	13/13	231 - 2,630	786	NA	NA
	Lower	12/12	245 - 10,200	2,470	NA	NA
Manganese	Upper	13/13	8.7 - 66.1	35.6	1,800	0
	Lower	12/12	7.5 - 91.0	26.4	NA	NA
Mercury	Upper	4/13	0.12 - 0.30	0.22	23	0
	Lower	0/12	NA	NA	NA	NA
Nickel	Upper	11/13	3.2 - 15.4	8.3	1,600	0
	Lower	8/12	3.4 - 35.0	12.9	NA	NA
Potassium	Upper	12/13	128 - 605	292	NA	NA
	Lower	9/12	279 - 1,470	633	NA	NA
Selenium	Upper	4/13	0.70 - 1.2	0.94	390	0
	Lower	9/12	0.75 - 2.6	1.2	NA	NA
Silver	Upper	0/13	NA	NA	390	0
	Lower	1/12	1.0	NA	NA	NA
Sodium	Upper	13/13	195 - 614	288	NA	NA
	Lower	12/12	195 - 1,550	590	NA	NA
Tin	Upper	0/13	NA	NA	47,000	0
	Lower	1/12	9.2	NA	NA	NA

Table 10.8.3
Grid-Based Locations
Inorganics Detected in Soil

Element	Sample Interval	Freq. of Detections	Range of Detections (mg/kg)	Mean of Detections (mg/kg)	RBC (mg/kg)	Number of Samples Exceeding RBC
Inorganics (28 samples collected: 16 upper interval and 12 lower interval, 4 samples duplicated)						
Vanadium	Upper	13/13	4.9 - 24.3	15.9	550	0
	Lower	12/12	5.5 - 48.8	23.0	NA	NA
Zinc	Upper	13/13	4.5 - 168	76.2	23,000	0
	Lower	12/12	6.0 - 65.6	25.5	NA	NA

Semivolatile Organic Compounds in Soil

Twelve semivolatile organic compounds were detected in grid-based soil samples. Three compounds exceeded their RBCs, consisting of: benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene. Because all of the RBC exceedances were cPAH compounds, the BEQ calculation summarizes these samples. BEQs exceeded the RBC (88 μg/kg) in four surface grid-based samples: GDASB00601, GDASB00701, GDASB00901, and GDASB01301. None of the SVOCs detected in grid-based samples exceeded their SSLs.

Pesticides and PCBs in Soil

Nine pesticides were detected in the grid-based soil samples. None of the detections exceeded the RBCs. Two upper-interval samples detected pesticides above the SSLs. Alpha-BHC, beta-BHC, and delta-BHC exceeded SSLs in sample GDASB00901 and beta-BHC also exceeded its SSL in sample GDASB00501. None of the lower-interval detections exceeded SSLs in grid-based samples.

Other Organic Compounds in Soil

Fifteen dioxin compounds were detected among the three upper-interval samples; 11 were detected in the lower-interval sample. Calculations of TEQs were based on detection in an individual sample. The TEQs calculated ranged from 1.22E-03 to 7.09E-03 μg/kg in the upper interval, with a mean of 3.45E-03 μg/kg. The TEQs calculated for the lower interval sample were 6.7E-04 μg/kg. All TEQs were below the TCDD RBC of 1.0 μg/kg.

Inorganics in Soil

Twenty-two metals were detected in grid-based soil samples. An outlier analysis was performed on the dataset, which resulted in the additional sampling event to assess arsenic detected in GDASB006. That sample contained two elements, arsenic and beryllium, at concentrations above the RBCs. The only other RBC exceedance was arsenic in sample GDASB0A6, one of the extra samples collected to assess the high arsenic concentration detected in sample GDASB006.

Only two elements, arsenic and chromium, exceeded SSLs. Arsenic's SSL (15 mg/kg) was exceeded in both of the above-mentioned upper-interval samples. Chromium's SSL (19 mg/kg) was exceed in three upper- and five lower-interval samples.

10.8.3 Groundwater Sampling and Analysis

The *Final Zones A and B RFI Work Plan* proposed three shallow and three deep grid-based monitoring wells. All of these wells were installed (Figure 10.8.2). As proposed, shallow groundwater samples were analyzed for the standard suite of parameters and deep groundwater samples were collected and analyzed for TDS, chloride, and sulfate as well as the standard suite of parameters. The standard suite of parameters consists of VOCs, SVOCs, metals, cyanide, pesticides, and PCBs at DQO Level III. One sample was duplicated and submitted for Appendix IX parameters at DQO Level IV.

Second-, third-, and fourth-quarter analytical parameters for grid-based groundwater samples were based upon the first-quarter detections. Second-quarter samples were analyzed at DQO Level III for VOCs and metals. Third- and fourth-quarter samples were analyzed at DQO Level III for VOCs, metals, cyanide, hexavalent chromium, dioxin, TDS, sulfate, and chlorides. Second-, third-, and fourth-quarter groundwater samples were collected by the CEERD in April, June, and October 1996, respectively. Table 10.8.4 summarizes the grid-based groundwater sampling.

10.8.4 Nature and Extent of Chemicals Detected in Groundwater

Table 10.8.5 summarizes the organic analytical results for groundwater. Table 10.8.6 summarizes inorganic analytical results.

Volatile Organic Compounds in Groundwater

Bromodichloromethane, 2-butanone (MEK), carbon disulfide, and 1,1,1-trichloroethane were the only VOCs detected in grid-based groundwater samples. The bromodichloromethane detection (3.4 μg/L) in the first-quarter sample from monitoring well NBCA-GDA-02D exceeded its RBC (0.17 μg/L).

Semivolatile Organic Compounds in Groundwater

No SVOCs were detected in grid-based groundwater samples.

Pesticides and PCBs in Groundwater

No pesticides or PCBs were detected in grid-based groundwater samples.

Hess Oil Tank Farm

LEGEND

- Shallow Monitoring Well
- Deep Monitoring Well

Zone A RCRA Facility Investigation Report
Naval Base Charleston
Charleston, SC

FIGURE 10.8.2 - Grid-Based Groundwater Sample Locations

Table 10.8.4
Grid-Based Locations
Groundwater Sampling Summary

Event	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
December 1995 (1st round)	3 shallow 3 deep	3 shallow 3 deep	Standard Suite[a] for all samples TDS, sulfate, chloride for deep samples	Standard Suite[a] for all samples TDS, sulfate, chloride for deep samples	None
April 1996 (2nd round)	3 shallow 3 deep	3 shallow 3 deep	VOCs and metals[b]	VOCs and metals	None
June 1996 (3rd round)	3 shallow 3 deep	3 shallow 3 deep	VOCs, metals, cyanide, Cr IV, dioxin, TDS, sulfate, and chlorides.[c]	VOCs, metals, cyanide, Cr IV, dioxin, TDS, sulfate, and chlorides.	None
October 1996 (4th round)	3 shallow 3 deep	3 shallow 3 deep	VOCs, metals, cyanide, Cr IV, dioxin, TDS, sulfate, and chlorides.[c]	VOCs, metals, cyanide, Cr IV, dioxin, TDS, sulfate, and chlorides.	None

Notes:
a = Standard suite consists of VOCs, SVOCs, metals, cyanide, pesticides, and PCBs.
b = Second-round parameters based upon detections from first round.
c = Third- and fourth-round parameters.

Table 10.8.5
Grid-Based Locations
Organic Compounds Detected in Groundwater

Compound	Event	Sampling Interval	Frequency of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	RBC (μg/L)	Number of Samples Exceeding RBC
Volatile Organic Compounds (3 shallow samples and 3 deep samples collected; 1 duplicate collected for Appendix IX analysis)							
Bromodichloro-methane	Dec. 95	Shallow	0/3	NA	NA	0.17	0
	Apr. 96	Shallow	0/3	NA	NA	0.17	0
	June 96	Shallow	0/3	NA	NA	0.17	0
	Oct. 96	Shallow	0/3	NA	NA	0.17	0
	Dec. 95	Deep	1/3	3.4	NA	0.17	1
	Apr. 96	Deep	0/3	NA	NA	0.17	0
	June 96	Deep	0/3	NA	NA	0.17	0
	Oct. 96	Deep	0/3	NA	NA	0.17	0
2-Butanone (MEK)	Dec. 95	Shallow	0/3	NA	NA	1900	0
	Apr. 96	Shallow	0/3	NA	NA	1900	0
	June 96	Shallow	0/3	NA	NA	1900	0
	Oct. 96	Shallow	0/3	NA	NA	1900	0
	Dec. 95	Deep	0/3	NA	NA	1900	0
	Apr. 96	Deep	0/3	NA	NA	1900	0
	June 96	Deep	1/3	4	NA	1900	0
	Oct. 96	Deep	0/3	NA	NA	1900	0
Carbon disulfide	Dec. 95	Shallow	0/3	NA	NA	1000	0
	Apr. 96	Shallow	0/3	NA	NA	1000	0
	June 96	Shallow	1/3	1.1	NA	1000	0
	Oct. 96	Shallow	0/3	NA	NA	1000	0

Table 10.8.5
Grid-Based Locations
Organic Compounds Detected in Groundwater

Compound	Event	Sampling Interval	Frequency of Detection	Range of Detections (μg/L)	Mean of Detections (μg/L)	RBC (μg/L)	Number of Samples Exceeding RBC
Volatile Organic Compounds (3 shallow samples and 3 deep samples collected; 1 duplicate collected for Appendix IX analysis)							
Carbon disulfide (continued)	Dec. 95	Deep	2/3	2.2 - 4.3	3.3	1000	0
	Apr. 96	Deep	0/3	NA	NA	1000	0
	June 96	Deep	1/3	4.9	NA	1000	0
	Oct. 96	Deep	0/3	NA	NA	1000	0
1,1,1-trichloroethane	Dec. 95	Shallow	0/3	NA	NA	540	0
	Apr. 96	Shallow	0/3	NA	NA	540	0
	June 96	Shallow	1/3	2.1	NA	540	0
	Oct. 96	Shallow	0/3	NA	NA	540	0
	Dec. 95	Deep	0/3	NA	NA	540	0
	Apr. 96	Deep	0/3	NA	NA	540	0
	June 96	Deep	0/3	NA	NA	540	0
	Oct. 96	Deep	0/3	NA	NA	540	0
Dioxins, Furans, and Organotins (3 Shallow samples collected and 3 Deep samples collected for Dioxins during 3rd round event)							
TCDD TEQ[a]	June 96	Shallow	2/3	2.6 E-08 - 2.9 E-08	2.7 E-08	4.5E-7	0
	Oct. 96	Shallow	3/3	3.5 E-08 - 1.1 E-07	6.2 E-08	4.5E-7	0
	June 96	Deep	0/3	NA	NA	4.5E-7	0
	Oct. 96	Deep	3/3	1.2 E-08 - 1.5 E-07	6.3 E-08	4.5E-7	0

Notes:

a = Calculated from method described in USEPA *Interim Supplemental Guidance to RAGS: Human Health Risk Assessment*, Bulletin 2, November 1995.

Table 10.8.6
Grid-Based Locations
Inorganics Detected in Groundwater

Parameter	Event	Interval	Freq. of Detections	Range of Detections (μg/L)	Mean of Detections (μg/L)	RBC (μg/L)	# Exceeding RBC
Inorganics (3 shallow samples collected; 3 deep samples collected, 1 sample duplicated for Appendix IX analyses)							
Aluminum	Dec. 95	Shallow	3/3	955 - 2,840	1,610	37,000	0
	Apr. 96	Shallow	2/3	1,600 - 1,850	1,730	37,000	0
	June 96	Shallow	3/3	65.6 - 600	372	37,000	0
	Oct. 96	Shallow	1/3	5,220	NA	37,000	0
	Dec. 95	Deep	2/3	40.6 - 316	178	37,000	0
	Apr. 96	Deep	0/3	NA	NA	37,000	0
	June 96	Deep	2/3	73.2 - 114	94	37,000	0
	Oct. 96	Deep	2/3	1,180 - 1,560	1,370	37,000	0
Antimony	Dec. 95	Shallow	0/3	NA	NA	15	0
	Apr. 96	Shallow	0/3	NA	NA	15	0
	June 96	Shallow	0/3	NA	NA	15	0
	Oct. 96	Shallow	1/3	4.0	NA	15	0
	Dec. 95	Deep	0/3	NA	NA	15	0
	Apr. 96	Deep	1/3	7.1	NA	15	0
	June 96	Deep	0/3	NA	NA	15	0
	Oct. 96	Deep	0/3	NA	NA	15	0
Arsenic	Dec. 95	Shallow	1/3	68.3	NA	0.045	1
	Apr. 96	Shallow	0/3	NA	NA	0.045	0
	June 96	Shallow	2/3	4.4 - 7.4	5.9	0.045	2
	Oct. 96	Shallow	2/3	2.6 - 4.9	3.8	0.045	2

Table 10.8.6
Grid-Based Locations
Inorganics Detected in Groundwater

Parameter	Event	Interval	Freq. of Detections	Range of Detections (µg/L)	Mean of Detections (µg/L)	RBC (µg/L)	# Exceeding RBC
Inorganics (3 shallow samples collected; 3 deep samples collected, 1 sample duplicated for Appendix IX analyses)							
Arsenic (continued)	Dec. 95	Deep	1/3	4.0	NA	0.045	1
	Apr. 96	Deep	0/3	NA	NA	0.045	0
	June 96	Deep	1/3	8.0	NA	0.045	1
	Oct. 96	Deep	1/3	11.1	NA	0.045	1
Barium	Dec. 95	Shallow	3/3	21.3 - 102	52.2	2,600	0
	Apr. 96	Shallow	0/3	NA	NA	2,600	0
	June 96	Shallow	3/3	24.9 - 71.1	40.3	2,600	0
	Oct. 96	Shallow	3/3	20.8 - 98.1	64.3	2,600	0
	Dec. 95	Deep	3/3	59.9 - 156	94	2,600	0
	Apr. 96	Deep	0/3	NA	NA	2,600	0
	June 96	Deep	3/3	38.8 - 179	96	2,600	0
	Oct. 96	Deep	3/3	35.9 - 165	91.4	2,600	0
Beryllium	Dec. 95	Shallow	0/3	NA	NA	0.016	0
	Apr. 96	Shallow	0/3	NA	NA	0.016	0
	June 96	Shallow	0/3	NA	NA	0.016	0
	Oct. 96	Shallow	0/3	NA	NA	0.016	0
	Dec. 95	Deep	0/3	NA	NA	0.016	0
	Apr. 96	Deep	0/3	NA	NA	0.016	0
	June 96	Deep	0/3	NA	NA	0.016	0
	Oct. 96	Deep	1/3	3.3	NA	0.016	1

Table 10.8.6
Grid-Based Locations
Inorganics Detected in Groundwater

Parameter	Event	Interval	Freq. of Detections	Range of Detections (μg/L)	Mean of Detections (μg/L)	RBC (μg/L)	# Exceeding RBC
Inorganics (3 shallow samples collected; 3 deep samples collected, 1 sample duplicated for Appendix IX analyses)							
Cadmium	Dec. 95	Shallow	0/3	NA	NA	18	0
	Apr. 96	Shallow	0/3	NA	NA	18	0
	June 96	Shallow	0/3	NA	NA	18	0
	Oct. 96	Shallow	1/3	1.2	NA	18	0
	Dec. 95	Deep	0/3	NA	NA	18	0
	Apr. 96	Deep	0/3	NA	NA	18	0
	June 96	Deep	0/3	NA	NA	18	0
	Oct. 96	Deep	0/3	NA	NA	18	0
Calcium	Dec. 95	Shallow	3/3	43,100 - 151,000	90,500	NA	NA
	Apr. 96	Shallow	3/3	60,600 - 150,000	96,700	NA	NA
	June 96	Shallow	3/3	57,600 - 121,000	92,400	NA	NA
	Oct. 96	Shallow	3/3	49,100 - 150,000	94,800	NA	NA
	Dec. 95	Deep	3/3	78,300 - 410,000	222,000	NA	NA
	Apr. 96	Deep	3/3	74,500 - 411,000	220,000	NA	NA
	June 96	Deep	3/3	47,400 - 442,000	222,000	NA	NA
	Oct. 96	Deep	3/3	45,100 - 524,000	254,000	NA	NA
Chromium	Dec. 95	Shallow	2/3	5.0 - 6.1	5.6	180	0
	Apr. 96	Shallow	0/3	NA	NA	180	0
	June 96	Shallow	0/3	NA	NA	180	0
	Oct. 96	Shallow	2/3	7.4 - 9.6	8.5	180	0

Table 10.8.6
Grid-Based Locations
Inorganics Detected in Groundwater

Parameter	Event	Interval	Freq. of Detections	Range of Detections (µg/L)	Mean of Detections (µg/L)	RBC (µg/L)	# Exceeding RBC
Inorganics (3 shallow samples collected; 3 deep samples collected, 1 sample duplicated for Appendix IX analyses)							
Chromium (continued)	Dec. 95	Deep	1/3	7.3	NA	180	0
	Apr. 96	Deep	0/3	NA	NA	180	0
	June 96	Deep	0/3	NA	NA	180	0
	Oct. 96	Deep	3/3	1.6 - 136	NA	180	0
Chromium (hexavalent)	June 96	Shallow	0/3	NA	NA	180	0
	Oct. 96	Shallow	0/3	NA	NA	180	0
	Dec. 95	Deep	1/1	2	NA	180	0
	Apr. 96	Deep	1/1	4	NA	180	0
	June 96	Deep	0/3	NA	NA	180	0
	Oct. 96	Deep	0/3	NA	NA	180	0
Cobalt	Dec. 95	Shallow	0/3	NA	NA	2,200	0
	Apr. 96	Shallow	0/3	NA	NA	2,200	0
	June 96	Shallow	0/3	NA	NA	2,200	0
	Oct. 96	Shallow	1/3	10.3	NA	2,200	0
	Dec. 95	Deep	1/3	12.1	NA	2,200	0
	Apr. 96	Deep	1/3	16.6	NA	2,200	0
	June 96	Deep	1/3	17.9	NA	2,200	0
	Oct. 96	Deep	1/3	23.4	NA	2,200	0

Table 10.8.6
Grid-Based Locations
Inorganics Detected in Groundwater

Parameter	Event	Interval	Freq. of Detections	Range of Detections (μg/L)	Mean of Detections (μg/L)	RBC (μg/L)	# Exceeding RBC
Inorganics (3 shallow samples collected; 3 deep samples collected, 1 sample duplicated for Appendix IX analyses)							
Copper	Dec. 95	Shallow	3/3	3.4 - 10.1	7.9	1,500	0
	Apr. 96	Shallow	1/3	8.8	NA	1,500	0
	June 96	Shallow	0/3	NA	NA	1,500	0
	Oct. 96	Shallow	0/3	NA	NA	1,500	0
	Dec. 95	Deep	1/3	5.7	NA	1,500	0
	Apr. 96	Deep	2/3	7.0 - 7.6	7.3	1,500	0
	June 96	Deep	1/3	7.8	NA	1,500	0
	Oct. 96	Deep	2/3	22.5 - 445	234	1,500	0
Iron	Dec. 95	Shallow	3/3	8,230 - 72,100	34,000	NA	NA
	Apr. 96	Shallow	3/3	8,880 - 18,300	13,700	NA	NA
	June 96	Shallow	3/3	7,320 - 16,900	11,400	NA	NA
	Oct. 96	Shallow	3/3	8,390 - 14,400	10,600	NA	NA
	Dec. 95	Deep	3/3	187 - 17,450	10,000	NA	NA
	Apr. 96	Deep	2/3	7,760 - 22,600	15,200	NA	NA
	June 96	Deep	2/3	119 - 22,500	11,300	NA	NA
	Oct. 96	Deep	2/3	5,120 - 21,600	13,400	NA	NA
Lead	Dec. 95	Shallow	1/3	3.2	NA	15 [a]	0
	Apr. 96	Shallow	0/3	NA	NA	15 [a]	0
	June 96	Shallow	0/3	NA	NA	15 [a]	0
	Oct. 96	Shallow	2/3	1.8 - 3.2	2.5	15 [a]	0

Table 10.8.6
Grid-Based Locations
Inorganics Detected in Groundwater

Parameter	Event	Interval	Freq. of Detections	Range of Detections (µg/L)	Mean of Detections (µg/L)	RBC (µg/L)	# Exceeding RBC
Inorganics (3 shallow samples collected; 3 deep samples collected, 1 sample duplicated for Appendix IX analyses)							
Lead (continued)	Dec. 95	Deep	0/3	NA	NA	15 *	0
	Apr. 96	Deep	0/3	NA	NA	15 *	0
	June 96	Deep	1/3	18.5	NA	15 *	1
	Oct. 96	Deep	0/3	NA	NA	15 *	0
Magnesium	Dec. 95	Shallow	3/3	17,600 - 38,300	27,100	NA	NA
	Apr. 96	Shallow	3/3	19,000 - 91,900	49,400	NA	NA
	June 96	Shallow	3/3	25,300 - 86,200	51,000	NA	NA
	Oct. 96	Shallow	3/3	15,600 - 48,400	32,300	NA	NA
	Dec. 95	Deep	3/3	111,000 - 1,610,000	718,000	NA	NA
	Apr. 96	Deep	3/3	141,000 - 1,540,000	704,000	NA	NA
	June 96	Deep	3/3	93,200 - 1,410,000	646,000	NA	NA
	Oct. 96	Deep	3/3	96,500 - 1,590,000	724,000	NA	NA
Manganese	Dec. 95	Shallow	3/3	79.8 - 336	189	840	0
	Apr. 96	Shallow	3/3	96 - 343	199	840	0
	June 96	Shallow	3/3	94.6 - 577	269	840	0
	Oct. 96	Shallow	3/3	94 - 305	188	840	0
	Dec. 95	Deep	3/3	344 - 2,370	1,390	840	2
	Apr. 96	Deep	3/3	301 - 2,350	1,290	840	2
	June 96	Deep	3/3	204 - 2,460	1,320	840	2
	Oct. 96	Deep	3/3	183 - 2,690	1,520	840	2

Table 10.8.6
Grid-Based Locations
Inorganics Detected in Groundwater

Parameter	Event	Interval	Freq. of Detections	Range of Detections (μg/L)	Mean of Detections (μg/L)	RBC (μg/L)	# Exceeding RBC
Inorganics (3 shallow samples collected; 3 deep samples collected, 1 sample duplicated for Appendix IX analyses)							
Nickel	Dec. 95	Shallow	0/3	NA	NA	730	0
	Apr. 96	Shallow	0/3	NA	NA	730	0
	June 96	Shallow	0/3	NA	NA	730	0
	Oct. 96	Shallow	1/3	9.4	NA	730	0
	Dec. 95	Deep	1/3	17.7	NA	730	0
	Apr. 96	Deep	0/3	NA	NA	730	0
	June 96	Deep	0/3	NA	NA	730	0
	Oct. 96	Deep	1/3	79.4	NA	730	0
Potassium	Dec. 95	Shallow	3/3	4,130 - 18,400	12,300	NA	NA
	Apr. 96	Shallow	3/3	4,350 - 36,800	20,200	NA	NA
	June 96	Shallow	3/3	5,140 - 33,800	20,800	NA	NA
	Oct. 96	Shallow	3/3	18,000 - 26,800	22,800	NA	NA
	Dec. 95	Deep	3/3	26,400 - 370,000	172,000	NA	NA
	Apr. 96	Deep	3/3	36,600 - 369,000	178,000	NA	NA
	June 96	Deep	3/3	23,500 - 360,000	171,000	NA	NA
	Oct. 96	Deep	3/3	63,100 - 606,000	312,000	NA	NA
Silver	Dec. 95	Shallow	0/3	NA	NA	180	0
	Apr. 96	Shallow	0/3	NA	NA	180	0
	June 96	Shallow	0/3	NA	NA	180	0
	Oct. 96	Shallow	1/3	1.3	NA	180	0

Table 10.8.6
Grid-Based Locations
Inorganics Detected in Groundwater

Parameter	Event	Interval	Freq. of Detections	Range of Detections (μg/L)	Mean of Detections (μg/L)	RBC (μg/L)	# Exceeding RBC
Inorganics (3 shallow samples collected; 3 deep samples collected, 1 sample duplicated for Appendix IX analyses)							
Silver (continued)	Dec. 95	Deep	0/3	NA	NA	180	0
	Apr. 96	Deep	0/3	NA	NA	180	0
	June 96	Deep	1/3	9.6	NA	180	0
	Oct. 96	Deep	2/3	6.0 - 20.6	13.3	180	0
Sodium	Dec. 95	Shallow	3/3	10,600 - 215,000	95,100	NA	NA
	Apr. 96	Shallow	1/3	698,000	NA	NA	NA
	June 96	Shallow	3/3	15,500 - 651,000	246,000	NA	NA
	Oct. 96	Shallow	3/3	60,600 - 229,000	128,000	NA	NA
	Dec. 95	Deep	3/3	801,000 - 11,100,000	5,210,000	NA	NA
	Apr. 96	Deep	3/3	978,000 - 11,100,000	5,250,000	NA	NA
	June 96	Deep	3/3	672,000 - 9,970,000	4,840,000	NA	NA
	Oct. 96	Deep	3/3	642,000 - 8,970,000	4,460,000	NA	NA
Thallium	Dec. 95	Shallow	0/3	NA	NA	2.9	0
	Apr. 96	Shallow	0/3	NA	NA	2.9	0
	June 96	Shallow	0/3	NA	NA	2.9	0
	Oct. 96	Shallow	0/3	NA	NA	2.9	0
	Dec. 95	Deep	1/3	163	NA	2.9	1
	Apr. 96	Deep	1/3	23	NA	2.9	1
	June 96	Deep	1/3	17	NA	2.9	1
	Oct. 96	Deep	0/3	NA	NA	2.9	0

Table 10.8.6
Grid-Based Locations
Inorganics Detected in Groundwater

Parameter	Event	Interval	Freq. of Detections	Range of Detections (μg/L)	Mean of Detections (μg/L)	RBC (μg/L)	# Exceeding RBC
Inorganics (3 shallow samples collected; 3 deep samples collected, 1 sample duplicated for Appendix IX analyses)							
Tin	Dec. 95	Shallow	0/3	NA	NA	22,000	0
	Apr. 96	Shallow	0/3	NA	NA	22,000	0
	June 96	Shallow	0/3	NA	NA	22,000	0
	Oct. 96	Shallow	0/3	NA	NA	22,000	0
	Dec. 95	Deep	0/3	NA	NA	22,000	0
	Apr. 96	Deep	0/3	NA	NA	22,000	0
	June 96	Deep	0/3	NA	NA	22,000	0
	Oct. 96	Deep	2/3	99.8 - 111	105	22,000	0
Vanadium	Dec. 95	Shallow	1/3	4.1	NA	260	0
	Apr. 96	Shallow	1/3	7.7	NA	260	0
	June 96	Shallow	0/3	NA	NA	260	0
	Oct. 96	Shallow	3/3	1.3 - 13.6	7.7	260	0
	Dec. 95	Deep	2/3	4.4 - 9.9	7.2	260	0
	Apr. 96	Deep	0/3	NA	NA	260	0
	June 96	Deep	0/3	NA	NA	260	0
	Oct. 96	Deep	0/3	NA	NA	260	0
Zinc	Dec. 95	Shallow	3/3	7.5 - 89.0	41.6	11,000	0
	Apr. 96	Shallow	0/3	NA	NA	11,000	0
	June 96	Shallow	0/3	NA	NA	11,000	0
	Oct. 96	Shallow	0/3	NA	NA	11,000	0

Table 10.8.6
Grid-Based Locations
Inorganics Detected in Groundwater

Parameter	Event	Interval	Freq. of Detections	Range of Detections (µg/L)	Mean of Detections (µg/L)	RBC (µg/L)	# Exceeding RBC
Inorganics (3 shallow samples collected; 3 deep samples collected, 1 sample duplicated for Appendix IX analyses)							
Zinc (continued)	Dec. 95	Deep	3/3	5.6 - 86.8	33.1	11,000	0
	Apr. 96	Deep	0/3	NA	NA	11,000	0
	June 96	Deep	0/3	NA	NA	11,000	0
	Oct. 96	Deep	1/3	1,440	NA	11,000	0
TDS	Dec. 95	Deep	3/3	2,800,000 - 39,000,000	17,900,000	NA	NA
	June 96	Deep	3/3	2,300,000 - 36,000,000	16,900,000	NA	NA
	Oct. 96	Deep	3/3	2,380,000 - 194,000,000	67,600,000	NA	NA
	June 96	Shallow	3/3	90,000 - 2,700,000	1,130,000	NA	NA
	Oct. 96	Shallow	3/3	268,000 - 12,000,000	4,260,000	NA	NA
Sulfate	Dec. 95	Deep	3/3	270,000 - 355,000	302,000	NA	NA
	June 96	Deep	3/3	240,000 - 2,100,000	937,000	NA	NA
	Oct. 96	Deep	2/3	2,150,000 - 193,000,000	97,600,000	NA	NA
	June 96	Shallow	3/3	7,200 - 47,000	21,700	NA	NA
	Oct. 96	Shallow	2/3	328,000 - 590,000	459,000	NA	NA
Chloride	Dec. 95	Deep	3/3	1,300,000 - 20,000,000	9,270,000	NA	NA
	June 96	Deep	3/3	1,200,000 - 8,200,000	5,280,000	NA	NA
	Oct. 96	Deep	3/3	3,420 - 1,080,000,000	362,000,000	NA	NA
	June 96	Shallow	3/3	23,000 - 1,300,000	462,000	NA	NA
	Oct. 96	Shallow	2/3	177,000 - 6,950,000	3,560,000	NA	NA

Table 10.8.6
Grid-Based Locations
Inorganics Detected in Groundwater

Parameter	Event	Interval	Freq. of Detections	Range of Detections (μg/L)	Mean of Detections (μg/L)	RBC (μg/L)	# Exceeding RBC
Inorganics (3 shallow samples collected; 3 deep samples collected, 1 sample duplicated for Appendix IX analyses)							
Cyanide	Dec. 95	Shallow	0/3	NA	NA	730	0
	June 96	Shallow	0/3	NA	NA	730	0
	Oct. 96	Shallow	0/3	NA	NA	730	0
	Dec. 95	Deep	1/3	68	NA	730	0
	June 96	Deep	0/3	NA	NA	730	0
	Oct. 96	Deep	0/3	NA	NA	730	0

Note:
NA = Not applicable
a = Lead does not have an RBC. Therefore, the USEPA Treatment Technique Action Level (TTAL) of 15 μg/L has been substituted for the RBC.

Other Organic Compounds in Groundwater

Two dioxins compounds were detected in grid-based groundwater samples. TEQs were calculated based on detection in an individual sample. All TEQs were below the TCDD RBC of 4.5 E-07 μg/L.

Inorganics in Groundwater

Twenty-three metals were detected in grid-based groundwater samples. Five of these exceeded their respective RBCs: arsenic, beryllium, lead, manganese, and thallium.

Arsenic exceeded its RBC (0.045 μg/L) in all sample detections, consisting of: NBCA-GDA-001 first- and fourth-quarter samples, NBCA-GDA-002 third-quarter sample, NBCA-GDA-003 third- and fourth-quarter samples, and NBCA-GDA-01D first-, third-, and fourth-quarter samples.

Beryllium exceeded its RBC (0.016 μg/L) in the one sample it was detected in, the fourth-quarter sample from deep well NBCA-GDA-02D (3.3 μg/L).

Lead, which does not have an RBC or MCL, exceeded the USEPA TTAL in the third-quarter sample from well NBCA-GDA-03D.

Manganese was detected in all grid-based samples collected in Zone A. The RBC (840 μg/L) was exceeded in all four samples in two deep wells: NBCA-GDA-02D and NBCA-GDA-03D.

Thallium exceeded its RBC (2.9 μg/L) in the first-, second-, and third-quarter samples from well NBCA-GDA-03D.

10.8.5 Grid-Based Detection Summary

Because the grid-based data are not subject to fate and transport or risk assessment evaluation, the previous presentation does not include the same amount of information provided for detections in the site-specific discussions. Therefore, the locations and appropriate comparison criteria for grid-based detections are included in Tables 10.8.7 and 10.8.8 for soil and groundwater, respectively.

Table 10.8.7 Chemicals Detected in Zone A Grid-Based Soil Samples

Name	ID	Surface Conc.	Subsurface Conc.	RBC (THQ = 0.1)	Surface UTL	Subsurface UTL
Volatile Organic Compounds (ug/kg)						
Acetone	GDASB002	10	12	780000	NA	NA
	GDASB003	17	12			
	GDASB006	ND	18			
	GDASB007	ND	23			
	GDASB011	128	260			
2-butanone (MEK)	GDASB005	1.4	ND	4700000	NA	NA
	GDASB011	7.8	12			
Carbon disulfide	GDASB005	ND	2.7	780000	NA	NA
	GDASB011	1.8	19			
Toluene	GDASB003	ND	1.3	1600000	NA	NA
	GDASB012	1.7	ND			
Trichloroethene	GDASB005	2.7	2.4	58000	NA	NA
	GDASB006	2.2	ND			
	GDASB007	1.6	ND			
	GDASB008	1.9	ND			
	GDASB009	1.2	ND			
	GDASB010	2.4	ND			
	GDASB011	1.2	ND			
	GDASB013	1.9	ND			
Semivolatile Organic Compounds (ug/kg)						
BEQs	GDASB003	0.19	ND	88	NA	NA
	GDASB006	1385	ND			
	GDASB007	434	ND			
	GDASB009	429	ND			
	GDASB013	567	ND			
	GDASB014	ND	0.16			
Benzo(a)anthracene	GDASB006	660	ND	880	NA	NA
	GDASB007	280	ND			
	GDASB009	250	ND			
	GDASB013	500	ND			
Benzo(a)pyrene	GDASB006	830	ND	88	NA	NA
	GDASB007	325	ND			
	GDASB009	340	ND			
	GDASB013	450	ND			
Benzo(b)fluoranthene	GDASB006	1800	ND	880	NA	NA
	GDASB007	500	ND			
	GDASB009	390	ND			
	GDASB013	390	ND			
Benzo(g,h,i)perylene	GDASB006	650	ND	230000	NA	NA
	GDASB007	240	ND			
	GDASB009	230	ND			
	GDASB013	330	ND			
Benzo(k)fluoranthene	GDASB006	1100	ND	8800	NA	NA
	GDASB007	415	ND			
	GDASB009	390	ND			
	GDASB013	450	ND			
Bis(2-ethylhexyl)phthalate	GDASB005	290	ND	46000	NA	NA
Chrysene	GDASB003	190	ND	88000	NA	NA
	GDASB006	980	ND			
	GDASB007	360	ND			

Table 10.8.7 Chemicals Detected in Zone A Grid-Based Soil Samples

Name	ID	Surface Conc.	Subsurface Conc.	RBC (THQ = 0.1)	Surface UTL	Subsurface UTL
	GDASB009	270	ND			
	GDASB013	530	ND			
	GDASB014	ND	160			
Dibenz(a,h)anthracene	GDASB006	230	ND	88	NA	NA
Fluoranthene	GDASB006	740	ND	310000	NA	NA
	GDASB007	475	ND			
	GDASB009	250	ND			
	GDASB013	870	ND			
	GDASB014	ND	330			
Indeno(1,2,3-cd)pyrene	GDASB006	670	ND	880	NA	NA
	GDASB007	265	ND			
	GDASB009	210	ND			
	GDASB013	230	ND			
Phenanthrene	GDASB006	180	460	230000	NA	NA
	GDASB007	190	ND			
	GDASB013	400	ND			
	GDASB014	ND	200			
Pyrene	GDASB006	870	ND	230000	NA	NA
	GDASB007	525	ND			
	GDASB009	360	ND			
	GDASB013	1300	ND			
Pesticides/PCBs (ug/kg)						
roclor-1260	GDASB003	86	ND	320	NA	NA
	GDASB007	54	ND			
4,4'-DDD	GDASB003	43	ND	2700	NA	NA
	GDASB006	31	ND			
	GDASB007	5.8	ND			
	GDASB008	25	ND			
	GDASB009	20	ND			
	GDASB010	8.9	ND			
	GDASB012	62	1.4			
4,4'-DDE	GDASB001	7.8	ND	1900	NA	NA
	GDASB003	52	ND			
	GDASB006	60	ND			
	GDASB007	60	ND			
	GDASB008	70	ND			
	GDASB009	150	ND			
	GDASB010	2.4	ND			
	GDASB012	170	ND			
	GDASB014	26	ND			
4,4'-DDT	GDASB005	5.7	ND	1900	NA	NA
	GDASB006	ND	4.6			
	GDASB007	21	4.9			
	GDASB008	18	ND			
	GDASB009	70	2.7			
	GDASB011	34	ND			
	GDASB012	42	ND			
lpha-BHC	GDASB009	8.7	ND	100	NA	NA
eta-BHC	GDASB005	3.1	ND	350	NA	NA
	GDASB009	31	ND			
delta-BHC	GDASB009	4.7	ND	350	NA	NA

Table 10.8.7 Chemicals Detected in Zone A Grid-Based Soil Samples

Name	ID	Surface Conc.	Subsurface Conc.	RBC (THQ = 0.1)	Surface UTL	Subsurface UTL
alpha-Chlordane	GDASB007	1.1	ND	1800	NA	NA
	GDASB008	9.8	ND			
	GDASB009	1.6	ND			
	GDASB010	1.6	ND			
	GDASB012	71	2.1			
gamma-Chlordane	GDASB007	4.7	ND	1800	NA	NA
	GDASB008	14	ND			
	GDASB009	4.1	ND			
	GDASB010	2.1	ND			
	GDASB012	53	ND			
Heptachlor epoxide	GDASB007	1.9	ND	70	NA	NA
	GDASB008	2.2	ND			
	GDASB009	5.8	ND			
	GDASB012	27	ND			
Dioxin (ug/kg)						
TCDD TEQ a	GDASB003	NA	0.00067	1	NA	NA
	GDASB005	0.00204	NA			
	GDASB007	0.00709	NA			
	GDASB011	0.00122	NA			
Inorganics (mg/kg)						
Aluminum	GDASB001	6010	8180	7800	12800	28240
	GDASB002	3640	7750			
	GDASB003	7470	12300			
	GDASB005	10170	5780			
	GDASB006	5650	9430			
	GDASB007	5265	11000			
	GDASB008	6850	3850			
	GDASB009	7270	14200			
	GDASB010	9020	NA			
	GDASB011	11200	7570			
	GDASB012	7320	17500			
	GDASB013	7710	4630			
	GDASB014	8180	7400			
Arsenic	GDASB001	6.6	6.9	0.43	9.4	9.8
	GDASB002	1.7	1.1			
	GDASB003	4.0	3.7			
	GDASB005	5.6	5.6			
	GDASB006	30.1	3.3			
	GDASB007	7.5	4.1			
	GDASB008	3.9	1.6			
	GDASB009	4.5	6.2			
	GDASB010	3.6	NA			
	GDASB011	4.1	5.5			
	GDASB012	4.0	6.2			
	GDASB013	3.8	ND			
	GDASB014	3.2	2.4			
	GDASB0A6	15.3	NA			
	GDASB0B6	7.2	NA			
	GDASB0C6	6.4	NA			
Barium	GDASB001	19.3	16.2	550	53.0	40.0

Table 10.8.7 Chemicals Detected in Zone A Grid-Based Soil Samples

Name	ID	Surface Conc.	Subsurface Conc.	RBC (THQ = 0.1)	Surface UTL	Subsurface UTL
	GDASB002	6.5	20.2			
	GDASB003	22.4	13.5			
	GDASB005	21.9	10.9			
	GDASB006	46.5	22.6			
	GDASB007	22.4	15.4			
	GDASB008	18.5	5.7			
	GDASB009	34.2	13.0			
	GDASB010	25.3	NA			
	GDASB011	21.5	13.8			
	GDASB012	15.6	24.5			
	GDASB013	18.9	10.7			
	GDASB014	21.4	31.0			
Beryllium	GDASB006	0.32	ND	0.15	NA	NA
Cadmium	GDASB013	2.8	ND	3.9	NA	NA
Calcium	GDASB001	3360	166000	NA	NA	NA
	GDASB002	4410	1090			
	GDASB003	44400	2240			
	GDASB005	65300	262000			
	GDASB006	5160	837			
	GDASB007	24600	1010			
	GDASB008	804	3500			
	GDASB009	1390	491			
	GDASB010	9450	NA			
	GDASB011	10000	233000			
	GDASB012	49300	4580			
	GDASB013	4260	2630			
	GDASB014	797	31700			
Chromium	GDASB001	8.0	36.3	39	50.4	63.4
	GDASB002	5.7	7.4			
	GDASB003	18.5	13.2			
	GDASB005	32.9	55.4			
	GDASB006	20.0	13.3			
	GDASB007	14.3	13.8			
	GDASB008	11.5	6.3			
	GDASB009	14.8	31.8			
	GDASB010	12.9	NA			
	GDASB011	18.4	63.4			
	GDASB012	25.9	41.6			
	GDASB013	11.8	7.6			
	GDASB014	10.0	12.6			
Cobalt	GDASB003	1.7	1.6	470	4.4	1.7
	GDASB006	4.4	ND			
	GDASB007	1.6	ND			
	GDASB008	ND	1.6			
	GDASB011	3.6	ND			
	GDASB012	1.6	ND			
	GDASB014	ND	1.7			
Copper	GDASB001	6.2	8.8	310	165	33.7
	GDASB002	2.2	2.3			
	GDASB003	24.8	2.3			
	GDASB005	8.0	11.2			
	GDASB006	70.9	3.2			

Table 10.8.7 Chemicals Detected in Zone A Grid-Based Soil Samples

Name	ID	Surface Conc.	Subsurface Conc.	RBC (THQ = 0.1)	Surface UTL	Subsurface UTL
	GDASB007	40.7	2.7			
	GDASB008	30.0	1.1			
	GDASB009	17.4	2.9			
	GDASB010	4.0	NA			
	GDASB011	12.3	12.9			
	GDASB012	9.3	4.1			
	GDASB013	5.0	2.1			
	GDASB014	7.0	9.2			
Iron	GDASB001	4560	8170	NA	NA	NA
	GDASB002	1530	2610			
	GDASB003	7570	9630			
	GDASB005	6780	5180			
	GDASB006	13700	8550			
	GDASB007	6890	7810			
	GDASB008	5810	2550			
	GDASB009	8740	20900			
	GDASB010	7040	NA			
	GDASB011	12400	7180			
	GDASB012	6420	37400			
	GDASB013	5860	2560			
	GDASB014	6650	9060			
Lead	GDASB001	19.2	4.2	400	140	22
	GDASB002	4.1	4.3			
	GDASB003	57.9	7.0			
	GDASB005	14.6	2.8			
	GDASB006	93.1	12.2			
	GDASB007	69.0	8.5			
	GDASB008	51.2	2.6			
	GDASB009	67.4	13.8			
	GDASB010	14.1	NA			
	GDASB011	14.4	2.4			
	GDASB012	19.2	9.6			
	GDASB013	31.4	8.5			
	GDASB014	15.7	25.6			
Magnesium	GDASB001	231	4270	NA	NA	NA
	GDASB002	231	269			
	GDASB003	955	358			
	GDASB005	2630	10200			
	GDASB006	443	474			
	GDASB007	752	307			
	GDASB008	279	438			
	GDASB009	421	1380			
	GDASB010	628	NA			
	GDASB011	881	9520			
	GDASB012	2040	1300			
	GDASB013	442	245			
	GDASB014	288	859			
Manganese	GDASB001	26.1	30.3	180	98.1	85.5
	GDASB002	8.7	10.4			
	GDASB003	66.1	11.7			
	GDASB005	38.8	40.7			
	GDASB006	62.2	15.7			

Table 10.8.7 Chemicals Detected in Zone A Grid-Based Soil Samples

Name	ID	Surface Conc.	Subsurface Conc.	RBC (THQ = 0.1)	Surface UTL	Subsurface UTL
	GDASB007	57.2	7.5			
	GDASB008	24.5	16.5			
	GDASB009	40.1	21.7			
	GDASB010	23.7	NA			
	GDASB011	24.0	38.9			
	GDASB012	48.0	21.2			
	GDASB013	25.4	11.1			
	GDASB014	17.9	91.0			
Mercury	GDASB006	0.30	ND	2.3	0.30	NA
	GDASB007	0.26	ND			
	GDASB008	0.19	ND			
	GDASB009	0.12	ND			
Nickel	GDASB001	ND	15.1	160	13.6	35.0
	GDASB002	ND	3.4			
	GDASB003	9.6	ND			
	GDASB005	11.9	28.5			
	GDASB006	14.1	ND			
	GDASB007	7.7	ND			
	GDASB008	4.8	3.8			
	GDASB009	5.2	ND			
	GDASB010	6.8	NA			
	GDASB011	7.1	35.0			
	GDASB012	15.4	4.5			
	GDASB013	3.2	3.6			
	GDASB014	5.2	9.1			
Potassium	GDASB001	128	566	NA	NA	NA
	GDASB003	313	285			
	GDASB005	605	1100			
	GDASB006	213	279			
	GDASB007	309	291			
	GDASB008	149	ND			
	GDASB009	213	804			
	GDASB010	241	NA			
	GDASB011	403	1470			
	GDASB012	420	593			
	GDASB013	267	ND			
	GDASB014	242	312			
Selenium	GDASB001	ND	2.6	39	1.2	1.7
	GDASB003	0.70	0.83			
	GDASB005	1.2	0.95			
	GDASB006	ND	0.77			
	GDASB007	ND	1.1			
	GDASB008	ND	0.86			
	GDASB010	0.88	NA			
	GDASB011	0.97	1.3			
	GDASB012	ND	1.2			
	GDASB014	ND	0.75			
Silver	GDASB002	ND	1.0	39	NA	NA
Sodium	GDASB001	207	823	NA	NA	NA
	GDASB002	255	259			
	GDASB003	315	250			
	GDASB005	614	1550			

Table 10.8.7 Chemicals Detected in Zone A Grid-Based Soil Samples

Name	ID	Surface Conc.	Subsurface Conc.	RBC (THQ = 0.1)	Surface UTL	Subsurface UTL
	GDASB006	269	248			
	GDASB007	239	256			
	GDASB008	208	205			
	GDASB009	212	1460			
	GDASB010	261	NA			
	GDASB011	343	1220			
	GDASB012	411	259			
	GDASB013	227	195			
	GDASB014	195	353			
Tin	GDASB013	ND	9.2	4700	NA	NA
Vanadium	GDASB001	10.4	24.0	55	29.2	77.3
	GDASB002	4.9	9.3			
	GDASB003	13.5	20.0			
	GDASB005	20.2	33.4			
	GDASB006	19.7	18.6			
	GDASB007	15.7	22.9			
	GDASB008	16.5	5.6			
	GDASB009	18.9	41.4			
	GDASB010	18.2	NA			
	GDASB011	24.3	35.0			
	GDASB012	18.4	48.8			
	GDASB013	11.7	5.5			
	GDASB014	13.9	10.9			
Zinc	GDASB001	37.5	39.1	2300	208	165
	GDASB002	4.5	6.0			
	GDASB003	130	8.7			
	GDASB005	69	60.7			
	GDASB006	94.7	14.7			
	GDASB007	91.3	8.0			
	GDASB008	116	12.9			
	GDASB009	58.5	16.6			
	GDASB010	17.3	NA			
	GDASB011	29.9	65.6			
	GDASB012	50.4	15.5			
	GDASB013	168	31.3			
	GDASB014	124	27.1			

Notes:

a = Calculated from the method described in USEPA *Interim Supplemental Guidance to RAGS: Human Health Risk Assessment*, Bulletin 2, November 1995.

NA = Not applicable

ND = Not detected

For compounds detected in both the primary and duplicate sample, the concentration for both detections are averaged and listed as one detection.

For compounds detected in only one of the primary and duplicate sample, the detected concentration is listed.

Table 10.8.8 Chemicals Detected in Zone A Grid-Based Groundwater Samples

Name	Location	Qtr. 1 Conc.	Qtr. 2 Conc.	Qtr. 3 Conc.	Qtr. 4 Conc.	RBC (THQ=0.1)	UTL	MCL
Volatile Organic Compounds (ug/l)								
Bromodichloromethane	GDAGW02D	3.4	ND	ND	ND	0.17	NA	NA
2-butanone (MEK)	GDAGW03D	ND	ND	4	ND	190	NA	NA
Carbon disulfide	GDAGW003	ND	ND	1.1	ND	100	NA	NA
	GDAGW01D	2.2	ND	ND	ND			
	GDAGW03D	4.3	ND	4.9	ND			
1,1,1-trichloroethane	GDAGW001	ND	ND	2.1	ND	54	NA	200
Dioxin (ug/l)								
TCDD TEQ a	GDAGW001	NA	NA	ND	1.1E-07	4.5E-07	NA	3E-08
	GDAGW002	NA	NA	2.6E-08	4.2E-08			
	GDAGW003	NA	NA	2.9E-08	3.5E-08			
	GDAGW01D	NA	NA	ND	2.7E-08			
	GDAGW02D	NA	NA	ND	1.5E-07			
	GDAGW03D	NA	NA	ND	1.2E-08			
Inorganics (ug/l)								
Aluminum	GDAGW001	1020	ND	65.6	ND	3700	3210	NA
	GDAGW002	2840	1,600	451	5,220			
	GDAGW003	955	1,850	600	ND			
	GDAGW01D	316	ND	114	ND			
	GDAGW02D	40.6	ND	73.2	1,560			
	GDAGW03D	ND	ND	ND	1,180			
ntimony	GDAGW002	ND	ND	ND	4	1.5	NA	6
	GDAGW03D	ND	7.1	ND	ND			
Arsenic	GDAGW001	68.3	ND	ND	2.6	0.045	11.1	50
	GDAGW002	ND	ND	4.4	ND			
	GDAGW003	ND	ND	7.4	4.9			
	GDAGW01D	4.0	ND	8.0	11.1			
Barium	GDAGW001	33.3	ND	24.9	74.2	260	179	2000
	GDAGW002	102	ND	71.1	98.1			
	GDAGW003	21.3	ND	25.0	20.8			
	GDAGW01D	65.6	ND	38.8	35.9			
	GDAGW02D	156	ND	179	165			
	GDAGW03D	59.9	ND	71.5	73.3			
Beryllium	GDAGW02D	ND	ND	ND	3.3	0.016	NA	4
Cadmium	GDAGW001	ND	ND	ND	1.2	1.8	NA	5
Calcium	GDAGW001	77400	79500	98500	85400	NA	NA	NA
	GDAGW002	151000	150000	121000	150000			
	GDAGW003	43100	60600	57600	49100			
	GDAGW01D	78300	74500	47400	45100			
	GDAGW02D	179000	174000	176000	194000			
	GDAGW03D	410000	411000	442000	524000			
Chromium	GDAGW001	5.0	ND	ND	7.4	18	8.7	100
	GDAGW002	6.1	ND	ND	9.6			
	GDAGW01D	ND	ND	ND	1.6			
	GDAGW02D	7.3	ND	ND	48.9			
	GDAGW03D	ND	ND	ND	136			
Chromium (hexavalent)	GDAGW02D	2	4	ND	ND	18	NA	NA
obalt	GDAGW001	ND	ND	ND	10.3	220	12.1	NA
	GDAGW02D	12.1	16.6	17.9	23.6			
Copper	GDAGW001	10.1	8.8	ND	ND	150	15.7	1300 b

Table 10.8.8 Chemicals Detected in Zone A Grid-Based Groundwater Samples

Name	Location	Qtr. 1 Conc.	Qtr. 2 Conc.	Qtr. 3 Conc.	Qtr. 4 Conc.	RBC (THQ=0.1)	UTL	MCL
	GDAGW002	10.1	ND	ND	ND			
	GDAGW003	3.4	ND	ND	ND			
	GDAGW01D	5.7	7.6	ND	ND			
	GDAGW02D	ND	ND	7.8	22.5			
	GDAGW03D	ND	7.0	ND	445			
Iron	GDAGW001	72100	18300	7320	8960	NA	NA	NA
	GDAGW002	21800	13900	16900	14400			
	GDAGW003	8230	8880	9860	8390			
	GDAGW01D	12500	7760	7040	5120			
	GDAGW02D	17450	22600	23000	21600			
	GDAGW03D	187	ND	ND	ND			
Lead	GDAGW002	3.2	ND	ND	3.2	15 b	4.7	15 b
	GDAGW003	ND	ND	ND	1.8			
	GDAGW03D	ND	ND	18.5	ND			
Magnesium	GDAGW001	17600	19000	25300	48400	NA	NA	NA
	GDAGW002	38300	37300	41600	32900			
	GDAGW003	25300	91900	86200	15600			
	GDAGW01D	111000	141000	93200	96500			
	GDAGW02D	432000	430000	435000	485000			
	GDAGW03D	1610000	1540000	1410000	1590000			
Manganese	GDAGW001	336	343	577	305	84	2,690	NA
	GDAGW002	152	158	134	166			
	GDAGW003	79.8	96	94.6	94			
	GDAGW01D	344	301	204	183			
	GDAGW02D	2370	2350	2460	2690			
	GDAGW03D	1470	1220	1310	1700			
Nickel	GDAGW001	ND	ND	ND	9.4	73	21.1	100
	GDAGW02D	17.7	ND	ND	ND			
	GDAGW03D	ND	ND	ND	74.4			
Potassium	GDAGW001	4130	4350	5140	23600	NA	NA	NA
	GDAGW002	18400	19400	23500	26800			
	GDAGW003	14500	36800	33800	18000			
	GDAGW01D	26400	36600	23500	63100			
	GDAGW02D	120000	129000	129000	267000			
	GDAGW03D	370000	369000	360000	606000			
Silver	GDAGW001	ND	ND	ND	1.3	18	NA	NA
	GDAGW01D	ND	ND	ND	6.0			
	GDAGW02D	ND	ND	9.6	20.6			
Sodium	GDAGW001	10600	ND	15500	229000	NA	NA	NA
	GDAGW002	59700	ND	71700	60600			
	GDAGW003	215000	698000	651000	94200			
	GDAGW01D	801000	978000	672000	642000			
	GDAGW02D	3720000	3680000	3890000	3770000			
	GDAGW03D	11100000	11100000	9970000	8970000			
Thallium	GDAGW03D	163	23	17	ND	0.29	NA	2
Tin	GDAGW02D	ND	ND	ND	99.8	2200	NA	NA
	GDAGW03D	ND	ND	ND	111			
Vanadium	GDAGW001	ND	ND	ND	13.6	26	10.9	NA
	GDAGW002	4.1	ND	ND	8.1			
	GDAGW003	ND	7.7	ND	1.3			
	GDAGW02D	4.4	ND	ND	ND			
	GDAGW03D	9.9	ND	ND	ND			

Table 10.8.8 Chemicals Detected in Zone A Grid-Based Groundwater Samples

Name	Location	Qtr. 1 Conc.	Qtr. 2 Conc.	Qtr. 3 Conc.	Qtr. 4 Conc.	RBC (THQ=0.1)	UTL	MCL
Zinc	GDAGW001	89	ND	ND	ND	1100	83.2	NA
	GDAGW002	28.3	ND	ND	ND			
	GDAGW003	7.5	ND	ND	ND			
	GDAGW01D	86.5	ND	ND	ND			
	GDAGW02D	5.6	ND	ND	ND			
	GDAGW03D	6.9	ND	ND	1440			
Cyanide	GDAGW03D	0.068	ND	ND	ND	73	0.05	200
Other compounds (mg/l)								
TDS	GDAGW001	NA	NA	90	268	NA	NA	NA
	GDAGW002	NA	NA	590	12000			
	GDAGW003	NA	NA	2700	500			
	GDAGW01D	2800	NA	2300	2380			
	GDAGW02D	12000	NA	12500	642000			
	GDAGW03D	39000	NA	36000	194000			
Sulfate	GDAGW001	NA	NA	11	ND	NA	NA	NA
	GDAGW002	NA	NA	7.2	590			
	GDAGW003	NA	NA	47	328			
	GDAGW01D	270	NA	240	2150			
	GDAGW02D	355	NA	470	ND			
	GDAGW03D	280	NA	2100	193000			
Chloride	GDAGW001	NA	NA	64	ND	NA	NA	NA
	GDAGW002	NA	NA	23	6950			
	GDAGW003	NA	NA	1300	177			
	GDAGW01D	1300	NA	1200	6250			
	GDAGW02D	6500	NA	6450	3420			
	GDAGW03D	20000	NA	8200	1080000			

Notes:

a = Calculated from the method described in USEPA *Interim Supplemental Guidance to RAGS: Human Health Risk Assessment*, Bulletin 2, November 1995.

b = Treatment Technique Action Level (TTAL)

NA = Not applicable

ND = Not detected

THQ = Target Hazard Quotient

For compounds detected in both the primary and duplicate sample, the concentration for both detections are averaged and listed as one detection.

For compounds detected in only one of the primary and duplicate sample, the detected concentration is listed.

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SECTION 11

11.0 CONCLUSIONS AND RISK MANAGEMENT DECISIONS

This section will be submitted for insertion into the document at a later date following finalization of the project team's risk-management decisions with respect to several Zone A sites.

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SECTION 12

12.0 REFERENCES

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