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MCRD PARRIS ISLAND
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RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION/REMEDIAL INVESTIGATION FOR SITE 2 BORROW PIT LANDFILL AND SITE 15 DIRT ROADS VOLUME 1 OF 2 TEXT MCRD PARRIS ISLAND SC
8/7/2000
TETRA TECH NUS

ZD DOC 170

RCRA Facilities Investigation/ Remedial Investigation for Site/SWMU 2 - Borrow Pit Landfill and Site/SWMU 15 - Dirt Roads

Marine Corps Recruit Depot

Parris Island, South Carolina

Volume I - Text

Southern Division
Naval Facilities Engineering Command

Contract Number N62467-94-D-0888
Contract Task Order 0020

August 2000

ADDENDUM TO FINAL RFI/RI REPORT

A review of the data validation has indicated that two reported detections of thallium in groundwater samples are actually non-detects. Consequently, thallium was not detected in any groundwater samples collected at Site 2. The risks resulting from exposures to groundwater were recalculated for construction workers, child residents, and adult residents with thallium removed as a COPC. Attached are copies of the revised RAGS Part D tables. As previous discussed in the RI report, all cancer risks where less than or within EPA' s target risk range of 10^{-4} to 10^{-6}. The hazard index for an adult resident exposed to groundwater exceeded the acceptable level of 1.0, but the hazard quotients for the individual target organs were less than 1.0 indicating that no adverse health effects are anticipated for adult residents exposed to groundwater under the defined conditions. The hazard index for a child resident exposed to groundwater exceeded the acceptable level of 1.0 with iron being the primary contributor to the hazard index. As discussed in the RI report, the hazard index for a child exposed to iron was calculated using an reference dose based on adult nutritional requirements. The hazard index is less than 1.0 when calculated using a reference dose based on child nutritional requirements. Therefore all cancer risks and hazard indices are within acceptable levels.

TABLE 6-4

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH GROUNDWATER
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	Minimum[1] Concentration	Minimum Qualifier	Maximum[1] Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background[2] Value	Screening[3] Toxicity Value		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for[4] Contaminant Deletion or Selection
Volatile Organic Compounds																	
67-64-1	Acetone	1.8	J	3.3	J	µg/L	PAI-02-GW-04-01	2/3	5	3.3	N/A	61	N	N/A	N/A	No	BSL
75-15-0	Carbon Disulfide	4		4		µg/L	PAI-02-GW-05-01	1/5	1	4	N/A	100	N	N/A	N/A	No	BSL
67-66-3	Chloroform	2.9		2.9		µg/L	PAI2-GW2-01	1/5	1	2.9	N/A	0.15	C	80 (5)	MCL	Yes	ASL
74-87-3	Chloromethane	0.35		0.35		µg/L	PAI2-GW3-01-AVG	1/5	1	0.35	N/A	2.1	C	N/A	N/A	No	BSL
Semivolatile Organic Compounds																	
117-81-7	Bis(2-Ethylhexyl)phthalate	1	J	1	J	µg/L	PAI2-GW1-01, PAI2-GW2-01, PAI-02-GW-04-01, PAI-02-GW-05-01	4/5	5	1	N/A	4.8	C	6	MCL	No	BSL
84-66-2	Diethyl Phthalate	1	J	1	J	µg/L	PAI-02-GW-05-01	1/5	5	1	N/A	2900	N	N/A	N/A	No	BSL
Inorganics - Unfiltered																	
7429-90-5	Aluminum	189		1010		µg/L	PAI2-GW1-01	3/5	22 - 79.5	1010	N/A	3700	N	50 To 200	SMCL	No	BSL
7440-38-2	Arsenic	1		1.5		µg/L	PAI-02-GW-01-01	4/5	0.9	1.5	N/A	0.045	C	50	MCL	Yes	ASL
7440-39-3	Barium	33.7		148		µg/L	PAI2-GW3-01-AVG	5/5	N/A	148	N/A	260	N	2000	MCL	No	BSL
7440-70-2	Calcium	6370		281000		µg/L	PAI-02-GW-04-01	5/5	N/A	281000	N/A	N/A		N/A	N/A	No	NUT
7440-47-3	Chromium	5.2		5.2		µg/L	PAI2-GW3-01-AVG	1/5	6.4 - 11.9	5.2	N/A	5500	N	100	MCL	No	BSL
7440-50-8	Copper	5.2		28.8		µg/L	PAI2-GW1-01	2/5	2.6	28.8	N/A	150	N	1000	SMCL	No	BSL
7439-89-6	Iron	439		8370		µg/L	PAI-02-GW-05-01	5/5	N/A	8370	N/A	1100	N	300	SMCL	Yes	ASL
7439-96-5	Magnesium	2580		778000		µg/L	PAI-02-GW-04-01	5/5	N/A	778000	N/A	N/A		N/A	N/A	No	NUT
7439-96-5	Manganese	37		187		µg/L	PAI-02-GW-05-01	5/5	N/A	187	N/A	73	N	50	SMCL	Yes	ASL
7400-09-7	Potassium	400		245000		µg/L	PAI-02-GW-04-01	4/5	558	245000	N/A	N/A		N/A	N/A	No	NUT
7440-23-5	Sodium	18100		5990000		µg/L	PAI-02-GW-04-01	5/5	N/A	5990000	N/A	N/A		N/A	N/A	No	NUT
7440-66-6	Zinc	5.5		13.3		µg/L	PAI2-GW2-01	2/5	4.1 - 33.4	13.3	N/A	1100	N	5000	SMCL	No	BSL

Notes.

1 Minimum/maximum detected concentration.

2 Background value for inorganics is two times the mean concentration.

3 *USEPA Region III Risk-Based Concentration Table, April 13, 2000 (Cancer benchmark value = 1E-06, HI = 0.1)*

4 Rationale Codes Selection Reason: Above Screening Levels (ASL)

Deletion Reason: No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

5 Value is for total trihalomethanes.

Shading indicates that a chemical was retained as a COPC.

Definitions:
N/A = Not Applicable
SQL = Sample Quantitation Limit
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
MCL = Federal Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
J = Estimated Value
C = Carcinogenic

TABLE 6-10

CHEMICALS RETAINED AS COPCs
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Surface Soil	Subsurface Soil	Soil to Air	Soil to Groundwater	Groundwater	Sediment	Surface Water	Fish Tissue
Volatile Organic Compounds								
Chloroform					X			
Semivolatile Organic Compounds								
Bis(2-Ethylhexyl) phthalate							X	
Benzo(a)pyrene								X
Inorganics								
Arsenic					X			
Hexavalent chromium								
Iron					X			
Manganese					X			
Thallium								

Notes
X - Indicates chemical was retained as a COPC.

TABLE 6-12

EXPOSURE POINT CONCENTRATIONS
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Groundwater (µg/L)	Surface Water (µg/L)	Shellfish Tissue (mg/kg)
Volatile Organic Compounds			
Chloroform	2.9	N/A	N/A
Semivolatile Organic Compounds			
Benzo(a)pyrene Equivalents	N/A	N/A	0.0034
Bis(2-Ethylhexyl) phthalate	N/A	77	N/A
Inorganics			
Arsenic	1.5	5.9	N/A
Hexavalevent Chromium	N/A	N/A	1.6
Iron	8370	N/A	N/A
Manganese	187	N/A	N/A
Thallium	N/A	N/A	N/A

Notes
No COPCs were identified for Site 15.
N/A - Chemical is not a COPC for this medium.
The maximum detected concentration is used as the exposure point concentration since less than 10 samples were collected for each medium.

TABLE 6-24

SUMMARY OF CANCER RISKS AND HAZARD INDICES
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks >10^{-4}	Chemicals with Cancer Risks >10^{-5}	Chemicals with Cancer Risks >10^{-4}	Hazard Index	Chemicals with HI > 1
Construction Worker	Groundwater	Dermal Contact	1.7E-08	--	--	--	0.09	--
	Surface Water	Ingestion	1.2E-08	--	--	--	0.003	--
		Dermal Contact	1.8E-06	--	--	Bis(2-Ethylhexyl)phthalate	0.45	--
		Total	1.8E-06	--	--	Bis(2-Ethylhexyl)phthalate	0.45	--
		Total All Media	1.8E-06				0.54	
Adolescent Recreational User	Surface Water	Ingestion	1.1E-08	--	--	--	0.0002	--
		Dermal Contact	4.4E-06	--	--	Bis(2-Ethylhexyl)phthalate	0.11	--
		Total	4.6E-06	--	--	Bis(2-Ethylhexyl)phthalate	0.11	--
Adult Recreational User	Surface Water	Ingestion	4.2E-09	--	--	--	0.0002	--
		Dermal Contact	2.6E-06	--	--	Bis(2-Ethylhexyl)phthalate	0.11	--
		Total	2.6E-06	--	--	Bis(2-Ethylhexyl)phthalate	0.11	--
	Shellfish	Ingestion	1.4E-06	--	--	cPAHs	0.07	--
		Total All Media	4.0E-06				0.18	
Child Resident	Surface Water	Ingestion	9.9E-08	--	--	--	0.004	--
		Dermal Contact	4.3E-06	--	--	Bis(2-Ethylhexyl)phthalate	0.17	--
		Total	4.3E-06	--	--	Bis(2-Ethylhexyl)phthalate	0.18	--
	Groundwater	Ingestion	1.2E-05	--	Arsenic	--	2.7	Iron
		Dermal Contact	5.0E-08	--	--	--	0.05	
		Inhalation	9.7E-08	--	--		0.02	--
		Total	1.3E-05	--	Arsenic		2.8	Iron
		Total All Media	1.7E-05				3.0	
Adult Resident	Surface Water	Ingestion	1.7E-08	--		--	0.0002	--
		Dermal Contact	1.0E-05	--	Bis(2-Ethylhexyl)phthalate		0.11	--
		Total	1.0E-05	--	Bis(2-Ethylhexyl)phthalate		0.11	--
	Groundwater	Ingestion	2.1E-05	--	Arsenic	--	1.2	--
		Dermal Contact	1.2E-07	--	--	--	0.03	--
		Inhalation	1.7E-07	--	--	--	0.01	--
		Total	2.2E-05	--	Arsenic	--	1.2	--
		Total All Media	3.2E-05				1.3	
Lifelong Resident	Surface Water	Ingestion	1.2E-07	--		--	NA	--
		Dermal Contact	1.4E-05	--	Bis(2-Ethylhexyl)phthalate		NA	--
		Total	1.4E-05	--	Bis(2-Ethylhexyl)phthalate		NA	--
	Groundwater	Ingestion	3.4E-05	--	Arsenic	--	NA	--
		Dermal Contact	1.7E-07	--	--	--	NA	
		Inhalation	2.6E-07	--	--	--	NA	--
		Total	3.4E-05	--	Arsenic	--	NA	--
		Total All Media	4.9E-05				NA	

TABLE 2.9

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Site 2 - Borrow Pit Landfill

CAS Number	Chemical	Minimum (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
	Volatile Organic Compounds																
67-64-1	Acetone	1.8	J	3.3	J	ug/L	PAI-02-GW-04-01	2/3	5	3.3	N/A	370	N	N/A	N/A	No	BSL
75-15-0	Carbon Disulfide	4		4		ug/L	PAI-02-GW-05-01	1/5	1	4	N/A	100	N	N/A	N/A	No	BSL
67-66-3	Chloroform	2.9		2.9		ug/L	PAI-02-GW-02-01	1/5	1	2.9	N/A	0.15	C	80 (5)	MCL	Yes	ASL
74-87-3	Chloromethane	0.35		0.35		ug/L	PAI-02-GW-03-01-AVG	1/5	1	0.35	N/A	1.5	C	N/A	N/A	No	BSL
	Semivolatile Organic Compounds																
117-81-7	Bis(2-Ethylhexyl)phthalate	1	J	1	J	ug/L	PAI-02-GW-01-01, PAI-02-GW-02-01, PAI-02-GW-04-01, PAI-02-GW-05-01	3/5	5	1	N/A	4.8	C	6	MCL	No	BSL
84-66-2	Diethyl Phthalate	1	J	1	J	ug/L	PAI-02-GW-05-01	1/5	5	1	N/A	2900	N	N/A	N/A	No	BSL
	Inorganics - Unfiltered																
7429-90-5	Aluminum	189		1010		ug/L	PAI-02-GW-01-01	3/5	22 - 79.5	1010	N/A	3700	N	50 To 200	SMCL	No	BSL
7440-38-2	Arsenic	1.1		1.5		ug/L	PAI-02-GW-01-01	4/5	0.9	1.5	N/A	0.045	C	50	MCL	Yes	ASL
7440-39-3	Barium	33.7		148		ug/L	PAI-02-GW-03-01-AVG	5/5	N/A	148	N/A	260	N	2000	MCL	No	BSL
7440-70-2	Calcium	6370		114000		ug/L	PAI-02-GW-03-01-AVG	5/5	N/A	114000	N/A	N/A		N/A	N/A	No	NUT
7440-47-3	Chromium	5.2		5.2		ug/L	PAI-02-GW-03-01-AVG	1/5	6.4 - 11.9	5.2	N/A	5500	N	100	MCL	No	BSL
7440-50-8	Copper	5.2		28.8		ug/L	PAI-02-GW-01-01	2/5	2.6	28.8	N/A	150	N	1000	SMCL	No	BSL
7439-89-6	Iron	439		8370		ug/L	PAI-02-GW-05-01	5/5	N/A	8370	N/A	1100	N	300	SMCL	Yes	ASL
7439-96-5	Magnesium	2580		778000		ug/L	PAI-02-GW-04-01	5/5	N/A	778000	N/A	N/A		N/A	N/A	No	NUT
7439-96-5	Manganese	37		187		ug/L	PAI-02-GW-05-01	5/5	N/A	187	N/A	73	N	50	SMCL	Yes	ASL
7440-09-7	Potassium	400		245000		ug/L	PAI-02-GW-04-01	4/5	558	245000	N/A	N/A		N/A	N/A	No	NUT
7440-23-5	Sodium	18100		5990000		ug/L	PAI-02-GW-04-01	5/5	N/A	5990000	N/A	N/A		N/A	N/A	No	NUT
7440-66-6	Zinc	5.5		13.3		ug/L	PAI-02-GW-02-01	2/4	4.1 - 33.4	13.3	N/A	1100	N	5000	SMCL	No	BSL

Notes:

(1) Minimum/maximum detected concentration.

(2) Background value for inorganics is two times the mean concentration.

(3) USEPA Region III Risk-Based Concentration Table, April 13, 2000. (Cancer benchmark value = 1E-06, HI = 0.1)

(4) Rationale Codes Selection Reason: Above Screening Levels (ASL)
Deletion Reason: No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

(5) Value is for total trihalomethanes.

Shading indicates chemical was retained as a COPC.

Definitions:
N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
MCL = Federal Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic

TABLE 3.1

MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY

MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Site 2 - Borrow Pit Landfill

Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL of Normal	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure			Central Tendency		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale	Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
Chloroform	ug/L	2.9	(1)	2.9		ug/L	2.9	Max	(1)	N/A	N/A	N/A
Arsenic	ug/L	1.32	(1)	1.5		ug/L	1.5	Max	(1)	N/A	N/A	N/A
Iron	ug/L	3750	(1)	8370		ug/L	8370	Max	(1)	N/A	N/A	N/A
Manganese	ug/L	120	(1)	187		ug/L	187	Max	(1)	N/A	N/A	N/A

Notes:

(1) - Not enough samples to calculate an UCL or to perform the Shapiro-Wilk W Test.

TABLE 7.1
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Site 2 - Borrow Pit Landfill
Receptor Population: Construction Workers
Receptor Age: Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Dermal	Chloroform	2.9	ug/L	2.9	ug/L	M	4.3E-06	mg/kg/day	2.0E-03	mg/kg/day	N/A	N/A	2.1E-03
	Arsenic	1.5	ug/L	1.5	ug/L	M	2.9E-07	mg/kg/day	1.2E-04	mg/kg/day	N/A	N/A	2.4E-03
	Iron	8370	ug/L	8370	ug/L	M	1.6E-03	mg/kg/day	4.5E-02	mg/kg/day	N/A	N/A	3.6E-02
	Manganese	187	ug/L	187	ug/L	M	3.6E-05	mg/kg/day	8.0E-04	mg/kg/day	N/A	N/A	4.6E-02
	(Total)												8.6E-02
												Total Hazard Index Across All Exposure Routes/Pathways	8.6E-02

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Specify if subchronic.

TABLE 7.6
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Site 2 - Borrow Pit Landfill
Receptor Population: Child Resident
Receptor Age: Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	Chloroform	2.9	ug/L	2.9	ug/L	M	1.9E-04	mg/kg/day	1.0E-02	mg/kg/day	N/A	N/A	1.9E-02
	Arsenic	1.5	ug/L	1.5	ug/L	M	9.6E-05	mg/kg/day	3.0E-04	mg/kg/day	N/A	N/A	3.2E-01
	Iron	8370	ug/L	8370	ug/L	M	5.4E-01	mg/kg/day	3.0E-01	mg/kg/day	N/A	N/A	1.8E+00
	Manganese	187	ug/L	187	ug/L	M	1.2E-02	mg/kg/day	2.0E-02	mg/kg/day	N/A	N/A	6.0E-01
													2.7E+00
Dermal	Chloroform	2.9	ug/L	2.9	ug/L	M	1.9E-04	mg/kg/day	1.0E-02	mg/kg/day	N/A	N/A	1.9E-02
	Arsenic	1.5	ug/L	1.5	ug/L	M	1.6E-07	mg/kg/day	1.2E-04	mg/kg/day	N/A	N/A	1.3E-03
	Iron	8370	ug/L	8370	ug/L	M	8.8E-04	mg/kg/day	4.5E-02	mg/kg/day	N/A	N/A	2.0E-02
	Manganese	187	ug/L	187	ug/L	M	2.0E-05	mg/kg/day	8.0E-04	mg/kg/day	N/A	N/A	2.5E-02
	(Total)												6.4E-02
												Total Hazard Index Across All Exposure Routes/Pathways	2.8E+00

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Specify if subchronic.

TABLE 7.8
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Site 2 - Borrow Pit Landfill
Receptor Population: Adult Resident
Receptor Age: Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	Chloroform	2.9	ug/L	2.9	ug/L	M	7.9E-05	mg/kg/day	1.0E-02	mg/kg/day	N/A	N/A	7.9E-03
	Arsenic	1.5	ug/L	1.5	ug/L	M	4.1E-05	mg/kg/day	3.0E-04	mg/kg/day	N/A	N/A	1.4E-01
	Iron	8370	ug/L	8370	ug/L	M	2.3E-01	mg/kg/day	3.0E-01	mg/kg/day	N/A	N/A	7.6E-01
	Manganese	187	ug/L	187	ug/L	M	5.1E-03	mg/kg/day	2.0E-02	mg/kg/day	N/A	N/A	2.6E-01
													1.2E+00
Dermal	Chloroform	2.9	ug/L	2.9	ug/L	M	7.9E-05	mg/kg/day	1.0E-02	mg/kg/day	N/A	N/A	7.9E-03
	Arsenic	1.5	ug/L	1.5	ug/L	M	9.2E-08	mg/kg/day	1.2E-04	mg/kg/day	N/A	N/A	7.5E-04
	Iron	8370	ug/L	8370	ug/L	M	5.2E-04	mg/kg/day	4.5E-02	mg/kg/day	N/A	N/A	1.1E-02
	Manganese	187	ug/L	187	ug/L	M	1.2E-05	mg/kg/day	8.0E-04	mg/kg/day	N/A	N/A	1.4E-02
	(Total)												3.5E-02
												Total Hazard Index Across All Exposure Routes/Pathways	1.2E+00

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Specify if subchronic.

TABLE 8.1
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Site 2 - Borrow Pit Landfill
Receptor Population: Construction Workers
Receptor Age: Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Dermal	Chloroform	2.9	ug/L	2.9	ug/L	M	6.1E-08	mg/kg/day	3.1E-02	(mg/kg/day) $^{-1}$	1.9E-09
	Arsenic	1.5	ug/L	1.5	ug/L	M	4.2E-09	mg/kg/day	3.7E+00	(mg/kg/day) $^{-1}$	1.5E-08
	Iron	8370	ug/L	8370	ug/L	M	2.3E-05	mg/kg/day	NA	(mg/kg/day) $^{-1}$	- -
	Manganese	187	ug/L	187	ug/L	M	5.2E-07	mg/kg/day	NA	(mg/kg/day) $^{-1}$	- -
	(Total)										1.7E-08
										Total Risk Across All Exposure Routes/Pathways	1.7E-08

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

TABLE 8.6
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Site 2 - Borrow Pit Landfill
Receptor Population: Child Resident
Receptor Age: Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Chloroform	2.9	ug/L	2.9	ug/L	M	1.6E-05	mg/kg/day	6.1E-03	(mg/kg/day) $^{-1}$	9.7E-08
	Arsenic	1.5	ug/L	1.5	ug/L	M	8.2E-06	mg/kg/day	1.5E+00	(mg/kg/day) $^{-1}$	1.2E-05
	Iron	8370	ug/L	8370	ug/L	M	4.6E-02	mg/kg/day	NA	(mg/kg/day) $^{-1}$	- -
	Manganese	187	ug/L	187	ug/L	M	1.0E-03	mg/kg/day	NA	(mg/kg/day) $^{-1}$	- -
											1.2E-05
Dermal	Chloroform	2.9	ug/L	2.9	ug/L	M	1.6E-05	mg/kg/day	6.1E-03	(mg/kg/day) $^{-1}$	9.7E-08
	Arsenic	1.5	ug/L	1.5	ug/L	M	1.4E-08	mg/kg/day	3.7E+00	(mg/kg/day) $^{-1}$	5.0E-08
	Iron	8370	ug/L	8370	ug/L	M	7.6E-05	mg/kg/day	NA	(mg/kg/day) $^{-1}$	- -
	Manganese	187	ug/L	187	ug/L	M	1.7E-06	mg/kg/day	NA	(mg/kg/day) $^{-1}$	- -
	(Total)										1.5E-07
										Total Risk Across All Exposure Routes/Pathways	1.3E-05

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

TABLE 8.8
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Site 2 - Borrow Pit Landfill
Receptor Population: Adult Resident
Receptor Age: Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Chloroform	2.9	ug/L	2.9	ug/L	M	2.7E-05	mg/kg/day	6.1E-03	(mg/kg/day) $^{-1}$	1.7E-07
	Arsenic	1.5	ug/L	1.5	ug/L	M	1.4E-05	mg/kg/day	1.5E+00	(mg/kg/day) $^{-1}$	2.1E-05
	Iron	8370	ug/L	8370	ug/L	M	7.9E-02	mg/kg/day	NA	(mg/kg/day) $^{-1}$	- -
	Manganese	187	ug/L	187	ug/L	M	1.8E-03	mg/kg/day	NA	(mg/kg/day) $^{-1}$	- -
											2.1E-05
Dermal	Chloroform	2.9	ug/L	2.9	ug/L	M	2.7E-05	mg/kg/day	6.1E-03	(mg/kg/day) $^{-1}$	1.7E-07
	Arsenic	1.5	ug/L	1.5	ug/L	M	3.2E-08	mg/kg/day	3.7E+00	(mg/kg/day) $^{-1}$	1.2E-07
	Iron	8370	ug/L	8370	ug/L	M	1.8E-04	mg/kg/day	NA	(mg/kg/day) $^{-1}$	- -
	Manganese	187	ug/L	187	ug/L	M	4.0E-06	mg/kg/day	NA	(mg/kg/day) $^{-1}$	- -
	(Total)										2.8E-07
										Total Risk Across All Exposure Routes/Pathways	2.2E-05

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

TABLE 9.1
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Future
Receptor Population: Construction Workers
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 2 - Borrow Pit Landfill	Chloroform	- -	- -	1.9E-09	1.9E-09	Chloroform	Liver	- -	- -	2.1E-03	2.1E-03
			Arsenic	- -	- -	1.5E-08	1.5E-08	Arsenic	Skin	- -	- -	2.4E-03	2.4E-03
			Iron	- -	- -	- -	- -	Iron	Liver	- -	- -	3.6E-02	3.6E-02
			Manganese	- -	- -	- -	- -	Manganese	CNS	- -	- -	4.6E-02	4.6E-02
			(Total)	- -	- -	1.7E-08	1.7E-08	(Total)		- -	- -	8.6E-02	8.6E-02
Surface Water	Surface Water	Site 2 - Borrow Pit Landfill	Bis(2-ethylhexyl)phthalate	1.2E-08	- -	1.8E-06	1.8E-06	Bis(2-ethylhexyl)phthalate	Liver	3.0E-03	- -	4.5E-01	4.5E-01
			(Total)	1.2E-08	- -	1.8E-06	1.8E-06	(Total)		3.0E-03	- -	4.5E-01	4.5E-01

Total Risk Across Groundwater	1.7E-08
Total Risk Across Surface Water	1.8E-06
Total Risk Across All Media and All Exposure Routes	1.8E-06

Total Hazard Index Across All Media and All Exposure Routes	5.4E-01
Total Skin HI	2.4E-03
Total Liver HI	4.9E-01
Total CNS HI	4.6E-02

TABLE 9.4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Receptor Population: Child Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 2 - Borrow Pit Landfill	Chloroform	9.7E-08	9.7E-08	- -	1.9E-07	Chloroform	Liver	1.9E-02	1.9E-02	- -	3.7E-02
			Arsenic	1.2E-05	- -	5.0E-08	1.2E-05	Arsenic	Skin	3.2E-01	- -	1.3E-03	3.2E-01
			Iron	- -	- -	- -	- -	Iron	Liver	1.8E+00	- -	2.0E-02	1.8E+00
			Manganese	- -	- -	- -	- -	Manganese	CNS	6.0E-01	- -	2.5E-02	6.2E-01
			(Total)	1.2E-05	9.7E-08	5.0E-08	1.3E-05	(Total)		2.7E+00	1.9E-02	4.6E-02	2.8E+00
Surface Water	Surface Water	Site 2 - Borrow Pit Landfill	Bis(2-ethylhexyl)phthalate	9.9E-08	- -	4.2E-06	4.3E-06	Bis(2-ethylhexyl)phthalate	Liver	4.1E-03	- -	1.7E-01	1.8E-01
			(Total)	9.9E-08	- -	4.2E-06	4.3E-06	(Total)		4.1E-03	- -	1.7E-01	1.8E-01

Total Risk Across Groundwater	1.3E-05
Total Risk Across Surface Water	4.3E-06
Total Risk Across All Media and All Exposure Routes	1.7E-05

Total Hazard Index Across All Media and All Exposure Routes	3.0E+00

Total Skin HI	3.2E-01
Total Liver HI	2.0E+00
Total CNS HI	6.2E-01

TABLE 9.5
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Receptor Population: Adult Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 2 - Borrow Pit Landfill	Chloroform	1.7E-07	1.7E-07	- -	3.3E-07	Chloroform	Liver	7.9E-03	7.9E-03	- -	1.6E-02
			Arsenic	2.1E-05	- -	1.2E-07	2.1E-05	Arsenic	Skin	1.4E-01	- -	7.5E-04	1.4E-01
			Iron	- -	- -	- -	- -	Iron	Liver	7.6E-01	- -	1.1E-02	7.8E-01
			Manganese	- -	- -	- -	- -	Manganese	CNS	2.6E-01	- -	1.4E-02	2.7E-01
			(Total)	2.1E-05	1.7E-07	1.2E-07	2.2E-05	(Total)		1.2E+00	7.9E-03	2.7E-02	1.2E+00
Surface Water	Surface Water	Site 2 - Borrow Pit Landfill	Bis(2-ethylhexyl)phthalate	1.7E-08	- -	1.0E-05	1.0E-05	Bis(2-ethylhexyl)phthalate	Liver	1.8E-04	- -	1.1E-01	1.1E-01
			(Total)	1.7E-08	- -	1.0E-05	1.0E-05	(Total)		1.8E-04	- -	1.1E-01	1.1E-01

Total Risk Across Groundwater	2.2E-05
Total Risk Across Surface Water	1.0E-05
Total Risk Across All Media and All Exposure Routes	3.2E-05

Total Hazard Index Across All Media and All Exposure Routes	1.3E+00

Total Skin HI	1.4E-01
Total Liver HI	1.2E-01
Total CNS HI	2.7E-01

TABLE 9.6
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Receptor Population: Lifetime Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 2 - Borrow Pit Landfill	Chloroform	2.6E-07	2.6E-07	- -	5.3E-07	Chloroform	Liver	- -	- -	- -	- -
			Arsenic	3.3E-05	- -	1.7E-07	3.4E-05	Arsenic	Skin	- -	- -	- -	- -
			Iron	- -	- -	- -	- -	Iron	Liver	- -	- -	- -	- -
			Manganese	- -	- -	- -	- -	Manganese	CNS	- -	- -	- -	- -
			(Total)	3.4E-05	2.6E-07	1.7E-07	3.4E-05	(Total)		- -	- -	- -	- -
Surface Water	Surface Water	Site 2 - Borrow Pit Landfill	Bis(2-ethylhexyl)phthalate	1.2E-07	- -	1.4E-05	1.4E-05	Bis(2-ethylhexyl)phthalate	Liver	- -	- -	- -	- -
			(Total)	1.2E-07	- -	1.4E-05	1.4E-05	(Total)		- -	- -	- -	- -
						Total Risk Across Groundwater	3.4E-05	Total Hazard Index Across All Media and All Exposure Routes					- -
						Total Risk Across Surface Water	1.4E-05						
						Total Risk Across All Media and All Exposure Routes	4.9E-05						

TABLE 10.1
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Future
Receptor Population: Construction Workers
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 2 - Borrow Pit Landfill	Chloroform	- -	- -	1.9E-09	1.9E-09	Chloroform	Liver	- -	- -	2.1E-03	2.1E-03
			Arsenic	- -	- -	1.5E-08	1.5E-08	Arsenic	Skin	- -	- -	2.4E-03	2.4E-03
			Iron	- -	- -	- -	- -	Iron	Liver	- -	- -	3.6E-02	3.6E-02
			Manganese	- -	- -	- -	- -	Manganese	CNS	- -	- -	4.6E-02	4.6E-02
			(Total)	- -	- -	1.7E-08	1.7E-08	(Total)		- -	- -	8.6E-02	8.6E-02
Surface Water	Surface Water	Site 2 - Borrow Pit Landfill	Bis(2-ethylhexyl)phthalate	1.2E-08	- -	1.8E-06	1.8E-06	Bis(2-ethylhexyl)phthalate	Liver	3.0E-03	- -	4.5E-01	4.5E-01
			(Total)	1.2E-08	- -	1.8E-06	1.8E-06	(Total)		3.0E-03	- -	4.5E-01	4.5E-01

Total Risk Across Groundwater	1.7E-08
Total Risk Across Surface Water	1.8E-06
Total Risk Across All Media and All Exposure Routes	1.8E-06

Total Hazard Index Across All Media and All Exposure Routes	5.4E-01

Total Skin HI	2.4E-03
Total Liver HI	4.9E-01
Total CNS HI	4.6E-02

TABLE 10.4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Receptor Population: Child Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 2 - Borrow Pit Landfill	Arsenic	1.2E-05	- -	5.0E-08	1.2E-05	Arsenic	Skin	3.2E-01	- -	1.3E-03	3.2E-01
			Iron	- -	- -	- -	- -	*Iron*	Liver	*1.8E+00*	- -	*2.0E-02*	*1.8E+00*
			(Total)	1.2E-05	- -	5.0E-08	1.2E-05	(Total)		2.1E+00	- -	2.1E-02	2.1E+00
Surface Water	Surface Water	Site 2 - Borrow Pit Landfill	Bis(2-ethylhexyl)phthalate	9.9E-08	- -	4.2E-06	4.3E-06	Bis(2-ethylhexyl)phthalate	Liver	4.1E-03	- -	1.7E-01	1.8E-01
			(Total)	9.9E-08	- -	4.2E-06	4.3E-06	(Total)		4.1E-03	- -	1.7E-01	1.8E-01
						Total Risk Across Groundwater	1.2E-05					Total Hazard Index Across All Media and All Exposure Routes	2.3E+00
						Total Risk Across Surface Water	4.3E-06						
						Total Risk Across All Media and All Exposure Routes	1.7E-05						

Total Skin HI	3.2E-01
Total Liver HI	#REF!
Total Blood HI	#REF!

TABLE 10.5
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Receptor Population: Adult Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 2 - Borrow Pit Landfill	Arsenic	2.1E-05	- -	1.2E-07	2.1E-05
			(Total)	2.1E-05	- -	1.2E-07	2.1E-05
Surface Water	Surface Water	Site 2 - Borrow Pit Landfill	Bis(2-ethylhexyl)phthalate	1.7E-08	- -	1.0E-05	1.0E-05
			(Total)	1.7E-08	- -	1.0E-05	1.0E-05
						Total Risk Across Groundwater	2.1E-05
						Total Risk Across Surface Water	1.0E-05
						Total Risk Across All Media and All Exposure Routes	3.1E-05

Chemical	Non-Carcinogenic Hazard Quotient				
	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Arsenic	Skin	1.4E-01	- -	7.5E-04	1.4E-01
(Total)		1.4E-01	- -	7.5E-04	1.4E-01
Bis(2-ethylhexyl)phthalate	Liver	1.8E-04	- -	1.1E-01	1.1E-01
(Total)		1.8E-04	- -	1.1E-01	1.1E-01
				Total Hazard Index Across All Media and All Exposure Routes	2.4E-01
				Total Skin HI	1.4E-01
				Total Liver HI	1.1E-01

TABLE 10.6
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Receptor Population: Lifetime Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 2 - Borrow Pit Landfill	Arsenic	3.3E-05	--	1.7E-07	3.4E-05	Arsenic	Skin	--	--	--	--
			Iron	--	--	--	--	*Iron*	Liver	--	--	--	--
			(Total)	3.3E-05	--	1.7E-07	3.4E-05	(Total)		--	--	--	--
Surface Water	Surface Water	Site 2 - Borrow Pit Landfill	Bis(2-ethylhexyl)phthalate	1.2E-07	--	1.4E-05	1.4E-05	Bis(2-ethylhexyl)phthalate	Liver	--	--	--	--
			(Total)	1.2E-07	--	1.4E-05	1.4E-05	(Total)		--	--	--	--

Total Risk Across Groundwater	3.4E-05
Total Risk Across Surface Water	1.4E-05
Total Risk Across All Media and All Exposure Routes	4.8E-05
Total Hazard Index Across All Media and All Exposure Routes	--

PARRIS ISLAND

SITE 02

UNFILTERED GROUNDWATER DATA - ANALYTICAL DATABASE

SAMPLE NUMBER: COLLECTION DATE: LOCATION:	PAI-02-GW-001-01 08/07/98 PAI-02-GW-001	PAI-02-GW-002-01 08/24/98 9 PAI-02-GW-002 cind 09/15/98	PAI-02-GW-003-01 08/07/98 PAI-02-MW-03	PAI-02-GW-003-01D 08/07/98 PAI-02-MW-03	PAI-02-GW-004-01 08/20/98 PAI-02-GW-004	PAI-02-GW-005-01 08/19/98 PAI-02-GW-005	/ /
INORGANICS (µg/L)							
IRON	1290	780	4270	4850	439	8370	
LEAD	1.1 U	5.5 U	1.1 U	1.1 U	5.5 U	5.5 U	
MAGNESIUM	4030	2580	190000	215000	778000	31800	
MANGANESE	148	37.0	104	108	100	187	
MERCURY	0.1 U	0.20 U	0.1 U	0.1 U	0.20 U	0.20 U	
NICKEL	9.2 U	4.4 U	4.4 U	4.4 U	4.4 U	4.4 U	
POTASSIUM	558 U	400	45400	50000	245000	6470	
SELENIUM	0.7 U	3.5 U	0.7 U	0.7 U	3.5 U	3.5 U	
SILVER	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U	
SODIUM	25500	18100	1430000	1580000	5990000	142000	
THALLIUM	1.8 U	18.0 U	1.8 U	1.8 U	18.0 U	18.0 U	
TIN		1000 UJ				1000 UJ	
VANADIUM	2.6 U	2.7 U	7.3 U	6.3 U	6.7 U	3.2 U	
ZINC	33.4 U	13.3	13.5 U	14 U	4.1 U	5.5	
MISCELLANEOUS PARAMETERS (mg/L)							
CHLORIDE	50	36.0	3200	3100	12000	500	
FLUORIDE	0.4	0.30	20	20	26.0	0.60	
HARDNESS as CaCO3	48	30.0	1400	1200	4200	500	
HEXAVALENT CHROMIUM		0.005 UJ			0.005 U	0.005 U	
NITRATE/NITRITE, AS N	0.02	6.8 J	0.05 U	0.05 U	0.02 U	0.01 U	
SULFATE	25	13.0	430	410	1500	5.0	
TOTAL DISSOLVED SOLIDS	130	110	5900	5900	23000	1300	
TOTAL ORGANIC CARBON	1	1.8	4.4	4.2	8.1	1.0 U	
TOTAL SUSPENDED SOLIDS	12	2.0	21	16	59.0	9.0	

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Rev. 1
8/7/00

RCRA FACILITIES INVESTIGATION/ REMEDIAL INVESTIGATION FOR SITE/SWMU 2 - BORROW PIT LANDFILL and SITE/SWMU 15 - DIRT ROADS

MARINE CORPS RECRUIT DEPOT PARRIS ISLAND, SOUTH CAROLINA

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, South Carolina 29406

Submitted by:
Tetra Tech, NUS, Inc.
661 Andersen Drive
Foster Plaza 7
Pittsburgh, Pennsylvania 15220

CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0020

AUGUST 2000

PREPARED UNDER THE SUPERVISION OF:

DAVID D. BRAYACK, P.E.
TASK ORDER MANAGER
TETRA TECH NUS, INC.
PITTSBURGH, PENNSYLVANIA

APPROVED FOR SUBMITTAL BY:

DEBBIE WROBLEWSKI
PROGRAM MANAGER
TETRA TECH NUS, INC.
PITTSBURGH, PENNSYLVANIA

The geologic work described and professional opinions rendered in the RFI/RI Report for Site/SWMU 2 – Borrow Pit Landfill and Site/SWMU 15 – Dirt Roads, Marine Corps Recruit Depot, South Carolina, were developed in accordance with commonly accepted procedures consistent with applicable standards of practice.

Gary L. Gunter
South Carolina
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ACRONYM LIST

ABB-ES	ABB Environmental Services
AOC	Area of Concern
AVS	Acid Volatile Solids
AWQC	Ambient Water Quality Criteria
ASTDR	Agency for Toxic Substances and Disease Registry
B&R Environmental	Brown & Root Environmental
BAF	Bioaccumulation Factors
BCF	Bioconcentration Factor
BEHP	bis(2-ethylhexyl)phthalate
BSAF	Biota Sediment Accumulation Factor
bgs	below ground surface
CAMP	Corrective Action Management Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
cm/s	centimeters per second
CMS	Corrective Measures Study
COC	Chemical of Concern
COE	U.S. Army Corps of Engineers
COPC	Chemical of Potential Concern
CSF	Cancer Slope Factor
CTO	Contract Task Order
CWA	Clean Water Act
DEHP	diethylexyl phthalate
DQO	Data Quality Objective
ERA	Ecological Risk Assessment
ER-L	Effects Range Low
ER-M	Effects Range Medium
ERT	Environmental Response Team
ESI	Extended Site Inspection
F	Filtered
FDEP	Florida Department of Environmental Protection
FEMA	Federal Emergency Management Agency
gpd/ft	gallons per day per foot
gpm	gallons per minute

GW	Groundwater
HEAST	Health Effects Assessment Summary Tables
HI	Hazard Index
HQ	Hazard Quotient
IAS	Initial Assessment Study
ICV	Initial calibration verification
ID	Inside Diameter
IDW	Investigation Derived Waste
IEUBK Model	Integrated Exposure Uptake Biokinetic Model
ILCR	Incremental Lifetime Cancer Risk
IR	Installation Restoration
IRIS	Integrated Risk Information System
LOAEL	Lowest Observed Adverse Effect Level
MCLs	Maximum Contaminant Levels
MCRD	Marine Corps Recruit Depot
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mS/cm	milliSiemens per centimeter
msl	mean sea level
MW	Monitoring Well
NACIP	Naval Assessment and Control of Installation Pollutants
NAVFAC	Naval Facilities Engineering Command
Navy	United States Navy
NCEA	National Center for Environmental Assessment
NEESA	Naval Energy and Environmental Support Activity
NOAA	National Oceanographic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NPL	National Priorities List
NTU	Nephelometric Turbidity Units
OC	Organic Carbon
PAHs	Polycyclic Aromatic Hydrocarbons
PAI	Parris Island
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PCBs	Polychlorinated Biphenyls
PCE	Tetrachloroethene
PEL	Probable Effects Level
PI	Parris Island

PID	Photo-Ionization Detector
PR	Preliminary Review
psi	pounds per square inch
PVC	Polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
QAP	Quality Assurance Plan
RBC	Risk-based Concentration
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facilities Assessment
RfC	Reference Concentration
RfD	Reference Dose
RFI	RCRA Facilities Investigation
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RPD	Relative percent difference
SARA	Superfund Amendments and Reauthorization Act
SCDHEC	South Carolina Department of Health & Environmental Control
SCDNR	South Carolina Department of Natural Resources
SD	Sediment
SMDP	Scientific/Management Decision Point
SOUTHDIV	Southern Division
SOUTHNAVFAC	Southern Division Naval Facilities
SS	Surface Soil
SSL	Soil Screening Level
SVOCs	Semivolatile Organic Compounds
SW	Surface Water
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCE	Trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TEF	Toxicity Equivalence Factor
TEL	Threshold Effects Level
TOC	Total Organic Carbon
TP	Test Pit
TRV	Toxicity Reference Value
TSS	Total suspended solids

TtNUS	Tetra Tech, NUS, Inc.
UCL	Upper Confidence Limit
µg/kg	micrograms per kilogram
µg/l	micrograms per liter
U.S. EPA	United States Environmental Protection Agency
USFWS	United States Fish & Wildlife Service
VOCs	Volatile Organic Compounds
VS	Verification Step
WQC	Water Quality Criteria
WQS	Water Quality Standard

RESPONSE TO
REGULATORY COMMENTS

USEPA Review of Draft RCRA Facilities Investigation/Remedial Investigation for Site/SWMU 2 - Borrow Pit Landfill and Site/SWMU 15 - Dirt Road

General Technical Comments

1. **Comment:** Does historical information exist that can explain what happened to the 33,016 tons of waste reportedly disposed of at the Site?

   Response: The first paragraph of the Nature and Extent of Contamination Section on Page E-4 will be replaced with the following paragraph.

   Wastes were allegedly disposed of at Site 2. In addition, a review of aerial photographs indicates that the site was disturbed at the reported time of disposal. However, hand borings and test pits were conducted as part of RI/RFI activities to determine whether waste materials are present at the site. The only evidence of waste at Site 2 was the presence of visually stained soils near the water table. The stained soils may be of natural origin. Furthermore, surface and subsurface soil and sediment at Site 2 were not found to contain chemicals in excess of those found in background media and the most stringent of residential human health RBCs or ecological screening values.

2. **Comment:** Were geophysical techniques considered to establish the boundaries of the borrow pit? If so, this information should be provided and referenced in the Report.

   Response: No. Historic aerial photographs and surface features were used to identify the location and maximum potential extent of the site.

3. **Comment:** Reference to water level depths vary throughout the report, and, at times, seem to be inconsistent. For example, pg.1-3 states water table is 15 to 17 ft bgs and the ES says water is 3.5 to 14.5 ft bgs. Correct this discrepancy.

   Response: The 15 to 17 ft bgs reference was from an historic document that only used three monitoring wells that are located approximately 10 feet higher in elevation than the more current wells. To avoid confusion. The reference to 15 to 17 ft bgs on page 1-3 will be deleted.

4. **Comment:** Were aerial photographs available and used to establish the history of the borrow pit including time frames preceding, during, and after the pit was closed? If so, this information should be provided and referenced in the Report.

Response: Aerial photographs were used to establish the possible extent of activities (disturbed areas) - see Figure 1-2. These are the areas that were investigated during the RI. Four aerial photographs (from 1945, 1955, 1965, and 1972) will be included in an appendix of the RI. The following discussion of these photos will be included in the Section 1.4.2., Background and History.

Appendix G of the report contains four aerial photographs of Site 2 from 1945, 1955, 1965, and 1972. No development within the vicinity of Site 2 is observed in the 1945 photograph. In 1965, surface water is observed within the present day boundary of Site 2, indicating that borrow soil had likely been removed from the area. By 1972, the existing dirt road surrounding Site 2 is observed and reforestation of the site is noted indicating that operations had ceased within the boundaries of Site 2 by this time.

5. **Comment:** Sect. 1.4.2 states that wastes were located in central and eastern portion of landfill. Why were no subsurface soil samples collected in the central portion of landfill?

Response: Sample PAI-02-TP-11 was collected from near the center of the borrow pit. This location was selected because some staining of the soils was noted during earlier testing. Several test pits were installed on the eastern portion of the site and the subsurface soils encountered were identical to those observed elsewhere and there was no evidence of waste disposal.

6. **Comment:** The Acronym List does not included many of the acronyms used in the RI; for example, PI, PAI, TP, MW, GW, SD, SS, and SW were not included. Revise the Acronym List.

Response: The referenced letters are parts of sample identifications and are not acronyms. However, to aid in use of the report, the terms will be defined in the acronym list.

7. **Comment:** The dates between the Executive Summary and Section 1.0 do not agree. For example, the Executive Summary, page ES-1, Historical Information, first paragraph, states "From 1966 to 1968, the landfill reportedly served as the disposal site..". Section 1.0, Introduction, page 1-3, Site Borrow Pit Landfill, first paragraph, states "Site 2, Borrow Pit Landfill, is a landfill that was in operation from 1965 to 1968." Correct this discrepancy.

Response: The different dates were taken from different references. For clarity, only the 1966 date will be used.

8. **Comment:** Clarify the basis for establishing "background." This is critical since the background concentrations were used as a basis for determining acceptable levels of concentrations of contaminates. A better discussion of background samples should be provided and a figure showing their location should be included.

Response: The requested sample locations and descriptions are provided in Appendix A. Validated analytical data is presented in Appendix C. Summary calculation sheets will be generated and also presented in Appendix C.

9. **Comment:** Record Discrepancies - Many of the records generated at Parris Island during the investigation indicate poor records keeping practices not in accordance with EPA protocols. These practices should be stopped and future records improved to meet all EPA and quality assurance requirements. This following are examples of record discrepancies identified during this review:

General response: The following comments are divided into four general categories, as follows.

- Photocopied and three-hole punched versions of the field forms are not legible.
- Changes to the field forms were made without properly initialing and dating the changes
- During the cross out of some information, the underlying data could not be read after photocopying.
- Whiteout was used on some forms.

To resolve the these administrative issues, Tetra Tech is taking the following steps.

- Remind the field personnel on how to properly make changes to field forms.
- The original forms have been compiled and are being stored in the project file at Tetra Tech for inspection. Underlying information is legible on these original forms.
- A clean electronic photocopy of the forms has been generated and will be included in the administrative record and will be distributed to interested parties.

Additional responses are presented below.

9a. **Comment:** The Soil & Sediment Sample Log Sheets, located in Appendix A, A-8 and A-9 contain numerous "cross-outs" that were not initialed or dated. The Soil & Sediment Sample Log Sheets in A-9 were crossed-out with what appears to be a marking pen obliterating the information. A single line mark out that does not obliterate the information should be used.

Response: The referenced cross-outs with a marking pen were not modifications to field information, but were markups of a standardized form which listed all possible analytes. Analytes that were not to be tested for (as per the work plan) were crossed out. This action aided the field personnel in filling the correct number of sample bottles. This action is similar to a check mark or circle of information. Underlying information is readable on the original forms.

9b. **Comment:** The Surface Water Log Sheet for Sample ID No.: PAI-02-SW-04-00, contains a date in the C.O.C. No. space in lieu of the COC number. The C.O.C. No. is not recorded on this form. Additionally, the samples were taken on 07/23 & 23/98, the Secchi Disk reading was added to this record on 08/12/98 instead of generating a new record.

Response: A reference to COC No. 02268 will be added to this sheet and the sheet will be reissued. A new sample was not collected on 8/12/98 only a field measurement was added and therefore a new sample log sheet was not generated.

9c. **Comment:** Other records appear to have had information removed such as by the use of correction fluid or correction tape in lieu of using a single line "cross-out" and initial and dated the change; for example, Appendix A, A-7, Surface Water Sample Log Sheet PAI-02-03-00, one of the C.O.C. numbers has been removed. The use of correction fluid or tape is an unexcuseable breach of proper field protocol and MUST not be done in the future.

Response: Agreed, the underlying information is readable on the original information.

9d. **Comment:** The C.O.C. No. is missing from Soil & Sediment Sample Log Sheet for samples PAI-15-SD-03-01 and PAI-02-SS-01-01.

Response: The reference to COC No. 2254 and 1309 will be added and these sheets reissued.

9e. **Comment:** The Soil & Sediment Sample Log Sheets, in Appendix A, A-9, also contained "cross-outs" that were not initialed and dated nor was a single line used for the "cross-out." However, in the Sample Collection Information section the samples are inconsistently taken for analysis. For example, some of the Surface Soil samples are taken for "Hexavalent Chromium" and other samples this is "crossed-out;" other samples were taken for TOC and PH and others were "crossed-out;" and on other Log Sheets only TCI/PCBs and Lead were sampled. A rationale for the revision to these records was not noted on the record. Provide an explanation for these discrepancies.

Response: The referenced cross-outs with a marking pen were not modifications to field information, but were markups of a standardized form which listed all possible analytes. Analytes that were not to be tested for (as per the work plan) were crossed out. This action aided the field personnel in filling the correct number of sample bottles. This action is similar to a check mark or circle of information. Underlying information is readable on the original forms.

Except as noted in the "Deviations from Work Plan" section of the report, the samples were analyzed in accordance with the Work Plan. Rationale for analysis of specific samples is provided in the work plan.

9f. **Comment:** The Surface Water Sample Log Sheets, in Appendix A, A-6, contained two Sample Log Sheets with different sample collections for analysis. PAI-02-SB-01-01 sampled for TCL VOCs, TCL SVOC, TAL Metals, and Cyanide. PAI-02-SB-01-30 these same sample collection for analysis were "crossed-out" and TOC, pH, GeoTech were added. No rationale was provided as to explain these revisions or a basis for the inconsistent sample collections. Provide an explanation.

Response: The referenced cross-outs with a marking pen were not modifications to field information, but were markups of a standardized form which listed all possible analytes. Analytes that were not to be tested for (as per the work plan) were crossed out. This action aided the field personnel in filling the correct number of sample bottles. This action is similar to a check mark or circle of information. Underlying information is readable on the original forms.

Except as noted in the "Deviations from Work Plan" section of the report, the samples were analyzed in accordance with the Work Plan. Rationale for analysis of specific samples is provided in that document.

9g. **Comment:** Appendix A, A-14, Test Pit Log Sheets, are missing Test Pit Log records for PAI-02-TP-10, PAI-02-TP-11, PAI-02-TP-12, and PAI-02-TP-13. Appendix A, A-15, Test Pit Sample Log Sheets, contains Soil & Sediment Log Sheets for PAI-02-SB-02A-02, PAI-02-SB-10-07, and PAI-02-SB-11-02, and Test Pit Logs for PAI-02-SB-07, PAI-02-TP-11, TP-12 (sic), PAI-02-TP-13. The purpose of Test Pit Log for PAI-02-SB-10-07 is not clear. Provide an explanation.

Response: Test Pit No: PAI-02-SB-10 and TP-12 will be re-labeled PAI-02-TP-10 and PAI-02-TP-12, respectively. These sheets will be reissued. PAI-02-TP-11 and PAI-02-TP 13 is presented on Pages A-165 and A-167, respectively.

9h. **Comment:** It appears the correlation between Sample ID No. PAI-02-SB-01-30 and the COC listed as 02259 is incorrect. COC 02259 could not be located in this Appendix to the RI. Provide a clarification and correct these discrepancies.

Response: The COC number will be clarified to be 2249, which is present on page A101.

9i. Chain of Custody (COC) Records contain numerous deficiencies including:

9i1) **Comment:** Some "Cross-outs" and "Mark-outs" that were not initialed or dated.

Response: Proper protocol will be discussed with the samplers involved.

9i2) **Comment:** Some entries were "written-over," and in some cases the numerical value could not be interpreted.

Response: Proper protocol will be discussed with the samplers involved.

9i3) **Comment:** Some COCs contained "Check Marks" in lieu of a numerical value, making it difficult to correlate number of containers to the number of samples.

Response: Proper protocol will be discussed with the samplers involved.

9i4) **Comment:** Some COC records were incomplete/missing information including signatures, dates, shipping information, and receipt by lab. Provide a clarification and correct these discrepancies.

Response: Signed COCs 2249, 2279, and 2229 will be reissued.

9i5) **Comment:** In some cases, the Sample ID Numbers and the numbers on the COC are not the same, and there is inconsistent use of a numbering scheme. This may be due in part to the renumbering of the samples. Provide a clarification.

Response: Samples from several sites at Parris Island were collected at the same time. Therefore the COCs also contain information from other sites.

9i6) **Comment:** Of the 22 COC records, the COC record numbers were missing from 2 records and partially obliterated for 4 records possibly during the copying or hole punching process. Provide a clarification and correct these discrepancies.

Response: The original forms contain all the relevant information. Copies of these forms will be in the administrative record.

9i7) **Comment:** Some of the COCs listed on various Sample Log records were not included Appendix A, A-11; for example, COC 2259. Correct these discrepancies.

Response: The reference to COC 2259 will be clarified to be 2249.

9i8) **Comment:** COCs 00263, 2280, 2212, 01307, and 0130 filed with the Sample Log Sheets in Appendix A, A-12. Correct these discrepancies.

Response: The referenced COC are part of the background data set and therefore belong in Appendix A-12.

9i9) **Comment:** Appendix A, A-11, page A-114, part of the record was not copied, missing information.

Response: This information will be included on the electronic version of the field forms.

9i10) **Comment:** Explain the differences between the number of blanks described in section 3.2.12 and the total numbers on the COCs in Appendix A, A-11, such as:

	3.2.1.2	COC
Source Water Blank	1	
Trip Blanks	12	18
Equipment Rinse	1	8
Rinse	2	
Duplicate GW Samples	2	

Response: The discussion in Section 3.2.12 is specific to Site 2 activities, whereas the COCs contain samples from several sites. Therefore a comparison of QA/QC samples will not normally match.

Comment: Most of these discepancies are the result of sloppy field and Chain of Custody procedures. In general, these problems raise questions about the reliability of the data gathered and the methods used to gather field information. EPA is concerned that these procedures be corrected. Field personnel should be instructed such that these problems are not repeated in the future.

Response: Acknowledged.

10. **Comment:** During the review, it was noted that laboratory analysis sheets were not included in the appendices. Although the Navy did supply Data Validation Reports, it is requested that the laboratory analysis sheets be added to the report. These may be submitted in an electronic format, such as a spreadsheet program, on a standard 3 ½" floppy disc or a "compact" disk.

Response: An electronic copy of the laboratory analysis sheets will be provided to interested parties.

Specific Technical Comments

1. **Comment:** Appendix C, Analytical Data: did not include a legend or define U, J, UR, UJ, R, etc.

Response: The referenced qualifiers are defined on page D-4.

2. **Comment:** Section 1.4.2, page 1-3, first paragraph: described the pit as covering an area of 1.9 acres, 10 feet deep. Later, in the second paragraph, the waste level is described as "half filled ... approximately 6 feet deep" and "Most of the waste were located in the central and east portions of the Site 2". Were the Test Pits dug in the best locations to sufficiently detect and verify the location and extent of the borrow pit contents?

Response: The test pits were dug throughout the suspected disposal area, including the central and east portions of the site.

3. **Comment:** Appendix A, A-2 and A-14: the PID/FID readings (ppm) were inconsistently recorded on the Boring Logs and Test Pit Logs. Some logs are either missing readings or readings were recorded once and applied for multiple sample depths. The practice of allowing incomplete data on records must be discontinued and future records must contain all relevant data.

Response: PID readings were recorded for the one soil boring (PAI-02-SB01) installed at Site 2. PID readings of zero were recorded at all depth intervals for this soil boring as indicated in the soil boring log of Appendix A-2. PID readings were not recorded for surface soil samples and associated hand holes. For the test pits, PID readings were collected continuously during excavation. Only significant changes (0.5 ppm) in PID readings from background (zero ppm) were recorded. The text of Section 3.2.3, Test Pitting/Subsurface Soil Sampling, will be revised to indicate these procedures.

4. **Comment:** Appendix A, A-14: Test Pit Logs dimension descriptions must be improved. Future pit logs should include details on pit depth, length, and width and sketches to better depict the pit. The Test Pit Log for Test Pit No: PAI-02-TP-06 references three photographs, they must be included in the RI.

   Response: Except for depth, all the test pits were installed the same. Text will be added to Section 3.2.3 of the report describing the dimensions of the test pits. The reference to photographs will be crossed out.

5. **Comment:** Section 3.2.6, page 3-6, second paragraph: states "In addition to these samples, PAI-02-SS-06-01 and PAI-02-SS-08-01 were analyzed for hexavalent chromium. The three hexavalent chromium samples were randomly distributed across the site." The Soil Sample Log Sheets, in Appendix A, A-9, identify the total samples taken to be analyzed for hexavalent chromium as three; Sample ID No. PAI-02-SS-01-01, PAI-02-SS-06-01, and PAI-02-SS-08-01. Also, Appendix C, C-5, provides the analytical data for Samples PAI-02-SS-01-01, PAI-02-SS-06-01, and PAI-02-SS-08-01. Correct the discrepancy between the text and the data.

   Response: PAI-02-SS-01-01 will be added to the referenced sentence.

6. **Comment:** Section 3.2.7, page 3-7, second paragraph: states "Sample PAI-02-GW-04-01 was also analyzed for hexavalent chromium." Appendix A, A-10, Sample Log Data Sheet, identifies a sample taken for CR (VI) (hexavalent chromium). The Chain of Custody Records for PAI-02-GW-002-01, PAI-02-GW-004-01, and PAI-02-GW-005-01 identifies samples for Cr (VI). Appendix C, Analytical Data, C-3, Groundwater, page C-038, provides analytical results for hexavalent chromium for three samples, PAI-02-GW-002-01, PAI-02-GW-004-01, and PAI-02-GW-005-01. Correct the discrepancy between the text and the data.

   Response: The sentence after the referenced statement indicates that PAI-02-GW2 and -05 were analyzed for hexavalent chromium.

7. **Comment:** Groundwater Sample Log Sheet, Appendix A, A-10: for samples taken on 08/24/98 and 09/15/98 are numbered with the same Sample ID No.: PAI2-GW2-01. It is not clear why the second sample was collected, its purpose, and use in the RI. The sample results and data from the 09/15/98 sample are not included in Appendix C, Analytical Data, C-3, Groundwater. Section 3.2.7, page 3-7, first and second paragraphs, discusses samples PAI2-GW2-01 and PAI2-GW2-01A. The same situation exists for PAI-02-GW-05 and PAI-02-GW-05-01A. Neither of these samples contains an "01A" designator. Provide a clarification.

Response: The original sample was not analyzed for all of the planned parameters. Therefore, the wells were resampled on 09/15/98.

The results are presented in Appendix C. A dual date will be added to the data sheets.

8. **Comment:** Appendix A, A-7: contains Surface Water Sample Log Sheets for samples PAI-02-SW-01-00 (COC No. 2268/2269), PAI-02-SW-02-00 (COC No. 2268/2269), PAI-02-SW-03-00 (COC No. 2269), and PAI-02-SW-04-00 (contained a date in lieu of a COC No.). According to the Chain Of Custody Records in Appendix A, A-11, Sample Log Sheets and the corresponding the COC numbers as follows: PAI-02-SW-01-00 shown on COC No. 2268, PAI-02-SW-02-00 shown on COC No. 2268, PAI-02-SW-03-00 shown on COC no number (may be No. 2269), and PAI-02-SW-04-00 (date in lieu of COC number) COC No. 2268. Clarify the discrepancies for number of Surface Water samples between the Sample Logs and the COCs.

Response: The forms will be marked up as indicated.

9. **Comment:** Appendix A, A-11, page A-101: contains a COC for samples taken from 07/08 - 07/15/98, with Project No. 7803, Site Name is listed as Jericho Island, and is different than the other COCs are assigned Project No. 7394. One Station Location identified as PAI-02-SB-001-30 (PAI-02-SB-01) appears to be a sample from the borrow pit. The Soil & Sediment Sample Data Sheet for PAI-02-SB-01-30 identified the corresponding COC No. as 2259. COC 2259 was not be found in the RI. Appendix A, A-11, page A-120, contains a COC with Project No. 7115, but does not list any samples that contain the numbering prefix PAI. Is this COC part of this RI?

Response: The Sample Data Sheet will be revised to reference COC 2249 instead of COC 2259.

The COC on Page 119 is for the Parris Island samples collected in 1995. The COC is included because the data is referenced in the text.

10. **Comment:** Section 4.0, page 4-1, last paragraph: discusses filtered and non-filtered surface and groundwater samples. However, the Groundwater and Surface Water Sample Log Sheets, located in Appendix A, A-7 and A-10, do not identify which samples were filtered and which were not. The analytical data in Appendix C, C-3, does denote an "F" for some samples for what appears to indicate "Filtered," for example, PAI-02-GW-001-01-F. However, the "F" designator is not defined or explained in Section 3 nor Appendix C.

Response: The definition of "F" will be added to the acronym list.

11. **Comment:** Section 4.0, page 4-2: discusses the background sample location as "two areas...Pinckney Island and an undeveloped area on the southern portion of Parris Island." Appendix A, A-12, contains Sample Log Sheets for three locations: Parris Island, Pinckney Island, and Jericho Island (PAI-10-SD-16-01A). Jericho Island is not discussed in Section 4.0. Provide a clarification.

Response: Based on work plan considerations, the three background samples collected on Parris Island were identified with Jericho Island nomenclature.

12. **Comment:** Pg.2-2, last sentence: If flow in the upper portion of the surficial aquifer is toward closest water body, is direction of flow in the lower portion of this aquifer the same, or should this sentence read that flow in the surficial aquifer is toward closest water body.

Response: The sentence will be revised to reflect that flow in the surficial aquifer is generally toward the closest water body.

13. **Comment:** Pg.3-1, 3rd bullet: Explain why no hand auger soil borings were collected at locations 01, 06 or 08.

Response: Soils boring were conducted at these locations, however, copies of the log sheets could not be located. Subsequent test pits were dug in the vicinity of these soil borings. These test pits did not reveal the presence of waste material at these locations.

14. **Comment:** Pg.3-3, sect 3.2.2, last para: States MW-1,2, and 3 are in top of surficial aquifer. Well logs show these wells to be 26, 30, and 26 ft deep, with 20 ft of screen each. This appears to be deep for the upper portion of the aquifer. Due to the depth of these wells and the length of screen, these wells appear to span at least the upper and middle to lower portion of the aquifer. A discussion of what constitutes the upper and lower aquifer is necessary.

Response: The ground surface elevation at these wells is 14.7 to 17.8 feet above mean sea level. Therefore, these well only extent approximately 11 to 13 feet into the water table. The terms shallow and deep are arbitrary and will be removed from this discussion.

15. **Comment:** Pg.3-3, Sect.3-2, 3rd sent: Sentence states PAI-02-SB-01-01 was collected from 0-1 ft bgs and is a subsurface soil sample. Depths of 0-1 feet are normally considered a surface soil sample. Explain this discrepancy.

Response: This sample is identified as a subsurface sample because of work plan nomenclature and results from the groundwater being very shallow at this location.

16. **Comment:** Pg.3-2, 1st para: A better description of how pits were dug and dimensions of pits must be provided.

Response: The following discussion will be added to Section 3.2.3.

The test pits were dug using a 1/4 cubic yard bucket. The test pits were all approximately 24 inches wide and 5 to 7 feet long. The depth of the pit was variable based on the depth to the water table which ranged from 2.5 feet bgs in the central portion to 8 feet bgs in the northeastern portion of the site.

17. **Comment:** Pg.3-4, 1st sent: The portion of this sentence in parenthesis is confusing. Is there one borehole or two? The provided information appears to indicate that there are two boreholes and that they are identified with the same number differing only in the last 2 digits which indicate depth. If this is the case, why were 2 boreholes needed? If not, a clarification is required.

Response: As indicated, two boreholes were drilled to collect the samples. The number of boreholes needed to collect samples are determined in the field based on efficiency and sampling needs. These boreholes were at the same location, therefore are assigned the same location identification.

18. **Comment:** Pg.3-3,3-4, sect 3.2.3: Information about depths and dimensions of test pits must be provided.

Response: The following will be added to Section 3.2.3.

The test pit were dug using a 1/4 cubic yard bucket. The test pits were all approximately 24 inches wide and 5 to 7 feet long. The depth of the pit was variable based on the depth to the water table. which ranged from 2.5 feet bgs in the central portion to 8 feet bgs in the northeastern portion of the site.

19. **Comment:** Pg.3-14, sect 3.4: A ground water contour map is needed.

Response: The monitoring wells are located on the perimeter of the landfill and adjacent to a tidally influenced surface water. As a result, representative groundwater contour maps cannot be generated.

Baseline Human Health Risk Assessment General Comments

1. **Comment:** According to EPA Region 4 guidance (EPA, 1995), it is unacceptable to use data from filtered groundwater samples in a baseline risk assessment. Although the risks and hazards calculated in the baseline risk assessment are based on unfiltered groundwater data, the report presents both filtered and unfiltered groundwater data in many of the tables. In addition, the text in Section 6.1.2.2 discusses filtered and unfiltered groundwater analytical results. To avoid confusion, all references to filtered groundwater data should be removed from Section 6 - Baseline Human Health Risk Assessment.

   Response: As discussed during the April 2000 partnering team meeting, the reference to filtered data will be deleted from Section 6.0 of the report. However, the reference EPA Region 4 guidance pertains to the calculation of exposure point concentrations and references EPA's Risk Assessment Guidance for Superfund (RAGS). RAGS states that "the use of filtered samples for estimating exposures is very controversial because these data may underestimate chemical concentrations in water from an unfiltered tap." RAGS assumes that the concentration of chemicals in filtered samples will be less than those in unfiltered samples. Usually the concentration of a chemical will be higher in an unfiltered sample than in a filtered sample but there are instances when the concentration of a chemical in filtered samples is higher than those in unfiltered samples. This is the case for groundwater at Site 2 where the concentrations of barium and zinc are slightly higher in filtered groundwater samples as compared to unfiltered groundwater samples. Also the concentrations of arsenic, barium, magnesium, potassium, silver, sodium, and zinc are slightly higher in filtered surface water samples as compared to unfiltered surface water samples. RAGS and EPA Region IV risk assessment guidance does not make any recommendations on which data to use when filter sample results are higher than unfiltered sample results. The human health risk assessment conservatively used the maximum chemical concentration in both filtered and unfiltered groundwater and surface water samples in the selection of COPCs and calculation of exposure point concentrations.

2. **Comment:** The reviewers copy of the baseline human health risk assessment did not contain any groundwater tables with estimated cancer risks and hazard indices for future onsite residents. These tables must be provided.

   Response: Agree. The tables will be added to Appendix E as requested.

3. **Comment:** The baseline human health risk assessment did not contain a remedial goal options section (RGOs). EPA Region 4 guidance (EPA, 1995) recommends that a range of RGOs be presented for the risk manager's use as the last component of the risk assessment. RGOs should be calculated for each chemical of concern (COC) in each land use scenario that either exceeds a 1E-04 cumulative cancer risk or exceeds a total noncarcinogenic hazard index of 1. Although none of the land use scenarios exceeded a cumlative cancer risk of 1E-04, the hazard indices for child and adult residents exceeded 1, primarily due to ingestion of groundwater.

   Response: Agree. A section presenting RGOs for groundwater will be added to the human health risk assessment.

Baseline Human Health Risk Assessment Specific Comments

1. **Comment: Section 6.1.2, Page 6-4:** Elimination of essential nutrients should be based on professional judgment. Although these elements are only toxic at high concentrations, there are several instances where the concentration of an essential nutrient is more than three times its background concentration. The risk assessment should contain a qualitative discussion of essential nutrients when the maximum detected concentration significantly exceeds the respective background concentration.

   Response: Agree. A review of the data indicates that concentrations of sodium in surface soil and calcium in sediment at Site 2 and calcium in sediment at Site 15 exceeds background concentrations. A qualitative discussion of the significance of these exceedences will be added to the uncertainty section to the human health risk assessment.

2. **Comment: Section 6.1.2.1, Site 15, Page 6-5:** The text states that, the detection limits for PCBs were compared to the screening criteria to ensure that there were no problems with elevated detection limits. The reported detection limits for PCBs were below the screening criteria for PCBs. Since the raw data are not included in the report, the range of detection limits for PCBs should be provided here so that the reader can verify the information.

   Response: Agree. The text will be revised as follows: "The reported detection limits for PCBs (8.8 to 82 ug/kg) were below the screening criteria for PCBs (320 ug/kg)." It should be noted that the raw data for the PCBs is included in Appendix C. Also, the raw analytical sheets will be provided electronically to interested parties.

3. **Comment:** **Section 6.1.2.2, Site 2, Page 6-6:** The text states, the maximum detected concentration of thallium exceeds the screening criteria in only unfiltered groundwater samples. However, Table 6-4 indicates that the detected concentration of thallium in filtered groundwater samples also exceeded the screening criterion. As discussed in General Comment Number 1, all references to filtered groundwater data should be removed from the baseline risk assessment to avoid confusion.

Response: Agree. The discussion of thallium in groundwater on Page 6-6 will be deleted. Also see the response to General Comment 1.

4. **Comment:** **Section 6.1.2.4, Site 15, Page 6-7:** The text states that, the detection limits for PCBs were compared to the screening criteria to ensure that there were no problems with elevated detection limits. The reported detection limits for PCBs were below the screening criteria for PCBs. Since the raw data are not included in the report, the range of detection limits for PCBs should be provided here so that the reader can verify the information.

Response: Agree. The text will be revised as follows: "The reported detection limits for PCBs (11 to 17 ug/kg) were below the screening criteria for PCBs (320 ug/kg)." It should be noted that the raw data for the PCBs is included in Appendix C. Also, the raw analytical sheets will be provided electronically to interested parties.

5a. **Comment:** **Section 6.1.2.5, Page 6-7 and Table 6-8, Page 6-44:** This section estimates concentrations of chemicals in fish using detected concentrations in sediment, bioaccumulation potential, total organic content in sediment, and a lipid content of 0.7. The estimated concentration in fish is then compared with the EPA Region 3 risk-based concentration (RBC) for fish. The text states that the estimated concentrations of polynuclear aromatic hydrocarbons (PAHs) and hexavalent chromium exceeded the RBCs for fish. However, Table 6-8 indicates that estimated concentrations of aluminum, arsenic, iron, manganese, mercury, and vanadium also exceeded their respective RBCs. These metals were apparently eliminated as chemicals of potential concern (COPCs) in fish tissue following a comparison with background concentrations in sediment. Since this section of the risk assessment screens chemicals based on estimated concentrations in fish tissue, it is inappropriate to eliminate these metals as COPCs in fish based on a comparison with background concentrations in sediment.

Response: Disagree. The concentration of inorganics in sediment are less than background values and therefore inorganics are not site related constituents. Consequently, inorganics should not be considered as COPCs in fish tissue. The Navy realizes that the presentation of the

estimated concentrations of inorganics in fish tissue in Table 6-8 is confusing and proposes to remove inorganics from the table (with the exception of hexavalent chromium).

5b. **Comment:** Also, endosulfan sulfate is listed on Table 6-8 as a chemical that was detected in sediment at Site 2. However, this compound is not listed in previous tables in the risk assessment (Table 4-6 or Table 6-6). Reconcile this discrepancy.

Response: Agree. Endosulfan sulfate will be removed from Table 6-8.

5c. **Comment:** Finally, it appears that the last paragraph on this page should be moved to the end of Section 6.1.2.6.

Response: Agree. The text will be revised as suggested.

6. **Comment: Section 6.2.3.3, Page 6-11:** Please specify that future residents are evaluated for exposure to groundwater via ingestion, dermal contact, and inhalation.

Response: Agree. The text will be revised as suggested.

7. **Section 6.2.7.2, Page 6-16:** The last sentence on this page should read, The following steady-state equation is used to estimate DA_{event} for inorganics:

Response: Agree. The text will be revised as suggested.

8. **Comment: Tables 8.6 and 8.7:** These tables present the same information. Should one be for the adolescent recreational user?

Response: Due to what appears to be an inadvertent error during reproduction and distribution, a revised Appendix E will be reissued to the Partnering Team.

9. **Comment: Table 9.4:** This table appears to contain incorrect information. It appears to contain exposure information for adult recreational users, not adult residents (see Table 8.6).

Response: Disagree. Table 9-4 addresses Child Resident.

Screening-level Ecological Risk Assessment General Comments

1. **Comment:** The screening steps of the ecological risk assessment are well written and in general compliance with current EPA guidance. However, based on the results of the screen, it is not clear why food chain modeling was conducted. It is recommended that in the future the scientific management decision point (SMDP) be conducted at the end of step two in EPA's process to prevent unnecessary evaluation.

   While food-chain modeling has an appropriate place in ecological risk assessment, it should be reserved for evaluating contaminants that are likely to bioaccumulate and/or biomagnify through that exposure route. Contaminants that are not known to be bioaccumulative need not be addressed through food chain modeling unless they are present in unusually high concentrations. The risk assessment makes this argument in later sections after the food-chain modeling is completed; however, in the future it would be more prudent to present that information before a decision is made about conducting the modeling. The presentation of this line of reasoning after the modeling is conducted leads one to the obvious conclusion, if the modeling was not likely to show risk (based on the contaminants mode of toxicity), other methods of analyzing potential risks may have been more appropriate.

   Response: The food chain modeling in question was conducted for contaminants (excluding VOCs) whose concentrations exceeded ecological screening values. This is standard procedure for ecological risk assessments at MCRD Parris Island. According to conversations with Lynn Wellman and Ted Simon of EPA Region IV (Wellman, 2000; Simon, 2000), the reviewer's comment reflects recently amended guidance regarding the implementation of EPA's (1997) *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments.* Under the amended guidance (EPA, 2000), food chain modeling is initially conducted in Step 3 instead of Step 2, and usually does not need to be performed for chemicals that do not bioaccumulate or biomagnify (e.g., SVOCs). The ecological risk assessment for Site 2/15 was conducted prior to dissemination of EPA's amended guidance. The Navy concurs that unnecessary evaluation should be prevented to the maximum extent possible.

2. **Comment:** The sampling rationale for SWMU 15 is unclear. In Figure 3-5, it appears most of the samples collected to delineate contamination from this SWMU were located along the side of the roads which were presumably sprayed with waste oils. However, in Figure 3-4, no samples were collected along the side of the road where it had been paved. This may overlook contamination that migrated off the road and into the roadside soils prior to paving along the 1.5 miles of road along Elliot's Beach.

Response: The samples were collected in accordance with the approved work plan. The intent of the sampling was to determine whether potentially contaminated waste oils sprayed onto roads are migrating into the adjacent sediment at environmentally significant concentrations. The roads were not paved until after the work plan was completed and therefore did not enter into the decision for selecting sample locations.

3. **Comment:** The tables included in Appendix F should be laid out in a way that allows for the reviewer to easily check the calculations (for at least one example). The review was not able to verify the dose calculations based on the information presented in the current tables.

Response: The dose calculations in Appendix F–3 can be verified by a review of the equations and discussion in Section 7.4.2 of the text. However, examples will be provided in Appendix F-3 showing the equations and the values used to calculate the hazard quotients.

Screening-level Ecological Risk Assessment Specific Comments

1. **Comment:** **Section 7.2.3.2, Page 7-6, Paragraph 2**. It is unclear, based on the information available why the soil-to-groundwater migration pathway is considered incomplete based on depth to groundwater. Section 2.6 indicates that groundwater in the area is commonly 3 feet below ground surface. The text should be corrected or expanded upon to clarify the reason for considering this pathway incomplete.

Response: The statement is based on the work plan, which on page 2-9 states (Sec 2.3.1.2 of work plan) that "The depth to the water table at high tide beneath Site 15 is 1 to 4 feet. This greatly exceeds the estimated required depth of less than 4 inches for contaminant immobilization, and percolation to the groundwater was therefore determined to be unlikely."

The depth of 4 inches was calculated in the Initial Assessment Study (IAS) (NEESA, 1986) using an American Petroleum Institute equation (API, 1972) for calculating the volume of soil required to immobilize spilled oil. The following text will be added to Section 7.2.3.2.

> The depth to the water table at high tide beneath Site 15 is 1 to 4 feet. This greatly exceeds the estimated required depth of less than 4 inches for waste oil immobilization (NEESA, 1986).

2. **Comment:** **Section 7.2.4, Page 7-7, Paragraph 4**. Since volatile organic contaminants are included among the contaminants of concern for this site, the inhalation pathway should be described as potentially complete. In other sections of the report (and the conceptual site model)

this pathway is correctly considered complete; however, in this section the text makes it seem as though it is incomplete.

Response: Concur; the text in Section 7.2.4 will be revised to describe the inhalation pathway as potentially complete for some receptors. The text of Section 7.9.3 currently discusses the uncertainty resulting from the lack of inhalation toxicity data.

3. **Comment: Section 7.3.3, Page 7-11, Paragraph 1**. In accordance with EPA guidance to insure the conservative nature of the screening-level risk assessment the minimum published body weight (not average) and the maximum ingestion rate needs to be used in calculating daily doses.

Response: The Navy concurs with EPA guidance (EPA, 1997) that calls for the use of estimates of body weight and food ingestion rates to maximize the conservative nature of screening level risk assessments. In general, maximum food ingestion rates and minimum body weights were used to calculate daily doses. However, EPA's (1993) Wildlife Exposure Factors Handbook provides food and water ingestion rates as grams ingested per gram of body weight. In nearly all cases there are more body weight data than ingestion rate data, and often there are only one or two values for an ingestion rate. Arbitrary use of a maximum ingestion rate and a minimum body weight can result in doses that are less conservative than using averages. This result comes from using the minimum body weight to calculate ingestion. Therefore, professional interpretation of the data is sometimes required to select the most appropriate value. The wording in Section 7.3.3 did not clearly state this and will be revised.

Furthermore, the reviewer's comment was taken from Section 2.2.1 of EPA (1997), which describes how doses should be calculated in Step 2 of the 8-step process. Section 2.3 of EPA (1997) further describes how estimated doses are used to calculate risks in Step 2 of the 8-step process. As mentioned in the response to General Comment # 1, however, a new approach has evolved at EPA Region IV in which food chain modeling of estimated doses is initially conducted in Step 3 instead of Step 2. Step 3 of the 8-step process includes the refinement of preliminary contaminants of potential concern. Section 3.2 of EPA (1997) states that Step 3 includes an assessment of doses and resulting hazard quotients that are calculated using more realistic assumptions. Therefore, it could be argued that doses initially calculated in Step 3 should not necessarily utilize the most conservative assumptions available.

The Navy concurs that the initial calculation of doses (via food chain modeling) and resulting hazard quotients should use conservative assumptions to the maximum practicable extent, whether the initial risk calculation is accomplished in Step 2 or Step 3. Potential follow-up dose

calculations in Step 3 will use less conservative assumptions. This will be clearly described in future risk assessments.

4. **Comment:** **Section 7.3.3.12, Page 7-15, Paragraph 1**. Due to their smaller home range and body weight, smaller wading birds (such as the little blue heron) are typically better suited to modeling at hazardous waste sites.

   Response: A written discussion of which species of wading bird is the most appropriate representative of this guild was disseminated to the MCRD Partnering Team on April 20, 2000. As discussed therein, the daily food ingestion rate (as a percentage of body weight) is similar for most wading bird species, and is approximately 18 percent for the great blue heron, and approximately 19 percent for the green heron, little blue heron, snowy egret, and tri-colored heron. Because the smaller heron species have slightly greater food ingestion rates than the great blue heron, and because home ranges are usually smaller for the smaller heron species, the Navy concurs that future ecological risk assessments will use smaller wading birds than the great blue heron. Specifically, the green heron will be used to represent wading birds.

5. **Comment:** **Section 7.4.2.1, Page 7-17, Paragraph 1**. To maintain the conservative nature of the screening level risk assessment, the prey items included in the food-chain model should be assumed to be those with highest level of exposure. For example, since shrews are carnivorous their exposure is assumed to be higher for any contaminant that would bioaccumulate, it should be assumed that a hawks diet is made up of 100 percent shrews.

   Response: The current ecological risk assessment estimated the ingested doses to the hawk and fox by assuming that prey items consisted of equal amounts of shrews and mice. Although the incorporation of the requested revision would not significantly affect the results of the risk assessment, the Navy concurs that the requested approach would better maintain the conservative nature of the risk assessment. Thus, future ecological risk assessments will incorporate the requested approach.

REFERENCES

American Petroleum Institute, 1972. The Migration of Petroleum Products in Soil and Groundwater: Principles and Countermeasures Publication No. 4149, Committee on Environmental Affairs, Washington, DC.

EPA (U.S. Environmental Protection Agency). 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, June 5, Edison, New Jersey.

Naval Energy and Environmental Support Activity (NEESA). September 1986. Initial Assessment Study of MCRD Parris Island, South Carolina, NEESA13-095.

Simon, T.W. (U.S. Environmental Protection Agency, Waste Management Division, Atlanta, Georgia). 2000. Personal Communication with M.L. Whitten, April 14 (Tetra Tech NUS, Inc., Aiken, South Carolina).

Wellman, L.. (U.S. Environmental Protection Agency, Waste Management Division, Atlanta, Georgia). 2000. Personal Communication with M.L. Whitten, April 13 (Tetra Tech NUS, Inc., Aiken, South Carolina).

SCDHEC Review of Draft RCRA Facilities Investigation/Remedial Investigation for Site/SWMU 2 - Borrow Pit Landfill and Site/SWMU 15 - Dirt Road

JS Comments on the SWMUs 2/15 RFI Report

1. **Comment:** Section 2.0, This section constantly references the Site 3 RI/RFI. To make this a stand-alone document, please cut-and-paste the pertinent information from the Site 3 RI/RFI into this section.

   Response: In order to minimize the size of these already large reports, it is the Navy's policy for MCRD Parris Island reports not to repeat redundant information, especially when the referenced reports are final and readily available. Also, the information is summarized in Section 2.0. Per discussion during the July 31, 2000 partnering team conference call, a reference to the ecological site summary contained within Section 7.0 will be added to Section 2.7

2. **Comment:** Section 3.1, page 3-1, 3rd bullet, Please explain why surface soil samples PAI-02-SS-01, PAI-02-SS-06, and PAI-02-SS-08 were not collected.

   Response: The soil samples were collected and analyzed. As indicated in the text, it was the hand auger logs for these borings that could not be located and therefore, it was assumed (conservatively) that the borings were not completed. Note that these locations were later addressed by test pits and that these missing logs do not represent data gaps.

3. **Comment:** Section 3.2.5, Composite sediment samples were taken for SWMU 15 near Elliott's Beach. It is unclear what the advantage is of composite sampling. It is not very useful for RFI purposes since the purpose of the RFI is to delineate nature and extent of contamination. Commingling the sediment samples does not reveal any information concerning the conditions of the area from which the original sediment sample was collected.

   Response: The samples were collected in this way at the request of the South Carolina Department of Natural Resources. Note that even though these samples were collected during an RI, the actual use of the data was to determine whether contamination was present. As a result, composite samples provide a more comprehensive approach to ensure that contamination is not missed.

4. **Comment:** Section 3.2.6, Surface soil samples for SWMU 15 were limited to only lead and TCL PCBs analysis. Apparently the basis for this limited analysis is that the 1996 data concluded that only lead and PCBs were of concern. Please incorporate this 1996 data into the report.

Additionally, include a description of the complete list of analytes for which the 1996 surface soil samples were analyzed.

Response: These samples were tested in accordance with the approved work plan (dated March 9, 1999). Rationale for the analytical matrix can be found in that document, but in general the work plan concludes that only PCBs (in waste oil) and lead (presumably from leaded gasoline) are potential environmental concerns. The 1996 data were not used to limit the 1998 analysis to only PCBs and lead. A reference to the approved work plan will be added to the text of Section 3.2.6.

The 1996 data is discussed in Section 4.0 and the validated data is presented in Appendix C. The locations of the 1996 soil samples will be added to Figures 3-4 and 3-5.

5. **Comment:** Table 3-3, Samples taken from the 0-1 foot interval are considered surface soil samples rather than subsurface soil samples. Please revise.

Response: This sample was identified as a subsurface sample because of the nomenclature from the work plan. The sample was collected from a down gradient location (monitoring well) and is not part of the site surface soils.

6. **Comment:** Figure 3-4, This figure should clearly identify which portions of the road leading to Elliott's Beach are paved.

Response: Figure 3-4 will be revised to indicate paved areas. Additionally, per a DHEC request, a legend will be added to indicate that green demarcated areas are forested/wooded and blue areas are surface water bodies according to the 1979 USGS 7.5 Minute Quadrangle for MCRD Parris Island. A similar legend will be added to the other report figures.

7. **Comment:** General, Apparently, six background samples were taken from Pickney Island and undeveloped southern portions of Parris Island. Please include a discussion of the basis for selecting these locations. Additionally, please include a figure identifying the exact locations of the samples.

Response: The location and description of the background samples are provided in Appendix A-12 of the report. The rationale for these locations is provided in the respective work plans, as modified during the partnering team meetings. The introduction to Section 4.0 will be revised to indicate that the background samples were biased clean to avoid nearby anthropogenic sources of contamination. The following table will be added to Appendix A-12.

Sample ID	Closest potential source of anthropogenic contamination
PAI-10-SS-15, PAI-10-SS-16, PAI-10-SS-17, PAI-10-SD-16 and PAI-10-SW-16	The MCRD Parris Island golf course located approximately 2,000 to 2,500 feet east of the samples.
PAI-10-SD-17, PAI-10-SW-17, PAI-10-SD-18, PAI-10-SW-18	An industrialized portion of the Depot, located approximately 1,500 feet north of the samples.
Samples collected at Pinckney Island	Pinckney Island is a nature reserve with no development within the vicinity of the background samples. The closest source of contamination is a road that is over 1,000 feet away from the samples.

8. **Comment** Page 4-3, Site 15, See comment # 4.

Response: See the response to comment #4.

9. **Comment:** Section 4.1.2, page 4-4, See comment #4.

Response: See the response to comment #4.

10. **Comment:** Table 4-1, A true background data set should not have any organic contamination. Since this data set appears to contain isolated detections of organics, the adequacy of this data as true background is in question. Additional data may be necessary. Please see comment #7.

Response: Disagree. The presence of infrequent detections of several organic compounds in these samples is not an indication of site related contamination. Rather these type of detections are common with any data set and result from anthropogenic, field sampling, and laboratory sources. Note that the organic detections are not used in background screening process.

Also, for site/SWMU boundary determinations, it is important to distinguish site related contamination from other sources. Otherwise, the boundary of a site/SMWU commonly becomes undefined.

11. **Comment:** Table 4-2, Please incorporate EPA Region III Residential RBCs into this table.

Response: Per the partnering team conference call conducted on July 31, 2000, human health and ecological screening criteria will be added to the tables of Section 4 due to the relatively few numbers of chemicals detected at Site 2. However, for future sites, the inclusion of this information will be decided on a site-by-site basis.

12. **Comment:** Section 4.2.1, page 4-4, Explain why the chloroform concentration of 2.9 • g/l was compared to the EPA Region III Tap-Water RBC rather than the MCL. The corresponding MCL for chloroform is 0.1 mg/l (100 • g/l); therefore, this detection is well below the MCL. With respect to groundwater, the Department typically reverts to the RBCs in the absence of an MCL.

Response: Since Section 4.0 presents the "Nature and Extent of Contamination", the criteria used in evaluate the data in this section were based on the most conservative realistic criteria available. For human health considerations, RBCs are generally more conservative than MCLs.

13. **Comment:** Figures, Include screening criteria including background concentrations, media specific human health and ecological screening values for comparison purposes. This will aid in identifying the magnitude of any exceedances.

Response: The intent of the figures in Section 4.0 was to provide a relatively simple overview of the data. Per the partnering team conference call conducted on July 31, 2000, human health and ecological screening criteria will be added to the figures of Section 4 due to the relatively few numbers of chemicals detected at Site 2. However, for future sites, the inclusion of this information will be decided on a site-by-site basis.

14. **Comment:** Section 4.5, page 4-9, Explain why only three subsurface soil samples were collected.

Response: The three samples were collected in accordance with the approved work plan. Three samples are more than sufficient to characterize a relatively uniform media. The approved work plan will be referenced in Sections 3.2.3 and 4.5.

15. **Comment:** Section 8.0, page 8-2, #3 (2nd bullet) and #4(1st bullet), It is claimed that the Bis-2 detections may be an artifact of laboratory analysis; however, there is no mention of Bis-2 detections in the blank sample. The analytical results (including the blank) must be incorporated into the document to support the determination as to whether or not Bis-2 is a result of laboratory contamination.

Response: The referenced information can be found in Appendix D. Page D-62, D96, and D115 are examples of blank detection.

16. **Comment:** Section 8.0, page 8-2, #4, 1st bullet, It can not be stated with certainty that non-carcinogenic toxic effects would not be anticipated when the hazard index slightly exceeds unity. Please revise the statement to say that non-carcinogenic toxic effects may not be anticipated due to only a slight exceedance of unity.

Response: The text will be revised as follows. "The associated hazard index for site contaminants did not exceed unity, indicating that ..."

17. **Comment:** Section 8.0, page 8-3, #6, 2nd and 3rd bullets, These conclusions drawn in these two paragraphs concerning metals with HIs greater than 1.0 but with concentrations less than background are contingent upon the acceptability of the background data set.

Response: The Navy believes that the quality of the background data set is adequate.

18. **Comment:** Section 8.0, page 8-3, #7, This section requests that SWMU 15 be removed from being considered a SWMU. This area will always be a SWMU. If an NFA determination is granted for this site, it will simply be a SWMU, which does not require any further action at this time. Additional information may become available in the future which may require re-evaluation of the site.

Response: Acknowledged. The second part of the sentence will be deleted.

19. **Comment:** Appendix C-3, The footnote should indicate the meaning of the blank sections in the analytical results spreadsheet.

Response: The following statement will be added to sheet C-29. " A blank indicates that the sample was not analyzed for that parameter.

20. **Comment:** Appendix E-3, The RBC table included in this appendix is over a year old. The most recent version of the table is dated April 13, 2000.

Response: Acknowledged. The human health risk assessment was conducted in spring of 1999 and submitted to the partnering team at that time. The April 2000 RBC tables were reviewed and do not have an impact on the findings of the report.

SB Comments on the SWMUs 2/15 RFI Report

1.) **Comment:** General Comment: Various sections throughout the document refer to previously collected samples. Please provide a map, preferable in an overlay format, showing all previously sampled locations as they relate to the most recent sample locations for sites 2 and 15.

Response: The location of the three groundwater monitoring wells are presented on Figure 3-1. Additionally, Figure 3-3 will be revised to show the surface water and sediment sample collected in 1988 and Figures 3-4 and 3-5 will be revised to show soil samples collected at Site 15 in 1995.

2.) **Comment:** Section 2.7, Ecology, Page 2-3, Paragraph 1: The text states that a discussion of the ecosystems present and endangered species can be found in the Site 3 RI/RFI or the IAS. All documents should be stand alone documents and not refer the reader to another report. It is not necessary to revise this document because site specific ecological information is provided; however, future reports should include summary information from the referenced text instead of referring the reader directly to another document.

Response: In order to minimize the size of these already large reports, it is the Navy's policy not to repeat redundant information, especially when the reports are final and readily available. Per discussion during the July 31, 2000 partnering team conference call, a reference to the ecological site summary contained within Section 7.0 will be added to Section 2.7

3.) **Comment:** General Comment : The text states in Section 3.0, Investigation Summary, that subsurface soil samples were collected from a depth interval of 0-1 foot bgs, and surface soil samples were collected from a depth of 6 feet bgs. Hand augers were used for the collection of some of the surface soil samples, but not for others. For risk assessment purposes, the surface soil interval should be defined as 0-1 foot bgs and the subsurface interval as any depth below 1 foot - the water table. Please clarify why these depth intervals were selected for the subsurface and surface soil samples, and the method of collection for each sample.

Response: In accordance with the work plan, a single soil sample was initially collected at the location of an off site monitoring well. This sample was targeted to be a subsurface sample location, but because of the depth to groundwater, the sample was collected at a 0-1 foot depth. In accordance with the work plan, the sample was identified as a subsurface soil sample. No surface soil samples were collected below 1 foot. The method of collecting the samples is provided in Section 3.2.6 and 3.2.3.

4.) **Comment:** Section 3.2.5, Sediment Sampling, Page 3-5, Paragraph 1: Three composite sediment samples were collected at Site 15. Composite samples can cause contaminant dilution and is not generally recommended for samples that will be used in risk calculations. Please provide more details in regards to the type of composite sampling method utilized and the rationale for the collection method.

Response: The sample was collected in accordance with the approved work plan. The composite sample method was recommended by the SCDNR for ecological purposes. As stated in Section 3.2.5, each of the three sediment samples (as shown on Figure 3-4) was composted from five collection points approximately 30 feet from the survey point and in a 100-foot line perpendicular to the shore. The three composite sediment samples were collected in road run-off depositional areas. Note that even though these samples were collected during an RI, the actual use of the data was to determine whether contamination was present. As a result, composite samples provide a more comprehensive approach to ensure that contamination is not missed.

5.) **Comment:** Section 4.1.2, Comparison of 1998 and 1996 Data, Page 4-4: This would be a good place to include the sample location map including current and historical data. Please refer to Comment 1.

Response: Please see the response to comment 1.

6.) **Comment:** Table 4-1, Page 4-11: Several parameters were not detected in the background data set and their respective concentrations were left blank in the table. Please include a less than symbol and the detection limit for each analyte that was not detected. Include the depth of the surface soil sample background interval in the Surface Soil column.

Response: The detection for each sample result was different and therefore a single number can not be presented. In general, any detection of these chemicals was considered potentially significant. Surface soils by definition are 0 to 1 foot.. As per discussion during the July 31, 2000 partnering team conference call, a range of detection limits will be placed in each of the blank spaces of Table 4-1.

7.) **Comment:** Table 4-4, Site 2-Groundwater Data, page 4-14: Groundwater data is compared to background surface water data because no site specific background data is available. When no site specific background information is available the best alternative is to use a similar on-base well that has not received any site influence. Although the groundwater to surface water discharge pathway is a valid route of contaminant migration, groundwater samples should not be compared to background surface water samples. Background samples should be compared only

to similar types of samples. For example, soil samples should only be compared to background soil samples of similar soil types and depths.

Response: The purpose of presenting the background surface water data is presented in a foot note to the table. As indicated, protection of surface water ecological receptors is the primary concern with groundwater from this site. The surface water data were not used as background for groundwater.

8.) **Comment:** Figure 4-5, Subsurface soil results map, Page 4-29: The map compares subsurface soil samples to RBCs for the human health risk screen. All soil samples below the 0-1 foot interval should be compared to SSLs.

Response: The subsurface data was compared to RBCs because the RBCs are more conservative and in the future, under an unrestricted use scenario, subsurface soils may be surface soils. This comparison was conducted as such because the Navy was pursuing a No Further Action for this site.

9.) **Comment:** Section 6.5.1.4. Retention of Bis(2-ethylhexyl) phthalate as a COPC, Page 6-27: The text suggests that bis(2-ethylhexyl) phthalate is not related to Site 2; however, this section fails to mention that it was detected in groundwater monitoring wells at Site 2. Please include information regarding groundwater contamination in this section of the text.

Response: Agreed, the paragraph will be revised to indicated BEHP was detected in both surface water and groundwater and that its detection in these media may overestimate site risks.

10.) **Comment:** Table 6-10, Chemicals Retained as COPCs at Site 2, Page 6-46: The table lists Benzo(b) fluoranthene as a COPC for the fish tissue pathway. This is inconsistent with the COPCs listed in 6.1.2.5 Shellfish Tissue Section. Please revise the table or text as needed.

Response: Benzo(b)fluoranthene is not a COPC for the fish tissue pathway and will be removed from Table 6-10.

11.) **Comment:** Table 6-11, Selection of Exposure Pathways, Page 6-47: The adolescent and adult recreational user receptors in the surface soil exposure medium lists none in the Type of Analysis column; however, the rationale states that the recreational users **may** be exposed to surface soil. Please clarify why the exposure pathways are eliminated since the rationale lists them as valid pathways.

Response: The rationale for the adolescent and adult recreational user is incorrect in Table 6-11. The rationale for adolescent and adult recreational users will be changed to "Adolescent and adult recreational users do not have significant contact with surface soil at the site."

12.) **Comment:** Table 6-11, Selection of Exposure Pathways, Page 6-49: The trespasser is listed as being evaluated quantitatively; however, the rationale states that access to the base is restricted. Please clarify.

Response: The Type of Analysis column for the adolescent trespasser exposed to sediment is incorrect in Table 6-11. The Type of Analysis for the adolescent trespasser exposed to soil will be changed to "none."

13.) **Comment:** Figure 6-1, Summary of Human Health RA Process, Page 6-65: The first diamond in the flow chart shows that if no chemicals were detected positively then no risk to potential receptors exists. This may not always be the case. On-site contamination may still be present in areas that have not yet been sampled or identified. The chart should be revised to say no known risk to potential receptors based on existing data.

Response: Figure 6-1 will be revised as suggested.

14.) **Comment:** Section 7.1, Overview of Methods, Step 1: Preliminary Problem Formulation, Page 7-1: The Preliminary Problem Formulation Section of the Ecological Risk Assessment states that a conceptual site model is developed. EPAs 8 Step ERA Process suggests that the conceptual site model be developed in Step 3 of the process. After the refinement of COPCs, a more thorough and realistic CSM can be developed. Assessment endpoints should be selected at this point of the ERA. If assessment and measurement endpoints are selected in the Preliminary Problem Formulation as discussed in Step 1 of the ERA, they should be referred to as **preliminary** assessment and measurement endpoints since they will most likely need to be refined in Step 3 of the process.

Response: Page 1-1 of EPA's 8-Step Process Document (EPA, 1997) explains how a conceptual model should be developed in Step 1 for the screening-level problem formulation, and further describes five issues that should be addressed at this stage (one of which is the selection of endpoints). This conceptual model is further refined in Step 3 for sites that proceed to that step. The Navy concurs that any endpoints selected in Step 1 should be thought of as *preliminary* endpoints, and that the conceptual model discussed in Step 1 is a *preliminary* conceptual model. This is why Section 7.2 of the RFI/RI for Site 2/15 is entitled "Preliminary Problem Formulation".

All sub-headings in that section are considered to be "preliminary" until (when applicable) they are further refined in Step 3. For the Site 2/15 assessment, the endpoints did not change in Step 3.

15.) **Comment:** Section 7.3.3.12, Other Potential Receptors, Page 7-14: The text states that aquatic invertebrates were eliminated from the food chain model due to the lack of toxicity data. Although aquatic invertebrate data is limited, bioaccumulation studies of oysters have been conducted at the University of South Carolina. Due to the limited contamination detected at Sites 2 and 15, it is not necessary to reopen the literature search as part of this RFI. Future assessments should include a thorough literature search to prevent the exclusion of risk evaluations of aquatic invertebrates.

Response: Any sources of information, points-of-contact, etc. regarding the studies mentioned in the comment would be greatly appreciated.

16.) **Comment:** Section 7.9.1, Uncertainty in the Preliminary Problem Formulation, Page 7-31: The text states that contaminant concentrations may have resulted from non-Navy sources. Proper sampling strategy and the placement of adequate control/background samples should eliminate or reduce this uncertainty.

Response: The Navy concurs that proper sampling strategy and the placement of adequate reference/background samples should *reduce* the uncertainty regarding whether or not contamination is site-related. However, it is difficult (if not impossible) to totally *eliminate* this uncertainty when samples are collected in rivers and tidally influenced areas.

DH Comments on SWMUs 2 and 15 RFIs.

1, **Comment:** The Division of Hydrogeology has reviewed the above referenced document, dated 23 December, 1999. This document was received on 14 January, 2000. It provides physical descriptions of Site 2 and Site 15 that include the histories of these two sites. It briefly describes previous studies performed at these sites, and presents analytical data generated during this current RI/RFI.

This document was reviewed with respect to R.61-79 of the South Carolina Hazardous Waste Management Regulations (SCHWMR), and appropriate guidance documents.

The Division of Hydrogeology found this report well written, easy to follow, and very informative. It is recommended that this document can be approved as written. The Tier I Team should meet to discuss the path forward for SWMUs 2 and 15.

Response: Acknowledged.

SCDNR Review of Draft RCRA Facilities Investigation/Remedial Investigation for Site/SWMU 2 - Borrow Pit Landfill and Site/SWMU 15 - Dirt Road

1. **Comment:** Based on the information presented in the Draft RCRA Facilities Investigation/Remedial Investigation Report for Site/SWMU 2 - Borrow Pit Landfill and Site SWMU 15 - Dirt Road, the SCDNR concurs with the recommendation of No Further Action for this site. However, we have the following specific comments that should be addressed:

   Response: Acknowledged.

2. **Comment:** **p. ES-5** In the last sentence it is stated that "fish do not reside at this site". Unless there is site-specific data to support this conclusion, this statement should be deleted. Many species of estuarine fishes utilize shallow subtidal and intertidal habitats during at least a portion of each tidal cycle. The absence of water at low tide should not be interpreted to mean that "fish do not reside at this site".

   Response: Concur. The sentence will be revised as requested.

3. **Comment:** **p. 7-3** Benthic and nektonic invertebrates (e.g., oysters, shrimp, blue crab, fiddler crabs, etc.) should be added to the list of potential ecological receptors at Site 2.

   Response: The fifth paragraph of Section 7.2.1 (page 7-3) currently states that the tidal inlet provides habitat for mollusks and crustaceans. However, the sixth paragraph of that section, which provides examples of species presumably occurring in the inlet, will be revised to include the organisms in the reviewer's comment.

EXECUTIVE SUMMARY

PURPOSE AND OBJECTIVES OF REPORT

This Remedial Investigation (RI)/RCRA Facility Investigation (RFI) report summarizes the field activities and results for the Borrow Pit Landfill (Site 2/Solid Waste Management Unit [SWMU] 2) and Site/SWMU 15 – Dirt Roads located at the Marine Corps Recruit Depot (MCRD) Parris Island, South Carolina. The report encompasses the 1998 and 1999 activities and also references previous investigations, as relevant. The historical activities include an Initial Assessment Study in 1986, a Verification Step in 1990, and an Interim RCRA Facility Assessment in 1990. This RI/RFI report describes the collection of soil, sediment, surface water, and groundwater samples in accordance with the RI/RFI Work Plan, evaluates the analytical data, assesses human health and ecological risks, and provides recommendations.

HISTORICAL INFORMATION

MCRD Parris Island is located along the southern coast of South Carolina, approximately 1 mile south of the city of Port Royal and 3 miles south of the city of Beaufort within Beaufort County. MCRD Parris Island covers approximately 8,047 acres that consist of dry land, salt marshes, saltwater creeks, and ponds. MCRD Parris Island is the reception and recruit training facility for the Marine Corps for enlisted men from states east of the Mississippi River and for enlisted women nationwide.

Site 2, Borrow Pit Landfill, is a landfill. It is located in the central portion of Horse Island, in the north section of MCRD Parris Island. The southwestern border of the landfill is located approximately 100 feet from a marsh area. The landfill occupies approximately 1.9 acres and is currently covered with mature pine trees.

In the 1960s, Site 2 consisted of a pit that had been dug to provide fill dirt for the base. From 1966 to 1968, the landfill reportedly served as the disposal site for domestic trash, construction debris, solid paint wastes, cleaning rags (contaminated with oil, mineral spirits, and kerosene), spent absorbent, solvent sludge (aliphatic petroleum and chlorinated solvent compounds), perchloroethylene (PCE) still bottoms, metal shavings, polychlorinated-biphenyls (PCB)-contaminated oil, mercury amalgam, and beryllium wastes from the MCRD. The 1986 Initial Assessment Study indicated that an estimated 33,000 tons of solid waste refuse and 16 tons of solid paint wastes were disposed in this landfill during the period of operation. Liquid paint wastes including thinners (mineral spirits, kerosene, and diesel fuel) and a stripper (methylene chloride) were reportedly also brought to this landfill by paint shop personnel and burned. Since 1968, no documented significant disposal or intrusive activities have taken place at Site 2.

Site 15 is approximately 0.5 mile of dirt road accessing the Borrow Pit Landfill and 1.5 miles of dirt road accessing Elliot's Beach. In the past, the MCRD routinely sprayed the Depot's dirt and gravel roads with oils to reduce dust. From about 1918 until 1966, waste lubricating oil, cutting oil, petroleum-based solvents (kerosene, gasoline, mineral spirits), hydraulic fluids, and water-based coolants were transported by roads and grounds personnel from various Depot shops and sprayed for dust suppression. From 1918 to 1940, an estimated 11,000 gallons were sprayed on all Depot roads, the majority of which was applied during the 1930s. Most of the Depot roads were paved in the 1940s. However, from the early 1940s to 1966, approximately 16,200 gallons of waste oils and hydraulic fluids continued to be applied to the dirt roads accessing Elliot's Beach and the Borrow Pit Landfill. Most of the dirt road accessing Elliot's Beach was recently paved and only 0.25 mile of dirt road remains.

The RI/RFI field investigation was conducted from May 1998 to September 1998 and in October 1999 and included sampling of soils, surface water, sediment, and groundwater, test pitting operations, and establishment of background conditions. The purpose of these activities was to characterize the nature and extent of contamination at Sites 2 and 15 where the potential for off-site migration exists. Both human health and ecological risk assessments are included in this report to support site decisions.

Data collected during the investigation have been entered into a database. The database was used in this report to support the risk assessments, including the comparison of analytical results to state and federal standards and to background levels. Data evaluation and recommendations for Sites 2 and 15 are included herein. Data validation on these data consisted of either a data review or a full data validation. The full data validation was performed on approximately 10 percent of the data packages received from a laboratory. All analytes were covered by at least one full data validation. A data review was performed on the remaining data packages for the purposes of identifying false positive and negative results.

INVESTIGATION SUMMARY

During the RI/RFI investigation, groundwater, surface soils, sediment, and surface water samples were collected and analyzed for TCL/TAL and other selected parameters (e.g. geotechnical properties). Select samples were analyzed for Appendix IX constituents. 1998 field activities at Sites 2 and 15 include the following:

- 2 groundwater monitoring wells were installed and developed (1 shallow and 1 deep)
- 5 groundwater samples were collected from three existing and the two new monitoring wells using low flow sample techniques
- A tidal influence study was conducted using the monitoring wells and surface water bodies

- Slug tests were conducted on each well to determine hydraulic parameters
- 4 surface water samples were collected
- 7 sediment samples were collected
- 15 surface soil samples were collected
- Sample locations were surveyed to establish horizontal and vertical control

1999 field activities at Site 2 include the following:

- Test pitting operations were performed at 17 locations
- 3 subsurface soil samples were collected from selected test pits

SITE GEOLOGY/HYDROGEOLOGY RESULTS

The Borrow Pit soils located at Site 2 and the adjacent Site 15 dirt road represent areas where soils have been removed by man for use as fill material. The removed soils may include surface soil, subsoil, and in some instances substratum.

Soils collected from the Borrow Pit Landfill during the 1998 and 1999 field events consisted of fine to medium sands with a varying silt content, as confirmed by the lithologic descriptions during the sampling events. Rust-colored soils indicating possible fill material was encountered at several Site 2 sample locations at a depth of 1 foot to 6.5 feet below ground surface (bgs). Subsequent test pitting sampling did not find evidence of remaining waste. Sediment samples collected from the tidal inlet area consist of silts overlying sand and shells, coarse sand and shells, and silty sands. The Site 15 dirt road soils consisted of fine sand with varying silt and shell content. Sediment samples collected at Site 15 consisted of fine sands with a varying silt and clay content and sandy silts and clays.

Subsurface materials at Site 2 were classified from the drilling of one soil test boring during the TtNUS field investigation, the soil logs for the existing wells, test pits, and the hand-auger borings collected within the Site 2 facility. Generally, the shallow subsurface geology inland of the tidal inlet consists of silty sand to a depth of approximately 25 feet bgs and sand with varying clay content to a depth of approximately 30 feet bgs. The subsurface geology along Archers Creek consists of predominantly fine to medium sand with a varying clay content to the termination of the boring at 48 feet bgs. A clayey, fine to coarse sand was encountered from 36 to 40 feet bgs that seems to correspond with the confining unit encountered at a site located approximately 2,000 feet northeast of Site 2.

Based on water-level measurements, the shallow water table occurs at depths across the site ranging from 3.5 to 14.5 feet bgs. The saturated thickness of the surficial aquifer ranges from 21.5 to 32.5 feet.

Within the borrow pit, groundwater was encountered in the hand-auger borings and test pits at depths from 2.5 to 8 feet bgs. Within the vicinity of the topographically upgradient monitoring wells, groundwater was encountered at depths from 12.1 to 14.5 feet bgs.

Recharge of the shallow aquifer beneath the site is likely to occur primarily through infiltration of precipitation inland of the tidal inlet. Groundwater flow is generally toward the west-northwest, although groundwater near the marsh appears to flow toward the adjacent tidal inlet. Based on the groundwater elevation data collected during this field event, the vertical gradient within the surficial aquifer is downward. Site 2 is located within the 100-year flood plain.

Slug tests were performed. The geometric average hydraulic conductivity for the shallow surficial aquifer wells was calculated to be 1.13 feet per day (3.99×10^{-4} cm/sec). The deep surficial well conductivity was determined to be 3.08 feet per day (1.08×10^{-3} cm/sec). The values for the shallow and deep wells are within the typical range of hydraulic conductivity for clayey, silty sands, silts, and sandy silts

The upper surficial is general divided from the lower Floridan Aquifer by the Hawthorn Formation, which acts as a confining unit. The Hawthorn Formation is a phosphatic sand and clay unit with a reported thickness of approximately 2 to 40 feet in the study area.

The Floridan Aquifer, which underlies the site, extends continuously from South Carolina into Florida. Groundwater of this aquifer occurs mainly under artesian conditions at MCRD Parris Island. The Floridan aquifer is the most important source of groundwater in the Low Country area, and wells generally less than 250 feet deep tap this aquifer system. The aquifer is the only source of potable groundwater west, north, and east of MCRD Parris Island.

NATURE AND EXTENT OF CONTAMINATION

Wastes were allegedly disposed of at Site 2. In addition, a review of aerial photographs indicates that the site was disturbed at the reported time of disposal. However, hand borings and test pits were conducted as part of RI/RFI activities to determine whether waste materials are present at the site. The only evidence of waste at Site 2 was the presence of visually stained soils near the water table. The stained soils may be of natural origin. Furthermore, surface and subsurface soil and sediment at Site 2 were found not to contain chemicals in excess of those found in background media and the most stringent of residential human health RBCs or ecological screening values.

Surface soils and sediments at Site 15 were found to contain two isolated detections of chemicals in excess of the background media and the most stringent human health RBCs (residential) or ecological screening values. Bis(2-ethylhexyl) phthalate was detected in one sediment sample at a concentration of

1.5 times the U.S. EPA Region IV Ecological Screening Level. Similarly, PCBs were detected in one sediment sample (from a previous sample event) at a concentration of 1.2 times the U.S. EPA Region IV Ecological Screening Level.

Several metals, one volatile organic compound, and one semi-volatile organic compound were detected in Site 2 groundwater at concentrations in excess of the most stringent human health RBCs (residential) or ecological screening values. These results are summarized as follows.

- Chloroform, arsenic and thallium were the only chemicals detected in site groundwater at concentrations that could result in potential risk to human health. Chloroform was detected in 1 of 5 wells, arsenic in 3 of 5 wells, and thallium in 2 of 5 wells. This evaluation assumes that site groundwater would be used as a potable water supply. However, the maximum concentration of arsenic and chloroform detected were actually less than the U.S. EPA MCLs, indicating that risks from these chemicals are within acceptable U.S. EPA ranges. Thallium was detected at concentrations greater than MCLs. However, the maximum concentration of thallium was detected in an upgradient monitoring well indicating that thallium is not site related contamination. Also, the presence of an adjacent salt water preclude potable use of site groundwater.

- Aluminum, iron, copper, zinc, and bis(2-ethylhexyl) phthalate were the only chemicals identified in the site groundwater at concentrations exceeding established ecological criteria. This evaluation assumes that the groundwater seeps into the adjacent surface water, mixing does not occur in the surface water, and that the most sensitive receptor is continuously exposed to the seep. Under this scenario, the maximum hazard quotient would be approximately 12 (for aluminum). However, with the exception of bis (2-ethylhexyl) phthalate, none of these chemicals were detected in the adjacent surface water at concentrations greater than ecological screening levels. Since bis(2-ethylhexyl) phthalate is a common laboratory artifact and it was detected in background surface water samples at higher concentrations than detected at this site, it may not be a site contaminant.

Two metals and one semi-volatile organic compound were detected in Site 2 surface water at concentrations in excess of the most stringent human health RBCs (residential) or ecological screening values. These results are summarized as follows.

- Bis(2-ethylhexyl) phthalate (2 of 4 samples) and arsenic (1 or 4 samples) were detected in the surface water at concentrations that represent a potential threat to human health. The potential threat to human health conservatively assumes potable use of the saline water and regular consumption of fish living at the site. Actual threats would be less since salt water is not used for drinking water

- Silver was detected in two of four surface water samples and was the only chemical detected at concentrations in excess of the most stringent surface water ecological screening values. The hazard quotient for silver was four. However, the maximum detected concentration of silver was less than the associated ambient water quality criteria.

HUMAN HEALTH RISK ASSESSMENT SUMMARY

The initial human health screening determined that surface soils and sediments at Sites 2 and 15 do not represent a potential threat to human health under the most stringent screening criteria.

A site specific risk assessment was conducted which evaluated potential risks to on-site residents, construction workers and adolescent and adult recreational users. Thallium was the only groundwater chemical detected at concentrations greater than MCLs and the most stringent human health RBCs (residential). However, the site specific risk assessment, did not identify thallium as a threat to human health.

Several chemicals were detected in site surface water at concentrations greater than background and the most stringent human health screening criteria. The site specific human health risk values were greater than $1x10^{-6}$ but were less than $1x10^{-4}$. This value is within the acceptable U.S. EPA target risk range. The associated hazard index did not significantly exceed unity, indicating that non-carcinogenic toxic effects would not be anticipated.

Potential threats to human health associated with consumption of oysters in the nearby Archers Creek were considered. Conservative estimates of potential oyster concentrations were calculated using maximum surface water and sediment data from Site 2 and assuming equilibrium partitioning between these media and the oysters. PAHs and hexavalent chromium in site sediments were identified as potential concerns. The results of the risk assessment found that potential risks were greater than $1x10^{-6}$, but were less than $1x10^{-4}$. This value is within the acceptable U.S. EPA target risk range. The associated hazard index did not exceed unity, indicating that non-carcinogenic toxic effects would not be anticipated. Also, based on this conservative modeling, exceedances of U.S. FDA values would not be expected.

ECOLOGICAL RISK ASSESSMENT SUMMARY

The food chain modeling for Site 15 terrestrial receptors found that under the most conservative assumptions, Arochlor-1254 in surface soils results in a HQ of 1.0 (NOAELs) for the shrew. Hazard quotients for the other terrestrial receptors under this scenario did not exceed unity. These conservative assumptions assume that the shrew is exposed to the maximum concentration for its whole life. Under a

more realistic scenario that is based on mean chemical concentrations, adverse risks to terrestrial receptors are not expected.

The food chain modeling for Site 15 aquatic receptors (Elliot's Beach) found that under the most conservative assumptions, aluminum, iron, and vanadium in sediments result in hazard quotients greater than 1.0 for at least one receptor. However, the maximum concentrations of these metals in sediments are less than background values, indicating that these detected metals are not site-related contamination.

The food chain modeling for Site 2 terrestrial and aquatic receptors found that under the most conservative assumptions, aluminum, iron, and vanadium result in hazard quotients greater than 1.0 for one or more receptors. However, the maximum concentrations of these metals were less than background values, indicating that these metals are not site-related contamination.

RECOMMENDATIONS

The analytical data for Site 15 is adequate to demonstrate that there is no significant risk to human health and ecological receptors. As a result, a no further action should be pursued.

Test pitting operations did not find evidence of waste remaining at Site 2. Furthermore, the analytical data for Site 2 is adequate to demonstrate that there is no significant risk to human health and ecological receptors at the site under the current conditions. Remediation of surface soils, sediments, surface water, and groundwater is not required and no further action is recommended.

1.0 INTRODUCTION

1.1 PURPOSE OF REPORT

Tetra Tech NUS, Inc. (TtNUS) has prepared this remedial investigation (RI)/RCRA Facility Investigation (RFI) report summarizing field activities conducted at Site 2/Solid Waste Management Unit (SWMU) 2 – Borrow Pit Landfill and Site/SWMU 15 – Dirt Roads, located at the Marine Corps Recruit Depot (MCRD) Parris Island, South Carolina. This report was prepared for the United States Navy (Navy) Southern Division (SOUTHDIV) Naval Facilities Engineering Command (NAVFAC) under Contract Task Order (CTO) 0020, for the Comprehensive Long-Term Environmental Action Navy (CLEAN) III Contract Number N62467-94-D-0888.

1.2 REGULATORY SETTING

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Superfund Amendments and Reauthorization Act of 1986 (SARA) established a program for the cleanup of hazardous waste disposal and spill sites nationwide. This program contains provisions for the cleanup of contamination from past hazardous waste operations and past hazardous material spills and is the framework for Installation Restoration (IR) Programs at Navy and Marine Corps installations. The Resource Conservation and Recovery Act (RCRA), as amended, also establishes a clean-up program that provides for current and future hazardous waste management practices, as well as cleanup of past disposal sites at permitted or interim status Navy/Marine Corps installations. SOUTHDIVNAVFAC has the responsibility for implementing the Navy's IR Program at MCRD Parris Island.

Because of the past hazardous waste activities conducted at MCRD Parris Island, South Carolina, the MCRD meets criteria for conducting IR activities under the CERCLA regulatory framework. To date, the MCRD has completed steps equivalent to the preliminary assessment/site inspection phases of the CERCLA remedial action process at Site/SWMU 2 and Site/SWMU 15. The MCRD also meets the criteria for conducting IR activities under the authority of RCRA because, in 1980, the MCRD submitted a RCRA Part A application. Per RCRA, this action required the MCRD to conduct corrective action for the release of hazardous waste or hazardous constituents from SWMUs. An interim RCRA Facility Assessment (RFA) was conducted in 1990 as part of this requirement. Since this time, the MCRD has withdrawn its Part A application.

Because of the circumstances surrounding the MCRD's IR Program history, discussions have been held among representatives from the U.S. Marine Corps, U.S. Navy, South Carolina Department of Health and Environmental Control (SCDHEC), and the United States Environmental Protection Agency (U.S. EPA),

Region IV to determine the appropriate regulatory framework for conducting IR activities at the MCRD. From these discussions, it has been decided that this report will encompass both CERCLA and RCRA requirements and the title, RI/RFI, reflects this decision. For ease of reading and clarity, Site/SWMU 2 will be referred to as Site 2 and Site/SWMU 15 will be referred to as Site 15 for the remainder of this document.

1.3 SCOPE OF RI/RFI

The 1998 RI/RFI field investigation was conducted from May 1998 to September 1998 and in October 1999. Field activities at Site 2 included sampling of soils, surface water, and sediment, as well as an investigation of site groundwater. The purpose of these activities was to characterize the nature and extent of contamination at Site 2 where the potential for off-site migration exists from past landfilling activities. Additionally, a test pitting program was conducted at Site 2 to determine if waste material was present at Site 2. Field activities at Site 15 included sampling of surface soil and sediment to determine whether past dust-suppression activities have impacted dirt roads at the Depot. Both human health and ecological risk assessments are included in this report to support site decisions.

Data collected during the investigation have been entered into a database. The database was used in this report to support the risk assessments, including the comparison of analytical results to state and federal standards and to background levels. Data evaluation and recommendations are included herein. Data validation on these data consisted of either a data review or a full data validation. The full data validation was performed on approximately 10 percent of the data packages received from a laboratory. All analytes were covered by at least one full data validation. A data review was performed on the remaining data packages for the purposes of identifying false positive and negative results.

1.4 HISTORICAL INFORMATION

1.4.1 Facility Background

MCRD Parris Island is located along the southern coast of South Carolina, approximately 1 mile south of the city of Port Royal and 3 miles south of the city of Beaufort within Beaufort County. MCRD Parris Island covers approximately 8,047 acres that consist of dry land, salt marshes, saltwater creeks, and ponds, as shown in Figure 1-1. MCRD Parris Island is the reception and recruit training facility for the Marine Corps for enlisted men from states east of the Mississippi River and for enlisted women nationwide.

1.4.2 Background and History

Site 2 – Borrow Pit Landfill

Site 2, Borrow Pit Landfill, is a landfill that was in operation from 1966 to 1968. It is located in the central portion of Horse Island, in the north section of MCRD Parris Island, as shown in Figure 1-2. The southwestern border of the landfill is located approximately 100 feet from a marsh area. The landfill occupies approximately 1.9 acres and is currently covered with mature pine trees.

In the 1960s, Site 2 consisted of a pit that had been dug to provide fill dirt for the base. When waste disposal at the Borrow Pit Landfill was initiated, the unlined pit consisted of a hole approximately 10 feet deep. The 1986 Initial Assessment Study indicated that from 1966 to 1968, the landfill served as the disposal site for domestic trash, construction debris, solid paint wastes, cleaning rags (contaminated with oil, mineral spirits, and kerosene), spent absorbent, solvent sludge (aliphatic petroleum and chlorinated solvent compounds), perchloroethylene (PCE) still bottoms, metal shavings, polychlorinated-biphenyls (PCB)-contaminated oil, mercury amalgam, and beryllium wastes from the MCRD. An estimated 33,000 tons of solid waste refuse and 16 tons of solid paint wastes were reportedly disposed in this landfill during the period of operation. Most of the wastes were located in the central and eastern portions of Site 2 (Naval Energy and Environmental Support Activities, NEESA, September 1986). Liquid paint wastes including thinners (mineral spirits, kerosene, and diesel fuel) and a stripper (methylene chloride) were also reportedly brought to this landfill by paint shop personnel and burned. During the 3-year period, approximately 2,800 gallons of liquid paint wastes may have been burned annually in this landfill (NEESA, September 1986). The landfill was the facility's primary landfill after the termination of operations at the Site/SWMU 1 - Incinerator Landfill and the temporary suspension of operations at the Site/SWMU 3 - Causeway Landfill. When the landfill operations were terminated, the pit was believed to be approximately half filled with wastes and approximately 6 feet deep. Since 1968, no documented significant disposal or intrusive activities have taken place at Site 2.

Appendix G of the report contains four aerial photographs of Site 2 from 1945, 1955, 1965, and 1972. No development within the vicinity of Site 2 is observed in the 1945 photograph. In 1965, surface water is observed within the present day boundary of Site 2, indicating that borrow soil had likely been removed from the area. By 1972, the existing dirt road surrounding Site 2 is observed and reforestation of the site is noted indicating that operations had ceased within the boundaries of Site 2 by this time.

Site 15 – Dirt Roads

Site 15 is approximately 0.5 mile of dirt road and accessing the Borrow Pit Landfill (Figure 1-2) and 1.5 miles of dirt road accessing Elliot's Beach (Figure 1-3). In the past, the MCRD routinely sprayed the

Depot's dirt and gravel roads with oils to reduce dust. From about 1918 until 1966, waste lubricating oil, cutting oil, petroleum-based solvents (kerosene, gasoline, mineral spirits), hydraulic fluids, and water-based coolants were transported by roads and grounds personnel from various Depot shops and sprayed for dust suppression. From 1918 to 1940, an estimated 11,000 gallons were sprayed on all Depot roads, the majority of which was applied during the 1930s. Most of the Depot roads were paved in the 1940s. However, from the early 1940s to 1966, approximately 16,200 gallons of waste oils and hydraulic fluids continued to be applied to the dirt roads accessing Elliot's Beach and the Borrow Pit Landfill. Most of the dirt road accessing Elliot's Beach was recently paved and only 0.25 mile of dirt road remains.

1.4.3 Previous Site 2 Investigations

Several investigations conducted at MCRD Parris Island have included Site 2. Based on the results of past investigations, it was determined that further evaluation was needed and a recommendation was made to conduct an RI/RFI. These earlier investigations are as follows.

Initial Assessment Study

In 1986, the Naval Energy and Environmental Support Activity (NEESA) conducted an initial assessment study (IAS) (NEESA, 1986) under the Naval Assessment and Control of Installation Pollutants (NACIP) Program. The IAS is equivalent to the preliminary assessment phase of the CERCLA process. The purpose of the IAS (Phase I of the NACIP Program) was to identify potentially contaminated sites at MCRD Parris Island that may pose a threat to human health or the environment. The IAS concluded that horizontal migration to the tidal inlet was likely and recommended further investigation to assess potential long-term impacts to human health and the environment. The study recommended NACIP Phase II (Verification Step) field activities be conducted at the site.

Verification Step

Based on the recommendations of the IAS, McClelland Consultants conducted a Verification Step (VS) (McClelland, 1990) at Site 2. The purpose of this investigation was to perform limited sampling and investigations at sites identified by the Navy for evaluation of potential environmental contamination. During this investigation (between February 1988 and March 1988), three soil borings and three monitoring wells were installed around the landfill, and one surface water/sediment sample was collected in the basin just west of the landfill (see Figures 3-1 and 3-3 in Section 3.0).

The groundwater samples and the surface water sample were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, PCBs, and dissolved metals (arsenic,

barium, beryllium, cadmium, chromium, lead, mercury, selenium, silver). The sediment sample collected at this site was analyzed for VOCs, SVOCs, pesticides, PCBs, total metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver), and EP toxic metals (arsenic, cadmium, chromium, lead, and mercury).

Chloroform was detected at a concentration of 12 µg/L in a groundwater sample collected northeast of the landfill. Additionally, 1,2-dichloroethane was detected at a concentration of 20 µg/L south of the landfill. No other organic priority pollutants were identified in the groundwater samples. Dissolved chromium (0.10 µg/L), lead (0.073 mg/L), arsenic (0.007 mg/L), and barium (0.14 mg/L) were also detected in the groundwater.

Dissolved cadmium (0.083 mg/L), chromium (0.14 mg/L), and lead (0.025 mg/L) were detected in the surface water sample collected at the site. The shallow sediment sample identified chloroform at a concentration of 81 µg/kg, as well as arsenic (9.59 mg/kg), barium (3.0 mg/kg), chromium (3.11 mg/kg), and lead (4.81 mg/kg). Several of these results exceed U.S. EPA Region IV Waste Management Division Saltwater Surface Water and Sediment Screening Values. These exceedances are listed as follows.

Metal	SW Screening Value (µg/L)	Sediment Screening Value (mg/kg)
Arsenic	(NE)*	7.24
Cadmium	9.3	(NE)*
Chromium	103	(NE)*
Lead	8.5	(NE)*

* NE - Region IV screening value not exceeded

In the study, Site 2 was recommended for a detailed RI based on the presence of 1,2-dichloroethane above maximum contaminant levels (MCLs), chloroform in the groundwater, and chloroform in the sediment sample collected from the marsh west of the site. No federal standard existed for chloroform in sediment. Additional work was also recommended based on the presence of dissolved lead, chromium, and cadmium in the groundwater and surface water above their respective U.S. EPA Interim Primary Drinking Water Standards.

Interim RCRA Facility Assessment

An interim RFA was performed from January 1990 through March 1990. The RFA (Kearney, 1990) was based on the results of a Preliminary Review (PR) of the U.S. EPA Region IV and SCDHEC files and the VS. An RFI was suggested for Site 2 due to the past detections of contaminants in sediment, surface water, and groundwater and because the site is located in the vicinity of a state of South Carolina shellfish harvest area.

1.4.4 Previous Site 15 Investigations

Several investigations conducted at MCRD Parris Island have included Site 15. Based on the results of past investigations, it was determined that further evaluation was needed and a recommendation was made to conduct an RI/RFI. These earlier investigations are as follows.

Initial Assessment Study

In the IAS (NEESA, 1986), Site 15 was not recommended for a VS. The IAS concluded that evaporation and biodegradation would have been responsible for reducing the volume of waste oil and other fluids migrating through the surface soils in these areas. Additionally, the IAS concluded that contaminant migration to the groundwater via infiltration was unlikely. However, because MCRD Parris Island had been placed on the National Priorities List (NPL), the regulatory agencies determined that sampling for PCBs and lead should be conducted to evaluate potential concerns from spraying waste oils.

Interim RCRA Facility Assessment

In the RFA (Kearney, 1990), Site 15 was recommended for RFA Phase II sampling. This recommendation was based on the detection of contaminants in soil resulting from past management practices conducted at the Depot.

Relative Risk Evaluation

During December 1995, two surface soil samples were collected at Site 15 - Dirt Roads in support of the Relative Risk Evaluation of potential sites at multiple Navy facilities (see Figures 3-4 and 3-5 in Section 3.0). A Technical Memorandum was prepared to provide the sampling rationale and the analytical results of the sample collection conducted at the various Naval Activities throughout the SOUTHDIV area of responsibility (B&R Environmental, 1996). All samples were analyzed for Target Analyte List (TAL) metals, cyanide, Target Compound List (TCL) pesticides and PCBs, TCL VOCs, and TCL SVOCs. One surface soil sample was collected at the dirt roads located near Site 2 - Borrow Pit Landfill where metals, di-n-butyl phthalate, three VOCs, pesticides, and one PCB (Aroclor 1254) were detected. In addition, a surface soil sample was collected at the dirt road accessing Elliot's Beach in which metals, di-n-butyl phthalate, two VOCs, and two pesticides were detected. Of the compounds detected, arsenic, beryllium, and iron were detected in the soil above their respective U.S. EPA Region III risk-based concentrations (RBCs) for soil ingestion (residential). Analytical results from this testing are provided in Appendix C.

1.5 REPORT ORGANIZATION

This report is divided into eight sections. Section 1.0, Introduction, provides historic information about MCRD Parris Island and Sites 2 and 15. Section 2.0, Environmental Setting, provides geological and geographical information about MCRD Parris Island and the surrounding areas. Section 3.0, Investigation Summary, summarizes the sampling program and presents the Site 2 geology and hydrogeology based on the field results. Section 4.0, Nature and Extent of Contamination, addresses the nature and extent of site contamination for all media investigated. Section 5.0, Contaminant Fate and Transport, is a reference-like section describing the chemical and physical properties of the analytes positively detected at Site 2. Section 6.0, Human Health Risk Assessment, and Section 7.0, Ecological Risk Assessment, present the methodology and results of the human health and ecological risk assessments, respectively. Section 8.0, Conclusions, focuses on the magnitude of site-related risks and remedies, if any, to address those risks. Appendices A through G provide support documentation for the field investigation and supplemental information for the evaluation of results.

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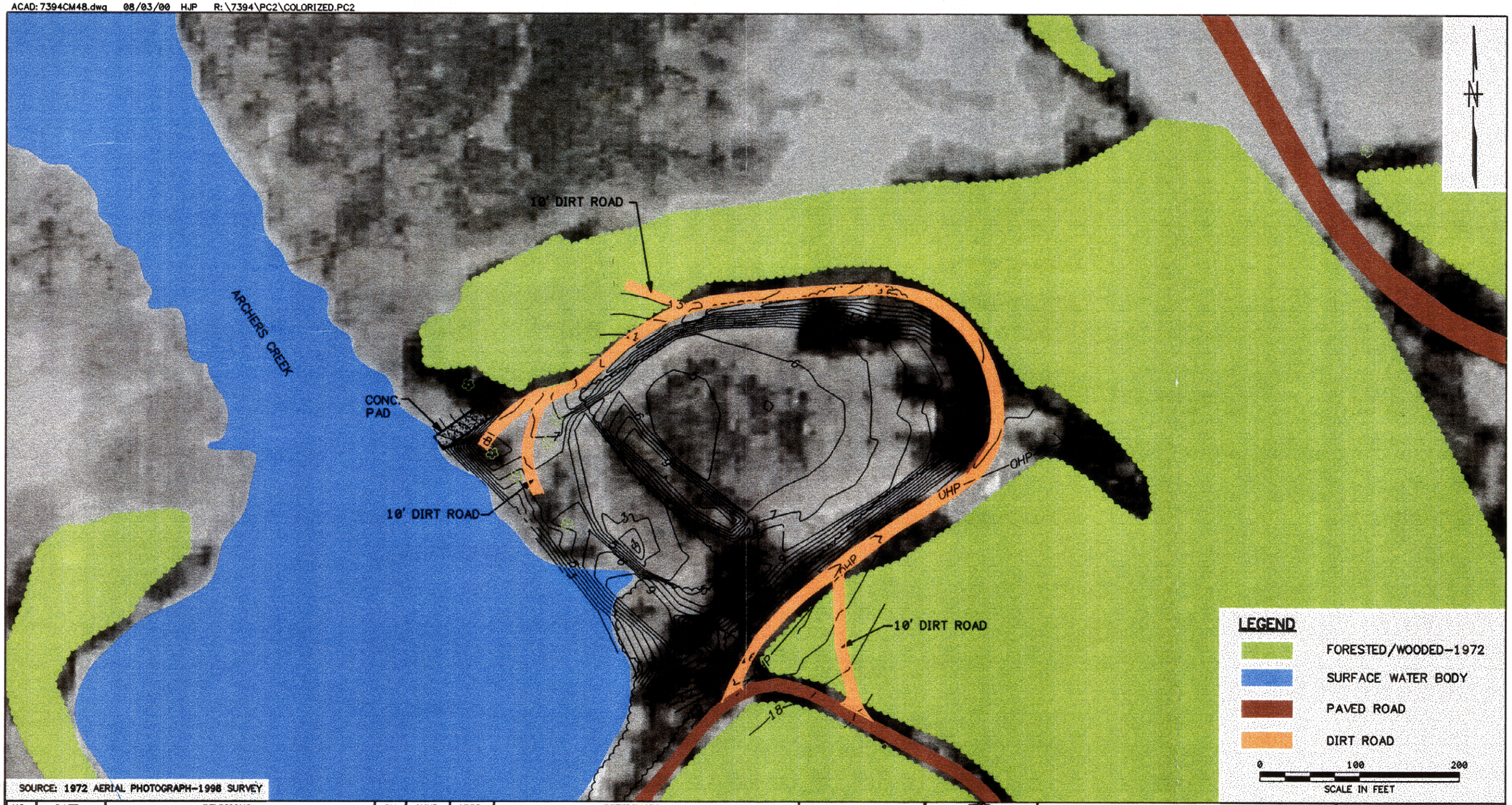
SOURCE: USGS 7.5 MINUTE PARRIS ISLAND QUADRANGLE, 1956. PHOTOREVISED 1979.

DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER	OWNER NO.
D. PERRY	16-MAR-99		7394	—
CHECKED BY	DATE	DEPOT LOCATION MAP MCRD, PARRIS ISLAND, SOUTH CAROLINA	APPROVED BY	DATE
—	—		—	—
COST/SCHEDULE-AREA			APPROVED BY	DATE
			—	—
SCALE			DRAWING NO.	REV
AS NOTED			FIGURE 1-1	0

P:\GIS\MCRD_PARRISISLAND\PARRIS.APR 16-MAR-99 DNP DEPOT LOCATION - SITE 2/15 LAYOUT

170 A B01

ACAD: 7394CM48.dwg 08/03/00 HJP R:\7394\PC2\COLORIZED.PC2



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY MF DATE 3/22/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

SITE LAYOUT
SITE 2 – BORROW PIT LANDFILL
AND SITE 15 – DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 1-2
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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SOURCE: U.S.G.S. 7.5 MINUTE PARRIS ISLAND QUADRANGLE, 1956, PHOTREVISED 1979.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY MF DATE 3/22/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

SITE LAYOUT
SITE 15-DIRT ROADS AT ELLIOT'S BEACH
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 1-3
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

2.0 ENVIRONMENTAL SETTING

This section contains general information relative to the environmental setting common to all the sites currently under investigation at MCRD Parris Island. A comprehensive discussion of the environmental setting at the MCRD can be found in the RI/RFI report for Site/SWMU 3 (TtNUS, 1999) or the IAS (NEESA, 1986).

2.1 CLIMATE

MCRD Parris Island is in the southernmost region of South Carolina, where the climate is milder than elsewhere in the state. This low-lying coastal area has numerous islands, inlets, streams, and marshes and a temperature regime that clearly reflects the influences of its maritime and southerly location. The climate is subtropical, with long and hot summers followed by short and mild winters. Precipitation is abundant, averaging about 49 inches per year and remaining within the range of 40 to 58 inches during most years. Precipitation in the amount of 0.1 inch or more falls on an average of about 77 days per year. The annual distribution shows a major monthly maximum of about 7 inches in July and a major monthly minimum of about 2 inches in November. The period from April through October, which includes the growing season for most crops in this area, receives an average of about 34 inches of rain, about 70 percent of the annual total.

2.2 TOPOGRAPHY

MCRD Parris Island lies in the Lower Coastal Plain physiographic province. Elevations range from sea level to 22 feet above mean sea level (msl). The Depot consists of Parris Island (the largest and most developed island), seven smaller, named islands, many small unnamed islands, salt marshes, and related tidal creeks. Because of the low elevation, most of the Depot is within the 100-year flood plain. The majority of the area of Parris Island north of Ballast Creek, the east-central area of Page Field, and the central part of Horse Island are the only surfaces above the 100-year flood plain (NEESA, 1986).

The Depot covers 8,047 acres: 1,502 acres are devoted to forest management; 744 acres are grass and facilities; 4,344 acres are saltwater marsh; and the remainder consists of creeks, ponds, and causeways. Dry land makes up 3,274 acres (NEESA, 1986).

2.3 SURFACE WATER DRAINAGE

Drainage off the land surface is to the nearest surface water body. Three generally east-west creeks drain much of the Depot. Archers Creek is at the northern boundary of the Depot and connects Battery Creek to the north with the Broad River to the west of Parris Island (see Figure 1-1). Ribbon Creek drains

the area between Horse and Parris Islands and flows westward into the Broad River. Ballast Creek enters the Beaufort River and drains central Parris Island. Smaller unnamed creeks drain the areas west and east of Page Field.

The Beaufort and Broad Rivers meet at the southern end of Parris Island to form Port Royal Sound, which extends about 4 miles southeastward to the Atlantic Ocean.

2.4 SOILS

Soils at MCRD Parris Island have been mapped by the U.S. Soil Conservation Service as both individual soils and groupings of soils (units). The Depot has been mapped as having 15 individual soil types, but only eight types are present beneath the identified sites. Three soil units have been mapped for the Depot (the Wando-Seabrook-Seewee, Coosaw-Williman-Ridgeland, Bohicket-Capers-Handsboro Soil Unit). A further discussion of the soils and soil units identified at the MCRD can be found in the Site 3 RI/RFI (TtNUS, 1999) or the IAS (NEESA, 1986).

2.5 GEOLOGY

Four geological units are present in the Beaufort-Jasper County Area. These units from the oldest (Eocene age) to the youngest (Pleistocene age) are the Santee Limestone, Cooper Marl, Hawthorn Formation, and Pleistocene sands and clays. A further discussion of the descriptive and structural geology of the Beaufort-Jasper County area can be found in the Site 3 RI/RFI (TtNUS, 1999) or the IAS (NEESA, 1986).

2.6 HYDROGEOLOGY

Two primary aquifers are present within the Beaufort-Jasper County Area: the surficial aquifer and the Floridan Aquifer. These aquifers are generally separated by the Hawthorn Formation and Cooper Marl, which act as confining units to the underlying Floridan Aquifer.

In the MCRD Parris Island area, the shallow, unconfined aquifer generally consists of permeable, fine to medium, Pleistocene age sands. Surface relief is relatively low. The area is drained by fresh and brackish water streams inland and by tidal streams along the coast. The water table in the MCRD Parris Island area usually ranges from 0 to 10 feet below ground surface (bgs) and is most commonly found at a depth of 3 feet bgs. Water-table fluctuations are a function of recharge, evaporation, and transpiration and have been observed to be as great as 6.5 feet at some locations (Glowacz, and others, 1980). The direction of groundwater flow of the surficial aquifer is generally toward the nearest surface water body, such as a pond, river, tidal creek, or the ocean.

In the Beaufort-Jasper County Area, the Floridan Aquifer system occurs near land surface, and confining beds vary from essentially 0 to more than 150 feet in thickness. Groundwater in the Floridan aquifer occurs in solutionally enlarged openings or cavities in the limestone. In general, groundwater occurs in a series of broadly defined water-bearing (permeable) zones that serve as aquifers and are separated by less permeable rocks. Two hydrogeologic zones within the Floridan aquifer lie beneath the MCRD Parris Island area. These two hydrogeologic units consist of a 200-foot-thick Upper Hydrogeologic Unit that contains an upper permeable zone and an 800-foot-thick Lower Hydrogeologic Unit that has a somewhat lower permeability compared to the Upper Unit.

A further discussion of the hydrogeological characteristics of the Beaufort-Jasper County area can be found in the Site 3 RI/RFI (TtNUS, 1999) or the IAS (NEESA, 1986).

2.7 ECOLOGY

Discussions on the ecoystems present and threatened and endangered plants and animals that occur or potentially occur on MCRD Parris Island can be found in the Site 3 RI/RFI (TtNUS, 1999) or the IAS (NEESA, 1986). Furthermore, Section 7.2 contains a summary of the ecological setting at Sites 2 and 15.

3.0 INVESTIGATION SUMMARY

The field investigation for Site/SWMU 2 (Site 2) and Site/SWMU 15 (Site 15) was performed from May through September 1998 and in October 1999. During the field investigation, monitoring wells were installed, groundwater, soil, sediment, and surface water samples were collected, a tidal study was performed, aquifer tests were conducted, and test pitting was performed. Information collected during the investigation was used to supplement existing geologic and hydrogeologic information at Site 2. The following sections discuss deviations from the work plan, the field activities that were conducted, and the site-specific geologic and hydrogeologic settings at Sites 2 and 15. A summary of the RFI/RI sampling activities is provided in Tables 3-1 to 3-10. The site layout for Site 2 and Site 15 is shown on Figures 1-2 and 1-3.

3.1 DEVIATIONS FROM THE WORK PLAN

Several deviations to the approved work plan for Sites 2 and 15 (B&R Environmental, 1998b) were made during the field effort. The deviations are presented as follows.

- The method of well installation was changed from the approved work plan method of mud rotary drilling to the use of 4-1/4-inch inner diameter (ID) hollow-stem augers after consultation with SCDHEC.

- The approved work plan stated that surface water samples would be collected at low tide. However, the tidal inlet to be sampled southwest of Site 2 was dry at low tide. Therefore, the surface water samples were collected at the proposed locations on the receding tide when water was available to sample.

- Hand augers soil borings were not performed at surface soil sample locations PAI-02-SS-01, PAI-02-SS-06, and PAI-02-SS-08. Hand auger soil borings were taken at all other surface soil sample locations at Site 2.

- One surface soil location, PAI-15-SS-07, was added to Site 15. The sample was added to characterize a section of road not included on the original map for the Elliot's Beach roadways.

- Secchi Disk readings were not obtained for three of the surface water locations (PAI-02-SW-01, PAI-02-SW-02, and PAI-02-SW-03) due to the shallowness of the surface water at the proposed locations at the time of sampling.

- Per correspondence on August 20, 1998, the MCRD Parris Island Partnering Team agreed to forgo 100 percent data validation of analytical packages. Instead, the Partnering Team agreed that data validation would consist of either a data review or a full data validation. The full data validation would be performed on approximately 10 percent of the data packages received from a laboratory and all analytes would be covered by at least one full data validation. A data review would be performed on the remaining data packages for the purposes of identifying false positive and negative results.

- Instead of only RCRA Appendix IX parameters, groundwater samples PAI2-GW2-01 and PAI-02-GW-05-01 were analyzed for TCL, VOCs, SVOCs, pesticides, PCBs, TAL metals (total and dissolved), and cyanide, as well as for RCRA Appendix IX parameters.

Two deviations to the Test Pit Work Plan for Site 2 (TtNUS, 1999) were made during the 1999 field effort. The deviations are presented as follows.

- Two additional test pits (PAI-02-TP-15 and PAI-02-TP-16) were performed to extend coverage to the berm along the southwest boundary of the site. Also, an additional test pit (PAI-02-TP-02A) was dug adjacent to test pit PAI-02-TP-02 to collect a sample for laboratory analysis.

- The sample identification numbers (IDs) were changed from the proposed IDs to reflect the test pit where the sample was collected. For example, sample PAI-02-SB-10-07 was collected from test pit PAI-02-TP-10 at a depth of seven feet.

3.2 FIELD INVESTIGATION

The following sections discuss the activities conducted during the field investigation at Sites 2 and 15. First, a history of investigative activities at Sites 2 and 15 is presented. Next, the specific field activities conducted during the investigation are discussed. They include monitoring well installation; subsurface soil, surface water, sediment, surface soil, and groundwater sampling; the performance of slug tests and a tidal influence study; test pitting; and investigation-derived waste management. Lastly, quality assurance/quality control samples and sample analysis are discussed.

3.2.1 Sampling History

Previous investigations conducted at Sites 2 and 15 include an IAS (NEESA, 1986). A subsequent Verification Step (McClelland, 1990) was conducted at Site 2 to identify potentially contaminated sites at MCRD Parris Island that may pose a threat to human health or the environment. A verification step was not performed at Site 15 based on the results of the IAS. An interim RFA (Kearny, 1990) was performed at Sites 2 and 15 per RCRA permitting requirements. Lastly, a Relative Risk Evaluation (B&R

Environmental, 1996) was performed on soil samples collected at Site 15. These investigations are described in Section 1.4.3.

3.2.2 Monitoring Well Installation

Two monitoring wells [PAI-02-MW-04(S) and PAI-02-MW-05(D)] were installed during the 1998 field investigation at the locations indicated on Figure 3-1. The shallow surficial aquifer well was installed to a depth of 13.6 feet below ground surface (bgs) and the deep surficial aquifer well was installed to a depth of 36 feet bgs. The well permit authorization is provided in Appendix A.

The monitoring wells were installed through the ID of 8-inch outside-diameter augers to help ensure a proper sand pack. The wells were installed in accordance with SCDHEC regulations. The surficial aquifer monitoring well was constructed with a 10-foot screen section with 0.010-inch slot openings and #1 sand due to the fines encountered. The deep surficial well was constructed using a 5-foot screen section with 0.020-inch slot screens and #2 sand. A boring log illustrating the material encountered to a depth of 48 feet was completed at the monitoring location. Monitoring well construction sheets were completed for both wells installed. Copies of these forms are provided in Appendix A.

A licensed South Carolina driller employed by Parratt Wolff, Inc. of Hillsborough, North Carolina installed the new monitoring wells. The newly installed monitoring wells along with existing monitoring wells PAI2-MW1(S), PAI2-MW2(S), PAI2-MW3(S) were developed using a surge block and a submersible pump. Well development logs were completed during development and are provided in Appendix A. Construction details of all of the monitoring wells are provided in Table 3-2.

As indicated in Table 3-2, four wells PAI2-MW1(S), PAI2-MW2(S), PAI2-MW-3(S), and PAI-02-MW-04(S) were installed and screened in the upper part of the surficial aquifer. The wells were installed so that the well screen intercepted the water table. PAI-02-MW-05(D) was installed within the surficial aquifier.

3.2.3 Test Pitting/Subsurface Soil Sampling

In 1998, subsurface soil samples (refer to Figure 3-1) were collected from the soil boring locations using split spoon-sampling techniques. Soil boring PAI-02-SB-01 was performed at the well nest location as an exploratory boring to attempt to locate the Hawthorn Formation or a confining unit and to obtain lithologic samples. A subsurface sample, PAI-02-SB-01-01, was collected from a depth of zero to 1-foot bgs. The sample was analyzed for TCL VOCs, SVOCs, pesticides, PCBs, TAL metals, and cyanide. Subsurface sample PAI-02-SB-01-30 was collected from a depth of 30 to 32 feet bgs within the screened interval of the deep surficial well [PAI-02-MW-05(D)] for geotechnical evaluation, including TOC, pH, natural moisture content, grain-size analysis, Atterberg Limits, porosity, bulk density, and specific gravity. A

Shelby tube sample (identified as PAI-02-SB-01-36 in order to maintain a consistent sample nomenclature with PAI-02-SB-01, which was less than 5 feet away) was collected from a depth of 36 to 38 feet bgs and analyzed for vertical hydraulic conductivity. The water table was encountered at the time of drilling at a depth of approximately 2 feet bgs. The results of the ecological/geotechnical sampling are presented in Appendix A. All of the split-spoon samples collected were screened in the field using a photoionization detector (PID). None of the samples had elevated PID readings and there were no visual signs of contamination. Copies of the soil samples log sheets are provided in Appendix A. A summary of the subsurface soil samples collected is presented in Table 3-3.

In 1999, subsurface soil samples were collected during the performance of test pits in accordance with the approved Work Plan Addendum (TtNUS, 1999). The location of the test pits are shown on Figure 3-2. Seventeen test pits were performed (PAI-02-TP-01, PAI-02-TP-02, PAI-02-TP-02A, and PAI-02-TP-03 through PAI-02-TP-16). The test pits were dug using a ¼ cubic yard bucket. The test pits were all approximately 24 inches wide and 5 to 7 feet long. The depth of the pit was variable based on the depth to the water table which ranged from 2.5 feet bgs in the central portion to 8 feet bgs in the northeastern portion of the site.

Subsurface samples were collected from three of the test pits for chemical analyses. Subsurface sample PAI-02-SB-02A-02 was collected from test pit PAI-02-TP-02A located adjacent to test pit PAI-02-TP-02. The sample was collected at a depth of 2 feet bgs. Sample PAI-02-SB-10-07 was collected from test pit PAI-02-TP-10 at a depth of 7 feet bgs. Sample PAI-02-SB-11 was collected from test pit PAI-02-TP-11 at a depth of 2 feet. The test pit samples were analyzed for TCL VOCs, SVOCs, pesticides, PCBs and TAL metals. The water table was encountered across the site ranging from 2.5 to 8 feet bgs. The greater depths were encountered in the northeastern portion of the site and while digging within the bermed materials. Neither soil staining nor garbage were observed in any of the test pits. PID readings were continuously screened during excavation. Only significant changes (0.5 ppm) in PID readings from background (zero ppm) were recorded. The PID values ranged from 0 to 54 ppm. The highest PID reading was detected at test pit PAI-02-TP-02 at 54 ppm. Copies of the soil sample log sheets are provided in Appendix A along with copies of the test pit logs. A summary of the subsurface soil samples is included in Table 3-3.

3.2.4 Surface Water Sampling

Four surface water samples (PAI-02-SW-01-00 through PAI-02-SW-04-00) were collected in the tidal inlet adjacent to and southwest of Site 2. All surface water samples were sampled during a receding tide. At low tide, the tidal inlet adjacent to Site 2 was completely devoid of water. The samples were obtained by dipping the appropriate containers in the water to collect the samples. All of the samples were analyzed for TCL VOCs, SVOCs, pesticides, PCBs, TAL metals (totals and dissolved), cyanide, TOC, hardness,

and pH. The analytical parameters are summarized in Table 3-4. Surface water quality parameters collected during sampling are listed in Table 3-5, and the locations are shown on Figure 3-3.

Samples PAI-02-SW-02-00, PAI-02-SW-03-00, and PAI-02-SW-04-00 were analyzed for hexavalent chromium. The three hexavalent chromium samples were randomly distributed across the site. All water samples were analyzed for TOC and hardness ($CaCO_3$). The purpose of this supplemental analysis was to support the risk assessment by determining the speciation of total chromium. Surface water sampling was performed in accordance with the work plan (B&R Environmental, 1998b), except Secchi Disk readings were not obtained due to the shallowness of the surface water at locations PAI-02-SW-01, PAI-02-SW-02, and PAI-02-SW-03. A Secchi Disk reading was taken at sample location PAI-02-SW-04. Copies of the surface water sample log sheets are provided in Appendix A.

The surface water quality parameters indicate that, at the time of sampling, the water temperature ranged from 29.3° to 31.2° C. The pH readings varied from 7.28 to 7.43. The specific conductance varied slightly between 46.2 to 46.8 mS/cm. Dissolved oxygen varied from 7.38 to 8.14 mg/L. Salinity remained fairly constant, ranging only from 3.02 to 3.05 percent. Turbidity of the samples varied from 12 to 119 NTUs. The Secchi Disk reading at location PAI-02-SW-04 was measured to be 2 feet.

3.2.5 Sediment Sampling

A total of five sediment samples (PAI-02-SD-01-01, PAI-02-SD-02-01, PAI-02-SD-02-02, PAI-02-SD-03-01, and PAI-02-SD-04-01) were collected southwest of Site 2 during the field investigation. Site 2 sediment sample locations are shown on Figure 3-3. Also, three composite sediment samples were collected as part of the investigation of Site 15. Site 15 sediment sample locations are shown on Figure 3-4. Sediment sampling was performed in accordance with the work plan (B&R Environmental, 1998b). A disposable plastic or pre-cleaned stainless-steel trowel was used to collect the sample to the appropriate depth. The sample material for all the analytical parameters, except for TCL VOCs, was directly placed in the appropriate containers and placed on ice. The volatile samples were collected using Encore® samplers. The samplers were then capped and placed on ice. Copies of the sediment sample log sheets are provided in Appendix A.

All of the sediment samples collected from Site 2 sediment were analyzed for TCL VOCs, SVOCs, pesticides, PCBs, TAL metals (Total), cyanide, TOC, and pH. In addition, samples PAI-02-SD-02-01, PAI-02-SD-03-01, and PAI-02-SD-04-01 were analyzed for hexavalent chromium. The three hexavalent chromium samples were randomly distributed across the site. All of the Site 2 sediment samples were tested for grain-size and bulk density. Each of the three Site 15 sediment samples was a composite from five collection locations. The sediment sample locations presented on Figure 3-4 are approximated. Actual samples were collected in the marsh approximately 30 feet out from the survey point and in a 100

foot line perpendicular to the shore. The samples were mixed in a pre-cleaned stainless-steel bowl and composited to form a single sample. The composite samples were analyzed for TCL SVOCs, pesticides, PCBs, and TAL metals (Total). The laboratory analyses for the samples are summarized in Table 3-6. The results of the ecological/geotechnical sampling are presented in Appendix A.

3.2.6 Surface Soil Sampling

A total of eight surface soil samples (PAI-02-SS-01-01 to PAI-02-SS-08-01) were collected from Site 2 during the field investigation. As part of the investigation, hand auger borings were utilized within the Site 2 boundaries at five surface soil locations (PAI-02-SS-02 through PAI-02-SS-05 and PAI-02-SS-07) to determine the presence and depth of garbage and or ash on the site. The auger samples were collected to a depth of 6 feet bgs. The soils were classified as to their lithology. Seven surface soil samples (PAI-15-SS-01-01 to PAI-15-SS-07-01) were collected from Site 15, including soils in the road adjacent to Site 2 and from the roadways at Elliot's Beach. Sample PAI-15-SS-07-01 was added to the investigation to characterize soil along a road not indicated on the original Elliot's Beach site map. The soil samples were collected from a depth of 0 to 1 foot bgs. Surface soil sample locations are shown on Figures 3-4 and 3-5. The analytical methods performed on the samples are summarized in Table 3-7. Sample log sheets for soils are presented in Appendix A.

Surface materials consisting of grasses and other organic material were removed before the sample was obtained. A disposable plastic or pre-cleaned stainless-steel trowel was used to collect the sample to a depth of 1 foot. The sample material for all the analytical parameters except the volatiles was placed directly in the appropriate containers and then placed on ice. The volatiles were collected using Encore® samplers. Soil was collected in the samplers, and the samplers were capped and then on ice. All the Site 2 surface soil samples were analyzed for TCL VOCs, SVOCs, pesticides, PCBs, TAL metals (Total), and cyanide. In addition to these samples, PAI-02-SS-01-01, PAI-02-SS-06-01 and PAI-02-SS-08-01 were analyzed for hexavalent chromium. The three hexavalent chromium samples were randomly distributed across the site. Sample PAI-02-SS-07-01 was also analyzed for TOC, grain-size, bulk density, natural moisture content, and Atterberg Limits. The Site 15 surface soil samples were analyzed for total lead and TCL PCBs. Surface soil sampling was performed in accordance with the approved work plan (B&R Environmental, 1998b).

3.2.7 Groundwater Sampling

Groundwater sampling was performed using a peristaltic pump and disposable tubing. The tubing was lowered in the wells to approximately the midpoint of the well screens. The wells were then purged in accordance with the low-flow sampling techniques specified in the approved work plan (B&R Environmental, 1998b). Water-level data and water-quality parameters, such as temperature, pH, specific

conductance, turbidity, dissolved oxygen, and salinity, were collected during purging of the monitoring wells and recorded on low-flow purge data sheets and groundwater sample log sheets (included in Appendix A). The groundwater sample from each well, with the exception of TCL VOCs, was collected by reducing the flow to minimize volatilization of the sample and collecting the sample in the appropriate containers directly from the tubing after it passed through the peristaltic pump. The TCL VOC samples were collected by removing the tubing from the well and allowing the water in the tubing to flow under gravity backward through the tubing into the sample container.

Groundwater samples were collected during two sampling events at Site 2. Samples PAI2-GW1-011, PAI2-GW2-01, PAI2-GW3-01, PAI2-GW3-01-D, PAI-02-GW-04-01, and PAI-02-GW-05-01 were collected in August 1998. Samples PAI2-GW2-01A and PAI-02-GW-05-01A were collected in September 1998. Groundwater samples PAI2-GW1-01, PAI2-GW3-01, PAI2-GW3-01-D, and PAI-02-GW-04-01 were analyzed for TOC, hardness, TCL VOCs, SVOCs, pesticides, PCBs, TAL metals (total), TAL metals (dissolved), cyanide, total dissolved solids (TDS), total suspended solids (TSS), chloride, fluoride, nitrate/nitrite, and sulfate. Sample PAI-02-GW-04-01 was also analyzed for hexavalent chromium. Samples PAI2-GW2-01 and PAI-02-GW-05-01 were analyzed for TOC, hardness, hexavalent chromium, TCL VOCs, SVOCs, pesticides, PCBs, TAL metals (total), TAL metals (dissolved) and cyanide. Samples PAI2-GW2-01A and PAI-02-GW-05-01A were analyzed for RCRA Appendix IX parameters. Appendix IX analysis was conducted at the two groundwater monitoring wells to satisfy SCDHEC requirements under the state RCRA program. The collected analytical parameters are summarized in Table 3-8. The groundwater quality information (including dissolved oxygen, salinity, temperature, pH, and turbidity) was also collected from all the samples and is summarized in. The depth-to-water measurements shown on Table 3-10 were collected at the start of the tidal influence study. The groundwater sample locations are indicated on Figure 3-1.

As indicated on Table 3-9, the pH of the groundwater at Site 2 varied between 4.74 (PAI2-GW2-01) to 8.10 (PAI-02-GW-05-01). The temperature readings varied from 22 °C (PAI2-GW1-01 and PAI2-GW2-01) to 28.1 °C (PAI-02-GW-04-01). The specific conductance varied from 0.132 mS/cm (PAI2-GW2-01A) to 35.2 mS/cm (PAI-02-GW-04-01). Salinity readings ranged from 0 (PAI2-GW1-01, PAI2-GW2-01, and PAI2-GW2-01A) to 2.24 (PAI-02-GW-04-01) percent. The salinity readings indicate that groundwater samples PAI2-GW1-01, PAI2-GW2-01, and PAI2-GW2-01A are considered to be fresh and the remaining samples are considered to be brackish or saline (fresh water is less than 0.048 percent as identified by SCDHEC, 1998). The groundwater samples (PAI-02-GW-04-01 and PAI-02-GW-05-01) from the well cluster installed in the surficial aquifer indicate salinity readings were lower in the deeper

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1 Sample identification number PAI2-GW1-01 indicates the groundwater sample was collected from monitoring well PAI2-MW1(S).

well. Dissolved oxygen readings for all samples varied from 1.87 to 10.24 mg/L. The wells were purged in an effort to reduce the turbidity to less than the benchmark of 5 Nephelometric Turbidity Units (NTUs). Turbidity of the samples collected ranged from 0 to 5 NTUs.

3.2.8 Slug Tests

Slug tests were performed on the two new monitoring wells and the three existing wells. Rising head slug tests were performed in wells PAI2-MW1(S), PAI2-MW2(S), PAI2-MW3(S), and PAI-02-MW-04(S). Rising and falling head slug tests were performed at monitoring well PAI-02-MW-05(D). The procedure for performing the rising head slug test consisted of injecting a slug of known volume below the water level within the well. After the water level re-stabilized, the slug was suddenly removed to create a drop of water level within the well. A 20-pounds-per-square-inch (psi) pressure transducer and a data logger were used to record the rate of water-level recovery. The procedure for performing the falling-head slug test consisted of rapidly injecting a slug of known volume into the well below the water surface, so that the water level within the well rose. The subsequent rate of water-level recovery to the original static water level (time versus recovery) was measured. The data were analyzed using the Hvorslev Method (Hvorslev, 1951). All slug test calculations and data are located in Appendix A. Slug test results are discussed in Section 3.4.

3.2.9 Tidal Influence Study

A tidal influence study was performed in September 1998. The results of this study indicate several of the wells installed at Site 2 are tidally influenced. The largest tidal fluctuation (3.5 feet) occurred at the deep surficial monitoring well PAI-02-MW-05(D). Tidal fluctuations of approximately 1.2 feet and 0.12 feet occurred at shallow monitoring wells PAI-02-MW-04(S) and PAI2-MW3(S), respectively. Wells PAI2-MW1(S) and PAI2-MW2(S) exhibited minor fluctuations (0.01 foot) that are not thought to be tidal in nature. A control point at Archer Creek Bridge was also monitored during the same time as the Site 2 wells.

3.2.10 Surveying

All monitoring well, soil boring, sediment, surface water, and surface soil sample locations were surveyed for horizontal and vertical control by Donaldson, Garrett & Associates, Inc. of Macon, Georgia (South Carolina licensed) in accordance with the work plan (B&R Environmental, 1998b). Permanent concrete monuments installed at Site/SWMU 3 and Elliot's Beach were used to establish site control for Site 2 and Site 15. The concrete monuments have plaques containing the northing, easting, and ground surface elevation at that point. The northing and easting coordinates are tied into the South Carolina State Plane Coordinate System, North American Datum 1983 (NAD83).

3.2.11 Investigation Derived Waste (IDW)

During the investigation, 55-gallon drums of water (decontamination, development, and purge waters) and soil IDW were generated and stored within the Depot's waste storage facility pending final disposition of the IDW. All IDW was handled in accordance with the Master Work Plan (B&R Environmental, 1998a) and the work plan for Sites 2 and 15 (B&R Environmental, 1998b).

A composite sample was collected from the drummed decontamination waters and analyzed for TCL VOCs, SVOCs, PCBs, pesticides, and TAL inorganics. Additionally, a composite sample was collected from the drummed soils and analyzed for the previously mentioned parameters plus Toxicity Characteristic Leaching Procedure (TCLP) inorganics. Analytical results from groundwater samples collected during the field investigation were used to characterize development and purge waters.

Site 2 soil IDW was characterized as nonhazardous. One inorganic element (arsenic) was detected in the soil IDW composite sample in excess of U.S. EPA Region III Risk-Based Concentrations (RBCs) for residential dermal contact (U.S. EPA, 1998). Arsenic exceeded its RBC of 0.43 mg/kg, with a concentration of 2.2 mg/kg. However, background arsenic soil and sediment detections ranged from 1.2 to 12 mg/kg. Per concurrence of the MCRD Parris Island Partnering Team, soil IDW was spread at Site 2.

Decontamination, development, and purge waters were also found to be nonhazardous. All liquid IDW was discharged to the Depot's wastewater treatment facility. Fenn-Vac, Inc., the IDW subcontractor, conducted the discharge of waters and the spreading of soils.

3.2.12 Quality Assurance/Quality Control (QA/QC) Samples

Quality assurance (QA) objectives are evaluated by assessing the PARCC parameters, as defined in the Master Quality Assurance Plan (QAP). The PARCC parameters are precision, accuracy, representativeness, comparability, and completeness. QA/QC samples were collected to provide information pertaining to these key quality characteristics. The QA/QC sample results from this investigation are summarized in the following subsections.

The following QA/QC samples were collected during the investigation of Site 2 and Site 15: one source water blank, 12 trip blanks, one equipment rinse blank for Site 2, two rinse blanks for Site 15, and two duplicate groundwater samples for Site 2.

QA/QC sample log sheets are provided in Appendix A. Appendix D contains the data validation summaries and a detailed PARCC discussion. The sample chain-of-custody (COC) forms can be found in Appendix A.

Precision

Precision is a measure of the degree to which two or more measurements are in agreement. Field sampling precision was assessed through the collection and analysis of field duplicate samples. The precision of the laboratory's analytical program was assessed through the calculation of relative percent difference (RPD) for the matrix spike/matrix spike duplicate (MS/MSD) samples. According to the QAP, field duplicate results are considered to be precise if the RPD is less than 50 percent for solid samples and less than 30 percent for aqueous samples. Laboratory duplicates for solid and aqueous matrices are considered to be precise if the RPD is less than 35 percent and 20 percent, respectively. No results were qualified for RPD noncompliance. Based on the validation results, the data appear to be precise.

Accuracy

Accuracy is the degree of agreement between an observed value and an accepted reference value. Accuracy in the field is assessed through the use of field equipment rinsate blanks, trip blanks, and source water blanks and also through adherence to sample handling, preservation, and holding times. Laboratory accuracy is assessed through the analysis of matrix spike, standard reference materials, and the determination of percent recoveries. Spike recoveries (e.g., blank, surrogate, and matrix spikes) are compared to acceptance limits statistically derived by the laboratory in accordance with established practices identified in the analytical method followed and further defined in the laboratory QAP.

Percent Recovery

In the Site 2 groundwater samples, the initial calibration verification (ICV) percent recoveries for hexavalent chromium and tin were less than the 90 percent quality control limit. As a result, non-detects for these parameters were qualified with "UJ" or estimated.

The MS percent recovery was less than the 75 percent quality control limit for selenium. As a result, positive selenium results in groundwater were qualified with "J" and non-detects with "UJ" or estimated. Similarly, the MS percent recovery for lead was less than the 30 percent quality control limit in soil, sediment, and surface water samples. The nondetected results for lead in these media were qualified as rejected or "UR."

The continuing calibration verification (CCV) percent recovery for thallium was less than the 90 percent quality control limit. Therefore, the non-detect results for thallium in the Site 2 source water samples were qualified as "UJ" or estimated.

Surrogate recoveries in sediment samples were below quality control limits for PAHs. As a result, the non-detected PAH results were rejected and qualified as "UR."

Holding Times

The holding times for hexavalent chromium for the source water samples collected from Site 2 were exceeded by 8 hours due to the delivery time. As a result, the detected results were qualified with "J" and non-detected results for this metal were qualified as "UJ" or estimated. Cyanide holding times were exceeded by 1 day, resulting in estimated ("UJ") non-detect results in some sediment and soil samples at Site 15.

Laboratory and Field Blanks

Several VOCs and SVOCs were found in the field/trip blanks. Various inorganics were found in the laboratory/preparation blank. Positive sample results less than 5 times the maximum blank concentration (or 10 times for typical laboratory contaminants) were qualified as "U" or non-detect due to blank contamination. Details are presented in Appendix D.

Representativeness

Representativeness was qualified through the field sampling procedures and evaluation of laboratory analytical data. The site data accurately and precisely depict the actual characteristics of the environmental conditions that exist at Site 2 and Site 15. U.S. EPA-approved work plans and standardized sampling, handling, analytical, and reported procedures were followed to ensure that the final data accurately represent actual site conditions. Validated results support this finding.

Comparability

Comparability, the confidence of comparing one data set to another, was satisfied through the strict adherence of field sampling and laboratory analysis to their respective SOPs. Both programs (field and laboratory) adhered to their respective SOPs and were reviewed by third parties. The majority of sampling for this investigation occurred during the spring/summer 1998. Standardized sampling and analysis methods and data reporting formats (including use of consistent units of measure and reporting of solid matrix sample results on a dry-weight basis) were used. As a result, data collected for these sites are comparable and usable.

Completeness

Completeness is the percentage of analyses with valid results as compared to the total number of analyses for each analytical method in a given matrix. For this project, 90 percent completeness is acceptable for meeting the data completeness objective. For Sites 2 and 15, no positive data results were rejected. In other cases, the non-detected results of several parameters (e.g., acetone, 2-butanone, 2-hexanone, 4-methyl-2-pentanone, lead, acrolein, acrylonitrile, methacrylonitrile, and methyl methacrylate) were rejected. The amount of rejected nondetected data was approximately 2 percent and only at Site 2. As a result, the amount of usable and valid data available was 98 percent at Site 2 and 100 percent at Site 15, values that meet the project objective for completeness. Appendix D presents the details of the validation reports.

Detection Limits

Samples analyzed for PAHs were diluted by a factor of two to five due to matrix interferences. This dilution may account for elevated detection limits for the PAHs. Similarly, samples analyzed for pesticides were diluted by a factor of 10 due to matrix interference, which elevated the pesticide detection limits for samples.

3.2.13 Sample Analysis

Chemical analysis of environmental samples was conducted at three laboratories. Soils, sediment, and surface water samples were analyzed for chemical parameters at RECRA Environmental, Inc in Chicago, Illinois. Groundwater samples were analyzed at Laucks Testing Laboratory, of Seattle, Washington. Both laboratories are certified by South Carolina. All analytical results are presented in Appendix C, including positive detections and detection limits for non-detected parameters. The appendix is divided into background results and Sites 2 and 15 sample results. In addition, Appendix C is divided into soils, sediments, surface water, groundwater, and test pit data.

Kiber Environmental Services of Norcross, Georgia performed the geotechnical analysis. Results are presented in Appendix A.

3.3 SITE-SPECIFIC GEOLOGY

The site-specific geology at Site 2 was interpreted by classifying subsurface materials collected during drilling activities in 1998. A cross-section of Site 2 wells was developed from the data collected during the field investigation and is illustrated on Figure 3-6. Information from the Soil Survey of Beaufort and

Jasper Counties, South Carolina, 1980 (U.S. Department of Agriculture, Soil Conservation Service) was used for the correlation of soil types.

The Soil Survey of Beaufort and Jasper Counties indicates that the Wando-Seabrook-Seewee Soil Unit is present on Horse Island, located at the northwestern end of the causeway. Also present on Horse Island are Borrow Pit Soils. These soils are present in the area of the Site 2 Borrow Pit Landfill and the adjacent Site 15 dirt road. The soils adjacent to the sampling areas at Elliot's Beach consist of Seewee, Coosaw, Wahee, and Capers soils.

The Borrow Pit soils located at Site 2 and the adjacent Site 15 dirt road represent areas where soils have been removed by man for use as fill material. The removed soils may include surface soil, subsoil, and in some instances substratum.

Soils collected from the Borrow Pit Landfill during the 1998 and 1999 field events consisted of fine to medium sands with a varying silt content, as confirmed by the lithologic descriptions during the sampling events. Rust-colored soils indicating possible fill material was encountered at soil locations PAI-02-SS-01, PAI-02-SS-02, and PAI-02-SS-07 at depths ranging from 1 foot to 6.5 feet bgs. Subsequent test pitting did not find evidence of remaining wastes. Test pits PAI-02-TP-05 and PAI-02-TP-16 indicated that the southwest berm was constructed of fill material consisting of fine sands. Sediment samples collected from the tidal inlet area consist of silts overlying sand and shells, coarse sand and shells, and silty sands. The Site 15 dirt road soils consisted of fine sand with varying silt and shell content. Sediment samples collected at Site 15 consisted of fine sands with a varying silt and clay content and sandy silts and clays.

Subsurface materials at Site 2 were classified from the drilling of one soil test boring during the TtNUS field investigation, the soil logs for the existing wells, and the hand-auger borings collected within the Site 2 facility. Soil boring PAI-02-SB-01 was sampled continuously to the termination of the boring using split-spoon sampling techniques. The site-specific geology at the unit has been affected by human activities. Landfilled debris was not encountered at the facility; however, soils were encountered at depths of 5.5 feet (PAI-02-SS-07) and 6.5 feet (PAI-02-SS-02) were observed to have a "rusty" colored stain or stained appearance. This material was not encountered in the remainder of the hand auger borings or the soil boring located outside the bermed area.

Figure 3-5 shows the cross-sectional transect A-A' that was developed from the soil boring data collected during the current investigation. The location of Cross-Section A-A' is shown on Figure 3-1. Generally, the shallow subsurface geology inland of the tidal inlet consists of silty sand to a depth of approximately 25 feet bgs and sand with varying clay content to a depth of approximately 30 feet bgs. The subsurface

geology along Archers Creek consists of predominantly fine to medium sand with a varying clay content to the termination of the boring at 48 feet bgs. A clayey, fine to coarse sand was encountered from 36 to 40 feet bgs that seems to correspond with the confining unit encountered at Site/SWMU 1, located approximately 2,000 feet northeast of Site 2.

Subsurface soil and sediment samples analyzed for ecological/geotechnical parameters confirm the lithology of the soil/sediment encountered. Details of the results of the ecological/geotechnical sampling are presented in Appendix A.

Based on the results of a falling head permeability test performed on an undisturbed sample PAI-02-SB-01-36 (sample depth 36 to 40 feet bgs) collected within this unit, the clayey sand material likely acts as a confining unit to the overlying sands. The sands beneath the clayey sand unit become progressively drier and denser with depth. Assuming this clayey sand unit exists across the site, this confining unit is at least 4 feet thick.

3.4 SITE-SPECIFIC HYDROGEOLOGY

The hydrogeologic conditions at Site 2 were interpreted from data obtained during the subsurface investigation activities at the site, groundwater-level measurements and slug tests performed during the 1998 investigation.

Based on water-level measurements indicated on Cross-Section A-A' (refer to Figure 3-6), the shallow water table occurs at depths across the site ranging from 3.5 to 14.5 feet bgs. Assuming the 4 feet of clayey sand encountered at 36 to 40 feet bgs acts as a confining unit to the overlying sands of the upper surficial aquifer, the saturated thickness of the surficial aquifer ranges from 21.5 to 32.5 feet. Within the borrow pit, groundwater was encountered in the hand-auger borings and test pits at depths from 2.5 to 8 feet bgs. Within the vicinity of the topographically upgradient monitoring wells, groundwater was encountered at depths from 12.1 to 14.5 feet bgs.

Recharge of the shallow aquifer beneath the site is likely to occur primarily through infiltration of precipitation inland of the tidal inlet. Groundwater flow away from the tidal inlet, based on groundwater data from wells PAI2-MW1(S), PAI2-MW2(S), and PAI2-MW3(S) is toward the west-northwest. Groundwater in the vicinity of well PAI-02-MW-04(S) appears to flow toward the adjacent tidal inlet. Based on the groundwater elevation data collected during this field event, the vertical gradient within the surficial aquifer is downward. Site 2 is located within the 100-year flood plain. This was determined by reviewing the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (1986).

Rising-head slug tests were performed in the shallow surficial aquifer monitoring wells at Site 2. A rising and falling head slug test was performed in the deep surficial aquifer monitoring well, PAI-02-MW-05(D). The geometric average hydraulic conductivity for the four shallow surficial aquifer wells was calculated to be 1.13 feet per day (3.99×10^{-4} cm/sec). The deep surficial well conductivity was determined by averaging rising and falling head tests. The hydraulic conductivity in well PAI-02-MW-05(D) was calculated to be 3.08 feet per day (1.08×10^{-3} cm/sec). The values for the shallow and deep wells are within the typical range of hydraulic conductivity for clayey, silty sands, silts, and sandy silts (Fetter, 1980). Hydraulic conductivity curves and calculations based on the slug tests are included in Appendix A. The result of a falling head permeability test performed on an undisturbed sample collected from boring location PAI-02-SB-01 at a depth of 36 to 40 feet bgs indicates the material encountered has a vertical hydraulic conductivity of 1.8×10^{-5} cm/sec and is consistent with clayey sands (Fetter, 1980).

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TABLE 3-1

SAMPLING RATIONALE
SITE 2 – BORROW PIT LANDFILL AND SITE 15 – DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Sample Location	Sampling Rationale
Groundwater	
PAI2-MW1(S), PAI2-MW2(S), and PAI2-MW3(S)	Collected to provide analytical data from the shallow surficial aquifer topographically upgradient of the landfill.
PAI-02-MW-04(S)	Collected to provide analytical data from the shallow surficial aquifer downgradient of the landfill.
PAI-02-MW-05(D)	Collected to provide analytical data from the deep surficial aquifer downgradient of the landfill.
Surface Water	
PAI-02-SW-01-00 through PAI-02-SW-04-00	Collected to assess potential migration and accumulation of chemicals from the borrow pit landfill to the surface water adjacent to the landfill.
Sediment	
PAI-02-SD-01-01 through PAI-02-SD-04-01	Collected to assess potential contaminant migration and accumulation of chemicals from the borrow pit landfill to the shallow sediment (0 to 0.5 feet bgs) adjacent to the landfill. Collected to assess recent migration to sediment.
PAI-02-SD-02-02	Collected to assess potential contaminant migration and accumulation of chemicals from the borrow pit landfill to sediment (0.5 to 1 foot bgs) adjacent to the landfill. Collected to assess historical migration to sediment.
PAI-15-SD-01 and PAI-15-SD-02	Collected to assess potential contaminant migration and accumulation of chemicals from the dirt roads near Elliot's Beach to the sediment along the Broad River.
PAI-15-SD-03	Collected to assess potential contaminant migration and accumulation of chemicals from the dirt roads near Elliot's Beach to the sediment along an unnamed stream east of Elliot's Beach.
Surface Soil	
PAI-02-SS-01 to PAI-02-SS-08	Collected to characterize the nature and extent of contamination of the surface soil atop the borrow pit landfill.
PAI-15-SS-01 to PAI-15-SS-04	Collected to characterize the nature and extent of contamination of the surface soil adjacent to the dirt roads surrounding the Borrow Pit Landfill.
PAI-15-SS-05 to PAI-15-SS-07	Collected to characterize the nature and extent of contamination of the surface soil near a picnic area at Elliot's Beach.
Subsurface Soil	
PAI-02-SB-01	Samples collected during monitoring well installation to provide geotechnical data.
PAI-02-SB-02A, PAI-02-SB-10, PAI-02-SB-11	Samples collected during test pitting operations to determine whether subsurface soil had been impacted by landfilling activities.

TABLE 3-2

MONITORING WELL CONSTRUCTION DETAILS
SITE 2 – BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Well Number	Installation Date	Ground Elevation (ft. msl)	Measuring Point Elevation (ft. msl)	Total Depth (feet bgs)	Depth to Water (feet bgs)	Screened Interval (feet bgs)
PAI2-MW1(S)	1988	16.0	19.42	26	13.45	6-26
PAI2-MW2(S)	1988	17.1	20.41	30	14.54	5-30
PAI2-MW3(S)	1988	13.95	17.33	26	12.09	6-26
PAI-02-MW-04(S)	1998	5.0	7.63	13.6	3.54	3.6-13.6
PAI-02-MW-05(D)	1998	5.0	7.98	36	3.96	31-36

Depths to groundwater measured prior to beginning tidal influence study for Site 2.
bgs -below ground surface
ft. msl -feet above mean sea level

TABLE 3-3

SUMMARY OF SUBSURFACE SOIL SAMPLES COLLECTED
SITE 2 – BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Sample ID	Date Collected	Media	Depth Collected (Feet)	Analysis
PAI-02-SB-01-01	1998	Subsurface soil	0-1	(1)
PAI-02-SB-01-30*	1998	Subsurface soil	30-32	(1), (4), (5)
PAI-02-SB-01-36*	1998	Subsurface soil	36-38	(6)
PAI-02-SB-02A-02	1999	Subsurface soil	2	(2)
PAI-02-SB-10-07	1999	Subsurface soil	7	(2)
PAI-02-SB-11-02	1999	Subsurface soil	2	(2)

TAL - Target Analyte List
PCBs - Polychlorinated biphenyls
TCL- Target Compound List
TOC - Total Organic Carbon
* denotes top of sample interval

1. TCL VOCs, SVOCs, pesticides, PCBs, TAL Metals (Totals), cyanide.
2. TCL VOCs, SVOCs, pesticides, PCBs, TAL metals (Totals)
3. TOC, pH.
4. Natural moisture content, grain-size analysis and Atterberg Limits.
5. Porosity, grain-size analysis, bulk density and specific gravity.
6. Shelby Tube (for Vertical Conductivity).

TABLE 3-4

**SUMMARY OF SURFACE WATER SAMPLES COLLECTED
SITE 2 – BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA**

Sample ID	Date Collected	Media	Depth Collected	Analysis
PAI-02-SW-01-00	1998	Surface water	Surface	(1), (3), (4)
PAI-02-SW-02-00	1998	Surface water	Surface	(1), (2), (3), (4)
PAI-02-SW-03-00	1998	Surface water	Surface	(1), (2), (3), (4)
PAI-02-SW-04-00	1998	Surface water	Surface	(1), (2), (3), (4), (5)

TAL - Target Analyte List
TCL - Target Compound List
TOC - Total Organic Carbon
PCBs - Polychlorinated biphenyls

1. TOC, Hardness ($CaCO_3$).
2. Hexavalent Chromium.
3. TCL VOCs, SVOCs, pesticides, PCBs, TAL Metals (Totals), TAL Metals (Dissolved) cyanide.
4. Dissolved oxygen, salinity, temperature, pH, and turbidity.
5. Secchi disk.

TABLE 3-5

SUMMARY OF SURFACE WATER QUALITY PARAMETERS
SITE 2 –BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Sample Number	Temperature (°C)	pH	Specific Conductance (mS/cm)	Dissolved Oxygen (mg/L)	Salinity (%)	Turbidity (NTU)	Secchi Disk (feet)
PAI-02-SW-01-00	30.1	7.43	46.3	7.52	3.02	119	NM
PAI-02-SW-02-00	30.4	7.40	46.2	7.38	3.02	13	NM
PAI-02-SW-03-00	29.3	7.35	46.6	8.14	3.05	12	NM
PAI-02-SW-04-00	31.2	7.28	46.8	7.47	3.05	115	2

NM - Secchi disk reading not taken-water was too shallow to obtain meaningful readings.
mS/cm - milliSiemens per centimeter
mg/L - milligram per Liter
NTU - Nephlometric Turbidity Units

TABLE 3-6

SUMMARY OF SEDIMENT SAMPLES COLLECTED
SITE 2 – BORROW PIT LANDFILL AND SITE 15 – DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Sample ID	Date Collected	Media	Depth Collected (Feet)	Analysis
PAI-02-SD-01-01	1998	Sediment	0-0.5	(1), (2), (4)
PAI-02-SD-02-01 PAI-02-SD-02-02	1998 1998	Sediment Sediment	0-0.5 0.5-1	(1), (2), (3) (4) (1), (2)
PAI-02-SD-03-01	1998	Sediment	0-0.5	(1), (2), (3), (4)
PAI-02-SD-04-01	1998	Sediment	0-0.5	(1), (2), (3), (4)

Sample ID	Date Collected	Media	Depth Collected (Feet)	Analysis
PAI-15-SD-01-01	1998	Sediment	0-0.5	(5)
PAI-15-SD-02-01	1998	Sediment	0-0.5	(5)
PAI-15-SD-03-01	1998	Sediment	0-0.5	(5)

TAL - Target Analyte List
TCL - Target Compound List
TOC - Total Organic Carbon
PCBs - Polychlorinated biphenyls

1. TCL VOCs, SVOCs, pesticides, PCBs, TAL Metals (Total), cyanide.
2. TOC, pH.
3. Hexavalent Chromium.
4. Grain size analysis and bulk density.
5. TCL SVOCs,pesticides, PCBs, TAL Metals (Total)

TABLE 3-7

SUMMARY OF SURFACE SOIL SAMPLES COLLECTED
SITE 2 – BORROW PIT LANDFILL AND SITE 15 – DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Sample ID	Date Collected	Media	Depth Collected (Feet)	Analysis
PAI-02-SS-01-01	1998	Soil	0-1	(1)
PAI-02-SS-02-01	1998	Soil	0-1	(1)
PAI-02-SS-03-01	1998	Soil	0-1	(1)
PAI-02-SS-04-01	1998	Soil	0-1	(1)
PAI-02-SS-05-01	1998	Soil	0-1	(1)
PAI-02-SS-06-01	1998	Soil	0-1	(1), (3)
PAI-02-SS-07-01	1998	Soil	0-1	(1), (2), (4)
PAI-02-SS-08-01	1998	Soil	0-1	(1), (3)

Sample ID	Date Collected	Media	Depth Collected (Feet)	Analysis
PAI-15-SS-01-01	1998	Soil	0-1	(5)
PAI-15-SS-02-01	1998	Soil	0-1	(5)
PAI-15-SS-03-01	1998	Soil	0-1	(5)
PAI-15-SS-04-01	1998	Soil	0-1	(5)
PAI-15-SS-05-01	1998	Soil	0-1	(5)
PAI-15-SS-06-01	1998	Soil	0-1	(5)
PAI-15-SS-07-01	1998	Soil	0-1	(5)

TAL - Target Analyte List
TCL - Target Compound List
TOC - Total Organic Carbon
PCBs - Polychlorinated biphenyls

1. TCL VOCs, SVOCs, pesticides, PCBs, TAL Metals (Total), cyanide.
2. TOC, pH.
3. Hexavalent Chromium.
4. Natural moisture content, grain-size analysis, Atterberg Limits, and bulk density.
5. TCL PCBs and Lead.

TABLE 3-8

SUMMARY OF GROUNDWATER SAMPLES COLLECTED
SITE 2 – BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Sample ID	Date Collected	Media	Depth Collected	Analysis
PAI2-GW1-01	1998	Groundwater	Shallow surficial	(1), (3), (5), (6)
PAI2-GW2-01 PAI2-GW2-01A	1998 1998	Groundwater Groundwater	Shallow surficial Shallow surficial	(1), (2), (3), (5), (6) (4)
PAI2-GW3-01 PAI2-GW3-01-D	1998 1998	Groundwater Groundwater	Shallow surficial Shallow surficial	(1), (3), (5), (6) (1), (3), (5), (6)
PAI-02-GW-04-01	1998	Groundwater	Shallow surficial	(1), (2), (3), (5), (6)
PAI-02-GW-05-01 PAI-02-GW-05-01A	1998 1998	Groundwater Groundwater	Deep surficial Deep surficial	(1), (2), (3), (5), (6) (4)

PAI-02-GW-02-01A – Addendum sampling performed in September 1998. All other samples collected in August 1998.

PAI-02-GW-03-01D - duplicate
TCL - Target Compound List
TOC - Total Organic Carbon
TSS - Total suspended solids
TAL - Target Analyte List
PCBs - Polychlorinated biphenyls
TDS - Total dissolved solids

1. TOC, Hardness ($CaCO_3$).
2. Hexavalent Chromium.
3. TCL VOCs, SVOCs, pesticides, PCBs, TAL Metals (Totals), TAL Metals (Dissolved) cyanide.
4. RCRA Appendix IX Organics (including VOCs, organics, SVOCs, and herbicides).
5. TDS, TSS, chloride, fluoride, nitrate/nitrite, sulfate.
6. Dissolved oxygen, salinity, temperature, pH, and turbidity.

TABLE 3-9

**SUMMARY OF GROUNDWATER QUALITY PARAMETERS
COLLECTED DURING PURGING
SITE 2 – BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA**

Sample Number	Temperature (°C)	pH	Specific Conductance (mS/cm)	Dissolved Oxygen (mg/L)	Salinity (%)	Turbidity (NTU)
PAI2-GW1-01	22.0	4.92	0.171	6.72	0.0	0
PAI2-GW2-01	22.0	4.74	0.162	3.78	0.0	0
PAI2-GW2-01A	22.9	4.82	0.132	10.24	0.0	0
PAI2-GW3-01	23.2	5.40	7.62	1.87	0.41	5
PAI2-GW3-01D	23.2	5.40	7.62	1.87	0.41	5
PAI-02-GW-04-01	28.1	6.82	35.2	6.27	2.24	1
PAI-02-GW-05-01	25.2	5.91	1.66	2.93	0.07	4
PAI-02-GW-05-01A	23.7	8.10	1.57	NM	0.07	0

PAI-02-GW-03-01-D - Duplicate
PAI-02-GW-02-01A - Addendum sampling performed in September 1998. All other samples collected in August 1998.
mS/cm - milliSiemens per centimeter
mg/L - milligram per Liter
NTU - Nephlometric Turbidity Units
NM – Not measured

TABLE 3-10
WATER- LEVEL MEASUREMENTS
SITE 2 – BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Well Number	Date Measured	Measuring Point Elevation (ft. msl)	Depth to Water (ft. from TPVC)	Groundwater Elevation (ft. msl)
PAI2-MW1(S)	09/01/98	19.42	16.87	2.55
PAI2-MW2(S)	09/01/98	20.41	17.85	2.56
PAI2-MW3(S)	09/01/98	17.33	15.47	1.86
PAI-02-MW-04(S)	09/01/98	7.63	6.17	1.46
PAI-02-MW-05(D)	09/01/98	7.98	6.94	1.04

ft msl -feet above mean sea level
TPVC-top of polyvinyl chloride (PVC)

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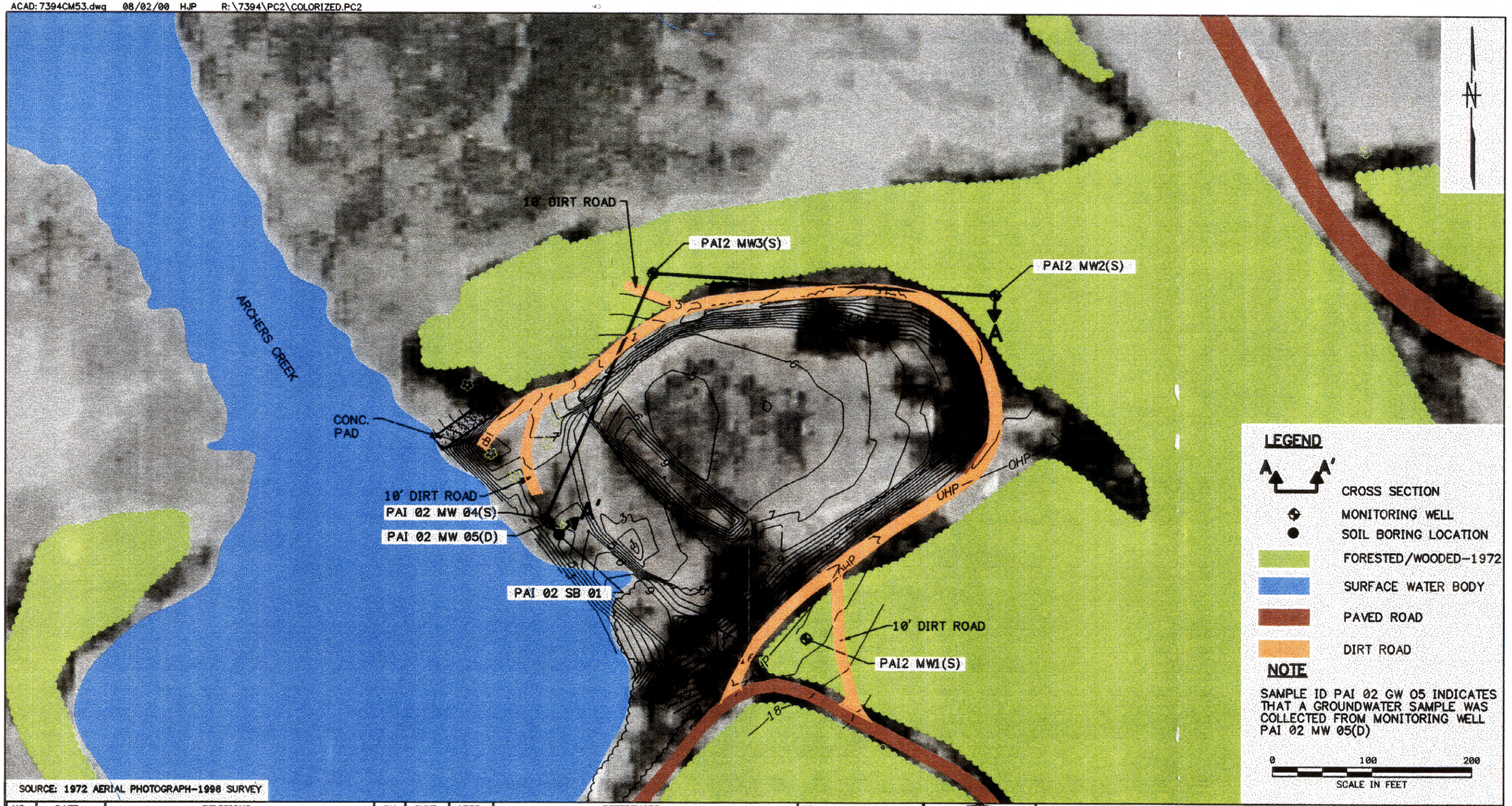

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY MF DATE 3/22/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

MONITORING WELL AND SOIL BORING LOCATION MAP
SITE 2 – BORROW PIT LANDFILL
AND SITE 15 – DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 3-1
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

170A B2Y

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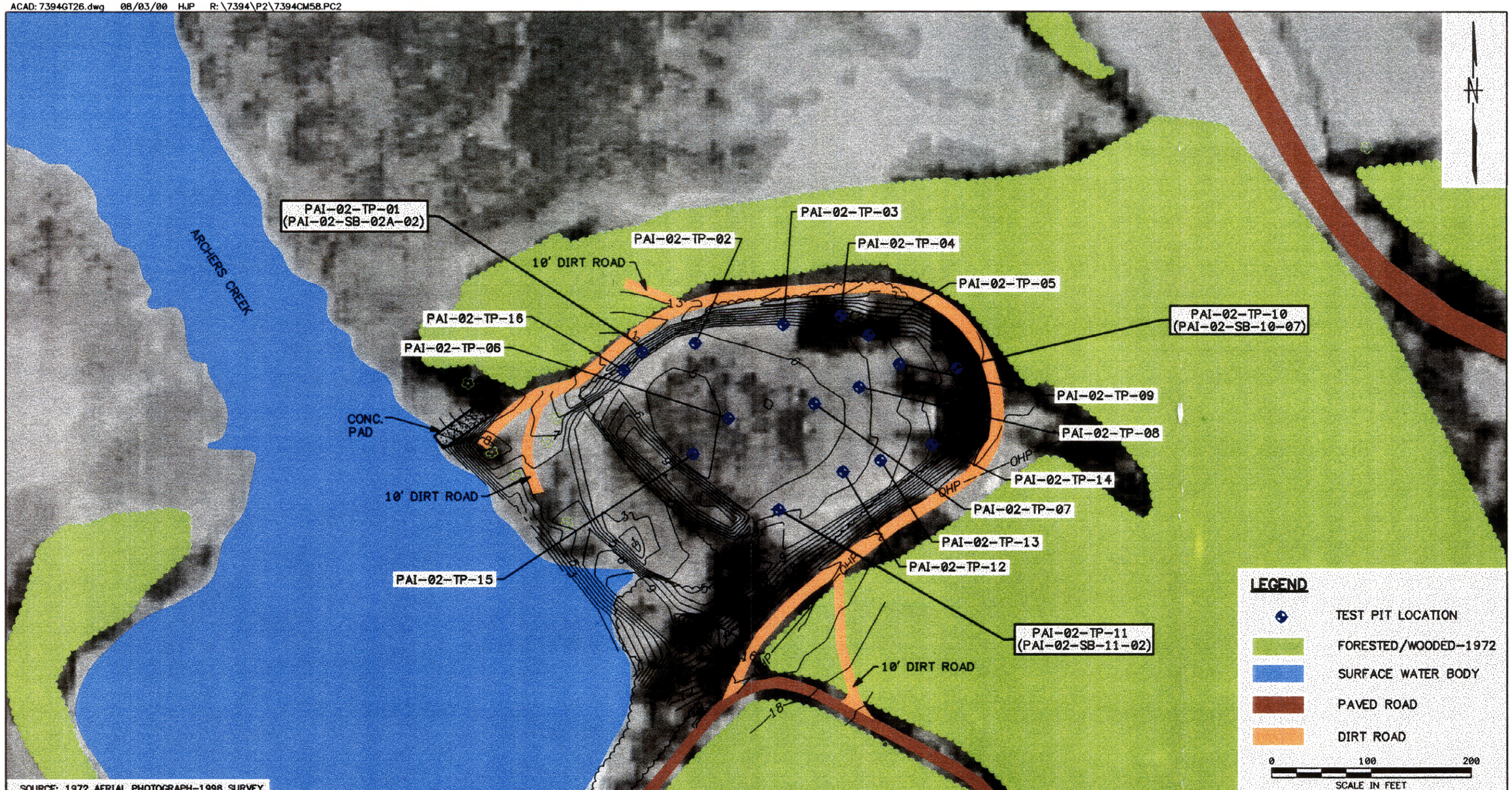

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 11/19/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

TEST PIT AND SUBSURFACE
SOIL SAMPLE LOCATION MAP
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 3-2
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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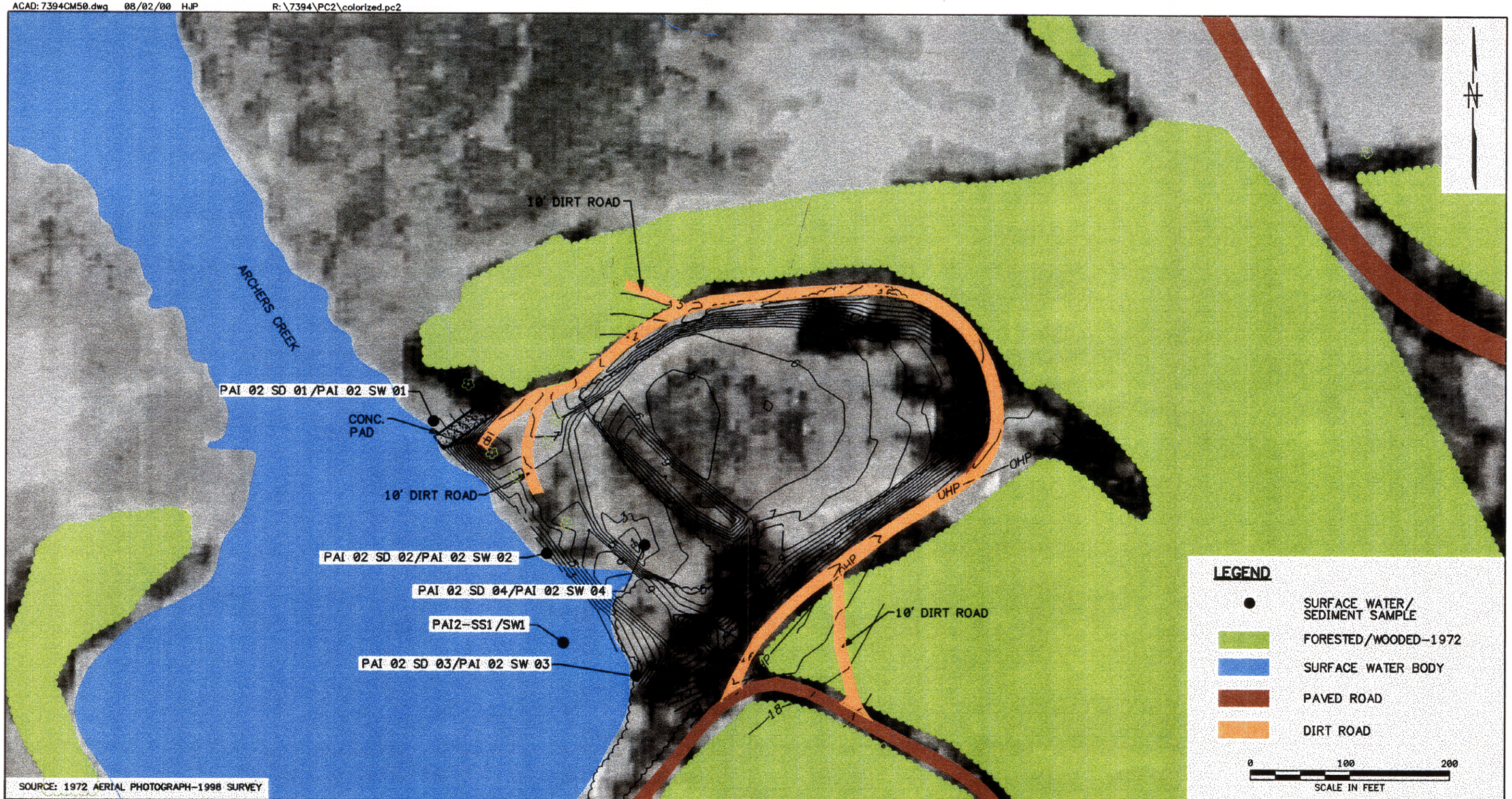


NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY MF DATE 3/22/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

SURFACE WATER AND SEDIMENT SAMPLE LOCATION MAP
SITE 2 - BORROW PIT LANDFILL AND 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 3-3
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

ACAD: 7394CM52.dwg 08/03/00 HJP R:\7394\PC2\colorized.pc2

SOURCE: U.S.G.S. 7.5 MINUTE PARRIS ISLAND QUADRANGLE, 1956. PHOTOREVISED 1979.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

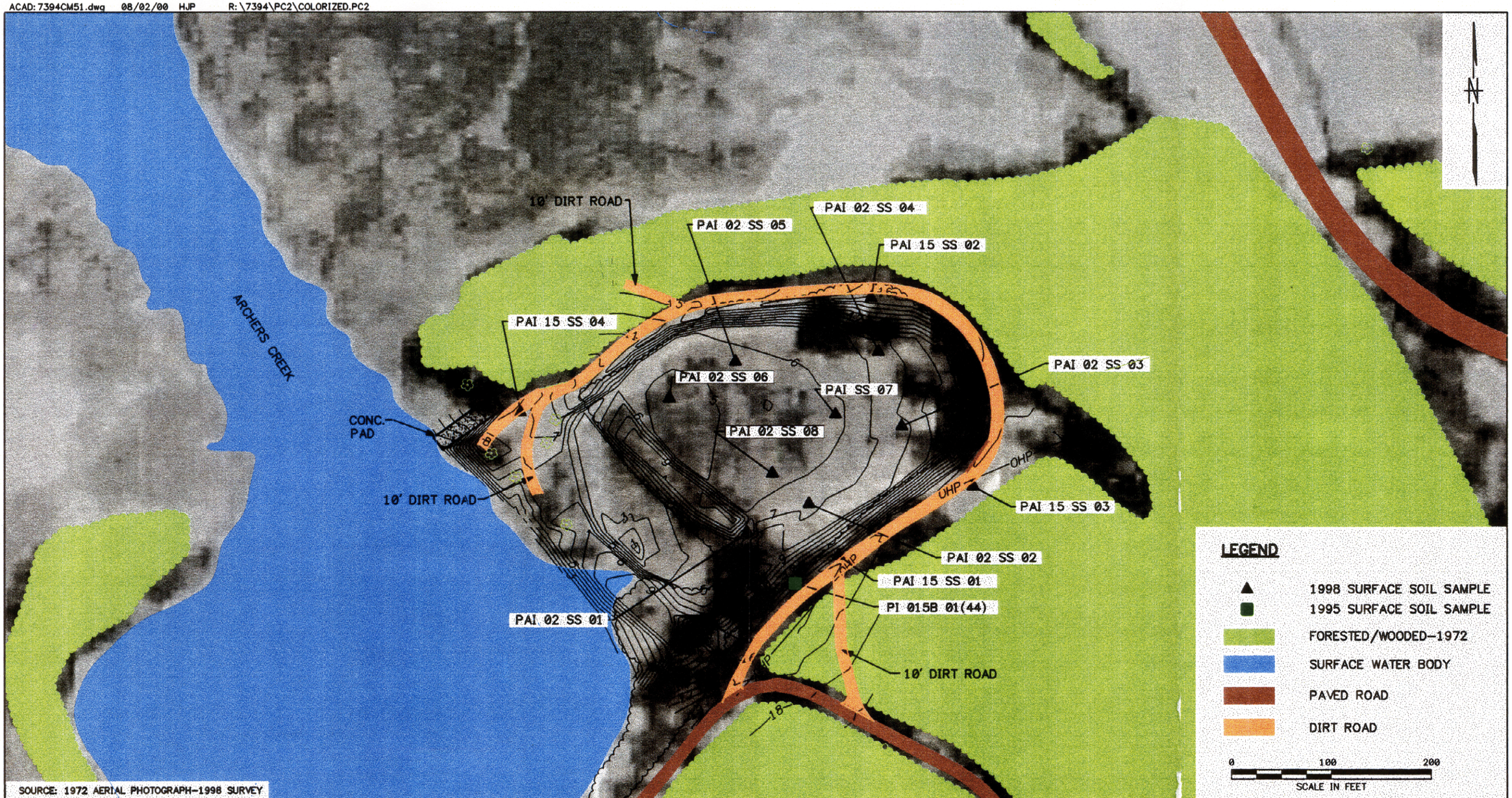
DRAWN BY MF DATE 3/22/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

SURFACE SOIL AND SEDIMENT SAMPLE LOCATION MAP
SITE 15-DIRT ROADS AT ELLIOT'S BEACH
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 3-4
REV. 0

FORM CADD NO. SDIV_BHDWG - REV 0 - 1/20/98

ACAD: 7394CM51.dwg 08/02/00 HJP R:\7394\PC2\COLORIZED.PC2



SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

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COST/SCHED-AREA
SCALE AS NOTED

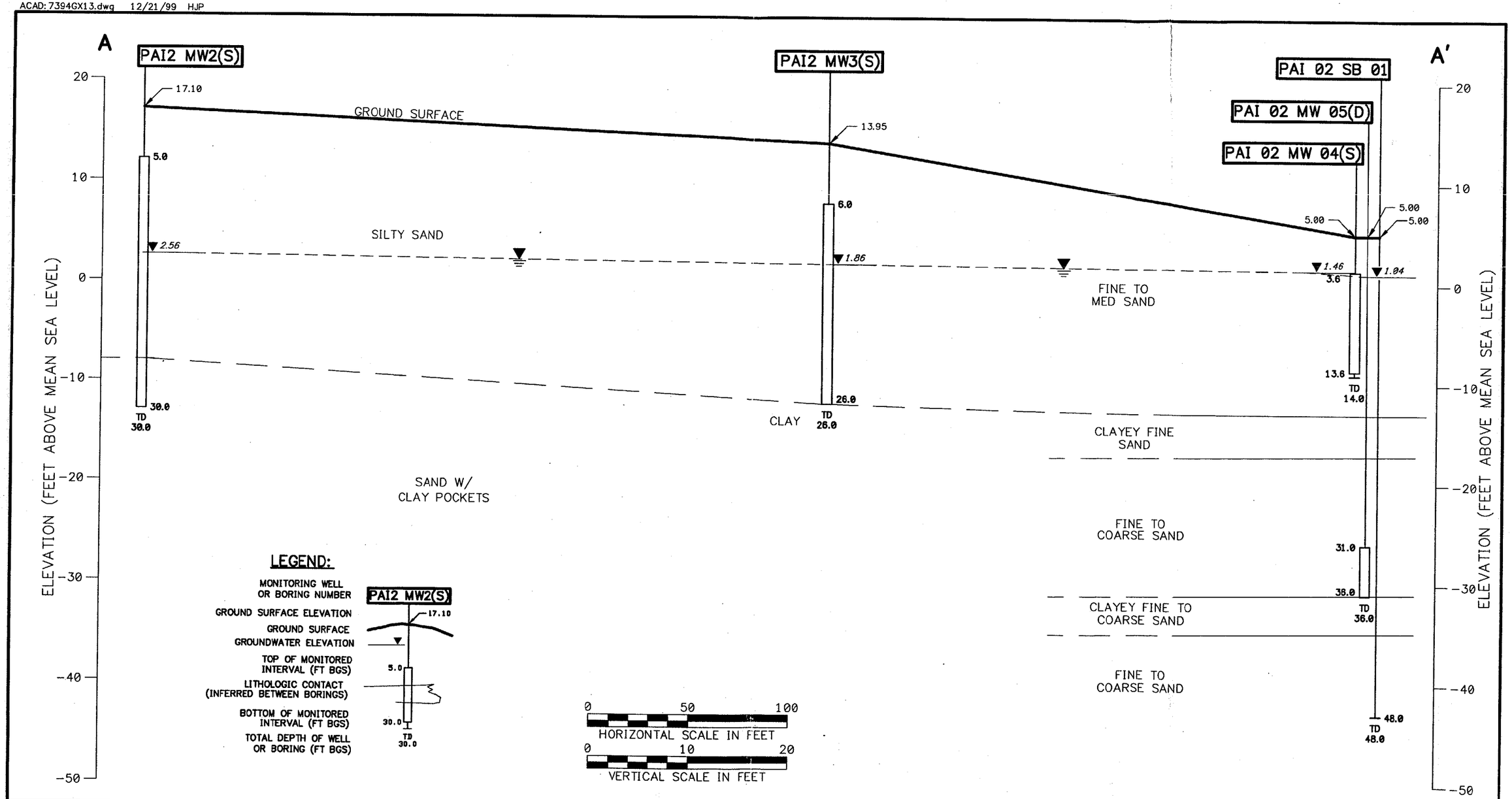
DEPARTMENT OF THE NAVY · NAVAL FACILITIES ENGINEERING COMMAND

SURFACE SOIL
SAMPLE LOCATION MAP
SITE 2 – BORROW PIT LANDFILL
AND SITE 15 – DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 3-5
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

ACAD: 7394GX13.dwg 12/21/99 HJP



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY KW DATE 4/1/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

CROSS SECTION A-A'
SITE 2-BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 3-6
REV. 0

FORM CADD NO. SOUTH-BH.DGN - REV 0 - 9/9/98

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4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents the analytical results of the 1998 and 1999 field investigation sampling conducted at Site/SWMU 2 (Site 2) and Site/SWMU 15 (Site 15). Site 2 is the Borrow Pit Landfill. It was operated from 1965 to 1968. This unlined pit reportedly served as the disposal pit for the following wastes from the MCRD:

- domestic trash
- construction debris
- cleaning rags saturated with oil, mineral spirits, and kerosene
- spent absorbent
- solvent sludge (aliphatic petroleum and chlorinated solvent compounds)
- perchloroethylene still bottoms
- metal shavings
- PCB-contaminated oil
- mercury amalgam
- beryllium wastes
- solid and liquid paint wastes, e.g., diesel fuel and methylene chloride

The former landfill occupies approximately 1.9 acres and is presently covered by mature pine trees. No significant disposal or intrusive activities have occurred at Site 2 since 1968.

Site 15 is approximately 1.5 miles of dirt and gravel road leading to Elliot's Beach and 0.5 mile of road leading to Site 2. These roads were routinely sprayed with oil for dust control. From 1918 to 1966, the following materials were transported on these roads and sprayed on them for dust control: waste lube oil, cutting oil, petroleum-based solvents (kerosene, gasoline, mineral spirits), hydraulic fluids, and water-based coolants. Currently, most of the road leading to the beach has been paved with approximately 0.25 mile unpaved.

Samples were collected from Site 2 and Site 15 in the spring and summer of 1998 and in the fall of 1999. A summary of the analytical program is provided in Tables 3-1 and 3-2. Sample locations are shown on Figures 3-1 through 3-5. During the field investigation sampling at Site 2, eight surface soil samples, four filtered and non-filtered groundwater samples, four filtered and non-filtered surface water samples, five sediment samples, and three subsurface samples were collected and analyzed. At Site 15, a total of seven surface soil samples and three sediment samples were collected. A complete set of analytical results is presented in Appendix C.

Analytical results were also compared to human health and ecological criteria on a preliminary basis. Data presented in Section 4.0 figures exceed background levels and human health risk-based concentrations (RBCs) or ecological screening values. A detailed discussion pertaining to the comparison of analytical results to U.S. EPA human health and ecological criteria is provided in the human health and ecological risk assessments presented in Sections 6.0 and 7.0, respectively. Inorganic background levels are based on samples collected from areas that are remote from the investigative sites and other waste management activities at Parris Island and are therefore biased toward clean. For each background area, sample locations were visually located in the field to confirm the absence of waste management activities and represent a range of undisturbed soils and sediment types. The two locations selected for background samples consist of Pickney Island and an undeveloped area on the southern portion of Parris Island. See Appendix A for sample locations. Six background samples were collected for all media of concern, except groundwater. Positive detections were noted for most inorganic parameters (see Table 4-1). The background values presented in Table 4-1 are based on U.S. EPA Region IV protocol and equal two times the mean value. A complete set of analytical results is presented in Appendix C.

Data were validated in accordance with U.S. EPA National Functional Guidance for Organic and Inorganic Data Review (U.S. EPA, 1994a,b).

The analytical results for the sampled media are summarized in the following sections.

4.1 SURFACE SOIL

4.1.1 1998 Results

Summary statistics of all positive results for the 1998 surface soil sampling at Site 2 and Site 15 are provided in Table 4-2. Positive detections of organics and inorganics for surface soil at Site 2 and Site 15 that exceed background levels and U.S. EPA Region III human health or U.S. EPA Region IV ecological criteria are shown on Figure 4-1 and Figure 4-2 and are discussed below. The human health criteria consist of the soil concentration equal to the lower of a 1E-06 incremental lifetime cancer risk or a hazard quotient equal to 1.0 under the residential use scenario (EPA Region III RBCs). The ecological criteria consist of U.S. EPA Region 4 ecological screening criteria. See Sections 6.0 and 7.0 for a more detailed evaluation.

Site 2

Organic compounds detected in surface soil at Site 2 include the VOCs acetone, chloroform, and toluene. The detected SVOCs are anthracene, benzo(b)fluoranthene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, and phenanthrene. No pesticides or PCBs were detected.

Chloroform was detected the most (6 out of 8 samples) at levels that ranged from 2 µg/kg to 18 µg/kg. Acetone (2 out of 7) and toluene (1 out of 8) were detected less frequently. The maximum concentration of acetone (170 µg/kg), however, was higher than the other detected VOCs. Toluene was detected at a maximum level of 3 µg/kg. All VOCs were detected at concentrations that were less than human health RBCs or ecological screening values (see Figure 4-1).

Phenanthrene (6 out of 8) and benzo(b)fluoranthene (4 out of 8) were detected the most when compared to the other detected SVOCs. Anthracene, chrysene, and indeno(1,2,3-cd)pyrene were detected once and fluoranthene was detected in two of the eight samples. The range of maximum detections for the more frequently detected SVOCs was 2.3 µg/kg to 41 µg/kg (phenanthrene). The maximum concentrations of the less frequently detected SVOCs were relatively low, ranging from 1.3 µg/kg to 7.7 µg/kg (fluoranthene). The concentrations of all SVOCs were below the human health RBCs and ecological screening criteria (Figure 4-1).

Inorganics were also detected throughout the surface soil samples collected at Site 2. They included the following metals: aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, vanadium, and zinc. Essential nutrients (calcium, magnesium, potassium, and sodium) were also detected.

The following metals were detected in all samples: aluminum, barium, chromium, iron, and vanadium. The other metals were found less frequently: antimony (1/8), arsenic (4/8), cobalt (5/8), copper (2/8), lead (5/8), manganese (6/8), mercury (5/8), nickel (1/8), selenium (1/8), and zinc (3/8). Aluminum and iron were detected at maximum levels of 4,290 mg/kg and 1,930 mg/kg, respectively. The range of maximum detections for the remaining metals (excluding the essential nutrients) was 0.05 mg/kg (mercury) to 58.1 mg/kg (manganese). The maximum levels of chromium and copper slightly exceed background levels. The concentrations of all inorganics were below the human health RBCs and ecological screening criteria (Figure 4-1).

Site 15

At Site 15, lead was detected at concentrations ranging from 4 mg/kg to 18.4 mg/kg (see Table 4-1). This maximum level was detected at sample location PAI-15-SS-07 (see Figure 4-2). This maximum

concentration is only slightly greater than background (13 mg/kg). This level is less than human health RBCs and ecological screening criteria.

4.1.2 Comparison of 1998 and 1996 Data

Two soil samples for evaluation of Site 15 – Dirt Roads were collected in 1996 (see Figures 3-4 and 3-5). One sample was collected near Site 2 – Borrow Pit Landfill and the other sample was collected at Elliot's Beach. Sample results are presented in the Parris Island Site 2 Work Plan and in Appendix C. Based on the work plan, the only potential concern with Site 15 was PCBs and lead.

PCBs were detected in one of two samples collected during the 1996 sample event. The detected concentration was 24J µg/kg, which is just above the minimum screening value of 20 µg/kg. PCBs were not detected in any of the seven samples from 1998 sample event, indicating that PCBs are not a wide spread concern with the dust control practices on the dirt roads.

Lead was detected in both of the 1996 sample results at concentrations of 4 and 15 mg/kg. These detections are consistent with the 1998 sample results in which lead was detected in all seven samples at concentrations ranging from 4 to 18.4 mg/kg.

4.2 GROUNDWATER

4.2.1 1998 Results

Summary statistics of positive results for the 1998 groundwater sampling at Site 2 are provided in Table 4-3. Positive detections of organics and inorganics for groundwater at Site 2 that exceeded human health or ecological criteria are shown on Figure 4-3. The human health criteria consist of the groundwater concentration equal to the lower of a 1E-06 incremental lifetime cancer risk or a hazard quotient equal to 1.0 under the potable water use scenario (EPA Region III RBCs). The ecological criteria is based on the assumption that groundwater would become surface water. The lower of the EPA Region 4 fresh water and brackish water screening levels is then used. See Sections 6.0 and 7.0 for a more detailed evaluation. Based on groundwater elevation contouring, monitoring wells PAI2-MW1(S) and PAI2-MW2(S) are upgradient of Site 2. The other groundwater monitoring wells are downgradient of Site 2.

Organic compounds detected in groundwater at Site 2 included the following VOCs: acetone, carbon disulfide, chloroform, and chloromethane. Three of the four VOCs were only detected once. Acetone was detected twice. Detected SVOCs included bis(2-ethylhexyl) phthalate (four out of five samples) and di-ethyl phthalate (detected once). No pesticides or PCBs were detected in groundwater.

VOCs were detected in groundwater at concentrations ranging from 0.35 µg/L to 4 µg/L (carbon disulfide). Of the VOCs, only chloroform, at 2.9 µg/L, exceeded a human health RBC (see Figure 4-3). Bis(2-ethylhexyl) phthalate and diethyl phthalate were detected at a concentration of 1 µg/L. Bis(2-ethylhexyl) phthalate was detected at concentrations exceeding ecological screening criteria in three samples.

The following inorganics were detected in the filtered and non-filtered groundwater samples collected from Site 2: aluminum, arsenic, barium, chromium, copper, iron, manganese, thallium, and zinc. Essential nutrients (calcium, magnesium, potassium, and sodium) were also detected.

Iron (total) was detected at a maximum level of 8,370 µg/L. Aluminum (total) was detected at a maximum concentration of 1,010 µg/L. The remaining metals (excluding essential nutrients) were detected at maximum levels ranging from 1.5 µg/L (arsenic, total) to 187 µg/L (manganese, total).

Filtered results were relatively similar to total results. Iron was detected at a maximum level of 7,980 µg/L. Aluminum was detected at maximum concentration of 512 µg/L. The remaining metals (excluding essential nutrients) were detected at maximum levels ranging from 1.2 µg/L (arsenic) to 243 µg/L (barium). Concentrations of aluminum, copper, iron, thallium and zinc in filtered groundwater samples exceed ecological screening.

For the inorganics, if the area groundwater was used for potable water, then arsenic and thallium would exceed human health RBCs (Figure 4-3).

4.2.2 Comparison of 1998 and 1988 Data

Three groundwater monitoring wells were sampled in 1988. Results from this testing are presented in Table 4-4, along with maximum detected results from the 1998 data. Also presented are the detected concentrations of these chemicals in background surface water. In 1988, arsenic, barium, chromium, lead, and two chlorinated VOCs were detected in one or more monitoring wells. The same wells were re-sampled in 1998. A comparison of the two data sets indicates that the concentration of these 5 of the 6 chemicals decreased by a factor of 5 to 20 over the ten year period. This magnitude of decrease may be an indication of natural attenuation of site contaminants.

Only barium was detected at a higher concentration in 1998 than in 1988. However, the increase in barium concentration in groundwater was only 6% (140 to 148) and the difference is within typical analytical accuracy. In addition, the groundwater in this well is saline indicating a strong connection

between groundwater in this well and the adjacent surface water. Note that both the 1988 and 1998 data are less than the surface water background concentration for barium.

4.3 SURFACE WATER

4.3.1 1998 Results

Summary statistics of positive results for the 1998 surface water sampling at Site 2 are provided in Table 4-5. Positive detections of organics and inorganics for surface water at Site 2 that exceeded background levels and/or human health AWQC or ecological criteria are shown on Figure 4-3. The human health criteria consist of the surface water concentration equal to the lower of a 1E-06 incremental lifetime cancer risk or a hazard quotient equal to 1.0 for consumption of surface water and organisms (EPA water quality standards). The EPA Region 4 brackish water screening levels is then used. See Sections 6.0 and 7.0 for a more detailed evaluation.

Organic compounds detected in surface water at Site 2 included acetone, PCE, bis(2-ethylhexyl) phthalate, phenanthrene, and endosulfan sulfate. These organics were detected in one or two of the total samples. Bis(2-ethylhexyl) phthalate was detected at a maximum level of 77 µg/L. The remaining organics were detected at maximum concentrations ranging from 0.078 µg/L (endosulfan sulfate) to 0.8 µg/L (acetone). PCE was detected once at a level of 0.3 µg/L. Bis(2-ethylhexyl) phthalate, exceeded its human health AWQC value at two sample locations (see Figure 4-3).

The following inorganics were detected in the non-filtered surface water sampled collected from Site 2: aluminum, antimony, arsenic, barium, cobalt, iron, manganese, silver, and zinc. Filtered metals results included arsenic, barium, cobalt, silver, and zinc. Essential nutrients (calcium, magnesium, potassium, and sodium) were also detected in both the filtered and unfiltered samples.

In the unfiltered samples, aluminum was detected at a maximum concentration of 1,850 µg/L. Iron was detected at a maximum level of 1,220 µg/L. The range of maximum detections of the other metals was 0.72 µg/L (silver) to 34.7 µg/L (manganese). Antimony, cobalt, and silver were detected at maximum levels greater than the background concentrations. As shown on Figure 4-3, arsenic exceeded human health AWQC criteria at one sample location.

Filtered results indicated that barium and zinc were detected in all the samples. For these two analytes, maximum levels ranged from 52.8 µg/L (zinc) to 233 µg/L (barium). The range of the other detected metals was 0.77 µg/L (cobalt) to 5.9 µg/L (arsenic). Arsenic, barium, cobalt, silver, and zinc were detected at maximum levels greater than background concentrations. Most maximum levels were

detected at sample location PAI-03-SW-02-F. As shown on Figure 4-3, silver exceeded ecological criteria at two locations.

4.3.2 Comparison of 1998 and 1988 Data

One surface water sample was collected in 1988 (see Figure 3-3). This sample contained cadmium, chromium, and lead at concentrations greater than U.S. EPA Region IV Ecological Screening Values, (see Table 4-4). In 1998, four surface water samples were collected at Site 2, including the area of the previous surface water sample. Of the three metals detected in 1988, only chromium was detected in the 1998 samples. Also, the 1998 chromium concentration was a factor of approximately 30 less than detected 1988. This magnitude of decrease may be an indication of natural attenuation of site contaminants.

4.4 SEDIMENT

4.4.1 1998 Results

Summary statistics of positive results for the 1998 sediment sampling at Site 2 and Site 15 are provided in Table 4-6 and Table 4-7, sediment grain size and TOC data for Site 2 and Site 15 is provided in Table 4-8. Positive detections of organics and inorganics for sediment at Site 2 and Site 15 that exceeded background levels and human health or ecological criteria are shown on Figures 4-4 and 4-2. The human health criteria consist of the soil concentration equal to the lower of a 1E-06 incremental lifetime cancer risk or a hazard quotient equal to 1.0 under the residential use scenario (EPA Region III RBCs) assuming that the sediment is the same as surface soils. The ecological criteria consist of the EPA Region 4 Screening Values. See Sections 6.0 and 7.0 for a more detailed evaluation.

Site 2

Organic compounds detected in sediment at Site 2 included the following: chloroform, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene. No pesticides or PCBs were detected in sediment.

Chloroform was detected at a maximum level of 5 µg/kg. The SVOCs were detected in one or two of the four samples. Maximum SVOC concentrations ranged from 8 µg/kg [benzo(k)fluoranthene] to 38 µg/kg (fluoranthene). All maximum organic concentrations were detected in sample PAI-03-SD-04. As shown on Figure 4-4, concentrations of all organics were less than human health RBCs or ecological screening criteria.

The following inorganics were detected in the sediment at Site 2: aluminum, arsenic, barium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, vanadium, and zinc. Essential nutrients (calcium, magnesium, potassium, and sodium) were also detected. Cobalt (2/5), mercury (1/5), and zinc (3/5) were the only metals not detected in all the samples. Aluminum was detected at a maximum concentration of 5,560 mg/kg. The maximum level of iron was 5,390 mg/kg. The range of maximum detections for the other metals was 0.04 mg/kg (mercury) to 52.4 mg/kg (manganese). The maximum level of selenium (0.42 mg/kg) as potentially greater than the background level (none detected with a non-detect range of 0.17 to 1.2 mg/kg). The other metals were within background concentrations. As shown on Figure 4-4, concentrations of all inorganics were less than human health RBCs or ecological screening criteria.

Site 15

At Site 15, several PAHs and inorganics were detected in this sediments. The following PAHs were detected: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene. Bis(2-ethylhexyl) phthalate was also detected in sediment. The maximum levels of the PAHs ranged from 0.012 mg/kg [benzo(a)pyrene and benzo(k)fluoranthene] to 0.046 mg/kg [indeno(1,2,3-cd)pyrene], which are relatively low.

The following inorganics were detected in the sediment at Site 15: aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, vanadium, and zinc. Essential nutrients (calcium, magnesium, potassium, and sodium) were also detected. The maximum levels of antimony (nondetected in background), of cobalt and nickel only slightly exceeded the background levels. The remaining detected metals did not exceed background concentrations. Aluminum was detected at a maximum concentration of 15,500 mg/kg. The maximum level of iron was 14,700 mg/kg.

The range of maximum detections for the other metals was 0.16 mg/kg (cadmium) to 113 mg/kg (manganese).

As shown on Figure 4-2, with the exception of one detection of bis(2-ethylhexyl) phthalate, concentrations of all chemicals were below human health RBCs or ecological screening criteria. The bis(2-ethylhexyl) phthalate exceeded the screening criteria by 50 percent.

4.4.2 Comparison of 1998 and 1988 Data

One sediment sample was collected in 1988 (see Figure 3-3). This sample contained arsenic, barium, chromium, lead, and chloroform at detectable concentrations. Of these chemicals, only chloroform was detected at concentrations greater than background. Chloroform was also detected in 2 of 4 sediment samples in 1998, but the maximum concentration detected in the current data is a factor of 15 less than detected in 1988. This magnitude of decrease may be an indication of natural attenuation of site contaminants.

4.5 SUBSURFACE SOIL

Summary statistics of positive results for the 1999 subsurface soil sampling at Site 2 are provided in Table 4-8. Three subsurface soil samples were collected in accordance with the approved Work Plan Addendum (TtNUS, 1999). Positive detections of organics and inorganics for subsurface sol that exceeded background levels and human health or ecological criteria are shown on Figure 4-5.

The one VOC detected in the subsurface soil at Site 2 was methylene chloride. It was detected in two of the three subsurface sol samples with maximum detection (0.009 mg/kg) at both PAI-02-SB-02A-02 and PAI-02-SB-10-07. As shown on Figure 4-8, methylene chloride did not exceed background, human health RBC, and/or ecological screening values.

SVOCs, pesticides, or PCBs were not detected in the subsurface soil samples.

The following inorganics were detected in the subsurface soil at Site 2: aluminum, barium, chromium, copper, iron, lead, manganese, and zinc. The essential nutrients calcium, magnesium, and potassium were also detected.

Manganese was only detected at sample location PAI-02-SB-10. The other metals were detected at all three sample locations. Aluminum was detected at a maximum concentration of 2860 mg/kg. The maximum level of iron was 337 mg/kg. The range of maximum detections for the other metals was 0.53 mg/kg (copper) to 11.4 mg/kg (barium). No inorganics exceeded background, human health RBCs, and/or ecological screening values (Figure 4-5).

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TABLE 4-1

SUMMARY OF DETECTED BACKGROUND CONCENTRATIONS
SITE 2 - BORROW PIT LANDFILL AND SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Parameter	Surface Soil	Sediment	Surface Water Filtered	Surface Water Unfiltered
Organics	(µg/kg)	(µg/kg)	(µg/l)	(µg/l)
4-Methyl-2-pentanone	7.3	26	N/A	<2 to <5
2-Butanone	<6 to <8	22	N/A	<2 to <5
Acetone	267	<7 to <110	N/A	<2 to <5
Chloromethane	<4 to <8	<7 to <18	N/A	0.68
Carbon Disulfide	<4 to <8	9.2	N/A	<1 to <2
Toluene	5.7	9.7	N/A	<0.5 to <1
Xylenes	<4 to <8	<7 to <18	N/A	1
Bis(2-ethylhexyl) phthalate	<340 to <390	421	N/A	45
Fluorene	646	<10 to <1200	N/A	<0.24 to <5
Indeno(1,2,3-cd)pyrene	<43 to <370	518	N/A	2.6
Beta-BHC	<1.8 to <8.9	7.1	N/A	<0.024 to <0.05
Inorganics	(mg/kg)	(mg/kg)	(µg/l)	(µg/l)
Aluminum	7270	24200	<22 to <99.4	3100
Arsenic	1.4	12	4.3	5.1
Barium	24	28	256	38
Beryllium	0.095	0.98	<0.2 to <0.6	<0.2 to <0.8
Cadmium	<0.03 to <0.22	0.28	<0.3 to <2	<0.3 to <0.2
Calcium	766	4000	650000	637000
Chromium	6.2	35.2	20	22.5
Cobalt	0.36	2.6	<0.6 to <3.7	<0.6 to <3.7
Copper	1.5	10	13	7
Iron	3920	21500	48	2090
Lead	12.5	21	11	<1 to <11
Magnesium	515	6400	1900000	1900000
Manganese	129	186	18	53
Mercury	0.11	0.09	<0.1 to <0.2	<0.1 to <0.2
Nickel	1.8	6	<1 to <4.4	<1 to <4.4
Potassium	313	3200	890000	830000
Selenium	0.29	<0.17 to <1.2	<1.7 to <7	<1.7 to <7
Sodium	241	19000	15900000	16000000
Thallium	0.098	0.41	<1.6 to<18	<1.6 to <18
Vanadium	9.5	50	15	18
Zinc	9.7	45	66	11

Background concentration is calculated as 2 times the average background concentration.
For chemicals in which at least one detection was noted, the average was calculated using 1/2 the detection limit for non detected chemicals.
Detection limits presented for organic compounds are CRQLS. Actual method detection limits are lower.
Chemicals not detected in the background data set were not presented in this table. They include antimony, silver, and most organic compounds.

TABLE 4-2

SUMMARY STATISTICS - SURFACE SOIL
SITE 2 - BORROW PIT LANDFILL AND SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Parameter	Frequency of Detection	Range of Positive Detects	Range of Nondetects	Location of Maximum Positive Detect	Average of Positive Detects	Average All	Background Level	Human Health (1) Screening Criteria	Ecological (2) Screening Criteria
SITE 2									
Volatiles (mg/kg)									
Acetone	2/7	0.018 - 0.17	0.02 - 0.16	PAI-02-SS-08-01	0.094	0.045429	NA	7,800	NA
Chloroform	6/8	0.002 - 0.018	0.007 - 0.008	PAI-02-SS-04-01	0.007	0.006188	NA	100	NA
Toluene	1/8	0.003	0.006 - 0.008	PAI-02-SS-01-01	0.003	0.00325	NA	16,000	0.050
Semivolatiles (mg/kg)									
Anthracene	1/8	0.0013	0.0017 - 0.022	PAI-02-SS-02-01	0.0013	0.002325	NA	23,000	0.100
Benzo(b)fluoranthene	4/8	0.0009 - 0.0023	0.0017 - 0.022	PAI-02-SS-07-01	0.0015	0.00257	NA	0.870	0.100
Chrysene	1/8	0.0029	0.0043 - 0.055	PAI-02-SS-07-01	0.0029	0.005781	NA	87	0.100
Fluoranthene	2/8	0.0047 - 0.0077	0.0043 - 0.055	PAI-02-SS-01-01	0.0062	0.006663	NA	3,100	0.100
Indeno(1,2,3-cd)pyrene	1/8	0.0047	0.0043 - 0.055	PAI-02-SS-08-01	0.0047	0.005719	NA	0.870	0.100
Phenanthrene	6/8	0.0032 - 0.041	0.0036 - 0.0073	PAI-02-SS-06-01	0.014	0.011419	NA	1,600(3)	0.100
Inorganics (mg/kg)									
Aluminum	8/8	1710 - 4290	NA	PAI-02-SS-04-01	2548	2548.75	7270	78,000	50
Antimony	1/8	0.17	0.15 - 1.3	PAI-02-SS-01-01	0.17	0.16625	ND	31	3.5
Arsenic	4/8	0.18 - 1	0.18 - 0.23	PAI-02-SS-07-01	0.56	0.33375	1.4	0.430	10
Barium	8/8	4.4 - 12	NA	PAI-02-SS-02-01	8	8.025	23.6	5,500	165
Calcium	7/8	53.1 - 477	47.3	PAI-02-SS-06-01	168	150.34375	766	NA	NA
Chromium	8/8	3.5 - 7.5	NA	PAI-02-SS-07-01	5.07	5.075	6.23	120,000 (4)	64
Cobalt	5/8	0.03 - 0.19	0.04	PAI-02-SS-04-01	0.084	0.06	0.36	4,700	20
Copper	2/8	1.1 - 1.7	0.36 - 0.75	PAI-02-SS-05-01	1.4	0.568125	1.5	3,100	40
Iron	8/8	382 - 1930	NA	PAI-02-SS-04-01	693	693.25	3920	23,000	200
Lead	5/8	1.7 - 5.7	2.6 - 5.2	PAI-02-SS-04-01	3.68	3.075	12	400 (5)	50
Magnesium	5/8	53.1 - 174	63.7 - 236	PAI-02-SS-04-01	89	82.69375	515	NA	NA
Manganese	6/8	2.6 - 58.1	1.8 - 3.6	PAI-02-SS-04-01	14	11.275	128	1,600	100
Mercury	5/8	0.03 - 0.05	0.02 - 0.03	PAI-02-SS-06-01	0.042	0.03125	0.11	23.0 (6)	0.1
Nickel	1/8	1.2	0.05 - 0.41	PAI-02-SS-04-01	1.2	0.22875	1.8	1,600	30
Potassium	2/8	87.8 - 102	47.8 - 87.5	PAI-02-SS-05-01	94.9	46.38125	312	NA	NA
Selenium	1/8	0.18	0.19 - 0.24	PAI-02-SS-04-01	0.18	0.11125	0.285	390	0.81
Sodium	6/8	189 - 2100	432 - 606	PAI-02-SS-07-01	957	783.125	240	NA	NA
Vanadium	8/8	1.4 - 4.1	NA	PAI-02-SS-04-01	2.08	2.0875	9.5	550	2
Zinc	3/8	1.2 - 2.3	0.92 - 3.2	PAI-02-SS-01-01	1.6	1.15125	9.70	23,000	50
SITE 15									
Inorganics (mg/kg)									
Lead	7/7	4 - 18.4	NA	PAI-15-SS-07-01	8.48	8.48	12.5	400	50

NA Not Applicable or Available
ND Not Detected
(1) U.S. EPA Region 3 Residential Soil RBCs (April 13, 2000)
(2) U.S. EPA Region 4 Soil Screening Levels
(3) Value is for naphthalene
(4) Value is for trivalent chromium
(5) OSWER Screening level
(6) Value is for mercuric chloride

TABLE 4-3
SUMMARY STATISTICS - GROUNDWATER
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Parameter	Frequency of Detection	Range of Positive Detects	Range of Nondetects	Location of Maximum Positive Detect	Average of Positive Detects	Average All	Human Health (1) Screening Criteria	Ecological (2) Screening Criteria
Volatiles (µg/L)								
Acetone	2/3	1.8 - 3.3	5	PAI-02-GW-04-01	2.55	2.52	610	NA
Carbon Disulfide	1/5	4	1	PAI-02-GW-05-01	4	1.2	1000	NA
Chloroform	1/5	2.9	1	PAI2-GW2-01	2.9	0.98	0.15	289
Chloromethane	1/5	0.35	1	PAI2-GW3-01-AVG	0.35	0.47	2.1	2700
Semivolatiles (µg/L)								
Bis(2-Ethylhexyl) phthalate	4/5	1	5	PAI2-GW1-01	1	1.3	4.8	0.3
Diethyl Phthalate	1/5	1	5	PAI-02-GW-05-01	1	2.2	29000	75.9
Inorganics - Unfiltered (µg/L)								
Aluminum	3/5	189 - 1010	22-79.5	PAI2-GW1-01	492	305	37000	87
Arsenic	4/5	1.0 - 1.5	0.9	PAI2-GW1-01	1.24	1.08	0.045	36
Barium	5/5	33.7 - 148	NA	PAI2-GW3-01-AVG	73	73	2600	NA
Calcium	5/5	6370 - 281000	NA	PAI-02-GW-04-01	104484	104484	NA	NA
Chromium	1/5	5.2	6.4-11.9	PAI2-GW3-01-AVG	5.2	4.4	55000 (3)	11
Copper	2/5	5.2 - 28.8	2.6	PAI2-GW1-01	17	7.58	1500	2.9
Iron	5/5	439 - 8370	NA	PAI-02-GW-05-01	3087	3087	11000	1000
Magnesium	5/5	2580 - 778000	NA	PAI-02-GW-04-01	203782	203782	NA	NA
Manganese	5/5	37 - 187	NA	PAI-02-GW-05-01	115	115	730	NA
Potassium	4/5	400 - 245000	558	PAI-02-GW-04-01	74892	59969	NA	NA
Sodium	5/5	18100 - 5990000	NA	PAI-02-GW-04-01	1536120	1536120	NA	NA
Thallium	2/5	18	1.8 - 18	PAI2-GW2-01	18	9.36	2.6	4
Zinc	2/5	5.5 - 13.3	4.1 - 33.4	PAI2-GW2-01	9.4	8.89	11000	58.91
Inorganics - Filtered (µg/L)								
Aluminum	2/5	195 - 512	22 - 60.4	PAI2-GW1-01-F	353	151	37000	87
Arsenic	2/5	1.1-1.2	0.9	PAI2-GW2-01-F	1.15	1.55	0.045	36
Barium	5/5	172-243	NA	PAI-02-GW-04-01-F	214	241	2600	NA
Calcium	5/5	6670 - 276000	NA	PAI-02-GW-04-01-F	101344	101344	NA	NA
Chromium	1/5	5	6.4-15.2	PAI2-GW3-01-F-AVG	5	4.71	55000 (9)	11
Copper	2/5	3.9-22.9	2.6	PAI2-GW1-01-F	13.4	6.14	1500	2.9
Iron	5/5	405 - 7980	NA	PAI-02-GW-05-01-F	2697	2697	11000	1000
Magnesium	5/5	2520 - 772000	NA	PAI-02-GW-04-01-F	197534	197534	NA	NA
Manganese	5/5	35.5 - 181	NA	PAI-02-GW-05-01-F	111	111	730	NA
Potassium	4/5	602 - 238000	682	PAI-02-GW-04-01-F	72108	57754	NA	NA
Sodium	5/5	21200 - 5970000	NA	PAI-02-GW-04-01-F	1491780	1491780	NA	NA
Thallium	1/5	18	1.8-18	PAI-02-GW-04-01-F	18	7.56	2.6	4
Zinc	4/5	13.4 - 113	24.75	PAI2-GW1-01-F	73.75	61.5	11000	58.91

NA Not Applicable or Available
(1) U.S. EPA Region 3 Tapwater RBCs (April 13, 2000)
(2) U.S. EPA Region 4 Freshwater Surface Water Screening Values
(3) Value is for total chromium

TABLE 4-4

COMPARISON OF HISTORIC DATA (1988 AND 1996) WITH CURRENT DATA (1998)
SITE 2 - BORROW PIT LANDFILL AND SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Site 2 – Surface Water Data (µg/l)

Parameter	1988 Data (SW-1)	1998 Data Site 2 Maximum	1998 Data Background
Cadmium	83		
Chromium	140	5.2	20
Lead	25		11

SW-1 is at the same approximate location as PAI-02-SW-03

Site 2 – Sediment Data (mg/kg)

Parameter	1988 Data (SS-1)	1998 Data Site 2 Maximum	1998 Data Background
Arsenic	9.6	2.1	12
Barium	3	7.9	28
Chromium	3.11	10.1	35.2
Lead	4.8	7.1	21
Chloroform	81	5	

SD-1 is at the same approximate location as PAI-02-SD-03

Site 15 – Soil Data (mg/kg)

Parameter	1996 Data		1998 Data	1998 Data
	015B	015A	Maximum	Background
Lead	15	4	18.4	12.5
Aroclor-1254	0.024J			

Blank indicates that parameter was not detected.

Site 2 - Groundwater Data (µg/l)

Parameter	1988 Data			1998 Data Maximum	1998 Surface Water Data[1] Background
	GW-1	GW-2	GW-3		
Arsenic	7	7		1.5	4.3
Barium	110	100	140	148	256
Chromium			100	5.2	20
Lead	73	15	11		11
Chloroform			12	2.9	
1,2-Dichloroethane	20				

Site 2 groundwater is being presented with surface water background data because site specific groundwater data is not available and protection of ecological receptors in the adjacent surface water is a primary concern.

Monitoring well locations are the same as the 1998 sample locations.

TABLE 4-5
SUMMARY STATISTICS - SURFACE WATER
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Parameter	Frequency of Detection	Range of Positive Detects	Range of Nondetects	Location of Maximum Positive Detect	Average of Positive Detects	Average All	Human Health (1) Screening Criteria	Ecological (2) Screening Criteria
Volatiles (µg/L)								
Acetone	2/2	0.6 - 0.8	NA	PAI-02-SW-02-00	0.7	0.7	NA	NA
Tetrachloroethene (PCE)	1/4	0.3	0.5	PAI-02-SW-02-00	0.3	0.26	0.8	NA
Semivolatiles (µg/L)								
Bis(2-Ethylhexyl) phthalate	2/4	14 - 77	10	PAI-02-SW-01-00	45.5	25	1.8	NA
Phenanthrene	2/4	0.074 - 0.16	0.097 - 0.098	PAI-02-SW-04-00	0.117	0.08	NA	23.5
Pesticides (µg/L)								
Endosulfan Sulfate	2/4	0.04 - 0.078	0.048 - 0.05	PAI-02-SW-01-00	0.059	0.04	110	NA
Inorganics - Unfiltered (µg/L)								
Aluminum	3/4	1030 - 1850	477	PAI-02-SW-02-00	1376	1092	NA	NA
Antimony	1/4	2.8	1.8 - 2.2	PAI-02-SW-04-00	2.8	1.4	14	NA
Arsenic	2/4	2.9 - 4.4	2.1	PAI-02-SW-01-00	3.65	2.35	0.018	36
Barium	4/4	19 - 21.4	NA	PAI-02-SW-04-00	20.6	20.6	1000	NA
Calcium	4/4	268000 - 303000	NA	PAI-02-SW-01-00	289000	289000	NA	NA
Cobalt	2/4	0.89 - 1.1	0.4	PAI-02-SW-01-00	0.995	0.59	NA	NA
Iron	3/4	417 - 1220	210	PAI-02-SW-02-00	824	644	300	NA
Magnesium	4/4	859000 - 950000	NA	PAI-02-SW-02-00	918250	918250	NA	NA
Manganese	2/4	31.6 - 34.7	17.4 - 33.4	PAI-02-SW-01-00	33	22	50	NA
Potassium	4/4	566000 - 642000	NA	PAI-02-SW-01-00	597500	597500	NA	NA
Silver	1/4	0.72	0.7	PAI-02-SW-02-00	0.72	0.44	NA	0.23
Sodium	4/4	7930000 - 8610000	NA	PAI-02-SW-01-00	8265000	8265000	NA	NA
Zinc	4/4	4.4 - 10.4	NA	PAI-02-SW-04-00	7.32	7.3	9100	86
Inorganics - Filtered (µg/L)								
Arsenic	2/4	3.5 - 5.9	2.1	PAI-02-SW-02-00-F	4.7	2.8	0.018	36
Barium	4/4	18.1 - 233	NA	PAI-02-SW-02-00-F	72	72	1000	NA
Calcium	4/4	264000 - 316000	NA	PAI-02-SW-02-00-F	293500	293500	NA	NA
Cobalt	2/4	0.67 - 0.77	0.4	PAI-02-SW-01-00-F	0.72	0.46	NA	NA
Magnesium	4/4	857000 - 998000	NA	PAI-02-SW-02-00-F	930250	930250	NA	NA
Potassium	4/4	581000 - 679000	NA	PAI-02-SW-02-00-F	618000	618000	NA	NA
Silver	2/4	0.82 - 0.93	0.7	PAI-02-SW-01-00-F	0.87	0.61	NA	0.23
Sodium	4/4	8120000 - 9200000	NA	PAI-02-SW-02-00-F	8545000	8545000	NA	NA
Zinc	4/4	4.1 - 52.8	NA	PAI-02-SW-02-00-F	16.6	16.6	9100	86

NA Not Applicable or Available
(1) Ambient Water Quality Criteria
(2) U.S. EPA Region 4 Saltwater Screening Values

TABLE 4-6
SUMMARY STATISTICS - SEDIMENT
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Parameter	Frequency of Detection	Range of Positive Detects	Range of Nondetects	Location of Max Positive Detect	Average of Positive Results	Average All	Background Level	Human Health [1] Screening Criteria	Ecological [2] Screening Criteria
Volatiles (mg/kg)									
Chloroform	2/5	0.004 - 0.005	0.006 - 0.008	PAI-02-SD-04-01	0.0045	0.0039	NA	100	NA
Semivolatiles (mg/kg)									
Benzo(a)anthracene	1/4	0.0082	0.012 - 0.031	PAI-02-SD-04-01	0.0082	0.011	NA	0.87	0.0748
Benzo(a)pyrene	2/4	0.0073 - 0.012	0.029 - 0.031	PAI-02-SD-04-01	0.00965	0.0123	NA	0.087	0.0888
Benzo(b)fluoranthene	2/4	0.0056 - 0.018	0.012	PAI-02-SD-04-01	0.0118	0.0089	NA	0.870	0.0888
Benzo(k)fluoranthene	1/4	0.008	0.0047 - 0.012	PAI-02-SD-04-01	0.008	0.0055	NA	8.7	0.0888
Chrysene	2/4	0.011 - 0.021	0.029 - 0.031	PAI-02-SD-04-01	0.016	0.015	NA	87	0.108
Fluoranthene	1/4	0.038	0.012 - 0.031	PAI-02-SD-04-01	0.038	0.018	NA	3100	0.113
Indeno(1,2,3-cd)pyrene	2/4	0.007 - 0.012	0.029 - 0.031	PAI-02-SD-04-01	0.0095	0.012	NA	0.87	0.0888
Phenanthrene	2/4	0.008 - 0.011	0.023 - 0.025	PAI-02-SD-04-01	0.0095	0.01	NA	1600 [3]	0.0867
Pyrene	1/4	0.03	0.023 - 0.062	PAI-02-SD-04-01	0.03	0.025	NA	2300	0.153
Inorganics (mg/kg)									
Aluminum	5/5	3140 - 5560	NA	PAI-02-SD-02-02	4498	4498	24,200	78000	NA
Arsenic	5/5	0.79 - 2.1	NA	PAI-02-SD-01-01	1.51	1.518	12	0.430	7.24
Barium	5/5	4.9 - 7.9	NA	PAI-02-SD-02-02	6.92	6.92	28	5500	NA
Calcium	5/5	362 - 32800	NA	PAI-02-SD-03-01	7411	7411.4	4000	NA	NA
Chromium	5/5	5.9 - 10.1	NA	PAI-02-SD-01-01	8.22	8.22	35.2	120000 [4]	52.3
Cobalt	2/5	0.35 - 0.52	0.74 - 0.88	PAI-02-SD-03-01	0.43	0.413	2.6	4700	NA
Copper	5/5	1.2 - 3.2	NA	PAI-02-SD-01-01	2.4	2.4	10	3100	18.7
Iron	5/5	2650 - 5390	NA	PAI-02-SD-01-01	3824	3824	21,500	23000	NA
Lead	5/5	3.2 - 7.1	NA	PAI-02-SD-02-02	5.72	5.72	21	400	30.2
Magnesium	5/5	777 - 2380	NA	PAI-02-SD-02-01	1473	1473.4	6400	NA	NA
Manganese	5/5	22.7 - 52.4	NA	PAI-02-SD-04-01	35	35.28	186	1600	NA
Mercury	1/5	0.04	0.02 - 0.04	PAI-02-SD-02-02	0.04	0.02	0.09	23 [5]	0.13
Nickel	5/5	0.82 - 2.1	NA	PAI-02-SD-01-01	1.6	1.604	6	1600	15.9
Potassium	5/5	426 - 1010	NA	PAI-02-SD-02-01	792	792.4	3200	NA	NA
Selenium	5/5	0.23 - 0.42	NA	PAI-02-SD-01-01	0.336	0.336	ND	390	NA
Sodium	5/5	2770 - 6650	NA	PAI-02-SD-02-01	4598	4598	19,000	NA	NA
Vanadium	5/5	6.1 - 12.8	NA	PAI-02-SD-01-01	9.98	9.98	50	550	NA
Zinc	3/5	10.9 - 12.6	4.4 - 6.7	PAI-02-SD-01-01	11	8.05	45	23000	124

NA = Not Applicable or Available
ND = Not Detected
(1) U.S. EPA Region 3 Residential Soil RBCs (April 13, 2000)
(2) U.S. EPA Region 4 Sediment Screening Levels
(3) Value is for naphthalene
(4) Value is for trivalent chromium
(5) Value is for mercuric chloride

TABLE 4-7

SUMMARY STATISTICS - SEDIMENT
SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Parameter	Frequency of Detection	Range of Positive Detects	Range of Nondetects	Location of Max Positive Detect	Average of Positive Results	Average All	Background Level	Human Health (1) Screening Criteria	Ecological (2) Screening Criteria
Semivolatiles (mg/kg)									
Benzo(a)anthracene	1/3	0.015	0.006 - 0.011	PAI-15-SD-03-01	0.015	0.0078	NA	0.87	0.0748
Benzo(a)pyrene	1/3	0.012	0.006 - 0.011	PAI-15-SD-03-01	0.012	0.0068	NA	0.087	0.0888
Benzo(b)fluoranthene	2/3	0.0038 - 0.033	0.0044	PAI-15-SD-03-01	0.0184	0.013	NA	0.87	0.0888
Benzo(g,h,i)perylene	1/3	0.013	0.0095 - 0.018	PAI-15-SD-03-01	0.013	0.0089	NA	NA	0.0888
Benzo(k)fluoranthene	1/3	0.012	0.0024 - 0.0044	PAI-15-SD-03-01	0.012	0.0051	NA	8.7	0.0888
Bis(2-Ethylhexyl)phthalate	1/3	0.28	0.44 - 0.66	PAI-15-SD-02-01	0.28	0.27	NA	46	0.182
Chrysene	3/3	0.011 - 0.028	NA	PAI-15-SD-03-01	0.018	0.018	NA	87	0.108
Fluoranthene	2/3	0.0093 - 0.034	0.011	PAI-15-SD-03-01	0.021	0.016	NA	3100	0.113
Fluorene	1/3	0.013	0.017 - 0.022	PAI-15-SD-02-01	0.013	0.01	NA	NA	0.0212
Indeno(1,2,3-cd)pyrene	2/3	0.013 - 0.046	0.011	PAI-15-SD-02-01	0.029	0.021	NA	0.87	0.0888
Phenanthrene	2/3	0.0081 - 0.014	0.0088	PAI-15-SD-02-01	0.011	0.0088	NA	1600	0.0867
Pyrene	1/3	0.028	0.012 - 0.022	PAI-15-SD-03-01	0.028	0.015	NA	2300	0.153
Inorganics (mg/kg)									
Aluminum	3/3	648 - 15500	NA	PAI-15-SD-03-01	6952	6952	24,200	78000	NA
Antimony	1/3	0.2	0.18 - 0.29	PAI-15-SD-02-01	0.2	0.145	ND	31	2
Arsenic	3/3	0.3 - 6.5	NA	PAI-15-SD-03-01	3.8	3.8	12	0.43	7.24
Barium	3/3	1.9 - 19.4	NA	PAI-15-SD-03-01	9.3	9.3	28	5500	NA
Beryllium	1/3	0.71	0.06 - 0.21	PAI-15-SD-03-01	0.71	0.28	0.98	16	NA
Cadmium	1/3	0.16	0.03	PAI-15-SD-03-01	0.16	0.06	0.28	3.9	0.676
Calcium	3/3	346 - 5550	NA	PAI-15-SD-03-01	2218	2218	4000	NA	NA
Chromium	3/3	2 - 27.8	NA	PAI-15-SD-03-01	12.6	12	35.2	120000	52.3
Cobalt	2/3	0.69 - 3.1	0.06	PAI-15-SD-03-01	1.8	1.27	2.6	4700	NA
Copper	2/3	4 - 8.7	0.58	PAI-15-SD-03-01	6.3	4	10	3100	18.7
Iron	3/3	604 - 14700	NA	PAI-15-SD-03-01	6388	6388	21,500	23000	NA
Lead	3/3	2.7 - 11.3	NA	PAI-15-SD-03-01	7.6	7.6	21	400	30.2
Magnesium	3/3	370 - 4220	NA	PAI-15-SD-03-01	1960	1960	6400	NA	NA
Manganese	3/3	5.3 - 113	NA	PAI-15-SD-03-01	50	50	186	1600	NA
Nickel	2/3	1.5 - 6.5	0.11	PAI-15-SD-03-01	4	2.68	6	1600	15.9
Potassium	3/3	205 - 2560	NA	PAI-15-SD-03-01	1154	1154	3200	NA	NA
Sodium	3/3	2040 - 10200	NA	PAI-15-SD-03-01	5333	5333	19000	NA	NA
Vanadium	3/3	2.3 - 37.4	NA	PAI-15-SD-03-01	17	17	50	550	NA
Zinc	2/3	12.9 - 32.3	1.9	PAI-02-SD-01-01	22.6	15	45	23000	124

NA = Not Applicable or Available
ND = Not Detected
(1) U.S. EPA Region 3 Residential Soil RBCs (April 13, 2000)
(2) U.S. EPA Region 4 Sediment Screening Levels

TABLE 4-8

SEDIMENT GRAIN SIZE AND TOC
SITE 2 - BORROW PIT LANDFILL AND SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

SAMPLE ID	TOC %	GRAIN SIZE			
		% GRAVEL	% SAND	% SILT	% CLAY
PAI-02-SD-01-01	0.97	3.2	57.1	17.0	22.7
PAI-02-SD-02-01	1.6	0.0	71.9	6.7	21.4
PAI-02-SD-03-01	0.86	1.1	88.2	2.7	8.0
PAI-02-SD-04-01	0.36	0.0	93.1	0.6	6.3

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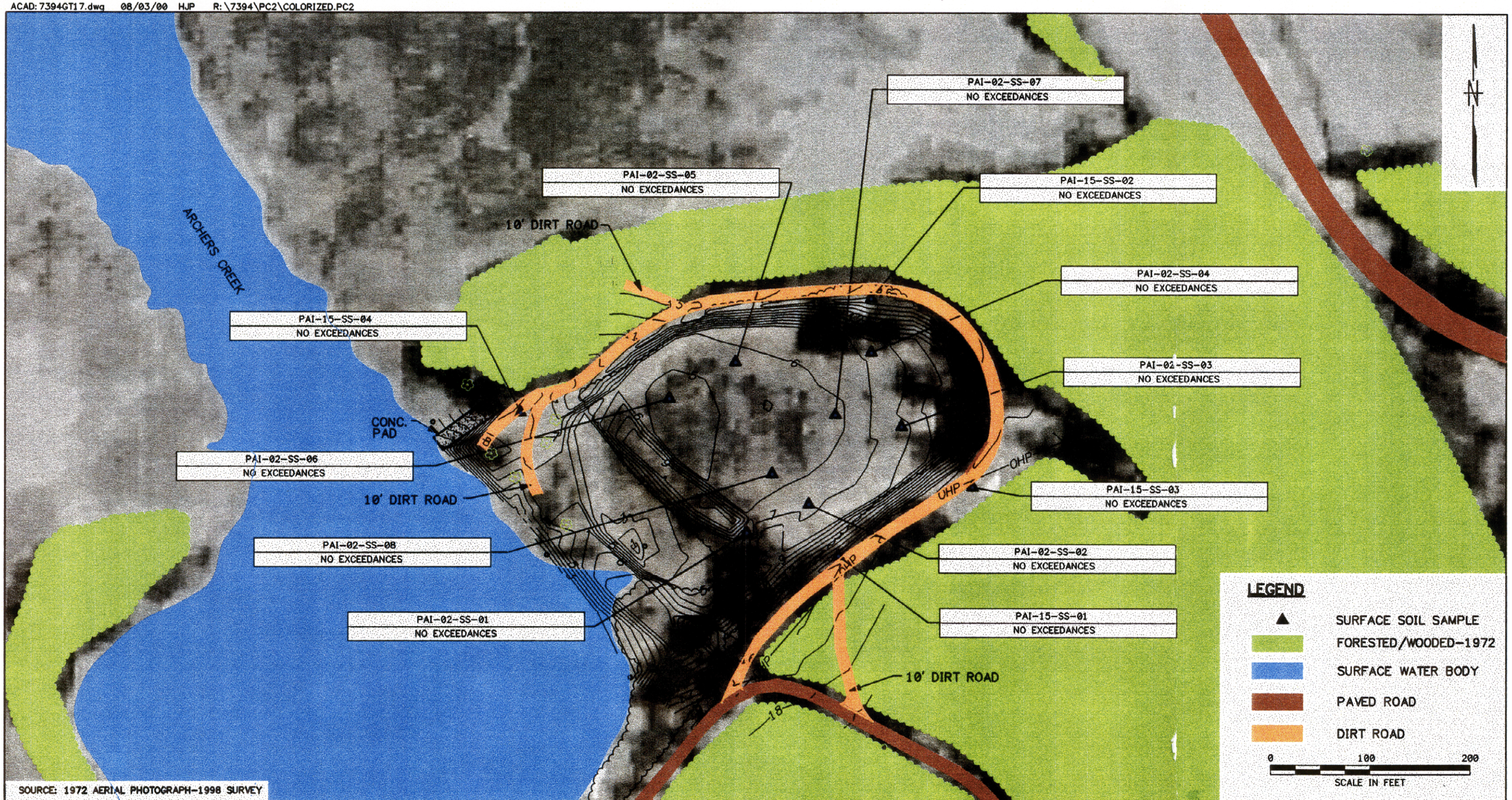

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY KW DATE 2/15/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

SURFACE SOIL SAMPLE RESULTS
THAT EXCEED BACKGROUND, HUMAN HEALTH RBCs,
AND/OR ECOLOGICAL SCREENING VALUES
SITE 2 – BORROW PIT LANDFILL
AND SITE 15 – DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
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DRAWING NO. FIGURE 4-1
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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SURFACE SOIL SCREENING LEVELS (UG/KG) (1) (REFER TO NOTES)		
CHEMICAL	HUMAN HEALTH	ECOLOGICAL (2)
BIS(2-ETHYLHEXYL) PHTHALATE		182

SOURCE: U.S.G.S. 7.5 MINUTE PARRIS ISLAND QUADRANGLE, 1956. PHOTOREVISED 1979.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY KW DATE 2/26/99
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SCALE AS NOTED

SURFACE SOIL AND SEDIMENT RESULTS THAT EXCEED BACKGROUND, HUMAN HEALTH RBCs AND/OR ECOLOGICAL SCREENING VALUES
SITE 15 - DIRT ROADS AT ELLIOT'S BEACH
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
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APPROVED BY DATE
DRAWING NO. FIGURE 4-2
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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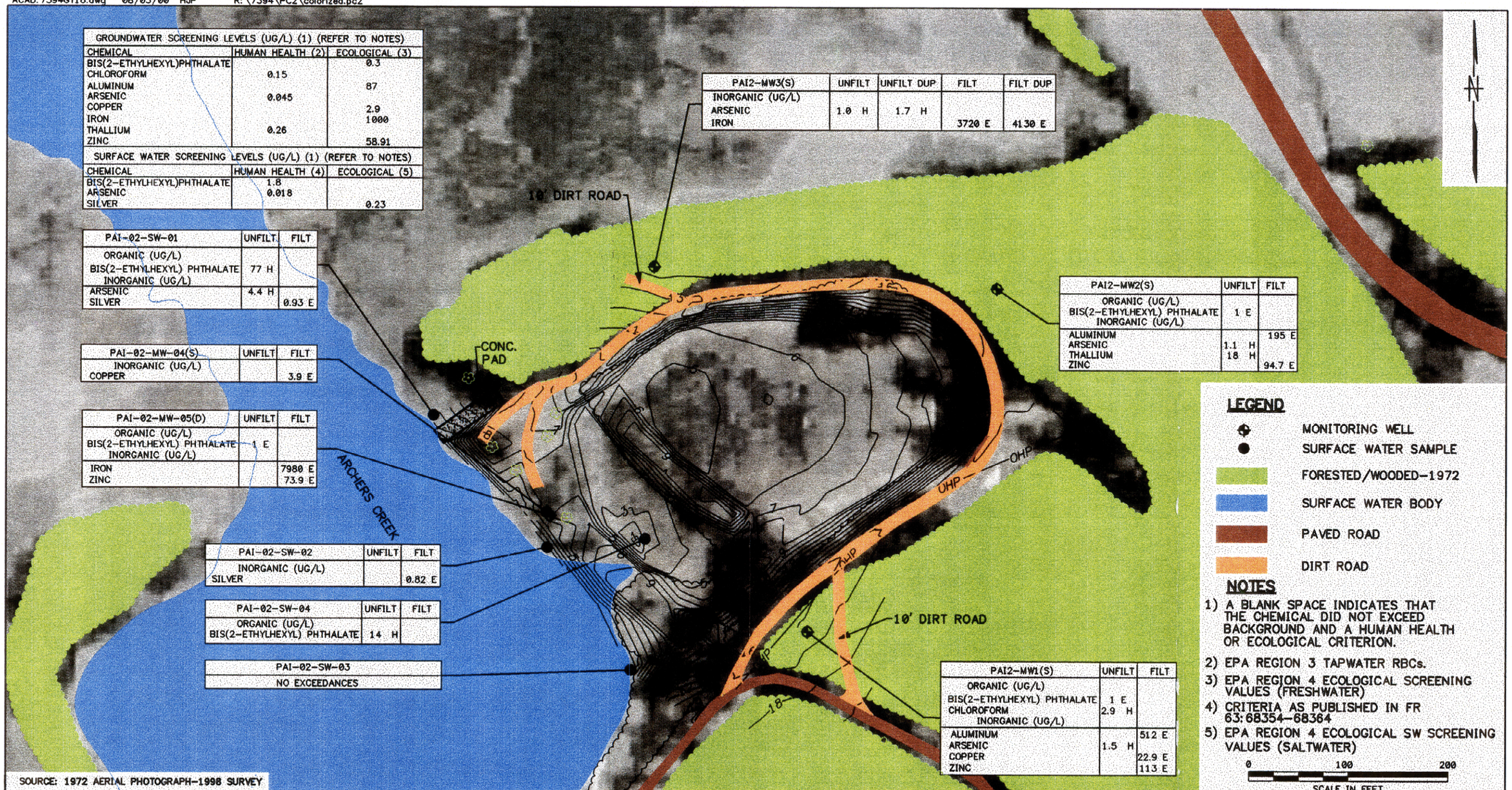

GROUNDWATER SCREENING LEVELS (UG/L) (1) (REFER TO NOTES)

CHEMICAL	HUMAN HEALTH (2)	ECOLOGICAL (3)
BIS(2-ETHYLHEXYL)PHTHALATE		0.3
CHLOROFORM	0.15	
ALUMINUM		87
ARSENIC	0.045	
COPPER		2.9
IRON		1000
THALLIUM	0.26	
ZINC		58.91

SURFACE WATER SCREENING LEVELS (UG/L) (1) (REFER TO NOTES)

CHEMICAL	HUMAN HEALTH (4)	ECOLOGICAL (5)
BIS(2-ETHYLHEXYL)PHTHALATE	1.8	
ARSENIC	0.018	
SILVER		0.23

PAI2-MW3(S)	UNFILT	UNFILT DUP	FILT	FILT DUP
INORGANIC (UG/L)				
ARSENIC	1.0 H	1.7 H		
IRON			3720 E	4130 E

PAI-02-SW-01	UNFILT	FILT
ORGANIC (UG/L)		
BIS(2-ETHYLHEXYL) PHTHALATE	77 H	
INORGANIC (UG/L)		
ARSENIC	4.4 H	
SILVER		0.93 E

PAI-02-MW-04(S)	UNFILT	FILT
INORGANIC (UG/L)		
COPPER		3.9 E

PAI-02-MW-05(D)	UNFILT	FILT
ORGANIC (UG/L)		
BIS(2-ETHYLHEXYL) PHTHALATE	1 E	
INORGANIC (UG/L)		
IRON		7980 E
ZINC		73.9 E

PAI-02-SW-02	UNFILT	FILT
INORGANIC (UG/L)		
SILVER		0.82 E

PAI-02-SW-04	UNFILT	FILT
ORGANIC (UG/L)		
BIS(2-ETHYLHEXYL) PHTHALATE	14 H	

PAI-02-SW-03
NO EXCEEDANCES

PAI2-MW2(S)	UNFILT	FILT
ORGANIC (UG/L)		
BIS(2-ETHYLHEXYL) PHTHALATE	1 E	
INORGANIC (UG/L)		
ALUMINUM		195 E
ARSENIC	1.1 H	
THALLIUM	18 H	
ZINC		94.7 E

PAI2-MW1(S)	UNFILT	FILT
ORGANIC (UG/L)		
BIS(2-ETHYLHEXYL) PHTHALATE	1 E	
CHLOROFORM	2.9 H	
INORGANIC (UG/L)		
ALUMINUM		512 E
ARSENIC	1.5 H	
COPPER		22.9 E
ZINC		113 E

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

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COST/SCHED-AREA
SCALE AS NOTED

DEPARTMENT OF THE NAVY - NAVAL FACILITIES ENGINEERING COMMAND

GROUNDWATER AND SURFACE WATER RESULTS THAT EXCEED BACKGROUND, HUMAN HEALTH RBCs AND/OR ECOLOGICAL SCREENING VALUES
SITE 2 - BORROW PIT LANDFILL
AND SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4-3
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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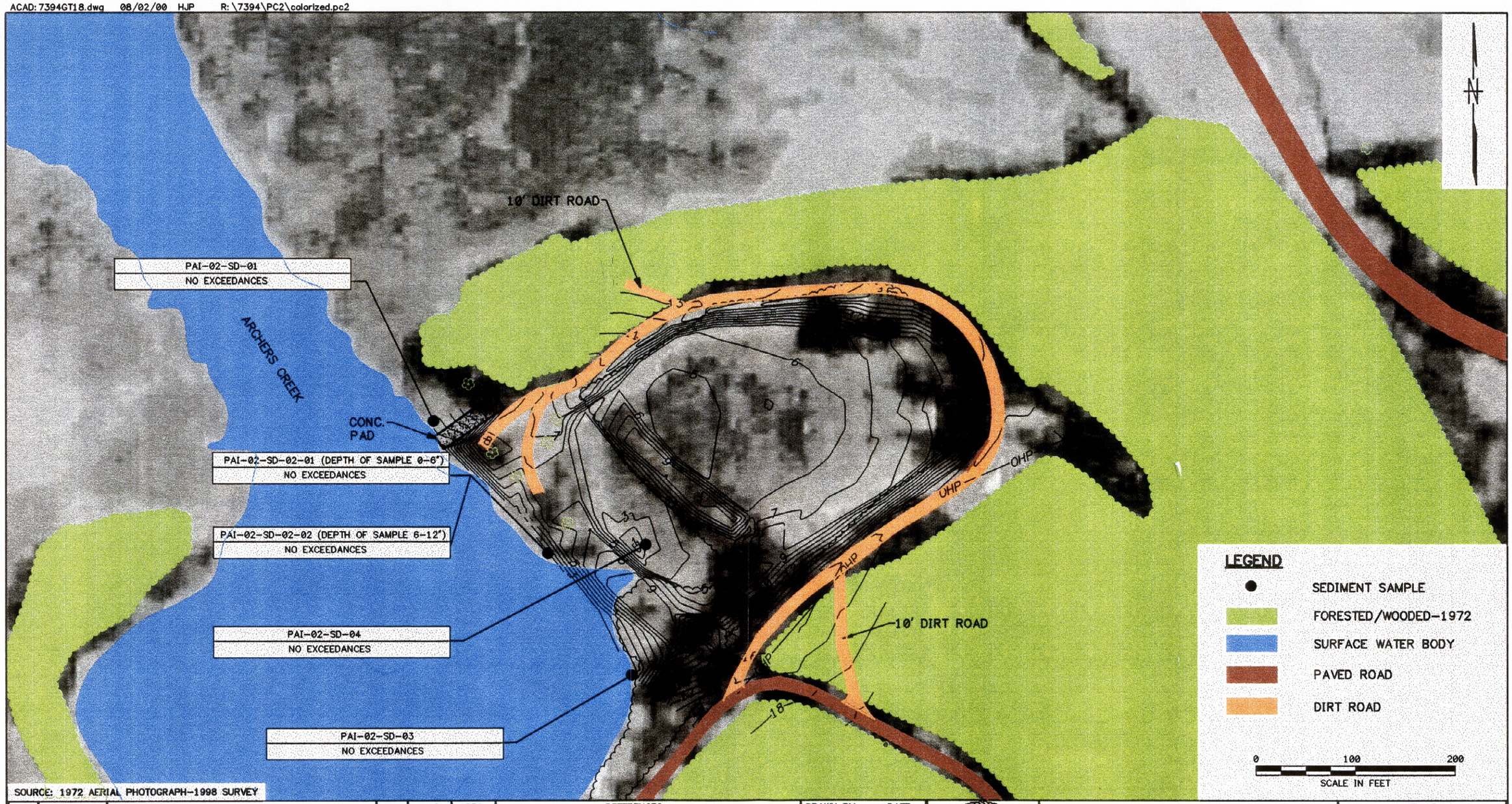

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY KW DATE 2/15/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

SEDIMENT SAMPLE RESULTS THAT EXCEED BACKGROUND, HUMAN HEALTH RBCs, AND/OR ECOLOGICAL SCREENING VALUES
SITE 2 – BORROW PIT LANDFILL AND SITE 15 – DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4-4
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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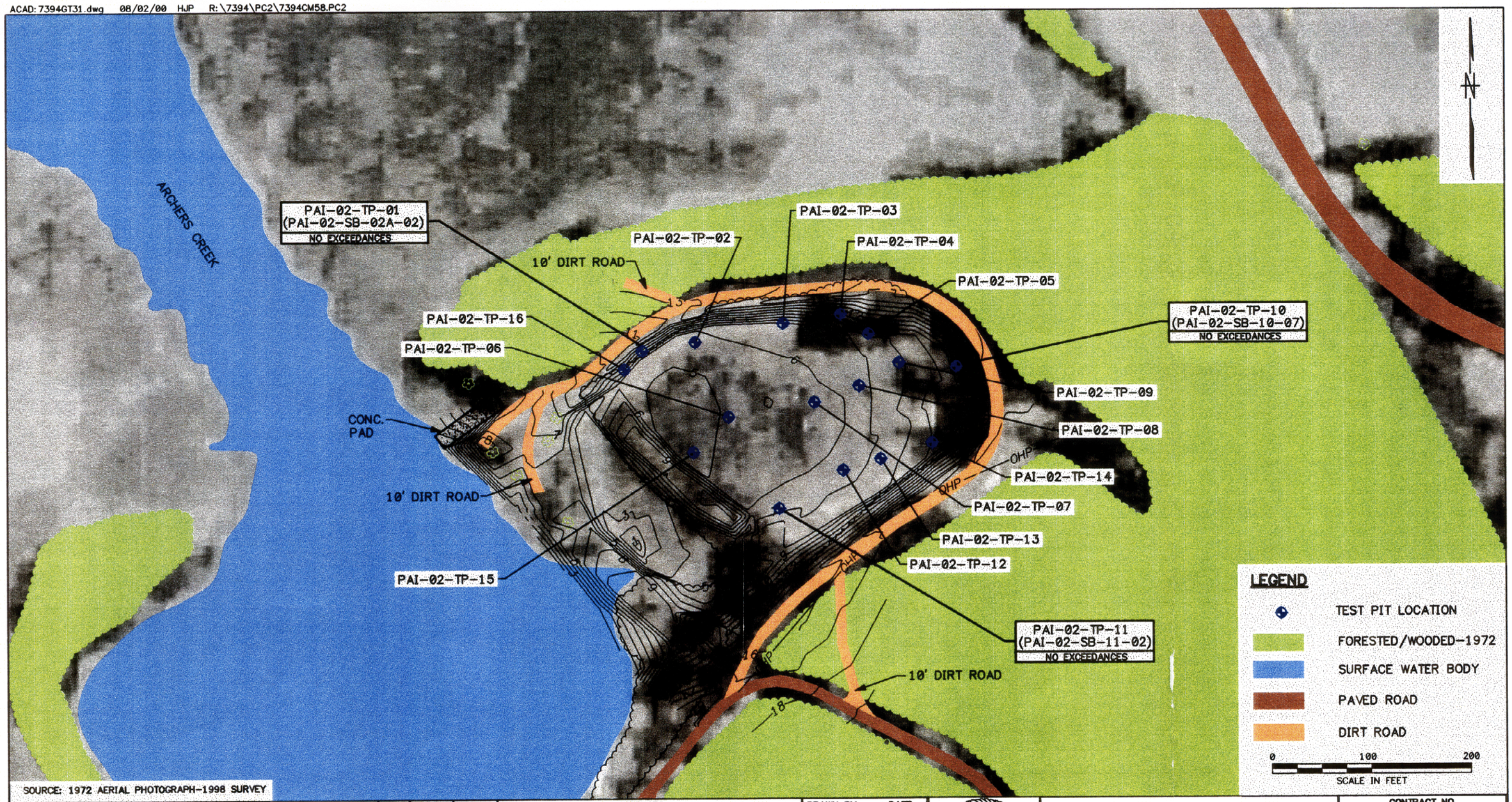

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 11/19/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

TEST PIT AND SUBSURFACE
SOIL SAMPLE LOCATION MAP
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
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DRAWING NO. FIGURE 4-5
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

5.0 CHEMICAL FATE AND TRANSPORT ANALYSIS

This section contains information on contaminant fate and transport and the chemical properties affecting contaminant migration at Site/SWMU 2 (Site 2) and Site/SWMU 15 (Site 15). Section 5.1 contains a discussion of the chemical and physical properties of the analytes detected in all media. Section 5.2 presents brief discussions of contaminant persistence, and Section 5.3 presents a summary of contaminant migration.

5.1 CHEMICAL AND PHYSICAL PROPERTIES

Chemical and physical properties of the compounds detected on site are presented and discussed in this section. These parameters are used to estimate the environmental behavior of site chemicals. Physical and chemical properties of the organic chemicals detected at MCRD Parris Island Site 2 and Site 15 are provided in Table 5-1. Physical and chemical properties for inorganics are provided in Table 5-2.

Empirically determined literature values of the water solubility, octanol/water partition coefficient, organic carbon partition coefficient, vapor pressure, Henry's Law constant, bioconcentration factor, and specific gravity are presented, when available. Calculated values, which were obtained using approximation methods, are presented when literature values are not available.

5.2 CHEMICAL PERSISTENCE

The persistence of various classes of chemicals is discussed in this section. Several transformation mechanisms affect chemical persistence, such as hydrolysis, biodegradation, photolysis, and oxidation/reduction reactions. The following general classes of compounds are discussed:

- Ketones
- Monocyclic aromatics
- Miscellaneous VOCs
- PAHs
- Phthalate esters
- Pesticides
- Polychlorinated biphenyls (PCBs)
- Metals

5.2.1 Ketones

Ketones are highly volatile in the pure form and water soluble, and these two processes dominate the fate of these compounds in the environment. Hydrolysis is generally not a significant fate process for this class of chemicals, nor is bioconcentration significant, based on the low K_{ow}s (Howard, 1990).

Acetone is completely miscible in water and is unlikely to adsorb to soil or sediments or bioaccumulate. It has a high vapor pressure in the pure form and, once released to the air, photolysis and reaction with hydroxyl radicals result in an average half-life of 22 days. Acetone biodegrades upon release to soil, groundwater, and surface water. The estimated half-life in a model river from volatilization is 20 hours (Howard, 1990).

5.2.2 Monocyclic Aromatics

Monocyclic aromatic compounds, such as toluene, are not considered to be persistent in the environment, particularly in comparison to chemicals like PCBs and pesticides. Monocyclic aromatics are subject to degradation via the action of both soil and aquatic microorganisms. The biodegradation of these compounds in the soil matrix is dependent on the abundance of microflora, macronutrient availability, soil reaction (pH), temperature, etc. In the event that these compounds discharge to surface water bodies, volatilization and biodegradation may occur relatively rapidly. However, chlorinated monocyclic aromatics are not expected to be as susceptible to microbial degradation. Additional environmental degradation processes, such as hydrolysis and photolysis, are considered to be insignificant fate mechanisms for monocyclic aromatics in aquatic systems (U.S. EPA, 1982). However, some monocyclic aromatics, such as toluene, have been shown to undergo clay-, mineral-, and soil-catalyzed oxidation (Dragun, 1988).

Miscellaneous VOCs

Carbon disulfide, chloroform, chloromethane, and PCE were detected at Site 2. The VOCs detected at Site 2 tend to volatilize and degrade in the atmosphere via reaction with photochemically produced hydroxyl radicals. For example, in air, the half-life of carbon disulfide is 9 days. For chloromethane, the half-life for this VOC to volatilize from a lake is 18 days (Howard, 1990). PCE has a half-life of approximately 4.2 hours when volatilizing from river surface water. Carbon disulfide will volatilize upon release to surface water (half-life of 2.6 hours estimated from a model river).

Chloromethane and PCE are not expected to sorb strongly to soils. Soil is a natural sink for carbon disulfide via adsorption and biodegradation. Chloromethane, chloroform, and PCE will leach rapidly to underlying groundwater. Carbon disulfide will also leach into groundwater where it biodegrades.

Chloromethane does not readily bioconcentrate in sediment or biota. PCE tends to bioconcentrate in the fatty tissue of organisms, such as fish. The BCF values for this VOC can range from 10 to 100 (Howard, 1990). Chloroform does not readily bioconcentrate in aquatic organisms (Howard, 1990).

5.2.3 Polynuclear Aromatic Hydrocarbons (PAHs)

PAHs have very low water solubilities, vapor pressures, and Henry's Law constants and high organic carbon coefficients (K_{oc}s) and octanol water coefficients (K_{ow}s). The low-molecular-weight PAHs (e.g., acenaphthene, anthracene, fluorene, phenanthrene) may volatilize from surface waters, whereas the high-molecular-weight PAHs [e.g., benzo(a)pyrene, benzo(a)anthracene, chrysene, etc.] are less likely to volatilize. PAHs in soil are much more likely to bind to soil and be transported via mass transport mechanisms than to go into solution.

Bioconcentration of PAHs in aquatic organisms is greater for the higher-molecular-weight compounds than the lower-molecular-weight compounds. PAHs can be bioaccumulated from water, sediments, or lower organisms in the food chain.

Land-spreading applications have indicated that PAHs are amenable to microbial degradation in soil. Temperature, pH, oxygen concentrations, initial chemical concentrations, and moisture influence the rate of degradation. Photolysis, hydrolysis, and oxidation are not important fate processes for the degradation of PAHs in soil (ATSDR, 1989). Half-lives available for PAHs are summarized in Table 5-3.

The most important fates of PAHs in water are photo-oxidation, chemical oxidation, and biodegradation. PAHs do not contain functional groups that are susceptible to hydrolytic action; therefore, hydrolysis is considered to be an insignificant degradation mechanism. Water depth, turbidity, and temperature influence the rate of photodegradation. Benzo(a)pyrene, chrysene, fluorene, and pyrene are reported to be resistant to photodegradation. PAHs may also be oxidized by chlorination and ozonation and may be metabolized by microbes under oxygenated conditions (ATSDR, 1989).

5.2.4 Phthalate Esters

Phthalate esters are considered to be relatively persistent chemicals in the environment. Although numerous studies have demonstrated that phthalate esters undergo biodegradation, it appears that this is a slow process in both soils and surface waters. Certain microorganisms have been shown to excrete products that increase the solubility of phthalate esters and enhance their biodegradation (Gibbons and Alexander, 1989).

Biodegradation of bis(2-ethylhexyl) phthalate and other phthalates in water is an important fate mechanism, with a half-life of 2 to 3 weeks reported for bis(2-ethylhexyl) phthalate (Howard, 1989). Bioaccumulation is also a significant fate process. Hydrolysis of phthalate esters is very slow, with calculated half-lives of 3 years (dimethyl phthalate) to 2,000 years [bis(2-ethylhexyl) phthalate] (U.S. EPA, 1979). Similarly, photolysis and volatilization are considered to be insignificant degradation mechanisms (U.S. EPA, 1979; Howard, 1989). Diethyl phthalate was also detected. This compound will adsorb to particulates and sediment.

5.2.5 Pesticides

Whether pesticides are sprayed, dusted, or applied directly to the soil, the soil is the ultimate sink for these chemicals. Runoff may carry pesticides to adjacent surface water bodies. Bioconcentration of pesticides in the food chain is another important fate mechanism. Hydrolysis, oxidation, and photolysis are not generally important fate mechanisms for pesticides in soil or water. Hydrolysis half-lives for several pesticides are reported in periods of months to years (U.S. EPA, 1979).

Endosulfan sulfate, an isomer of endosulfan, was detected at Site 2. No pesticides were detected in media at Site 15, i.e., surface soil and sediment. Endosulfan will biodegrade and undergo hydrolysis under alkaline conditions. Its half-life in soil is 5 days. Its half-life in air is 1.23 hours. Volatilization and leaching are not significant fate processes for endosulfan due to to endosulfan's high rate of soil sorption. It will volatilize and biodegrade in water significantly and may also undergo photolysis and oxidation. This compound tends to bioconcentrate in biota significantly, i.e., the BCF values range from factors of 100 to 1,000 (Howard, 1990).

5.2.6 Polychlorinated Biphenyls (PCBs)

PCBs are considered to be very persistent organic chemicals. Biodegradation is the only process known to transform PCBs under environmental conditions, and only the lighter compounds are measurably biodegraded (U.S. EPA, 1979). Although some microorganisms (e.g., Phanaerochaete chrysosporium) may biodegrade PCBs, such fungi may not exist in local soil. There is experimental evidence to suggest that heavier PCBs (five or more chlorine atoms per molecule) can undergo photolytic degradation, but there are no data to suggest that this process operates under environmental conditions (U.S. EPA, 1979). Base-, acid-, and neutral-promoted hydrolysis are considered to be inconsequential degradation mechanisms for PCBs (U.S. EPA, 1982).

5.2.7 Metals

Metals are highly persistent environmental contaminants. They do not biodegrade, photolyze, hydrolyze, etc. The major fate mechanisms for metals are adsorption to the soil matrix (as compared to being part of the soil structure) and bioaccumulation.

The mobility of metals is influenced primarily by their physical and chemical properties in combination with the physical and chemical characteristics of the soil matrix. Factors that assist in predicting the mobility of inorganic species are the soil/pore water pH, soil/pore water Eh, and cation exchange capacity. The mobility of metals generally increases with decreasing soil pH and cation exchange capacity.

5.3 CHEMICAL MIGRATION

This section presents a brief overview of contaminant fate and transport issues for several major chemical classes detected at Site 2 and Site 15.

5.3.1 Volatile Organics

Volatile organic chemicals are typically considered to be fairly soluble and have a low capacity for retention by soil organic carbon; therefore, these are the organic compounds most frequently detected in groundwater. These types of chemicals may migrate through the soil column after being released by a spill event or by subsurface waste burial as infiltrating precipitation solubilizes them. A fraction of these chemicals is retained by the soil, but most will continue migrating downward to the water table. At that time, migration occurs primarily laterally with the hydraulic gradient. Again, some portion of the chemical may be retained by the saturated soil.

Several of these compounds have specific gravities less than that of water (e.g., toluene). These compounds are typically found in fuels, and if a large enough fuel spill occurs, these compounds may move through the soil column as a bulk liquid, until they reach the water table. There, instead of going into solution, the majority of the release may remain as a discrete fuel layer on the water table surface, with some of the material going into solution at the water/fuel interface.

Similarly, compounds with specific gravities greater than that of water (e.g., PCE) are often used in various industrial applications such as degreasing. If a large enough spill of these solvents occurs, these chemicals may also migrate as a bulk liquid but will not stop at the water table (i.e., these chemicals will mix/sink into the aquifer).

5.3.2 Polycyclic Aromatic Hydrocarbons

PAHs are generally considered to be fairly immobile chemicals in the environment. They are large molecules with high organic carbon partition coefficients and low solubilities when compared to the volatile organics. These compounds, when found in the soil, generally do not migrate vertically to a great extent. Instead, they are more likely to adhere to soil particles and be removed from the site via surface runoff and erosional processes.

5.3.3 Pesticides

Pesticides were used at this installation. Many of the detected compounds are no longer licensed for general sale and use in the United States. Therefore, it is assumed that much of what was detected in the soil and sediments is representative of past application for insect control.

Like the PAHs, pesticides as a class of compounds are not considered to be very mobile in the environment. These chemicals, upon application or disposal, tend to remain affixed to soil particles. Migration of pesticides occurs primarily by erosion via the action of wind or water.

5.3.4 Inorganics

Because metals are frequently incorporated into the soil matrix and remain bound to particulate matter, they also migrate from the source areas via bulk movement processes (erosion). The larger particles (greater than 0.45 microns, which are removed via the filtration step prior to water analysis) are not generally considered to be mobile in groundwater. The metals detected in unfiltered groundwater samples are often representative of suspended soil material in the samples.

There are some instances, however, where these metals are found at such concentrations or in such form as to be able to migrate in solution. It is possible that industrial activities could saturate all available exchange sites in soil and hence a metal may be mobilized. Metals are also more mobile under acidic conditions. Finally, a metal solution may be utilized in some industrial applications. In these cases, it is possible for metals to migrate vertically through the soil column and reach the groundwater.

TABLE 5-1

FATE AND TRANSPORT PHYSICAL AND CHEMICAL CHARACTERISTICS FOR ORGANICS
SITE 2 - BORROW PIT LANDFILL AND SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Specific Gravity (@ 20/4°C)[1]	Vapor Pressure (mm Hg @ 20°C)[1]	Solubility (mg/L @ 20°C)[1]	Octanol/ Water Partition Coefficient (K_{ow})[1]	Organic Carbon Partition Coefficient (K_{oc})[2]	Henry's Law Constant (atm-m^3/mole)[1]	Bioconcentration Factor (mg/L/mg/kg) (BCF)[2]
VOLATILE ORGANICS							
Acetone	0.7899	2.66E+02 (25°C)	Miscible	5.75E-01	7.8E+03[3]	4.276E-05 (25°C)	3.81E-01[4]
Toluene	0.8669	2.8E+01 (25°C)	5.15E+02	4.90E+02	1.82E+02[3]	5.92E-03 (25°C)	1.48E+02
Carbon disulfide	1.2632	2.98E+02	2.90E+03	1.45E+02	4.57E+01[3]	1.921E-02 (25°C)	2.6E+01[4]
Chloroform	1.5	1.51E+02	8.2E+03	9.33E+02	31	2.87E-03	3.75
Chloromethane	0.991	4.31E+03	4,000	8.128	5	2.4E-02	2.9
Tetrachloroethene	1.626	1.4E+01	150	2,512	159-501	1.8E-02	226
POLYNUCLEAR AROMATIC HYDROCARBONS (PAHs)							
Anthracene	1.283 (25/4°C)	1.95E-04 (25°C)	1.29E+0 (25°C)	2.82E+04	2.95E+04[3]	8.6E-05 (25°C)	4.70E+03
Benzo(b)fluoranthene	NA	5.00E-07	1.2E-03 (25°C)	3.72E+06	1.23E+06[3]	1.20E-05	1.40E+05
Benzo(k)fluoranthene	NA	9.59E-11	5.5E-04 (25°C)	6.92E+06	1.23E+06[3]	1.04E-03	1.40E+05
Benzo(a)pyrene	1.351	5.00E-09	3.8E-03 (25°C)	9.55E+05	1.02E+06[3]	4.9E-07 (25°C)	1.40E+05
Chrysene	1.274 (20°C)	6.3E-09 (25°C)	6E-03 (25°C)	4.07E+05	3.98E+05[3]	1.05E-06 (25°C)	5.30E+04
Fluoranthene	1.252	5.0E-06 (25°C)	2.65E-01 (25°C)	2.14E+05	1.07E+05[3]	6.5E-06 (25°C)	1.20E+04
Indeno(1,2,3-cd)pyrene	NA	1E-010 (25°C)	6.20E-02	4.57E+07	3.47E+06[3]	6.95E-08 (25°C)	3.50E+05
Phenanthrene	0.980 (4°C)	1E+0 (118.2°C)	8.16E-01 (21°C)	2.88E+04	1.40E+04	3.93E-05 (25°C)	4.70E+03
Pyrene	1.271 (23/4°C)	2.5E+0 (200°C)	1.6E-01 (26°C)	1.51E+05	1.05E+05[3]	5.1E-06 (25°C)	1.20E+04
PHTHALATE ESTERS							
Bis(2-ethylhexyl)phthalate	0.99 (20/20°C)	1.2E+0 (200°C)	4E-01 (25°C)	2.00E+05	1.51E+07[3]	3.00E-07	2.30E+08
Di-ethylphthalate	1.12	1.65E-03	1,080	2.95E+02	142	4.8E-06	117
PESTICIDES							
Endosulfan Sulfate	NA	1E-05	0.51	6,761	2,884	1.12E-05	NA
PCBs							
Aroclor-1254	NA	7.71 E-05	0.012-0.057	3.2E+06	NA	2.0E-03	26,000-660,000
Aroclor-1260	1.58 (25°C)[2]	4.05E-05[2]	2.7E-03[2]	1.4E+07[2]	6.70E+06	7.4E-01[2]	1.30E+06

1 U.S. EPA, September 1992, Handbook of RCRA Groundwater Monitoring Constituents: Chemical and Physical Properties.
2 U.S. EPA, December 1982, Aquatic Fate Process Data for Organic Priority Pollutants.
3 U.S. EPA, July 1996, Soil Screening Guidance.
4 Lyman et at., 1990, Eq. 5-2.
5 Lyman et al., 1990; Equation 4-5
6 Howard, 1989, Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume 1.
7 ATSDR, October 1989, Toxicity Profile for Xylenes.
8 Verschueren, 1983, Handbook of Environmental Data of Organic Chemicals.

NA - Not Available

TABLE 5-2

FATE AND TRANSPORT PHYSICAL AND CHEMICAL CONSTANTS FOR INORGANICS
SITE 2 - BORROW PIT LANDFILL AND SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Molecular Weight (g/mol)[1]	Specific Gravity (20/4 C)[1]	Vapor Pressure (25 C) (mm Hg)[1]	Solubility (25 C) (mg/L)[1]	Henry's Law Constant (25 C) (atm-m^3/mol)[1]	Bioconcentration Factor (L/kg)[2]
Inorganics						
Aluminum	26.98[3]	2.708 (20 C)[3]	NA	NA	NA	NA
Antimony	121.75	6.684 (25 C)	1 (886 C)	insoluble	NA	NA
Arsenic	74.9216	5.727 (14 C)	1 (372 C)	insoluble	NA	NA
Barium	137.33	3.51 (20 C)	10 (1049 C)	hydrolyzes	NA	NA
Beryllium	9.01218	1.85 (20 C)	1 (1520 C)	insoluble	NA	NA
Cadmium	112.41	8.642 (UT)	NA	insoluble	NA	NA
Chromium	51.996	7.2 (28 C)	1 (1616 C)	insoluble	NA	NA
Cobalt	58.9332	8.9 (UT)	30 (2375 C)	insoluble	NA	NA
Copper	63.546	8.92 (UT)	1 (1628 C)	insoluble	NA	NA
Lead	207.2	11.2960 (16 C)	1 (970 C)	insoluble	NA	NA
Manganese	54.938[4]	7.2[4]	NA	NA	NA	NA
Mercury	200.59	13.5939	100 (260 C)	0.056	1.14E-02 (UT)	3133[5]
Nickel	58.69	8.9 (UT)	1 (1800 C)	insoluble	NA	NA
Selenium	78.96	4.81 (20/4+1 C)	NA	NA	NA	NA
Silver	107.8682	10.5 (20 C)	1 (1310 C)	insoluble	NA	NA
Thallium	204.383	11.85 (UT)	1 (825 C)	insoluble	NA	NA
Vanadium	50.9415	5.96 (UT)	NA	insoluble	NA	NA
Zinc	65.38	7.14 (UT)	1 (487 C)	insoluble	NA	NA

1 Handbook of RCRA Ground-Water Monitoring Constituents: Chemical and Physical Properties, September 1992. Solubility of metals in water is dependent on other parameters, such as pH and temperature.
2 Aquatic Fate Process Data for Organic Priority Pollutants, December 1982.
3 The Condensed Chemical Dictionary, Van Nostrand Reinhold Company, New York, 1971.
4 Chemical, Physical, and Biological Properties of Compounds Present at Hazardous Waste Sites, Clement Associates, September 1985.
5 W. Lyman, W. Reehl, and D. Rosenblatt, 1990. Handbook of Chemical Property Estimation Methods.

TABLE 5-3

SUMMARY OF PAH HALF-LIFE VALUES
SITE 2 - BORROW PIT LANDFILL AND SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

PAHs	Half-Life				
	Air	Surface Water	Groundwater	Sediment	Soil
2-Methylnaphthalene	NA	2.25 days	NA	NA	NA
Acenaphthene	0.9-9 h	3-300 h	24.6-204 days	NA	12.3-102 days
Acenaphthylene	0.2-1.3 h	42.5-60 days	85-120 days	NA	42.5-60 days
Anthracene	0.6-1.7 h	0.6-1.7 h	100-920 days	NA	3.3-175 days
Benzo(a)anthracene	1-3 h	1-3 h	204-1360 days	NA	4-6,250 days
Benzo(a)pyrene	0.4-1.1 h	2 h	114-1060 days	NA	2 days
Benzo(b)fluoranthene	1.4-14.3 h	8.7-720 h	2.0-3.3 years	NA	360-610 days
Benzo(g,h,i)perylene	0.32-3.21 h	1.6-1.8 years	3.2-3.6 years	NA	1.6-1.8 years
Benzo(k)fluoranthene	1.1-11 h	4-499 h	4.9-11.7 years	NA	2.5-5.9 years
Chrysene	0.8-8 h	4.4-13 h	2.0-5.5 years	NA	1.0-2.7 years
Fluoranthene	2-20 h	21-63 h	280-880 days	NA	44-182 days
Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA
Naphthalene	< 1 day	16 h	219 days	4.9 h	110 days
Phenanthrene	2-20 h	3-25 h	32-400 days	NA	2.5-26 days
Pyrene	0.7-2 h	0.7-2 h	1.1-10.4 years	NA	3-35 h

Source: D. Mackay, W.Y. Shiu, & K.C. Ma, *Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals - PAHs, Polychlorinated Dioxins, and Dibenzofurans*. 1992.
NA = Not Available
h = hours

6.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

The baseline human health risk assessment contained in this section was performed to characterize and quantify potential health risks at Site/SWMU 2, the Borrow Pit Landfill (Site 2) and Site/SWMU 15, Dirt Roads (Site 15), in the absence of remedial action. The results of the baseline risk assessment are also used to focus the evaluation of remedial action alternatives, if action is required. The baseline risk assessment consists of five major components:

- Data evaluation
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Uncertainty analysis

Methods for selection of chemicals of potential concern (COPCs) to be evaluated quantitatively in the baseline human health risk assessment, as well as those chemicals identified as COPCs for Site 2 and Site 15, are described in Section 6.1, Data Evaluation. The data evaluation section is primarily concerned with the selection of COPCs that are representative of the type and magnitude of potential human health effects. The COPC screening process involves the comparison of maximum site concentrations to risk-based screening levels and other health-based standards. Recent and historical data available for the site are considered during the selection process. A discussion of data usability is also provided.

Section 6.2, Exposure Assessment, identifies potential receptor populations and exposure pathways by which receptors may come in contact with contaminants at the site. Potential exposure routes under current and future land uses are developed from information on source area, chemical concentrations, chemical release mechanisms, patterns of human activity, and other pertinent information. A concise conceptual site model illustrates the potential receptors and exposure pathways evaluated in the baseline risk assessment. The exposure assessment also includes the calculation of quantitative estimates of chemical intake for each identified receptor, pathway, and route of exposure under the reasonable maximum exposure (RME) scenario. Equations and relevant exposure input parameters used in estimating chemical intakes are provided.

Section 6.3, Toxicity Assessment, presents the chemical-specific toxicity criteria for the identified COPCs that are used in the quantification of potential human health risks. These toxicity criteria, when integrated with the estimated chemical intakes developed in the exposure assessment, provide the basis for quantifying potential human health risks.

Methods used for characterizing risks associated with noncarcinogenic and carcinogenic effects for exposure to COPCs are provided in Section 6.4, Risk Characterization. Actual numerical results of the baseline human health risk assessment for Site 2 and Site 15 are summarized.

Because the quantitative risk estimates developed in the risk characterization are based on a number of assumptions (concerning exposure, land use, toxicity, etc.), various uncertainties are associated with the risk assessment process. A discussion of the uncertainties associated with the risk evaluation for Site 2 and Site 15 is contained in Section 6.5, Uncertainty Analysis.

To assess potential public health risks, four major aspects of chemical contamination and exposure must be considered: contaminants with toxic characteristics must be found in environmental media; the contaminants must be released by either natural processes or by human action; potential exposure points must exist; and human receptors must be present at the point of exposure. Risk is a function of both toxicity and exposure; without one of the factors listed above, there is no risk.

An illustration of the baseline human health risk assessment process is provided in Figure 6-1.

The baseline human health risk assessment for Site 2 and Site 15 was conducted using the most recent guidance from the U.S. EPA (U.S. EPA, 1989 and 1992a), including Regional supplemental guidance (U.S. EPA Region IV, 1995a). To maintain consistency among risk assessments performed at various sites at the Base, methodologies presented in the *Master Workplan for MCRD, Parris Island, South Carolina* (B&R Environmental, 1998b) were also used to develop the baseline risk assessment for this site.

6.1 DATA EVALUATION

Data evaluation is a site-specific task that uses a variety of information to determine which of the detected chemicals at a site are most likely to present a risk to potential human receptors. The end result of this qualitative selection process is a list of COPCs for each environmental medium under consideration. Section 6.1.1 provides a summary of data usability as it pertains to the baseline human health risk assessment. The selection of COPCs for the site is contained in Section 6.1.2.

6.1.1 Data Usability

This section addresses the usability of data collected as part of the 1998 RI/RFI field investigation. The use of approved work plans for the 1998 RI/RFI promotes quality by identifying appropriate sample locations, analytical parameters, analytical methods, and data quality objectives (DQOs). The results of

measures (field and laboratory quality control, data validation, etc.) taken to ensure the quality of data collected during the 1998 RI/RFI field investigation are summarized in Appendix D of this report.

All sample data collected for Site 2 and Site 15 were used to assess potential human health risks. The qualification of data during the formal data validation process is not expected to compromise the results of the baseline human health risk assessment. Analytical data qualified as estimated were utilized, even though the reported positive concentrations or sample-specific quantitation limits may be somewhat imprecise. The use of estimated data adds to the uncertainty associated with the risk assessment; however, the associated uncertainty is expected to be negligible compared to the other uncertainties inherent in the risk evaluation process (i.e., uncertainties with land uses, exposure scenarios, toxicological criteria, etc.).

6.1.2 Selection of COPCs

The overall goal of the baseline human health risk assessment is to quantify risks associated with those chemicals that represent a potentially significant human health hazard on the basis of toxicity, environmental concentration, and mobility. U.S. EPA guidance (U.S. EPA, 1989 and U.S. EPA, Region IV, 1995a) recommends focusing the baseline risk assessment by quantifying risk only for a select list of COPCs at a site. These chemicals, which are a subset of all detected chemicals in a given medium, are defined as those chemicals likely to dominate the overall potential risks for a site.

For the purposes of this baseline risk assessment, COPCs for a particular medium are limited to those chemicals that exceed a selection criterion. The maximum concentration of a chemical detected in soil, sediment, and groundwater was compared to the risk-based concentrations (RBCs) screening criteria for that chemical. RBCs have been determined for cancer risk levels of 1×10^{-6} and noncancer (hazard quotient) levels of 1.0 and are presented in the most recent version of the U.S. EPA Region III Risk-Based Concentration Table (April 13, 2000). The screening values in the report tables were divided by 10 for noncarcinogens to screen to the more conservative hazard quotient of 0.1. Chemicals detected in groundwater were retained as COPCs if the maximum detected concentration exceeded the screening criteria for tap water. The maximum concentrations of chemicals detected in soil or sediment were compared to Region III residential screening criteria for soil ingestion. U.S. EPA Soil Screening Levels (U.S. EPA, 1996c) for transfer to air or groundwater were used to evaluate the inhalation pathway and the potential for chemicals to migrate from soil to groundwater. Chemicals with concentrations exceeding these screening criteria will be retained as COPCs.

Concentrations (maximum) of chemicals detected in surface water were compared to the Water Quality Standard (WQS) for human health (consumption of water and organisms), and the chemicals were retained as COPCs whenever the standards were exceeded. If WQSs were not available for detected

chemicals, comparisons were made to the U.S. EPA Region III tap water screening criteria. This is a conservative comparison since the WQS are based on using surface water as a potable water source and the surface water at the site is salt water.

Inorganic COPCs were also selected based on a comparison of site-specific chemical concentrations to background chemical concentrations for soils, surface water, and sediment. Comparisons were made between the maximum concentration of the site-specific chemical and twice the mean of the background chemical concentrations. If the maximum detected concentration was less than twice the mean of the background chemical concentrations, then that chemical was not retained as a COPC.

Samples were analyzed for both total chromium and hexavalent chromium. Consequently, criteria for trivalent chromium were used to evaluated concentrations of total chromium.

The initial list of COPCs for an area under investigation includes any chemical detected at least once in validated environmental samples from the area. Essential human nutrients (magnesium, potassium, calcium, and sodium) are then eliminated from the initial list of COPCs. They can be eliminated because they are only toxic at high doses.

Maximum detected concentrations (in a single sample) in each sample medium for Site 2 and Site 15 were compared to the risk-based and health-based screening criteria. If the maximum concentration exceeded any of the screening criteria, that chemical was retained as a COPC for all significant exposures involving that medium. For example, if arsenic was retained for soil, this chemical was evaluated as a COPC for both ingestion and dermal exposure routes. If none of the chemicals detected in a medium exceeded criteria, that medium was dropped from further consideration and the potential risks associated with exposure to that medium are regarded as relatively insignificant.

Table 6-1 lists the screening criteria used in the selection of COPCs. A medium-specific discussion of the specific criteria used for COPC selection and the results for the selection process is provided in the remainder of this section. A copy of all the screening criteria is included in Appendix E.

Appendix E also contains a comparison of maximum surface soil, sediment, and groundwater analytical results against U.S. EPA Region IX Preliminary Remediation Goals (PRGs) (December 3, 1999). This comparison was performed as a result of recent U.S. EPA Region 4 guidance recommending the use of Region IX PRGs instead of Region III Risk-Based Concentrations during the COPC screening step in the human health risk assessment process. The use of PRGs rather than RBCs in the screening process did not result in any additional compounds being retained as COPCs for Site 2 or Site 15.

6.1.2.1 Surface Soil

Site 2

Eight surface soil samples were collected at Site 2 and analyzed for VOCs, SVOCs, pesticides/PCBs, and inorganics. A comparison of the maximum detected concentrations to the risk-based screening levels is presented in Table 6-2. The concentrations of all compounds were below the risk-based COPC screening levels with the exception of arsenic. However, the maximum detected concentration of arsenic is less than its background concentration; consequently, arsenic will not be retained as a COPC as a result of exceeding risk-based screening levels.

Concentrations of all chemicals detected in surface soil were less than the U.S. EPA soil screening levels (SSLs) for soil to air; therefore, exposures through inhalation of fugitive dust were not retained for evaluation in the risk assessment.

Maximum detected concentrations in surface soil were also compared to U.S. EPA soil screening levels for migration to groundwater. Concentrations of all compounds were below the U.S. EPA soil screening levels for migration to groundwater.

Site 15

Two surface soil samples were collected in 1996 and seven surface soil samples were collected in 1998 at Site 15 and analyzed for PCBs and lead. A comparison of the maximum detected concentrations to the risk-based screening levels is presented in Table 6-3. Lead was the only chemical detected in surface soil at Site 15. The maximum detected concentration of lead was below the risk-based COPC screening levels.

The source of potential contamination at Site 15 is the waste oils that were sprayed on the road. There is some concern that the waste oil may have contained PCBs. Aroclor-1254 was detected in one of two soil samples collected in 1996. The detected concentration of Aroclor-1254 was less than the screening criteria. Since PCBs were not detected in surface soil samples collected in 1998, the detection limits for PCBs were compared to the screening criteria to ensure that there were no problems with elevated detection limits. The reported detection limits for PCBs (8.8 to 82 µg/kg) were below the screening criteria for PCBs (320 µg/kg).

6.1.2.2 Groundwater

Site 2

Five groundwater samples were collected at Site 2 and analyzed for VOCs, SVOCs, pesticides/PCBs, and inorganics. A comparison of the maximum detected concentrations to the risk-based screening levels is presented in Table 6-4. The following chemicals were detected at maximum concentrations in groundwater that exceeded the risk-based COPC screening levels:

- VOCs (chloroform)
- Inorganics (arsenic, iron, manganese, and thallium)

Site 15

No groundwater samples were collected at Site 15.

6.1.2.3 Surface Water

Site 2

Four surface water samples were collected at Site 2 and analyzed for VOCs, SVOCs, pesticides/PCBs, and inorganics. A comparison of the maximum detected concentrations to the risk-based screening levels is presented in Table 6-5. The following chemicals were detected at maximum concentrations in surface water that exceeded the risk-based COPC screening levels.

- SVOCs [bis(2-ethylhexyl) phthalate]

Site 15

No surface water samples were collected at Site 15.

6.1.2.4 Sediment

Site 2

Four sediment samples were collected at Site 2 and analyzed for VOCs, SVOCs, pesticides/PCBs, and inorganics. A comparison of the maximum detected concentrations to the risk-based screening levels is presented in Table 6-6. The concentrations of all compounds were below the risk-based COPC screening

levels, with the exception of arsenic and iron. However, the maximum detected concentrations of arsenic and iron were less than their respective background concentrations; consequently, arsenic and iron will not be retained as COPCs.

Site 15

Three sediment samples were collected at Site 15 and analyzed for SVOCs, pesticides/PCBs, and inorganics. A comparison of the maximum detected concentrations to the risk-based screening levels is presented in Table 6-7. The concentrations of all compounds were below the risk-based COPC screening levels with the exception of aluminum, arsenic, and iron. However, the maximum detected concentrations of aluminum, arsenic, and iron were less than their respective background concentrations; consequently, aluminum, arsenic, and iron will not be retained as COPCs.

The source of potential contamination at Site 15 is the waste oils that were sprayed on the road. There is some concern that the waste oil may have contained PCBs. Since PCBs were not detected in sediment samples, the detection limits for PCBs were compared to the screening criteria to ensure that there were no problems with elevated detection limits. The reported detection limits for PCBs (11 to 17 µg/kg) were below the screening criteria for PCBs (320 µg/kg).

6.1.2.5 Shellfish Tissue

Concentrations of chemicals in the tissue of shellfish were estimated using the methodology presented in Section 7.0 of this report. The maximum detected chemical concentration in soil and a lipid content of 0.7 (Sullivan, 1992) was used in the calculations. A comparison of the estimated fish tissue concentrations with USFDA action levels and U.S. EPA Region III RBCs is presented in Table 6-8. The following had calculated concentrations in fish tissue that exceeded the risk-based COPC screening levels.

- PAHs [benzo(a)pyrene]
- Inorganics (hexavalent chromium)

In accordance with U.S. EPA Region IV guidance, since at least one carcinogenic PAH had estimated fish tissue concentrations exceeding the screening criteria, all carcinogenic PAHs will be retained as COPCs for fish tissue.

6.1.2.6 Subsurface Soil Samples

Three subsurface sol samples were collected from test pits during the supplemental investigation in October 1999 and analyzed for VOCs, SVOCs, Pesticides/PCBs, and inorganics. A comparison of the

maximum detected concentrations to the screening criteria is presented in Table 6-9. The concentrations of all compounds were below the risk-based COPC screening levels.

Concentrations of all chemicals detected in subsurface soil were less than the U.S. EPA SSLs for soil to air; therefore, exposures through inhalation of fugitive dust were not retained for evaluation in the risk assessment.

Maximum detected concentrations in subsurface soil were also compared to U.S. EPA soil SSLs for migration to groundwater. Concentrations of all compounds were below the U.S. EPA SSLs for migration to groundwater.

Table 6-10 presents a summary of the chemicals retained as COPCs in surface soil, subsurface soil, groundwater, sediment, surface water and shellfish tissue at Site 2. No COPCs were identified for Site 15.

6.2 EXPOSURE ASSESSMENT

The exposure assessment defines and evaluates the exposures experienced by likely receptor populations at a site. In order to have an exposure, several factors must be present: a source and mechanism of release; a route of contaminant transport through an environmental medium; a contact point for a human receptor; and an exposure route at the point of contact. All four components must be present for the exposures to occur.

The exposure assessment presented in this section of the report consists of several subsections that characterize the physical site setting and the potential receptors of concern, identify the potential contaminant migration and exposure pathways, define the contaminant concentrations at the point of exposure, and present the equations used to quantify exposure in terms of contaminant intake (dose). Appendix E of this report contains sample calculations for the quantification of contaminant intakes, as well as the chemical-specific intakes for Site 2 and Site 15.

6.2.1 Exposure Setting

There is no development in close proximity to MCRD Parris Island, because it is an island. The surrounding areas are estuarine, however, and support commercial and recreational fishing, shellfish harvesting, boating, and water recreation. The mainland closest to Parris Island is developed as a residential area. Hilton Head, a major recreational area, is located approximately 3 miles southwest of Parris Island, across Port Royal Sound.

Because it is an island, MCRD Parris Island has a single point of access for vehicular traffic. Military police stationed at the entrance currently monitor incoming traffic, stopping those without official stickers.

Site 2 is located in the central portion of Horse Island in the northern section of MCRD Parris Island, as shown in Figure 1-1. The southwestern border of the landfill is located approximately 100 feet from a marsh area. The landfill occupies approximately 1.9 acres and is currently covered with mature pine trees. The water table is approximately 3 to 17 feet below ground surface. Surface water adjacent to Site 2 is tidally influenced and the surrounding water bodies are dry during low tide.

Site 15 is approximately 1.5 miles of dirt road accessing Elliot's Beach and 0.5 mile of road accessing Site 2. In the past, the MCRD routinely sprayed the Depot's dirt and gravel roads with oils to reduce dust. Most of the dirt road accessing Elliot's Beach was recently paved and only 0.25 mile of the dirt road remains. The depth to the water table at high tide beneath Site 15 is 1 to 4 feet.

6.2.2 Conceptual Site Model

This section discusses the conceptual site model for Site 2 and Site 15. A conceptual site model facilitates consistent and comprehensive evaluation of the potential risks to human health by creating a framework for identifying the pathways by which human receptors may come in contact with contaminated media resulting from the source area. A conceptual site model depicts the relationships among the following elements that are necessary for defining complete exposure pathways:

- Site sources of contamination
- COPCs in environmental media
- Contaminant release mechanisms
- Contaminant transport pathways
- Exposure mechanisms and exposure routes
- Potential receptors

The conceptual site model for Site 2 is provided in Figure 6-2. The potential sources of contamination at Site 2 are the wastes disposed within the landfill. Contaminants may be released from the landfill by mechanisms such as leaching of COPCs from soil/waste material via infiltrating water to subsurface soil and subsequent migration through the subsurface soil to the water table. Migration via surface water runoff is not expected to occur at Site 2 because the surface elevation of Site 2 is lower than the surrounding areas; consequently, surface water will pool at Site 2 as opposed to flowing off the site.

The conceptual site model for Site 15 is provided in Figure 6-3. The potential sources of contamination at Site 15 are the waste oils that were sprayed on the road to suppress dust. Contaminants may be released

from Site 15 by mechanisms such as leaching of COPCs from surface soil via infiltrating water to subsurface soil and subsequent migration through the subsurface soil to the water table. Contaminants may also have been released from Site 15 via erosion of surface soil during rain storms.

Chemicals adsorbed to surface soil at Sites 2 and 15 may also be released from a site via wind erosion of loose soil material. These particulates are carried downwind and potentially off site if the grain size is small enough and the wind velocity is great enough. Additionally, chemicals may also be released from soil at Sites 2 and 15 via volatilization.

Once released from the source, contaminants are transported in media such as soil, groundwater, surface water, sediment, or air. Potential receptors may be exposed either directly or indirectly to contaminants in these media by a variety of exposure mechanisms, such as direct contact and immersion. Typically, several exposure routes (ingestion, dermal contact, inhalation, etc.) are associated with a particular exposure mechanism.

The conceptual site models presented in Figures 6-2 and 6-3 also indicate those exposure routes that are carried through the quantitative risk assessment for each potential receptor. An objective of the development of the conceptual site model, as well as the baseline human health risk assessment, is to focus attention on those pathways that contribute the most to the potential impacts on human health and the environment and to provide the rationale for eliminating other exposure pathways that are considered to be minor components of the overall risk.

6.2.3 Potential Exposure Pathways

Potential receptors can come into contact with contaminants in a variety of ways, which are generally the result of interactions between a receptor's behavior or lifestyle and an exposure medium. This assessment defines an exposure route as a stylized description of the behavior that brings a receptor into contact with a contaminated medium.

6.2.3.1 Air

This pathway is based on the scenario that a receptor is immersed in air that contains suspended particulates and/or volatile organic vapors originating from the source area. Subsequent exposure of the receptor occurs upon inhalation of the ambient air.

A qualitative comparison of maximum detected concentrations in surface soil at Sites 2 and 15 to U.S. EPA SSLs, based on intermedium transfer (from soil to air), was performed to determine if additional quantitative analysis of this potential exposure pathway was warranted. The SSLs are based on

residential land use and lifetime exposure scenarios and are, therefore, conservative values for potential receptors under current and future land use conditions. Exposures to fugitive dust and VOCs released from soil were found to be relatively insignificant, based on the qualitative screening. This screening is summarized in Tables 6-2 and 6-3. Maximum detections of all chemicals in surface soil were less than the SSLs; therefore, exposure via the inhalation pathway is considered to be minimal and was not considered for further evaluation.

6.2.3.2 Direct Contact with Soil and Sediment

Potential receptors may come into direct contact with soil and sediment, which may be affected by the release of chemicals from the source area. During the receptor's period of contact, the individual may be exposed via incidental ingestion of soil and sediment and via dermal absorption of contaminants from soil and sediment. Since no COPCs were identified in soil and sediment at Sites 2 and 15, potential exposures through direct contact with soil and sediment will not be quantitatively evaluated in the human health risk assessment.

6.2.3.3 Direct Contact with Groundwater

Human receptors using groundwater as a potable water supply may be exposed to groundwater via ingestion, dermal contact, and inhalation. Groundwater is not currently used as a potable water supply at the site nor is it expected to be in the future. In addition, there are no off-site residents located downgradient in the immediate vicinity of the site who might use groundwater as a potable water supply. Construction workers may have dermal contact groundwater if excavation below the water table occurs. Hypothetical future residents may be exposed to groundwater via ingestion, dermal contact, and inhalation.

6.2.3.4 Direct Contact with Surface Water

Receptors may come into direct contact with surface water adjacent to Sites 2 and 15. These surface waters may contain contaminants in a dissolved phase. Individuals may be exposed via dermal contact and/or incidental ingestion.

6.2.3.5 Ingestion of Fish

The surface water bodies adjacent to Site 2 are tidally influenced and are dry at low tide. Consequently, any fish in surface water adjacent to Site 2 originated from outside of this area. Since the unlined Borrow Pit landfill is located approximately 100 feet from the marsh immediately adjacent to Class SFH water (that portion of Archers Creek from the Parris Island Bridge to the Board River) which, by definition, is

"protected for shellfish harvesting", ingestion of shellfish by recreational users will be retained for quantitative evaluation in the risk assessment.

6.2.4 Potential Receptors

Potential receptors were identified for both current and future land use conditions. The receptors were identified by analyzing the interaction of current land use practices and the identified sources of contamination. Future site use is expected to remain the same as current, i.e., is industrial. The surface water bodies adjacent to Sites 2 and 15 are small and dry at low tide and do not support recreational activities such as boating, fishing, or swimming. The receptors identified for Sites 2 and 15 are as follows:

- Individuals (**construction workers**) who may contact surface and subsurface soils while excavating will be evaluated for exposure to surface soil and surface water/sediment. Dermal exposure to shallow groundwater may also be possible for this receptor. Since no COPCs were identified for soil and sediment, construction workers will be evaluated only for potential exposures to groundwater and surface water.

- **Maintenance workers** may be exposed to site media while performing maintenance activities (e.g., mowing, landscaping), site inspections, or daily duties. The maintenance worker is assumed to be different receptor than the military personnel receptor. The maintenance worker is assumed to be a long-term employee at the site who is engaged exclusively in maintenance activities, whereas the military personnel is assumed to be an instructor or a trainee. Although it is possible for military personnel to perform maintenance activities, the exposure duration for military personnel (three to six years) is less than the exposure duration for the maintenance worker (25 years), therefore the maintenance worker is a more conservative scenario. The maintenance worker will be evaluated for exposure to surface soil and sediment only. Exposure to groundwater will not be evaluated for these receptors because shallow groundwater at Site 2 and Site 15 is not used as a potable water supply under current conditions. No COPCs were identified for surface soil and sediment at Sites 2 and 15; consequently, potential exposures to surface soil and sediment by maintenance workers are expected to be within acceptable levels.

- Adolescent and adult recreational users may contact surface water and sediment while wading at Site 2. Since no COPCs were identified for sediment, exposures will only be evaluated for surface water. It will also be assumed that adult recreational users may be exposed to potentially contaminated shellfish at Site 2.

- **Hypothetical Future On-Site Residents** are evaluated as potential receptors. Future on-site residents are assumed be exposed to surface and subsurface soil on a daily basis and to surface

water and sediment, less frequently. In addition, it will be assumed that future on-site residents use groundwater at Sites 2 and 15 as a potable water supply. Future child and adult residents are not receptors under current or expected future land use and are included only to provide an indication of potential risks if the base was to close and then be developed for residential use. Although military personnel reside at the base under current conditions, the residential scenario is not applicable for these receptors since they do not reside in the areas of investigation and they are assigned to the base for a relatively short period of time (e.g., three to six years). No COPCs were identified for soil and sediment at Sites 2 and 15. Consequently, potential exposures to soil and sediment by future residents are expected to be within acceptable levels.

Exposures to adolescent trespassers were not evaluated since access to the site is restricted. If an individual did trespass on the site, their potential exposures would be similar to those of a future resident exposed to surface water and sediment.

A summary of the rationale used for the selection or elimination of a potential receptor group is provided in Table 6-11.

6.2.6 Exposure Point Concentrations

According to U.S. EPA guidance (U.S. EPA 1989 and 1992b), risk assessments are conducted using a representative exposure point concentration for each COPC. The exposure point concentration is typically defined as the upper 95 percent confidence limit (UCL), which is based on the distribution of a data set. However, when small data sets (i.e., less than 11 samples) are available for a site and/or medium, the 95 percent UCL is not considered to be a good estimate of the sample mean. In those cases, the maximum detected concentration is used as the exposure point concentration. It should be noted that a sample and its duplicate sample were averaged prior to the determination of the exposure point concentration.

No COPCs were identified for soil and sediment at Site 2 and Site 15; therefore, no exposures will be evaluated for these media. Only five groundwater samples and four surface water samples were collected at Site 2. Therefore, exposure point concentrations for these media are based on the maximum detected concentration.

U.S. EPA Region IV has adopted a Toxicity Equivalence Factor (TEF) approach to evaluate potentially carcinogenic PAHs. These TEFs are based on the relative potency of each compound relative to that of benzo(a)pyrene. TEFs for the individual carcinogenic PAHs are as follows:

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

The TEFs are used to convert each individual carcinogenic PAH concentration into an equivalent concentration of benzo(a)pyrene.

Estimation of chemical concentrations in fish tissue is discussed in the ecological risk assessment presented in Section 7.0.

Exposure point concentrations for COPCs for groundwater, surface water, and shellfish tissue at Site 2 are summarized in Table 6-12.

6.2.7 Quantification of Exposure

Estimates of exposure are based on the contaminant concentrations at the exposure points and on scenario-specific assumptions and intake parameters. The models and equations used to quantify intakes are described in this section and have been obtained from a variety of U.S. EPA guidance documents, which are cited in the specific intake estimation sections below.

Exposure model parameters for all receptors are presented in Tables 6-13 to 6-21. The parameters are based on those presented in the Master Workplan for MCRD, Parris Island, South Carolina (B&R Environmental, 1998b) and standard U.S. EPA Region IV default values. The parameters are used in the equations presented in this section, along with the exposure point concentrations previously defined to estimate contaminant intakes, which will be used to determine potential risks. Individual chemical intakes for each receptor/exposure route combination are presented in Appendix E.

No COPCs were identified in surface soil, subsurface soil, and sediment; therefore, no potential exposures will be evaluated for these media.

6.2.7.1 Incidental Ingestion of Surface Water/Ingestion of Groundwater

Construction workers may incidentally ingest surface water during construction activities. Adolescent and adult recreational users and future child and adult residents may contact surface water while wading. Future child and adult residents may use groundwater as a potable water supply. Intakes associated with ingestion of water are evaluated using the following equations (U.S. EPA, 1989):

$$Intake_{wi} = \frac{(C_w)(IR_w)(EF)(ED)}{(BW)(AT)} \text{ for Groundwater}$$

$$Intake_{wi} = \frac{(C_{swi})(CR)(ET)(EF)(ED)}{(BW)(AT)} \text{ for Surface Water}$$

where: $Intake_{swi}$ = intake of chemical "i" from water (mg/kg/day)

C_{sw} = concentration of chemical "i" in water (mg/L)

CR = contact rate for surface water (L/hour)

IR_w = Ingestion rate for groundwater (L/day)

ET = exposure time for surface water (hours/day)

EF = exposure frequency (days/year)

ED = exposure duration (years)

BW = body weight (kg)

AT = averaging time (days):

for noncarcinogens, AT = ED x 365 days/year

for carcinogens, AT = 70 years x 365 days/year

It is assumed that construction workers may incidentally ingest (CR) 0.01 L/hr (similar to wading, U.S. EPA, 1995a) 8 hours a day (ET) 250 days/year (EF) for 1 year (ED) while at the site. It was assumed that adolescent and adult recreational users and future adult residents may incidentally ingest 0.01 L/hr, 2.6 hours a day for 45 days a year. An exposure duration of 6 years was used for the adult recreational user and 24 years for the adult resident. It was assumed that a future child resident may incidentally ingest 0.05 L/hr, 2.6 hours a day, 45 days a year for 6 years. For potable use of groundwater, it was assumed that a child would ingest 1 L/day, 350 days a year for 6 years and an adult would ingest 2 L/day, 350 days a year for 24 years.

6.2.7.2 Dermal Contact with Groundwater/Surface Water

Construction workers may contact groundwater during construction activities if excavation occurs below the water table. In addition, construction workers may come into contact with surface water during construction activities. Adolescent and adult recreational users and future child and adult residents may

contact surface water while wading. Future child and adult residents may use groundwater as a potable water supply. The following equation is used to assess exposures resulting from dermal contact with water (U.S. EPA, 1998):

$$DAD_{wi} = \frac{(DA_{event})(EV)(ED)(EF)(SA)}{(BW)(AT)}$$

where: DAD_{wi} = dermally absorbed dose of chemical "i" from water (mg/kg/day)
DA_{event} = absorbed dose per event (mg/cm^2/event)
EV = event frequency (events/day)
ED = exposure duration (years)
EF = exposure frequency (days/year)
SA = skin surface area available for contact (cm^2)
BW = body weight (kg)
AT = averaging time (days):
for noncarcinogens, AT = ED x 365 days/year
for carcinogens, AT = 70years x 365 days/year

The absorbed dose per event (DA_{event}) is estimated using a nonsteady-state approach for organic compounds and a more traditional steady-state approach for inorganics. For organics, the following equations apply:

$$\text{If } t_{event} \le t^*, \text{ then: } DA_{event} = (2K_p)(C_{sw})(CF)\left(\sqrt{\frac{6\,\tau\, t_{event}}{\pi}}\right)$$

$$\text{If } t_{event} > t^*, \text{ then: } DA_{event} = (K_p)(C_{sw})(CF)\left(\frac{t_{event}}{1+B} + 2\tau\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right)$$

where: t_{event} = duration of event (hour/event)
t^* = time it takes to reach steady-state conditions (hours)
K_p = permeability coefficient from water through skin (cm/hour)
C_{sw} = concentration of chemical "i" in water (mg/L)
τ = lag time (hour)
π = constant (unitless; equal to 3.141592654)
CF = conversion factor (10^{-3} L/cm^3)
B = partitioning constant derived by Bunge Model (dimensionless)

For organic COPCs for groundwater and surface, values for the chemical-specific parameters (t_{event}, t^*, K_p, τ, and B) are obtained from the current dermal guidance (U.S. EPA, 1998).

The following steady-state equation is used to estimate DA_{event} for inorganics:

$$DA_{event} = (K_p)(C_{sw})(t_{event})$$

The recommended default value of 0.001 cm/hour was used for the inorganic selected as COPCs.

Current guidance (U.S. EPA, 1992a) is used to develop the following default assumptions concerning the amount of skin surface area available for contact. For construction workers, the exposed skin surface area (SA) was assumed to be 2,490 cm^2. This value represents the hands and forearms being exposed to groundwater/surface water (U.S. EPA, 1992a). It was assumed that a construction worker would be exposed to groundwater and surface water for 8 hours/day (ET) for 250 days/year over 1 year (ED) while at the site. For adult recreational users and future adult residents exposed to surface water, the exposed skin area was assumed to be 5700 cm^2 which is 25 percent of the total body surface area. A value of 3820 cm^2 was used as the exposed skin area for the adolescent trespasser. For a future child resident exposed to surface water the exposed skin area was assumed to be 2000 cm^2 which is 25 percent of the total body surface area for a child. It was assumed that the adolescent and adult recreational user and future child and adult residents would be exposed to surface water 2.6 hours/day, 45 days a year over 6 years. For potable use of groundwater, it was assumed that the entire body would be available for exposure for a child (6,600 cm^2) and adult (18,000 cm^2) resident. It was assumed that a child would be exposed to groundwater while bathing 15 min/day, 350 days/year, for 6 years and that an adult would be exposed 15 min/day, 350 days/year for 24 years.

6.2.7.3 Ingestion of Fish

Recreational users who consume fin and shell fish caught in the area may be exposed to COPCs in fish tissue. Intakes associated with ingestion of fish are evaluated using the following equation (U.S. EPA, 1989):

$$Intake_{fishi} = \frac{(C_{fishi})(IR)(FI)(EF)(ED)}{(BW)(AT)}$$

where:

$Intake_{fishi}$	=	intake of contaminant "i" from ingestion of fish (mg/kg/day)
C_{fishi}	=	concentration of contaminant "i" in fish tissue (mg/kg)
IR	=	fish ingestion rate (kg/day or kg/meals)
FI	=	fraction ingested from contaminated source (decimal fraction)
EF	=	exposure frequency (days/year or meals/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)

AT = averaging time (days);
for noncarcinogens, AT = ED x 365 days/year;
for carcinogens, AT = 70 years x 365 days/year

U.S. EPA recommends an ingestion rate (IR) of 0.0141 kg/day for marine fish (U.S. EPA, 1997c). Shellfish season in South Carolina runs from September 16 through May 14, therefore a exposure frequency (EF) of 8 months or 240 days was assumed. The U.S. EPA Region IV standard default value of 30 years was used for the exposure duration (ED) (U.S. EPA, 1995a). All other exposure parameters for ingestion of fish tissue are standard U.S. EPA default values.

6.3 TOXICITY ASSESSMENT

The toxicity assessment examines information concerning the potential human health effects associated with exposure to COPCs. The goal of the toxicity assessment is to provide, for each COPC, a quantitative estimate of the relationship between the magnitude and type of exposure and the severity or probability of human health effects. The toxicity values presented in this section are integrated with the outputs of the exposure assessment to characterize the potential for the occurrence of adverse health effects.

The toxicological evaluation involves a critical review and interpretation of toxicity data from epidemiological, clinical, animal, and in vitro studies. This review of the data ideally determines both the nature of the health effects associated with a particular chemical and the probability that a given quantity of a chemical could result in the referenced effect. This analysis defines the relationship between the dose received and the incidence of an adverse effect for the COPC.

The entire toxicological database is used to guide the derivation of cancer slope factors (CSFs) for carcinogenic effects and reference doses (RfDs) for noncarcinogenic effects. These data may include epidemiological studies, long-term animal bioassays, short-term tests, and comparisons of molecular structure. Data from these sources are reviewed to determine if a chemical is likely to be toxic to humans. Because of the lack of available human studies, however, the majority of toxicity data used to derive CSFs and RfDs come from animal studies.

For noncarcinogenic effects, the most appropriate animal model (i.e., the species most biologically similar to the human) is identified. Pharmacokinetic data often enter into this determination. In the absence of sufficient data to identify the most appropriate animal model, the most sensitive species is chosen. The RfD is generally derived from the most comprehensive toxicology study that characterizes the dose-response relationship for the critical effect of the chemical. Preference is given to studies using the exposure route of concern; in the absence of such data, however, an RfD for one route of exposure may be extrapolated from data from a study that used a different route of exposure. Such extrapolation must

take into account pharmacokinetic and toxicological differences between the routes of exposure. Uncertainty factors are applied to the highest no-observed-adverse-effect-level (NOAEL) to adjust for inter- and intraspecies variation, deficiencies in the toxicological database, and use of subchronic rather than chronic animal studies. Additional uncertainty factors may be applied to estimate a NOAEL from a lowest-observed-adverse-effect-level (LOAEL) if the key study failed to determine a NOAEL.

CSFs for weights-of-evidence of Group A or B chemicals are generally derived from positive cancer studies that adequately identify the target organ in the test animal data and characterize the dose-response relationship. CSFs are derived for Group C compounds for which the data are sufficient but are not derived for Group D or E chemicals. No consideration is given to similarity in the animal and human target organ(s) because a chemical capable of inducing cancer in any animal tissue is considered potentially carcinogenic to humans. Preference is given to studies using the route of exposure of concern, in which normal physiologic function was not impaired and in which exposure occurred during most of the animal's lifetime. Exposure and pharmacokinetic considerations are used to estimate equivalent human doses for computation of the CSF. When a number of studies of similar quality are available, the data may be combined in the derivation of the CSF.

Toxicological profiles for each of the COPCs are presented in Appendix E. These profiles present a summary of the available literature on carcinogenic and noncarcinogenic effects associated with human exposure to the chemical.

6.3.1 Carcinogenic Effects

The toxicity information considered in the assessment of potential carcinogenic risks includes a weight-of-evidence classification and a slope factor. The weight-of-evidence classification qualitatively describes the likelihood that a chemical is a human carcinogen and is based on an evaluation of the available data from human and animal studies. A chemical may be placed in one of three groups in U.S. EPA's classification system to denote its potential for carcinogenic effects:

- Group A - known human carcinogen
- Group B1 or B2 - probable human carcinogen
- Group C - possible human carcinogen

Chemicals that cannot be classified as a human carcinogen because of a lack of data are placed in Group D, and those for which there is evidence of noncarcinogenicity in humans are in Group E.

The CSF is the toxicity value used to quantitatively express the carcinogenic hazard of cancer-causing chemicals. It is defined as the upper-bound estimate of the probability of cancer incidence per unit dose

averaged over a lifetime. Slope factors are derived from studies of carcinogenicity in humans and/or laboratory animals and are typically calculated for compounds in Groups A, B1, and B2, although some Group C carcinogens also have slope factors and some B2 carcinogens have none (e.g., lead). Slope factors are specific to a chemical and route of exposure and are expressed in units of $(mg/kg/day)^{-1}$ for both oral and inhalation routes. Inhalation cancer toxicity values are usually expressed as inhalation unit risks in units of reciprocal $\mu g/m^3$ $(1/\mu g/m^3)$. Because cancer risk characterization requires an estimate of reciprocal dose in units of 1/mg/kg/day, the inhalation unit risk must be converted to the mathematical equivalent of an inhalation cancer slope factor, or risk per unit dose (mg/kg/day). This is done by assuming that humans weigh 70 kilograms and inhale 20 m^3 of air per day [i.e., the inhalation unit risk $(1/\mu g/m^3)$ is divided by 20 m^3, multiplied by 70 kg, and multiplied by 1,000 µg/mg to yield the mathematical equivalent of an inhalation slope factor (1/mg/kg/day)].

CSFs for COPCs at Site 2 are presented in Table 6-22 (no COPCs were identified at Site 15). The primary sources of information for these values are U.S. EPA's Integrated Risk Information System (IRIS). The U.S. EPA intends that IRIS supersede all other sources of toxicity information for risk assessment. If values were not available in IRIS, the annual Health Effects Assessment Summary Tables (HEAST) (U.S. EPA, 1997c) were consulted. U.S. EPA Region III Risk-Based Concentration Tables (U.S. EPA, 2000) are also used as a quick tabulated reference for available CSFs. If no CSF is available from any of these sources, carcinogenic risks are not quantified and potential exposures are addressed in Section 6.5, Uncertainty Analysis.

CSFs also exist for several (but not all) Class C compounds, which are identified as "possible" human carcinogens. These compounds typically exhibit inadequate evidence of carcinogenicity in humans and limited evidence in animals. In this human health risk assessment, Class C compounds are evaluated the same as Class A, B1, and B2 compounds. The uncertainty associated with this approach is discussed in Section 6.5.

Dermal CSFs are derived from the corresponding oral values. Regional guidance (U.S. EPA, Region IV, 1996b) is used as a basis for determining the dermal CSFs. In the derivation of a dermal CSF, the oral CSF is divided by the gastrointestinal absorption efficiency to determine a CSF based on an absorbed dose rather than an administered dose, as follows:

$$CSF_{dermal} = (CSF_{oral}) / (ABS_{GI})$$

The oral CSF is divided by the absorption efficiency because CSFs are expressed as reciprocal doses. Dermal CSFs and the absorption efficiencies used in their determination are also included in Table 6-20.

As discussed in Section 6.2.6, U.S. EPA Region IV has adopted a Toxicity Equivalence Factor (TEF) approach to evaluate potentially carcinogenic PAHs. These TEFs are based on the relative potency of each compound relative to that of benzo(a)pyrene. U.S. EPA Region IV also requires that dermal exposures to PAHs be evaluated using the TEF approach. Consequently, the oral and dermal CSF for benzo(a)pyrene is used to evaluate exposures to all carcinogenic PAHs in terms of benzo(a)pyrene equivalents.

6.3.2 Noncarcinogenic Effects

For noncarcinogens, it is assumed that there exists a dose below which no adverse health effects will be seen. Below this "threshold" dose, exposure to a chemical can be tolerated without adverse effects. For noncarcinogens, a range of exposure exists that can be tolerated. Toxic effects are manifested only when physiologic protective mechanisms are overcome by exposures to a chemical above its threshold level. Maternal and developmental endpoints are considered systemic toxicity.

The potential for noncarcinogenic health effects resulting from exposure to chemicals is assessed by comparing an exposure estimate (intake or dose) to a reference dose (RfD). The RfD is expressed in units of mg/kg/day and represents a daily intake of contaminant per kilogram of body weight that is not sufficient to cause the threshold effect of concern. An RfD is specific to the chemical, the route of exposure, and the duration over which the exposure occurs.

To derive an RfD, the U.S. EPA reviews all relevant human and animal studies for each compound and selects the study (studies) pertinent to the derivation of the specific RfD. Each study is evaluated to determine the NOAEL or, if the data are inadequate for such a determination, the LOAEL. The NOAEL corresponds to the dose (in mg/kg/day) that can be administered over a lifetime without inducing observable adverse effects. The LOAEL corresponds to the lowest daily dose that induces an observable adverse effect. The toxic effect characterized by the LOAEL is referred to as the "critical effect." To derive an RfD, the NOAEL (or LOAEL) is divided by uncertainty factors to ensure that the RfD will be protective of human health. Uncertainty factors are applied to account for extrapolation of data from laboratory animals to humans (interspecies extrapolation), variation in human sensitivity to the toxic effects of a compound (intraspecies differences), derivation of a chronic RfD based on a subchronic rather than a chronic study, and/or derivation of an RfD from the LOAEL rather than the NOAEL. In addition to these uncertainty factors, modifying factors between 1 and 10 may be applied to reflect additional qualitative considerations in evaluating the data. Or most compounds, the modifying factor is 1.

A dermal RfD is developed from an oral RfD by multiplying by the gastrointestinal tract absorption factor as follows:

$$RfD_{dermal} = (RfD_{oral})(ABS_{GI})$$

The resulting dermal RfD is, therefore, based on absorbed dose, which is what is calculated by the dermal exposure algorithms.

RfDs for the COPCs at Site 2 are presented in Table 6-23 (no COPCs were identified for Site 15). The primary source of these values is the IRIS database (U.S. EPA, 1999b), followed by other U.S. EPA sources described for the carcinogens. Table 6-23 also includes the primary target organs affected by a particular chemical. This information may be used in the risk characterization section to segregate risks by target organ effects, unless the total Hazard Index is below unity. This ensures that "risks" are not overestimated when different compounds affect different target organs.

6.4 RISK CHARACTERIZATION

This section provides a characterization of the potential human health risks associated with the potential exposure to COPCs at Site 2. Section 6.4.1 outlines the methods used to quantitatively estimate the type and magnitude of potential risks for human receptors. A summary of the risk characterization for Sites 2 and 15 is provided in Section 6.4.2.

6.4.1 Methodology for Estimation of Quantitative Risks

Potential human health risks resulting from exposure to COPCs are estimated using algorithms established by the U.S. EPA (U.S. EPA, 1989). The methods described by the U.S. EPA are protective of human health and are likely to overestimate (rather than underestimate) risk. The methodology uses specific algorithms to calculate risk as a function of chemical concentration, human exposure parameters, and toxicity.

Risks from hazardous chemicals are calculated for either carcinogenic or noncarcinogenic effects. Some carcinogenic chemicals may also exhibit noncarcinogenic effects. Potential impacts are then characterized for both types of health effects.

6.4.1.1 Carcinogenic Effects

Risks attributable to exposure to carcinogenic COPCs are estimated as the probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. At low doses, the incremental lifetime cancer risk (ILCR) is determined as follows (U.S. EPA, 1989):

$$ILCR_i = (Intake_i)(CSF_i)$$

where: $ILCR_i$ = Incremental Lifetime Cancer Risk for chemical "i", expressed as a unitless probability

$Intake_i$ = Intake of chemical "i" (mg/kg/day)

CSF_i = Cancer slope factor of chemical "i" (kg/day/mg)

Estimated ILCRs are compared to the U.S. EPA target risk range, 10^{-4} to 10^{-6}. Risks below 1×10^{-6} (1/1,000,000, or a risk less than 1 in 1 million) are generally considered to be "acceptable" by the U.S. EPA, whereas risks greater than 1×10^{-4} (1 in 10,000) are generally considered to be "unacceptable" by the Agency. Depending on the risk management goals for the site, risks within 10^{-4} to 10^{-6} are also typically regarded as "acceptable."

When carcinogenic risks exceed 1×10^{-2} using the above methodology, the U.S. EPA (U.S. EPA, 1989) specifies that the one-hit model be used, as follows:

$$ILCR_i = 1 - \exp(-Intake_i)(CSF_i)$$

Risks are estimated for all carcinogenic compounds regardless of the class designation (A, B, or C).

6.4.1.2 Noncarcinogenic Effects

The hazards associated with the effects of noncarcinogenic COPCs are evaluated by comparing an exposure level or intake to an RfD. The ratio of the intake to the RfD is called the Hazard Quotient (HQ) and is defined as follows (U.S. EPA, 1989):

$$HQ_i = \frac{Intake}{RfD_i}$$

where: HQ_i = Hazard Quotient for chemical "i" (unitless)

$Intake_i$ = Intake of chemical "i" (mg/kg/day)

RfD_i = Reference Dose of chemical "i" (mg/kg/day)

A Hazard Index (HI) is generated by summing the individual HQs for all the COPCs. If the HI exceeds unity, there exists a potential for noncarcinogenic (toxic) effects to occur. When the HI exceeds unity, it is necessary to segregate the HQs by target organ effects since the HQs for all noncarcinogens are not considered to be truly additive unless similar target organs are affected.

The estimation of noncarcinogenic effects (i.e., the calculation of HQs/HIs) should not be construed as a probability in the manner of the ILCR, but rather a numerical indicator of the extent to which a predicted intake exceeds, or is less than, an RfD.

6.4.2 Results of the Risk Characterization

This section contains a summary of the results of the risk characterization for Site 2 (no COPCs were identified for Site 15). Potential cancer risks and hazard indices were calculated for construction workers and adult recreational users and are summarized in Table 6-24. Maintenance workers exposed to surface soil and sediment were also identified as a potential receptor group at Site 2, but since no COPCs were identified for these media, no potential exposures were evaluated for the maintenance workers. Potential cancer risks and HIs were not calculated for Site 15 because no COPCs were identified for this area. Sample calculations are presented in Appendix E. Results of the risk assessment in RAGS Part D format is included in Appendix E.

Construction Workers

All estimated cancer risks for construction workers exposed to groundwater and surface water at Site 2 were less than or within U.S. EPA's target risk range of 10^{-4} to 10^{-6}. The estimated cancer risk for construction workers was 1.7×10^{-8} for exposure to groundwater and 1.8×10^{-6} for exposure to surface water. The total cancer risk across all media was 1.8×10^{-6}.

The estimated HIs for construction workers at Site 2 were 0.42 for exposure to groundwater and 0.45 for exposure to surface water, which are below the acceptable level of 1.0. The cumulative HI across all media at Site 2 was 0.87, which is below the acceptable level of 1.0.

Adolescent Recreational Users

The estimated cancer risk for adolescent recreational users exposed to surface water was 4.4×10^{-6} which is within U.S. EPA's acceptable risk range of 10^{-4} to 10^{-6}. The hazard index for adolescent recreational users exposed to surface water was 0.11 which is less than the acceptable level of 1.0.

Adult Recreational Users

The estimated cancer risk for adult recreational users exposed to surface water was 2.6×10^{-6} which is within U.S. EPA's acceptable risk range of 10^{-4} to 10^{-6}. The hazard index for the adult recreational users exposed to surface water was 0.11 which is less than the acceptable level of 1.0.

The estimated cancer risk for adult recreational users from ingestion of shellfish was 1.4×10^{-6} which is within U.S. EPA's acceptable risk range of 10^{-4} to 10^{-6}. The hazard index for the adult recreational users from ingestion of shellfish was 0.07 which is less than the acceptable level of 1.0.

Onsite Resident

The estimated cancer risk for a hypothetical future lifelong (child and adult) resident exposed to surface water was 1.4×10^{-5} which is within U.S. EPA's acceptable risk range of 10^{-4} to 10^{-6}. The hazard index for a future hypothetical child resident was 0.18 and the hazard index for a future hypothetical adult resident was 0.11 which is less than the acceptable level of 1.0.

The estimated cancer risk for a hypothetical future lifelong (child and adult) resident exposed to groundwater was 3.4×10^{-5} which is within U.S. EPA's acceptable risk range of 10^{-4} to 10^{-6}. The hazard index for a future hypothetical child resident was 19 and the hazard index for a future hypothetical adult resident was 8.35 which exceeds the acceptable level of 1.0. Thallium (HI = 16.6) and iron (HI = 1.8) were the main contributors to the HI for a child and thallium (HI = 7.2) was the main contributor to the hazard index for an adult. It should be noted that exposures to groundwater were estimated using the maximum detected concentration in groundwater and that the maximum detected concentration of thallium occurred in a monitoring well located upgradient of the Borrow Pit Landfill. In addition, the RFD for iron is based on the Recommended Dietary Allowance (RDA) for adult nutrition. Children require more iron in their diets than adults do, consequently using an RFD based on the adult RDA for iron to evaluate exposures to children results in an overestimation of the risks for children. The uncertainty resulting from using a RFD based on the adult RDA for iron is discussed in Section 6.5.3.3

6.5 UNCERTAINTY ANALYSIS

There is uncertainty associated with all aspects of the baseline human health risk assessment presented in this section. A summary of the uncertainties, including a discussion of how they may affect the final risk numbers, is provided in this section.

Uncertainty in the selection of COPCs is related to the current status of the predictive databases, the grouping of samples, and the procedures used to include or exclude constituents as COPCs. Uncertainty associated with the exposure assessment includes the values used as input variables for a given intake route/scenario, the assumptions made to determine exposure point concentrations, and the predictions regarding future land use and population characteristics. Uncertainty in the toxicity assessment includes the quality of the existing toxicity data needed to support dose-response relationships and the weight-of-evidence used for determining the carcinogenicity of COPC. Uncertainty in risk characterization includes that associated with exposure to multiple chemicals and the cumulative uncertainty from combining conservative assumptions made in earlier activities.

Generally, risk assessments carry two types of uncertainty: measurement and informational uncertainty. Measurement uncertainty refers to the usual variance that accompanies scientific measurements. For example, this type of uncertainty is associated with analytical data collected for each site. The risk assessment reflects the accumulated variances of the individual values used.

Informational uncertainty stems from inadequate availability of information needed to complete the toxicity and exposure assessments. Often, this gap is significant, such as the absence of information on the effects of human exposure to low doses of a chemical, on the biological mechanism of action of a chemical, or on the behavior of a chemical in soil.

Once the risk assessment is complete, the results must be reviewed and evaluated to identify the type and magnitude of uncertainty involved. Reliance on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. For example, to account for uncertainties in the development of exposure assumptions, conservative estimates must be made to ensure that the particular assumptions made are protective of sensitive subpopulations or the maximum exposed individuals. If a number of conservative assumptions are combined in an exposure model, the resulting calculations can propagate the uncertainties associated with those assumptions, thereby producing a much larger uncertainty for the final results. This uncertainty is biased toward over predicting both carcinogenic and noncarcinogenic risks. Thus, both the results of the risk assessment and the uncertainties associated with those results must be considered when making risk management decisions.

This interpretation is especially relevant when the risks exceed the point-of-departure for defining "acceptable" risk. For example, when risks calculated using a high degree of uncertainty are below an "acceptable" risk level (i.e., 1×10^{-6}), the interpretation of no significant risk is typically straightforward. However, when risks calculated using a high degree of uncertainty are above an "acceptable" risk level (i.e., 1×10^{-4}), a conclusion can be difficult unless uncertainty is considered.

6.5.1 Uncertainty in Selection of COPCs

There is a minor amount of uncertainty associated with the selection of COPCs that may impact the numerical risk estimates presented in Section 6.4, Risk Characterization. The most significant issues related to uncertainty in COPC selection for Sites 2 and 15 are the screening levels used and the absence of screening levels for a few chemicals detected in the site media. A brief discussion of each of these issues is provided below.

6.5.1.2 COPC Screening Levels

The use of predetermined screening values based on conservative land use scenarios (i.e., residential land use for soil and sediment and ingestion/inhalation for groundwater/surface water), in combination with the use of risk-based screening values corresponding to a 1×10^{-6} ILCR and a 0.1 HI, should ensure that the significant contributors to risk from a site are evaluated. The elimination of chemicals that are present at concentrations that correspond to a less than 1×10^{-6} ILCR and less than 0.1 HI should not affect the final conclusions of the risk assessment since these chemicals are not expected to cause a potential health concern.

6.5.1.3 Absence of COPC Screening Levels

There are several compounds [benzo(g,h,i)perylene and phenanthrene] for which there are no available health criteria and for which no risk-based COPC screening criteria could be developed. The screening criterion for naphthalene was used as a surrogate since these compounds are chemically/toxicologically similar. Therefore, there is some uncertainty associated with screening these compounds using the screening criterion for naphthalene. The maximum detected concentrations of benzo(g,h,i)perylene and phenanthrene in soil and sediment are approximately three or more orders of magnitude lower than the screening criteria for naphthalene. The maximum detected concentration of phenanthrene in surface water is more than an order of magnitude lower than the screening criteria for naphthalene. Consequently, the absence of screening criteria for benzo(g,h,i)perylene and phenanthrene and the use of naphthalene as a surrogate for these compounds does not affect the conclusions of the risk assessment.

There are no U.S. EPA Region III RBCs for essential nutrients (calcium, magnesium, potassium, and sodium), U.S. EPA's Risk Assessment Guidance for Superfund (RAGS), Volume 1, Part A states that "Chemicals that are (1) essential human nutrients, (2) present at low concentrations (i.e., only slightly elevated above naturally occurring levels), and (3) toxic only at very high doses (i.e., much higher than those that could be associated with contact at the site) need not be considered further in the quantitative risk assessment. Examples of such chemicals are iron, magnesium, calcium, potassium, and sodium." As shown in Tables 6-2 to 6-9 the maximum detected concentration of all essential nutrients in soil, sediment, and surface water are less than background levels with the exception of sodium in surface soil and calcium in subsurface soil at Site 2 and calcium in sediment at Site 15. There is no background data available for groundwater.

Essential nutrient screening levels were derived using recommended daily allowances advocated by the Food and Nutrition Board. The development of the essential nutrient screening levels is presented in Appendix E. Table 6-25 presents a comparison of the maximum detected concentration in surface soil, subsurface soil, sediment, surface water, and groundwater with essential nutrient screening levels. The

maximum detected concentration of calcium, magnesium, potassium, and sodium in surface soil, subsurface soil, and sediment are less than their respective screening levels. The maximum detected concentration of magnesium, potassium, and sodium in surface water exceeded their respective screening levels, although as discussed above concentrations of these chemicals were within background levels in surface water. Maximum detected concentrations of magnesium and sodium in groundwater exceeded their respective screening levels. The maximum detected concentrations of magnesium and sodium occurred in monitoring well PAI-02-GW-04 which is located adjacent to Archer's Creek. Groundwater samples from this well contained high levels of total dissolved solids which are indicative of salt water, consequently groundwater from this well is not suitable for drinking water. Therefore, no adverse health effects are anticipated from exposure to essential nutrients in soil, sediment, surface water and groundwater at the site.

6.5.1.4 Retention of Bis(2-ethylhexyl) phthalate as a COPC

Bis(2-ethylhexyl) phthalate was retained as a COPC in surface water at Site 2. Bis(2-ethylhexyl) phthalate was not detected in surface soil or sediment at Site 2. Bis (2-ethylexy) phthalate was detected in four of five groundwater samples at a concentration of 1 µg/L. Bis(2-ethylhexyl) phthalate has a high organic carbon partition coefficient and a low water solubility, which indicates that bis(2-ethylhexyl) phthalate will strongly bind to soil and sediment and will not readily leach to groundwater or surface water. The maximum detected concentration of 77 µg/L is equal to approximately 23 percent of its solubility limit of 340 µg/L (U.S. EPA, 1996c). Concentrations greater than 10 percent of the chemical's solubility limit typically indicate that dense nonaqueous phase liquids (DNAPL) is present (U.S. EPA, 1992d), yet no DNAPL was observed in surface water at Site 2. This suggests that the presence of bis(2-ethylhexyl) phthalate in surface water may not be site related but be due to contamination from sampling. Consequently, the retention of bis(2-ethylhexyl) phthalate as a COPC may result in an overestimation of site risks.

6.5.2 Uncertainty in the Exposure Assessment

Uncertainty in the exposure assessment arises because of the methods used to calculate exposure point concentrations, the determination of land use conditions, the selection of receptors and scenarios, and the selection of exposure parameters. Each of these is discussed below.

6.5.2.1 Land Use

The current land use patterns at the site are well established, thereby reducing the uncertainty associated with land use assumptions. Land use at the site is currently limited and is expected to be limited in the future.

6.5.2.2 Exposure Point Concentrations

Since fewer than 11 samples were collected for groundwater and surface water, the distribution of the chemical was not defined and the maximum detected concentration was used as the exposure point concentration. As a result, the estimations of risk, where the maximum concentrations were used as the exposure point concentration, are most likely to be overstated because it is unlikely that potential receptors would be exposed to the maximum concentration over the entire exposure period.

6.5.2.3 Exposure Routes and Receptor Identification

Receptors quantitatively evaluated in the human health risk assessment for Site 2 included construction workers and recreational users. Since Site 2 is a landfill, it is very unlikely that any construction activity or any other activity will occur on the site. Consequently, there is uncertainty associated with the selection of a construction worker as a receptor at Site 2.

6.5.2.4 Exposure Parameters

Each exposure factor selected for use in the risk assessment has some associated uncertainty. Generally, exposure factors are based on surveys of physiological and lifestyle profiles across the United States. The attributes and activities studied in these surveys generally have a broad distribution. To avoid underestimation of exposure, the U.S. EPA guidelines on the Reasonable Maximum Exposure (RME) receptor were used, which generally consist of the 95th percentile for most parameters. Therefore, the selected values for the RME receptor represent the upper bound of the observed or expected habits of the majority of the population.

Generally, the uncertainty can be assessed quantitatively for a number of assumptions made in determining factors for calculating exposures and intakes. Many of these parameters were determined from statistical analyses on human population characteristics. Often, the database used to summarize a particular exposure parameter (i.e., body weight) is quite large. Consequently, the values chosen for such variables in the RME scenario have low uncertainty. For many parameters for which limited information exists (i.e., dermal absorption of organic chemicals from soil), there is greater uncertainty. However, there are often sufficient data to estimate these parameters with low uncertainty.

Many of the quantities used to calculate exposures and risks in this report are selected from a distribution of possible values. For the RME scenario, the value representing the 95th percentile is generally selected for each parameter to ensure that the assessment bounds the actual risks from a postulated exposure. This risk number is used in risk management decisions but does not indicate what a more average or typical exposure might be or what risk range might be expected for individuals in the exposed population.

6.5.3 Uncertainty in the Toxicological Evaluation

Uncertainties associated with the toxicity assessment (determination of RfDs and CSFs and use of available criteria) are presented in this section.

6.5.3.1 Derivation of Toxicity Criteria

Uncertainty associated with the toxicity assessment is associated with hazard assessment and dose-response evaluations for the COPCs. The hazard assessment deals with characterizing the nature and strength of the evidence of causation or the likelihood that a chemical that induces adverse effects in animals will also induce adverse effects in humans. Hazard assessment of carcinogenicity is evaluated as a weight-of-evidence determination, using the U.S. EPA methods. Positive animal cancer test data suggest that humans contain tissue(s) that may also manifest a carcinogenic response; however, the animal data cannot necessarily be used to predict the target tissue in humans. In the hazard assessment of noncancer effects, however, positive animal data suggest the nature of the effects (i.e., the target tissues and type of effects) anticipated in humans.

Uncertainty in hazard assessment arises from the nature and quality of the animal and human data. Uncertainty is reduced when similar effects are observed across species, strain, sex, and exposure route; when the magnitude of the response is clearly dose related; when pharmacokinetic data indicate a similar fate in humans and animals; when postulated mechanisms of toxicity are similar for humans and animals; and when the chemical of concern is structurally similar to other chemicals for which the toxicity is more completely characterized.

Uncertainty in the dose-response evaluation includes the determination of a CSF for the carcinogenic assessment and derivation of an RfD for the noncarcinogenic assessment. Uncertainty is introduced from interspecies (animal to human) extrapolation, which, in the absence of quantitative pharmacokinetic or mechanistic data, is usually based on consideration of interspecies differences in basal metabolic rate. Uncertainty also results from intraspecies variation. Most toxicity experiments are performed with animals that are very similar in age and genotype, so that intragroup biological variation is minimal, but the human population of concern may reflect a great deal of heterogeneity including unusual sensitivity or tolerance to the COPC. Even toxicity data from human occupational exposure reflect a bias, because only those individuals sufficiently healthy to attend work regularly (the "healthy worker effect") and those not unusually sensitive to the chemical are likely to be occupationally exposed. Finally, uncertainty arises from the quality of the key study from which the quantitative estimate is derived and the database. For cancer effects, the uncertainty associated with dose-response factors is mitigated by assuming the 95 percent upper bound for the slope factor. Another source of uncertainty in carcinogenic assessment is the method

by which data from high doses in animal studies are extrapolated to the dose range expected for environmentally exposed humans. The linearized multistage model, which is used in nearly all quantitative estimations of human risk from animal data, is based on a nonthreshold assumption of carcinogenesis. There is evidence to suggest, however, that epigenetic carcinogens, as well as many genotoxic carcinogens, have a threshold below which they are noncarcinogenic (Williams and Weisburger, 1991); therefore, the use of the linearized multistage model is conservative for chemicals that exhibit a threshold for carcinogenicity.

For noncancer effects, additional uncertainty factors may be applied in the derivation of the RfD to mitigate poor quality of the key study or gaps in the database. Additional uncertainty for noncancer effects arises from the use of an effect level in the estimation of an RfD, because this estimation is predicated on the assumption of a threshold below which adverse effects are not expected. Therefore, an uncertainty factor is usually applied to estimate a no-effect level. Additional uncertainty arises in estimation of an RfD for chronic exposure from less-than-chronic data. Unless empirical data indicate that effects do not worsen with increasing duration of exposure, an additional uncertainty factor is applied to the no-effect level in the less-than-chronic study. Uncertainty in the derivation of RfDs is mitigated by the use of uncertainty and modifying factors that normally range between 3 and 10. The resulting combination of uncertainty and modifying factors may reach 1,000 or more.

The derivation of dermal RfDs and CSFs from oral values may cause uncertainty. This is particularly the case when no gastrointestinal absorption rates are available in the literature or when only qualitative statements regarding absorption are available. Whenever possible, gastrointestinal absorption rates from U.S. EPA Region IV were used for all chemicals in the human health risk assessment. U.S. EPA is currently revising the dermal guidance and has interim gastrointestinal absorption rates that differ from those recommended by U.S. EPA Region IV. For example, U.S. EPA Region IV recommends a gastrointestinal absorption rate of 20 percent for chloroform and 19 percent for bis(2-ethylhexyl) phthalate. The draft U.S. EPA dermal guidance states that gastrointestinal absorption rates for chloroform and bis(2-ethylhexyl) phthalate are over 50 percent and recommends that the oral CSF be used as the dermal CSF for these compounds. Consequently, risks from dermal exposures evaluated using the draft U.S. EPA guidance will be lower than those evaluated using the U.S. EPA Region IV guidance. Based on the EPA Region IV guidance cancer risks from dermal exposures to surface water exceed 1×10^{-6} for all receptor groups. Based on the draft EPA dermal cancer risks from exposures to surface water are less than 1×10^{-6} for all receptor groups except the future child resident whose cancer risk slightly exceeds 1×10^{-6}. Therefore, dermal exposures based on the U.S. EPA Region IV guidance may overestimate cancer risks.

6.5.3.2 Use of Arsenic Toxicity Criteria

The carcinogenicity of arsenic via ingestion is not confirmed by the available data. However, the U.S. EPA has proposed an oral unit risk factor that was used for all oral and dermal exposures to arsenic at this site. Since arsenic is selected as a COPC for groundwater and surface water at Site 2, the risks associated with this chemical may be overstated. Although the more restrictive basis for evaluating risk associated with exposure to arsenic is to assume it is a carcinogen, carcinogenic effects are not the primary health effects expected to be manifested upon exposure to arsenic. The preponderance of scientific information indicates that humans are capable of metabolizing arsenic to expedite its elimination from the body (ATSDR, 1988). Its elimination from the body obviously mitigates the possibility for arsenic to manifest carcinogenic effects. Therefore, evaluating arsenic as a noncarcinogen would be more appropriate.

6.5.3.3 Use of Iron Toxicity Criteria From NCEA

The estimated hazard index (HI) for hypothetical child residents exposed to iron in groundwater was 1.8, which exceeded the acceptable level of 1.0. No toxicity criteria are available for iron in EPA's Integrated Risk Information System (IRIS) or in EPA's Health Effects Assessment Summary Tables. EPA's National Center for Environmental Assessment has derived a provisional RfD of 0.3 mg/kg/day. NCEA's provision RfD was used to evaluate exposures to iron in groundwater by child and adult residents. The RfD for iron is based on the Recommended Dietary Allowance (RDA) for adult human nutrition. Children and adolescents require more iron in their diets than adults do, consequently, using a RfD based on the adult RDA for iron to evaluate exposures to children results in an overestimation of the risks for children.

Iron is an essential nutrient and deriving a RfD for such chemicals poses a special problem in that the dose adversity curve is "U-shaped." Thus, the RfD must be protective against deficiency as well as toxicity. The National Academy of Science has determined that the RDA for iron is 10 mg/day. (0.13 mg/kg/day) for adult men and 15 mg/day (0.24 to 0.33 mg/kg/day) for females aged 11 to 50 years. The RDA is 6 mg/day (1 mg/kg/day) for non-breastfed infants aged 0 to 6 months, 10 mg/kg/day (0.36 to 1.11 mg/kg/day) for children aged 6 months to 10 years, and 12 mg/day (0.18 to 0.27 mg/kg/day) for males aged 11 to 14 years. A RfD of 1.1 mg/kg/day is recommended for child based on the above information.

The HI for child residents exposed to iron in groundwater was recalculated using an RfD of 1.1 mg/kg/day which is based on child nutritional requirements. The resulting HI is 0.49 which is less than the acceptable level of 1.0, indicating that no adverse health effects are anticipated for child residents exposed to groundwater under the defined conditions.

6.5.4 Uncertainty in the Risk Characterization

Uncertainty in risk characterization results primarily from assumptions made regarding additivity of effects from exposure to multiple COPCs from various exposure routes. High uncertainty exists when summing cancer risks for several substances across different exposure pathways. This assumes that each substance has a similar effect and/or mode of action. Often compounds affect different organs, have different mechanisms of action, and differ in their fate in the body, so additivity may not be an appropriate assumption. However, the assumption of additivity is made to provide a conservative estimate of risk.

Finally, the risk characterization does not consider antagonistic or synergistic effects. Little or no information is available to determine the potential for antagonism or synergism for the COPCs. Therefore, this uncertainty cannot be discussed for its impact on the risk assessment, since it may either underestimate or overestimate potential human health risk.

6.6 REMEDIAL GOAL OPTIONS

U.S. EPA Region IV guidance specifies that Remedial Goal Options (RGO's) should be developed for those media with estimated lifeline cancer risks greater than 1×10^{-4} and total HI greater than 1.0. As shown in Table 6-24 all estimated lifetime cancer risks are less than 1×10^{-4} and all HIs are less than 1.0 with the exception of child and adult residents exposed to groundwater. Thallium and iron are the major risk drivers for child residents and thallium is the major risk driver for adult residents. As previously discussed, the exposures to groundwater were estimated using the maximum detected concentration in groundwater and that the maximum detected concentration of thallium occurred in a monitoring well located up gradient of the Borrow Pit Landfill. Consequently, the presence of thallium in groundwater at the Borrow Pit Landfill is not believed to be site-related. Thallium was not detected in any on-site freshwater wells, therefore, there is no unacceptable risk resulting from exposure to thallium in on-site groundwater.

As discussed in Section 6.5.3.3, the HI presented in Table 6-24 for exposure to iron groundwater by a child resident was calculated using a RfD based on adult nutritional requirements. The HI for a child resident exposed to iron in groundwater is within acceptable levels when using a RfD based on child nutritional requirements. Therefore, there are no unacceptable risks resulting from a child resident exposed to iron in groundwater at the Borrow Pit Landfill.

Therefore, since all cancer risks and HIs are within acceptable levels, RGOs are not required to be developed for the Borrow Pit Landfill.

TABLE 6-1

SCREENING CRITERIA USED IN SELECTION OF COPCs
SITE 2 - BORROW PIT LANDFILL AND SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	EPA Region III RBC[1] Residential (µg/kg)		EPA SSL[2] Soil to Air (µg/kg)		EPA SSL[2] Soil to Groundwater (µg/kg)		EPA Region III RBC[1] Tap Water (µg/L)		EPA MCL[3] (µg/L)	EPA AWQC[4] (µg/L)	EPA Region III RBC[1] Fish (µg/kg)	
Volatile Organic Compounds													
67-64-1	Acetone	7800000	N	1000000	N	16000	N	610	N	N/A	N/A	140000	N
75-15-0	Carbon Disulfide	7800000	N	720000	N	32000	N	1000	N	N/A	N/A	140000	N
67-66-3	Chloroform	100000	C	300	C	600	C	0.15	C	100/80	5.7	520	C
74-87-3	Chloromethane	49000	C	N/A		N/A		2.1	C	N/A	N/A	240	C
75-09-2	Methylene Chloride	85000	C	13000	C	20	C	4.1	C	5	4.7	0.42	C
127-18-4	Tetrachloroethene	12000	C	11000	C	60		1.1	C	5	0.8	61	C
108-88-3	Toluene	16000000	N	650000	N	12000		750	N	1000	6800	270000	N
Semivolatile Organic Compounds													
120-12-7	Anthracene	23000000	N	N/A		12000000	N	1800	N	N/A	9600	410000	N
56-55-3	Benzo(a)anthracene	870	C	N/A		2000	C	0.092	C	N/A	0.0044	4.3	C
50-32-8	Benzo(a)pyrene	87	C	N/A		8000	C	0.0092	C	0.002	0.0044	0.43	C
205-99-2	Benzo(b)fluoranthene	870	C	N/A		5000	C	0.092	C	N/A	0.0044	4.3	C
207-08-9	Benzo(k)fluoranthene	8700	C	N/A		49000	C	0.92	C	N/A	0.0044	43	C
117-81-7	Bis(2-ethylhexyl)phthalate	46000	C	3100000	N	3600000	C	4.8	C	N/A	1.8	230	C
218-01-9	Chrysene	87000	C	N/A		160000	C	9.2	C	N/A	0.0044	430	C
84-66-2	Diethyl Phthalate	63000000	N	2000000	sat	470000	N	29000	N	N/A	23000	1100000	N
206-44-0	Fluoranthene	3100000	N	N/A		4300000	N	1500	N	N/A	300	54000	N
193-39-5	Indeno(1,2,3-cd)pyrene	870	C	N/A		14000	C	0.092	C	N/A	0.0044	4.3	C
85-01-8	Phenanthrene	1600000 (5)	N	N/A		N/A		6.5 (5)	N	N/A	N/A	27000 (5)	N
129-00-0	Pyrene	2300000	N	N/A		4200000	N	180	N	N/A	960	41000	N
Pesticides/PCBs													
11097-69-1	Aroclor-1254	320	C	NA		NA		0.033	C	0.5	0.00017	1.6	C
1031-07-8	Endosulfan Sulfate	470000[6]	N	N/A		18000[6]	N	220[6]	N	N/A	110	8100[6]	N
Inorganics													
7429-90-5	Aluminum	78000000	N	N/A		N/A		37000	N	50 To 200[7]	N/A	1400000	N
7440-36-0	Antimony	31000	N	N/A		5000	N	15	N	6	14	540	N
7440-38-2	Arsenic	430	C	750000	C	29000	C	0.045	C	50	0.018	2.1	C
7440-39-3	Barium	5500000	N	69000000	N	1600000	N	2600	N	2000	1000	95000	N
7440-70-2	Calcium	N/A		N/A		N/A		N/A		N/A	N/A	N/A	
7440-47-3	Chromium	120000000[8]	N	270000[8]	C	38000[9]	C	55000[9]	N	100[9]	N/A	2000000[9]	N
1854-02-99	Hexavalent Chromium	230000	N	270000	C	38000	C	110	N	N/A	N/A	4100	N
7440-48-4	Cobalt	4700000	N	N/A		N/A		2200	N	N/A	N/A	81000	N
7440-50-8	Copper	3100000	N	N/A		N/A		1500	N	1000[7]	1300	54000	N
7439-89-6	Iron	23000000	N	N/A		N/A		11000	N	300[7]	300	410000	N
7439-92-1	Lead	400000[10]		N/A		N/A		N/A		15 (11)	N/A	N/A	
7439-95-4	Magnesium	N/A		N/A		N/A		N/A		N/A	N/A	N/A	
7439-96-5	Manganese	1600000	N	N/A		N/A		730	N	50[7]	50	27000	N
7487-94-7	Mercury	23000[12]	N	10		2		11	N	2	0.05	140[13]	N
7440-02-0	Nickel	1600000	N	13000000	C	130000	N	730	N	100	610	27000	N
7440-09-7	Potassium	N/A		N/A		N/A		N/A		N/A	N/A	N/A	
7782-49-2	Selenium	390000	N	N/A		5000	N	180	N	50	N/A	6800	N
7440-22-4	Silver	390000	N	NA		34	N	180	N	100 (7)	NA	6800	N
7440-23-5	Sodium	N/A		N/A		N/A		N/A		N/A	N/A	N/A	
7440-28-0	Thallium	5500	N	N/A		700		2.6	N	2	1.7	95	N
7440-62-2	Vanadium	550000	N	N/A		6000000	N	260	N	N/A	N/A	9500	N
7440-66-6	Zinc	23000000	N	N/A		12000000	N	11000	N	5000[7]	9100	410000	N

Notes:

1 USEPA Region III Risk-Based Concentration Table, April 13,2000. (Cancer benchmark value = 1E-06, HI = 1.0)
2 USEPA Soil Screening Level Guidance: Technical Background Document. May 1996c.
3 USEPA Drinking Water Regulations and Health Advisories, October 1996.
4 Federal Register 68354-68364, December, 1998.
5 Value is for naphthalene.
6 Value is for endosulfan.
7 Secondary MCLs
8 Value is for trivalent chromium.
9 Value is for total chromium.
10 OSWER Screening level.
11 Action level.
12 Value is for mercuric chloride.
13 Value is for methyl mercury.

Definitions: N/A = Not Applicable
C = Carcinogenic
N = Non-Carcinogenic
sat = saturation concentration
MCL = Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
RBC = Risk-Based Concentration
SSL = Soil Screening Level.
AWQC = Ambient Water Quality Criteria.

TABLE 6-2

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH SURFACE SOIL
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	Minimum[1] Concentration	Minimum Qualifier	Maximum[1] Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value[2]	US EPA Region III RBC[3]		US EPA[4] SSL Soil to Air		US EPA[5] SSL Soil to Groundwater		COPC Flag	Rationale for[6] Contaminant Deletion or Selection
Volatile Organic Compounds																			
67-64-1	Acetone	0.018	J	0.17	J	mg/kg	PAI-02-SS-08-01	2/7	0.02 - 0.16	0.17	N/A	780	N	100000	sat	16	N	No	BSL
67-66-3	Chloroform	0.002	J	0.018		mg/kg	PAI-02-SS-04-01	6/8	0.007 - 0.008	0.018	N/A	100	C	0.3	C	0.6		No	BSL
108-88-3	Toluene	0.003	J	0.003	J	mg/kg	PAI-02-SS-01-01	1/8	0.006 - 0.008	0.003	N/A	1600	N	650	sat	12		No	BSL
Semivolatile Organic Compounds																			
120-12-7	Anthracene	0.0013	J	0.0013		mg/kg	PAI-02-SS-02-01	1/8	0.0017 - 0.022	0.0013	N/A	2300	N	N/A		12000	N	No	BSL
205-99-2	Benzo(b)fluoranthene	0.0009		0.0023		mg/kg	PAI-02-SS-07-01	4/8	0.0017 - 0.022	0.0023	N/A	0.87	C	N/A		5	C	No	BSL
218-01-9	Chrysene	0.0029	J	0.0029	J	mg/kg	PAI-02-SS-07-01	1/8	0.0043 - 0.055	0.0029	N/A	87	C	N/A		160	C	No	BSL
206-44-0	Fluoranthene	0.0047	J	0.0077		mg/kg	PAI-02-SS-01-01	2/8	0.0043 - 0.055	0.0077	N/A	310	N	N/A		4300	N	No	BSL
193-39-5	Indeno(1,2,3-cd)pyrene	0.0047	J	0.0047	J	mg/kg	PAI-02-SS-08-01	1/8	0.0043 - 0.055	0.0047	N/A	0.87	C	N/A		14	C	No	BSL
85-01-8	Phenanthrene	0.0032	J	0.041	J	mg/kg	PAI-02-SS-06-01	6/8	0.0036 - 0.0073	0.041	N/A	160[7]	N	N/A		N/A		No	BSL
Inorganics																			
7429-90-5	Aluminum	1710		4290		mg/kg	PAI-02-SS-04-01	8/8	N/A	4290	7270	7800	N	N/A		N/A		No	BSL, BKG
7440-36-0	Antimony	0.17		0.17		mg/kg	PAI-02-SS-01-01	1/8	0.15 - 1.3	0.17	N/A	3.1	N	N/A		5		No	BSL
7440-38-2	Arsenic	0.18		1		mg/kg	PAI-02-SS-07-01	4/8	0.18 - 0.23	1	1.4	0.43	C	750	C	29		No	BKG
7440-39-3	Barium	4.4		12		mg/kg	PAI-02-SS-02-01	8/8	N/A	12	24	550	N	690000	N	1600		No	BSL, BKG
7440-70-2	Calcium	53.1		477		mg/kg	PAI-02-SS-06-01	7/8	47.3	477	766	N/A		N/A		N/A		No	NUT, BKG
7440-47-3	Chromium VI	3.5		7.5		mg/kg	PAI-02-SS-07-01	8/8	N/A	7.5	6.2	23	N	270	N	38		No	BSL
7440-48-4	Cobalt	0.03		0.19		mg/kg	PAI-02-SS-04-01	5/8	0.04	0.19	0.36	470	N	N/A		N/A		No	BSL , BKG
7440-50-8	Copper	1.1		1.7		mg/kg	PAI-02-SS-05-01	2/8	0.36 - 0.75	1.7	1.5	310	N	N/A		N/A		No	BSL
7439-89-6	Iron	382		1930		mg/kg	PAI-02-SS-04-01	8/8	N/A	1930	3920	2300	N	N/A		N/A		No	BSL, BKG
7439-92-1	Lead	1.7		5.7		mg/kg	PAI-02-SS-04-01	5/8	2.6 - 5.2	5.7	12.5	400[8]		N/A		N/A		No	BSL, BKG
7439-96-5	Magnesium	53.1		174		mg/kg	PAI-02-SS-04-01	5/8	63.7 - 236	174	515	N/A		N/A		N/A		No	NUT, BKG
7439-96-5	Manganese	2.6		58.1		mg/kg	PAI-02-SS-04-01	6/8	1.8 - 3.6	58.1	128	160	N	N/A		N/A		No	BSL, BKG
7487-94-7	Mercury	0.03		0.05		mg/kg	PAI-02-SS-06-01, PAI-02-SS-04-01, PAI-02-SS-01-01	5/8	0.02 - 0.03	0.05	0.11	2.3[9]	N	10		2		No	BSL, BKG
7440-02-0	Nickel	1.2		1.2		mg/kg	PAI-02-SS-04-01	1/8	0.05 - 0.41	1.2	1.8	160	N	13000	N	130		No	BSL, BKG
7440-09-07	Potassium	87.8		102		mg/kg	PAI-02-SS-05-01	2/8	47.8 - 87.5	102	313	N/A		N/A		N/A		No	NUT, BKG
7782-49-2	Selenium	0.18		0.18		mg/kg	PAI-02-SS-04-01	1/8	0.19 - 0.24	0.18	0.29	39	N	N/A		5		No	BSL, BKG
7440-23-5	Sodium	189		2100		mg/kg	PAI-02-SS-07-01	6/8	432 - 606	2100	241	N/A		N/A		N/A		No	NUT
7440-62-2	Vanadium	1.4		4.1		mg/kg	PAI-02-SS-04-01	8/8	N/A	4.1	4.8	55	N	N/A		6000	N	No	BSL, BKG
7440-66-6	Zinc	1.2		2.3		mg/kg	PAI-02-SS-01-01	3/8	0.92 - 3.2	2.3	4.9	2300	N	N/A		12000	N	No	BSL, BKG

Notes:

1 Minimum/maximum detected concentration.

2 Background values presented for inorganics is two times the mean concentration.

3 USEPA Region III Risk-Based Concentration Table, April 13, 2000. (Cancer benchmark value = 1E-06, HI = 0.1)

4 USEPA Soil Screening Level Guidance: Technical Background Document. May 1996c.

5 USEPA Soil Screening Level Guidance: Technical Background Document. May 1996. (Based on a DAF [Dilutional Attenuation Factor] of 20)

6 Rationale Codes Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

7 No value available. Therefore value for naphthalene is used based on similar chemical/toxicological characteristics.

8 OSWER screening level.

9 Value for mercuric chloride.

Definitions:
N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic

TABLE 6-3

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH SURFACE SOIL
SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	Minimum[1] Concentration	Minimum Qualifier	Maximum[1] Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background[2] Value	US EPA[3] Region III RBC		US EPA[4] SSL Soil to Air	US EPA[5] SSL Soil to Groundwater	COPC Flag	Rationale for[6] Contaminant Deletion or Selection
PCBs																	
11097-69-1	Aroclor-1254 1996 Data	0.024	J	0.024	J	mg/kg	015B	1/2	0.038 - 0.082	0.024	N/A	0.32	C	N/A	N/A	No	BSL
Metals																	
7439-92-1	Lead 1996 Data	4		15		mg/kg	015B	2/2	N/A	15	12.5	400[7]		N/A	N/A	No	BSL
7439-92-1	Lead 1998 Data	4		18.4		mg/kg	PAI-15-SS-07-01	7/7	N/A	18.4	12.5	400[7]		N/A	N/A	No	BSL

Notes:

1 Minimum/maximum detected concentration.

2 Background value for inorganics is two times the mean concentration.

3 USEPA Region III Risk-Based Concentration Table, April 13, 2000. (Cancer benchmark value = 1E-06, HI = 0.1)

4 USEPA Soil Screening Level Guidance: Technical Background Document. May 1996c.

5 USEPA Soil Screening Level Guidance: Technical Background Document. May 1996c. (Based on a DAF [Dilutional Attenuation Factor] of 20)

6 Rationale Codes Selection Reason:
Deletion Reason.

7 OSWER screening level.

Definitions:

N/A = Not Applicable

SQL = Sample Quantitation Limit

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered

J = Estimated Value

C = Carcinogenic

N = Non-Carcinogenic

TABLE 6-4

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH GROUNDWATER
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	Minimum[1] Concentration	Minimum Qualifier	Maximum[1] Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background[2] Value	Screening[3] Toxicity Value		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for[4] Contaminant Deletion or Selection
Volatile Organic Compounds																	
67-64-1	Acetone	1.8	J	3.3	J	µg/L	PAI-02-GW-04-01	2/3	5	3.3	N/A	61	N	N/A	N/A	No	BSL
75-15-0	Carbon Disulfide	4		4		µg/L	PAI-02-GW-05-01	1/5	1	4	N/A	100	N	N/A	N/A	No	BSL
67-66-3	Chloroform	2.9		2.9		µg/L	PAI2-GW2-01	1/5	1	2.9	N/A	0.15	C	80 (5)	MCL	Yes	ASL
74-87-3	Chloromethane	0.35		0.35		µg/L	PAI2-GW3-01-AVG	1/5	1	0.35	N/A	2.1	C	N/A	N/A	No	BSL
Semivolatile Organic Compounds																	
117-81-7	Bis(2-Ethylhexyl)phthalate	1	J	1	J	µg/L	PAI2-GW1-01, PAI2-GW2-01, PAI-02-GW-04-01, PAI-02-GW-05-01	4/5	5	1	N/A	4.8	C	6	MCL	No	BSL
84-66-2	Diethyl Phthalate	1	J	1	J	µg/L	PAI-02-GW-05-01	1/5	5	1	N/A	2900	N	N/A	N/A	No	BSL
Inorganics - Unfiltered																	
7429-90-5	Aluminum	189		1010		µg/L	PAI2-GW1-01	3/5	22 - 79.5	1010	N/A	3700	N	50 To 200	SMCL	No	BSL
7440-38-2	Arsenic	1		1.5		µg/L	PAI-02-GW-01-01	4/5	0.9	1.5	N/A	0.045	C	50	MCL	Yes	ASL
7440-39-3	Barium	33.7		148		µg/L	PAI2-GW3-01-AVG	5/5	N/A	148	N/A	260	N	2000	MCL	No	BSL
7440-70-2	Calcium	6370		281000		µg/L	PAI-02-GW-04-01	5/5	N/A	281000	N/A	N/A		N/A	N/A	No	NUT
7440-47-3	Chromium	5.2		5.2		µg/L	PAI2-GW3-01-AVG	1/5	6.4 - 11.9	5.2	N/A	5500	N	100	MCL	No	BSL
7440-50-8	Copper	5.2		28.8		µg/L	PAI2-GW1-01	2/5	2.6	28.8	N/A	150	N	1000	SMCL	No	BSL
7439-89-6	Iron	439		8370		µg/L	PAI-02-GW-05-01	5/5	N/A	8370	N/A	1100	N	300	SMCL	Yes	ASL
7439-96-5	Magnesium	2580		778000		µg/L	PAI-02-GW-04-01	5/5	N/A	778000	N/A	N/A		N/A	N/A	No	NUT
7439-96-5	Manganese	37		187		µg/L	PAI-02-GW-05-01	5/5	N/A	187	N/A	73	N	50	SMCL	Yes	ASL
7400-09-7	Potassium	400		245000		µg/L	PAI-02-GW-04-01	4/5	558	245000	N/A	N/A		N/A	N/A	No	NUT
7440-23-5	Sodium	18100		5990000		µg/L	PAI-02-GW-04-01	5/5	N/A	5990000	N/A	N/A		N/A	N/A	No	NUT
7440-28-0	Thallium	18		18		µg/L µg/L	PAI2-GW2-01 PAI-02-GW-04-01	2/5	1.8 - 18	18	N/A	0.26	N	2	MCL	Yes	ASL
7440-66-6	Zinc	5.5		13.3		µg/L	PAI2-GW2-01	2/5	4.1 - 33.4	13.3	N/A	1100	N	5000	SMCL	No	BSL

Notes:

1 Minimum/maximum detected concentration.

2 Background value for inorganics is two times the mean concentration.

3 USEPA Region III Risk-Based Concentration Table, April 13, 2000. (Cancer benchmark value = 1E-06, HI = 0.1)

4 Rationale Codes Selection Reason: Above Screening Levels (ASL)
Deletion Reason: No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

5 Value is for total trihalomethanes.

Shading indicates that a chemical was retained as a COPC.

Definitions:
N/A = Not Applicable
SQL = Sample Quantitation Limit
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
MCL = Federal Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
J = Estimated Value
C = Carcinogenic

TABLE 6-5

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH SURFACE WATER
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	Minimum[1] Concentration	Minimum Qualifier	Maximum[1] Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background[2] Value	Screening[3] Toxicity Value		COPC Flag	Rationale for[4] Contaminant Deletion or Selection
Volatile Organic Compounds															
67-64-1	Acetone	0.6	J	0.8	J	µg/L	PAI-02-SW-02-00	2/2	N/A	0.8	N/A	370[5]	N	No	BSL
127-18-4	Tetrachloroethene	0.3	J	0.3	J	µg/L	PAI-02-SW-02-00	1/4	0.5	0.3	N/A	0.8		No	BSL
Semivolatile Organic Compounds															
117-81-7	Bis(2-Ethylhexyl)phthalate	14		77		µg/L	PAI-02-SW-01-00	2/4	10	77	44.8	1.8		Yes	ASL
85-01-8	Phenanthrene	0.074	J	0.16		µg/L	PAI-02-SW-04-00	2/4	0.097 - 0.098	0.16	N/A	73[5,6]	N	No	BSL
Pesticides															
	Endosulfan Sulfate	0.04	J	0.078		µg/L	PAI-02-SW-01-00	2/4	0.048 - 0.05	0.078	N/A	110		No	BSL
Inorganics - unfiltered															
7429-90-5	Aluminum	1030		1850		µg/L	PAI-02-SW-02-00	3/4	477	1850	3113	3700[5]	N	No	BSL, BKG
7440-36-0	Antimony	2.8		2.8		µg/L	PAI-02-SW-04-00	1/4	1.8 - 2.2	2.8	N/A	14.0		No	BSL
7440-38-2	Arsenic	2.9		4.4		µg/L	PAI-02-SW-01-00	2/4	2.1	4.4	5.13	0.018		No	BKG
7440-39-3	Barium	19		21.4		µg/L	PAI-02-SW-04-00	4/4	N/A	21.4	38.4	1000		No	BSL, BKG
7440-70-2	Calcium	268000	J	303000	J	µg/L	PAI-02-SW-01-00	4/4	N/A	303000	637000	N/A			NUT, BKG
7440-48-4	Cobalt	0.89		1.1		µg/L	PAI-02-SW-01-00	2/4	0.4	1.1	N/A	220[5]	N	No	BSL
7439-92-1	Iron	417		1220		µg/L	PAI-02-SW-02-00	3/4	210	1220	2091	300		No	BKG
7439-96-5	Magnesium	859000		950000		µg/L	PAI-02-SW-02-00	4/4	N/A	950000	1918667	N/A			NUT, BKG
7439-96-5	Manganese	31.6		34.7		µg/L	PAI-02-SW-01-00	2/4	17.4 - 33.4	34.7	53.1	50		No	BSK, BKG
7440-09-07	Potassium	566000		642000		µg/L	PAI-02-SW-01-00	4/4	N/A	642000	831333	N/A			NUT, BKG
7440-22-4	Silver	0.72		0.72		µg/L	PAI-02-SW-02-00	1/4	0.7	0.72	N/A	18[5]	N	No	BSL
7440-23-5	Sodium	7930000		8610000		µg/L	PAI-02-SW-01-00	4/4	N/A	8610000	16226667	N/A			NUT, BKG
7440-66-6	Zinc	4.4		10.4		µg/L	PAI-02-SW-04-00	4/4	N/A	10.4	10.6	9100		No	BSL, BKG

Notes:

1 Minimum/maximum detected concentration.

2 Background values presented for inorganics is two times the mean concentration.

3 Criteria as published in FR 63:68354-68364 unless otherwise noted.

4 Rationale Codes Selection Reason: Above Screening Levels (ASL)
Deletion Reason: No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

5 Water quality criteria not available EPA Region III RBC for tap water ingestion used (Cancer benchmark value = 1E-6, HI = 0.1).

6 No value available. Therefore, value for napthalene is used based on similar chemical/toxicological characteristics.

Shading indicates that a chemical was retained as a COPC.

Definitions:
N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
MCL = Federal Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
J = Estimated Value
N = Non-Carcinogenic

TABLE 6-6

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH SEDIMENT
SITE 2 - BORROW PIT LANDFILL
MCRD PARIS ISLAND, SOUTH CAROLINA
PAGE 1 OF 2

CAS Number	Chemical	Minimum[1] Concentration	Minimum Qualifier	Maximum[1] Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background[2] Value	Screening[3] Toxicity Value		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for[4] Contaminant Deletion or Selection
Volatile Organic Compounds																	
67-66-3	Chloroform	0.004	J	0.005	J	mg/kg	PAI-02-SD-04-01	2/5	0.006 - 0.008	0.005	N/A	100	C	N/A	N/A	No	BSL
Semivolatile Organic Compounds																	
56-55-3	Benzo(a)anthracene	0.0082	J	0.0082	J	mg/kg	PAI-02-SD-04-01	1/4	0.012 - 0.031	0.0082	N/A	0.87	C	N/A	N/A	No	BSL
50-32-8	Benzo(a)pyrene	0.0073		0.012		mg/kg	PAI-02-SD-04-01	2/4	0.029 - 0.031	0.012	N/A	0.087	C	N/A	N/A	No	BSL
205-99-2	Benzo(b)fluoranthene	0.0056		0.018		mg/kg	PAI-02-SD-04-01	2/4	0.012	0.018	N/A	0.87	C	N/A	N/A	No	BSL
207-08-9	Benzo(k)fluoranthene	0.008		0.008		mg/kg	PAI-02-SD-04-01	1/4	0.0047 - 0.012	0.008	N/A	8.7	C	N/A	N/A	No	BSL
218-01-9	Chrysene	0.011	J	0.021		mg/kg	PAI-02-SD-04-01	2/4	0.029 - 0.031	0.021	N/A	87	C	N/A	N/A	No	BSL
206-44-0	Fluoranthene	0.038		0.038		mg/kg	PAI-02-SD-04-01	1/4	0.012 - 0.031	0.038	N/A	310	N	N/A	N/A	No	BSL
193-39-5	Indeno(1,2,3-cd)pyrene	0.007	J	0.012		mg/kg	PAI-02-SD-04-01	2/4	0.029 - 0.031	0.012	N/A	0.87	C	N/A	N/A	No	BSL
85-01-8	Phenanthrene	0.008	J	0.011		mg/kg	PAI-02-SD-04-01	2/4	0.023 - 0.025	0.011	N/A	160 (5)	N	N/A	N/A	No	BSL
129-00-0	Pyrene	0.03		0.03		mg/kg	PAI-02-SD-04-01	1/4	0.023 - 0.062	0.03	N/A	230	N	N/A	N/A	No	BSL
Inorganics																	
7429-90-5	Aluminum	3140		5560		mg/kg	PAI-02-SD-02-02	5/5	N/A	5560	24284	7800	N	N/A	N/A	No	BSL, BKG
7440-38-2	Arsenic	0.79		2.1		mg/kg	PAI-02-SD-01-01	5/5	N/A	2.1	12.2	0.43	C	N/A	N/A	No	BKG
7440-39-3	Barium	4.9		7.9		mg/kg	PAI-02-SD-02-02, PAI-02-SD-02-01, PAI-02-SD-01-01	5/5	N/A	7.9	28.0	550	N	N/A	N/A	No	BSL, BKG
7440-70-2	Calcium	362		32800		mg/kg	PAI-02-SD-03-01	5/5	N/A	32800	4002	N/A		N/A	N/A	No	NUT
7440-47-3	Chromium	5.9		10.1		mg/kg	PAI-02-SD-01-01	5/5	N/A	10.1	35.2	12000[6]	N	N/A	N/A	No	BSL, BKG
1854-02-99	Hexavalent Chromium	1.1		1.6		mg/kg	PAI-02-SD-02-01	2/3	1	1.6	N/A	23	N	N/A	N/A	No	BSL
7440-48-4	Cobalt	0.35		0.52		mg/kg	PAI-02-SD-03-01	2/5	0.74 - 0.88	0.52	2.63	470	N	N/A	N/A	No	BSL, BKG
7440-50-8	Copper	1.2		3.2		mg/kg	PAI-02-SD-01-01	5/5	N/A	3.2	10.1	310	N	N/A	N/A	No	BSL, BKG
7439-89-6	Iron	2650		5390		mg/kg	PAI-02-SD-01-01	5/5	N/A	5390	21450	2300	N	N/A	N/A	No	BKG
7439-92-1	Lead	3.2		7.1		mg/kg	PAI-02-SD-02-02, PAI-02-SD-01-01	5/5	N/A	7.1	20.6	400[7]		N/A	N/A	No	BSL, BKG
7439-96-5	Magnesium	777		2380		mg/kg	PAI-02-SD-02-01	5/5	N/A	2380	6437	N/A		N/A	N/A	No	NUT, BKG
7439-96-5	Manganese	22.7		52.4		mg/kg	PAI-02-SD-04-01	5/5	N/A	52.4	185.7	160	N	N/A	N/A	No	BSL, BKG
7487-94-7	Mercury	0.04		0.04		mg/kg	PAI-02-SD-02-02	1/5	0.02 - 0.04	0.04	0.090	2.3[8]	N	N/A	N/A	No	BSL, BKG
7440-02-0	Nickel	0.82		2.1		mg/kg	PAI-02-SD-01-01	5/5	N/A	2.1	5.95	160	N	N/A	N/A	No	BSL, BKG
7440-09-7	Potassium	426		1010		mg/kg	PAI-02-SD-02-01	5/5	N/A	1010	3190	N/A		N/A	N/A	No	NUT, BKG
7782-49-2	Selenium	0.23		0.42		mg/kg	PAI-02-SD-01-01	5/5	N/A	0.42	N/A	39	N	N/A	N/A	No	BSL
7440-23-5	Sodium	2770		6650		mg/kg	PAI-02-SD-02-01	5/5	N/A	6650	19110	N/A		N/A	N/A	No	NUT, BKG
7440-62-2	Vanadium	6.1		12.8		mg/kg	PAI-02-SD-01-01	5/5	N/A	12.8	49.6	55	N	N/A	N/A	No	BSL, BKG
7440-66-6	Zinc	10.9		12.6		mg/kg	PAI-02-SD-01-01	3/5	4.4 - 6.7	12.6	45.0	2300	N	N/A	N/A	No	BSL, BKG

TABLE 6-6

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH SEDIMENT
SITE 2 - BORROW PIT LANDFILL
MCRD PARIS ISLAND, SOUTH CAROLINA
PAGE 2 OF 2

Notes:

1 Minimum/maximum detected concentration.

2 Background values presented for inorganics is two times the mean concentration.

3 USEPA Region III Risk-Based Concentration Table, April 13, 2000. (Cancer benchmark value = 1E-06, HI = 0.1)

4 Rationale Codes Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

5 No value available. Therefore, value for napthalene is used based on similar chemical/toxicological characteristics.

6 No hexavalent chromium detected. Therefore, total chromium is evaluated as trivalent chromium.

7 OSWER screening level.

8 Value for mercuric chloride.

Definitions:
N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic

TABLE 6-7

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH SEDIMENT
SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 1 OF 2

CAS Number	Chemical	Minimum[1] Concentration	Minimum Qualifier	Maximum[1] Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background[2] Value	US EPA[3] REGION III RBC		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for[4] Contaminant Deletion or Selection
Semivolatile Organic Compounds																	
56-55-3	Benzo(a)anthracene	0.015		0.015		mg/kg	PAI-15-SD-03-01	1/3	0.006 - 0.011	0.015	N/A	0.87	C	N/A	N/A	No	BSL
50-32-8	Benzo(a)pyrene	0.012		0.012		mg/kg	PAI-15-SD-03-01	1/3	0.006 - 0.011	0.012	N/A	0.087	C	N/A	N/A	No	BSL
205-99-2	Benzo(b)fluoranthene	0.0038		0.033		mg/kg	PAI-15-SD-03-01	2/3	0.0044	0.033	N/A	0.87	C	N/A	N/A	No	BSL
191-24-2	Benzo(g,h,i)perylene	0.013		0.013		mg/kg	PAI-15-SD-03-01	1/3	0.0095 - 0.018	0.013	N/A	160 (5)		N/A	N/A	No	BSL
207-08-9	Benzo(k)fluoranthene	0.012		0.012		mg/kg	PAI-15-SD-03-01	1/3	0.0024 - 0.0044	0.012	N/A	8.7	C	N/A	N/A	No	BSL
117-81-7	Bis(2-Ethylhexyl)phthalate	0.28		0.28		mg/kg	PAI-15-SD-02-01	1/3	0.44 - 0.66	0.28	N/A	46	C	N/A	N/A	No	BSL
218-01-9	Chrysene	0.011	J	0.028		mg/kg	PAI-15-SD-03-01	3/3	N/A	0.028	N/A	87	C	N/A	N/A	No	BSL
206-44-0	Fluoranthene	0.0093		0.034		mg/kg	PAI-15-SD-03-01	2/3	0.011	0.034	N/A	310	N	N/A	N/A	No	BSL
86-73-7	Fluorene	0.013		0.013		mg/kg	PAI-15-SD-02-01	1/3	0.017 - 0.022	0.013	N/A	310	N	N/A	N/A	No	BSL
193-39-5	Indeno(1,2,3-cd)pyrene	0.013		0.046		mg/kg	PAI-15-SD-02-01	2/3	0.011	0.046	N/A	0.87	C	N/A	N/A	No	BSL
85-01-8	Phenanthrene	0.0081		0.014		mg/kg	PAI-15-SD-02-01	2/3	0.0088	0.014	N/A	160 (5)	N	N/A	N/A	No	BSL
129-00-0	Pyrene	0.028		0.028		mg/kg	PAI-15-SD-03-01	1/3	0.012 - 0.022	0.028	N/A	230	N	N/A	N/A	No	BSL
Inorganics																	
7429-90-5	Aluminum	648		15500		mg/kg	PAI-15-SD-03-01	3/3	N/A	15500	24284	7800	N	N/A	N/A	No	BKG
7440-36-0	Antimony	0.2		0.2		mg/kg	PAI-15-SD-02-01	1/3	0.18 - 0.29	0.2	N/A	3.1	N	N/A	N/A	No	BSL
7440-38-2	Arsenic	0.3		6.5		mg/kg	PAI-15-SD-03-01	3/3	N/A	6.5	12.22	0.43	C	N/A	N/A	No	BKG
7440-39-3	Barium	1.9		19.4		mg/kg	PAI-15-SD-03-01	3/3	N/A	19.4	28.0	550	N	N/A	N/A	No	BSL, BKG
7440-41-7	Beryllium	0.71		0.71		mg/kg	PAI-15-SD-03-01	1/3	0.06 - 0.21	0.71	0.977	16	N	N/A	N/A	No	BSL, BKG
7440-43-9	Cadmium	0.16		0.16		mg/kg	PAI-15-SD-03-01	1/3	0.03	0.16	0.278	3.9	N	N/A	N/A	No	BSL, BKG
7440-70-2	Calcium	346		5550		mg/kg	PAI-15-SD-03-01	3/3	N/A	5550	4002	N/A		N/A	N/A	No	NUT
7440-47-3	Chromium	2		27.8		mg/kg	PAI-15-SD-03-01	3/3	N/A	27.8	35.2	12000 (6)	N	N/A	N/A	No	BSL, BKG
7440-48-4	Cobalt	0.69		3.1		mg/kg	PAI-15-SD-03-01	2/3	0.06	3.1	2.63	470	N	N/A	N/A	No	BSL
7440-50-8	Copper	4		8.7		mg/kg	PAI-15-SD-03-01	2/3	0.58	8.7	10.1	310	N	N/A	N/A	No	BSL, BKG
7439-89-6	Iron	604		14700		mg/kg	PAI-15-SD-03-01	3/3	N/A	14700	21450	2300	N	N/A	N/A	No	BKG
7439-92-1	Lead	2.7		11.3		mg/kg	PAI-15-SD-03-01	3/3	N/A	11.3	20.6	400 (7)		N/A	N/A	No	BSL, BKG
7439-96-5	Magnesium	370		4220		mg/kg	PAI-15-SD-03-01	3/3	N/A	4220	6437	N/A		N/A	N/A	No	NUT, BKG
7439-96-5	Manganese	5.3		113		mg/kg	PAI-15-SD-03-01	3/3	N/A	113	186	160	N	N/A	N/A	No	BSL, BKG
7440-02-0	Nickel	1.5		6.5		mg/kg	PAI-15-SD-03-01	2/3	0.11	6.5	5.95	160	N	N/A	N/A	No	BSL
7440-09-7	Potassium	205		2560		mg/kg	PAI-15-SD-03-01	3/3	N/A	2560	3190	N/A		N/A	N/A	No	NUT, BKG
7440-23-5	Sodium	2040		10200		mg/kg	PAI-15-SD-03-01	3/3	N/A	10200	19110	N/A		N/A	N/A	No	NUT, BKG
7440-62-2	Vanadium	2.3		37.4		mg/kg	PAI-15-SD-03-01	3/3	N/A	37.4	49.6	55	N	N/A	N/A	No	BSL, BKG
7440-66-6	Zinc	12.9		32.3		mg/kg	PAI-15-SD-03-01	2/3	1.9	32.3	45.0	2300	N	N/A	N/A	No	BSL, BKG

Notes:

1 Minimum/maximum detected concentration.

Definitions: N/A = Not Applicable
SQL = Sample Quantitation Limit

TABLE 6-7

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH SEDIMENT
SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 2 OF 2

2 Background values presented for inorganics is two times the mean concentration.

3 USEPA Region III Risk-Based Concentration Table, April 13, 2000. Residential RBC for soil (Cancer benchmark value = 1E-06, HI = 0.1)

4 Rationale Codes Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

5 No value available. Therefore, value for napthalene is used based on similar chemical/toxicological characteristics.

6 No hexavalent chromium detected. Therefore, total chromium is evaluated as trivalent chromium.

7 OSWER screening level.

COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic

TABLE 6-8

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
INGESTION OF OYSTERS
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Units	Sediment[1] Concentration	Osyter[2] Tissue Concentration	Background[3] Sediment Concentration	USFDA Action Level	EPA Region III[4] RBC Fish Ingestion	COPC Flag	Rationale for[5] Contaminant Deletion or Selection
Semivolatiles								
Benzo(a)anthracene	mg/kg	0.0082	0.002	NA	NA	0.0043 c	No	BSL
Benzo(a)pyrene	mg/kg	0.012	0.003	NA	NA	0.00043 c	Yes	ASL
Benzo(b)fluoranthene	mg/kg	0.018	0.004	NA	NA	0.0043 c	No	BSL
Benzo(k)fluoranthene	mg/kg	0.008	0.002	NA	NA	0.043 c	No	BSL
Chrysene	mg/kg	0.021	0.004	NA	NA	0.43	No	BSL
Fluoranthene	mg/kg	0.038	0.008	NA	NA	5.4 n	No	BSL
Indeno(1,2,3-cd)pyrene	mg/kg	0.012	0.003	NA	NA	0.0043	No	BSL
Phenanthrene	mg/kg	0.011	0.006	NA	NA	2.7[6] n	No	BSL
Pyrene	mg/kg	0.03	0.006	NA	NA	4.1 n	No	BSL
Inorganics								
Chromium (hexavalent)	mg/kg	1.6	1.6	NA	12	0.41 n	Yes	ASL

Notes:

1 Maximum detected concentration.

2 Calculated from the sediment concentration following the methodology presented in Section 7.

3 Background values presented for inorganics is two times the mean concentration.

4 USEPA Region III Risk-Based Concentration Table, April 13, 2000. (Cancer benchmark value = 1E-06, HI = 0.1)

5 Rationale Codes
Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Background Levels (BKG)
No Toxicity Information (NTX)
Below Screening Level (BSL)

6 No value available. Therefore, value for napthalene is used based on similar chemical/toxicological characteristics.

Shading indicates that a chemical was retained as a COPC.

TABLE 6-9

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH SUSUBRFACE SOIL
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	Minimum (1) Concentration	Minimum Qualifier	Maximum (1) Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background (2) Value	US EPA (3) Region III RBC		US EPA (4) SSL Soil to Air		US EPA (5) SSL Soil to Groundwater		COPC Flag	Rationale for (6) Contaminant Deletion or Selection
	Volatile Organic Compounds																		
75-09-2	Methylene Chloride	0.009		0.009		mg/kg	PAI-02-SB-02A-02 PAI-02-SB-10-07	2/3	0.009	0.009	N/A	85	C	13	C	0.02	C	No	BSL
	Inorganics																		
7429-90-5	Aluminum	1250		2860		mg/kg	PAI-02-SB-10-07	3/3	N/A	2860	7270	7800	N	N/A		N/A		No	BSL, BKG
7440-39-3	Barium	4		11.4		mg/kg	PAI-02-SB-11-02	3/3	N/A	11.4	23.6	550	N	690000	N	1600		No	BSL, BKG
7440-70-2	Calcium	64.3		150		mg/kg	PAI-02-SB-02A-02	2/3	43.4	150	766	N/A		N/A		N/A		No	NUT, BKG
7440-47-3	Chromium	2.5		5.6		mg/kg	PAI-02-SB-10-07	3/3	N/A	5.6	6.23	23 (7)	N	270	C	38		No	BSL, BKG
7440-50-8	Copper	0.21		0.53		mg/kg	PAI-02-SB-11-02	3/3	N/A	0.53	1.52	310	N	N/A		N/A		No	BSL, BKG
7439-89-6	Iron	265		337		mg/kg	PAI-02-SB-02A-02	3/3	N/A	337	3920	2300	N	N/A		N/A		No	BSL, BKG
7439-92-1	Lead	0.99		3.1		mg/kg	PAI-02-SB-10-07	3/3	N/A	3.1	12.5	400 (8)		N/A		N/A		No	BSL, BKG
7439-96-5	Magnesium	57.7		90.9		mg/kg	PAI-02-SB-02A-02	2/3	28.3	90.9	515	N/A		N/A		N/A		No	NUT, BKG
7439-96-5	Manganese	4.2		4.2		mg/kg	PAI-02-SB-10-07	1/3	1.4 - 1.5	4.2	129	160	N	N/A		N/A		No	BSL, BKG
7440-09-7	Potassium	29.2		41.9		mg/kg	PAI-02-SB-02A-02	3/3	N/A	41.9	313	N/A		N/A		N/A		No	NUT, BKG
7440-66-6	Zinc	1.2		1.5		mg/kg	PAI-02-SB-02A-02	3/3	N/A	1.5	9.70	2300	N	N/A		12000	N	No	BSL, BKG

Notes:

1 Minimum/maximum detected concentration.

2 Background values presented for inorganics is two times the mean concentration.

3 USEPA Region III Risk-Based Concentration Table, April 13, 2000. (Cancer benchmark value = 1E-06, HI = 0.1)

4 USEPA Soil Screening Level Guidance: Technical Background Document. May 1996.

5 USEPA Soil Screening Level Guidance: Technical Background Document. May 1996. (Based on a DAF [Dilutional Attenuation Factor] of 20)

6 Rationale Codes Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

7 The valence state of chromium was not determined in the analysis therefore

8 OSWER screening level.

9 Value for mercuric chloride.

Definitions: N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic

TABLE 6-10

CHEMICALS RETAINED AS COPCs
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Surface Soil	Subsurface Soil	Soil to Air	Soil to Groundwater	Groundwater	Sediment	Surface Water	Fish Tissue
Volatile Organic Compounds								
Chloroform					X			
Semivolatile Organic Compounds								
Bis(2-Ethylhexyl) phthalate							X	
Benzo(a)pyrene								X
Inorganics								
Arsenic					X			
Hexavalent chromium								
Iron					X			
Manganese					X			
Thallium					X			

Notes
X - Indicates chemical was retained as a COPC.

TABLE 6-11

SELECTION OF EXPOSURE PATHWAYS
SITE 2 - BORROW PIT LANDFILL AND SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 1 OF 4

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current/Future	Surface Soil	Surface Soil	Surface Soil	Construction Workers	Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Construction workers may have contact with soil during excavation activities.
				Full-time Employees	Adult	Ingestion Dermal	On-Site On-Site	None None	No full-time employees at Sites 2 and 15.
				Maintenance Workers	Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Maintenance workers may have contact with soil during normal work activities.
				Military Personnel	Adult	Ingestion Dermal	On-Site On-Site	None None	No military personnel at Sites 2 and 15.
				Trespassers	Adolescents	Ingestion Dermal	On-Site On-Site	None None	Access to site is restricted
				Residents	Child	Ingestion Dermal	On-Site On-Site	Quant Quant	Site may be residential in the future.
					Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Site may be residential in the future.
				Recreational User	Adolescents	Ingestion Dermal	On-Site On-Site	None None	Recreational users do not have significant contact with surface soil at the site.
					Adult	Ingestion Dermal	On-Site On-Site	None None	Recreational users do not have significant contact with surface soil at the site.
	Air	Surface Soil	Surface Soil	Construction Workers	Adult	Inhalation	On-site	Quant	Construction workers may be exposed to fugitive dust and volatile emissions during construction activities.
				Full-time Employees	Adult	Inhalation	On-site	None	No full-time employees at Sites 2 and 15.
				Maintenance Workers	Adult	Inhalation	On-site	Quant	Maintenance workers may be exposed to fugitive dust and volatile emissions during construction activities.
				Military Personnel	Adult	Inhalation	On-site	None	No full-time military personnel at Sites 2 and 15.
				Trespassers	Adolescents	Inhalation	On-site	None	Access to base is restricted.
				Residents	Child	Inhalation	On-Site	Quant	Site may be residential in the future.
					Adult	Inhalation	On-Site	Quant	Site may be residential in the future.
				Recreational User	Adolescents	Inhalation	On-site	None	Recreational users do not have significant contact with surface soil at the site.
					Adult	Inhalation	On-site	None	Recreational users do not have significant contact with surface soil at the site.

TABLE 6-11

SELECTION OF EXPOSURE PATHWAYS
SITE 2 - BORROW PIT LANDFILL AND SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 2 OF 4

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
	Subsurface Soil	Subsurface Soil	Subsurface Soil	Construction Workers	Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Construction workers may have contact with soil during excavation activities.
				Residents	Child	Ingestion Dermal	On-Site On-Site	Quant Quant	Site may be residential in the future.
					Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Site may be residential in the future.
	Air	Subsurface Soil	Subsurface Soil	Construction Workers	Adult	Inhalation	On-site	Quant	Construction workers may be exposed to fugitive dust and volatile emissions during construction activities.
				Residents	Child	Inhalation	On-Site	Quant	Site may be residential in the future.
					Adult	Inhalation	On-Site	Quant	Site may be residential in the future.
	Groundwater	Groundwater	Shallow Aquifer	Construction Workers	Adult	Ingestion Dermal	On-Site On-Site	None Quant	Groundwater is not used as a potable water supply at the base. Construction workers may contact groundwater during excavation activities.
				Full-time Employees	Adult	Ingestion Dermal	On-Site On-Site	None None	No full-time employees at Sites 2 and 15.
				Maintenance Workers	Adult	Ingestion Dermal	On-Site On-Site	None None	Groundwater is not used as a potable water supply at the base.
				Military Personnel	Adult	Ingestion Dermal	On-Site On-Site	None None	Site is not used by military personnel.
				Trespassers	Adolescents	Ingestion Dermal	On-Site On-Site	None None	Access to base is restricted.
				Residents	Child	Ingestion Dermal	On-Site On-Site	Quant Quant	Site may be residential in the future.
					Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Site may be residential in the future.
				Recreational User	Adolescents	Ingestion Dermal	On-Site On-Site	None None	Recreational users are not exposed to groundwater.
					Adult	Ingestion Dermal	On-Site On-Site	None None	Recreational users are not exposed to groundwater.
	Groundwater	Air	Shallow Aquifer	Construction Workers	Adult	Inhalation	On-site	None	Groundwater is not used as a potable water supply at the base.
				Full-time Employees	Adult	Inhalation	On-site	None	No full-time employees at Sites 2 and 15.
				Maintenance Workers	Adult	Inhalation	On-site	None	Groundwater is not used as a potable water supply at the Sites 2 and 15.
				Military Personnel	Adult	Inhalation	On-Site	None	Sites 2 and 15 is not used by military personnel.

TABLE 6-11

SELECTION OF EXPOSURE PATHWAYS
SITE 2 - BORROW PIT LANDFILL AND SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 3 OF 4

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
	Groundwater	Air	Shallow Aquifer	Trespassers	Adolescents	Inhalation	On-Site	None	Access to base is restricted.
				Residents	Child	Inhalation	On-Site	Quant	Site may be residential in the future.
					Adult	Inhalation	On-Site	Quant	Site may be residential in the future.
				Recreational User	Adolescents	Inhalation	On-Site	None	Recreational users are not exposed to groundwater.
					Adult	Inhalation	On-Site	None	Recreational users are not exposed to groundwater.
	Sediment	Sediment	Sediment	Construction Workers	Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Construction workers may contact sediment during construction activities.
				Full-time Employees	Adult	Ingestion Dermal	On-Site On-Site	None None	No full-time employees at Sites 2 and 15.
				Maintenance Workers	Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Maintenance workers may contact sediment during normal work activities.
				Military Personnel	Adult	Ingestion Dermal	On-Site On-Site	None None	Site is not used by military personnel.
				Trespassers	Adolescents	Ingestion Dermal	On-Site On-Site	None None	Access to base is restricted.
				Residents	Child	Ingestion Dermal	On-Site On-Site	Quant Quant	Site may be residential in the future.
					Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Site may be residential in the future.
				Recreational User	Adolescents	Ingestion Dermal	On-Site On-Site	None None	Exposures to surface water will neglect exposures to sediment.
					Adult	Ingestion Dermal	On-Site On-Site	None None	Exposures to surface water will neglect exposures to sediment.
	Surface Water	Surface Water	Surface Water	Construction Workers	Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Construction workers may contact surface water during construction activities.
				Full-time Employees	Adult	Ingestion Dermal	On-Site On-Site	None None	No full-time employees at Sites 2 and 15.
				Maintenance Workers	Adult	Ingestion Dermal	On-Site On-Site	None None	Maintenance workers do not contact surface water.
				Military Personnel	Adult	Ingestion Dermal	On-Site On-Site	None None	Site is not used by military personnel.
				Trespassers	Adolescents	Ingestion Dermal	On-Site On-Site	None None	Access to base is restricted.

TABLE 6-11

SELECTION OF EXPOSURE PATHWAYS
SITE 2 - BORROW PIT LANDFILL AND SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 4 OF 4

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
	Surface Water	Surface Water	Surface Water	Residents	Child	Ingestion	On-Site	Quant	Site may be residential in the future.
						Dermal	On-Site	Quant	
					Adult	Ingestion	On-Site	Quant	Site may be residential in the future.
						Dermal	On-Site	Quant	
				Recreational User	Adolescents	Ingestion	On-Site	Quant	Recreational users may contact surface water while wading.
						Dermal	On-Site	Quant	
					Adult	Ingestion	On-Site	Quant	Recreational users may contact surface water while wading.
						Dermal	On-Site	Quant	
	Surface Water	Surface Water	Fish	Recreational User	Adult	Ingestion	On-Site	Quant	Recreational user may harvest shellfish in off-site surface water.

TABLE 6-12

EXPOSURE POINT CONCENTRATIONS
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Groundwater (µg/L)	Surface Water (µg/L)	Shellfish Tissue (mg/kg)
Volatile Organic Compounds			
Chloroform	2.9	N/A	N/A
Semivolatile Organic Compounds			
Benzo(a)pyrene Equivalents	N/A	N/A	0.0034
Bis(2-Ethylhexyl) phthalate	N/A	77	N/A
Inorganics			
Arsenic	1.5	5.9	N/A
Hexavalevent Chromium	N/A	N/A	1.6
Iron	8370	N/A	N/A
Manganese	187	N/A	N/A
Thallium	18	N/A	N/A

Notes
No COPCs were identified for Site 15.
N/A - Chemical is not a COPC for this medium.
The maximum detected concentration is used as the exposure point concentration since less than 10 samples were collected for each medium.

TABLE 6-13

VALUES USED FOR DAILY INTAKE CALCULATIONS
CONSTRUCTION WORKERS EXPOSED TO GROUNDWATER
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Dermal	DAevent	Absorbed dose per event	mg/cm2-event	See Text	See Text	N/A	N/A	Dermally Absorbed Dose (mg/kg/day)
	SA	Skin Surface Available for Contact	cm2	2490	(1)	N/A	N/A	
	EV	Event Frequency	events/day	1	(1)	N/A	N/A	$= \frac{DA_{event} \times EV \times EF \times ED \times SA}{BW \times AT}$
	ET	Exposure Time	hours/event	8	EPA, 1989	N/A	N/A	
	EF	Exposure Frequency	days/year	250	EPA, 1995	N/A	N/A	
	ED	Exposure Duration	years	1	(1)	N/A	N/A	See text for calculation of DAevent.
	BW	Body Weight	kg	70	EPA, 1993	N/A	N/A	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	N/A	N/A	
	AT-N	Averaging Time (Non-Cancer)	days	365	EPA, 1989	N/A	N/A	

Notes:

1 - Professional judgment.

Sources:

U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure..

U.S. EPA Region 4, 1995: Supplement Guidance to RAGS: Region 4 Bulletins. Exposure Assessment Human Health Risk Assessment Bulletin No. 3.

TABLE 6-14

VALUES USED FOR DAILY INAKE CALCULATIONS
CONSTRUCTION WORKERS EXPOSED TO SURFACE WATER
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	µg/L	See Table 6-12	See Table 6-12	N/A	N/A	Intake (mg/kg/day) =
	CR	Contact Rate	L/hour	0.01	EPA, 1995	N/A	N/A	$\frac{CW \times CR \times CF \times ET \times EF \times ED}{BW \times AT}$
	CF	Conversion factor	ug/mg	0.001	- -	N/A	N/A	
	ET	Exposure Time	hours/event	8	(1)	N/A	N/A	
	EF	Exposure Frequency	events/year	250	EPA, 1995	N/A	N/A	
	ED	Exposure Duration	years	1	(1)	N/A	N/A	
	BW	Body Weight	kg	70	EPA, 1993	N/A	N/A	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	N/A	N/A	
	AT-N	Averaging Time (Non-Cancer)	days	365	EPA, 1989	N/A	N/A	
Dermal	DAevent	Absorbed dose per event	mg/cm2-event	See Text	See Text	N/A	N/A	Dermally Absorbed Dose (mg/kg/day)
	SA	Skin Surface Available for Contact	cm2	2490	(1)	N/A	N/A	
	EV	Event Frequency	events/day	1	(1)	N/A	N/A	$= \frac{DA_{event} \times EV \times EF \times ED \times SA}{BW \times AT}$
	ET	Exposure Time	hours/event	8	EPA, 1989	N/A	N/A	
	EF	Exposure Frequency	days/year	250	EPA, 1995	N/A	N/A	
	ED	Exposure Duration	years	1	(1)	N/A	N/A	See text for calculation of DAevent.
	BW	Body Weight	kg	70	EPA, 1993	N/A	N/A	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	N/A	N/A	
	AT-N	Averaging Time (Non-Cancer)	days	365	EPA, 1989	N/A	N/A	

Notes:

1 - Professional judgment.

Sources:

U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure..

U.S. EPA Region 4, 1995: Supplement Guidance to RAGS: Region 4 Bulletins. Exposure Assessment Human Health Risk Assessment Bulletin No. 3.

TABLE 6-15

VALUES USED FOR DAILY INTAKE CALCULATIONS
ADOLESCENT RECREATIONAL USERS EXPOSED TO SURFACE WATER
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	ug/L	See Text	See Text	NA	NA	Intake (mg/kg/day) =
	CR	Contact Rate	L/hour	0.01	EPA, 1988	NA	NA	$\frac{CW \times CR \times CF \times ET \times EF \times ED}{BW \times AT}$
	CF	Conversion factor	ug/mg	0.001	- -	NA	NA	
	ET	Exposure Time	hours/event	2.6	EPA, 1988	NA	NA	
	EF	Exposure Frequency	events/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	10	(1)	NA	NA	
	BW	Body Weight	kg	45	EPA, 1997	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	3650	EPA, 1989	NA	NA	
Dermal	DAevent	Absorbed dose per event	mg/cm2-event	See Text	See Text	NA	NA	Dermally Absorbed Dose (mg/kg/day)
	SA	Skin Surface Available for Contact	cm2	3820	(2)	NA	NA	$= \frac{DAevent \times EV \times EF \times ED \times SA}{BW \times AT}$
	EV	Event Frequency	events/day	1	(1)	NA	NA	
	ET	Exposure Time	hours/event	2.6	EPA, 1988	NA	NA	
	EF	Exposure Frequency	days/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	10	(1)	NA	NA	See text for calculation of DAevent.
	BW	Body Weight	kg	45	EPA, 1997	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	3650	EPA, 1989	NA	NA	

Notes:
1 - Professional judgement.
2 - Assume 25 percent of total body surface area available for contact.
Sources:
EPA, 1988: Superfund Exposure Assessment Manual.

TABLE 6-16

VALUES USED FOR DAILY INTAKE CALCULATIONS
ADULT RECREATIONAL USERS EXPOSED TO SURFACE WATER
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	µg/L	See Table 6-12	See Table 6-12	N/A	N/A	Intake (mg/kg/day) =
	CR	Contact Rate	L/hour	0.01	EPA, 1995	N/A	N/A	$\frac{CW \times CR \times CF \times ET \times EF \times ED}{BW \times AT}$
	CF	Conversion factor	ug/mg	0.001	- -	N/A	N/A	
	ET	Exposure Time	hours/event	2.6	EPA, 1989	N/A	N/A	
	EF	Exposure Frequency	events/year	45	EPA, 1995	N/A	N/A	
	ED	Exposure Duration	years	6	EPA, 1995	N/A	N/A	
	BW	Body Weight	kg	70	EPA, 1993	N/A	N/A	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	N/A	N/A	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	N/A	N/A	
Dermal	DAevent	Absorbed dose per event	mg/cm2-event	See Text	See Text	N/A	N/A	Dermally Absorbed Dose (mg/kg/day)
	SA	Skin Surface Available for Contact	cm2	5700	(1)	N/A	N/A	$= \frac{DAevent \times EV \times EF \times ED \times SA}{BW \times AT}$
	EV	Event Frequency	events/day	1	(1)	N/A	N/A	
	ET	Exposure Time	hours/event	2.6	EPA, 1989	N/A	N/A	
	EF	Exposure Frequency	days/year	45	EPA, 1995	N/A	N/A	
	ED	Exposure Duration	years	6	EPA, 1995	N/A	N/A	See text for calculation of DAevent.
	BW	Body Weight	kg	70	EPA, 1993	N/A	N/A	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	N/A	N/A	
	AT-N	Averaging Time (Non-Cancer)	days	2,190	EPA, 1989	N/A	N/A	

Notes:

1 - Professional judgment.

Sources:

U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure..

TABLE 6-17

VALUES USED FOR DAILY INTAKE CALCULATIONS
ADULT RECREATIONAL USERS INGESTING SHELLFISH
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	Site-Specific Value	Site-Specific Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Cfish	Chemical Concentration in fish	mg/kg	See Table 6-12	See Table 6-12	NA	NA	Intake (mg/kg/day) =
	IR	Fish/shellfish ingestion rate	kg/day	0.014	EPA, 1997	NA	NA	$\frac{Cfish \times IR \times FI \times EF \times ED}{BW \times AT}$
	FI	Fraction ingested from source	unitless	1	EPA, 1995	NA	NA	
	EF	Exposure Frequency	day/year	240	(1)	NA	NA	
	ED	Exposure Duration	years	30	EPA, 1995	NA	NA	
	BW	Body Weight	kg	70	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	10950	EPA, 1989	NA	NA	

Notes:

1 - Length of shellfish harvesting season.

Sources:

U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure..

U.S. EPA Region 4, 1995: Supplement Guidance to RAGS: Region 4 Bulletins. Exposure Assessment Human Health Risk Assessment Bulletin No. 3.

U.S. EPA, 1997. Exposure Factors Handbook. Volume 2.

TABLE 6-18

VALUES USED FOR DAILY INTAKE CALCULATIONS
FUTURE CHILD RESIDENTS EXPOSED TO SURFACE WATER
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	ug/L	See Table 6-12	See Table 6-12	N/A	N/A	Intake (mg/kg/day) =
	CR	Contact Rate	L/hour	0.05	EPA, 1995	N/A	N/A	$\frac{CW \times CR \times CF \times ET \times EF \times ED}{BW \times AT}$
		Conversion factor	ug/mg	0.001	- -	N/A	N/A	
	ET	Exposure Time	hours/event	2.6	EPA, 1989	N/A	N/A	
	EF	Exposure Frequency	events/year	45	EPA, 1995	N/A	N/A	
	ED	Exposure Duration	years	6	EPA, 1995	N/A	N/A	
	BW	Body Weight	kg	15	EPA, 1993	N/A	N/A	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	N/A	N/A	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	N/A	N/A	
Dermal	DAevent	Absorbed dose per event	mg/cm2-event	See Text	See Text	N/A	N/A	Dermally Absorbed Dose (mg/kg/day)
	SA	Skin Surface Available for Contact	cm2	2000	(1)	N/A	N/A	$= \frac{DAevent \times EV \times EF \times ED \times SA}{BW \times AT}$
	EV	Event Frequency	events/day	1	(1)	N/A	N/A	
	ET	Exposure Time	hours/event	2.6	EPA, 1989	N/A	N/A	
	EF	Exposure Frequency	days/year	45	EPA, 1995	N/A	N/A	
	ED	Exposure Duration	years	6	EPA, 1995	N/A	N/A	See text for calculation of DAevent.
	BW	Body Weight	kg	15	EPA, 1993	N/A	N/A	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	N/A	N/A	
	AT-N	Averaging Time (Non-Cancer)	days	2,190	EPA, 1989	N/A	N/A	

Notes:

1 - Professional judgement.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

EPA Region 4, 1995: Supplement Guidance to RAGS: Region 4 Bulletins. Exposure Assessment Human Health Risk Assessment Bulletin No. 3.

TABLE 6-19

VALUES USED FOR DAILY INTAKE CALCULATIONS
FUTURE CHILD RESIDENTS EXPOSED TO GROUNDWATER
SITE 2 - BORROW POINT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	ug/L	See Table 6.12	See Table 6.12	N/A	N/A	Intake (mg/kg/day) =
	IR	Ingestion Rate	L/day	e significant conta	EPA, 1995	N/A	N/A	$\frac{CW \times IR \times CF \times EF \times ED}{BW \times AT}$
		Conversion factor	ug/mg	0.001	- -	N/A	N/A	
	EF	Exposure Frequency	events/year	350	EPA, 1995	N/A	N/A	
	ED	Exposure Duration	years	6	EPA, 1995	N/A	N/A	
	BW	Body Weight	kg	15	EPA, 1993	N/A	N/A	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	N/A	N/A	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	N/A	N/A	
Dermal	DAevent	Absorbed dose per event	mg/cm2-event	See Text	See Text	N/A	N/A	Dermally Absorbed Dose (mg/kg/day)
	SA	Skin Surface Available for Contact	cm2	6600	EPA, 1997	N/A	N/A	$= \frac{DAevent \times EV \times EF \times ED \times SA}{BW \times AT}$
	EV	Event Frequency	events/day	1	EPA, 1997	N/A	N/A	
	ET	Exposure Time	hours/event	0.25	EPA, 1997	N/A	N/A	
	EF	Exposure Frequency	days/year	350	EPA, 1995	N/A	N/A	
	ED	Exposure Duration	years	6	EPA, 1995	N/A	N/A	See text for calculation of DAevent.
	BW	Body Weight	kg	15	EPA, 1993	N/A	N/A	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	N/A	N/A	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	N/A	N/A	

Notes:

1 - Professional judgement.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

EPA Region 4, 1995: Supplement Guidance to RAGS: Region 4 Bulletins. Exposure Assessment Human Health Risk Assessment Bulletin No. 3.

TABLE 6-20

VALUES USED FOR DAILY INTAKE CALCULATIONS
FUTURE ADULT RESIDENTS EXPOSED TO SURFACE WATER
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	ug/L	See Table 6.12	See Table 6.12	N/A	N/A	Intake (mg/kg/day) =
	CR	Contact Rate	L/hour	0.01	EPA, 1995	N/A	N/A	$\frac{CW \times CR \times CF \times ET \times EF \times ED}{BW \times AT}$
		Conversion factor	ug/mg	0.001	- -	N/A	N/A	
	ET	Exposure Time	hours/event	2.6	EPA, 1989	N/A	N/A	
	EF	Exposure Frequency	events/year	45	EPA, 1995	N/A	N/A	
	ED	Exposure Duration	years	24	EPA, 1995	N/A	N/A	
	BW	Body Weight	kg	70	EPA, 1993	N/A	N/A	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	N/A	N/A	
	AT-N	Averaging Time (Non-Cancer)	days	8,760	EPA, 1989	N/A	N/A	
Dermal	DAevent	Absorbed dose per event	mg/cm2-event	See Text	See Text	N/A	N/A	Dermally Absorbed Dose (mg/kg/day)
	SA	Skin Surface Available for Contact	cm2	5700	(1)	N/A	N/A	$= \frac{DAevent \times EV \times EF \times ED \times SA}{BW \times AT}$
	EV	Event Frequency	events/day	1	(1)	N/A	N/A	
	ET	Exposure Time	hours/event	2.6	EPA, 1989	N/A	N/A	
	EF	Exposure Frequency	days/year	45	EPA, 1995	N/A	N/A	
	ED	Exposure Duration	years	24	EPA, 1995	N/A	N/A	See text for calculation of DAevent.
	BW	Body Weight	kg	70	EPA, 1993	N/A	N/A	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	N/A	N/A	
	AT-N	Averaging Time (Non-Cancer)	days	8,760	EPA, 1989	N/A	N/A	

Notes:

1 - Professional judgement.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

TABLE 6-21

VALUES USED FOR DAILY INTAKE CALCULATIONS
FUTURE ADULT RESIDENTS EXPOSED TO GROUNDWATER
SITE 2 - BORROW POINT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	ug/L	See Table 6-12	See Table 6-12	-	N/A	Intake (mg/kg/day) =
	IR	Ingestion Rate	L/day	2	EPA, 1995	N/A	N/A	
		Conversion factor.	ug/mg	0.001	- -	N/A	N/A	$\frac{CW \times IR \times CF \times EF \times ED}{BW \times AT}$
	EF	Exposure Frequency	events/year	350	EPA, 1995	N/A	N/A	
	ED	Exposure Duration	years	24	EPA, 1995	N/A	N/A	
	BW	Body Weight	kg	70	EPA, 1993	N/A	N/A	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	N/A	N/A	
	AT-N	Averaging Time (Non-Cancer)	days	8760	EPA, 1989	N/A	N/A	
Dermal	DAevent	Absorbed dose per event	mg/cm2-event	See Text	See Text	N/A	N/A	Dermally Absorbed Dose (mg/kg/day)
	SA	Skin Surface Available for Contact	cm2	18000	EPA, 1997	N/A	N/A	$= \frac{DAevent \times EV \times EF \times ED \times SA}{BW \times AT}$
	EV	Event Frequency	events/day	1	EPA, 1997	N/A	N/A	
	ET	Exposure Time	hours/event	0.25	EPA, 1997	N/A	N/A	
	EF	Exposure Frequency	days/year	350	EPA, 1995	N/A	N/A	
	ED	Exposure Duration	years	24	EPA, 1995	N/A	N/A	See text for calculation of DAevent.
	BW	Body Weight	kg	70	EPA, 1993	N/A	N/A	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	N/A	N/A	
	AT-N	Averaging Time (Non-Cancer)	days	8760	EPA, 1989	N/A	N/A	

Notes:

1 - *Professional judgement.*

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

EPA Region 4, 1995: Supplement Guidance to RAGS: Region 4 Bulletins. Exposure Assessment Human Health Risk Assessment Bulletiin No. 3.

TABLE 6-22

CANCER TOXICITY DATA -- ORAL/DERMAL
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor(1)	Adjusted Dermal Cancer Slope Factor(2)	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (3) (MM/DD/YY)
VOCs							
Chloroform	6.1E-03	20%	3.1E-02	$(mg/kg/day)^{-1}$	B2	IRIS	7/28/00
SVOCs							7/28/00
Benzo(a)pyrene	7.3E+00	31%	2.4E+01	$(mg/kg/day)^{-1}$	B2	IRIS	7/28/00
Bis(2-ethylhexyl)phthalate	1.4E-02	19%	7.4E-02	$(mg/kg/day)^{-1}$	B2	IRIS	7/28/00
Inorganics							
Arsenic	1.5E+00	41%	3.7E+00	$(mg/kg/day)^{-1}$	A	IRIS	7/28/00
Hexavalent Chromium	N/A	2%	N/A	$(mg/kg/day)^{-1}$	N/A	N/A	N/A
Iron	N/A	15%	N/A	$(mg/kg/day)^{-1}$	N/A	N/A	N/A
Manganese	N/A	4%	N/A	$(mg/kg/day)^{-1}$	D	N/A	N/A
Thallium	N/A	15%	N/A	$(mg/kg/day)^{-1}$	N/A	N/A	N/A

Notes:

IRIS = Integrated Risk Information System

HEAST= Health Effects Assessment Summary Tables

1 - USEPA Region IV, February 26, 1996.

2 - CSFdermal = CSForal/Oral to Dermal Adjustment Factor.

3 - For IRIS values, provide the date IRIS was searched.
For HEAST values, provide the date of HEAST.

EPA Group:

A - Human carcinogen

B1 - Probable human carcinogen - indicates that limited human data are available

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans

C - Possible human carcinogen

D - Not classifiable as a human carcinogen

E - Evidence of noncarcinogenicity

Weight of Evidence:

Known/Likely

Cannot be Determined

Not Likely

TABLE 6-23

NON-CANCER TOXICITY DATA -- ORAL/DERMAL
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Oral to Dermal Adjustment Factor[1]	Adjusted Dermal RfD[2]	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ[3] (MM/DD/YY)
VOCs										
Chloroform	Chronic	1.0E-02	mg/kg/day	20%	2.0E-03	mg/kg/day	Liver	1000	IRIS	07/28/00
SVOCs										
Benzo(a)pyrene	N/A	N/A	mg/kg/day	31%	N/A	mg/kg/day	N/A	N/A	IRIS	N/A
Bis(2-ethylhexyl)phthalate	Chronic	2.0E-02	mg/kg/day	19%	3.8E-03	mg/kg/day	Liver	1000	IRIS	
Inorganics										
Arsenic	Chronic	3.0E-04	mg/kg/day	41%	1.2E-04	mg/kg/day	Skin	3	IRIS	07/28/00
Hexavalent Chromium	Chronic	3.0E-03	mg/kg/day	2%	6.0E-05	mg/kg/day	None	100	IRIS	07/28/00
Iron	Chronic	3.0E-01	mg/kg/day	15%	4.5E-02	mg/kg/day	Liver	N/A	EPAIII	04/13/00
Manganese	Chronic	2.0E-02	mg/kg/day	4%	8.0E-04	mg/kg/day	CNS	1	IRIS	07/28/00
Thallium	Chronic	7.0E-05	mg/kg/day	15%	1.1E-05	mg/kg/day	Liver, Blood	N/A	EPAIII	04/13/00

Notes;

1 - USEPA Region IV, February 26, 1996.

2 - RfDdermal = RfDoral x Oral to Dermal Adjustment Factor

3 For IRIS values date that IRIS was searched.

For HEAST values, provide the date of HEAST.

FOR EPAIII, date of RBC Table.

N/A = Not Applicable

IRIS = Integrated Risk Information System

HEAST= Health Effects Assessment Summary Tables

EPAIII = USEPA Region III Risk-Based Concentration Table, April 12, 1999.

TABLE 6-24

SUMMARY OF CANCER RISKS AND HAZARD INDICES
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks >10^{-4}	Chemicals with Cancer Risks >10^{-5}	Chemicals with Cancer Risks >10^{-6}	Hazard Index	Chemicals with HI > 1
Construction Worker	Groundwater	Dermal Contact	1.7E-08	--	--	--	0.42	--
	Surface Water	Ingestion	1.2E-08	--	--	--	0.003	--
		Dermal Contact	1.8E-06	--	--	Bis(2-Ethylhexyl)phthalate	0.45	--
		Total	1.8E-06	--	--	Bis(2-Ethylhexyl)phthalate	0.45	--
		Total All Media	1.8E-06				0.87	
Adolescent Recreational User	Surface Water	Ingestion	1.1E-08	--	--	--	0.0002	--
		Dermal Contact	4.4E-06	--	--	Bis(2-Ethylhexyl)phthalate	0.11	--
		Total	4.6E-06	--	--	Bis(2-Ethylhexyl)phthalate	0.11	--
Adult Recreational User	Surface Water	Ingestion	4.2E-09	--	--	--	0.0002	--
		Dermal Contact	2.6E-06	--	--	Bis(2-Ethylhexyl)phthalate	0.11	--
		Total	2.6E-06	--	--	Bis(2-Ethylhexyl)phthalate	0.11	--
	Shellfish	Ingestion	1.4E-06	--	--	cPAHs	0.07	--
		Total All Media	4.0E-06				0.18	
Child Resident	Surface Water	Ingestion	9.9E-08	--	--	--	0.004	--
		Dermal Contact	4.3E-06	--	--	Bis(2-Ethylhexyl)phthalate	0.17	--
		Total	4.3E-06	--	--	Bis(2-Ethylhexyl)phthalate	0.18	--
	Groundwater	Ingestion	1.2E-05	--	Arsenic	--	19.2	Iron, Thallium
		Dermal Contact	5.0E-08	--	--	--	0.23	
		Inhalation	9.7E-08	--	--		0.02	--
		Total	1.3E-05	--	Arsenic		19.4	Iron, Thallium
		Total All Media	1.7E-05				19.6	
Adult Resident	Surface Water	Ingestion	1.7E-08	--		--	0.0002	--
		Dermal Contact	1.0E-05	--	Bis(2-Ethylhexyl)phthalate		0.11	--
		Total	1.0E-05	--	Bis(2-Ethylhexyl)phthalate		0.11	--
	Groundwater	Ingestion	2.1E-05	--	Arsenic	--	8.2	Thallium
		Dermal Contact	1.2E-07	--	--	--	0.13	
		Inhalation	1.7E-07	--	--	--	0.01	--
		Total	2.2E-05	--	Arsenic	--	8.35	Thallium
		Total All Media	3.2E-05				8.5	
Lifelong Resident	Surface Water	Ingestion	1.2E-07	--		--	NA	--
		Dermal Contact	1.4E-05	--	Bis(2-Ethylhexyl)phthalate		NA	--
		Total	1.4E-05	--	Bis(2-Ethylhexyl)phthalate		NA	--
	Groundwater	Ingestion	3.4E-05	--	Arsenic	--	NA	--
		Dermal Contact	1.7E-07	--	--	--	NA	
		Inhalation	2.6E-07	--	--	--	NA	--
		Total	3.4E-05	--	Arsenic	--	NA	--
		Total All Media	4.9E-05				NA	

TABLE 6-25
COMPARISON OF ESSENTIAL NUTRIENT CONCENTRATIONS TO SCREENING LEVELS
MCRD PARRIS ISLAND, SOUTH CAROLINA

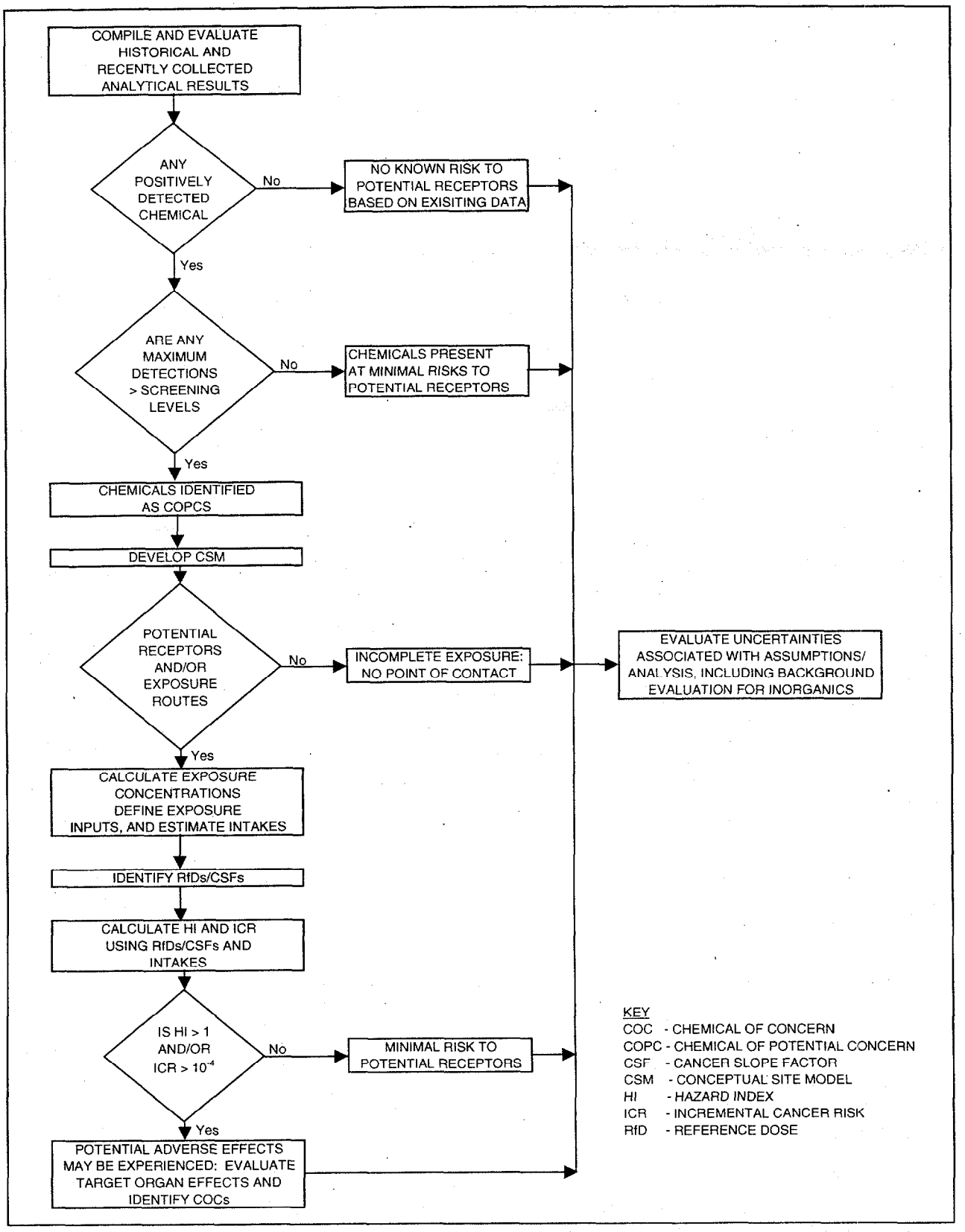
Chemical	Site 2			Site 15	Essential Nutrient Screening Levels (mg/kg)
	Surface Soil (mg/kg)	Subsurface Soil (mg/kg)	Sediment (mg/kg)	Sediment (mg/kg)	
Calcium	477 (B)	150 (B)	32,800	5550	1,000,000
Magnesium	174 (B)	90.9 (B)	2,380 (B)	4,220 (B)	460,468
Potassium	102 (B)	41.9 (B)	1,010 (B)	2,560 (B)	1,000,000
Sodium	2,100	ND	6,650 (B)	10,200 (B)	1,000,000

Chemical	Ground Water (ug/L)	Surface Water (ug/L)	Essential Nutirent Screening Levels (ug/L)
Calcium	281,000	303,000 (B)	1,000,000
Magnesium	778,000	950,000 (B)	118,807
Potassium	245,000	642,000 (B)	297,016
Sodium	559,000	861,000 (B)	396,022

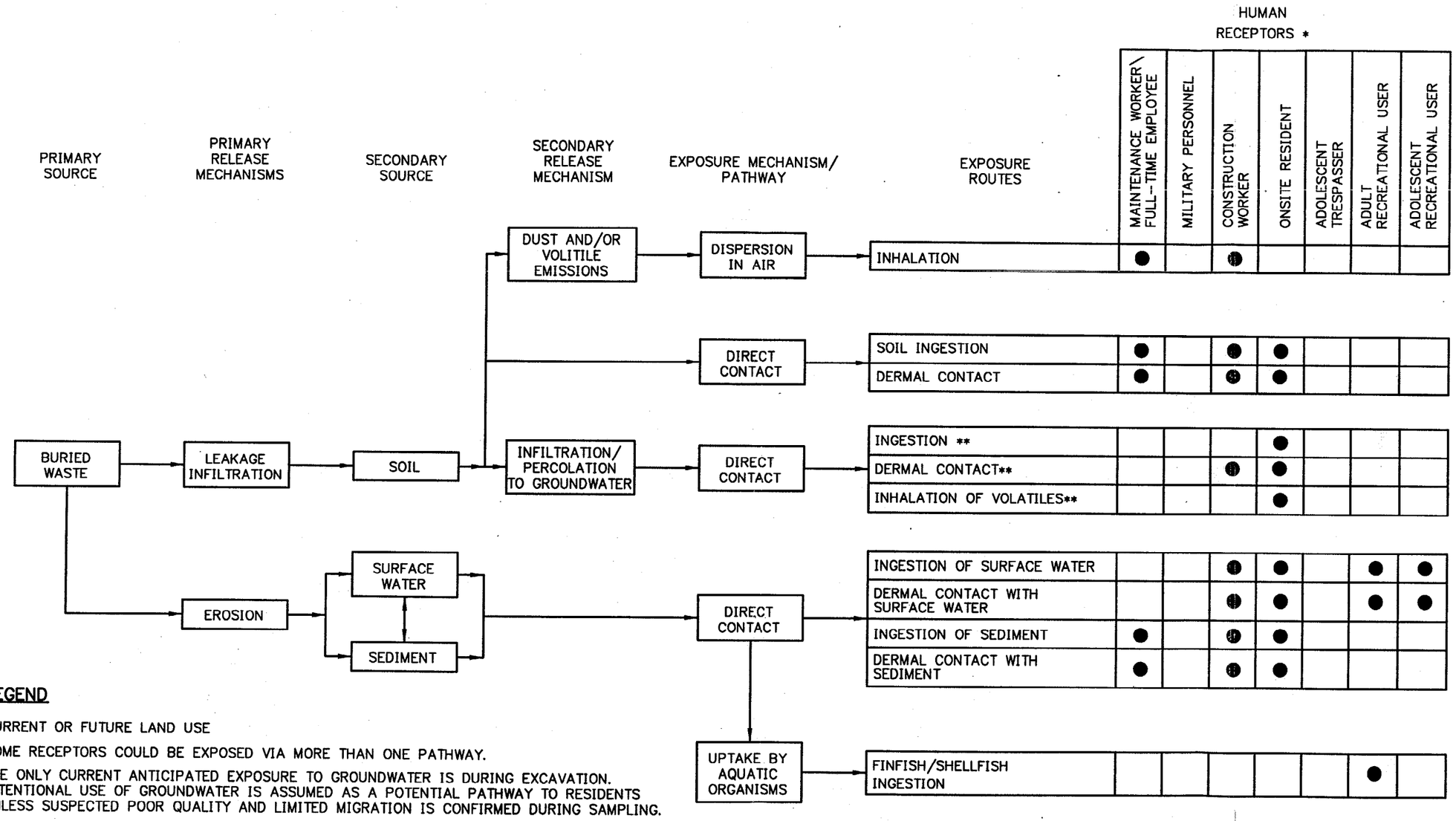
Notes:
(B) - Below background concentration.

FIGURE 6-1

**SUMMARY OF HUMAN HEALTH RISK ASSESSMENT PROCESS
SITE 2 - BORROW PIT LANDFILL AND
SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA**



ACAD: 7394KF05.dwg 09/09/99 HJP



LEGEND

● CURRENT OR FUTURE LAND USE

* SOME RECEPTORS COULD BE EXPOSED VIA MORE THAN ONE PATHWAY.

** THE ONLY CURRENT ANTICIPATED EXPOSURE TO GROUNDWATER IS DURING EXCAVATION. INTENTIONAL USE OF GROUNDWATER IS ASSUMED AS A POTENTIAL PATHWAY TO RESIDENTS UNLESS SUSPECTED POOR QUALITY AND LIMITED MIGRATION IS CONFIRMED DURING SAMPLING.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

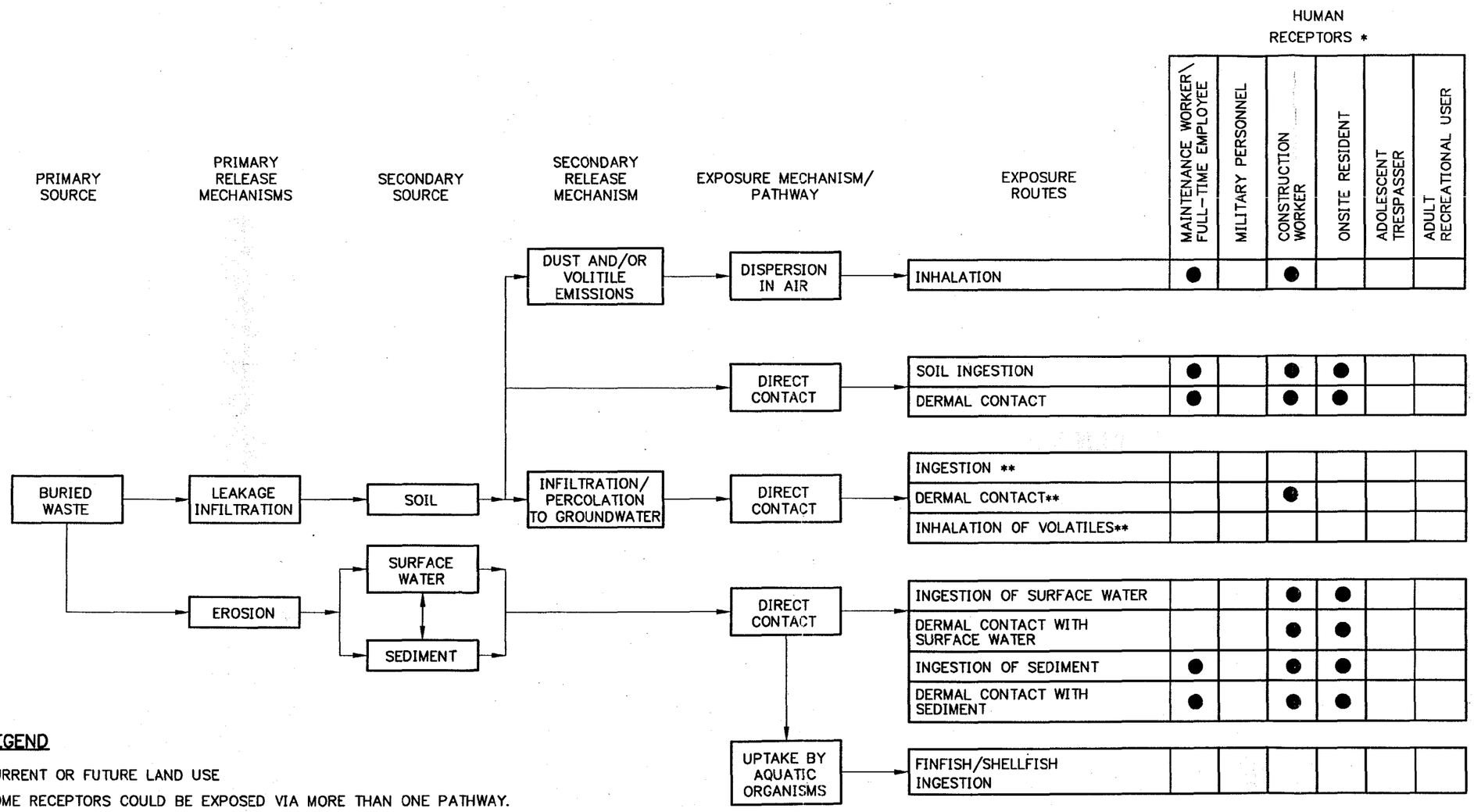
DRAWN BY KW DATE 3/30/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE NOT TO SCALE

CONCEPTUAL SITE MODEL
SITE 2-BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 6-2
REV. 0

FORM CADD NO. SDV_BH12.DGN - REV 0 - 1/20/98

ACAD: 7394KF04.dwg 09/09/99 HJP



LEGEND

● CURRENT OR FUTURE LAND USE

* SOME RECEPTORS COULD BE EXPOSED VIA MORE THAN ONE PATHWAY.

** THE ONLY CURRENT ANTICIPATED EXPOSURE TO GROUNDWATER IS DURING EXCAVATION. INTENTIONAL USE OF GROUNDWATER IS ASSUMED AS A POTENTIAL PATHWAY TO RESIDENTS UNLESS SUSPECTED POOR QUALITY AND LIMITED MIGRATION IS CONFIRMED DURING SAMPLING.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY KW DATE 3/30/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE NONE

CONCEPTUAL SITE MODEL
SITE 15-DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 6-3
REV. 0

FORM CADD NO. SDV_BH12.DGN - REV 0 - 1/20/98

7.0 ECOLOGICAL RISK ASSESSMENT

The RI/RFI process requires an assessment of the potential adverse effects of site contamination on the environment. Ecological receptors that utilize Site/SWMU 2 (Site 2) and Site/SWMU 15 (Site 15), as well as nearby areas, could potentially be at risk from environmental contamination associated with Sites 2 and 15. Accordingly, an ecological risk assessment was performed to characterize the potential risks from site-related contaminants to ecological receptors.

7.1 OVERVIEW OF METHODS

This section provides an outline of the general approach that was taken to assess the impacts of site contamination on ecological receptors. This assessment generally followed a two-step process, as follows:

Step 1: Preliminary Problem Formulation (Section 7.2) and Ecological Effects Evaluation (Section 7.3)

- Preliminary Problem Formulation - This first phase of an ecological risk assessment discusses the goals, breadth, and focus of the assessment. It includes general descriptions of the site, with emphasis on the habitats and ecological receptors that are present. This phase also involves characterization of contaminant sources and migration pathways, evaluation of routes of contaminant exposure, and selection of analytes to be assessed. Assessment and measurement endpoints are also selected in this phase, and a conceptual model is developed that describes how contaminants associated with Sites 2 and 15 may come into contact with ecological receptors.

- Preliminary Ecological Effects Evaluation - In this phase, medium-specific ecological screening guidelines for each analyte (i.e., concentrations of each contaminant above which adverse effects to ecological receptors may occur) are identified. Contaminant doses associated with toxicity to representative ecological receptors are also identified. This step is undertaken concurrently with the exposure assessment described below.

Step 2: Preliminary Exposure Assessment (Section 7.4) and Risk Calculation (Section 7.5)

- Preliminary Exposure Estimate - This portion of the ecological risk assessment includes the identification of data used to represent concentrations of contaminants to which ecological receptors may be exposed in various media and the selection of exposure point contaminant concentrations from those data. Contaminant doses for representative receptors are also calculated.

- Preliminary Risk Calculation - In this step, exposure point concentrations are compared to guidelines in order to characterize potential risk to ecological receptors. Contaminant doses associated with toxicity are compared to calculated doses for representative receptors. Analytes that are found to pose potential risk after these comparisons are selected as ecological contaminants of potential concern (COPCs).

When these two steps are completed, the results are interpreted, ecological contaminants of concern (COCs) are selected, and the uncertainties associated with the ecological risk assessment are addressed. COCs are COPCs that are shown to present unacceptable risks to ecological receptors based on their concentrations, distributions, and modes of toxicity. The above process, described in further detail below, represents the general approach recommended in the most recent U.S. EPA guidance for performing ecological risk assessments (U.S. EPA, 1998b; U.S. EPA, 1987b), which served as the basis for the ecological risk assessment methodology. Furthermore, the ecological risk assessment was conducted in accordance with Department of the Navy policy (DON, 1999) and other available guidance documents (U.S. EPA, 1995b; Wentsel et al., 1996) and publications (Ingersoll et al., 1997; Suter, 1993; Calabrese and Baldwin, 1993). The methods used in this ecological risk assessment and discussed below were summarized in the Master Work Plan for MCRD Parris Island (B&R Environmental, 1998b). Revisions to the Master Work Plan have been discussed with the MCRD Parris Island partnering team.

Due to the potential complexity of ecological risk assessments, they are often conducted using a tiered approach and punctuated with Scientific/Management Decision Points (SMDPs). SMDPs are meetings involving the risk managers and risk assessment team and are conducted to evaluate the work up to that point and to ensure that the ecological risk assessment is proceeding in an efficient manner. Information analyzed in one tier is evaluated to determine whether the objectives of the study have been met. The results are then used to identify the data required for the next tier, if necessary. The Tier 1 ERA is also known as a Screening Risk Assessment. The Screening Risk Assessment uses conservative (i.e. stringent) assumptions to evaluate site data and determine whether additional ecological risk assessment or accelerated site cleanup may be warranted, or that the site poses negligible ecological risks.

The second tier is a baseline ERA (BERA), which is conducted if the results of the screening-level ERA indicate that additional study is warranted. The BERA is a more focused study of the initial COPCs, and comprises Steps 3 through 7 of the 8-step ERA process. The BERA begins with a more balanced evaluation of the conservativeness inherent in the first two steps of the ERA process (U.S. EPA, 1997; DON, 1999).

7.2 PRELIMINARY PROBLEM FORMULATION

7.2.1 Habitat Types and Ecological Receptors at Site 2

Site 2 consists of a borrow pit landfill located in the northern portion of MCRD Parris Island. The landfill is roughly rectangular in shape and covers an area of approximately 2 acres (Figure 1-2). The site perimeter is bounded to the north, east, and south by a dirt road leading to a boat ramp. The remainder of the site perimeter consists of a 3 to 5 feet high berm along the southwestern boundary of the site. A narrow strip of marsh habitat adjacent to an inlet of Archer's Creek is located southwest of the berm.

Habitat at Site 2 consists of pine forest. The dominant overstory species are slash pine (*Pinus elliottii*) and loblolly pine (*Pinus taeda*). Other trees include sassafras (*Sassafras albidum*), black cherry (*Prunus serotina*), and red bay (*Persea borbonia).* The midstory and much of the understory consist almost exclusively of wax myrtle (*Myrica cerifera*). Scattered shrubs and vines include poison ivy (*Rhus radicans*), muscadine grape (*Vitis rotundifolia*), and greenbrier (*Smilax rotundifolia*).

The narrow strip of marsh to the west and southwest of the site is dominated by needlerush (*Juncus roemerianus*). Cordgrass (*Spartina alterniflora*), sea oxeye (*Borrichia frutescens*), and glasswort (*Salicornia virginica*) are present in portions of the marsh.

The site is small in areal extent, yet a variety of wildlife species occurs there. White-tailed deer (*Odocoileus virginianus*), raccoons *(Procyon lotor*), and gray squirrels (*Sciurus carolinensis*) are known to forage on the site. Other mammals expected to occur at Site 2 include the opossum (*Didelphis virginiana*), short-tailed shrew (*Blarina carolinensis*), cotton rat (*Sigmodon hispidus*), and cotton mouse (*Peromyscus gossypinus*). Mammalian carnivores expected to occur, at least occasionally, on the site include the red fox (*Vulpes vulpes*) and striped skunk (*Mephitus mephitus*). A variety of birds, reptiles, and amphibians utilize the site.

Mink (*Mustela vison*), river otters (*Lutra canadensis*), marsh rabbits (*Sylvilagus palustris*), and rice rats (*Oryzomys palustris*) probably forage along the edge of the marsh southwest of the site. The tidal inlet provides habitat for a variety of fauna, particularly fish and crustaceans. Several species of animals probably prey upon these fish, mollusks, and crustaceans. These include mammals such as the raccoon, mink, and river otter and wading birds such as the tricolored heron (*Egretta tricolor*), great blue heron (*Ardea herodias*), green heron (*Butorides striatus),* and snowy egret (*Egretta thula*). An active osprey (*Pandion haliaetus*) nest is located on a nesting platform at the edge of the inlet immediately southwest of the site.

Fish such as red drum (*Sciaenops ocellatus*), spotted seatrout (*Cynoscion nebulosus*), southern flounder (*Paralichthys lethostigma*), whiting (*Menticirrhus americanus*), and striped mullet (*Mugil cephalus)* are

known to occur in Archer's Creek and presumably occur in the tidal inlet near the site. Smaller fish such as mud minnows (*Umbra pygmaea*) and mummichogs (*Fundulus heteroclitus*), as well as benthic and nektonic invertebrates such as oysters, shrimp, and crabs, also are expected to occur in the inlet.

Endangered and threatened species that could potentially occur at or near the site consist of the bald eagle (*Haliaeetus leucocephalus*), wood stork (*Mycteria americana*), and American alligator (*Alligator mississippiensis*). An active bald eagle nest is located approximately 1 mile southeast of the site, and bald eagles (state and federally listed as threatened) could potentially forage on fish in Archer's Creek. Wood storks (state and federally listed as endangered) forage in various locations throughout the Depot, and they could potentially forage in the tidal inlet near the site. An alligator was observed near the site during sampling activities. Although common in some parts of its range, the alligator is federally listed as threatened due to its similarity in appearance to the endangered American crocodile (*Crocodylus acutus*).

Although other endangered and threatened species occur in Beaufort County (Table 2-2 of Volume I, Master Work Plan), the site provides poor habitats for these species. For example, the manatee (*Trichechus manatus*), shortnose sturgeon (*Acipenser brevirostrum*), and various sea turtles have been seen, at least occasionally, in the Broad River, Beaufort River, and Port Royal Sound. Similarly, the Atlantic bottlenosed dolphin (Tursiops truncatus) is a year-round resident of these areas. Although not threatened or endangered, dolphins are afforded protection under the Federal Marine Mammal Act. However, these species usually are not associated with shallow marshes and small tidal inlets like those near Site 2. With the exception of the bald eagle, wood stork, and alligator, the likelihood of endangered and threatened species in the vicinity of the site is remote.

7.2.2 Habitat Types and Ecological Receptors at Site 15

Site 15 consists of approximately 0.5 mile of dirt road accessing the Site 2 Borrow Pit Landfill and approximately 1.5 miles of road near Elliot's Beach (Figures 1-2 and 1-3) Most of the Elliot's Beach road has been paved, and the only unpaved portion is within the picnic area at Elliot's Beach.

Habitat in the vicinity of the Borrow Pit road consists of pine forest on the downslope side of the road and temperate evergreen forest on the upslope side. This particular pine forest was described in Section 7.2.1. The area on the upslope side of the road is dominated by laurel oak (*Quercus laurifolia*). Other trees include black cherry, red bay, and loblolly pine. Common understory shrubs and vines include saw palmetto (*Serenoa repens*), yaupon holly (*Ilex vomitoria*), muscadine grape, and greenbriar.

A variety of habitats exist in the vicinity of the Elliot's Beach road. Approximately 20 acres of mowed grass with scattered live oaks (*Quercus virginiana*) occur in the picnic area. Mowed grass extends seaward to the edge of a 5-foot bluff along the shoreline, where concrete slabs have been recently placed

as riprap. The shoreline at the picnic area is rock and gravel, with no emergent vegetation. A boat ramp is located approximately 3,000 feet southeast of the picnic area, at the mouth of Whale Creek. An extensive saltwater marsh, dominated by cordgrass, is located upstream along Whale Creek.

Wooded areas near Elliot's Beach consist of temperate evergreen forest. This transitions into pine forest when proceeding inland. The temperate evergreen forest includes tree species such as live oak, laurel oak, cabbage palmetto (*Sabal palmetto*), red bay, and sweet bay (*Magnolia virginiana*). Common understory species include wax myrtle, yaupon holly, muscadine grape, and greenbrier. The pine forest includes these species but is dominated by slash pine and loblolly pine. The understory of the pine forest near Elliot's Beach is thickly vegetated with sweet gum (*Liquidambar styraciflua*), saw palmetto, oaks (*Quercus* spp), and numerous vines.

Terrestrial and aquatic animal species known and expected to occur in the vicinity of Site 15 are those described in Section 7.2.1.

The most likely endangered and threatened species that could potentially occur at or near Site 15 consist of the bald eagle, woodstork, and American alligator. Wood storks could potentially forage in the extensive marsh upstream of the boat ramp near Elliot's Beach. Bald eagles and alligators could potentially forage in the marsh or in the Broad River.

Other endangered and threatened species known to occur in Beaufort County that could potentially occur near Site 15 consist of aquatic species such as the manatee (*Trichechus manatus*), shortnose sturgeon (*Acipenser brevirostrum*), and various sea turtles. These species are occasionally seen in the Broad River, Beaufort River, and Port Royal Sound. There are no sandy beach habitats favored as nesting sites by sea turtles near Site 15. Thus, the likelihood of sea turtles near the site (except for occasional transients) is remote. The possibility that manatees and shortnose sturgeon may occasionally occur in the Broad River near Elliot's Beach cannot be ruled out.

7.2.3 Contaminant Sources and Migration Pathways

7.2.3.1 Site 2

The contaminant source at Site 2 is buried material from historical landfilling activities at the site. The contaminant migration pathways that were evaluated for the site include volatilization, wind erosion, overland runoff, and infiltration of contaminants. Constituents in soil could volatilize from surficial material or become airborne through wind erosion. However, the vegetation and thick layer of pine needles in the former landfill minimize the wind erosion pathway. Contaminated fugitive dust could be generated during future ground-disturbing activities such as construction or excavation. Contaminants could then be

dispersed in the surrounding environment and transported to downwind locations, where they could become deposited in surface soil, surface water, or sediment. Infiltrating precipitation could cause the contamination of subsurface soil and groundwater. Groundwater from the site could possibly discharge to surface water in the marsh, where groundwater contaminants could be subsequently deposited in sediment or in the tissues of aquatic organisms.

Precipitation runoff could conceivably carry constituents to nearby surface water and sediment in the marsh, but in the site's current condition, this would be possible only during major storm events. The landfill is in a borrow pit, all portions of which are lower than the surrounding terrain. Thus, there is no route for surface water runoff from the landfill. The pit is approximately 8 feet deep at the northwestern end and decreases to approximately 5 feet deep along the northern and southern sides. The shallowest portion of the borrow pit (the southwest side) is bounded by a berm. The berm is 4 to 5 feet high, except at one point near the southwestern corner of the site, where it decreases to 2 feet. There is no visible evidence of water flow into or out of the pit. Thus, under current conditions, the precipitation runoff pathway is absent.

7.2.3.2 Site 15

The contaminant source at Site 15 is waste oils that were sprayed on the dirt roads to suppress dust. This practice ended in 1966. Contaminant migration pathways include volatilization, wind erosion, overland runoff, and infiltration of contaminants. However, previous studies of Site 15 have concluded that percolation of waste oils to groundwater is unlikely, based on the depth to the water table. The depth to the water table at high tide beneath Site 15 is 1 to 4 feet. This greatly exceeds the estimated required depth of less than 4 inches for waste oil immobilization (NEESA, 1986). Therefore, infiltration of contaminants via the soil-to-groundwater migration pathway is considered to be incomplete at Site 15.

Airborne contaminants could be transported to downwind locations where they could become deposited in surface soil, surface water, or sediment. Precipitation runoff from the Elliot's Beach road could carry constituents to nearby surface water and sediment in the Broad River. Precipitation runoff from most portions of the Borrow Pit road drains into the borrow pit. However, the portion of the road located west of the landfill could carry constituents to surface water in the Archer's Creek inlet or to the marsh southwest of the landfill.

Most of the dirt roads near Elliot's Beach have been paved, thereby reducing the migration pathways in that portion of Site 15.

7.2.4 Exposure Routes

Aquatic and semi-aquatic organisms in the Archer's Creek inlet, the marsh near the inlet, the Broad River, and the marsh adjacent to Whale Creek could be exposed to contaminants through direct contact with surface water and sediments, incidental ingestion of surface water and sediments, and consumption of contaminated food items. Aquatic and semi-aquatic organisms near Site 2 could also be exposed to constituents from contaminated groundwater that discharges to surface water.

Terrestrial animals could be exposed to soil contaminants through ingestion of contaminated food items. Animals can incidentally ingest soil while grooming fur, preening feathers, digging, grazing close to the soil, or feeding on items to which soil has adhered (such as roots and tubers). Terrestrial vegetation can be exposed to contaminants via direct aerial deposition and root translocation. Aerial deposition was not investigated, primarily because the contaminant sources at the site are largely covered by vegetation, pine needles, and pavement, reducing the amount of bare soil and fugitive dust. Terrestrial animal receptors could also come into contact with contaminants in surface water through drinking, although the salinity of the estuarine surface water near the sites largely precludes its use as drinking water. In addition, this exposure route represents a negligible portion of total exposure for most receptors (Sample et al., 1996). Nevertheless, organisms that prey on aquatic species could incidentally ingest surface water when consuming food items. Therefore, this exposure route was investigated for wading birds and the raccoon.

Exposure to contaminants in the soil via dermal contact may occur but is unlikely to represent a major exposure pathway because fur, feathers, and chitinous exoskeletons probably minimize transfer of contaminants across dermal tissue. In addition, little information is available (e.g., absorption factors) to evaluate dermal exposures to wildlife.

Inhalation of volatile and semivolatile compounds might occur, but inhalation does not represent a significant exposure pathway because air contaminant concentrations are assumed to be quite low, even for burrowing wildlife. In addition, inhalation ecotoxicity data for chronic exposure are lacking. Therefore, the air pathway was not considered for ecological receptors.

7.2.5 Selection of Analytes to be Investigated

The analytes that were initially included for quantitative analysis were all analytes detected in surface water, sediment, surface soil, and groundwater samples collected in 1998 sampling activities. However, calcium, magnesium, potassium, and sodium were excluded since they are essential nutrients that are toxic only at extremely high concentrations. Due to the scarcity of data for these essential nutrients, it was not possible to develop ranges of toxicity for them even at high concentrations. The limited toxicity

data available indicate that high dietary intake of these nutrients is well tolerated. The process that was used to select COPCs from the detected analytes is described in Section 7.5. Profiles describing the environmental fate, transport, and toxicity of COPCs are presented in Appendix F.

7.2.6 Assessment and Measurement Endpoints

As discussed in U.S. EPA (1997b) and Wentsel et al. (1996), one of the major tasks in preliminary problem formulation is the selection of assessment and measurement endpoints. An assessment endpoint is "an explicit expression of actual environmental values that are to be protected" and measurement endpoints are "measurable ecological characteristics that are related to the valued characteristic chosen as the assessment endpoint" (U.S. EPA, 1997b). The assessment endpoints selected for this ecological risk assessment were based on the environmental setting, contaminants known to exist at the sites, contaminant fate and transport mechanisms, exposure pathways, mechanisms of ecotoxicity, and likely categories of receptors that could be affected by site-related contaminants. The assessment endpoints at Site 2 and Site 15 consist of the protection of the following groups of receptors from adverse effects of site-related contaminants on growth, survival, and reproduction:

- benthic invertebrate communities
- fish communities (forage fish and higher trophic level fish)
- piscivorous birds
- omnivorous birds
- carnivorous birds
- vermivorous birds
- predatory mammals
- omnivorous mammals
- herbivorous mammals
- mammals that feed on soil invertebrates
- terrestrial and aquatic vegetation

Amphibians and reptiles were not included as assessment endpoints at either Site 2 or Site 15 since toxicity data for amphibians and reptiles are sparse, resulting in a small, sporadic toxicity database.

Measurement endpoints serve as surrogates for assessment endpoints, since they are more easily quantified or observed than assessment endpoints. Measurement endpoints consisted of contaminant concentrations associated with adverse effects on growth, survival, and reproduction of aquatic organisms (surface water screening levels), benthic organisms (sediment screening levels), and terrestrial

vegetation and soil invertebrates (surface soil screening levels). In addition, measurement endpoints for representative receptor groups were contaminant doses associated with adverse effects on growth, survival, and reproduction of these receptors. Taken together, the measurement endpoints address all of the groups of receptors chosen as assessment endpoints.

7.2.7 Conceptual Site Model

The conceptual model is designed to diagram the potentially exposed receptor populations and applicable exposure pathways, based on the physical nature of the site and the potential contaminant sources. Actual or potential exposures of ecological receptors associated with Sites 2 and 15 were determined by identifying the most likely pathways of contaminant release and transport. A complete exposure pathway has three components: a source of contaminants that can be released to the environment; a route of contaminant transport through an environmental medium; and an exposure route or contact point for an ecological receptor. Preliminary conceptual models for Sites 2 and 15 are presented in Figures 7-1 and 7-2, respectively. Dermal (direct contact) and inhalation exposure routes are included in the conceptual models since they are theoretically possible, but as mentioned earlier, they represent minor exposure routes and were not investigated. Similarly, Figure 7-2 shows a complete exposure route for direct contact and ingestion of surface water since that is theoretically possible. However, because of their low mobility, the potential contaminants of concern in the waste oils sprayed on the dirt roads are not expected to result in significant surface water contamination.

7.3 PRELIMINARY ECOLOGICAL EFFECTS EVALUATION

For this ecological risk assessment, exposure-point concentrations of detected analytes in surface water, groundwater, sediment, and surface soil were compared to ecologically based guidelines to determine if the analytes should be selected as COPCs. In addition, toxic doses of contaminants were compared to modeled doses for representative receptors. The methods used for the selection of ecological screening levels are discussed below.

7.3.1 Ecological Screening Values

The initial ecological screening value comparison consisted of the comparison of maximum concentrations of chemicals detected in Site 2 and Site 15 media to Region IV approved ecological screening values (ESVs) (U.S. EPA, 1995b). If the maximum concentration was less than the ESV, the chemical was eliminated from further consideration. If the maximum concentration equaled or exceeded the ESV, or if an ESV was not available, the chemical was considered to be an ecological COPC and was retained for further study in the ecological risk assessment.

The ESVs used for the initial screening of groundwater, surface water, and sediment were those established by U.S. EPA Region IV (U.S. EPA, 1995b; U.S. EPA, 1998b). Since the surface water nearest Site 2 is a tidal inlet, the surface water samples were saline; therefore, saltwater ESVs were used for the surface water screening value comparison. Three of the groundwater samples were essentially fresh water, with salinity values of 0.1 to 0.96 ppt. The salinity was greater in the other two samples, however, with values of 6.0 and 23 ppt. Because of the range of salinity in these five samples, the lowest of fresh or salt surface water ESVs were used in the initial screening process for groundwater analytes.

Surface soil ESVs established by U.S. EPA Region IV (U.S. EPA, 1998b) were used for the initial screening of surface soil analytes. These values consist of ESVs generated by the U.S. Fish and Wildlife Service (Beyer, 1990), Oak Ridge National Laboratory (Efroymson et al., 1997a,b), The Netherlands (MHSPE, 1994, Crommentuijn et al., 1997), and Canada (CCME, 1997). The ESVs are generally the lowest value from among the six documents cited above.

Following recent discussions with U.S. EPA Region IV (ABB, 1997), the ESV for benzo(a)pyrene was used as a surrogate for high molecular weight PAHs, the ESV for naphthalene was used as a surrogate for low molecular weight PAHs when ESVs were not available for those compounds, and the ESV for diethylhexyl phthalate (DEHP) was used when ESVs were not available for phthalates. Unless data were available to support speciation of metals, the ESV for the most toxic form of metals was used. For chromium in surface soil, speciation data were available. Specifically, three soil samples at Site 2 were analyzed for hexavalent chromium, and all eight soil samples at that site were analyzed for total chromium. An ESV of 64 ppm (CCME, 1997) was used for screening the total chromium data. An ESV of 0.4 ppm (Efroymson, 1997a) was to have been used for screening the hexavalent chromium data, but hexavalent chromium was not detected in any soil sample. The detection limits for hexavalent chromium in these three samples (0.89, 0.91, and 1.1 ppm) were slightly greater, however, than the ESV for hexavalent chromium.

7.3.2 Toxicity Reference Values

Contaminant exposure via the food chain was modeled to investigate potential risks to representative receptors. Toxicity reference values (TRVs), which are contaminant doses associated with adverse effects on growth, survival, and reproduction, were obtained for comparison to doses that the receptors may receive in the environment. TRVs were preferentially selected that represent a threshold for sublethal effects, such as impairment of reproduction or growth, and were obtained for each class of receptor (birds, mammals, fish), as discussed below.

Since toxicity data for the specific receptors chosen herein were usually not available, toxicity data from laboratory species were extrapolated to receptor species. Most of the toxicity data were obtained from

ORNL wildlife toxicity data (Sample et al., 1996). Data were also obtained from an U.S. EPA Environmental Response Team (ERT, 1997) report, the Integrated Risk Information System (IRIS), and the Agency for Toxic Substances and Disease Registry (ATSDR). No-observed-adverse-effects-levels (NOAELs) and lowest-observed-adverse-effects-levels (LOAELs) were used in the models. Following U.S. EPA Region IV guidance, LOAELs were divided by a factor of 10 to obtain NOAELs if NOAELS were not available for a contaminant. Following discussions with U.S. EPA Region IV, VOCs were not included in food chain modeling, since analytes with log K_{ow} values less than 3.5 (VOCs) generally do not accumulate in animal tissue (Suter, 1993). TRVs used in this ecological risk assessment and their sources are presented in Table 7-1.

7.3.3 Representative Receptors

Species used in the food chain modeling (Table 7-2) were chosen to represent the groups of receptors most likely to be exposed to the highest contaminant concentrations because of their position in the food web, diet (ingestion rate and food type), home range (contained within the area of contamination), and body size. The socio-cultural nature of the receptor species (e.g., threatened or endangered species) was also considered. The selected species are assumed to be representative of other species within the same trophic group or guild and represent the groups of organisms specified in the assessment endpoints. For each of the representative species, information on life history was collected, including diet, body weight, food ingestion rates, and home range. Maximum food ingestion rates and minimum body weights were generally used to calculate doses. Information regarding the representative receptors chosen for this ecological risk assessment is presented below. The representative species associated with terrestrial habitats (i.e., short-tailed shrew, cotton mouse, red fox, woodcock, robin, and red-tailed hawk) were primarily applicable only at Site 2, since most of the former dirt roads at Site 15 have been paved. However, as a conservative approach, risks to terrestrial receptors were also evaluated at Site 15.

7.3.3.1 Short-tailed shrew (Blarina carolinensis)

The short-tailed shrew was selected as a representative insectivorous small mammal. It can be found in forested areas, brushy areas, and near marshes. It feeds primarily on insects but will prey on earthworms, snails, centipedes, slugs, and even small vertebrates (Burt and Grossenheider, 1980). The short-tailed shrew has a voracious appetite for its body size, and as a result, may receive high doses of contaminants relative to other small mammals. Its home range is approximately 0.5 to 2.4 acres (U.S. EPA, 1993), allowing it to potentially spend all or much of its time on Site 2.

7.3.3.2 Cotton mouse (Peromyscus gossypinus)

The cotton mouse was chosen as a representative herbivorous small mammal. It is frequently associated with forested areas and moist habitats along the wetland/upland interface (Burt and Grossenheider, 1980). It is common in the Southeast and feeds on grasses, sedges, seeds, fruits, grains, and bark. Since its home range is usually less than 1 acre (U.S. EPA, 1993), it could reside permanently within Site 2.

7.3.3.3 Raccoon (Procyon lotor)

The raccoon was selected as a representative mammalian omnivore. The raccoon is found in a variety of habitats and particularly in swamps, floodplain forests, and marshes. The raccoon is an opportunistic feeder that will consume terrestrial and aquatic plants and animals. Crustaceans are common forage items for raccoons in marine and estuarine environments (U.S. EPA, 1993). The raccoon is the primary mammalian predator of the blue crab (Darnell, 1959). A common but false belief regarding the raccoon's food habits is that a raccoon always washes its food before eating it. When foraging in shallow water, however, a raccoon will sometimes dip a food item in water prior to eating it (Brown, 1997; Lowery, 1974). The size of a raccoon's home range depends on factors such as age, sex, habitat, food sources, and season. A literature review of several studies reported home ranges of up to 6,000 acres, although values of 200 to 600 acres were most common (U.S. EPA, 1993). Raccoon home ranges during a 1-year period on a Georgia coastal island were 160 acres for adult males and 96 acres for adult females (Lotze, 1979).

7.3.3.4 Red fox (*Vulpes vulpes*)

The red fox was chosen as a representative mammalian predator. The red fox is common in South Carolina and the entire eastern United States. It is one of only a few mid-size carnivorous mammals in the region. Its principal food items are small mammals (especially mice and voles) but it also preys on insects and birds. The red fox utilizes many habitat types, but prefers deciduous woodlands and edge areas. Home ranges vary from 50 to over 3,000 acres, but most values in the literature are within a range of 140 to 2100 acres (U.S. EPA, 1993). Thus, although the red fox is known to exist at MCRD Parris Island, Site 2 would comprise only a small portion of its home range.

7.3.3.5 American woodcock (*Scolopax minor*)

The American woodcock was selected as a representative vermivorous (earthworm-eating) avian species. It also consumes insects and other soil invertebrates. The species is common in South Carolina and the entire eastern United States. The woodcock prefers moist woodlands and thickets. Its home range varies from approximately 8 to 185 acres (U.S. EPA, 1993).

7.3.3.6 American robin (Turdus migratorius)

The American robin was chosen as a representative omnivorous bird. Common winter food items include seeds and fruit. Insects and invertebrates, especially earthworms, are eaten more frequently in the spring and summer. The robin is common in South Carolina and the entire eastern United States in a variety of habitats. During the non-breeding seasons, robins in South Carolina are joined by migratory individuals from the northern United States, roaming over large areas and usually forming communal roosts within 1 to 2 miles of foraging areas. The home range during breeding season is approximately 0.5 to 2.0 acres (U.S. EPA, 1993). Therefore, a robin might forage exclusively at Site 2 only during nesting.

7.3.3.7 Great blue heron (Ardea herodias)

The great blue heron was selected as a representative avian carnivore. The species is common in South Carolina and the entire eastern United States. It forages primarily in marshes and along gently sloping shorelines, particularly where small fish are plentiful in shallow areas. Fish are the preferred prey, commonly comprising about 90 to 98 percent of the diet, and are usually less than 25 cm in length. Great blue herons will also consume reptiles, amphibians, and crustaceans (U.S. EPA, 1993). Breeding populations in South Carolina are non-migratory. The distance between foraging areas and communal nesting/roosting areas ranges from 0 to 12 miles (U.S. EPA, 1993). Parnell and Soots (1978) found that the average distance between foraging areas and nesting/roosting areas along the North Carolina coast was 4 to 5 miles. While feeding, individual herons defend areas averaging 1.5 to 20 acres (U.S. EPA, 1993).

7.3.3.8 Osprey (Pandion haliaetus)

In addition to the great blue heron, the osprey was selected as a representative avian piscivore. The osprey would generally be expected to prey on larger fish compared to the great blue heron. Ospreys are found near freshwater or saltwater, and their diet is almost completely restricted to fish. The distance ospreys travel from their nests to forage depends on the availability of suitable nest sites near areas with sufficient fish. Most values in the literature for the osprey's foraging radius were within a range of 0.3 to 6 miles (U.S. EPA, 1993). An active osprey nest is located at the edge of the Archer's Creek inlet adjacent to Site 2, and at least two active osprey nests are located at the mouth of Whale Creek near Elliot's Beach.

7.3.3.9 Red-tailed hawk (Buteo jamaicensis)

The red-tailed hawk was selected as a representative avian carnivore. This hawk is common in South Carolina and the entire eastern United States, and it forages in a variety of habitats. The red-tailed hawk

feeds primarily on small mammals but will also consume small birds, lizards, snakes, and insects (U.S. EPA, 1993). Breeding populations in South Carolina are non-migratory. The home range size is highly variable, depending on the available habitat. Mean home ranges varied from 150 to over 4,300 acres in several studies summarized by U.S. EPA (1993). The home range shown in Table 7-2 (940-2,440 acres) represents the data from habitats most similar to those at MCRD Parris Island (U.S. EPA, 1993). The habitat at Site 2 would constitute a minor portion of the hawk's foraging area.

7.3.3.10 Mummichog (Fundulus heteroclitus)

The mummichog represents a forage fish, i.e., a fish that is a food source of other organisms. The mummichog is one of the most abundant and productive fish species in coastal areas from the Gulf of St. Lawrence to Texas. It inhabits brackish coves, inlets, tidal creeks, and salt marshes. The mummichog feeds primarily on crustaceans, polychaetes, insects, algae, and detritus and is an important food source for many predators. It is one of the most stationary estuarine fish, with a summer home range of approximately 40 yards along tidal creeks; however, some may move as much as 400 yards (Abraham, 1985).

7.3.3.11 Red drum (Sciaenops ocellatus)

The red drum represents upper trophic level fish. This fish is distributed in coastal and estuarine waters from Massachusetts to Mexico. It uses sight and touch to forage primarily on bottom-dwelling animals. Crabs, shrimps, and fish compose the bulk of the diet for adults, and juveniles feed on copepods, amphipods, and small shrimp (Manooch and Raver, 1984; Pattillo et al., 1997). Red drum become sexually mature at 3 years of age. Eggs are spawned in nearshore and inshore waters close to barrier island passes and channels (Pattillo et al., 1997). Red drum are known to occur in the Broad River and probably occur in the tidal inlets near Sites 2 and 15. The body weight of red drum shown in Table 7-2 (1400 g) and used as representative of red drum in the food chain modeling calculations is the approximate maximum weight of a fish that an osprey could lift and carry (Henny, 1988). A sediment ingestion rate could not be located for red drum. However, approximately 15 percent of an adult red drum's diet is composed of detritus (Gerking, 1994). It is assumed that this material is composed entirely of sediment as conservative estimate.

7.3.3.12 Other Potential Receptors

Potential risks to species such as shellfish or other aquatic invertebrates cannot be determined using the food chain model since ingestion toxicity data for these receptors do not exist or are not available. For example, body burdens associated with adverse effects on aquatic invertebrates can be found in the literature, but NOAELs for oral ingestion are sparse. It should be noted that ambient water quality criteria

(AWQCs) for most contaminants are based, in part, on sensitive aquatic species. Also, sediment guidelines are based on potential risks to sediment invertebrates. Thus, the surface water and sediment screening assessment accounts for the exclusion of the aquatic invertebrate species from the food chain modeling.

The osprey was selected to represent piscivorous birds rather than the bald eagle for two reasons. Active osprey nests are located at the shoreline adjacent to the Site 2 landfill and at Elliot's Beach. Thus, ospreys are assumed to forage to a greater extent than eagles at these areas. More importantly, food ingestion on a body weight basis (and thus, the potential dosage) is greater for the osprey than the eagle (U.S. EPA, 1993). For this reason, the use of the osprey as a representative piscivorous bird ensures that risks to the bald eagle are also assessed. The great blue heron rather than the wood stork was selected to represent piscivorous birds since data for body weight and food ingestion rate have been better established to the heron than for the wood stork.

7.4 PRELIMINARY EXPOSURE ESTIMATE

7.4 1 Exposure Point Concentrations

Data used to obtain exposure point contaminant concentrations in this ecological risk assessment were obtained from samples collected in 1996 and 1998. Raw data are presented in Appendix C. The maximum detected concentrations of analytes in surface water (filtered and unfiltered samples), sediment, and surface soil were used as exposure point concentrations and were compared to ecological screening levels.

The maximum detected concentrations in filtered and unfiltered groundwater at Site 2 were used as exposure point contaminants in that medium. Although aquatic and semi-aquatic organisms will not be directly exposed to groundwater contaminants, they could be exposed via groundwater discharge to aquatic environments. Comparing groundwater concentrations to Region IV surface water screening levels is a conservative measure of potential impacts to aquatic media from contaminated groundwater discharge. This measure does not take into account dilution at the discharge point(s), the amount of discharge, location of the point(s) of discharge, direction of groundwater flow, or bioavailability of groundwater contaminants.

U.S. EPA Region IV considers 0- to 1-foot soil samples to be representative of surface soils. Surface soil samples were collected from this depth.

7.4.2 Contaminant Doses for Representative Receptors

Contaminants with maximum concentrations less than Region IV approved ESVs were dropped from further consideration, and those with concentrations that equaled or exceeded ecological screening levels were retained as preliminary COPCs. A simple food chain model was then used to predict dietary exposures of preliminary COPCs for representative receptor species. The predicted exposures were compared to TRVs in the risk calculation step. Both the maximum and mean concentrations of contaminants were used in the model. Means were calculated using one-half the detection limit for "nondetects." Mean concentrations were presented in Tables 4-2 (surface soil), 4-5 (surface water), and 4-6 (sediment). Mean concentrations were used to provide balance to the assessment. The actual dose a receptor species receives as the result of indirect or direct exposure is dependent upon the habits of the species and other factors.

7.4.2.1 Dose Equation

Food chain modeling utilized the following equation to estimate contaminant intake from the ingestion of food and water and incidental ingestion of soil or sediment:

$$PD = [(C_{soil}\ FI * SA * F) + (C_{water} * W * FI) + (C_{food} * F * FA * FI)]/WR$$

where:

PD	=	predicted dose from the ingestion of food, water, and the incidental ingestion of soil or sediment (mg/kg/day)
C_{soil}	=	concentration in soil or sediment (mg/kg)
FI	=	fractional intake (portion of home range that overlaps affected area; assumed to be 100 percent)
SA	=	portion of diet that equals soil or sediment
F	=	food consumed (kg/day)
C_{water}	=	concentration in water (mg/L)
W	=	water consumed (L/day)
WR	=	weight of receptor (kg)
FA	=	portion of diet consisting of animals or vegetation
C_{food}	=	contaminant concentration (vegetation or prey; mg/kg)

The contaminant concentration in food (C_{food} in the equation shown above) was calculated using bioaccumulation factors (BAFs), bioconcentration factors (BCFs), and biota sediment accumulation factors (BSAFs) from published sources (see Appendix F). Values of 1.0 were assumed where BAFs, BCFs, and BSAFs were not available.

Surface soil data were used in the food chain modeling to calculate doses to the shrew, mouse, robin, woodcock, fox, and hawk as follows. Chemical concentrations in terrestrial invertebrates (food items of the shrew, robin, and woodcock) were estimated by multiplying each chemical's surface soil concentration by its associated soil-to-invertebrate BAF. Chemical concentrations in vegetation (food items of the mouse and robin) were estimated by multiplying each chemical's surface soil concentration by its associated soil-to-plant BAF. The resulting estimated concentrations in invertebrates and plants were multiplied by the associated food-to-mammal BAF to derive estimated concentrations in the shrew and mouse, respectively. The estimated mammal concentrations were then used to derive an estimated dose to the hawk and fox. Prey items of the hawk and fox were assumed to consist of equal amounts of shrews and mice. Incidental ingestion of surface soil was also included in the dose equations for the shrew, mouse, robin, woodcock, and fox. Incidental ingestion of surface soil is negligible for birds of prey (Sample and Suter, 1994) and therefore, was not included in the dose equations for the hawk and osprey.

Sediment data were used to calculate doses to the raccoon, heron, osprey, mummichog, and red drum. Since BSAFs do no exist for inorganic compounds, concentrations of inorganic compounds (i.e., metals) in food items of the raccoon, heron, osprey, mummichog, and red drum were assumed to be equal to sediment concentrations. This is a conservative assumption since accumulation transfer through the food chain does not occur for most metals.

The following equation (U.S. EPA, 1997d) was used to estimate tissue concentrations (i.e., the theoretical bioaccumulation potential) of organic compounds in food items of the raccoon, heron, osprey and red drum:

$$TBP = BSAF(C_s/f_{oc})f_l$$

where

TBP	=	theoretical bioaccumulation potential (mg/kg)
C_s	=	chemical concentration in sediment (mg/kg)
BSAF	=	biota-sediment accumulation factor (ratio of the concentration of a chemical in tissue, normalized to lipid, to the concentration of the chemical in surface sediment, normalized to organic carbon)
f_{oc}	=	total organic carbon (TOC) content of sediment expressed as a decimal fraction
f_l	=	organism lipid content expressed as a decimal fraction

The average TOC in sediment samples at Site 2 was 0.958 percent. Thus, the f_{oc} used for that site in the TBP calculations was 0.00958. TOC was not measured in sediment samples at Site 15, so the f_{oc} for that site was assumed to be the same as at Site 2. Lipid content values were assumed to be 3.5 percent for

the mummichog (Iannuzzi, et al., 1996) and 1.1 percent for the red drum (Sullivan and Otwell, 1992). Prey items of the raccoon, heron, and red drum were assumed to consist exclusively of mummichogs, and the osprey was assumed to forage exclusively on red drum.

Incidental ingestion of sediment was also included in the dose equations for the raccoon and red drum but was assumed to be negligible for the heron and osprey (Sample and Suter, 1994). Incidental ingestion of surface water was included in the dose equations for the raccoon and heron.

As stated above, sediment data were used to calculate doses to the raccoon, heron, osprey, mummichog, and red drum. However, BSAFs have not been generated for inorganic chemicals. Therefore, a subsequent food chain modeling iteration was also conducted for Site 2 using filtered surface water data. In this iteration, concentrations in prey items of the raccoon, heron, red drum, and osprey were calculated by multiplying fish BCFs by surface water concentrations. This was not conducted for Site 15 since surface water samples were not collected at that site.

BSAFs were not used to calculate doses to the mummichog. Food items of the mummichog consist of a variety of crustaceans, polychaetes, insects, algae, and detritus (Abraham, 1985) and BSAFs have not been generated for these organisms. Instead, chemical concentrations in food items of the mummichog were conservatively assumed to be equal to measured sediment concentrations.

Most input parameters shown in Table 7-2 for representative receptors were obtained from U.S. EPA's Wildlife Exposure Factors Handbook: Volumes I and II (1993). In general, the values used for the input parameters were the most conservative mean values (e.g., highest mean [upper-bound] food ingestion rate) presented in the U.S. EPA publication. Wet weight food ingestion rates were calculated as follows:

- shrew: 0.541 grams food/gram body weight/day (g/g bw/day) (U.S. EPA, 1993)
- cotton mouse: 8.6 g/day; calculated using rodent equation: $0.621 \times wt^{0.564}$ (U.S. EPA, 1993); converted to wet weight assuming 50 percent water content in food items (vegetation)
- raccoon: 856 g/day; calculated using mammal equation: $0.235 \times wt^{0.822}$ (U.S. EPA, 1993); converted to wet weight assuming 75 percent water content in food items (aquatic organisms)
- red fox: 0.11 g/g bw/day (U.S. EPA, 1993)
- woodcock: 0.77 g/g bw/day (U.S. EPA, 1993)
- robin: 0.89 g/g bw/day (U.S. EPA, 1993)
- heron: 0.18 g/g bw/day (U.S. EPA, 1993)
- osprey: 0.21 g/g bw/day (U.S. EPA, 1993)
- hawk: 0.112 g/g bw/day (U.S. EPA, 1993)

- mummichog: 0.058g/g bw/day (Iannuzzi et al., 1996)
- red drum: 0.02 g/g bw/day (Evans and Engel, 1994)

7.4.2.2 Ingestion of Surface Water

Since water in the tidal inlet near the Site 2 landfill is saline, surface water at that site was not considered to be a source of drinking water. However, some organisms that prey on aquatic species could incidentally ingest surface water while consuming food items. For example, a wading bird or raccoon would probably ingest a small amount of surface water when ingesting aquatic prey. Therefore, the incidental ingestion of unfiltered surface water was investigated for the great blue heron and raccoon at Site 2. The incidental ingestion of surface water was assumed to be negligible for the other representative receptors listed in Table 7-2, due to their feeding habits. The osprey, for example, usually consumes prey items after carrying them to a perch (e.g., tree or nest) and would not incidentally ingest surface water with the prey item. Incidental ingestion of surface water at Elliot's Beach was not investigated. Previous investigations have concluded that site-related surface water contamination was not an issue; therefore, surface water samples were not collected at that site.

A literature review was conducted for data on the amount of surface water incidentally ingested while consuming aquatic prey items. No helpful information was found. Instead, a value was experimentally derived as follows. A euthanized shrimp (11.6 g wet weight) and minnow (0.3 g wet weight), each held by forceps, were submersed in water and then allowed to drip onto a tared, electronic balance. After 60 trials, the average mass of water that dripped from the shrimp was 0.46 g, which equates to 0.0397 g water per gram shrimp (0.46/11.6). After 190 trials, the average mass of water that dripped from the minnow was 0.0484 g, which equates to 0.161 g water per gram minnow (0.0484/0.3). Based on these results, an organism consuming shrimp immediately removed from the water would incidentally ingest an amount of surface water equal to 3.97 percent of the shrimp's body weight. Similarly, consumption of minnows would result in the ingestion of surface water at a ratio of 16.1 percent of the minnow's body weight. The greater of these two values was chosen and conservatively rounded to 20 percent. Thus, daily water consumption in the dose equation for the raccoon and great blue heron was assumed to be 20 percent of the respective food consumption.

7.5 PRELIMINARY RISK CALCULATION

The preliminary risk calculation step in the ecological risk assessment process compared contaminant doses for representative receptors to doses associated with toxic effects (U.S. EPA, 1997b). Prior to this step, the maximum concentrations of contaminants in each medium were compared to Region IV ESVs. The ratio of the exposure point contaminant concentration to the ESV or the modeled dose to the TRV is called the Hazard Quotient (HQ), defined as follows:

$$HQ_i = EPC_i/ESV_i \text{ or } ID_i/TRV$$

where: HQ_i = Hazard Quotient for analyte "i" (unitless)
EPC_i = Exposure Point Concentration for analyte "i" (µg/L or µg/kg or mg/kg)
ESV_i = Ecological Screening Value for analyte "i" (µg/L or µg/kg or mg/kg)
ID_i = Intake Dose for analyte "i" (mg/kg/day)
TRV_i = Toxicity Reference Value for analyte "i" (mg/kg/day)

When the ratio of the exposure point concentration or intake dose to its respective guideline equaled or exceeded 1.0, adverse impacts were considered possible, and the contaminant was retained as a COPC. The HQ value should not be construed as being probabilistic; rather, it is a numerical indicator of the extent to which an exposure point concentration or intake dose exceeds or is less than a guideline. When an HQ value equals or exceeds 1.0, it is an indication that ecological receptors are potentially at risk; additional evaluation or data may be necessary to confirm with greater certainty whether ecological receptors are actually at risk, especially since most guidelines are conservatively derived.

The use of HQs is probably the most common method used for risk characterization in ecological risk assessments. Advantages of this method include the following (Barnthouse et al., 1986):

- The HQ method is relatively easy to use, is generally accepted, and can be applied to any data.
- The method is useful when a large number of contaminants must be screened.

This method of risk characterization has some inherent limitations. One primary limitation is that it is a "no/maybe" method for relating toxicity to exposure. That is, it uses single values for exposure concentrations and guidelines. The HQ method does not account for the variability in both these parameters.

The results of the comparison of maximum contaminant concentrations in each medium to Region IV screening levels are presented in screening tables. The screening tables include the frequency of detection for each analyte, the maximum exposure point concentration, and contaminant-specific Region IV screening level. Tables were also generated that present the HQ values for each representative receptor used in the food chain modeling using maximum contaminant concentrations. Separate tables are provided for average concentrations.

In summary, the COPC selection process was as follows:

1. The maximum concentrations of detected chemicals in Site 2 surface water, groundwater, sediment, and surface soil and in Site 15 sediment and surface soil were compared to Region IV screening levels (ESVs), with the exception of the essential nutrients mentioned earlier. If the maximum concentration was less than the Region IV ESV, the chemical was dropped from further consideration; if it equaled or exceeded the Region IV ESV, the chemical was selected as a COPC. If no Region IV ESV was available, the chemical was selected as a COPC.

2. All COPCs (except VOCs) identified in surface water, sediment, and surface soil were used in the food chain modeling.

3. Groundwater data were not used in the food chain modeling. Aquatic and semi-aquatic organisms will not be directly exposed to groundwater contaminants. It is assumed that potential groundwater discharge to aquatic environments is taken into account through the evaluation of surface water and sediment COPCs.

7.6 SCREENING RESULTS

7.6.1 Surface Water

Eleven analytes in surface water samples were retained as COPCs at Site 2 (Table 7-3). The COPCs consisted of two VOCs (acetone and PCE), one SVOC [bis(2-ethylhexyl) phthalate], one pesticide (endosulfan sulfate),and seven metals (aluminum, antimony, barium, cobalt, iron, manganese, and silver). The HQ for silver was 4.04. Region IV screening values were not available for the remaining 10 COPCs.

7.6.2 Sediment

7.6.2.1 Site 2

There were nine sediment COPCs at Site 2 (Table 7-4). One VOC (chloroform) was detected in sediment. It was retained as a COPC since a Region IV screening value was not available. In addition, Region IV screening values were not available for any of the eight metals that were retained as COPCs (aluminum, barium, hexavalent chromium, cobalt, iron, manganese, selenium, and vanadium). Several PAHs were detected in sediments, but all concentrations were less than Region IV screening values. No pesticides or PCBs were detected in sediments.

7.6.2.2 Site 15

Sediment COPCs at Site 15 consisted of one SVOC and seven metals (Table 7-5). The HQ for bis(2-ethylhexyl) phthalate was 1.54. Region IV screening values were not available for any of the metals that were COPCs (aluminum, barium, beryllium, cobalt, iron, manganese, and vanadium). Pesticides,

and PCBs were not detected in sediments. Several PAHs were detected in sediments, but all concentrations were less than Region IV screening values.

7.6.3 Surface Soil

7.6.3.1 Site 2

Five analytes in surface soil were retained as COPCs at Site 2 (Table 7-6). Two VOCs (acetone and chloroform) were retained as COPCs since no Region IV screening values were available. Three metals were soil COPCs including aluminum (HQ = 85.8), iron (HQ = 9.6), and vanadium (HQ = 2.1). Pesticides and PCBs were not detected in soils.

7.6.3.2 Site 15

Aroclor-1254 was the only COPC detected in surface soils at Site 15 (Table 7-7). This PCB compound was detected in one sample collected in 1996.

7.6.4 Groundwater

Ten analytes in groundwater samples were retained as COPCs (Table 7-8). These consisted of two VOCs (acetone and carbon disulfide), one SVOC [bis(2-ethylhexyl) phthalate], and seven metals (aluminum, barium, copper, iron, manganese, thallium, and zinc). HQ values ranged from 1.92 (zinc) to 11.61 (aluminum). Zinc concentrations exceeded the Region IV screening level only in filtered samples. Region IV screening values were not available for acetone, carbon disulfide, barium, and manganese. In addition, Region IV screening levels for salt surface water were not available for bis(2-ethylhexyl) phthalate, aluminum, and iron. Therefore, the screening levels shown in Table 7-8 for those three analytes are Region IV screening values for fresh surface water. The remaining screening levels in Table 7-8 were the lowest of fresh and salt surface water screening levels.

7.6.5 Food Chain Modeling

7.6.5.1 Site 2

Based on surface soil data, aluminum and iron had at least one HQ greater than 1.0 for the terrestrial food chain modeling using maximum and mean concentrations (Tables 7-9 and 7-10). Vanadium had an HQ greater than 1.0 for the shrew using the maximum concentrations but no HQs greater than 1.0 using mean concentrations.

Based on the aquatic food chain modeling using sediment and surface water data, aluminum, iron, and vanadium had at least one HQ greater than 1.0 using maximum and mean concentrations (Tables 7-11 and 7-12).

The results of the food chain modeling using filtered surface water indicated that no inorganic COPCs had HQ s greater than 1.0 (Tables 7-13 and 7-14).

7.6.5.2 Site 15

Based on the aquatic food chain modeling using sediment data, aluminum, iron, and vanadium had at least one HQ greater than 1.0 using maximum and mean concentrations (Tables 7-15 and 7-16).

Based on the terrestrial food chain modeling using surface soil data, no HQs exceeded 1.0, but one HQ for Aroclor-1254 equaled 1.0 (Table 7-17). All HQs were less than 1.0 using mean concentrations (Table 7-18).

7.7 STEP 3A: REFINEMENT OF CONTAMINANTS OF POTENTIAL CONCERN

The ERA, up to this point, can be considered to be a "screening-level" assessment, or "Tier 1" assessment, since it is based primarily on a conservative initial screening of contaminant concentrations against contaminant-specific screening levels. As noted in Section 7.6, maximum concentrations of several analytes exceed conservative ecological screening levels. The use of conservative guidelines and maximum detected concentrations in the screening-level assessment is necessary to ensure that potential risks are not underestimated. However, if the hazard quotients derived from comparisons of maximum concentrations to conservative screening levels are used as the single factor for including a COPC in a baseline ERA without consideration of other relevant information, additional ecological studies such as toxicity testing or tissue analyses could be undertaken for COPCs that do not actually pose significant risks. For this reason, refinement of COPCs, the first sub-step within Step 3, was incorporated into this ERA. Step 3a involves the consideration of factors such as background data (mainly for inorganics), toxicological evaluation of COPCs, frequency of detection, and comparisons of COPCs to alternate guidelines (U.S. EPA, 1997; DON, 1999).

Some factors that are outside the boundaries of the simple concentration ESV comparisons have already been presented, such as average contaminant concentrations and LOAELs in the food chain modeling. The frequency of detection and spatial analysis of elevated contaminant concentrations were also evaluated as part of Step 3a to determine whether potential risks are widespread or limited to a small area. The magnitude of the HQs was also considered. As described earlier, the relationship between the magnitude of an HQ and toxicity is not necessarily linear. However, the magnitude of an HQ can be used

as a rough approximation of the extent of potential risks, especially if there is sufficient confidence in the guideline used.

The use of less conservative guidelines provides balance to the conservative screening-level assessment. For example, the Region IV sediment ESV for bis(2-ethylhexyl) phthalate is based on the threshold effects level (TEL) established by FDEP (1994). Contaminant concentrations below the TEL (i.e., the minimal effects range) are not considered to represent significant hazards to aquatic organisms, and contaminant concentrations between the TEL and the Probable Effects Level (PEL) constitute the possible effects range (i.e., adverse biological effects are possible). Therefore, ascribing risk to a sediment contaminant detected at a concentration that exceeds the TEL but is below the PEL can be misleading. For this reason, when contaminant concentrations exceed Region IV ESVs, or no Region IV ESV was available, alternative guidelines are presented for sediment and surface soils (Tables 7-19 and 7-20).

Alternative sediment guidelines shown in Table 7-19 include values available from U.S. EPA Region III BTAG, U.S. EPA Region V, Ontario Ministry of Environment, and other sources. Effects Range-Low (ER- L) and Effects Range-Medium (ER-M) values derived by Long et al., (1995) were not available for any sediment COPC, and bis(2-ethylhexyl) phthalate was the only sediment COPC for which a PEL value (FDEP, 1994) was available.

Surface soil guidelines from Oak Ridge National Laboratory indicative of toxicity to soil invertebrates and terrestrial plants (Efroymson et al., 1997a, 1997b) are presented in Table 7-20. In addition, guidelines from U.S. EPA Region III BTAG (1995c) were available for some surface soil COPCs. Soil guidelines from Beyer (1990) and Dutch values (MHSP&E, 1994) were not available for the five soil COPCs identified in the current study.

Few sources of ESVs other than Region IV values are available for surface water. However, U.S. EPA Region III BTAG (1995c) has a few ESVs for analytes in surface water for which U.S. EPA Region IV has no values. These were considered after the initial screening.

Background samples have been collected and analyzed as part of current RFI/RI activities at MCRD Parris Island. As a result, soil, sediment, and surface water background data are available for use in assessing the extent to which chemical concentrations at Sites 2 and 15 are due to site-related activities. Background data are provided in Table 4-1.

A "weight-of-evidence" approach (U.S. EPA, 1997b) was used to determine the extent of potential risks when HQ values exceeded 1.0, although analytes were automatically selected as COPCs if their

maximum concentration HQ exceeded 1.0 after screening against Region IV ESVs. Conclusions regarding the potential risks associated with Sites 2 and 15 and recommendations for additional ecological study or remedial considerations are presented in Section 8.0.

7.8 STEP 3A DISCUSSION

7.8.1 Site 2 - Surface Water

Acetone and PCE were the only VOCs detected in surface water, and both were retained as COPCs since no Region IV ESVs were available. The maximum concentration of PCE (0.3 µg/L) was well below the Region III BTAG ESV of 450 µg/L (U.S. EPA, 1995c). The maximum concentration of acetone (0.8 µg/L) does not appear to be high, although a definitive conclusion regarding its ecological significance cannot be made without adequate toxicity data. However, acetone is a common laboratory contaminant, and in general, VOCs do not bioaccumulate or biomagnify.

A Region IV ESV was not available for bis(2-ethylhexyl) phthalate, the only SVOC that was a COPC in surface water. The maximum concentration of bis(2-ethylhexyl) phthalate was 77 µg/L, which is less than the U.S. EPA Region III BTAG ESV of 360 µg/L (U.S. EPA, 1995c). This compound was not detected in surface soil or sediment, and its maximum concentration in groundwater was only 1 µg/L, suggesting that the presence of this compound in two surface water samples is not site related. Phthalates are common environmental contaminants due to their use in plastics. Phthalates can also be an artifact of the sampling and/or analytical methods.

A Region IV ESV was not available for endosulfan sulfate, the only pesticide that was detected in surface water. Endosulfan sulfate is a metabolite of endosulfan. The Region IV ESV for endosulfan is 0.0087 µg/L, which is also the AWQC. Surface water ESVs for endosulfan sulfate were not available from any source, but the toxicity of endosulfan sulfate to mammals is approximately the same as the parent compound (U.S. EPA, 1980). Food chain modeling did not identify endosulfan sulfate HQs greater than 1.0 for any receptor (Table 7-11). However, as shown in Table 7-11, toxicity reference values based on oral ingestion were not available for fish. Therefore, the predicted concentrations of endosulfan sulfate in whole body mummichog and red drum tissues (Appendix F-3) were compared to values from the Environmental Residue Effects Databse (ERED, 1998). The concentrations predicted using the TBP equation described in Section 7.4.2.1, and based on one-half the maximum detection limit in sediment samples (endosulfan sulfate was not detected in sediments) were 0.082 mg/kg in the mummichog, and 0.026 mg/kg in the red drum. The predicted concentrations using the 0.025 mg/kg deteciton limit would be twice the above values (0.164 mg/kg in mummichog, and 0.052 mg/kg in red drum). These values are less than the only NOED concentration availabel in the ERED data base, a value of 0.195 mg/kg based on mortality in pinfish. Endosulfan sulfate and the parent compound were not detected in groundwater,

sediment, or surface soil. Because endosulfan binds to soil and sediment, its absence in sediment and soil suggests that the presence of this compound in surface water may not be site related.

Silver was the only metal COPC in surface water that had a corresponding Region IV ESV, and the HQ for silver was 4.04. Although there is an acute AWQC for silver (2.3 µg/L), data on chronic aquatic toxicity are sparse. There is no chronic AWQC, and the Region IV ESV is based on a single species. Silver was detected in one unfiltered surface water sample (0.72 µg/L) and in two filtered samples (0.82 and 0.93 µg/L); the detected values were slightly greater than the instrument detection limit (0.7 µg/L). The HQ for silver for the raccoon in the food chain modeling was well below 1.0. The lack of toxicity data prevented the generation of HQs for birds and fish in the food-chain modeling. Silver was not detected in groundwater, sediment, or surface soil.

Region IV saltwater ESVs were not available for aluminum, antimony, barium, cobalt, iron, and manganese. However, maximum concentrations of antimony and barium were well below U.S. EPA Region III BTAG ESVs of 500 µg/L and 10,000 µg/L for antimony and barium, respectively. Maximum concentrations of barium, iron, and manganese were less than background concentrations. In addition, aluminum, antimony, iron, and manganese were not detected in filtered water samples (Table 4-5). As discussed by U.S. EPA (1996a), concentrations of dissolved metals, rather than total metals, more closely approximate the bioavailable fraction of metals in the water column. Aluminum, iron, and vanadium were the only inorganic COPCs in surface water with HQs greater than 1.0 in the aquatic food chain modeling (Tables 7-11 and 7-12). However, as discussed in Section 7.4.2, HQ values for representative aquatic receptors were based on the assumption that food items were equal to sediment concentrations. This assumption was used since BSAFs do no exist for inorganic compounds. A method that probably more closely approximates the contaminant concentrations in food items of these receptors is the use of BCFs and surface water concentrations. All HQ values calculated by this method were less than 1.0 using maximum concentrations of COPCs detected in filtered surface water.

Surface water is often a poor indicator of potential contaminant release and environmental conditions in dynamic systems, such as the tidal inlet adjacent to Site 2, due to the "snapshot" effect. Surface water conditions at the site are heavily influenced by several factors. The concentrations of analytes in surface water near Site 2 will change in relation to the amount of tidal influence and the related amount of water near the site at any given time. For example, tides may bring in analytes from other areas. Tides and tidal movement can also influence the physical chemistry of the surface water, thereby potentially altering the bioavailability of surface water contaminants. Incoming tides, for example, can increase the amount of suspended particulates, which can bind to analytes in solution and reduce their bioavailability. The amount of groundwater discharge can also influence the concentrations of analytes in surface water. If

the surface water samples were collected at or near seeps, representative concentrations may be overestimated if groundwater is contaminated or vice versa at seeps with little contamination.

7.8.2 Site 2 - Groundwater

Acetone and carbon disulfide were the only VOCs that were COPCs in groundwater; a Region IV ESV was not available for either of these compounds. Carbon disulfide was detected in 1 of 5 samples, at 4 µg/L. This exceeded the U.S. EPA Region III BTAG ESV of 2.0 µg/L (U.S. EPA, 1995c), but carbon disulfide was not detected in surface water, sediment, or surface soil. Acetone was detected in two groundwater samples (1.8 and 3.3 µg/L); its maximum concentration in surface water was 0.8 µg/L, and it was not detected in sediment.

Bis(2-ethylhexyl) phthalate was the only SVOC that was a groundwater COPC. Its maximum concentration (1.0 µg/L) exceeded the Region IV fresh water ESV, but was much less than the U.S. EPA Region III BTAG ESV of 360 µg/L in salt water and 30 µg/L in fresh water (U.S. EPA, 1995c). A Region IV ESV for bis(2-ethylhexyl) phthalate in salt water was not available. Phthalates were not detected in sediment or in surface soil.

Maximum groundwater concentrations of five metals (aluminum, copper, iron, thallium, and zinc) exceeded Region IV surface water ESVs, and Region IV ESVs were not available for barium and manganese. As stated in Section 7.4.1, groundwater contaminant concentrations are compared to surface water ESVs as a conservative measure to determine if potential risks to aquatic biota may be possible via discharge of contaminated groundwater. Since dilution will occur upon discharge, groundwater concentrations must, for the most part, significantly exceed surface water concentrations to be of concern. Concentrations of none of the organic or inorganic COPCs in Site 2 groundwater, with the exception of iron, significantly exceeded surface water concentrations. The mean iron concentration in unfiltered groundwater samples was 3,750 µg/L, and 3,271 µg/L in filtered samples. The mean iron concentration in unfiltered surface water was 644 µg/L, while iron was not detected in filtered surface water. Maximum concentrations of iron in unfiltered surface water, however, were less than background concentrations.

7.8.3 Site 2 - Sediment

Region IV ESVs were not available for any of the nine sediment COPCs at Site 2. The maximum concentration of chloroform (5 µg/kg) was less than the sediment guideline of 22 µg/kg (Table 7-19) derived from the secondary chronic value using the equilibrium partitioning approach (Jones et al., 1997).

Maximum concentrations of barium, hexavalent chromium, cobalt, iron, and manganese were less than alternate sediment screening values (Table 7-19). Alternate screening values were not available for aluminum, selenium, and vanadium. Maximum concentrations of aluminum, barium, cobalt, iron, manganese, and vanadium were less than background concentrations (Tables 4-1 and 7-4). Selenium was not detected in background samples.

Aluminum, iron, and vanadium were the only sediment COPCs with HQs greater than 1.0 in the aquatic food chain modeling. However, as stated above, maximum concentrations of these three COPCs were less than background concentrations. Thus, their presence in sediments at Site 2 does not appear to be site related. Furthermore, aluminum and iron are two of the most common elements in the earth's crust, and vanadium is generally not considered to be toxic in the environment (Mailman, 1980). As discussed earlier, the HQs greater than 1.0 for aluminum, iron, and vanadium may be due more to the method of HQ calculation, wherein concentrations of metals in prey items were set equal to sediment concentrations. Aluminum, iron, and vanadium were not detected in filtered surface water samples. With this in mind, and since concentrations of these metals were less than the only sediment ESVs available, concentrations of aluminum, iron, and vanadium in sediments are not considered to represent significant potential risks to aquatic receptors.

7.8.4 Site 2 - Surface Soil

Region IV screening values were not available for acetone or chloroform, the two VOCs that were COPCs in surface soil. Alternate screening values were not available for acetone (Table 7-20). Acetone was detected in 2 of 7 samples from Site 2. Acetone is a common laboratory contaminant. The maximum concentration of chloroform (18 µg/kg) was considerably less than the alternate ESV of 300 µg/kg (Table 7-20). As stated previously, VOCs do not generally bioaccumulate or biomagnify.

Several metals were detected in Site 2 surface soils but only aluminum, iron, and vanadium had concentrations that exceeded Region IV ESVs (Table 7-6). All three COPCs had at least one HQ value greater than 1.0 in the terrestrial food chain modeling using maximum contaminant concentrations (Table 7-9). The HQ value for vanadium slightly exceeded 1.0 for the shrew using maximum concentrations but was less than 1.0 for the other receptors and was less than 1.0 using mean concentrations (Tables 7-9 and 7-10). Concentrations of aluminum exceeded the few available alternate screening values, and concentrations of iron and vanadium exceeded some but were less than other alternate screening levels (Table 7-20). Aluminum and iron are two of the most common elements in the earth's crust. Maximum concentrations of aluminum, iron, and vanadium were considerably less than background concentrations (Tables 4-1 and 7-6). Thus, their presence in surface soils at Site 2 does not appear to be site related.

7.8.5 Site 15 - Sediment

Bis(2-ethylhexyl) phthalate was the only SVOC that was a COPC in sediment at Site 15. This compound was detected in 1 of 3 samples and its HQ was relatively low (HQ = 1.54). The single detected value of 280 µg/kg was considerably less than three alternate screening values for this compound (Table 7-19). Phthalates are common environmental contaminants due to their use in plastics. All HQ values for bis(2-ethylhexyl) phthalate in the food chain modeling were less than 1.0.

Region IV screening values were not available for any of the metals that were sediment COPCs (aluminum, barium, beryllium, cobalt, iron, manganese, and vanadium). Maximum concentrations of barium, cobalt, and iron, and manganese were less than alternate sediment screening values (Table 7-19). Alternate screening values were not available for aluminum, beryllium, and vanadium. Maximum concentrations of aluminum, barium, iron, manganese, and vanadium were considerably less than background concentrations (Tables 4-1 and 7-5). Beryllium was detected in 1 of 3 samples at a concentration of 0.71 mg/kg; this slightly exceeded the background concentration of 0.52 mg/kg. Cobalt concentrations exceeded the background value (2.6 mg/kg) in one sample (3.1 mg/kg).

Aluminum, iron, and vanadium were the only sediment COPCs with HQs greater than 1.0 in the aquatic food chain modeling. However, as stated above, maximum concentrations of these three COPCs were considerably less than background concentrations. Thus, their presence in sediments at Site 15 does not appear to be site related. Furthermore, aluminum and iron are two of the most common elements in the earth's crust. As discussed earlier, the HQs greater than 1.0 for aluminum, iron, and vanadium may be due more to the method of HQ calculation, wherein concentrations of metals in prey items were set equal to sediment concentrations. With this in mind, and since concentrations of these metals were less than background values and/or less than the only sediment ESVs available, concentrations of aluminum, iron, and vanadium in sediments are not considered to represent significant potential risks to aquatic receptors.

7.8.6 Site 15 - Surface Soil

Surface soil samples collected in 1998 were analyzed for PCBs and lead. Lead concentrations in all samples were less than Region IV ESVs (Table 7-7). One PCB compound (Aroclor-1254) was detected in a surface soil sample collected at Site 15 near the landfill in 1996, but no PCB compounds were detected in 1998 samples. PCB detection limits in 1998 samples ranged from 8.8 to 9.4 µg/kg (Appendix C), well below the Region IV ESV of 20 µg/kg. The sample location where the 24 µg/kg value was detected in 1996 (PI-015B-01) was in approximately the same location of PAI-15-SS-01, where PCBs were not detected in 1998. Thus, since PCBs were detected in only one sample, and since the single

detected concentration only slightly exceeded the Region IV ESV, potential risks to ecological receptors from PCBs appear to be negligible.

7.8.7 Food Chain Modeling Considerations

Several conservative assumptions were used in the food chain modeling. For example, the receptors were assumed to spend 100 percent of their life on the sites. While this may be plausible for smaller receptors (e.g., short-tailed shrew and cotton mouse), Sites 2 and 15 comprise a very small portion of the home range of other receptors. Ingestion rates were obtained from captive studies, which may overestimate the amount of food ingested relative to wild animals that may have limited food resources. These conservative assumptions tend to overestimate risks.

Typical home ranges for the woodcock, fox, and red-tailed hawk (terrestrial receptors) and the great blue heron, raccoon, and osprey (semi-aquatic receptors) are much larger than Site 2 (2 acres) or Site 15. Site 15 consists of approximately 2.0 miles of former dirt roads (most of which are now paved). Assuming an average width of 10 feet, Site 15 is approximately 2.4 acres in areal extent. U.S. EPA (1993) presents typical home ranges of 140 to 2,100 acres for the red fox, 8 to 185 acres for the woodcock, 940 to 2,440 acres for the red-tailed hawk, and 96 to 160 acres for the raccoon, and the great blue heron, and osprey roam over areas of several square miles in extent. The home range of the robin is approximately 0.5 to 2.1 acres during the nesting season, while robins often roam 1 to 2 miles between roosting areas and foraging areas during the non-breeding seasons. If these area-use factors (overlap of site size with home range and time per year potentially on site) were used in the modeling, HQ values would drop significantly, especially for the more wide-ranging species.

7.9 SCREENING LEVEL AND STEP 3A UNCERTAINTY ANALYSIS

Uncertainty is associated with all aspects of the ecological risk assessment process. This section provides a summary of the general uncertainties involved in this ecological risk assessment, with a discussion of how they may affect the final risk values and conclusions.

The results of an ecological risk assessment must be reviewed and evaluated to identify the types and magnitudes of uncertainties involved. Relying on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. If numerous conservative assumptions are combined in the ecological risk assessment process, the resulting calculations will propagate the uncertainties associated with each of those assumptions. The resulting bias is toward over-predicting risks. Thus, both the results of the risk assessment and the uncertainties associated with those results must be considered.

Generally, risk assessments carry two types of uncertainty: measurement and informational. Measurement uncertainty refers to the variability inherent in measured data. The risk assessment reflects the accumulated variances of the individual values used for several different parameters. Informational uncertainty stems from the limited availability of necessary information. Often the gap between what is needed and what is available is significant. As examples, information is often absent regarding the effects of some contaminants on wildlife receptors, the biological mechanisms of contaminants, and the impacts of physiological differences on exposure pathways.

- Uncertainty is associated with each of the steps of the risk assessment process:

- Uncertainty in preliminary problem formulation can result from limited information regarding contaminant sources, release mechanisms, and exposure routes.

- Uncertainty in the ecological effects characterization arises from the quality of the existing screening values and toxicity data to support a determination of potential adverse impacts to ecological receptors.

- Uncertainty associated with the exposure assessment includes the methods used and the assumptions made to determine exposure point concentrations or calculate contaminant doses.

7.9.1 Uncertainty in the Preliminary Problem Formulation

The marsh and tidal inlet near the Site 2 landfill and the Broad River at Elliot's Beach (Site 15) could receive contaminant inputs from more than one source, although, initially, contaminants are conservatively assumed to stem directly from activities related to the sites. Since contaminant concentrations may reflect inputs from many sources, including non-Navy sources, uncertainties exist regarding whether risk characterized at the site stems from site-related contaminants.

7.9.2 Uncertainty in the Ecological Effects Characterization

Uncertainty in this risk assessment also arises from the nature and quality of the available toxicity data used to derive guidelines. This uncertainty is reduced when similar effects are observed across species, strain, sex, and exposure route; when the magnitude of the response is clearly dose related; and when mechanisms of toxicity are similar for laboratory and wildlife species. Most guidelines are based on conservative assumptions. Although an inherent level of conservatism is needed in a screening-level ecological risk assessment to ensure that the most sensitive receptors are protected, conservative guidelines may heavily overestimate potential risks and the resulting HQ values may be misleading. Region IV screening levels and the NOAELs and LOAELs used in this assessment are based on

laboratory studies that do not take into account mitigating or ameliorating physical and chemical conditions in the environment. That is, the most bioavailable (i.e., toxic) form of the contaminant is usually applied to the exposure medium. In reality, bioavailability is rarely, if ever, 100 percent. Conversely, laboratory studies frequently ignore potentially exacerbating conditions such as the possibility of synergistic effects of complex mixtures of chemicals and altered sediment chemistry due to periodic hypoxia and resultant pH depression. Ecological guidelines may underestimate potential risks when these factors are inadequately determined.

Conservative guidelines for surface water are set to protect the majority of aquatic organisms from adverse effects on growth, survival, and reproduction. The laboratory testing that is used for the development of guidelines generally uses the most toxic form of the element (ionic species derived from a metal salt such as $AgNO_3$ or CuCl). These guidelines overestimate toxicity by not taking into account the speciation of the metal in a natural water system. U.S. EPA recognizes that other factors such as hardness and organic carbon concentrations have an effect on the toxicity of a metal. U.S. EPA has incorporated hardness coefficients into the freshwater guidelines for many metals, but coefficients for organic carbon have yet to be proposed.

As mentioned earlier, few data are available for investigating dietary exposures and related risks to reptiles and amphibians. The absence of toxicity data for these organisms precludes modeling of potential risks to them. As a result, direct conclusions about the potential risks to reptiles and amphibians cannot be made, and only qualitative inferences can be drawn.

Similarly, few data are available for investigating dietary exposures and related risks to the mummichog and red drum, the species selected as representative fish species to use in the aquatic food chain modeling. Specifically, dietary NOAELs and LOAELs for fish were not available for the COPCs identified at Sites 2 and 15. As a result, direct conclusions about the potential risks to fish through ingestion cannot be made, and only qualitative inferences can be drawn. It should be noted that AWQCs for most contaminants are based, in part, on sensitive aquatic species (including fish species). Thus, the surface water screening assessment at least partially accounts for fish species.

Ecological risk assessments, unlike human health risk assessments, must consider risks to many different species. Calculation of risks for every potential receptor species is not possible. For this ecological risk assessment, conservative guidelines protective of a wide range of ecological receptors were sought. The underlying assumption associated with the use of these guidelines is that contaminant concentrations in excess of these values are indicative of potential impacts to actual receptors inhabiting the area. However, species-specific physiological differences that may influence an organism's response to a contaminant or subtle behavioral differences that may increase/decrease a receptor's contact with a

contaminant are seldom known. Also, some contaminants were present for which no suitable guidelines were available, and as a result, they could not be quantitatively assessed. The use of guidelines, while necessary, will introduce error into the results of an assessment.

7.9.3 Uncertainty in the Exposure Assessment

Uncertainty in the exposure assessment arises mainly in the methods used to obtain exposure-point concentrations. The maximum detected contaminant concentrations were used to represent the highest contaminant concentrations to which ecological receptors might be exposed. If the samples evaluated in this ecological risk assessment are representative of contaminant concentrations associated with the sites, then this approach is conservative and should overestimate potential risks to ecological receptors. The maximum concentration of a contaminant in a given medium may have been collected in a "hot spot" of contamination and may be much higher than the remaining values in the data set. Although use of maximum values is appropriate for screening in an ecological risk assessment, maximum values may grossly over-predict potential risks. To somewhat mitigate these uncertainties, average concentrations were also used, but they do not fully account for the uncertainties involved in selecting exposure-point contaminant concentrations.

Contaminant concentrations in a given medium may under-predict potential risks if sample locations are not properly selected. For example, sediment samples should be collected from areas where sediment deposition is expected to be maximal. Otherwise, sediment data may not be adequate for estimating ecological risks. For this ERA, five sediment samples were collected along the inlet near Site 2, and three sediment samples were collected along the shorelines of the Broad River and Whale Creek near Elliott's Beach (Site 15). Sediment grain size and percent total organic carbon (TOC) data are available for four samples from Site 2 (Table 4-8). The high silt/clay content (28-40 percent) in two of the samples (SD-01-01 and SD-02-01) suggest that these samples were collected from depositional areas. The extent to which the other two samples shown in Table 4-8 were located in depositional areas is uncertain. Their sand content was high (88-93 percent), suggesting that they might not have been collected from depositional areas. However, one sample (SD-04-01) was collected in the marsh between the former landfill and the Archer's Creek inlet. This sample was collected at approximately the lowest point in the marsh, which would presumably be a depositional area. The high sand content in this sample (93 percent) and in sample SD-03-01 (88 percent) might be a result flow patterns in the inlet. Nevertheless, although the sample locations are believed to be representative of sediments near Site 2, some degree of uncertainty remains. Sediment grain size and TOC data were not available for the sediment samples at Site 15. Therefore, although the sample locations are believed to be representative of sediments at the site, some degree of uncertainty exists regarding whether the samples are representative of sediments at Site 15.

Dermal and inhalation exposures were not evaluated in this ecological risk assessment. As discussed in Section 7.2.3, these exposure routes are usually miniscule, but since they cannot be quantitatively assessed, only limited, qualitative conclusions regarding their significance can be drawn and uncertainties remain. Dermal exposure is usually limited by the outer coverings of most receptors. Nonetheless, certain portions of some receptors, such as food pads, eyes, and nose do not contain fur or feathers, for example, and may have a higher chance of exposure. However, these areas generally constitute a small portion of the total surface area of most receptors. Although some of the concentrations of contaminants in surface soils and sediments are elevated, they do not appear to be high enough qualitatively to warrant concern over dermal exposure. Surface water can reach the dermis regardless of outer coverings such as fur and feathers, but interpretability of the surface water data is low.

Inhalation of contaminants is assumed to be miniscule. Airborne aerosols, particulates, and vapors are not assumed to be applicable for aquatic media. As mentioned earlier, bare soil is minimal at the sites. As a result, airborne particles would be expected to be minimal. Concentrations of VOCs in surface soils at Site 2 were low. Nevertheless, burrowing wildlife (e.g., moles) would be exposed to some contaminants via inhalation. However, data regarding inhalation exposure and toxicity for wildlife were not available.

Uncertainty is also associated with the use of literature-based BAFs, BCFs, and BSAFs used in the screening-level food chain modeling. These values often vary considerably between species and sites. This can lead to both over- and underestimation of potential risks.

7.9.4 Uncertainty in the Risk Characterization

Uncertainty in the risk characterization is affected by all aspects of the ecological risk assessment process described in the above sections. Uncertainty in risk characterization also stems, in part, from combining different components of the ecological risk assessment in this step. Each of those components already contains uncertainty. Thus, uncertainties may be propagated when these components are combined. To try to reduce the overall uncertainty in the risk assessment, the weight of evidence approach is used to make risk decisions. This approach takes the results of all aspects of the assessment into account, including the uncertainties, to make determinations of potential risk versus no risk.

7.10 SUMMARY

7.10.1 Site 2

Several metals and organic compounds were detected in groundwater, surface water, sediment, and soil at Site 2. A comparison of analytes and their detected concentrations in groundwater to those in surface water and sediment shows that, with the possible exception of iron, there is no evidence of significant migration of contaminants from groundwater into surface water and sediment. All concentrations of iron in Site 2 sediment and surface water samples, however, were considerably less than background values. With the exception of silver, which was detected in two surface water samples at concentrations slightly greater than the instrument detection limit, concentrations of metals in surface water and sediments were less than Region IV ESVs. Since silver was not detected in any other medium at Site 2, its presence in two surface water samples may not be site related.

Concentrations of metals for which Region IV ESVs were not available in surface water and sediments were either less than background concentrations or less than alternate screening values or their HQ values in the aquatic food chain modeling indicated negligible potential risks to aquatic receptors.

Concentrations of organic compounds in surface water and sediments were low, and none exceeded Region IV ESVs. No PAHs were COPCs in sediments. Pesticides and PCBs were not detected in any sediment samples, and a comparison of detection limits provided in Appendix C with ESVs indicates that the detection limits were sufficiently low enough to conclude that potential risks from these compounds are negligible in Site 2 sediments.

Several metals and organic compounds were detected in Site 2 surface soils but only aluminum, iron, and vanadium had concentrations that exceeded Region IV ESVs. Concentrations of the only organic COPCs were either less than alternate screening values (chloroform) or may have been due to laboratory contamination (acetone). All concentrations of PAH compounds were less than Region IV ESVs. As in sediment, pesticides and PCBs were noticeably absent, in spite of generally adequate detection limits. The HQ value for vanadium only slightly exceeded 1.0 for one representative receptor in the food chain modeling maximum concentration scenario. Maximum concentrations of aluminum, iron, and vanadium were considerably less than background concentrations, suggesting that the presence of these metals in surface soils at Site 2 is not site related.

7.10.2 Site 15

Site 15 consists of dirt roads accessing the Site 2 landfill and Elliot's Beach. Based on the contaminant source at Site 15 (waste oils that were sprayed on the roads for dust suppression) and the physical

nature of the site, contamination of groundwater and surface water from site-related activities is not believed to exist. Sediment samples were analyzed for SVOCs, pesticides, PCBs, and metals, and surface soil samples were analyzed for PCBs and lead.

PCBs were not detected in surface soil samples collected in 1998, in spite of adequate detection limits. One PCB (Aroclor-1254) was detected in 1 of 2 samples collected in 1996. This detection was just slightly greater than screening levels. Lead concentrations in all surface soil samples were less than Region IV ESVs. Thus, potential risks to terrestrial receptors at Site 15 appear to be negligible. Pesticides and PCBs were not detected in any sediment samples, in spite of generally adequate detection limits. Several metals and SVOCs (including several PAH compounds) were detected in Site 15 sediments, but bis(2-ethylhexyl) phthalate was the only analyte with concentrations that exceeded Region IV ESVs. This compound was detected in 1 of 3 samples and its HQ was relatively low (HQ = 1.54). The single detected value of 280 µg/kg was considerably less than alternate screening values. All HQ values for bis(2-ethylhexyl) phthalate in the food chain modeling were less than 1.0.

Region IV screening values were not available for the metals that were sediment COPCs (aluminum, barium, beryllium, cobalt, iron, manganese, and vanadium). Aluminum, iron, and vanadium were the only sediment COPCs with HQs greater than 1.0 in the aquatic food chain modeling. However, maximum concentrations of these three COPCs were less than background concentrations. Thus, their presence in sediments at Site 15 does not appear to be site related. Concentrations of all COPCs in sediments were either less than background concentrations or less than alternate screening values or their HQ values in the aquatic food chain modeling indicated negligible potential risks to aquatic wildlife. Thus, sediment COPCs are not considered to represent significant potential risks to aquatic receptors.

TABLE 7-1

TOXICITY REFERENCE VALUES (TRVs) FOR MAMMALS, BIRDS, AND FISH
SITE 2 - BORROW PIT LANDFILL AND SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Mammal NOAEL Derived TRV (mg/kg/day)	Mammal LOAEL Derived TRV (mg/kg/day)	Avian NOAEL Derived TRV (mg/kg/day)	Avian LOAEL Derived TRV (mg/kg/day)	Fish NOAEL Derived TRV (mg/kg/day)	Fish LOAEL Derived TRV (mg/kg/day)	NOAEL Source	LOAEL Source
Semivolatile Organic Compounds								
Bis(2-ethylhexyl)phthalate	18.3	183	1.1	11	NA	NA	Sample et al., 1996	Sample et al., 1996
Pesticides/PCBs								
Aroclor-1254	0.068	0.68	0.18	1.8	NA	NA	Sample et al., 1996	Sample et al., 1996
Endosulfan Sulfate[1]	0.15	1.5	10	100	NA	NA	Sample et al., 1996	Sample et al., 1996
Inorganic Compounds								
Aluminum	1.93	19.3	109.7	1097	NA	NA	Sample et al., 1996	Sample et al., 1996
Antimony	0.125	1.25	NA	NA	NA	NA	Sample et al., 1996	Sample et al., 1996
Barium	5.1	51	20.8	41.7	NA	NA	Sample et al., 1996	Sample et al., 1996
Beryllium	0.66	6.6	NA	NA	NA	NA	Sample et al., 1996	Sample et al., 1996
Chromium (hexavalent)	3.28	13.14	NA	NA	NA	NA	Sample et al., 1996	Sample et al., 1996
Cobalt	1	10	1	10	NA	NA	ERT, 1997	ERT, 1997
Iron	50	500	100	1000	NA	NA	ERT, 1997	ERT, 1997
Manganese	88	284	977	9770	NA	NA	Sample et al., 1996	Sample et al., 1996
Selenium	0.2	0.33	0.4	0.8	NA	NA	Sample et al., 1996	Sample et al., 1996
Silver	1.8	18	NA	NA	NA	NA	Rungby & Danscher, 1984	Rungby & Danscher, 1984
Vanadium	0.21	2.1	11.4	114	NA	NA	Sample et al., 1996	Sample et al., 1996

NA = NOAEL/LOAEL not available
1 Endosulfan used as a surogate for Endosulfan sulfate.

TABLE 7-2

EXPOSURE PARAMETERS FOR REPRESENTATIVE ECOLOGICAL RECEPTORS SITE 2 - BORROW PIT LANDFILL AND SITE 15 - DIRT ROADS MCRD PARRIS ISLAND, SOUTH CAROLINA

Receptor	Representative Group	Body Weight[1] (grams)	Food Ingestion[1,2] (grams/day)	Assumed Diet for Exposure Assessment[1]	Home Range[1] (acres)
Short-tailed shrew (*Blarina carolinensis*)	Insectivorous mammal	9.73[3]	5.2	90% invertebrates 10% soil	0.96[1] to 2.4[3]
Cotton mouse (*Peromyscus gossypnius*)	Herbivorous Mammal	31[4]	8.6	98% vegetation 2% soil[5]	0.05 to 0.3[5]
Raccoon (*Procyon lotor*)	Omnivorous Mammal	3990	856	90.6% aquatic invertebrates 9.4% sediment	96 to 160
Red fox (*Vulpes vulpes*)	Predatory Mammal	4530	498	97.2% prey 2.8% soil	140 to 2100
American woodcock (*Scolopax minor*)	Vermivorous Bird	197	152	89.6% invertebrates 10.4% soil	8 to 185
American robin (*Turdus migratorius*)	Omnivorous Bird	77.3	69	35% invertebrates 60% vegetation 5% soil[6]	0.5 to 2.1 (nesting season)
Great Blue Heron (*Ardea herodias*)	Piscivorous Bird	2229	401	100% fish soil, sediment: none[6]	0.2 to 5 miles[7]
Osprey (*Pandion haliaetus*)	Piscivorous Bird	1486	312	100% fish soil, sediment: none[6]	0.3 to 6 miles[7]
Red-tailed hawk (*Buteo jamaicensis*)	Carnivorous Bird	1126	126	100% prey soil, sediment: none[6]	940 to 2440
Mummichog (*Fundulus heteroclitus*)	Forage fish	3.0[8]	0.174[8]	N/A; exposure assumed equal to sediment concentrations	40-400 yds in tidal creeks[9]
Red drum (*Sciaenops ocellatus*)	Upper trophic level fish	1400[10]	28[11]	85% prey, 15% sediment[12]	not available

1. Exposure parameters are from U.S. EPA (1993) unless otherwise noted.
2. Food ingestion includes intended food items and incidentally ingested soil or sediment. For example, a shrew would be expected to consume 4.7 g invertebrates plus 0.5 g soil per day. See Section 7.4.2.1 of text for ingestion formulas.
3. Cothran et al. (1991)
4. Lowery (1974)
5. Based on deer mouse (*Peromyscus maniculatus*)
6. Sample and Suter (1994)
7. Foraging radius (home range acreage not available)
8. Iannuzzi et al. (1996)
9. Abraham (1985)
10. Wenner (1992). See Section 7.3.3.11 of text.
11. Evans and Engel (1994)
12. Gerking (1994). See Section 7.3.3.11 of text.

TABLE 7-3

SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SITE 2 - BORROW PIT LANDFILL - SURFACE WATER
MCRD PARRIS ISLAND, SOUTH CAROLINA

Analyte	Frequency of Detection	Range of Detection		Location of Maximum	EPA Region 4 Screening Level	Maximum Hazard Quotient	Selected as COPC (Yes/No?)
		Minimum	Maximum				
VOLATILE ORGANIC COMPOUNDS (µg/L)							
Acetone	2/2	0.6	0.8	PAI-02-SW-02-00	NA	NA	Yes
Tetrachloroethene	1/4	0.3	0.3	PAI-02-SW-02-00	NA	NA	Yes
SEMIVOLATILE ORGANIC COMPOUNDS (µg/L)							
Bis(2-Ethylhexyl)phthalate	2/4	14	77	PAI-02-SW-01-00	NA	NA	Yes
Phenanthrene	2/4	0.074	0.16	PAI-02-SW-04-00	23.5	0.01	No
PESTICIDES/PCBs (µg/L)							
Endosulfan Sulfate	2/4	0.04	0.078	PAI-02-SW-01-00	NA	NA	Yes
METALS/INORGANICS (µg/L)							
Aluminum	3/4	1030	1850	PAI-02-SW-02-00	NA	NA	Yes
Antimony	1/4	2.8	2.8	PAI-02-SW-04-00	NA	NA	Yes
Arsenic	2/4	2.9	5.9	PAI-02-SW-02-00-F	36	0.16	No
Barium	4/4	18.1	233	PAI-02-SW-02-00-F	NA	NA	Yes
Cobalt	2/4	0.67	1.1	PAI-02-SW-01-00-F	NA	NA	Yes
Iron	3/4	417	1220	PAI-02-SW-02-00	NA	NA	Yes
Manganese	2/4	31.6	34.7	PAI-02-SW-01-00	NA	NA	Yes
Silver	2/4	0.72	0.93	PAI-02-SW-01-00-F	0.23	4.04	Yes
Zinc	4/4	4.1	52.8	PAI-02-SW-02-00-F	86	0.61	No

NOTE: The maximum concentrations shown above indicate the maximum concentration of filtered and unfiltered samples. See Table 4-4 and Appendix C for filtered vs. unfiltered data. The denominator in the frequency of detection refers to the number of sample locations; one filtered plus one unfiltered sample was collected at each sample location.

TABLE 7-4

SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SITE 2 - BORROW PIT LANDFILL - SEDIMENT
MCRD PARRIS ISLAND, SOUTH CAROLINA

Analyte	Frequency of Detection	Range of Detections		Location of Maximum	EPA Region 4 Screening Level	Maximum Hazard Quotient	Selected as COPC (Yes/No?)
		Minimum	Maximum				
VOLATILE ORGANIC COMPOUNDS (µg/kg)							
Chloroform	2/5	4	5	PAI-02-SD-04-01	NA	NA	Yes
SEMIVOLATILE ORGANIC COMPOUNDS (µg/kg)							
Benzo(a)anthracene	1/4	8.2	8.2	PAI-02-SD-04-01	74.8	0.11	No
Benzo(a)pyrene	2/4	7.3	12	PAI-02-SD-04-01	88.8	0.14	No
Benzo(b)fluoranthene	2/4	5.6	18	PAI-02-SD-04-01	88.8	0.20	No
Benzo(k)fluoranthene	1/4	8	8	PAI-02-SD-04-01	88.8	0.09	No
Chrysene	2/4	11	21	PAI-02-SD-04-01	108	0.19	No
Fluoranthene	1/4	38	38	PAI-02-SD-04-01	113	0.34	No
Indeno(1,2,3-cd)pyrene	2/4	7	12	PAI-02-SD-04-01	88.8	0.14	No
Phenanthrene	2/4	8	11	PAI-02-SD-04-01	86.7	0.13	No
Pyrene	1/4	30	30	PAI-02-SD-04-01	153	0.20	No
METALS/INORGANICS (mg/kg)							
Aluminum	5/5	3140	5560	PAI-02-SD-02-02	NA	NA	Yes
Arsenic	5/5	0.79	2.1	PAI-02-SD-01-01	7.24	0.29	No
Barium	5/5	4.9	7.9	PAI-02-SD-02-02*	NA	NA	Yes
Chromium (total)	5/5	5.9	10.1	PAI-02-SD-01-01	52.3	0.19	No
Chromium (hexavalent)	2/3	1.1	1.6	PAI-02-SD-02-01	NA	NA	Yes
Cobalt	2/5	0.35	0.52	PAI-02-SD-03-01	NA	NA	Yes
Copper	5/5	1.2	3.2	PAI-02-SD-01-01	18.7	0.17	No
Iron	5/5	2650	5390	PAI-02-SD-01-01	NA	NA	Yes
Lead	5/5	3.2	7.1	PAI-02-SD-02-02*	30.2	0.24	No
Manganese	5/5	22.7	52.4	PAI-02-SD-04-01	NA	NA	Yes
Mercury	1/5	0.04	0.04	PAI-02-SD-02-02	0.13	0.31	No
Nickel	5/5	0.82	2.1	PAI-02-SD-01-01	15.9	0.13	No
Selenium	5/5	0.23	0.42	PAI-02-SD-01-01	NA	NA	Yes
Vanadium	5/5	6.1	12.8	PAI-02-SD-01-01	NA	NA	Yes
Zinc	3/5	10.9	12.6	PAI-02-SD-01-01	124	0.10	No

* Maximum concentration also measured at the following locations:

Barium	Lead
PAI-02-SD-02-01	PAI-02-SD-01-01
PAI-02-SD-01-01	

TABLE 7-5

SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SITE 15 - DIRT ROADS - SEDIMENT
MCRD PARRIS ISLAND, SOUTH CAROLINA

Analyte	Frequency of Detection	Range of Detections		Location of Maximum	EPA Region 4 Screening Level	Maximum Hazard Quotient	Selected as COPC (Yes/No?)
		Minimum	Maximum				
SEMIVOLATILES (µg/kg)							
Benzo(a)anthracene	1/3	15	15	PAI-15-SD-03-01	74.8	0.20	No
Benzo(a)pyrene	1/3	12	12	PAI-15-SD-03-01	88.8	0.14	No
Benzo(b)fluoranthene	2/3	3.8	33	PAI-15-SD-03-01	88.8	0.37	No
Benzo(g,h,i)perylene	1/3	13	13	PAI-15-SD-03-01	88.8	0.15	No
Benzo(k)fluoranthene	1/3	12	12	PAI-15-SD-03-01	88.8	0.14	No
Bis(2-Ethylhexyl)phthalate	1/3	280	280	PAI-15-SD-02-01	182	1.54	Yes
Chrysene	3/3	11	28	PAI-15-SD-03-01	108	0.26	No
Fluoranthene	2/3	9.3	34	PAI-15-SD-03-01	113	0.30	No
Fluorene	1/3	13	13	PAI-15-SD-02-01	21.2	0.61	No
Indeno(1,2,3-cd)pyrene	2/3	13	46	PAI-15-SD-02-01	88.8	0.52	No
Phenanthrene	2/3	8.1	14	PAI-15-SD-02-01	86.7	0.16	No
Pyrene	1/3	28	28	PAI-15-SD-03-01	153	0.18	No
METALS/INORGANICS (mg/kg)							
Aluminum	3/3	648	15500	PAI-15-SD-03-01	NA	NA	Yes
Antimony	1/3	0.2	0.2	PAI-15-SD-02-01	2	0.10	No
Arsenic	3/3	0.3	6.5	PAI-15-SD-03-01	7.24	0.90	No
Barium	3/3	1.9	19.4	PAI-15-SD-03-01	NA	NA	Yes
Beryllium	1/3	0.71	0.71	PAI-15-SD-03-01	NA	NA	Yes
Cadmium	1/3	0.16	0.16	PAI-15-SD-03-01	0.676	0.24	No
Chromium	3/3	2	27.8	PAI-15-SD-03-01	52.3	0.53	No
Cobalt	2/3	0.69	3.1	PAI-15-SD-03-01	NA	NA	Yes
Copper	2/3	4	8.7	PAI-15-SD-03-01	18.7	0.47	No
Iron	3/3	604	14700	PAI-15-SD-03-01	NA	NA	Yes
Lead	3/3	2.7	11.3	PAI-15-SD-03-01	30.2	0.37	No
Manganese	3/3	5.3	113	PAI-15-SD-03-01	NA	NA	Yes
Nickel	2/3	1.5	6.5	PAI-15-SD-03-01	15.9	0.41	No
Vanadium	3/3	2.3	37.4	PAI-15-SD-03-01	NA	NA	Yes
Zinc	2/3	12.9	32.3	PAI-15-SD-03-01	124	0.26	No

NA = Ecological Screening Level not available.

TABLE 7-6

SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SITE 2 - BORROW PIT LANDFILL - SURFACE SOIL
PARRIS ISLAND, SOUTH CAROLINA

Parameter	Frequency of Detection	Range of Detection		Location of Maximum	EPA Region 4 Screening Level	Maximum Hazard Quotient	Selected as COPC (Y/N?)
		Minimum	Maximum				
Volatiles (µg/kg)							
Acetone	2/7	18	170	PAI-02-SS-08-01	NA	NA	Yes
Chloroform	6/8	2	18	PAI-02-SS-04-01	NA	NA	Yes
Toluene	1/8	3	3	PAI-02-SS-01-01	50	0.06	No
Semivolatiles (µg/kg)							
Anthracene	1/8	1.3	1.3	PAI-02-SS-02-01	100	0.01	No
Benzo(b)fluoranthene	4/8	0.9	2.3	PAI-02-SS-07-01	100	0.02	No
Chrysene	1/8	2.9	2.9	PAI-02-SS-07-01	100	0.03	No
Fluoranthene	2/8	4.7	7.7	PAI-02-SS-01-01	100	0.08	No
Indeno(1,2,3-cd)pyrene	1/8	4.7	4.7	PAI-02-SS-08-01	100	0.05	No
Phenanthrene	6/8	3.2	41	PAI-02-SS-06-01	100	0.41	No
Inorganics (mg/kg)							
Aluminum	8/8	1710	4290	PAI-02-SS-04-01	50	85.80	Yes
Antimony	1/8	0.17	0.17	PAI-02-SS-01-01	3.5	0.05	No
Arsenic	4/8	0.18	1	PAI-02-SS-07-01	10	0.10	No
Barium	8/8	4.4	12	PAI-02-SS-02-01	165	0.07	No
Chromium	8/8	3.5	7.5	PAI-02-SS-07-01	64	0.12	No
Cobalt	5/8	0.03	0.19	PAI-02-SS-04-01	20	0.01	No
Copper	2/8	1.1	1.7	PAI-02-SS-05-01	40	0.04	No
Iron	8/8	382	1930	PAI-02-SS-04-01	200	9.65	Yes
Lead	5/8	1.7	5.7	PAI-02-SS-04-01	50	0.11	No
Manganese	6/8	2.6	58.1	PAI-02-SS-04-01	100	0.58	No
Mercury	5/8	0.03	0.05	PAI-02-SS-06-01*	0.1	0.50	No
Nickel	1/8	1.2	1.2	PAI-02-SS-04-01	30	0.04	No
Selenium	1/8	0.18	0.18	PAI-02-SS-04-01	0.81	0.22	No
Vanadium	8/8	1.4	4.1	PAI-02-SS-04-01	2	2.10	Yes
Zinc	3/8	1.2	2.3	PAI-02-SS-01-01	50	0.05	No

NA = Not Available
* Maximum concentration also measured at the following locations:
PAI-02-SS-04-01
PAI-02-SS-01-01

TABLE 7-7

SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SITE 15 - DIRT ROADS - SURFACE SOIL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Analyte	Frequency of Detection	Range of Detections		Location of Maximum	EPA Region 4 Screening Level	Maximum Hazard Quotient	Selected as COPC (Yes/No?)
		Minimum	Maximum				
PESTICIDES/PCBs (µg/kg)							
Aroclor-1254*	1/9	24	24	PI-015B-01	20	1.2	Yes
METALS/INORGANICS(mg/kg)							
Lead	7/7	4	18.4	PAI-15-SS-07-01	50	0.37	No

* Aroclor-1254 was detected in one sample that was collected in 1996.

TABLE 7-8

SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SITE 2 - BORROW PIT LANDFILL - GROUNDWATER
MCRD PARRIS ISLAND, SOUTH CAROLINA

Parameter	Frequency of Detection	Range of Detection		Location of Maximum Positive Detect	EPA Region 4 Screening Level	Maximum Hazard Quotient	Selected as COPC (Yes/No?)
		Minimum	Maximum				
VOLATILE ORGANIC COMPOUNDS (µg/L)							
Acetone	2/3	1.8	3.3	PAI-02-GW-04-01	NA	NA	Yes
Carbon Disulfide	1/5	4	4	PAI-02-GW-05-01	NA	NA	Yes
Chloroform	1/5	2.9	2.9	PAI2-GW2-01	289	0.01	No
Chloromethane	1/5	0.35	0.35	PAI2-GW3-01-AVG	2700	1.30E-04	No
SEMIVOLATILE ORGANIC COMPOUNDS (µg/L)							
Bis(2-Ethylhexyl) phthalate	4/5	1	1	PAI2-GW2-01*	0.3	3.33	Yes
Diethyl Phthalate	1/5	1	1	PAI2-GW-05-01	75.9	1.32E-02	No
METALS/INORGANICS (µg/L)							
Aluminum	1/5	189	1010	PAI2-GW1-01	87	11.61	Yes
Arsenic	4/5	1.0	1.5	PAI2-GW1-01	36	0.04	No
Barium	5/5	33.7	243	PAI-02-GW-04-01-F	NA	NA	Yes
Chromium	1/5	5	5.2	PAI2-GW3-01-AVG	11	0.47	No
Copper	2/5	3.9	28.8	PAI2-GW1-01	2.9	9.93	Yes
Iron	5/5	405	8370	PAI-02-GW-05-01	1000	8.37	Yes
Manganese	5/5	35.5	187	PAI-02-GW-05-01	NA	NA	Yes
Thallium	2/5	18	18	PAI2-GW2-01	4	4.50	Yes
Zinc	4/5	5.5	113	PAI2-GW1-01-F	58.91	1.92	Yes

* Maximum concentration also measured at the following locations:
PAI-02-GW-05-01
PAI2-GW1-01
PAI-02-GW-04-01

Note: The maximum concentrations shown above indicate the maximum concentration of filtered and unfiltered samples. See Table 4-3 and Appendix C for filtered vs. unfiltered data. The denominator in the frequency of detection refers to the number of sample lcoations; one filtered plus one unfiltered sample was collected at each sample location.

TABLE 7-9

RESULTS OF FOOD CHAIN MODELING
TERRESTRIAL RECEPTORS
MAXIMUM CONCENTRATIONS
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological Contaminant of Potential Concern	Shrew		Mouse		Robin		Hawk		Fox		Woodcock	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
METALS AND INORGANICS												
Aluminum	**1.75E+02**	**1.75E+01**	**1.28E+01**	**1.28E+00**	**2.41E+00**	2.41E-01	8.83E-03	8.83E-04	**7.32E+00**	7.32E-01	**4.57E+00**	4.57E-01
Iron	**2.77E+00**	2.77E-01	**1.07E+01**	**1.07E+00**	**1.14E+01**	**1.14E+00**	**1.12E+00**	1.12E-01	**2.26E+00**	2.26E-01	**2.06E+00**	2.06E-01
Vanadium	**1.41E+00**	1.41E-01	1.14E-01	1.,14E-02	2.06E-02	2.06E-03	1.05E-04	1.05E-05	6.55E-02	6.55E-03	3.86E-02	3.86E-03

TABLE 7-10

RESULTS OF FOOD CHAIN MODELING
TERRESTRIAL RECEPTORS
MEAN CONCENTRATIONS
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological Contaminant of Potential Concern	Shrew		Mouse		Robin		Hawk		Fox		Woodcock	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
METALS AND INORGANICS												
Aluminum	**1.04E+02**	**1.04E+01**	**7.61E+00**	7.61E-01	**1.43E+00**	1.43E-01	5.25E-03	5.25E-04	**4.35E+00**	4.35E-01	**2.72E+00**	2.72E-01
Iron	9.94E-01	9.94E-02	**3.85E+00**	3.85E-01	**4.10E+00**	4.10E-01	4.03E-01	4.03E-02	8.12E-01	8.12E-02	7.43E-01	7.43E-02
Vanadium	7.18E-01	7.18E-02	5.81E-02	5.81E-03	1.05E-02	1.05E-03	5.34E-05	5.34E-06	3.34E-02	3.34E-03	1.96E-02	1.96E-03

TABLE 7-11

RESULTS OF FOOD CHAIN MODELING
AQUATIC RECEPTORS
MAXIMUM CONCENTRATIONS
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological Contaminant of Potential Concern	Raccoon		Heron		Mummichog		Red Drum		Osprey	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Semivolatile Organic Compounds										
Bis(2-ethylhexyl) phthalate	1.80E-04	1.80E-05	2.51E-03	2.51E-04	NA	NA	NA	NA	ND	ND
Pesticides										
Endosulfan Sulfate	1.08E-01	1.08E-02	1.48E-03	1.48E-04	NA	NA	NA	NA	5.42E-04	5.42E-05
Inorganics										
Aluminum	**6.18E+02**	**6.18E+01**	**9.12E+00**	9.12E-01	NA	NA	NA	NA	**1.06E+01**	**1.06E+00**
Antimony	9.60E-04	9.60E-05	NA	NA	NA	NA	NA	NA	NA	NA
Barium	3.33E-01	3.33E-02	6.84E-02	3.41E-02	NA	NA	NA	NA	7.97E-02	3.98E-02
Chromium (hexavalent)	1.10E-01	2.74E-02	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	1.12E-01	1.12E-02	9.36E-02	9.36E-03	NA	NA	NA	NA	1.09E-01	1.09E-02
Iron	**2.31E+01**	**2.31E+00**	**9.70E+00**	9.70E-01	NA	NA	NA	NA	**1.13E+01**	**1.13E+00**
Manganese	1.28E-01	3.96E-02	9.65E-03	9.65E-04	NA	NA	NA	NA	1.13E-02	1.13E-03
Selenium	6.86E-01	4.16E-01	2.88E-01	1.44E-01	NA	NA	NA	NA	2.20E-01	1.10E-01
Silver	1.71E-05	1.71E-06	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	**1.31E+01**	**1.31E+00**	2.02E-01	2.02E-02	NA	NA	NA	NA	2.36E-01	2.36E-02

NA = NOAEL/LOAEL not available
ND = Not detected in sediment

TABLE 7-12

RESULTS OF FOOD CHAIN MODELING
AQUATIC RECEPTORS
MEAN CONCENTRATIONS
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological Contaminant of Potential Concern	Raccoon		Heron		Mummichog		Red Drum		Osprey	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Semivolatile Organic Compounds										
Bis(2-ethylhexyl) phthalate	5.91E-05	5.91E-06	8.24E-04	8.24E-05	NA	NA	NA	NA	ND	ND
Pesticides										
Endosulfan Sulfate	8.41E-02	8.41E-03	1.15E-03	1.15E-04	NA	NA	NA	NA	4.21E-04	4.21E-05
Inorganics										
Aluminum	**5.00E+02**	**5.00E+01**	**7.38E+00**	7.38E-01	NA	NA	NA	NA	**8.61E+00**	8.61E-01
Antimony	4.89E-04	4.89E-05	NA	NA	NA	NA	NA	NA	NA	NA
Barium	2.91E-01	2.91E-02	5.99E-02	2.99E-02	NA	NA	NA	NA	6.99E-02	3.48E-02
Chromium (hexavalent)	7.50E-02	1.87E-02	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	8.86E-02	8.86E-03	7.43E-02	7.43E-03	NA	NA	NA	NA	8.67E-02	8.67E-03
Iron	**1.64E+01**	**1.64E+00**	**6.88E+00**	6.88E-01	NA	NA	NA	NA	**8.03E+00**	8.03E-01
Manganese	8.60E-02	2.67E-02	6.50E-03	6.50E-04	NA	NA	NA	NA	7.58E-03	7.58E-04
Selenium	5.96E-01	3.61E-01	2.50E-01	1.25E-01	NA	NA	NA	NA	1.76E-01	8.82E-02
Silver	1.05E-05	1.05E-06	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	**1.02E+01**	**1.02E+00**	1.57E-01	1.57E-02	NA	NA	NA	NA	1.84E-01	1.84E-02

NA = NOAEL/LOAEL not available
ND = Not detected in sediment

TABLE 7-13

RESULTS OF FOOD CHAIN MODELING
AQUATIC RECEPTORS
MAXIMUM CONCENTRATIONS - FILTERED SURFACE WATER
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological Contaminant of Potential Concern	Raccoon		Heron		Mummichog		Red Drum		Osprey	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Inorganics										
Barium	6.87E-02	6.87E-03	8.46E-03	4.22E-03	NA	NA	NA	NA	9.41E-03	4.69E-03
Cobalt	5.54E-02	5.54E-03	4.16E-02	4.16E-03	NA	NA	NA	NA	4.85E-02	4.85E-03
Silver	7.24E-05	7.24E-06	NA	NA	NA	NA	NA	NA	NA	NA

NA = NOAEL/LOAEL not available

TABLE 7-14

RESULTS OF FOOD CHAIN MODELING
AQUATIC RECEPTORS
MEAN CONCENTRATIONS - FILTERED SURFACE WATER
SITE 2 - BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological Contaminant of Potential Concern	Raccoon		Heron		Mummichog		Red Drum		Osprey	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Inorganics										
Barium	3.91E-02	3.91E-03	2.65E-03	1.32E-03	NA	NA	NA	NA	2.94E-03	1.47E-03
Cobalt	3.52E-02	3.52E-03	2.48E-02	2.48E-03	NA	NA	NA	NA	2.90E-02	2.90E-03
Silver	4.77E-05	4.77E-06	NA	NA	NA	NA	NA	NA	NA	NA

NA = NOAEL/LOAEL not available

TABLE 7-15

RESULTS OF FOOD CHAIN MODELING
AQUATIC RECEPTORS
MAXIMUM CONCENTRATIONS
SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological Contaminant of Potential Concern	Raccoon		Heron		Mummichog		Red Drum		Osprey	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Semivolatile Organic Compounds										
Bis(2-ethylhexyl) phthalate	1.12E-02	1.12E-03	1.67E-01	1.67E-02	NA	NA	NA	NA	6.14E-02	6.14E-03
Metals and Inorganics										
Aluminum	**1.72E+04**	**1.72E+03**	**2.54E+02**	**2.54E+01**	NA	NA	NA	NA	**2.97E+02**	**2.97E+01**
Barium	8.16E-01	8.16E-02	1.68E-01	8.37E-02	NA	NA	NA	NA	1.96E-01	9.77E-02
Beryllium	2.31E-01	2.31E-02	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	6.65E-01	6.65E-02	5.58E-01	5.58E-02	NA	NA	NA	NA	6.51E-01	6.51E-02
Iron	**6.31E+01**	**6.31E+00**	**2.64E+01**	**2.64E+00**	NA	NA	NA	NA	**3.09E+01**	**3.09E+00**
Manganese	2.75E-01	8.54E-02	2.08E-02	2.08E-03	NA	NA	NA	NA	2.43E-02	2.43E-03
Vanadium	**3.82E+01**	**3.82E+00**	5.90E-01	5.90E-02	NA	NA	NA	NA	6.89E-01	6.89E-02

NA = NOAEL/LOAEL not available

TABLE 7-16

RESULTS OF FOOD CHAIN MODELING
AQUATIC RECEPTORS
MEAN CONCENTRATIONS
SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological Contaminant of Potential Concern	Raccoon		Heron		Mummichog		Red Drum		Osprey	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Semivolatile Organic Compounds										
Bis(2-ethylhexyl) phthalate	1.10E-02	1.10E-03	1.65E-01	1.65E-02	NA	NA	NA	NA	6.06E-02	6.06E-03
Metals and Inorganics										
Aluminum	**7.73E+02**	**7.73E+01**	**1.14E+01**	**1.14E+00**	NA	NA	NA	NA	**1.33E+01**	**1.33E+00**
Barium	3.91E-01	3.91E-02	8.04E-02	4.01E-02	NA	NA	NA	NA	9.39E-02	4.68E-02
Beryllium	9.16E-02	9.16E-03	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	2.73E-01	2.73E-02	2.29E-01	2.29E-02	NA	NA	NA	NA	2.67E-01	2.67E-02
Iron	**2.74E+01**	**2.74E+00**	**1.15E+01**	**1.15E+00**	NA	NA	NA	NA	**1.34E+01**	**1.34E+00**
Manganese	1.22E-01	3.78E-02	9.21E-03	9.21E-04	NA	NA	NA	NA	1.07E-02	1.07E-03
Vanadium	**1.74E+01**	**1.74E+00**	2.69E-01	2.69E-02	NA	NA	NA	NA	3.14E-01	3.14E-02

NA = NOAEL/LOAEL not available

TABLE 7-17

RESULTS OF FOOD CHAIN MODELING
TERRESTRIAL RECEPTORS
MAXIMUM CONCENTRATIONS
SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological Contaminant of Potential Concern	Shrew		Mouse		Robin		Hawk		Fox		Woodcock	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Pesticides/PCBs												
Aroclor-1254	1.00E+00	1.00E-01	1.35E-02	1.35E-03	2.56E-01	2.56E-02	1.68E-01	1.68E-02	4.25E-01	4.25E-02	5.45E-01	5.45E-02

TABLE 7-18

RESULTS OF FOOD CHAIN MODELING
TERRESTRIAL RECEPTORS
MEAN CONCENTRATIONS
SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological Contaminant of Potential Concern	Shrew		Mouse		Robin		Hawk		Fox		Woodcock	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Pesticides/PCBs												
Aroclor-1254	3.50E-01	3.50E-02	4.69E-03	4.69E-04	8.92E-02	8.92E-03	5.85E-02	5.85E-03	1.48E-01	1.48E-02	1.90E-01	1.90E-02

TABLE 7-19

COMPARISON OF ECOLOGICAL COPCs IN SEDIMENT TO VARIOUS GUIDELINES SITE 2 – BORROW PIT LANDFILL AND SITE 15 – DIRT ROADS MCRD PARRIS ISLAND, SOUTH CAROLINA

COPC	Site 2 Maximum	Site 2 Mean	Site 15 Maximum	Site 15 Mean	Region 4 ESV	Other
VOLATILE ORGANIC COMPOUNDS (µg/kg)						
Chloroform	5	3.9	ND	ND	NA	22[a]
SEMIVOLATILE ORGANIC COMPOUNDS (µg/kg)						
Bis(2-ethylhexyl) phthalate	ND	ND	280	277	182	1300[b] 2647[c] 890,000[a]
METALS (mg/kg)						
Aluminum	5560	4498	15500	6953	NA	NA
Barium	7.9	6.9	19.4	9.3	NA	20[d]
Beryllium	ND	ND	0.71	0.28	NA	NA
Chromium (hexavalent)	1.6	1.1	ND	ND	NA	81[b]
Cobalt	0.52	0.41	3.1	1.3	NA	50[e]
Iron	5390	3824	14700	6388	NA	17000[d] 20000[f]
Manganese	52.4	35.3	113	50	NA	460[f] 300[d]
Selenium	0.42	0.34	ND	ND	NA	NA
Vanadium	12.8	10.0	37.4	17.0	NA	NA

NA Ecological Screening Value Not Available
ND Not Detected

a Derived from secondary chronic value using equilibrium partitioning approach (Jones et al., 1997)
b U.S. EPA Region III BTAG Ecological Screening Value (U.S. EPA, 1995c)
c Probable Effects Level (FDEP, 1994)
d U.S. EPA Region V guideline indicating nonpolluted conditions; concentrations exceeding this are assumed to represent at least moderately polluted conditions (Giesy and Hoeke, 1990)
e Open water disposal guideline, Ontario Ministry of Environment (Giesy and Hoeke, 1990)
f Ontario Ministry of Environment lowest effect level (Jones et al. ,1997)

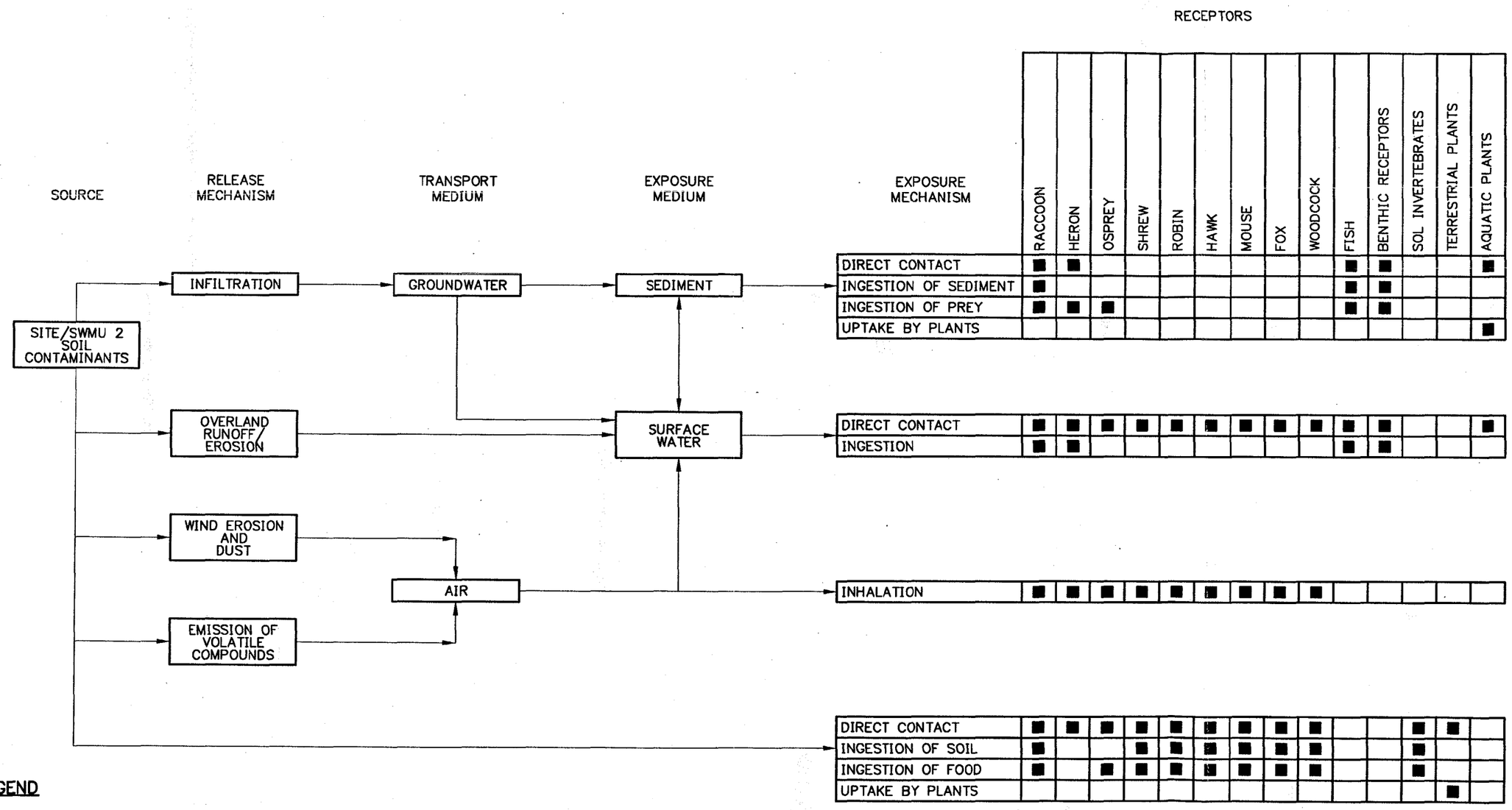
TABLE 7-20

COMPARISON OF SURFACE SOIL CHEMICALS OF POTENTIAL CONCERN (COPCs) TO OTHER GUIDELINES
SITE 2 - BORROW PIT LANDFILL AND SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

COPC	Maximum	Mean	ORNL Earthworms/ microorganisms	ORNL Soil Phytotoxicity	BTAG Region III Fauna	BTAG Region III Flora	Beyer (1990) "A" Value	Beyer (1990) "B" Value	Dutch (1994) Target	Dutch (1994) Intervention
VOLATILE ORGANIC COMPOUNDS (µg/kg)										
Acetone[1]	170	45.4	NA	NA	NA	NA	NA	NA	NA	NA
Chloroform[1]	18	6.2	NA	NA	300	300	NA	NA	NA	NA
PESTICIDES AND PCBs (µg/kg)										
Aroclor – 1254[2]	24.0	6.95	NA	NA	NA	NA	NA	NA	NA	NA
METALS AND INORGANIC COMPOUNDS (mg/kg)										
Aluminum[1]	4290	2548.8	600	50	NA	1	NA	NA	NA	NA
Iron[1]	1930	693.2	200	NA	12	3,260	NA	NA	NA	NA
Vanadium[1]	4.1	2.1	20	2.0	58	0.5	NA	NA	NA	NA

NA – Not Available
1 COPC in surface soil at Site 2
2 COPC in surface soil at Site 15

ACAD: 7394KF08.dwg 09/09/99 HJP



LEGEND

■ COMPLETE EXPOSURE PATHWAY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY KW DATE 4/1/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE NONE

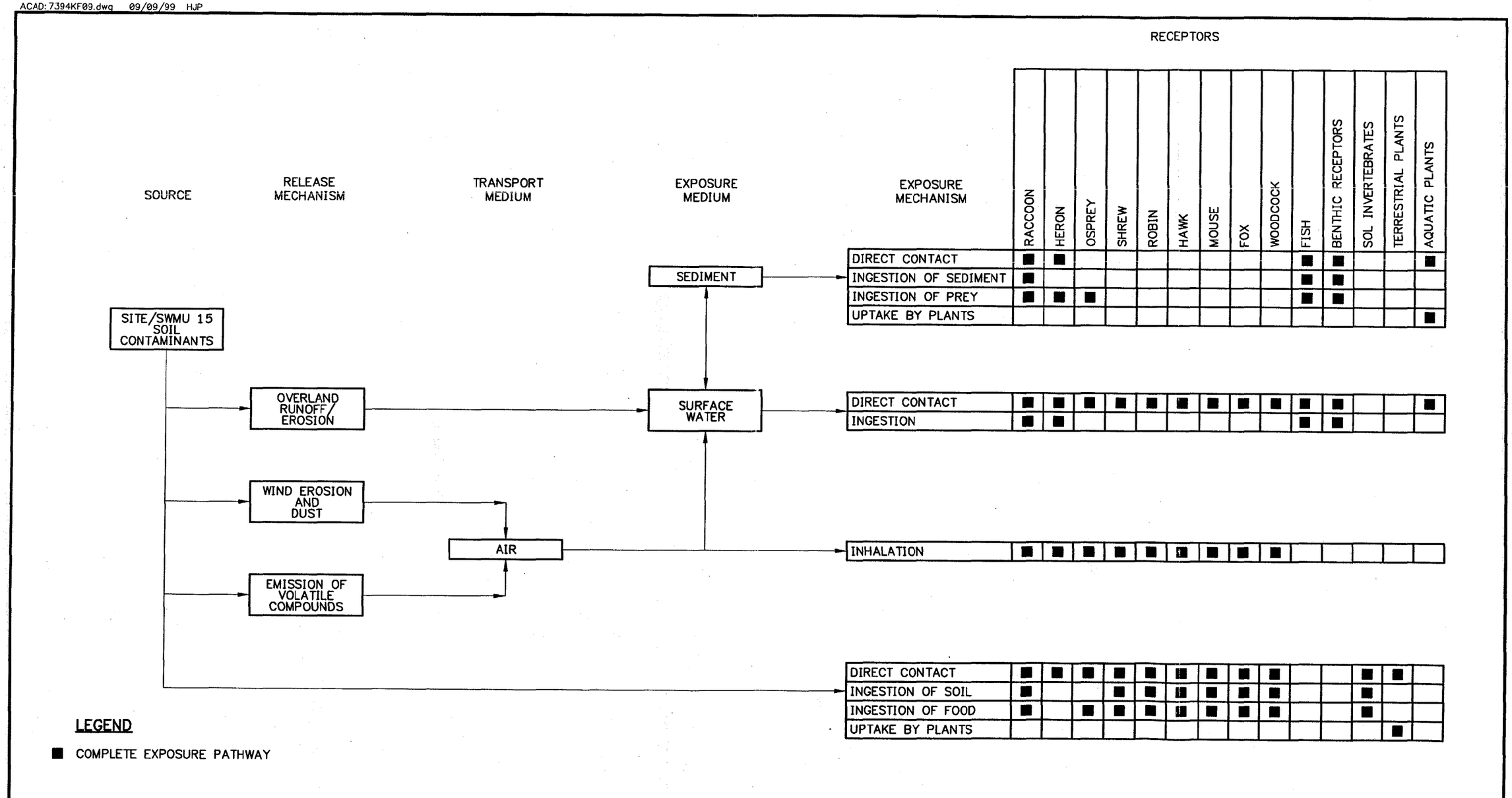
CONCEPTUAL SITE MODEL
SITE 2-BORROW PIT LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 7-1
REV. 0

FORM CADD NO. SDV_BH12.DGN - REV 0 - 1/20/98

170 A B42

ACAD: 7394KF09.dwg 09/09/99 HJP



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 4/20/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE NONE

CONCEPTUAL SITE MODEL
SITE 15 - DIRT ROADS
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 7-2
REV. 0

FORM CADD NO. SDV_BH12.DGN - REV 0 - 1/20/98

8.0 CONCLUSIONS AND RECOMMENDATIONS

The conclusions developed during the Sites/SWMUs (Sites) 2 and 15 RI/RFI are summarized as follows.

1.0 Subsurface, surface soils and sediments at Site 2 were not found to contain chemicals in excess of those found in background media and the most stringent of human health RBCs (residential) or ecological screening values. In addition, hand borings and test pits in the area of the alleged fill material did not find evidence of waste remaining in the borrow pit area. The only evidence of waste at Site 2 was the presence of visually stained soils near the water table.

2.0 Surface soils and sediments at Site 15 were found to contain two isolated detections of chemicals in excess of the background media and the most stringent human health RBCs (residential) or ecological screening values. Bis(2-ethylhexyl) phthalate was detected in one sediment sample at a concentration of 1.5 times the U.S. EPA Region IV Ecological Screening Level. Similarly, PCBs were detected in one sediment sample (from a previous sample event) at a concentration of 1.2 times the U.S. EPA Region IV Ecological Screening Level. PCBs were not detected in the more extensive current sample event.

3.0 Several metals, one volatile organic compound, and one semi-volatile organic compound were detected in Site 2 groundwater at concentrations in excess of the most stringent human health RBCs (residential) or ecological screening values. These risks are summarized as follows.

- Chloroform, arsenic and thallium were the only chemicals detected in site groundwater at concentrations that could result in potential risk to human health. Chloroform was detected in 1 of 5 wells, arsenic in 3 of 5 wells, and thallium in 2 of 5 wells. This evaluation assumes that site groundwater would be used as a potable water supply. However, the maximum concentration of arsenic and chloroform detected were actually less than the U.S. EPA MCLs, indicating that risks from these chemicals are within acceptable U.S. EPA ranges. Thallium was detected at concentrations greater than MCLs. However, the maximum concentration of thallium was detected in an upgradient monitoring well indicating that thallium is not site related contamination. Also, the presence of an adjacent salt water marsh preclude potable use of site groundwater.

- Aluminum, iron, copper, zinc, and bis(2-ethylhexyl) phthalate were the only chemicals identified in the site groundwater at concentrations exceeding established ecological criteria. This evaluation assumes that the groundwater seeps into the adjacent surface water, mixing does not occur in the surface water, and that the most sensitive receptor is continuously

exposed to the seep. Under this scenario, the maximum hazard quotient would be approximately 12 (for aluminum). However, with the exception of bis(2-ethylhexyl) phthalate, none of these chemicals were detected in the adjacent surface water at concentrations greater than ecological screening levels. Since bis(2-ethylhexyl) phthalate is a common laboratory artifact and it was detected in background surface water samples at higher concentrations than detected at this site, it may not be a site contaminant.

4.0 Two metals and one semi-volatile organic compound were detected in Site 2 surface water at concentrations in excess of the most stringent human health RBCs (residential) or ecological screening values. These risks are summarized as follows.

- Bis(2-ethylhexyl) phthalate (2 of 4 samples) and arsenic (1 of 4 samples) were detected in the surface water at concentrations that represent a potential threat to human health. These chemicals represent a potential threat to human health assuming use of the adjacent salt water for potable use and regular consumption of fish living at the site. The site specific human health risk values, which used onsite residents, construction workers, and adult recreational users as potential receptors, were greater than $1x10^{-6}$ but were less than $1x10^{-4}$. This value is within the acceptable U.S. EPA target risk range. The associated hazard index for site contaminants did not exceed unity, indicating that non-carcinogenic toxic effects would not be anticipated. Also, since bis(2-ethylhexyl) phthalate is a common laboratory artifact and it was detected in background surface water samples at higher concentrations than detected at this site, it may not be a site contaminant.

- Silver was detected in two of four surface water samples and was the only chemical detected at concentrations in excess of the most stringent surface water ecological screening values. The hazard quotient for silver was four. However, the maximum detected concentration of silver was less than the associated ambient water quality criteria.

5.0 Potential threats to human health associated with consumption of oysters in the nearby Archers Creek were considered. Conservative estimates of potential oyster concentrations were calculated using maximum surface water and sediment data from Site 2 and assuming equilibrium partitioning between these media and the oysters. PAHs and hexavalent chromium in site sediments were identified as potential concerns. The results of the risk assessment found that potential risks were greater than $1x10^{-6}$, but were less than $1x10^{-4}$. This value is within the acceptable U.S. EPA target risk range. The associated hazard index did not exceed unity, indicating that non-carcinogenic toxic effects would not be anticipated. Also, based on this conservative modeling, exceedances of U.S. FDA values would not be expected.

6.0 The results of the food chain modeling for ecological receptors are summarized as follows.

- The food chain modeling for Site 15 terrestrial receptors found that under the most conservative assumptions, Arochlor-1254 in surface soils result in a HQ of 1.0 (NOAELs) for the shrew. Hazard quotients for the other terrestrial receptors under this scenario did not exceed unity. These conservative assumptions assume that the shrew is exposed to the maximum concentration for its whole life. Under a more realistic scenario that is based on mean chemical concentrations, adverse risks to terrestrial receptors are not expected.

- The food chain modeling for Site 15 aquatic receptors (Elliot's Beach) found that under the most conservative assumptions, aluminum, iron, and vanadium in sediments result in hazard quotients greater than 1.0 for at least one receptor. However, the maximum concentrations of these metals in sediments are less than background values, indicating that these detected metals are not site-related contamination.

- The food chain modeling for Site 2 terrestrial and aquatic receptors found that under the most conservative assumptions, aluminum, iron, and vanadium result in hazard quotients greater than 1.0 for one or more receptors. However, the maximum concentrations for each of the three metals in sediment were less than background values, indicating that these metals are not site-related contamination.

7.0 The analytical data for Site 15 is adequate to demonstrate that there is no significant risk to human health and ecological receptors. As a result, a no further action should be pursued.

8.0 Test pitting operations did not find evidence of waste remaining at the site. Furthermore, the analytical data for Site 2 is adequate to demonstrate that there is no significant risk to human health and ecological receptors at the site under the current conditions. Remediation of soils, sediments, surface water, and groundwater is not required and no further action is recommended.

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