REVISED FINAL

PHASE II RCRA FACILITY INVESTIGATION REPORT FOR 16 SOLID WASTE MANAGEMENT UNITS

AT

FORT STEWART, GEORGIA
VOLUME I OF III

REGULATORY AUTHORITY
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The undersigned certifies that I am a qualified groundwater scientist who has received a baccalaureate or postgraduate degree in the natural sciences or engineering and have sufficient training and experience in groundwater hydrology and related fields, as demonstrated by state registration and completion of accredited university courses, to enable me to make sound professional judgments regarding groundwater monitoring and contaminant fate and transport. I further certify that this report was prepared by myself or a subordinate working under my direction.

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ACRONYMS

ADA	Air Defense Artillery
ADD	average daily dose
amsl	above mean sea level
ARAR	applicable or relevant and appropriate requirement
Army	U.S. Army
AST	aboveground storage tank
ASTM	American Society for Testing and Materials
AT123D	Analytical Transient 1-, 2-, 3-Dimensional
AUF	area use factor
AWQC	Ambient Water Quality Criteria
BAF	bioaccumulation factor
BCF	bioconcentration factor
bgs	below ground surface
BHC	benzene hexachloride
BN	battalion
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAP	Corrective Action Plan
CB	chemical/biological
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMCOC	contaminant migration chemical of concern
CMCOPC	contaminant migration constituent of potential concern
COC	contaminant of concern
COPC	contaminant of potential concern
CSM	Conceptual Site Model
DAF	dilution attenuation factor
DEH	Directorate of Engineering and Housing
DF	dilution factor
DO	dissolved oxygen
DOL	Directorate of Logistics
DPT	direct-push technology
DPW	Directorate of Public Works
DQO	data quality objective
DRMO	Defense Reutilization and Marketing Organization
ECOPC	ecological contaminant of potential concern
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency
EPRE	ecological preliminary risk evaluation
EP Tox	Extraction Procedure Toxicity
ERA	Ecological Risk Assessment
ESV	ecological screening value
FR	Federal Register
FSMR	Fort Stewart Military Reservation
GAF	gastrointestinal absorption factor
GEPD	Georgia Environmental Protection Division
GSSL	generic soil screening level
HAZWRAP	Hazardous Waste Remedial Actions Program
HELP	Hydrologic Evaluation of Landfill Performance

ACRONYMS (continued)

HHCOC	human health chemical of concern
HHCOPC	human health contaminant of potential concern
HHPRE	human health preliminary risk evaluation
HI	hazard index
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HQ	hazard quotient
IDW	investigation-derived waste
IEUBK	Integrated Exposure Uptake Biokinetic
ILCR	incremental lifetime cancer risk
IRA	Interim Removal Action
IWTP	Industrial Wastewater Treatment Plant
LAS	Land Application System
LOAEL	lowest observed adverse effect level
MCL	maximum contaminant level
MOGAS	motor gasoline
NFA	no further action
NGTC	National Guard Training Center
NGVD	National Geodetic Vertical Datum
NOAEL	no observed adverse effect level
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity unit
OB	open burn
OD	open detonation
ODAST	One-dimensional Analytical Solute Transport
OWS	oil/water separator
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PETN	pentaerythrite tetranitrate
PID	photoionization detector
POL	petroleum, oil, and lubricants
POTW	publicly owned treatment works
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QCSR	Quality Control Summary Report
RBC	risk-based concentration
RBCA	Risk-based Corrective Action
RCRA	Resource Conservation and Recovery Act
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
Redox	oxidation-reduction
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
SDWA	Safe Drinking Water Act
SESOIL	Seasonal Soil Compartment Model
SMCL	secondary maximum contaminant level

ACRONYMS (continued)

SPT BN	Support Battalion
SRC	site-related contaminant
SSL	soil screening level
SQB	sediment quality benchmark
SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit
TAC	Tactical Air Command
TC	toxicity characteristic
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TEF	toxicity equivalence factor
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TRPH	total recoverable petroleum hydrocarbons
TRV	toxicity reference value
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
UST	underground storage tank
UXO	unexploded ordnance
VOC	volatile organic compound
WQS	water quality standard

EXECUTIVE SUMMARY

This report summarizes the results of the Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) for the 16 Solid Waste Management Units (SWMUs) at Fort Stewart, Georgia. The 16 SWMUs include: Camp Oliver Landfill, SWMU 2; TAC-X Landfill, SWMU 3; Inactive EOD Area in Red Cloud Range, Hotel Area, SWMU 9; Inactive EOD Area North of Garrison Area, SWMU 10; Inactive EOD Area Located Approximately Three Miles Northeast of Garrison Area, SWMU 11; Active EOD Containing Open Detonation Unit and Open Burn Unit, SWMU 12A; Old Fire Training Area, SWMU 14; DRMO Hazardous Waste Storage Area, SWMU 17; Industrial Wastewater Treatment Plant, SWMU 18; Old Sludge Drying Beds, SWMU 19; Old Radiator Shop/Paint Booth, SWMU 24B; Motorpools, SWMUs 27A through 27V; Evans Army Heliport POL Storage Facility, SWMU 29; DEH Asphalt Tanks, SWMU 31; Supply Diesel Tank, SWMU 32; DEH Equipment Wash Rack, SWMU 34; and NGTC Equalization Basin, SWMU 37. Four of the 16 sites—Old Sludge Drying Beds, SWMU 19; Old Radiator Shop/Paint Booth, SWMU 24B; Motorpools, SWMUs 27A through 27V; and NGTC Equalization Basin, SWMU 37—had not been investigated previously and were investigated as Phase I RFIs. This report has been prepared by Science Applications International Corporation (SAIC) for the U.S. Army Corps of Engineers (USACE), Savannah District, under Contract DACA21-95-D-0022, Delivery Order No. 0009. The RFI was conducted in accordance with USACE Guidance EM 200-1-3 and the Georgia Environmental Protection Division (GEPD)–approved Sampling and Analysis Plan (SAP) (SAIC 1997).

The 16 SWMUs investigation consisted of 38 SWMU sites (including 22 motorpool sites) as designated under Hazardous Waste Permit HW-045. The sites were divided into 45 distinct geographic areas for investigation. Seven (SWMUs 2, 3, 9, 10, 11, 12A, and 29) of the 38 SWMUs are located outside the garrison area. The remaining 31 (SWMUs 14, 17, 18, 19, 24B, 27A through 27V, 31, 32, 34, and 37) are located within the garrison area.

OBJECTIVES AND SCOPE OF THE INVESTIGATION

The specific objectives of the Phase I and Phase II RFIs for the 16 SWMUs at Fort Stewart, Georgia, as defined in the Phase II RFI SAP (SAIC 1997) (approved by the GEPD in October 1997) are listed below.

Phase I RFI

- Determine if contamination of the environment has occurred.
- Determine whether contaminants, if present, constitute a threat to human health or the environment.
- Determine the need for future action and/or no further action (NFA).

Phase II RFI

- Determine the horizontal and vertical extent of contamination.
- Determine whether contaminants present a threat to human health or the environment.

- Determine the need for future action and/or NFA.

- Gather data necessary to support a Corrective Action Plan (CAP), if warranted.

The information provided in this report is based upon data collected previously during the Phase I RFI (if available) and data collected as part of the Phase II field sampling and analysis. At some of the sites, the Phase II sampling program incorporated an observational approach to sampling, as defined in the Phase II RFI SAP (SAIC 1997). This observational approach used field screening techniques to determine the horizontal and vertical extent of contamination at the SWMU and to identify suitable locations for installation of permanent monitoring wells. The scope of the fieldwork for the Phase I and Phase II sites included the activities listed below.

Phase I Sites

- Collection of direct-push soil samples using a push probe.

- Collection of direct-push groundwater samples using a push probe.

- Installation of permanent groundwater monitoring points or monitoring wells to confirm the nature of potential contamination at a specific push-probe location.

- Collection of surface water and sediment samples at SWMUs at which surface water and sediment were available.

- Surveying of the positions of all sample locations.

Phase II Sites

- Collection of direct-push soil samples using a push probe.

- Collection of direct-push groundwater samples using a push probe, including vertical-profile probes.

- Installation of permanent groundwater monitoring wells both upgradient and downgradient of the site.

- Groundwater sampling at existing monitoring wells (if available) and sampling of newly installed wells around the SWMUs.

- Collection of surface water and sediment samples at SWMUs at which surface water and sediment were available.

- Surveying of the positions of all sample locations.

Nature and Extent of Contamination

Site-related contaminants (SRCs) were identified for each site by comparing the analytical results obtained from soil, groundwater, surface water, and sediment against the reference background criteria. Contaminants with concentrations above the reference background criteria were identified as SRCs. The results of the chemical analyses on surface soil, subsurface soil, and groundwater were screened against the reference

background criteria for the Fort Stewart Military Reservation. Surface water and sediment were screened against site-specific background criteria.

In general, reference background samples were collected from each medium at locations upgradient or upstream of each site so as to be representative of naturally occurring conditions at sites under investigation. Upgradient or upstream samples were not collected at sites under a Phase I RFI (i.e., SWMUs 19, 24B, 27A through 27V and 37). The reference background concentrations for surface soil, subsurface soil, and groundwater were calculated as two times the average concentration of all of the locations selected to be in the background data set. If a chemical was not detected at a site, then one-half the detection limit was used as the concentration when calculating the reference mean background concentration. Surface water and sediment background samples were collected during the Phase II RFI and applied to the SWMUs on a site-specific basis.

Inorganics were considered to be SRCs if their concentrations were above the reference background concentrations, while organics were considered SRCs if they were simply detected because organic constituents are considered to potentially be man-made. SRCs from the nature and extent of contamination evaluation were further evaluated as potential concerns based upon fate and transport characteristics and upon their potential risk to human health and ecological receptors. A summary of SRCs by medium for each SWMU is presented in Table ES-1.

Fate and Transport Analysis

Fate and transport analysis was performed on each SWMU. This analysis included developing a site-specific Conceptual Site Model (CSM) identifying potential contaminant release and migration pathways and determining the potential for SRCs in surface soil, subsurface soil, and/or sediment to migrate to groundwater.

The maximum concentrations of the SRCs determined from nature and extent analysis were compared to U.S. Environmental Protection Agency (EPA) Generic Soil Screening Levels (GSSLs). Generally, if contaminant concentrations in soil fall below the GSSLs and there are no significant ecological receptors of concern, then no further study or action is warranted. SRCs were identified as contaminant migration constituents of potential concern (CMCOPCs) if they were detected at concentrations that exceeded their respective GSSLs. To evaluate leaching of CMCOPCs from soil to groundwater at the 16 SWMUs, groundwater concentrations of CMCOPCs were compared to maximum contaminant levels (MCLs). If an MCL for a chemical was not available, the groundwater concentration was compared to the risk-based concentration, as established by EPA Region III (EPA 1999b). A summary of the results of the fate and transport analysis (CMCOPCs) is presented in Table ES-2.

A weight-of-evidence approach was used to evaluate each CMCOPC identified based on leaching to groundwater. In some instances, the potential impact of CMCOPCs to groundwater, and possibly to surface water, was evaluated (modeled concentrations were compared to risk-based criteria) in a human health baseline risk assessment. CMCOPCs that indicated a potential risk to human health (i.e., that exceeded risk-based screening criteria) from modeling were identified as contaminant migration chemicals of concern, and remedial levels were developed based on protection of groundwater. SWMUs for which a human health baseline risk assessment was performed are identified in Table ES-2.

Human Health Preliminary Risk Evaluation

A human health preliminary risk evaluation (HHPRE) using a Step i risk evaluation approach based on guidance from GEPD was performed for each SWMU to determine the potential human health risks associated with the maximum concentrations of identified SRCs. The Step i risk evaluation involves the components listed below.

- For inorganics, compare detected concentrations to naturally occurring background levels to determine if detected inorganics are naturally occurring or are associated with past activities at the site.

- Identify potential migration and exposure pathways associated with the site and identify potential exposure scenarios to determine appropriate action levels.

- Identify available risk-based action levels for each contaminant detected above background levels or develop levels if they do not exist.

- Compare sample concentrations to action levels to determine if site conditions warrant further evaluation.

Chemicals that exceeded action levels were identified as human health contaminants of potential concern (HHCOPCs). A summary of the HHPRE results (HHCOPCs) is presented in Table ES-2.

A weight-of-evidence approach was used to evaluate each HHCOPC identified in the preliminary risk assessment. In some instances, HHCOPCs were evaluated further in a human health baseline risk assessment. HHCOPCs and/or CMCOPCs (see previous section) that either had hazard indices of 0.1 or incremental lifetime cancer risks of 1×10^{-6} were identified as human health contaminants of concern. Remedial levels were developed that were protective of the most sensitive receptor population, based on a minimum risk level of 3.0 for the total hazard index and 1×10^{-4} for the total incremental lifetime cancer risk. SWMUs for which a human health baseline risk assessment was performed are identified in Table ES-2.

Ecological Preliminary Risk Evaluation

An ecological preliminary risk evaluation (EPRE) based on guidance from GEPD was performed to determine the potential risk to ecological receptors associated with the maximum concentrations of the identified SRCs. The EPRE compared measured concentrations of detected substances to conservative ecological screening values to identify substances detected at the facility that pose a potential hazard to ecological receptors and that are identified as ecological contaminants of potential concern (ECOPCs). A summary of the results of the EPRE (ECOPCs) is presented in Table ES-2.

A weight-of-evidence approach was used to evaluate each ECOPC identified in the preliminary risk evaluation. In some instances, ECOPCs were evaluated further in a supplemental preliminary risk evaluation (SPRE). The SPRE presented a comparison of more realistic exposure estimates to toxicity reference values based on the lowest observed adverse effects levels. The exposure estimates were calculated using measured concentrations and more realistic exposure assumptions such as diets, absorption efficiencies, and area use factors. SWMUs for which an SPRE was performed are identified in Table ES-2.

Conclusions and Recommendations

A weight-of-evidence approach was used with the results from the fate and transport evaluation, HHPRE, human health baseline risk assessment (if performed), EPRE, and SPRE (if performed) to determine the recommendation for each SWMU. The recommendations fell into the following three categories:

- **No Further Action:** NFA was recommended for a SWMU if: (1) the contaminant levels in soil, groundwater, surface water, and sediment were below the reference background criteria, fate and transport values (GSSLs), and/or human health or ecological screening criteria or (2) significant uncertainty was evident, indicating minimal potential risk of migration to groundwater and/or a surface water body and/or to human health and ecological receptors.

- **Additional Investigation (Phase II RFI or additional monitoring):** A Phase II RFI or additional monitoring was recommended if the nature and extent of potential contaminants had not been determined, and further investigation or additional monitoring was required to evaluate extent or potential migration in the future.

- **Corrective Action Plan:** A CAP was recommended if the nature and extent of contamination at a SWMU was determined by the Phase II RFI, there was a potential risk of migration of contaminants to groundwater and/or surface water bodies or a potential risk to human health and ecological receptors, or institutional controls need to be applied to protect the health and safety of humans coming in contact with the site (i.e., inactive EOD areas). Such a site requires a CAP to evaluate appropriate remedial actions to eliminate or minimize these potential risks.

The recommendations for each SWMU are presented in Table ES-3.

Table ES-1. Summary of Site-related Contaminants

SWMU	Type of Investigation	Site-related Contaminants				
		Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment
2	Phase II	2 VOCs, 14 pest., 1 SVOC, and 6 metals	1 VOC, 3 pest., 1 SVOC, and 3 metals	3 VOCs and 3 metals	None	alpha-Chlordane
3	Phase II	4 pest., BEHP, As, Cr, and Pb	2 VOCs, BEHP, 3 pest., Cr, and Cd	3 VOCs, 3 pest., Ba, Cd, Cr, Pb, and Hg	1 SVOC, As, Ba, Cr, and Pb	6 VOCs, As, Ba, Cr, Pb, Hg, and Se
9	Phase I[a]	As, Cr, and Ag	NC	NC	NP	NP
10	Phase II	As, Ba, Cr, and Pb	NC[b]	None	Cd, Cr, and Hg	As, Ba, and Pb
11	Phase II	As, Ba, Cr, Pb, and Ag	NC[b]	None	NP	NP
12A	Phase II	3 SVOCs, 4 exp., and 16 metals	Al, As, Ba, Cr, Fe, Pb, and V	BEHP, 1 exp., and 8 metals	RDX, Pb, Mn, and Hg	1 SVOC, 1 exp., and 9 metals
14	Phase I	2 VOCs, BEHP, and Hg	5 VOCs, Cr, and Hg	1 VOC, Pb, and Hg	NP	NP
17	Phase II	1 VOC	3 VOCs	3 VOCs and Pb	None	None
18	Phase II	1 VOC, Pb, and Hg	5 VOCs, 2 SVOCs, Ba, Cr, Pb, and Hg	9 VOCs, Ba, Cd, and Pb	1 SVOC and Ba	(6 VOCs, 4 SVOCs, As, Ba, Cd, Cr, Pb, Hg, Se, and Ag)[c]
19	Phase I	4 VOCs, 7 pest., and 5 metals	6 VOCs, 9 pest., and 5 metals	BEHP, 7 pest., and 3 metals	NP	NP
24B	Phase I	1 VOC, 10 SVOCs, and 6 metals	2 VOCs	1 VOC, 11 SVOCs, and Hg	NP	NP
27A (Bldg. 1339A)	Phase I	None	2 VOCs and 3 SVOCs	2 VOCs and BEHP	NP	NP
27A (Bldg. 1339B)	Phase I	BEHP and Pb	2 VOCs	1 VOC	NP	NP
27A (Bldg. 1322)	Phase I	3 VOCs and Pb	3 VOCs	Acetone	NP	NP
27B	Phase I	None	1 VOC	ND	NP	NP
27C	Phase I	1 VOC	2 VOCs and 1 SVOC	4 VOCs	NP	NP
27D	Phase I	3 VOCs	1 VOC	None	NP	NP
27E (Bldg. 1628)	Phase I	None	1 VOC	None	NP	NP

Note: Footnotes appear on page ES-8.

Table ES-1. Summary of Site-related Contaminants (continued)

SWMU	Type of Investigation	Site-related Contaminants				
		Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment
27E (Bldg. 1720)	Phase I	NC	2 VOCs and BEHP	1 SVOC	NP	NP
27F (NW Bldg. 1340)	Phase I	NC	3 VOCs and Pb	10 VOCs and 4 SVOCs	NP	NP
27F (NE Bldg. 1340)	Phase I	3 VOCs	8 VOCs and 4 SVOCs	None	NP	NP
27G	Phase I	NC	3 VOCs	1 SVOC	NP	NP
27H (Bldg. 1071)	Phase I	NC	2 VOCs, 11 SVOCs, Pb, and Hg	1 VOC and 9 SVOCs	NP	NP
27H (Bldg. 1056)	Phase I	NC	1 VOC, 1 SVOC, Cd, and Pb	2 VOCs and 4 SVOCs	NP[d]	NP[d]
27I (Block 9900)	Phase I	NC	1 VOC and Pb	None	NC	1 VOC and Pb
27I (Block 10300)	Phase I	NC	None	None	Pb	None
27J (Bldg. 10535)	Phase I	None	None	1 VOC and 1 SVOC	NP	NP
27J (Bldg. 10531)	Phase I	1 VOC and 1 SVOC	NC	2 SVOCs	NP	NP
27K	Phase I	NC	4 VOCs	1 VOC	NP	NP
27L (Block 10200)	Phase I	None	1 VOC and 1 SVOC	8 VOCs and 2 SVOCs	Acetone	None
27M (Block 10100)	Phase I	1 VOC and Pb	2 SVOCs and Pb	1 VOC	NC	Pb
27N (Block 9800)	Phase I	NC	2 SVOCs and Pb	None	NC	5 SVOCs
27O (Block 9700)	Phase I	Pb	None	1 SVOC	1 VOC	Pb
27P (Block 9500)	Phase I	1VOC and 1 SVOC	1 VOC, 6 SVOCs, and Pb	None	NC	1 VOC and Pb

Note: Footnotes appear on page ES-8.

Table ES-1. Summary of Site-related Contaminants (continued)

SWMU	Type of Investigation	Site-related Contaminants				
		Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment
27Q (Block 9400)	Phase I	Pb	None	None	NC	Pb
27R	Phase I	None	1 VOC and 2 SVOCs	None	NP	NP
27S	Phase I	NC	6 VOCs	None	NP	NP
27T	Phase I	4 SVOCs	None	1 VOC and 1 SVOC	NC	4 VOCs, 9 SVOCs, and Cd
27U	Phase I	1 VOC and Pb	2 VOCs and Pb	4 VOCs	NP	NP
27V	Phase I	1 VOC and Pb	1 VOC and Pb	None	NP	NP
29	Phase II	8 VOCs and Ag	16 VOCs and 14 SVOCs	3 VOCs, 3 SVOCs, As, Ba, and Cr	NP	NP
31	Phase II and IRA	None	6 VOCs and 17 SVOCs	4 VOCs	NP	NP
32	Phase II	2 VOCs, Ba, Cd, Cr, Pb, and Hg	2 VOCs, Pb, and Hg	4 VOCs and 2 SVOCs	NP	NP
34	Phase II	4 VOCs, 2 SVOCs, Ba, Cd, Pb, and Hg	1 VOC, Ba, Cd, Cr, and Pb	3 VOCs	NP	NP
37	Phase I	1 VOC and Hg	2 VOCs and Hg	4 VOCs	NP	(4 VOCs, Ba, Cd, Cr, Pb, Hg, and Se)[c]

[a]Phase II RFI was not required at this time. The Phase II RFI will be conducted upon closure of the Red Cloud Range, Hotel Area.
[b]Per the GEPD–approved SAP, subsurface soil was not collected because subsurface soil sampling in an EOD area requires approval by the Secretary of the Army.[2]
[c]Results from sediment within the NGTC Equalization Basin.
[d]Sediment was collected; however, the oil/water separator does not discharge to the drainage ditch.
BEHP = Bis(2-ethylhexyl)phthalate.
NA = Not applicable.
NC = Not collected based on field screening results or because no medium (i.e., surface water) was available during the RFI.
ND = Not detected.
NP = No pathway exists.
SVOC = Semivolatile organic compound.
VOC = Volatile organic compound.

Table ES-2. Summary of CMCOPCs, HHCOPCs, and ECOPCs

SWMU	CMCOPCs		HHCOPCs					ECOPCs				HHBRA or SPRE Performed?
	Soil	Sediment	Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment	Surface Soil	Groundwater	Surface Water	Sediment	
2	2 pest., Ar, Ca, and Hg	None	As and Cr	None	None	None	None	4,4'-DDE, Cd, Cr, and Pb	1 VOC, Pb, and Hg	None	None	HHBRA and SPRE
3	None	As	As	None	1 pest. and Hg	1 SVOC, As, Cr, and Pb	As	Pb and Cr	2 pest., Ba, Cd, Pb, and Hg	1 SVOC, Ba, and Pb	2 VOCs, As, Ba, and Se	HHBRA and SPRE
9[a]	NA[a]	NA[a]	NA[a]	NC[a]	NC[a]	NP	NP	NA[a]	NC[a]	NP	NP	
10	NA[b]	NA[b]	NA[b]	NC	NA[b]	NA[b]	NA[b]	NA[b]	NA[b]	NA[b]	NA[b]	
11	NA[b]	NA[b]	NA[b]	NC	NA[b]	NA[b]	NA[b]	NA[b]	NA[b]	NP	NP	
12A	Ar, Cd, Cr, Pb, Ag, 1 SVOC, and 2 exp.	None	As and Pb	As	BEHP	Hg	None	1 SVOC, Cd, Cr, and Pb	BEHP	Pb and Hg	Ba	HHBRA and SPRE
14	1 VOC	NA	None	None	None	NP	NP	None	Pb, Hg, and 1 VOC	NP	NP	
17	None	None	None	None	1 VOC	None	None	None	1 VOC and Pb	None	None	HHBRA
18	Cr and Hg	(1 VOC, 1 SVOC, Ar, Ba, Cd, Cr, Hg, and Se)[c]	None	None	3 VOCs and Pb	1 SVOC	As	Pb	4 VOCs, Ba, and Pb	Ba and BEHP	None	HHBRA and SPRE
19	2 pest.	NA	None	None	BEHP, 2 pest., and As	NP	NP	Cd, Pb, and 1 pest.	BEHP, 5 pest., Ba, and Hg	NP	NP	HHBRA and SPRE
24B	1 VOC, 3 SVOCs, and Pb	NA	4 SVOCs, As, and Pb	None	1 VOC, 9 SVOCs, and Hg	NP	NP	NP	Hg and 9 SVOCs	NP	NP	
27A (Bldg. 1339A)	None	NA	None	None	BEHP	NP	NP	None	1 VOC and BEHP	NP	NP	
27A (Bldg. 1339B)	None	NA	None	None	Benzene	NP	NP	Pb	Xylenes	NP	NP	
27A (Bldg. 1322)	None	NA	None	None	Acetone	NA	NA	Pb	None	NP	NP	HHBRA

Note: Footnotes appear on page ES-11.

Table ES-2. Summary of CMCOPCs, HHCOPCs, and ECOPCs (continued)

SWMU	CMCOPCs		HHCOPCs					ECOPCs				HHBRA or SPRE Performed?
	Soil	Sediment	Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment	Surface Soil	Groundwater	Surface Water	Sediment	
27B	None	NP	None	None	None	NP	NP	None	None	NP	NP	
27C	None	NP	None	None	None	NP	NP	None	2 VOCs	NP	NP	
27D	None	NP	None	None	None	NP	NP	None	None	NP	NP	
27E (Bldg. 1628)	None	NP	None	None	None	NP	NP	None	None	NP	NP	
27E (Bldg. 1720)	None	NP	NA	None	None	NP	NP	NA	1 SVOC	NP	NP	
27F (NW Bldg. 1340)	None	NP	NA	None	4 VOCs and 4 SVOCs	NP	NP	NA	2 VOCs and 4 SVOCs	NP	NP	
27F (NE Bldg. 1340)	1 VOC	NP	None	None	None	NP	NP	None	None	NP	NP	
27G	None	NP	NA	None	1 SVOC	NP	NP	NA	None	NP	NP	HHBRA
27H (Bldg. 1071)	2 SVOCs	NP	NC	1 SVOC	1 VOC and 7 SVOCs	NP	NP	NC	8 SVOCs	NP	NP	
27H (Bldg. 1056)	None	NP	NC	None	3 SVOCs	NP	NP	NC	2 SVOCs	NP	NP	
27I (Block 9900)	None	None	NC	None	None	NC	None	NC	None	NC	Pb	
27I (Block 10300)	None	NA	NC	None	None	Pb	None	NC	None	Pb	None	
27J (Bldg. 10535)	None	NP	None	None	None	NP	NP	None	1 VOC and 1 SVOC	NP	NP	
27J (Bldg. 10531)	None	NP	None	NC	1 SVOC	NP	NP	None	2 SVOCs	NP	NP	
27K	None	NP	NA	None	None	NP	NP	NA	None	NP	NP	
27L (Block 10200)	None	None	None	None	4 VOCs and 2 SVOCs	Acetone	None	None	2 VOCs and 1 SVOC	None	None	
27M (Block 10100)	1 VOC	None	None	None	1 VOC	NC	None	Pb	None	NC	Pb	
27N (Block 9800)	None	None	NA	None	None	NC	1 SVOC	NA	None	NC	None	HHBRA

Note: Footnotes appear on page ES-11.

Table ES-2. Summary of CMCOPCs, HHCOPCs, and ECOPCs (continued)

SWMU	CMCOPCs		HHCOPCs					ECOPCs				HHBRA or SPRE Performed?
	Soil	Sediment	Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment	Surface Soil	Groundwater	Surface Water	Sediment	
27O (Block 9700)	None	None	None	NA	None	None	None	Pb	1 SVOC	None	Pb	
27P (Block 9500)	None	None	None	None	None	NC	None	None	None	NC	Pb	
27Q (Block 9400)	None	None	None	NA	None	NC	None	Pb	None	NC	Pb	
27R	None	NP	None	None	None	NP	NP	None	None	NP	NP	
27S	None	NP	NA	None	None	NP	NP	NA	None	NP	NP	
27T	None	Cd	1 SVOC	None	None	NA	4 SVOCs	None	1 SVOC	NA	Cd	HHBRA
27U	None	NP	None	None	Benzene	NP	NP	Pb	None	NP	NP	
27V	None	NP	None	None	None	NP	NP	None	None	NP	NP	
29	7 VOCs	NP	None	None	1 VOC, 2 SVOCs, and As	NP	NP	None	1 VOC, 2 SVOCs, and Ba	NP	NP	HHBRA
31	1 VOC and 1 SVOC	NP	None	None	Acetone	NP	NP	None	Xylenes	NP	NP	HHBRA
32	1 VOC	NP	None	None	Acetone	NP	NP	Cd, Pb, and Cr	1 VOC and 1 SVOC	NP	NP	HHBRA
34	2 VOCs	NP	None	None	Acetone	NP	NP	Cd and Pb	1 VOC	NP	NP	HHBRA
37	1 VOC	1 VOC[b] and Cd	None	None	Benzene	NP	NP	None	Xylenes	NP	NA	

[a]Phase II RFI was not required at this time. The Phase II RFI will be conducted upon closure of the Red Cloud Range, Hotel Area.
[b]With the concurrence of GEPD, fate and transport analysis and human health and ecological preliminary risk assessments were deemed unnecessary. SRCs were determined solely on comparison to background criteria (see Table ES-1).
[c]Results from sediment within the NGTC Equalization Basin.
BEHP = Bis(2-ethylhexyl)phthalate.
HHBRA = Human health baseline risk assessment.
NA = Not applicable.
NC = Sample not collected based on field screening results or because no medium (i.e., surface water) was available during the RFI.
NP = No pathway exists.
SVOC = Semivolatile organic compound.
VOC = Volatile organic compound.

Table ES-3. SWMU-specific Recommendations

SWMU	Recommendation
2	CAP
3	CAP
9	CAP
10	CAP
11	CAP
12A	Long-term compliance monitoring and CAP
14	NFA
17	NFA
18	Long-term monitoring and CAP
19	NFA
24B	Phase II RFI
27A (Building 1339A)	NFA
27A (Building 1339B)	NFA
27A (Building 1322)	NFA
27B	NFA
27C	NFA
27D	NFA
27E (Building 1628)	NFA
27E (Building 1720)	NFA
27F (NW Building 1340)	Phase II RFI
27F (NE Building 1340)	NFA
27G	NFA
27H (Building 1071)	Phase II RFI

SWMU	Recommendation
27H (Building 1056)	Phase II RFI
27I (Block 9900)	NFA
27I (Block 10300)	NFA
27J (Building 10535)	NFA
27J (Building 10531)	Phase II RFI
27K	NFA
27L (Block 10200)	Phase II RFI
27M (Block 10100)	NFA
27N (Block 9800)	NFA
27O (Block 9700)	NFA
27P (Block 9500)	NFA
27Q (Block 9400)	NFA
27R	NFA
27S	NFA
27T	Phase II RFI
27U	NFA
27V	NFA
29	CAP
31	NFA
34	NFA
32	NFA
37	NFA

1.0 INTRODUCTION

This report summarizes the results of the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) for 16 Solid Waste Management Units (SWMUs), at Fort Stewart, Georgia. The 16 SWMUs include: Camp Oliver Landfill, SWMU 2; Tactical Air Command (TAC)-X Landfill, SWMU 3; Inactive Explosive Ordnance Disposal (EOD) Area in Red Cloud Range, Hotel Area, SWMU 9; Inactive EOD Area North of Garrison Area, SWMU 10; Inactive EOD Area Located Approximately Three Miles Northeast of Garrison Area, SWMU 11; Active EOD Containing Open Detonation (OD) Unit and Open Burn (OB) Unit, SWMU 12A; Old Fire Training Area, SWMU 14; Defense Reutilization and Marketing Organization (DRMO) Hazardous Waste Storage Area, SWMU 17; Industrial Wastewater Treatment Plant (IWTP), SWMU 18; Old Sludge Drying Beds, SWMU 19; Old Radiator Shop/Paint Booth, SWMU 24B; Motorpools, SWMUs 27A through 27V; Evans Army Heliport Petroleum, Oil, and Lubricants (POL) Storage Facility, SWMU 29; Directorate of Engineering and Housing (DEH) Asphalt Tanks, SWMU 31; Supply Diesel Tank, SWMU 32; DEH Equipment Wash Rack, SWMU 34; and National Guard Training Center (NGTC) Equalization Basin, SWMU 37. Four of the 16 sites—Old Sludge Drying Beds, SWMU 19; Old Radiator Shop/Paint Booth, SWMU 24B; Motorpools, SWMUs 27A through 27V; and NGTC Equalization Basin, SWMU 37—had not been previously investigated and were investigated as Phase I RFIs. This report has been prepared by Science Applications International Corporation (SAIC) for the U.S. Army (Army) Corps of Engineers (USACE)–Savannah District under Contract DACA21-95-D-0022, Delivery Order No. 0009. The RFI was conducted in accordance with USACE Guidance EM 200-1-3.

1.1 OBJECTIVES AND SCOPE OF THE INVESTIGATION

The specific objectives of the Phase I and Phase II RFIs for the 16 SWMUs at Fort Stewart, Georgia, as defined in the Phase II RFI Sampling and Analysis Plan (SAP) (SAIC 1997) [approved by the Georgia Environmental Protection Division (GEPD) in October 1997] are listed below.

Phase I RFI

- Determine if contamination of the environment has occurred.
- Determine whether contaminants, if present, constitute a threat to human health or the environment.
- Determine the need for future action and/or no further action (NFA).

Phase II RFI

- Determine the horizontal and vertical extent of contamination.
- Determine whether contaminants present a threat to human health or the environment.
- Determine the need for future action and/or NFA.
- Gather data necessary to support a Corrective Action Plan (CAP), if warranted.

The information provided in this report is based upon data collected previously during the Phase I RFI (if available) and data collected as part of the Phase II field sampling and analysis. At some of the sites, the

Phase II sampling program incorporated an observational approach to sampling, as defined in the Phase II RFI SAP (SAIC 1997). This observational approach used field screening techniques to determine the horizontal and vertical extent of contamination at the SWMU and to identify suitable locations for installation of permanent monitoring wells. The scope of the fieldwork for the Phase I and II sites included the activities listed below.

Phase I Sites

- Collection of direct-push soil samples using a push probe.
- Collection of direct-push groundwater samples using a push probe.
- Collection of surface water and sediment samples at SWMUs where surface water and/or sediment was available.
- Surveying of the positions of all sample locations.

Phase II Sites

- Collection of direct-push soil samples using push probes.
- Collection of direct-push groundwater samples using push probes, including vertical-profile probes.
- Installation of permanent groundwater monitoring wells both upgradient and downgradient of the site.
- Groundwater sampling at existing monitoring wells (if available) and sampling of newly installed wells around the SWMUs.
- Collection of surface water and sediment samples at SWMUs where surface water and/or sediment was available.
- Surveying of the positions of all sample locations.

1.2 REPORT ORGANIZATION

This Phase II RFI Report consists of three volumes: 12 chapters of text in Volume I, 7 appendices in Volume II, and a final appendix in Volume III. Chapter 1.0 describes the purpose of this investigation, summarizes the scope of work performed, and presents the organization of the report. General information is presented in Chapters 2.0 through 8.0. Chapter 2.0 describes the Fort Stewart Military Reservation (FSMR) Installation and discusses the history of the FSMR and FSMR regulator history. Chapter 3.0 presents the regional setting of the FSMR, including the demographics, topography, regional geology and hydrogeology, surface drainage, soils, and ecology. Chapter 4.0 summarizes the investigation activities and methodologies used in completing the Phase II RFI fieldwork. Chapter 5.0 describes the results of the background interpretation for surface soil, subsurface soil, groundwater, surface water, and sediment and their relationship to each site. Chapter 6.0 identifies general considerations affecting contaminant fate and transport. Chapter 7.0 presents the general methodology for the human health preliminary risk evaluation (HHPRE), and Chapter 8.0 presents the general methodology for the ecological preliminary risk evaluation (EPRE).

SWMU–specific information corresponding to Chapters 2.0 through 8.0 is presented in Chapters 9.0 and 10.0, including site-specific conclusions on nature and extent of contaminants, fate and transport, HHPRE, and EPRE. Chapter 9.0, identified by a gray tab, designates in sequential order the SWMUs that are recommended for NFA because contaminant levels in soil, groundwater, sediment, and surface water are below reference background criteria or the sites do not pose a risk to human health and the environment based on human health and ecological risk assessments. Chapter 10.0, identified by a blue tab, designates in sequential order the SWMUs that are recommended for additional investigation or a CAP. Secondary tabs are used to separate the individual SWMUs behind the gray or blue tab. Chapter 11.0 presents conclusions and recommendations identifying the SWMUs being recommended for NFA or SWMUs that indicate risk to human health or environment and are recommended for additional investigation or a CAP. References are presented in Chapter 12.0.

Volume II of this report contains nine appendices. Appendix A contains the direct-push technology and boring logs. Appendix B contains monitoring well construction diagrams. Appendix C is the Quality Control Summary Report. Appendix D provides a comparison of metal data from the Phase I and Phase II RFIs. Appendix E contains the geotechnical laboratory test results. Appendix F is the background data summary. Appendix G contains the chain-of-custody forms.

Volume III of this report contains five appendices. Appendix H provides the analytical data results. In addition, the analytical data are provided in electronic format (i.e., on CDs). Appendix I presents the methodology for the human health baseline risk assessment. Appendix J contains the toxicity profiles for contaminants of potential concern (COPCs). Appendix K presents Fate and Transport Input Data and Model Description. Appendix L presents the revised response to GEPD comments received on the final Phase II RFI Report for 16 SWMUs submitted in February 1999 and the meeting minutes for the comment response meeting with GEPD held on September 14, 1999.

2.0 SITE HISTORY AND CONTAMINANTS

2.1 INSTALLATION DESCRIPTION

Fort Stewart (then known as Camp Stewart) was established in June 1940 as an antiaircraft artillery training center. Between January and September 1945, the Installation operated as a prisoner-of-war camp. The Installation was deactivated in September 1945. In August 1950 Fort Stewart was reactivated to train antiaircraft artillery units for the Korean Conflict. The training mission was expanded to include armor training in 1953. Fort Stewart was designated a permanent Army installation in 1956 and became a flight training center in 1966. Aviation training at the Fort Stewart facilities was phased out in 1973. In January 1974 the 1st Battalion, 75th Infantry was activated at Fort Stewart. Fort Stewart then became a training and maneuver area, providing tank, field artillery, helicopter gunnery, and small arms training for regular Army and National Guard units. The 24th Infantry Division, which was reflagged as the 3d Infantry Division in May 1966, was permanently stationed at Fort Stewart in 1975. These activities comprise the Installation's primary mission today.

The FSMR is located in portions of Liberty, Bryan, Long, Tattnall, and Evans counties, Georgia, approximately 40 miles west-southwest of Savannah, Georgia (Figures 2-1 and 2-2). The cantonment, or garrison area, of the FSMR is located within the Liberty County portion of the FSMR, on the southern boundary of the reservation. Hinesville, Georgia, is the nearest city to the garrison area and is located immediately south of the reservation's boundary.

2.2 SITE LOCATION AND HISTORY

The Phase I RFIs were conducted in response to a RCRA Facility Assessment (RFA) submitted to the GEPD in June 1990. The RFA listed 24 SWMUs requiring some type of RFI action (Geraghty and Miller 1992). The objective of the Phase I investigations at Fort Stewart was to determine if a release to the environment had occurred from any of the 24 identified SWMUs and to decide if the site had the potential for a release to the environment. After the Phase I RFI Report, 11 oil/water separators (OWSs) were added under SWMU 27 for a total of 32 OWSs distributed over 29 sites. Each site represents a distinct geographic area requiring an investigation. Sixteen of the original 24 SWMUs presented in the Phase I RFI Report were recommended for a Phase II RFI, or initial investigation (Phase I), and are presented in this Phase II RFI Report. In addition, a recently identified site, the NGTC Equalization Basin (SWMU 37), is also presented in this report. Thus, 17 SWMUs were investigated: 13 Phase II RFIs (SWMUs 2, 3, 9, 10, 11, 12, 14, 17, 18, 29, 31, 32, and 34) and four Phase I RFIs (SWMUs 19, 24B, 27A through 27V, and 37). Site descriptions for the SWMUs are presented under the respective SWMU sections in Chapters 9.0 and 10.0.

Seven of the 16 SWMUs are located outside the garrison area (i.e., SWMUs 2, 3, 9, 10, 11, 12A, and 29) and are presented in Figure 2-3. The remaining SWMUs (i.e., SWMUs 14, 17, 18, 19, 24B, 27A through 27V, 31, 32, 34, and 37) are located within the garrison area and are presented in Figure 2-4. Table 2-1 is a summary table identifying the SWMU designation from the Phase I Report, the SWMU designation from the Hazardous Waste Permit (HW-045), the level of investigation (Phase I or Phase II), and the site investigation requirements as determined by geographic location.

Table 2-1. List of Solid Waste Management Units Included in This Report

SWMU Number	SWMU Name on Hazardous Waste Permit HW-045	SWMU Name Phase I RFI Designation	Number of Site Investigations under Each SWMU	Investigation Type
2	Camp Oliver Landfill	Camp Oliver Landfill, SWMU 2 (FST-002)	1	Phase II
3	TAC-X Landfill	TAC-X Landfill, SWMU 3 (FST-003)	1	Phase II
9	Inactive EOD Area in Red Cloud Range, Hotel Area	Inactive EOD Area, SWMU 9 (FST-009)	[a]	[a]
10	Inactive EOD Area North of Garrison Area	Inactive EOD Area, SWMU 10 (FST-010)	1	Phase II
11	Inactive EOD Area Located Approximately Three Miles Northeast of Garrison Area	Inactive EOD Area, SWMU 11 (FST-011)	1	Phase II
12A	Active EOD Containing Open Detonation Unit and Open Burn Unit	Active EOD Area, SWMU 12 (FST-012)	1	Phase II
12B	Open Detonation (OD) Unit	Not identified in Phase I RFI	1[b]	Phase II[b]
12C	Open Burn (OB) Unit	Not identified in Phase I RFI	1[b]	Phase II[b]
14	Old Fire Training Area	Old Fire Training Area, SWMU 14 (FST-014)	1	Phase II
17	DRMO Hazardous Waste Storage Area	Hazardous Waste Storage Area, SWMU 17 (FST-017)	1	Phase II
18	Industrial Wastewater Treatment Plant	Industrial Wastewater Treatment Plant, SWMU 18 (FST-018)	1	Phase II
19	Old Sludge Drying Beds	Old Sludge Drying Beds, SWMU 19 (FST-019)	1	Phase I
24B	Old Radiator Shop/Paint Booth	Paint Booth, SWMU 24B (FST-24B)	1	Phase I
27A	3d Squadron, 7th Cavalry Motorpool and Four Associated Oil/Water Separators	2d Squadron, 4th Cavalry	3	Phase I
27B	1st BN, 3d ADA Motorpool and Associated Oil/Water Separator	1st BN, 5th ADA	1	Phase I
27C	92d ECB (H) Motorpool and associated Oil/Water Separator	92d ECB (H)	1	Phase I
27D	26th SPT BN Motorpool and Associated Two Oil/Water Separators	224th SPT BN	1	Phase I
27E	703d SPT BN (Main) Motorpool and Associated Two Oil/Water Separators	724th SPT BN (Main)	2	Phase I
27F	3d Engineer Brigade Motorpool and Associated Two Oil/Water Separators	24th Inf. Div Engineer Brigade	2	Phase I
27G	DISCOM Motorpool and Associated Oil/Water Separator	DISCOM	1	Phase I

Note: Footnotes appear on page 2-8.

Table 2-1. List of Solid Waste Management Units Included in This Report (continued)

SWMU Number	SWMU Name on Hazardous Waste Permit HW-045	SWMU Name Phase I RFI Designation	Number of Site Investigations under Each SWMU	Investigation Type
27H	DOL Maintenance Motorpool and Associated Two Oil/Water Separators	DOL Maintenance	2	Phase I
27I	NGTC Block 9900, 10300 Motorpool and Associated Two Oil/Water Separators	NGTC Block 9900, 10300	2	Phase I
27J	GANG MATES Motorpool and Associated Two Oil/Water Separators	GANG MATES	2	Phase I
27K	3d BN, 69th Armor Motorpool Wash Rack and Oil/Water Separator	3d BN, 69th Armor	1	Phase I
27L	NGTC Block 10200 Wash Rack and Oil/Water Separator	Not identified in Phase I RFI	1	Phase I
27M	NGTC Block 10100 Wash Rack and Oil/Water Separator	Not identified in Phase I RFI	1	Phase I
27N	NGTC Block 9800 Wash Rack and Oil/Water Separator	Not identified in Phase I RFI	1	Phase I
27O	NGTC Block 9700 Wash Rack and Oil/Water Separator	Not identified in Phase I RFI	1	Phase I
27P	NGTC Block 9500 Wash Rack and Oil/Water Separator	Not identified in Phase I RFI	1	Phase I
27Q	NGTC Block 9400 Wash Rack and Oil/Water Separator	Not identified in Phase I RFI	1	Phase I
27R	396 Transportation Company Wash Rack and Oil/Water Separator	Not identified in Phase I RFI	1	Phase I
27S	Two 103d MI BN Wash Racks and Associated Two Oil/Water Separators	Not identified in Phase I RFI	1	Phase I
27T	293 MP Company Wash Rack and Oil/Water Separator	Not identified in Phase I RFI	1	Phase I
27U	Two Wright Army Airfield Wash Racks and Oil/Water Separator	Not identified in Phase I RFI	1	Phase I
27V	Auto Craft Center Oil/Water Separator	Not identified in Phase I RFI	1	Phase I
29	Evans Army Heliport POL Storage Facility	Evans Army Heliport POL Storage Facility, SWMU 29 (FST-029)	1	Phase II
31	DEH Asphalt Tanks	DEH Asphalt Tanks, SWMU 31 (FST-031)	1	Phase II
32	Supply Diesel Tank	Supply Diesel Tank, SWMU 32 (FST-032)	1	Phase II
34	DEH Equipment Wash Rack	DEH Equipment Wash Rack, SWMU 34 (FST-034)	1	Phase II
37	NGTC Equalization Basin	Not identified in Phase I RFI	1	Phase I
		Total Number of Site Investigations[c]	44	

[a]Because SWMU 9 is contained within an active range, the site investigation at SWMU 9 was deferred until the range is closed.
[b]SWMUs 12B and 12C are contained within SWMU 12A.
[c]Total number includes 32 OWSs at 29 sites.

2.3 PREVIOUS INVESTIGATIONS

Results of previous investigations are presented under the respective SWMU sections in Chapters 9.0 and 10.0.

2.4 PRELIMINARY CONCEPTUAL SITE MODEL

Based upon a review of the history of operations at the SWMUs and the results of the Phase I RFI, representative preliminary Conceptual Site Models (CSMs) were developed identifying the potential migration pathways of contaminants. Discussions for the preliminary CSMs for each SWMU or groups of SWMUs are presented in the following sections. The final CSMs are presented under the respective SWMUs in Chapters 9.0 and 10.0.

2.4.1 Camp Oliver Landfill (SWMU 2) and TAC-X Landfill (SWMU 3)

Materials such as municipal/sanitary solid waste and construction and demolition debris were disposed of at the Camp Oliver Landfill and TAC-X Landfill using trench-and-fill landfill construction techniques.

The buried material and decomposition products associated with the landfills and the leachate generated from the infiltration/percolation of precipitation and the contact with fluctuating groundwater levels represent a potential source of contaminants at the former landfills. Leachate migration represents the most likely pathway for contaminant migration at the landfills. Potential contaminant pathways include surface runoff, migration of leachate from seeps to surface water, and migration of leachate to groundwater.

The characteristics of leachate are determined by the character of the buried material. Typically, leachate from municipal/sanitary landfills has a low pH (less than 6), significant negative oxidation-reduction (Redox) potential, and no dissolved oxygen (DO), which is indicative of reducing conditions. The leachate often has high concentrations of organic compounds, with volatile organic compounds (VOCs) being more prevalent in younger landfills (during active decomposition). The reducing conditions facilitate the dissolution of metals, which may be indicated by high total dissolved solids (TDS) concentrations and high specific conductance. The main COPCs at the former landfills are VOCs, semivolatile organic compounds (SVOCs), and metals.

2.4.2 Inactive EOD Areas (SWMUs 9, 10, and 11)

Explosive residuals, unexploded ordnance (UXO), and RCRA metals are the main concerns at the inactive EOD areas. The sites are characterized by small craters where ordnance was disposed of on the surface. The Phase I RFI indicated only one detection of explosive residuals in the soil across the three sites. Contamination at the surface from the disposal of ordnance represents the main potential migration pathway for contamination at the inactive EOD sites. The main COPCs are explosive constituents and RCRA metals. Surface water drainages are not present at SWMU 9 or SWMU 11; therefore, constituents are not likely to migrate to surface water. Surface drainage from SWMU 10 may potentially impact Taylors Creek, which is east of SWMU 10.

2.4.3 Active EOD Area (SWMU 12A)

The Active EOD Area (SWMU 12A) contains OD and OB treatment areas. Contamination at the surface from the disposal of ordnance represents the main potential migration pathway for contamination at the active EOD site. Explosive residuals, UXO, organic contaminants (SVOCs only), and RCRA metals are the COPCs at the active EOD areas. Surface drainage at SWMU 12A flows to Canoochee Creek and the swampy area located northeast and southeast, respectively, of the site.

3.0 PHYSICAL CHARACTERISTICS OF THE SITE

3.1 DEMOGRAPHICS

The FSMR is located in portions of Liberty, Bryan, Long, Tattnall, and Evans counties, Georgia, approximately 40 miles west-southwest of Savannah (Figure 2-1). The cantonment, or garrison area, of the FSMR is located within Liberty County, Georgia (Figure 2-2). Liberty County occupies 328,768 acres and had a total population of 52,745 in 1990. Forty-one percent of the county population lives in Hinesville, the largest city in Liberty County. The total population of Fort Stewart in 1990 was 13,774, 55 percent of which were employed by the Armed Forces. Forty-one percent of the Fort Stewart population lived in group quarters, while the remaining population lived in households (U.S. Department of Commerce 1990).

3.2 TOPOGRAPHY

The FSMR occupies a low-lying, flat region on the coastal plain of Georgia. Surface elevations range from approximately 20 feet to 100 feet above mean sea level (amsl) within the FSMR and generally decrease from northwest to southeast across the reservation. The topography is dominated by terraces dissected by surface water drainages. The terraces are remnants of sea level fluctuations. The four terraces present within the FSMR are the Wicomico, Penholoway, Talbot, and Pamlico (Metcalf and Eddy 1996a).

3.3 SURFACE DRAINAGE

The principal surface water body accepting drainage from the FSMR is the Canoochee River, which joins the Ogeechee River (part of the northwestern boundary of the reservation). Canoochee Creek is a tributary of the Canoochee River that drains much of the western portion of the FSMR.

The site-specific surface drainage characteristics of each SWMU are described in their respective sections in Chapters 9.0 and 10.0. Generally, the surface water drainage (if present) at the SWMUs consists of shallow swales or drainage ditches not directly linked to specific surface water bodies (i.e., creeks or rivers). The drainage swales/ditches (if present) typically drain to a low or depression area where the surface water percolates into the soil.

As discussed in Chapter 2.0, SWMUs outside the garrison area (SWMUs 2, 3, 9, 10, 11, 12A, and 29) are separate, individual remote locations and have site-specific surface water features and drainage characteristics. Only four of these sites, SWMUs 2, 3, 10, and 12A have surface water bodies in their immediate proximity.

At the majority of the SWMUs within the garrison area (SWMUs 14, 17, 18, 24B, 27A–V, 31, 32, and 34), the surface water drainage (if present) consists of shallow swales or drainage ditches to collect and direct surface water runoff from the area in which the SWMU happens to be located (e.g., motorpool) and are not specific to the SWMU in question. Therefore, the surface water/sediment is potentially influenced by many other sources.

The potential surface water drainage from SWMUs contained within the garrison primarily drains to two areas of the garrison area. SWMUs 14, 17, 18, 24B, 27A–H, 27K, 27K, 31, and 34 drain to a swales or ditches that ultimately may drain to Mill and/or Taylors Creek. However, the primary surface water drainage at these SWMUs is percolation into surface/subsurface soil.

SWMUs 27I and 27L–27T (all OWSs) are located along Troupe Avenue, and potential surface runoff from these SWMUs may migrate to the drainage ditch/swale along Troupe Avenue that ultimately drains to a low area southeast of Troupe Avenue. The effluent from eight of the SWMUs along Troupe Avenue (27I, Block 9900; 27I, Block 10300; 27L, Block 10200; 27M, Block 10100; 27N, Block 9800; 27O; 27P; and 27Q) discharges directly into the drainage ditch/swale along Troupe Avenue and adjacent to the sites. SWMUs 27I, 27J, and 37 are also located in the southeastern portion of the garrison area; however, the surface drainage does not influence the Troupe Avenue drainage swale(s). Potential runoff from SWMUs 27I and 27J is allowed to percolate into adjacent surface/subsurface soil. Potential runoff from SWMU 37 may migrate to a drainage ditch downgradient of the SWMU; however, surface runoff primarily is allowed to percolate into the surface/subsurface soil.

3.4 REGIONAL GEOLOGY

The FSMR is located within the coastal plain physiographic province. This province is typified by southeastward-dipping strata that increase in thickness from 0 foot at the fall line (located approximately 350 miles inland from the Atlantic coast) to approximately 4,200 feet at the coast. State geologic records describe a probable petroleum exploration well (the No. 1 Jelks-Rogers) located in the region as having encountered crystalline basement rocks at a depth of 4,254 feet below ground surface (bgs). This well provided the most complete record for Cretaceous, Tertiary, and Quaternary sedimentary strata. Figure 3-1 presents a geologic column for the Tertiary and Quaternary sections in the Fort Stewart area.

The Cretaceous section is approximately 1,970 feet in thickness and is dominated by clastics. The Tertiary section is approximately 2,170 feet in thickness and is dominated by limestone, with a 175-foot-thick cap of dark green phosphatic clay. This clay is regionally extensive and is known as the Hawthorn Group. The interval from approximately 110 feet to the surface is Quaternary in age and composed primarily of sand with interbeds of clay or silt. This section is undifferentiated (Metcalf and Eddy 1996a).

State geologic records contain information regarding a well drilled in October 1942, 1.8 miles north of Flemington at Liberty Field of Camp Stewart (now known as Fort Stewart). This well is believed to have been an artesian well located approximately 0.25 mile north of the runway at Wright Army Airfield within the FSMR. The log for this well describes a 410-foot section, the lowermost 110 feet of which consisted predominantly of limestone above which 245 feet of dark green phosphatic clay typical of the Hawthorn Group were encountered. The uppermost 55-foot interval was Quaternary-age interbedded sands and clays. The top 15 feet of these sediments were described as sandy clay (Metcalf and Eddy 1996a).

3.5 SOILS

The major soil types in the area of FSMR range from well-drained, nearly pure sand to poorly drained mixtures of loam, sand, and clay. The soils lack natural strength and are vulnerable to erosion if stripped of vegetation. Boring logs showing the types of soils encountered under the Phase II RFI at the SWMUs, including soil from screening probes, groundwater screening probes, and monitoring well boreholes, are given in Appendix A.

Geotechnical analyses were conducted on one bulk sample and one Shelby tube sample taken from the monitoring well boreholes. The bulk samples were analyzed for grain-size distribution [in accordance with American Society for Testing and Materials (ASTM) D422], moisture content (ASTM D2216), and Atterberg limits (ASTM D4318). In addition, the Shelby tube samples were analyzed for specific gravity (ASTM D854), porosity (EM 1110-2-1906), and permeability (ASTM D5084). Results of the geotechnical analyses are

summarized in each SWMU section as presented in Chapters 9.0 and 10.0. The geotechnical laboratory data sheets and chains of custody are included in Appendix E.

3.6 HYDROGEOLOGY

The hydrogeology in the vicinity of the FSMR is dominated by two aquifers, referred to as the Principal Artesian and the surficial aquifer, that are separated by a confining unit (Figure 3-1).

The Principal Artesian aquifer is the lowermost hydrologic unit; is regionally extensive from South Carolina through Georgia, Alabama, and most of Florida; and is regionally known as the Floridan Aquifer. This aquifer is subdivided into upper and lower hydrogeologic units. The upper hydrogeologic unit is composed primarily of Miocene-age argillaceous sands and clays and Oligocene- to Eocene-age limestones (including the Ocala Group and the Suwannee Limestone, where present) at the top. The upper hydrogeologic unit ranges in thickness from 200 feet to 260 feet and is most productive where it is thickest and where secondary permeability is most developed. The lower hydrologic unit is comprised of the Eocene-age Avon Park Limestone at the base. The transmissivity of the aquifer in the Savannah area ranges from about 28,000 square feet/day to 33,000 square feet/day (Krause and Randolph 1989). Groundwater from this aquifer is primarily used for drinking water (Arora 1984). Thirteen groundwater production wells are used for potable water supply on the FSMR, and one additional production well is available for use in fire protection.

The confining layer for the Principal Artesian aquifer is the phosphatic clays of the upper Hawthorn Group. These sediments are regionally extensive and range from 60 feet to 80 feet in thickness at the FSMR. There are minor occurrences of aquifer material within the Hawthorn Group; however, they have limited utilization (Miller 1990).

The uppermost hydrologic unit is the surficial aquifer, which consists of widely varying amounts of sand, silt, and clay ranging from 35 feet to 150 feet in thickness. This aquifer is primarily used for domestic lawn and agricultural irrigation, with wells typically yielding 2 gallons to 180 gallons per minute.

Water levels were measured from temporary piezometers at the SWMUs. The resulting data were used to determine the placement of permanent monitoring wells around respective SWMUs.

Water levels were also measured in newly installed and existing monitoring wells around the SWMUs. The potentiometric surface based on the water levels in the monitoring wells is presented for the respective SWMUs in Chapters 9.0 and 10.0.

3.7 ECOLOGY

Approximately 7.8 square miles of the 436.8 square miles at the FSMR comprise the garrison area. The remainder is used for ranges and training areas (approximately 11 percent) or held as non-use areas.

Eighty-four percent of the land is forested (approximately 367.2 square miles). Sixty-six percent of the forest area is pine, with the major species including the slash, loblolly, and longleaf pines. Thirty-four percent of the forest is composed of river bottomlands and swamps whose major species include tupelo, other gum trees, water oak, and bald cypress trees. The open range and training areas comprise 11 percent of the Installation and consist of grasses, shrubs, and scrub tree (oak) growth.

Aquatic habitats on the FSMR include a number of natural or man-made ponds and lakes, the Canoochee River, Canoochee Creek and its tributaries, and a number of bottomland swamps and pools. The Ogeechee River borders the installation along its northeast boundary. Organic detritus content is high, and dark coloring of the water is not unusual. Dense growths of aquatic vegetation are also typical, especially during the summer months.

Both terrestrial and aquatic fauna are abundant in the unimproved areas of the FSMR. Major game species found on the installation include white-tailed deer, feral hog, wild turkey, rabbit, squirrel, and bobwhite in addition to numerous other mammal, bird, reptile, and amphibian species (Environmental Science and Engineering 1982). Dominant fish include bluegill, largemouth bass, crappie, sunfish, channel catfish, minnows, and shiners. Three federally listed threatened or endangered species reside at the FSMR: the American bald eagle, Eastern indigo snake, and red-cockaded woodpecker.

3.8 METEOROLOGY

Fort Stewart has a humid, subtropical climate with long, hot summers. Average temperatures range from 50°F in the winter to 80°F in the summer. Average annual precipitation is 48 inches, with slightly over half falling from June through September. Prolonged drought is rare in the area, but severe local storms (tornadoes and hurricanes) do occur. Under normal conditions, wind speeds rarely exceed 5 knots, but gusty winds of more than 25 knots may occur during summer thunderstorms (Geraghty and Miller 1992).

4.0 SUMMARY OF INVESTIGATION ACTIVITIES

4.1 SAMPLING METHODOLOGIES

This section describes the general RFI procedures and methodology followed at the 16 SWMUs from January 13 through June 12, 1998. In addition, sampling to address specific GEPD comments on the final Phase II RFI for 16 SWMUs was performed during field mobilizations conducted July 10, 1999, through November 4, 1999. The sampling methodologies and types of testing for physical and chemical characterization of the site are also described. Specific numbers of samples and types of physical and chemical characterization as well as locations are presented under the respective SWMU discussions in Chapters 9.0 and 10.0. The sampling strategy included installation and collection of direct-push soil and groundwater samples, installation and sampling of monitoring wells, groundwater sampling of existing monitoring wells, and surface water and sediment sampling. Table 4-1 presents a summary table of the media sampled, with the number of samples collected per medium for each SWMU investigated. Table 4-2 presents a summary of the types of analyses performed on each medium at each site.

4.1.1 Soil Sampling

Soil sampling was conducted using two methods: (1) direct-push methods and (2) hollow-stem augers during installation of soil borings and monitoring wells.

4.1.1.1 Direct-push soil sampling

Direct-push soil probes were completed within or around the perimeter of a SWMU to evaluate the potential extent of contamination. The direct-push soil probes were selected for the following reasons:

- to determine the extent of contamination in surface and subsurface soil at the SWMU and
- to minimize generation of investigation-derived waste (IDW).

The direct-push soil samples were taken using a 4-foot macro sampler by pushing the sampler from the ground surface down to the water table in continuous 4-foot intervals. Each 4-foot sample was split into two 2-foot samples. The headspace of the soil samples was field-tested for VOCs using a photoionization detector (PID). The sample from each boring having the highest detected organic vapor concentration in the headspace gas was then sent off-site for quantitative laboratory analysis for VOCs with rapid (24-hour) turnaround. If no VOCs were detected in the headspace gas, then the sample from the 2-foot interval directly above the water table was sent for analysis because COPCs at the SWMUs would tend to be distributed at the soil/water interface. These samples served to confirm the presence or absence of contamination using quantitative data. Results of the laboratory VOC analyses are presented in Chapters 9.0 and 10.0. Logs for the direct-push soil probes showing headspace readings and depths sampled are included in Appendix A.

Samples designated for possible VOC laboratory analysis were collected first from each interval using a stainless steel spoon and placed into laboratory sample containers. A portion of the remaining sample was then placed into containers designated for headspace analyses. The remaining portion of the sample was used for field lithologic description.

Table 4-1. Summary of Media and Investigation Technologies for the SWMUs

Area	Media or Investigation Technology												
	Surface Water Samples	Sediment Samples	Wastewater Samples	Direct-push Groundwater Screening Samples	Direct-push Vertical-profile Samples[a]	Surface Soil Samples	Soil Borings[b]	Direct-push Groundwater Samples	3/4-Inch-diameter Permanent Monitoring Point[c]	Monitoring Wells Installed	Subsurface Soil Samples	Existing Wells Sampled	Geotechnical Samples
SWMU 2 Camp Oliver Landfill	2	2			1	11	6	3		3	8	4	2
SWMU 3 TAC-X Landfill	2	3		3	1	10	7	3		4	7	4	4
SWMU 9 Inactive EOD Area[d]													
SWMU 10 Inactive EOD Area	2	2		8		3							
SWMU 11 Inactive EOD Area				8		3							
SWMU 12A Active EOD Area	5	5				11				3	3	7	3
SWMU 14 Old Fire Training Area					1	9	10			4	11	4	4
SWMU 17 DRMO Hazardous Waste Storage	2	2		6	1	6				3	3		3
SWMU 18 IWTP	8[e]	8[e]	2	25	14	6	10			9	12		10
SWMU 19 Old Sludge Drying Beds						8		8	1		8		

Note: Footnotes appear on page 4-3.

Table 4-1. Summary of Media and Investigation Technologies for the SWMUs (continued)

Area	Media or Investigation Technology												
	Surface Water Samples	Sediment Samples	Wastewater Samples	Direct-push Groundwater Screening Samples	Direct-push Vertical-profile Samples[a]	Surface Soil Samples	Soil Borings[b]	Direct-push Groundwater Samples	3/4-Inch-diameter Permanent Monitoring Point[c]	Monitoring Wells Installed	Subsurface Soil Samples	Existing Wells Sampled	Geotechnical Samples
SWMU 24B Old Radiators Shop/Paint Booth						5		6			4		
SWMUs 27A–27V Motorpools	3	12		119			5	119	13	5[f]	119[g]		
SWMU 29 Evans Heliport POL				18	2	15	9			9	12		6
SWMU 31 DEH Asphalt Tanks				9	1	6	3			3	7		3
SWMU 32 Supply Diesel Tank				4	1	6	3			3	6		3
SWMU 34 DEH Wash Rack				4	1	6	3			3	6		3
SWMU 37 NGTC Equalization Basin		4[e]	4[e]	6	1	4					5		1

[a]The temporary piezometer location at the site indicating the highest concentration from screening was the initial vertical profile. If required, subsequent vertical profiles were installed based on field screening results and groundwater flow direction. Therefore, three groundwater samples were taken for each vertical profile (i.e., 10 feet to 30 feet bgs, 30 feet to 40 feet bgs, and 40 feet to 50 feet bgs) unless site-specific subsurface conditions (i.e., refusal) prevented sampling.
[b]Includes borings for installation of monitoring wells.
[c]With the concurrence of GEPD, 3/4-inch-diameter permanent monitoring points were installed, and the groundwater was resampled to confirm direct-push groundwater results.
[d]Because SWMU 9 is located within an active range, the Phase II RFI was deferred until closure of the range.
[e]Sediment and surface water samples included samples collected from their respective equalization basins.
[f]With the concurrence of GEPD, a 2-inch PVC monitoring well was installed, and the groundwater was resampled to confirm direct-push groundwater results.
[g]Continuous soil sampling was performed. The soil sample indicating the highest organic concentration from screening was sent off-site for analysis.

Table 4-2. Summary of Media Sampled and Laboratory Analyses Performed for the SWMUs

SWMU Number	SWMU Name	VOCs	SVOCs	TPH–Recoverable[a]	Pesticides/PCBs	RCRA Metals	Lead	Explosive Constituents	Geotechnical[b,c]
Surface Soil									
SWMU 2	Camp Oliver Landfill	X	X		X	X			
SWMU 3	TAC-X Landfill	X	X		X	X			
SWMU 9[d]	Inactive EOD Area[d]								
SWMU 10	Inactive EOD Area					X		X	
SWMU 11	Inactive EOD Area					X		X	
SWMU 12A	Active EOD Area		X			X		X	
SWMU 14	Old Fire Training Area	X	X			X			
SWMU 17	DRMO Hazardous Waste Storage Area	X	X			X			
SWMU 18	Industrial Wastewater Treatment Plant	X	X			X			
SWMU 19	Old Sludge Drying Bed	X	X		X	X			
SWMU 24B	Old Radiator Shop/Paint Booth	X	X			X			
SWMUs 27A–27V	Motorpools	X	X			X[e]	X		
SWMU 29	Evans Army Heliport POL Storage Facility	X	X			X			
SWMU 31	DEH Asphalt Tanks	X	X			X			
SWMU 32	Supply Diesel Tank	X	X			X			
SWMU 34	DEH Equipment Wash Rack	X	X			X			
SWMU 37	NGTC Equalization Basin	X	X			X			
Subsurface Soil									
SWMU 2	Camp Oliver Landfill	X	X		X	X			X
SWMU 3	TAC-X Landfill	X	X		X	X			X
SWMU 9[d]	Inactive EOD Area[d]								
SWMU 10	Inactive EOD Area								
SWMU 11	Inactive EOD Area								
SWMU 12A	Active EOD Area		X			X		X	X
SWMU 14	Old Fire Training Area	X	X			X			X
SWMU 17	DRMO Hazardous Waste Storage Area	X	X			X			X
SWMU 18	Industrial Wastewater Treatment Plant	X	X			X			X
SWMU 19	Old Sludge Drying Bed	X	X		X	X			

Note: Footnotes appear on page 4-7.

Table 4-2. Summary of Media Sampled and Laboratory Analyses Performed for the SWMUs (continued)

SWMU Number	SWMU Name	VOCs	SVOCs	TPH–Recoverable[a]	Pesticides/PCBs	RCRA Metals	Lead	Explosive Constituents	Geotechnical[b,c]
SWMU 24B	Old Radiator Shop/Paint Booth	X	X			X			
SWMUs 27A–27V	Motorpools	X	X			X[e]	X		
SWMU 29	Evans Army Heliport POL Storage Facility	X	X			X			X
SWMU 31	DEH Asphalt Tanks	X	X			X			X
SWMU 32	Supply Diesel Tank	X	X			X			X
SWMU 34	DEH Equipment Wash Rack	X	X			X			X
SWMU 37	NGTC Equalization Basin	X	X			X			X
Sediment									
SWMU 2	Camp Oliver Landfill	X	X		X	X			
SWMU 3	TAC-X Landfill	X	X		X	X			
SWMU 9[d]	Inactive EOD Area[d]								
SWMU 10	Inactive EOD Area					X		X	
SWMU 11	Inactive EOD Area								
SWMU 12A	Active EOD Area		X			X		X	
SWMU 14	Old Fire Training Area								
SWMU 17	DRMO Hazardous Waste Storage Area	X	X			X			
SWMU 18	Industrial Wastewater Treatment Plant	X	X			X			
SWMU 19	Old Sludge Drying Bed								
SWMU 24B	Old Radiator Shop/Paint Booth								
SWMUs 27A–27V	Motorpools	X	X			X[e]	X		
SWMU 29	Evans Army Heliport POL Storage Facility								
SWMU 31	DEH Asphalt Tanks								
SWMU 32	Supply Diesel Tank								
SWMU 34	DEH Equipment Wash Rack								
SWMU 37	NGTC Equalization Basin	X	X			X			
Groundwater[f]									
SWMU 2	Camp Oliver Landfill	X	X		X	X			
SWMU 3	TAC-X Landfill	X	X		X	X			

Note: Footnotes appear on page 4-7.

Table 4-2. Summary of Media Sampled and Laboratory Analyses Performed for the SWMUs (continued)

SWMU Number	SWMU Name	VOCs	SVOCs	TPH–Recoverable[a]	Pesticides/PCBs	RCRA Metals	Lead	Explosive Constituents	Geotechnical[b,c]
SWMU 9[d]	Inactive EOD Area[d]								
SWMU 10	Inactive EOD Area							X	
SWMU 11	Inactive EOD Area							X	
SWMU 12A	Active EOD Area		X			X[g]		X	
SWMU 14	Old Fire Training Area	X	X			X			
SWMU 17	DRMO Hazardous Waste Storage Area	X	X	X		X			
SWMU 18	Industrial Wastewater Treatment Plant	X	X	X		X			
SWMU 19	Old Sludge Drying Bed	X	X		X	X			
SWMU 24B	Old Radiator Shop/Paint Booth	X	X			X			
SWMUs 27A–27V	Motorpools	X	X			X[e]	X		
SWMU 29	Evans Army Heliport POL Storage Facility	X	X	X		X			
SWMU 31	DEH Asphalt Tanks	X	X	X		X			
SWMU 32	Supply Diesel Tank	X	X	X		X			
SWMU 34	DEH Equipment Wash Rack	X	X	X		X			
SWMU 37	NGTC Equalization Basin	X		X					
Surface Water									
SWMU 2	Camp Oliver Landfill	X	X		X	X			
SWMU 3	TAC-X Landfill	X	X		X	X			
SWMU 9[d]	Inactive EOD Area[d]								
SWMU 10	Inactive EOD Area					X		X	
SWMU 11	Inactive EOD Area								
SWMU 12A	Active EOD Area		X			X		X	
SWMU 14	Old Fire Training Area								
SWMU 17	DRMO Hazardous Waste Storage Area	X	X			X			
SWMU 18	Industrial Wastewater Treatment Plant	X	X			X			
SWMU 19	Old Sludge Drying Bed								
SWMU 24B	Old Radiator Shop/Paint Booth								

Note: Footnotes appear on page 4-7.

Table 4-2. Summary of Media Sampled and Laboratory Analyses Performed for the SWMUs (continued)

SWMU Number	SWMU Name	VOCs	SVOCs	TPH–Recoverable[a]	Pesticides/PCBs	RCRA Metals	Lead	Explosive Constituents	Geotechnical[b,c]
SWMUs 27A–27V[h]	Motorpools	X	X			X[e]	X		
SWMU 29	Evans Army Heliport POL Storage Facility								
SWMU 31	DEH Asphalt Tanks								
SWMU 32	Supply Diesel Tank								
SWMU 34	DEH Equipment Wash Rack								
SWMU 37	NGTC Equalization Basin	X	X			X			

[a]Performed on groundwater screening samples only.
[b]One soil sample from each monitoring well was analyzed for grain-size distribution, Atterberg limits, and moisture content.
[c]One soil sample from each SWMU was analyzed for permeability, porosity, specific gravity, and total organic carbon.
[d]Because SWMU 9 is located within an active range, the Phase II RFI was deferred until closure of the active range.
[e]RCRA metals analysis was performed on media at two of the motorpools.
[f]One groundwater sample from each site was analyzed for ferric iron and sulfate to be used in the future to perform a Risk-based Corrective Action.
[g]Additional metals analyses were performed to meet Subpart X monitoring requirements.
[h]Surface water was available at some sites only after rainfall events.
X = Analyzed for on all samples.

4.1.1.2 Permanent monitoring points

Permanent monitoring points were installed at some SWMUs under Phase I investigation to confirm groundwater sample results obtained from direct-push groundwater sampling. The confirmation resampling and the installation of the permanent monitoring points at each location were approved by GEPD prior to the installation. The permanent monitoring points were installed using techniques similar to those described for direct-push groundwater sampling (see Section 4.1.2.1). A 3/4-inch-inside-diameter polyvinyl chloride (PVC) monitoring point with a 10-foot screened interval with a filter pack was installed to intersect the water table. The permanent monitoring point was installed approximately 1 foot away from the location to be resampled. Groundwater samples were collected using the same procedures as those described for direct-push groundwater sampling (see Section 4.1.2.1).

4.1.1.3 Soil sampling at soil boring and monitoring well locations

Soil samples were also taken during the drilling of boreholes for the installation of soil borings and monitoring wells using the hollow-stem auger drilling method. Auger-drilled soil boreholes were advanced using 4.25-inch-inside-diameter hollow-stem augers using either a CME-55 or Ingersoll-Rand A-300 drill rig. The borehole samples were collected to obtain the following:

- relatively undisturbed samples for geotechnical testing,

- lithographic descriptions of the soil profile at each monitoring well,
- background surface and subsurface soil samples for characterization, and
- surface and subsurface soil samples for characterizing the nature and extent of contaminants.

During the drilling of each soil borehole, soil samples were collected with a split-barrel sampler continuously over 5-foot intervals from the ground surface to the water table. The 5-foot core was split into two 2.5-foot sections. A portion of each 2.5-foot section was field-tested for VOC headspace gas using a PID. As with the direct-push soil samples, the borehole sample having the highest detected organic vapor concentration in the headspace gas was then sent off-site for quantitative laboratory analysis. If no VOCs were detected in the headspace gas, then the sample from the 2.5-foot interval directly above the soil/water interface was sent for analysis because contaminants typically tend to be distributed at the water table interface. In addition, the surface sample taken from a depth of 0 to 1 foot bgs was sent off-site for analysis for use in the HHPRE and EPRE; therefore, two soil samples were collected from each borehole for chemical analyses. Results of the chemical analyses are presented under the respective SWMUs in Chapters 9.0 and 10.0. Boring logs for the drilling of soil borings and monitoring wells are included in Appendix A.

Decontamination of drilling and downhole sampling equipment was accomplished in accordance with the procedures specified in the Phase II RFI SAP (SAIC 1997). These procedures included washing with water and phosphate-free detergent, rinsing alternately with water and isopropyl alcohol, air drying, and placing the equipment on clean plastic or wrapping it in plastic or aluminum foil to prevent cross-contamination.

At monitoring well boreholes, one soil sample from the screened interval in each borehole was analyzed for geotechnical parameters to support contaminant transport evaluation. Bulk soil samples were taken from all monitoring well boreholes. The soil was collected directly from the 5-foot split-barrel core and placed into containers. The samples were tested for moisture content, Atterberg limits, and grain-size distribution. At one well at each site, a relatively undisturbed sample was collected for geotechnical analysis using a thin-walled (Shelby) tube sampler. The Shelby tube sampler was inserted into the hollow-stem auger string and hydraulically pushed approximately 2 feet. The ends of the Shelby tube sampler were sealed with wax to preserve the moisture content in accordance with ASTM D1587-94, and the tubes were shipped to an off-site laboratory for analysis. The Shelby tube sample was tested for soil porosity, specific gravity, and permeability. Soil from these locations was also sampled for total organ carbon (TOC).

4.1.2 Groundwater Sampling

4.1.2.1 Direct-push groundwater sampling

The direct-push groundwater samples were taken for the following reasons:

- to delineate the extent of contamination in groundwater,
- to determine the most appropriate locations for monitoring wells based on contamination, and
- to estimate the approximate direction of groundwater flow to determine the most appropriate locations for downgradient monitoring wells.

A single grab sample of groundwater was obtained at the water table from the direct-push locations. Multiple grab samples of groundwater at varying depth intervals were collected at vertical-profile stations to measure

the vertical distribution of contamination. The locations of the direct-push groundwater probes are presented under each SWMU in Chapters 9.0 and 10.0.

The direct-push groundwater samples at the water table probe locations were taken using direct-push sampling techniques (Dietrich Power Punch devices mounted on a Mobil B-47 drilling rig or Geoprobe devices mounted on trucks). The sampling device used for shallow groundwater sampling had a 7/8-inch-inside-diameter screen/casing. The device was pushed down to between 3 feet and 5 feet below the level of the water table that was encountered, and a grab groundwater sample was retrieved at the water table using a peristaltic pump or stainless steel bailer. At the vertical-profile locations, multiple depths were sampled from the same hole using a dual wall system that prevented cross-contamination of the sample intervals to a maximum of 50 feet or when the Hawthorn layer was reached, whichever was encountered first. The Hawthorn layer is a confining unit that prevents downward migration of contaminants. The samples were then sent off-site for laboratory analyses for site-specific screening parameters with rapid (24-hour) turnaround. The site-specific screening parameter was typically VOCs; however, explosive constituents were analyzed at SWMUs where EOD disposal had historically occurred. Results of the site-specific screening analyses are presented under the respective SWMUs in Chapters 9.0 and 10.0.

To assist in estimating the direction of groundwater flow, water levels were measured in temporary piezometers that were set in the direct-push holes. Following installation of all temporary piezometers, each piezometer was surveyed for horizontal and vertical elevation. Unfortunately, field parameter measurements were not taken during groundwater screening sampling as proposed in the SAP because an insufficient amount of sample was available. The results of these measurements are presented under the respective SWMUs in Chapters 9.0 and 10.0.

4.1.2.2 Monitoring well installation and development

Monitoring wells were installed at SWMUs under Phase II investigation and with the concurrence of GEPD at some Phase I RFI sites (SWMUs 27F, Northeast of Building 1340; 27J, Building 10535; 27N, Block 9800; 27S; and 27U) to confirm or deny potential contamination at selected Geoprobe locations. The monitoring well boreholes were drilled using the hollow-stem-auger drilling method. Auger-drilled monitoring well boreholes were advanced using 4.25-inch inside diameter hollow-stem augers using a CME-55 or Ingersoll Rand A-300 drill rig. The resulting borehole was approximately 9.5 inches in diameter. The total depth of each borehole was dictated by the depth at which the water table was encountered. Boreholes were drilled to allow 7 feet of screen (total screen length 10 feet) to be placed beneath the water table.

The wells were constructed of 2-inch-diameter Schedule 40 PVC with flush-threaded couplings. Well screens were constructed of factory-slotted pipe in 10-foot-long sections. Slot size, determined from the sieve analysis results from the direct-push soil probes and field sieve analyses, was 0.008 inch (No. 8 slot). No. 8 slot size was used for all monitoring well screens. Filter pack materials consisted of DSI Extra-fine Sand. A 2-foot-thick bentonite seal consisting of commercially available pellets was placed above the filter pack. After placement of the pellets, a small volume of approved water was used to hydrate the pellets for a minimum of one hour. Grout composed of Type I Portland cement, 3 pounds of dry powdered bentonite per 94-pound sack of dry cement, and a maximum of 7 gallons of approved water per sack of cement was placed in the remaining annulus starting at just above the bentonite seal using a rigid-side discharge tremie pipe. The annulus was grouted to the ground surface for aboveground completions and to approximately 2 feet bgs for flush-mounted completions. The site requirements determined whether a monitoring well was completed aboveground or flush. For aboveground completions a protective iron/steel casing was installed as the grout was being placed within the well annulus. The protective casing was set approximately 5 feet below and extended approximately 3 feet above the ground. A protective concrete pad with measurements of 3 feet by 3 feet square and with a thickness of 4 inches was poured around the exterior of the protective casing, and four steel posts were

installed to protect the aboveground completions. Well construction diagrams are presented in Appendix B. Well construction details are summarized under each respective SWMU in Chapters 9.0 and 10.0.

The wells were installed such that the screened interval bisected the water table so that any nonaqueous-phase liquid floating on the water table surface could be detected in the well.

The wells were developed throughout the field investigation a minimum of 48 hours after installation. Well development was accomplished using a downhole positive-displacement pump. A surge block was used to agitate and mobilize particulates around the well screen by rapidly surging the surge block up and down. Well development continued until field parameters stabilized, turbidity was less than 10 nephelometric turbidity units (NTUs), sediment within the well was less than 0.1 foot, a minimum of five times the standing water volume in the well had been removed or a maximum of 12 hours had passed, and five times the volume of any water added during completion had been removed. Water quality parameters (pH, conductivity, temperature, DO, Eh, and turbidity) were measured during well development to verify that all field parameters had reached equilibrium. At some wells turbidity remained higher than 10 NTUs after 12 hours of development, but all other development criteria had been met. Well development is summarized under each respective SWMU in Chapters 9.0 and 10.0.

4.1.2.3 Monitoring well sampling

Groundwater sampling was conducted at least 14 days after well development. Monitoring wells were sampled using low-flow micropurging techniques to minimize the volume of purge water, the disturbance of the aquifer, and, thereby, the turbidity of the sample. The wells were checked for free product, and water levels were measured prior to purging and sampling. Field parameters (pH, conductivity, temperature, DO, Eh, and turbidity) were monitored during micropurging. The purge rate was adjusted, as necessary, to avoid purging any well to dryness and to equal the recharge of the aquifer. Purging was considered complete when the field parameters stabilized within plus or minus 10 percent after a minimum of three readings at 5-minute intervals and a turbidity of less than 10 NTUs was achieved. Purging times varied, requiring from 8 hours to 12 hours of purging to attain a turbidity of less than 10 NTUs. At some wells turbidity did not reduce to below 10 NTUs after 6 consecutive hours of purging. In such cases a field decision was made to increase the target turbidity to 25 NTUs, and up to 4 additional hours of purging were performed to achieve 25 NTUs. After a total of 10 hours of purging, if the turbidity still had not dropped below 25 NTUs, filtered and unfiltered metal samples were taken. A list of wells that did not achieve 25 NTUs even after 10 hours of purging and the associated results of field parameter measurements recorded at the end of purging in each well are presented under the respective SWMUs in Chapters 9.0 and 10.0.

Sampling of each monitoring well began immediately after completion of purging, using the same micropurging pump. Groundwater samples were transferred directly into laboratory sample containers, with the portion designated for volatile organic analysis taken first. Filtered groundwater samples were collected by attaching a 0.45-micron filter to the end of the low-flow pump sampling line. A field test kit was used to measure ferric iron at selected monitoring wells. Ferric iron analyses were randomly distributed across existing and new wells. Groundwater samples were then sent off-site for laboratory chemical analysis. Total iron, ferric iron, and sulfate analyses were performed at selected locations to support contaminant fate and transport modeling and potential remedial alternative development.

4.1.3 Surface Water and Sediment Sampling

Surface water and sediment samples were collected at upstream (background) and downstream sampling locations where surface water was a potential migration pathway. Surface water samples were collected first, and then field measurements were taken for pH, specific conductance, temperature, DO, and turbidity. Sediment samples were collected using stainless steel scoops or an Eckman dredge depending on the depth of the water. Samples were then sent off-site for laboratory chemical analysis.

4.1.4 Wastewater and Sediment (Sludge) Sampling

Surface water and sediment (sludge) were collected in the equalization basin of the IWTP (SWMU 18) and the NGTC Equalization Basin (SWMU 37). In addition, influent and effluent wastewater was collected at SWMU 18.

4.1.5 Investigation-derived Waste Management

IDW was managed in accordance with the procedures specified in the Phase II RFI SAP (SAIC 1997). All IDWs were determined to be nonhazardous materials. Solid wastes were disposed of by transporting the material to the Fort Stewart Sanitary Landfill for use as daily cover. Liquid wastes were disposed of at the Fort Stewart IWTP.

4.2 DATA QUALITY ASSESSMENT

Multiple activities were performed to achieve the desired data quality in this project. Data quality objectives (DQOs) were established to guide the implementation of the field sampling and laboratory analysis. A quality assurance (QA) program was established to standardize procedures and to document activities. Upon receipt by the project team, data were subjected to a verification and validation review that identified and qualified problems related to the analysis. The review steps contributed to a final Quality Control Summary Report (QCSR), Appendix C, which ensures that data used in the investigation met the criteria and were employed appropriately.

The QA program established requirements for both field and laboratory quality control (QC) procedures. In general, field QC duplicates and QA split samples were required for each environmental sample matrix collected at sites being investigated; VOC trip blanks were to accompany each cooler containing water samples for VOC determinations; equipment rinsate blanks were collected; and analytical laboratory QC duplicates, matrix spikes, laboratory control samples, and method blanks were required for every 20 samples or fewer of each matrix and analyte. The primary goal of the QA program was to ensure that the quality of results for all environmental measurements was appropriate for the data's intended use. To this end, a Quality Assurance Project Plan (QAPP) and standardized field procedures were compiled to guide the investigation. Through the process of readiness review, training, equipment calibration, QC implementation, and detailed documentation, the project successfully accomplished the goals set by the QA program.

Project data quality determines its usability. The evaluation was based on the interpretation of laboratory QC measures, field QC measures, and the project DQOs. Daily Quality Control Reports and other field-generated documents such as sampling logs, boring logs, daily health and safety summaries, daily safety inspections, equipment calibration and maintenance logs, and sample management logs were peer-reviewed on-site. Analytical data generated for this project have been subjected to a process of data verification, validation, and review. The project implemented the use of data validation checklists to facilitate laboratory data validation. These checklists were completed by the project-designated validation staff and were reviewed by the project laboratory coordinator.

The checklists are sent with the analytical laboratory data deliverable (if requested) to the USACE–Savannah District, and a copy is also maintained at SAIC's Central Records.

A total of 1,250 environmental soil, sediment, groundwater, surface water, and field QC samples were collected, with approximately 94,000 discrete analyses (i.e., analytes) being obtained, reviewed, and integrated into the assessment. (These totals do not include field measurements and field descriptions.) The project produced acceptable results for more than 98 percent of the sample analyses performed and successfully collected all required investigation samples. In response to GEPD comments, analyte values reported below the project reporting levels were qualified as nondetects based on poor accuracy and precision (SAIC 1999a). Estimated concentrations for compounds such as methylene chloride, acetone, and toluene were considered to represent systemic project blank contamination, with values within three times the reporting levels being qualified as estimated and nondetect ("UJ") at the level observed. The rationale and acceptance for this data interpretation are discussed in the QCSR (see Appendix C) and in the comment response table and the minutes of the September 14, 1999, meeting with GEPD (see Appendix L).

A subset of field duplicate analysis compared groundwater filtered and total metals values. This comparison is presented in Appendix C. Filtered and total metal values show good agreement from analytical data obtained from established monitoring well locations, which were sampled using low-flow sampling techniques; however, Geoprobe filtered and unfiltered metals analysis showed very poor agreement (Phase I sites SWMUs 19, 24B, and 27A through 27V). Geoprobe total metal values (i.e., lead) provided positive results greater than five times the reporting level, while filtered values were consistently below the reporting level. The higher total metal values were apparently the result of particulate material in the sample due to the Geoprobe sampling methodology and the resulting high sample turbidity. The dissolved metal concentration was used as the concentration representative of the groundwater metal characteristics at Phase I sites (SWMUs 19, 24B, and 27A through 27V). Appendix D presents a discussion comparing the Phase I groundwater metal concentrations and Phase II groundwater metal concentrations using low-flow techniques and justification for using the dissolved metal concentration as representative of the groundwater characteristics at Phase I sites.

The overall quality of this SWMU investigation information met or exceeded the established project objectives. Through proper implementation of the project data verification, validation, and assessment process, project information was determined to be acceptable for use. Data, as presented, have been qualified as usable but as estimated, when necessary. Data produced for this study demonstrates that they can withstand scientific scrutiny, are appropriate for their intended purposes, are technically defensible, and are of known and acceptable sensitivity, precision, and accuracy. A more detailed data quality assessment may be found in Appendix C.

5.0 CONTAMINANT NATURE AND EXTENT

This section summarizes the results of the chemical laboratory analyses for soil, groundwater, surface water, and sediment background samples collected during the Phase II RFI for 16 SWMUs. The nature and extent interpretation for each SWMU is presented under the respective SWMU section included in Chapters 9.0 and 10.0.

5.1 BACKGROUND DATA ANALYSIS

The reference background criteria for the 16 SWMUs have been developed based on data from background samples collected from SWMUs across the FSMR. In general, reference background samples were collected in each medium at locations upgradient or upstream of each site so as to be representative of naturally occurring conditions at sites under Phase II investigation. Upgradient or upstream samples were not collected at sites under a Phase I RFI (SWMUs 19, 24B, 27, and 37). Soil data collected during the Phase I RFI and from SWMUs that received an RFI but were not investigated under this investigation were included in the background data set if they were determined to be upgradient of the site and of sufficient quality to be representative of natural background conditions at the FSMR. Phase I RFI SWMUs whose soil data were included in the background data set were the Burn Pits (SWMUs 4A, 4B, 4D, 4E, and 4F) and the Active EOD Area (SWMU 12A). Other RFI SWMUs whose soil data were included in the background set were the South Central Landfill (SWMU 1), the Burn Pits (SWMUs 4A, 4B, 4D, 4E, and 4F), the 724th Tanker Purging Station (SWMU 26), and Wright Army Airfield (SWMU 35). A summary of the sample stations by SWMU and the source of the data (Phase I or Phase II RFI) are presented in Table 5-1. The locations of all reference background samples are shown in Appendix F on Figures F-1 and F-2.

U.S. Environmental Protection Agency (EPA) Region IV methodology (EPA 1995) was used as guidance for the development of the background data set for the screening of metals data. In cases in which enough samples (e.g., more than 20) to define background are collected, a background upper tolerance level can be calculated. In cases in which fewer samples (e.g., less than 20) are collected to define background, background can be calculated as two times the mean background concentration (EPA 1995). Given that fewer than 20 background samples were collected for the FSMR, the latter method was used for calculating reference background concentrations for metals.

Appendix F presents both the summary of background data and the two-times-mean background concentrations. Given the limited number of reference background samples, the mean concentrations for soils in the eastern United States are also presented for comparative purposes only.

The concentrations of organics detected in background samples were not used to calculate reference background criteria because all organic compounds are considered to be potentially man-made. Organic compounds were not screened against background. All detected organic compounds are considered to be site-related contaminants (SRCs). The following sections discuss the background data analysis for each medium.

5.2. SURFACE SOIL

Surface soil samples were taken from ground surface to a depth of 1 foot or 2 feet, depending on the amount of recovery from the sampling device. Thirteen surface soil samples were used to develop the background

Table 5-1. Background Media Summary

SWMU Number	SWMU Name on Hazardous Waste Permit HW-045	Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment
1	South Central Landfill	SC-M17[a]	SC-M17[a]	MW10[a]	SW/SED1	SW/SED1
2	Camp Oliver Landfill	**MW5**[b]	**MW5**[b]	**MW5**[b]	SWS2	SWS2
3	TAC-X Landfill	**MW5**[b]	**MW5**[b]	**MW5**[b]	NB	NB
4A	Burn Pit A		**MW1**[c] (Phase I)	**MW1**[d]	NP	NP
4B	Burn Pit B		**MW3**[c] (Phase I)	**MW3**[d]	NP	NP
4C	Burn Pit C	**MW7**[d]	**MW7**[d]	**MW7**[d]	NP	NP
4D	Burn Pit D		**MW2**[c] (Phase I)	**MW2**[d]	NP	NP
4E	Burn Pit E		**MW3**[c] (Phase I)	**MW3**[d]	NP	NP
4F	Burn Pit F		**MW1**[c] (Phase I)	**MW1**[d]	NP	NP
10	Inactive EOD Area				SWS1	SWS1
12A	Active EOD Containing Open Detonation Unit and Open Burn Unit	**MW1**[e]	**MW1**[e]	**MW1**[b]	SWS1	SWS1
14	Old Fire Training Area			MW8[b]	NP	NP
17	DRMO Hazardous Waste Storage Area	**MW1**[b]	**MW1**[b]	**MW1**[b]	SWS1	SWS1
18	Industrial Wastewater Treatment Plant	**MW1**[b]	**MW1**[b]	**MW1**[b]	SWS1	SWS1
26	Former 724th Tanker Purging Station	**MW1**[b]	**MW1**[b]	**MW1**[b]	SWS1	SWS1
29	Evans Army Heliport POL Storage Facility	**MW5**[b]	**MW5**[b]	**MW5**[b]	NP	NP
31	DEH Asphalt Tanks	**MW1**[b]	**MW1**[b]	**MW1**[b]	NP	NP
32	Supply Diesel Tank	**MW1**[b]	**MW1**[b]	**MW1**[b]	NP	NP
34	DEH Equipment Wash Rack	**MW1**[b]	**MW1**[b]	**MW1**[b]	NP	NP
35	Wright Army Airfield Bulk Fuel System	HA-05[f] (Phase I)	HA-05[f] (Phase I)		NA	NA

[a]SAIC 1998a.
[b]Information provided in Chapters 9.0 and 10.0 under the respective Phase II RFI SWMUs.
[c]Rust Environment and Infrastructure 1996.
[d]SAIC 1998b.
[e]Radian 1997.
[f]Metcalf and Eddy 1996b.
NA = Not applicable.
NB = No site-specific background sample available; results from Former 724th Tanker Purging Station (SWMU 26) used.
NP = No surface water/sediment pathway exists.
Bold indicates background groundwater sample collected from the same borehole as sample for soil (i.e., monitoring well was constructed in the borehole).

data set (Table 5-1). The reference background surface soil concentration was calculated as two times the mean concentration of these 13 locations. Phase I data from SWMU 12A and SWMU 35 were determined to be of sufficient quality to be included in the background data set. If a chemical was not detected at a site, then one-half the detection limit was used as the concentration when calculating the reference mean background concentration. The sample results included in the data set are presented in Table F-1, Appendix F. The reference background concentration for organics is also presented in Table F-1; however, all detected organic compounds are considered to be SRCs because organic constituents are considered to be potentially man-made. Inorganics were considered SRCs if their concentrations were above the calculated reference background

concentration, and organics were considered SRCs if they were detected, no matter what the concentrations. SRCs identified in the nature and extent of contamination section for each site were carried through to the HHPRE and EPRE and are presented in Chapters 9.0 and 10.0.

5.3 SUBSURFACE SOIL

Subsurface soil samples were taken from the interval between a depth of 2 feet bgs and the water table. Eighteen subsurface soil samples were used in the development of the subsurface soil background data set (Table 5-1). Phase I data from SWMUs 4A, 4B, 4D, 4E, and 4F, 12A, and 35 were determined to be of sufficient quality to be included in the subsurface background set. The reference background subsurface soil concentration was calculated as two times the mean of the chemical detected at the 18 locations. If a chemical was not detected in a sample, then one-half the detection limit was used in calculating the mean background concentration. The sample results included in the background data set are presented in Table F-2, Appendix F. When identifying SRCs at each SWMU, inorganics were considered SRCs if their concentrations were above the calculated reference background concentration, and organics were considered SRCs if they were detected because organic constituents are considered potentially man-made. SRCs identified in the nature and extent of contamination section for each site were carried through to the HHPRE and EPRE and are presented in Chapters 9.0 and 10.0.

5.4 GROUNDWATER

Only groundwater samples collected using low-flow techniques (Phase II RFI) were used in the development of the groundwater background data set. Groundwater samples from 18 SWMUs were used to develop the groundwater background composite (Table 5-1). The reference background groundwater concentration was calculated as two times the mean of these 19 samples. If a chemical was not detected at a site, then one-half the detection limit was used in calculating the mean background concentration. The sample results included in the background data set are presented in Table F-3, Appendix F. In addition to RCRA metals, groundwater samples at the Active EOD Area (SWMU 12A) were also analyzed for metals corresponding to Appendix D of the Subpart X Permit. These additional metals were compared to metal concentrations from MW1 (the site background well) at SWMU 12A collected during compliance monitoring using non-low-flow techniques. The site reference background concentration for these additional metals was determined to be two times the average concentration at MW1.

In addition, as indicated in Chapter 4.0, with the concurrence of GEPD some monitoring wells were installed at the SWMUs under the Phase I RFI (SWMUs 27F, Northeast of Building 1340; 27J, Building 10535; 27N, Block 9800; 27S; and 27U) only to confirm or deny potential contamination at selected Geoprobe locations. Groundwater at these SWMUs was collected using direct-push technology (DPT) and had a high level of turbidity from particulates in the groundwater. Total and dissolved metal samples were collected at the SWMUs under the Phase I RFI to differentiate the metals concentrations associated with the particulates/fines in the groundwater. The dissolved metals concentration was determined to be representative of the groundwater characteristics at the Phase I sites (SWMUs 19, 24B, and 27A through 27V) and was screened against reference groundwater background criteria (Appendix D).

Inorganics in groundwater were considered SRCs if their concentrations were above the calculated reference background concentration, and organics were considered SRCs if they were detected, no matter what the concentration, because organic constituents are considered to potentially be man-made. SRCs identified in the nature and extent of contamination section for each site were carried through to the HHPRE and EPRE and are presented in Chapters 9.0 and 10.0.

5.5 SURFACE WATER

Surface water background samples were collected during the Phase II RFI and applied to the SWMUs on a site-specific basis except at the TAC-X Landfill (SWMU 3) and motorpools (SWMUs 27A through 27V). At these sites, no upstream surface water was available, so the site-specific background for the Former 724th Tanker Purging Station (SWMU 26) was used. The SWMU 26 surface water sample was collected upstream in Mill Creek prior to the water's entering the FSMR. The locations by SWMU where site-specific background surface water samples were collected are presented in Table 5-1. No Phase I RFI data were used. Six locations had site-specific surface water samples collected (Table 5-1). The reference background surface water concentration was calculated as two times the mean of the data taken at the site-specific background location. If a chemical was not detected at a site, then one-half the detection limit was used as the mean background concentration. The sample results comprising the site-specific background data are presented in Table F-4, Appendix F. Inorganics were considered SRCs if their concentrations were above the site-specific reference background concentration, and organics were considered SRCs if they were detected, no matter what the concentration, because organic constituents are considered to potentially be man-made. SRCs identified in the nature and extent of contamination section for each site were carried through to the HHPRE and EPRE and are presented in Chapters 9.0 and 10.0.

5.6 SEDIMENT

Sediment background samples were collected during the Phase II RFI and applied to the SWMUs on a site-specific basis except at the TAC-X Landfill (SWMU 3) and motorpools (SWMUs 27A through 27V). At these sites no upstream sediment was available. The site-specific background for the Former 724th Tanker Purging Station (SWMU 26) was used for the TAC-X Landfill. The SWMU 26 background sediment sample was collected upstream in Mill Creek prior to the water's entering the FSMR. The reference background criteria for surface soil, as discussed in Section 5.2, was used for background screening of the sediment at the SWMU 27 sites because the SWMU 27 sediment samples were collected from dry ditch bottoms. The locations by SWMU where site-specific background sediment samples were collected are presented in Table 5-1. No Phase I RFI data were used. Six locations had site-specific sediment samples collected (Table 5-1). The reference background sediment concentration was calculated as two times the mean of the data taken at the site-specific background location. If a chemical was not detected at a site, then one-half the detection limit was used as the mean background concentration. The sample results comprising the site-specific background data are presented in Table F-5, Appendix F. Inorganics were considered SRCs if their concentrations were above the site-specific background concentration, and organics were considered SRCs if they were detected, no matter what the concentration, because organic constituents are considered to potentially be man-made. SRCs identified in the nature and extent of contamination section for each site were carried through to the HHPRE and EPRE and are presented in Chapters 9.0 and 10.0.

5.7 SITE-RELATED CONTAMINANTS

Inorganics for surface soil, subsurface soil, and groundwater were screened against the reference background criteria. Inorganics for surface water and sediment were screened against site-specific background values. As discussed in the preceding sections, all organics that were detected were considered to be potential SRCs because organic constituents are considered to potentially be man-made. Organic analytes that were detected at least once and those inorganic analytes for which at least one sample result exceeded background are considered SRCs. Only the SRCs were carried through for evaluation under fate and transport, HHPRE, and EPRE.

6.0 CONTAMINANT FATE AND TRANSPORT

6.1 INTRODUCTION

This chapter describes the potential migration pathways and mechanisms for transport of chemical substances found in surface and subsurface soils, sediment, surface water, and groundwater at the 16 SWMUs. Section 6.2 discusses the persistence, mobility, and other physical and chemical properties of the organics and metals found at the 16 SWMUs. Section 6.3 presents the components of a conceptual model developed for the SWMUs discussed in Chapters 9.0 and 10.0 and describes contaminant release mechanisms through the primary transport medium (groundwater). Section 6.4 discusses the fate and transport of the contaminants at the 16 SWMUs with respect to their leachability and natural attenuation.

6.2 PHYSICAL AND CHEMICAL PROPERTIES

The fate and transport of organic compounds and metals are functions of both site characteristics and the physical/chemical properties of the contaminants. Such properties include solubility in water, tendency to transform or degrade (usually described by a half-life or an environmental half-life in a given medium), and chemical affinity for solids or organic matter [usually described by a partitioning coefficient (K_d, K_{oc}, or K_{ow})]. These properties and how they affect inorganic and organic contaminant behavior are described below.

6.2.1 Metals

Inorganic SRCs at 16 SWMUs are subject to movement with soil moisture and may be transported through the vadose zone to groundwater. Metals do not degrade, although some metals can transform to other oxidation states in soil, reducing their mobility and toxicity. Metals also react with soils or other solid surfaces by ion exchange, sorption, precipitation, or complexation. Such reactions are affected by the pH; Redox conditions; and type and amount of organic matter, clay, and hydrous oxides present. In general, these reactions are reversible and cause an element's mobility to be retarded. The retardation factor (R_d) numerically describes the extent to which the velocity of the contaminant relative to water is slowed. The R_d is largely derived from the soil/water distribution (or partitioning) coefficient (K_d) expressed by the following relation:

$$R_d = 1 + K_d \times \rho b / \theta ,$$

where

ρb = the soil bulk density (g/cm^3) and
θ = volumetric soil moisture content.

K_d for the metals at this site may vary by large ranges. It has been found that K_d can vary even by orders of magnitude between samples from the same site. The range of K_d values [obtained from EPA (1996a) and Sheppard and Thibault (1990)] for the inorganic SRCs at the 16 SWMUs is presented in Table 6-1.

Table 6-1. List of Distribution Coefficients for the Inorganic SRCs at the 16 SWMUs

SRCs	K_d[a] (L/kg)
Aluminum	1,500[b]
Antimony	45
Arsenic	29
Barium	41
Beryllium	790
Cadmium	75
Chromium	19
Cobalt	1,300 (100 to 9,700)[c]
Copper	35[b]
Iron	800 (290 to 2,240)[c]
Lead	270 (100 to 59,000)[c]
Manganese	750[c]
Mercury	52
Nickel	65
Selenium	5
Silver	8
Vanadium	1,000
Zinc	62

[a]The K_d values correspond to pH=6.8 (EPA 1996a) unless otherwise indicated.
[b]Baes et al. 1984.
[c]Sheppard and Thibault 1990.
K_d = Distribution coefficient.

6.2.2 Organic Compounds

The organic compounds detected in soils at the 16 SWMUs include VOCs, SVOCs, pesticides, and PCBs. These contaminants may be degraded in the environment by various processes, including hydrolysis, Redox, photolysis, or biodegradation. Half-lives of organic compounds in various media can vary from minutes to years, depending on the chemical and on the environmental conditions. Degradation may either enhance or reduce the toxicity of a chemical. The biodegradation rates for the organic compounds (SRCs) identified at the 16 SWMUs are presented in Table 6-2. These values are based on the biodegradation half-lives taken from the Handbook of Environmental Degradation Rates (Howard et al. 1991). Although a range of values is presented in that reference, only the lowest biodegradation rates corresponding to the highest half-lives are presented in this report to ensure conservatism in discussing contaminant loss through degradation/decay.

The mobility of an organic compound is affected by its volatility and its partitioning behavior between solids and water, water solubility, and concentration. The Henry's Law constant value (K_H) for a compound is a measurement of the ratio of the compound's vapor pressure to its aqueous solubility. The K_H value can be used to make general predictions about the compound's tendency to volatilize from water. Substances with K_H values less than 10^{-7} atmospheres/cubic meters/mole will generally volatilize slowly, while compounds with K_H values greater than 10^{-3} atmospheres/ cubic meters/mole will volatilize rapidly. Vapor pressure is a measurement of the pressure at which a compound and its vapor are in equilibrium. The value can be used to determine the extent to which a compound would travel in air, as well as the rate

Table 6-2. Physical and Chemical Properties of Organic Site-related Contaminants

Constituents	Mol. Wt	Solubility S_w (mg/L)		S_w @ Temp. °C		K_{OW} (mL/mL)		Vapor Pressure (torr @ °C)	Henry's Constant (K_h) atm×m^3/mol		K_h @ Temp. °C		Air Diff. Coeff. cm^2/s		K_{OC} mL/g		Biodegradation Rate λ 1/day	Log (K_{OW})
Volatile Organic Compounds																		
1,1-Dichloroethane	99.0	5.06E+03		20		6.17E+01		234 @ 25	5.45E-03				0. 091		5.34E+01	m	1.13E-03	1.79
1,1-Dichloroethene	96.9	2.25E+03	e			3.02E+01		591 @ 25	2.61E-02	e			0.009	e	6.50E+01	m	3.85E-03	1.48
1,1,1-Trichloroethane	133.4	4.40E+03		20		2.95E+02		100 @ 20	4.08E-03		25		0.019	s	1.35E+02	m	6.35E-04	2.47
1,1,2-Trichloroethane	133.4	4.42E+03	e	20		1.48E+02		30 @ 25	9.13E-04	e	25	#	0.078	e	7.50E+01	m	4.75E-04	2.17
1,1,2,2-Tetrachloroethane	167.9	2.97E+03	e			1.10E+03		10 @ 19.3	3.40E-04	e			0.071	e	7.90E+01	m	9.62E-04	3.04
1,2-Dichloroethane	99.0	8.69E+03		20		2.82E+01		8,690 @ 20	1.10E-03		25		0.091		3.80E+01	m	9.63E-04	1.45
1,2-Dichloroethene	96.9	8.00E+02			#	1.23E+02		202 @ 25	6.60E-03				0.114		7.75E+01		2.41E-04	2.09
1,2-Dichloropropane	113.0	2.70E+03		20		1.91E+02		42 @ 20	2.82E-03				0.080		4.70E+01	m	1.34E-04	2.28
1,3-*cis*-Dichloropropene	111	2.80E+03				1.15E+02		43 @ -	2.32E-03				0.1		7.25E+01		6.19E-03	2.06
1,3-*trans*-Dichloropropene	111	2.80E+03				1.12E+02		34 @ -	1.80E-03				0.08		7.08E+01			2.05
2-Butanone	72.1	2.75E+05				1.82E+00		100 @ 25	6.61E-07		25	#	0.092	s	1.15E+00		2.48E-02	0.26
2-Hexanone	100.2	3.50E+04		20		2.40E+01		2 @ 20	7.53E-06		20		0.078		1.51E+01			
4-Chloro-3-methylphenol	142.6	3.85E+03		20		1.26E+03			2.50E-06		20		0.056		7.93E+03			3.10
4-Methyl-2-pentanone	100.2	1.91E+04				5.25E+00		10 @ 30	1.03E-06				0.078		3.31E+00		2.48E-02	0.72
Acetone	58.1	1.00E+06	e			5.75E-01	e	270 @ 30	3.88E-05	e	25	#	0.110	s	5.75E-01	x	2.48E-02	-0.24
Benzene	78.1	1.75E+03	e	20		1.35E+02		95 @ 25	5.55E-03	e	25		0.088	e	6.20E+01	m	9.63E-04	2.13
Bromodichloromethane	163.8	4.50E+03				7.59E+01			2.12E-03				0.061		5.50E+01	x		1.88
Bromoform	252.7	3.20E+03				2.00E+02			5.32E-04				0.105	s	1.26E+02	m	9.62E-04	2.30
Bromomethane	94.9	1.75E+04		20		1.26E+01		1,420 @ 20	1.53E-04		25	#	0.110	s	9.00E+00	m	6.19E-03	1.10
Carbon disulfide	76.1	2.90E+03		20		1.45E+02		298 @ 20	2.94E-04		25	#	0.105	s	4.57E+01	x		2.16
Carbon tetrachloride	153.8	8.00E+02				5.37E+02		113 @ 25	2.93E-02				0.082	s	1.52E+02	m	1.93E-03	2.73
Chlorobenzene	112.6	4.88E+02		25		6.92E+02		11.8 @ 25	3.93E-03		25		0.073	s	2.24E+02	m	1.16E-03	2.84
Chlorodibromomethane	208.3	4.50E+03				1.23E+02		15 @ 25	7.83E-04		25		0.054		6.31E+01	x	3.85E-03	2.09
Chloroethane	64.5	5.74E+03		20		2.69E+01		2,660 @ 25	1.10E-02		25		0.107		1.70E+01		6.19E-03	1.43
Chloroform	119.4	9.30E+03		25		9.33E+01		160 @ 20	3.39E-03		25		0.091	s	5.30E+01	m	3.85E-04	1.97
Chloromethane	50.5	6.36E+03				8.13E+00		3,800 @ 20	8.82E-03		25		0.110	s	6.00E+00	m	6.19E-03	0.91
Dibromochloromethane	208.3	4.50E+03				1.23E+03			7.83E-04				0.054		6.31E+01	x	3.85E-03	2.09
Ethylbenzene	106.2	1.52E+02		20		1.41E+03		10 @ 25.9	7.88E-03	e	25		0.075	e	2.04E+02	m	3.04E-03	3.15
Methylene chloride	84.9	1.30E+04	e	25		1.78E+01		429 @ 25	2.19E-03	e	25		0.101	e	1.00E+01	m	6.19E-03	1.25
Styrene	104.1	3.00E+02		20		1.45E+03		5 @ 20	2.28E-03				0.071		9.12E+02	m	3.30E-03	3.16

Note: Footnotes appear on page 6-5.

Table 6-2. Physical and Chemical Properties of Organic Site-related Contaminants (continued)

Constituents	Mol. Wt	Solubility S_w (mg/L)		S_w @ Temp. °C		K_{OW} (mL/mL)		Vapor Pressure (torr @ °C)	Henry's Constant (K_h) atm×m^3/mol		K_h @ Temp. °C		Air Diff. Coeff. cm^2/s		K_{OC} mL/g		Biodegradation Rate λ 1/day	Log (K_{OW})
Tetrachloroethene	165.8	1.50E+02		25		3.39E+02		19 @ 25	1.84E-02	e	25		0.077	s	2.65E+02	m	4.19E-04	2.53
Toluene	92.1	5.15E+02		20		4.90E+02		28 @ 25	6.64E-03	e	25		0.087	t	1.40E+02	m	3.30E-03	2.69
Trichloroethene	131.4	1.10E+03	e	25		5.13E+02	e	77 @ 25	1.03E-02	e	25		0.079	e	9.40E+01	m	4.19E-04	2.71
Vinyl chloride	62.5	1.10E+00	e	25		3.16E+01	e	2,580 @ 20	2.70E-02		25		0.106	s	1.86E+01	x	2.41E-04	1.5
Xylenes	106.2	2.00E+02				5.89E+02		5 @ 20	5.25E-03		25		0.073	s	1.96E+02	m	1.93E-03	2.77
Semivolatile Organic Compounds																		
1,2-Dichlorobenzene	147.0	1.45E+02		25		2.40E+03		1.5 @ 25	1.90E-03		25		0.063		3.79E+02	m	9.63E-04	3.38
2,4-Dimethylphenol	122.2	5.90E+02			#	2.63E+02		98 @ 104	2.00E-06		25		0.074		2.09E+02	x	2.48E-02	2.42
2-Methylnapthalene	142.2	2.60E+01		25		7.24E+03		10 @ 105	2.20E-02				0.056		4.56E+03			3.86
Acenaphthene	154.2	3.42E+00		25		8.32E+03		10 @ 131	2.41E-04		25		0.062		4.90E+03	m	1.70E-03	3.92
Acenapthylene	152.2	3.93E+00		25		1.17E+04		3.93 @ 25	1.14E-04		25		0.062		7.40E+03		2.92E+03	4.07
Anthracene	178.2	1.29E+00		25		2.82E+04		1.95E-4 L	6.50E-05	e	25		0.042		2.35E+04	m	3.77E-04	4.45
Benzo(*a*)anthracene	228.3	1.00E-02		24		4.07E+05		5E-9 @ 20	3.35E-06	e	25	#	0.051		3.58E+05	m	2.55E-04	5.61
Benzo(*a*)pyrene	252.3	3.80E-03		25		9.55E+05		5E-9 @ 21	1.13E-06	e	25		0.043		9.69E+05	m	3.27E-04	5.98
Benzo(*b*)fluoranthene	252.3	1.50E-03		25		3.72E+06		5E-7 L	1.11E-04	e	25	#	0.044[a]		1230000	x	2.84E-04	6.57
Benzo(*k*)fluoranthene	252.3	3.00E-04			#	6.92E+06		1E-11 @ 20	8.29E-07	e	25	#	0.044		1.23E+06	x	8.10E-05	6.84
Bis(2-ethylhexyl)phthalate	390.6	1.30E+00		25		2.00E+05		1.2 @ 200	3.00E-07		20		0.032	s	1.11E+05	m	1.78E-03	5.30
Chrysene	228.3	6.00E-03		25		4.07E+05		6.3E-9 @ 25	9.46E-05	e	25		0.046		3.98E+05	x	1.73E-04	5.61
Di-*N*-butylphthalate	278.4	4.00E+02		25		1.58E+05		0.1 @ 115	9.38E-10	e	25		0.042		1.57E+03	m	3.01E-02	5.20
Di-*N*-octylphthalate	390.6	3.00E+00		25		1.58E+09		0.2 @ 150	3.45E-14		25		0.035		9.98E+08		1.90E-03	9.20
Dibenzo(*a,h*)anthracene	278.4	5.00E-04		25		9.33E+05		1E-10 L	7.30E-08		25		0.042		1.79E+06	m	1.84E-04	5.97
Fluoranthene	202.3	2.65E-01		25		2.14E+05		5E-6 L	1.61E-05	e	25		0.069		4.91E+04	m	3.94E-04	5.33
Fluorene	166.2	1.90E+00		25		1.51E+04		5.0E+5 @ 20	6.36E-05	e	25		0.055		7.71E+03	m	2.89E-03	4.18
Indeno(*1,2,3-c,d*)pyrene	276.3	1.40E-04	#			4.57E+07		1E-10 L	1.60E-06	e	25		0.044		3.47E+06	x	2.37E-04	7.66
N-nitrosodiphenylamine	198.2	3.51E+01		25		6.17E+02		1.00E-01	5.00E-06	e	25		0.0312	e	1.29E+03	x	5.10E-03	2.79
Naphthalene	128.2	3.10E+01	e	25		2.29E+03	e	0.082 @ 25	4.83E-04		25		0.059		1.19E+03	m	2.69E-03	3.36
Phenanthrene	178.2	8.16E-01		21		2.88E+04		1 @ 118	3.93E-05		25		0.054		1.82E+04		8.66E-04	4.46
Phenol	94.1	8.28E+04	e	25		3.02E+01	e	0.35 @ 25	3.97E-07	e	25		0.087		2.88E+01	x	2.48E-02	1.48
Pesticides/PCBs																		
4,4'-DDD	320.0	9.00E-02	e			1.26E+06	e	1E-7 @ 30	4.00E-06	e	25		0.041		4.58E+04	m	6.16E-05	6.10
4,4'-DDE	318.0	1.20E-01	e	25		5.75E+06	e	6.5E-6 @ 20	2.10E-05	e	25		0.041		8.64E+04	m	6.16E-05	6.76

Note: Footnotes appear on page 6-5.

Table 6-2. Physical and Chemical Properties of Organic Site-related Contaminants (continued)

Constituents	Mol. Wt	Solubility S_w (mg/L)		S_w @ Temp. °C		K_{OW} (mL/mL)		Vapor Pressure (torr @ °C)	Henry's Constant (K_h) atm×m^3/mol		K_h @ Temp. °C		Air Diff. Coeff. cm^2/s		K_{OC} mL/g		Biodegradation Rate λ 1/day	Log (K_{OW})
4,4'-DDT	354.5	2.50E-02	e	25		3.39E+06	e	1:5E-7 @ 20	8.10E-06	e	25		0.039		6.78E+05	m	6.16E-05	6.53
Aldrin	364.9	1.80E-01	e	25		3.16E+06	e	2.3E-5 @ 20	1.70E-04	e	25		0.013		4.87E+04	m	1.17E-03	6.50
alpha-BHC	290.8	2.00E+00	e	25		6.46E+03		0.06 @ 40	1.41E-02				0.0142	e	1.76E+03	m	2.57E-03	3.81
alpha-Chlordane	409.8	5.60E-02				6.03E+02			4.79E-05		25		0.012		3.80E+02		2.50E-04	2.78
Arochlor-1254	328.4	5.70E-02		24		1.07E+06		7.71E-5 @ 25	8.37E-03		25		0.041		6.75E+05		4.72E-03	6.03
beta-BHC	290.8	7.00E-01		25		6.31E+03		0.7 @ 25	9.29E-02		40	*	0.018		2.14E+03	m	2.80E-03	3.80
delta-BHC	290.8	2.13E+01		25		1.38E+04		0.02 @ 20	3.59E-04		20		0.018		8.7E+03		3.47E-03	4.14
Dieldrin	380.9	1.86E-01				1.23E+04		1.8E-7 @ 25	5.84E-05				0.013	w	2.55E+04	m	3.21E-04	4.09
Endrin ketone																		
Endosulfan II	407.0	3.30E-01		22		4.17E+03		1E-5 @ 25	1.62E-05		25		0.012	w	2.63E+03			3.62
Endosulfan sulfate	422.9	2.20E-01				4.57E+03			2.53E+01				0.011	w	2.88E+03			3.66
gamma-BHC (Lindane)	290.8	7.00E+00				1.74E+03		9.4E-6 @ 20	4.93E-03				0.018		1.35E+03	m	1.68E-03	3.24
gamma-Chlordane	409.8	5.60E-02				1.20E+05			4.86E-05	e			0.012	w	5.13E+04	m		5.08
Heptachlor	373.3	5.60E-02				1.82E+06	e	3E-4 @ 25	1.48E-03				0.037		9.53E+03	m	2.65E-03	6.26
Heptachlor epoxide	389.2	3.50E-01				1.00E+05	e		3.16E-05		25		0.012	w	8.32E+04	x		5.00
Methoxychlor	345.7	4.50E-02				1.20E+05	e	0.04 @ 24	1.58E-05	e	25		0.016	e	8.00E+04	m	1.90E-03	5.08
Explosives																		
2,4-Dinitrotoluene	182.1	2.70E+02	e	22		1.02E+02		0.0013 @ 59	9.26E-08	e	25		0.203	e	9.55E+01		1.93E-03	2.01
2,4,6-Trinitrotoluene	227.13	1.00E+02		25		3.39E+05		0.046 @ 82	0.0000002						2.14E+05			
2,6-Dinitrotoluene	182.1	2.70E+02		22		1.12E+02		6 @ 150	0.00533		150	*	0.055		7.07E+01		3.85E-03	2.05
HMX	296.2																	
RDX	222.26	6.00E+01		23		7.41E+00									4.67E+00			0.87

= Indicates RREL database (EPA 1994a) as the source.
* = Represents calculated values.
e = Soil Screening Guidance: Technical Background Document (EPA 1996a) is the source.
L = Source from EPA 1995.
m = Measured K_{oc} values.
s = Indicates Shen, Schmidt, and Card 1993 as the source.
w = EPA WATER7 database November 1990.
x = Calculated K_{oc} values from Soil Screening Guidance: Technical Background Document (EPA 1996a).
A blank indicates value not available.
Air diffusion coefficients were obtained from EPA 1987 unless otherwise indicated.
Biodegradation half-lives were taken from the Handbook of Environmental Degradation Rates (Howard et al. 1991) unless otherwise indicated.
Solubilities, Henry's Constant, and Log (K_{ow}) were taken from Risk Reduction Engineering Laboratory (RREL) Treatability Database (EPA 1994a) unless otherwise indicated.

of volatilization from soil and solution. In general, compounds with vapor pressures lower than 10^{-7} millimeters mercury will not be present in the atmosphere or soil vapor in significant amounts, while compounds with vapor pressures higher than 10^{-2} millimeters mercury will exist primarily in the soil vapor. Unless the soil is saturated, VOCs will exist primarily in the atmosphere and soil vapor. Polycyclic aromatic hydrocarbons (PAHs) and other SVOCs will exist in both the air and the soil. The air diffusion coefficient is a measurement of the rate of spontaneous mixing, presented in units of square centimeters per second, of one substance with another when in contact or separated by a permeable membrane. The rate of diffusion is proportional to the concentration gradient of a substance, increases with temperature, and is inversely related to density and pressure. In soil systems the principal type of diffusion is from a region of high concentration to a region of low concentration. Diffusion occurs most readily in gases, to a lesser extent in liquids, and least in solids.

Water solubility and the tendency to adsorb to particles or organic matter can correlate with retardation in groundwater transport. The adsorption coefficient/partitioning coefficient (K_d) of an organic compound is related to the organic carbon/water partitioning coefficient (K_{oc}) by

$$K_d = f_{oc} \times K_{oc}$$

where

f_{oc} = fraction of soil organic carbon content.

Chemical-specific K_{oc} values may be obtained from literature or may be calculated using empirical formulas relating the octanol-water partitioning coefficient (K_{ow}) to the K_{oc}. The K_{ow} (milliliters per milliliters) is the ratio of a contaminant's concentration in a system containing water and octanol. K_{ow} is used to estimate the tendency for a chemical to partition between environmental phases of different polarity. Organic compounds with log K_{ow} values less than one are highly hydrophilic, while organic compounds with log K_{ow} values greater than four are nearly insoluble in water and will partition to soil particles. Pesticides/PCBs and semivolatiles usually have higher log K_{ow} values. The most commonly used formula to relate K_{ow} to K_{oc} is

$$K_{oc} = 0.63 \times K_{ow} \text{ (Mills et al. 1985).}$$

Chemicals with relatively high water solubilities and low adsorption coefficients (e.g., acetone, methylene chloride) are expected to remain primarily as dissolved phases and be transported at the same rate as the groundwater flow. Chemicals with lower water solubilities and higher adsorption coefficients (e.g., SVOCs and pesticides) are expected to remain primarily adsorbed to the surface of the soils; their transportation with the groundwater would be very limited and at a much slower rate. Table 6-2 presents the solubility, Henry's Law constant (K_H), vapor pressure, air diffusion coefficients, and biodegradation rate constants for the organic compounds detected in soils and groundwater at the 16 SWMUs. Log K_{ow}, K_{ow}, K_{oc}, and K_d for these compounds are also presented in this table. Volatile organic SRCs at the 16 SWMUs generally have lower K_ds and are expected to move with the groundwater with little retardation. Although VOCs move faster in groundwater, they usually have a shorter half-life and degrade at a faster rate in the environment.

6.3 CONCEPTUAL SITE MODEL

The CSM is a statement of expected site conditions that serves as a paradigm with which observations can be compared and within which predictions can be made. The predictive function of the CSM, of primary importance to contaminant fate and transport analysis, relies on known information and informed

assumptions about the site. The better the information and the greater the accuracy of the assumptions, the more accurately the CSM describes the site and, therefore, the more reliable the predictions.

The CSM presented in this section summarizes the hydrogeologic components (presented in Chapter 2.0) and the distribution of contaminants in the subsurface soils and groundwater (presented in Chapters 9.0 and 10.0). Contaminant migration pathways and release mechanisms are also based on the information presented in Chapters 9.0 and 10.0. Site-specific CSMs for contaminant fate and transport are presented in Chapters 9.0 and 10.0. A summary of the model's elements follows.

6.3.1 Water Balance Components

The potential for contaminant transport begins with precipitation. The actual amount of rainwater available for flow is highly variable and dependent upon soil type and climatic conditions. A water balance calculation can be used as a tool to quantitatively account for all the components of the hydrologic cycle at the 16 SWMUs. A simple steady-state water balance model includes precipitation (P), evapotranspiration (ET), surface runoff (Sr), and groundwater recharge or percolation (Gr) and is defined as follows:

$$P = ET + Sr + Gr$$

or

$$\text{Rainwater available for flow} = Sr + Gr = P - ET.$$

The annual average components of water balance estimates for the individual SWMUs under Phase II RFI are presented under the SWMU–specific sections in Chapters 9.0 and 10.0. The water balance estimations were based on the Hydrologic Evaluation of Landfill Performance (HELP) model (EPA 1994b) calculations for an uncapped landfill cell using precipitation and temperature data for the years 1974 through 1978, which are the most current data available for Savannah, Georgia, in the HELP model.

6.3.2 Contaminant Release Mechanisms and Migration Pathways

6.3.2.1 Infiltration and surface runoff

The potential for contaminant transport begins with precipitation. The actual amount of rainwater available for flow is highly variable and dependent upon soil type and climatic condition. Local topography and geology influence both timing and quantity of runoff. Infiltration is affected by soil type, rainfall intensity, surface condition, and vegetation. The general topography of the 16 SWMUs is sloping from northwest to southeast. The regional topography is dominated by shallow terraces dissected by surface water drainage. The terraces are remnants of sea-level fluctuations. The principal surface water body accepting drainage from the 16 SWMUs is the Canoochee River, which joins the Ogeechee River (see Section 3.3)

6.3.2.2 Subsurface flow system

The infiltrated water that is not lost to evapotranspiration is integrated into the subsurface flow system. The subsurface flow system is comprised of the vadose zone and the saturated zone. The hydrology at the 16 SWMUs is dominated by two aquifers: the surficial aquifer and the Principal Artesian aquifer. The surficial aquifer consists of widely varying amounts of sand, silt, and clay ranging from 35 feet to 150 feet in thickness (Geraghty and Miller 1992). The top of the water table ranges from 2 feet to 15 feet bgs. The Principal Artesian aquifer is separated from the surficial aquifer by a confining layer.

6.3.2.3 Release mechanisms

The principal release mechanisms at the 16 SWMUs are infiltration and leaching to groundwater. Precipitation that does not leave the waste unit as surface runoff infiltrates into the subsurface. Some of the infiltrating water leaves this environment via evapotranspiration after little or no subsurface flow. The remainder of the water percolates into the subsurface flow system. The rate of percolation is controlled by soil cover, ground slope, saturated conductivity of the soil, and meteorological conditions.

Water infiltrating through contaminated surface and subsurface soils may leach contaminants into the groundwater. The factors that affect leaching rate include a contaminant's solubility, the partitioning coefficient, and the amount of infiltration. Whether it is a contaminant's partitioning coefficient or solubility that controls leaching depends on whether leaching is solubility-controlled or sorption-controlled. Insoluble compounds will precipitate out of solution in the subsurface or remain in their insoluble forms with little leaching. The contaminants detected at the 16 SWMUs generally do not form insoluble compounds in the natural environment, so sorption processes and the partitioning coefficient will have the greatest effect on leaching. Those contaminants with small partitioning coefficients will be leached more effectively than those with larger such coefficients.

Another factor that affects whether a contaminant will reach the water table through infiltration of rainwater is the contaminant's rate of decay. Most of the organic compounds decay at characteristic rates that are described by the substance's half-life. For a given percolation rate, those contaminants with long half-lives have a greater potential for contaminating groundwater than do those with shorter half-lives.

The water table at the 16 SWMUs may also cause direct leaching of waste that is submerged in water. Seasonal rises in the water table may increase this leaching during rainy seasons.

Contaminants that are sorbed onto surface soils at the 16 SWMUs can be released by desorption in surface runoff or captured with particulate matter by soil erosion during a rainstorm.

VOCs in surface soil are emitted to air via volatilization. The rate of emission is controlled by the vapor pressure of the organic compounds and decreases rapidly over a short period of time as the volatiles are depleted by release to the atmosphere. VOCs in the subsurface soils are emitted to the atmosphere via vertical diffusion through soil pores. Depending on how extensively diffusion has occurred, gaseous emissions from subsurface soils may be significant.

Particulate matter from contaminated surface soil can become airborne as a result of wind erosion. This process is controlled by vegetative cover, wind speed, moisture, and soil grain size in the surface soils.

6.4 FATE AND TRANSPORT ANALYSIS

6.4.1 Soil Leachability Analysis

Contaminant fate and transport analysis at each SWMU under Phase II RFI involves a series of screening steps to define the contaminant migration constituents of potential concern (CMCOPCs). The CMCOPCs are defined as the constituents that may pose the greatest problem if they migrate from the site source.

The first step of the screening process represents the development of the SRCs. The SRCs are selected by comparing the maximum detected concentrations of all the analytes measured in surface and subsurface soils with their respective FMSR reference background criteria. The FMSR reference background criteria

represent the average background concentration multiplied by a factor of two. If the maximum concentration of an analyte in the soil exceeds its reference background criterion, then that analyte is selected as an SRC.

The second step of the screening process involves comparing the maximum concentrations of the SRCs, developed in the previous step, with EPA generic soil screening levels (GSSLs). The GSSLs are set for Superfund sites for the migration to the groundwater pathway (EPA 1996a).

If an EPA–suggested GSSL for a constituent was not available, the GSSL was back-calculated from the target leachate concentration following EPA's soil screening guidance (EPA 1996a). The target leachate concentration was assumed to be equal to the MCL of the constituent, if available; otherwise, the EPA Region III–suggested risk-based concentration (RBC) for tap water corresponding to a 10^{-6} risk or hazard quotient (HQ) = 1 was used (SAIC 1999a).

The equation given in the soil screening guidance (EPA 1996a) is as follows:

$$\text{Screening Level in Soil} = C_w [K_d + (\theta_w + \theta_a H') / \rho_b]$$

where

C_w = target leachate concentration in (mg/L),
K_d = soil-water partition coefficient (L/kg) = $K_{oc} \times$ foc (for organics),
K_{oc} = soil organic carbon/water partition coefficient (L/kg),
foc = 0.002 (EPA 1996a),
θ_w (water-filled porosity) = 0.3 (EPA 1996a),
θ_a (air-filled porosity) = 0.13 (EPA 1996a),
H' = dimensionless Henry's Law constant, and
ρ_b (bulk density) = 1.5 gm/cubic-meter (EPA 1996a).

In the derivation of EPA GSSLs [dilution attenuation factor (DAF) = 1], direct partitioning is used, assuming groundwater is in contact with the analytes in soil; the groundwater concentration is assumed to be equal to the leachate concentration. However, as soil leachate moves through soil, contaminant concentrations are attenuated by adsorption and degradation. When the leachate reaches the water table, dilution by groundwater further reduces leachate concentrations. This reduction in concentration can be expressed by a DAF. A DAF of 20 is protective for sources up to 0.5 acre in size (EPA 1996a). Analyses presented in Appendix A of EPA's soil screening guidance (EPA 1996a) indicate that DAF of 20 can be protective of larger source areas as well. Considering the small soil contamination area of the majority of Fort Stewart's SWMUs, a DAF of 20 was used for organics. Although metals have higher adsorption factors, they do not biodegrade in the environments. The adsorption factor of a metal is a function of pH. Usually, adsorption of metals in soil is lower for a lower pH. For conservatism, a DAF of 20 was used for metals if the average pH of groundwater at the site was greater than or equal to 5 and the soil contamination area of the site was less than or equal to 0.5 acre in size. If the average pH of groundwater was less than 5 and the soil contamination area of the site was greater than 0.5 acre, then a DAF of 1 was used for metals.

The GSSL is defined as the concentration of a contaminant in soil that represents a level of contamination below which there is no concern under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), provided conditions associated with soil screening levels (SSLs) are met. Generally, if contaminant concentrations in soil fall below the GSSL and there are no significant ecological receptors of concern, then no further study or action is warranted for that area. However, it should be noted

here that the purpose of this screening is not to identify the contaminants that may pose a risk at a downgradient location, but to target those contaminants that may pose the greatest problem if they migrate from the site. SRCs were identified as CMCOPCs if they exceeded the GSSL. To evaluate leaching of CMCOPCs at the 16 SWMUs from soil to groundwater, groundwater concentrations of CMCOPCs were compared to MCLs. If an MCL for the chemical was not available, the groundwater concentration was compared to the EPA Region III–suggested RBCs corresponding to a 10^{-6} risk or an HQ of 0.1.

6.4.2 Vadose Zone SESOIL Modeling of the Contaminant Migration Constituents of Potential Concern

Vadose zone modeling of CMCOPCs (if any) using the Seasonal Soil Compartment (SESOIL) model (Appendix K) was performed for the SWMUs that required a baseline risk assessment. SESOIL was used to predict the maximum groundwater concentration of the CMCOPCs in soil.

The input data for SESOIL can be grouped into four types: climatic, chemical, soil, and application data. There are a total of 61 separate parameters contained in these four data groups. Wherever possible, site-specific parameter values were used for modeling. Certain parameters, however, were not available and were estimated based on a pertinent scientific literature search, geochemical investigations, and consistency checks between model results and historical data. Conservative estimates were used when a range of values was indicated or when parameter values were not available.

6.4.2.1 Climate data

The climatic data file of SESOIL consists of an array of values for various climatic parameters (Appendix K, Table K-1). The climatic parameters were taken from the SESOIL database. The nearest rain gauge station to FSMR in the SESOIL database is Savannah, Georgia.

6.4.2.2 Chemical data

The pollutant fate cycle of SESOIL focuses on the various chemical transport and transformation processes that may occur in the soil zone. These processes include volatilization/diffusion, adsorption/desorption, cation exchange, biodegradation, hydrolysis, and metal complexation. The chemical's solubility in water, air diffusion coefficient, Henry's Law constant, and organic carbon partitioning coefficient are parameters required as input to the model. These chemical-specific values are presented in Table 6-2.

The lowest biodegradation rates from the Handbook of Environmental Degradation Rates (Howard et al. 1991), presented in Table 6-2, were used. If the biodegradation rate of a chemical was not found in the literature, it was assumed to be zero. The process of hydrolysis was not considered in this study because the rates of hydrolysis for certain organic chemicals may vary by more than 14 orders of magnitude. The use of such values in the model would place a high degree of uncertainty on the SESOIL results. Therefore, hydrolysis parameters were set to zero for this analysis, resulting in conservative output.

6.4.2.3 Soil data

The soil data file of SESOIL contains input parameters describing the physical characteristics of the subsurface soil. The parameters include: soil bulk density, intrinsic permeability, soil disconnectedness index, soil porosity, organic carbon content, soil moisture content, infiltration rate, depth to the water table, aquifer thickness, and area of the source. The infiltration rate was based on a water balance calculation using the HELP model (EPA 1994b) (see Section 6.3.1).

If a site-specific soil parameter was not available, a conservative default value was used (Appendix K, Tables K-2.1 through K-2.5). There is no measurement method for the Freundlich exponent (used in calculating the adsorbed contaminant concentration); therefore, the SESOIL default value was used for this parameter. The intrinsic permeability for the vadose zone was calibrated. The soil disconnectedness index replaces moisture retention curves (or characteristic curves) used by other unsaturated zone leaching models. The SESOIL User's Guide (General Sciences Corporation 1996) defines this parameter as being the exponent relating the "wetting" and "drying" time-dependent permeability of soil to its saturated permeability. This one-variable approach of using the soil disconnectedness index in SESOIL simplifies the data estimation process and reduces computation time.

6.4.2.4 Initial condition/source-term concentrations

Analytical data from soil samples collected during the RFI for 16 SWMUs were used as initial concentrations for SESOIL modeling. These data are presented in Chapter 9.0 or Chapter 10.0 for the individual SWMUs. The loading of initial concentrations as input to SESOIL was based on the soil sampling intervals. The initial condition/source-term concentrations used for the SWMUs are presented in Appendix K, Tables K-3.1 through K-3.5.

6.4.2.5 Model application

The SESOIL model used for leachate modeling in the RFI estimates pollutant concentrations introduced into the subsurface via direct application and/or interaction with other media. The model defines the soil compartment as a column extending from the ground surface through the unsaturated zone to the upper level of the saturated soil zone. Processes simulated in SESOIL are categorized in three cycles: hydrologic cycle, sediment cycle, and pollutant cycle. Each cycle is a separate submodule in the SESOIL code. The hydrologic cycle includes rainfall, surface runoff, infiltration, soil–water content, evapotranspiration, and groundwater recharge. The pollutant cycle includes advective transport, volatilization, adsorption/desorption, and degradation/decay. A contaminant in SESOIL can partition into up to four phases (aqueous, gaseous, adsorbed, and free liquid). Data requirements for SESOIL are not extensive because the model uses a minimum number of soil and chemical parameters and meteorological values as input. Output from the SESOIL model includes pollutant concentrations at various soil depths and pollutant loss through surface runoff, percolation to groundwater, volatilization, and degradation. The mathematical formulations used in the SESOIL code generally consider the rate at which the modeled processes occur, the interaction of these processes, and the initial conditions of the waste area and surrounding hydrogeologic formations. The models were arranged in four layers (Appendix K, Tables K-3.1 through K-3.5). Layers 1 through 3 were divided into sublayers to facilitate contaminant loading at intervals closely approximating the actual sampling points and the analytical results. The first three layers are constituent loading zones. The fourth layer represents the leaching zone. This layer was divided into sublayers to improve model precision. The fourth layer is very thin and lies just above the water table; it was used to record predicted leachate concentrations at the water table/vadose zone interface. The SESOIL simulations were continued until the maximum concentration in groundwater was attained.

6.4.3 Saturated Zone Groundwater Modeling

Saturated zone modeling using the Analytical Transient 1-,2-, 3-Dimensional (AT123D) and One-dimensional Analytical Solute Transport (ODAST) (see Appendix K) was performed to support ecological and baseline risk assessments. Saturated zone modeling was performed if the CMCOPCs from the vadose zone or ecological contaminants of potential concern (ECOPCs)/human health contaminants of potential concern (HHCOPCs) in groundwater had the potential to migrate to the nearest surface water receptor.

AT123D was used for the modeling of organic contaminants, while ODAST was used for the modeling of inorganic contaminants. ODAST was selected over AT123D for the modeling of inorganic contaminants because the maximum simulation period in AT123D is limited to 100 years. Simulation for a period of 1,000 years was performed for inorganic chemicals using ODAST because inorganic chemicals usually do not biodegrade and move very slowly.

6.4.3.1 AT123D modeling

AT123D is a well-known and commonly used analytical groundwater pollutant fate and transport model (see Appendix K). The model computes the spatial–temporal concentration distribution of chemicals in the aquifer system and predicts the transient spread of a chemical plume through a groundwater aquifer. The fate and transport processes accounted for in AT123D are advection, dispersion, adsorption/retardation, and decay. This model can be used as a tool for estimating the dissolved concentration of a chemical in one, two, or three dimensions in the groundwater resulting from a mass release (either continuous or instant or depleting source) over a source area (i.e., point, line, area, or volume source).

Steady-state constant-source AT123D models were developed by calibrating the model against the maximum-observed or SESOIL–predicted maximum concentrations in groundwater beneath the SWMUs. Parameters needed for AT123D model simulations are listed in Appendix K, Tables K-7.1 and K-7.2. If a site-specific parameter was not available, the EPA default value was used. For conservatism, source concentrations were assumed to be constant in the model, and the biodegradation rate for a chemical was taken from the lowest biodegradation rate mentioned in the Handbook of Environmental Degradation Rates (Howard et al. 1991).

Conservative steady-state concentrations of organic chemicals predicted by the AT123D model at the ecological or human receptor locations were used in the respective baseline risk assessment.

6.4.3.2 ODAST modeling

The ODAST program evaluates the one-dimensional analytical solute transport solution considering convection, dispersion, decay, and adsorption in porous media. It uses an analytical equation (Appendix K) published by Van Genuchten and Alves (1982). It includes two simple function-type subroutines using FORTRAN computer code. One subroutine calculates the product of the exponential [exp(A)] and the complementary error function [erfc(B)]; the FORTRAN code was written by Van Genuchten and Alves (1982). The input data for this program is very short and simple. The list of parameters required for ODAST modeling is also provided in Appendix K, Tables K-5.1 through K-5.4.

The ODAST model was used to predict the maximum concentration of inorganic chemicals at the ecological/human receptor location from the maximum-observed or SESOIL–predicted maximum groundwater concentration beneath the SWMUs. It was assumed that the source concentration remains at the maximum-observed/SESOIL–predicted concentration for a period of 70 years. Models developed using ODAST were simulated for a period of 1,000 years. The maximum concentration predicted by ODAST at the receptor location was used for the respective human/ecological risk assessment.

6.4.4 Natural Attenuation of the Contaminant Migration Constituents of Potential Concern

Natural attenuation refers to the observed reduction in contaminant concentrations as contaminants migrate from the source in environmental media. This reduction in concentration in groundwater is due to a number of fate and transport processes, including simple dilution, dispersion, sorption, volatilization, and biotic and abiotic transformations. Abiotic processes of natural attenuation, which include advection,

dispersion, sorption, dilution, volatilization, hydrolysis, dehydrogalogenation, and reduction reactions, usually occur universally. Intrinsic bioremediation of fuel hydrocarbon in groundwater occurs universally, while only some sites contaminated with chlorinated solvents exhibit intrinsic bioremediation. Biodegradation parameters collected during the Phase II RFI include dissolved oxygen, Redox potential, pH, sulfate (SO_4^{2-}), ferrous [Fe(II)], conductivity, temperature, and TOC.

Organic chemicals can be degraded in the environment through biotic and abiotic processes, which include hydrolysis, Redox, photolysis, biodegradation, or volatilization. As already discussed in Section 6.2, environmental half-lives of organic compounds in various media can vary from minutes to years, depending on the chemical and on the environmental conditions. Organic chemicals with differing chemical structures will biodegrade at different rates. Primary biodegradation consists of any biologically induced structural change in an organic chemical, while complete biodegradation is the biologically mediated degradation of an organic compound into carbon dioxide, water, oxygen, and other metabolic inorganic products. The biodegradation rate of an organic compound is proportional to the concentration:

$$-dC/dt = kC^n$$

where

- C = concentration,
- k = biodegradation rate constant = 1/t Ln (a/[a-x]),
- t = time,
- a = initial concentration,
- x = change in concentration with time, and
- n = reaction order, n=1 for first-order kinetics.

The half-life ($t_{1/2}$ = Ln2/k) is the time necessary for half of the chemical concentration to react. The biodegradation rate of an organic chemical is generally dependent upon the presence and population size of soil microorganisms capable of degrading the chemical. Based on the above equation and the maximum concentrations of these constituents, a simple first-order correlation can be obtained between the constituent's half-life and the time required to degrade the contaminant to the concentration equal to its MCL/RBC.

Metals do not degrade in nature. However, as discussed in Section 6.2.1, metals may be naturally attenuated by ion exchange, Redox, precipitation, or complexation. Although these reactions may be reversible, they cause metals' mobility to be highly retarded.

6.4.5 Identification of Soil Remedial Levels

Remedial levels for soils based on leaching to groundwater are developed for the Phase II sites that require human health baseline risk assessments. An unsaturated zone contaminant transport model (SESOIL) is used to predict the concentration of contaminants in the percolating rainwater before reaching the water table. The SESOIL results are then converted into likely average groundwater concentrations at the site by using dilution factors (DFs). DFs are developed by using the hydraulic analysis method (EPA 1996a), which involves calculating the rate of flow through the aquifer system and the rate of rainwater percolating into the aquifer. Soil remedial levels are calculated based on the ratio of the MCL to the predicted maximum site groundwater concentration for a given analyte. If an MCL was not available for a constituent, the remedial level was based on the risk/hazard for the worst case scenario evaluated in the human health baseline risk assessment.

7.0 HUMAN HEALTH PRELIMINARY RISK EVALUATION METHODOLOGY

The HHPRE uses a Step 1 risk evaluation approach that is based on guidance from the GEPD (Figure 7-1). This evaluation is conducted to determine if there are potential risks to human health associated with contamination detected at the 16 SWMUs. Step 1 involves the following components:

- for inorganics, compare detected concentrations to naturally occurring statistical background levels (Appendix F) to determine if detected inorganics are naturally occurring or are associated with past activities at the site;
- identify potential migration and exposure pathways associated with the site and potential exposure scenarios to determine appropriate action levels;
- identify available risk-based action levels for each contaminant detected above background levels or develop levels if they do not exist; and
- compare sample concentrations to action levels to determine if site conditions warrant further evaluation.

Chemicals that exceed action levels will be identified as HHCOPCs.

7.1 DATA EVALUATION

The objective of the data evaluation step is to develop a set of chemical data that is suitable for use in the HHPRE. The data for the 16 SWMUs were evaluated to determine if they are of sufficient quality for use in the quantitative risk assessment.

The data used in the risk assessment were verified and validated using the methodology described in the QAPP [Part II of the SAP (SAIC 1997)]. Data qualified during the validation as rejected ("R") were not used in the risk assessment.

Detection limits achieved during sample analysis were reviewed to ensure that the required detection limits were met. Typically, detection limit requirements are established to ensure that characterization has occurred to levels that are low enough to determine if chemicals are present at hazardous levels. These levels are chemical-specific and related to each chemical's toxicity. Required detection limits are presented in the QAPP [Part II of the SAP (SAIC 1997)]. In some cases recommended detection limits cannot be achieved by a laboratory (e.g., if matrix or chemical interference requires that a sample be diluted). Samples with elevated detection limits that exceeded 10 times the required detection limit were excluded from the risk assessment data set.

With GEPD concurrence (see Appendix L), all volatile and semivolatile organics were removed from further consideration if the reported sample concentration was at or below 2 μg/L or 2 μg/kg. All acetone values at or below 30 μg/L or 30 μg/kg were treated as nondetects (see Chapter 4.0 and Appendix C). All methylene chloride and toluene values at or below 15 μg/L or 15 μg/kg were also treated as nondetects (see Chapter 4.0 and Appendix C).

Inorganics that are essential nutrients were eliminated, unless they were found at exceptionally high concentrations (EPA 1989). Evidence suggests that there is little potential for toxicity resulting from overexposure to the essential nutrients calcium, magnesium, potassium, and sodium. The highly controlled physiological regulatory mechanisms of these inorganics suggest that there is little, if any, potential for bioaccumulation, and available toxicity data demonstrate that high dietary intakes of these nutrients are well tolerated (National Academy of Sciences 1977; National Research Council 1982; National Research Council 1984).

Background screening for inorganics has been discussed in Chapter 5.0; therefore, it will not be addressed in this section of the document.

7.2 EXPOSURE EVALUATION

The objective of this exposure evaluation is to identify potential exposure pathways that could result in human contact with SRCs. A complete exposure pathway consists of five elements: (1) a potential receptor population, (2) a source of contamination, (3) a transport or retention medium, (4) a point of contact for a receptor, and (5) a route of exposure (ingestion, dermal absorption, or inhalation) through which the chemical may be taken into the body. When all of these elements are present, human exposure to SRCs may take place. The assessment considers both on-site and off-site receptors and their relationship to the potential migration pathways, exposure pathways, and points of exposure for SRCs.

For the purposes of the HHPRE, the exposure assessment identifies potential exposure pathways for selection of pertinent risk-based action. Site-specific discussions are given in Chapters 9.0 and 10.0.

7.2.1 Receptor Assessment

This section identifies those populations that may be exposed to SRCs. These populations will vary among the different sites. For the purposes of this report, different types of sites (e.g., active versus those no longer in use or secured versus unsecured sites) and the general receptor populations that may be present are discussed separately. Site-specific descriptions of receptor populations are given in Chapters 9.0 and 10.0.

Generally, receptor populations are divided into two groups: on-site and off-site receptors. On-site receptors are those individuals who may be present within the site boundaries and come into direct contact with the contaminants present. The exposure of an off-site receptor requires that the contaminant be transported to an off-site exposure point.

The on-site receptors will vary from site to site depending upon the current land use. The sites can generally be divided into different categories depending on the current land use, with receptor populations common to each category. These categories are summarized in Table 7-1 and are discussed below.

Sites that are currently in use would be secured (i.e., the site would be surrounded by a fence or other deterrent and access to the site would be limited to personnel working at the site). The occupational receptor populations would include Installation personnel assigned to work at the site and contract workers (e.g., construction, building maintenance, and repair crews). However, the area of contamination at some of the active sites is not limited to the secured areas, and some soil contamination may exist in open areas adjacent to the site. At these sites juvenile trespassers and other nonoccupational populations may be exposed to the contamination present.

Table 7-1. Generalized Site Descriptions and Associated Receptor Populations

Site Description	On-site Receptors	Off-site Receptors
Active; contamination limited to secured area.	Occupational receptor Construction worker	Occupational receptor
Active; contamination extends outside secured area.	Occupational receptor Construction worker Juvenile trespasser	Occupational receptor
Inactive; secured area.	Occupational receptor Construction worker	Occupational receptor
Inactive; unsecured areas within the garrison area.	Occupational receptor Construction worker Juvenile trespasser	Occupational receptor
Inactive; unsecured areas outside the garrison area.	Occupational receptor Construction worker Juvenile trespasser Sportsman (hunter)	Occupational receptor Recreational user

Inactive sites can be divided into secured areas and unsecured or open sites. The secured, inactive sites are located within the garrison area and are represented by sites that are no longer in active use but have equipment or other items that are still present at the site. On-site receptors for these sites would include personnel who enter the site for specific purposes or tasks. Although juvenile trespassers may enter a secured, inactive site, these sites are located in the garrison area and, given the amount of activity in the surrounding area, it is unlikely that a juvenile would be able to enter the sites unnoticed.

The unsecured sites are located in open areas, where a juvenile trespasser may cross the site. Hunting is allowed on the FSMR, so hunters may also represent an on-site receptor population. Military personnel may be present on sites located within active training areas.

Although a receptor population may be identified under current conditions, potential changes in land use may result in the presence of more sensitive receptor populations in the future. The sites within the garrison area are located in developed industrial areas. Although the activities at the sites may change or the sites may become inactive, the sites are likely to remain secured. Therefore, on-site receptors would be limited to personnel working on the site. Inactive sites may be developed for various types of industrial operations; however, as previously discussed, the on-site populations are not likely to change.

None of the sites in the 16 SWMUs is likely to be used for residential purposes. However, to be sure that the first step of the risk assessment process does not exclude any potential future receptors, this assessment assumes that residential use of the site could occur in the future. Residential use of the site is highly unlikely, but is presented as a scenario in accordance with Risk-based Corrective Action (RBCA) guidance.

Off-site receptors include people living and working in the area of the sites as well as recreational users (hunting, fishing, or hiking). The off-site receptor population would change from occupational receptors to residential receptors if the area surrounding a site were to be developed into Installation housing or a residential area.

7.2.2 Migration Pathway Analysis

This section provides a general discussion of the potential chemical transport pathways that may lead to potential exposure points. In general, the major routes of migration are volatilization into air, wind

erosion resulting in fugitive dust, erosion of surface soils into nearby surface waters, leaching of contaminants into groundwater, migration through groundwater, and discharge of groundwater into a surface water body. Sites within the 16 SWMUs may have all or some of these potential migration pathways. The discussion below provides a description of potential migration pathways.

Air. SRCs in soils may be released via volatilization. This migration pathway is generally limited to VOCs found in the surface soils. Particulate-bound chemicals may also be transported to and through the air via generation of fugitive dust. This pathway is limited to compounds that have a high affinity for soils and a low vapor pressure, thus reducing the possibility of volatilization. This migration pathway is limited to chemicals found in surface soils at sites that lack sufficient vegetative cover.

Groundwater. Migration of soil contaminants to groundwater could occur as rainwater infiltrates and percolates through the soil to the groundwater table. The extent of contaminant migration depends primarily on the amount of rainfall, evaporation, solubility of the chemical in water, adsorption of the chemical to the soil, and distance to the groundwater. In general, VOCs [such as benzene, toluene, ethylbenzene, and xylenes (BTEX)] travel more easily through soils than do SVOCs because they are more soluble in water. Solubility of metals is dependent on the metal species and is difficult to generalize. The depth to groundwater at the sites varies from 2 feet to 15 feet bgs.

Contaminants in groundwater may be transported to off-site locations, including surface water bodies. The transportation of contaminants to surface water is generally limited to contaminants that are soluble in water and have a low affinity for soils.

Surface Water. Surface water may serve as a reservoir for contaminants discharged into the water from groundwater or from erosion of contaminated particulates in surface soils. Surface water may serve as a migration pathway as contaminants migrate downstream from their source.

Sediment. Sediment may act as a reservoir for chemicals with a high affinity of sorbing onto solid particles.

7.2.3 Identification of Exposure Pathways

Potential human exposure may occur by primary pathways (i.e., exposure pathways in which the receptor comes in direct contact with contaminated environmental media) or through secondary pathways involving the transfer of SRCs to food sources (i.e., crops, livestock, and game). Potential primary pathways for exposure of receptor populations include incidental ingestion, inhalation of volatile organics and airborne particulates, and dermal contact.

The potential primary and secondary exposure pathways for contaminants present in various environmental media (e.g., soils, groundwater) are discussed in the following sections.

Surface Soil. Potential primary pathways for exposure of receptor populations include ingestion of soils, inhalation of volatile organics and airborne particulates, and dermal contact with soils. Off-site receptors may be exposed via inhalation of fugitive dust. It is unlikely that the volatile compounds will migrate off-site in any significant concentrations; therefore, off-site receptor populations would not be exposed to volatilized compounds.

Indirect exposure pathways for soils would include uptake of contaminants into food sources. Hunting is allowed on the FSMR. Game species may bioaccumulate contaminants as a result of ingesting soils and contaminated vegetation. Current off-site receptors may be exposed as a result of consuming contaminated game. Fort Stewart does not currently lease agricultural lands and is unlikely to allow

agricultural practices within the Installation in the future; therefore, exposure via uptake into food crops is not a viable exposure pathway.

Subsurface Soil. Potential primary exposure pathways for subsurface soils include ingestion of soils, inhalation of volatile organics, and dermal contact with soils. These pathways exist for construction workers or other individuals who would be involved in an excavation. Off-site receptors are unlikely to be directly exposed to contaminants in subsurface soils; however, indirect exposures could occur if contaminants migrated to groundwater.

Groundwater. The surficial groundwater aquifer underlying Fort Stewart is 2 feet to 13 feet bgs. Below this aquifer is the Principal Artesian aquifer, which is hydrogeologically isolated from the surficial aquifer. Drinking water in the area is obtained from the Principal Artesian aquifer, not the surficial groundwater aquifer. The shallow aquifer is currently used in some areas of the region for irrigation or watering of lawns. Direct exposure to irrigation water could include dermal contact and inhalation of volatiles released from the groundwater.

Sediment. Potential direct exposure pathways for sediment would include incidental ingestion by children playing in the surface waters. Exposure via dermal contact is likely to be minimal given that the water is likely to remove the majority of the sediment before chemicals can be absorbed via the skin. Contaminants in sediment may bioaccumulate in benthic (bottom-dwelling) fish and invertebrates, which may be consumed by humans.

Surface Water. Potential direct exposure pathways for surface water include incidental ingestion of water and dermal contact by children playing in the creek. In addition, volatiles released from the water may result in exposure of children and sportsman fishing in the creek. Ingestion of fish may result in exposure to chemicals bioaccumulated into the fish tissue.

7.3 SELECTION OF SCREENING VALUES

Screening values generally represent risk-based action levels and applicable or relevant and appropriate requirements (ARARs) that are publicly available. Screening values inherently incorporate assumptions about land use. In identifying COPCs, it is generally accepted that screening levels will reflect any potential future land uses, and thus usually reflect a conservative residential use scenario (EPA 1991; EPA 1999b; ASTM 1995). Due to their conservative nature, screening values can be used with a high degree of confidence to indicate sites requiring NFA.

Step 1 screening levels generally reflect residential land uses; use of these levels in the first step of the risk process ensures that no chemical will be screened from consideration prematurely. EPA does provide guidance and default parameter values for developing screening levels that reflect industrial land-use assumptions. These levels are developed using equations and default values from EPA (1991). Residential land use is unlikely at any of the sites within the 16 SWMUs.

If risk-based screening values are not publicly available, it generally means that (1) the chemical is not considered to be toxic, except perhaps at extremely high concentrations (e.g., aluminum, sodium); (2) there are no dose-response data indicating a toxic effect; or (3) EPA is currently reviewing toxicity information, and no reference dose or cancer slope factor is currently available.

The following were used as sources of screening values for various media:

- RBCs developed by EPA Region III (EPA 1999b),

- RCRA-based cleanup standards for lead (EPA 1994c), and

- Safe Drinking Water Act (SDWA) technology action levels (EPA 1991).

The RBCs developed by EPA Region III were based on an incremental cancer risk of 1×10^{-6} for carcinogens and a hazard index (HI) of one for noncarcinogens. The screening values for noncarcinogens used in this assessment were based on an HI of 0.1, instead of an HQ of one.

In some cases a screening value was available for a specific compound but not its isomers. In these cases the screening value for the parent compound was used in the risk analysis. A list of these compounds is given below.

- Chlordane was used for alpha-chlordane and gamma-chlordane.

- Endosulfan was used for endosulfan II and endosulfan sulfate.

- Endrin was used for endrin ketone.

- 1,3-Dichloropropene was used for 1,3-*cis*-dichloropropene and 1,3-*trans*-dichloropropene.

For some compounds that did not have screening values, values were available for similar chemicals. If the chemistries of the two compounds were similar, then substitute values were used. There were no screening values for delta-BHC, although screening values were available for the other isomers and technical BHC. Technical BHC is the commercial product used and consists of a mixture of the various isomers. The screening value for technical BHC was used, resulting in a conservative assumption, given that this value takes into account the toxicity of delta-BHC and other more toxic isomers.

Some of the PAHs do not have screening values. The screening value for 2-methylnaphthalene was used for 1-methylnaphthalene based on the similarities in chemical structures. Pyrene was used as a surrogate for phenanthrene. Acenaphthene is similar to acenaphthylene, with acenaphthylene having an additional double bond; therefore the screening value for acenaphthylene was used for acenaphthene.

Benzo(*g,h,i*)perylene does not have a chemical structure that is similar to the PAHs that have toxicity values. Benzo(*g,h,i*)perylene is a questionable carcinogen. Numerous studies have failed to show an increase in the incidence of tumors (EPA 1999a). However, as a conservative measure, it was assumed that this PAH is carcinogenic. The cancer slope factor for carcinogenic PAHs is estimated using toxicity equivalence factors (TEFs), which adjust the slope factor based on the relative carcinogenic potency of the PAH as compared to benzo(*a*)pyrene. Given that benzo(*g,h,i*)perylene is a questionable carcinogen, it is assumed that this PAH would have a TEF of 0.01, which is equal to those of the weaker carcinogenic PAHs.

Screening values for soils, sediments, groundwater, and surface water are discussed below. A summary of the toxicity data for the SRCs is given in Appendix I.

7.3.1 Screening Values for Soils and Sediments

There are no separate risk screening values for sediments. The exposure pathways for sediments include ingestion; therefore, soil screening values for ingestion of soils were used, resulting in a conservative assumption given that the amount of sediment ingested is likely to be far less than that of incidental soil ingestion. Incidental soil ingestion results from soil adhering to the hand and being ingested as a result of

hand-to-mouth behavior. Sediments adhering to the skin are likely to be washed off as the hand is removed from the water; therefore, the amount of sediment adhering to the hand is likely to be much lower than would be the amount of soil. In addition, a person is not as likely to come in contact with sediment as compared to soils; therefore, the frequency of exposure will be lower.

Screening values were selected for residential land-use scenarios. The screening values for soils have been taken from the following sources:

- soil RBCs developed by EPA Region III (EPA 1999b), and
- RCRA-based cleanup standards for lead (EPA 1994c).

The default residential exposure assumptions for soil are described below.

- The assumptions for the soil ingestion pathways are twofold. For noncarcinogens, the receptor is a child (age 1 to 6) who ingests 200 milligrams of soil per day for 6 years. For carcinogens, the soil ingestion rate is age-adjusted over a time period of birth until age 30, assuming an adult ingests 114 milligrams per day (EPA 1996a; EPA 1999b).
- For inhalation of volatiles or fugitive dust, a resident is assumed to be exposed to airborne contaminants for 30 years (EPA 1996a).

The potential exposure pathways for soils present at the 16 SWMUs include ingestion of surface soils, ingestion of subsurface soils (construction worker), inhalation of volatiles, and inhalation of fugitive dust for future land-use scenarios. The value for soil ingestion was used instead of the value for exposure via air because exposure via inadvertent ingestion of soils is a more likely exposure pathway for the majority of the sites.

Toxicity values have been developed for both elemental mercury and mercuric chloride. Given that the exact nature of the mercury detected at the 16 SWMUs is unknown, elemental mercury would be more representative of the various types of mercury that may be present. However, elemental mercury does not have an oral reference dose; therefore, screening values could not be developed for all of the environmental media assessed. For the purposes of this study, the screening value for mercuric chloride was used.

Chromium may exist in two valence states, trivalent (Cr^{+3}) and hexavalent (Cr^{+6}) chromium. Hexavalent chromium is significantly more toxic than trivalent and is more mobile in the environment. However, hexavalent chromium is not naturally occurring and is unstable in the environment, oxidizing to the trivalent state. The risk-based screening values for residential soils include both trivalent and hexavalent chromium. It is unlikely that the chromium present is hexavalent chromium, given that there is no likely source for it. In addition, the value given represents the total chromium present, which includes naturally occurring trivalent chromium. As a conservative assumption, however, the hexavalent chromium value was used for the screening value.

Region III does not have screening levels for lead because lead does not have a reference dose. The EPA cleanup standard for lead represents the maximum concentration in soil that is not likely to have a significant impact upon the health of a child. The EPA screening level is based on a child consuming 200 milligrams of soil per day and estimates lead blood concentrations using biokinetic models.

7.3.2 Screening Values for Groundwater

The groundwater screening values reflect the use of groundwater as a source of drinking water (EPA 1999b). These values include the Region III screening values for tap water. As previously discussed, groundwater at this site is unlikely to be used as a drinking water source, but may be used as a source of water for future irrigation or watering. The drinking water screening values are considered to be health-protective values, given the conservative assumptions used in their derivation.

The default residential exposure assumptions for groundwater are described below.

- The assumptions for the groundwater pathway are twofold. For noncarcinogens, the receptor is an adult who ingests 2 liters of groundwater per day. For carcinogens, the water ingestion rate is age-adjusted over a time period of birth until age 30, assuming a child age 1 to 6 ingests 1 liter per day (EPA 1996a; EPA 1999b).

- Inhalation of volatiles is assumed to occur during showering.

There is no reference dose for lead; however, EPA has derived a technology action level for acceptable lead levels at the tap (EPA 1991). The 15 micrograms per liter action level was used for the lead screening value.

Toxicity values have been developed for both elemental mercury and mercuric chloride. Given that the exact nature of the mercury detected at the 16 SWMUs is unknown, elemental mercury would be more representative of the various types of mercury that may be present. However, elemental mercury does not have an oral reference dose; therefore, screening values could not be developed for all of the environmental media assessed. For the purposes of this study, the screening value for mercuric chloride was used.

7.3.3 Screening Values for Surface Water

Screening values surface water include: Georgia Ambient Water Quality Standards (WQSs) (GEPD 1999c), EPA Region IV WQSs for human health–water and organism ingestion, EPA Region III risk-based criteria for tap water (EPA 1999b), and EPA action levels for drinking water. The different criteria are designed to be protective of human health depending on the types of exposure. The Georgia Ambient WQSs (GEPD 1999c) and the EPA Region IV WQSs for human health–water and organism ingestion, represent the maximum concentrations of contaminants in water that will not present an unreasonable risk to human health if the waters are treated and used as a drinking water source or if aquatic life is harvested from the waters and consumed. The risk-based criteria for tap water and EPA action levels are values applied to water coming from the tap within a home where the water is used for drinking, bathing, cooking, etc.

The WQSs are applicable to many of the surface waters found within the 16 SWMUs. However, the numbers of chemicals addressed in these criteria are limited. Therefore, in the absence of a WQS value, the drinking water standards were applied. This is a conservative approach, given that the drinking water standards assume that the surface water is not treated and that the amount of water ingested is significantly greater for drinking water from a tap than for incidental ingestion from surface waters.

7.4 RISK EVALUATION

The risk evaluation compares the maximum value detected in each medium with the respective screening value for that chemical. If chemical concentrations exceed a screening value, then a risk may exist, and the chemical should be evaluated more carefully (see Figure 7-1).

The selection of COPCs for each environmental medium (surface soil, subsurface soil, groundwater, sediment, or surface water) at each of the sites is addressed in the respective SWMU chapters. The selection process involves two steps. The initial step is the comparison of the maximum concentrations to the appropriate screening values. (Selection of the screening values was discussed in Section 7.3.) Given the conservative nature of the screening values, a weight-of-evidence analysis of those chemicals passing the screening is done to determine if those chemicals selected should be analyzed further in a baseline risk assessment.

7.5 UNCERTAINTY

There are uncertainties associated with all phases of the Tier I risk analysis, including collection and laboratory analysis of the samples and selection of screening concentrations. For the purposes of this report, the general uncertainties are discussed in the following narrative. Site-specific uncertainties, if any, will be discussed as part of the human health risk assessment.

Uncertainties associated with the collection and laboratory analysis of the sampling data may impact the results of the selection process. These uncertainties result from the potential for contamination of samples during collection, preparation, or analysis and from normal error in the analytical techniques. The laboratory validation process minimizes these uncertainties.

The use of blank contamination data also contributes uncertainty to the analysis. Common laboratory contaminants may be excluded from the risk assessment because the associated blank samples were contaminated when these chemicals were actually present in the site-related samples. Conversely, a chemical may be included in the risk assessment because its corresponding blank was "clean" when, in fact, the chemical was a result of laboratory contamination. Site activities and the chemicals expected to result from these activities must be considered when interpreting the data. The data validation process minimizes the uncertainty associated with blank contamination.

Uncertainty is associated with the criteria used for the selection of the screening values. The use of conservative assumptions when selecting the screening values, coupled with the use of low toxicity assessment endpoints [i.e., the use of an HI of 0.1 and an incremental lifetime cancer risk (ILCR) of 1:1,000,000], ensures that those chemicals most likely to contribute significantly to potential risks are evaluated. This is likely to result in chemicals being included as COPCs when they do not present a significant risk to human health.

The use of surrogate values for screening chemicals that do not have screening values adds uncertainty concerning the potential risks associated with those chemicals. Small differences in the structure of a molecule can sometimes have significant effects upon the level of toxicity. This may result in chemicals being included or excluded from the list of COPCs, depending upon differences in the toxicity of the screening compound and the surrogate.

7.6 REMEDIAL LEVELS FOR PROTECTION OF HUMAN HEALTH

Some of the sites within 16 SWMUs (e.g., SWMU 31) will have Interim Removal Actions (IRAs) performed to reduce contamination associated with the site. Remedial levels were calculated for all COPCs at these sites. Remedial levels are based on ARARs or are RBCs designed to be protective of the most sensitive populations.

The risk-based remedial levels for carcinogenic COPCs are calculated using the following formula:

$$RL = \frac{(TR)(ST)}{(I_{oral} \times CSF_{oral}) + (I_{der} \times CSF_{der}) + (I_{inh} \times CSF_{inh})}$$

where

RL	=	remedial level for a given COPC,
ST	=	source-term concentration of the COPC in a given medium,
TR	=	target risk,
I_{oral}	=	intake via oral route (mg/kg/day),
CSF_{oral}	=	oral cancer slope factor ([mg/kg/day]$^{-1}$),
I_{der}	=	intake via dermal route (mg/kg/day),
CSF_{der}	=	cancer slope factor based on absorbed dose of the chemical ([mg/kg/day]$^{-1}$),
I_{inh}	=	intake via inhalation (mg/kg/day), and
CSF_{inh}	=	inhalation cancer slope factor ([mg/kg/day]$^{-1}$).

The equations and exposure factors used to estimate the intake of carcinogens are given in Appendix I, Section I.2.4. The cancer slope factors are discussed in Appendix I, Sections I.3.1 and I.3.3 and listed in Table J-1 in Appendix J. The units for the remedial levels will be the same as the units for the source-term concentration.

The risk-based remedial levels based on systemic toxicity are calculated using the following formula:

$$RL = \frac{(THI)(ST)}{(I_{oral} / RfD_{oral}) + (I_{der} / RfD_{der}) + (I_{inh} / RfD_{inh})}$$

where

RL	=	remedial level for a given COPC,
ST	=	source-term concentration of the COPC in a given medium,
THI	=	target hazard index,
I_{oral}	=	intake via oral route (mg/kg/day),
RfD_{oral}	=	oral reference dose (mg/kg/day),
I_{der}	=	intake via dermal route (mg/kg/day),
RfD_{der}	=	reference dose based on absorbed dose of the chemical (mg/kg/day),
I_{inh}	=	intake via inhalation (mg/kg/day), and
RfD_{inh}	=	inhalation reference dose (mg/kg/day).

The equations and exposure factors used to estimate the intake of carcinogens are given in Appendix I, Section I.2.4. The cancer slope factors are discussed in Appendix I, Sections I.3.2 and I.3.3. The reference doses are given in Table J-1 in Appendix J. The units for the remedial levels will be the same as the units for the source-term concentration.

doses are given in Table J-1 in Appendix J. The units for the remedial levels will be the same as the units for the source-term concentration.
Remedial levels will be estimated for 10^{-6}, 10^{-5}, and 10^{-4} cancer risk levels for each carcinogenic contaminant of concern (COC). Cleanup levels will be estimated for each noncarcinogenic COC at HQ levels of 0.1, 1, and 3. The remedial levels will be protective of current and possible future receptor populations identified in the receptor analysis. Constituents that have both reference doses and cancer slope factors will have remedial levels calculated using both types of toxicological values.

Remedial levels for groundwater may include both RBCs and regulatory levels such as MCLs. Given that MCLs take into consideration both human health and the limitations of technology in removing contaminants from water, these values will be used as remedial levels. In the absence of an MCL, an RBC will be calculated.

RBCs will be used as remedial levels for the other environmental media. The scenarios used to derive the remedial levels for a specific site are discussed in the site-specific sections.

8.0 ECOLOGICAL PRELIMINARY RISK EVALUATION

The state of Georgia allows RCRA facilities to set remediation levels based on an assessment of risk to human health and the environment. All RCRA facilities in Georgia that choose to set risk-based remediation levels, such as Fort Stewart, must prepare risk assessment documentation and propose remediation levels in accordance with the Guidance for Selecting Media Remediation Levels at RCRA Solid Waste Management Units (GEPD 1996). This guidance for ecological risk assessments (ERAs) is based on the guidance contained in EPA Region IV Bulletins, Supplemental Guidance to RAGS, Ecological Risk Assessment (EPA 1996d) and a 1994 draft of Ecological Risk Assessment for Superfund, Process for Designing and Conducting Ecological Risk Assessments (EPA 1994d; EPA 1997a). EPA has also proposed guidelines for conducting ERAs (EPA 1996b). In cases in which GEPD and EPA guidelines differ, the GEPD guidance document takes precedence.

Risk is the likelihood of experiencing adverse effects. The assessment of risk for ecological receptors at 16 SWMUs focuses on identifying and evaluating the potential for harmful effects on ecological receptors as a result of exposure to chemicals released to the environment.

The assessment of risk for ecological receptors at the 16 SWMUs is being conducted under a phased approach in accordance with GEPD (1996) and EPA Region IV (1996d) guidance. The two phases are

- the EPRE and
- the ERA.

The EPRE compares measured concentrations of detected substances to conservative ecological screening values (ESVs) to identify substances detected at the facility that pose a potential hazard to ecological receptors. An ERA is "a qualitative and/or quantitative appraisal of the actual or potential impacts of contaminants from a hazardous waste site on plants and animals other than humans or domesticated species" (EPA 1997a). EPA Region IV (EPA 1996d) and GEPD (1996) guidance emphasizes that ERAs are based on quantitative and site-specific data.

According to GEPD guidance, the risk assessment process terminates with the EPRE if there is no potential hazard or risk to ecological receptors. If contaminants are found to be potential hazards in the EPRE, then additional work may be required. Only those substances that are indicated to be potential hazards in the EPRE are evaluated as ECOPCs in an ERA, if one is required.

The need for an ERA is a risk management decision based on the nature and magnitude of risk to ecological receptors in the environmental setting of the 16 SWMUs. If risk managers decide an ERA is not required, then no further data are collected and ecological risk-based remedial levels are developed based on existing data from the individual SWMUs. Should an ERA be required for one or more of the 16 SWMUs, additional site-specific data will be collected to quantify exposure and evaluate effects (GEPD 1996). Appropriate site-specific data for ERAs include concentrations of contaminants in animals and plants (tissue residues) and toxicity tests (EPA 1997a). Remedial levels for protection of ecological resources are developed and proposed in the ERA for only those substances identified as environmental contaminants of concern in the ERA (GEPD 1996).

This section presents the methods for conducting the EPRE for the 16 SWMUs at Fort Stewart in accordance with GEPD guidance (GEPD 1996). The EPREs for SWMUs that have at least one substance

detected in an environmental medium at a concentration exceeding the respective background criterion are presented in Chapters 9.0 and 10.0.

According to GEPD (1996), the ecological risk evaluation process consists of five steps:

i. ecological screening value comparison,
ii. preliminary problem formulation,
iii. preliminary ecological effects evaluation,
iv. preliminary exposure estimate, and
v. preliminary risk calculation.

These five steps correspond to the five steps of the EPA Region IV EPRE (EPA 1996d).

As shown in the flowchart of the GEPD ERA process (Figure 8-1), the first step of the EPRE (Step i) is to screen substances as ECOPCs by comparing the maximum detected concentration to the ESVs. Those substances detected in surface water, groundwater, or sediment at concentrations exceeding background criteria are screened at SWMUs where aquatic biota are potentially exposed to those media. This approach assumes that the most sensitive receptors are those that live in direct contact with the medium and are exposed to contaminants by multiple pathways. If no ECOPCs are identified based on the ESV comparison (Step i), then no further evaluation of risk to aquatic receptors is required. If ECOPCs are identified based on the screening, then they are evaluated further (Steps ii through v). Because there are no ESVs for surface soil, all substances in surface soil at a SWMU are evaluated further in EPRE Steps ii through v. These last four steps of the EPRE represent a preliminary evaluation of the risk to ecological receptors from exposure to ECOPCs occurring at a SWMU.

The preliminary problem formulation (Step ii) identifies categories of potential ecological receptors that occur at the 16 SWMUs and categories of ECOPCs—the substances in surface soil, sediment, surface water, and groundwater that might pose a risk to those receptors in the environmental setting. Preliminary assessment endpoints, ecological receptors, and surrogate species that represent the ecological receptors are selected for evaluation in the preliminary risk calculation (EPA 1996d).

The preliminary ecological effects evaluation (Step iii) identifies toxicity reference values (TRVs) for use in the preliminary risk calculation (EPA 1996d). For the 16 SWMUs, TRVs are average daily doses (ADDs) (milligram per kilogram of body weight per day) for the surrogate species. In accordance with GEPD guidance (GEPD 1996), TRVs are derived from published laboratory toxicity studies.

The preliminary exposure estimate (Step iv) evaluates the potential pathways of exposure for ecological receptors according to the preliminary assessment endpoints. The equations used to calculate ADDs for surrogate species from published values for exposure parameters and measured maximum concentrations of contaminants in surface soil, sediment, surface water, and groundwater at the 16 SWMUs are presented in Step iv (Section 8.4).

The preliminary risk calculation (Step v) calculates an HQ, the ratio of the estimated ADD for the surrogate species at the SWMU and the TRV for the surrogate species, for each ECOPC. HQs are used to evaluate the risk to ecological receptors; to identify ECOPCs in surface soil, sediment, surface water, and groundwater at the 16 SWMUs for ecological receptors; and to support risk management decisions about the need for further evaluation of SWMUs in an ERA and, ultimately, about the need for remediation.

Both terrestrial and aquatic habitats are present at one or more of the 16 SWMUs. Media of concern to ecological receptors are surface soil, surface water, sediment, and groundwater. Surface soil, surface water, and sediment can be contacted or ingested directly by ecological receptors, or their presence in these media can result in the accumulation of contaminants in plants and animals, which can cause ecological receptors ingesting biota to be exposed. Groundwater is also evaluated because it can potentially discharge to springs, seeps, and surface water (EPA 1996d). Thus, up to four media are evaluated in the EPRE for the 16 SWMUs.

8.1 ECOLOGICAL SCREENING VALUE COMPARISON (Step i)

The ESVs used to identify ECOPCs at the 16 SWMUs are EPA Region IV screening values for hazardous waste sites. These are given in Table 8-1 for the substances detected in surface water or groundwater and those detected in sediment at the 16 SWMUs. For analytes without Region IV ESVs, screening values are proposed based on other methods and data obtained from published sources (e.g., Clayton and Clayton 1981) and toxicological databases such as the Hazardous Substances Data Bank and Integrated Risk Information System. Screening values are conservative to prevent elimination of any contaminant that might pose ecological risk. If no data are available to support the development of an ESV for an analyte, the analyte is an ECOPC by default (GEPD 1997a).

For the protection of aquatic biota potentially exposed to surface water and groundwater, such as fish and amphibians, EPA Region IV ESVs are the chronic Ambient Water Quality Criteria (AWQC) for the protection of aquatic life, such as aquatic plants, invertebrates, and fish, or similarly derived values (EPA 1996d). There are no EPA Region IV ESVs for some SRCs, so proposed ESVs for selected analytes are identified from published data sources (Suter and Tsao 1996; Clayton and Clayton 1981). The proposed ESVs are given in Table 8-1.

Sediment ESVs are based on observations of direct toxicity to sediment-dwelling organisms (EPA 1996d). EPA Region IV ESVs for sediment are not available for some SRCs. The proposed ESVs for sediment are given in Table 8-1.

The results of the screening value comparisons for surface water, sediment, and groundwater are presented in the individual sections for each SWMU along with substances detected above background concentrations (see Chapters 9.0 and 10.0). The maximum detected concentrations in samples from each SWMU are used to screen for ECOPCs for aquatic receptors.

A preliminary problem formulation (Step ii), preliminary ecological effects evaluation (Step iii), preliminary exposure estimate (Step iv), and preliminary risk calculation (Step v) are conducted for all SRCs in surface soil because there are no ESVs for terrestrial biota exposed to soil.

8.2 PRELIMINARY PROBLEM FORMULATION (Step ii)

The preliminary problem formulation (Step ii) identifies categories of potential ecological receptors and the substances that may pose a risk to those receptors in the environmental setting of the 16 SWMUs. Preliminary assessment endpoints, ecological receptors, and the surrogate species representative of ecological receptors are selected for evaluation in the preliminary risk calculation.

Table 8-1. Ecological Screening Values for Surface Water and Sediment

Analyte	Surface Water ESV (µg/L)	Sediment ESV (µg/kg)
RCRA Metals		
Antimony	160	12
Arsenic	190	7.24
Barium	4.0[a]	No ESV
Cadmium	0.66[b]	1
Calcium	No ESV	No ESV
Chromium (III)	117.32[b]	52.3
Chromium (VI)	11.00	52.3
Cobalt	23[a]	50[c]
Copper	6.54[b]	18.7
Iron	1,000[a]	20,000[d]
Lead	1.32[b]	30.2
Magnesium	No ESV	No ESV
Manganese	120[a]	No ESV
Mercury	0.0123	0.13
Nickel	87.7	15.9
Potassium	No ESV	No ESV
Selenium	5	No ESV
Silver	0.012[b]	2
Zinc	58.9	124
Volatile Organic Compounds		
1,1,1-Trichloroethane	528	0.17[e]
1,1,2,2-Tetrachloroethane	240	0.94[e]
1,1,2-Trichloroethane	940	No ESV
1,1-Dichloroethane	47[a]	No ESV
1,2-Dichloroethene	590[a]	No ESV
1,3-*cis*-Dichloropropene	0.055[a]	No ESV
1,3-*trans*-Dichloropropene	0.055[a]	No ESV
2-Hexanone	99[a]	No ESV
Acetone	1,500[a]	0.00863[f]
Benzene	53	0.057[e]
Bromodichloromethane	No ESV	No ESV
Bromomethane	48	No ESV
Carbon disulfide	0.92[a]	No ESV
Chloroethane	No ESV	No ESV
Chloroform	289	0.1[e]
Chloromethane	No ESV	No ESV
Dibromochloromethane	6,400[a]	No ESV
Ethylbenzene	453	3.5[e]
Methyl ethyl ketone	14,000[a]	0.273[f]
4-Methyl-2-pentanone	170[a]	No ESV
Methylene chloride	1,930	0.385[f]
Styrene	10,000[c]	No ESV
Tetrachloroethene	84	0.53[e]
Toluene	175	0.877[f]
Trichloroethene	47[a]	1.6[e]

Note: Footnotes appear on pages 8-6 and 8-7.

Table 8-1. Ecological Screening Values for Surface Water and Sediment (continued)

Analyte	Surface Water ESV (µg/L)	Sediment ESV (mg/kg)
Vinyl chloride	No ESV	No ESV
Xylenes, total	1.8[a]	0.285[f]
Semivolatile Organic Compounds		
1,2-Dichlorobenzene	15.8	0.34[e]
2,4-Dimethylphenol	21.2	No ESV
2-Methylnaphthalene	No ESV	330
4-Chloro-3-methylphenol	No ESV	No ESV
Acenaphthene	17	330
Benzo(*a*)anthracene	0.027[a]	330
Benzo(*a*)pyrene	0.014[a]	330
Benzo(*b*)fluoranthene	No ESV	No ESV
Benzo(*g,h,i*)perylene	No ESV	0.17[d]
Bis(2-ethylhexyl)phthalate	0.3	182
Chrysene	No ESV	330
Di-*N*-butylphthalate	9.4	11[e]
Di-*N*-octylphthalate	No ESV	No ESV
Dibenzofuran	3.7[a]	2[e]
Fluoranthene	39.8	330
Indeno(*1,2,3-cd*)pyrene	No ESV	0.2[d]
Naphthalene	62	330
Phenanthrene	6.3[a]	330
Phenol	256	No ESV
Pyrene	No ESV	330
Explosives		
2,6-Dinitrotoluene	100[g]	No ESV
RDX	970[h]	1.3[h]
HMX	330[h]	0.47[h]
Pesticides/PCBs		
beta-BHC	5,000	No ESV
delta-BHC	No ESV	No ESV
alpha-Chlordane	0.0043[i]	1.7
gamma-Chlordane	0.0043[i]	1.7[i]
4,4'-DDD	0.0064	3.3
4,4'-DDE	10.5	3.3
4,4'-DDT	0.001	3.3
Heptachlor	0.0038[a]	No ESV

ESV = EPA Region IV ESVs (EPA 1996d) and, where indicated, alternative values for analytes without ESVs.

[a]Chronic National Ambient Water Quality Criteria or Tier II values as reported in Suter and Tsao (1996), Table 1 or Table 3.

[b]Hardness dependent; assumes 50 mg/L $CaCO_3$.

[c]Fish LC_{50} (Clayton and Clayton 1981).

[d]OME-L: Ontario Ministry of Environment "Low" values (Persaud, Jaagumagi, and Hayton 1993).

[e]Sediment quality benchmark (SQB) = surface water ESV (mg/L) × K_{ow} (L/kg) × f_{oc}, where ESV values are from EPA Ecotox Thresholds (EPA 1996d) and faction organic carbon (f_{oc}) assumed to be 1 percent.

Table 8-1. Ecological Screening Values for Surface Water and Sediment (continued)

[f]For calculation of site-specific SQBs calculated as in footnote d, assuming $f_{oc} = 0.01$.

Compound	K_{ow}* (L/kg)	Surface Water ESV (mg/L)	Source of Surface Water ESV
Acetone	0.5754	1.5	Chronic Tier II value (Suter and Tsao 1996)
Methyl ethyl ketone	1.95	14	Chronic Tier II value (Suter and Tsao 1996)
Methylene chloride	19.95	1.93	EPA Region IV screening value
Toluene	501	0.175	EPA Region IV screening value
Xylenes, total	1585	0.0018	Chronic Tier II value (Suter and Tsao 1996)

* K_{ow}s from log K_{ow}s reported in HAZWRAP (1994).
[g]Etnier 1987; calculated as one-half criterion continuous concentration for 2,4-dinitrotoluene.
[h]Talmage et al. 1999.
[i]EPA Region IV ESV value for chlordane.

GEPD (1996) specifies that the EPRE develop "risk characterization for a model ecological receptor." Development of risk characterization for multiple ecological receptors, such as mammals and birds, is allowable for sites at which more than one type of potentially hazardous chemical is detected (GEPD 1997b). Characterizing the risk to multiple receptors can make the EPRE more protective of ecological resources if each receptor type is more sensitive to one or more chemical contaminant. The risk characterization for surface soil, sediment, surface water, and groundwater at the 16 SWMUs considers both mammals and birds as ecological receptors.

8.2.1 Environmental Setting

Ten of the 16 SWMUs (SWMUs 14, 17, 18, 19, 24B, 27, 31, 32, 34, and 37) are located in the cantonment or garrison area of the FSMR (see Figure 2-4). The garrison area of the FSMR is almost entirely industrial in character. The remaining seven SWMUs (SWMUs 2, 3, 9, 10, 11, 12, and 29) are located in the generally forested land surrounding the cantonment area (see Figure 2-3). These areas are used for ranges and training areas or held as non-use areas. The open range and training areas comprise 11 percent of the Installation and consist of grasses, shrubs, and scrub oak.

Sixty-six percent of the approximately 367.2 square miles of forest in the FSMR is pine forest, with the major species being slash pine, loblolly pine *(P. taeda)*, and longleaf pine *(P. palustris)*. The remainder of the FSMR forest is composed of river bottomlands and swamps, whose major species include tupelo, other gum trees, water oak (*Quercus nigra*), and bald cypress trees (*Taxodium distidium*). The understory of the pine forest is saw-palmetto *(Serenoa repens)*. The forests are managed by controlled burning, as evidenced by the presence of burn marks on the mature trees.

The principal surface water body receiving drainage from the FSMR is the Canoochee River, which joins the Ogeechee River (part of the northwestern boundary of the reservation). The individual 16 SWMU sites are located within different subwatersheds (see Figure 2-3).

The principal habitat types present at the 16 SWMUs are industrial, industrial with managed grass or neighboring forestland, forestland, managed grassland, unmanaged grassland, and aquatic. The habitat types present at the 16 SWMUs are presented in Table 8-2. More than one type of habitat may occur at a

Table 8-2. Habitat Types at 16 SWMUs

SWMU	Site Name	Habitat Type					
		Industrialized Areas	Industrialized Areas with Habitats[a]	Forestlands	Managed Grasslands	Unmanaged Grasslands	Aquatic Habitats
2	Camp Oliver Landfill	–	–	–	–	●	●
3	TAC-X Landfill	–	–	●	–	–	●
9	Inactive EOD Area in Red Cloud Range, Hotel Area	NA	NA	NA	NA	NA	NA
10	Inactive EOD Area North of Garrison Area	–	–	–	–	●	●
11	Inactive EOD Area Located Approximately Three Miles Northeast of Garrison Area	–	–	–	–	●	–
12A	Active EOD Containing Open Detonation Unit and Open Burn Unit	–	–	–	–	●	●
14	Old Fire Training Area	–	–	–	–	●	–
17	DRMO Hazardous Waste Storage Area	–	●	–	–	–	●
18	Industrial Wastewater Treatment Plant	–	–	–	●	–	●
19	Old Sludge Drying Beds	–	–	–	●	●	–
24B	Old Radiator Shop/Paint Booth	●	–	–	–	–	–
27A (Building 1339A)	3d Squadron, 7th Cavalry Motorpool and Four Associated Oil/Water Separators	–	●	–	–	–	–
27A (Building 1339B)		–	●	–	–	–	–
27A (Building 1322)		–	●	–	–	–	–
27B	1st BN, 3d ADA Motorpool and Associated Oil/Water Separator	–	●	–	–	–	–
27C	92d ECB (H) Motorpool and Associated Oil/Water Separator	●	–	–	–	–	–
27D	26th SPT BN Motorpool and Associated Two Oil/Water Separators	●	–	–	–	–	–

Note: Footnotes appear on page 8-10.

Table 8-2. Habitat Types at 16 SWMUs (continued)

SWMU	Site Name	Habitat Type					
		Industrialized Areas	Industrialized Areas with Habitats[a]	Forestlands	Managed Grasslands	Unmanaged Grasslands	Aquatic Habitats
27E (Wash Rack 1628)	703d SPT BN (Main) Motorpool and Associated Two Oil/Water Separators	–	●	–	–	–	–
27E (Building 1720)		–	●	–	–	–	–
27F (NW of Building 1340)	3d Engineer Brigade Motorpool and Associated Two Oil/Water Separators	–	●	–	–	–	–
27F (NE of Building 1340)		–	●	–	–	–	–
27G	DISCOM Motorpool and Associated Oil/Water Separator	–	●	–	–	–	–
27H (Building 1071)	DOL Maintenance Motorpool and Associated Two Oil/Water Separators	●	–	–	–	–	–
27H (Building 1056)		●	–	–	–	–	–
27I (Block 9900)	NGTC Block 9900, 10300 Motorpool and Associated Two Oil/Water Separators	–	●	–	–	–	–
27I (Block 10300)		–	●	–	–	–	–
27J (Building 10535)	GANG MATES Motorpool and Associated Two Oil/Water Separators	–	●	–	–	–	–
27J (Building 10531)		–	●	–	–	–	–
27K	3d BN, 69th Armor Motorpool Wash Rack and Oil/Water Separator	–	●	–	–	–	–
27L	NGTC Block 10200 Wash Rack and Oil/Water Separator	–	●	–	–	–	–
27M	NGTC Block 10100 Wash Rack and Oil/Water Separator	–	●	–	–	–	–
27N	NGTC Block 9800 Wash Rack and Oil/Water Separator	–	●	–	–	–	–

Note: Footnotes appear on page 8-10.

Table 8-2. Habitat Types at 16 SWMUs (continued)

SWMU	Site Name	Habitat Type					
		Industrialized Areas	Industrialized Areas with Habitats[a]	Forestlands	Managed Grasslands	Unmanaged Grasslands	Aquatic Habitats
27O	NGTC Block 9700 Wash Rack and Oil/Water Separator	–	•	–	–	–	–
27P	NGTC Block 9500 Wash Rack and Oil/Water Separator	–	•	–	–	–	–
27Q	NGTC Block 9400 Wash Rack and Oil/Water Separator	–	•	–	–	–	–
27R	396 Transportation Company Wash Rack and Oil/Water Separator	–	•	–	–	–	–
27S	Two 103d MI BN Wash Racks and Associated Two Oil/Water Separators	–	•	–	–	–	–
27T	293 MP Company Wash Rack and Oil/Water Separator	–	•	–	–	–	–
27U	Two Wright Army Airfield Wash Racks and Oil/Water Separator	–	•	–	•	•	–
27V	Auto Craft Center Oil/Water Separator	–	•	–	–	–	–
29	Evans Army Heliport POL Storage Facility	–	–	–	•	–	–
31	DEH Asphalt Tanks	–	–	–	•	–	–
32	Supply Diesel Tank	–	–	–	•	•	–
34	DEH Equipment Wash Rack	–	•	–	–	–	–
37	NGTC Equalization Basin	–	–	–	•	–	–

[a]Industrialized areas with managed grass or neighboring habitats.
NA = Not applicable.
• = Indicates habitat type(s) identified at the SWMU by the on-site biologist.

given SWMU. Brief descriptions of the principal habitat types follow. These descriptions are based on observations made by SAIC personnel during the field sampling investigation conducted in January through March 1998.

8.2.1.1 Industrialized areas

Much of the garrison area consists of man-made structures and surfaces with little or no natural habitat. Buildings, paved roads, gravel or asphalt parking lots, and sidewalks cover the majority of the surface of these areas, many of which are surrounded by chain-link fence. Characteristic flora of industrialized areas consists of grasses and herbaceous weeds growing in spaces between man-made surfaces. Fauna consists mainly of birds that nest in man-made structures or feed upon refuse. Industrial SWMUs are isolated, and mammals, amphibians, and reptiles are unlikely to visit them. SWMUs 24B, 27C, 27D, and 27H are located in industrialized areas with no habitat for wildlife. No ecological risk evaluation was conducted for surface soil at these four SWMUs because of the lack of suitable habitat.

8.2.1.2 Industrialized areas with managed grass or neighboring habitats

The majority of the SWMUs within the garrison area are located adjacent to man-made structures and have small areas of managed grass and/or neighboring forest or grassland habitats. These SWMUs are similar to the industrialized areas described above, but they are bordered by habitats that probably contain animals that might visit them in search of food or water. The neighboring habitats vary from simple, small patches of managed grass to complex, mature forest. Characteristic flora and fauna of these habitats vary depending upon the neighboring habitat type and are described under the section related to that habitat type. The remaining SWMUs in the SWMU 27 complex (i.e., those not listed as having industrial habitat type) as well as SWMUs 17 and 34 are industrialized areas with managed grass or neighboring forest or grassland habitats. Of the SWMUs that are industrialized areas with managed grass or neighboring habitat, no ecological risk evaluation was conducted for surface soil at SWMUs 27G, 27S, and 27V because of the very small areas of open vegetated or bare soil surface.

8.2.1.3 Forestlands

The FSMR beyond the garrison area consists mainly of managed pine forests of two types. Palmetto-pine forest has a canopy of pine trees, such as long-leaf pine, loblolly pine, and slash pine, with an understory of palmetto. Fauna includes a wide variety of birds, mammals, and reptiles. Common species include white-tailed deer (*Odocoileus virginianus*), feral hogs (*Sus scrofa*), wild turkey (*Meleagris gallopavo*), and nine-banded armadillos (*Dasypus novemcinctus*). Palmetto-pine forests are typically managed by controlled burning of the understory.

The other common forest habitat type at the FSMR is pine-oak forest or mixed pine/hardwood forest. Characteristic flora of this habitat type includes slash pine, long-leaf pine, loblolly pine, sweetgum (*Liquidamber styraciflua*), blackgum (*Nyssa sylvatica*), live oak (*Quercus virginiana*), Southern red oak (*Q. falcata*), and white oak (*Q. alba*). Saw-palmetto is commonly found as one of several understory plants. Fauna of the pine-oak forest is similar to that of the palmetto-pine forest, with the addition of gray squirrels (*Scurius carolinensis*), which feed heavily upon acorns. The habitat at SWMU 3 is predominately pine-oak forest.

8.2.1.4 Managed grasslands

Managed grasslands are found throughout the FSMR. Managed grasslands are typified by planted grass of one or more species maintained by mowing, application of fertilizers, etc. Many of the SWMUs that

exist on the border of or outside the garrison area contain large areas of managed grasses. Common fauna includes earthworms and other soil-dwelling invertebrates, birds such as robins, and mammals such as shrews and rabbits. Managed grasslands are found at SWMUs 18, 19, 27U, 29, 31, 32, and 37.

8.2.1.5 Unmanaged grasslands

Unmanaged grasslands are typically formerly managed grasslands that have undergone succession into meadows of native grasses and weeds because they are no longer mowed. Most of these areas are bordered on one or more sides by forest and are optimal animal foraging sites. Many of these areas have more sand on the surface than vegetation. Immature pine trees are commonly found growing sporadically throughout unmanaged grasslands along with sweetgum and blackgum. Unmanaged grasslands support a diverse fauna, including a large number of small mammals such as shrews, voles, and mice as well as birds and groundhogs (*Marmota monax*). Predators frequent these areas to prey upon the resident fauna. SWMUs 2, 10, 11, 12A, 14, 19, 27U, and 32 contain areas of unmanaged grassland.

8.2.1.6 Aquatic habitats

Aquatic environments are found throughout the FSMR and include streams, tributaries of the Canoochee River, and man-made ponds and basins. Aquatic environments characteristically contain gum trees and water oak, along with other common flora of the surrounding forest. Fauna consists of amphibians, reptiles, fish, aquatic invertebrates, and birds. Aquatic environments are present at SWMUs 2, 3, 10, 12A, 17, and 18. The equalization basin at SWMU 37 is not considered to be an aquatic habitat.

In addition to the above-mentioned aquatic habitat types, many of the OWSs contain ephemeral ponds with aquatic insects and other biota. Due to their isolation and small size (less than 0.1 hectare), ephemeral ponds at the OWSs are not considered to be aquatic habitats and have not been evaluated in the ecological risk evaluation.

Numerous SWMUs are located adjacent to shallow storm water drainage ditches that may contain ephemeral pools of water throughout various times of the year. Temporary pools in drainage ditches may serve as drinking holes for terrestrial animals and potentially as breeding locations for insects and amphibians. These shallow ditches are generally vegetated with grasses and are periodically mowed. In the ecological risk evaluation for the 16 SWMUs, sediment samples taken from drainage ditches at OWSs were evaluated as surface soil, and surface water samples were evaluated as a source of drinking water for terrestrial mammals only. Drainage ditches were not considered to be aquatic habitat in the ecological risk evaluation for the 16 SWMUs.

8.2.2 Surface Soil

The EPRE for surface soil (0 foot to 1 foot) and drainage ditch sediment at the 16 SWMUs evaluated the potential for risk to ecological receptors from ECOPCs. All analytes detected in surface soil and drainage ditch sediment are ECOPCs because there are no EPA Region IV ESVs for soil.

The categories of ecological receptors that are potentially directly exposed to substances in surface soil at the 16 SWMUs are soil bacteria and fungi, vegetation, and animals that come in direct contact with or ingest soil (e.g., soil-dwelling invertebrates). Other categories of receptors are potentially indirectly exposed to soil contaminants that are taken up and stored in the cells or tissues of those organisms that are directly exposed. Herbivorous invertebrates (e.g., insects) and vertebrates (e.g., birds and mammals) are potentially indirectly exposed when they ingest vegetation growing in contaminated soil. Carnivorous

animals are potentially exposed when they ingest animals directly or indirectly exposed to contaminated soil.

The proposed ecological receptors for the surface soil and drainage ditch sediment at the 16 SWMUs are carnivorous small mammals and birds that prey upon soil-dwelling invertebrates. These receptors are proposed because many of the substances detected in soil samples from one or more of the 16 SWMUs potentially biomagnify in soil-dwelling invertebrates (e.g., cadmium, lead, pesticides). In general, there are also greater amounts of published data on the effects of these substances on mammals and birds than there are for other vertebrate wildlife such as reptiles and amphibians.

The preliminary assessment endpoint for surface soil at the 16 SWMUs is protection of small mammals and bird populations from adverse effects. The surrogate species to represent the generic small mammal and bird receptors are the short-tailed shrew (*Blarina brevicauda*) and the American robin (*Turdus migratorius*). The home range of the shrew is small, and robins are territorial during the spring mating season. Earthworms and other soil-dwelling invertebrates represent a large percentage of both species' diets. The life history and behavior of these two surrogate species ensure a conservative estimate of risk.

8.2.3 Surface Water and Groundwater

The EPRE for the 16 SWMUs evaluated the potential for risk to ecological receptors from exposure to surface water or groundwater, which potentially emerges as surface water. For both surface water and groundwater, the same ecological receptor and surrogate species are used to evaluate the potential risk over the same exposure pathways.

The ecological receptors that are potentially directly exposed to substances in surface water or groundwater after it has emerged as surface water are aquatic plants and animals, terrestrial animals that come in direct contact with or ingest surface water, and those animals ingesting aquatic biota that live in the creeks. Amphibians potentially breed in standing water or natural wetlands. Other terrestrial animals potentially drink from creeks or wetland pools. Terrestrial predators of aquatic biota, such as fish-eating birds and mammals, are also likely to be indirectly exposed to contaminants in surface water, and potentially groundwater, through ingestion of aquatic prey. The types of ecological receptors exposed to surface water vary by location. Some SWMUs do not have aquatic habitat and thus do not have aquatic biota. Surface water at these SWMUs is a source of exposure to only those terrestrial animals that come in direct contact with or ingest surface water.

Based on the ECOPCs, the habitat, and the potential exposure pathways at the 16 SWMUs, the proposed ecological receptors for surface water and groundwater are aquatic biota, such as fish and amphibians, and terrestrial animals. Aquatic biota are directly exposed to ECOPCs in surface water. Terrestrial animals are potentially exposed by ingestion of surface water and of aquatic biota that have bioaccumulated substances in their tissues.

The preliminary assessment endpoints for surface water and groundwater at the 16 SWMUs are protection of:

- aquatic biota,
- terrestrial mammal populations from adverse effects from drinking surface water, and

- fish-eating mammals and bird populations from adverse effects from ingesting fish and other aquatic biota.

The aquatic biota assessment endpoint was not evaluated further in the EPRE. No additional evaluation of this assessment endpoint was included because EPA Region IV ESVs for surface water are the only reasonable published values that might serve as surface water TRVs, and there are no additional adjustments to exposure for aquatic biota. The results of the ESV comparison for surface water and groundwater, therefore, identify the ECOPCs for aquatic biota at the 16 SWMUs.

The surrogate species to represent the terrestrial ecological receptors exposed to surface water and groundwater are the raccoon (*Procyon lotor*), the mink (*Mustela vison*), and the green heron (*Butorides striatus*). These species are potentially found at Fort Stewart (GEPD 1997c) and potentially obtain food from creeks and other aquatic habitats. The raccoon is common to the coastal plain of Georgia. Raccoons drink water from shallow surface water bodies and ingest more water per unit body weight than do larger mammals such as the white-tailed deer (*Odocoileus virginianus*): 0.082 gram per gram per day (EPA 1993) versus 0.065 gram per gram per day (Sample and Suter 1994). Mink and herons ingest fish and other aquatic biota living in streams. Thus, the life history and behavior of these species ensure a conservative estimate of risk in accordance with GEPD (1996) and EPA (1997a) guidance.

8.2.4 Sediment

The potential for risk to ecological receptors from exposure to ECOPCs in sediment at the 16 SWMUs was evaluated at several SWMUs with aquatic habitat. The ecological receptors that are potentially exposed to ECOPCs in sediment at the 16 SWMUs are sediment-dwelling biota and terrestrial animals that come in contact with sediment or ingest sediment-dwelling biota living in creek sediments.

Based on the ECOPCs in sediment, the habitat, and the potential exposure pathways, the proposed ecological receptors for sediment are sediment-dwelling biota and terrestrial animals that prey upon sediment-dwelling invertebrates.

The preliminary assessment endpoints for sediment at the 16 SWMUs are protection of:

- sediment-dwelling biota and
- terrestrial animal populations from adverse effects from ingesting sediment-dwelling invertebrates.

The assessment endpoint for sediment-dwelling biota was not evaluated further in the EPRE. No additional evaluation of this assessment endpoint was included because EPA Region IV ESVs for sediment are the only reasonable published values that might serve as sediment TRVs, and there are no additional adjustments to exposure for sediment-dwelling invertebrates. The results of the ESV comparison for sediment, therefore, identify the ECOPCs for sediment-dwelling invertebrates at the 16 SWMUs.

The surrogate species to represent the terrestrial animals exposed to ECOPCs in sediment is the green heron. The green heron is potentially found at Fort Stewart (GEPD 1997c) and potentially uses creeks and ponds as sources of food. Herons ingest biota living in stream sediments. Thus, the life history and behavior of the heron ensure a conservative estimate of risk in accordance with GEPD (1996) and EPA (1997a) guidance.

8.3 PRELIMINARY ECOLOGICAL EFFECTS EVALUATION (Step iii)

The preliminary ecological effects evaluation (Step iii) identifies TRVs for use in the preliminary risk calculation (Step v). As described below, TRVs are derived from no observed adverse effect levels (NOAELs) from laboratory toxicity studies on test species. In the EPRE for the 16 SWMUs, TRVs were required for shrews and robins ingesting contaminated biota exposed to surface soil at the 16 SWMUs, raccoons ingesting contaminated water from drainage ditches, and fish-eating mammals (mink) and wading birds (green herons) ingesting contaminated biota exposed to surface water and sediment in creeks and ponds. The derivation of TRVs for the surrogate species is described below.

First, chronic NOAELs for test species were derived from published chronic or subchronic NOAEL or lowest observed adverse effect level (LOAEL) benchmarks for the test species exposed to the substance in controlled laboratory studies. The derivations of NOAELs for mammals and birds are shown in Tables 8-3 and 8-4, respectively. If a chronic NOAEL was not available for a contaminant, a chronic NOAEL was estimated from a subchronic NOAEL by dividing by an uncertainty factor of 10 (Sample, Opresko, and Suter 1996). Published LOAELs might be used to derive a NOAEL by dividing the LOAEL by a conservative uncertainty factor of 10 (EPA 1996d). Subchronic LOAELs were divided by an uncertainty factor of 100 to estimate a chronic NOAEL.

Most NOAELs and LOAELs for test species were those reported in Sample, Opresko, and Suter (1996). Some NOAELs were found in published toxicity studies or other risk assessments. In some cases, if neither a NOAEL or LOAEL was available for a contaminant, the benchmark for a related compound was used as a surrogate. The chronic NOAELs for PAHs for birds were derived from Shortelle et al. (1997), as cited in QST (1997).

The estimated bird NOAEL for pyrene reported in QST (1997) was used as the chronic NOAEL for the test species. Shortelle et al. (1997), as cited in QST (1997), used linear regression of NOAELs for chemicals for which there are benchmark values for both mammals and birds published in Opresko, Sample, and Suter (1995) to predict the bird NOAEL for SVOCs for which there were mammal data but no bird data. These predicted NOAELs are for a "composite" bird with a body weight equal to the average of all bird test species for the NOAELs used in the regression. These estimated bird NOAELs were used in ERAs for operable units at Fort Sheridan, Illinois (QST 1997; SAIC 1998c).

Once the published and estimated NOAELs for test species were identified or derived as described above, they were used to derive NOAELs for the 16 SWMUs surrogate species, as described below, and these derived NOAELs were used as the TRVs in the EPRE.

Chronic NOAELs for test species of the same taxonomic class as the surrogate species were adjusted for the body weight of the surrogate species to derive TRVs for the surrogate species. That is, mammal test species data were used for mammal surrogate species, and bird test species data were used for bird surrogate species. NOAELs for test species based on ADDs (milligrams per kilograms per day) were adjusted to the surrogate species based on body weight, according to the following equation:

$$\text{surrogate species NOAEL} = \text{test species NOAEL} \times (bw_{ts}/bw_{ss})^z,$$

where bw_{ts} and bw_{ss} are the body weights (kilograms) of the test species and surrogate species, respectively, and where $z = 0.25$ for mammals and $z = 0$ for birds (Sample, Opresko, and Suter 1996). For example, the published NOAEL for a chemical might be based on data for a 0.35-kilogram rat. The NOAEL for a 0.022-kilogram field mouse would be nearly two times larger than the rat NOAEL. The calculated NOAELs for the surrogate species were the TRVs used in the EPRE.

Table 8-3. Derivation of NOAELs for Mammal Test Species

Ecological Constituent of Potential Concern	Test Species	Test Species Body Weight (kg) BW_t	Benchmark (mg/kgBW/d)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor (DCF)	Endpoint Conversion Factor (ECF)	NOAEL (mg/kgBW/d) Benchmark x DCF x ECF
INORGANICS										
Aluminum	Mouse	3.00E-02	1.93E+01	Chronic	LOAEL	Reproduction	Ondreicka et al. (1966) in [1]	1.0	0.1	1.93E-00
Antimony	Mouse	3.00E-02	1.25E-00	Chronic	LOAEL	Longevity	Schroeder et al. (1968b) in [1]	1.0	0.1	1.25E-01
Arsenic	Mouse	3.00E-02	1.26E-00	Chronic	LOAEL	Reproduction	Schroeder and Mitchner (1971) in [1]	1.0	0.1	1.26E-01
Barium	Rat	4.35E-01	5.06E-00	Chronic	NOAEL	Growth	Perry et al. (1983) in [1]	1.0	1.0	5.06E-00
Beryllium	Rat	3.50E-01	6.60E-01	Chronic	NOAEL	Longevity	Schroeder and Mitchner (1975) in [1]	1.0	1.0	6.60E-01
Cadmium	Rat	3.03E-01	1.00E-00	Chronic	NOAEL	Reproduction	Sutou et al. (1980b) in [1]	1.0	1.0	1.00E-00
Calcium	None	None	None	None	None	None	None	None	None	No NOAEL
Chromium	Rat	3.50E-01	2.74E+03	Chronic	NOAEL	Reproduction	Ivankovic and Preussmann (1975) in [1]	1.0	1.0	2.74E+03
Cobalt	Rat	3.50E-01	1.00E-00	Chronic	NOAEL	Mortality	Underhill et al. (1931) in [2]	1.0	1.0	1.00E-00
Copper	Mink	1.00E-00	1.17E+01	Chronic	NOAEL	Reproduction	Aulerich et al. (1982) in [1]	1.0	1.0	1.17E+01
Iron	None	None	None	None	None	None	None	None	None	No NOAEL
Lead[a]	Rat	3.50E-01	8.00E-00	Chronic	NOAEL	Reproduction	Azar et al. (1973) in [1]	1.0	1.0	8.00E-00
Magnesium	None	None	None	None	None	None	None	None	None	No NOAEL
Manganese	Rat	3.50E-01	8.80E+01	Chronic	NOAEL	Reproduction	Laskey et al. (1982) in [1]	1.0	1.0	8.80E+01
Mercury	Mink	1.00E-00	1.01E-00	Chronic	NOAEL	Reproduction	Aulerich et al. (1974) in [1]	1.0	1.0	1.01E-00
Nickel	Rat	3.50E-01	4.00E+01	Chronic	NOAEL	Reproduction	Ambrose et al. (1976) in [1]	1.0	1.0	4.00E+01
Potassium	None	None	None	None	None	None	None	None	None	No NOAEL
Selenium	Rat	3.50E-01	2.00E-01	Chronic	NOAEL	Reproduction	Rosenfeld and Beath (1954) in [1]	1.0	1.0	2.00E-01
Silver	Rat	3.50E-01	1.01E+02	Chronic	NOAEL	None	Walker (1971) in [4]	1.0	1.0	1.01E+02
Sodium	None	None	None	None	None	None	None	None	None	No NOAEL
Vanadium	Rat	2.60E-01	2.10E-00	Chronic	LOAEL	Reproduction	Domingo et al. (1986) in [1]	1.0	0.1	2.10E-01
Zinc	Rat	3.50E-01	1.60E+02	Chronic	NOAEL	Reproduction	Schlicker and Cox (1968) in [1]	1.0	1.0	1.60E+02
ORGANICS										
Volatile Organic Compounds										
Acetone	Rat	3.50E-01	1.00E+02	Subchronic	NOAEL	Reproduction	EPA (1986c) in [1]	0.1	1.0	1.00E+01
Benzene	Mouse	3.00E-02	2.64E+02	Chronic	LOAEL	Reproduction	Nawrot and Staples (1979) in [1]	1.0	0.1	2.64E+01
Bromodichloromethane	Mouse	3.00E-02	1.79E+01	Chronic	LOAEL	Gavage	NTP (1986) in [3]	1.0	0.1	1.79E-00
Bromoform	Rat	3.50E-01	1.79E+01	Subchronic	NOAEL	Hepatic lesions	NTP 1989 [3]	0.1	1.0	1.79E-00
Bromomethane	None	None	None	None	None	None	None	None	None	No NOAEL
Carbon disulfide	Rat	3.50E-01	1.10E+01	Chronic	NOAEL	Fetal toxicity	Hardin et al. (1981) in [3]	1.0	1.0	1.10E+01
Carbon tetrachloride	Rat	3.50E-01	1.60E+01	Chronic	NOAEL	Reproduction	Alumot et al. 1976a in [1]	1.0	1.0	1.60E+01
Chlorobenzene	Rat	3.50E-01	5.00E+01	Chronic	NOAEL	Increase liver/ kidney	Knapp et al. 1971 [3]	1.0	1.0	5.00E+01

Note: Footnotes appear on page 8-19.

Table 8-3. Derivation of NOAELs for Mammal Test Species (continued)

Ecological Constituent of Potential Concern	Test Species	Test Species Body Weight (kg) BW_t	Benchmark (mg/kgBW/d)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor (DCF)	Endpoint Conversion Factor (ECF)	NOAEL (mg/kgBW/d) Benchmark x DCF x ECF
Chloroethane	None	None	None	None	None	None	None	None	None	No NOAEL
Chloroform	Rat	3.50E-01	1.50E+02	Subchronic	NOAEL	Gonad atrophy	Palmer et al. (1979) in [1]	0.1	1.0	1.50E+01
Chloromethane	None	None	None	None	None	None	None	None	None	No NOAEL
Dibromochloromethane	Rat	3.50E-01	2.14E+01	Subchronic	NOAEL	Hepatic lesions	NTP (1985) in [3]	0.1	1.0	2.14E-00
1,1-Dichloroethane	None	None	None	None	None	None	None	None	None	No NOAEL
1,1-Dichloroethene	Rat	3.50E-01	3.00E+01	Chronic	NOAEL	Mortality	Quast et al. (1983) in [1]	1.0	1.0	3.00E+01
1,2-Dichloroethane	Mouse	3.50E-02	5.00E+01	Chronic	NOAEL	Reproduction	Lane et al. (1982) in [1]	1.0	1.0	5.00E+01
1,2-Dichloroethene	Mouse	3.00E-02	4.52E+02	Subchronic	NOAEL	Blood chemistry	Palmer et al. (1979) in [1]	0.1	1.0	4.52E+01
1,3-Dichloropropene	Rats	3.50E-01	3.00E-00	Subchronic	NOAEL	Increase in organ weight	Dow Chemical 1973 [3]	0.1	1.0	3.00E-01
Ethylbenzene	Rat	3.50E-01	9.71E+01	None	NOAEL	None	Wolfe et al. (1956) in [3]	0.1	1.0	9.71E-00
Methylene chloride	Rat	3.50E-01	5.85E-00	Chronic	NOAEL	Liver histology	NCA (1982) in [1]	1.0	1.0	5.85E-00
Methyl ethyl ketone	Rat	3.50E-01	1.77E+03	Chronic	NOAEL	Reproduction	Cox et al. (1975) in [1]	1.0	1.0	1.77E+03
4-Methyl-2-pentanone	Rat	3.50E-01	2.50E+02	Subchronic	NOAEL	Liver/kidney	Microbiological Associates (1986) in [1]	0.1	1.0	2.50E+01
Styrene	Dog	1.00E+01	2.00E+02	Chronic	NOAEL	Unknown	Quast et al. (1979)	1.0	1.0	2.00E+02
Tetrachloroethene	Mouse	3.00E-02	1.40E+01	Subchronic	NOAEL	Hepatotoxicity	Buben and O'Flaherty (1985) in [1]	0.1	1.0	1.40E-00
1,1,2,2-Tetrachloroethane	None	None	None	None	None	None	None	None	None	No NOAEL
Toluene	Mouse	3.00E-02	2.60E+02	Chronic	LOAEL	Reproduction	Nawrot and Staples (1979) in [1]	1.0	0.1	2.60E+01
1,1,1-Trichloroethane	Mouse	3.50E-02	1.00E+03	Chronic	NOAEL	Reproduction	Lane et al. (1982) in [1]	1.0	1.0	1.00E+03
1,1,2-Trichloroethane	Mouse	3.50E-02	3.90E-00	Subchronic	NOAEL	Clinical serum chemistry	White et al. 1985 and Sanders et al. 1985 [3]	0.1	1.0	3.90E-01
Trichloroethene	Mouse	3.00E-02	7.00E+01	Subchronic	LOAEL	Hepatotoxicity	Buben and O'Flaherty (1985) in [1]	0.1	0.1	7.00E-01
Vinyl chloride	Rat	3.50E-01	1.70E-00	Chronic	LOAEL	Mortality	Feron et al. (1981) in [1]	1.0	0.1	1.70E-01
Xylenes, total	Mouse	3.00E-02	2.06E-00	Chronic	NOAEL	Reproduction	Marks et al. (1982) in [1]	1.0	1.0	2.06E-00
Semivolatile Organic Compounds										
Acenaphthene	Mouse	3.00E-02	1.75E+02	Chronic	NOAEL	None	ATSDR (1997) in [4]	1.0	1.0	1.75E+02
Benzo(*a*)anthracene	Mouse	3.00E-02	1.33E+01	Chronic	NOAEL	None	Neal and Rigdon (1967) in [4]	1.0	1.0	1.33E+01
Benzo(*a*)pyrene	Mouse	3.00E-02	1.00E+01	Chronic	LOAEL	Reproduction	Mackenzie and Angevine (1981) in [1]	1.0	0.1	1.00E-00
Benzo(*b*)fluoranthene	Mouse	3.00E-02	1.33E+01	Chronic	NOAEL	None	Neal and Rigdon (1967) in [4]	1.0	1.0	1.33E+01
Benzo(*g,h,i*)perylene	Mouse	3.00E-02	1.33E+01	Chronic	NOAEL	None	Neal and Rigdon (1967) in [4]	1.0	1.0	1.33E+01
Benzo(*k*)fluoranthene	Mouse	3.00E-02	1.00E+01	Chronic	LOAEL	Reproduction	Opresko (1995) in [4]	1.0	0.1	1.00E-00
Bis(2-ethylhexyl)phthalate	Mouse	3.00E-02	1.83E+01	Chronic	NOAEL	Reproduction	Lamb et al. (1987) in [1]	1.0	1.0	1.83E+01
Chlorobenzene	None	None	None	None	None	None	None	None	None	No NOAEL
Chrysene	Mouse	3.00E-02	1.33E+01	Chronic	NOAEL	None	Neal and Rigdon (1967) in [4]	1.0	1.0	1.33E+01
Dibenzofuran	None	None	None	None	None	None	None	None	None	No NOAEL

Note: Footnotes appear on page 8-19.

Table 8-3. Derivation of NOAELs for Mammal Test Species (continued)

Ecological Constituent of Potential Concern	Test Species	Test Species Body Weight (kg) BW_t	Benchmark (mg/kgBW/d)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor (DCF)	Endpoint Conversion Factor (ECF)	NOAEL (mg/kgBW/d) Benchmark × DCF × ECF
1,2-Dichlorobenzene	Rat	3.50E-01	1.20E+02	Chronic	NOAEL	Gavage	IRIS (EPA 1997b)	1.0	1.0	1.20E+02
2,4-Dimethylphenol	None	None	None	None	None	None	None	None	None	No NOAEL
Di-*N*-butylphthalate	Mouse	3.00E-02	5.50E+02	Chronic	NOAEL	Reproduction	Lamb et al. (1987) in [1]	1.0	1.0	5.50E+02
Di-*N*-octylphthalate	None	None	None	None	None	None	None	None	None	No NOAEL
Fluoranthene	Mouse	3.00E-02	5.00E+02	Chronic	LOAEL	None	ATSDR (1997) in [4]	1.0	0.1	5.00E+01
2-Hexanone	None	None	None	None	None	None	None	None	None	No NOAEL
Indeno(*1,2,3-cd*)pyrene	Mouse	3.00E-02	1.33E+01	Chronic	NOAEL	None	Neal and Rigdon (1967) in [4]	1.0	1.0	1.33E+01
2-Methylnaphthalene	Rat	3.50E-01	5.00E+01	Chronic	LOAEL	None	ATSDR (1997) in [4]	1.0	0.1	5.00E-00
4-Chloro-3-methylphenol	None	None	None	None	None	None	None	None	None	No NOAEL
Naphthalene	Rat	3.50E-01	5.00E+01	Chronic	LOAEL	None	ATSDR (1997) in [4]	1.0	0.1	5.00E-00
N-Nitrosodiphenylamine	None	None	None	None	None	None	None	None	None	No NOAEL
Phenanthrene	Mouse	3.00E-02	1.00E+01	Chronic	LOAEL	Reproduction	Opresko (1995) in [4]	1.0	0.1	1.00E-00
Phenol	Rat	3.50E-01	6.00E+01	Subchronic	NOAEL	Developmental	NTP (1983) in [3]	0.1	1.0	6.00E-00
Pyrene	Mouse	3.00E-02	1.00E+01	Chronic	LOAEL	Reproduction	Opresko (1995) in [4]	1.0	0.1	1.00E-00
Pesticides/PCBs										
Aldrin	Rat	3.50E-01	2.00E-01	Chronic	NOAEL	Reproduction	EPA (1988a) in [1]	1.0	1.0	2.00E-01
alpha-BHC	Rat	3.50E-01	1.60E-00	Chronic	NOAEL	Reproduction	Grant et al. (1977) in [1]	1.0	1.0	1.60E-00
beta-BHC	Rat	3.50E-01	4.00E-00	Subchronic	NOAEL	Organ histology	Van Velsen et al. (1986) in [1]	0.1	1.0	4.00E-01
delta-BHC	Rat	3.50E-01	1.60E-00	Chronic	NOAEL	Reproduction	[alpha-BHC surrogate]	1.0	1.0	1.60E-00
gamma-BHC (Lindane)	Rat	3.50E-01	8.00E-00	Chronic	NOAEL	Reproduction	Palmer et al. (1978) in [1]	1.0	1.0	8.00E-00
alpha-Chlordane	Mouse	3.00E-02	4.58E-00	Chronic	NOAEL	Reproduction	[Chlordane surrogate]	1.0	1.0	4.58E-00
gamma-Chlordane	Mouse	3.00E-02	4.58E-00	Chronic	NOAEL	Reproduction	[Chlordane surrogate]	1.0	1.0	4.58E-00
4,4'-DDD	Rat	3.50E-01	8.00E-01	Chronic	NOAEL	Reproduction	Fitzhugh (1948) in [1]	1.0	1.0	8.00E-01
4,4'-DDE	Rat	3.50E-01	8.00E-01	Chronic	NOAEL	Reproduction	Fitzhugh (1948) in [1]	1.0	1.0	8.00E-01
4,4'-DDT	Rat	3.50E-01	8.00E-01	Chronic	NOAEL	Reproduction	Fitzhugh (1948) in [1]	1.0	1.0	8.00E-01
Dieldrin	Rat	3.50E-01	2.00E-01	Chronic	LOAEL	Reproduction	Treon and Cleveland (1955) in [1]	1.0	0.1	2.00E-02
Endosulfan II	Rat	3.50E-01	1.50E-00	Subchronic	NOAEL	Reproduction	[Endosulfan surrogate]	0.1	1.0	1.50E-01
Endosulfan sulfate	Rat	3.50E-01	1.50E-00	Subchronic	NOAEL	Reproduction	[Endosulfan surrogate]	0.1	1.0	1.50E-01
Endrin ketone	Mouse	3.00E-02	9.20E-01	Chronic	LOAEL	Reproduction	[Endrin surrogate]	1.0	0.1	9.20E-02
Heptachlor	Mink	1.00E-00	1.00E-00	Chronic	LOAEL	Reproduction	Crum et al. (1993) in [1]	1.0	0.1	1.00E-01
Heptachlor epoxide	Mink	1.00E-00	1.00E-00	Chronic	LOAEL	Reproduction	[Heptachlor surrogate]	1.0	0.1	1.00E-01
Methoxychlor	Rat	3.50E-01	4.00E-00	Chronic	NOAEL	Reproduction	Gray et al. (1988) in [1]	1.0	1.0	4.00E-00

Note: Footnotes appear on page 8-19.

Table 8-3. Derivation of NOAELs for Mammal Test Species (continued)

Ecological Constituent of Potential Concern	Test Species	Test Species Body Weight (kg) BW_t	Benchmark (mg/kgBW/d)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor (DCF)	Endpoint Conversion Factor (ECF)	NOAEL (mg/kgBW/d) Benchmark x DCF x ECF
Explosives										
2,4-Dinitrotoluene	Mouse	3.00E-02	1.35E+01	Chronic	NOAEL	Reproduction	Ellis et al. (1979)	1.0	1.0	1.35E+01
2,6-Dinitrotoluene	Rat	3.50E-01	7.00E-00	Subchronic	NOAEL	Reproduction	ATSDR (1989)	0.1	1.0	7.00E-01
2,4,6-Trinitrotoluene	Rat	3.50E-01	1.60E+02	Subchronic	LOAEL	Reproduction	Dilley et al. (1982)	0.1	0.1	1.60E-00
HMX	None	None	None	None	None	None	None	None	None	No NOAEL
RDX	None	None	None	None	None	None	None	None	None	No NOAEL

[a] = Lead acetate.
ATSDR = Agency for Toxic Substances and Disease Registry.
DCF = 1 if chronic, 0.1 if subchronic (Sample, Opresko, and Suter 1996).
ECF = 1 if NOAEL, 0.1 if LOAEL (Sample, Opresko, and Suter 1996).
IRIS = Integrated Risk Information System.
[1] = Sample, Opresko, and Suter (1996).
[2] = Clayton and Clayton (1981).
[3] = IRIS (EPA 1997b).
[4] = QST (1997); all values assumed to be chronic.

Table 8-4. Derivation of NOAELs for Bird Test Species

Ecological Constituent of Potential Concern	Test Species	Test Species Body Weight (kg) BW_t	Benchmark (mg/kgBW/d)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor (DCF)	Endpoint Conversion Factor (ECF)	NOAEL (mg/kgBW/d) Benchmark × DCF × ECF
INORGANICS										
Aluminum	Ringed dove	1.55E-01	1.10E+02	Chronic	NOAEL	Reproduction	Carriere et al. (1986) in [1]	1.0	1.0	1.10E+02
Antimony	Composite bird	8.50E-01	3.57E-01	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	3.57E-01
Arsenic	Mallard duck	1.00E+00	5.14E+00	Chronic	NOAEL	Mortality	USFWS (1979) in [1]	1.0	1.0	5.14E+00
Barium	Chick (14 days old)	1.21E-01	2.08E+02	Subchronic	NOAEL	Mortality	Johnson et al. (1960) in [1]	0.1	1.0	2.08E+01
Beryllium	Composite bird	8.50E-01	1.67E+00	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	1.67E+00
Cadmium	Mallard duck	1.15E+00	1.45E+00	Chronic	NOAEL	Reproduction	White and Finley (1978) in [1]	1.0	1.0	1.45E+00
Calcium	None	None	None	None	None	None	None	None	None	No NOAEL
Chromium	Black duck	1.25E+00	1.00E+00	Chronic	NOAEL	Reproduction	Haseltine et al. (unpubl.) in [1]	1.0	1.0	1.00E+00
Cobalt	None	None	None	None	None	None	None	None	None	No NOAEL
Copper	Chick (5 weeks old)	5.34E-01	4.70E+01	Chronic	NOAEL	Mortality	Mehring et al. (1960) in [1]	1.0	1.0	4.70E+01
Iron	None	None	None	None	None	None	None	None	None	No NOAEL
Lead[a]	Quail	1.50E-01	1.13E+00	Chronic	NOAEL	Reproduction	Edens et al. (1976) in [1]	1.0	1.0	1.13E+00
Magnesium	None	None	None	None	None	None	None	None	None	No NOAEL
Manganese	Quail	7.20E-02	9.77E+02	Chronic	NOAEL	Growth	Laskey and Edens (1985) in [1]	1.0	1.0	9.77E+02
Mercury	Quail	1.50E-01	4.50E-01	Chronic	NOAEL	Reproduction	Hill and Schaffner (1976) in [1]	1.0	1.0	4.50E-01
Nickel	Mallard duckling	7.82E-01	7.74E+01	Chronic	NOAEL	Growth	Cain and Pafford (1981) in [1]	1.0	1.0	7.74E+01
Potassium	None	None	None	None	None	None	None	None	None	No NOAEL
Selenium	Mallard duck	1.00E+00	5.00E-01	Chronic	NOAEL	Reproduction	Heinz et al. (1989) in [1]	1.0	1.0	5.00E-01
Silver	Composite bird	8.50E-01	5.79E+01	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	5.79E+01
Sodium	None	None	None	None	None	None	None	None	None	No NOAEL
Vanadium	Mallard duck	1.17E+00	1.14E+01	Chronic	NOAEL	Mortality	White and Dieter (1978) in [1]	1.0	1.0	1.14E+01
Zinc	Leghorn chicken	1.94E+00	1.45E+01	Chronic	NOAEL	Reproduction	Stahl et al. (1990) in [1]	1.0	1.0	1.45E+01
ORGANICS										
Volatile Organic Compounds										
Acetone	None	None	None	None	None	None	None	None	None	No NOAEL
Benzene	None	None	None	None	None	None	None	None	None	No NOAEL
Bromodichloromethane	None	None	None	None	None	None	None	None	None	No NOAEL
Bromoform	None	None	None	None	None	None	None	None	None	No NOAEL
Bromomethane	None	None	None	None	None	None	None	None	None	No NOAEL
Carbon disulfide	None	None	None	None	None	None	None	None	None	No NOAEL
Carbon tetrachloride	None	None	None	None	None	None	None	None	None	No NOAEL
Chlorobenzene	None	None	None	None	None	None	None	None	None	No NOAEL
Chloroethane	None	None	None	None	None	None	None	None	None	No NOAEL
Chloroform	None	None	None	None	None	None	None	None	None	No NOAEL

Note: Footnotes appear on page 8-23.

Table 8-4. Derivation of NOAELs for Bird Test Species (continued)

Ecological Constituent of Potential Concern	Test Species	Test Species Body Weight (kg) BW_t	Benchmark (mg/kgBW/d)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor (DCF)	Endpoint Conversion Factor (ECF)	NOAEL (mg/kgBW/d) Benchmark × DCF × ECF
Chloromethane	None	None	None	None	None	None	None	None	None	No NOAEL
Dibromochloromethane	None	None	None	None	None	None	None	None	None	No NOAEL
1,1-Dichloroethane	None	None	None	None	None	None	None	None	None	No NOAEL
1,1-Dichloroethene	None	None	None	None	None	None	None	None	None	No NOAEL
1,2-Dichloroethane	Chicken	1.60E+00	1.72E+01	Chronic	NOAEL	Reproduction	Alumot et al. (1976b) in [1]	1.0	1.0	1.72E+01
1,2-Dichloroethene	None	None	None	None	None	None	None	None	None	No NOAEL
1,3-Dichloropropene	None	None	None	None	None	None	None	None	None	No NOAEL
Ethylbenzene	None	None	None	None	None	None	None	None	None	No NOAEL
Methylene chloride	None	None	None	None	None	None	None	None	None	No NOAEL
Methyl ethyl ketone	None	None	None	None	None	None	None	None	None	No NOAEL
4-Methyl-2-pentanone	None	None	None	None	None	None	None	None	None	No NOAEL
Styrene	None	None	None	None	None	None	None	None	None	No NOAEL
Tetrachloroethene	None	None	None	None	None	None	None	None	None	No NOAEL
1,1,2,2-Tetrachloroethane	None	None	None	None	None	None	None	None	None	No NOAEL
Toluene	None	None	None	None	None	None	None	None	None	No NOAEL
1,1,1-Trichloroethane	None	None	None	None	None	None	None	None	None	No NOAEL
1,1,2-Trichloroethane	None	None	None	None	None	None	None	None	None	No NOAEL
Trichloroethene	None	None	None	None	None	None	None	None	None	No NOAEL
Vinyl chloride	None	None	None	None	None	None	None	None	None	No NOAEL
Xylenes, total	None	None	None	None	None	None	None	None	None	No NOAEL
Semivolatile Organic Compounds										
Acenaphthene	Composite bird	8.50E-01	8.78E+01	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	8.78E+01
Benzo(*a*)anthracene	Composite bird	8.50E-01	1.24E+01	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	1.24E+01
Benzo(*a*)pyrene	Composite bird	8.50E-01	9.97E+00	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	9.97E+00
Benzo(*b*)fluoranthene	Composite bird	8.50E-01	1.24E+01	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	1.24E+01
Benzo(*g,h,i*)perylene	Composite bird	8.50E-01	1.24E+01	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	1.24E+01
Benzo(*k*)fluoranthene	Composite bird	8.50E-01	9.97E+00	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	9.97E+00
Bis(2-ethylhexyl)phthalate	Ringed dove	1.55E-01	1.10E+00	Chronic	NOAEL	Reproduction	Peakall (1974) in [1]	1.0	1.0	1.10E+00
Chlorobenzene	None	None	None	None	None	None	None	None	None	No NOAEL
Chrysene	Composite bird	8.50E-01	1.24E+01	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	1.24E+01
Dibenzofuran	None	None	None	None	None	None	None	None	None	No NOAEL
1,2-Dichlorobenzene	None	None	None	None	None	None	None	None	None	No NOAEL
2,4-Dimethylphenol	None	None	None	None	None	None	None	None	None	No NOAEL
Di-*N*-butylphthalate	Ringed dove	1.55E-01	1.11E+00	Chronic	LOAEL	Reproduction	Peakall (1974) in [1]	1.0	0.1	1.11E-01

Note: Footnotes appear on page 8-23.

Table 8-4. Derivation of NOAELs for Bird Test Species (continued)

Ecological Constituent of Potential Concern	Test Species	Test Species Body Weight (kg) BW_t	Benchmark (mg/kgBW/d)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor (DCF)	Endpoint Conversion Factor (ECF)	NOAEL (mg/kgBW/d) Benchmark × DCF × ECF
Di-*N*-octylphthalate	None	None	None	None	None	None	None	None	None	No NOAEL
Fluoranthene	Composite bird	8.50E-01	1.95E+02	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	1.95E+02
2-Hexanone	None	None	None	None	None	None	None	None	None	No NOAEL
Indeno(*1,2,3-cd*)pyrene	Composite bird	8.50E-01	1.24E+01	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	1.24E+01
2-Methylnaphthalene	Composite bird	8.50E-01	3.39E+01	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	3.39E+01
4-Chloro-3-methylphenol	None	None	None	None	None	None	None	None	None	No NOAEL
Naphthalene	Composite bird	8.50E-01	3.39E+01	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	3.39E+01
N-Nitrosodiphenylamine	None	None	None	None	None	None	None	None	None	No NOAEL
Phenanthrene	Composite bird	8.50E-01	9.97E+00	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	9.97E+00
Phenol	None	None	None	None	None	None	None	None	None	No NOAEL
Pyrene	Composite bird	8.50E-01	9.97E+00	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	9.97E+00
Pesticides/PCBs										
Aldrin	Composite bird	8.50E-01	1.73E+00	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	1.73E+00
alpha-BHC	Japanese quail	1.50E-01	5.63E-01	Chronic	NOAEL	Reproduction	Vos et al. (1971) in [1]	1.0	1.0	5.63E-01
beta-BHC	Japanese quail	1.50E-01	5.63E-01	Chronic	NOAEL	Reproduction	[alpha-BHC surrogate]	1.0	1.0	5.63E-01
delta-BHC	Japanese quail	1.50E-01	5.63E-01	Chronic	NOAEL	Reproduction	[alpha-BHC surrogate]	1.0	1.0	5.63E-01
gamma-BHC (Lindane)	Mallard duck	1.00E+00	2.00E+00	Chronic	NOAEL	Reproduction	Chakravarty et al. (1986) in [1]	1.0	1.0	2.00E+00
alpha-Chlordane	Red-winged blackbird	6.40E-02	2.14E+00	Chronic	NOAEL	Mortality	[Chlordane surrogate]	1.0	1.0	2.14E+00
gamma-Chlordane	Red-winged blackbird	6.40E-02	2.14E+00	Chronic	NOAEL	Mortality	[Chlordane surrogate]	1.0	1.0	2.14E+00
4,4'-DDD	Brown pelican	3.50E+00	2.80E-02	Chronic	LOAEL	Reproduction	Anderson et al. (1975) in [1]	1.0	0.1	2.80E-03
4,4'-DDE	Brown pelican	3.50E+00	2.80E-02	Chronic	LOAEL	Reproduction	Anderson et al. (1975) in [1]	1.0	0.1	2.80E-03
4,4'-DDT	Brown pelican	3.50E+00	2.80E-02	Chronic	LOAEL	Reproduction	Anderson et al. (1975) in [1]	1.0	0.1	2.80E-03
Dieldrin	Barn owl	4.66E-01	7.70E-02	Chronic	NOAEL	Reproduction	Mendenhall et al. (1983) in [1]	1.0	1.0	7.70E-02
Endosulfan II	Gray partridge	4.00E-01	1.00E+01	Chronic	NOAEL	Reproduction	[Endosulfan surrogate]	1.0	1.0	1.00E+01
Endosulfan sulfate	Gray partridge	4.00E-01	1.00E+01	Chronic	NOAEL	Reproduction	[Endosulfan surrogate]	1.0	1.0	1.00E+01
Endrin ketone	Screech owl	1.81E-02	1.04E-01	Chronic	LOAEL	Reproduction	[Endrin surrogate]	1.0	0.1	1.04E-02
Heptachlor	None	None	None	None	None	None	None	None	None	No NOAEL
Heptachlor epoxide	None	None	None	None	None	None	None	None	None	No NOAEL
Methoxychlor	Composite bird	8.50E-01	8.42E+00	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	8.42E+00

Note: Footnotes appear on page 8-23.

Table 8-4. Derivation of NOAELs for Bird Test Species (continued)

Ecological Constituent of Potential Concern	Test Species	Test Species Body Weight (kg) BW_t	Benchmark (mg/kgBW/d)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor (DCF)	Endpoint Conversion Factor (ECF)	NOAEL (mg/kgBW/d) Benchmark × DCF × ECF
Explosives										
2,4-Dinitrotoluene	None	None	None	None	None	None	None	None	None	No NOAEL
2,6-Dinitrotoluene	None	None	None	None	None	None	None	None	None	No NOAEL
2,4,6-Trinitrotoluene	None	None	None	None	None	None	None	None	None	No NOAEL
HMX	None	None	None	None	None	None	None	None	None	No NOAEL
RDX	None	None	None	None	None	None	None	None	None	No NOAEL

[a] = Lead acetate.
DCF = 1 if chronic, 0.1 if subchronic (Sample, Opresko, and Suter 1996).
ECF = 1 if NOAEL, 0.1 if LOAEL (Sample, Opresko, and Suter 1996).
[1] = Sample, Opresko, and Suter 1996.
[2] = QST (1997).

The TRVs for ECOPCs derived for shrews, raccoons, and mink are shown in Table 8-5 and those for robins and green heron in Table 8-6.

The EPA Region IV ESVs for surface water used to identify ECOPCs for surface water and groundwater at the 16 SWMUs were considered to be protective of aquatic life; therefore, the preliminary risk calculations for aquatic biota exposed to surface water and groundwater at the SWMUs with aquatic habitat were not required to evaluate the preliminary assessment endpoints for aquatic receptors. The EPA Region IV ESVs for sediment used to identify ECOPCs were considered to be protective of sediment-dwelling biota; therefore, preliminary risk calculations for sediment-dwelling invertebrates exposed to sediment in creeks and ponds were not required to evaluate the assessment endpoint for sediment-dwelling invertebrates.

8.4 PRELIMINARY EXPOSURE ESTIMATE (Step iv)

For shrews and robins, which are indirectly exposed by ingestion of biota, the maximum detected concentration of each analyte in the 0-foot to-1-foot interval of the 16 SWMUs surface soil samples and drainage ditch sediment samples was used as the exposure point concentration to calculate the maximum ADDs.

For raccoons, which are directly exposed only by ingestion of surface water, and mink and herons, which are indirectly exposed only by ingestion of aquatic biota, the maximum detected concentration of each analyte in surface water grab samples was used as the exposure point concentration to calculate the maximum ADDs. The maximum concentrations of ECOPCs in sediment from SWMUs with aquatic habitats were used as the exposure point concentrations for calculation of ADDs for green herons ingesting sediment-dwelling invertebrates. The maximum detected concentration of each analyte in samples from the 16 SWMUs monitoring wells, Geoprobe, and vertical-profile locations was used as the exposure point concentration to calculate the maximum ADDs for raccoons, mink, or green herons directly or indirectly exposed to groundwater potentially discharging to surface water.

The ADD to shrews and robins from substances in surface soil was calculated as the product of the maximum detected concentration, the unitless soil-to-invertebrate bioaccumulation factor (BAF_i), and the daily specific food ingestion rate (IR) of the receptor. That is,

$$\text{ADD (mg/kg/d)} = \text{max. soil concentration (mg/kg)} \times BAF_i \times \text{IR (kg/kg/d)}.$$

The ADD to raccoons by ingestion of substances in surface water and groundwater was calculated as the product of the maximum detected concentration, the unit conversion factor (0.001 microgram per milligram), and the daily specific water ingestion rate (IR_w) of the receptor. That is,

$$\text{ADD (mg/kg/d)} = \text{max. water concentration } (\mu g/L) \times 0.001\ (\mu g/mg) \times IR_w\ (L/kg/d).$$

The ADD to mink and green herons from ingestion of biota exposed to substances in surface water and groundwater was calculated as the product of the maximum detected concentration, the unitless bioconcentration factor (BCF) for the contaminant in fish tissue, and the daily specific food ingestion rate (IR) of the receptor. That is,

$$\text{ADD (mg/kg/d)} = \text{max. water concentration } (\mu g/L) \times 0.001\ (\mu g/mg) \times BCF \times \text{IR (kg/kg/d)}.$$

Table 8-5. Derivation of NOAELs and Screening Toxicity Reference Values for Mammal Receptors

Analyte	Test Species	Test Species Body Weight (kg) BW_t	Test Species $NOAEL_t$ (mg/kgBW/d)	Raccoon		Short-tailed Shrew		Mink	
				Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^{0.25}$	NOAEL (mg/kgBW/d) $NOAEL_t \times BW_{conv}$	Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^{0.25}$	NOAEL (mg/kgBW/d) $NOAEL_t \times BW_{conv}$	Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^{0.25}$	NOAEL (mg/kgBW/d) $NOAEL_t \times BW_{conv}$
INORGANICS									
Aluminum	Mouse	3.00E-02	1.93E+00	2.66E-01	5.14E-01	1.19E+00	2.30E+00	4.16E-01	8.03E-01
Antimony	Mouse	3.00E-02	1.25E-01	2.66E-01	3.33E-02	1.19E+00	1.49E-01	4.16E-01	5.20E-02
Arsenic	Mouse	3.00E-02	1.26E-01	2.66E-01	3.35E-02	1.19E+00	1.50E-01	4.16E-01	5.24E-02
Barium	Rat	4.35E-01	5.06E+00	5.19E-01	2.63E+00	2.32E+00	1.17E+01	8.12E-01	4.11E+00
Beryllium	Rat	3.50E-01	6.60E-01	4.92E-01	3.25E-01	2.20E+00	1.45E+00	7.69E-01	5.08E-01
Cadmium	Rat	3.03E-01	1.00E+00	4.74E-01	4.74E-01	2.12E+00	2.12E+00	7.42E-01	7.42E-01
Calcium	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
Chromium	Rat	3.50E-01	2.74E+03	4.92E-01	1.35E+03	2.20E+00	6.02E+03	7.69E-01	2.11E+03
Cobalt	Rat	3.50E-01	1.00E+00	4.92E-01	4.92E-01	2.20E+00	2.20E+00	7.69E-01	7.69E-01
Copper	Mink	1.00E+00	1.17E+01	6.39-E-01	No NOAEL	2.86E+00	3.35E+01	1.00E+00	1.17E+01
Iron	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
Lead	Rat	3.50E-01	8.00E+00	4.92E-01	3.93E+00	2.20E+00	1.76E+01	7.69E-01	6.15E+00
Magnesium	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
Manganese	Rat	3.50E-01	8.80E+01	4.92E-01	4.33E+01	2.20E+00	1.93E+02	7.69E-01	6.77E+01
Mercury	Mink	1.00E+00	1.01E+00	6.39E-01	6.46E-01	2.86E+00	2.89E+00	1.00E+00	1.01E+00
Nickel	Rat	3.50E-01	4.00E+01	4.92E-01	1.97E+01	2.20E+00	8.79E+01	7.69E-01	3.08E+01
Potassium	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
Selenium	Rat	3.50E-01	2.00E-01	4.92E-01	9.84E-02	2.20E+00	4.40E-01	7.69E-01	1.54E-01
Silver	Rat	3.50E-01	1.01E+02	4.92E-01	4.98E+01	2.20E+00	2.22E+02	7.69E-01	7.78E+01
Sodium	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
Vanadium	Rat	2.60E-01	2.10E-01	4.57E-01	9.59E-02	2.04E+00	4.28E-01	7.14E-01	1.50E-01
Zinc	Rat	3.50E-01	1.60E+02	4.92E-01	7.87E+01	2.20E+00	3.52E+02	7.69E-01	1.23E+02
ORGANICS									
Volatile Organic Compounds									
Acetone	Rat	3.50E-01	1.00E+01	4.92E-01	4.92E+00	2.20E+00	2.20E+01	7.69E-01	7.69E+00
Benzene	Mouse	3.00E-02	2.64E+01	2.66E-01	7.02E+00	1.19E+00	3.13E+01	4.16E-01	1.10E+01
Bromodichloromethane	Mouse	3.00E-02	1.79E+00	2.66E-01	4.76E-01	1.19E+00	2.13E+00	4.16E-01	7.45E-01

Note: Footnotes appear on page 8-28.

Table 8-5. Derivation of NOAELs and Screening Toxicity Reference Values for Mammal Receptors (continued)

Analyte	Test Species	Test Species Body Weight (kg) BW_t	Test Species $NOAEL_t$ (mg/kgBW/d)	Raccoon		Short-tailed Shrew		Mink	
				Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^{0.25}$	NOAEL (mg/kgBW/d) $NOAEL_t \times BW_{conv}$	Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^{0.25}$	NOAEL (mg/kgBW/d) $NOAEL_t \times BW_{conv}$	Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^{0.25}$	NOAEL (mg/kgBW/d) $NOAEL_t \times BW_{conv}$
Bromoform	Rat	3.50E-01	1.79E+00	4.92E-01	8.80E-01	2.20E+00	3.93E+00	7.69E-01	1.38E+00
Bromomethane	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
Carbon disulfide	Rat	3.50E-01	1.10E+01	4.92E-01	5.41E+00	2.20E+00	2.42E+01	7.69E-01	8.46E+00
Carbon tetrachloride	Rat	3.50E-01	1.60E+01	4.92E-01	7.87E+00	2.20E+00	3.52E+01	7.69E-01	1.23E+01
Chlorobenzene	Rat	3.50E-01	5.00E+01	4.92E-01	2.46E+01	2.20E+00	1.10E+02	7.69E-01	3.85E+01
Chloroethane	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
Chloroform	Rat	3.50E-01	1.50E+01	4.92E-01	7.38E+00	2.20E+00	3.30E+01	7.69E-01	1.15E+01
Chloromethane	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
Dibromochloromethane	Rat	3.50E-01	2.14E+00	4.92E-01	1.05E+00	2.20E+00	4.70E+00	7.69E-01	1.65E+00
1,1-Dichloroethane	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
1,1-Dichloroethene	Rat	3.50E-01	3.00E+01	4.92E-01	1.48E+01	2.20E+00	6.59E+01	7.69E-01	2.31E+01
1,2-Dichloroethane	Mouse	3.50E-02	5.00E+01	2.77E-01	1.38E+01	1.24E+00	6.18E+01	4.33E-01	2.16E+01
1,2-Dichloroethene	Mouse	3.00E-02	4.52E+01	2.66E-01	1.20E+01	1.19E+00	5.38E+01	4.16E-01	1.88E+01
1,3-Dichloropropene	Rat	3.50E-01	3.00E-01	4.92E-01	1.48E-01	2.20E+00	6.59E-01	7.69E-01	2.31E-01
Ethylbenzene	Rat	3.50E-01	9.71E+00	4.92E-01	4.78E+00	2.20E+00	2.13E+01	7.69E-01	7.47E+00
Methylene chloride	Rat	3.50E-01	5.85E+00	4.92E-01	2.88E+00	2.20E+00	1.29E+01	7.69E-01	4.50E+00
Methyl ethyl ketone	Rat	3.50E-01	1.77E+03	4.92E-01	8.71E+02	2.20E+00	3.89E+03	7.69E-01	1.36E+03
4-Methyl-2-pentanone	Rat	3.50E-01	2.50E+01	4.92E-01	1.23E+01	2.20E+00	5.49E+01	7.69E-01	1.92E+01
Styrene	Dog	1.00E+01	2.00E+02	1.14E+00	2.27E+02	5.08E+00	1.02E+03	1.78E+00	3.56E+02
Tetrachloroethene	Mouse	3.00E-02	1.40E+00	2.66E-01	3.73E-01	1.19E+00	1.66E+00	4.16E-01	5.83E-01
1,1,2,2-Tetrachloroethane	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
Toluene	Mouse	3.00E-02	2.60E+01	2.66E-01	6.91E+00	1.19E+00	3.09E+01	4.16E-01	1.08E+01
1,1,1-Trichloroethane	Mouse	3.50E-02	1.00E+03	2.77E-01	2.77E+02	1.24E+00	1.24E+03	4.33E-01	4.33E+02
1,1,2-Trichloroethane	Mouse	3.50E-02	3.90E-01	2.77E-01	1.08E-01	1.24E+00	4.82E-01	4.33E-01	1.69E-01
Trichloroethene	Mouse	3.00E-02	7.00E-01	2.66E-01	1.86E-01	1.19E+00	8.32E-01	4.16E-01	2.91E-01
Vinyl chloride	Rat	3.50E-01	1.70E-01	4.92E-01	8.36E-02	2.20E+00	3.74E-01	7.69E-01	1.31E-01
Xylenes, total	Mouse	3.00E-02	2.06E+00	2.66E-01	5.48E-01	1.19E+00	2.45E+00	4.16E-01	8.57E-01

Note: Footnotes appear on page 8-28.

Table 8-5. Derivation of NOAELs and Screening Toxicity Reference Values for Mammal Receptors (continued)

Analyte	Test Species	Test Species Body Weight (kg) BW_t	Test Species $NOAEL_t$ (mg/kgBW/d)	Raccoon		Short-tailed Shrew		Mink	
				Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^{0.25}$	NOAEL (mg/kgBW/d) $NOAEL_t \times BW_{conv}$	Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^{0.25}$	NOAEL (mg/kgBW/d) $NOAEL_t \times BW_{conv}$	Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^{0.25}$	NOAEL (mg/kgBW/d) $NOAEL_t \times BW_{conv}$
Semivolatile Organic Compounds									
Acenaphthene	Mouse	3.00E-02	1.75E+02	2.66E-01	4.66E+01	1.19E+00	2.08E+02	4.16E-01	7.28E+01
Benzo(*a*)anthracene	Mouse	3.00E-02	1.33E+01	2.66E-01	3.54E+00	1.19E+00	1.58E+01	4.16E-01	5.54E+00
Benzo(*a*)pyrene	Mouse	3.00E-02	1.00E+00	2.66E-01	2.66E-01	1.19E+00	1.19E+00	4.16E-01	4.16E-01
Benzo(*b*)fluoranthene	Mouse	3.00E-02	1.33E+01	2.66E-01	3.54E+00	1.19E+00	1.58E+01	4.16E-01	5.54E+00
Benzo(*g,h,i*)perylene	Mouse	3.00E-02	1.33E+01	2.66E-01	3.54E+00	1.19E+00	1.58E+01	4.16E-01	5.54E+00
Benzo(*k*)fluoranthene	Mouse	3.00E-02	1.00E+00	2.66E-01	2.66E-01	1.19E+00	1.19E+00	4.16E-01	4.16E-01
Bis(2-ethylhexyl)phthalate	Mouse	3.00E-02	1.83E+01	2.66E-01	4.87E+00	1.19E+00	2.18E+01	4.16E-01	7.61E+00
Chlorobenzene	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
Chrysene	Mouse	3.00E-02	1.33E+01	2.66E-01	3.54E+00	1.19E+00	1.58E+01	4.16E-01	5.54E+00
Dibenzofuran	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
1,2-Dichlorobenzene	Rat	3.50E-01	1.20E+02	4.92E-01	5.90E+01	2.20E+00	2.64E+02	7.69E-01	9.23E+01
2,4-Dimethylphenol	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
Di-*N*-butylphthalate	Mouse	3.00E-02	5.50E+02	2.66E-01	1.46E+02	1.19E+00	6.54E+02	4.16E-01	2.29E+02
Di-*N*-octylphthalate	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
Fluoranthene	Mouse	3.00E-02	5.00E+01	2.66E-01	1.33E+01	1.19E+00	5.95E+01	4.16E-01	2.08E+01
2-Hexanone	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
Indeno(*1,2,3-cd*)pyrene	Mouse	3.00E-02	1.33E+01	2.66E-01	3.54E+00	1.19E+00	1.58E+01	4.16E-01	5.54E+00
2-Methylnaphthalene	Rat	3.50E-01	5.00E+00	4.92E-01	2.46E+00	2.20E+00	1.10E+01	7.69E-01	3.85E+00
4-Chloro-3-methylphenol	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
Naphthalene	Rat	3.50E-01	5.00E+00	4.92E-01	2.46E+00	2.20E+00	1.10E+01	7.69E-01	3.85E+00
N-Nitrosodiphenylamine	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
Phenanthrene	Mouse	3.00E-02	1.00E+00	2.66E-01	2.66E-01	1.19E+00	1.19E+00	4.16E-01	4.16E-01
Phenol	Rat	3.50E-01	6.00E+00	4.92E-01	2.95E+00	2.20E+00	1.32E+01	7.69E-01	4.61E+00
Pyrene	Mouse	3.00E-02	1.00E+00	2.66E-01	2.66E-01	1.19E+00	1.19E+00	4.16E-01	4.16E-01

Note: Footnotes appear on page 8-28.

Table 8-5. Derivation of NOAELs and Screening Toxicity Reference Values for Mammal Receptors (continued)

Analyte	Test Species	Test Species Body Weight (kg) BW_t	Test Species $NOAEL_t$ (mg/kgBW/d)	Raccoon		Short-tailed Shrew		Mink	
				Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^{0.25}$	NOAEL (mg/kgBW/d) $NOAEL_t \times BW_{conv}$	Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^{0.25}$	NOAEL (mg/kgBW/d) $NOAEL_t \times BW_{conv}$	Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^{0.25}$	NOAEL (mg/kgBW/d) $NOAEL_t \times BW_{conv}$
Pesticides/PCBs									
Aldrin	Rat	3.50E-01	2.00E-01	4.92E-01	9.84E-02	2.20E+00	4.40E-01	7.69E-01	1.54E-01
alpha-BHC	Rat	3.50E-01	1.60E+00	4.92E-01	7.87E-01	2.20E+00	3.52E+00	7.69E-01	1.23E+00
beta-BHC	Rat	3.50E-01	4.00E-01	4.92E-01	1.97E-01	2.20E+00	8.80E-01	7.69E-01	3.08E-01
delta-BHC	Rat	3.50E-01	1.60E+00	4.92E-01	7.87E-01	2.20E+00	3.52E+00	7.69E-01	1.23E+00
gamma-BHC (Lindane)	Rat	3.50E-01	8.00E+00	4.92E-01	3.94E+00	2.20E+00	1.76E+01	7.69E-01	6.15E+00
alpha-Chlordane	Mouse	3.00E-02	4.58E+00	2.66E-01	1.22E+00	1.19E+00	5.45E+00	4.16E-01	1.91E+00
gamma-Chlordane	Mouse	3.00E-02	4.58E+00	2.66E-01	1.22E+00	1.19E+00	5.45E+00	4.16E-01	1.91E+00
4,4'-DDD	Rat	3.50E-01	8.00E-01	4.92E-01	3.93E-01	2.20E+00	1.76E+00	7.69E-01	6.15E-01
4,4'-DDE	Rat	3.50E-01	8.00E-01	4.92E-01	3.93E-01	2.20E+00	1.76E+00	7.69E-01	6.15E-01
4,4'-DDT	Rat	3.50E-01	8.00E-01	4.92E-01	3.93E-01	2.20E+00	1.76E+00	7.69E-01	6.15E-01
Dieldrin	Rat	3.50E-01	2.00E-02	4.92E-01	9.84E-03	2.20E+00	4.40E-02	7.69E-01	1.54E-02
Endosulfan II	Rat	3.50E-01	1.50E-01	4.92E-01	7.38E-02	2.20E+00	3.30E-01	7.69E-01	1.15E-01
Endosulfan sulfate	Rat	3.50E-01	1.50E-01	4.92E-01	7.38E-02	2.20E+00	3.30E-01	7.69E-01	1.15E-01
Endrin ketone	Mouse	3.00E-02	9.20E-02	2.66E-01	2.45E-02	1.19E+00	1.09E-01	4.16E-01	3.83E-02
Heptachlor	Mink	1.00E+00	1.00E-01	6.39E-01	6.39E-02	2.86E+00	2.86E-01	1.00E+00	1.00E-01
Heptachlor epoxide	Mink	1.00E+00	1.00E-01	6.39E-01	6.39E-02	2.86E+00	2.86E-01	1.00E+00	1.00E-01
Methoxychlor	Rat	3.50E-01	4.00E+00	4.92E-01	1.97E+00	2.20E+00	8.79E+00	7.69E-01	3.08E+00
2,4-Dinitrotoluene	Mouse	3.00E-02	1.35E+01	2.66E-01	3.59E+00	1.19E+00	1.61E+01	4.16E-01	5.62E+00
2,6-Drinitrotoluene	Rat	3.50E-01	7.00E-01	4.92E-01	3.44E-01	2.20E+00	1.54E+00	7.69E-01	5.38E-01
2,4,6-Drinitrotoluene	Rat	3.50E-01	1.60E+00	4.92E-01	7.87E-01	2.20E+00	3.52E+00	7.69E-01	1.23E+00
HMX	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
RDX	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL

BW(kg) Raccoon = 5.98.
BW (kg) Shrew = 0.015.
BW (kg) Mink = 1.0.

Table 8-6. Derivation of NOAELs and Screening Toxicity Reference Values for Bird Receptors

Analyte	Test Species	Test Species Body Weight (kg) BW_t	Test Species $NOAEL_t$ (mg/kgBW/d)	American Robin		Green Heron	
				Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^0$	NOAEL (mg/kgBW/d) $NOAEL_t$ x BW_{conv}	Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^0$	NOAEL (mg/kgBW/d) $NOAEL_t$ x BW_{conv}
INORGANICS							
Aluminum	Ringed dove	1.55E-01	1.10E+02	1.00E+00	1.10E+02	1.00E+00	1.10E+02
Antimony	Composite bird	8.50E-01	3.57E-01	1.00E+00	3.57E-01	1.00E+00	3.57E-01
Arsenic	Mallard duck	1.00E+00	5.14E+00	1.00E+00	5.14E+00	1.00E+00	5.14E+00
Barium	Chick (14 days old)	1.21E-01	2.08E+01	1.00E+00	2.08E+01	1.00E+00	2.08E+01
Beryllium	Composite Bird	8.50E-01	1.67E+00	1.00E+00	1.67E+00	1.00E+00	1.67E+00
Cadmium	Mallard duck	1.15E+00	1.45E+00	1.00E+00	1.45E+00	1.00E+00	1.45E+00
Calcium	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Chromium	Black duck	1.25E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Cobalt	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Copper	Chick (5 weeks old)	5.34E-01	4.70E+01	1.00E+00	4.70E+01	1.00E+00	4.70E+01
Iron	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Lead	Quail	1.50E-01	1.13E+00	1.00E+00	1.13E+00	1.00E+00	1.13E+00
Magnesium	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Manganese	Quail	7.20E-02	9.77E+02	1.00E+00	9.77E+02	1.00E+00	9.77E+02
Mercury	Quail	1.50E-01	4.50E-01	1.00E+00	4.50E-01	1.00E+00	4.50E-01
Nickel	Mallard duckling	7.82E-01	7.74E+01	1.00E+00	7.74E+01	1.00E+00	7.74E+01
Potassium	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Selenium	Mallard duck	1.00E+00	5.00E-01	1.00E+00	5.00E-01	1.00E+00	5.00E-01
Silver	Composite bird	8.50E-01	5.79E+01	1.00E+00	5.79E+01	1.00E+00	5.79E+01
Sodium	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Vanadium	Mallard duck	1.17E+00	1.14E+01	1.00E+00	1.14E+01	1.00E+00	1.14E+01
Zinc	Leghorn chicken	1.94E+00	1.45E+01	1.00E+00	1.45E+01	1.00E+00	1.45E+01

Note: Footnotes appear on page 8-32.

Table 8-6. Derivation of NOAELs and Screening Toxicity Reference Values for Bird Receptors (continued)

Analyte	Test Species	Test Species Body Weight (kg) BW_t	Test Species $NOAEL_t$ (mg/kgBW/d)	American Robin		Green Heron	
				Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^0$	NOAEL (mg/kgBW/d) $NOAEL_t \times BW_{conv}$	Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^0$	NOAEL (mg/kgBW/d) $NOAEL_t \times BW_{conv}$
ORGANICS							
Volatile Organic Compounds							
Acetone	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Benzene	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Bromodichloromethane	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Bromoform	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Bromomethane	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Carbon disulfide	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Carbon tetrachloride	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Chlorobenzene	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Chloroethane	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Chloroform	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Chloromethane	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Dibromochloromethane	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
1,1-Dichloroethane	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
1,1-Dichloroethene	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
1,2-Dichloroethane	Chicken	1.60E+00	1.72E+01	1.00E+00	1.72E+01	1.00E+00	1.72E+01
1,2-Dichloroethene	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
1,3-Dichloropropene	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Ethylbenzene	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Methylene chloride	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Methyl ethyl ketone	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
4-Methyl-2-pentanone	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Styrene	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Tetrachloroethene	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
1,1,2,2-Tetrachloroethane	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Toluene	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
1,1,1-Trichloroethane	None	None	No NOAEL	None	No NOAEL	None	No NOAEL

Note: Footnotes appear on page 8-32.

Table 8-6. Derivation of NOAELs and Screening Toxicity Reference Values for Bird Receptors (continued)

Analyte	Test Species	Test Species Body Weight (kg) BW_t	Test Species $NOAEL_t$ (mg/kgBW/d)	American Robin		Green Heron	
				Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^0$	NOAEL (mg/kgBW/d) $NOAEL_t \times BW_{conv}$	Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^0$	NOAEL (mg/kgBW/d) $NOAEL_t \times BW_{conv}$
1,1,2-Trichloroethane	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Trichloroethene	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Vinyl chloride	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Xylenes, total	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Semivolatile Organic Compounds							
Acenaphthene	Composite bird	8.50E-01	8.78E+01	1.00E+00	8.78E+01	1.00E+00	8.78E+01
Benzo(*a*)anthracene	Composite bird	8.50E-01	1.24E+01	1.00E+00	1.24E+01	1.00E+00	1.24E+01
Benzo(*a*)pyrene	Composite bird	8.50E-01	9.97E+00	1.00E+00	9.97E+00	1.00E+00	9.97E+00
Benzo(*b*)fluoranthene	Composite bird	8.50E-01	1.24E+01	1.00E+00	1.24E+01	1.00E+00	1.24E+01
Benzo(*g,h,i*)perylene	Composite bird	8.50E-01	1.24E+01	1.00E+00	1.24E+01	1.00E+00	1.24E+01
Benzo(*k*)fluoranthene	Composite bird	8.50E-01	9.97E+00	1.00E+00	9.97E+00	1.00E+00	9.97E+00
Bis(2-ethylhexyl)phthalate	Ringed dove	1.55E-01	1.10E+00	1.00E+00	1.10E+00	1.00E+00	1.10E+00
Chlorobenzene	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Chrysene	Composite bird	8.50E-01	1.24E+01	1.00E+00	1.24E+01	1.00E+00	1.24E+01
Dibenzofuran	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
1,2-Dichlorobenzene	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
2,4-Dimethylphenol	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Di-*N*-butylphthalate	Ringed dove	1.55E-01	1.11E-01	1.00E+00	1.11E-01	1.00E+00	1.11E-01
Di-*N*-octylphthalate	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Fluoranthene	Composite bird	8.50E-01	1.95E+02	1.00E+00	1.95E+02	1.00E+00	1.95E+02
2-Hexanone	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Indeno(*1,2,3-cd*)pyrene	Composite bird	8.50E-01	1.24E+01	1.00E+00	1.24E+01	1.00E+00	1.24E+01
2-Methylnaphthalene	Composite bird	8.50E-01	3.39E+01	1.00E+00	3.39E+01	1.00E+00	3.39E+01
4-Chloro-3-methylphenol	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Naphthalene	Composite bird	8.50E-01	3.39E+01	1.00E+00	3.39E+01	1.00E+00	3.39E+01
N-Nitrosodiphenylamine	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Phenanthrene	Composite bird	8.50E-01	9.97E+00	1.00E+00	9.97E+00	1.00E+00	9.97E+00
Phenol	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Pyrene	Composite bird	8.50E-01	9.97E+00	1.00E+00	9.97E+00	1.00E+00	9.97E+00

Note: Footnotes appear on page 8-32.

Table 8-6. Derivation of NOAELs and Screening Toxicity Reference Values for Bird Receptors (continued)

Analyte	Test Species	Test Species Body Weight (kg) BW_t	Test Species $NOAEL_t$ (mg/kgBW/d)	American Robin		Green Heron	
				Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^0$	NOAEL (mg/kgBW/d) $NOAEL_t$ x BW_{conv}	Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^0$	NOAEL (mg/kgBW/d) $NOAEL_t$ x BW_{conv}
Pesticides/PCBs							
Aldrin	Composite bird	8.50E-01	1.73E+00	1.00E+00	1.73E+00	1.00E+00	1.73E+00
alpha-BHC	Japanese quail	1.50E-01	5.63E-01	1.00E+00	5.63E-01	1.00E+00	5.63E-01
beta-BHC	Japanese quail	1.50E-01	5.63E-01	1.00E+00	5.63E-01	1.00E+00	5.63E-01
delta-BHC	Japanese quail	1.50E-01	5.63E-01	1.00E+00	5.63E-01	1.00E+00	5.63E-01
gamma-BHC (Lindane)	Mallard duck	1.00E+00	2.00E+00	1.00E+00	2.00E+00	1.00E+00	2.00E+00
alpha-Chlordane	Red-winged blackbird	6.40E-02	2.14E+00	1.00E+00	2.14E+00	1.00E+00	2.14E+00
gamma-Chlordane	Red-winged blackbird	6.40E-02	2.14E+00	1.00E+00	2.14E+00	1.00E+00	2.14E+00
4,4'-DDD	Brown pelican	3.50E+00	2.80E-03	1.00E+00	2.80E-03	1.00E+00	2.80E-03
4,4'-DDE	Brown pelican	3.50E+00	2.80E-03	1.00E+00	2.80E-03	1.00E+00	2.80E-03
4,4'-DDT	Brown pelican	3.50E+00	2.80E-03	1.00E+00	2.80E-03	1.00E+00	2.80E-03
Dieldrin	Barn owl	4.66E-01	7.70E-02	1.00E+00	7.70E-02	1.00E+00	7.70E-02
Endosulfan II	Gray partridge	4.00E-01	1.00E+01	1.00E+00	1.00E+01	1.00E+00	1.00E+01
Endosulfan sulfate	Gray partridge	4.00E-01	1.00E+01	1.00E+00	1.00E+01	1.00E+00	1.00E+01
Endrin ketone	Screech owl	1.81E-02	1.04E-02	1.00E+00	1.04E-02	1.00E+00	1.04E-02
Heptachlor	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Heptachlor epoxide	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Methoxychlor	Composite bird	8.50E-01	8.42E+00	1.00E+00	8.42E+00	1.00E+00	8.42E+00
Explosives							
2,4-Dinitrotoluene	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
2,6-Dinitrotoluene	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
2,4,6-Trinitrotoluene	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
HMX	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
RDX	None	None	No NOAEL	None	No NOAEL	None	No NOAEL

BW (kg) Robin = 0.08.
BW (kg) Green heron = 0.25.

The ADD to green herons from ingestion of invertebrates exposed to substances in sediment was calculated as the product of the maximum detected concentration, the unitless bioaccumulation factor (BAF_i) for the contaminant in invertebrate tissue, and the daily specific water ingestion rate (IR_w) of the receptor. That is,

$$\text{ADD (mg/kg/d)} = \text{max. sediment concentration (mg/kg)} \times BAF_i \times \text{IR (kg/kg/d)}.$$

The exposure parameters for shrews and robins exposed to substances in surface soil and raccoons, mink, and green herons exposed to ECOPCs in surface water, sediment, or groundwater are presented in Table 8-7.

Table 8-7. Exposure Parameters for Surrogate Species

Parameter	Surrogate Species				
	Shrew	Robin	Raccoon	Mink	Green Heron
Body weight (kg)	0.015[a]	0.077[a]	4.31[b]	1[a]	0.25[c]
Food ingestion rate (kg/kg/d)	0.6[d]	1.2[d]	–	0.137[d]	0.192[c]
Water ingestion rate (L/kg/d)	–	–	0.08[b]	–	–
Area use factor	1	1	1	1	1
Relative bioavailability	100 percent	100 percent	100 percent	100 percent	100 percent
Diet	100 percent earthworm	100 percent earthworm	–	100 percent fish	100 percent fish (for surface water and groundwater); 100 percent sediment-dwelling invertebrates (for sediment)
Source medium	Surface soil	Surface soil	Surface water; groundwater	Surface water; groundwater	Surface water; groundwater; sediment

[a]Sample, Opresko, and Suter (1996), Table B.1.
[b]EPA 1993.
[c]EPA Region IV Supplemental Guidance to RAGS (EPA 1996d), Table A.
[d]Converted from values reported as kilograms per day in Sample, Opresko, and Suter (1996) by dividing by body weight (kilograms).
– = Not required for preliminary risk calculation.

The exposures of surrogate species were estimated using conservative assumptions (Table 8-7). It was assumed that the receptors spend their entire lives and obtain 100 percent of their diet or drinking water at the facility [i.e., the area use factor (AUF) equals one]. Shrews and robins were assumed to eat only soil-dwelling invertebrates such as worms that bioaccumulate contaminants from soil, in accordance with EPA Region IV requirements that the screening be based on exposure through two trophic transfers (EPA 1997a). Raccoons were assumed to drink only water from the creeks or ponds at the individual SWMUs but were assumed to eat no solid food from the SWMU. Mink were assumed to eat only fish from creeks and ponds. Herons were assumed to eat only fish when evaluating surface water and groundwater, and only sediment-dwelling invertebrates when evaluating sediment. Chemicals in surface soil and sediment were assumed to bioaccumulate in the soil- and sediment-dwelling invertebrate prey of ecological receptors at levels equal to published bioaccumulation factors (BAFs) for earthworms and other invertebrates as reported in Hazardous Waste Remedial Actions Program (HAZWRAP) (1994).

Chemicals in surface water and groundwater were assumed to bioaccumulate in aquatic biota at levels equal to published BCFs for fish (HAZWRAP 1994).

8.5 PRELIMINARY RISK CALCULATION (Step v)

The preliminary risk calculation (Step v) uses HQs, the ratio of the ADD calculated using the measured maximum concentration and the TRV, to evaluate the potential for risk. The HQs of ECOPCs with consistent modes of toxicity and effects endpoints are added to produce an HI. An HI greater than one for a category of COPCs is a useful indicator of potential risk when no individual COPC in that category has an HQ greater than one. An HI assumes that the effects of the individual COPCs in the category are additive. Metals are assumed to have distinct modes of toxicity and effects endpoints. Therefore, HIs are calculated only for VOCs, SVOCs, and pesticides/PCBs when no individual ECOPC has an HQ greater than one and when HQs are calculated for more than one chemical.

Because of the uncertainties in quantifying exposure and effects, the exposure and effects assessments for each of the SWMUs were designed to produce HQs that minimized the probability of falsely concluding that there was no risk when in fact there was. Therefore, ECOPCs with HQs and HIs less than one indicated little to no likelihood of risk to the ecological receptors. To minimize the probability of falsely concluding there was risk when there was none, an ERA using site-specific data for those ECOPCs with calculated HQs or HIs exceeding one was recommended (GEPD 1996).

The HQs and HIs for ECOPCs in the relevant media at each of the 16 SWMUs are presented in the Chapters 9.0 and 10.0. Conclusions and recommendations are presented in Chapter 11.0.

8.6 UNCERTAINTIES

The EPRE for the 16 SWMUs was designed to minimize the probability of falsely concluding that there was no risk when in fact there was risk (GEPD 1996). The EPA Region IV ESV comparison was designed to be conservative and to screen out only those substances for which there was little probability that they would pose a hazard to ecological receptors. The preliminary ecological effects and exposure assessments were designed to produce preliminary risk calculations that overestimated a risk. Using conservative exposure and effects assumptions (e.g., AUF equal to one, maximum detected concentrations, and TRVs based on NOAELs), as required by the guidance documents (GEPD 1996; EPA 1997a), overestimates risk to ecological receptors. Therefore, contaminants with HQs and HIs less than or equal to one indicate little to no likelihood of hazard to the ecological receptors.

Because of the conservatism of the TRVs and exposure estimates, HQs and HIs exceeding one do not necessarily mean that the ecological receptors are at risk of ecologically significant adverse effect. ECOPCs with small HQs may not be potential hazards unless the receptors obtain all of their food from the individual SWMU and the TRVs closely approximate the actual toxicity threshold. ECOPCs with large HQs may not be potential hazards if the TRVs for those contaminants greatly overestimate the toxicity to the receptors at the 16 SWMUs. TRVs can overestimate toxicity because of differences in the form of the chemical tested, the means by which the chemical was administered to the test species, or if the test endpoint is not expected to cause a significant ecological effect. Most ECOPCs at the 16 SWMUs that are judged not to be potential hazards have small HQs for ecological receptors that are unlikely to obtain 100 percent of their food from the SWMUs. Aluminum and lead are ECOPCs that have TRVs that probably overestimate toxicity to ecological receptors at the 16 SWMUs; therefore, aluminum and lead are not considered to be potential hazards where HQs for terrestrial receptors are less than 10.

The published NOAEL for aluminum is based on a laboratory study that orally administered aluminum salts dissolved in water to the test species (Sample, Opresko, and Suter 1996). The uptake of aluminum dissolved in water overestimates the uptake from ingested tissue and especially soil. In addition, only one dose was administered, and the observed effect on the test species was of questionable ecological significance to wildlife populations. The effect endpoint for aluminum was growth rates (Ondreika, Ginter, and Kortus 1966). The NOAEL, estimated as one-tenth the nonlethal LOAEL, overestimates the potential for adverse effects to endpoint receptor populations because individual growth rates are not directly linked to reduced population sizes. The bird TRV for aluminum is based on a NOAEL for aluminum sulfate, $Al_2(SO_4)_3$ (Carriere et al. 1986). No LOAEL was observed, and aluminum is unlikely to occur as a sulfate in natural soil with clay minerals. The TRV for aluminum probably overestimates risk to ecological receptors by several orders of magnitude.

The TRV for lead is the observed NOAEL for rats exposed to lead acetate over three generations, resulting in sublethal effects on offspring, namely reduced offspring weights and kidney damage (Azar, Trochimowicz, and Maxwell 1973). These are not necessarily ecologically significant, so a TRV based on a NOAEL is perhaps an unreasonable basis for characterizing risk. The bird TRV for lead is based on a NOAEL for lead acetate; the observed LOAEL was 10-fold larger (Edens et al. 1976). Furthermore, it is unlikely that 100 percent of the lead in surface soil is in the form of lead acetate. The conservative default BAF value of 0.4 for lead probably overestimates bioaccumulation by a factor of five or more.

In addition to conservative exposure and effects parameters used in the preliminary risk calculations, groundwater was treated as surface water in the EPRE in accordance with EPA Region IV guidance (EPA 1996d), which is a conservative treatment of groundwater. Groundwater is not expected to rapidly migrate away from some SWMUs because of soil characteristics and hydraulic gradients. The concentration of ECOPCs in groundwater might, therefore, decline to safe levels by adsorption or biodegradation before the groundwater discharges to the nearest aquatic habitat with biota. ECOPCs in groundwater at some SWMUs, therefore, might not pose a hazard to aquatic and terrestrial receptors. At some Phase II SWMUs, the likelihood that groundwater discharges to nearby aquatic habitats was considered when evaluating the potential for ECOPCs in groundwater to pose a hazard to aquatic and terrestrial receptors. If the data indicated that groundwater discharge was unlikely, then groundwater ECOPCs were judged not to be potential hazards.

To evaluate the uncertainty associated with ECOPCs that are judged to pose a potential risk to wildlife receptors, supplemental risk calculations are made using realistic diets, site-specific AUFs, mean sample concentrations, and LOAEL–based TRVs. Supplemental risk calculations are made for shrews and robins exposed to ECOPCs in surface soil; raccoons, mink, and green herons exposed to ECOPCs in surface water or groundwater potentially discharging to surface water; and green herons or raccoons exposed to ECOPCs in sediment. Raccoons are evaluated instead of green herons when an ECOPC has no TRV for birds but does have a TRV for mammals. Supplemental risk estimates are calculated for only those ECOPCs that are present at maximum concentrations resulting in maximum exposures to a wildlife receptor that exceed the NOAEL–based TRVs (HQ of greater than 1) or for which there are no TRVs for either mammals or birds.

Supplemental risk calculations for shrews and robins are made using published dietary fractions of plant tissue, animal tissue, and incidental soil (Table 8-8) instead of 100 percent earthworms. Evaluating the exposure from ingested plants requires uptake factors, similar to BAFs for animal tissue. Uptake factors for vegetative parts of plants are required for shrews, and factors for reproductive parts of plants are required for robins. Plant uptake factors for inorganic substances are those reported in Baes et al. (1984) converted to a wet-weight basis assuming 80 percent water content and for organic compounds are those reported in HAZWRAP (1994), which are already reported on a wet-weight basis. Means of measured

concentrations instead of maximum concentrations are used to estimate exposure for the supplemental risk calculations. Modeled maximum groundwater concentrations predicted to occur at a distance equal to the distance to the nearest surface water body are also considered in the uncertainty evaluation.

In addition to the adjustments to the exposure estimates, TRVs based on observed or estimated LOAELs instead of NOAELs are used to calculate supplemental HQs. LOAELs reported in Sample, Opresko, and Suter (1996) and other sources (Tables 8-9 and 8-10) are used to derive body-weight-adjusted TRVs (Tables 8-11 and 8-12) for the supplemental evaluations. For those ECOPCs for which there are no NOAEL–based TRVs for any receptor, toxicity data for surrogate chemicals are used to derive LOAEL–based TRVs for use in the supplemental risk calculations. The supplemental risk calculations are presented in the uncertainty discussions in the subsections for the individual SWMUs.

Table 8-8. Exposure Parameters for Surrogate Species for Supplementary Risk Calculations

Parameter	Surrogate Species				
	Shrew	Robin	Raccoon	Mink	Green Heron
Body weight (kg)	0.015[a]	0.077[a]	3[b]	1[a]	0.241[c]
Food ingestion rate (kg/kgBW/d)	0.6[d]	1.2[d]	0.166[b]	0.137[a]	0.26[e]
Water ingestion rate (L/kgBW/d)	--	--	0.0083[b]	0.099[a]	0.094[f]
Home range (ha) or foraging distance (km)	0.39[g]	0.81[h]	52[i]	1.23[j]	ND
Diet[k]	13% plant (vegetative), 87% animal (invertebrates)	50% plant (reproductive), 50% animal (invertebrates)	40% plant (reproductive), 60% animal (invertebrates)	100% fish	100% fish
Soil ingestion (fraction of food)	0.13	0.104	0.094	--	--

[a]Sample, Opresko, and Suter (1996), Table B.1.
[b]Personal communication from Rod Stafford (GEPD) to Tom Burns (SAIC), September 1999.
[c]Average, 16 adults; The Birds of North America, No. 129, 1994.
[d]Converted from values reported as kilograms per day in Sample, Opresko, and Suter (1996) by dividing by body weight (kg/kgBW/d).
[e]Calculated free-living metabolic rate and dietary composition, EPA 1993, Figure 4-7, p. 4-17.
[f]Calculated from Sample, Opresko, and Suter 1996., equation 27, p 9.
[g]EPA 1993, hectares, manitoba/tamarack bog.
[h]EPA 1993, hectares, fledglings, Ontario/deciduous forest.
[i]EPA 1993, hectares, average adult, both sexes, Georgia, coastal island.
[j]EPA 1993, kilometers, mean, male juvenile, Sweden/stream.
[k]Plant and animal fractions based on dietary information in EPA 1993.
-- = Not required for supplementary risk calculation.
ND = No data.

Table 8-9. Derivation of LOAEL Toxicity Reference Values for Mammal Test Species

Ecological Constituent of Potential Concern	Test Species	Test Species Body Weight (kg) BWt	Benchmark (mg/kgBW/d)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor (DCF)	Endpoint Conversion Factor (ECF)	TRV (mg/kgBW/d) Benchmark × DCF × ECF
INORGANICS										
Cadmium	Rat	3.03E-01	1.00E+01	Chronic	LOAEL	Reproduction	Sutou et al. (1980b) in [1]	1.0	1.0	1.00E+01
Chromium	Rat	3.50E-01	2.74E+03	Chronic	NOAEL	Reproduction	Ivankovic and Preussmann (1975) in [1]	1.0	10.0	2.74E+04
Lead	Rat	3.50E-01	8.00E+01	Chronic	LOAEL	Reproduction	Azar et al. (1973) in [1]	1.0	1.0	8.00E+01
Mercury	Mink	1.00E-00	1.01E-00	Chronic	NOAEL	Reproduction	Aulerich et al. (1974) in [1]	1.0	10.0	1.01E+01
ORGANICS										
Volatile Organic Compounds										
Acetone	Rat	3.50E-01	5.00E+01	Subchronic	LOAEL	Hepatotoxicity	EPA (1986c) in [1]	0.1	1.0	5.00E-00
Chloroethane	Rat	3.50E-01	1.80E+02	Subchronic	LOAEL	Mortality	Value for chloromethane in [2]	0.1	1.0	1.80E+01
Chloromethane	Rat	3.50E-01	1.80E+02	Subchronic	LOAEL	Mortality	LD_{50} reported in [2]	0.1	1.0	1.80E+01
Methylene chloride	Rat	3.50E-01	5.00E+01	Chronic	LOAEL	Liver histology	NCA (1982) in [1]	1.0	1.0	5.00E+01
Vinyl chloride	Rat	3.50E-01	1.70E-00	Chronic	LOAEL	Mortality	Feron et al. (1981) in [1]	1.0	1.0	1.70E-00
Semivolatile Organic Compounds										
Benzo(*b*)fluoranthene	Mouse	3.00E-02	1.33E+01	Chronic	NOAEL	None	Neal and Rigdon (1967) in [3]	1.0	10.0	1.33E+02
Pesticides/PCBs										
4,4'-DDE	Rat	3.50E-01	4.00E-00	Chronic	LOAEL	Reproduction	Value from 4,4'-DDT in [1]	1.0	1.0	4.00E-00

DCF = 1 if chronic, 0.1 if subchronic (Sample, Opresko, and Suter 1996).
ECF = 10 if NOAEL, 1.0 if LOAEL (Sample, Opresko, and Suter 1996).
[1] = Sample, Opresko, and Suter (1996).
[2] = Registry of Toxic Effects of Chemical Substances, downloaded in January 1999.
[3] = QST (1997).

Table 8-10. Derivation of LOAEL Toxicity Reference Values for Bird Test Species

Ecological Constituent of Potential Concern	Test Species	Test Species Body Weight (kg) BWt	Benchmark (mg/kgBW/d)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor (DCF)	Endpoint Conversion Factor (ECF)	TRV (mg/kgBW/d) Benchmark × DCF × ECF
INORGANICS										
Cadmium	Mallard duck	1.15E-00	2.00E+01	Chronic	LOAEL	Reproduction	White and Finley (1978) in [1]	1.0	1.0	2.00E+01
Chromium	Black duck	1.25E-00	5.00E-00	Chronic	LOAEL	Reproduction	Haseltine et al. (unpubl.) in [1]	1.0	1.0	5.00E-00
Lead	Quail	1.50E-01	1.13E+01	Chronic	LOAEL	Reproduction	Edens et al. (1976) in [1]	1.0	1.0	1.13E+01
Mercury	Quail	1.50E-01	9.00E-01	Chronic	LOAEL	Reproduction	Hill and Schaffner (1976) in [1]	1.0	1.0	9.00E-01
ORGANICS										
Volatile Organic Compounds										
Acetone	None	None	None	None	None	None	None	None	None	No TRV
Chloroethane	None	None	None	None	None	None	None	None	None	No TRV
Chloromethane	None	None	None	None	None	None	None	None	None	No TRV
Methylene chloride	None	None	None	None	None	None	None	None	None	No TRV
Vinyl chloride	None	None	None	None	None	None	None	None	None	No TRV
Semivolatile Organic Compounds										
Benzo(*b*)fluoranthene	Composite bird	8.50E-01	1.24E+01	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	10.0	1.24E+02
Pesticides/PCBs										
4,4'-DDE	Brown pelican	3.50E-00	2.80E-02	Chronic	LOAEL	Reproduction	Value from 4,4'-DDT in [1]	1.0	1.0	2.80E-02

DCF = Duration conversion factor; 1 if chronic, 0.1 if subchronic (Sample, Opresko, and Suter 1996).
ECF = Endpoint conversion factor; 10 if NOAEL, 1.0 if LOAEL (Sample, Opresko, and Suter 1996).
[1] = Sample, Opresko, and Suter (1996).
[2] = QST (1997).

Table 8-11. Derivation of LOAEL Toxicity Reference Values for Mammal Receptors

Ecological Constituent of Potential Concern	Test Species	Test Species Body Weight BWt (kg)	TRVt (mg/kgBW/d)	Raccoon		Short-tailed Shrew		Mink	
				Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^{0.25}$	TRV (mg/kgBW/d) $TRV_t \times BW_{conv}$	Body-weight Conversion Factor BWconv $(BW_t / BW)^{0.25}$	TRV (mg/kgBW/d) $TRV_t \times BW_{conv}$	Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^{0.25}$	TRV (mg/kgBW/d) $TRV_t \times BW_{conv}$
INORGANICS									
Cadmium	Rat	3.03E-01	1.00E+01	5.64E-01	5.64E-00	2.12E-00	2.12E+01	7.42E-01	7.42E-00
Chromium	Rat	3.50E-01	2.74E+04	5.84E-01	1.60E+04	2.20E-00	6.02E+04	7.69E-01	2.11E+04
Lead	Rat	3.50E-01	8.00E+01	5.84E-01	4.68E+01	2.20E-00	1.76E+02	7.69E-01	6.15E+01
Mercury	Mink	1.00E-00	1.01E+01	7.60E-01	7.67E-00	2.86E-00	2.89E+01	1.00E-00	1.01E+01
ORGANICS									
Volatile Organic Compounds									
Acetone	Rat	3.50E-01	5.00E-00	5.84E-01	2.92E-00	2.20E-00	1.10E+01	7.69E-01	3.85E-00
Chloroethane	Rat	3.50E-01	1.80E+01	5.84E-01	1.05E+01	2.20E-00	3.96E+01	7.69E-01	1.38E+01
Chloromethane	Rat	3.50E-01	1.80E+01	5.84E-01	1.05E+01	2.20E-00	3.96E+01	7.69E-01	1.38E+01
Methylene chloride	Rat	3.50E-01	5.00E+01	5.84E-01	2.92E+01	2.20E-00	1.10E+02	7.69E-01	3.85E+01
Vinyl chloride	Rat	3.50E-01	1.70E-00	5.84E-01	9.94E-01	2.20E-00	3.74E-00	7.69E-01	1.31E-00
Semivolatile Organic Compounds									
Benzo(*b*)fluoranthene	Mouse	3.00E-02	1.33E+02	3.16E-01	4.21E+01	1.19E-00	1.58E+02	4.16E-01	5.54E+01
Pesticides/PCBs									
4,4'-DDE	Rat	3.50E-01	4.00E-00	5.84E-01	2.34E-00	2.20E-00	8.79E-00	7.69E-01	3.08E-00

BW(kg) Raccoon = 3 per Rod Stafford (GEPD), September 1999.
BW(kg) Short-tailed shrew = 0.015 per Sample, Opresko, and Suter (1996), Table B.1.
BW(kg) Mink = 1 per Sample, Opresko, and Suter (1996), Table B.1.

Table 8-12. Derivation of LOAEL Toxicity Reference Values for Bird Receptors

Ecological Constituent of Potential Concern	Test Species	Test Species Body Weight BW_t (kg)	TRV_t (mg/kgBW/d)	American Robin		Green Heron	
				Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^0$	TRV (mg/kgBW/d) $TRV_t \times BW_{conv}$	Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^0$	TRV (mg/kgBW/d) $TRV_t \times BW_{conv}$
INORGANICS							
Cadmium	Mallard duck	1.15E-00	2.00E+01	1.00E-00	2.00E+01	1.00E-00	2.00E+01
Chromium	Black duck	1.25E-00	5.00E-00	1.00E-00	5.00E-00	1.00E-00	5.00E-00
Lead	Quail	1.50E-01	1.13E+01	1.00E-00	1.13E+01	1.00E-00	1.13E+01
Mercury	Quail	1.50E-01	9.00E-01	1.00E-00	9.00E-01	1.00E-00	9.00E-01
ORGANICS							
Volatile Organic Compounds							
Acetone	None	None	No TRV	None	None	None	None
Chloroethane	None	None	No TRV	None	None	None	None
Chloromethane	None	None	No TRV	None	None	None	None
Methylene chloride	None	None	No TRV	None	None	None	None
Vinyl chloride	None	None	No TRV	None	None	None	None
Semivolatile Organic Compounds							
Benzo(*b*)fluoranthene	Composite bird	8.50E-01	1.24E+02	1.00E-00	1.24E+02	1.00E-00	1.24E+02
Pesticides/PCBs							
4,4'-DDE	Brown pelican	3.50E-00	2.80E-02	1.00E-00	2.80E-02	1.00E-00	2.80E-02

BW(kg) American robin = 0.077 (Sample, Opresko, and Suter 1996;,Table B.1).
BW(kg) Green heron = 0.241 (Birds of North America, No. 129, 1994).

10.0. RESULTS OF THE RCRA FACILITY INVESTIGATION AT THE 16 SWMUS RESULTING IN RECOMMENDATION OF FURTHER INVESTIGATION OR A CAP

INDEX OF SITES RECOMMENDED FOR FURTHER INVESTIGATION OR A CAP

The following table provides an index of the sites contained in the 16 SWMUs for which further investigation or a CAP is recommended. Fort Stewart respectfully requests that the Installation's RCRA Subpart B permit be amended to annotate the revised status of these SWMUs, if approved by GEPD.

Section Number	SWMU Number and Designation	SWMU Name on Hazardous Waste Permit HW-045
10.1	2	Camp Oliver Landfill
10.2	3	TAC-X Landfill
10.3	9	Inactive EOD Area in Red Cloud Range, Hotel Area
10.4	10	Inactive EOD Area North of Garrison Area
10.5	11	Inactive EOD Area Located Approximately Three Miles Northeast of Garrison Area
10.6	12A	Active EOD Containing Open Detonation Unit and Open Burn Unit
10.7	18	Industrial Wastewater Treatment Plant
10.8	24B	Old Radiator Shop/Paint Booth
10.9	27F (Northwest of Building 1340)	3d Engineer Brigade Motorpool and Associated Two Oil/Water Separators
10.10	27H (Building 1056)	DOL Maintenance Motorpool and Associated Two Oil/Water Separators
10.11	27H (Building 1071)	DOL Maintenance Motorpool and Associated Two Oil/Water Separators
10.12	27J (Building 10531)	GANG MATES Motorpool and Associated Two Oil/Water Separators
10.13	27L	NGTC Block 10200 Wash Rack and Oil/Water Separator
10.14	27T	293 MP Company Wash Rack and Oil/Water Separator
10.15	29	Evans Army Heliport POL Storage Facility

10.2 SWMU 3: TAC-X LANDFILL

10.2.1 History and Description of SWMU 3, TAC-X Landfill

The TAC-X Landfill is located about 1.25 miles south of the northern Fort Stewart boundary, approximately 3.5 miles south-southwest of Pembroke, Georgia, and less than 1 mile southeast of Dean Field and the TAC-X (Noncommissioned Officers' Academy). The site is accessed by a 0.1-mile unpaved road on the southwestern side of Fort Stewart 42. The TAC-X Landfill comprises approximately 5 acres, with two trenchlike depressions present at the site. One of the trenches was reportedly unused. The reported dimensions of the disposal trench are 20 feet wide by 400 feet long by 5 feet to 6 feet deep. A site reconnaissance in November 1993 observed household-type debris (e.g., plastic spoons and bags) within the overburden pile on the western side of the disposal trench. Aged refuse is reported to be present at the bottom of the disposal trench (Geraghty and Miller 1992). A site reconnaissance in September 1996 indicated no evidence of any landfill operations. The site is nearly flat, but slopes gently toward the south. Pine trees, brush, and grass cover most of the site. The southernmost portion of the site is marshy, with surface water present.

The TAC-X Landfill was active from the 1960s until 1982. The waste disposed of at the landfill from the 1960s to 1979 included residential waste, food cans, brush, plastic, and cardboard boxes. From 1979 to 1982, the wastes included grass clippings, tree branches, root stumps, and chunks of asphalt and concrete.

The investigations that have been performed at SWMU 3 are summarized below in sequential order.

10.2.1.1 1980 Investigation

USACE installed four monitoring wells (TX-M1 through TX-M4) (Figure 10.2-1) in 1980. Groundwater and surface water samples were collected in 1980.

Groundwater. Iron was detected at concentrations that exceeded the drinking water standard of 0.3 mg/L.

Surface Water. Chemical data from the site indicated that the surface water in the area was not being significantly degraded by the results of past operation of the landfill. Iron concentrations in the surface water near the landfill were reported as high; however, concentrations of iron near background values were reported a short distance from the landfill.

10.2.1.2 1982 Investigation

Four soil borings (TX-B1 through TX-B4) were installed to a depth of 50 feet, and one soil boring (TX-B5) was installed to a depth of 100 feet during a 1982 Environmental Science and Engineering study. Subsurface soil samples were collected for analysis of geotechnical parameters. No samples were submitted for analysis of analytical parameters.

10.2.1.3 1993 Phase I RCRA Facility Investigation

In 1993, as part of the Phase I RFI, one surface soil sample was collected from a location near the southern end of the marshy area and analyzed for VOCs, total RCRA metals, and pesticides/PCBs. Groundwater samples were collected from four monitoring wells using non-low-flow techniques.

Groundwater was analyzed for VOCs, total RCRA metals, and pesticides/PCBs. Due to drought conditions, a surface water sample was not collected from the marshy area. Analytical results for the Phase I RFI are presented in Table 10.2-1. Groundwater and surface water sampling locations are presented in Figure 10.2-1.

Surface Soil

VOCs. Concentrations of VOCs were not reported above the detection limits in the surface soil sample.

Pesticides. Pesticides were not reported above the detection limits in the surface soil sample.

RCRA Metals. Arsenic and lead were detected above reference background criteria in the surface soil sample. Arsenic and lead were detected at concentrations of 24.0 mg/kg and 73.97 mg/kg, respectively. Arsenic and lead are SRCs in surface soil based upon the Phase I RFI.

Groundwater

VOCs. 2-Butanone was detected in groundwater (13.0 μg/L) in monitoring well TX-M3. Toluene was detected (6.7 μg/L) in the duplicate groundwater sample from monitoring well TX-M1 (the background well), but the concentration was below its respective MCL.

RCRA Metals. Lead was detected in monitoring well TX-M3 above the reference background criterion. Lead was not detected above its EPA action level. Non-low-flow techniques were used to collect the groundwater samples, and the elevated lead concentration may be due to particulates in groundwater; therefore, the metal data from the Phase I RFI were not used in evaluating SWMU 3.

Pesticides/PCBs. Concentrations of pesticides/PCBs were not reported above the detection limit in the groundwater samples.

10.2.2 Summary of Phase II RCRA Facility Investigation Activities

Initial screening consisted of using DPT techniques to collect groundwater samples from each of six Geoprobe borings for VOC analysis. The results of the Geoprobe screening at locations GP1, GP2, and GP3 were used to determine the presence of and to characterize any leachate. A vertical-profile boring, VP1, was installed in the center of the landfill to determine the vertical extent of groundwater contamination, and groundwater samples were collected at 10-foot intervals and analyzed for VOCs.

Originally, three soil borings and one background well were installed at the site. Boring logs and monitoring well diagrams are presented in Appendices A and B, respectively. During redevelopment of existing wells, it was determined that the screened interval was below the water table. Three additional monitoring wells were installed near existing wells at the water table. A surface soil sample and a subsurface soil sample were collected from each boring/well. In addition, three surface soil samples were collected from within the trenches of the landfill. All surface and subsurface soil samples were analyzed for VOCs, SVOCs, pesticides/PCBs, and RCRA metals. Phase II RFI sampling locations are presented in Figure 10.2-1.

Four monitoring wells were installed at the site during the Phase II RFI activities. Monitoring well construction details for the Phase II RFI wells are presented in Table 10.2-2. Geotechnical samples were collected from the four monitoring well boreholes, and the results are presented in Table 10.2-3.

Monitoring well MW5 was installed upgradient of the site as a new background well. Sounding with a tape indicated that the total well depths of MW1, MW2, MW3, and MW4 were 49.2 feet, 28.02 feet, 48.01 feet, and 47.88 feet bgs, respectively. Existing wells MW2, MW3, and MW4 were not screened across the water table, so new wells (MW6, MW7, and MW8) were installed adjacent to the old wells in accordance with guidance from GEPD, DPW, and USACE. All new and existing monitoring wells were developed until the turbidity was less than 10 NTUs. Monitoring well development data are presented in Table 10.2-4. In addition, groundwater samples were collected from three hand-auger holes (GP4, GP5, and GP6) located in the depression area downgradient of the trenches. The groundwater samples collected from the eight monitoring wells and three hand-auger locations were analyzed for VOCs, SVOCs, pesticides/PCBs, and RCRA metals. In addition, dissolved RCRA metals analysis was performed on the groundwater samples collected at GP4, GP5, and GP6 locations. Conductivity, temperature, pH, DO, Redox, and turbidity were measured in the field during sampling, and the results are presented in Table 10.2-5.

Two surface water samples and two sediment samples were collected from the depression area into which the two trenches drain. No upstream locations were available at the site for sampling. The surface water and sediment samples were analyzed for VOCs, SVOCs, pesticides/PCBs, and RCRA metals. One of the sediment locations (SWS1) was resampled for VOCs only on November 30, 1999, to confirm or deny the elevated concentrations of VOCs.

10.2.3 Physical Characteristics of the Site

10.2.3.1 Topography

There are approximately 6 feet of relief across the site. The elevation is approximately 73 feet amsl along the northern boundary and slopes gently to approximately 67 feet amsl along the southern boundary. Two disposal trenches run approximately north to south, terminating in a small, swampy depression. Standing water can accumulate in the depression after rainfall events and was present during the investigation. Soil from the trenches is mounded along their sides. The site is heavily forested.

10.2.3.2 Surface drainage

The surface drainage at the site flows to the swampy depression along the south/southwestern boundary of the site. The trenches on-site also drain to the swampy depression. The swampy area ultimately makes its way to Canoochee River.

10.2.3.3 Soils

The soils present across the site consist of alternating layers of sand and clayey sands, as indicated in cross sections A-A′ and B-B′ (Figures 10.2-2 and 10.2-3, respectively).

10.2.3.4 Hydrogeology

Groundwater was encountered at approximately 5 feet bgs along the northern boundary of the site at SB1 to approximately 12 feet bgs along the southern boundary. The shallow groundwater flow direction across the site is to the south-southwest toward the swampy depression area, and the hydraulic gradient is 0.0093 foot/foot (Figure 10.2-4). The deep groundwater flow direction across the site is also to the south-southeast, and the hydraulic gradient is 0.002 foot/foot (Figure 10.2-5).

10.2.3.5 Ecology

As stated in Section 8.2, the habitats at SWMU 3 are classified as "forestlands" consisting mainly of well-spaced, mature pine and aquatic habitats. The surrounding forest is mixed pine–hardwood and much denser, with a thick understory. Just south of the old trench area is a wetland, or ephemeral pond, with tannic water exceeding 1 foot in depth at many places. Sediments in this area are soft and organic. Aquatic flora occurs along the old trenches and at the mouth of the wetland area.

In addition to the expected terrestrial fauna, this SWMU holds the potential for a diverse herpetile community due to the presence of the wetland area. No amphibians or reptiles were observed during the investigation; however, field observations were made prior to the breeding season of most amphibians.

The preliminary assessment endpoints, ecological receptors, and surrogate species representative of those receptors selected for evaluation in the preliminary risk calculation are described in Section 8.2.

10.2.4 Nature and Extent of Contamination

10.2.4.1 Surface soil

Ten surface soil samples were collected from three soil borings, four monitoring wells, and three surface soil locations. The surface soil samples were analyzed for VOCs, SVOCs, pesticides/PCBs, and RCRA metals. The results of the surface soil analyses are presented in Table 10.2-6 and Figure 10.2-6.

VOCs. No VOCs were detected in surface soil.

SVOCs. Bis(2-ethylhexyl)phthalate was detected at MW6 at a concentration 0.248 mg/kg; therefore, it is considered to be a potential SRC. Because bis(2-ethylhexyl)phthalate was detected in a single surface soil sample located off to the side of the SWMU boundary and approximately 340 feet from the disposal trenches and at a concentration near its detection limit, the SWMU may not be the source of the bis(2-ethylhexyl)phthalate.

Pesticides/PCBs. Four pesticides [alpha-BHC, gamma-BHC (lindane), heptachlor epoxide, and methoxychlor] were detected in two surface soil samples (SS1 and SS3) above site reference background criteria and, therefore, are considered to be SRCs in surface soil. No PCBs were detected in surface soil.

RCRA Metals. Only chromium was detected above the reference background criterion in one sample (SB1) at a concentration of 7.8 mg/kg.

10.2.4.2 Subsurface soil

Seven subsurface soil samples were collected from three soil borings and four monitoring wells. The subsurface soil samples were analyzed for VOCs, SVOCs, pesticides/PCBs, and RCRA metals. The results of the subsurface soil analyses are presented in Table 10.2-7 and Figure 10.2-7.

VOCs. Only two VOCs were detected at SWMU 3. Acetone and 2-butanone were detected in SB1 at concentrations of 0.0932 mg/kg and 0.0044 mg/kg, respectively. 2-Butanone and acetone are considered to be SRCs in subsurface soil.

SVOCs. Bis(2-ethylhexyl)phthalate was detected at MW8 at a concentration 0.387 mg/kg; therefore, it is considered to be an SRC. However, because it was detected in only one sample and not found in the trench area, bis(2-ethylhexyl)phthalate is probably not site-related.

Pesticides/PCBs. 4,4'-DDE, aldrin, and methoxychlor were detected at one sample location (SB1) at concentrations of 0.00064 mg/kg, 0.00061 mg/kg, and 0.0048 mg/kg, respectively, and are considered to be SRCs in subsurface soil. No PCBs were detected in subsurface soil.

RCRA Metals. Cadmium and chromium were detected above the reference background criteria in one sample (MW6) and, therefore, are considered to be SRCs in subsurface soil. The concentration of cadmium (0.25 mg/kg) was scarcely higher than its reference background criterion of 0.24 mg/kg, so it is not considered to be site-related. Chromium was detected at one sample location at a concentration two times its respective reference background concentration.

10.2.4.3 Groundwater

Groundwater grab samples were collected from three DPT locations and one vertical-profile location and were analyzed for VOCs. Groundwater samples were subsequently collected from three DPT locations and eight monitoring wells for more detailed analyses for VOCs, SVOCs, pesticides/PCBs, and RCRA metals. The results of the groundwater analyses are presented in Table 10.2-8 and Figure 10.2-8.

VOCs: Groundwater Screening Results (GP1, GP2, GP3, and VP1). Acetone was detected in two of the samples obtained from the vertical-profile boring at concentrations of 264 μg/L (10 feet to 20 feet) and 59.9 μg/L (20 feet to 30 feet); therefore, acetone is considered to be an SRC in groundwater.

VOCs: Hand-auger Samples from Site Depression (GP4, GP5, and GP6). No VOCs were detected in groundwater samples collected from hand-augered samples collected at SWMU 3.

VOCs: Monitoring Wells (MW4, MW5, MW6, MW7, and MW8). 2-Hexanone was detected at MW6 at a concentration of 5.6 μg/L; therefore, 2-hexanone is considered to be an SRC in groundwater for SWMU 3.

SVOCs. No SVOCs were detected in groundwater.

Pesticides/PCBs: Hand-auger Samples from Site Depression (GP4, GP5, and GP6). 4,4'-DDT; beta-BHC; and delta-BHC were detected in groundwater from GP4 at concentrations of 0.025 μg/L, 0.016 μg/L, and 0.082 μg/L, respectively. In addition, delta-BHC was detected at GP5 and GP6 at concentrations of 0.033 μg/L and 0.024 μg/L, respectively. Pesticides were detected in only the groundwater samples obtained using a hand auger in the swampy area along the southern boundary, which potentially receives runoff from adjacent areas. 4,4'-DDT; beta-BHC; and delta-BHC are SRCs in groundwater.

Pesticides/PCBs: Monitoring Wells (MW4, MW5, MW6, MW7, and MW8). No pesticides/PCBs were detected in groundwater obtained from the monitoring wells.

RCRA Metals: Hand-auger Samples from Site Depression (GP4, GP5, and GP6). Groundwater samples collected from the hand-auger borings were turbid; therefore, a filtered fraction was also collected. Barium and cadmium were detected above reference background criteria at concentrations of 92.3 μg/L and 0.82 μg/L, respectively, at GP4; however, the respective filtered concentrations were

below the reference background criteria. Chromium and lead were detected above reference background criteria in both GP4 and GP5. The chromium concentrations were 6.8 μg/L and 5.8 μg/L in GP4 and GP5, respectively. The lead concentrations were 11.1 μg/L and 6.6 μg/L in GP4 and GP5, respectively. Neither compound was detected in the filtered fraction from GP4 or GP5. Mercury was detected above the reference background criterion in GP5 at a concentration of 0.46 μg/L, but was below the reference background criterion in the filtered fraction. All detections from GP6 were below the reference background criteria. Barium, cadmium, chromium, lead, and mercury are considered to be SRCs from the hand-auger samples.

RCRA Metals: Monitoring Wells (MW4, MW5, MW6, MW7, and MW8). Groundwater was collected from the monitoring wells using low-flow sampling techniques. Barium, chromium, lead, and mercury were detected in groundwater; however, only mercury was detected above the reference background criterion. Mercury concentrations above the reference background criterion (0.14 μg/L) were identified in MW3 and MW4 at 0.15 μg/L and 0.16 μg/L, respectively. These two concentrations are only slightly above the reference background criterion and are within the normal distribution of the mercury background concentration. None of the concentrations were above MCLs. Mercury is considered to be an SRC in groundwater from monitoring wells.

10.2.4.4 Surface water

Surface water samples were collected in the swampy area along the southern boundary of SWMU 3. Because both SWS1 and SWS2 are downgradient sampling locations, the site reference background criteria for surface water (SWS1) were taken from the Phase II RFI for the 724th Tanker Purging Station (SWMU 26). Although the background surface water sample (SWS1) from SWMU 26 is upgradient of the garrison area in Mill Creek, it is an appropriate background sample for the creek flowing past the TAC-X Landfill for the following reasons: (1) the regional proximity of the creeks and (2) the fact that the creeks in this area (i.e., Mill, Taylors, and Horse) are chemically similar due to similar climate, vegetation, underlying geology, etc. The results of the surface water analyses are presented in Table 10.2-9 and Figure 10.2-9.

VOCs. No VOCs were detected in surface water.

SVOCs. Benzo(*b*)fluoranthene was detected in SWS1 at a concentration of 6.6 μg/L; therefore, benzo(*b*)fluoranthene is an SRC for surface water.

RCRA Metals. Arsenic, barium, chromium, and lead were detected in surface water at concentrations above reference background criteria (taken from SWS1 at SWMU 26) and are considered to be SRCs for the site. Arsenic, barium, and lead were detected at SWS2 at 7.3 μg/L, 59.6 μg/L, and 9 μg/L, respectively. Chromium was detected at SWS1 and SWS2 at concentrations of 0.62 μg/L and 13.9 μg/L respectively. Therefore, arsenic, barium, chromium, and lead are considered to be SRCs in surface water.

10.2.4.5 Sediment

Sediment samples were collected in the swampy area along the southern boundary of the site. Both SWS1 and SWS2 are downgradient sampling locations; therefore, the results from sediment sample (SWS1) collected during the Phase II RFI for the 724th Tanker Purging Station (SWMU 26) were used for the site reference background criteria. The background surface water sample (SWS1) from SWMU 26 is upgradient of the garrison area in Mill Creek and is an appropriate background sample for the creek flowing past the TAC-X Landfill for the following reasons: (1) the regional proximity of the creeks and

(2) the fact that the creeks in the area (i.e., Mill, Taylors, and Horse) are chemically similar due to similar climate, vegetation, underlying geology, etc. The results of the sediment analyses are presented in Table 10.2-10 and Figure 10.2-9.

VOCs. Acetone and methylene chloride were detected in sediment at SWS1 collected January 17, 1998, at concentrations of 7.7 mg/kg and 6.49 mg/kg, respectively. The concentrations of acetone and methylene chloride at SWS1 collected on January 17, 1998, were believed to be the result of field or laboratory contamination because no acetone or methylene chloride was indicated in the associated surface water samples. The SWS1 location was resampled on November 11, 1999. Acetone was detected at a concentration of 0.618 mg/kg, and methylene chloride was not detected in the resampled sediment, indicating that the elevated levels of acetone and methylene chloride were probably the result of field or laboratory contamination. In addition, carbon disulfide, 2-butanone, benzene, toluene, and 2-hexanone were detected in the sediment sample collected November 11, 1999, at concentrations of 0.006 mg/kg, 0.495 mg/kg, 0.0033 mg/kg, 0.212 mg/kg, and 0.0034 mg/kg, respectively. Methylene chloride was not considered to be an SRC in sediment. Acetone, carbon disulfide, 2-butanone, benzene, toluene, and 2-hexanone are considered to be SRCs in sediment.

SVOCs. No SVOCs were detected in the sediment.

Pesticides/PCBs. No pesticides/PCBs were detected in the sediment.

RCRA Metals. Arsenic, barium, chromium, lead, mercury, and selenium were detected in the sediment at SWS1 at concentrations greater than the reference background criteria (taken from SWS1 at SWMU 26) and, therefore, are considered to be SRCs. Arsenic, barium, lead, mercury, and selenium were detected at SWS1 at concentrations of 29.7 mg/kg, 60 mg/kg, 14.7 mg/kg, 0.08 mg/kg, and 2.6 mg/kg, respectively. Only chromium was detected above the reference background criterion at both sediment locations. Chromium was detected at concentrations of 23.3 mg/kg and 1.2 mg/kg at SWS1 and SWS2, respectively. The SWS1 sediment sample had significantly higher concentrations of metals than the SWS2 sample, even exceeding the reference background concentrations for surface and subsurface soils.

10.2.4.6 Site-related contaminant summary

Table 10.2-10 presents a summary of the SRCs for the site.

10.2.5 Fate and Transport Considerations

This section presents the site-specific components of the CSM developed for SWMU 3 and describes the contaminant release mechanisms through the primary transport medium (groundwater). This section also discusses the fate and transport of contaminants at the site with respect to their leachability and natural attenuation. This section is a site-specific extension for SWMU 3 of Chapter 6.0, which presents a general discussion on the contaminant fate and transport for the 16 SWMUs.

10.2.5.1 Conceptual Site Model

Water Balance Components

The annual average water balance estimates for SWMU 3 indicate that evapotranspiration accounts for 65 percent (31.2 inches) of total precipitation (48 inches). Consequently, 35 percent (16.8 inches) of the

total annual precipitation is available for flow. Groundwater recharge accounts for 34.2 percent (16.42 inches) of the total precipitation, while surface runoff accounts for the remaining 0.79 percent (0.38 inch) of the total. The water balance estimations were based on the HELP model (EPA 1994b) calculations for an uncapped landfill cell, using precipitation and temperature data for the years 1974 through 1978 at Savannah, Georgia.

Contaminant Release and Migration Pathways

Past and present contaminant migration pathways include those listed below.

- Rainwater percolating through contaminated buried materials/debris and soil below the site leached and transported contaminants to the water table.
- Buried material degraded and leached contaminants to adjacent soil and groundwater.
- Runoff from exposed material and surface contaminants migrated to surface water in the adjacent swamp and then toward the tributary to Canoochee River.
- Fluctuating groundwater levels contacted contaminated buried material or soil and distributed contaminants in the soil at the water table interface.
- Groundwater flow transported contaminants within the water table aquifer to the adjacent swamp and then toward the tributary to Canoochee River.

Additional current pathways might include the two described below.

- Organic compounds in groundwater and probably in soil are being biologically degraded.
- Organic compounds in soil and probably in groundwater are being volatized.

The most likely pathways of contaminant migration at SWMU 3 are (1) groundwater flow to the swamp located adjacent to the site and (2) overland flow to the adjacent swamp.

In the saturated zone, the contaminants are carried laterally either in solution or sorbed to fine particulates (colloids) to the hypothetical receptor locations. Groundwater velocity is a function of hydraulic conductivity, hydraulic gradient, and effective porosity of soil. The horizontal hydraulic conductivity is estimated to be 2.85E-04 centimeters per second (295 feet/year), assuming that horizontal permeability is 10 times greater than the measured vertical permeability in the laboratory sample. The average hydraulic gradient for the site was calculated to be 0.0093 foot/foot. Assuming an effective porosity of 0.16 [based on specific yield of sandy clay (Mills et. al 1985)], the groundwater velocity was calculated to be approximately 17.14 feet/year toward the swamp next to the site. The swamp drains to the southeast for approximately 0.5 mile, at which point the water enters an unnamed tributary. This unnamed tributary flows to the southeast for approximately 5 miles, at which point it enters Canoochee River. The hydraulic gradient for deep groundwater was calculated to be 0.002 foot/foot. Using the hydraulic conductivity and the effective porosity mentioned above, the deep groundwater velocity was calculated to be 3.68 feet/year toward the Canoochee River, which is approximately 10,000 feet away from SWMU 3.

10.2.5.2 Fate and transport analysis

Results of Soil Leachability Analysis

The site characterization data identified organic and inorganic SRCs in soil, sediment, groundwater, and surface water. Four metals exceeded their reference background criteria in soil; however, none of these metals exceeded their GSSLs based on leaching to groundwater (Table 10.2-11). None of the VOCs, SVOCs, or pesticides exceeded their respective GSSLs (Table 10.2-11). Based on leaching to groundwater, there are no CMCOPCs in soil.

Sediment and surface water samples were collected from the swamp adjacent to the site. Of the SRCs identified in sediment, only arsenic, at a concentration of 29.7 mg/kg, slightly exceeded its GSSL of 29 mg/kg (Table 10.2-12). Arsenic was detected in surface water; however, the surface water concentration (0.0073 mg/L) did not exceed its MCL (0.05 mg/L). Arsenic was evaluated as an HHCOPC in sediment (see Attachment 10.2A). Arsenic was not detected in groundwater. Arsenic in sediment is not considered to be a CMCOPC based on leaching to groundwater.

10.2.6 Human Health Preliminary Risk Evaluation of SWMU 3

SRCs were identified for the following media: sediment, surface soil, subsurface soil, groundwater, and surface water. Evaluation of the potential risks resulting from exposure to these constituents and the identification of HHCOPCs are addressed in this section.

10.2.6.1 Exposure evaluation

The exposure evaluation addresses what human receptor populations, both on-site and off-site, might be exposed to contaminants present at the site. The exposure evaluation also addresses how contaminants might migrate and the potential exposure pathways for the various receptors.

Receptor Assessment

The landfill is currently inactive and is covered by heavy vegetation. The landfill is located outside the garrison area near an active training area. However, training activities do not take place on the landfill. Given its location, very few non-military individuals are likely to enter the site; therefore, on-site occupational receptors do not represent a viable exposure population; however, hunters and juvenile trespassers might cross the area. Off-site receptors would include military personnel training near the site.

Potential off-site receptors include recreational users and military personnel training in the area. Recreational users include hunters and juveniles hiking in the area.

The potential receptors include the following:

- hunters,
- juvenile trespassers, and
- off-site occupational receptors.

Migration and Exposure Pathway Analysis

Potential migration pathways for soils include leaching into groundwater, volatilization, soil runoff, and potential bioaccumulation of contaminants into game species. Runoff from the site collects in a marshy area located at the southern end of the landfill.

The site is currently vegetated; therefore, migration of contaminants via fugitive dust is not a viable migration pathway. The vegetation might serve as a source of food for wildlife. Bioaccumulation of contaminants into forage consumed by wildlife might result in bioaccumulation of contaminants into the tissue of game animals.

The marshy area is not likely to be used for recreational purposes (e.g., fishing or swimming); however, juveniles might play along the edge of the marshy area.

The migration and exposure pathways are shown in Figure 10.2-9. The on-site resident scenario is not considered to be a viable scenario for this site; however, in accordance with RBCA guidance, it is used to derive screening values. The exposure pathways associated with this scenario are presented to show what pathways would be associated with an on-site resident exposure scenario.

10.2.6.2 Risk evaluation

The results of the human health risk screening are given below.

SRCs for surface soils included four pesticides (alpha- and gamma-BHC, heptachlor epoxide, and methoxychlor), bis(2-ethylhexyl)phthalate, and three metals (arsenic, chromium, and lead). Arsenic was the only compound that exceeded its risk-based screening value for direct exposure (i.e., ingestion) (Table 10.2-13). The maximum concentration of arsenic [24 mg/kg (Phase I RFI data)] was above the screening value of 0.43 mg/kg; therefore, arsenic is an HHCOPC in surface soil.

SRCs for subsurface soils included two volatile organics, three pesticides (4,4'-DDE, aldrin, and methoxychlor), bis(2-ethylhexyl)phthalate, and two metals (cadmium and chromium). None of the maximum concentrations of the SRCs exceeded their respective screening values for soil ingestion (Table 10.2-13); therefore, there are no HHCOPCs in subsurface soils.

SRCs for groundwater included two volatile organics, three pesticides (beta- and delta-BHC and 4,4'-DDT), and five metals. The maximum concentrations of delta-BHC and mercury exceeded their screening values (Table 10.2-13). The concentrations of the remaining SRCs were below their respective screening values.

Delta-BHC had a maximum concentration of 0.082 μg/L as compared to a screening value of 0.037 μg/L. Mercury had a maximum concentration of 0.46 μg/L as compared to a screening value of 0.37 μg/L; therefore, delta-BHC and mercury are HHCOPCs in groundwater.

SRCs for surface water included four metals (arsenic, barium, chromium, and lead) and benzo(*b*)fluoranthene. Arsenic, chromium, lead, and benzo(*b*)fluoranthene exceeded their AWQC screening values (Table 10.2-13). Arsenic had a maximum value of 7.3 μg/L compared to an AWQC screening value of 0.018 μg/L. The maximum concentration of benzo(*b*)fluoranthene was 6.6 μg/L, while the AWQC screening value was 0.0044 μg/L. Chromium had a maximum value of 13.9 μg/L, which is only slightly above its AWQC of 11 μg/L. Lead was detected at a maximum concentration of 9 μg/L, approximately seven times its respective AWQC.

Barium did not have an AWQC screening value, so the tap water screening value was used. The concentrations of this contaminant were below its screening value. Arsenic, chromium, lead, and benzo(*b*)fluoranthene are HHCOPCs for surface water.

Arsenic was the only SRC in sediment to exceed its screening value. The screening value is based on the assumption that sediment ingestion is similar, in frequency and quantity of material ingested, to surface soil exposure. However, exposure via inadvertent ingestion of sediment is unlikely given that the overlying water would probably wash the sediment off before ingestion would be likely to occur.

10.2.6.3 Uncertainties

The potential human health risks associated with 2-hexanone could not be evaluated. The contribution of this chemical to the potential risk of a receptor might or might not be significant. As a conservative measure, this chemical was included as a possible HHCOPC.

The screening value for technical BHC was used to evaluate concentrations of delta-BHC. Technical-grade BHC has a mixture of various isomers; therefore, the toxicity of technical BHC might be greater or less than that of delta-BHC. Additional human health uncertainties have been addressed in Section 7.5 of the HHPRE (Chapter 7.0).

10.2.7 Ecological Preliminary Risk Evaluation of SWMU 3

The EPRE was conducted in accordance with GEPD (1996) guidance (see Chapter 8.0). At sites where surface water, sediment, or groundwater was collected, an ESV comparison was conducted. If ECOPCs for aquatic biota were identified in surface water, sediment, or groundwater based on the ESV comparison (Step i), then further evaluation was required for those media. If no ECOPCs were identified based on the Step i screening of those media, then those ECOPCs were not considered further. At sites where surface soil was collected, substances detected in surface soil were evaluated in EPRE Steps ii through v because there are no ESVs for surface soil. The results of the five steps of the EPRE are presented below.

10.2.7.1 Ecological screening value comparison (Step i)

Four RCRA metals—arsenic, barium, chromium, and lead—were detected in surface water at concentrations exceeding their reference background criteria. One organic compound, benzo(*b*)fluoranthene, was detected in surface water. The results of the ESV comparison for surface water are presented in Table 10.2-14. The ECOPCs identified by the ESV comparison for surface water were barium, lead, and benzo(*b*)fluoranthene. There is no surface water ESV for benzo(*b*)fluoranthene, so it is an ECOPC by default (GEPD 1997a). Barium and lead were detected at concentrations exceeding their respective surface water ESVs and are considered to be potential ECOPCs for surface water.

Six VOCs and six RCRA metals were detected in sediment at concentrations exceeding the background criteria for sediment collected from Mill Creek off-post and upstream of Fort Stewart [from Mill Creek sample SWS1 collected under the Phase II RFI for the former Tanker Purging Facility (SWMU 26)]. The results of the ESV comparison for sediment are presented in Table 10.2-15. Two VOCs and three RCRA metals were identified as ECOPCs in sediment. Concentrations of acetone, carbon disulfide, and arsenic exceeded their respective sediment ESVs, so they are ECOPCs for sediment-dwelling invertebrates. Barium and selenium do not have ESVs for sediment, so they are ECOPCs by default (GEPD 1997a).

These five constituents are considered to be potential ECOPCs in sediment and were evaluated in the preliminary risk calculations for SWMU 3 receptors.

Five RCRA metals—barium, cadmium, chromium, lead, and mercury—were detected in groundwater at concentrations exceeding reference background criteria. Two VOCs and three pesticides were detected in groundwater. The maximum metal and pesticide concentrations were detected in the hand-auger-collected groundwater samples, GP4 and GP5, located in the site depression downgradient of the trenches. Only 2-hexanone and mercury were detected in groundwater from the monitoring wells. Mercury was detected at concentrations of 0.15 μg/L and 0.16 μg/L in MW3 and MW4, respectively, which are only slightly above the reference background criterion (0.14 μg/L). MW3 and MW4 are deep wells (total depth of each approximately 48 feet bgs) that were installed during the 1980 investigation. 2-Hexanone was detected at only MW6, a shallow groundwater monitoring well. The remaining VOC, acetone, was detected in VP1 at a depth of 10 feet to 20 feet bgs and 20 feet to 30 feet bgs at concentrations of 264 μg/L and 59.9 μg/L, respectively. The pesticides 4,4'-DDE; beta-BHC; and delta-BHC were detected in only the hand-auger-collected groundwater samples.

The results of the ESV comparison for groundwater are presented in Table 10.2-16. The ECOPCs identified by the ESV comparison for groundwater were 4,4'-DDT; delta-BHC; barium; cadmium; lead; and mercury. There is no ESV for delta-BHC, so it is an ECOPC by default (GEPD 1997a). The four RCRA metals and 4,4'-DDT exceeded their respective surface water ESVs and are considered to be potential ECOPCs.

Because there are no ESVs for soil, all analytes detected in soil were evaluated further in EPRE Steps ii through v.

10.2.7.2 Preliminary problem formulation (Step ii)

The ecological habitat is described in Section 10.2.3.5. The preliminary assessment endpoints, ecological receptors, and surrogate species representative of those receptors selected for evaluation in the preliminary risk calculation are described in Section 8.2.

10.2.7.3 Preliminary effects (Step iii)

In the EPRE, TRVs were required for shrews and robins ingesting contaminated biota exposed to surface soil at the site, for raccoons ingesting water, for mink and green herons ingesting aquatic biota, and for herons ingesting sediment-dwelling invertebrates. The derivation of TRVs is discussed in Section 8.3. The TRVs derived for shrews, raccoons, and mink are presented in Table 8-5, and TRVs for robins and green herons are presented in Table 8-6.

10.2.7.4 Preliminary exposure (Step iv)

The ecological receptors are probably exposed by ingestion of contaminated soil or biota exposed to contaminated soil, drinking water, aquatic biota exposed to surface water, or sediment-dwelling biota exposed to sediment. The exposure parameters for the surrogate species—shrews, raccoons, mink, green herons, and robins—are presented in Table 8-7.

10.2.7.5 Preliminary risk calculation (Step v)

The preliminary risk calculation (Step v) uses HQs, the ratios of the measured maximum concentrations and the TRVs, to evaluate the potential for risk. The HQs of ECOPCs with consistent modes of toxicity and effects endpoints are added to calculate an HI. Metals are assumed to have distinct modes of toxicity and effects endpoints; therefore, HIs are calculated for only VOCs and SVOCs when no individual ECOPC has an HQ greater than one and HQs are calculated for more than one chemical. ECOPCs with HQs and HIs less than one indicate little to no likelihood of risk to the ecological receptors. An ERA using site-specific data is indicated for those ECOPCs with calculated HQs or HIs exceeding one (GEPD 1996).

Surface Soil. The preliminary risk calculations for shrews and robins exposed to ECOPCs detected in surface soil are presented in Table 10.2-17. This table shows the maximum detected concentrations, ADDs, TRVs, and HQs for these receptors.

Chromium and lead are the only ECOPCs present in surface soil at concentrations resulting in ADDs exceeding the TRVs for the surrogate species. The lead HQ is 39.8 for the robin. The chromium HQ for the robin is 1.9. The HI calculated for bis(2-ethylhexyl)phthalate and pesticides/PCBs does not exceed one.

Surface Water. The preliminary risk calculations for raccoons, mink, and green herons exposed to ECOPCs detected in drinking water or surface water are presented in Table 10.2-18. This table shows the maximum detected concentrations, ADDs, TRVs, and HQs for the receptors. HQs exceeding one are shown bordered by a double line.

The only ECOPC present in surface water at a concentration resulting in ADDs exceeding the TRVs for the surrogate species is benzo(*b*)fluoranthene. The benzo(*b*)fluoranthene HQs are 4.3 and 2.7 for mink and green herons, respectively.

Sediment. The preliminary risk calculations for green herons exposed to ECOPCs detected in sediment are presented in Table 10.2-19. This table shows the maximum detected concentrations, ADDs, TRVs, and HQs for the receptors. There are no ECOPCs present in sediment at concentrations resulting in an ADD exceeding the TRV for the green heron. There are no green heron TRVs for the two VOCs (acetone and carbon disulfide), so these constituents could not be evaluated. In the discussion of uncertainties (see Section 10.2.7.6), these constituents are evaluated using the raccoon, which has TRVs.

Groundwater. The preliminary risk calculations for raccoons, mink, and green herons exposed to ECOPCs detected in groundwater are presented in Table 10.2-20. This table shows the maximum detected concentrations, ADDs, TRVs, and HQs for the receptors. HQs exceeding one are shown bordered by a double line.

The ECOPCs present in groundwater at maximum concentrations resulting in ADDs exceeding the TRVs for the surrogate species are 4,4'-DDT and mercury. These results are for shallow groundwater. The risk to mink and green herons from mercury in deep groundwater is discussed in Section 10.2.7.6. The 4,4'-DDT HQ is 58.3 for the green heron. The mink and the green heron have mercury HQs of 3.9 and 12.4, respectively. The pesticide/PCB HIs calculated for raccoons and mink do not exceed one. An HI was not calculated for RCRA metals in groundwater because they are assumed to have dissimilar mechanisms of toxicity.

10.2.7.6 Uncertainties

The risks to ecological receptors from ECOPCs in surface soil and groundwater at SWMU 3 are overestimated by the preliminary risk calculations (see Section 10.2.7.5). Although deep groundwater potentially discharges to the nearest surface water body (Canoochee River), the maximum concentration of mercury predicted to occur at discharge at a distance of 10,000 feet, the estimated distance to Canoochee River, using the shallow groundwater concentration (0.46 μg/L) is 0.00000018 μg/L (see Appendix K, Table K-6.1). This predicted concentration at discharge downgradient of SWMU 3 is well below the freshwater ESV for mercury (0.012 μg/L). Therefore, mercury in deep groundwater at SWMU 3 (as represented by samples from wells 03-MW1, 03-MW3, and 03-MW4) is unlikely to pose a risk to aquatic biota in downgradient surface water bodies.

The supplemental risk calculations for robins exposed to chromium and lead in surface soil are presented in Table 10.2-21. The ADDs calculated using a realistic diet (EPA 1993), the site-specific AUF, and mean soil concentrations of ECOPCs do not exceed LOAEL–based TRVs (HQs less than 1). Chromium and lead in surface soil at SWMU 3 are, therefore, unlikely to pose a risk to wildlife receptors.

The supplemental risk evaluations for mink and green herons exposed to the PAH benzo(*b*)fluoranthene in surface water are presented in Tables 10.2-22 and 10.2-23, respectively. The ADDs calculated using realistic diets (EPA 1993), the site-specific AUFs, and mean surface water concentrations do not exceed LOAEL–based TRVs (HQs less than 1). Benzo(*b*)fluoranthene in surface water at SWMU 3 is, therefore, unlikely to pose a risk to wildlife receptors.

The supplemental risk evaluations for raccoons exposed to acetone and carbon disulfide in sediment are presented in Table 10.2-24 because TRVs for these VOCs were not available for green herons. The ADDs calculated using a realistic diet (EPA 1993), the site-specific AUF, and mean sediment concentrations do not exceed LOAEL–based TRVs (HQs less than 1). Acetone and carbon disulfide in sediment at SWMU 3 are, therefore, unlikely to pose a risk to wildlife receptors.

The supplemental risk evaluations for mink and green herons exposed to mercury and 4,4'-DDT in groundwater potentially discharging to surface water in the adjacent marshy area or in downgradient surface water bodies are presented in Tables 10.2-25 and 10.2-26, respectively. These supplemental calculations use the mean of all groundwater sample concentrations for SWMU 3. The mink ADDs calculated using realistic diets (EPA 1993), the site-specific AUFs, and mean groundwater concentrations do not exceed the LOAEL–based TRVs (HQ less than 1). The green heron HQs for 4,4'-DDT and mercury are 6.7 and 2, respectively, assuming that the site-specific AUF is 1.

Mercury and 4,4'-DDT are unlikely to pose a risk to green herons for several reasons. An AUF of 1 overestimates green heron exposures both at the marshy area adjacent to SWMU 3 and at downgradient surface water bodies. Green herons are unlikely to obtain all their food from SWMU 3 or any given stretch of the Canoochee River given the abundance of suitable foraging habitats at Fort Stewart and its environs. If green herons obtain less than half their food from the marshy area at SWMU 3, then they will not be at risk from mercury in shallow groundwater. The maximum concentration of mercury predicted to occur at the Canoochee River, a distance of approximately 10,000 feet downgradient, is 1.8×10^{-7} μg/L (see Appendix K, Table K-6.1), which is many times less than the mean concentration (0.021 μg/L). The ODAST model was used to predict the groundwater concentration of mercury adjacent to Canoochee River. The ODAST input parameters are presented in Appendix K, Table K-5.2. Upon discharge and dilution in a downgradient surface water body, the concentration of mercury would probably not result in a risk quotient greater than 1 for the green heron.

Green herons are also not at risk from 4,4'-DDT in shallow groundwater at SWMU 3 if they obtain less than 15 percent of their diet from the marshy area, which is likely given the wide area over which green herons forage. Also, 4,4'-DDT has a high K_{ow} (log K_{ow} = 6.4), which indicates that 4,4'-DDT adsorbs strongly to organic matter. Thus, measured 4,4'-DDT levels in unfiltered shallow groundwater samples from the marshy area at SWMU 3 probably overestimate the risk of 4,4'-DDT to green herons. Green herons are unlikely to be at risk from 4,4'-DDT in shallow groundwater at SWMU 3.

Therefore, the ECOPCs in surface soil, surface water, sediment and shallow and deep groundwater at SWMU 3 are unlikely to pose a risk to wildlife receptors.

10.2.8 Conclusions and Risk Management and Site Recommendations for SWMU 3

10.2.8.1 Conclusions

Nature and Extent of Contamination

- The groundwater flow direction is toward the south/southwest, with an horizontal hydraulic gradient of 0.0093 foot/foot.

- Low, isolated concentrations of one SVOC [bis(2-ethylhexyl)phthalate] and four pesticides (alpha-BHC, gamma-BHC, heptachlor epoxide, and methoxychlor) were detected in surface soil. Arsenic, chromium, and lead were detected above reference background criteria in one of 10 surface soil samples.

- Low, isolated concentrations of two VOCs (2-butanone and acetone), one SVOC [bis(2-ethylhexyl)phthalate], and three pesticides (4,4'-DDE; aldrin; and methoxychlor) were detected in subsurface soil. Chromium and cadmium were detected at concentrations above reference background criteria in one (MW6) of seven subsurface soil samples.

- Low, isolated concentrations of acetone (a VOC) and three pesticides (4,4'-DDT; beta-BHC; and delta-BHC) were detected in groundwater collected from Geoprobe locations. Total concentrations of barium, cadmium, chromium, lead, and mercury were detected at concentrations above reference background criteria in groundwater collected from Geoprobe locations. However, corresponding dissolved metal concentrations for all five constituents were below reference background concentrations, indicating that the total metals might be associated with particulates in the groundwater.

- A low, isolated concentration of 2-hexanone (a VOC) was detected in groundwater collected from monitoring well MW6. Mercury was detected at concentrations (0.15 μg/L and 0.16 μg/L) slightly above the reference background criteria (0.14 μg/L) in two of eight groundwater samples collected from the monitoring wells.

- One SVOC [benzo(*b*)fluoranthene] was detected in surface water. Arsenic, barium, chromium, and lead were detected in surface water above reference background criteria.

- Seven VOCs (acetone, methylene chloride, 2-butanone, 2-hexanone, benzene, carbon disulfide, and toluene) were detected in sediment. Acetone and methylene chloride were initially detected at one of two sediment locations at concentrations of 7.7 mg/kg and 6.49 mg/kg, respectively. These elevated concentrations were believed to be the result of field and laboratory contamination, and the location

concentrations were believed to be the result of field and laboratory contamination, and the location was resampled. Acetone was detected at a concentration of 0.618 mg/kg and methylene chloride was not detected in the resampled sediment, indicating that the elevated levels of acetone and methylene chloride were probably the results of field or laboratory contamination. Methylene chloride is not considered to be an SRC in sediment. 2-Butanone, 2-hexanone, benzene, carbon disulfide, and toluene were detected in only the resampled sediment; therefore, 2-butanone, 2-hexanone, acetone, benzene, carbon disulfide, and toluene are considered to be SRCs in sediment.

- Arsenic, barium, chromium, lead, mercury, and selenium were detected in sediment above reference background criteria. Sediment samples from SWS1 had significantly higher concentrations than did those from SWS2.

Fate and Transport

- Based on the leachability analysis, there are no CMCOPCs in soil.

- The arsenic concentration (29.7 mg/kg) in sediment slightly exceeded its GSSL (29 mg/kg). Arsenic was detected in surface water above its respective reference background criterion; however, it did not exceed its MCL. Arsenic was not detected in groundwater. Arsenic is not considered to be a CMCOPC based on leaching to groundwater.

Human Health Preliminary Risk Evaluation

- Arsenic was the only chemical identified as a potential HHCOPC in surface soil.

- There are no HHCOPCs in subsurface soil for this site.

- Based on the human health screening, delta-BHC and mercury are potential HHCOPCs in groundwater.

- The maximum concentrations of benzo(*b*)fluoranthene and arsenic exceeded the human health criteria and AWQC for surface water. Chromium and lead exceeded their respective AWQC. Therefore, benzo(*b*)fluoranthene, arsenic, chromium, and lead are HHCOPCs for surface water.

- Arsenic was the only chemical identified as a potential HHCOPC in sediment.

Ecological Preliminary Risk Evaluation

- Barium, benzo(*b*)fluoranthene, and lead in surface water and arsenic, carbon disulfide, and acetone in sediment are potential hazards to aquatic biota in the ditch at SWMU 3 because these ECOPCs occur at levels that exceed EPA Region IV ESVs. There are no ESVs for barium and selenium for SWMU 3 sediment, so they are ECOPCs by default.

- With the exception of benzo(*b*)fluoranthene in surface water, none of the ADDs for wildlife receptors for the ECOPCs in surface water or sediments exceeded their respective TRVs. The HQs for benzo(*b*)fluoranthene for the mink and the green heron are 4.3 and 2.7, respectively. Heron TRVs are not available for acetone and carbon disulfide, so HQs could not be calculated for the green herons exposed to these ECOPCs in sediment. The supplemental risk calculations for mink and green herons exposed to benzo(*b*)fluoranthene in surface water and raccoons exposed to acetone

surface water and acetone and carbon disulfide in sediment are unlikely to pose a risk to wildlife receptors.

- Chromium and lead in surface soil at SWMU 3 are ECOPCs because preliminary HQs exceed 1. The supplemental risk calculations for chromium and lead result in HQs less than 1; therefore, chromium and lead in surface soil are unlikely to pose a risk to robins.

- Barium; cadmium; lead; mercury; 4,4'-DDT; and delta-BHC in shallow groundwater are ECOPCs for wetland biota because they are present at levels exceeding surface water ESVs. Amphibians dwelling or breeding in the marshy area adjacent to SWMU 3 may not be at risk if the concentrations of ECOPCs in unfiltered shallow groundwater samples overestimate dissolved concentrations at the surface.

- Mercury and 4,4'-DDT in shallow groundwater are ECOPCs for wildlife receptors because the preliminary HQs exceed 1. Based on the magnitude of HQs calculated in the supplemental risk calculations, mercury and 4,4'-DDT are unlikely to be potential hazards to wildlife receptors feeding in the marshy area adjacent to SWMU 3.

- Mercury in deep groundwater at SWMU 3 is an ECOPC for aquatic biota because it occurs at a level that exceeds the EPA Region IV surface water ESV. Mercury is unlikely to be a potential hazard to aquatic biota living in downgradient surface water bodies because the predicted maximum discharge concentration of mercury does not exceed the ESV.

- Mercury in deep groundwater at SWMU 3 is an ECOPC for wildlife receptors because the preliminary HQs exceed 1. Mercury is unlikely to be a potential hazard to wildlife receptors ingesting aquatic biota living in downgradient surface water bodies because the maximum predicted concentration at the discharge point is many times less than the mean groundwater concentration. In addition, the supplemental risk calculations using the mean groundwater concentration of mercury result in HQs less than 1 for the mink and 3.0 for the green heron.

10.2.8.2 Risk management and site recommendations

- There are no CMCOPCs in soil. Arsenic was detected in one of the two sediment samples, and its concentration slightly exceeded its GSSL. Arsenic was not detected in groundwater, and its maximum concentration in surface water did not exceed its MCL. Off-site migration of arsenic will be limited due to its high retardation factor. Arsenic in sediment is not expected to be a significant contributor (CMCOPC) of contaminants to groundwater and surface water and does not require further investigation and/or evaluation.

- HHCOPCs were identified in surface soils, groundwater, sediment, and surface water (see Section 10.2.8.1). Arsenic was identified as an HHCOPC in surface soil and sediment. Mercury and delta-BHC were identified as HHCOPCs in groundwater. Surface water COPCs included arsenic, chromium, lead, and benzo(*b*)fluoranthene. A human health baseline risk assessment was performed to address the risks associated with exposure to these HHCOPCs (see Attachment 10.2A). Current on-site receptor populations include an Installation worker, a juvenile trespasser, and a sportsman. However, due to the limited potential exposure of a sportsman from bioaccumulation, the sportsman was not assessed in the baseline risk assessment. Future on-site and off-site land-use populations include an Installation worker, a juvenile trespasser/wader, and a resident (adult and child). Arsenic was identified as an HHCOC in surface soil because it exceeded the target risk level for the on-site

was identified as an HHCOC in surface soil because it exceeded the target risk level for the on-site Installation workers (both current and future). Benzo(*a*)fluoranthene was identified as a COC in surface water (exceeded the target risk value) for the current and future on-site juvenile trespasser and the current and future off-site juvenile wader. The remaining constituents (chromium and lead in surface water, mercury and delta-BHC in groundwater, and arsenic in surface water and sediment) and their potential impact to receptors did not indicate significant risk above the target risk values. A remedial level was derived for arsenic in surface soil and benzo(*a*)fluoranthene in surface water. The recommended risk-based remedial level for arsenic in surface soil is 55.5 mg/kg. This concentration is greater than the maximum detected concentration of 24 mg/kg. Given that the maximum concentration of arsenic is below the recommended remedial value, no further action is required to address arsenic in surface soil. The maximum concentration of 0.0066 mg/L of benzo(*a*)fluoranthene in surface water was below the remedial level of 0.0505 mg/L; therefore, no further action is required for benzo(*a*)fluoranthene.

- Acetone, arsenic, barium, carbon disulfide, and selenium were identified as ECOPCs in sediment. However, preliminary and supplemental risk calculations resulted in HQs less than 1 for wildlife receptors. Therefore, ECOPCs in sediment are unlikely to pose a risk to wildlife receptors, and further investigation and/or evaluation is not required.

- Benzo(*b*)fluoranthene, barium, and lead were indicated as ECOPCs in surface water. Preliminary and supplemental risk calculations for mink and green herons exposed to ECOPCs in surface water result in HQs less than 1. Therefore, ECOPCs in surface water are unlikely to pose a risk to wildlife receptors, and further investigation and/or evaluation is not required.

- Chromium and lead were indicated as ECOPCs in surface soil at SWMU 3. However, supplemental risk calculations for chromium and lead resulted in HQs less than 1. Therefore, chromium and lead in surface soil are unlikely to pose a risk to robins, and further investigation and/or evaluation is not required.

- Barium; cadmium; lead; mercury; 4,4'-DDT; and delta-BHC in shallow groundwater are ECOPCs for wetland biota because they are present at levels exceeding surface water ESVs. The unfiltered shallow groundwater (hand-augered samples) overestimates the potential concentration (dissolved portion) of constituents in surface water. Therefore, the wetlands biota located in the marshy area are not at a significant risk from these constituents, and further investigation and/or evaluation is not required.

- Mercury and 4,4'-DDT in shallow groundwater are ECOPCs for wildlife receptors. Based on the magnitude of the HQs calculated in the supplemental risk calculations, mercury and 4,4'-DDT are unlikely to be potential hazards to wildlife receptors feeding in the marshy area adjacent to SWMU 3, and further investigation and/or evaluation is not required (see Section 10.2.7.6).

- Mercury in deep groundwater at SWMU 3 is an ECOPC for aquatic biota and wildlife receptors. Mercury is unlikely to be a potential hazard to aquatic biota living in downgradient surface water bodies because the predicted maximum discharge concentration of mercury after dilution does not exceed the ESV. Mercury is unlikely to be a potential hazard to wildlife receptors ingesting aquatic biota living in downgradient surface water bodies because the supplemental risk calculations using the mean groundwater concentration of mercury result in HQs less than 1 for mink and 3.0 for green herons using conservative exposure assumptions. Therefore, further investigation and/or evaluation of mercury in deep groundwater is not required.

- Based on information presented in this section, an NFA status is recommended for SWMU 3 regarding further investigation of the site. However, Fort Stewart recommends that a CAP proposing institutional controls (e.g., deed restrictions, land use restrictions) be prepared. It is anticipated that the CAP will be submitted to GEPD in the first fiscal quarter (October through December) of 2001. The potential abandonment or use of the monitoring wells will be evaluated in the CAP.

Table 10.2-1. Summary of Phase I RFI Results, SWMU 3

SURFACE SOIL		
Analyte	Reference Background Criteria	Sampling Location
		SS1
Metals (mg/kg)		
Arsenic	2.10	**24.0**
Barium	14.70	8.0
Lead	8.81	**73.97**

GROUNDWATER						
Analyte	Reference Background Criteria	Sampling Location				
		TX-M1[a]	TX-M1	TX-M2	TX-M3	TX-M4
Volatile Organic Compounds (µg/L)						
Toluene	0.00		**6.7**			
2-Butanone	0.00				**13.0**	
Metals (µg/L)						
Barium	71.72				60.0	
Lead	4.69				**6.0**	

[a]Site-specific background location.

Bold indicates concentrations above reference background criteria.

Table 10.2-2. Monitoring Well Construction Summary, SWMU 3

Well No.	Date Installed	Size/Type	Coordinates	Total Depth (feet)	Screen Interval (feet bgs)	Top of Filter Pack Elevation (feet bgs)	Top of Casing Elevation (feet)
03-MW5	1/16/98	2-inch PVC	N 761429.40 E 815833.51	13.0	2.2 to 12.2	1.0	76.03
03-MW6	1/27/98	2-inch PVC	N 760759.51 E 816010.77	14.0	4.0 to 14.0	3.0	74.36
03-MW7	1/27/98	2-inch PVC	N 760640.37 E 815695.57	14.0	4.0 to 14.0	3.0	70.46
03-MW8	1/27/98	2-inch PVC	N 760830.42 E 815498.23	15.0	3.0 to 12.98	1.0	70.42

Note: All elevations are NGVD 1929.

Table 10.2-3. Summary of Geotechnical Analyses, SWMU 3

Station	03-MW5	03-MW6	03-MW7	03-MW8
Sample ID	**031513**	**031613**	**031713**	**031813**
Depth (feet)	**5 to 7.5**	**14 to 16**	**6 to 8**	**5 to 7**
Moisture content (%)	12.8	21.6	17.3	19.3
Liquid limit	NP	NP	NP	NP
Plastic limit	NP	NP	NP	NP
Plasticity index	NP	NP	NP	NP
Gravel (%)	0	0	0	0
Sand (%)	94.8	98.7	98.5	98.3
Fines (%)	5.2	1.3	1.5	1.7
Specific gravity	2.65	2.63	NA	NA
Porosity	0.3	0.43	NA	NA
Permeability (cm/sec)	4.50E-05	1.20E-05	NA	NA
Total organic carbon[a]	615	NA	NA	NA

[a]Sample ID is 031512, collected at 3 feet to 5 feet bgs.
NA =Not analyzed.
NP = Non-plastic.

Table 10.2-4. Well Development Summary, SWMU 3

Well No.	Date	Total Development Time (hours)	Total Volume Removed (gallons)	Final Turbidity Reading (NTUs)	Total Well Depth (feet)
03-MW1	1/17/98	3 hours, 4 minutes	250	2.3	49.2
03-MW2	1/16/98	3 hours, 40 minutes	40	0.9	28.02
03-MW3	1/16/98	3 hours, 53 minutes	260	1.8	48.01
03-MW4	1/17/98	3 hours, 45 minutes	265	2.6	47.88
03-MW5	1/21/98	3 hours	150	6.8	14.88
03-MW6	1/29/98	1 hour	65	4.8	17.72
03-MW7	1/29/98	39 minutes	70	6.8	17.52
03-MW8	1/29/98	2 hours	205	8.0	15.77

Table 10.2-5. Field Parameter Measurements during Groundwater and Surface Water Sampling, SWMU 3

Parameter	pH (su)	Conductivity (mS/cm)	Temperature (°C)	Turbidity (NTUs)	DO (mg/L)	Redox (mV)
Groundwater						
03-MW1	5.26	52	19.0	2.1	3.40	2.8
03-MW2	5.02	29	17.28	9.3	8.33	40.2
03-MW3	5.08	41.00	16.81	2.0	NA	232.3
03-MW4	5.46	57	17.63	2.1	4.76	15.7
03-MW5[a]	5.07	52	15.78	19	1.29	386
03-MW6	4.81	52	16.26	6.0	6.79	48.6
03-MW7	4.88	18.0	14.89	24.7	NA	374.4
03-MW8	5.25	34	15.33	8.7	NA	306.0
Average[b]	5.11					
Surface Water						
03-SWS1	6.11	20	12.04	14.8	10.56	348
03-SWS2	5.97	20	11.34	21.9	10.44	334

[a]Site-specific background location.
[b]Site-specific background location not included in average.
NA = Not analyzed.

Table 10.2-6. Summary of Analytes Detected in Surface Soil, SWMU 3

Station	Reference Background Criteria	03-MW5[a]	03-MW6	03-MW7	03-MW8	03-SB1	03-SB2	03-SB3	03-SS1	03-SS2	03-SS3
Sample ID		031511	031611	031711	031811	031A11	031B11	031C11	037111	037211	037311
Date		01/16/98	01/27/98	01/27/98	01/27/98	01/16/98	01/16/98	01/16/98	01/16/98	01/16/98	01/16/98
Depth (feet)		0 to 2	0 to 1	0 to 1	0 to 1	0 to 2	0 to 2	0 to 2	0 to 1	0 to 1	0 to 1
Sample Type		Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab
Semivolatile Organic Compounds (mg/kg)											
Bis(2-ethylhexyl)phthalate	0.00		**0.248**								
Pesticides (mg/kg)											
alpha-BHC	0.00								**0.00047**		
gamma-BHC (Lindane)	0.00								**0.0012**		
Heptachlor epoxide	0.00								**0.00036**		**0.00054**
Methoxychlor	0.00										**0.0086**
Metals (mg/kg)											
Arsenic	2.10					1	0.69		0.71		0.37
Barium	14.70	7.1	6.4	3.5	5.4	11.3	6.2	4.3	6.7	6.2	4.8
Chromium	6.21	2.5	2.5	1.2	1	**7.8**	3.6	1.6	5.1	2.6	0.95
Lead	8.81	1.6	1.1	1.1	6.8	3.6	1.9	1.2	2.4	1.7	2.6
Mercury	0.03			0.03	0.03				0.02		
Selenium	0.41		0.23		0.19			0.21			

[a]Site-specific background location.
Bold indicates concentrations above reference background criteria.

Table 10.2-7. Summary of Analytes Detected in Subsurface Soil, SWMU 3

Station	Reference Background Criteria	03-MW5[a]	03-MW6	03-MW7	03-MW8	03-SB1	03-SB2	03-SB3
Sample ID		031512	031612	031712	031812	031A12	031B12	031C12
Date		01/16/98	01/27/98	01/27/98	01/27/98	01/16/98	01/16/98	01/16/98
Depth (feet)		3 to 5	4 to 6	4 to 6	3 to 5	3 to 5	3 to 5	3 to 5
Sample Type		Grab	Grab	Grab	Grab	Grab	Grab	Grab
Volatile Organic Compounds (mg/kg)								
2-Butanone	0.00					**0.0044**		
Acetone	0.00					**0.0932**		
Semivolatile Organic Compounds (mg/kg)								
Bis(2-ethylhexyl)phthalate	0.00				**0.387**			
Pesticides/PCBs (mg/kg)								
4,4'-DDE	0.00					**0.00064**		
Aldrin	0.00					**0.00061**		
Methoxychlor	0.00					**0.0048**		
Metals (mg/kg)								
Arsenic	8.04	2.8	3.8	1.2		1.1	0.55	
Barium	17.00	4.5	11	3.8	1.6	6.6	8.7	4.6
Cadmium	0.24		**0.25**	0.1				
Chromium	11.60	4.1	**25.5**	6.1	0.65	5.7	3.6	1.9
Lead	11.10	1.1	5.7	2.4	0.91	3	2	1.3
Mercury	0.05					0.05		
Selenium	1.12		0.68	0.2	0.17			

[a]Site-specific background location.

Bold indicates concentrations above reference background criteria.

Table 10.2-8. Summary of Analytes Detected in Groundwater, SWMU 3

Station	Reference Background Criteria	MCL	03-GP1	03-GP2	03-GP3	03-VP1	03-VP1	03-VP1	03-GP4[a]	03-GP4[a]	03-GP5[a]	03-GP5[a]
Sample ID			034151	034251	034351	034751	034752	034753	038411	F038411	038511	F038511
Date			01/16/98	01/16/98	01/16/98	02/01/98	02/01/98	02/01/98	01/30/98	01/30/98	01/30/98	01/30/98
Depth (feet)						10 to 20	20 to 30	30 to 40				
Filtered			Total	Total	Total	Total	Total	Total	Total	Dissolved	Total	Dissolved
Sample Type			Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab
Volatile Organic Compounds (µg/L)												
2-Hexanone	0.00									NA		NA
Acetone	0.00					**264**	**59.9**		ND	NA		NA
Pesticides/PCBs (µg/L)												
4,4'-DDT	0.00		NA	NA	NA	NA	NA	NA	**0.025**	NA		NA
beta-BHC	0.00		NA	NA	NA	NA	NA	NA	**0.016**	NA		NA
delta-BHC	0.00		NA	NA	NA	NA	NA	NA	**0.082**	NA	**0.033**	NA
Metals (µg/L)												
Barium	71.72	2,000	NA	NA	NA	NA	NA	NA	**92.3**	21.4	37.8	12.3
Cadmium	0.43	5	NA	NA	NA	NA	NA	NA	**0.82**			
Chromium	3.56	100	NA	NA	NA	NA	NA	NA	**6.8**		**5.8**	
Lead	4.69	15	NA	NA	NA	NA	NA	NA	**11.1**		**6.6**	
Mercury	0.14	2	NA	NA	NA	NA	NA	NA			**0.46**	0.14
Other Analytes (µg/L)												
Sulfate	26,717.50		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Note: Footnotes appear on page 10.2-26.

Table 10.2-8. Summary of Analytes Detected in Groundwater, SWMU 3 (continued)

Station	Reference Background Criteria	MCL	03-GP6[a]	03-GP6[a]	03-MW1	03-MW2	03-MW3	03-MW4	03-MW5[b]	03-MW6	03-MW7	03-MW8
Sample ID			038611	F038611	034111	034211	034311	034411	034511	034611	034711	034811
Date			01/30/98	01/30/98	02/14/98	02/14/98	02/14/98	02/14/98	02/16/98	02/16/98	02/16/98	02/17/98
Depth (feet)					49.2	28.02	48.01	47.88	14.88	17.72	17.52	15.77
Filtered			Total	Dissolved	Total	Total	Total	Total	Total	Total	Total	Total
Sample Type			Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab
Volatile Organic Compounds (µg/L)												
2-Hexanone	0.00			NA						**5.6**		
Acetone	0.00		ND	NA					ND			
Pesticides/PCBs (µg/L)												
4,4'-DDT	0.00			NA								
beta-BHC	0.00			NA								
delta-BHC	0.00		**0.024**	NA								
Metals (µg/L)												
Barium	71.72	2,000	27.5	15.5	25.5	15.5	39.4	24.5	18.8	19.5	20.9	14.9
Cadmium	0.43	5										
Chromium	3.56	100	3		0.89		2.5	0.79	0.85	0.87	3.1	0.6
Lead	4.69	15				1.8		2.5		2.7		1.1
Mercury	0.14	2	0.14	0.13			**0.15**	**0.16**				
Other Analytes (mg/kg)												
Sulfate	26,717.50			NA	NA	NA	NA	174	NA	NA	NA	NA

[a]GP4, GP5, and GP6 were originally planned to be collected using Geoprobe technology. However, the Geoprobe rig could not access the site; therefore, a hand auger was used to obtain the groundwater samples.
[b]Site-specific background location.
NA = Not analyzed.
ND = Not detected.
Bold indicates concentrations above reference background criteria.

Table 10.2-9. Summary of Analytes Detected in Surface Water and Sediment, SWMU 3

SURFACE WATER			
Station	**Reference Background Criteria[a]**	**03-SWS1**	**03-SWS2**
Sample ID		**032111**	**032211**
Date		**01/17/98**	**01/17/98**
Sample Type		**Grab**	**Grab**
Semivolatile Organic Compounds (µg/L)			
Benzo(*b*)fluoranthene	0.00	**6.6**	
Metals (µg/L)			
Arsenic	0.94		**7.3**
Barium	44.8	14.7	**59.6**
Chromium	0.6	**0.62**	**13.9**
Lead	5.2		**9**

SEDIMENT				
Station	**Reference Background Criteria[a]**	**03-SWS1**	**03-SWS1**	**03-SWS2**
Sample ID		**033112**	**032111**	**032211**
Date		**11/30/99**	**01/17/98**	**01/17/98**
Sample Type		**Grab**	**Grab**	**Grab**
Volatile Organic Compounds (mg/kg)				
2-Butanone	0.00	0.495		
2-Hexanone	0.00	0.0034		
Acetone	0.00	0.618	**7.7**	
Benzene	0.00	0.0033		
Carbon disulfide	0.00	0.006		
Methylene chloride	0.00		**6.49**	
Toluene	0.00	0.212		
Metals (mg/kg)				
Arsenic	0.37	NA	**29.7**	
Barium	3.00	NA	**60**	2.8
Chromium	0.37	NA	**23.3**	**1.2**
Lead	1.38	NA	**14.7**	1.1
Mercury	0.02	NA	**0.08**	0.02
Selenium	0.24	NA	**2.6**	0.2

[a]Site reference background is SWS1 in Mill Creek from 724th Tanker Purging Station, SWMU 26.
NA = Not analyzed.
Bold indicates concentrations above reference background criteria.

Table 10.2-10. Summary of Site-related Contaminants, SWMU 3

Analyte	Maximum Concentration (mg/kg)			Maximum Concentration (µg/L)	
	Surface Soil	Subsurface Soil	Sediment	Groundwater	Surface Water
Volatile Organic Compounds					
2-Butanone	ND	0.0044	0.495	ND	ND
2-Hexanone	ND	ND	0.0034	5.6	ND
Acetone	ND	0.0932	0.618	264	ND
Benzene	ND	ND	0.0033	ND	ND
Carbon disulfide	ND	ND	0.006	ND	ND
Methylene chloride	ND	ND	ND	ND	ND
Toluene	ND	ND	0.212	ND	ND
Semivolatile Organic Compounds					
Benzo(*b*)fluoranthene	ND	ND	ND	ND	6.6
Bis(2-ethylhexyl)phthalate	0.248	0.387	ND	ND	ND
Pesticides/PCBs					
4,4'-DDE	ND	0.00064	ND	ND	ND
4,4'-DDT	ND	ND	ND	0.025	ND
Aldrin	ND	0.00061	ND	ND	ND
alpha-BHC	0.00047	ND	ND	ND	ND
beta-BHC	ND	ND	ND	0.016	ND
delta-BHC	ND	ND	ND	0.082	ND
gamma-BHC (Lindane)	0.0012	ND	ND	ND	ND
Heptachlor epoxide	0.00054	ND	ND	ND	ND
Methoxychlor	0.0086	0.0048	ND	ND	ND
Metals					
Arsenic	24[a]	BRBC	29.7	ND	7.3
Barium	BRBC	BRBC	60	92.3	59.6
Cadmium	ND	0.25	ND	0.82	ND
Chromium	7.8	25.5	23.3	6.8	13.9
Lead	73.97[a]	BRBC	14.7	11.1	9
Mercury	BRBC	BRBC	0.08	0.46	ND
Selenium	BRBC	BRBC	2.6	BRBC	ND

[a]Phase I RFI data.
BRBC = Below reference background criteria.
ND = Not detected.

Table 10.2-11. GSSL Screening of Site-related Contaminants in Soil, SWMU 3

Site-related Contaminant	Maximum Concentration	GSSL[a]	CMCOPC?
Volatile Organic Compounds (mg/kg)			
2-Butanone[b]	0.0044	7.685	No
Acetone	0.0932	16	No
Semivolatile Organic Compounds (mg/kg)			
Bis(2-ethylhexyl)phthalate	0.387	3,600	No
Pesticides/PCBs (mg/kg)			
4,4'-DDE	0.00064	54	No
Aldrin	0.00061	0.5	No
alpha-BHC	0.00047	0.0005	No
gamma-BHC (Lindane)	0.0012	0.009	No
Heptachlor epoxide	0.00054	0.7	No
Methoxychlor	0.0086	160	No
Metals (mg/kg)			
Arsenic	24[c]	29	No
Cadmium	0.25	8	No
Chromium	25.5	38	No
Lead[b]	73.97[c]	400	No

[a]GSSL = EPA GSSL with a DAF of 20 for inorganics and volatile and semivolatile organics. A DAF of 20 for inorganics was used because average pH of groundwater is greater than 5 (Table 10.2-5); unless otherwise indicated (SAIC 1999a), GSSL is taken from Soil Screening Guidance: Technical Background Document (EPA 1996a).

[b]A screening level of 400 mg/kg is used for lead based on Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities (EPA 1994e).

[c]Phase I RFI data.

Table 10.2-12. GSSL Screening of Site-related Contaminants in Sediment, SWMU 3

Site-related Contaminant	Maximum Concentration	GSSL[a]	CMCOPC?
Volatile Organic Compounds (mg/kg)			
2-Butanone	0.495	7.685	No
2-Hexanone	0.0034	6.9	No
Acetone	0.618	16	No
Benzene	0.0033	0.03	No
Carbon disulfide	0.006	32	No
Toluene	0.212	12	No
Metals (mg/kg)			
Arsenic	29.7	29	Yes[b]
Barium	60	1,600	No
Chromium	23.3	38	No
Lead[c]	14.7	400	No
Mercury	0.08	2	No
Selenium	2.6	5	No

[a]GSSL = EPA GSSL with a DAF of 20 for inorganics and volatile and semivolatile organics. A DAF of 20 for inorganics was used because average pH of groundwater is greater than 5 (Table 10.2-5); unless otherwise indicated (SAIC 1999a), GSSL is taken from Soil Screening Guidance: Technical Background Document (EPA 1996a).

[b]Arsenic is not considered to be a CMCOPC because its maximum concentration only slightly exceeded the conservative GSSL, and it was not detected in groundwater. Arsenic is also being evaluated as an HHCOPC in sediment in the human health baseline risk assessment.

[c]A screening level of 400 mg/kg is used for lead based on Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities (EPA 1994e).

Table 10.2-13. Human Health Risk Screening for Surface Soil, Subsurface Soil, Groundwater, Surface Water, and Sediment, SWMU 3

SURFACE SOIL						
Analyte	**Results > Detection Limit**	**Minimum Detect**	**Maximum Detect**	**EPA Region III Residential**	**HHCOPC?**	**Justification**
Semivolatile Organic Compounds (mg/kg)						
Bis(2-ethylhexyl)phthalate	1/10	0.248	0.248	46	No	Max Detect < Risk Criteria
Pesticides/PCBs (mg/kg)						
alpha-BHC	1/10	0.00047	0.00047	0.10	No	Max Detect < Risk Criteria
gamma-BHC (Lindane)	1/10	0.0012	0.0012	0.49	No	Max Detect < Risk Criteria
Heptachlor epoxide	2/10	0.00036	0.00054	0.07	No	Max Detect < Risk Criteria
Methoxychlor	1/10	0.0086	0.0086	39	No	Max Detect < Risk Criteria
Metals (mg/kg)						
Arsenic	5/10	0.37	24.0[a]	0.43	Yes	Max Detect > Risk Criteria
Chromium	9/10	0.95	7.8	23	No	Max Detect < Risk Criteria
Lead	10/10	1.1	73.97[a]	400	No	Max Detect < Risk Criteria

SUBSURFACE SOIL							
Analyte	**Results > Detection Limit**	**Minimum Detect**	**Maximum Detect**	**EPA Region III Residential**	**EPA Region III Industrial**	**HHCOPC?**	**Justification**
Volatile Organic Compounds (mg/kg)							
2-Butanone	1/6	0.0044	0.0044	4,700	NA	No	Max Detect < Risk Criteria
Acetone	1/6	0.0932	0.0932	780	NA	No	Max Detect < Risk Criteria
Semivolatile Organic Compounds (mg/kg)							
Bis(2-ethylhexyl)phthalate	1/6	0.387	0.387	46	NA	No	Max Detect < Risk Criteria
Pesticides/PCBs (mg/kg)							
4,4'-DDE	1/6	0.00064	0.00064	1.9	NA	No	Max Detect < Risk Criteria
Aldrin	1/6	0.00061	0.00061	0.04	NA	No	Max Detect < Risk Criteria
Methoxychlor	1/6	0.0048	0.0048	39	NA	No	Max Detect < Risk Criteria
Metals (mg/kg)							
Cadmium	2/6	0.1	0.25	3.9	NA	No	Max Detect < Risk Criteria
Chromium	6/6	0.65	25.5	23	610	No	Max Detect < Risk Criteria

Note: Footnotes appear on page 10.2-33.

Table 10.2-13. Human Health Risk Screening for Surface Soil, Subsurface Soil, Groundwater, Surface Water, and Sediment, SWMU 3 (continued)

GROUNDWATER						
Analyte	**Freq. of Detection**	**Minimum Detect**	**Maximum Detect**	**Human Health Criteria**	**HHCOPC?**	**Justification**
Volatile Organic Compounds (µg/L)						
2-Hexanone	1/16	5.6	5.6	150	No	Max Detect < Risk Criteria
Acetone	2/16	59.9	264	370	No	Max Detect < Risk Criteria
Pesticides/PCB (µg/L)						
4,4'-DDT	1/10	0.025	0.025	0.2	No	Max Detect < Risk Criteria
beta-BHC	1/10	0.016	0.016	0.037	No	Max Detect < Risk Criteria
delta-BHC	3/10	0.024	0.082	0.037	Yes	Max Detect > Risk Criteria
Metals (µg/L)						
Barium	10/10	14.9	92.3	260	No	Max Detect < Risk Criteria
Cadmium	1/10	0.82	0.82	1.8	No	Max Detect < Risk Criteria
Chromium	10/10	0.6	6.8	10.9	No	Max Detect < Risk Criteria
Lead	6/10	1.1	11.1	15	No	Max Detect < Risk Criteria
Mercury	14/10	0.14	0.46	0.37	Yes	Max Detect > Risk Criteria

SURFACE WATER							
Analyte	**Freq. of Detection**	**Minimum Detect**	**Maximum Detect**	**Human Health Criteria**	**Ambient Water Quality Criteria**	**HHCOPC?**	**Justification**
Semivolatile Organic Compounds (µg/L)							
Benzo(*b*)fluoranthene	1/2	6.6	6.6	0.092	0.0044	Yes	Max Detect > Risk Criteria and AWQC
Metals (µg/L)							
Arsenic	1/2	7.3	7.3	0.045	0.018	Yes	Max Detect > AWQC
Barium	2/2	14.7	59.6	260	2,000	No	Max Detect < Risk Criteria
Chromium	2/2	0.62	13.9	18	11	Yes	Max Detect > AWQC
Lead	1/2	9	9	15	1.2	Yes	Max Detect > AWQC

Note: Footnotes appear on page 10.2-33.

Table 10.2-13. Human Health Risk Screening for Surface Soil, Subsurface Soil, Groundwater, Surface Water, and Sediment, SWMU 3 (continued)

SEDIMENT						
Analyte	**Results > Detection Limit**	**Minimum Detect**	**Maximum Detect**	**EPA Region III Residential**	**HHCOPC?**	**Justification**
Volatile Organic Compounds (mg/kg)						
2-Butanone	1/2	0.495	0.495	4,693	No	Max Detect < Risk Criteria
2-Hexanone	1/2	0.0034	0.0034	312.9	No	Max Detect < Risk Criteria
Acetone	1/2	0.618	0.618	780	No	Max Detect < Risk Criteria
Benzene	1/2	0.0033	0.0033	22.03	No	Max Detect < Risk Criteria
Carbon disulfide	1/2	0.006	0.006	782.1	No	Max Detect < Risk Criteria
Toluene	1/2	0.212	0.212	1,564	No	Max Detect < Risk Criteria
Metals (mg/kg)						
Arsenic	1/2	29.7	29.7	0.43	Yes	Max Detect < Risk Criteria
Barium	2/2	2.8	60	550	No	Max Detect < Risk Criteria
Chromium	2/2	1.2	23.3	23.4	No	Max Detect < Risk Criteria
Lead	2/2	1.1	14.7	400	No	Max Detect < Risk Criteria
Mercury	2/2	0.02	0.08	2.3	No	Max Detect < Risk Criteria
Selenium	2/2	0.2	2.6	39	No	Max Detect < Risk Criteria

[a]Phase I RFI data.
NA = Not applicable.

Table 10.2-14. Ecological Screening Value Comparison for Analytes Detected in Surface Water, SWMU 3

Analyte	SWMU 3 Maximum	ESV	ECOPC Aquatic Biota?	Justification
Semivolatile Organic Compounds (µg/L)				
Benzo(*b*)fluoranthene	6.6	No ESV	Yes	ECOPC by Default
Metals (µg/L)				
Arsenic	7.3	190	No	Max Detect < ESV
Barium	59.6	4.0[a]	Yes	Max Detect > ESV
Chromium	13.9	117.32[b]	No	Max Detect < ESV
Lead	9	1.32[b]	Yes	Max Detect > ESV

[a]Chronic National Ambient Water Quality Criteria or Tier II values as reported in Suter and Tsao (1996), Table 1 or Table 3.
[b]Hardness dependent; assumes 50 mg/L $CaCO_3$.
ESV = EPA Region IV ESVs (EPA 1996d) and, where indicated, alternative values for analytes without ESVs.
Cells with double borders indicate concentrations exceeding ESVs or, when there is no ESV, concentrations that become ECOPCs by default.

Table 10.2-15. Ecological Screening Value Comparison for Analytes Detected in Sediment, SWMU 3

Analyte	SWMU 3 Maximum	ESV	ECOPC Aquatic Biota?	Justification
Volatile Organic Compounds (mg/kg)				
2-Butanone	0.495	27.3	No	Max Detect < ESV
2-Hexanone	0.0034	0.024[a]	No	Max Detect < ESV
Acetone	0.618	0.00863[a]	Yes	Max Detect > ESV
Benzene	0.0033	0.057	No	Max Detect < ESV
Carbon disulfide	0.006	0.0013[a]	Yes	Max Detect > ESV
Toluene	0.212	0.877[a]	No	Max Detect < ESV
Metals (mg/kg)				
Arsenic	29.7	7.24	Yes	Max Detect > ESV
Barium	60	No ESV	Yes	ECOPC by Default
Chromium	23.3	52.3	No	Max Detect < ESV
Lead	14.7	30.2	No	Max Detect < ESV
Mercury	0.08	0.13	No	Max Detect < ESV
Selenium	2.6	No ESV	Yes	ECOPC by Default

[a]Sediment quality benchmark = Surface water ESV (mg/L) × K_{ow} (L/kg) × f_{oc}, where fraction organic carbon (f_{oc}) is assumed to be 0.01 and ESV and K_{ow} are as shown below.

Compound	K_{ow}* (L/kg)	Surface Water ESV (mg/L)	Source of Surface Water ESV
2-Hexanone	24	0.099	Chronic Tier II value (Suter and Tsao 1996)
Acetone	0.5754	1.5	Chronic Tier II value (Suter and Tsao 1996)
Carbon disulfide	144.5	0.00092	Chronic Tier II value (Suter and Tsao 1996)

*K_{ow}s from log K_{ow}s reported in HAZWRAP 1994, except carbon disulfide and 2-hexanone from EPA (1990) Treatability Database.

ESV = EPA Region IV ESVs for sediment (EPA 1996d) and, where indicated, alternative values for analytes without ESVs.

Table 10.2-16. Ecological Screening Value Comparison for Analytes Detected in Groundwater, SWMU 3

Analyte	SWMU 3 Maximum	ESV	ECOPC Aquatic Biota?	Justification
Volatile Organic Compounds (µg/L)				
2-Hexanone	5.6	99[a]	No	Max Detect < ESV
Acetone	264	1,500[a]	No	Max Detect < ESV
Pesticides/PCBs (µg/L)				
4,4'-DDT	0.025	0.001	Yes	Max Detect > ESV
beta-BHC	0.016	5,000	No	Max Detect < ESV
delta-BHC	0.082	No ESV	Yes	ECOPC by Default
Metals (µg/L)				
Barium	92.3	4.0[a]	Yes	Max Detect > ESV
Cadmium	0.82	0.66[b]	Yes	Max Detect > ESV
Chromium	6.8	117.32[b]	No	Max Detect < ESV
Lead	11.1	1.32[b]	Yes	Max Detect > ESV
Mercury	0.46	0.0123	Yes	Max Detect > ESV

[a]Chronic National Ambient Water Quality Criteria or Tier II values as reported in Suter and Tsao (1996), Table 1 or Table 3.
[b]Hardness dependent; assumes 50 mg/L $CaCO_3$.
ESV = EPA Region IV ESVs (EPA 1996d) and, where indicated, alternative values for analytes without ESVs.
Cells with double borders indicate concentrations exceeding ESVs or, when there is no ESV, concentrations that become ECOPCs by default.

Table 10.2-17. Preliminary Risk Calculations for ECOPCs in Surface Soil, SWMU 3

ECOPC	C_{Max} (mg/kg)	BAF_i	Short-tailed Shrew			American Robin		
			ADD (mg/kg/d) = $C_{Max} \times BAF_i \times IR_S$	TRV (mg/kg/d)	HQ = ADD/TRV	ADD (mg/kg/d) = $C_{Max} \times BAF_i \times IR_R$	TRV (mg/kg/d)	HQ = ADD/TRV
Semivolatile Organic Compounds								
Bis(2-ethylhexyl)phthalate	0.248	5.00E-02	6.57E-03	2.18E+01	3.02E-04	1.88E-02	1.10E+00	1.71E-02
Pesticides/PCBs								
alpha-BHC	0.00047	2.60E+00	6.48E-04	3.52E+00	1.84E-04	1.86E-03	5.63E-01	3.30E-03
gamma-BHC (Lindane)	0.0012	2.00E-02	1.27E-05	1.76E+01	7.23E-07	3.65E-05	2.00E+00	6.48E-05
Heptachlor epoxide[a]	0.00054	1.00E+00	2.86E-04	2.86E-01	1.00E-03	8.21E-04	No TRV	No HQ
Methoxychlor	0.0086	5.70E-01	2.60E-03	8.79E+00	2.96E-04	7.45E-03	8.42E+00	1.32E-02
				HI=	1.48E-03		**HI=**	1.66E-02
Metals								
Arsenic	24.0[b]	6.60E-03	8.40E-02	1.50E-01	5.60E-01	2.41E-01	5.14E+00	4.28E-01
Chromium	7.8	1.60E-01	6.61E-01	6.02E+03	1.10E-04	1.90E+00	1.00E+00	1.90E+00
Lead	73.97[b]	4.0E-01	1.57E+01	1.76E+01	8.92E-01	4.50E+01	1.13E+00	3.98E+01

[a]Default BAF; assumed to be 1.
[b]Phase I RFI data.
ADD = Average daily dose (mg/kg/d).
BAF_i = Soil-to-invertebrate bioaccumulation factor (HAZWRAP 1994).
C_{max} = Maximum detected surface soil concentration (mg/kg).
HQ = Hazard quotient; HI = hazard index = sum of HQs.
IR_R = Robin food ingestion rate (kg/kgBW/d) = 1.52.
IR_S = Shrew food ingestion rate (kg/kgBW/d) = 0.53.
TRV = NOAEL (mg/kg/d); see Tables 8-5 and 8-6.
Cells with double borders indicate HQ > 1.

Table 10.2-18. Preliminary Risk Calculations for ECOPCs in Surface Water, SWMU 3

ECOPC	C_{Max} (µg/L)	BCF	Raccoon			Mink			Green Heron		
			ADD (mg/kg/d) = C_{Max} × 0.001 × IR_W	TRV (mg/kg/d)	HQ = ADD/ TRV	ADD (mg/kg/d) = C_{Max} × 0.001 × BCF × IR_M	TRV (mg/kg/d)	HQ = ADD/ TRV	ADD (mg/kg/d) = C_{Max} × 0.001 × BCF × IR_H	TRV (mg/kg/d)	HQ = ADD/ TRV
Semivolatile Organic Compounds											
Benzo(*b*)fluoranthene	6.6	2.60E+04	5.28E-04	3.54E+00	1.49E-04	2.35E+01	5.54E+00	4.25E+00	3.29E+01	1.24E+01	2.66E+00
Metals											
Barium	59.6	4.00E+00	4.77E-03	2.63E+00	1.82E-03	3.27E-02	4.11E+00	7.95E-03	4.58E-02	2.08E+01	2.20E-03
Lead	9	3.00E+02	7.20E-04	3.93E+00	1.83E-04	3.70E-01	6.15E+00	6.01E-02	5.18E-01	1.13E+00	4.59E-01

0.001 (mg/µg) = Conversion from µg/L to mg/L.
ADD = Average daily dose (mg/kg/d).
BCF = Water-to-fish bioconcentration factor (HAZWRAP 1994).
C_{Max} = Maximum detected concentration (µg/L).
HQ = Hazard quotient; HI = hazard index = sum of HQs.
IR_H = Heron food ingestion rate (kg/kg/d) = 0.192.
IR_M = Mink food ingestion rate (kg/kg/d) = 0.137.
IR_W = Raccoon water ingestion rate (L/kg/d) = 0.08.
TRV = NOAEL (mg/kg/d).
Cells with double borders indicate concentrations exceeding ESVs or, when there is no ESV, concentrations that become ECOPCs by default.

Table 10.2-19. Preliminary Risk Calculations for ECOPCs in Sediment, SWMU 3

ECOPC	C_{Max} (mg/kg)	BAF_i	Green Heron		
			ADD (mg/kg/d) = $C_{Max} \times BAF_i \times IR_H$	TRV (mg/kg/d)	HQ = ADD/TRV
Volatile Organic Compounds					
Acetone	0.618	5.00E-02	5.93E-03	No TRV	No HQ
Carbon disulfide	0.006	5.00E-02[a]	5.76E-05	No TRV	No HQ
Metals					
Arsenic	29.7	6.60E-03	3.76E-02	5.14E+00	7.33E-03
Barium	60	7.50E-03	8.64E-02	2.08E+01	4.15E-03
Selenium	2.6	7.60E-01	3.79E-01	5.00E-01	7.59E-01

[a]BAF for carbon disulfide assumed to be the same as for other VOCs in HAZWRAP 1994.
ADD = Average daily dose (mg/kg/d).
BAF_i = Soil-to-invertebrate bioaccumulation factor (HAZWRAP 1994).
C_{Max} = Maximum detected surface soil concentration (mg/kg).
IR_H = Heron food ingestion rate (kg/kg/d) = 0.192.
HQ = Hazard quotient; HI = hazard index = sum of HQs.
TRV = NOAEL (mg/kg/d); see Tables 8-5 and 8-6.

Table 10.2-20. Preliminary Risk Calculations for ECOPCs in Groundwater, SWMU 3

ECOPC	C_{Max} (µg/L)	BCF	Raccoon ADD (mg/kg/d) = C_{Max} × 0.001 × IR_W	Raccoon TRV (mg/kg/d)	Raccoon HQ = ADD/TRV	Mink ADD (mg/kg/d) = C_{Max} × BCF × 0.001 × IR_M	Mink TRV (mg/kg/d)	Mink HQ = ADD/TRV	Green Heron ADD (mg/kg/d) = C_{Max} ×0.001 × BCF × IR_H	Green Heron TRV (mg/kg/d)	Green Heron HQ = ADD/TRV
Pesticides/PCBs											
4,4'-DDT	0.025	3.40E+04	2.00E-06	3.93E-01	5.09E-06	1.16E-01	6.15E-01	1.89E-01	1.63E-01	2.80E-03	5.83E+01
Delta-BHC	0.082	6.90E+02	6.56E-06	7.87E-01	8.34E-06	7.75E-03	1.23E+00	6.30E-03	1.09E-02	5.63E-01	1.93E-02
					HI= 1.34E-05			**HI=** 1.96E-01			**HI=** 5.83E+01
Metals											
Barium	92.3	4.00E+00	7.39E-03	2.63E+00	2.81E-03	5.06E-02	4.11E+00	1.23E-02	7.09E-02	2.08E+01	3.40E-03
Cadmium	0.82	5.00E+01	6.56E-05	4.74E-01	1.38E-04	5.62E-03	7.42E-01	7.57E-03	7.87E-03	1.45E+00	5.43E-03
Lead	11.1	3.00E+02	8.89E-04	3.93E+00	2.26E-04	4.56E-01	6.15E+00	7.41E-02	6.39E-01	1.13E+00	5.66E-01
Mercury[a]	0.46	6.30E+04	3.68E-05	6.46E-01	5.70E-05	3.97E+00	1.01E+00	3.93E+00	5.56E+00	4.50E-01	1.24E+01

[a]Assumes mercuric chloride.
0.001 (mg/µg) = Conversion from µg to mg.
ADD = Average daily dose (mg/kg/d).
BCF = Water-to-fish bioconcentration factor (HAZWRAP 1994).
C_{Max} = Maximum detected concentration (µg/L).
HQ = Hazard quotient; HI = hazard index = sum of HQs.
IR_H = Heron food ingestion rate (kg/kg/d) = 0.192.
IR_M = Mink food ingestion rate (kg/kg/d) = 0.137.
IR_W = Raccoon water ingestion rate (L/kg/d) = 0.080.
TRV = NOAEL (mg/kg/d).
Cells with double borders indicate HQ > 1.

Table 10.2-21. Supplemental Risk Calculations for ECOPCs in Surface Soil for American Robin, SWMU 3

ECOPC	Site Concentration Mean (mg/kg)	SP_r	American Robin						
			ADD_P (mg/kgBW/d) = Mean × SP_r × I_P × AUF	BAF_i	ADD_A (mg/kgBW/d) = Mean × BAF_i × I_A × AUF	ADD_S (mg/kgBW/d) = Mean × I_S × AUF	ADD_{total} (mg/kgBW/d) = ADD_P + ADD_A + ADD_S	Body-weight-adjusted LOAEL TRV (mg/kgBW/d)	HQ = ADD_{total}/TRV
Metals									
Chromium	2.93E+00	9.00E-04	1.58E-03	1.60E-01	2.81E-01	3.66E-01	6.49E-01	5.00E+00	1.30E-01
Lead	2.49E+00	1.80E-03	2.69E-03	4.00E-01	5.98E-01	3.11E-01	9.11E-01	1.13E+01	8.06E-02

ADD_A = Average daily dose; animal.
ADD_P = Average daily dose; plant.
ADD_S = Average daily dose; soil.
ADD_{total} = Average daily dose; total.
AF = Animal fraction.
AUF = Area use factor = 1.
BAF_i = Soil-to-animal bioaccumulation factor; invertebrate.
HQ = Hazard quotient.
I_A = TUF × IR_f × AF.
I_A (kg/kgBW/d) = 6.00E-01.
I_P (kg/kgBW/d) = 6.00E-01.
I_P = TUF × IR_f × PF.
IR_f = Food ingestion rate.
I_S (kg/kgBW/d) = 1.25E-01.
I_S = TUF × IR_f × SF.
PF = Plant fraction.
SF = Soil fraction.
SP_r = Soil-to-plant bioaccumulation factor; reproductive parts.
TRV = Toxicity reference value.
TUF = Temporal use factor.

Table 10.2-22. Supplemental Risk Calculations for ECOPCs in Surface Water for Mink, SWMU 3

ECOPC	Site Concentration Mean (µg/L)	BCF	Mink				
			ADD_A (mg/kgBW/d) = Mean × 0.001 × BCF × I_A × AUF	ADD_W (mg/kgBW/d) = Mean × 0.001 × IR_W × AUF	ADD_{total} (mg/kgBW/d) = ADD_A + ADD_W	Body-weight-adjusted LOAEL TRV (mg/kgBW/d)	HQ = ADD_{total}/TRV
Semivolatile Organic Compounds							
Benzo(*b*)fluoranthene	5.90E+00	2.60E+04	1.68E+00	4.67E-05	1.68E+00	5.54E+01	3.04E-02

0.001 = Conversion from µg/L to mg/L.
ADD_A = Average daily dose; animal.
ADD_{total} = Average daily dose; total.
ADD_W = Average daily dose; drinking water.
AF = Animal fraction.
AUF = 8.00E-02.
AUF assumes 328 feet (100 meters) of stream are contaminated at mean concentration.
BCF = Water-to-animal bioconcentration factor.
HQ = Hazard quotient.
I_A = TUF × IR_f × AF.
I_A (kg/kgBW/d) = 1.37E-01.
IR_f = Food ingestion rate.
IR_W (L/kgBW/d) = 9.90E-02.
IR_W =Water ingestion rate.
TRV = Toxicity reference value.
TUF = Temporal use factor.

Table 10.2-23. Supplemental Risk Calculations for ECOPCs in Surface Water for Green Heron, SWMU 3

ECOPC	Site Concentration Mean (µg/L)	BCF	Green Heron				
			ADD_A (mg/kgBW/d) = Mean × 0.001 × BCF × I_A × AUF	ADD_W (mg/kgBW/d) = Mean × 0.001 × IR_W × AUF	ADD_{total} (mg/kgBW/d) = ADD_A + ADD_W	Body-weight-adjusted LOAEL TRV (mg/kgBW/d)	HQ = ADD_{total}/TRV
Semivolatile Organic Compounds							
Benzo(*b*)fluoranthene	5.90E+00	2.60E+04	3.99E+01	5.55E-04	3.99E+01	1.24E+02	3.22E-01

0.001 = Conversion from µg/L to mg/L.
ADD_A = Average daily dose; animal.
ADD_{total} = Average daily dose; total.
ADD_W = Average daily dose; drinking water.
AF = Animal fraction.
AUF = 1.00E+00.
AUF assumes 328 feet (100 meters) of stream are contaminated at mean concentration.
BCF = Water-to-animal bioconcentration factor.
HQ = Hazard quotient.
I_A = TUF × IR_f × AF.
I_A (kg/kgBW/d) = 2.60E-01.
IR_f = Food ingestion rate.
IR_W (L/kgBW/d) = 9.40E-02.
IR_W = Water ingestion rate.
TRV = Toxicity reference value.
TUF = Temporal use factor.

Table 10.2-24. Supplemental Risk Calculations for ECOPCs in Sediment for Raccoon, SWMU 3

ECOPC	Site Concentration Mean (mg/kg)	BAF_i	Raccoon		
			ADD (mg/kg/d) = Mean × BAF_i × I_A × AUF	Body-weight-adjusted LOAEL TRV (mg/kgBW/d)	HQ = ADD/TRV
Volatile Organic Compounds					
Acetone	3.21E-01	5.00E-02	1.60E-03	2.92E-00	5.47E-04
Carbon disulfide	4.70E-03	5.00E-02	2.34E-05	6.42E+01	3.65E-07
				HI =	5.47E-04

ADD = Average daily dose.
AF = Animal fraction.
AUF = Area use factor = 1.
BAF_i = Soil-to-invertebrate bioaccumulation factor (HAZWRAP 1994); carbon disulfide BAF assumed to equal those for other VOCs.
HI = Hazard index (sum of HQs).
HQ = Hazard quotient.
I_A = TUF × IR_f × AF.
I_A (kg/kgBW/d) = 9.96E-02.
IR_f = Food ingestion rate.
TRV = Toxicity reference value.
TUF = Temporal use factor.

Table 10.2-25. Supplemental Risk Calculations for ECOPCs in Groundwater for Mink, SWMU 3

ECOPC	Site Concentration Mean[a] (µg/L)	BCF	Mink				
			ADD_A (mg/kgBW/d) = Mean × 0.001 × BCF × I_A × AUF	ADD_W (mg/kgBW/d) = Mean × 0.001 × IR_W × AUF	ADD_{total} (mg/kgBW/d) = ADD_A + ADD_W	Body-weight-adjusted LOAEL TRV (mg/kgBW/d)	HQ = ADD_{total}/TRV
Metals							
Mercury	1.21E-01	6.30E+04	8.35E-02	9.58E-07	8.35E-02	1.01E+01	8.27E-03

[a]Mean of all groundwater samples.
0.001 = Conversion from µg/L to mg/L.
ADD_A = Average daily dose; animal.
ADD_{total} = Average daily dose; total.
ADD_W = Average daily dose; drinking water.
AF = Animal fraction = 1.0.
AUF = Area use factor = 8.00E-02.
AUF assumes 328 feet (100 meters) of stream are contaminated at mean concentration.
BCF = Water-to-animal bioconcentration factor.
HQ = Hazard quotient.
I_A = TUF × IR_f × AF.
I_A (kg/kgBW/d) = 1.37E-01.
IR_f = Food ingestion rate.
IR_W (L/kgBW/d) = 9.90E-02.
IR_W = Water ingestion rate.
TRV = Toxicity reference value.
TUF = Temporal use factor.

Table 10.2-26. Supplemental Risk Calculations for ECOPCs in Groundwater for Green Heron, SWMU 3

ECOPC	Site Concentration Mean[a] (µg/L)	BCF	Green Heron				
			ADD_A (mg/kgBW/d) = Mean × 0.001 × BCF × I_A × AUF	ADD_W (mg/kgBW/d) = Mean × 0.001 × IR_W × AUF	ADD_{total} (mg/kgBW/d) = ADD_A + ADD_W	Body-weight-adjusted LOAEL TRV (mg/kgBW/d)	HQ = ADD_{total}/TRV
Metals							
Mercury	1.21E-01	6.30E+04	1.98E+00	1.14E-05	1.98E+00	9.00E-01	2.20E+00
Pesticides							
4,4'-DDT	2.12E-02	3.40E+04	1.87E-01	1.99E-06	1.87E-01	2.80E-02	6.69E+00

[a]Mean of all groundwater samples.
0.001 = Conversion from µg/L to mg/L.
ADD_A = Average daily dose; animal.
ADD_{total} = Average daily dose; total.
ADD_W = Average daily dose; drinking water.
AF = Animal fraction.
AUF = Area use factor = 1.00E+00.
AUF assumes 328 feet (100 meters) of stream are contaminated at mean concentration.
BCF = Water-to-animal bioconcentration factor.
HQ = Hazard quotient.
I_A = TUF × IR_f × AF.
I_A (kg/kgBW/d) = 2.60E-01.
IR_f = Food ingestion rate.
IR_W (L/kgBW/d) = 9.40E-02.
IR_W = Water ingestion rate.
TRV = Toxicity reference value.
TUF = Temporal use factor.
Cells with double borders indicate HQ >1.

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Table 10.2A-26. Remedial Levels for Surface Soil, SWMU 3

Constituent of Concern	Maximum Detected Concentration (mg/kg)	Risk-based Remedial Levels (mg/kg)		
		ILCR		
		1×10^{-6}	1×10^{-5}	5×10^{-5}
Arsenic	24	0.6	6.1	**30.3**

Bold indicates concentrations above recommended remedial levels.

Table 10.2A-27. Remedial Levels for Surface Water, SWMU 3

Constituent of Concern	Maximum Detected Concentration (mg/L)	Risk-based Remedial Levels (mg/L)		
		ILCR		
		1×10^{-6}	1×10^{-5}	5×10^{-5}
Benzo(*b*)fluoranthene	0.0066	0.0010	0.0101	**0.0505**

Bold indicates concentrations above recommended remedial levels.

Table 10.2A-24. Hazard Indices and Carcinogenic Risks for Future Off-site Resident Child, SWMU 3

Chemical	Groundwater[a]			Surface Soil[a]		Total Hazard Index[a]
	Oral HQ	Dermal HQ	Total	Inhalation HQ	Total	
Arsenic	NA	NA	NA	ND	ND	—
delta-BHC	ND	ND	—	NA	NA	—
Mercury	4.16E-02	3.33E-04	4.19E-02	NA	NA	4.19E-02
Pathway Total	**4.16E-02**	**3.33E-04**	**4.19E-02**	—	—	**4.19E-02**

Chemical	Groundwater[b]			Surface Soil[b]		Total Cancer Risk[b]
	Oral ILCR	Dermal ILCR	Total	Inhalation ILCR	Total	
Arsenic	NA	NA	NA	1.36E-09	1.36E-09	1.36E-09
delta-BHC	3.99E-07	7.85E-09	4.07E-07	NA	NA	4.07E-07
Mercury	ND	ND	—	NA	NA	—
Pathway Total	**3.99E-07**	**7.85E-09**	**4.07E-07**	**1.36E-09**	**1.36E-09**	**4.08E-07**

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2.
[b]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1.
NA = Not applicable; this chemical is not present in this environmental medium.
ND = The toxicity data required to quantify the risk are not available.
— = No data.

Table 10.2A-25. Carcinogenic Risks for Future Off-site Resident Adult, SWMU 3

Chemical	Groundwater[a]			Surface Soil[a]		Total Cancer Risk[a]
	Oral ILCR	Dermal ILCR	Total	Inhalation ILCR	Total	
Arsenic	NA	NA	NA	1.71E-09	1.71E-09	1.71E-09
delta-BHC	8.56E-07	5.00E-08	9.06E-07	NA	NA	9.06E-07
Mercury	ND	ND	—	NA	NA	—
Pathway Total	**8.56E-07**	**5.00E-08**	**9.06E-07**	**1.71E-09**	**1.71E-09**	**9.08E-07**

[a]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1.
NA = Not applicable; this chemical is not present in this environmental medium.
ND = The toxicity data required to quantify the risk are not available.
— = No data.

Table 10.2A-23. Hazard Indices and Carcinogenic Risks for Future Off-site Juvenile Wader, SWMU 3

Chemical	Surface Soil[a]		Surface Water[a]			Total Hazard Index[a]
	Inhalation HQ	Total	Oral HQ	Dermal HQ	Total	
Arsenic	ND	—	1.54E-03	1.50E-03	3.04E-03	3.04E-03
Benzo(*b*)fluoranthene	NA[b]	NA[b]	ND	ND	—	—
Chromium	NA[b]	NA[b]	2.93E-04	5.87E-03	6.16E-03	6.16E-03
delta-BHC	NA[b]	NA[b]	ND	ND	—	—
Lead	NA[b]	NA[b]	NA[c]	NA[c]	NA[c]	—
Mercury	NA[b]	NA[b]	9.71E-05	5.55E-04	6.52E-04	6.52E-04
Pathway Total	—	—	**1.93E-03**	**7.93E-03**	**9.86E-03**	**9.86E-03**

Chemical	Surface Soil[d]		Surface Water[d]			Total Cancer Risk[d]
	Inhalation ILCR	Total	Oral ILCR	Dermal ILCR	Total	
Arsenic	1.02E-10	1.02E-10	9.90E-08	9.66E-08	1.96E-07	1.96E-07
Benzo(*b*)fluoranthene	NA[b]	NA[b]	4.36E-08	6.48E-06	6.53E-06	6.53E-06
Chromium	NA[b]	NA[b]	ND	ND	—	—
delta-BHC	NA[b]	NA[b]	1.34E-09	1.87E-08	2.01E-08	2.01E-08
Lead	NA[b]	NA[b]	ND	ND	—	—
Mercury	NA[b]	NA[b]	ND	ND	—	—
Pathway Total	**1.02E-10**	**1.02E-10**	**1.44E-07**	**6.60E-06**	**6.74E-06**	**6.74E-06**

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2.
[b]NA = Not applicable; this chemical is not present in this environmental medium.
[c]NA = Not applicable; lead is evaluated separately using a biokinetic uptake model.
[d]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1.
ND = The toxicity data required to quantify the risk are not available.
— = No data.

Table 10.2A-22. Hazard Indices and Carcinogenic Risks for Future Off-site Installation Worker, SWMU 3

Chemical	Groundwater[a]		Surface Soil[a]		Total Hazard Index[a]
	Oral HQ	Total	Inhalation HQ	Total	
Arsenic	NA	NA	ND	—	—
delta-BHC	ND	—	NA	NA	—
Mercury	6.36E-03	6.36E-03	NA	NA	6.36E-03
Pathway Total	**6.36E-03**	**6.36E-03**	—	—	**6.36E-03**

Chemical	Groundwater[b]		Surface Soil[b]		Total Cancer Risk[b]
	Oral ILCR	Total	Inhalation ILCR	Total	
Arsenic	NA	NA	1.39E-09	1.39E-09	1.39E-09
delta-BHC	2.55E-07	2.55E-07	NA	NA	2.55E-07
Mercury	ND	—	NA	NA	—
Pathway Total	**2.55E-07**	**2.55E-07**	**1.39E-09**	**1.39E-09**	**2.56E-07**

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2.
[b]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1.
NA = Not applicable; this chemical is not present in this environmental medium.
ND = The toxicity data required to quantify the risk are not available.
— = No data.

Table 10.2A-20. Hazard Indices and Carcinogenic Risks for Future On-site Resident Child, SWMU 3

Chemical	Groundwater[a]			Surface Soil[a]				Total Hazard Index[a]
	Oral HQ	Dermal HQ	Total	Oral HQ	Dermal HQ	Inhalation HQ	Total	
Arsenic	NA	NA	NA	3.02E-01	1.25E-03	ND	3.03E-01	3.03E-01
delta-BHC	ND	ND	ND	NA	NA	NA	NA	—
Mercury	4.16E-02	3.33E-04	4.19E-02	NA	NA	NA	NA	4.19E-02
Pathway Total	**4.16E-02**	**3.33E-04**	**4.19E-02**	**3.02E-01**	**1.25E-03**	—	**3.03E-01**	**3.45E-01**

Chemical	Groundwater[b]			Surface Soil[b]				Total Cancer Risk[b]
	Oral ILCR	Dermal ILCR	Total	Oral ILCR	Dermal ILCR	Inhalation ILCR	Total	
Arsenic	NA	NA	NA	1.17E-05	4.83E-08	1.36E-09	1.17E-05	1.17E-05
delta-BHC	3.99E-07	7.85E-09	4.07E-07	NA	NA	NA	NA	4.07E-07
Mercury	ND	ND	—	NA	NA	NA	—	—
Pathway Total	**3.99E-07**	**7.85E-09**	**4.07E-07**	**1.17E-05**	**4.83E-08**	**1.36E-09**	**1.17E-05**	**1.21E-05**

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2.
[b]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1.
NA = Not applicable; this chemical is not present in this environmental medium.
ND = The toxicity data required to quantify the risk are not available.
— = No data.

Table 10.2A-21. Carcinogenic Risks for Future On-site Resident Adult, SWMU 3

Chemical	Groundwater[a]			Surface Soil[a]				Total Cancer Risk[a]
	Oral ILCR	Dermal ILCR	Total	Oral ILCR	Dermal ILCR	Inhalation ILCR	Total	
Arsenic	NA	NA	NA	6.24E-06	1.52E-07	1.71E-09	6.40E-06	6.40E-06
delta-BHC	8.56E-07	5.00E-08	9.06E-07	NA	NA	NA	NA	9.06E-07
Mercury	ND	ND	—	NA	NA	NA	NA	—
Pathway Total	**8.56E-07**	**5.00E-08**	**9.06E-07**	**6.24E-06**	**1.52E-07**	**1.71E-09**	**6.40E-06**	**7.30E-06**

[a]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1.
NA = Not applicable; this chemical is not present in this environmental medium.
ND = The toxicity data required to quantify the risk are not available.
— = No data.

Table 10.2A-19. Hazard Indices and Carcinogenic Risks for Future On-site Juvenile Trespasser, SWMU 3

Chemical	Surface Soil[a]				Surface Water[a]			Sediment[a]		Total Hazard Index[a]
	Oral HQ	Dermal HQ	Inhalation HQ	Total	Oral HQ	Dermal HQ	Total	Oral HQ	Total	
Arsenic	1.87E-03	1.35E-04	ND	2.01E-03	1.54E-03	1.50E-03	3.04E-03	4.07E-03	4.07E-03	9.12E-03
Benzo(*b*)fluoranthene	NA[b]	NA[b]	NA[b]	NA[b]	ND	ND	—	NA[b]	NA[b]	—
Chromium	NA[b]	NA[b]	NA[b]	NA[b]	2.93E-04	5.87E-03	6.16E-03	NA[b]	NA[b]	6.16E-03
delta-BHC	NA[b]	NA[b]	NA[b]	NA[b]	ND	ND	—	NA[b]	NA[b]	—
Lead	NA[b]	NA[b]	NA[b]	NA[b]	NA[c]	NA[c]	NA[c]	NA[b]	NA[b]	—
Mercury	NA[b]	NA[b]	NA[b]	NA[b]	9.71E-05	5.55E-04	6.52E-04	NA[b]	NA[b]	6.52E-04
Pathway Total	**1.87E-03**	**1.35E-04**	—	**2.01E-03**	**1.93E-03**	**7.93E-03**	**9.86E-03**	**4.07E-03**	**4.07E-03**	**1.59E-02**

Chemical	Surface Soil[d]				Surface Water[d]			Sediment[d]		Total Cancer Risk[d]
	Oral ILCR	Dermal ILCR	Inhalation ILCR	Total	Oral ILCR	Dermal ILCR	Total	Oral ILCR	Total	
Arsenic	1.20E-07	8.68E-09	1.02E-10	1.29E-07	9.90E-08	9.66E-08	1.96E-07	2.62E-07	2.62E-07	5.87E-07
Benzo(*b*)fluoranthene	NA[b]	NA[b]	NA[b]	NA[b]	4.36E-08	6.48E-06	6.53E-06	NA[b]	NA[b]	6.53E-06
Chromium	NA[b]	NA[b]	NA[b]	NA[b]	ND	ND	—	NA[b]	NA[b]	—
delta-BHC	NA[b]	NA[b]	NA[b]	NA[b]	1.34E-09	1.87E-08	2.01E-08	NA[b]	NA[b]	2.01E-08
Lead	NA[b]	NA[b]	NA[b]	NA[b]	ND	ND	—	NA[b]	NA[b]	—
Mercury	NA[b]	NA[b]	NA[b]	NA[b]	ND	ND	—	NA[b]	NA[b]	—
Pathway Total	**1.20E-07**	**8.68E-09**	**1.02E-10**	**1.29E-07**	**1.44E-07**	**6.60E-06**	**6.74E-06**	**2.62E-07**	**2.62E-07**	**7.14E-06**

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2.
[b]NA = Not applicable; this chemical is not present in this environmental medium.
[c]NA = Not applicable; lead is evaluated separately using a biokinetic uptake model.
[d]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1.
ND = The toxicity data required to quantify the risk are not available.
— = No data.

Table 10.2A-17. Hazard Indices and Carcinogenic Risks for Current Off-site Juvenile Wader, SWMU 3

Chemical	Surface Water[a]			Total Hazard Index[a]
	Oral HQ	Dermal HQ	Total	
Arsenic	1.54E-03	1.50E-03	3.04E-03	3.04E-03
Benzo(*b*)fluoranthene	ND	ND	—	—
Chromium	2.93E-04	5.87E-03	6.16E-03	6.16E-03
Lead	NA	NA	NA	—
Pathway Total	**1.83E-03**	**7.37E-03**	**9.20E-03**	**9.20E-03**

Chemical	Surface Water[b]			Total Cancer Risk[b]
	Oral ILCR	Dermal ILCR	Total	
Arsenic	9.90E-08	9.66E-08	1.96E-07	1.96E-07
Benzo(*b*)fluoranthene	4.36E-08	6.48E-06	6.53E-06	6.53E-06
Chromium	ND	ND	ND	—
Lead	NA	NA	NA	—
Pathway Total	**1.43E-07**	**6.58E-06**	**6.72E-06**	**6.72E-06**

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2.
[b]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1.
NA = Not applicable; lead is evaluated separately using a biokinetic uptake model.
ND = The toxicity data required to quantify the risk are not available.
— = No data.

Table 10.2A-18. Hazard Indices and Carcinogenic Risks for Future On-site Installation Worker, SWMU 3

Chemical	Groundwater[a]		Surface Soil[a]				Total Hazard Index[a]
	Oral HQ	Total	Oral HQ	Dermal HQ	Inhalation HQ	Total	
Arsenic	NA	NA	2.31E-02	5.64E-04	ND	2.37E-02	2.37E-02
delta-BHC	ND	—	NA	NA	NA	NA	—
Mercury	6.36E-03	6.36E-03	NA	NA	NA	NA	6.36E-03
Pathway Total	**6.36E-03**	**6.36E-03**	**2.31E-02**	**5.64E-04**	—	**2.37E-02**	**3.00E-02**

Chemical	Groundwater[b]		Surface Soil[b]				Total Cancer Risk[b]
	Oral ILCR	Total	Oral ILCR	Dermal ILCR	Inhalation ILCR	Total	
Arsenic	NA	NA	3.72E-06	9.06E-08	1.39E-09	3.81E-06	3.81E-06
delta-BHC	2.55E-07	2.55E-07	NA	NA	NA	NA	2.55E-07
Mercury	ND	—	NA	NA	NA	NA	—
Pathway Total	**2.55E-07**	**2.55E-07**	**3.72E-06**	**9.06E-08**	**1.39E-09**	**3.81E-06**	**4.06E-06**

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2.
[b]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1.
NA = Not applicable; this chemical is not present in this environmental medium.
ND = The toxicity data required to quantify the risk are not available.
— = No data.

Table 10.2A-15. Hazard Indices and Carcinogenic Risks for Current On-site Installation Worker, SWMU 3

Chemical	Surface Soil[a]			Total Hazard Index[a]
	Oral HQ	Dermal HQ	Total	
Arsenic	2.31E-02	5.64E-04	2.37E-02	2.37E-02
Chemical	**Surface Soil[b]**			**Total Cancer Risk[b]**
	Oral ILCR	**Dermal ILCR**	**Total**	
Arsenic	3.72E-06	9.06E-08	3.81E-06	3.81E-06

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2.
[b]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1.

Table 10.2A-16. Hazard Indices and Carcinogenic Risks for Current On-site Juvenile Trespasser, SWMU 3

Chemical	Surface Soil[a]			Surface Water[a]			Sediment[a]		Total Hazard Index[a]
	Oral HQ	Dermal HQ	Total	Oral HQ	Dermal HQ	Total	Oral HQ	Total	
Arsenic	1.87E-03	1.35E-04	2.01E-03	1.54E-03	1.50E-03	3.04E-03	4.07E-03	4.07E-03	9.12E-03
Benzo(*b*)fluoranthene	NA[b]	NA[b]	NA[b]	ND	ND	ND	NA[b]	NA[b]	—
Chromium	NA[b]	NA[b]	NA[b]	2.93E-04	5.87E-03	6.16E-03	NA[b]	NA[b]	6.16E-03
Lead	NA[b]	NA[b]	NA[b]	NA[c]	NA[c]	NA[c]	NA[b]	NA[b]	—
Pathway Total	**1.87E-03**	**1.35E-04**	**2.01E-03**	**1.83E-03**	**7.37E-03**	**9.20E-03**	**4.07E-03**	**4.07E-03**	**1.53E-02**
Chemical	**Surface Soil[d]**			**Surface Water[d]**			**Sediment[d]**		**Total Cancer Risk[d]**
	Oral ILCR	**Dermal ILCR**	**Total**	**Oral ILCR**	**Dermal ILCR**	**Total**	**Oral ILCR**	**Total**	
Arsenic	1.20E-07	8.68E-09	1.29E-07	9.90E-08	9.66E-08	1.96E-07	2.62E-07	2.62E-07	5.87E-07
Benzo(*b*)fluoranthene	NA[b]	NA[b]	NA[b]	4.36E-08	6.48E-06	6.53E-06	NA[b]	NA[b]	6.53E-06
Chromium	NA[b]	NA[b]	NA[b]	ND	ND	ND	NA[b]	NA[b]	—
Lead	NA[b]	NA[b]	NA[b]	NA[c]	NA[c]	NA[c]	NA[b]	NA[b]	—
Pathway Total	**1.20E-07**	**8.68E-09**	**1.29E-07**	**1.43E-07**	**6.58E-06**	**6.72E-06**	**2.62E-07**	**2.62E-07**	**7.11E-06**

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2.
[b]NA = Not applicable; this chemical is not present in this environmental medium.
[c]NA = Not applicable; lead is evaluated separately using a biokinetic uptake model.
[d]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1.
ND = The toxicity data required to quantify the risk are not available.
— = No data.

Table 10.2A-13. Estimated Intakes for Future Off-site Resident Adult, SWMU 3

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a,b] Average Daily Dose for Carcinogens (mg/kg/d)	Dermal Exposure[a,b] Average Daily Dose for Carcinogens (mg/kg/d)	Inhalation Exposure[a] Average Daily Dose for Carcinogens (mg/kg/d)
Surface soil	Arsenic	7.09	mg/kg	NA[c]	NA[c]	1.14E-10
Groundwater	delta-BHC	0.0000405	mg/L	4.76E-07	2.69E-08	NA[d]
	Mercury	0.000195	mg/L	ND	ND	NA[d]

[a]The equations used to calculate oral, dermal, and inhalation exposures in surface soil are presented in Appendix I, Section I.2.4.2.
[b]The equations used to calculate oral and dermal exposures in groundwater are presented in Appendix I, Section I.2.4.3.
[c]NA = Not applicable; this receptor is not exposed via this pathway.
[d]NA = Not applicable; inhalation exposure is not a viable pathway for this chemical.
ND = The toxicity data required to quantify the risk are not available.

Table 10.2A-14. Toxicity Values for Constituents of Potential Concern, SWMU 3

Chemical	Oral Reference Dose (mg/kg/d)	Ref.[a]	Oral Cancer Slope Factor 1/(mg/kg/d)	Ref.[a]	Gastrointestinal Absorption Factor	Dermal Reference Dose[b] (mg/kg/d)	Dermal Cancer Slope Factor[c] 1/(mg/kg/d)	Inhalation Reference Dose (mg/kg/d)	Ref.[a]	Inhalation Cancer Slope Factor 1/(mg/kg/d)	Ref.[a]
Arsenic	3.00E-04	I	1.50E+00	I	4.10E-01	1.23E-04	3.66E+00	ND		5.00E+01	I
Benzo(*b*)fluoranthene	ND		7.30E-01[d]	I	3.10E-01	ND	2.35E+00	ND		3.10E-01[d]	I
Chromium[e]	3.00E-03	I	ND		2.00E-02	6.00E-05	ND	2.86E-05	I	4.10E+01	H
delta-BHC[f]	ND		1.80E+00	I	9.70E-01	ND	1.86E+00	ND		1.80E+00	I
Lead	ND		ND		NA	ND	ND	ND		ND	
Mercury[g]	3.00E-04	I	ND		7.00E-02	2.10E-05	ND	8.57E-05	I	ND	

[a]References: I = IRIS (EPA 1999a); H = HEAST (EPA 1997c).
[b]Dermal dose calculated using the following formula: oral reference dose × gastrointestinal absorption factor.
[c]Dermal cancer slope factor calculated using the following formula: oral reference dose ÷ gastrointestinal absorption factor.
[d]Cancer slope factor based on toxicity equivalency factor of 0.1 relative to benzo(*a*)pyrene (EPA 1999a). Reference is for cancer slope factor for benzo(*a*)pyrene.
[e]Toxicity values given are for hexavalent chromium.
[f]Values given are for technical-grade BHC.
[g]Oral and dermal reference dose values are for mercuric chloride.
NA = Not applicable.
ND = No data available.

Table 10.2A-11. Estimated Intakes for Future Off-site Juvenile Wader, SWMU 3

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a]		Dermal Exposure[a]		Inhalation Exposure[b]	
				Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)	Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)	Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)
Surface soil	Arsenic	7.09	mg/kg	NA[c]	NA[c]	NA[c]	NA[c]	4.75E-11	6.79E-12
Surface water	Arsenic	0.0073	mg/L	4.62E-07	6.60E-08	1.85E-07	2.64E-08	NA[c]	NA[c]
	Benzo(*b*) fluoranthene	0.0066	mg/L	ND	5.97E-08	ND	2.87E-05	NA[c]	NA[c]
	Chromium	0.0139	mg/L	8.80E-07	ND	3.52E-07	ND	NA[c]	NA[c]
[d]	delta-BHC	0.000082[e]	mg/L	ND	7.42E-10	ND	1.01E-08	NA[c]	NA[c]
	Lead	0.009	mg/L	NA[f]	ND	NA[f]	ND	NA[c]	NA[c]
[d]	Mercury	0.00046[e]	mg/L	2.91E-08	ND	1.17E-08	ND	NA[c]	NA[c]

[a]The equations used to calculate oral and dermal exposures in surface water are presented in Appendix I, Section I.2.4.4.
[b]The equation used to calculate inhalation exposure in surface soil is presented in Appendix I, Section I.2.4.2.
[c]NA = Not applicable; this receptor is not exposed via this pathway.
[d]Shallow groundwater discharging to surface water.
[e]Exposure concentration based on shallow groundwater samples GP4, GP5, and GP6.
[f]NA = Not applicable; lead is evaluated separately using a biokinetic uptake model.
ND = The toxicity data required to quantify the risk are not available.

Table 10.2A-12. Estimated Intakes for Future Off-site Resident Child, SWMU 3

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a,b]		Dermal Exposure[a,b]		Inhalation Exposure[a]	
				Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)	Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)	Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)
Surface soil	Arsenic	7.09	mg/kg	NA[c]	NA[c]	NA[c]	NA[c]	ND	9.03E-11
Groundwater	delta-BHC	0.0000405	mg/L	ND	2.22E-07	ND	ND	NA[d]	NA[d]
	Mercury	0.000195	mg/L	1.25E-05	ND	6.99E-09	ND	NA[d]	NA[d]

[a]The equations used to calculate oral, dermal, and inhalation in surface soil exposures are presented in Appendix I, Section I.2.4.2.
[b]The equations used to calculate oral and dermal exposures in groundwater are presented in Appendix I, Section I.2.4.3.
[c]NA = Not applicable; this receptor is not exposed via this pathway.
[d]NA = Not applicable; inhalation exposure is not a viable pathway for this chemical.
ND = The toxicity data required to quantify the risk are not available.

Table 10.2A-9. Estimated Intakes for Future On-site Resident Adult, SWMU 3

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a,b] Average Daily Dose for Carcinogens (mg/kg/d)	Dermal Exposure[a,b] Average Daily Dose for Carcinogens (mg/kg/d)	Inhalation Exposure[a] Average Daily Dose for Carcinogens (mg/kg/d)
Surface soil	Arsenic	7.09	mg/kg	4.16E-06	4.16E-08	1.14E-10
Groundwater	delta-BHC	0.0000405	mg/L	4.76E-07	2.69E-08	NA
	Mercury	0.000195	mg/L	ND	ND	NA

[a]The equations used to calculate oral, dermal, and inhalation exposures in surface soil are presented in Appendix I, Section I.2.4.2.
[b]The equations used to calculate oral and dermal exposures in groundwater are presented in Appendix I, Section I.2.4.3.
NA = Not applicable; inhalation exposure is not a viable pathway for this chemical.
ND = The toxicity data required to quantify the risk are not available.

Table 10.2A-10. Estimated Intakes for Future Off-site Installation Worker, SWMU 3

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a,b] Average Daily Dose for Noncarcinogens (mg/kg/d)	Oral Exposure[a,b] Average Daily Dose for Carcinogens (mg/kg/d)	Inhalation Exposure[a] Average Daily Dose for Noncarcinogens (mg/kg/d)	Inhalation Exposure[a] Average Daily Dose for Carcinogens (mg/kg/d)
Surface soil	Arsenic	7.09	mg/kg	NA[c]	NA[c]	ND	9.20E-11
Groundwater	delta-BHC	0.0000405	mg/L	ND	1.42E-07	NA[d]	NA[d]
	Mercury	0.000195	mg/L	1.91E-06	ND	NA[d]	NA[d]

[a]The equations used to calculate oral and inhalation exposures in surface soil are presented in Appendix I, Section I.2.4.2.
[b]The equations used to calculate oral exposure in groundwater is presented in Appendix I, Section I.2.4.3.
[c]NA = Not applicable; this receptor is not exposed via this pathway.
[d]NA = Not applicable; inhalation exposure is not a viable pathway for this chemical.
ND = The toxicity data required to quantify the risk are not available.

Table 10.2A-7. Estimated Intakes for Future On-site Juvenile Trespasser, SWMU 3

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a,b,c]		Dermal Exposure[a,b,c]		Inhalation Exposure[a]	
				Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)	Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)	Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)
Surface soil	Arsenic	7.09	mg/kg	5.61E-07	8.02E-08	1.66E-08	2.37E-09	ND	6.79E-12
Surface water	Arsenic	0.0073	mg/L	4.62E-07	6.60E-08	1.85E-07	2.64E-08	NA[d]	NA[d]
	Benzo(*b*) fluoranthene	0.0066	mg/L	ND	5.97E-08	ND	2.87E-05	NA[d]	NA[d]
	Chromium	0.0139	mg/L	8.80E-07	ND	3.52E-07	ND	NA[d]	NA[d]
[e]	delta-BHC	0.000082[f]	mg/L	ND	7.42E-10	ND	1.01E-08	NA[d]	NA[d]
	Lead	0.009	mg/L	NA[g]	ND	NA[g]	ND	NA[d]	NA[d]
[e]	Mercury	0.00046[f]	mg/L	2.91E-08	ND	1.17E-08	ND	NA[d]	NA[d]
Sediment	Arsenic	29.7	mg/kg	1.22E-06	1.75E-07	NA[d]	NA[d]	NA[d]	NA[d]

[a]The equations used to calculate oral, dermal, and inhalation exposures in surface soil are presented in Appendix I, Section I.2.4.2.
[b]The equations used to calculate oral and dermal exposures in surface water are presented in Appendix I, Section I.2.4.4.
[c]The equation used to calculate oral exposure in sediment is presented in Appendix I, Section I.2.4.5.
[d]NA = Not applicable; this receptor is not exposed via this pathway.
[e]Shallow groundwater discharging to surface water.
[f]Exposure concentration based on shallow groundwater samples GP4, GP5, and GP6.
[g]NA = Not applicable; lead is evaluated separately using a biokinetic uptake model.
ND = The toxicity data required to quantify the risk are not available.

Table 10.2A-8. Estimated Intakes for Future On-site Resident Child, SWMU 3

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a,b]		Dermal Exposure[a,b]		Inhalation Exposure[a]	
				Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)	Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)	Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)
Surface soil	Arsenic	7.09	mg/kg	9.06E-05	7.77E-06	1.54E-07	1.32E-08	ND	9.03E-11
Groundwater	delta-BHC	0.0000405	mg/L	ND	2.22E-07	ND	ND	NA	NA
	Mercury	0.000195	mg/L	1.25E-05	ND	6.99E-09	ND	NA	NA

[a]The equations used to calculate oral, dermal, and inhalation exposures in surface soil are presented in Appendix I, Section I.2.4.2.
[b]The equations used to calculate oral and dermal exposures in groundwater are presented in Appendix I, Section I.2.4.3.
NA = Not applicable; inhalation exposure is not a viable pathway for this chemical.
ND = The toxicity data required to quantify the risk are not available.

Table 10.2A-5. Estimated Intakes for Current Off-site Juvenile Wader, SWMU 3

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a]		Dermal Exposure[a]	
				Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)	Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)
Surface water	Arsenic	0.0073	mg/L	4.62E-07	6.60E-08	1.85E-07	2.64E-08
	Benzo(*b*)fluoranthene	0.0066	mg/L	ND	5.97E-08	ND	2.87E-05
	Chromium	0.0139	mg/L	8.80E-07	ND	3.52E-07	ND
	Lead	0.009	mg/L	NA	ND	NA	ND

[a]The equations used to calculate oral and dermal exposures in surface water are presented in Appendix I, Section I.2.4.4.
NA = Not applicable; lead is evaluated separately using a biokinetic uptake model.
ND = The toxicity data required to quantify the risk are not available.

Table 10.2A-6. Estimated Intakes for Future On-site Installation Worker, SWMU 3

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a,b]		Dermal Exposure[a]		Inhalation Exposure[a]	
				Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)	Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)	Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)
Surface soil	Arsenic	7.09	mg/kg	6.94E-06	2.48E-06	6.94E-08	2.48E-08	ND	9.20E-11
Groundwater	delta-BHC	0.0000405	mg/L	ND	1.42E-07	NA	NA	NA	NA
	Mercury	0.000195	mg/L	1.91E-06	ND	NA	NA	NA	NA

[a]The equations used to calculate oral, dermal, and inhalation exposures in surface soil are presented in Appendix I, Section I.2.4.2.
[b]The equation used to calculate oral exposure in groundwater is presented in Appendix I, Section I.2.4.3.
NA = Not applicable; this receptor is not exposed via this pathway.
ND = The toxicity data required to quantify the risk are not available.

Table 10.2A-3. Estimated Intakes for Current On-site Installation Worker, SWMU 3

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a]		Dermal Exposure[a]	
				Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)	Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)
Surface soil	Arsenic	7.09	mg/kg	6.94E-06	2.48E-06	6.94E-08	2.48E-08

[a]The equations used to calculate oral and dermal exposures for surface water are presented in Appendix I, Section I.2.4.4.

Table 10.2A-4. Estimated Intakes for Current On-site Juvenile Trespasser, SWMU 3

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a,b,c]		Dermal Exposure[a,b]	
				Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)	Average Daily Dose for Noncarcinogens (mg/kg/d)	Average Daily Dose for Carcinogens (mg/kg/d)
Surface soil	Arsenic	7.09	mg/kg	5.61E-07	8.02E-08	1.66E-08	2.37E-09
Surface water	Arsenic	0.0073	mg/L	4.62E-07	6.60E-08	1.85E-07	2.64E-08
	Benzo(*b*)fluoranthene	0.0066	mg/L	ND	5.97E-08	ND	2.87E-05
	Chromium	0.0139	mg/L	8.80E-07	ND	3.52E-07	ND
	Lead	0.009	mg/L	NA[d]	ND	NA[d]	ND
Sediment	Arsenic	29.7	mg/kg	1.22E-06	1.75E-07	NA[e]	NA[e]

[a]The equations used to calculate oral and dermal exposures from surface soil are presented in Appendix I, Section I.2.4.2.
[b]The equations used to calculate oral and dermal exposures from surface water are presented in Appendix I, Section I.2.4.4.
[c]The equation used to calculate oral exposure from sediment is presented in Appendix I, Section I.2.4.5.
[d]NA = Not applicable; lead is evaluated separately using a biokinetic uptake model.
[e]NA = Not applicable; this pathway is not assessed for sediment.
ND = The toxicity data required to quantify the risk are not available.

Table 10.2A-2. Exposure Parameters for Potential Receptor Populations, SWMU 3 (continued)

Parameter	Units	On-site Installation Worker	On-site Juvenile Trespasser	On-site Resident Adult	On-site Resident Child	Off-site Installation Worker	Off-site Resident Adult	Off-site Resident Child	Off-site Juvenile Wader
Dermal Contact while Bathing									
Skin area	m^2	NA	NA	2	0.170	NA	2	0.170	NA
Exposure time	hours/day	NA	NA	0.17	0.33	NA	0.17	0.33	NA
Exposure frequency	days/year	NA	NA	350	350	NA	350	350	NA
Exposure duration	years	NA	NA	30	6	NA	30	6	NA
Body weight	kg	NA	NA	70	15	NA	70	15	NA
Carcinogen averaging time	days	NA	NA	25,550	NA	NA	25,550	NA	NA
Noncarcinogen averaging time	days	NA	NA	NA	2,190	NA	NA	2,190	NA

NA = Not applicable.

Table 10.2A-2. Exposure Parameters for Potential Receptor Populations, SWMU 3 (continued)

Parameter	Units	On-site Installation Worker	On-site Juvenile Trespasser	On-site Resident Adult	On-site Resident Child	Off-site Installation Worker	Off-site Resident Adult	Off-site Resident Child	Off-site Juvenile Wader
SURFACE WATER									
Incidental Ingestion									
Water ingestion rate	L/hour	NA	0.05	NA	NA	NA	NA	NA	0.05
Exposure time	hours/day	NA	2	NA	NA	NA	NA	NA	2
Exposure frequency	days/year	NA	52	NA	NA	NA	NA	NA	52
Exposure duration	years	NA	10	NA	NA	NA	NA	NA	10
Body weight	kg	NA	45	NA	NA	NA	NA	NA	45
Carcinogen averaging time	days	NA	25,550	NA	NA	NA	NA	NA	25,550
Noncarcinogen averaging time	days	NA	3,650	NA	NA	NA	NA	NA	3,650
Dermal Contact while Wading									
Skin area	m^2	NA	0.4	NA	NA	NA	NA	NA	0.4
Exposure time	hours/day	NA	2	NA	NA	NA	NA	NA	2
Exposure frequency	days/year	NA	52	NA	NA	NA	NA	NA	52
Exposure duration	years	NA	10	NA	NA	NA	NA	NA	10
Body weight	kg	NA	45	NA	NA	NA	NA	NA	45
Carcinogen averaging time	days	NA	25,550	NA	NA	NA	NA	NA	25,550
Noncarcinogen averaging time	days	NA	3,650	NA	NA	NA	NA	NA	3,650
GROUNDWATER									
Drinking Water Ingestion									
Drinking water ingestion	L/day	1	NA	2	1	1	2	1	NA
Fraction ingested from area	unitless	1	NA	1	1	1	1	1	NA
Exposure frequency	days/year	250	NA	350	350	250	350	350	NA
Exposure duration	years	25	NA	30	6	25	30	6	NA
Body weight	kg	70	NA	70	15	70	70	15	NA
Carcinogen averaging time	days	25,550	NA	25,550	NA	25,550	25,550	NA	NA
Noncarcinogen averaging time	days	9,125	NA	NA	2,190	9,125	NA	2,190	NA
Inhalation of VOCs									
Inhalation rate	m^3/hour	NA	NA	0.4	NA	NA	0.4	NA	NA
Exposure time	hours/day	NA	NA	0.17	NA	NA	0.17	NA	NA
Exposure frequency	days/year	NA	NA	350	NA	NA	350	NA	NA
Exposure duration	years	NA	NA	30	NA	NA	30	NA	NA
Body weight	kg	NA	NA	70	NA	NA	70	NA	NA
Carcinogen averaging time	days	NA	NA	25,550	NA	NA	25,550	NA	NA
Noncarcinogen averaging time	days	NA	NA	10,950	NA	NA	10,950	NA	NA

Note: Footnotes appear on page 10.2A-17.

Table 10.2A-2. Exposure Parameters for Potential Receptor Populations, SWMU 3

Parameter	Units	On-site Installation Worker	On-site Juvenile Trespasser	On-site Resident Adult	On-site Resident Child	Off-site Installation Worker	Off-site Resident Adult	Off-site Resident Child	Off-site Juvenile Wader
SURFACE SOIL									
Incidental Ingestion									
Soil ingestion rate	g/day	0.1	0.1	0.1	0.2	NA	NA	NA	NA
Fraction ingested from area	unitless	1	0.25	1	1	NA	NA	NA	NA
Exposure frequency	days/year	250	52	350	350	NA	NA	NA	NA
Exposure duration	years	25	10	30	6	NA	NA	NA	NA
Body weight	kg	70	45	70	15	NA	NA	NA	NA
Carcinogen averaging time	days	25,550	25,550	25,550	NA	NA	NA	NA	NA
Noncarcinogen averaging time	days	9,15	3,650	NA	2,190	NA	NA	NA	NA
Dermal Contact									
Skin area	cm^2/event	5,000	3,700	5,000	1,700	NA	NA	NA	NA
Adherence factor	mg/cm^2	0.2	0.2	0.2	0.2	NA	NA	NA	NA
Exposure frequency	events/year	250	52	350	350	NA	NA	NA	NA
Exposure duration	years	25	10	30	6	NA	NA	NA	NA
Body weight	kg	70	45	70	15	NA	NA	NA	NA
Carcinogen averaging time	days	25,550	25,550	25,550	NA	NA	NA	NA	NA
Noncarcinogen averaging time	days	9,125	3,650	NA	2,190	NA	NA	NA	NA
Inhalation of Dust									
Inhalation rate	m^3/hour	2.5	1.9	0.80	0.68	2.5	0.80	0.68	1.9
Exposure time	hours/day	8	6	18.4	18.4	8	18.4	18.4	6
Exposure frequency	days/year	250	52	350	350	250	350	350	52
Exposure duration	years	25	10	30	6	25	30	6	10
Body weight	kg	70	45	70	15	70	70	15	45
Carcinogen averaging time	days	25,550	25,550	25,550	NA	25,550	25,550	NA	25,550
Noncarcinogen averaging time	days	9,125	3,650	NA	2,190	9,125	NA	2,190	3,650
SEDIMENT									
Incidental Ingestion									
Sediment ingestion rate	g/day	NA	0.1	NA	NA	NA	NA	NA	NA
Fraction ingested from area	unitless	NA	0.13	NA	NA	NA	NA	NA	NA
Exposure frequency	days/year	NA	52	NA	NA	NA	NA	NA	NA
Exposure duration	years	NA	10	NA	NA	NA	NA	NA	NA
Body weight	kg	NA	45	NA	NA	NA	NA	NA	NA
Carcinogen averaging time	days	NA	25,550	NA	NA	NA	NA	NA	NA
Noncarcinogen averaging time	days	NA	3,650	NA	NA	NA	NA	NA	NA

Note: Footnotes appear on page 10.2A-17.

Table 10.2A-1. Selected Exposure and Modeled Concentrations, SWMU 3

HHCOPCs			
Medium/Units	**Chemical**	**Maximum Detected Concentration**	**95 Percent Upper Confidence Limit**
Soil (mg/kg)	Arsenic	24.0	**7.09**
Groundwater (μg/L)	delta-BHC	0.082	**0.0405**
	Mercury	0.46	**0.195**
Surface water (μg/L)	Arsenic	**7.3**	22.3
	Benzo(*b*)fluoranthene	**6.6**	10.3
	Chromium	**13.9**	49.2
	Lead	**9.0**	31.9
Sediment (mg/kg)	Arsenic	**29.7**	108

Bold indicates exposure concentration selected.

The remedial levels for COCs should not result in an ILCR greater than 1×10^{-4} (GEPD 1996). Only one COC has been identified in surface water and another in surface soil for this site, and these COCs are risk drivers for different receptor populations. Therefore, it is recommended that the risk-based remedial level for an ILCR of 5.0×10^{-5} be used. This level will provide a margin of safety, given that this value is below the maximum acceptable limit.

The recommended risk-based remedial level for arsenic in surface soil is 30.3 mg/kg. This concentration is greater than the maximum detected concentration of 24 mg/kg. Given that the maximum concentration is below the recommended remedial value, no further action is required to address the presence of arsenic in surface soil.

The recommended risk-based remedial level for benzo(*b*)fluoranthene in surface water is 0.0505 mg/L. This value is greater than the maximum detected value of 0.0066 mg/L. Given that the maximum concentration is below the recommended remedial value, no further action is required to address the presence of benzo(*b*)fluoranthene in surface water.

contact with soil would be higher for the juvenile trespasser than for the sportsman. Similarly, the sportsman may be exposed to COPCs in surface water as a result of bioaccumulation in fish and direct contact with the surface water. The surface water present on the site is limited to a swampy area that has no recreational value, and the sportsman would not be fishing in this type of area. The surface water may migrate south toward the Canoochee River, but water flow is slow, and the constituents present are likely to either degrade or be removed from the water column by various mechanisms including adsorption onto sediments and emergent vegetation, and volatilization. Therefore, significant exposure of receptors at the Canoochee River is unlikely. Given the absence of significant exposure pathways, the sportsman was not assessed further in the baseline risk assessment.

Future land-use populations include an Installation worker, a juvenile trespasser/wader, and a resident. These receptor populations represent both on-site and off-site receptors. The residential receptor population was divided into an adult and a child because the adult receptor is at greater risk from exposure to carcinogens, while the child is at greater risk from exposure to noncarcinogens. The reader is referred to Appendix I, Section I.2.2 ("Identification of Potential Receptor Populations and Associated Exposure Pathways") for a more detailed discussion on the potential exposure pathways and the differences between the exposure of the adult and child resident receptors.

Juvenile receptors (i.e., a juvenile trespasser and a juvenile wader) had ILCRs that exceeded the target level of 1×10^{-6}. Benzo(*b*)fluoranthene in surface water is the risk driver, with ILCRs that exceeded 1×10^{-6} for all of the juvenile receptors; therefore, benzo(*b*)fluoranthene was identified as a COC in surface water.

The on-site Installation workers (both current and future) had ILCRs that exceeded the target level of 1×10^{-6}. Arsenic in surface soil is the risk driver, with ILCRs that exceeded 1×10^{-6} for both the current and future Installation workers; therefore, arsenic was identified as a COC in surface soil.

The ILCRs for the future on-site resident child and resident adult exceeded the target level of 1×10^{-6}, with ILCR values of 1.21×10^{-5} and 7.30×10^{-6}, respectively. Arsenic in surface soil was identified as a COC for both of these receptors, with an ILCR of 1.17×10^{-5} for the resident child and of 6.40×10^{-6} for the resident adult.

Chromium (surface water), lead (surface water), mercury (groundwater), and delta-BHC (groundwater) are not risk drivers at this site; therefore, these constituents are not considered to be COCs. Arsenic was identified as a COC in surface soil only. It is not a COC in surface water or sediment. Benzo(*b*)fluoranthene was identified as a COC in surface water.

Remedial levels were derived for arsenic in surface soil and benzo(*b*)fluoranthene in surface water.

10.2A.7 REMEDIAL LEVELS

A remedial level was derived for arsenic in surface soil based on incidental ingestion, dermal, and inhalation exposure of an on-site resident child. A remedial level was derived for benzo(*b*)fluoranthene in surface water based on incidental ingestion and dermal exposure of a juvenile playing in the surface water. The development of the remedial level followed the protocols given in Appendix I, Section I.6. The remedial levels in surface soil and surface water are given in Tables 10.2A-26 and 10.2A-27, respectively.

The total HI for this receptor is 4.19×10^{-2}, which is more than an order of magnitude below the target value of 1.0; therefore, adverse systemic health risks are not expected for this receptor population.

The total ILCR for this receptor is 4.08×10^{-7}. This ILCR value is below the target risk value of 1×10^{-6}; therefore, the cancer risks for this receptor are within acceptable limits.

Off-site Resident Adult. The calculated risk values for the off-site resident adult are given in Table 10.2A-25. Only ILCRs are calculated for this receptor population. The noncarcinogenic risks are calculated for the resident child.

The total ILCR for this receptor is 9.08×10^{-7}, which is below the target risk value of 1×10^{-6}; therefore, the cancer risks for this receptor are within acceptable limits.

10.2A.5 UNCERTAINTY ASSESSMENT

A discussion of the general uncertainties associated with the analysis of risks at sites within the 16 SWMUs is provided in Appendix I, Section I.5.

It was conservatively assumed that the off-site concentrations of COPCs in various environmental media are equal to the on-site concentrations. However, as COPCs migrate the concentrations in environmental media generally decrease as a result of dilution, degradation, and other physicochemical processes. Assuming that the concentrations of COPCs remain constant is likely to result in an overestimation of the exposure of off-site receptors.

The exact chemical forms of chromium and mercury were not known. As a conservative measure, it was assumed that chromium existed in the more toxic hexavalent state, although this form of chromium is very unstable and readily oxidizes to the less toxic trivalent state.

10.2A.6 RISK SUMMARY

The purpose of the risk summary is to provide an overview of the risk assessment results, including identification of the COPCs assessed, the receptor populations, and the risk characterization results.

The baseline risk assessment addressed the risks associated with exposure to the following HHCOPCs: arsenic (surface soil, surface water, and sediment), chromium (surface water), lead (surface water), mercury (groundwater), delta-BHC (groundwater), and benzo(*b*)fluoranthene (surface water). No CMCOPCs were identified for this site.

The potential risks associated with exposure to lead are quantified based on the blood lead levels resulting from exposure to lead in various media. The potential risks associated with exposure to lead could not be quantified, given that the IEUBK model (EPA 1994f) used to estimate blood lead levels does not address intermittent exposures such as incidental ingestion of surface water as a result of wading. Given that the primary exposure pathway is incidental ingestion, the exposure concentration in surface water was compared to risk-based screening values for drinking water.

The sportsman may be exposed to COPCs in surface soil through bioaccumulation into deer foraging on the vegetation at SWMU 3 as well as through direct exposure. However, arsenic (the only surface soil COPC) does not readily bioaccumulate in either plants or animals. Therefore, exposure via bioaccumulation into venison is not likely to be a significant exposure pathway. Exposure via direct

On-site Resident Child. The calculated risk values for the on-site resident child are given in Table 10.2A-20.

The total HI for this receptor is 3.45×10^{-1}, which is below the target value of 1.0; therefore, adverse systemic health risks are not expected for this receptor population.

The total ILCR for this receptor is 1.21×10^{-5}. This ILCR value is above the target risk value of 1×10^{-6}. The major risk driver is arsenic in surface soil (ILCR = 1.17×10^{-5}).

On-site Resident Adult. The calculated risk values for the on-site resident adult are given in Table 10.2A-21. Only ILCRs are calculated for this receptor population. The noncarcinogenic risks are calculated for the resident child.

The total ILCR for this receptor is 7.30×10^{-6}, which is above the target risk value of 1×10^{-6}. Arsenic in surface soil is the primary risk driver, with an ILCR of 6.40×10^{-6}. The remaining COPCs had carcinogenic risks below 1×10^{-6}.

Off-site Installation Worker. The calculated risk values for the off-site Installation worker are given in Table 10.2A-22.

The total HI for this receptor is 6.36×10^{-3}, which is more than two orders of magnitude less than the target value of 1.0; therefore, adverse systemic health risks are not expected for this receptor population.

The total ILCR for this receptor is 2.56×10^{-7}, which is below the target risk value of 1×10^{-6}; therefore, the cancer risks for this receptor are within acceptable limits.

Off-site Juvenile Wader. The calculated risk values for the current off-site juvenile trespasser are given in Table 10.2A-23.

The total HI for this receptor is 9.86×10^{-3}, which is more than two orders of magnitude below the target value of 1.0; therefore, adverse systemic health risks are not expected for this receptor population.

The off-site juvenile wader may be exposed to lead in surface water via incidental ingestion and dermal contact. The exposure concentration of lead in surface water is 9 μg/L, which is below the action level for lead in drinking water of 15 μg/L. This action level represents the maximum concentration of lead in drinking water that would not result in adverse health effects in a child. The amount of water ingested by a child via incidental ingestion of surface water (approximately 5.2 L/year) is more than an order of magnitude less than that for a child being exposed via drinking water (350 L/year). Dermal exposure is likely to be minimal for the juvenile wader given the low dermal absorption rate of 0.001 cm/hour (EPA 1995). Given that the concentration of lead in surface water is less than the drinking water screening level, it is unlikely that exposure of a juvenile to lead in surface water would cause adverse health effects.

The total ILCR is 6.74×10^{-6}, which is above the target risk value of 1×10^{-6}. Benzo(*b*)fluoranthene in surface water is the primary risk driver, with an ILCR value of 6.53×10^{-6}. The remaining COPCs had carcinogenic risks below 1×10^{-6}.

Off-site Resident Child. The calculated risk values for the off-site resident child are given in Table 10.2A-24.

lead in drinking water of 15 μg/L. This action level represents the maximum concentration of lead in drinking water that would not result in adverse health effects in a child. The amount of water ingested by a child via incidental ingestion of surface water (approximately 5.2 L/year) is more than an order of magnitude less than that for a child being exposed via drinking water (350 L/year). Dermal exposure is likely to be minimal for the juvenile wader given the low dermal absorption rate of 0.001 cm/hour (EPA 1995). Given that the concentration of lead in surface water is less than the drinking water screening level, it is unlikely that exposure of a juvenile to lead in surface water would cause adverse health effects.

The total ILCR for this receptor is 6.72×10^{-6}, which exceeds the target risk value of 1×10^{-6}. Benzo(*b*)fluoranthene in surface water is the primary risk driver, with an ILCR value of 6.53×10^{-6}. The remaining COPCs had carcinogenic risks below 1×10^{-6}.

10.2A.4.2 Future Land-use Scenarios

Future potential on-site receptors are the Installation worker, the juvenile trespasser, and the resident. Future off-site receptors include an Installation worker, a juvenile wader, and a resident. The potential risks to each of these receptor populations are discussed below.

On-site Installation Worker. The calculated risk values for the on-site Installation worker are given in Table 10.2A-18.

The total HI for this receptor is 3.00×10^{-2}, which is more than an order of magnitude less than the target value of 1.0; therefore, adverse systemic health risks are not expected for this receptor population.

The total ILCR for this receptor is 4.06×10^{-6}, which exceeds the target risk value of 1×10^{-6}. Arsenic is the primary risk driver, with an ILCR of 3.81×10^{-6}. The remaining COPCs had carcinogenic risks below 1×10^{-6}.

On-site Juvenile Trespasser. The calculated risk values for the juvenile trespasser are given in Table 10.2A-19.

The total HI for this receptor is 1.59×10^{-2}, which is more than an order of magnitude below the target value of 1.0; therefore, adverse systemic health risks are not expected for this receptor population.

The on-site juvenile trespasser may be exposed to lead in surface water via incidental ingestion and dermal contact. The exposure concentration of lead in surface water is 9 μg/L, which is below the action level for lead in drinking water of 15 μg/L. This action level represents the maximum concentration of lead in drinking water that would not result in adverse health effects in a child. The amount of water ingested by a child via incidental ingestion of surface water (approximately 5.2 L/year) is more than an order of magnitude less than that for a child being exposed via drinking water (350 L/year). Dermal exposure is likely to be minimal for the juvenile wader given the low dermal absorption rate of 0.001 cm/hour (EPA 1995). Given that the concentration of lead in surface water is less than the drinking water screening level, it is unlikely that exposure of a juvenile to lead in surface water would cause adverse health effects.

The total ILCR for this receptor is 7.14×10^{-6}, which exceeds the target risk value of 1×10^{-6}. Benzo(*b*)fluoranthene in surface water is the primary risk driver, with an ILCR value of 6.53×10^{-6}. The remaining COPCs had carcinogenic risks below 1×10^{-6}.

10.2A.4 RISK CHARACTERIZATION RESULTS

The risk characterization followed the procedure outlined in Appendix I, Section I.4. Quantitative estimates of noncarcinogenic and carcinogenic risks were calculated for the COPCs for each potentially complete exposure pathway.

10.2A.4.1 Current Land-use Scenarios

Current potential receptors are the Installation worker and the juvenile trespasser. There is no current use of groundwater at this site; therefore, current land-use receptors are not a risk from exposure to COPCs in groundwater. The potential risks to each of these receptor populations are discussed below.

On-site Installation Worker. The calculated risk values for the current on-site Installation worker are given in Table 10.2A-15.

The total HI for this receptor is 2.37×10^{-2}, which is more than an order of magnitude below the target value of 1.0; therefore, adverse systemic health risks are not expected for this receptor population.

The total ILCR for this receptor is 3.81×10^{-6}. This value exceeds the target risk value of 1×10^{-6}. Arsenic is the only COPC identified for this receptor.

On-site Juvenile Trespasser. The calculated risk values for the current on-site juvenile trespasser are given in Table 10.2A-16.

The total HI for this receptor is 1.53×10^{-2}, which is more than an order of magnitude below the target value of 1.0; therefore, adverse systemic health risks are not expected for this receptor population.

The on-site juvenile trespasser may be exposed to lead in surface water via incidental ingestion and dermal contact. The exposure concentration of lead in surface water is 9 μg/L, which is below the action level for lead in drinking water of 15 μg/L. This action level represents the maximum concentration of lead in drinking water that would not result in adverse health effects in a child. The amount of water ingested by a child via incidental ingestion of surface water (approximately 5.2 L/year) is more than an order of magnitude less than that for a child being exposed via drinking water (350 L/year). Dermal exposure is likely to be minimal for the juvenile wader given the low dermal absorption rate of 0.001 cm/hour (EPA 1995). Given that the concentration of lead in surface water is less than the drinking water screening level, it is unlikely that exposure of a juvenile to lead in surface water would cause adverse health effects.

The total ILCR for this receptor is 7.11×10^{-6}, which exceeds the target value of 1×10^{-6}. Benzo(*b*)fluoranthene in surface water is the primary risk driver, with an ILCR value of 6.53×10^{-6}. The remaining COPCs had carcinogenic risks below 1×10^{-6}.

Off-site Juvenile Wader. The calculated risk values for the current on-site juvenile trespasser are given in Table 10.2A-17.

The total HI for this receptor is 9.20×10^{-3}, which is more than two orders of magnitude below the target value of 1.0; therefore, adverse systemic health risks are not expected for this receptor population.

The off-site juvenile wader may be exposed to lead in surface water via incidental ingestion and dermal contact. The exposure concentration of lead in surface water is 9 μg/L, which is below the action level for

For the purposes of this risk assessment, the systemic and carcinogenic risks will be estimated for the resident child, and the resident adult will be assessed for only carcinogenic risk. The estimated intakes for the resident child and the resident adult are given in Tables 10.2A-8 and 10.2A-9, respectively.

Future off-site receptors include an Installation worker, a juvenile wader, a resident child, and a resident adult. The estimated intakes for the Installation worker and the juvenile wader are given in Tables 10.2A-10 and 10.2A-11, respectively. As was previously discussed, the potential intake of lead by the juvenile wader was not quantified because exposure to lead is evaluated using a biokinetic model, which is appropriate only when evaluating chronic exposure. The potential risk associated with exposure to lead in surface water was addressed qualitatively by comparing the surface water concentration to the risk-based screening value for drinking water. The estimated intakes for the off-site resident child and resident adult are given in Tables 10.2A-12 and 10.2A-13, respectively.

10.2A.3 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to determine the increased likelihood and magnitude of adverse human health effects based on the extent of exposure to contamination. The toxicity assessment for SWMU 3 was carried out as described in Appendix I, Section I.3. The toxicity values for arsenic and chromium are given in Table 10.2A-14.

Some of the COPCs did not have toxicity values that were directly applicable, or the exact nature of the constituent (e.g., valence state) had to be defined. These constituents included delta-BHC, chromium, and lead.

The delta isomer of BHC does not have toxicity values; however, toxicity values have been developed for other isomers and technical-grade BHC. Technical-grade BHC is representative of the pesticide lindane, which would primarily consist of gamma-BHC, but would also have other isomers of BHC present. Given that this toxicity value would reflect the toxicity of delta-BHC, as opposed to the other toxicity values that represent the toxicity of a related isomer, the technical-grade BHC values were used.

Chromium may exist in two valence states, trivalent and hexavalent chromium. For the purposes of this risk assessment, it was assumed that all chromium was the more toxic hexavalent chromium.

No suitable dose-response values exist for assessing the risks associated with exposure to lead in groundwater via any of the three identified exposure pathways. EPA has developed the IEUBK Model, which is used to estimate blood levels in children 0 year to 7 years old following exposure to lead in surface water. EPA has identified a blood level of 10 μg/dL as a concentration of concern that should be avoided (EPA 1994f). If the blood lead levels for children are less than 10 μg/dL, it can be inferred that there is no substantial risk for older receptors.

The toxicity values for mercury include values for elemental mercury and for mercuric chloride (EPA 1999a). The oral RfD for mercuric chloride was used to assess oral and dermal exposure to mercury in groundwater and surface water.

Benzo(*b*)fluoranthene is a carcinogenic PAH; however, a cancer slope factor has not been directly derived for this constituent. A TEF of 0.1 has been derived for benzo(*a*)fluoranthene based on its carcinogenicity relative to benzo(*a*)pyrene (EPA 1995). Therefore, the oral cancer slope factor for benzo(*a*)fluoranthene is 0.73 per (mg/kg-day).

Exposure concentrations of fugitive dust in air were calculated using the formulas described in Appendix I, Section I.2.3. These values were based on the exposure concentrations for surface soil. For the purposes of estimating exposure of an off-site receptor to fugitive dust, it was assumed that no dilution of the air concentrations occurred and that the exposure concentrations for both on-site and off-site receptors were the same.

Similarly, the estimated concentrations for exposure of off-site receptors to COPCs in groundwater were assumed to be equal to the exposure concentrations for on-site receptors. This is a very conservative assumption given that the primary groundwater flow is to the south toward the swamp, where buildings are not likely to be constructed. Therefore, the groundwater exposure concentrations for off-site receptors are likely to be significantly lower than those for on-site receptors.

10.2A.2.4 Quantification of Exposure

The equations used to estimate exposures to receptor populations are discussed in Appendix I, Section I.2.4. The default exposure factors for the current on-site trespasser assumes that the child spends all of his time on the site. The exposure parameter values used to estimate potential exposure are given in Table 10.2A-2.

Lead is a COPC in surface water. Exposure to lead is not assessed based on the applied dose of the constituent, but on the blood lead concentrations. The blood lead concentration is estimated using the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children (EPA 1994f), which is based on daily exposure to lead in various environmental media. This model can be used to estimate blood levels in children 0 year to 7 years old. However, the receptor populations that are likely to be exposed to lead in surface water are limited to children playing in the surface water and receiving intermittent exposures. The potential intake for the juvenile wader cannot be quantified; therefore, the potential risks to this receptor will be addressed qualitatively by comparing the surface water concentration to the risk-based screening value for drinking water. The drinking water standard is protective of human health based on a residential use of the water (i.e., the water is used for drinking and bathing). The dose received from this type of exposure would exceed the potential exposure dose for a juvenile wader; therefore, the use of the drinking water standard is a conservative measure that would be protective of the juvenile wader.

A potential intake was estimated for each receptor population for all applicable pathways. The estimated intakes for the current on-site receptors, the Installation worker and the juvenile trespasser, are given in Tables 10.2A-3 and 10.2A-4, respectively. A juvenile wading in the surface water adjacent to the site boundary represents an off-site receptor population. The estimated intakes for this receptor are given in Table 10.2A-5.

Future on-site receptor populations include an Installation worker, a juvenile trespasser, and a resident. The estimated intakes for the Installation worker and the juvenile trespasser are given in Tables 10.2A-6 and 10.2A-7, respectively. The resident population is divided into a resident child and a resident adult because the differences in behavior, exposure duration, and physiology between an adult and a child result in different doses of constituents in various environmental media. The child has a higher incidental soil ingestion rate because of the increased amount of hand-to-mouth behavior in children. This factor, coupled with the child's lower body weight, results in the child's receiving a higher dose of constituents in surface soil relative to the adult. The resident child is more sensitive to noncarcinogens than the resident adult. The increased exposure duration for the adult resident relative to the child resident results in a higher carcinogenic dose to the resident adult relative to the resident child; therefore, the resident adult is more sensitive to carcinogens in groundwater. However, the resident adult is not always more sensitive to exposure to carcinogens because this sensitivity changes with different environmental media.

Future Land-use Receptor Populations. The potential on-site receptor populations for the future land-use scenario receptor populations include an on-site Installation worker, an on-site juvenile trespasser, an off-site juvenile wader, and both an on-site and an off-site resident. Although no changes in land use are expected at this site, for the purposes of this risk assessment, it was assumed that the groundwater drinking wells have been placed at the site and the vegetative cover has been removed.

The on-site Installation worker may be exposed to COPCs in surface soil and groundwater. The potential exposure pathways include ingestion, dermal contact, and inhalation of fugitive dust. The exposure pathway for groundwater would be ingestion of drinking water.

The on-site trespasser may be exposed to COPCs in surface soil, surface water, and sediment. Exposure to COPCs in groundwater may occur when the constituents in groundwater migrate to surface water as a result of groundwater discharging into the marshy area. The exposure pathways for surface soil include incidental ingestion, dermal contact, and inhalation of fugitive dust. Exposure pathways for COPCs within the marshy area include dermal contact with surface water and incidental ingestion of surface water and sediment.

The on-site resident is presented for baseline purposes and is not considered to be a viable receptor population. The on-site resident may be exposed to COPCs in surface soil and groundwater. Potential exposure pathways for the on-site resident include incidental ingestion of soils, dermal contact with soils, inhalation of fugitive dust, ingestion of groundwater, and dermal contact with groundwater. The absence of volatile COPCs in groundwater excludes inhalation as a potential exposure pathway. If the site were developed for residential purposes, it would be landscaped and vegetated. Therefore, exposure via inhalation of fugitive dust is not a likely exposure pathway. However, as a conservative assumption, this pathway will be evaluated.

Off-site migration includes fugitive dust and the migration of COPCs in groundwater. Future off-site receptor populations include an Installation worker, a resident, and a juvenile wader.

The off-site Installation worker may be exposed to COPCs in surface soils via inhalation of fugitive dust. This receptor may also be exposed to COPCs in groundwater via ingestion.

The off-site resident is likely to be exposed via inhalation of fugitive dust and exposure to COPCs in groundwater. Groundwater exposure pathways include ingestion and dermal contact. The absence of volatile COPCs excludes the inhalation pathway.

The off-site wader may be exposed to COPCs in surface soil and surface water. Exposure to COPCs in surface soil is likely to occur via inhalation of fugitive dust. Exposure to COPCs in the surface water may occur via incidental ingestion and dermal contact.

10.2A.2.3 Estimation of Exposure Concentrations

The estimation of exposure concentrations for on-site receptors to COPCs in groundwater is discussed in Appendix I, Section I.2.3. Exposure concentrations were calculated using either analytical results or environmental fate and transport models. The analytical results from the surface soil, groundwater, sediment, and surface water samples were used to calculate the exposure concentrations in each of the respective environmental media. The exposure point concentrations are equal to 95 percent of the upper confidence limit of the mean unless this value was greater than the maximum detected concentration. In that case, the exposure concentration defaulted to the maximum concentration. The values selected as the exposure concentrations for risk evaluation are presented in Table 10.2A-1.

The CSM for risk assessment is shown in Figure 10.2A-1. This model illustrates the potential receptor populations and their routes of exposure for COPCs.

Impacted environmental media at this site include surface soil, groundwater, sediment, and surface water. Surface water present at the site extends beyond the boundaries of the SWMU, migrating south toward the Canoochee River.

Current Land-use Populations. The following receptor populations were used to evaluate potential risks associated with current land use: an on-site Installation worker, an on-site juvenile trespasser, and an off-site juvenile playing in the water. For the purposes of this document, the last receptor will be referred to as a juvenile wader. At present, there is no work being done by FSMR at this site. However, a worker may be present on the site in the near future, so as a conservative measure, this receptor population will be addressed. The off-site juvenile wader is representative of a juvenile playing in the surface water that is migrating off-site. The water adjacent to the site would have the highest concentrations of COPCs; therefore, it is assumed that the receptor is exposed at a point adjacent to the site.

The sportsman is not considered to be a viable receptor population because it is unlikely that this receptor would receive a significant exposure to HHCOPCs. The sportsman may be exposed to COPCs in surface soil through bioaccumulation into game and direct exposure. Similarly, the sportsman may be exposed to COPCs in surface water as a result of bioaccumulation in fish and direct contact with the surface water. The BAFs for the uptake of arsenic from soil into plants and from forage into venison are 0.04 and 0.002, respectively; therefore, arsenic is not likely to bioaccumulate into venison. More conservative receptor populations (i.e., the juvenile trespasser) address direct exposure to HHCOPCs in surface soils. The surface water present on the site is limited to a swampy area that has no recreational value; therefore, the sportsman would not be fishing at this site. The surface water may migrate south toward the Canoochee River, but water flow is slow, and the constituents present are likely to either degrade or be removed from the water column by various mechanisms including absorption onto sediments and emergent vegetation, and volatilization. Therefore, significant exposure of receptors at the Canoochee River is unlikely. Given that the potential exposure pathways are not likely to result in a significant exposure, the sportsman scenario will not be evaluated at this site.

The on-site Installation worker is representative of an individual who is employed by Fort Stewart and is present on the site for work purposes. This type of individual would include soldiers, maintenance workers, and game management personnel. The on-site Installation worker may be exposed to COPCs in surface soil via incidental ingestion and dermal contact. The site is currently vegetated; therefore, exposure via inhalation of fugitive dust is not considered to be a viable pathway.

The juvenile trespasser would be exposed to COPCs in surface soils, surface water, and sediment. The surface water and sediment exposure may take place within the marshy area in the southern portion of the site.

Exposure pathways for surface soils include ingestion and dermal contact. Given the presence of vegetation on the site, exposure via inhalation of fugitive dust is not a likely exposure pathway. Exposure pathways for COPCs in the marshy area include dermal contact with surface water and incidental ingestion of surface water and sediment.

The off-site juvenile wader could be exposed to surface water COPCs at points south of the site in the swampy area. This receptor is likely to be exposed to constituents in the surface water via incidental ingestion and dermal contact.

ATTACHMENT 10.2A
SWMU 3: TAX-X LANDFILL
HUMAN HEALTH BASELINE RISK ASSESSMENT

The human health baseline risk assessment consists of five elements: (1) identification of COPCs, (2) exposure assessment, (3) toxicity assessment, (4) risk characterization, and (5) assessment of uncertainty.

10.2A.1 IDENTIFICATION OF COPCS

The CMCOPCs and HHCOPCs have been discussed in the sections on contaminant fate and transport (Section 10.2.5) and the HHPRE (Section 10.2.6), respectively. There are no CMCOPCs in soils or sediments at this site.

HHCOPCs were identified in surface soils, groundwater, sediment, and surface water (Section 10.2.8.1). Arsenic was identified as an HHCOPC in surface soil and sediment. Mercury and delta-BHC were identified as HHCOPCs in groundwater. Surface water COPCs included arsenic, chromium, lead, and benzo(*b*)fluoranthene.

10.2A.2 EXPOSURE ASSESSMENT

The exposure assessment quantifies the amount of a COPC an individual may come in contact with at each site. The exposure assessment considers all pathways of potential human exposure, the magnitude of exposure, and the frequency and duration of exposure. The process for estimating exposure consists of the following elements: (1) characterization of the exposure setting in terms of the physical and demographic characteristics of the site, (2) identification of receptor populations, (3) identification of the exposure pathways by which an individual may come in contact with a COPC, (4) estimation of the exposure point concentration, and (5) quantification of the intake or dose to which an individual may be exposed.

10.2A.2.1 Exposure Setting

The exposure setting describes the physical features at the site that are important when identifying the human populations that may be exposed to COPCs, either currently or in the future.

The landfill is located approximately 17 miles northwest of the Fort Stewart garrison area. It is accessed by a 0.1-mile unpaved road on the southwestern side of Fort Stewart 42. The TAC-X Landfill comprises approximately 5 acres. The site is nearly flat, but slopes gently toward the south. The site is heavily forested with pine trees. Brush and grass cover some portions of the site. The southernmost portion of the site is marshy, with surface water present. The marshy area extends south approximately 2 miles to the Canoochee River.

10.2A.2.2 Identification of Potential Receptor Populations and Exposure Pathways

A complete exposure pathway consists of four elements: (1) a source of contamination, (2) a transport or retention medium, (3) a point of contact with the chemical, and (4) a route of exposure (ingestion, dermal absorption, or inhalation) at the point of contact through which the chemical may be taken into the body. When all of these elements are present, the pathway is considered to be complete.

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ATTACHMENT 10.2A
SWMU 3: TAC-X LANDFILL

HUMAN HEALTH BASELINE RISK ASSESSMENT

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11.0 CONCLUSIONS AND RECOMMENDATIONS

11.1 CONCLUSIONS

Nature and Extent of Contamination

The results of the chemical analyses on surface soil, subsurface soil, and groundwater were screened against the reference background criteria for the FSMR. Surface water and sediment were screened against the site-specific background criteria.

Inorganics were considered to be SRCs if their concentrations were above the reference background concentrations, and organics were considered to be SRCs if they were simply detected because organic constituents are considered to potentially be man-made. The maximum concentration of SRCs was carried through to fate and transport, HHPRE, and EPRE analysis. A summary of SRCs by medium for each SWMU is presented in Table 11-1.

Fate and Transport Analysis

Fate and transport analysis was performed on each SWMU. This analysis included developing a site-specific CSM and determining the potential for SRCs in surface soil, subsurface soil, and/or sediment to migrate to groundwater.

The maximum concentrations of the identified SRCs determined from nature and extent analysis were compared to EPA GSSLs. Generally, if contaminant concentrations in soil and/or sediment fall below their respective GSSLs and there are no significant ecological receptors of concern, then no further study or action is warranted. SRCs were identified as CMCOPCs if they were detected at concentrations that exceeded their respective GSSLs. A summary of the results of the fate and transport analysis (CMCOPCs) is presented in Table 11-2.

A weight-of-evidence approach was used to evaluate each CMCOPC identified based on leaching to groundwater. In some instances, the potential impact of CMCOPCs to groundwater, and possibly to surface water, was evaluated (modeled concentrations were compared to risk-based criteria) in a human health baseline risk assessment (see following section). CMCOPCs that indicated a potential risk to human health (i.e., that exceeded risk-based screening criteria) were identified as CMCOCs, and remedial levels were developed based on protection of groundwater. SWMUs for which a human health baseline risk assessment was performed are identified in Table 11-2.

Human Health Preliminary Risk Evaluation

An HHPRE using a Step i risk evaluation approach based on guidance from GEPD was performed on each SWMU to determine the potential human health risks associated with the maximum concentrations of the identified SRCs. A summary of the HHPRE results (HHCOPCs) is presented in Table 11-2.

A weight-of-evidence approach was used to evaluate each HHCOPC identified in the preliminary risk assessment. In some instances, HHCOPCs were evaluated further in a human health baseline risk assessment. HHCOPCs and/or CMCOPCs (see previous section) that either had HIs of 0.1 or ILCRs of 1×10^{-6} were identified as HHCOCs. Remedial levels were developed that were protective of the most sensitive receptor population, based on a minimum risk level of 3.0 for the total HI and 1×10^{-4} for the total ILCR. SWMUs for which a human health baseline risk assessment was performed are identified in Table 11-2.

Ecological Preliminary and Supplemental Risk Evaluation

An EPRE based on guidance from GEPD was performed on each SWMU to determine the potential risk to ecological receptors associated with the maximum concentrations of the identified SRCs. The EPRE compared measured concentrations of detected constituents to conservative ESVs to identify constituents detected at the facility that pose a potential hazard to ecological receptors and that are identified as ECOPCs to ecological receptors. A summary of the results of the EPRE (ECOPCs) is presented in Table 11-2.

A weight-of-evidence approach was used to evaluate each ECOPC identified in the preliminary risk evaluation. In some instances, ECOPCs were evaluated further in a supplemental preliminary risk evaluation (SPRE). The SPRE presented a comparison of more realistic exposure estimates to TRVs based on LOAELs. The exposure estimates were calculated using measured concentrations and more realistic exposure assumptions such as diets, absorption efficiencies, and AUFs. SWMUs for which a SPRE was performed are identified in Table 11-2.

11.2 RECOMMENDATIONS

A weight-of-evidence approach was used with the results from the fate and transport evaluation, HHPRE, and EPRE to determine the recommendation for each SWMU. The recommendations fell into following three categories:

- **No Further Action:** NFA was recommended for a SWMU if: (1) the contaminant levels in soil, groundwater, surface water, and sediment were below the reference background criteria, fate and transport values (GSSLs), or human health or ecological screening criteria or (2) significant uncertainty was evident, indicating minimal potential risk of migration to groundwater and/or surface water bodies and/or to human health and ecological receptors.

- **Additional Investigation (Phase II RFI or additional monitoring):** A Phase II RFI or additional monitoring was recommended if the nature and extent of potential contaminants had not been determined, and further investigation or additional monitoring was required to evaluate the extent or potential migration of contaminants in the future.

- **Corrective Action Plan:** A CAP was recommended if the nature and extent of contamination at a SWMU was determined by the Phase II RFI, there was a potential risk of migration of contaminants to groundwater and/or surface water bodies or a potential risk to human health and ecological receptors, or institutional controls need to be applied to protect the health and safety of humans coming in contact with the site (i.e., inactive EOD areas). Such a site requires a CAP to evaluate appropriate remedial actions to eliminate or minimize these potential risks.

The recommendations for each SWMU are presented in Table 11-3.

Table 11-1. Summary of Site-related Contaminants

SWMU	Type of Investigation	Site-related Contaminants				
		Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment
2	Phase II	2 VOCs, 14 pest., 1 SVOC, and 6 metals	1 VOC, 3 pest., 1 SVOC, and 3 metals	3 VOCs and 3 metals	None	alpha-Chlordane
3	Phase II	4 pest., BEHP, As, Cr, and Pb	2 VOCs, BEHP, 3 pest., Cr, and Cd	3 VOCs, 3 pest., Ba, Cd, Cr, Pb, and Hg	1 SVOC, As, Ba, Cr, and Pb	6 VOCs, As, Ba, Cr, Pb, Hg, and Se
9	Phase I[a]	As, Cr, and Ag	NC	NC	NP	NP
10	Phase II	As, Ba, Cr, and Pb	NC[b]	None	Cd, Cr, and Hg	As, Ba, and Pb
11	Phase II	As, Ba, Cr, Pb, and Ag	NC[b]	None	NP	NP
12A	Phase II	3 SVOCs, 4 exp., and 16 metals	Al, As, Ba, Cr, Fe, Pb, and V	BEHP, 1 exp., and 8 metals	RDX, Pb, Mn, and Hg	1 SVOC, 1 exp., and 9 metals
14	Phase I	2 VOCs, BEHP, and Hg	5 VOCs, Cr, and Hg	1 VOC, Pb, and Hg	NP	NP
17	Phase II	1 VOC	3 VOCs	3 VOCs and Pb	None	None
18	Phase II	1 VOC, Pb, and Hg	5 VOCs, 2 SVOCs, Ba, Cr, Pb, and Hg	9 VOCs, Ba, Cd, and Pb	1 SVOC and Ba	(6 VOCs, 4 SVOCs, As, Ba, Cd, Cr, Pb, Hg, Se, and Ag)[c]
19	Phase I	4 VOCs, 7 pest., and 5 metals	6 VOCs, 9 pest., and 5 metals	BEHP, 7 pest., and 3 metals	NP	NP
24B	Phase I	1 VOC, 10 SVOCs, and 6 metals	2 VOCs	1 VOC, 11 SVOCs, and Hg	NP	NP
27A (Bldg. 1339A)	Phase I	None	2 VOCs and 3 SVOCs	2 VOCs and BEHP	NP	NP
27A (Bldg. 1339B)	Phase I	BEHP and Pb	2 VOCs	1 VOC	NP	NP
27A (Bldg. 1322)	Phase I	3 VOCs and Pb	3 VOCs	Acetone	NP	NP
27B	Phase I	None	1 VOC	ND	NP	NP
27C	Phase I	1 VOC	2 VOCs and 1 SVOC	4 VOCs	NP	NP
27D	Phase I	3 VOCs	1 VOC	None	NP	NP
27E (Bldg. 1628)	Phase I	None	1 VOC	None	NP	NP

Note: Footnotes appear on page 11-5.

Table 11-1. Summary of Site-related Contaminants (continued)

SWMU	Type of Investigation	Site-related Contaminants				
		Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment
27E (Bldg. 1720)	Phase I	NC	2 VOCs and BEHP	1 SVOC	NP	NP
27F (NW Bldg. 1340)	Phase I	NC	3 VOCs and Pb	10 VOCs and 4 SVOCs	NP	NP
27F (NE Bldg. 1340)	Phase I	3 VOCs	8 VOCs and 4 SVOCs	None	NP	NP
27G	Phase I	NC	3 VOCs	1 SVOC	NP	NP
27H (Bldg. 1071)	Phase I	NC	2 VOCs, 11 SVOCs, Pb, and Hg	1 VOC and 9 SVOCs	NP	NP
27H (Bldg. 1056)	Phase I	NC	1 VOC, 1 SVOC, Cd, and Pb	2 VOCs and 4 SVOCs	NP[d]	NP[d]
27I (Block 9900)	Phase I	NC	1 VOC and Pb	None	NC	1 VOC and Pb
27I (Block 10300)	Phase I	NC	None	None	Pb	None
27J (Bldg. 10535)	Phase I	None	None	1 VOC and 1 SVOC	NP	NP
27J (Bldg. 10531)	Phase I	1 VOC and 1 SVOC	NC	2 SVOCs	NP	NP
27K	Phase I	NC	4 VOCs	1 VOC	NP	NP
27L (Block 10200)	Phase I	None	1 VOC and 1 SVOC	8 VOCs and 2 SVOCs	Acetone	None
27M (Block 10100)	Phase I	1 VOC and Pb	2 SVOCs and Pb	1 VOC	NC	Pb
27N (Block 9800)	Phase I	NC	2 SVOCs and Pb	None	NC	5 SVOCs
27O (Block 9700)	Phase I	Pb	None	1 SVOC	1 VOC	Pb
27P (Block 9500)	Phase I	1VOC and 1 SVOC	1 VOC, 6 SVOCs, and Pb	None	NC	1 VOC and Pb

Note: Footnotes appear on page 11-5.

Table 11-1. Summary of Site-related Contaminants (continued)

SWMU	Type of Investigation	Site-related Contaminants				
		Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment
27Q (Block 9400)	Phase I	Pb	None	None	NC	Pb
27R	Phase I	None	1 VOC and 2 SVOCs	None	NP	NP
27S	Phase I	NC	6 VOCs	None	NP	NP
27T	Phase I	4 SVOCs	None	1 VOC and 1 SVOC	NC	4 VOCs, 9 SVOCs, and Cd
27U	Phase I	1 VOC and Pb	2 VOCs and Pb	4 VOCs	NP	NP
27V	Phase I	1 VOC and Pb	1 VOC and Pb	None	NP	NP
29	Phase II	8 VOCs and Ag	16 VOCs and 14 SVOCs	3 VOCs, 3 SVOCs, As, Ba, and Cr	NP	NP
31	Phase II and IRA	None	6 VOCs and 17 SVOCs	4 VOCs	NP	NP
32	Phase II	2 VOCs, Ba, Cd, Cr, Pb, and Hg	2 VOCs, Pb, and Hg	4 VOCs and 2 SVOCs	NP	NP
34	Phase II	4 VOCs, 2 SVOCs, Ba, Cd, Pb, and Hg	1 VOC, Ba, Cd, Cr, and Pb	3 VOCs	NP	NP
37	Phase I	1 VOC and Hg	2 VOCs and Hg	4 VOCs	NP	(4 VOCs, Ba, Cd, Cr, Pb, Hg, and Se)[c]

[a]Phase II RFI was not required at this time. The Phase II RFI will be conducted upon closure of the Red Cloud Range, Hotel Area.
[b]Per the GEPD–approved SAP, subsurface soil was not collected because subsurface soil sampling in an EOD area requires approval by the Secretary of the Army.
[c]Results from sediment within the NGTC Equalization Basin.
[d]Sediment was collected; however, the OWS does not discharge to the drainage ditch.
BEHP = Bis(2-ethylhexyl)phthalate.
NA = Not applicable.
NC = Not collected based on field screening results or because no medium (i.e., surface water) was available during the RFI.
ND = Not detected.
NP = No pathway exists.

Table 11-2. Summary of CMCOPCs, HHCOPCs, and ECOPCs

SWMU	CMCOPCs		HHCOPCs					ECOPCs				HHBRA or SPRE Performed?
	Soil	Sediment	Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment	Surface Soil	Groundwater	Surface Water	Sediment	
2	2 pest., Ar, Ca, and Hg	None	As and Cr	None	None	None	None	4,4'-DDE, Cd, Cr, and Pb	1 VOC, Pb, and Hg	None	None	HHBRA and SPRE
3	None	As	As	None	1 pest. and Hg	1 SVOC, As, Cr, and Pb	As	Pb and Cr	2 pest., Ba, Cd, Pb, and Hg	1 SVOC, Ba, and Pb	2 VOCs, As, Ba, and Se	HHBRA and SPRE
9[a]	NA[a]	NA[a]	NA[a]	NC[a]	NC[a]	NP	NP	NA[a]	NC[a]	NP	NP	
10	NA[b]	NA[b]	NA[b]	NC	NA[b]	NA[b]	NA[b]	NA[b]	NA[b]	NA[b]	NA[b]	
11	NA[b]	NA[b]	NA[b]	NC	NA[b]	NA[b]	NA[b]	NA[b]	NA[b]	NP	NP	
12A	Ar, Cd, Cr, Pb, Ag, 1 SVOC, and 2 exp.	None	As and Pb	As	BEHP	Hg	None	1 SVOC, Cd, Cr, and Pb	BEHP	Pb and Hg	Ba	HHBRA and SPRE
14	1 VOC	NA	None	None	None	NP	NP	None	Pb, Hg, and 1 VOC	NP	NP	
17	None	None	None	None	1 VOC	None	None	None	1 VOC and Pb	None	None	HHBRA
18	Cr and Hg	(1 VOC, 1 SVOC, Ar, Ba, Cd, Cr, Hg, and Se)[c]	None	None	3 VOCs and Pb	1 SVOC	As	Pb	4 VOCs, Ba, and Pb	Ba and BEHP	None	HHBRA and SPRE
19	2 pest.	NA	None	None	BEHP, 2 pest., and As	NP	NP	Cd, Pb, and 1 pest.	BEHP, 5 pest., Ba, and Hg	NP	NP	HHBRA and SPRE
24B	1 VOC, 3 SVOCs, and Pb	NA	4 SVOCs, As, and Pb	None	1 VOC, 9 SVOCs, and Hg	NP	NP	NP	Hg and 9 SVOCs	NP	NP	
27A (Bldg. 1339A)	None	NA	None	None	BEHP	NP	NP	None	1 VOC and BEHP	NP	NP	
27A (Bldg. 1339B)	None	NA	None	None	Benzene	NP	NP	Pb	Xylenes	NP	NP	
27A (Bldg. 1322)	None	NA	None	None	Acetone	NA	NA	Pb	None	NP	NP	HHBRA

Note: Footnotes appear on page 11-8.

Table 11-2. Summary of CMCOPCs, HHCOPCs, and ECOPCs (continued)

SWMU	CMCOPCs		HHCOPCs					ECOPCs				HHBRA or SPRE Performed?
	Soil	Sediment	Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment	Surface Soil	Groundwater	Surface Water	Sediment	
27B	None	NP	None	None	None	NP	NP	None	None	NP	NP	
27C	None	NP	None	None	None	NP	NP	None	2 VOCs	NP	NP	
27D	None	NP	None	None	None	NP	NP	None	None	NP	NP	
27E (Bldg. 1628)	None	NP	None	None	None	NP	NP	None	None	NP	NP	
27E (Bldg. 1720)	None	NP	NA	None	None	NP	NP	NA	1 SVOC	NP	NP	
27F (NW Bldg. 1340)	None	NP	NA	None	4 VOCs and 4 SVOCs	NP	NP	NA	2 VOCs and 4 SVOCs	NP	NP	
27F (NE Bldg. 1340)	1 VOC	NP	None	None	None	NP	NP	None	None	NP	NP	
27G	None	NP	NA	None	1 SVOC	NP	NP	NA	None	NP	NP	HHBRA
27H (Bldg. 1071)	2 SVOCs	NP	NC	1 SVOC	1 VOC and 7 SVOCs	NP	NP	NC	8 SVOCs	NP	NP	
27H (Bldg. 1056)	None	NP	NC	None	3 SVOCs	NP	NP	NC	2 SVOCs	NP	NP	
27I (Block 9900)	None	None	NC	None	None	NC	None	NC	None	NC	Pb	
27I (Block 10300)	None	NA	NC	None	None	Pb	None	NC	None	Pb	None	
27J (Bldg. 10535)	None	NP	None	None	None	NP	NP	None	1 VOC and 1 SVOC	NP	NP	
27J (Bldg. 10531)	None	NP	None	NC	1 SVOC	NP	NP	None	2 SVOCs	NP	NP	
27K	None	NP	NA	None	None	NP	NP	NA	None	NP	NP	
27L (Block 10200)	None	None	None	None	4 VOCs and 2 SVOCs	Acetone	None	None	2 VOCs and 1 SVOC	None	None	
27M (Block 10100)	1 VOC	None	None	None	1 VOC	NC	None	Pb	None	NC	Pb	
27N (Block 9800)	None	None	NA	None	None	NC	1 SVOC	NA	None	NC	None	HHBRA

Note: Footnotes appear on page 11-8.

Table 11-2. Summary of CMCOPCs, HHCOPCs, and ECOPCs (continued)

SWMU	CMCOPCs		HHCOPCs					ECOPCs				HHBRA or SPRE Performed?
	Soil	Sediment	Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment	Surface Soil	Groundwater	Surface Water	Sediment	
27O (Block 9700)	None	None	None	NA	None	None	None	Pb	1 SVOC	None	Pb	
27P (Block 9500)	None	None	None	None	None	NC	None	None	None	NC	Pb	
27Q (Block 9400)	None	None	None	NA	None	NC	None	Pb	None	NC	Pb	
27R	None	NP	None	None	None	NP	NP	None	None	NP	NP	
27S	None	NP	NA	None	None	NP	NP	NA	None	NP	NP	
27T	None	Cd	1 SVOC	None	None	NA	4 SVOCs	None	1 SVOC	NA	Cd	HHBRA
27U	None	NP	None	None	Benzene	NP	NP	Pb	None	NP	NP	
27V	None	NP	None	None	None	NP	NP	None	None	NP	NP	
29	7 VOCs	NP	None	None	1 VOC, 2 SVOCs, and As	NP	NP	None	1 VOC, 2 SVOCs, and Ba	NP	NP	HHBRA
31	1 VOC and 1 SVOC	NP	None	None	Acetone	NP	NP	None	Xylenes	NP	NP	HHBRA
32	1 VOC	NP	None	None	Acetone	NP	NP	Cd, Pb, and Cr	1 VOC and 1 SVOC	NP	NP	HHBRA
34	2 VOCs	NP	None	None	Acetone	NP	NP	Cd and Pb	1 VOC	NP	NP	HHBRA
37	1 VOC	1 VOC[b] and Cd	None	None	Benzene	NP	NP	None	Xylenes	NP	NA	

[a]Phase II RFI was not required at this time. The Phase II RFI will be conducted upon closure of the Red Cloud Range, Hotel Area.
[b]With the concurrence of GEPD, fate and transport analysis and human health and ecological preliminary risk assessments were deemed unnecessary. SRCs were determined solely on comparison to background criteria (see Table 11-1).
[c]Results from sediment within the NGTC Equalization Basin.
BEHP = Bis(2-ethylhexyl)phthalate.
HHBRA = Human health baseline risk assessment.
NA = Not applicable.
NC = Sample not collected based on field screening results or because no medium (i.e., surface water) was available during the RFI.
NP = No pathway exists.
SPRE = Supplemental Preliminary Risk Evaluation.

Table 11-3. SWMU-specific Recommendations

SWMU	Recommendation
2	CAP
3	CAP
9	CAP
10	CAP
11	CAP
12A	Long-term compliance monitoring and CAP
14	NFA
17	NFA
18	Long-term monitoring and CAP
19	NFA
24B	Phase II RFI
27A (Building 1339A)	NFA
27A (Building 1339B)	NFA
27A (Building 1322)	NFA
27B	NFA
27C	NFA
27D	NFA
27E (Building 1628)	NFA
27E (Building 1720)	NFA
27F (NW Building 1340)	Phase II RFI
27F (NE Building 1340)	NFA
27G	NFA
27H (Building 1071)	Phase II RFI

SWMU	Recommendation
27H (Building 1056)	Phase II RFI
27I (Block 9900)	NFA
27I (Block 10300)	NFA
27J (Building 10535)	NFA
27J (Building 10531)	Phase II RFI
27K	NFA
27L (Block 10200)	Phase II RFI
27M (Block 10100)	NFA
27N (Block 9800)	NFA
27O (Block 9700)	NFA
27P (Block 9500)	NFA
27Q (Block 9400)	NFA
27R	NFA
27S	NFA
27T	Phase II RFI
27U	NFA
27V	NFA
29	CAP
31	NFA
34	NFA
32	NFA
37	NFA

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