FINAL

REMEDIAL INVESTIGATION
ARCHITECT OF THE CAPITOL,
LIBRARY OF CONGRESS CAMPUS FACILITY

FORT GEORGE G. MEADE, MARYLAND

JULY 2006

Prepared for:
United States Army Corps of Engineers
Baltimore District
10 South Howard Street
Baltimore, Maryland 21201

Environmental Management Office
Fort George G. Meade
238 Ross Road
Fort Meade, Maryland 20755

Prepared by:
Malcolm Pirnie, Inc.
300 East Lombard Street
Suite 610
Baltimore, Maryland 21202

FINAL
REMEDIAL INVESTIGATION
ARCHITECT OF THE CAPITOL,
LIBRARY OF CONGRESS CAMPUS FACILITY
FORT GEORGE G. MEADE, MARYLAND

DoD Contract Number: DACA31-00-D-0043
Delivery Order: 014

Reviewed and Approved by:

_____ Heather Polinsky, Vice President
Project Officer
Malcolm Pirnie, Inc.

_____ Daniel P. Sheehan, P.E., Senior Associate
Project Manager
Malcolm Pirnie, Inc.

Malcolm Pirnie, Inc. prepared this report at the direction of the United States Army Corps of Engineers (USACE). This document should be used only with the approval of the USACE. This report is based, in part, on information provided in other documents and is subject to the limitations and qualifications presented in the referenced documents.

JULY 2006

TABLE OF CONTENTS

Table of Contents i
Acronyms vii
Executive Summary xi
1 INTRODUCTION 1-1
1.1 Objective and Purpose of Report 1-1
1.2 Background 1-2
1.2.1 Facility Description 1-2
1.2.2 Facility History 1-2
1.2.3 LOC Parcel Description 1-4
1.2.4 LOC Parcel History 1-5
1.2.5 Previous Investigations 1-5
1.2.6 Areas of Concern 1-13
1.3 Report Organization 1-17
2 FIELD INVESTIGATION PROGRAM 2-1
2.1 Field Investigation Overview 2-2
2.2 Field Investigation Procedures 2-4
2.2.1 Sampling Nomenclature 2-4
2.2.2 Soil Sampling 2-5
2.2.3 Surface Water Sampling 2-8
2.2.4 Sediment Sampling 2-8
2.2.5 Monitoring Well Installation and Development 2-8
2.2.6 Groundwater Sampling 2-9
2.2.7 Equipment Decontamination 2-10
2.2.8 Investigation-Derived Waste Management 2-11
2.2.9 Off-site Laboratory Analysis 2-12
2.2.10 Site Surveying 2-17
2.3 Site Specific Field Investigation Summary 2-18
2.3.1 Soils 2-22
2.3.2 Groundwater 2-26
2.3.3 Surface Water 2-29
2.3.4 Sediment 2-29
3 PHYSICAL CHARACTERISTICS 3-1
3.1 FGGM Physical Characteristics 3-1
3.1.1 Physiography and Topography 3-1
3.1.2 Climate 3-1
3.1.3 Surface Water Hydrology 3-1
3.1.4 Regional Geology and Hydrogeology 3-1
3.2 Site Characteristics 3-10
3.2.1 Land Use 3-11
3.2.2 Topography 3-11
3.2.3 Surface Water Hydrology 3-12
3.2.4 Geology and Hydrogeology 3-12
4 NATURE AND EXTENT OF CONTAMINATION 4-1
4.1 Identification of ARARs 4-1
4.1.1 Definition of ARARs 4-1
4.1.2 Development of ARARs and TBCs 4-2

4.1.3 Identification of ARARs and TBCs 4-2
4.2 Decontamination Fluid Sampling Results....4-4
4.2.1 2000 Sample Event 4-4
4.2.2 2001 Sample Event 4-4
4.2.3 2004/2005 Sample Event 4-4
4.3 Nature and Extent of Contamination 4-5
4.3.1 Surface Soils 4-6
4.3.2 Subsurface Soil 4-14
4.3.3 Sediment 4-21
4.3.4 Surface Water 4-24
4.3.5 Groundwater....4-26
5 FATE AND TRANSPORT 5-1
5.1 Transport Mechanisms and Contaminant Properties 5-1
5.1.1 Organic Contaminants....5-2
5.1.2 Inorganic Contaminants 5-14
5.2 Potential Pathways of Contaminant Transport 5-17
5.2.1 On-site Deposition of Windblown Dust 5-17
5.2.2 Soil/Sediment Transport by Storm Water Runoff 5-17
5.2.3 Soil/Surface Water to Air Transport....5-17
5.2.4 Surface Water to Sediment Transport 5-17
5.2.5 Sediment to Surface Water Transport 5-18
5.2.6 Soil/Vadose Zone to Shallow Groundwater Transport 5-18
5.2.7 Shallow Groundwater to Soil/Vadose Zone Transport 5-18
5.2.8 Shallow Groundwater to Surface Water Transport....5-18
5.2.9 Shallow Groundwater to Deep Groundwater....5-19
5.3 Site Fate and Transport....5-19
6 HUMAN HEALTH RISK ASSESSMENT 6-1
6.1 Introduction 6-1
6.1.1 Objectives....6-1
6.1.2 Overview of the Human Health Risk Assessment Process 6-1
6.2 Data Evaluation 6-2
6.2.1 Soil 6-2
6.2.2 Groundwater....6-5
6.2.3 Surface Water 6-6
6.2.4 Sediment 6-7
6.3 Exposure Assessment....6-7
6.3.1 Human Receptors 6-7
6.3.2 Exposure Pathways....6-8
6.3.3 Data Utilization 6-10
6.3.4 Estimates of Chemical Intake / Exposure....6-12
6.4 Toxicity Assessment....6-16
6.4.1 Non-cancer Health Effects from Chronic Exposure....6-17
6.4.2 Carcinogenic Risks from Lifetime Exposure....6-18
6.4.3 Chemical Mixtures 6-19
6.4.4 Lead 6-19
6.4.5 Qualitative Assessment of COPCs without Toxicity Criteria....6-19
6.5 Risk Characterization 6-19
6.5.1 Risk Estimation....6-20
6.5.2 Lead 6-22

6.5.3 Qualitative Assessment of COPCs without Toxicity Criteria.....6-24
6.5.4 Uncertainty Evaluation 6-24
6.6 SUMMARY AND CONCLUSIONS 6-27
7 Screening level ECOLOGICAL RISK ASSESSMENT 7-1
7.1 Objectives and Overview.....7-1
7.2 Problem Formulation 7-2
7.2.1 Site Characterization.....7-2
7.2.2 Ecological Endpoints 7-4
7.2.3 Exposure Pathways.....7-6
7.3 Data Evaluaiton 7-7
7.3.1 Surface Soil 7-7
7.3.2 Surface Water 7-9
7.3.3 Sediment 7-9
7.4 Exposure Assessment.....7-10
7.4.1 Exposure Scenarios and Pathways.....7-10
7.4.2 Exposure Estimates 7-10
7.4.3 Toxicity Reference Values.....7-13
7.5 Risk Characterization 7-14
7.5.1 Discussion of Risk Estimates 7-14
7.5.2 Uncertainty Analysis.....7-15
7.6 Summary and Conclusions 7-18
8 SUMMARY AND CONCLUSIONs.....8-1
8.1 Nature and Extent of Contamination 8-1
8.1.1 Soils.....8-1
8.1.2 Sediment 8-2
8.1.3 Surface Water 8-3
8.1.4 Groundwater.....8-3
8.2 Fate and Transport.....8-4
8.2.1 Transport Pathways 8-5
8.2.2 Fate and Transport of Contaminants in Specific Media 8-5
8.3 Risk Assessment.....8-6
8.3.1 Human Health Risk Assessment.....8-6
8.3.2 Ecological Risk Assessment 8-8
8.4 Recommendations 8-9
9 REFERENCES.....9-1

Figures

Figure 1-1: Installation Location

Figure 1-2: Site Location

Figure 1-3: Carbon Tetrachloride Delineation

Figure 1-4: Carbon Tetrachloride Delineation

Figure 1-5: Areas of Concern

Figure: 2-1: Sampling Locations

Figure 3-1: Hydrogeologic Cross-Section Across Anne Arundel County

Figure 3-2: Proposed Development Plan for LOC Parcel

Figure 3-3: Site-Specific Hydrogeologic Cross-Section

Figure 3-4: Patapsco Formation Across the LOC Parcel

Figure 3-5: Groundwater Potentiometric Surface Map

Figure 4-1: Surface Soil Exceedances

Figure 4-2: Subsurface Soil Exceedances

Figure 4-3: Sediment Exceedances

Figure 4-4: Surface Water Exceedances

Figure 4-5: Groundwater DPT Exceedances

Figure 4-6: Groundwater Monitoring Well Exceedances

Figure 5-1: Fate and Transport Conceptual Model

Figure 6-1: Human Health Conceptual Site Model

Figure 7-1: National Wetland Inventory Map

Figure 7-2: Ecological Conceptual Site Model

Tables

Table 1-1: Carbon Tetrachloride Source Delineation Analytical Data Summary [(1)].....1-9
Table 1-2: Summary of UST/AST Status 1-10
Table 2-1: Analytical Test Methods.....2-12
Table 2-2: Summary of Analyses.....2-12
Table 2-3: LOC parcel Survey Data.....2-17
Table 2-4: Summary of Field Investigation 2-19
Table 3-1: Regional Geologic Formation Summary.....3-6
Table 3-2: Summary of Boring Depths.....3-13
Table 3-3: Depth to Groundwater 3-16
Table 4-1: ARARs and TBCs for Soil.....4-36
Table 4-2: ARARs and TBCs for Sediment.....4-36
Table 4-3: ARARs and TBCs for Surface Water.....4-36
Table 4-4: ARARs and TBCs for Groundwater 4-36
Table 4-5: Surface Soil Analytical Results.....4-36
Table 4-6: Subsurface Soil Analytical Results 4-36
Table 4-7: Sediment Analytical Results 4-36
Table 4-8: Surface Water Analytical Results 4-36
Table 4-9: DPT Groundwater Analytical Results 4-36
Table 4-10: Monitoring Well Groundwater Analytical Results.....4-36
Table 5-1: Organic Contaminant Detections by Media 5-2
Table 5-2: Chemical Properties of Organic Compounds 5-5
Table 5-3: Fate and Transport Mechanisms and Pathways for Organics.....5-9
Table 5-4: Inorganic Contaminant Detections by Media.....5-14
Table 5-5: Fate and Transport Mechanisms and Pathways for Inorganics.....5-15
Table 5-6: Transport Pathways.....5-19
Table 7-1: Surface Soil Data Summary 7-19
Table 7-2: Surface Water Data Summary.....7-19
Table 7-3: Sediment Data Summary.....7-19
Table 7-4: Exposure Point Concentrations 7-19
Table 7-5: Exposure Factors for Ecological Receptors.....7-19
Table 7-6: Summary of Plant Uptake Factors.....7-19
Table 7-7: Summary of Invertebrate Uptake Factors.....7-19
Table 7-8: Toxicity Information for Eastern Cottontail Rabbit, Short-tailed Shrew and Muskrat..7-19
Table 7-9: Toxicity Information for American Robin and Mallard 7-19
Table 7-10: Risk Characterization for Terrestrial Plants and Soil Invertebrates 7-19
Table 7-11: Risk Characterization for Eastern Cottontail Rabbit, Short-tailed Shrew and American robin.....7-19
Table 7-12: Risk Characterization for Aquatic Organisms 7-19
Table 7-13: Risk Characterization for Muskrat and Mallard.....7-19
Table 7-14: Alternate Risk Characterization for Terrestrial Plants and Soil Invertebrates.....7-19
Table 7-15: Toxicity Information for Eastern Cottontail Rabbit and Short-tailed Shrew.....7-19
Table 7-16: Toxicity Information for American Robin.....7-19
Table 7-17: Alternate Risk Characterization for Eastern Cottontail Rabbit, Short-tailed Shrew and American robin.....7-19
Table 8-1: Human Health Risk Assessment Summary.....8-7

Appendices

Appendix A – Site Surveying Report

- 2001 Survey
- 2005 Survey

Appendix B – Boring Logs and Well Permits

- 2000 Boring Logs
- 2000 Well Permits
- 2001 Boring Logs
- 2001 Well Permits
- 2004 Boring Logs
- 2004 Well Permits

Appendix C – Monitoring Well Records

- 2000 Monitoring Well Records
- 2001 Monitoring Well Records
- 2004 Monitoring Well Records

Appendix D – RAGS Part D Tables

Appendix E – ProUCL Results

- Surface Soil ProUCL Results
- All Soils ProUCL Results
- Groundwater ProUCL Results

Appendix F – Exposure Assessment Modeling Tables

- Volatile Chemical Release to Indoor Air During Showering
- Volatile Chemical and Respirable Particulate Release to Indoor Air During Excavation Activities
- Dermal Exposure Assessment Worksheets

Appendix G – Dietary Exposure Estimate Calculations

ACRONYMS

°C	degrees Celcius
°F	degrees Fahrenheit
AAFES	Army & Air Force Exchange Service
AEG	AEG Environmental, Inc.
AF	adherence factor
ALM	Adult Lead Model
amsl	above mean sea level
AOC	Architect of the Capitol
ARAR	applicable or relevant and appropriate requirements
AST	above-ground storage tank
ASTM	American Society for Testing and Materials
AT	averaging time
ATSDR	Agency for Toxic Substances and Disease Registry
B&O	Baltimore and Ohio
BCF	bioconcentration factor
bgs	below ground surface
BTAG	Biological Technical Assistance Group
BRAC	Base Realignment and Closure
BTEX	benzene, toluene, ethylbenzene, xylene
BW	body weight
CERCLA	Comprehensive Environmental Response, Compensation and Liabilities Act
CD	compact disc
CDI	chronic daily intakes
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COMAR	Code of Maryland Regulations
COPC	chemicals of potential concern
CPS	cancer potency slope
CPSi	CPS factors for inhalation exposures
CPSo	CPS factors for oral exposures
DAF	dilution attenuation factor
DI	deionized
DoD	Department of Defense
DOT	Department of Transportation
DPT	direct push technology
DRMO	Defense Reutilization and Marketing Office
ECO-SSL	Ecological Soil Screening Levels
ED	exposure duration
EE	estimated exposure
EF	exposure frequency

EMO	Environmental Management Office
EPA	Environmental Protection Agency
EPC	exposure point concentration
EPC	exposure point concentration
ET	exposure time
EW	existing well
FA	fraction absorbed
FFS	Focused Feasibility Study
FGGM	Fort George G. Meade
FEMA	Federal Emergency Management Agency
FI	fraction ingested
FR	fraction of total food intake
FS	fraction of soil/sediment
FSP	Field Sampling Plan
FW	Fresh Water
GW	groundwater
HASP	Health and Safety Plan
HEAST	Health Effects Assessment Summary Tables
HE	High Explosive
HHRA	Health Human Risk Assessment
HI	Hazard Index
HSA	hollow stem auger
HQ	hazard quotient
IDW	investigation derived waste
IEUBK	Integrated Exposure Uptake Biokinetic Model for Lead in Children
IR	ingestion rate
IR-W	ingestion rate-water
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
IUF	invertebrate uptake factor
Kd	distribution coefficient
Kh	Henry's law constant
Kow	Octanol/water partition coefficient
Koc	Organic carbon adsorption coefficient
Kp	dermal permeability coefficient
kV	kilovolt
LOAEL	lowest-observed-adverse-effects-levels
LOC	Library of Congress
MCL	maximum contaminant levels
MD	Maryland
MDE	Maryland Department of the Environment
MDL	method detection limit
MI	mobility index

MS/MSD	matrix spike/matrix spike duplicate
NAPL	non-aqueous phase liquid
NCP	National Contingency Plan
ND	non-detect
NIR	normalized ingestion rate
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effect level
NSA	National Security Agency
NW	new well
NWI	National Wetland Inventory
PAH	polynuclear aromatic hydrocarbons
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PEF	particulate emissions factor
PID	Photoionization Detector
PbB	blood lead level
PPRTVs	Provisional Peer-Reviewed Toxicity Values
PQL	practical quantitation limit
PSS1	palustrine scrub-shrub broad-leaved deciduous
PUB	palustrine unconsolidated bottom
PUF	plant uptake factors
PVC	polyvinyl chloride
PW	production well
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
QCS/AR	Quality Control Summary and Analytical Results
RAGS	Risk Assessment Guidance for Superfund
RBC	risk based concentration
RCRA	Resource Conservation and Recovery Act
RfC	reference concentration
RfD	reference dose
RI	Remedial Investigation
RK&K	Rummel, Klepper & Kahl
RME	reasonable maximum exposures
S	water solubility
SA	surface area
SD	sediment
SLERA	screening level ecological risk assessment
SPT	Standard Penetration Test
SQL	sample quantitation limit
SSL	soil screening level
SVOC	semivolatile organic compound
SW	surface water

TAL	Target Analyte List
TBC	to be considered
TCE	trichloroethylene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TEGD	Technical Enforcement Guidance Document
TIC	tentatively identified compound
TMP	Transportation Motor Pool
TRV	threshold reference values
UCL	upper confidence limit
UF	uptake factors
URS	URS Group Inc.
U.S.	United States
USACE	United States Army Corp of Engineers
USCS	Unified Soil Classification System
USDOE	United States Department of Energy
USGS	United States Geological Survey
UST	underground storage tank
VFs	volatilization factors
VOC	volatile organic compound
VP	vapor pressure
WTS	Waste Technology Services

EXECUTIVE SUMMARY

Malcolm Pirnie, Inc. was contracted by the U.S. Army Corps of Engineers (USACE), Baltimore District, to conduct a Remedial Investigation (RI) at the Architect of the Capitol (AOC) Library of Congress (LOC) Campus Facility at Fort George G. Meade (FGGM). A field investigation was conducted in two phases (2000/2001 and 2004/2005) to acquire sufficient data to assess the nature and extent of contamination and risk to human health and the environment. A summary of the objectives, site description, nature and extent of contamination, fate and transport mechanisms, risk assessment, and recommendations are provided in the following sections.

ES.1 Background

All work was conducted in accordance with the Scope of Work developed by the USACE, with field investigation procedures further developed in the November 1999 *Final Work Plan*, the November 2000 *Revised Final Work Plan Addendum*, and the October 2004 *Site Specific Work Plan*. These work plans were approved by the USACE, the Maryland Department of Environment (MDE), and U.S. Environmental Protection Agency (EPA) Region III. The activities in the RI were geared toward collecting the information necessary to evaluate the types and magnitude of contamination, as well as the transport mechanisms and impacts of contamination in various media, including surface water, groundwater, soil, and sediment.

The specific objectives of the RI were to:

- Collect environmental data from identified or potential release areas,
- Characterize the nature and extent of constituents in environmental media at or adjacent to the site,
- Eliminate from further consideration those releases that pose no significant threat to the public health or the environment, and
- Complete a risk assessment to quantify risk to human health and ecological receptors.

ES.2 Site Description

FGGM is located in Anne Arundel County, Maryland (MD), almost midway between the cities of Baltimore, MD, and Washington, D.C. FGGM lies approximately four miles east of Interstate 95 and one-half mile east of the Baltimore-Washington Parkway, between MD Routes 175 and 198. FGGM is located near the communities of Odenton, Laurel, Columbia, and Jessup.

The LOC parcel is an east-west roughly rectangular 100-acre parcel that is situated along the southern portion of FGGM. The site is bounded to the south by MD Route 32 (Patuxent Highway), to the north by Rock Avenue, to the east by Pepper Road, and to the west by Remount Road. Bethel Cemetery and the Fort Meade Post Cemetery are located along Rock Avenue in the northeastern corner of the 100-acre parcel, but the two cemeteries are excluded from the LOC parcel. The topography of the site is generally flat. Elevation of the 100-acre site generally ranges from about 120 feet above mean sea level (amsl) along the Rogue Harbor Branch to about 140 feet amsl at the eastern and western boundaries. The area surrounding the LOC parcel is light industrial and residential.

The right-of-way of the former Baltimore and Ohio (B&O) Railroad divides the study area longitudinally. Remains of the railroad and associated structures are located along the site in an east-west direction. Many old warehouses, structures, and railway still exist; however, in some areas, the rails have been removed for construction of other facilities. The parcel is bisected by the Rogue Harbor Branch, which flows south to Lake Allen.

Based on field reconnaissance and inspection of aerial photographs of the site, several areas of concern were identified on the LOC parcel. The areas of concern were derived from identified or potential release areas and include: the Former Defense Reutilization and Marketing Office (Former DRMO), Transportation Motor Pool Facility (TMP), Electrical Substation, Tractor Trailer Storage Area, Warehouse Area, Disturbed Area, Suspected Fill Area, Compost Area, Gravel Fill Area, Demolished Warehouse Area, Area West of Rogue Harbor Branch, Former Railroad Bed, and Commissary Warehouse Area.

The 100-acre LOC parcel was transferred to the AOC from the Army on October 21, 1993. This transfer was to accommodate the varied long-term storage and service needs of the LOC and other Legislative Branch Agencies. Although AOC refers to the 100-acre parcel as the Congressional Parcel, for the sake of consistency with previous histrorical documentation, the site is referred to as the LOC parcel in this report. The AOC is managing the site and construction of new facilities for its various clients. Currently, much of the LOC parcel is used for warehouse storage, making use of the large warehouse buildings in the eastern portion of the site. The AOC has constructed a new book storage facility and water tank for the LOC immediately west of the existing warehouse area, and additional construction is planned for the surrounding area. The TMP is currently in operation, and the Tractor-Trailer Storage Area and electrical substation are still in use.

ES.3 Nature and Extent of Contamination

Soil, sediment, surface water, and groundwater samples were collected at the various areas of concern on the LOC parcel to define the nature and extent of contamination.

Surface and Subsurface Soil

Several volatile organic compound (VOCs), semivolatile organic compound (SVOCs), pesticides, polychlorinated biphenyls (PCBs), and metals were detected in the surface soil and subsurface soil samples collected at the site. Numerous VOCs were identified in several surface and subsurface soil samples, but due to the limited number of VOC detections and relatively low concentrations, no discernable distribution pattern can be identified for VOCs in soil. All VOC detections were located in areas with previous industrial activity. No VOCs were detected above their respective residential or industrial EPA risk based concentrations (RBCs).

There were no discernible patterns to the surficial semivolitile organic compounds (SVOC) contamination, indicating that multiple small sources may have been present, and there does not appear to have been any significant, ongoing spills, leaks, or sources. Several SVOCs were detected above the residential soil RBC, but only one exceeded the industrial soil EPA RBC. SVOCs also exceeded the EPA soil screening levels (SSLs).

Two PCBs were detected in the surface and subsurface soil samples collected at the site. One detection exceeded the EPA RBC for residential soil, and one detection equaled the EPA RBC for residential soil. PCB detections in surface soil are isolated and no distribution pattern can be identified.

Several pesticides were detected in soil samples collected at the site. No pesticides were detected above the EPA RBCs or EPA SSLs. These detections are typical of areas of similar industrial usage.

Numerous metals, including aluminum, arsenic, barium, beryllium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, selenium, vanadium and zinc, were detected in most surface and subsurface soil samples. Other metals, including antimony, cadmium, sodium, mercury, selenium, and thallium, were detected in some of the other surface and subsurface soil samples collected at the site. Due to the variations in inorganics concentrations across the site and downgradient of the site, no contours could be established indicating definitive source areas and migration/transport pathways. The majority of metals concentrations decreased from the surface to subsurface depths in the site soil borings.

Sediment

Three sediment samples (upstream, midpoint, and downstream) were collected from Rogue Harbor Branch. Acetone was the only VOC detected in the three sediment samples collected from Rogue Harbor Branch, and it was detected at concentrations below the EPA Region III Biological Technical Assistance Group (BTAG) Freshwater Sediment Screening Benchmarks. No SVOCs or PCBs were detected in the sediment samples. Six pesticides were detected in the sediment samples, but only one was detected at a concentration above the screening criteria. Numerous metals were detected in the three sediment samples collected at the site. Aluminum, barium, iron, and lead concentrations exceeded the EPA Region III BTAG Freshwater Sediments Screening Benchmark. There was minimal variation in the concentrations in the sediment samples collected at the site.

Surface Water

Three surface water samples (upstream, midpoint, and downstream) were collected from Rogue Harbor Branch. No VOCs, SVOCs, PCBs, or pesticides were detected in the surface water samples collected from Rogue Harbor Branch. Numerous metals were detected in the three surface water samples. Aluminum, barium, iron, lead, and manganese concentrations in the surface water exceeded the EPA Region III BTAG Freshwater Screening Benchmark. There was minimal variation in metals concentrations in the surface water samples collected at the site.

Groundwater

Numerous VOCs, some of which were detected above EPA RBCs, were identified in several direct ush technology (DPT) and monitoring well groundwater samples collected at the site. All VOC detections were located in areas with previous industrial activity.

Several SVOCs were detected in the groundwater at this site. Bis(2-Ethylhexyl)phthalate, 2-methylnaphthalene, carbazole, and naphthalene exceeded the RBC for tap water and EPA MCLs. The remaining SVOCs did not exceed their respective screening criteria. With the exception of the SVOCs detected in the vicinity of the former underground storage tanks (USTs), there is no discernible pattern of SVOC contamination in the site groundwater.

The pesticides chlordane and heptachlor epoxide were each detected in the groundwater at one location. Heptachlor epoxide exceeded the EPA RBC for tap water, but was below the EPA MCLs. Chlordane was detected at a concentration below the screening criteria.

No discernible distribution pattern was indicated based on the dissolved groundwater data. Dissolved metals, some of which were detected above EPA RBCs, including aluminum, antimony, arsenic, barium, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc were detected throughout the site, but in no specific lateral pattern, indicating that these metals may be naturally occurring. Evaluation of the data does not suggest the presence of a significant dissolved metals contaminant plume beneath the LOC site.

ES.4 Fate and Transport

A qualitative evaluation of contaminant fate and transport was performed for the LOC parcel, including site physical characteristics, physical and chemical properties of the detected contaminants, and the nature and extent of contamination.

Soils and Sediments

Polynuclear aromatic hydrocarbons (PAHs), metals, and pesticides remain in the soil column because these compounds strongly adsorb to soil, especially the fine fraction (silt and clay). Thus, these compounds tend to remain at the source area with little migration. Biodegradation is expected to be an important fate process for PAHs and pesticides at the site. Due to the potential for transport of soil particles by storm water runoff or surface water, these compounds can migrate when adsorbed to soil or sediment particles. It is expected that transport from on-site to downgradient locations is accomplished by these mechanisms.

Groundwater

VOCs were infrequently detected in groundwater samples collected from the site. However, due to the relatively flat hydraulic gradient, the probability of further significant migration appears to be limited. A carbon tetrachloride plume in the southwest corner of the LOC parcel, which appears to be originating from off-site, was delineated during a previous investigation of an adjacent area of the FGGM property and is traveling in a southeasterly direction.

PAHs were the most frequent SVOCs detected in the groundwater. Transport of these compounds is expected to occur as a slow leaching from the soil column to groundwater. Biodegradation would occur more rapidly under aerobic conditions. It is expected that the while these compounds could be transported along with groundwater to discharge points, this transport would be extremely slow (due to the flat gradient and fine particle size) and likely insignificant due to the compounds' affinity for soil particles.

Numerous metals were detected in groundwater; however, the constituents most frequently detected at concentrations above the RBCs were aluminum, arsenic, iron, chromium, manganese, and vanadium. These dissolved phase metals will be transported with flowing groundwater but likely will not migrate as rapidly as the organics.

Chlordane and heptachlor epoxide were the only pesticides detected in the groundwater monitoring wells. However, both chlordane and heptachlor epoxide were only detected in one groundwater sample; therefore, transport of pesticides in groundwater are not of significant

concern due to their infrequent detection and especially when considered in conjunction with the relatively flat hydraulic gradient at the site.

ES.5 Risk Assessment

Human Health Risk Assessment

A human health risk assessment was conducted for the site, utilizing the groundwater, soil, sediment, and surface water data obtained in the remedial investigation. A number of current and future exposure scenarios were included in the assessment, including:

- outdoor site worker exposure to chemicals in surface soil;
- indoor site worker exposure to volatile chemicals in groundwater that may migrate to indoor air;
- construction worker exposure to chemicals in surface and subsurface soil;
- construction/utility worker exposure to chemicals in surface and subsurface soil and groundwater; and
- off-site resident (adult and child) exposure to chemicals in groundwater; and
- adolescent recreationist exposure to chemicals detected in surface water and sediment.

Exposure of off-site residents (adult and child) to chemicals in shallow groundwater is the only scenario that results in a potential for non-carcinogenic health effects and increased cancer risk should shallow groundwater be used for potable purposes in the future, in the absence of remedial action. The hazard indices for non-carcinogenic effects for this scenario, which are greater than the EPA acceptable level, are predominantly due to arsenic, iron, chromium, and vanadium. However, chromium, which was reported as total chromium, was conservatively evaluated as if it were hexavalent chromium and may not represent the level of risk identified in the assessment. The excess lifetime cancer risks, which are greater than the EPA acceptable risk range, are predominantly due to arsenic.

Lead in soil should not pose a risk to construction and construction/utility workers at the site and lead in groundwater should not pose a risk to off-site residents should groundwater be used for potable purposes in the future.

The LOC parcel is not currently used or planned to be used for residential purposes. Furthermore, shallow groundwater is not currently used or planned to be used at the LOC parcel and downgradient properties, which consist of a closed sanitary landfill and a wildlife refuge. The site and downgradient properties are unlikely to be used for residential purposes in the future, and even if they were, ehty would ot likely use shallow groundwater as a potable supply. Therefore, the consideration of the residential use exposure scenario is considered to be very conservative.

Evaluation of all other listed exposure scenarios, currently and in the future in the absence of remedial action, indicates that, adverse, non-carcinogenic health effects are unlikely and excess lifetime cancer risks are less than or within the EPA acceptable risk range.

Ecological Risk Assessment

A screening-level ecological risk assessment (SLERA) was conducted for the site to identify and characterize the potential for health risks to ecological communities and wildlife receptors as a result of chemical releases at the site. Two ecosystems of concern were evaluated: the wooded upland portions of the site and the portion of Rogue Harbor Branch and associated wetlands that lies within the site.

An evaluation of the potential for risks to terrestrial and aquatic/semi-aquatic plant and invertebrate communities was accomplished via the comparison of detected chemical concentrations to conservative risk-based ecotoxicity screening benchmarks. An assessment of the potential for ecological risks to upper trophic level terrestrial and semi-aquatic receptors was accomplished via the comparison of estimated dietary exposures to threshold reference values, derived from dose-response studies found in the scientific literature.

Detected concentrations of a number of chemicals in surface soil, predominantly metals, pose the potential for adverse ecological health effects in terrestrial plants and soil invertebrates based on the comparison to conservative benchmarks. Based on the dietary exposure estimates for upper trophic level terrestrial wildlife, the detected concentrations of a few pesticides and metals may pose the potential for adverse ecological health effects. However, some consideration should be given to areas from which the samples with maximum detected metals concentrations were collected. These areas are likely to be associated with industrial activities and are therefore, less likely to be used by wildlife receptors with the same frequency and intensity as the exposure assessment parameters would indicate.

Similarly, a number of metals in surface water and/or sediment pose the potential for adverse ecological effects in aquatic organisms and benthic invertebrates, based on the comparison of the maximum detected chemical concentrations to conservative benchmarks. Based on the dietary exposure estimates for upper trophic level semi-aquatic wildlife, there is little to no potential for adverse health effects.

ES.6 Recommendations

Based upon the results of the human health evaluation, it appears that further action is required in the form of a Feasibility Study to support the selection of viable remedial alternatives for mitigating the identified potential for human health risks, specifically as a result of potential future residential potable use of shallow groundwater. Based on the results of the ecological risk assessment and consistent with EPA (1997c), a more thorough assessment of the potential for ecological risk may be warranted.

1 INTRODUCTION

Malcolm Pirnie, Inc. was contracted by the United States (U.S.) Army Corps of Engineers (USACE), Baltimore District to conduct a Remedial Investigation (RI) at the Architect of the Capitol (AOC) Library of Congress (LOC) Campus Facility at Fort George G. Meade (FGGM) under Contracts DACA31-94-0017, Delivery Order No. 0144 and DACA31-00-D-0043, Delivery Order No. 014.

1.1 OBJECTIVE AND PURPOSE OF REPORT

As reported in the October 7, 1993 Congressional Record-House (page H7634), "… the Secretary of the Army shall transfer, no later than September 30, 1994, without reimbursement or transfer of funds, to the Architect of the Capitol, a portion of the real property, including improvements thereon, consisting of not more than 100 acres located at Fort George G. Meade in Anne Arundel County, Maryland…". The transferred property is to be utilized to:

> "… provide facilities to accommodate the varied long term storage and service needs of the Library of Congress and other Legislative Branch agencies. (c) The exact acreage and legal description of the property to be transferred under this section shall be determined by a survey satisfactory to the Architect of the Capitol and the Secretary of the Army, and in consultation with officials of Anne Arundel County, Maryland. The property in Fort George G. Meade identified which would meet the Library's goal is located generally north of State Route 32 and south of Rock Avenue and First Street. The Architect is directed to consult with appropriate officials in Anne Arundel County, Maryland, concerning the exact acreage and legal description of the property."

Thus, on October 21, 1993, Public Law 103-110 authorized the Army to transfer the 100-acre parcel of land along Maryland (MD) Route 32 in FGGM, MD (**Figure 1-1**). Prior to the land transfer, the U.S. Army (Army) requested an environmental study of the property in support of the property transfer and a feasibility study of its appropriateness for the required uses by the LOC.

The overall objectives of this RI are to characterize the nature and extent of potential chemical contamination on the parcel and evaluate potential human and environmental health risks associated with detected contamination. The work was conducted under the requirements of the Department of Defense (DoD) Installation Restoration Program (IRP), which are consistent with the U.S. Environmental Protection Agency (EPA) guidelines. The EPA guidelines followed during the RI are set forth in "*Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*" (EPA, 1988).

All work was conducted in accordance with the Scope of Work developed by the USACE, with field investigation procedures further developed in the November 1999 *Final Work Plan*, the November 2000 *Revised Final Work Plan Addendum*, and the October 2004 *Site Specific Work Plan*. These work plans were approved by the USACE, the Maryland Department of Environment (MDE), and U.S. EPA Region III. The activities in the RI were geared toward collecting the information necessary to evaluate the types and magnitude of contamination, as well as the transport mechanisms and impacts of contamination on various media, such as surface water, groundwater, soil, and sediment.

The specific objectives of the RI were to:

- Collect environmental data from identified or potential release areas,
- Characterize the nature and extent of constituents in environmental media at or adjacent to the site,
- Eliminate from further consideration those releases that pose no significant threat to the public health or the environment, and
- Complete a risk assessment to quantify risk to human health and ecological receptors.

1.2 BACKGROUND

1.2.1 Facility Description

FGGM is located in Anne Arundel County, MD, almost midway between the cities of Baltimore, MD, and Washington, D.C. FGGM lies approximately four miles east of Interstate 95 and one-half mile east of the Baltimore-Washington Parkway, between MD Routes 175 and 198. FGGM is located near the communities of Odenton, Laurel, Columbia, and Jessup (**Figure 1-1**).

The workforce at FGGM has approximately 39,000 members, composed of military, civilian and contractor personnel. Approximately 6,000 family members reside on post. Following the 1988 Base Realignment and Closure (BRAC)[1] realignment, the installation covered approximately 5,415 acres. The current installation boundaries encompass the area previously referred to as the cantonment area, which is used for administrative, recreational, and housing facilities. FGGM contains approximately 65.5 miles of paved roads, 3.3 miles of secondary roads, and about 1,300 buildings.

FGGM's mission is to provide base operations support for facilities and infrastructure and quality of life and protective services in support of DoD activities and federal agencies. The wide range of support is provided to more than 78 partner organizations from all four services and to several federal agencies. Major tenant units include the National Security Agency (NSA), the Defense Information School, the Defense Courier Service, the Army Field Band, and the EPA.

1.2.2 Facility History

FGGM became an Army installation in 1917. Authorized by an Act of Congress in May 1917, it was one of 16 cantonments built for troops drafted for the war with the Central Powers in Europe. The U.S. Government commandeered 4,000 acres of land, which had been previously used for fruit farming. Additional surrounding land was purchased, bringing the total acreage to 9,349 acres. The present Maryland site was selected on June 23, 1917, and construction commenced on July 2, 1917. The first contingent of troops arrived in September 1917. The post was originally named Camp Meade for Major General George Gordon Meade, whose defensive strategy at the Battle of Gettysburg proved a major factor in turning the tide of the Civil War in favor of the North. In 1928, when the post was renamed Fort Leonard Wood,

[1] BRAC is a DoD controlled program that manages cleanup efforts at military installations undergoing base closure or alignment. Congress authorized four rounds of base closure for 1988, 1991, 1993, and 1995.

Pennsylvanians registered such a large protest that the installation was permanently named FGGM on March 5, 1929.

During World War I, over 100,000 men passed through the installation. The 79th, 92nd and 11th Infantry Divisions trained at the base, and an Ordnance Supply School was established in 1918. When the war ended in November 1918, FGGM served as a demobilization center for troops returning from overseas.

FGGM became a permanent installation after World War I. The Tank Corps School was established on January 30, 1920. The installation was also used as a summer training site for the Citizens Military Training Corps, the Reserve Officers Training Corps, the National Guard, and Officers Reserve Corps units. Most of the temporary buildings were replaced by 1928. By 1940, there were 251 permanent and 218 temporary buildings and over 2,100 enlisted men on base. By December 1941, the total land acquired by FGGM had grown to approximately 13,800 acres. On the newly acquired land were chapels, clinics, a hospital, several theatres, service clubs, libraries, one main Post Exchange, and other various shops. There were also several athletic facilities, including a golf course, softball and baseball fields, four swimming pools, and two lakes stocked with fish.

FGGM became a training center during World War II; its ranges and other facilities were used by more than 200 units and approximately 3,500,000 men between 1942 and 1946. The wartime peak military personnel figure at FGGM (70,000) was reached in March 1945. The Tank Destroyer Force was founded at the base in 1942. The Special Service Unit Training Center was operational from March 2, 1942, to November 1, 1944. FGGM acted as a Prisoner of War Information Bureau. Italian and German prisoners were held at FGGM beginning in 1943.

With the conclusion of World War II, FGGM reverted to routine peacetime activities, but later returned to build-up status. Many crises, including Korea, West Berlin and Cuba, along with Vietnam-related problems, required support from FGGM.

One key post-World War II event at FGGM was the transfer of the Second U.S. Army Headquarters from Baltimore on June 15, 1947. This transfer brought an acceleration of post activity, because the Second U.S. Army Headquarters exercised command over Army units throughout a then seven-state area. A second important development occurred on January 1, 1966, when the Second U.S. Army merged with the First U.S. Army. The consolidated headquarters moved from Fort Jay, New York, to FGGM to administer activities of Army installations in a 15-state area. Other significant post World War II developments included the relocation of the NSA to FGGM in 1954 and the construction of Tipton Airfield in 1960.

In 1988, FGGM was realigned under the first round of BRAC. The BRAC program authorized 9,000 acres to be excessed from FGGM, including Tipton Airfield and the Patuxent Research Refuge. Between 1991 and 2000, approximately 8,471 of the 9000 acres were transferred out of DoD control.

In support of Operation Desert Shield in 1990, FGGM began processing Army Reserve and National Guard units within several states for the Presidential call-up. The base sent two of its own active duty units, the 85th Medical Battalion and the 519th Military Police Battalion, to Saudi Arabia. In all, approximately 2,700 personnel from 42 units deployed from FGGM during Operation Desert Shield/Desert Storm.

On October 1, 2002, FGGM became a subordinate element of the Installation Management Agency (Northeast Region) after nine years as part of the Military District of Washington. The Northeast Region area of responsibility stretches from Maine to North Carolina with headquarters at Fort Monroe, Virginia.

1.2.3 LOC Parcel Description

The LOC parcel is an east-west roughly rectangular parcel that is situated along the southern portion of FGGM (**Figure 1-2**). The site is bounded to the south by MD Route 32 (Patuxent Highway), to the north by Rock Avenue, to the east by Pepper Road, and to the west by Remount Road. Bethel Cemetery and the Fort Meade Post Cemetery are located along Rock Avenue in the northeastern corner of the 100-acre parcel, but the two cemeteries are excluded from the LOC parcel. The LOC parcel is located in the northwestern quadrant of the Odenton U.S. Geological Survey (USGS) Quadrangle, 7.5-minute series topographic map. Latitudinal and longitudinal coordinates are approximately 39° 05' North and 76° 44' West. The topography of the site is generally flat. Elevation of the 100-acre site generally ranges from about 120 feet above mean sea level (amsl) along the Rogue Harbor Branch to about 140 feet amsl at the eastern and western boundaries. The area surrounding the LOC parcel is light industrial and residential.

The right-of-way of the former Baltimore and Ohio (B&O) Railroad divides the study area longitudinally. Remains of the railroad and associated structures are located along the site in an east-west direction. Many old warehouses, structures, and railway still exist; however, in some areas, the rails have been removed for construction of other facilities.

The parcel is bisected by the Rogue Harbor Branch (also called Midway Branch on USGS Odenton Quadrangle, photo revised 1979), which flows south to Lake Allen (also called Soldier Lake on the USGS Odenton Quadrangle). The outlet from Lake Allen flows south to the Little Patuxent River. The Little Patuxent River is a primary tributary of the Patuxent River, which is the principal drainage system for Anne Arundel County.

The western portion of the 100-acre parcel is the site of the Former Defense Reutilization and Marketing Office (Former DRMO) and Transportation Motor Pool Facility (TMP). This portion of the site contains several warehouses and buildings, including paved areas and improvements associated with the Former DRMO and the TMP. The area between the TMP and the Rogue Harbor Branch is mostly woodland, including each side of the floodplain of the Rogue Harbor Branch. A fenced parking lot for tractor-trailer and vehicle storage, a fenced 13 kilovolt (kV) electrical substation, and a sewage pump station are east of the Rogue Harbor Branch.

The east-central portion of the 100-acre parcel, east of the Rogue Harbor Branch, includes five buildings formerly used as the FGGM commissary and commissary warehouses. The eastern most portion of the site contains a temporary warehouse storage area consisting of 17 warehouse buildings with a paved access drive. A book storage facility for the LOC was constructed adjacent to the western-most warehouse, and an associated retention pond is located north of MD Route 32. Directly west of the new LOC warehouse is a vacant field. A water tank and support building (constructed in 2005) are located along Rock Avenue at the entrance to the warehouse area.

Numerous utility lines underlie the parcel. The utility systems at FGGM consist of a water distribution system, a sanitary sewer system, an electrical system, and a mechanical branch

system for heating/cooling. Telephone and gas lines also transect the parcel along with several storm water drainage systems. A fire control system was installed in 2004 in the eastern portion of the site by the AOC.

Although AOC refers to the 100-acre parcel as the Congressional Parcel, for the sake of consistency with previous histrorical documentation, the site is referred to as the LOC parcel in this report.

1.2.4 LOC Parcel History

The history of the property dates back to the Civil War when the former Annapolis Elkridge Railroad (now the B&O) transported troops and supplies. Buildings were constructed along the railroad to store materials brought in or shipped out by the rail system. During World War I, additional buildings were constructed, including warehouses, a commissary, horse stables, a riding trail, and riding rinks. Prior to construction of MD Route 32, the State of Maryland purchased the railroad right-of-way; portions not needed for MD Route 32 were transferred to FGGM.

As described Section 1.1, the 100-acre parcel was transferred to the AOC from the Army on October 21, 1993. This transfer was to accommodate the varied long-term storage and service needs of the LOC and other Legislative Branch Agencies. The AOC is managing the site and construction of new facilities for its various clients (e.g., LOC, House of Representatives, and Senate). Currently, much of the 100-acre LOC parcel is used for warehouse storage, making use of the large warehouse buildings in the eastern portion of the site. The AOC has constructed a new book storage facility and water tank for the LOC immediately west of the existing warehouse area, and additional construction is planned for the surrounding area. The TMP is currently operating, and the Tractor-Trailer Storage Area and electrical substation are still in use.

1.2.5 Previous Investigations

Summaries of previous investigations and studies conducted at the LOC parcel are provided in the following sections.

1.2.5.1 Soil Vapor Study

A Phase I study of the 100-acre parcel associated with transfer of the site to the LOC was conducted in May 1994 by Rummel, Klepper & Kahl (RK&K). According to the 1994 Phase I report, a soil vapor study conducted in March and April 1990 indicated that petroleum hydrocarbon contamination is present in the TMP and in the vicinity of several underground storage tanks (USTs) that serviced the warehouses in the eastern portion of the LOC parcel. Significant contaminant concentrations were documented near the former UST at Building 15; however, the petroleum contamination was reported to have been confined to the proximity of the tank. The soil vapor study also indicated that petroleum hydrocarbon contamination was evident at the TMP. However, significant migration of vapors had not extended beyond the fenced area of the TMP. A previous soil vapor study also indicated low levels of petroleum contamination at the location of a UST between Buildings 68 and 69. The tank was subsequently replaced in 1988.

1.2.5.2 RK&K Phase I of LOC parcel

The area addressed in the RK&K Phase I report extended farther west of Remount Road than the area being addressed under the current RI. The areas west of Remount Road contained structures associated with the current DRMO facilities, including Building 67, a Defense Property Disposal Office salvage yard, and the Covered Storage Facility. Previous investigations of this area west of Remount Road indicated soil and groundwater contamination with polychlorinated biphenyls (PCBs), chlorinated solvents, and petroleum hydrocarbons. Due to the identified soil and groundwater impact, the Phase I report recommended that this area west of Remount Road be excluded from the parcel being considered for transfer to the AOC. It should be noted, however, that a subsequent investigation of the parcel to the west of Remount Road (see Section 1.2.5.3) identified the existence of a carbon tetrachloride plume that has impacted groundwater at the southwest corner of the LOC parcel.

The RK&K Phase I report consisted of evaluations of the property, natural environment, hazardous wastes, utilities, and transportation. Findings of the Phase I study included petroleum contamination in soil and groundwater at the TMP area and petroleum contamination in soil and groundwater in the vicinity of fuel USTs associated with the warehouses in the eastern portion of the parcel. The Phase I report identified three areas of concern: 1) the DRMO area, 2) the TMP area, and 3) several of the warehouse areas that contained USTs. The report also recommended a Phase II Preliminary Site Investigation. The DRMO area referenced in the Phase I report included both the current DRMO (west of Remount Road) and the Former DRMO. As previously stated, based on the findings of impacted soil and groundwater west of Remount Road, the RK&K Phase I report recommended that the area west of Remount Road be excluded from the parcel being considered for transfer to the AOC.

As noted previously, the Former DRMO is part of the 100-acre parcel being addressed in this RI. The only potential area of concern identified in the Phase I report at the Former DRMO was a former hazardous materials storage shed. The TMP and warehouse areas identified in the Phase I report as areas of concern are also included in the 100-acre parcel transferred to the AOC.

1.2.5.3 Carbon Tetrachloride Delineation, DRMO Facility

In August 2000, a source delineation study was conducted for a carbon tetrachloride plume that was discovered during an investigation of the current DRMO facility. The carbon tetrachloride plume is located in the southwestern corner of the LOC Parcel near theintersection of Remount Road and MD Route 32. In this study, groundwater samples were collected from a total of four existing monitoring wells and 16 new direct push technology (DPT) locations (Figure 1-3). Fourteen of the DPT soil and groundwater sampling locations and one of the four monitoring wells sampled in the August 2000 study are located on the LOC parcel.

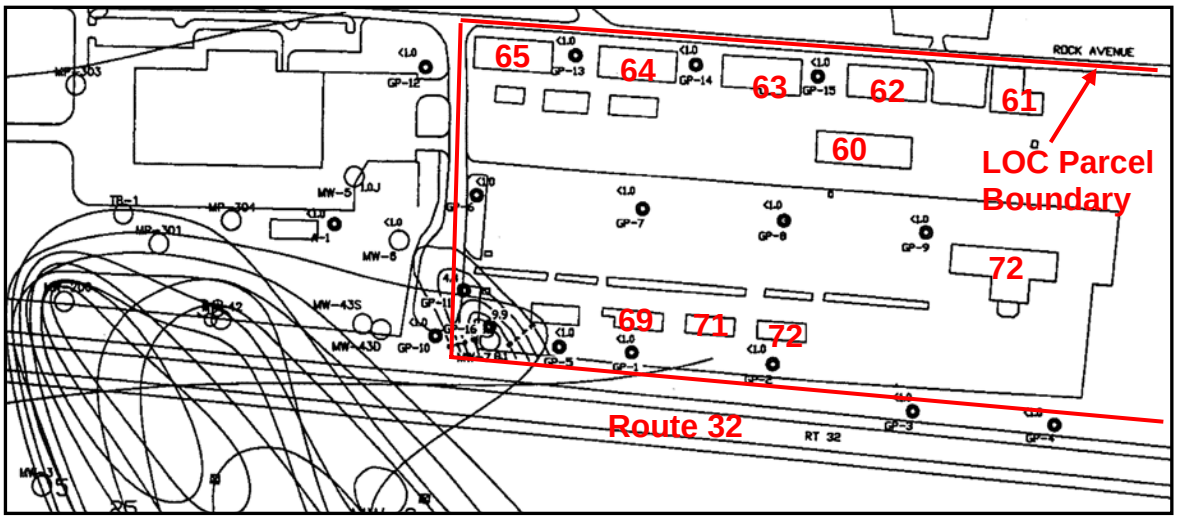

Figure 1-3: Carbon tetrachloride delineation (2003 RI)

Although the purpose of this study was to delineate the carbon tetrachloride plume, samples were analyzed for all volatile organic compounds (VOCs), not just carbon tetrachloride. The VOC levels detected at on the LOC parcel during the 2000 source delineation study are provided in Table 1-1. Based on the data collected, the upgradient portion of the carbon tetrachloride plume appears to be limited to a relatively small area (Figure 1-4). The highest concentration of carbon tetrachloride (9.23 ug/L) was detected in sample GP-16, which is located adjacent to MW-7 (8.1 ug/L carbon tetrachloride), both of which are located on the LOC parcel. Based on the delineation of the carbon tetrachloride plume presented in Figure 1-4, the plume appears to originate along Remount Road and be traveling in a south-easterly direction. The downgradient extent of the plume has not been delineated; however, carbon tetrachloride has been detected in three downgradient monitoring wells discussed in the 2003 Final RI and Baseline Risk Assessment. The source of the carbon tetrachloride plume is unknown, and it may be located outside the LOC parcel.

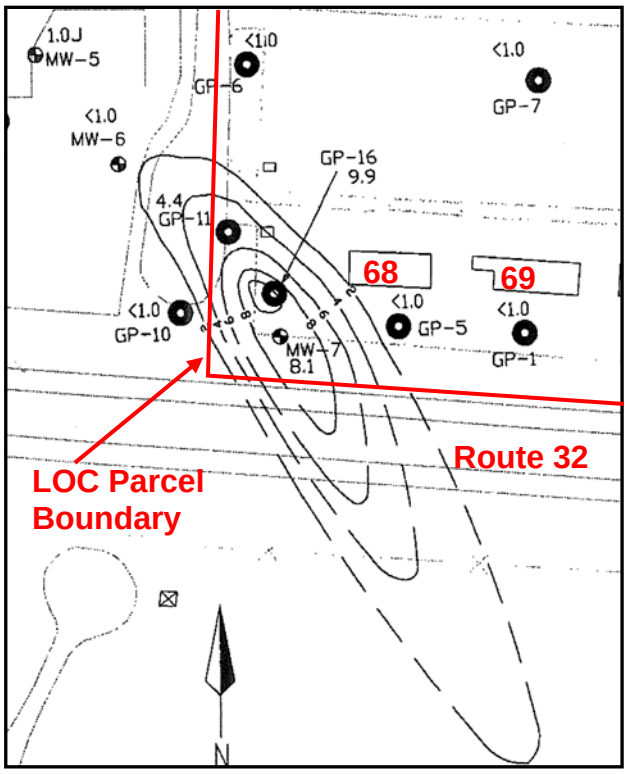

Figure 1-4: Carbon tetrachloride delineation (2004 FFS)

The 2003 Final RI and Baseline Risk Assessment for the current DRMO was not specific to carbon tetrachloride as it included all contaminants found throughout the current DRMO. Carbon tetrachloride was selected as a chemical of potential concern (COPC) in the baseline risk assessment. Carbon tetrachloride was identified as a potential driver for the risk assessment because it contributes to an unacceptable hazard index (HI) for inhalation of vapors from tap water in children. However, it should be noted that there is no anticipated future use of the groundwater on the LOC parcel or downgradient in the Patuxent Research Refuge. No other unacceptable risks were identified associated with carbon tetrachloride.

Carbon tetrachloride was identified in this RI in wells MW-7 and NW-4 which are both located in the southwest corner of the LOC parcel. The carbon tetrachloride results from these wells are included in the human health risk assessment presented in Section 6 of this report.

According to the Final DRMO RI and Baseline Risk Assessment, the tetrachloroethene (PCE) and 1,1,1-TCA plumes, which originate from the current DRMO, were not observed to impact the LOC parcel. However, the total VOC plume does impact the LOC parcel because it incorporates the carbon tetrachloride plume discussed above. Complete details about the impact to groundwater from activities at the current DRMO west of Remount Road can be found in the 2003 Final RI and Baseline Risk Assessment and 2004 Focused Feasibility Study.

Table 1-1: Carbon Tetrachloride Source Delineation Analytical Data Summary (1)

	Sample Number (2)								
Parameters (ug/L)	**GP-1 (3)**	**GP-2**	**GP-2D**	**GP-3**	**GP-4**	**GP-5**	**GP-6**	**GP-6D**	**GP-7**
Acetone	6.37	3.53 J (5)	4.06 J	9.23	3.14 J	<5	5.60	3.6 J	5.73
Carbon Disulfide	<1	<1	<1	1.42	<1	0.51 J	0.62 J	0.73 J	<1
Carbon Tetrachloride	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chloroform	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ethylbenzene	<1	<1	<1	<1	<1	<1	<1	<1	5.70
Methylene Chloride	1.94	1.33	1.28	<1	1.40	1.09	<1	<1	1.16
Tetrachloroethylene	<1	<1	<1	1.92	<1	<1	<1	<1	<1
Toluene	<1	<1	<1	<1	<1	<1	<1	<1	0.83 J
m,p-Xylenes	<1	<1	<1	<1	<1	<1	<1	<1	32.00
o-Xylene	<1	<1	<1	<1	<1	<1	<1	<1	17.20
	Sample Number								
	GP-8	**GP-9**	**GP-10**	**GP-11**	**GP-13**	**GP-14**	**GP-15**	**GP-16**	**MW-7 (4)**
Acetone	6.16	4.51 J	<5	<5	4.3 J	3.9 J	3.31 J	<5	<5
Carbon Disulfide	2.14	<1	<1	<1	<1	<1	<1	<1	<1
Carbon Tetrachloride	<1	<1	<1	4.36	<1	<1	<1	9.23	8.10
Chloroform	<1	<1	1.33	4.22	<1	0.58 J	<1	1.43	1.09
Ethylbenzene	<1	<1	<1	<1	<1	<1	<1	<1	<1
Methylene Chloride	<1	1.46	1.24	1.02	1.44	0.52 J	0.54 J	0.59 J	0.57 J
Tetrachloroethylene	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene	<1	<1	<1	<1	<1	<1	<1	<1	<1
m,p-Xylenes	<1	<1	<1	<1	1.38	<1	<1	<1	<1
o-Xylene	<1	<1	<1	<1	0.64 J	<1	<1	<1	<1

Notes:

(1) Final Summary Report, Source Area Delineation of Carbon Tetrachloride, DRMO Facility (URS, 2001)
Samples were collected in August 2000

(2) Only results from the AOC parcel are presented

(3) GP = Geoprobe sample

(4) MW = Monitoring Well

(5) J = Value is less than reporting limit but greater than the method detection limit

1.2.5.4 UST Tank Removal and Remediation

Numerous USTs were located at the various warehouse buildings on the LOC parcel. The majority of these USTs was fiberglass, of 550- or 1,000-gallon capacity, and used to store No. 2 fuel oil.

The USTs were removed from 1988 to 2000 under the supervision of FGGM and the MDE. Residual fuel oil contamination was detected in the soils and groundwater near Building 9; therefore, a recovery well system was installed to remove the identified contamination. The recovery well was operated until petroleum hydrocarbons were no longer detected in groundwater samples. Tank closure compliance reports were submitted by FGGM and approved by the MDE.

Numerous other USTs and above-ground storage tanks (ASTs) were located throughout the LOC parcel. UST/AST records at the FGGM Environmental Management Office (EMO) were reviewed and are summarized in **Table 1-2**.

Table 1-2: Summary of UST/AST Status

Building	Tank	Type	Contents	Size (gallons)	Installation Date	Status	Comments
9	A	UST	fuel oil #2	550	12/1/1982	removed 7/10/1995	
10	A	UST	fuel oil #2	550	12/1/1982	removed, no date provided	Information from Phase 1
12	A	UST	fuel oil #2	550	12/1/1982	removed 7/10/1995	
13	A	UST	fuel oil #2	550	12/1/1982	removed 7/10/1995	
14	A	UST	fuel oil #2	550	12/1/1982	removed 7/10/1995	
15	A	UST	fuel oil #2	1000	12/1/1982	removed 10/26/1992	
15	B	AST	unknown	unknown	unknown	unknown	
17	A	UST	fuel oil #2	550	12/1/1982	removed 7/10/1995	
17	B	UST	fuel oil #2	1000	12/1/1982	removed 7/10/1995	
18	A	UST	fuel oil #2	550	12/1/1982	removed 7/10/1995	
19	A	UST	fuel oil #2	550	12/1/1982	removed 7/11/1995	
20	A	UST	fuel oil #2	550	12/1/1982	removed 7/10/1995	
21	A	UST	fuel oil #2	1000	5/9/1969	removed 5/1/1988	
21	B	UST	fuel oil #2	1000	1986	unknown	
22	A	UST	fuel oil #2	1000	12/1/1982	removed 7/11/1995	
24	A	UST	fuel oil #2	550	12/1/1982	removed 7/11/1995	
25	A	UST	fuel oil #2	550	12/1/1982	removed 7/11/1995	
26	A	UST	fuel oil #2	550	12/1/1982	removed 9/29/1990	Information from Phase 1
27	A	UST	fuel oil #2	550	12/1/1982	removed 7/11/1995	
28	A	UST	fuel oil #2	1000	1/1/1975	removed 4/15/1993	Installation date from Phase 1
28	B	AST	unknown	unknown	unknown	unknown	
29	A	UST	fuel oil #2	550	12/1/1982	removed 9/25/1990	Information from Phase 1
30	A	UST	fuel oil #2	550	9/1/1983	removed 8/1/1990	Information from Phase 1

Building	Tank	Type	Contents	Size (gallons)	Installation Date	Status	Comments
31	A	UST	fuel oil #2	550	9/1/1983	removed 8/1/1990	Information from Phase 1
36A	A	UST	fuel oil #2	5000	12/14/1978	removed 8/2/1990	Information from Phase 1
38	A	UST	fuel oil #2	1000	7/6/1984	removed 7/11/1995	Installation date from Phase 1; UST report submitted to MDE indicates estimated age as 13 years
38	B	UST	fuel oil #2	1000	12/1/1982	removed 7/11/1995	UST report to MDE indicates estimated age as 13 years
39	A	UST	fuel oil #2	550	9/1/1983	removed 7/28/1995	
40	A	UST	fuel oil #2	1000	7/1/1984	removed 7/11/1995	
40	B	UST	fuel oil #2	550	7/1/1984	removed 7/11/1995	UST report to MDE indicates 1000 gallons; Phase 1 has no installation date, but report says same as 40A
41	A	UST	fuel oil #2	8000	unknown	unknown	Listed in Phase 1, not in MDE reports
44	A	UST	fuel oil #2	550	9/1/1983	removed 7/28/1995	
44	B	UST	fuel oil #2	1000	unknown	unknown	Listed in Phase 1, not in MDE reports
57	A	UST	fuel oil #2	550	7/1/1984	removed 8/11/1992	Not located on LOC parcel
58	A	UST	fuel oil #2	550	7/1/1984	removed 9/25/1990	Not located on LOC parcel
60	A	UST	fuel oil #2	2000	11/1/1978	removed 8/3/1995	
60G	A	UST	diesel fuel	550	5/1/1983	unknown	1997 site inspection report from MDE - no evidence to indicate UST at this location

Building	Tank	Type	Contents	Size (gallons)	Installation Date	Status	Comments
61	A	UST	fuel oil #2	4000	1/1/1969	removed 8/26/1988	
61	B	UST	fuel oil #2	2000	8/26/1988	removed 8/3/1995	
62	A	UST	fuel oil #2	550	1975	removed 7/28/1995	
63	A	UST	fuel oil #2	550	1983	removed 7/28/1995	
64	A	UST	fuel oil #2	1000	unknown	unknown	No data from MDE reports, information from Phase 1
64	B	UST	fuel oil #2	550	1983	removed 7/28/1995	
65	A	UST	fuel oil #2	550	1983	removed 7/28/1995	
66	A	UST	fuel oil #2	550	1984	removed 10/281994	
67	A	UST	fuel oil #2	550	1984	removed 10/28/1994	
68	A	UST	fuel oil #2	1000	unknown	unknown	no data from MDE reports, information from Phase 1
68	B	UST	diesel fuel	2000	unknown	unknown	no data from MDE reports, information from Phase 1
69	A	UST	fuel oil #2	12000	1/1/1969	removed 6/30/1988	
69	B	UST	fuel oil #2	10000	6/30/1988	removed 11/23/1999	
72A	A	UST	fuel oil #2	12000	1/1/1988	removed 1/24/2000	
72A	B	UST	waste oil	2000	1/1/1988	removed 5/9/1996	
72A	C	AST	waste oil	500	unknown	still in place	

During a 2003 Environmental, Occupational Health and Safety Baseline Assessment (Booz Allen Hamilton) for the LOC Parcel, disconnected fuel oil piping was visible at the west end of Building 60. This piping may be a remnant from the AST removed in 1995 or may represent a potential UST. To date, no UST has been confirmed at Building 60.

1.2.5.5 Army Range Inventory

The Army Range Inventory Program was conducted at FGGM in three phases. Phase 1 consisted of the completion of a preliminary questionnaire (called the Advance Range Survey) in which operational and closed, transferring, and transferred ranges were identified by

installation personnel. Operational ranges were identified by the Army Environmental Center in Phase 2 during an investigation in conjunction with FGGM range personnel. And in Phase 3, closed, transferring, and transferred ranges and sites with unexploded ordnance, discarded military munitions, or munitions constituents were identified through a document search, personnel interviews, and site visit. Phase 3 was conducted for both the active installation and the BRAC property, and the LOC parcel was included in the BRAC Phase 3 investigation.

No operational ranges were identified on the LOC parcel during the Phase 2 inventory; however, the BRAC Phase 3 inventory included the LOC parcel in the HE (High Explosive) Impact and Disposal area. The HE Impact and Disposal area encompassed the LOC Parcel as well as the majority of the Patuxent Research Refuge (7,950 total acres). The rationale for including the LOC parcel in the BRAC Phase 3 inventory is unclear, as historical range maps do not show the presence of ranges on the LOC parcel and the existence of warehouses and railroads at the time that the ranges were in use would have precluded the area from being used as a range or disposal area. Thus, based on historical maps and the presence of the railroads and warehouses, no former ranges or sites are known or suspected to be located at the LOC parcel.

1.2.6 Areas of Concern

Based on field reconnaissance and inspection of aerial photographs of the site, several areas of concern were identified on the LOC parcel. The areas of concern were derived from identified or potential release areas (**Figure 1-5**). For reporting purposes, the LOC parcel was subdivided into the areas of concern shown on **Figure 1-5**; however, the actual areas of concern are generally much smaller than those shown in the figure. A description of each area of concern, including a summary of results from previous investigations, is as follows:

Former DRMO – This area is located in the western portion of the site where the Defense Logistics Agency stored hazardous materials and wastes for FGGM and other federal facilities. The area consisted of numerous temporary World War II era wooden warehouses (Buildings 62, 63, 64, and 65), a brick building (Building 61), and several metal warehouse and maintenance buildings (Buildings 60, 70, 70A, and 70B). Buildings 61 through 65 were demolished in 2005; however, the other buildings remain intact.

USTs were located adjacent to the warehouses in the Former DRMO, and stained soil was observed west of Building 61 during a site visit conducted April 27 through May 2, 1994. According to documents reviewed at the FGGM EMO for this RI, the USTs in this area have all been removed, and no residual contamination at the Former DRMO was identified during the tank removal activities or the RI.

TMP – This area is located in the western portion of the site, adjacent to the Former DRMO facility. It includes Buildings 60A, 60B, 68, 69, 71, 72 and 72A, parking lots, a storage area, and a vehicle wash rack. These buildings are used by the Department of Public Works, Explosive Ordnance Disposal, and other tenants. Activities conducted in the TMP area include minor vehicle maintenance, vehicle and equipment storage, and administrative activities. A gas station, which includes several USTs, is also present at the TMP.

As described in Section 1.2.5, previous investigations (1990) in this area indicated the presence of petroleum contamination in soils and groundwater (Scope of Architect-Engineer Services, September 17, 1998). During the Final RI and Baseline Risk Assessment for the current DRMO

(2003), carbon tetrachloride was identified at concentrations above drinking water standards in groundwater in the southwestern corner of the TMP. It was concluded at the time of the study that the source of the carbon tetrachloride contamination was not known, but that the source may be located outside the LOC parcel.

Area West of the Rogue Harbor Branch – This undeveloped area is located immediately west of the Rogue Harbor Branch and is primarily wooded with areas of grass. It was identified as an area of concern because it is located in the floodplain of the Rogue Harbor Branch (which collects and conveys storm water runoff from portions of FGGM). No structures are located in this area, but the bed of a former rail line crosses the northern portion of the area. Numerous piles of metal, wood, concrete and related demolition debris are located throughout this area. A utility right-of-way bisects the area in an east-west direction. No previous investigations are known to have been conducted in this area.

Electrical and Sewer Substation – An electrical and sewer substation exists in the central portion of the site, adjacent to the Rogue Harbor Branch. The majority of this area was retained by FGGM (Figure 2-1) and is not officially part of the LOC Parcel; however, it is included in this RI as an area of concern since it may represent a potential source area and to provide an accurate assessment of the surrounding LOC Parcel. The transformers at the electrical substation may have contained PCBs, which could have been released to the adjacent soils if the transformers leaked. A fence and a gravel access road surround the substation. Wood and concrete debris was observed in the surrounding woods during a site visit conducted in 2004. No previous investigations are known to have been conducted in this area.

Demolished Warehouse Area – This area is located northeast of the electrical substation next to the rail bed in the central portion of the site. It was designated an area of concern due to the lack of knowledge on the materials historically handled and stored in this warehouse area. Numerous concrete foundations are still visible in this area and are surrounded by grass and trees. The area is currently used for outdoor storage. No previous investigations are known to have been conducted in this area.

Tractor-Trailer Storage – The Tractor-Trailer Storage Area is located in the central portion of the site. It was identified as an area of concern due to the historical use of the area for vehicle storage. The area includes a parking lot, access road, and small office (Building 39), which is currently used to support Army & Air Force Exchange Service (AAFES). No previous investigations are known to have been conducted in this area.

Disturbed Area – The Disturbed Area is located in the central portion of the site, south of the Tractor-Trailer Storage Area. The cause of the disturbance is unknown. This area was identified through the review of historic aerial photographs, which indicate a large area of disturbance to the ground surface. This area is currently undeveloped woodland with scattered debris. No previous investigations are known to have been conducted in this area.

Suspected Fill Area – Based on historical aerial photographs, a fill area is suspected in the central portion of the site, west of the warehouse area (Buildings 28 and 29). The materials placed in the Suspected Fill Area, if any, are unknown. This area is currently undeveloped woodland with scattered debris. No previous investigations are known to have been conducted in this area.

Compost Area – A compost area was observed in the central portion of the site (north of the Disturbed Area) in the review of historical aerial photographs. The area is currently

undeveloped woodland with scattered debris. The materials composted by FGGM in this area are unknown. No previous investigations are known to have been conducted in this area.

Commissary Warehouse –This area is located in the north central portion of the site and consists of several warehouses formerly used for the FGGM Commissary. A former UST was located between Buildings 36 and 38 in this area. The exact location of this UST is unknown. In addition, stained soils were noted adjacent to Buildings 36 and 40 during a site visit conducted April 27 through May 2, 1994. Building 37 was reportedly used for PCB waste-oil storage. Buildings 40, 41, and 44 have been demolished. The area surrounding the remaining buildings is either grass or pavement. No previous investigations are known to have been conducted in this area.

Gravel Fill Area – A Gravel Fill Area was observed in historic aerial photographs in the central portion of the site, south of the Suspected Fill Area. The source(s) of gravel fill in this area is unknown. The area is currently undeveloped woodland; however, the tree growth is newer than the surrounding areas, and several earthen mounds and debris are located in the woods. No previous investigations are known to have been conducted in this area.

Warehouse Area – This area is located in the eastern portion of the site and includes 17 warehouses and paved access roads. Railroads were formerly located north and south of the row of warehouses, and portions of the railroad are still present south of the warehouses. The areas directly surrounding the warehouses are grass or pavement. The areas north and south of the warehouses are undeveloped woodland and grassland. The majority of the warehouses are still in use and a few have been renovated. Outdoor storage is conducted in fenced areas between Buildings 17 and 19 and between Buildings 18 and 20. Construction debris and other debris were observed along the paved access road north of the warehouses during a site visit conducted in December 2004.

USTs were located adjacent to the majority of the warehouses in this area, and leaking USTs and an oil/water separator have been reported there. Stained soil was observed around virtually every UST in this area during a site visit conducted April 27 through May 2, 1994. Also, hazardous waste storage activities reportedly were conducted in this area. As reported in the *Initial Phase I Report Site Assessment* (RK&K, 1994), previous investigations in this area have indicated the presence of petroleum hydrocarbon contamination related to the USTs, with significant contamination detected at the UST adjacent to Building 15.

Former Recovery Well Structure – A former petroleum product recovery well existed in the eastern portion of the site adjacent to Building 9. Details about the former recovery well were not located during data collection at the FGGM EMO. No evidence of the former recovery well structure remains at the site, and no previous investigations are known to have been conducted in this area.

Former Railroad Bed – Former railroads traversed the LOC parcel in an east-west direction. The raised railroad bed and former railroad bridge abutments across Rogue Harbor Branch are still present in the central portion of the LOC parcel. The area is currently undeveloped woodland and grassland surrounding Rogue Harbor Branch. The majority of this area was retained by FGGM (Figure 2-1) and is not officially part of the LOC Parcel; however, it is included in this RI as an area of concern since it may represent a potential source area and to provide an accurate assessment of the surrounding LOC Parcel. No previous investigations are known to have been conducted in this area.

1.3 REPORT ORGANIZATION

A summary of the organizational format of the RI report is provided as follows:

- *Section 1.0* addresses the **Introduction** to the report, providing background information including the facility and site descriptions and histories, a discussion of previous investigations and areas of concern, and the report organization.
- *Section 2.0* summarizes the **Field Investigation Program** at the site, including a discussion of soil boring installations, DPT sampling of soil and groundwater, monitoring well installations and sampling, surface water and sediment sampling, and site surveying.
- *Section 3.0* describes the **Physical Characteristics** of FGGM and the LOC parcel, including geology/hydrogeology, climatology, ecology, and topography.
- *Section 4.0* discusses the **Nature and Extent of Contamination** detected at the site. A discussion of potential applicable or relevant and appropriate requirements (ARARs) is also provided.
- *Section 5.0* discusses the **Fate and Transport** mechanisms for contaminants at the site. Potential routes of transport, contaminant persistence and contaminant migration are discussed.
- *Section 6.0* presents the methodologies and results of the **Human Health Risk Assessment**.
- *Section 7.0* presents the methodologies and results of the **Screening Level Ecological Risk Assessment.**
- *Section 8.0* presents the **Summary and Conclusions** of the RI, including the nature and extent of contamination and the assessment of human health and environmental risk.
- *Section 9.0* presents the **References** used in the preparation of the RI report.

Appendices are provided in on the compact disc (CD) included with this report and include the following:

Appendix A – Site Surveying Report

- 2001 Survey
- 2005 Survey

Appendix B – Boring Logs and Well Permits

- 2000 Boring Logs
- 2000 Well Permits
- 2001 Boring Logs
- 2001 Well Permits

- 2004 Boring Logs
- 2004 Well Permits

Appendix C – Monitoring Well Records

- 2000 Monitoring Well Records
- 2001 Monitoring Well Records
- 2004 Monitoring Well Records

Appendix D – RAGS Part D Tables

Appendix E – ProUCL Results

- Surface Soil ProUCL Results
- All Soils ProUCL Results
- Groundwater ProUCL Results

Appendix F – Exposure Assessment Modeling Tables

- Volatile Chemical Release to Indoor Air During Showering
- Volatile Chemical and Respirable Particulate Release to Indoor Air During Excavation Activities
- Dermal Exposure Assessment Worksheets

Appendix G – Dietary Exposure Estimate Calculations

2 FIELD INVESTIGATION PROGRAM

This section documents the specific field investigation program for the RI of the 100-acre LOC parcel at FGGM, MD. The RI for the LOC parcel began in 1998, and the primary field efforts were conducted in two phases: 2000/2001 and 2004/2005. Field investigation procedures, sampling locations, analytical requirements, field documentation requirements, data quality objectives, and health and safety procedures were presented in the following EPA, MDE, and USACE-approved documents:

2000/2001 Field Investigations

- Final Field Sampling Plan Part I, Remedial Investigation for Library of Congress Campus Facility Fort George G. Meade, Maryland (FSP), (Malcolm Pirnie, 2000).
- Revised Final Field Sampling Plan Part I, Remedial Investigation for Library of Congress Campus Facility, Reference Sampling and Analysis, Fort George G. Meade, Maryland, (Malcolm Pirnie, 2000).
- *Quality Assurance Project Plan Part II*, Remedial Investigation for Library of Congress Campus Facility Fort George G. Meade, Maryland (QAPP), (Malcolm Pirnie, 2000).
- *Health and Safety Plan Part III*, Remedial Investigation for Library of Congress Campus Facility Fort George G. Meade, Maryland (HASP), (Malcolm Pirnie, 2000).

2004/2005 Field Investigations

- *Generic Field Sampling Plan,* Fort George G. Meade (Generic FSP), (EM Federal Corporation 2003).
- *Generic Quality Assurance Project Plan,* Fort George G. Meade (Generic QAPP), (EM Federal Corporation 2003).
- *Generic Health and Safety Plan,* Fort George G. Meade (Generic HASP), (EM Federal Corporation 2003).
- *Field Sampling Plan Part I*, Architect of the Capitol, Library of Congress, Remedial Investigation, Fort George G. Meade, Maryland, (Malcolm Pirnie, 2004).
- *Quality Assurance Project Plan Part II*, Architect of the Capitol, Library of Congress, Remedial Investigation, Fort George G. Meade, Maryland, (Malcolm Pirnie, 2004).
- *Health and Safety Plan Part III*, Architect of the Capitol, Library of Congress, Remedial Investigation, Fort George G. Meade, Maryland, (Malcolm Pirnie, 2004).

An overview of the field program, including identification of data gaps and how they were fulfilled, is presented in Section 2.1; detailed field investigation procedures are described in Section 2.2; a summary of field investigations performed at the site is provided in Section 2.3; and a summary of changes to the field investigation program and rationale is provided in Section 2.4.

2.1 FIELD INVESTIGATION OVERVIEW

To better define data gaps and establish a comprehensive field investigation approach, an assessment of the existing data, as it relates to the nature and extent of contamination and support of the risk assessment, was conducted. The identification of data needs based on the uses and decisions made was critical in establishing the field investigation approach for the project. These data needs focused on the following:

- Establishing background data
- Evaluating site physical characteristics such as topography, geology, hydrogeology and surface hydrology
- Determining the extent of surficial/subsurface soil and sediment contamination on the site
- Evaluating the potential migration of contaminants from source soils to groundwater on the site
- Evaluating the potential migration of contaminants from source soils to surface water and sediment to on-site and downgradient receptors
- Identification of potential exposure pathways and populations for evaluation during the baseline risk assessment

Based on a review of existing data and the data quality objectives for the project, the data gaps identified for the 2000/2001 RI field investigation are summarized as follows:

- Site-specific geologic and hydrogeologic data (e.g., the shallow water table elevation, soil type and characteristics)
- The vertical and lateral extents of soil contamination on the LOC parcel
- The presence/absence of contamination in other media such as sediment, surface water, and groundwater
- Quantitative evaluation of impacts to human health and the environment from exposure to contaminants in soil, groundwater, surface water, and sediment

Based on a review of the data gaps listed above, the following actions were taken to address these data gaps for the 2000/2001 RI field investigation:

- DPT soil borings and soil borings from the monitoring well installations were evaluated with data from the *Southeast Area Conceptual Site Model, Fort George G. Meade* to develop an understanding of the stratigraphy under the LOC Parcel.
- The shallow water table elevation and groundwater flow direction was determined by collecting water level measurements from all monitoring wells and temporary piezometers.
- Vertical and lateral extents of soil contamination at various areas of concern at the LOC parcel were investigated by surface soil sampling and installation of DPT soil borings. Surface and subsurface soil samples were analyzed for VOCs, SVOCs, PCBs, pesticides, and metals. Surface soil samples collected at transformer locations were analyzed for PCBs only.

- The presence/absence of contamination in sediment and surface water was investigated through the collection of samples from these media. Sediment and surface water samples were analyzed for VOCs, SVOCs, PCBs, pesticides, and metals.
- The presence/absence of contamination in groundwater was evaluated through the installation and sampling of permanent monitoring wells. Groundwater samples were also collected via DPT at locations where the Geoprobe rig was able to advance the tool string to the groundwater table depth. Groundwater samples were analyzed for VOCs, SVOCs, PCBs, pesticides, and metals.
- Impacts to human health and the environment from exposure to contaminants in all media (soils, groundwater, surface water and sediment) were evaluated through the performance of a baseline risk assessment.

Based on a review of the results of the 2000/2001 RI field investigation results and the data quality objectives for the project, the following additional data gaps were identified for the 2004/2005 RI field investigation:

- The potential existence of a completed soil-to-groundwater migration pathway, including the mobility of VOCs from soil to groundwater
- The presence/absence of dioxin/furans in soil in areas where burned material was encountered
- The presence/absence of contamination in groundwater in the Tractor-Trailer Storage Area, Commissary Warehouse Area, and the Area West of the Rogue Harbor Branch
- The vertical and lateral extents of elevated metals detected in soil on the LOC parcel

Based on a review of the data gaps listed above, the following actions were taken during the 2004/2005 RI field investigation to address the data gaps:

- Potential soil-to-groundwater migration pathways were investigated by collecting additional groundwater data.
- The presence/absence of VOC contamination in soil and groundwater was investigated through the collection of samples from these media.
- The presence/absence of dioxin/furan contamination in soil was investigated through a visual inspection of the samples for evidence of burning. If evidence had been identified, samples would have been collected and analyzed for dioxins/furans.
- Groundwater quality in the subject areas of concern was investigated through the collection of samples from monitoring wells and DPT borings. Groundwater samples were analyzed for VOCs, SVOCs, PCBs, pesticides, and metals.
- The vertical and lateral extent of elevated metals in the soil was investigated through the collection of additional surface and subsurface soil samples. Soil samples were analyzed for select metals or total metals, depending on the location.

2.2 FIELD INVESTIGATION PROCEDURES

The field investigation procedures discussed in this section are pertinent to the field events conducted July 2000 through August 2000, March 2001 through April 2001, and December 2004 through January 2005. Additional details on the areas of concern are provided in Section 1.0, and sample/well locations are provided on **Figure 2-1**.

2.2.1 Sampling Nomenclature

The sample nomenclature differed between the 2000/2001 and 2004/2005 sampling events. The sample nomenclatures are described in the relevant Work Plans and are summarized below for quick reference. The location identification nomenclature is used in the text, tables within the text, and figures; however, the sample identification nomenclature is used on the data tables provided at the end of Section 4 and in the companion QCS/AR Report.

2.2.1.1 2000/2001 Field Investigation

Location Identification

- DPTxx: DPT soil sampling location number xx
- DPT/GWxx: DPT soil and groundwater sampling location number xx
- SSxx: Surface soil sampling location number xx
- NWxx: New monitoring well number xx
- EWxx: Existing monitoring well number xx
- MWxx: Existing monitoring well number xx
- SW/SDxx: Surface water/Sediment sampling location number xx

Sample Identification

- SBxx-DPT-02: Soil sample collected from DPTxx location at 0-2 foot interval (no groundwater samples were collected at this location)
- SBxx-DPT/GW-02: Soil sample collected from DPT/GWxx location at 0-2 foot interval (a groundwater sample was also collected at this location)
- SBxx-HSA-02: Hollow stem auger soil sample collected from NWxx location at 0-2 foot interval
- SSxx-LOC-01: Hand auger surface soil sample collected from SSxx location at 0-1 foot interval
- SSxx-POL-01: Surface soil sample collected from pole mounted transformer location
- SSxx-GND-01: Surface soil sample collected from pad mounted transformer location

- GWxx-DPT: Groundwater sample collected from DPTxx location
- GWxx-LOC: Groundwater sample collected from new monitoring well NWxx
- EWxx-LOC: Groundwater sample collected from existing monitoring well EWxx
- MWxx-LOC: Groundwater sample collected from existing monitoring well MWxx

2.2.1.2 2004/2005 Field Investigation

Location Identification

- DPTxx: DPT soil sampling location number xx
- DPT/GWxx: DPT soil and groundwater sampling location number xx
- NWxx: Monitoring well number xx
- EWxx: Existing monitoring well number xx
- MWxx: Existing monitoring well number xx

Sample Identification

- AOC-SS-xx: Surface soil sample collected from location number xx
- AOC-SB-xx: Subsurface soil sample collected from location number xx
- AOC-GWxx: Groundwater sample collected from DPT boring at location xx
- NWxx-GW: Groundwater sample collected from monitoring well number xx
- EWxx-GW: Groundwater sample collected from existing monitoring well number xx
- MWxx-GW: Groundwater sample collected from existing monitoring well number xx

2.2.2 Soil Sampling

2.2.2.1 Hand Auger Sampling

Six surface soil samples were collected to a maximum depth of 2.5 feet below ground surface (bgs) during the 2000/2001 field investigation, and one subsurface soil sample was collected to a depth of six feet bgs during the 2004/2005 field investigation. The samples were collected with a stainless steel hand auger.

The soil was removed from the hand auger and placed in a decontaminated stainless steel bowl. Aliquots for VOC analysis were taken directly from the bowl using Encore samplers and immediately stored at 4 degrees Celsius (°C). After collection of the VOC sample, the soil samples were homogenized by first removing rocks, twigs, leaves, and other debris and then thoroughly mixed using a stainless steel spoon. After mixing, a portion of the sample was placed in each sample container.

Qualified field personnel logged the soils recovered from sampling efforts using the Unified Soil Classification System (USCS) in accordance with the USACE Borehole Logging Requirements. Information generated during the boring process was recorded in field boring logs, with additional information recorded in the field logbook.

The sample containers were then labeled, added to the chain-of-custody, and stored at 4°C for shipment to the laboratory. Sampling forms for all sampling tasks are provided in Appendix B of the *Quality Control Summary/Analytical Results (QCS/AR) Report*. All 2000/2001 samples were submitted to an off-site laboratory and analyzed for VOCs, SVOCs, PCBs, pesticides, and metals. The one 2004/2005 sample was submitted to an off-site laboratory and analyzed for metals.

2.2.2.2 Transformer Sampling

Ten surface soil samples were collected to investigate for the presence of PCBs at ten transformer locations during the 2000/2001 field investigation. No transformer soil sampling was conducted during the 2004/2005 field investigation. The transformer selection was based on the absence of PCB-free labels. Both pad-mounted and pole-mounted transformers were noted within the LOC parcel. Soil samples were collected directly below seven pole-mounted transformers to a maximum depth of one foot bgs. In addition, soil samples were collected in three areas adjacent to pad-mounted transformers to a maximum depth of one foot bgs. The samples were collected with a stainless steel hand auger.

The soil was removed from the hand auger and placed in a decontaminated stainless steel bowl. The soil samples were homogenized by first removing rocks, twigs, leaves, and other debris and then thoroughly mixed using a stainless steel spoon. After mixing, a portion of the sample was placed in each sample container.

Qualified field personnel logged the soils recovered from sampling efforts using the USCS in accordance with the USACE Borehole Logging Requirements. Information generated during the boring process was recorded on field boring logs, with additional information recorded in the field logbook.

The sample containers were then labeled, added to the chain-of-custody, and stored at 4°C for shipment to the laboratory. Sampling forms for all sampling tasks are provided in Appendix B of the *QCS/AR Report*. All samples were submitted to an off-site laboratory and analyzed for PCBs.

2.2.2.3 DPT Sampling

During the 2000/2001 field investigation, Geoprobe was used to advance 16 DPT soil borings to a depth of about ten feet below grade for the collection of one surface (0.5–2.5 feet) and one subsurface soil sample (eight to ten feet) from each boring. In addition, 13 DPT soil borings were advanced to depths between 15 and 20 feet for collection of an additional, deeper soil sample.

During the 2004/2005 field investigation, Geoprobe was used to advance 25 DPT soil borings. Surface soil samples were collected to a maximum depth of 2.5 feet bgs in all the borings. Subsurface soil samples were collected from 19 borings to a maximum depth of ten feet bgs.

Soil borings were advanced using a Geoprobe rig equipped with three-inch diameter stainless steel rods with inner disposable acetate sleeves for sample retention. Soil samples were collected continuously from the ground surface in four-foot DPT intervals for lithologic descriptions. Selected depths from the Geoprobe soil core were submitted to the off-site laboratory for analysis. For samples above the water table, the Geoprobe sampling sleeve was opened and screened for the presence of VOCs using a Photoionization Detector (PID). The entire length of the Geoprobe soil sample was screened with the PID as the inner sleeve was cut open. The selection of subsurface soil samples for analysis was based on the PID VOC screening, visual evidence of soil staining, or evidence of soil disturbance. If no elevated PID readings were detected, no visual staining observed, or no disturbances observed, samples for laboratory analysis were collected from six to eight feet bgs.

Qualified field personnel logged the soils recovered from DPT samples using USCS in accordance with the USACE Borehole Logging Requirements. Information generated during the sampling process was recorded on field sampling logs, with additional information recorded in the field logbook. Upon completion of the soil samplings, the boreholes were backfilled with a bentonite slurry.

All 2000/2001 DPT soil samples retained for analysis were submitted to an off-site laboratory and analyzed for VOCs, SVOCs, PCBs, pesticides, and metals. The 2004/2005 soil samples were submitted to an off-site laboratory and analyzed for VOCs, SVOCs, PCBs, pesticides, and/or metals, as appropriate to complete the characterization of the respective area.

All samples were placed in appropriate laboratory provided containers for analysis. Aliquots for VOC analysis were taken directly from the Geoprobe core samplers using Encore samplers and stored at 4°C. Soil samples requiring analyses for SVOCs, PCBs, pesticides, and metals were homogenized in decontaminated stainless steel bowls using stainless steel spoons prior to placement into the sample containers.

2.2.2.4 Hollow Stem Auger Sampling

Seven monitoring wells were constructed in 2000 using a hollow stem auger (HSA) drill rig. Split spoon soil samples were obtained using the American Society of Testing and Materials (ASTM) Standard Penetration Test (SPT) protocol during well construction for laboratory analysis. Three soil samples (one surface, one mid-depth, and one water table sample) were collected during the well installation. Each soil sample retrieved was screened with a PID to create a profile of VOC contamination over the depth of the boring.

Four wells were constructed in 2001 using a HSA drill rig, and two wells were installed in 2004 using a HSA drill rig. Each soil sample retrieved during well construction was screened with a PID to create a profile of VOC contamination over the depth of the boring. No soil samples were submitted for laboratory analysis from the four wells installed in 2001 because these wells were constructed at DPT sample locations from 2000 (i.e., soil sampling data already existed for the well areas). No soil samples were submitted for laboratory analysis from the two wells installed in 2004 because these wells were installed to evaluate the groundwater at the southeast end of the LOC parcel.

Soil logging procedures and sample collection procedures were as described in Section 2.2.2.3.

2.2.3 Surface Water Sampling

Surface water samples were collected during the 2000/2001 field investigation using a stainless steel Bacon-Bomb discrete sampler. No surface water samples were collected during the 2004/2005 field investigation. The samples were obtained from mid-depth within the tributary by lowering the sampler to the desired depth and retracting a pin that allowed water to enter the sampler. The pin was reactivated prior to raising the sampler to the surface to obtain the discrete sample. The samples were collected prior to sediment sampling at each location. Sampling was conducted in a downstream-to-upstream order to limit disturbance of sediments upstream of a sample location.

The sample containers were labeled, a chain-of-custody form was completed, and the samples were stored at 4°C for transport to the laboratory. Surface water samples were collected for off-site laboratory analysis for VOCs, SVOCs, PCBs, and total metals.

2.2.4 Sediment Sampling

Sediment samples were collected during the 2000/2001 field investigation using a stainless steel hand auger. No sediment samples were collected during the 2004/2005 field investigation. Sediment samples were collected for off-site laboratory analysis for VOCs, SVOCs, PCBs, and metals. Aliquots for VOC analysis were taken directly from the sampler using Encore samplers and stored at 4°C. Sediment samples collected for analysis for SVOCs, PCBs, and metals were homogenized in stainless steel bowls prior to being placed in the sample containers. The sample containers were then labeled, a chain-of-custody form was completed, and the samples were stored at 4°C for transport to the laboratory.

2.2.5 Monitoring Well Installation and Development

2.2.5.1 Monitoring Well Installation

Thirteen groundwater monitoring wells were installed at the site (seven in 2000, four in 2001, and two in 2004). The wells were constructed using a HSA drill rig. Monitoring wells were installed using minimum four-inch inside diameter HSAs (minimum six-inch outside diameter). A truck-mounted or track-mounted drilling rig advanced the augers. Each monitoring well was constructed in accordance with the Resource Conservation and Recovery Act (RCRA) Groundwater Monitoring Technical Enforcement Guidance Document (TEGD) and USACE EM1110-1-4000. The wells were constructed of two-inch diameter flush-threaded polyvinyl chloride (PVC) casing and well screen. The well screens were continuous wire wrapped of 0.01-inch slot screen sections and were ten feet in length. A filter sand product of suitable particle size distribution was placed in the annulus around the well screen to provide a filter zone. The filterpack extended from the bottom of the well to two feet above the top of the well screen. A minimum of one foot of bentonite seal was then placed above the filterpack while the remainder of the annular space was cement grouted to the surface. Copies of the Boring Logs and Well Permits are provided in Appendix B.

2.2.5.2 Monitoring Well Development

Each well was developed no sooner than 24 hours after construction using a pump and surge block to reduce turbidity. Development continued until the water was stable with respect to

specific conductance, turbidity, pH, dissolved oxygen, and temperature. A minimum of three well volumes was evacuated (one well volume being the volume equivalent of the sampling screen and tubing length). Specific conductance, turbidity, pH, dissolved oxygen, water level, and temperature readings were measured before, during, and after development and recorded in the field documents. Monitoring well development records are provided in Appendix C.

2.2.6 Groundwater Sampling

2.2.6.1 DPT Groundwater (GW) Sampling

Hollow steel rods were driven/hammered into the saturated zone for soil and groundwater sample collection. Groundwater samples were collected using a mill-slotted probe rod sleeved inside the hollow steel Geoprobe rods and held in place by a sacrificial point fitted with a watertight "O" ring seal. The Geoprobe rods were driven to a depth of approximately four to eight feet below the groundwater table and then retracted approximately two feet. The slotted probe was pushed out of the sleeve (the lower Geoprobe rod) into the resulting void using chase rods. The sacrificial point was displaced and lost. Groundwater entering the slotted probe rod was collected using clean, dedicated Teflon or polyethylene tubing. Retrieval of the groundwater sample was accomplished by manifolding the tubing to a peristaltic pump. Each DPT boring was purged using the low-flow groundwater sampling technique. Samples were collected when all field parameters stabilized. Stabilization of field parameters during purging was defined as less than ten percent change in value over two successive measurements for temperature, conductivity, dissolved oxygen, turbidity, and pH. Groundwater samples were collected directly into the appropriate laboratory containers using dedicated submersible pumps and tubing.

After collection in the appropriate sample container, the samples were secured in a cooler at 4°C. Groundwater samples were then shipped to an off-site laboratory and analyzed for VOCs, SVOCs, pesticides, PCBs, and/or total and dissolved metals. Both filtered and unfiltered metal samples were collected. In addition, quality assurance/quality control (QA/QC) samples were collected and analyzed as required by the QAPP.

2.2.6.2 Groundwater Monitoring Well Sampling

During the 2000/2001 field investigation, groundwater samples were collected for laboratory chemical analysis from 11 new monitoring wells (installed during the 2000/2001 field investigation) and one existing monitoring well. During the 2004/2005 field investigation, the 13 new monitoring wells (11 from the 2000/2001 investigation and two from the 2004/2005 investigation) and three existing monitoring wells were sampled. Sampling of groundwater at each well location began no sooner than two weeks following well development.

Groundwater samples were collected using a low flow submersible pump. Each well was purged using the low-flow groundwater sampling technique. Samples were collected when all field parameters stabilized. Stabilization of field parameters during purging was defined as less than ten percent change in value over two successive measurements for temperature, conductivity, dissolved oxygen, turbidity, and pH. Groundwater samples were collected directly into the appropriate laboratory containers using dedicated submersible pumps and tubing.

2.2.6.3 Water Level Measurements

Water level and bottom of well depth were measured using an electronic water level probe, to the nearest 0.01 foot. Water level measurements were obtained for all monitoring wells and temporary piezometers.

2.2.7 Equipment Decontamination

2.2.7.1 Field Equipment

The water level meter and other equipment lowered into monitoring wells were decontaminated by thoroughly washing internal and external surfaces with low-phosphate, laboratory grade detergent and rinsing with deionized (DI) demonstrated analyte-free water prior to use.

Field instrumentation was cleaned according to manufacturers' instructions. Probes, such as those used in pH and conductivity meters, and thermometers were rinsed prior to and after use with DI water.

2.2.7.2 Sampling Equipment

To avoid cross-contamination of samples, equipment used in sampling was decontaminated between each use and sampling location. Non-dedicated sampling equipment was cleaned initially and prior to being reused. The following procedures were followed for field decontamination:

- Wash and scrub with non-phosphate, laboratory grade detergent.
- Rinse with distilled water.
- Rinse with methanol.
- Thoroughly rinse with DI demonstrated analyte-free water.
- Rinse with 1% dilute nitric acid.
- Rinse with DI water.
- Air dry.

2.2.7.3 Geoprobe Rig and Equipment Decontamination Procedures

To prevent the possibility of cross-contamination between boreholes, the Geoprobe rig and all Geoprobe accessories were thoroughly decontaminated before arriving on-site and between each borehole. A pressurized steam cleaner was utilized for decontamination of the rig and accessories.

2.2.7.4 Decontamination Solutions

Detergent Wash

Alconox was used as the non-phosphate, laboratory-grade detergent for the RI field investigations at FGGM.

Solvent/Acid Rinses

Pesticide-grade methanol and 1% nitric acid solution were used for decontamination activities for the investigation.

Rinse Water

Distilled water was used for the soapy solution wash and initial rinses during the decontamination procedure while DI water was used as the final rinse water. To evaluate the water used during the decontamination procedure for the field investigation, rinsate blank samples were collected and analyzed.

2.2.8 Investigation-Derived Waste Management

2.2.8.1 Soils, Sediment and Groundwater

Residual sediment and soil from sampling activities and soil cuttings from drilling activities were generated during the field investigations. These wastes were containerized in 55-gallon drums and analyzed for the full Toxicity Characteristic Leaching Procedure (TCLP) list (VOCs, SVOCs, pesticides, herbicides, and metals) during the 2000/2001 field investigation. The “twenty-times” rule was applied to the analytical results for the containerized investigation-derived waste (IDW) from the 2004/2005 field investigation. Because the TCLP test involves a dilution factor of twenty, soil samples with total constituent concentrations less than twenty times the specified regulatory constituent concentration limit are considered to pass the TCLP test for that constituent.

Development and purge water were also containerized in a 55-gallon drum. The results of the groundwater data analysis (VOCs, SVOCs, pesticides, herbicides, and metals) were used to characterize the containerized aqueous wastewater.

Following the waste characterization analysis, disposal of the containerized IDW was coordinated with FGGM, AOC, and subcontractors Waste Technology Services (WTS) and AEG Environmental, Inc. (AEG).

2.2.8.2 Personal Protective Equipment

Disposable personal protective equipment (gloves) was double plastic bagged and disposed of as ordinary trash.

2.2.8.3 Decontamination Fluids

Decontamination fluids, such as nitric acid and methanol rinses, were containerized and properly disposed. No sampling was necessary for these fluids because of the knowledge of the contents for each. The concentration of site contaminants in the spent solvents was expected to be de minimus; visible contamination was removed during the soap and water wash and distilled water rinse steps.

Other decontamination fluids such as the Alconox wash and distilled and DI water rinses were also containerized in 55-gallon drums. The results of the groundwater data analysis (VOCs, SVOCs, pesticides, herbicides, and metals) were used to characterize the containerized aqueous wastewater.

Following the waste characterization analysis, disposal of the containerized IDW was coordinated with FGGM, AOC, and subcontractors WTS and AEG.

2.2.9 Off-site Laboratory Analysis

All environmental media samples were submitted to STL Savannah Laboratories for off-site analysis during the 2000/2001 field investigation and to GPL Laboratories during the 2004/2005 field investigation. The analytical methods used are listed in **Table 2-1**. **Table 2-2** provides a summary of the compounds analyzed for in the FGGM site samples.

Table 2-1: Analytical Test Methods

Analysis	Analytical Method	Media
TCL[1] VOCs	EPA 5035	Soil
TCL SVOCs	EPA 8270C	Soil
TCL Pesticides/PCBs	EPA 8081A/8082	Soil
TAL[2] Metals	EPA 6020/7000	Soil
Arsenic	EPA 6020/7000	Soil
Lead	EPA 6020/7000	Soil
Dioxin/Furan	EPA 8290	Soil
TCL VOCs	EPA 8260B	Aqueous
TCL SVOCs	EPA 8270C	Aqueous
TCL Pesticides/PCBs	EPA 8081A/8082	Aqueous
TAL Metals	EPA 6020/7000	Aqueous
TAL Dissolved Metals	EPA 6020/7000	Aqueous

[1] Target Compound List (TCL)
[2] Target Analyte List (TAL)

Table 2-2: Summary of Analyses

Sample Type	Sample ID	Analysis						
		TCL VOCs	TCL SVOCs	TCL Pest/PCBs	Total Metals/ Cyanide *	Dissolved Metals/ Cyanide	Arsenic	Lead
DPT Groundwater (2000/2001)	GW01-DPT	X	X	X	X	X		
	GW02-DPT	X	X	X	X	X		
	GW05-DPT	X	X	X	X			
	GW07-DPT	X	X	X	X			
	GW09-DPT	X	X	X	X	X		

Sample Type	Sample ID	Analysis						
		TCL VOCs	TCL SVOCs	TCL Pest/PCBs	Total Metals/ Cyanide *	Dissolved Metals/ Cyanide	Arsenic	Lead
	GW11-DPT	X	X	X	X	X		
	GW12-DPT	X	X	X	X	X		
	GW13-DPT	X	X	X	X	X		
DPT Groundwater (2004/2005)	AOC-GW-18	X	X	X	X	X		
	AOC-GW-19	X	X	X	X	X		
	AOC-GW-21	X						
	AOC-GW-24	X						
	AOC-GW-29	X	X	X	X	X		
	AOC-GW-30	X	X	X	X	X		
	AOC-GW-34	X	X	X	X	X		
	AOC-GW-35	X	X	X	X	X		
	AOC-GW-39	X	X	X	X	X		
	AOC-GW-43	X	X	X	X	X		
Monitoring Well Samples (2000/2001)	GW01-LOC	X	X	X	X	X		
	GW02-LOC	X	X	X	X	X		
	EW03-LOC	X	X	X	X	X		
	GW04-LOC	X	X	X	X	X		
	GW05-LOC	X	X	X	X	X		
	GW06-LOC	X	X	X	X	X		
	GW07-LOC	X	X	X	X	X		
	GW08-LOC	X	X	X	X	X		
	GW09-LOC	X	X	X	X	X		
	GW10-LOC	X	X	X	X	X		
	GW11-LOC	X	X	X	X	X		
	GW12-LOC	X	X	X	X	X		
Monitoring Well Samples (2004/2005)	EW2-GW-01	X	X	X	X	X		
	EW3-GW-01	X	X	X	X	X		
	MW7-GW-01	X						
	NW1-GW-01	X	X	X	X	X		
	NW2-GW-01	X	X	X	X	X		
	NW4-GW-01	X	X	X	X	X		
	NW5-GW-01	X	X	X	X	X		
	NW6-GW-01	X	X	X	X	X		
	NW7-GW-01	X	X	X	X	X		

Sample Type	Sample ID	Analysis						
		TCL VOCs	TCL SVOCs	TCL Pest/PCBs	Total Metals/ Cyanide *	Dissolved Metals/ Cyanide	Arsenic	Lead
	NW8-GW-01	X	X	X	X	X		
	NW9-GW-01	X	X	X	X	X		
	NW10-GW-01	X	X	X	X	X		
	NW11-GW-01	X	X	X	X	X		
	NW12-GW-01	X	X	X	X	X		
	NW13-GW-01	X	X	X	X	X		
	NW14-GW-01	X	X	X	X	X		
HSA Soil Borings (2000/2001) (samples collected from three depths)	SB01-HSA	X	X	X	X			
	SB02-HSA	X	X	X	X			
	SB03-HSA	X	X	X	X			
	SB04-HSA	X	X	X	X			
	SB05-HSA	X	X	X	X			
	SB06-HSA	X	X	X	X			
	SB07-HSA	X	X	X	X			
	SB08-HSA	X	X	X	X			
Hand Auger Soil Borings (2004/2005) (samples collected from one depth)	AOC-SB-24-5-6				X			
DPT Soil Borings (2000/2001) (samples collected from three depths)	SB01-DPT/GW	X	X	X	X			
	SB02-DPT/GW	X	X	X	X			
	SB03-DPT/GW**	X	X	X	X			
	SB04-DPT/GW	X	X	X	X			
	SB05-DPT/GW	X	X	X	X			
	SB07-DPT/GW	X	X	X	X			
	SB08-DPT/GW	X	X	X	X			
	SB09-DPT/GW	X	X	X	X			
	SB10-DPT/GW**	X	X	X	X			
	SB11-DPT/GW	X	X	X	X			
	SB12-DPT/GW	X	X	X	X			
	SB13-DPT/GW**	X	X	X	X			
DPT Soil Borings (2000/2001)	SB01-DPT	X	X	X	X			
	SB02-DPT	X	X	X	X			

Sample Type	Sample ID	Analysis						
		TCL VOCs	TCL SVOCs	TCL Pest/PCBs	Total Metals/ Cyanide *	Dissolved Metals/ Cyanide	Arsenic	Lead
(samples collected from two depths)	SB03-DPT	X	X	X	X			
	SB04-DPT	X	X	X	X			
	SB05-DPT	X	X	X	X			
	SB06-DPT	X	X	X	X			
	SB07-DPT	X	X	X	X			
	SB08-DPT	X	X	X	X			
	SB09-DPT	X	X	X	X			
	SB10-DPT	X	X	X	X			
	SB11-DPT	X	X	X	X			
	SB12-DPT	X	X	X	X			
	SB13-DPT	X	X	X	X			
	SB14-DPT	X	X	X	X			
	SB15-DPT	X	X	X	X			
	SB16-DPT	X	X	X	X			
	SB17-DPT	X	X	X	X			
DPT Soil Borings (2004/2005) (samples collected from two depths)	AOC-SB-18	X	X	X	X			
	AOC-SB-19	X	X	X	X			
	AOC-SB-20				X			
	AOC-SB-21				X			
	AOC-SB-22				X			
	AOC-SB-23				X			
	AOC-SB-24				X			
	AOC-SB-25						X	
	AOC-SB-26						X	
	AOC-SB-27						X	
	AOC-SB-28	X	X	X	X			
	AOC-SB-29	X	X	X	X			
	AOC-SB-30	X	X	X	X			
	AOC-SB-31	X	X	X	X			
	AOC-SB-32	X	X	X	X			
	AOC-SB-33	X	X	X	X			
	AOC-SB-34	X	X	X	X			
	AOC-SB-35	X	X	X	X			
	AOC-SB-39	X	X	X	X			

Sample Type	Sample ID	Analysis						
		TCL VOCs	TCL SVOCs	TCL Pest/PCBs	Total Metals/ Cyanide *	Dissolved Metals/ Cyanide	Arsenic	Lead
DPT Soil Borings (2004/2005) (samples collected from one depth)	AOC-SS-36						X	X
	AOC-SS-37							X
	AOC-SS-38						X	
	AOC-SS-40						X	
	AOC-SS-41						X	X
	AOC-SS-42							X
Surface Soil (2000/2001)	SS01-LOC	X	X	X	X			
	SS02-LOC	X	X	X	X			
	SS03-LOC	X	X	X	X			
	SS04-LOC	X	X	X	X			
	SS05-LOC	X	X	X	X			
	SS06-LOC	X	X	X	X			
Surface Soil (Transformer Sites) (2000/2001)	SSO1-POL			X				
	SSO2-POL			X				
	SS03-POL			X				
	SS04-POL			X				
	SS05-POL			X				
	SS01-GND			X				
	SS02-GND			X				
	SS03-GND			X				
Surface Water (2000/2001)	RHB-LWR	X	X	X	X			
	RHB-MID	X	X	X	X			
	RHB-UPR	X	X	X	X			
Sediment (2000/2001)	RHB-LWR	X	X	X	X			
	RHB-MID	X	X	X	X			
	RHB-UPR	X	X	X	X			

Notes:

* Analysis does not include cyanide for 2004/2005 samples.

** Samples collected from two depths

Laboratory analytical reports are included in the *QCS/AR Report,* submitted to USACE as a companion document to this RI Report. Method reporting levels for all compounds discussed in this report can also be found in the *QCS/AR Report*. Contract Laboratory Program (CLP) and EPA/SW-846 protocols were followed for chemical analysis with Level IV CLP and Level IV CLP-equivalent data packages generated.

Data validation of analytical results for the 2000/2001 sampling event was performed by URS Group, Inc. (URS), and data validation for the 2004/2005 analytical results was performed by TechLaw. The results of the detailed validation are provided in the *QCS/AR Report*. The analytical data was validated pursuant to the requirements of the EPA Region III modifications to the National Functional Guidelines for Organics and Inorganics.

2.2.10 Site Surveying

All 13 monitoring wells installed during this investigation were surveyed for horizontal and vertical location. Existing well EW-3 was also surveyed. Severn Surveys, a MD registered land surveyor, conducted the survey August 7, 2001, for the 11 wells installed during the 2000/2001 field investigation. Charles P. Johnson & Associates, a MD registered land surveyor, surveyed the wells installed during the 2004/2005 field investigation (NW-13 and NW-14) on April 15, 2005. The survey data is based on the control points provided at FGGM. The results are provided in MD State Plane Coordinates (S.P.C.). Elevations were recorded for ground level and, where available, top of casing (**Table 2-3**). Appendix A contains the surveyors' reports and control point information.

Table 2-3: LOC parcel Survey Data

Well Number	Northing MD S.P.C (feet)	Easting MD S.P.C (feet)	Elevation	
			Ground (feet)	Top of casing (feet)
NW01-LOC	518,127.834	1,385,845.133	109.35	NA
NW02-LOC	518,077.377	1,385,475.379	114.45	NA
EW03-LOC	518,460.682	1,384,654.870	118.88	122.62
NW04-LOC	518,077.234	1,384,715.075	120.99	NA
NW05-LOC	518,567.051	1,388,168.430	115.89	119.19
NW06-LOC	518,641.067	1,386,736.005	112.61	114.89
NW07-LOC	518,734.740	1,384,975.469	114.68	118.24
NW08-LOC	517,844.082	1,386,819.831	95.48	97.98
NW09-LOC	518,436.582	1,385,105.295	113.69	115.47
NW10-LOC	517,773.042	1,387,955.940	112.29	114.80
NW11-LOC	518,045.012	1,388,776.350	120.56	NA
NW12-LOC	517,986.134	1,389,897.813	126.11	127.81
NW13-LOC	517,641.672	1,389,769.233	140.18	142.66

NW14-LOC	517,860.356	1,390,961.515	150.53	153.25

2.3 SITE SPECIFIC FIELD INVESTIGATION SUMMARY

The following sections outline the specific RI field activities performed on the LOC parcel. Specific activities were based on the approved Scopes of Work issued for the project dated June 1999 and April 20, 2004. The field investigations for this site are summarized in **Table 2-4**. **Table 2-2** provides a summary of the analyses conducted for each sample. **Figure 2-1** provides the sampling locations for this site.

Table 2-4: Summary of Field Investigation

Location	DPT Groundwater Samples	Monitoring Well Samples	Monitoring Wells Installed	DPT/GW Soil Samples	DPT Soil Sample s	HSA Soil Samples	Surface Soil Samples	Sediment Samples	Surface Water Samples
Drainage Swale at Pepper Rd.							2		
Warehouse area UST/HazWst storage	2	2	2	9	2		7		
Buildings 28 and 29		2	1	3	6		1		
Building 20		2	1						
Recovery Well Structure	1			3					
North of Rock Avenue		6	3			15			
Between TMP and Compost Area	4	2	1	12					
Suspected Fill Area					6				
Area between Warehouses and Rock Ave.	2			5					
Gravel Fill Area	3	2	1	2			2		
Fenced Parking/Tractor-Trailer Storage	1			1	5		2		
Electrical Substation/ Sewage Substation					2		1		
Wooded Compost Area							1		

Location	DPT Groundwater Samples	Monitoring Well Samples	Monitoring Wells Installed	DPT/GW Soil Samples	DPT Soil Sample s	HSA Soil Samples	Surface Soil Samples	Sediment Samples	Surface Water Samples
Area West of Tributary	2			2	3		6		
TMP	2	8	3	2	2	6	2		
Railroad Bed/Demolished Warehouse Area					5		3		
Former DRMO		4	1		6				
Rogue Harbor Branch								3	3
Transformers							10		
Commissary Warehouses	1			1	3		4		

The following changes from the approved *FSP*s were made during implementation of the 2000/2001 RI field investigation:

- No deep soil samples (from the water table elevation) or groundwater samples were collected from DPT/GW-02, DPT/GW-03, DPT/GW-04, DPT/GW-06, DPT/GW-08, DPT/GW-10, or DPT/GW-14. Refusal (i.e., inability of the DPT rig to advance the boring) was encountered before reaching the groundwater elevation at these locations. No soil samples were collected from DPT/GW-14, since refusal was encountered at two feet bgs.

- Four new groundwater monitoring wells (NW) were installed at four of the above locations where refusal was encountered for DPT groundwater sample collection. Soil samples were not collected during monitoring well installation because soil samples were collected during the DPT sampling.
  - NW-9 was installed at location DPT/GW-8
  - NW-10 was installed at location DPT/GW-6
  - NW-11 was installed at location DPT/GW-4
  - NW-12 was installed at location DPT/GW-3

- New wells were not installed at the remaining DPT/GW refusal locations because representative groundwater samples were obtained from nearby DPT or monitoring well sample locations as detailed below:
  - DPT/GW-2 representative sample obtained at NW-12
  - DPT/GW-10 representative sample obtained at DPT/GW-09
  - DPT/GW-14 representative sample obtained at NW-4

- No groundwater sample was obtained from existing well (EW) EW-2 during the 2000-2001 sampling event. Conditions at the TMP (gas station) precluded collection of a representative groundwater sample. Based on conversations with FGGM personnel, it was determined that a sample from EW-2 would not be representative because the integrity of the well is believed to have been compromised during excavation/renovation of the gas station at the TMP. However, EW-2 was sampled and DPT/GW-18 was installed and sampled nearby during the 2004-2005 sampling event in order to provide answers to comments received from the EPA on the 2002 Draft Final RI Report.

- Installation of NW-3 was not completed because groundwater was not encountered at the maximum boring depth (45 feet bgs). Sufficient groundwater data exists to adequately characterize the area of concern without sample collection from locations EW-2 and NW-3.

- A survey was not conducted at the locations of the Geoprobe borings; however, the 12 monitoring wells were surveyed for horizontal and vertical control. It was not feasible to survey the DPT locations because the stakes marking the locations had been removed prior to the site survey in 2001.
- Surface soil samples were collected directly below pole-mounted transformers and adjacent to pad mounted transformers. The transformers were unavailable for direct sampling because the power supply to FGGM could not be interrupted. Samples were collected at transformers that were not labeled “PCB free”.

The following changes were made during implementation of the 2004/2005 RI field investigation:

- Sample locations were moved based on subsurface anomalies identified during the geophysical utility location. Samples were relocated within the general vicinity of the planned sample locations.
- AOC-GW-43 was analyzed for VOCs, SVOCs, pesticides, PCBs, total metal, and dissolved metals; however, the 2004 *FSP* only required that the sample be analyzed for VOCs.
- The duplicate groundwater sample collected for dissolved metal analysis at NW2-GW-01 was collected using a dedicated bailer due to pump failure. No significant impact to data quality is anticipated.
- Groundwater sample at NW4-GW-01 was collected using a dedicated bailer due to pump failure. No significant impact to data quality is anticipated.
- Groundwater sample at MW7-GW-01 was collected using a dedicated bailer due to improper fitting of dedicated tubing and pump. No significant impact to data quality is anticipated.
- A hand auger was used to collect sample AOC-SB-24 (5-6 foot interval) since the lab was unable to locate the original sample. The original sample was subsequently located, and the contract laboratory analyzed both samples.
- No dioxin or furan samples were collected at the LOC parcel because no visual evidence of burned material was encountered during the field investigation.

A brief discussion of the sampling program as implemented, including deviations from the *FSP*s, is provided in the following sections for soils, groundwater, surface water, and sediment.

2.3.1 Soils

Former DRMO

2000/2001 Field Investigation

- Eight soil samples (four surface and four subsurface at a designated depth from each boring) were collected from four DPT soil borings (DPT-13 through DPT-16) in the Former DRMO area.
- Two soil samples (one surface and one subsurface) were collected from planned soil/groundwater boring DPT/GW-8 in the Former DRMO area. The *FSP* called for the collection of an additional, deeper soil sample and a groundwater sample from this boring; however, refusal was encountered prior to reaching the groundwater table.

Transportation Motor Pool

2000/2001 Field Investigation

- Two soil samples (one surface and one subsurface at a designated depth) were collected from one DPT soil boring (DPT-12) within the TMP.
- Nine soil samples (one surface and two subsurface from each boring) were collected from three monitoring well borings (NW-1, NW-2, and NW-4) within the TMP.
- Nine soil samples (one surface, one mid-depth, and one water table sample from each boring) were collected from three DPT soil/groundwater borings (DPT/GW-11, DPT/GW-12, and DPT/GW-13) between the TMP and the Rogue Harbor Branch.
- One surface soil sample (SS-6) was collected between the TMP and the Rogue Harbor Branch.

2004/2005 Field Investigation

- Four soil samples (one surface and one subsurface at a designated depth from each boring) were collected from two DPT soil/groundwater borings (DPT/GW-18 and DPT/GW-19) within the TMP.

Electrical Substation

2000/2001 Field Investigation

- One surface soil sample (SS-5) was collected at the electrical substation.
- Two soil samples (one surface and one subsurface at a designated depth) were collected from one DPT soil boring (DPT-10) at this substation.
- Two soil samples (one surface and one subsurface at mid-depth) were collected from one new monitoring well boring (NW-8), south of the substation.

Tractor-Trailer Storage

2000/2001 Field Investigation

- Four soil samples (one surface and one subsurface at a designated depth from each boring) were collected from two DPT soil borings (DPT-9 and DPT-8) in this area.

2004/2005 Field Investigation

- Two soil samples (one surface and one subsurface at a designated depth) were collected from one DPT soil/groundwater boring (DPT/GW-29) within the Tractor-Trailer Storage Area.
- Two soil samples (one surface and one subsurface at a designated depth) were collected from one DPT soil boring (DPT-28) within the Tractor-Trailer Storage Area.

Warehouse Area

2000/2001 Field Investigation

- One surface soil sample (SS-3) was collected between Buildings 27 and 29.
- Eight soil samples (one surface and one subsurface at a designated depth from each boring) were collected from four DPT soil borings (DPT-1 through DPT-4) in this area.
- Three soil samples (one surface, one mid-depth, and one water table sample) were collected from DPT soil/groundwater boring (DPT/GW-9) in the area between the warehouses and Rock Avenue.
- Only two soil samples (one surface and one mid-depth) were collected from planned soil/groundwater boring DPT/GW-10, due to refusal.
- Six soil samples (one surface and one mid-depth from each boring) were collected from three DPT soil/groundwater borings (DPT/GW-2 through DPT/GW-4) in this area. The FSP called for the collection of an additional, deeper soil sample and a groundwater sample from each of these borings; however, refusal was encountered prior to reaching the groundwater table.

2004/2005 Field Investigation

- Two soil samples (one surface and one subsurface at a designated depth) were collected from a DPT soil/groundwater boring (DPT/GW-39) near the suspected location of a former UST by Building 15.
- Six surface soil samples (SS-36, SS-37, SS-38, SS-40, SS-41, and SS-42) were collected along the drip-line of the warehouses and/or along the railroad bed.

Disturbed Area

2000/2001 Field Investigation

- Three soil samples (one surface, one mid-depth, and one water table sample) were collected from one DPT soil/groundwater boring (DPT/GW-7) in this area.

Compost Area

2000/2001 Field Investigation

- One surface soil sample (SS-4) was collected in the wooded compost area.

Suspected Fill Area

2000/2001 Field Investigation

- Six soil samples (one surface and one subsurface at a designated depth from each boring) were collected from three DPT soil borings (DPT-5 through DPT-7) in this area.

Gravel Fill Area

2000/2001 Field Investigation

- Two soil samples (one surface and one mid-depth) were collected from one DPT soil/groundwater boring (DPT/GW-6) in this area. The *FSP* called for the collection of an additional, deeper soil sample and a groundwater sample from this boring; however, refusal was encountered prior to reaching the groundwater table.

2004/2005 Field Investigation

- Four soil samples (one surface and one subsurface at a designated depth) were collected from two DPT soil/groundwater borings (DPT/GW-34 and DPT/GW-35) in the Gravel Fill Area north of NW-10.

Demolished Warehouse Area

2000/2001 Field Investigation

- Two soil samples (one surface and one subsurface at a designated depth) were collected from one DPT soil boring (DPT-11) in this area.

2004/2005 Field Investigation

- Six soil samples (one surface and one subsurface at a designated depth) were collected from three DPT soil borings (DPT-25 through DPT-27) along the former railroad bed in proximity to DPT-11.

Former Recovery Well Structure

2000/2001 Field Investigation

- Three soil samples (one surface, one mid-depth, and one water table sample) were collected from one DPT soil/groundwater boring (DPT/GW-1) in this area.

Commissary Warehouse

2000/2001 Field Investigation

- Three soil samples (one surface, one mid-depth, and one water table sample) were collected from one DPT soil/groundwater boring (DPT/GW-5) in this area.

2004/2005 Field Investigation

- Six soil samples (one surface and one subsurface at a designated depth) were collected from three DPT soil borings (DPT-31 through DPT-33) near DPT/GW-05 and Building 36.

- Two soil samples (one surface and one subsurface at a designated depth) were collected from a DPT soil/groundwater boring (DPT/GW-30) near Building 37.

North of Rock Avenue

2000/2001 Field Investigation

- Eight soil samples (one surface and one subsurface at mid-depth from each boring) were collected from four monitoring well borings (NW-3, and NW-5 through NW-7) installed north of Rock Avenue.

Drainage Swale

2000/2001 Field Investigation

- Two surface soil samples (SS-1 and SS-2) were collected in the drainage swale.

Area West of Rogue Harbor Branch

2004/2005 Field Investigation

- Six soil samples (one surface and one subsurface at a designated depth) were collected from three DPT soil borings (DPT-20, DPT-22, and DPT-23) in the Area West of the Rogue Harbor Branch.
- Four soil samples (one surface and one subsurface at a designated depth) were collected from two DPT soil/groundwater borings (DPT/GW-21 and DPT/GW-24) in this area.
- One hand auger subsurface soil sample was collected from DTP/GW-24.

2.3.2 Groundwater

Former DRMO

2000/2001 Field Investigation

- One existing well (EW-3) in the Former DRMO area was sampled.
- One new groundwater monitoring well (NW-9) was installed and sampled in the Former DRMO area. NW-9 was installed because refusal was encountered at planned soil/groundwater boring DPT/GW-08 prior to collection of a DPT groundwater sample.

2004/2005 Field Investigation

- Two existing wells (EW-3 and NW-9) in the Former DRMO area were sampled.

Transportation Motor Pool

2000/2001 Field Investigation

- Groundwater samples were collected from three DPT locations (DPT/GW-11, DPT/GW-12, and DPT/GW-13) in the area between the TMP and the Rogue Harbor Branch.
- The *FSP* called for the collection of a groundwater sample from existing well EW-2; however, FGGM personnel indicated a sample collected from EW-2 would not be representative due to conditions at the TMP gas station. EW-2 was rebuilt following construction at the gas station, and present conditions indicate surface runoff from the gas station may impact sampling.

- Three groundwater monitoring wells were installed and sampled in the TMP area: one east of the motor pool building (NW-1), one at the wash rack (NW-2), and one at the southwest corner of the site (NW-4).

2004/2005 Field Investigation

- Five existing wells (EW-2, MW-7, NW-1, NW-2, and NW-3) in the TMP area were sampled. Current conditions at EW-2 still indicate that surface runoff from the gas station may impact sampling results; however, the groundwater sample from EW-2 was collected.
- A groundwater sample was collected from one DPT location (DPT/GW-18) in the current gas station.
- A groundwater sample was collected from one DPT location (DPT/GW-19) near Building 72A.

Electrical Substation

2000/2001 Field Investigation

- One groundwater monitoring well (NW-8) was installed and sampled south of the electrical substation.

2004/2005 Field Investigation

- One existing well (NW-8) in the Electrical Substation area was sampled.

Tractor-Trailer Storage Area

2004/2005 Field Investigation

- One groundwater sample was collected from a DPT location (DPT/GW-29) in the Tractor-Trailer Storage Area near DPT-08.

Warehouse Area

2000/2001 Field Investigation

- One groundwater sample was collected from DPT boring (DPT/GW-9) in the area between the warehouses and Rock Avenue.
- Two new groundwater monitoring wells were installed and sampled in the warehouse area: one between Buildings 28 and 29 (NW-11) and one east of Building 20 (NW-12). These wells were installed because refusal prevented the collection of DPT groundwater samples from borings DPT/GW-3 and DPT/GW-4.

2004/2005 Field Investigation

- One groundwater sample was collected from a DPT location (DPT/GW-39) near the suspected location of a former UST at Building 15.
- One groundwater sample was collected from a DPT location (DPT/GW-43) south of Rock Avenue and south of the Former Post Laundry Facility (current Recycling Center).
- Two existing wells (NW-11 andNW-12) in the Warehouse Area were sampled.

- Two new groundwater monitoring wells were installed and sampled in the warehouse area: one south of Building 20 and along the southern property line (NW-13) and one east of Building 12 (NW-14).

Disturbed Area

2000/2001 Field Investigation

- One groundwater sample was collected from boring DPT/GW-7, located in the disturbed area.

Gravel Fill Area

2000/2001 Field Investigation

- One new groundwater monitoring well (NW-10) was installed and sampled in the gravel fill area. NW-10 was installed because refusal was encountered at boring DPT/GW-6.

2004/2005 Field Investigation

- Two groundwater samples were collected from two DPT locations (DPT/GW-34 and DPT/GW-35) in the Gravel Fill Area north of NW-10.
- One existing well (NW-10) in this area was sampled.

Former Recovery Well Structure

2000/2001 Field Investigation

- One groundwater sample was collected from boring DPT/GW-1, located at the petroleum recovery well structure at the eastern end of the LOC parcel.

Commissary Warehouse

2000/2001 Field Investigation

- One groundwater sample was collected from boring DPT/GW-5, located at the Commissary Warehouse.

2004/2005 Field Investigation

- One groundwater sample was collected from a DPT location (DPT/GW-30) near Building 37 in the Commissary warehouse area.

North of Rock Avenue

2000/2001 Field Investigation

- Three groundwater monitoring wells (NW-5 through NW-7) were installed and sampled on the northern border of the site at Rock Avenue. Planned monitoring well NW-3 was not installed because groundwater was not encountered at the maximum boring depth (45 feet below grade).

2004/2005 Field Investigation

- Three existing monitoring wells (NW-5, NW-6, and NW-7) were sampled.

Area West of Rogue Harbor Branch

2004/2005 Field Investigation

- Two groundwater samples were collected from two DPT locations (DPT/GW-21 and DPT/GW-24) in the Area West of the Rogue Harbor Branch.

2.3.3 Surface Water

Rogue Harbor Branch

2000/2001 Field Investigation

- One surface water sample (RHB-UPR) was collected from the most upstream portion of the Rogue Harbor Branch within the LOC parcel.
- One surface water sample (RHB-LWR) was collected from the most downstream portion of the Rogue Harbor Branch within the LOC parcel.
- One surface water sample (RHB-MID) was collected from the middle portion of the Rogue Harbor Branch within the LOC parcel.

2.3.4 Sediment

Rogue Harbor Branch

2000/2001 Field Investigation

- One sediment sample (RHB-UPR) was collected from the most upstream portion of the Rogue Harbor Branch within the LOC parcel.
- One sediment sample (RHB-LWR) was collected from the most downstream portion of the Rogue Harbor Branch within the LOC parcel.
- One sediment sample (RHB-MID) was collected from the middle portion of the Rogue Harbor Branch within the LOC parcel.

3 PHYSICAL CHARACTERISTICS

Section 3.1 discusses the physical characteristics of FGGM, including data on topography, climate, hydrology, geology, hydrogeology, and ecology. Detailed descriptions of the physical characteristics for the LOC parcel are provided in Section 3.2.

3.1 FGGM PHYSICAL CHARACTERISTICS

This section provides a summary of the physical characteristics of FGGM, including topography, climate, surface water hydrology, geology, hydrogeology and ecology.

3.1.1 Physiography and Topography

FGGM lies in the western edge of the Coastal Plain Physiographic Province of western Anne Arundel County, MD. Topography within the region is relatively flat with some gentle hills and valleys. Elevations within the FGGM area range from approximately 80 to 230 feet amsl.

3.1.2 Climate

Historical climatological data for the FGGM area is available from the National Oceanic and Atmospheric Administration (NOAA) through the National Climatic Data Center.

The Chesapeake Bay moderates the climate in the FGGM area. The winters are relatively mild, and humidity is typically higher near the bay than in more inland areas. The average relative humidity in the area ranges from approximately 55 percent in the morning to approximately 75 percent in the evening. The mean daily temperature in the summer is approximately 75 degrees Fahrenheit (^{o}F), with a maximum recorded temperature of 105°F. The mean daily temperature in the winter is approximately 34°F, with a minimum recorded temperature of –7°F.

Precipitation is generally uniform throughout the year, with maximum precipitation in August and minimum precipitation in October. The average annual precipitation is 45.7 inches. The prevailing wind direction is from the north-northwest in the winter months and south to south-southwest in the summer months. Average wind speed ranges from 6.0 to 9.0 kilometers per hour year-round.

3.1.3 Surface Water Hydrology

Major surface water bodies within the region include the Patuxent River, the Little Patuxent River, Lake Allen and the Rogue Harbor Branch, a tributary of the Little Patuxent River. The Patuxent River drains about 900 square miles of land in portions of St. Mary's, Calvert, Charles, Anne Arundel, Prince George's, Howard, and Montgomery Counties. The Little Patuxent River is a primary tributary of the Patuxent River, which is the principal drainage system for Anne Arundel County.

3.1.4 Regional Geology and Hydrogeology

This section describes the sedimentary and hydrogeologic characteristics of the geologic formations that occur in the vicinity of FGGM. Published information from local and regional studies is presented in conjunction with data collected during the RI field investigation at the FGGM LOC parcel site.

3.1.4.1 Regional Geology

FGGM is located within the western edge of the Coastal Plain Physiographic Province of western Anne Arundel County, MD. In Maryland, the Coastal Plain area is bounded on the west by the Piedmont Province and by the Continental Shelf on the east, which occurs approximately 100 miles offshore (Hansen, 1968). A generic cross-section across Anne Arundel County is shown in **Figure 3-1**. The sediments of the Coastal Plain strike approximately northeast/southwest and dip to the southeast with increasing thickness. The Coastal Plain sediments were formed by complex depositional sequences, resulting in abrupt and subtle changes in particle size, area extent and thickness (KK&J, 1994).

Cretaceous sediments underlie the entire Coastal Plain of MD, but crop out only in a band extending along the edge of the Piedmont (Hansen, 1968). The Cretaceous sediments generally slope southeasterly at a dip of less than one degree; therefore, a maximum of approximately 1,000 feet of sediments is exposed along a 15-mile outcrop belt (Weaver et al., 1968; Hansen, 1968). Unconsolidated sediments of the Potomac Group of lower Cretaceous age underlie the LOC parcel. Pre-Cretaceous basement rocks underlie the Potomac Group. A detailed description of the Potomac Group is provided in the following sections.

Although not outcropped in the FGGM area, the Potomac Group is overlain by (stratigraphically lowest to highest) the Magothy, Matawan and Severn Formations of upper Cretaceous age (Hansen, 1968; Lucas, 1976; Mack and Achmad, 1986; Fleck and Andreasen, 1996; Bolton and Hayes, 1999). The Cretaceous sediments are overlain by the Brightseat, Aquia, Marlboro, and Nanjemoy Formations of Tertiary age (Lucas, 1976; Mack and Achmad, 1986; Mack and Mandle, 1977; Hansen, 1974). Although not outcropped in the FGGM area, these formations are present in the region; hence a brief description of these formations is provided in the following sections.

Pre-Cretaceous Basement Rocks

Crystalline metamorphic rocks and consolidated, red sandstones and shales form the basement rocks that underlie the Coastal Plain sediments of the Potomac Formation (Fleck and Wilson, 1990; Mack and Achmad, 1986). The crystalline metamorphic rocks are the oldest (likely Paleozoic) and stratigraphically lowest rocks found in the area. The consolidated, red sandstones, conglomerates, and shales are tentatively assigned Triassic to Jurassic age. Schist and Gneiss have also been encountered beneath the Coastal Plain sediments (Fleck and Wilson, 1990). Gabbro, metagabbro, and quartz diorite may also be present in the basement complex (Mack and Achmad, 1990; Achmad, 1991).

Potomac Group

The Potomac Group generally consists of sand-gravel and silt-clay facies. In the region, the Potomac Group is separated into three formations of lower Cretaceous age. The Potomac Group consists of (from stratigraphically lowest to highest) the Patuxent, Arundel, and Patapsco Formations. These formations were formed as a result of a fluvial sedimentary environment.

Variable combinations of gravel, sand, silt, and clay are characteristic of the Potomac Group. Potomac gravels are typically composed of partly-rounded quartzose pebbles and interstitial sand (Glaser, 1969). Sands occur as discontinuous lenses interbedded with clays, silty clays, and gravels. Sand lenses are typically cross-bedded, white to buff in color, with a silt-clay matrix. Individual sand grains primarily consist of angular quartz grains and, occasionally, feldspar.

Clay-silt beds are interbedded with sands and gravels at all stratigraphic levels and are generally developed as irregularly shaped massive bodies with little lateral continuity. Pale-gray to buff is the most common clay-silt color, with widespread coloration by ferric iron producing mottled hues of maroon, yellow, purple, and dark brown. Dark-gray to nearly black, lignic clays are characteristic of the Arundel Formation, but are also present at other stratigraphic levels (Glaser, 1969).

It is not always possible to recognize formation contacts within the Potomac Group either in outcrop or the subsurface. For example, the Arundel Formation is difficult to differentiate from the Patuxent Formation because facies changes within the formation have increased the sandiness of the section (Glaser, 1969; Hansen, 1969; Wilson and Fleck, 1990). Correlation of individual beds cannot be traced with certainty along either the strike or dip direction (Hansen, 1968).

Descriptions of the relevant formations and soils within the region are provided in the following sections.

Patuxent Formation

The Patuxent Formation is the basal formation of the Potomac Group. The formation dips to the southeast and unconformably overlies the red beds and crystalline metamorphic rocks of the pre-Cretaceous basement. The Patuxent consists of grayish tan, fine to coarse, frequently clayey, quartzose sands that are interbedded with thick sequences of hard, predominantly gray but also variegated red and brown clays (Fleck and Wilson, 1990; Lucas, 1976; Mack and Achmad, 1986; Wilson and Achmad, 1995). Sands occur in sequences ranging in thickness from less than ten feet to about 30 feet, with an average thickness of approximately 20 feet. The Patuxent Formation ranges from approximately 200 to 350 feet thick, with an average thickness of approximately 300 feet (Fleck and Wilson, 1990; Hansen, 1968).

Although sand percentage can be as high as 90 percent in some areas, the sands of the Patuxent Formation generally comprise between 30 and 40 percent of the total thickness of the formation (Fleck and Wilson, 1990; Hansen, 1968). For example, in an area where the formation is 300 feet thick, the total thickness of sand in that area would typically range from 90 to 120 feet. Sand thickness in the Patuxent Formation has been determined from electric logs using the inflection method (Fleck and Wilson, 1990). These data agree with the northward trend of increasing sand unit thickness within the Patuxent Formation of southern MD described by Hansen (1969).

An important characteristic of the Patuxent lithology is an overall upward decrease in average grain size. The basal portion consists of gravel and coarse sands with only small amounts of silty clay. However, the upper portion of the formation is predominantly fine sand and silty clay. Cycles of small-scale (five to 20 feet thick) upward-fining sequences occur throughout the Patuxent Formation (Chapelle, 1985).

The deposition of the Patuxent Formation occurred primarily in a braided stream environment. The river system grew progressively more meandering in late Patuxent time, as evidenced by the overall fining-upward trend of the formation. The gravel sequences likely represent in-channel sedimentation of braided streams. The trough cross-bedded sands probably record sub-aqueous sand waves and dunes. The clay lenses likely represent channel cutoffs that were subsequently in-filled with fine-grained material (Chapelle, 1985).

Arundel Formation

The Arundel Formation of lower Cretaceous age conformably overlies the Patuxent Formation. The Arundel consists of thick sequences of very hard, variegated red, brown, and gray to dark gray clays with some interbedded silty sands (Wilson and Fleck, 1990). The thickness of the Arundel in the area ranges from about 150 to 250 feet. Kaolinite and illite with minor amounts of mixed-layer clays are the dominant clay minerals in the Arundel (Chapelle, 1985). Some portions of the Arundel are characterized by ferruginous nodules, which are usually composed of siderite or pyrite (Fleck and Wilson, 1990; Hansen, 1968). Lignite is present to a variable extent, with some localities exhibiting abundant amounts and others very little (Chapelle, 1985).

The Arundel Formation is separated from the Patuxent and Patapsco Formations on the basis of lithology and stratigraphic correlations. The Patuxent-Arundel contact is difficult to identify even with the aid of paleontologic data. The contact is typically identified at the base of the appreciable thickness above the basement of gray or red clay lacking sand interbeds. The lithologic relation is typically characterized by dense, massive, gray clay, overlying an irregular channeled sand surface.

The clay and silt material that comprise the Arundel Formation indicates deposition in a low-energy flow regime. Arundel sedimentation likely occurred in a marshy environment, as evidenced by the presence of dinosaur fossils and lignitized plant material. Classic sedimentation was sufficient enough to develop peat beds. Stream gradients in this depositional environment were low, resulting in very sluggish streams that meandered on a broad flood plain (Chapelle, 1985; Hansen, 1968; Hansen, 1969).

Patapsco Formation

The Patapsco Formation crops out or underlies Pliocene and Pleistocene aged sediments in the area and dips to southeast. The Patapsco consists of fine to coarse, clayey to clean, quartzose sand and some gravels, interbedded with hard, variegated red, brown, and gray clays. The thickness of the Patapsco in the region is up to 900 feet, and sand lenses range in thickness from less than ten to about 50 feet (Fleck and Wilson, 1990). Silt- and clay-sized material typically comprises between 40 and 60 percent of the total section. The sands in the Patapsco Formation are predominantly quartz with trace amounts of feldspar and heavy minerals.

The Patapsco unconformably overlies the Arundel and is marked by a medium to coarse basal sand overlying the hard clays of the Arundel. The erosion unconformity between the Arundel Clay and Patapsco Formation defines the lower boundary of the Lower Patapsco aquifer (Wilson and Achmad, 1995). The Arundel-Patapsco contact in the area is marked by a “ferruginous ledge” separating gray clay below from overlying variegated clay and argillaceous sand (Clark et al., 1911; Chapelle, 1985).

The Mid-Patapsco Clay, a significant clay and silt layer that occurs within the Patapsco Formation, serves as the confining unit between the Lower and Upper Patapsco aquifers (USACE, 2004). The Mid-Patapsco Clay consists of beds of silty, fine, sandy clay. Unlike the thick, massive and relatively continuous Arundel Clay, this confining unit is heterogeneous and laterally discontinuous. The average thickness of the Mid-Patapsco Clay is about 35 feet, but it ranges from approximately zero to 60 feet (Wilson and Achmad, 1995).

The Patapsco Formation in the area was deposited under continental conditions, as evidenced by the lack of marine fossils or authigenic marine minerals. The profusion of fine-grained sediments in the section as a whole, and in fining-upward sequences, indicates that deposition occurred primarily in a meandering stream environment (Chapelle, 1985).

Magothy Formation

The Upper Cretaceous Magothy Formation unconformably overlies the Patapsco Formation in the region. The lithology of the Magothy consists of light gray, medium to coarse and gravelly quartzose sands, and subordinate, medium gray, clayey silts (Fleck and Wilson, 1990; Glaser, 1976; Wilson and Achmad, 1995). Thick beds of lignite and associated pyrite are common throughout the Magothy Formation (Fleck and Andreasen, 1996).

The contact with the underlying Patapsco is an erosional unconformity, marked by coarse and gravelly basal sands truncating either mottled red, brown, and gray to black clays or brownish gray, fine clayey sands (Fleck and Wilson, 1990; Lucas, 1976). Unlike the sediments of the Potomac Group, the Magothy sands and clays tend to be relatively homogenous bodies that are laterally traceable for many hundreds of feet (Glaser, 1969; Mack, 1976).

Matawan Formation

The Upper Cretaceous Matawan Formation unconformably overlies the Magothy Formation in the region (Lucas, 1976). The contact is typically marked by an abrupt change in lithology from a medium to coarse, white and gray sand of the Magothy Formation, to a dark green to black, glauconitic and slightly micaceous, tough clay of the Matawan Formation (Fleck and Andreasen, 1996). The Matawan Formation marks the first occurrence of glauconite in inner Coastal Plain sediments.

Severn Formation

The Upper Cretaceous Severn Formation disconformably overlies the Matawan Formation. The name Severn Formation was suggested for beds previously designated as the Monmouth Formation in the area (Fleck and Andreasen, 1996). The lithology of the Severn Formation consists of light gray to dark gray clays and medium to granular, clean, quartz dominant sands (Fleck and Wilson, 1990). At the base of the formation lies a white to light pinkish gray clay, which then coarsens upward through a dark gray, micaceous, very clayey silt and fine sand, to a medium gravelly quartzose sand. From the coarse sand, the Severn fines upward to a dark gray, micaceous, fine sandy clay (Fleck and Wilson, 1990).

Brightseat Formation

The lower Paleocene Brightseat Formation unconformably overlies the Severn Formation in the region. The lithology of the Brightseat consists of medium greenish gray, micaceous, glauconite-bearing, clayey, fine sand and silt (Fleck and Wilson, 1990).

Aquia Formation

The Late Paleocene Aquia Formation unconformably overlies the Brightseat and, in some areas, the Severn Formation. The lithology of the Aquia Formation consists of medium to coarse, medium to well-sorted glauconitic quartz sand. Hard beds of calcareous sandstone are also common (Fleck and Andreasen, 1996). Carbonate shell debris is abundant and, in some areas, makes up approximately 20 percent of the lithology (Hansen, 1974). The Aquia Formation has been interpreted as having been deposited in a regressive marine environment (Glaser, 1968; Hansen, 1974; Chapelle and Drummond, 1983).

Marlboro Formation

The Marlboro Clay consists of tough, pink to silvery gray clay. The formation is generally less than 20 feet thick, yet laterally extensive, occurring throughout southern MD. The Marlboro Clay was formed in an estuarine to marine depositional environment (Fleck and Andreasen, 1996).

Nanjemoy Formation

The Nanjemoy Formation is a marine deposit primarily composed of silty sand and clay. The lithology in outcrop has been described as glauconitic sand, silt, and silty clay with interbedded layers of dark-gray, silty clay (Fleck and Andreasen, 1996; Glaser, 1976).

Table 3-1 summarizes the geologic formations discussed above.

Table 3-1: Regional Geologic Formation Summary

System	Series	Group	Formation	General Lithology	Hydrogeologic Characteristics
TERTIARY	EOCENE	PAMUNKEY	Nanjemoy	Sand with clay layers	Confining layer
			Marlboro	Plastic clay	Confining layer
	PALEOCENE		Aquia	Glauconitic sand with indurated layers	Aquifer
			Brightseat	Sand, silt, and clay glauconitic	Confining layer or poor aquifer
CRETACEOUS	UPPER CRETACEOUS		Monmouth	Sand, silty to fine with some glauconite	Poor aquifer in some places
			Matawan	Silt and fine sand, clayey, glauconitic	Confining layer
			Magothy	Sand with interbedded thin layers of organic black clay. Contains pyrite and lignite	Aquifer
		POTOMAC	Patapsco	Sand layers interbedded with thick clay layers, variegated color (primarily hues of red and yellow)	Contains both a confining layer and aquifers

System	Series	Group	Formation	General Lithology	Hydrogeologic Characteristics
	LOWER CRETACEOUS		Arundel	Clay, variegated red, brown, and gray with some ferruginous nodules	Confining layer
			Patuxent	Sand, gray and yellow, with interbedded clay, with feldspar and lignite common	Aquifer with discontinuous confining units
LOWER PALEOZOIC OR PRECAMBRIAN			Basement complex	Crystalline metamorphic rocks and consolidated sandstones and shales	Confining layer

3.1.4.2 Regional Hydrogeology

The Lower Cretaceous sediments of the Potomac Group contain the primary system of aquifers in the vicinity of FGGM. These aquifers consist of multiple sand layers within the Patapsco and Patuxent Formations. Significant hydrogeologic units (from stratigraphically lowest to highest) within the vicinity of FGGM include the following:

- Patuxent Aquifer
- Arundel Clay Confining Layer
- Lower Patapsco Aquifer
- Mid-Patapsco Clay
- Upper Patapsco Aquifer

Other significant aquifers in the region, which are stratigraphically higher than the Lower Cretaceous aquifer system, include:

- Aquia Aquifer
- Magothy Aquifer

A general description of the hydrogeologic framework of the Lower Cretaceous aquifer system, as well as a description of each hydrogeologic unit, is provided in the following sections. Brief descriptions of the Magothy and Aquia aquifers are also provided.

Hydrogeologic Framework of the Lower Cretaceous Aquifer System

Geologic conditions in the area generally control the local hydrogeologic conditions. The geologic units that comprise the Lower Cretaceous Aquifer System are the Patuxent, Arundel, and Patapsco Formations (Andreasen, 1999; Mack and Achmad, 1986). Crystalline basement rocks that serve as the lower confining unit underlie the Cretaceous sediments of the Potomac Group.

The Patuxent aquifer crops out in a band adjacent to the Fall Line and dips to the southeast beneath the Chesapeake Bay. In some areas, the Patuxent aquifer has been further subdivided into the upper Patuxent and lower Patuxent aquifers (Chapelle, 1985). However, for the purposes of this report, the Patuxent formation will be considered as a single aquifer. The Patuxent aquifer is recharged directly by atmospheric precipitation where it outcrops. Much of the incoming water is subsequently discharged from the aquifer by evapotranspiration and seepage to perennial streams. However, a small amount of water enters the lower portion of the aquifer and flows downgradient.

The Patapsco aquifer has been informally subdivided into an upper and a lower aquifer, due to the presence of two discrete sand bodies within this formation (Andreasen, 1999; Chapelle, 1985; Mack and Achmad, 1986). The Arundel Clay separates the lower Patapsco aquifer from the upper Patuxent aquifer. The Arundel Formation is much less permeable than either the Patuxent or Patapsco aquifers; however, the Arundel has relatively high porosity and contains large amounts of water in storage (Chapelle, 1985). Recharge and discharge from the Patuxent and Patapsco aquifers are strongly influenced by Pleistocene erosion controls. As a result of erosion of lower Cretaceous sediments beneath the Chesapeake Bay, the upper portion of the bay is a major groundwater discharge area for lower Cretaceous sediments.

Patuxent Aquifer

The Patuxent aquifer, which directly overlies bedrock, is composed of lenticular, interfingering deposits of sand, silt, and clay. Wells drilled into this aquifer typically encounter sand layers capable of yielding relatively large quantities of water (Mack and Achmad, 1986). The approximate thickness of the Patuxent aquifer in the region is between 200 and 350 feet, of which roughly 60 percent is sand and 40 percent is clay and silt (Andreasen, 1999). Estimated transmissivity values for the total aquifer thickness have been estimated to range from 230 to 4,400 feet^2/day (Andreasen, 1999). These are consistent with other transmissivity values calculated for the entire Patuxent aquifer (Bennett and Meyer, 1952; Chapelle, 1985). Storage coefficients for the entire Patuxent aquifer have been reported to range from 1×10^{-5} to 1×10^{-3}, with an average of 2.6×10^{-4} (Fleck and Vroblesky, 1996). Some of the highest producing wells tapping the Patuxent aquifer in the region have yielded between one and two million gallons per day (mgd) or greater (Mack and Achmad, 1986).

Arundel Clay Confining Layer

The Arundel Clay is an effective confining unit (125 to 250 feet thick) that separates the Patuxent aquifer from the overlying lower Patapsco aquifer (Wilson and Achmad, 1995). This confining unit crops out in a band-shaped area across the northern portion of Anne Arundel County. Mack and Achmad (1986) obtained a vertical hydraulic conductivity of 5.9×10^{-7} feet/d from a model calibration.

Lower Patapsco Aquifer

The lower Patapsco aquifer is a semiconfined aquifer occurring in the sands of the Patapsco Formation. The approximate thickness of the lower Patapsco aquifer in the region is between

100 and 300 feet. Transmissivity values for the lower Patapsco aquifer range from approximately 1,000 to 6,400 $feet^2/d$ (Mack and Achmad, 1986; Achmad, 1991; Wilson and Achmad, 1995). These transmissivity values are within the values for the confined portion of the Patapsco aquifer reported by Bennett and Meyer (1952). Reported storage coefficients for the confined portion of the Patapsco range from 5.3×10^{-5} to 2.7×10^{-3}, with an average value of 6.1×10^{-4} (Bennett and Meyer, 1952; Chapelle, 1985). The lower Patapsco aquifer is capable of yielding from 0.5 to 2 mgd from individual wells in most localities (Mack and Achmad, 1986).

Mid-Patapsco Clay

The Mid-Patapsco Clay is a leaky confining layer that separates the lower and upper Patapsco aquifers and consists of beds of silty, fine sandy clay (Mack and Achmad, 1986). Unlike the relatively continuous Arundel Clay, this confining unit is heterogeneous and laterally discontinuous. The thickness of the confining unit in the area ranges from zero to approximately 60 feet (Wilson and Achmad, 1995). In some areas, the confining unit consists of massive beds of clay of very low vertical hydraulic conductivity. However, in other areas, the confining unit is relatively more permeable. The model-derived vertical hydraulic conductivity of the aquifer was determined to range from 3.0×10^{-2} to 3.0 feet/d (Wilson and Achmad, 1995).

Upper Patapsco Aquifer

The upper Patapsco aquifer is an unconfined to semiconfined aquifer, which overlies the Mid-Patapsco Clay above the lower Patapsco aquifer. The upper Patapsco aquifer generally consists of sands, silts, and gravels of the Patapsco Formation. In the vicinity of FGGM, the land surface forms the top of the aquifer.

The total thickness of the upper Patapsco aquifer in the region ranges from ten to 210 feet (Wilson and Achmad, 1995). Transmissivity values have been estimated to range from 330 to 4,800 $feet^2/d$. The saturated thickness ranges from approximately ten to 150 feet. The hydraulic conductivity has been estimated to range from eight to 145 feet/d, with an average of 33 feet/d. The general direction of groundwater flow within the upper Patapsco aquifer is to the east-northeast. The approximate pre-pumping hydraulic gradient ranges from 0.0014 to 0.009 feet/foot (Mack and Achmad, 1986; Achmad, 1991; Wilson and Achmad, 1995).

Magothy Aquifer

The Magothy aquifer is an important regional aquifer in the Coastal Plain of MD (Wilson and Fleck, 1990). The lithology of the Magothy aquifer consists primarily of fine to coarse quartz sands and gravels. The base of the Magothy aquifer consists of a coarse sand and gravel zone that corresponds to the base of the Magothy Formation and marks the unconformable contact with the underlying Patapsco Formation. The thickness of the Magothy ranges from a few feet to approximately 100 feet. The transmissivity of the Magothy aquifer has been estimated to range from about 1,000 to over 24,000 $feet^2/d$ (Hansen, 1972; Mack and Mandle, 1977; Fleck and Andreasen, 1996). Horizontal hydraulic conductivities have been calculated to range from 1.5 to 83 feet/d with an average of 40 feet/d (Fleck and Andreasen, 1996).

Aquia Aquifer

The Aquia aquifer is a significant regional aquifer in southern MD and is extensively tapped for fresh groundwater in Anne Arundel, Calvert, and St. Mary's Counties (Chapelle and Drummond, 1983). A highly permeable, medium to coarse sand facies within the Aquia Formation is the primary source of groundwater (Hansen, 1974). The thickness of the Aquia aquifer is variable,

ranging from a few feet to over 100 feet. Transmissivity values determined from pump tests have been reported to range from approximately 200 to over 5000 $feet^2/d$. The horizontal hydraulic conductivity has been estimated to be approximately four feet/d in some areas (Fleck and Andreasen, 1996). Storage coefficients in the Aquia aquifer have been reported to range from 1×10^{-3} to 4×10^{-3} (Hansen, 1972; Chapelle and Drummond, 1983).

3.1.4.3 Ecology

A variety of ecological communities are present at FGGM, including pine and mixed pine/hardwood woodlands and wetlands. Woodlands species that have been previously identified in the area include:

- Dogwood (Cornus florida)
- Beech (Fagus grandifolia)
- Tulip Tree (Liriodendron tulipfera)
- Eastern White Pine (Pinus echinita)
- Loblolly Pine (Pinus taeda)
- Virginia Pine (Pinus virginiana)
- White Oak (Quercus alba)
- Chestnut Oak (Quercus prinus)
- Northern Red Oak (Quercus rubra)

Shrub layers in the area have been reported to contain mountain laurel (*Kalmia latifolia)* and low blueberry (*Vaccinium vacillans*), as well as Beech and Flowering Dogwood. The woodlands and shrub layers provide adequate vegetative cover to support wildlife, although specific species have not been recorded.

Based on information from the National Wetland Inventory (NWI) and prior field investigations, limited wetlands are present within the FGGM area. Rogue Harbor Branch is classified in the Riverine ecological system and is a permanent lower perennial open water stream (RK&K, 1994). Several areas in the vicinity of the Rogue Harbor Branch are marshy and contain wetland vegetation. Standing water has also been reported in the vicinity of Rogue Harbor Branch. Wetland areas also occur in the southwestern portion of FGGM. These areas are associated with an intermittent streams and the Little Patuxent River and are classified as Palustrine with forested broad-leaved deciduous trees (RK&K, 1994).

3.2 SITE CHARACTERISTICS

This section provides a description of the LOC parcel specifics, including a discussion of land use, topography, surface hydrology, geology, hydrogeology, and ecology. The FGGM is located midway between Baltimore, MD, and Washington, D.C. The site is a 100-acre parcel of land at the southern end of FGGM. The site is bounded to the south and north by MD Route 32 (Patuxent Highway) and Rock Avenue, respectively, and to the east and west by Pepper Road and Remount Road, respectively.

3.2.1 Land Use

The LOC parcel is currently being used to accommodate the long-term storage and service needs of the LOC and other legislative branches. The LOC and House and Senate Offices share storage space at the property. The shared storage spaces are in 17 existing warehouses and a new book storage building (modules built in 2002 and 2004) on the eastern portion of the site. A 500,000-gallon at-grade water storage tank was constructed immediately west of the Warehouse Area in 2005 to meet fire protection requirements for the AOC. The western portion of the 100-acre parcel is the site of the Former DRMO and the TMP; it contains several warehouses and buildings, including paved areas and improvements, associated with the Former DRMO and the TMP. The area between the TMP and the Rogue Harbor Branch is mostly woodland (wooded areas are located to either side of the floodplain). East of the Rogue Harbor Branch is a fenced parking lot for tractor-trailer and vehicle storage, a fenced 13 kV electrical substation, and a sewage pump station.

The January 2005 *Master Plan, Congressional Campus at Fort George G. Meade (90% Submittal)* provides details about the proposed future use and development of the site. The Master Plan divides the AOC parcel into east (67 acres) and west parcels (33 acres). Eighteen buildable areas were projected with 75 percent coverage (impervious surface) identified for each buildable area (Figure 3-2). The majority of the buildable areas are proposed for administrative, warehouse, document storage, and security uses. Infrastructure improvements to support the proposed development presented in the Master Plan include demolition, landscaping, grading, transportation, electrical, water supply, stormwater management, etc. For the most part, the west parcel of the LOC Campus Facility will not be entirely developable until 2024 when the FGGM TMP lease ends. Potential development could occur in the area north of the TMP before 2024 as long as it does not restrict access to the TMP. Construction on the east parcel has already begun with the book storage facility and water tank. The LOC intends to develop the book storage facility to encompass approximately 13 modules over the next several years. A Copyright Facility and Logistics Warehouse are also in the design and planning phases and may be constructed on the east parcel in the near future.

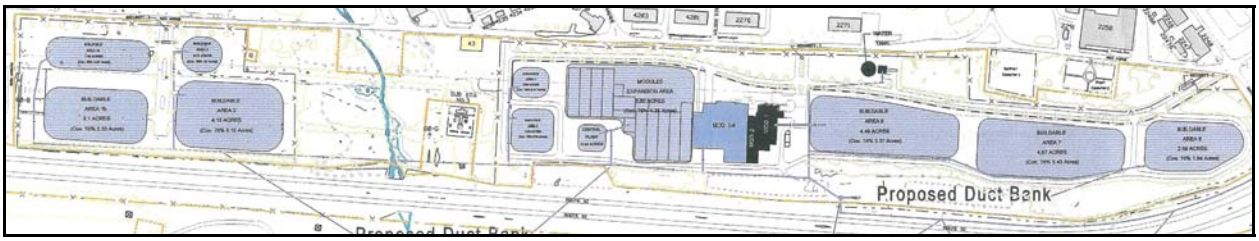

Figure 3-2: Proposed development plan for AOC parcel

3.2.2 Topography

The topography of the site is generally flat with some slightly rolling hills of less than five percent slopes. The elevation of the 100-acre LOC parcel generally ranges from approximately 120 feet amsl along the Rogue Harbor Branch to approximately 140 feet amsl at the eastern and western boundaries of the site. The LOC parcel is located in the northwestern quadrant of the Odenton USGS Quadrangle, 7.5-minute series topographic map. Latitudinal and longitudinal coordinates are approximately 39° 05’ North and 76° 44’ West.

3.2.3 Surface Water Hydrology

Surface water drainage within the site is controlled and directed by the storm water drains on the LOC parcel and the Rogue Harbor Branch. The LOC parcel is bisected by the Rogue Harbor Branch, which is a moderate-flowing tributary of the Little Patuxent River. Based on prior field observations, the Rogue Harbor Branch is ten to 20 feet wide with a shallow water depth of one to three feet and an average flow of less than ten cubic feet per second. Within about 1,500 feet south of the parcel, the Rogue Harbor Branch flows to Lake Allen (Soldier Lake) and continues at the outlet to flow approximately 3,500 feet to its confluence with the Little Patuxent River.

Federal Emergency Management Agency (FEMA) mapping does not indicate a 100-year floodplain for the Rogue Harbor Branch. According to 100-year floodplain mapping of the Rogue Harbor Branch developed in 1983 by RK&K Consulting Engineers, the floodplain extends an average of approximately 400 feet east and west of the stream centerline.

Comparison of geologic maps dated 1916 and 1976 indicates some changes of geological features. The Geologic Map of 1916 indicates that a stream existed approximately 2,900 feet east of the Rogue Harbor Branch and in the vicinity of the old warehouses in the eastern portion of the project. This stream is not located on the Geologic Map of 1976, and it is likely the streambed was filled during development of FGGM.

3.2.4 Geology and Hydrogeology

This section describes the sedimentary and hydrogeologic characteristics of the geologic formations that occur at the LOC parcel within the FGGM. Along with published local and regional studies, site-specific subsurface data from DPT borings, surface soil samples, and monitoring well borings at the LOC parcel are presented in the following sections.

3.2.4.1 Geology

The geologic characteristics of the site were evaluated from lithologic information obtained from the following:

- Thirty-three DPT borings for soil sample collection only
- Twenty-five DPT/GW borings for soil and/or groundwater sample collection
- Six surface soil samples collected at a depth of approximately two feet bgs using a hand auger
- Fourteen monitoring well borings used for monitoring well installation

The locations of the DPT borings, surface soil samples, and monitoring well borings are presented on **Figure 2-1**. Copies of the field lithologic logs are presented in Appendix B. A cross-section of the LOC parcel that was developed based on these lithologic logs is shown on **Figure 3-2**.

Several DPT/GW soil borings were not completed to the intended depth due to refusal. The intended depth was primarily based on the depth required to obtain groundwater samples. Lithology in these borings was logged down to the depth of refusal. **Table 3-2** indicates the total depth of all soil borings that were lithologically logged.

Table 3-2: Summary of Boring Depths

Boring ID	Type	Total Boring Depth (feet [ft])	Remarks
DPT-1	DPT (GeoProbe)	12	Soil sampled only
DPT-2	DPT (GeoProbe)	12	Soil sampled only
DPT-3	DPT (GeoProbe)	12	Soil sampled only
DPT-4	DPT (GeoProbe)	16	Soil sampled only
DPT-5	DPT (GeoProbe)	12	Soil sampled only
DPT-6	DPT (GeoProbe)	12	Soil sampled only
DPT-7	DPT (GeoProbe)	12	Soil sampled only
DPT-8	DPT (GeoProbe)	12	Soil sampled only
DPT-9	DPT (GeoProbe)	12	Soil sampled only
DPT-10	DPT (GeoProbe)	12	Soil sampled only
DPT-11	DPT (GeoProbe)	12	Soil sampled only
DPT-12	DPT (GeoProbe)	12	Soil sampled only
DPT-13	DPT (GeoProbe)	12	Soil sampled only
DPT-14	DPT (GeoProbe)	12	Soil sampled only
DPT-15	DPT (GeoProbe)	12	Soil sampled only
DPT-16	DPT (GeoProbe)	12	Soil sampled only
DPT-17	DPT (GeoProbe)	12	Soil sampled only
DPT/GW-1	DPT (GeoProbe)	20	Soil and groundwater sampled
DPT/GW-2	DPT (GeoProbe)	16	Refusal at 16 ft bgs, perched water encountered at 7 ft bgs
DPT/GW-3	DPT (GeoProbe)	35	Refusal at 35 ft bgs
DPT/GW-4	DPT (GeoProbe)	20	Refusal at 20 ft bgs
DPT/GW-5	DPT (GeoProbe)	24.5	Soil and groundwater sampled
DPT/GW-6	DPT (GeoProbe)	21	Groundwater boring only
DPT/GW-7	DPT (GeoProbe)	20	Soil and groundwater sampled
DPT/GW-8	DPT (GeoProbe)	20	Refusal at 20 ft bgs
DPT/GW-9	DPT (GeoProbe)	20	Soil and groundwater sampled
DPT/GW-10	DPT (GeoProbe)	22	Refusal at 22 ft bgs
DPT/GW-11	DPT (GeoProbe)	16	Groundwater encountered at ~ 9 ft bgs
DPT/GW-12	DPT (GeoProbe)	16	Soil and groundwater sampled
DPT/GW-13	DPT (GeoProbe)	20	Soil and groundwater sampled
DPT/GW-14	DPT (GeoProbe)	2	Refusal at 2 ft bgs
DPT/GW-EW2	DPT (GeoProbe)	25	Refusal at 25 ft
SS-01	Hand Auger	2	Surface soil sampled
SS-02	Hand Auger	2	Surface soil sampled
SS-03	Hand Auger	2	Surface soil sampled
SS-04	Hand Auger	2	Surface soil sampled
SS-05	Hand Auger	2	Surface soil sampled
SS-06	Hand Auger	2	Surface soil sampled
NW-01	HSA	34	Well installed
NW-02	HSA	34	Well installed
NW-03	HSA	45	Well not installed -- refusal at 45 ft (stiff clay layer)
NW-04	HSA	37	Well installed
NW-05	HSA	34	Well installed
NW-06	HSA	34	Well installed

Boring ID	Type	Total Boring Depth (feet [ft])	Remarks
NW-07	HSA	36	Well installed
NW-08	HSA	34	Well installed
NW-09	HSA	37	Well installed
NW-10	HSA	38	Well installed
NW-11	HSA	38	Well installed
NW-12	HSA	54	Well installed
NW-13	HSA	42	Well installed
NW-14	HSA	52	Well installed
DPT/GW-18	DPT (GeoProbe)	20	Soil and groundwater sampled
DPT/GW-19	DPT (GeoProbe)	15	Soil and groundwater sampled
DPT-20	DPT (GeoProbe)	10	Soil sampled only
DPT/GW-21	DPT (GeoProbe)	15	Soil and groundwater sampled
DPT-22	DPT (GeoProbe)	10	Soil sampled only
DPT-23	DPT (GeoProbe)	10	Soil sampled only
DPT/GW-24	DPT (GeoProbe)	10	Soil and groundwater sampled
DPT-25	DPT (GeoProbe)	10	Soil sampled only
DPT-26	DPT (GeoProbe)	10	Soil sampled only
DPT-27	DPT (GeoProbe)	10	Soil sampled only
DPT-28	DPT (GeoProbe)	10	Soil sampled only
DPT/GW-29	DPT (GeoProbe)	15	Soil and groundwater sampled
DPT/GW-30	DPT (GeoProbe)	20	Soil and groundwater sampled
DPT-31	DPT (GeoProbe)	15	Soil sampled only
DPT-32	DPT (GeoProbe)	10	Soil sampled only
DPT-33	DPT (GeoProbe)	10	Soil sampled only
DPT/GW-34	DPT (GeoProbe)	25	Soil and groundwater sampled
DPT/GW-35	DPT (GeoProbe)	25	Soil and groundwater sampled
DPT-36	DPT (GeoProbe)	5	Surface soil sampled
DPT-37	DPT (GeoProbe)	5	Surface soil sampled
DPT-38	DPT (GeoProbe)	5	Surface soil sampled
DPT/GW-39	DPT (GeoProbe)	15	Soil and groundwater sampled
DPT-40	DPT (GeoProbe)	5	Surface soil sampled
DPT-41	DPT (GeoProbe)	5	Surface soil sampled
DPT-42	DPT (GeoProbe)	5	Surface soil sampled
DPT/GW-43	DPT (GeoProbe)	15	Groundwater sampled

Monitoring wells were installed using a HSA drill rig. Groundwater monitoring wells were installed at seven of eight boring locations (NW-1, NW-2, NW-4, NW-5, NW-6, NW-7 and NW-8), and six additional monitoring wells were installed (NW-9, NW-10, NW-11, NW-12, NW-13, and NW-14). Monitoring well NW-3 was not constructed due to insufficient groundwater production in the boring. Based on the soil borings performed, the soils underlying the site consist of interbedded sands, silts, and clays with some gravel.

Based on the observed lithologies, the Patapsco Formation was the primary unit encountered during DPT boring and well installations. Specifically, the lower Patapsco aquifer outcrops throughout the central and western portions of the site (**Figure 3-3**). The Mid-Patapsco Clay was encountered in the far eastern portion of the site (during the installation of monitoring wells NW-3 and NW-14 and boring DPT/GW-43). Immediately north of the eastern portion of the site, near the Post Laundry Facility, the upper Patapsco aquifer was encountered in monitoring wells

that were installed there in a previous investigation. A description of these units is provided in the following sections.

Patapsco Formation

At the LOC parcel site, the upper portion of the Patapsco Formation occurs at the surface and overlies the Mid-Patapsco Clay, a discontinuous clay-confining unit separating the upper and lower Patapsco aquifers (USACE, 2004). This observation is supported by geophysical studies published by Hansen (1968) in the FGGM area. According to the geophysical logs, the relatively thin (approximately 20 to 40 feet) layer of the upper portion of the Patapsco outcrops in the FGGM area (Hansen, 1968). This is underlain by a relatively thick (approximately 150 feet) clay layer (Arundel Clay), which forms the confining unit for the lower Patapsco aquifer. The Mid-Patapsco Clay outcrops near the surface in the eastern boundary of the site, while the upper Patapsco outcrops in central and eastern portions of the site.

The upper portion of the Patapsco Formation at the LOC parcel site is characterized by interbedded layers of fine to medium sand, silt, and relatively thin clay layers. The thickness of the unit is variable over the extent of the site, ranging from less than five feet in the far western portion of the site to greater than 30 feet in some areas.

The thickness of the upper Patapsco was not fully penetrated in most areas of the site. These borings were either completed to below the groundwater table or not completed due to DPT rig refusal. Refusal was generally encountered in a very compact silty to clayey sand layer, present between two and 35 feet bgs. These compact silty sand lenses are characterized by yellowbrown to reddish quartzose sands, with appreciable amounts of silt-and clay-sized material in the pore space. The thickness of this sand lens was greater than 20 feet in some areas (DPT/GW-3).

Layers of hard, variegated red, brown and gray clays of low plasticity also characterize the Patapsco Formation in the area. In some borings, the clay appeared mottled from dark red to black at varying depths. The thickness of these clay layers was variable across the site, ranging from less than two feet thick to 15 feet thick in some areas. These relatively thin clay lenses within the upper portion of the Patapsco are very similar to and difficult to distinguish from the variegated clays that form the underlying confining unit. These clay beds were primarily distinguished from the underlying confining unit based on thickness. The confining unit is approximately 150 feet thick in the area (Hansen, 1968).

The Mid-Patapsco Clay, which separates the lower and upper Patapsco aquifers, was primarily observed at NW-3, which is located near the eastern boundary of the site (see **Figure 2-1**). In this area, the clay was initially encountered at a depth of approximately five feet bgs and extended to a depth of approximately 45 feet bgs, where the boring was terminated. The Mid-Patapsco Clay was not fully penetrated in this boring. Very hard, stiff, variegated redbrown and gray, low plasticity clays characterized the lithology of the confining unit in this area. Thin layers (less than two feet) of fine, silty to clayey sand were also observed in this boring. The clays observed in this area were very similar to and difficult to distinguish from the interbedded clays of the underlying Patapsco Formation, which was observed in other soil borings across the site. The massiveness of the clay in the area (NW-3) and the presence of very thin silty sand layers (compared to the thick sand sequences with thin interbedded clay layers) were used to distinguish the two units. The interbedded sands and clays of the Patapsco Formation were likely deposited in a meandering stream environment.

3.2.4.2 Soils

Based upon the United States Department of Agriculture's *Soil Survey for Anne Arundel County, MD* (1973), the soils likely to be encountered at the site include the Evesboro and Muirkirk soils, as well as Cut and Fill Land.

The Evesboro soils consist of well-drained loamy sands. The Muirkirk soils consist of loamy sand and sandy loam over deposits of clay. The sand and loam portions of the Muirkirk Series are well drained, and the clay portions are not well drained. Cut and Fill Land consists of miscellaneous soil types that have been disturbed and altered by construction processes. These altered soils have variable soil characteristics (RK&K, 1994).

3.2.4.3 Hydrogeology

The uppermost hydrogeologic unit within the sediments underlying the FGGM LOC parcel is the upper Patapsco aquifer. The upper Patapsco aquifer occurs within the sands and silty sands of the Cretaceous Patapsco Formation. Thick clay sediments form the Mid-Patapsco Clay that separates the upper and lower Patapsco aquifers.

Hydrogeologic data for the site was obtained from DPT and monitoring well borings, as well as subsequent groundwater sampling activities. Groundwater was reached in 18 of 25 DPT/GW borings at the site. Several borings (DPT/GW-3, DPT/GW-4, DPT/GW-6, DPT/GW-8, DPT/GW-10, DPT/GW-14 and DPT/GW-EW2) were not completed to the depth of groundwater because refusal was encountered above the water table. However, DPT/GW-3, DPT/GW-4, DPT/GW-6, and DPT/GW-8 were converted to permanent monitoring wells. Temporary piezometers were installed in four DPT borings (DPT/GW-2, DPT/GW-5, DPT/GW-11, and DPT/GW-13), which were subsequently used for groundwater sampling activities.

Thirteen new monitoring wells (NW) were installed during this RI, and three existing wells (EW) were also included in this during groundwater sampling. One monitoring well (NW-3), located near the eastern boundary of the site, was not completed due to insufficient groundwater production in this boring. The Mid-Patapsco Clay was prominent throughout boring for NW-3; therefore, groundwater was not encountered in this area. **Table 3-3** indicates the approximate depth to groundwater (if reached) for each boring and the approximate depth to groundwater observed during groundwater sampling activities.

Table 3-3: Depth to Groundwater

Boring/Well ID	Approximate Depth to GW during Boring Installation (ft bgs)	Approximate Depth to GW during Sampling (ft bgs)	Screened Interval Depth (ft bgs)
DPT/GW-1	18	18	NA
DPT/GW-2	7	9	5 – 15
DPT/GW-3*	Refusal at 35	NA	NA
DPT/GW-4*	Refusal at 20	NA	NA
DPT/GW-5	18	18	14.5 – 24.5
DPT/GW-6*	Refusal at 20	NA	NA
DPT/GW-7	20	9	NA
DPT/GW-8*	Refusal at 20	NA	NA
DPT/GW-9	18	16	NA
DPT/GW-10	Refusal at 22	NA	NA
DPT/GW-11	9	6	5 – 15
DPT/GW-12	16	16	NA

Boring/Well ID	Approximate Depth to GW during Boring Installation (ft bgs)	Approximate Depth to GW during Sampling (ft bgs)	Screened Interval Depth (ft bgs)
DPT/GW-13	19	7	5 – 15
DPT/GW-14	Refusal at 2	NA	NA
DPT/GW-EW2	Refusal at 25	NA	NA
NW-01	23	14	22.5 – 32.5
NW-02	24	19	22 – 32
NW-03	NA	NA	NA
NW-04	28	24	27 – 37
NW-05	22	20	20 – 30
NW-06	23	21	21 – 31
NW-07	25	21	23 – 33
NW-08	22	6	20 – 30
NW-09	19	19	22 – 37
NW-10	31	24	28 – 38
NW-11	31	31	28 – 38
NW-12	45	43	35 – 45
NW-13	50	33	29 – 39
NW-14	35	46	40 – 50
DPT/GW-18	13	13	20 – 25
DPT/GW-19	9	9	10 – 15
DPT/GW-21	10	10	10 – 15
DPT/GW-24	5	5	5 – 10
DPT/GW-29	11 f	11	10 – 15
DPT/GW- 30	10	10	10 – 20
DPT/GW-34	20	20	15 – 25
DPT/GW-35	20	20	15 – 25
DPT/GW-39	11	11	10 – 15
DPT/GW-43	7	7	10 – 15 ft bgs
EW-2	Unknown	24	Unknown (total depth 30 ft bgs)
EW-3	Unknown	24	Unknown (total depth 37 ft bgs)
MW-7	Unknown	23	Unknown (total depth 38 ft bgs)

Notes:
***** DPT/GW locations converted to monitoring wells (NW-09 through NW-12) in 2001.
NA = not applicable

Based on data collected during soil boring and sampling activities, groundwater occurrence at the site is inconsistent, and local groundwater levels are highly variable. Groundwater generally occurs in the unconsolidated sandy and silty sediments of the Upper Patapsco Formation. Perched groundwater conditions are evident in some areas of the site due to the presence of the interbedded sand and clay layers of the Patapsco Formation. The occurrence of groundwater is variable throughout the site due to the heterogeneous and discontinuous nature of the sand, silt, and clay sediments. A localized mounding effect was seen in the groundwater level measurements taken from wells screened in the Mid-Patapsco Clay. Therefore, measurements from these wells were excluded from the groundwater flow model, as they are not representative of the general direction of groundwater flow across the LOC parcel.

Hydraulic conductivity in the site vicinity, calculated from previous slug tests in wells west of Remount Road, ranges from 8.1 x 10^{-4} centimeters per second (cm/sec) to 1.1 x 10^{-3} cm/sec.

The overall general direction of groundwater flow at the site is generally to the southeast, towards the Little Patuxent River. However, topography, local surface drainage, and subsurface lithology significantly influence local hydrogeologic conditions. In the west-central portion of the LOC parcel, localized groundwater flow to the southwest may occur in response to probable gaining stream conditions along Rogue Harbor Branch as shown in **Figure 3-4**. Groundwater recharge occurs through infiltration and precipitation.

3.2.4.4 Ecology

A variety of ecological communities are present at FGGM, including pine and mixed pine/hardwood woodlands, and wetlands. Woodlands species that have been previously identified in the area are provided in Section 3.1.4.3. The woodlands and shrub layers provide adequate vegetative cover to support wildlife.

Wetland areas within the LOC parcel are associated with the Rogue Harbor Branch, which has been classified as Riverine ecological system. Several areas in the vicinity of the Rogue Harbor Branch appeared to be marshy and contained wetland vegetation. The junction of the Rogue Harbor Branch with MD Route 32 is apparently marshy, and some wetland vegetation is evident. Areas east of the Rogue Harbor Branch and north of the old railroad alignment have been reported to contain standing water.

Wildlife likely to occur in the site vicinity includes mammals such as White-tailed Deer (*Odocoileus virginianus*), Raccoon (*Procyon lotor*), Groundhog (*marmota monax*), Red Fox (*Vulpes vulpes*) and Eastern Cottontail (*Sylvilagus floridanus*). Small birds such as Common Flicker (*Colaptes auratus*), American Robin (*Turdus migratorius*), Common Crow (*Corvus brachyrynchos*), Mourning Dove (*Zenaida macroura*) and other wildlife may inhabit the site vicinity, as well. Amphibians (e.g., frogs) may inhabit areas associated with the Rogue Harbor Branch, and reptiles (e.g., snakes) may be present in the wooded and brush-covered portions of the site, as well. Fish species known to inhabit the Rogue Harbor Branch are common inhabitants of Coastal Plain Fish assemblages and include Bluespotted Sunfish (*Enneacanthus gloriosus*), Bluegill (*Lepomis macrochirus*), Pumpkinseed (*Lepomis gibbosus*), American Eel (*Anguilla rostrata*), Eastern Mudminnow (*Umbra pygmaea*), and Creek Chubsucker (*Erimyzon oblongus*).

4 NATURE AND EXTENT OF CONTAMINATION

This section provides a preliminary identification of the ARARs, the decontamination fluid sampling results, the environmental sample analytical results, and an assessment of the nature and extent of contamination for the LOC parcel.

The quality of the analytical data is presented in the QCS/AR Report (submitted separately to USACE). The results of the data validation as conducted by our subcontractors, URS and TechLaw, are provided in Appendices C through F of the QCS/AR Report. Based on the data validation results, the analytical data were considered acceptable and valid for use in determining the nature and extent of contamination and in performance of the human health and ecological risk assessments provided in Sections 6.0 and 7.0 of this report. Qualifiers were added to the data, as appropriate, by the laboratory and data validators.

Where multiple analytical results occur because of dilutions, re-extractions, or duplicates, the maximum concentration is reported in the tables within this section.

4.1 IDENTIFICATION OF ARARS

4.1.1 Definition of ARARs

The National Contingency Plan (NCP) and Section 121 of the CERCLA require that CERCLA remedial actions attain federal and state ARARs unless specific waivers are granted. State ARARs must be attained under Section 121(d) of CERCLA, if they are legally enforceable and consistently enforced statewide. ARARs may be classified as either applicable or relevant and appropriate. In addition to ARARs, other guidance and regulations may be classified as guidance "to be considered" (TBC).

Potential ARARs and TBCs are identified in this section to aid in development of remedial actions and in establishment of required cleanup levels. Additionally, ARARs and TBCs are used to scope and formulate remedial action alternatives and to govern implementation and operation of the selected remedial alternatives.

Discussions of ARARs and TBC criteria are provided as follows:

- **Applicable Requirements**. Applicable requirements refer to those federal or state requirements that would be legally enforceable. An example of an applicable requirement would be the Safe Drinking Water Act's Maximum Contaminant Levels (MCLs) for a site that contaminates a public drinking water supply.

- **Relevant and Appropriate Requirements**. Relevant and appropriate requirements are federal or state standards, criteria or guidelines that are not legally enforceable at a site, but their application is appropriate because they address problems similar to those on-site. Relevant and appropriate requirements have the same weight and consideration as applicable requirements. An example of relevant and appropriate requirements might be state groundwater protection levels established for other regulatory programs such as UST or RCRA Subtitle D.

- **To Be Considered (TBC)**. Other federal and state recommended standards or criteria applicable to a specific site which are not generally enforceable but are advisory are categorized as TBC. For example, where no specific ARAR exists for a chemical or

situation, or where such an ARAR is not sufficient to be protective of human health or the environment, federal and/or state guidance or advisories may be considered in determining the necessary level of cleanup for protection of public health and the environment. An example of a TBC is the use of EPA risk screening criteria or EPA Health Advisories for specific chemicals in determining action or cleanup levels.

4.1.2 Development of ARARs and TBCs

The development of ARARs and TBCs is conducted on a site-specific basis. ARARs and TBCs are further categorized as either chemical-specific, location-specific or action-specific. CERCLA actions may have to comply with them as follows:

- **Chemical-Specific**. Chemical-specific requirements define acceptable exposure levels for specific hazardous substances and, therefore, may be used as a basis for establishing preliminary remediation goals and cleanup levels for chemicals of concern in the designated media. Chemical-specific ARARs and TBCs are also used to determine treatment and disposal requirements for remedial actions. In the event a chemical has more than one requirement, the more stringent of the two requirements will be used.

- **Location-Specific**. Location-specific requirements set restrictions on the types of remedial actions that can be performed based on site-specific characteristics or location. Alternative remedial actions may be restricted or precluded based on Federal and State laws for hazardous waste facilities, proximity to wetlands or floodplains, or to man-made features such as existing landfills, disposal areas and local historic landmarks or buildings.

- **Action-Specific**. Action-specific requirements set controls or restrictions on the design, implementation and performance of remedial actions. They are triggered by the particular types of treatment or remedial actions that are selected to accomplish the cleanup. After remedial alternatives are developed, action-specific ARARs and TBCs that specify remedial action performance levels, as well as specific contaminant levels for discharge of media or residual chemical levels for media left in place, are used as a basis for assessing the feasibility and effectiveness of the remedial action.

4.1.3 Identification of ARARs and TBCs

4.1.3.1 Chemical-Specific ARARs and TBCs

As a basis for comparison of the contaminant concentrations discussed in this section, lists of chemical-specific ARARs and TBC criteria have been developed for the site. These chemical-specific ARARs and TBCs have been identified for soil, sediment, surface water and groundwater in **Tables 4-1** through **4-4**, respectively.

Chemical-specific ARARs and TBCs that have been identified from the following regulations and standards are:

ARARs

- Maryland Ambient Water Quality Criteria (Code of Maryland Regulations [COMAR} 26.08.02)

- EPA Ambient Water Quality Criteria (40 Code of Federal Regulations [CFR] 131)

- Safe Drinking Water Act Maximum Contaminant Levels (40 CFR 141 and 143)

TBC Criteria

- EPA Region III Risk-based Concentration (RBC) Tables
- EPA Region III Soil Screening Levels (SSLs)
- EPA Region III Biological Technical Assistance Group (BTAG) Screening Levels
- National Recommended Water Quality Criteria

4.1.3.2 Location-Specific ARARs and TBC

Identification of potential location-specific ARARs and TBC include the following:

- Maryland Guidelines for Discharge to Groundwater (COMAR 26.08.02.09-D)
- Maryland Department of the Environment Guidelines for Land Treatment of Municipal Wastewaters (MDE-WMA-001-11/87)
- Maryland Water Supply, Sewage Disposal, and Solid Waste Regulations (COMAR 26.04.04)
- Maryland Standards Applicable to Transportation of Hazardous Materials (COMAR 26.13.04)
- Resource Conservation and Recovery Act Regulations (40 CFR 261-270)
- Department of Transportation (DOT) Regulations (49 CFR 107, 171)
- National Oceanic and Atmospheric Administration Guidelines
- Maryland Ambient Air Quality Standards (COMAR 26.11.04)
- Clean Air Act Regulations
- Maryland Erosion and Sediment Control (COMAR 26.17.01)
- Maryland Stormwater Management (COMAR 26.17.02)

4.1.3.3 Action-Specific ARARs and TBC

Identification of potential action-specific ARARs and TBC may include the following based on the required remedial action:

- National (40 CFR 122) and Maryland Pollutant Discharge Elimination System (COMAR 26.08.03) permits
- Maryland and Federal Endangered Species Act
- Maryland Wetlands Regulations (COMAR 26.23.00 and 26.24.00)

- Federal Water Pollution Control Act Regulations (Clean Water Act)(33 CFR 323)
- Federal Wetlands Executive Order 11990
- Chesapeake Bay Preservation Regulations (VR 173-02-01)
- Maryland Cultural and Historical Resources (COMAR 26.20.02.05)
- Federal Floodplain Executive Order 11988
- Local Noise Statutes
- Well Construction Guidelines (COMAR 26.04.04)

The applicability and refinement of these chemical, location and action-specific ARARs and TBC to future remedial actions will be evaluated in detail on a more site-specific basis in the feasibility study process, if required.

4.2 DECONTAMINATION FLUID SAMPLING RESULTS

As discussed in Section 2.2.7, field water used for equipment decontamination consisted of distilled water and DI water. A more detailed discussion of the quality of the field water and any impacts to sampling and analysis is provided in the QCS/AR Report.

Samples of the distilled water and DI water used for each sample event were submitted to STL Savannah, Inc. and GPL Laboratories for analysis for VOCs, SVOCs, pesticides, PCBs, total metals, and cyanide.

4.2.1 2000 Sample Event

No VOCs, SVOCs, pesticides, PCBs or cyanide were detected in the DI water samples. Several metals, including aluminum, calcium, iron, magnesium, potassium, sodium, and zinc, were detected in the DI water samples.

4.2.2 2001 Sample Event

No pesticides or PCBs were detected in the DI water sample. Several metals, including aluminum, calcium, chromium, copper, magnesium, sodium, and zinc, were detected in the DI water sample.

Because distilled water was only used as an initial rinse with subsequent methanol, nitric acid and DI water rinses conducted as described in Section 2.2.7, no adverse impacts to field sample data quality are expected.

4.2.3 2004/2005 Sample Event

No pesticides or PCBs were detected in the DI water sample. Numerous metals were detected in the DI water samples. Methylene chloride, acetone, and bis(2-ethylhexyl) phthalate were also detected in the DI water samples. No action was required by the data validator for the data with the blank contamination because the sample results were above the blank action levels, not associated with the blank, or non-detected for the positive blank contamination evaluation.

Because distilled water was only used as an initial rinse with subsequent methanol, nitric acid and DI water rinses conducted as described in Section 2.2.7, no adverse impacts to field sample data quality are expected.

4.3 NATURE AND EXTENT OF CONTAMINATION

Soil, sediment, surface water and groundwater samples were collected at the LOC parcel to define the nature and extent of contamination. Surface soil and sediment samples were collected by hand auger, surface and subsurface soil and groundwater samples were collected by DPT methods, subsurface soil samples were collected from HSA borings, and groundwater water samples were also collected from monitoring wells. Sample locations are identified on **Figure 2-1**.

In this section, analytical data for the sampled media (from both the 2000 /2001 and 2004/2005 sampling events) are compared to EPA risk screening criteria. Groundwater data are screened against EPA RBCs, MCLs, MCLGs, and Secondary MCLs. Surface water data are screened using Maryland and federal water quality criteria and EPA Region III BTAG Freshwater Screening Benchmarks. Sediment data are compared to EPA Region III BTAG Freshwater Sediment Benchmarks. Soil data are screened against EPA RBCs for residential and industrial soils. The soil data is also screened against the EPA Region III SSLs with a dilution attenuation factor (DAF) of 20. A DAF of 20 was selected because there are no groundwater users on or adjacent to the site, and the source areas (if any) are less than half an acre. This initial screening using these criteria is only intended to assign significance to the analytical data and is not an analysis of risk or impacts. Although the site is currently an industrial site, comparison against EPA RBCs for residential soils are also made to address regulator comments about the potential for future residential use of the site.

In all data tables in Section 4.0, only those contaminants detected are presented. The EPA RBCs (residential soil, industrial soil, and tap water) were selected for comparison in the data tables presented in Section 4. Detections that exceeded their respective EPA RBCs have been highlighted for presentation and consistency purposes in all the tables in Section 4.

Analytical results are provided in the tables at the end of Section 4. **Table 4-5** provides the surface soil analytical results, **Table 4-6** the subsurface soil analytical results, **Table 4-7** the sediment analytical results, **Table 4-8** the surface water analytical results, **Table 4-9** the DPT groundwater analytical results, and **Table 4-10** the monitoring well groundwater results. Blank cells in **Tables 4-5 through 4-10** indicate that analysis was not performed for that compound or element. Cells with a "-" for the regulatory screening levels indicates that no screening criteria is available for that compound or element.

Data qualifiers were applied to the data by the contract laboratories and the data validators. The data qualifiers that appear in the tables in Section 4 are defined as follows:

2000/2001 Data Qualifiers	**2004/2005 Data Qualifiers**
J - Estimated concentration	J - Estimated concentration
B - Detected in associated QC blank	B - indicates an estimated concentration for inorganics
U - Concentration below PQL	B - Detected in associated QC blank for organics
UL - Not detected	U - Concentration below PQL
K - Estimated value, may be biased high	UJ - Element or compound not detected
N - Tentative identification	E - Concentration detected exceeded calibration range of instrument
R - Unreliable result	N - Tentative identification
L - Estimated value, may be biased low	R - Unreliable result.
E - Concentration detected exceeded calibration range of instrument	
P - For organics: For dual column analysis, the percent difference between the quantitated concentrations on the two columns is greater than 40%	
P - For inorganics: Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP)	

Data summary tables presenting the results and non-detects for all parameters are provided in Appendices C through F in the QCS/AR Report.

Detailed risk assessments, which characterize and evaluate human and environmental health risks based on detected contaminant concentrations and probable exposure pathways, are provided in Section 6.0 and Section 7.0.

4.3.1 Surface Soils

Surface soil samples were collected from 78 locations at the site with samples collected from approximately 0.0 ft to 2.5 ft bgs. DPT surface soil sampling was conducted at 54 locations (29 locations in 2000/2001 and 25 locations in 2004/2005). Surface soil samples were also collected using a HSA drilling rig and split spoon samplers from eight monitoring well construction locations at the site during the 2000/2001 sampling event. Hand auger surface soil samples were collected at six locations across the site during the 2000/2001 sampling event. Additional hand auger surface soil samples were also collected from ten electrical transformer locations at the LOC parcel during the 2000/2001 sampling event. The electrical transformer data include seven pole-mounted transformers and three pad-mounted transformers located throughout the site.

The surface soil samples were analyzed off-site for a combination of VOCs, SVOCs, pesticides, PCBs, and total metals. The specific analyses performed on each sample are provided in Table 2-2. All electrical transformer surface soil samples were analyzed for PCBs only. Seven duplicate samples were collected and analyzed for the same parameters as the field samples.

The soil samples were collected to assess the lateral and vertical extent of surface soil contamination. **Table 4-5** provides the analytical results for the surface soil samples collected at the site. In this table, and all other data tables in Section 4.0, only those contaminants detected are presented. Data summary tables presenting the results and non-detects for all parameters are provided in Appendices C through F in the QCS/AR Report. Additionally, the EPA Region III RBC Criteria for industrial soil and residential soil are presented for comparison purposes. The EPA Region III SSLs for soil migration to groundwater with a DAF of 20 are also provided for comparison.

The concentrations of analytes detected above the EPA RBCs in surface soils is presented on **Figure 4-1,** provided at the end of Section 4.

4.3.1.1 VOCs

Analytical Results

Six VOCs, including acetone, benzene, methylene chloride, PCE, toluene, and total xylenes were detected in the surface soil samples collected at the site. Detection frequencies and range of concentrations for each VOC detected in the surface soil samples are provided below:

			TBC (ug/kg)		
Compound	**Frequency of Detection**	**Concentration Range (ug/kg)**	**EPA SSLs**	**EPA RBC Industrial**	**EPA RBC Residential**
Acetone	19 / 54	7.5JB - 120	2.20E+04	9.20E+08	7.00E+07
Benzene	2 / 54	5J - 11J	1.90E+00	5.20E+04	1.20E+04
Methylene chloride (Dichloromethane)	8 / 54	3J - 15	1.90E+01	3.80E+05	8.50E+04
Tetrachloroethene (PCE)	5 / 54	3.1J - 15	4.70E+00	5.30E+03	1.20E+03
Toluene	2 / 54	4.6J - 8.7	8.80E+03	2.00E+08	1.60E+07
Xylenes, Total	2 / 54	8.5J - 9.2J	3.00E+03	2.00E+08	1.60E+07

- Exceedances of EPA Industrial RBC

- Exceedances of EPA Residential RBC

No VOCs were detected above their respective EPA RBCs for residential or industrial soil. Benzene was detected in two surface soil samples, and both benzene detections were above the EPA SSLs. PCE was detected in five surface soil samples, and four of the detections were above the EPA SSLs.

Four samples were collected as surface soil duplicates and are not included in the above table; however, the duplicates are included on **Table 4-5**. It should be noted that several VOC detections were at estimated concentrations lower than the practical quantitation limit (PQL) but

greater than the method detection limit (MDL) and therefore, if concentrations had exceeded the MDLs for these compounds, results were reported with a "J" flag as an estimated concentration.

Nature and Extent of Contamination

Six VOCs, including acetone, methylene chloride, benzene, toluene, xylenes, and PCE, were detected at various locations in the surface soils. Acetone, methylene chloride, and toluene are common laboratory contaminants and were detected at concentrations at least three orders of magnitude below the EPA RBC risk screening criteria for residential soils.

PCE was detected in five surface soil samples at concentrations ranging from 3.1 µg/kg to 15 µg/kg. The detected concentrations of PCE are well below the EPA RBC criteria for industrial soil, but above the EPA SSLs. During the 2000/2001 sampling event, PCE was detected in DPT-13 (in the Former DRMO at Building 61) and DPT/GW-5 (in the Former Commissary Warehouse Area at Building 36), and during the 2004/2005 sampling event PCE was detected in SS-19 (in the TMP at Building 72A), SS-28, and SS-29 (adjacent to the Electrical Substation and Tractor Trailer Storage Areas). The source of the PCE detections in these areas is unknown; however, PCE is a common cleaning solvent which may have been used or stored in the Former DRMO, including Building 61.

VOCs associated with petroleum compounds (i.e., benzene, toluene, and xylenes) were detected in the surface soils at four different locations below the corresponding EPA RBC screening levels. However, the two benzene detections were above the EPA SSLs. Benzene and toluene were detected in sample SB02-DPT/GW-02 (adjacent to Building 15 and the former UST), toluene and xylene were detected in sample SB16-DPT-02 (in the Former DRMO near Building 70A), xylene was detected at location SB04-DPT/GW-02 (in the Warehouse Area between Buildings 28 and 29), and benzene was detected in AOC-SS-29 (adjacent to the Electrical Substation and Tractor Trailer Storage Areas). With the exception of the Electrical Substation and Tractor Trailer Storage Areas, USTs were formerly located near where the petroleum compounds were detected. SS-29 is located along the access road to the Electrical Substation adjacent to the Tractor Trailer Storage Area which is frequently traveled by large trucks.

Due to the limited number of VOC detections and relatively low concentrations, no discernable distribution pattern can be identified for VOCs in surface soils. However, all VOC detections are located in areas with previous industrial activity (i.e., warehouses, electrical substation, and former DRMO).

4.3.1.2 SVOCs

Analytical Results

Seventeen SVOCs were detected in the surface soil samples collected at the site. Detection frequencies and range of concentrations for each semivolatile organic compound (SVOC) detected in the surface soil samples are provided below:

SVOCs	Frequency of Detection	Concentration Range (ug/kg)	TBC (ug/kg) EPA SSLs	EPA RBC Industrial	EPA RBC Residential
Anthracene	4 / 54	59J - 200J	4.70E+05	3.10E+08	2.30E+07
Benzo(a) anthracene	4 / 54	120J - 570	1.50E+03	3.90E+03	8.70E+02
Benzo(b) fluoranthene	4 / 54	120J - 950	4.50E+03	3.90E+03	8.70E+02
Benzo(g,h,i) perylene	2 / 54	130J - 470	-	-	-
Benzo(a) pyrene	5 / 54	32 - 540	3.70E+02	3.90E+02	8.70E+01
Benzyl Butyl Phthalate	1 / 54	96J - 96J	8.10E+04	1.50E+06	3.40E+05
1,1- Biphenyl	6 / 11	39 - 180J	9.60E+04	5.10E+07	3.90E+06
bis(2-Ethylhexyl) phthalate	17 / 54	92J - 2300	2.90E+06	2.00E+05	4.60E+04
Caprolactam	2 / 11	140 - 310J	-	5.10E+08	3.90E+07
Chrysene	5 / 54	74J - 810	1.50E+05	3.90E+05	8.70E+04
Dibenzofuran	4 / 54	79J - 140J	3.80E+03	2.00E+06	1.60E+05
Di-n-butyl phthalate	8 / 54	50J - 720	5.00E+06	1.00E+08	7.80E+06
Fluoranthene	6 / 54	54J - 960	6.30E+06	4.10E+07	3.10E+06
Indeno (1,2,3-cd) pyrene	3 / 54	100J - 410	1.30E+04	3.90E+03	8.70E+02
Naphthalene	4 / 54	93J - 560	1.50E+02	2.00E+07	1.60E+06
Phenanthrene	6 / 54	180J - 900	-	-	-
Pyrene	7 / 54	85J - 1100J	6.80E+05	3.10E+07	2.30E+06

- Exceedance of EPA Industrial RBC

- Exceedance of EPA Residential RBC

Benzo(b)fluoanthene was detected above the EPA RBC for residential soil, and benzo(a)pyrene was detected above the EPA RBCs for residential and industrial soils. Benzo(a)pyrene was also detected above the EPA SSL. Napthalene was also detected above the EPA SSL. No other SVOCs exceeded their respective screening criteria in the surface soils.

Four samples were collected as surface soil duplicates and are not included in the above table; however, the duplicates are included on **Table 4-5**. It should be noted that several VOC detections were at estimated concentrations lower than the PQL but greater than the MDL and therefore, if concentrations had exceeded the MDLs for these compounds, results were reported with a “J” flag as an estimated concentration.

Nature and Extent of Contamination

Seventeen SVOCs were detected in surface soils during analysis. SVOC detections were confined to nine sample locations which are located in parking lots, along paved access roads, or along Rock Avenue. Most of the SVOCs detected are polycyclic aromatic hydrocarbons (PAHs) which are ubiquitous in the environment and may be associated with vehicle exhaust, roadway runoff, etc. Phthalates were detected in a number of samples and may be at least partially attributable to the presence of plasticizers in investigation equipment (e.g., disposable gloves) and lab contamination.

4.3.1.3 PCBs

Analytical Results

Two PCBs, Aroclor-1248 and Aroclor-1260, were detected in the surface soil samples collected at the site. Detection frequencies and range of concentrations for each SVOC detected in the surface soil samples are provided below:

			TBC (ug/kg)		
Compound	**Frequency of Detection**	**Concentration Range (ug/kg)**	**EPA SSLs**	**EPA RBC Industrial**	**EPA RBC Residential**
Aroclor-1248	1 / 64	50 - 50	-	1.40E+03	3.20E+02
Aroclor-1260	2 / 64	63J - 720	-	1.40E+03	3.20E+02

- Exceedance of EPA Industrial RBC

- Exceedance of EPA Residential RBC

Aroclor-1248 was detected in only one of 64 samples at concentrations below the screening criteria. Aroclor-1260 was detected in 2 of 64 surface soil samples collected at the site at concentrations of 63 µg/kg and 720 µg/kg. The higher Aroclor-1260 detection exceeds the EPA RBC for residential soil but does not exceed the EPA RBC for industrial soil. No PCBs exceeded the EPA SSLs.

Four samples were collected as duplicates and are not included in the above discussion; however, the duplicates are included on **Table 4-5**. It should be noted that the lower Aroclor-1260 detection was an estimated concentration lower than the PQL but greater than the MDL and therefore, if the concentration had exceeded the MDLs for this compound, the result was reported with a "J" flag as an estimated concentration.

Nature and Extent of Contamination

The PCB detections were confined to three sample locations (SB07-DPT-02, SB08-DPT-02, and SS05-POL-01) in the Suspected Fill Area, Tractor Trailer Storage Area, and at an electrical transformer. Aroclor-1260 was the only PCB detected at one of the electrical transformer locations (SS05-POL-01). The PCB detections were identified during the 2000/2001 sampling event, and no PCB detections were identified during the 2004/2005 sampling event which included sample locations in the vicinity of SB07-DPT-02 and SB08-DPT-02. Thus, the PCB detections in surface soil are isolated and no distribution pattern can be identified.

4.3.1.4 Pesticides

Analytical Results

Six pesticides were detected in the surface soil samples collected at the site. Detection frequencies and range of concentrations for each pesticide detected in the surface soil samples are provided below:

			TBC (ug/kg)		
Compound	**Frequency of Detection**	**Concentration Range (ug/kg)**	**EPA SSLs**	**EPA RBC Industrial**	**EPA RBC Residential**
4,4'-DDT	7 / 54	1.9J - 790J	1.20E+03	8.40E+03	1.90E+03
4,4'-DDE	7 / 54	0.42J - 290	3.50E+04	8.40E+03	1.90E+03
4,4'-DDD	4 / 54	0.98J - 20J	1.10E+04	1.20E+04	2.70E+03
alpha-Chlordane	2 / 43	0.35JP - 26	9.20E+02	8.20E+03	1.80E+03
Endrin ketone	1 / 54	1.1JP - 1.1JP	-	-	-
Methoxy chlor	3 / 54	0.72JP - 9.2JP	3.10E+05	5.10E+06	3.90E+05

- Exceedance of EPA Industrial RBC

- Exceedance of EPA Residential RBC

No pesticides were detected above the EPA RBCs for industrial soil, residential soil, and the EPA SSLs in the surface soil samples collected at the site.

Four samples were collected as duplicates and are not included in the above table; however, the duplicates are included on **Table 4-5**. It should be noted that several pesticide detections were at estimated concentrations lower than the PQL but greater than the MDL and therefore, if concentrations had exceeded the MDLs for these compounds, results were reported with a "J" flag as an estimated concentration.

Nature and Extent of Contamination

Pesticides were detected in surface soil at 11 different sampling locations. The locations with the highest concentrations are located within the Commissary Warehouse Area (Building 36), the Area West of Rogue Harbor Branch, the Electrical Substation Area, the Tractor Trailer Storage Area, Former Railroad Bed, and the area north of Rock Avenue. These sampling areas consisted of grassy areas near buildings or roads, utility right-of-ways through wooded areas, and access roads through wooded areas. All these areas represent typical areas where pesticides may have been applied to control insects and other pests (i.e., Commissary Warehouse) or as part of a multi-purpose herbicide/pesticide to control unwanted vegetation growth and insects.

Samples AOC-31, AOC-32, and AOC-33 were collected during the 2004/2005 sampling event surrounding the 2000/2001 sampling location of SB05-DPT/GW. Surface soil samples collected from all 4 of these locations had pesticide detections below the screening criteria. It is unknown what was stored in Building 36 after it was used as a commissary warehouse, so it is unknown if pesticides were ever stored in Building 36. The pesticide detections at Building 36 may have resulted from pesticide storage in Building 36 or from pesticide applications surrounding the building.

With the exception of the samples collected around Building 36, no specific distribution pattern is discernable from the data.

4.3.1.5 Inorganics

Analytical Results

Twenty-three metals were detected in the surface soil samples collected at the site. Detection frequencies and range of concentrations for each metal detected in the surface soil samples are provided below:

			TBC (mg/kg)		
Metals (mg/kg)	**Frequency of Detection**	**Concentration Range (mg/kg)**	**EPA SSLs**	**EPA RBC Industrial**	**EPA RBC Residential**
Aluminum	60 / 60	110 - 7580	-	1.00E+06	7.80E+04
Antimony	14 / 60	0.048B - 1.2J	1.30E+01	4.10E+02	3.10E+01
Arsenic	62 / 66	0.42J - 89	2.60E-02	1.90E+00	4.30E-01
Barium	61 / 61	0.85J - 73	2.10E+03	7.20E+04	5.50E+03
Beryllium	40 / 61	0.015J - 2.5	1.20E+03	2.00E+03	1.60E+02
Cadmium	19 / 61	0.02 - 0.49J	5.50E+01	1.00E+03	7.80E+01
Calcium	59 / 61	5.6L - 4490N	-	-	-
Chromium	61 / 61	1.3 - 24.4J	4.20E+01	3.10E+03	2.30E+02
Cobalt	54 / 61	0.1J - 16	-	2.00E+04	1.60E+03
Copper	61 / 61	0.63L - 37	1.10E+04	4.10E+04	3.10E+03
Iron	61 / 61	590 - 78000	-	3.10E+05	2.30E+04
Lead	64 / 64	0.39L - 118	-	1.71E+03	4.00E+02
Magnesium	59 / 61	40J - 4180	-	-	-
Manganese	61 / 61	1 - 498	9.50E+02	2.00E+04	1.60E+03
Mercury	41 / 61	0.0044 - 0.23	-	1.00E+02	7.80E+00
Nickel	53 / 61	0.13J - 23.3	-	2.00E+04	1.60E+03
Potassium	59 / 61	31J - 448BN	-	-	-

			TBC (mg/kg)		
Metals (mg/kg)	**Frequency of Detection**	**Concentration Range (mg/kg)**	**EPA SSLs**	**EPA RBC Industrial**	**EPA RBC Residential**
Selenium	8 / 61	0.13J - 0.55L	1.90E+01	5.10E+03	3.90E+02
Silver	1 / 61	0.032J - 0.032J	3.10E+01	5.10E+03	3.90E+02
Sodium	16 / 61	1.8J - 260	-	-	-
Thallium	2 / 61	0.052J - 1.2L	3.60E+00	7.20E+01	5.50E+00
Vanadium	59 / 61	1.7 - 23.6	7.30E+02	1.00E+03	7.80E+01
Zinc	61 / 61	0.32K - 78.3J	1.40E+04	3.10E+05	2.30E+04

- Exceedance of EPA Industrial RBC

- Exceedance of EPA Residential RBC

Arsenic and iron were detected at concentrations greater than the EPA RBC for residential soil. Arsenic was also detected at concentrations greater than the EPA RBC for industrial soil. Arsenic was also detected above the EPA SSLSeven samples were collected as duplicates and are not included in the above table; however, the duplicates are included on **Table 4-5**. It should be noted that several inorganic detections were at estimated concentrations lower than the PQL but greater than the MDL and therefore, if concentrations had exceeded the MDLs for these compounds, results were reported with a “J”, “K”, “L”, or “B” flag as an estimated concentration.

Nature and Extent of Contamination

Arsenic and iron exceeded the residential EPA RBCs at most locations across the site. Arsenic was the only metal that exceeded the industrial EPA RBC. With the exception of arsenic and lead, the metals concentrations remain fairly consistent across the site, and no discernable patterns can be identified.

Arsenic exceeded the residential RBC at all but 6 of the 66 locations. The highest concentrations of arsenic (89 mg/kg, 61.8 mg/kg, 33.4 mg/kg, and 8.1 mg/kg) were detected along former railroad beds. The high detections are of concern but appear to be isolated to areas along the former railroad beds (the next highest detect was not along the former railroad [7.1 mg/kg]). The highest arsenic concentration (89 mg/kg) was detected at DPT-11 during the 2000/2001 sampling event. During the 2004/2005 sampling event samples additional samples were collected surrounding DPT-11 and along other sections of the former railroad bed. Arsenic concentrations in the surface soil collected at DPT-25 and DPT -27, located adjacent to DPT-11, were 33.4 mg/kg and 61.8 mg/kg, respectively. These samples are located along an elevated former railroad bed adjacent to Rogue Harbor Branch. Arsenic concentrations downgradient from the elevated bed were 3.3 mg/kg at DPT-26, and the arsenic concentration on the elevated railroad bed on the opposite shore of Rogue Harbor Branch was 3.4 mg/kg. Thus, the detections at DPT-11, DPT-25, and DPT-27 may represent the presence of arsenic “hot spots” associated with the former railroad activities. Potential historic activities, such as the use of arsenical herbicides to control vegetation in the rail alignment or the installation of arsenic-treated railroad ties likely contributed to the detected concentrations.

Surface soil samples were collected along the drip lines of four buildings in the Warehouse Area (SS-36, SS-37, SS-41, and SS42) to determine if lead paint from the buildings was adversely impacting the surrounding soils. Lead was detected in samples SS-36, SS-37, SS-41, and SS-42 ranging from 3.9 mg/kg to 82.6 mg/kg which are at levels below the screening criteria. Therefore, although lead paint may have been used on the warehouses due to their age, lead paint contamination in soil does not appear to be of concern in this area. Other elevated lead concentrations were detected in SS-32 (28.7 mg/kg in the drip line of Building 36), SB07-HSA-02 (85 mg/kg along Rock Avenue), and SS-29 (118 mg/kg) and DPT-8 (55 mg/kg) near the Electrical Substation.

The Reference Levels of Metals and Trace Elements in Soil, as reported in the MDE Cleanup Standards for Soil and Groundwater, provides Anticipated Typical Concentration (ATC) for metals in soil for the region in MD where the site is located. FGGM is located in the Eastern Maryland province as defined by MDE. The ATCs for Eastern Maryland for the metals in the surface soil that exceed the EPA RBCs are provided in the table below.

Analyte	Eastern Maryland ATC (mg/kg)
Arsenic	3.6E+00
Iron	1.5E+04

Based on comparison of the site analytical data to the MDE ATC for Eastern Maryland, the metals that exceeded the screening criteria discussed above would also exceed the ATC. However, the metals detections and exceedances are all within an order of magnitude of the ATC.

4.3.2 Subsurface Soil

Subsurface soil samples were collected from 56 soil boring locations at the site with samples collected at one or two depths. DPT subsurface soil sampling was conducted at 12 soil borings with samples collected at two depths. DPT subsurface soil sampling was conducted at 36 borings with samples collected at one depth. Subsurface soil samples were collected using a HSA drilling rig and split spoon samplers at eight monitoring well installation locations with samples collected at two depths. **Table 4-6** provides the analytical results for the subsurface soil samples collected at the site. Additionally, the EPA Region III RBC Criteria for industrial soil and residential soil are presented for comparison purposes. The EPA Region III SSLs for soil migration to groundwater with a DAF of 20 are also provided for comparison. The concentrations of analytes detected above the EPA RBCs in subsurface soils are presented on **Figure 4-2,** provided at the end of Section 4.

The subsurface soil samples were analyzed off-site for a combination of VOCs, SVOCs, pesticides, PCBs, and total metals. The specific analyses performed on each sample are provided in **Table 2-2**. Ten duplicate samples were collected and analyzed for the same parameters as the field samples.

4.3.2.1 VOCs

Analytical Results

Fourteen VOCs were detected in the subsurface soil samples collected at the site. Detection frequencies and range of concentrations for each VOC detected in the subsurface soil samples are provided below:

			TBC (ug/kg)		
Compound	**Frequency of Detection**	**Concentration Range (ug/kg)**	**EPA SSLs**	**EPA RBC Industrial**	**EPA RBC Residential**
Acetone	18 / 76	10 - 150	2.20E+04	9.20E+08	7.00E+07
Bromomethane	1 / 76	8.9 - 8.9	4.10E+01	1.40E+06	1.10E+05
2-Butanone (MEK)	3 / 63	20J - 22J	2.90E+04	6.10E+08	4.70E+07
Carbon disulfide	4 / 76	4.3J - 30	1.90E+04	1.00E+08	7.80E+06
Cyclohexane	1 / 12	610J - 610J	-	-	-
Ethylbenzene	7 / 76	51 - 2300	1.50E+04	1.00E+08	7.80E+06
Isopropylbenzene	2 / 12	200E - 960J	6.40E+04	1.00E+08	7.80E+06
Methylcyclohexane	2 / 12	140 - 2800J	-	-	-
Methylene chloride (Dichloromethane)	7 / 76	3.5J - 8.9	1.90E+01	3.80E+05	8.50E+04
m,p-Xylenes	2 / 12	180 - 1700J	3.00E+03	2.00E+08	1.60E+07
Toluene	1 / 76	1.9J - 1.9J	8.80E+03	2.00E+08	1.60E+07
1,2,4-Trichlorobenzene	1 / 12	5.3 - 5.3	2.80E+02	1.00E+07	7.80E+05
Vinyl Chloride	1 76	8.9 - 8.9	-	4.00E+03	9.00E+01
Xylenes, Total	5 / 76	11 - 7400	3.00E+03	2.00E+08	1.60E+07

- Exceedance of EPA Industrial RBC

- Exceedance of EPA Residential RBC

No VOCs were detected in subsurface soil above the residential or industrial EPA RBCs. However, total xylenes were detected above the EPA SSLs. Methylcyclohexane was detected in two samples and no screening criteria are available, and cyclohexane was detected inone sample and no screening criteria are available.

Ten samples were collected as duplicates and are not included in the above table; however, the duplicates are included on **Table 4-6**. It should be noted that several VOC detections were at estimated concentrations lower than the PQL but greater than the MDL and therefore, if concentrations had exceeded the MDLs for these compounds, results were reported with a “J” flag as an estimated concentration.

Nature and Extent of Contamination

VOCs associated with petroleum compounds (ethylbenzene, toluene, and xylenes) were detected in the subsurface soils at concentrations below the corresponding EPA RBC screening levels. The VOCs associated with petroleum compounds were detected in a total of ten samples collected at 9 different locations. The highest concentrations were detected in the Warehouse Area. Boring DPT/GW-2 and DPT/GW-39 are adjacent to Building 15, at the site of a former UST. Xylene and ethylbenzene were detected at both depths (11 and 15 ft bgs) in DPT/GW-2 and at both depths (5 and 8 Ft bgs) in DPT/GW-39. Ethylbenzene and xylene detections exceeded the EPA SSLs, but only at DPT/GW-2 and DPT/GW-39, and only at depths of 15 ft bgs and 8 ft bgs, respectively. Several other VOCs, including acetone, bromomethane, carbon disulfide, cyclohexane, isopropylbenzene, methylcyclohexane, methylene chloride, 1,2,4-trichlorobenzene and vinyl chloride were detected in DPT/GW-39 during the 2004/2005 sampling event. Xylene was also detected at location DPT/GW-1, the location of the former recovery well structure, at a depth of 18 ft bgs. These compounds were also detected at the Electrical Substation, Former DRMO, Gravel Fill Area, and adjacent to Rock Avenue. A monitoring well (NW-9) was installed at the Former DRMO DPT location during the 2001 field event. The detections of xylene and ethylbenzene at these locations, excluding the Gravel Fill Area (DPT-17) are likely associated with former operations involving petroleum compounds (USTs) and are located in the associated runoff locations. The source of the gravel fill and the history of that area are unknown, so the source of the ethylbenzene detection at DPT-17 is unknown.

Vinyl chloride and 1,2,4-trichlorobenzene were only detected in one sample, DPT/GW-39, as discussed above. Vinyl chloride was detected at 5 ft bgs and 1,2,4-trichlorobenzene was detected at 8 ft bgs.

Acetone and methylene chloride are common laboratory contaminants and were detected at concentrations at least four orders of magnitude below the risk screening criteria for residential soils. With the exception of the locations discussed above, acetone and methylene chloride detections are not considered to represent contamination at the site.

Due to the limited VOC detections, no discernable distribution pattern (besides the petroleum compounds at Building 15) can be identified. However, all VOC detections are located in areas with previous industrial activity (i.e., warehouses, electrical substation, and former DRMO).

4.3.2.2 SVOCs

Analytical Results

Fifteen SVOCs were detected in the DPT subsurface soil samples collected at the site. Detection frequencies and range of concentrations for each SVOC detected in the subsurface soil samples are provided below:

				TBC (ug/kg)		
Compound	**Frequency of Detection**	**Concentration Range (ug/kg)**		**EPA SSLs**	**EPA RBC Industrial**	**EPA RBC Residential**
Anthracene	1 / 76	5300J - 5300J		4.70E+05	3.10E+08	2.30E+07
Benzo(g,h,i) perylene	1 / 76	170J - 170J		-	-	-
1,1- Biphenyl	2 / 13	4900 - 9000		9.60E+04	5.10E+07	3.90E+06
bis(2-Ethyl hexyl)phthalate	24 / 76	62J - 2900		2.90E+06	2.00E+05	4.60E+04
Butylbenzyl-phthalate	1 / 76	600 - 600		8.10E+04	1.50E+06	3.40E+05
Dibenzo(a,h) anthracene	1 / 76	240J - 240J		1.40E+03	3.90E+02	8.70E+01
Dibenzofuran	2 / 76	210J - 4100J		3.80E+03	2.00E+06	1.60E+05
3,3'-Dichloro benzidine	1 / 76	690 - 690		4.90E+00	6.40E+03	1.40E+03
di-n-Butyl Phthalate	5 / 76	50J - 220J		5.00E+06	1.00E+08	7.80E+06
Di-n-octyl phthalate	1 / 76	400 - 400		4.90E+09	4.10E+07	3.10E+06
Fluoranthene	1 / 76	1900J - 1900J		6.30E+06	4.10E+07	3.10E+06
Fluorene	4 / 76	220J - 6300		1.40E+05	4.10E+07	3.10E+06
2-Methyl naphthalene	4 / 76	710 - 31000		4.40E+03	4.10E+06	3.10E+05
Naphthalene	3 / 76	1600 - 6100J		1.50E+02	2.00E+07	1.60E+06
N-Nitroso-di-n-propylamine	1 / 76	46 - 46		4.70E-02	4.10E+02	9.10E+01

- Exceedance of EPA Industrial RBC

- Exceedance of EPA Residential RBC

Dibenzo(a,h)anthracene exceeded the residential soil EPA RBC. No other SVOCs exceeded the residential EPA RBCs, and no SVOCs exceeded the industrial EPA RBCs. However, several SVOCs were detected above the EPA SSLs. Dibenzofuran, 3,3'-dichlorobenzidine, 2-methylnapthalene, naphthalene, and N-nitroso-di-n-propylamine were detected at concentrations above their respective EPA SSLs. .

Ten samples were collected as duplicates and are not included in the above table; however, the duplicates are included on **Table 4-6**. It should be noted that several SVOC detections were at estimated concentrations lower than the PQL but greater than the MDL and therefore, if concentrations had exceeded the MDLs for these compounds, results were reported with a "J" flag as an estimated concentration.

Nature and Extent of Contamination

Four phthalates were detected in a number of samples and may be at least partially attributed to the presence of plasticizers in disposable gloves, lab contamination, etc.

Most of the SVOCs detected are polycyclic aromatic hydrocarbons (PAHs). The detected PAHs included anthracene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, fluorene, and fluoranthene. The PAH and 2-methylnapthalene and naphthalene detections are confined to sample locations DPT-17, DPT/GW-2, and DPT/GW-39. Borings DPT/GW-2 and DPT/GW-39 are in the location of a former UST adjacent to Building 15, and PAHs were detected at two boring depths in each boring and are likely related to the UST use. DPT-17 is located in the Gravel Fill Area and detections are limited to one depth.

Due to the limited SVOC detections, no discernable distribution pattern can be identified with the exception of the former UST at Building 15. However, all SVOC detections are located in areas with previous industrial activity or disturbances (i.e., Warehouse Area, Gravel Fill Area, and Former DRMO).

4.3.2.3 Pesticides

Analytical Results

Pesticides were detected in the subsurface soil samples collected at the site. Detection frequencies and range of concentrations for each pesticide detected in the subsurface soil samples are provided below:

			TBC (ug/kg)		
Compound	**Frequency of Detection**	**Concentration Range (ug/kg)**	**EPA SSLs**	**EPA RBC Industrial**	**EPA RBC Residential**
4,4'-DDD	1 / 76	1.1J - 2.2J	1.10E+04	1.20E+04	2.70E+03
4,4-DDT	1 / 76	5.5 - 5.5	1.20E+03	8.40E+03	1.90E+03
Endosulfan I	1 / 76	0.22JP - 0.22JP	2.00E+04	6.10E+06	4.70E+05
Methoxychlor	2 / 76	20 - 22	3.10E+05	5.10E+06	3.90E+05
Toxaphene	2 / 76	200 - 200	6.30E+02	2.60E+03	5.80E+02

- Exceedance of EPA Industrial RBC
- Exceedance of EPA Residential RBC

Of the five pesticides detected in the subsurface soil samples (DDD, DDT, endosulfan I, methoxylchlor, and toxaphene), none were detected above the screening criteria.

Ten samples were collected as duplicates and are not included in the above table; however, the duplicates are included on **Table 4-6**. It should be noted that several pesticide detections were at estimated concentrations lower than the PQL but greater than the MDL and therefore, if concentrations had exceeded the MDLs for these compounds, results were reported with a “J” flag as an estimated concentration.

Nature and Extent of Contamination

Pesticide detections were confined to five locations. The locations are at the Warehouse Area, Former DRMO, Tractor-trailer Storage Area, Gravel Fill Area, and west of Rogue Harbor Branch. The sample west of Rogue Harbor Branch had pesticide detections at two depths (11 and 15 ft bgs). No specific distribution patterns are discernible for pesticides in subsurface soils.

4.3.2.4 PCBs

Aroclor-1248 was detected in one subsurface soil sample at the suspected fill area (DPT-7) during the 2000/2001 sampling event at a concentration of 320 µg/kg. No PCBs were detected in the subsurface soil sample collected at DPT/GW-30, located near DPT-7, during the 2004/2005 sampling event. The detected Aroclor-1248 concentration is below the industrial EPA RBC (1,400 µg/kg) but equals the residential EPA RBC (320 µg/kg). Due to the isolated PCB detection, no distribution pattern is discernable.

4.3.2.5 Inorganics

Analytical Results

Twenty-three metals were detected in the DPT subsurface soil samples collected at the site. Detection frequencies and range of concentrations for each metal detected in the subsurface soil samples are provided below:

			TBC (mg/kg)		
Compound	**Frequency of Detection**	**Concentration Range (mg/kg)**	**EPA SSLs**	**EPA RBC Industrial**	**EPA RBC Residential**
Aluminum	74 / 84	112J - 7710N	-	1.00E+06	7.80E+04
Antimony	7 / 84	0.062B - 47.6	1.30E+01	4.10E+02	3.10E+01
Arsenic	66 / 85	0.13J - 11	2.60E-02	1.90E+00	4.30E-01
Barium	71 / 84	0.53J - 39	2.10E+03	7.20E+04	5.50E+03
Beryllium	38 / 84	0.013J - 17.1	1.20E+03	2.00E+03	1.60E+02
Cadmium	18 / 84	0.047J - 0.33J	5.50E+01	1.00E+03	7.80E+01
Calcium	60 / 84	2.4J - 13800N	-	-	-
Chromium	72 / 84	1.5 - 58.8J	4.20E+01	3.10E+03	2.30E+02
Cobalt	52 / 84	0.07J - 6.6		2.00E+04	1.60E+03
Copper	72 / 84	0.92L - 92.8J	1.10E+04	4.10E+04	3.10E+03
Iron	74 / 84	7.2 - 22200	-	3.10E+05	2.30E+04
Lead	69 / 84	0.16J - 5220	-	1.71E+03	4.00E+02
Magnesium	62 / 84	3.9 - 2000K	-	-	-
Manganese	67 / 84	1K - 229	9.50E+02	2.00E+04	1.60E+03
Mercury	41 / 82	0.0048 - 0.032	-	1.00E+02	7.80E+00
Nickel	57 / 84	0.12J - 38.2	-	2.00E+04	1.60E+03
Potassium	70 / 84	27J - 680	-	-	-
Selenium	4 / 84	0.16B - 0.51L	1.90E+01	5.10E+03	3.90E+02
Silver	2 / 84	0.084J - 0.2B	3.10E+01	5.10E+03	3.90E+02
Sodium	19 / 84	1.2J - 150	-	-	-
Thallium	1 / 84	0.22J - 0.22J	3.60E+00	7.20E+01	5.50E+00
Vanadium	68 / 84	1.3 - 54	7.30E+02	1.00E+03	7.80E+01
Zinc	62 / 84	0.64 - 161J	1.40E+04	3.10E+05	2.30E+04

- Exceedance of EPA Industrial RBC
- Exceedance of EPA Residential RBC

Antimony, arsenic, and lead were detected in the subsurface soil at concentrations that exceeded the residential EPA RBCs. Arsenic and lead also exceeded the industrial EPA RBCs. No other metals exceeded their respective EPA RBCs for residential or industrial soil; however, several metals were detected above the EPA SSLs. Antimony, arsenic, and chromiumwere detected at concentrations above the the EPA SSLs.

Ten samples were collected as duplicates and are not included in the above table; however, the duplicates are included on **Table 4-6**. It should be noted that several inorganic detections were at estimated concentrations lower than the PQL but greater than the MDL and therefore, if concentrations had exceeded the MDLs for these compounds, results were reported with a “J”, “N”, and “K” flag as an estimated concentration.

Nature and Extent of Contamination

Arsenic exceeded the residential and industrial EPA RBCs at most sampling locations across the site. Antimony exceeded the residential EPA RBC at one location (DPT29). However, the metals concentrations remain fairly consistent across the site, and no discernable patterns can be identified.

Sixty-two of the 66 arsenic detections exceeded the residential EPA RBC. Arsenic was detected at a maximum concentration of 11 mg/kg in DPT/GW-1. The locations with arsenic exceedances are scattered throughout the site; however, the samples with the highest detections are located along former railroad beds. The locations with the highest surface soil detections (DPT-11, DPT-25, and DPT-27) also had detections in the subsurface soil. If the arsenic is not attributed to former railroad activities, it may be attributable to background concentrations. However, potential historic activities, such as the use of arsenical herbicides to control vegetation in the rail alignment and/or the use of arsenic preserved railroad ties, also could have contributed to the detected concentrations.

Concentrations of lead in the subsurface soil exceeded the residential EPA screening level for lead (400 mg/kg) at two locations (3,350 mg/kg at DPT/GW-29 and 5,220 mg/kg at DPT-33). Both subsurface soil samples were collected from a depth of 6 ft bgs. DPT-33 is located along the drip line of Building 36 in the Commissary Warehouse Area and DPT/GW is located along an access road to the Electrical Substation. An elevated lead level of 28.7 mg/kg was detected in the surface soil at DPT-32 which is adjacent to DPT-33 and also in the drip line of Building 36. Therefore, although lead paint may have been used on the Building 36 (due to its age), lead paint contamination in subsurface soil appears to be isolated.

The remaining metals were detected at various locations throughout the site at varying concentrations and varying depths. No distribution pattern is discernible for the other detected metals.

The ATCs for Eastern Maryland for the metals in the subsurface soil that exceed the EPA RBCs are provided in the table below.

Analyte	Eastern Maryland ATC (mg/kg)
Antimony	6.0E+00
Arsenic	3.6E+00
Lead	5.2E+01

Based on a comparison of the subsurface soil data to the MDE ATC for Eastern Maryland, the metals that exceeded the screening criteria discussed above would also exceed the ATC. However, the metals detections and exceedances are all within an order of magnitude of the ATC. With the exception of arsenic and lead in various locations, the detected metals are likely to be naturally occurring.

4.3.3 Sediment

Sediment samples were collected from three locations in Rogue Harbor Branch during the 2000 sampling event. One sediment sample was obtained from the most upstream portion of Rogue Harbor Branch, one from a mid-point in the stream, and one from the most downstream portion within the LOC parcel. Each sediment sample was analyzed for VOCs, SVOCs, pesticides, PCBs and metals.

Table 4-7 provides the analytical results for the sediment samples collected at the site. Only those contaminants detected are presented in the table. Additionally, the EPA Region III BTAG Freshwater (FW) Sediment Screening Benchmarks are presented for comparison purposes. The concentrations of analytes detected above the EPA Freshwater Sediment BTAG Screening Benchmarks in sediment are presented on **Figure 4-3,** provided at the end of Section 4.

4.3.3.1 VOCs

Acetone was the only VOC detected in sediment, and the detected concentrations were much lower than the EPA Region III BTAG FW Sediment Screening Benchmarks. Acetone is also a common laboratory contaminant and is, therefore, not evaluated further.

4.3.3.2 SVOCs

Bis(2-ethylhexyl)phthalate was the only SVOC detected in sediment, and the detected concentrations were much lower than the EPA Region III BTAG FW Sediment Screening Benchmarks. It was also detected in the method blanks and is qualified “B,” denoting a false positive due to laboratory contamination; therefore, it is not evaluated further.

4.3.3.3 Pesticides

Six pesticides (alpha-chlordane, gamma-chlordane, DDD, DDE, DDT, and endrin aldehyde) were detected in the sediment samples. The following table provides a summary of the concentration range and frequency of detection:

Pesticides (ug/kg)	Frequency of Detection	Concentration Range (ug/kg)	TBC (ug/kg) EPA FW Sediment BTAG
alpha-Chlordane	2 / 3	0.42J - 0.72J	100
gamma-Chlordane	2 / 3	0.67J - 0.95J	100
DDD	1 / 3	0.84J - 0.84J	0.011
DDE	2 / 3	0.54J - 1.1J	2.2
DDT	1 / 3	0.52J - 0.52J	1.58
Endrin aldehyde	1 / 3	0.33J - 0.33J	-

- Exceedance of EPA FW Sediment BTAG

Chlordane (alpha and gamma), DDE, and DDT were detected in several samples but at concentrations below the screening criteria. DDD was detected above the EPA Region III BTAG FW Sediment Screening Benchmarks in one sample (RHB-UPR). Endrin aldehyde was detected in one sediment sample; however, a BTAG screening value for endrin aldehyde is not available.

Concentrations in the upstream sample (RHB-UPR) were generally higher than the concentrations in the middle and lower branch samples indicating no discernable contribution from the LOC parcel.

4.3.3.4 PCBs

No PCBs were detected in sediment samples.

4.3.3.5 Inorganics

Analytical Results

Fifteen inorganics (aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, vanadium, and zinc) were detected in the sediment samples. The following table provides a summary of the concentration range and frequency of detection:

Total Metals (ug/l)	Frequency of Detection	Concentration Range (mg/kg)	TBC (mg/kg) EPA FW Sediment BTAG
Aluminum	3 / 3	400 - 1400K	87
Arsenic	3 / 3	0.87L - 1.2L	5
Barium	3 / 3	3.3 - 13	4
Beryllium	2 / 3	0.14 - 0.24K	0.66
Cadmium	3 / 3	0.031J - 0.16J	0.25
Chromium	3 / 3	1.6 - 4.9	
Cobalt	3 / 3	0.49J - 3.3	23
Copper	3 / 3	1.8J - 6.6	9
Iron	3 / 3	1500 - 2800	300
Lead	3 / 3	3.1 - 10	2.5
Manganese	3 / 3	9.9 - 50	82000
Mercury	2 / 3	0.0098 J - 0.015 J	0.1
Nickel	3 / 3	0.74J - 3.5J	52
Vanadium	3 / 3	2.2 - 5.9	20
Zinc	3 / 3	4.9 - 26	120

- Exceedance of EPA FW Sediment BTAG

Aluminum, barium, iron, and lead were above the EPA Region III BTAG Freshwater Sediment Screening Benchmarks.

It should be noted that several inorganic detections were at estimated concentrations lower than the PQL but greater than the MDL and therefore, if concentrations had exceeded the MDLs for these compounds, results were reported with a “J” flag as an estimated concentration.

Nature and Extent of Contamination

For most metals, the concentrations downstream (RHB-LWR) generally increased with respect to the upstream samples (RHB-MID and RHB-UPR), indicating a potential contribution from the LOC parcel. Rogue Harbor Branch is a small stream that runs through the site. Sediment present in the stream may originate from erosion of site soils along the stream bank and transport and deposition of site soils via storm run-off or wind.

The elevated concentrations of iron detected in the sediment are consistent with the elevated concentrations of iron detected in surface soil, subsurface soil, and groundwater throughout the site. The concentrations of aluminum detected in surface soil and subsurface soil surrounding Rogue Harbor Branch are consistent with the aluminum concentrations detected throughout the site; however, elevated concentrations of aluminum were detected in the total metals samples for groundwater collected upgradient of the site and surrounding Rogue Harbor Branch. No elevated concentrations of barium or lead were detected in the soil or groundwater samples surrounding Rogue Harbor Branch. Based on these results and since potential site sources can

not be differentiated from potential upgradient sources, a correlations between the elevated metals in the sediment and the surrounding soils can not be made conclusively.

4.3.4 Surface Water

Surface water samples were collected from three locations in Rogue Harbor Branch from the same locations as the sediment samples during the 2000 sampling event. One surface water sample was obtained from the most upstream portion of Rogue Harbor Branch, one from a mid-point in the stream, and one from the most downstream portion within the LOC parcel. All surface water samples were analyzed off-site for VOCs, SVOCs, pesticides, PCBs and total metals.

Table 4-8 provides the analytical results for the surface water samples collected at the site. Additionally, the Maryland Ambient Water Quality Criteria screening levels, National Water Quality Criteria, and EPA Region III RBC BTAG FW Screening Benchmarks are presented for comparison purposes. The concentrations of analytes detected above the EPA FW BTAG Screening Benchmarks in surface water are presented on **Figure 4-4,** provided at the end of Section 4.

4.3.4.1 VOCs

No VOCs were detected in the surface water collected at this site.

4.3.4.2 SVOCs

No SVOCs were detected in the surface water collected at this site.

4.3.4.3 Pesticides

No pesticides were detected in surface water collected at the site.

4.3.4.4 PCBs

No PCBs were detected in the surface water collected at the site.

4.3.4.5 Inorganics

Analytical Results

Twelve inorganics (aluminum, barium, beryllium, chromium, cobalt, copper, iron, lead, manganese, nickel, vanadium, and zinc) were detected in the surface water samples. The following table provides a summary of the concentration range and frequency of detection:

			ARARs (ug/L)				TBC (ug/L)
			Maryland and National Surface Water Standards				
			Aquatic Life Freshwater		Human Health for Consumption of:		
Total Metals (ug/l)	**Frequency of Detection**	**Concentration Range (ug/L)**	**Acute**	**Chronic**	**Drinking Water/Organism**	**Organism Only**	**EPA FW BTAG**
Aluminum	3 / 3	24J - 2900		-	-	-	87
Barium	3 / 3	67 - 90			2000	-	4
Beryllium	1 / 3	0.22 J - 0.22 J			4	-	0.66
Chromium	1 / 3	5.9J - 5.9J	16	11	100	-	85
Cobalt	3 / 3	1.0J - 5.9J		-	-	-	23
Copper	1 / 3	4.5 - 4.5	13	9	1,300	-	9
Iron	3 / 3	1300 - 8200		-	-	-	300
Lead	1 / 3	13 - 13	65	2.5	-	-	2.50
Manganese	3 / 3	200 - 390		-	-	-	120
Nickel	1 / 3	3.2J - 3.2J	470	52	610	44,600	52
Vanadium	3 / 3	8.6J - 8.6J		-	-	-	20
Zinc	3 / 3	1.7J - 43	120	120	7,400	26,000	120

- Exceedance of EPA Freshwater BTAG

Aluminum, barium, iron, lead, and manganese concentrations were greater than the EPA BTAG FW Screening Benchmarks, which is consistent with the exceedances identified for freshwater sediments.

One sample was collected as a duplicate and is not included in the above table, but is included on **Table 4-8**. It should be noted that several inorganic detections were at estimated concentrations lower than the PQL but greater than the MDL and therefore, if concentrations had exceeded the MDLs for these compounds, results were reported with a "J" flag as an estimated concentration.

Nature and Extent of Contamination

Most metals were detected in all surface water samples. Concentrations varied for each metal with distance downstream from the site. However, detected concentrations were greatest at RHB-MID, potentially indicating a contribution of metals from the LOC parcel.

The elevated concentrations of iron detected in the surface water are consistent with the elevated concentrations of iron detected in surface soil, subsurface soil, and groundwater throughout the site above the EPA screening criteria. The concentrations of aluminum detected in surface soil and subsurface soil surrounding Rogue Harbor Branch are consistent with the aluminum concentrations detected throughout the site; however, elevated concentrations of aluminum were detected in the total metals samples for groundwater collected upgradient of the

site and surrounding Rogue Harbor Branch. No elevated concentrations of barium, lead, or manganese were detected in the soil or groundwater samples surrounding Rogue Harbor Branch. Based on these results and since potential site sources can not be differentiated from potential upgradient sources, a correlation between the elevated metals in the surface water and the surrounding soils and/or groundwater can not be made conclusively.

4.3.5 Groundwater

During the 2000 sampling event, groundwater samples were collected from eight DPT locations at the site. All 2000 DPT groundwater samples were analyzed for VOCs, SVOCs, pesticides, PCBs, and total and dissolved metals with the exception of GW05-DPT and GW07-DPT which were not analyzed for dissolved metals due to a laboratory error. During the 2004/2005 sampling event, groundwater samples were collected from ten DPT locations at the site. Two DPT groundwater samples from 2004/2005 (AOC-GW-21 and AOC-GW-24) were only analyzed for VOCs, and the remaining eight samples were analyzed for VOCs, SVOCs, pesticides, PCBs, and total and dissolved metals. **Table 4-9** provides a summary of the analytical results for the DPT groundwater samples. The concentrations of analytes detected above the EPA RBC for tap water in DPT groundwater samples are presented on **Figure 4-5,** provided at the end of Section 4.

Groundwater samples were collected from a total of 16 monitoring wells at the site. The groundwater data include the data from 7 monitoring wells installed in 2000 (NW-1, NW-2, and NW-4 through NW-8), the four monitoring wells installed in March of 2001 at locations (NW-9, NW-10, NW-11, and NW-12), two monitoring wells installed in December 2004 (NW-13 and NW-14), and three existing wells (EW-2, EW-3 and MW-7). During the 2000/2001 sampling event, groundwater samples were collected form NW-1, NW-2, NW-4 through NW-12, and EW-3. During the 2004/2005 sampling event, groundwater samples were collected from NW-1, NW-2, NW-4 through NW-14, EW-2, EW-3, and MW-7. All monitoring well groundwater samples were analyzed for VOCs, SVOCs, pesticides, PCBs, and total and dissolved metals with the exception of MW-7 which was only analyzed for VOCs. **Table 4-10** provides a summary of the analytical parameters and results for the monitoring well groundwater samples collected at the site. Additionally, the EPA MCLs, Maryland Groundwater Cleanup Criteria, and EPA Region III RBC Criteria for Tap Water are provided for comparison purposes. The concentrations of analytes detected above the EPA RBC for tap water in monitoring well groundwater samples are presented on **Figure 4-6,** provided at the end of Section 4.

4.3.5.1 VOCs

DPT Analytical Results

Nine VOCs were detected in the DPT groundwater samples collected at the site. Detection frequencies and range of concentrations for each VOC detected in the DPT groundwater samples are provided below:

			ARARs (ug/L)		TBC (ug/L)
Parameters	**Frequency of Detection**	**Concentration Range (ug/L)**	**EPA MCLs**	**EPA MCLGs**	**EPA RBC III for Tap Water**
VOCs (ug/L)					
Acetone	10 / 18	7.1J - 19	-	-	5.50E+03
Benzene	1 / 18	4.3J - 4.3J	5	0	3.40E-01
Ethylbenzene	2 / 18	570 - 570	700	700	1.30E+03
Isopropylbenzene	1 / 10	430J - 430J	-	-	6.60E+02
Methylcyclohexane	1 / 10	460J - 460J	-	-	6.30E+03
m,p-Xylenes	1 / 10	620 - 620	10000	10000	2.10E+02
Tetrachloroethylene	3 / 18	1.2 - 17	5	0	1.00E-01
Toluene	1 / 18	2.6J - 2.6J	1000	1000	7.50E+02
Xylenes, Total	1 / 18	240 - 240	10000	10000	2.10E+02

- Exceedance of EPA RBC III for Tap Water

Benzene was detected in one sample greater than the EPA RBC for tap water, but less than the EPA MCLPCE was detected in four DPT groundwater samples greater than the EPA RBC for tap water. One PCE detections also exceeded the EPA MCL. Total xylenes and m,p-xylenes were each detected in one DPT sample below the EPA MCL for tap water but above the EPA RBC.

Trichloroethylene (TCE) was detected at a concentration of 2.8 µg/l, which is greater than the EPA RBC for tap water but less than the EPA MCL. The TCE detection and three toluene detections are classified "R" for unreliable result. Since supporting data is not available to confirm the results, these detections are not evaluated further.

One sample was collected as a duplicate and is not included in the above table; however, the duplicates are included on **Table 4-9**. It should be noted that several VOC detections were at estimated concentrations lower than the PQL but greater than the MDL and therefore, if concentrations had exceeded the MDLs for these compounds, results were reported with a "J" flag as an estimated concentration.

Monitoring Well Analytical Results

Thirteen VOCs were detected in the monitoring well groundwater samples collected at the site. Detection frequencies and range of concentrations for each VOC detected in the monitoring well groundwater samples are provided below:

Parameters	Frequency of Detection	Concentration Range (ug/L)	ARARs (ug/L) EPA MCLs	ARARs (ug/L) EPA MCLGs	TBC (ug/L) EPA RBC III for Tap Water
VOCs (ug/L)					
Benzene	1 / 28	8.6 - 8.6	5	0	3.40E-01
2-Butanone	5 / 28	3.7J - 10J	-	-	7.00E+03
Carbon Tetrachloride	2 / 28	1.8J - 21J	5	0	1.60E-01
Chloroform	1 / 28	2.3J - 2.3J	-	-	1.50E-01
Cyclohexane	1 / 16	1.5J - 1.5J	-	-	1.20E+04
Ethylbenzene	3 / 28	12 - 12	700	700	1.30E+03
Isopropylbenzene	2 / 16	1.4J - 1.5J	-	-	6.60E+02
Methylcyclohexane	1 / 16	1.1J - 1.1J	-	-	6.30E+03
Methylene Chloride	2 / 28	1.5 - 10	-	-	4.10E+00
m,p-Xylenes	1 / 16	6.2 - 6.2	10,000	10,000	2.10E+02
o-Xylene	1 / 16	4.2J - 4.2J	10,000	10,000	2.10E+02
MTBE	1 / 16	26 - 26	-	-	2.60E+00
Tetrachloroethene	1 / 28	2.6 - 2.6	5	0	1.00E-01

- Exceedance of EPA RBC III for Tap Water

Benzene, chloroform, MTBE, and PCE were each detected in one monitoring well groundwater sample at concentrations above their respective EPA RBC for tap water. Carbon tetrachloride was detected in two monitoring well samples at concentrations above the EPA RBC for tap water. 2-Butanone (five detections), cyclohexane (one detection), ethylbenzene (three detections), isopropylbenzene (two detections), methylcyclohexane (one detection), m,p-xylenes (one detection), and o-xylenes (one detection) were all detected below the screening criteria. Methylene chloride was detected in two groundwater monitoring well samples, and it exceeds the EPA RBC at one location (NW-8).

Four samples were collected as duplicates and are not included in the above table; however, the duplicates are included on **Table 4-10**. It should be noted that several VOC detections were at estimated concentrations lower than the PQL but greater than the MDL and therefore, if concentrations had exceeded the MDLs for these compounds, results were reported with a "J" flag as an estimated concentration.

Nature and Extent of Contamination

Benzene, cyclohexane, ethylbenzene, isopropylbenzene, methylcyclohexane, methylene chloride, m,p-xylenes, o-xylene, and MTBE were all detected at monitoring well EW-2 which is located in the current gas station at the TMP. This well was not sampled during the 2000/2001 sampling event because it was believed that a sample would not be representative based on conditions of the well. These adverse conditions (cracked well cap and unsealed flush-mounted well cover) still existed in 2004/2005, but a sample was still collected to address regulator comments. Therefore, these results are not expected to be representative of the site-wide groundwater, but rather conditions local to EW-2. This is assumption is supported by the

fact that the groundwater sample obtained from AOC-GW-18 (located within 10 feet of EW-2) only had detections of acetone and toluene, which were both below the screening criteria.

Ethylbenzene, isopropylbenzene, methylcyclohexane, and m,p-xylenes were detected in the DPT groundwater sample at AOC-GW-39 which is located at the location of the former UST adjacent to Building 15. This sample is co-located with GW02-DPT which also had detections of benzene, isopropylbenzene, and total xylenes. Ethylbenzene was also detected at GW01-LOC in the TMP, south of the gas station. These detections may represent the presence of "hot spots" associated with the former fuel storage/dispensing and related activities.

PCE was detected at four sample locations (NW-10, GW13-DPT, AOC-GW-30 and AOC-GW-35). GW13-DPT is located west of Rogue Harbor Branch. NW-10, AOC-GW-30 and AOC-GW-35 are located in the undeveloped area west of the AOC book storage facility, in the Gravel Fill Area and Suspected Fill Area. The source of the gravel fill and suspected fill are unknown, and the source of the PCE detections in these areas is unknown as well. However, PCE was historically used as a common cleaning solvent, and its detection is consistent with industrial activities, such as those conducted at FGGM.

The carbon tetrachloride and chloroform detected in the southwestern corner of the site in monitoring wells MW-7 and NW-4 can be attributed to the carbon tetrachloride contamination discussed in Section 1.2.5.3. The source of the carbon tetrachloride plume is unknown, and it may be located outside the LOC parcel.

Acetone, 2-butanone, and methylene chloride are considered common laboratory contaminants, and with the exception of AOC-GW-39 (discussed above), are not considered to represent contamination at the site. No site-wide pattern is discernable for the remaining VOC detections (isopropylbenzene) because the other VOC detections are isolated.

4.3.5.2 SVOCs

DPT Analytical Results

Eight SVOCs were detected in the DPT groundwater samples collected at the site. Detection frequencies and range of concentrations for each SVOC detected in the DPT groundwater samples are provided below:

			ARARs (ug/L)		TBC (ug/L)
Parameters	**Frequency of Detection**	**Concentration Range (ug/L)**	**EPA MCLs**	**EPA MCLGs**	**EPA RBC III for Tap Water**
SVOCs (ug/L)					
Acenaphthene	1 / 16	5.2J - 5.2J	-	-	3.70E+02
1,1- Biphenyl	1 / 8	260E - 260E	-	-	3.00E+02
bis(2-Ethylhexyl)phthalate	3 / 16	.63J - 67J	6	0	4.80E+00
Caprolactam	7 / 8	46 - 320E	-	-	1.80E+04
Fluorene	1 / 16	8.2J - 8.2J	-	-	2.40E+02
2-Methylnaphthalene	2 / 16	200 - 1300E	-	-	2.40E+01
Phenanthrene	2 / 16	9.4J - 300E	-	-	-
Pyrene	1 / 16	40 - 40	-	-	1.80E+02

- Exceedance of EPA RBC III for Tap Water

Bis(2-Ethylhexyl)phthalate and 2-methylnapthalene were detected above the EPA RBC screening criteria for tap water. Bis(2-ethylhexyl)phthalate was also detected above the EPA MCL.

One sample was collected as a duplicate and is included in the above table and on **Table 4-9**. It should be noted that several SVOC detections were at estimated concentrations lower than the PQL but greater than the MDL and therefore, if concentrations had exceeded the MDLs for these compounds, results were reported with a "J" flag as an estimated concentration. It is also noted that several SVOC detections were detected at concentration that exceeded the calibration range of the instrument and are reported with a "E" flag as an estimated concentration.

Monitoring Well Analytical Results

Nine SVOCs were detected in the monitoring well groundwater samples collected at the site. Detection frequencies and range of concentrations for each SVOC detected in the monitoring well groundwater samples are provided below:

Parameters	Frequency of Detection	Concentration Range (ug/L)	ARARs (ug/L) EPA MCLs	ARARs (ug/L) EPA MCLGs	TBC (ug/L) EPA RBC III for Tap Water
SVOCs (ug/L)					
1,1- Biphenyl	1 / 15	12J - 12J	-	-	3.00E+02
bis(2-ethylhexyl) phthalate	3 / 27	2.1 - 3.8J	6	0	4.80E+00
Caprolactam	2 / 15	1.5J - 1.6	-	-	1.80E+04
Carbazole	1 / 27	3.6J - 3.6J	-	-	3.30E+00
2,4-Dimethylphenol	1 / 27	3.9J - 3.9J	-	-	7.30E+02
Diethyl Phthalate	1 / 27	60 - 60	-	-	2.90E+04
Dimethyl Phthalate	1 / 27	5.6J - 5.6J	-	-	3.70E+05
2-Methylnaphthalene	3 / 27	6.2J - 20	-	-	2.40E+01
Naphthalene	3 / 27	9.9J - 18	-	-	6.50E+00

- Exceedance of EPA RBC III for Tap Water

Carbazole and naphthalene were detected above the EPA RBC screening criteria for tap water.

Four samples were collected as duplicates and are included in the above table and on **Table 4-10**. It should be noted that several SVOC detections were at estimated concentrations lower than the PQL but greater than the MDL and therefore, if concentrations had exceeded the MDLs for these compounds, results were reported with a "J" flag as an estimated concentration.

Nature and Extent of Contamination

Acenapthene, fluorene, phrenanthene, and 2-Methylnaphthalene were detected at DPT/GW-2 during the 2000/2001 sampling event, and all were below the EPA RBCs. 1,1'-Biphenyl, phrenanthene, 2-Methylnaphthalene, and pyrene were detected at AOC-GW-39 during the 2004/2005 sampling event, and was all were below the EPA RBC. AOC-GW-39 and DPT/GW-2 are co-located at the location of a former UST adjacent to Building 15. The concentrations detected at AOC-GW-39 in 2004 were greater than the concentrations detected at DPT/GW-2 in 2000/2001. Naphthalene was also detected at NW-1 above the EPA RBCs located in the TMP south of the Building 72A during both sampling events. Carbazole was also detected above the EPA RBC for tap water at NW-1 during the 2004/2005 sampling event. EW-2 is located within the active gas station at the TMP, and 2,4-dimethylphenol and bis(2-ethylhexyl) phthalate were detected below the EPA RBC at EW-2 during the 2004/2005 sampling event.

Caprolactam was detected in several samples during the 2004/2005 sampling event, and all detections were below the EPA RBCs.

Phthalates were detected in a number of samples and may be at least partially attributed to the presence of plasticizers in disposable gloves and lab contamination.

No site-wide pattern is discernable for SVOC contamination because the SVOC detections are not confined to a specific area of concern. However, petroleum products are currently or were formerly stored at Building 15, Building 72A, and the TMP. These detections may represent the presence of "hot spots" associated with the former fuel storage/dispensing and related activities.

4.3.5.3 Pesticides

No pesticides were detected in the DPT groundwater samples. Two pesticides (gamma-chlordane and heptachlor epoxide) were detected in the monitoring well samples collected at the site, and both were detected in monitoring well GW12-LOC. Gamma-chlordane was detected at a concentration of 0.009 µg/l, which is lower than the screening criteria. Heptachlor epoxide was detected at a concentration of 0.012 µg/l, which is greater than the EPA RBC for tap water of 0.0074 µg/l, but less than the EPA MCL of 0.20 µg/l. GW12-LOC is located adjacent to Building 20 in the warehouse area. The sampling area consisted of a grassy, vegetated area north of the former railroad bed.

4.3.5.4 PCBs

No PCBs were detected in the DPT or monitoring well groundwater samples.

4.3.5.5 Inorganics

DPT Analytical Results

Twenty-two metals were detected in DPT groundwater samples. The following table provides a summary of the concentration range and frequency of detection:

					ARARs (µg/L)		TBC (µg/L)
Parameters	**Frequency of Detection (Total)**	**Concentration Range (Total) (µg/l)**	**Frequency of Detection (Dissolved)**	**Concentration Range (Dissolved) (µg/l)**	**EPA MCLs/MCLGs**	**EPA Secondary MCLs**	**EPA RBC III for Tap Water**
Aluminum	16 / 16	1090 - 23100	6 / 14	10.6J - 1150	-	50 - 200	3.70E+04
Antimony	7 / 16	0.061 - 13.4	9 / 14	0.8 - 8.5J	6	-	1.50E+01
Arsenic	13 / 16	0.59J - 68	6 / 14	3.7L - 25.2	10/-	-	4.50E-02
Barium	16 / 16	9.4 - 174	14 / 14	14 - 190	2,000	-	2.60E+03
Beryllium	10 / 16	0.12B - 8.2	6 / 14	0.0043J - 0.66	4	-	7.30E+01
Cadmium	10 / 16	0.2 - 4J	3 / 14	0.58J - 1.8J	5	-	1.80E+01
Calcium	16 / 16	2100N - 180000	14 / 14	8400 - 180000	-	-	-
Chromium	14 / 16	5.8N - 400	0 / 14	0 - 0	100	-	1.10E+02
Cobalt	12 / 16	1.4 - 53.3	10 / 14	0.77 - 15.3	-	-	7.30E+02
Copper	12 / 16	5.5N - 360	0 / 14	0 - 0	1,300	1,000	1.50E+03
Iron	16 / 16	540J - 144000	13 / 14	384E - 71000	-	300	1.10E+04
Lead	14 / 16	1.8B - 246	2 / 14	2.1 - 2.7	15/0	-	1.50E+01
Magnesium	16 / 16	200 - 13000	14 / 14	1710 - 11000	-	-	-
Manganese	16 / 16	9.6 - 900	14 / 14	54 - 1100	-	50	7.30E+02
Mercury	2 / 16	0.21 - 0.3	0 / 14	0 - 0	2	-	3.70E+00
Nickel	13 / 16	2.3J - 30.6	9 / 14	0.1 - 35	-	-	7.30E+02
Potassium	16 / 16	140 - 14000	14 / 14	841B - 8400	-	-	-
Selenium	8 / 16	0.15 - 9.2L	4 / 14	0.15J - 1.4J	50	-	1.80E+02
Sodium	15 / 16	4760 - 490000	14 / 14	4440 - 470000	-	-	-
Vanadium	15 / 16	7.7J - 420	0 / 14	0 - 0	-	-	3.70E+01
Zinc	15 / 16	5.6E - 12000	12 / 14	7.8K - 7300	-	5,000	1.10E+04

- Exceedance of EPA RBC III for Tap Water

Total antimony, arsenic, beryllium, chromium, iron, lead, manganese, vanadium, and zinc exceeded the EPA RBCs or MCLs in the DPT groundwater samples. Dissolved antimony, arsenic, iron, and manganese were detected at concentrations above the EPA RBCs or MCLs in the DPT groundwater samples. For chromium and vanadium, the total concentrations were greater than the EPA RBCs or MCLs, but the dissolved values were below detection limits. Since the dissolved metals analysis values for these two constituents were below detection, the concentration of these compounds is most likely associated with suspended solids in the sample and is not present in groundwater in a dissolved state. The concentrations of total beryllium and zinc detected above the EPA RBCs were detected below the screening criteria in the dissolved analysis. Antimony, arsenic, iron, and manganese were detected above the EPA RBCs or MCLs in both the total and dissolved samples.

One sample was collected as a duplicate and is included in the above table and on **Table 4-9**. It should be noted that several inorganic detections were at estimated concentrations lower than the PQL but greater than the MDL and therefore, if concentrations had exceeded the MDLs for these compounds, results were reported with a "J", "L", or "B" flag as an estimated concentration.

Monitoring Well Analytical Results

					ARARs (µg/l)		TBC (µg/l)
Parameters	**Frequency of Detection (Total)**	**Concentration Range (Total) (µg/l)**	**Frequency of Detection (Dissolved)**	**Concentration Range (Dissolved) (µg/l)**	**EPA MCLs/MCLGs**	**EPA Secondary MCLs**	**EPA RBC III for Tap Water**
Aluminum	25 / 27	39.9 - 25400J	18 / 27	16J - 8260J	-	50 - 200	3.70E+04
Antimony	9 / 27	0.065 J - 1.2	3 / 27	0.063J - 0.095J	6		1.50E+01
Arsenic	14 / 27	2.8J - 63.2	7 / 27	1.9J - 15.4	10/-	-	4.50E-02
Barium	27 / 27	19 - 237	27 / 27	18 - 168	2,000	-	2.60E+03
Beryllium	16 / 27	0.21 - 8.8	15 / 27	0.028J - 8.8	4	-	7.30E+01
Cadmium	9 / 27	0.51 - 3.5	6 / 27	0.79J - 2	5	-	1.80E+01
Calcium	27 / 27	6110 - 49000	27 / 27	5840 - 46000	-	-	-
Chromium	22 / 27	5.1 - 235	11 / 27	1.4J - 51.3	100	-	1.10E+02
Cobalt	25 / 27	0.92 - 127	27 / 27	2 - 127	-	-	7.30E+02
Copper	18 / 27	6.8L - 144	12 / 27	1.2L - 129	1,300	1,000	1.50E+03
Iron	26 / 27	120 - 173000	22 / 27	13K - 32800	-	300	1.10E+04
Lead	12 / 27	2.4 - 38.6	4 / 27	2.1J - 6.8	15/0	-	1.50E+01
Magnesium	27 / 27	1200 - 10200	27 / 27	1200 - 12300	-	-	-
Manganese	27 / 27	21 - 575	27 / 27	13.2 - 716	-	50	7.30E+02
Mercury	5 / 26	0.11B - 0.3	2 / 27	0.1B - 0.22	2	-	3.70E+00
Nickel	26 / 27	1.9J - 261	26 / 27	1.2J - 2560	-	-	7.30E+02
Potassium	27 / 27	1780 - 7020	26 / 27	0.73J - 63200	-	-	-

					ARARs (µg/l)		TBC (µg/l)
Parameters	**Frequency of Detection (Total)**	**Concentration Range (Total) (µg/l)**	**Frequency of Detection (Dissolved)**	**Concentration Range (Dissolved) (µg/l)**	**EPA MCLs/MCLGs**	**EPA Secondary MCLs**	**EPA RBC III for Tap Water**
Selenium	13 / 27	0.3 - 4.5B	9 / 27	0.15 - 0.91J	50	-	1.80E+02
Silver	2 / 27	0.28B - 0.56	1 / 27	95700 - 95700	-	100	1.80E+02
Sodium	26 / 27	7300 - 120000	26 / 27	7800 - 120000	-	-	-
Thallium	0 / 27	0 - 0	1 / 27	0.072 - 0.072	2/0.5	-	2.60E+00
Vanadium	14 / 27	1.4J - 143J	6 / 27	1.4J - 26.7	-	-	3.70E+01
Zinc	26 / 27	6.6K - 197	21 / 27	5.7J - 197	-	5,000	1.10E+04

- Exceedance of EPA RBC III for Tap Water

Total arsenic, beryllium, chromium, iron, lead, and vanadium exceeded the EPA RBCs or MCLs in the groundwater monitoring well samples. Dissolved arsenic, beryllium, iron, nickel, and silver were detected at concentrations above the EPA RBCs or MCLs in the groundwater monitoring well samples. Arsenic, beryllium, and iron, were detected above the EPA RBCs or MCLs in both the total and dissolved samples. For chromium and vanadium, the total concentrations were greater than the EPA RBCs or MCLs, but the dissolved values were below the screening criteria. The concentrations of nickel and silver in the dissolved samples exceeded the EPA RBCs or MCLs, but the total metals concentrations for nickel and silver were below the screening criteria.Four samples were collected as a duplicate and are included in the above table and on **Table 4-10.** It should be noted that several inorganic detections were at estimated concentrations lower than the PQL but greater than the MDL and therefore, if concentrations had exceeded the MDLs for these compounds, results were reported with a “J”, “K”, or “B” flag as an estimated concentration.

Nature and Extent of Contamination

Dissolved thallium was detected in monitoring well NW-12 at the site, and its concentration (5.2 µg/l) was greater than the EPA MCL (2 µg/l)and the EPA RBC (0.26 µg/l). However, a thallium concentration of 7.6 µg/l was detected in the corresponding calibration blank. Therefore, the thallium detect in well GW12-LOC was rejected based on the blank detection as required by EPA Region III data validation guidance. In addition, thallium was not detected in the total sample from this well, further indicating the dissolved level was a false positive.

No discernible distribution pattern was indicated based on the dissolved groundwater data. Dissolved metals, some of which were detected above EPA RBCs, including arsenic, iron, nickel, and silver were detected throughout the site, but in no specific lateral pattern, indicating that these metals may be naturally occurring. Additionally, the presence of these dissolved metals at similar levels (with the exceptions discussed below) in the upgradient groundwater samples (NW-5, NW-6, and NW-7), supports the conclusion that the metals are naturally occurring. Since the presence of dissolved metals is likely naturally occurring, the data does not suggest the presence of a significant dissolved metals contaminant plume beneath the LOC site.

Total metals concentrations in the DPT groundwater samples and the monitoring well groundwater samples are comparable for most metals; however, concentrations in the total metals samples for the upgradient groundwater samples (NW-5, NW-6, and NW-7) are generally higher for specific total metals (aluminum, arsenic, chromium, and selenium).

Aluminum was detected at elevated concentrations in total metals for both DPT and monitoring well groundwater samples. However, dissolved aluminum was not detected at elevated levels in the DPT groundwater samples. This indicates that the elevated total aluminum concentrations in the DPT groundwater samples are from suspended solids. The dissolved aluminum concentrations in the upgradient monitoring well groundwater samples (NW-5, NW-6, and NW-7) were similar to the total metals concentrations in those monitoring wells and remained generally higher than the aluminum concentrations detected on site; thus, indicating a potential off-site source for the elevated aluminum concentrations.

Additionally, elevated metals concentrations (i.e., arsenic and iron) were detected in the surface soil and subsurface soil throughout the site. Based on these results and since potential site sources can not be differentiated from potential upgradient sources, a correlation between these elevated metals in the site groundwater and the surrounding soils can not be made conclusively.

Section 4 Tables

Table 4-1: ARARs and TBCs for Soil

Table 4-2: ARARs and TBCs for Sediment

Table 4-3: ARARs and TBCs for Surface Water

Table 4-4: ARARs and TBCs for Groundwater

Table 4-5: Surface Soil Analytical Results

Table 4-6: Subsurface Soil Analytical Results

Table 4-7: Sediment Analytical Results

Table 4-8: Surface Water Analytical Results

Table 4-9: DPT Groundwater Analytical Results

Table 4-10: Monitoring Well Groundwater Analytical Results

5 FATE AND TRANSPORT

This section provides a qualitative evaluation of contaminant fate and transport at the LOC parcel. Site physical characteristics, physical and chemical properties of the detected contaminants, and the nature and extent of contamination are discussed. A quantitative modeling effort was undertaken as part of this analysis.

A description of the issues to be discussed in each subsection is provided below:

- *Section 5.1* provides a general discussion of the mechanisms that influence the various contaminant transport pathways. Section 5.1 also identifies the physical and chemical properties of contaminants that control their environmental fate and transport.
- *Section 5.2* discusses the contaminant transport pathways that are applicable to the site.
- *Section 5.3* presents the conceptual fate and transport model developed for the site.
- *Section 5.4* discusses the specific transport mechanisms and pertinent physical and chemical properties of contaminants, where applicable, to support the site-specific conceptual fate and transport model.

5.1 TRANSPORT MECHANISMS AND CONTAMINANT PROPERTIES

The fate and transport of contaminants in the environment is influenced by the following mechanisms:

- **Adsorption/Desorption**. The process by which contaminant transport is retarded due to adsorption of contaminants to soil particles. Desorption is the reverse process of adsorption.
- **Advection**. The physical process by which contaminants are transported in solution at the average linear velocity of groundwater in the direction of groundwater flow.
- **Complexation**. The chemical process by which dissolved species are formed from two or more simpler dissolved species, each of which can exist in an aqueous solution.
- **Diffusion**. The chemical process that results in the movement of contaminants in response to concentration gradients.
- **Dispersion**. The mechanical process of mixing that results from local variations in the average velocity of groundwater.
- **Dissolution/Precipitation**. The chemical process by which a material is dissolved in a liquid solvent such as water. Precipitation is the reverse process of dissolution.
- **Ion Exchange**. The chemical process involving the reversible exchange of ions between a liquid and a solid.
- **Reduction/Oxidation**. A chemical reaction (redox reaction) involving changes in the oxidation states of elements.
- **Transformation**. The loss or degradation of contaminants from the environment as a result of chemical reactions or microbial activity.

- **Volatilization**. The transfer of contaminants from the liquid phase to the vapor phase (e.g., soil gas in unsaturated environments or the atmosphere).

The potential for a chemical to elicit an adverse human health or ecological effect depends upon the chemical's potential to migrate and persist in environmental media. Factors that influence chemical mobility include: the physical and chemical properties of a chemical, the physical characteristics of the environmental media, and the site chemistry. The following sections discuss the physical and chemical properties of organic and inorganic contaminants that influence the fate and transport mechanisms listed above.

5.1.1 Organic Contaminants

The organic compounds with the highest detected concentrations at the site were primarily volatile organics and semivolatile organics associated with petroleum contamination and sources of combustion, such as xylenes and PAHs. Benzo(a)anthracene, benzo(a)pyrene, and dibenzo(a,h)anthracene were detected above EPA RBCs; however, according to their log K_{oc} values these compounds are very immobile and therefore will not be discussed further in this section. While carbon tetrachloride, chloroform, toluene, PCE, naphthalene and 2-Methylnaphthalene were not detected in soils above action levels extracted from ARARs and TBCs, these contaminants were detected in groundwater samples at concentrations above the EPA Region III RBC Criteria for Tap Water. **Table 5-1** lists organic compounds detected at the LOC parcel (number of detects/number of samples). Of the detected volatile and semivolatile organics, naphthalene and 2-methylnaphthalene will be discussed further due to their detection at concentrations above ARARs and TBCs. Carbon tetrachloride, chloroform, toluene and PCE will also be discussed due to their detection at concentrations above EPA Region III RBC Criteria for Tap water.

Table 5-1: Organic Contaminant Detections by Media

Constituent	Soil	Sediment	Surface Water	Groundwater
VOCs (ug/kg)				
Acetone	37 / 130	2 / 3	-	11 / 46
Benzene	2 / 130	-	-	2 / 46
Bromomethane	1 / 130	-	-	4 / 46
2-Butanone	3 / 104	-	-	2 / 46
Carbon Disulfide	4/ 130	-	-	1 / 46
Carbon Tetrachloride	-	-	-	2 / 46
Chloroform	-	-	-	1 / 46
Cyclohexane	1 / 23	-	-	1 / 26
1,2-Dichloroethane	-	-	-	-
Ethylbenzene	7 / 130	-	-	4 / 46
2-Hexanone	-	-	-	-
Isopropylbenzene	2 / 23	-	-	3 / 26

Constituent	Soil	Sediment	Surface Water	Groundwater
Methycyclohexane	2 / 23	-	-	2 / 26
Methylene chloride	15 / 130	-	-	2 / 26
4-Methyl-2-pentanone	-	-	-	-
m,p-xylenes	2 / 23			2 / 26
Tert-butyl methyl ether	-	-	-	1 / 26
Tetrachloroethene	5 / 130	-	-	5 / 46
Toluene	3 / 130	-	-	2 / 46
1,2,4-Trichlorobenzene	1 / 23	-	-	-
Vinyl chloride	1 / 130	-	-	-
Xylenes	7 / 130	-	-	1 / 46
SVOCs (ug/kg)				
Acenaphthene	-	-	-	1 / 43
Anthracene	5 / 130	-	-	-
Benzo(a)anthracene	4 / 130	-	-	-
Benzo(a)pyrene	5 / 130	-	-	-
Benzo(b)fluoranthene	4 / 130	-	-	-
Benzo(g,h,i)perylene	3 / 130	-	-	-
Benzo(k)fluoranthene	-	-	-	-
Benzyl butyl phthalate	2 / 130	-	-	-
1,1'-Biphenyl	8 / 24			2 / 23
Bis(2-ethylhexyl)phthalate	41 / 130	2 / 3	-	6 / 43
Caprolactam	2 / 24	-	-	9 / 23
Carbazole	-	-	-	1 / 43
Chrysene	5 / 130	-	-	-
Dibenzo(a,h)anthracene	1 / 130	-	-	-
Dibenzofuran	6 / 130	-	-	-
3,3'-Dichlorobenzidine	1 / 130	-	-	-
Diethyl Phthalate	-	-	-	1 / 43
2,4-Dimethylphenol	-	-	-	1 / 43
Dimethyl Phthalate	-	-	-	1 / 43
Di-n-butylphthalate	13 / 130	-	-	-
2,4-Dinitrophenol	-	-	-	-

Constituent	Soil	Sediment	Surface Water	Groundwater
2,4-Dinitrotoluene	-	-	-	-
Di-n-octylphthalate	1 / 130	-	-	-
Fluoranthene	7 / 130	-	-	-
Fluorene	4 / 130	-	-	1 / 43
Indeno(1,2,3-cd)pyrene	3 / 130	-	-	-
2-Methylnaphthalene	4 / 130	-	-	5 / 43
Naphthalene	7 / 130	-	-	3 / 43
2-Nitroaniline	-	-	-	-
4-Nitroaniline	-	-	-	-
4-Nitrophenol	-	-	-	-
N-nitroso-d-propylamine	1 / 130	-	-	-
Phenanthrene	6 / 130	-	-	2 / 43
Pyrene	6 / 130	-	-	1 / 43
PCBs/Pesticides (ug/kg)				
PCBs	-	-	-	-
alpha-Chlordane	2 / 130	2 / 3	-	-
Aroclor 1248	2 / 140	-	-	-
Aroclor 1260	2 / 140	-	-	-
gamma-Chlordane	-	2 / 3	-	1 / 43
4,4'-DDD	5 / 130	1 / 3	-	-
4,4'-DDE	7 / 130	2 / 3	-	-
4,4'-DDT	8 / 130	1 / 3	-	-
Endrin ketone	1 / 130	-	-	-
Endrin aldehyde	-	1 / 3	-	-
Endosulfan I	1 / 130	-	-	-
Heptachlor epoxide	-	-	-	1 / 43
Methoxychlor	5 / 130	-	-	-
Toxaphene	2 / 130	-	-	-

As shown in **Table 5-1,** several pesticides were detected primarily in soil and sediment samples from Rogue Harbor Branch. Only DDT was detected above the EPA Residential RBCs in several surface soil samples. No pesticides were found at levels above screening criteria in sediment samples. The detected pesticides included: alpha- and gamma-chlordane, DDT and

its breakdown products (DDD and DDE), methoxychlor, endrin aldehyde, endrin ketone, heptachlor epoxide, and toxaphene. DDT, DDD, and DDE will be discussed further due to their frequency of detection in both surface soil and sediment.

One or more PCB congeners (Aroclors 1016, 1232, 1248, 1254 and 1260) were detected in five soil samples at concentrations ranging from 36 to 720 ug/kg. PCBs were not detected in sediment, surface water, or groundwater samples. Due to the infrequent detection of PCBs at concentrations below screening levels of concern and their relative immobility in soils, no discussion of the fate and transport characteristics of PCBs will be presented.

Table 5-2 presents a summary of some physical and chemical properties associated with organic compounds detected at the LOC parcel. The potential for chemical mobility and fate is determined by the chemical's properties and its interaction with the site's physical and chemical properties. Physical and chemical properties of organic compounds that affect mobility include:

- Vapor pressure (VP)
- Water solubility (S)
- Octanol/water partition coefficient (K_{ow})
- Organic carbon adsorption coefficient (sediment partition, K_{oc})
- Specific density
- Henry's law constant (K_h)
- Mobility index (MI)

Table 5-2: Chemical Properties of Organic Compounds

COMPOUNDS	CAS No.	Vp (mm Hg)	Sw (mg/L)	Log Kow	Log Koc (ml/g)	Spec. Density	Kh (atm x m^3/mol)	Mobility Description
VOLATILE ORGANIC COMPOUNDS (VOCs)								
Acetone	67-64-1	270	1,000,000	0.24	-0.24	0.7906	3.97E-05	EM
Benzene	71-43-2	7.60E+01	1784	2.13	1.77	0.88	5.43E-03	VM
Bromomethane	74-83-9	1.42E+03	0.0009	1.1	0.77	3.97	1.30E-02	VIM
2-Butanone	78-93-3	9.06E+01	136000	0.29	0.55	0.8054	5.77E-05	EM
Carbon Disulfide	75-15-0	2.60E+02	2940	1.84-2.16	1.66	1.2632	1.22E-02	EM
Carbon Tetrachloride	56-23-5	90	793	2.83	2.24	1.589	1.25E+00	SM
Chloroform	67-66-3	160	7920	1.97	1.60	1.484	1.50E-01	EM
1,2-Dichloroethane	75-45-6	4,279	2899	1.08	1.24	3.11	2.94E-02	EM
Ethylbenzene	67-66-3	160	8220	1.97	2.56	1.485	3.75E-03	SM
2-Hexanone	591-78-6	1.16E+01	20000-35000	1.38	NA	0.83	2.00E-03	NA
Methylene chloride	75-09-2	3.49E+02	20000	1.3	1.07	1.3182	2.00E-03	EM
4-Methyl-2-pentanone	123-42-2	8.00E-01	NA	NA	NA	0.94	NA	NA
PCE	127-18-4	14	150	2.6	2.42	1.623	1.53E-02	SM
Toluene	108-88-3	28.05	534.8	2.69	2.26	0.867	5.94E-03	SM

COMPOUNDS	CAS No.	Vp (mm Hg)	Sw (mg/L)	Log Kow	Log Koc (ml/g)	Spec. Density	Kh (atm x m^3/mol)	Mobility Description
Xylenes	1330-20-7	16-Jun	130	3.12-3.20	2.84	0.864	7.00E-03	IM
PESTICIDES/PCBs								
Chlordane (alpha & gamma)	5103-71-9	9.75E-06	0.056 - 0.10	8.69 - 9.65	3.49-4.64	1.63	1.34E-03	VIM
DDD	72-54-8	4.68E-06	0.020 - 0.090	5.061 - 6.217	6.00	1.476	2.16E-05	VIM
DDE	72-55-9	1.57E-05	0.04	5.69 - 6.956	6.65	NA	1.22E-03	VIM
DDT	50-29-3	1.70E-10	0.0012 - 0.0055	4.89 - 6.914	6.42	1.56	1.29E-05	VIM
Endrin aldehyde	72-20-8	2.00E-07	50	4.7	4.53	NA	2.90E-09	VIM
Endrin ketone	53494-70-5	NA	NA	NA	4.53	NA	NA	VIM
Heptachlor	76-44-8	4.00E-04	0.18	5.27	6.15	NA	1.48E-03	VIM
Heptachlor epoxide	1024-57-3	1.95E-05	0.2	5.4	4.92	NA	3.20E-05	VIM
Methoxychlor	50-29-3	1.70E-10	0.0012 - 0.0055	4.89 - 6.914	4.99	1.56	1.29E-05	VIM
Toxaphene	8001-35-2	5.00E-06	0.0003	3.3	5.41	1.65	2.10E-01	VIM
Aroclor 1016	12674-11-2	4.00E-04	0.42	5.6	NA	1.37	2.90E-04	NA
Aroclor 1232	11141-16-5	4.09-6E-3	0.45	5.1	NA	1.26	NA	NA
Aroclor 1248	12672-29-8	NA	NA	NA	NA	NA	NA	NA
Aroclor 1254	11097-69-1	7.71E-05	0.012	6.5	NA	1.54	2.00E-03	NA
Aroclor 1260	11096-82-5	4.00E-05	0.0027	6.1 - 9.3	207000.00	1.44	3.40E-04	VIM
SEMIVOLATILE ORGANIC COMPOUNDS (SVOCs)								
Acenaphthene	83-32-9	2.50E-03	3.9	3.92	3.85	1.07	1.84E-04	VIM
Anthracene	120-12-7	1.95E-04	0.0434	4.34 - 4.54	4.47	1.24	6.51E-05	VIM
Benzo(a)anthracene	56-55-3	5.00E-09	0.0094 - 0.0168	5.61 - 5.91	5.60	1.274	6.60E-07	VIM
Benzo(a)pyrene	50-32-8	2.4 - 5.6E-09	0.0038	5.81 - 6.50	6.01	1.351	<2.4E-06	VIM
Benzo(b)fluoranthene	205-99-2	5.00E-07	0.0012	6.57	6.09	NA	1.20E-05	VIM
Benzo(k)fluoranthene	207-08-9	9.59E-11	0.00055	6.85	6.09	NA	1.04E-03	VIM
Bis(2-ethylhexyl)phthalate	117-81-7	1 - 3.4E-07	0.34	4.20 - 7.453	7.18	0.985	1.10E-05	VIM
Chrysene	218-01-9	6.30E-07	0.0018 - 0.006	5.60 - 5.91	5.60	1.274	7.26E-20	VIM
Dibenz(a,h)anthracene	53-70-3	1.00E-10	0.005	5.97 - 6.58	6.58	1.282	7.33E-09	VIM
3,3-Dichlorobenzidine	91-94-1	4.00E-09	3.1	3.21	2.86	NA	5.11E-11	IM
Di-n-butylphthalate	84-74-2	1.00E-05	10.1	4.31 - 4.79	4.53	1.046	6.30E-05	VIM
2,4-Dinitrophenol	51-28-5	1.49E-05	5600	1.54	-2.00	1.683	2.82E-07	EM
2,4-Dinitrotoluene	121-14-2	1.40E-04	0.03	1.98	1.98	1.3208	8.97E-08	VM
Fluoranthene	206-44-0	5.00E-06	0.166	5.15 - 5.20	5.03	1.252	1.69E-02	VIM
Fluorene	86-73-7	6.00E-04	1.69	4.12 - 4.38	4.14	1.203	6.30E-05	VIM
Indeno(1,2,3-cd)pyrene	193-39-5	1.01E-10	0.062	5.97 - 7.70	6.54	NA	2.96E-20	VIM
2-Methylnaphthalene	91-57-6	5.40E-02	24.6	3.86	3.39	1.0058	3.18E-04	VIM
Naphthalene	91-20-3	5.40E-02	30	3.20 - 4.70	2.97	1.162	7.34E-04	IM
2-Nitroaniline	88-74-4	1.30E-02	12600	1.44	NA	NA	NA	NA
4-Nitroaniline	100-01-6	1.99E-05	800	1.39	NA	NA	NA	NA
4-Nitrophenol	100-02-7	3.00E-04	16000	1.91	2.18-2.42	1.27	3.50E-09	SM

COMPOUNDS	CAS No.	Vp (mm Hg)	Sw (mg/L)	Log Kow	Log Koc (ml/g)	Spec. Density	Kh (atm x m^3/mol)	Mobility Description
N-nitroso-d-propylamine	621-64-7	8.60E-02	9894	1.36	2.11	0.9163	1.47E-06	SM
Phenanthrene	85-01-8	2.10E-04	0.994 - 1.29	4.16 - 4.57	3.72 - 4.59	1.179	2.35E-05	VIM
Pyrene	129-00-0	2.50E-06	0.135	4.88 - 5.52	5.02	1.271	1.87E-05	VIM

NOTES:
EM = Extremely Mobile
VM = Very Mobile
SM = Slightly Mobile
IM = Immobile
VIM = Very Immobile
NA = Not Applicable (no data available)

CHEMICAL PARAMETERS ABBREVIATIONS:
Vp = Vapor Pressure
Sw = Aqueous Solubility
Log Kow = Octanol/Water partition coefficient
Log Koc = Organic carbon adsorption coefficient
Spec. Density. = Specific density in water (at 20°c with respect to water at 4°c)
Kh = Henry's law constant
MI = Mobility Index (from Ford and Gurba, 1984; and Dragun, 1988)

ATSDR Toxicological Profile Information Sheets (www.ATSDR.cdc.gov)
EPA Chemical Properties for SSL Development (www.EPA.gov)

Vapor pressure provides an indication of the rate at which a chemical volatilizes. Significant volatilization occurs at interfaces such as surface soil and air or surface water and air, and to a lesser extent, at the water table and overlying unsaturated shallow soils. Volatilization impacts selection of remedial technologies for groundwater and subsurface soils. Generally, vapor pressure for monocyclic aromatics is higher than that of PAHs. Chemicals with high vapor pressure such as VOCs enter the atmosphere more rapidly than those with low vapor pressures such as SVOCs.

Water solubility impacts the rate at which a compound leaches from soil via infiltrating precipitation. More soluble compounds (e.g., VOCs) leach more readily than less soluble compounds (e.g., SVOCs or inorganics). Water solubility data indicates that VOCs are several-orders-of-magnitude more soluble than PAHs; therefore, highly soluble compounds (e.g., VOCs) migrate more rapidly than less water soluble compounds (e.g., SVOCs or inorganics).

The octanol/water partition coefficient (K_{ow}) is the ratio of a chemical's soluble concentration in octanol divided by the soluble concentration in water. This coefficient correlates well with bioconcentration factors in aquatic organisms and adsorption to soil or sediment. A linear relationship has been demonstrated between the K_{ow} and the uptake of chemicals by fatty tissues in animal and human receptors (the bioconcentration factor - BCF) (Lyman et al., 1982). This coefficient also assists with characterizing the sorption of compounds by organic soils where experimental data does not exist.

The *organic carbon adsorption coefficient* (K_{oc}) describes the tendency of a chemical to adhere to soil particles high in organic carbon. The solubility of a chemical in water is inversely proportional to the K_{oc}. Compounds with a high soil/sediment adsorption coefficient generally have low water solubilities. For example, PCBs, which are relatively immobile in the environment, tend to preferentially sorb to soil/sediments and are less likely to migrate via aqueous transport mechanisms. However, erosional properties of surface soils and sediment that sorb immobile compounds must be considered in determining the potential for migration.

Specific density is the ratio of the weight of a given volume of pure chemical to the weight of the same volume of water at a specified temperature. Specific density primarily assists in determining the potential for a compound to form a non-aqueous phase (NAPL) on top or at the base of an aquifer, if the compound concentration exceeds one to ten percent of its corresponding S.

Henry's law constant (K_h) uses VP and S to determine volatilization rates from surface water and groundwater for a compound. This constant is an estimate of the concentration of a compound at equilibrium in the water phase and in the air directly above the water. A general method used for estimating the rate at which a compound volatilizes uses the Henry's Law constant as follows:

- $10^{-3} > K_h > 10^{-5}$ rapid volatilization
- $10^{-5} > K_h > 10^{-7}$ slow volatilization
- $K_h < 10^{-7}$ low volatilization

The *Mobility Index* (MI) quantitatively assesses the mobility of a compound based on its S, VP, and K_{oc} as defined by:

$$MI = \log ((S*VP)/K_{oc})$$

Ford and Gurba (1984) presented a relative scale that assists in evaluating MI, and Dragun presented a summary that related mobility to the K_{oc} as follows:

Relative MI[(1)]	**Mobility Description**	**log K_{oc}[(2)]**
>5	extremely mobile (EM)	< 1.7
0 to 5	very mobile (VM)	1.7 to 2
-5 to 0	slightly mobile (SM)	2 to 2.7
-10 to –5	immobile (IM)	2.7 to 3.3
< -10	very immobile (VIM)	> 3.3

Notes:
[1] From Ford and Gurba (1984)
[2] From Dragun (1988)

Table 5-3 summarizes the potential transport pathways of organic contaminants in soil, sediment, water, air, and biological systems, and identifies the applicable reactions and processes.

Table 5-3: Fate and Transport Mechanisms and Pathways for Organics

	Pathways						
Mechanisms	**S to Air**	**SW to Air**	**SW to Sed**	**Sed to SW**	**S/VZ to GW**	**GW to S/VZ**	**GW**
ORGANICS							
Volatilization	X	X		X		X	X
Hydrolysis				X	X		
Biodegradation							X
Advection							X
Dispersion							X
Diffusion							X
Desorption/Adsorption			X	X	X	X	X
Partitioning			X	X		X	X
Solubility				X	X	X	X
INORGANICS							
Particle Transport			X				
Ion Exchange					X		X
Dissolution			X	X	X		X
Desorption/Adsorption			X	X	X	X	X
Solubility			X	X	X		X

S to Air - Soil to Air
SW to Air - Surface Water to Air
SW to Sed - Surface Water to Sediment
Sed to SW - Sediment to Surface Water
S/VZ to GW - Soil/Vadose Zone to Groundwater
GW to S/VZ - Groundwater to Soil/Vadose Zone
GW - Groundwater

A general discussion of the fate and transport of the VOCs and SVOCs detected at the LOC parcel at levels of concern is presented below.

VOCs

The VOCs carbon tetrachloride, chloroform, toluene, and PCE were detected in groundwater at concentrations greater than the EPA Region III RBC Criteria for Tap Water. A discussion of the fate and transport of each of these VOCs is provided below. The fate and transport information and data was extracted from the *Agency for Toxic Substances and Disease Registry's (ATSDR's) Toxicological Profiles for toluene and PCE.* A discussion of the site-specific fate and transport of these compounds is discussed in Section 5.3.

Carbon Tetrachloride

Carbon tetrachloride is a stable chemical that is degraded very slowly, which contributes to the accumulation of the chemical in the atmosphere as well as the groundwater. Significant global transport of carbon tetrachloride is expected since it does not degrade readily in the atmosphere.

Carbon tetrachloride is very stable in air. Because carbon tetrachloride is volatile at ambient temperatures, most carbon tetrachloride that exists in the environment exists in the air. Most carbon tetrachloride released to the environment is expected to volatilize rapidly due to its high vapor pressure.

Although carbon tetrachloride is moderately soluble in water (793 mg/L at 20 ^{o}C), only about one percent of the total carbon tetrachloride in the environment exists in the dissolved phase. This is attributable to the relatively high rate of volatilization of low molecular weight chlorinated hydrocarbons from water. Because of this, carbon tetrachloride tends to volatilize readily from water. Additionally, it does not dissolve in water very easily.

Most carbon tetrachloride released to soil is expected to volatilize rapidly die to its high vapor pressure (90 mmHg at 20°C). A fraction of the carbon tetrachloride remaining in the soil may adsorb to the soil organic matter, based on a calculated soil sorption coefficient of 174 (Log Koc of 2.24). Carbon tetrachloride is expected to be moderately mobile in most soils, depending on the organic carbon content, and leaching to groundwater is possible. The composition of the soil organic matter and the water content of the soil may also affect sorption of carbon tetrachloride.

There is a little tendency for carbon tetrachloride to bioconcentrate in aquatic organisms. However, the log Kow of 2.83 suggests that bioaccumulation is at least possible under conditions of constant exposure, and biomagnification is not expected.

Carbon tetrachloride can be broken down or transformed in soil and water within several days; however, when it does break down, it forms chemicals that can destroy ozone

Chloroform

Most of the chloroform released into the environment will eventually enter the atmosphere. Since chloroform is relatively nonreactive in the atmosphere, it may be transported long distances before ultimately being degraded by indirect photochemical reactions.

Because of its low soil adsorption and slight, but significant, water solubility, chloroform will readily leach from soil into groundwater. In groundwater, chloroform is expected to persist for a long time.

Based on a Vp of 160 mmHg at 20°C, chloroform is expected to exist almost entirely in the vapor phase in the atmosphere. Chloroform has significant solubility in water (Sw of 7920 mg/L), so large amounts of chloroform in the environment can be removed by wet deposition. However, it is likely to reenter the atmosphere by volatilization.

The dominant fate process for chloroform in surface waters is volatilization. Chloroform present in surface water is expected to volatilize rapidly to the atmosphere. Using the Henry's law constant, a half-life of 3.5 hours was calculated for volatilization from a river model.

Based on measured Koc of 39.8 (log Koc of 1.60), chloroform is not expected to adsorb significantly to sediment or suspended organic matter in surface water. Chloroform slightly adsorbed to aquifer solids in laboratory studies which also revealed higher adsorption with increasing organic content of the solids.

The dominant transport mechanism for chloroform near the surface ins soil will probably be volatilization because of its high volatility and low soil adsorption. Volatilization rates seem

relatively constant over a wide variety of soil types. The leaching potential of chloroform is confirmed by the detection of chloroform in groundwater.

Chloroform does not appear to bioconcentrate in higher aquatic organisms, based on measured bioconcentration factors. Significant biomagnification of chloroform is unlikely.

Most of the chloroform present in the atmosphere breaks down eventually, but it is a slow process. The breakdown products in air include phosgene and hydrogen chloride, which are both toxic.

Toluene

Toluene in soil or water rapidly volatilizes to air, and that which remains is subject to microbial degradation. As a consequence of the volatilization and degradation occurring in air, soil, and water, there is little tendency for toluene levels to build up in the environment over time.

The rate of volatilization from soils depends on temperature, humidity, and soil type, but under typical conditions, more than 90% of the toluene in the upper soil layer volatilizes to air with 24 hours. Toluene present in deep soil deposits, however, is much less likely to volatilize. The rate of toluene transport to groundwater depends on the degree of adsorption to soil. The log K_{oc} is 2.52, which indicates that toluene will be moderately retarded by adsorption to soils rich in organic matter, but will be readily leached from soils with low organic content. Toluene can be degraded in soil by a number of bacterial species. Based on data from the aerobic degradation of toluene in water, the biodegradation half-life of toluene in soil is expected to range from four to 22 days. Soil biodegradation is not impeded by adsorption.

Toluene has a VP of 28.05 mmHg at 25°C, S of 534.8 mg/L, a K_h of 5.94 E-03. Toluene in the atmosphere is rapidly degraded by reaction with hydroxyl radicals. The estimated rate constant for this process is about 0.6-2.4 E-05, which corresponds to an atmospheric half-life of around 13 hours. Photolysis is not a significant degradation pathway for toluene.

The organic content of aquifer materials is an important determinant of toluene migration in groundwater; however, competitive sorption between gasoline components such as benzene and xylene decreases the interaction between toluene and soil, thereby allowing it to move more quickly through the aquifer. Degradation of toluene in water occurs primarily by microbial action. The biodegradation half-life of toluene in groundwater is estimated to range from seven to 28 days.

PCE

PCE has relatively low solubility in water and has medium-to-high mobility in soil, thus its residence time in surface environments is not expected to be more than a few days. However, it persists in the atmosphere for several months and may also persist in groundwater for several months or more.

PCE has a log K_{oc} of 2.42 indicating that PCE will be moderately retarded by adsorption to soils rich in organic matter, but will be readily leached from soils with low organic content. The Henry's law constant (1.53 E-02 at 25°C) was experimentally found to be the primary determinant of transport behavior in a wet, nonsorbing aggregated medium, suggesting that volatilization and movement in the gas phase accounts for a large portion of PCE movement in soils. Biodegradation of PCE in soil appears to occur only under specific conditions, and then only to a limited degree.

PCE has a VP of 14 mmHg at 25°C and S of 150 mg/L. The relatively low water solubility of PCE suggests that wet deposition as a result of scavenging by rainwater occurs very slowly compared to other VOCs. Dry deposition does not appear to be a significant removal process, although substantial evaporation from dry surfaces can be predicted from the high vapor pressure. The dominant transformation process for PCE in the atmosphere is a reaction with photochemically produced hydroxyl radicals. Reaction of PCE with ozone in the atmosphere is too slow to be an effective agent in PCE removal.

Existing evidence indicates that PCE does not readily transform in water. In natural waters, biodegradation may be the most important transformation process. However, various biodegradation screening tests and laboratory studies have shown PCE to be resistant to biotransformation or biodegraded only slowly. Because PCE is denser than water and only slightly soluble in water, that which is not immediately volatilized may be expected to sink.

SVOCs

The SVOCs detected in the soil samples were primarily PAHs. The SVOCs with the highest detected soil concentrations include naphthalene and 2-methylnaphthalene. These SVOCs were also detected in groundwater samples GW02-DPT and GW01-LOC at concentrations greater than Maryland Groundwater Cleanup Levels and EPA Region III RBC for Tap Water. A general discussion of the fate and transport of each of these SVOCs is provided below. The fate and transport data was extracted from the *ATSDR's Toxicological Profile for Naphthalene/1-methylnaphthalene/2-methylnaphthalene*. A discussion of the site-specific fate and transport of these compounds is discussed in Section 5.3.

Naphthalene and 2-Methylnaphthalene

Naphthalene is easily volatilized from aerated soils and is adsorbed to soils to a moderate extent. The extent of sorption depends on the organic carbon content of the soil, with rapid movement expected through sandy soils. The estimated soil adsorption coefficient for naphthalene in a soil with less than 0.6% organic carbon is 1.8. Naphthalene's movement through groundwater can be retarded to the extent that it is adsorbed to the aquifer solids, again depending on the organic carbon content of the aquifer materials and also on the presence of nonionic low-polarity organics, such as PCE, which may enhance its adsorption.

Naphthalene has a VP of 5.40 E-02 mmHg at 25°C, a S of 30 mg/L at 25°C, and a K_h of 7.34 E-04. Naphthalene released to the atmosphere may be transported to surface water and/or soil by wet or dry deposition. Naphthalene and 2-methylnaphthalene may also be removed from the atmosphere by reaction with photochemically produced hydroxyl radicals and atmospheric ozone.

Naphthalene's log K_{ow} ranges from 3.20 to 4.70, and its log K_{oc} ranges from 2.72 to 3.52. Based on these values, it is expected that only a small portion (less than 10%) of naphthalene in typical surface water would be associated with particulate matter, and it would remain instead largely in solution. Naphthalene and methylnaphthalenes are degraded in water by photolysis and biological processes. The half-life for photolysis of naphthalene in surface water is estimated to be 71 hours, but the half-life in deeper water (five meters) is estimated at 550 days. The half-life for photolysis of 2-methylnaphthalene was estimated at 54 hours. Biodegradation occurs slowly in unpolluted waters (half-lives up to 1,700 days) and more quickly with increasing

naphthalene concentration or if significant petroleum pollution is present (half-lives as low as seven days).

Biodegradation of naphthalene in soil will occur unless the majority of the contamination is adsorbed to the soil particles, decreasing its bioavailability. The estimated half-life of naphthalene reported for a solid waste site was 3.6 months. In sandy soils (92-94% sand) with low organic carbon (0.2 to 0.6%), naphthalene half-lives were measured at 11-18 days. Naphthalene is aerobically biodegraded to carbon dioxide, with salicylate as an intermediate product.

Limited data were available on the transport and partitioning of methylnaphthalenes in the environment. The VP (5.40 E-02 mmHg), S (24.6 mg/L), and K_h (3.18 E-04) for 2-methylnaphthalene are of similar magnitude to naphthalene's values. Therefore, 2-methylnapthalene is expected to partition in a manner similar to that of naphthalene in environmental media (ATSDR 1995).

Pesticides

Several pesticides were detected primarily in soil and sediment samples from Rogue Harbor Branch. Only DDT was detected above the EPA Residential RBCs in several surface soil samples. No pesticides were found at levels above screening criteria in sediment samples. The frequency of detection of DDT, DDD, and DDE in sediment and surface soil samples, however, warrants further discussion. Heptachlor epoxide was detected in one groundwater sample at a concentration greater than the EPA RBC for tap water, but less than the EPA MCL and Maryland Groundwater Cleanup Level. Due to the infrequency of detection for this compound, it will not be discussed further. A discussion of the fate and transport of DDT, DDE, and DDD is provided below. The fate and transport data was extracted from the *ATSDR's Toxicological Profile for DDT, DDE, and DDD.* A discussion of the site-specific fate and transport of these compounds is discussed in Section 5.3.

DDT, DDE, and DDD

When deposited on soil, DDT, DDE, and DDD are strongly adsorbed. DDT, DDE, and DDD have log K_{oc} of 5.146 to 6.26, 5.386 to 6.00, and 5.38, respectively, indicating that these compounds adsorb strongly to soil high in organic carbon. However, they may also revolatilize into the air, which is more likely to occur from moist soils than dry soils. They may also photodegrade on the soil surface and biodegrade. As a result of their strong binding to soil, DDT, DDE, and DDD mostly remain on the surface layers of soil; there is little leaching into the lower soil layers and groundwater. DDT, with a log K_{ow} of 4.89 to 6.914, may be taken up by plants that are eaten by animals and accumulate to high levels, primarily in adipose tissue and milk of the animals.

When in the atmosphere, about 50% of DDT will be found adsorbed to particulate matter and 50% will exist in the vapor phase. A smaller portion of DDE and DDD are adsorbed to particulate matter than DDT. Vapor-phase DDT, DDE, and DDD react with photochemically-produced hydroxyl radicals in the atmosphere. DDT, DDE, and DDD will be deposited on land and in surface water as a result of dry and wet deposition.

The dominant fate processes in the aquatic environment are volatilization and adsorption to biota, suspended particulate matter, and sediments. Transformation includes biotransformation and photolysis in surface waters.

5.1.2 Inorganic Contaminants

Table 5-4 lists inorganic contaminants detected at the LOC parcel (number of detections/number of samples).

Table 5-4: Inorganic Contaminant Detections by Media

Constituent	Soil	Sediment	Surface Water	Groundwater
Inorganics (mg/kg)				
Aluminum	134 / 144	3 / 3	4 / 4	41 / 43
Antimony	21 / 144	NA	NA	16 / 43
Arsenic	127 / 151	3 / 3	NA	27 / 43
Barium	132 / 145	3 / 3	4 / 4	43 / 43
Beryllium	77 / 145	3 / 3	1 / 4	27 / 43
Cadmium	37 / 145	3 / 3	NA	19 / 43
Calcium	119 / 145	NA	NA	43 / 43
Chromium	132 / 145	3 / 3 (Cr VI)	1 / 4	36 / 43
Cobalt	105 / 145	3 / 3	4 / 4	37 / 43
Copper	133 / 145	3 / 3	4 / 4	30 / 43
Iron	135 / 145	3 / 3	4 / 4	42 / 43
Lead	134 / 149	3 / 3	1 / 4	26 / 43
Magnesium	121 / 145	NA	NA	43 / 43
Manganese	125 / 145	3 / 3	4 / 4	43 / 43
Mercury (Inorganic)	82 / 142	2 / 3	NA	7 / 43
Nickel	109 / 145	3 / 3	2 / 4	39 / 43
Potassium	128 / 145	NA	NA	43 / 43
Selenium	12 / 145	NA	NA	21 / 43
Silver	3 / 145	NA	NA	3 / 43
Sodium	35 / 145	NA	NA	41 / 43
Thallium	3 / 145	NA	NA	-
Vanadium	125 / 145	3 / 3	1 / 4	29 / 43
Zinc	123 / 145	3 / 3	4 / 4	41 / 43

Arsenic, iron and antimony were the only inorganic contaminants detected in soil samples above EPA Industrial RBCs. Antimony, however, only exceeded the EPA Industrial RBC at one location and therefore it will not be discussed further in this section. Manganese, thallium, vanadium, beryllium and lead were detected in soil samples above EPA Residential RBCs. Dissolved aluminum, arsenic, chromium, iron, and manganese were detected above the EPA RBCs in groundwater monitoring well samples; however, these metals may be due to naturally occurring suspended solids rather than a particular source. Except for arsenic, iron and vanadium, inorganics were detected at concentrations comparable to regional background concentrations and appear to be naturally occurring. Vanadium was found in samples from upgradient monitoring wells NW-5, NW-6, and NW-7 at levels equal to or greater than those detected in on-site monitoring wells NW-8 and NW-9; therefore, vanadium levels are not suspected to be due to site activities and will not be discussed further. Therefore, only the fate and transport of arsenic and iron are included below. The reactions and processes that are expected to govern the fate and transport of the inorganic contaminants detected at the LOC parcel are:

- Dissolution/precipitation
- Adsorption/desorption
- Ion exchange
- Reduction-oxidation (redox) reactions
- Complexation

These processes are interrelated and complicate the fate and transport of inorganic species. Furthermore, some inorganic species that influence the reactions occur naturally and are present in background concentrations, while other inorganic species are derived from anthropogenic sources.

Table 5-5 summarizes the potential transport pathways of inorganic contaminants in soil, sediment, water, air, and biological systems, and identifies the applicable reactions and processes.

Table 5-5: Fate and Transport Mechanisms and Pathways for Inorganics

	Pathways						
Mechanisms	**S to Air**	**SW to Air**	**SW to Sed**	**Sed to SW**	**S/VZ to GW**	**GW to S/VZ**	**GW**
INORGANICS							
Particle Transport			**X**				
Ion Exchange					**X**		**X**
Dissolution			**X**	**X**	**X**		**X**
Desorption/Adsorption			**X**	**X**	**X**	**X**	**X**
Solubility			**X**	**X**	**X**		**X**

S to Air - Soil to Air
SW to Air - Surface Water to Air
SW to Sed - Surface Water to Sediment
Sed to SW - Sediment to Surface Water
S/VZ to GW - Soil/Vadose Zone to Groundwater

GW to S/VZ - Groundwater to Soil/Vadose Zone
GW - Groundwater

The general discussion of the fate and transport of arsenic is presented below.

Arsenic

Arsenic in soil may be transported by wind or in runoff or may leach into the subsurface soil. The mobility of arsenic in soils is dependent on the arsenic species present, the existence of oxidizing or reducing conditions, pH, and the soil mineralogy. A European study indicated that the most influential parameter affecting arsenic mobility is the iron content of the soil. Independent experiments indicated that arsenic mobility is related to sorption reactions of arsenic on iron oxide minerals, which are pH dependent. Arsenic that is adsorbed to iron and manganese oxides may be released under reducing conditions, which may occur in sediment or flooding conditions. In addition to reductive dissolution, when nutrient levels are adequate, microbial action can also result in dissolution. Drying of previously flooded soils increases arsenic adsorption, possibly due to alterations in iron mineralogy.

Arsenic in soil exists in various oxidation states and chemical species, depending on soil pH and redox potential. Transformations between the various oxidation states and species of arsenic occur as a result of biotic or abiotic processes. Microorganisms may methylate arsenical compounds applied to soils to arsines, which are lost through volatilization, and organic forms may be mineralized to inorganic forms. Arsenites (As(III)) are of greater environmental concern than arsenates (As(V)) because of their greater toxicity and higher mobility in soil.

Transport and partitioning of arsenic in water depends on the chemical form (oxidation state and counter ion) of the arsenic and on interactions with other materials present. Soluble forms move with the water and may be carried long distances through rivers. However, arsenic may be adsorbed from water onto sediments or soils, especially clays, iron oxides, aluminum hydroxides, manganese compounds, and organic material. Under oxidizing and mildly reducing conditions, groundwater arsenic concentrations are usually controlled by adsorption rather than by mineral precipitation. The extent of arsenic adsorption under equilibrium conditions is characterized by the distribution coefficient, K_d, which measures the equilibrium partitioning ratio of adsorbed to dissolved contaminant. The value of K_d depends strongly upon the pH of the water, the arsenic oxidation state, and the temperature. In acidic and neutral waters, some arsenic species are extensively adsorbed (for example, As(V) or arsenate). In waters with a high pH, K_d values are considerably lower. Sediment-bound arsenic may be released back into the water by chemical or biological interconversions of arsenic species.

Arsenic in water can undergo a complex series of transformations, including oxidation-reduction reactions, ligand exchange, precipitation, and biotransformation. The factors most strongly influencing fate processes in water include redox potential, pH, metal sulfide and sulfide ion concentrations, iron concentrations, temperature, salinity, and distribution and composition of the biota. Inorganic species of arsenic are predominant in the aquatic environment, occurring mainly as As(V) in oxidizing environments such as surface water and As(III) under reducing conditions such as may occur in groundwater containing high levels of arsenic. Organic arsenic species may also be present.

Iron

No ASTDR Toxicological Profile was available for iron; however, its properties in terms of fate and transport are assumed to be similar to arsenic, as described above.

5.2 POTENTIAL PATHWAYS OF CONTAMINANT TRANSPORT

This section discusses the potential transport pathways by which groups of contaminants can migrate between and within environmental media (i.e., air, surface water, soil, sediment, and groundwater) at the LOC parcel.

5.2.1 On-site Deposition of Windblown Dust

Wind can act as a contaminant transport agent by eroding soil and exposed sediment and blowing it off-site. The net transport is influenced by: wind velocity, the grain size/density of the soil/sediment particles and the amount of vegetative cover over the site. Most of the eastern and western portions of the LOC parcel are covered by improvements (such as buildings and pavement) or grass and shrubbery. The central portion of the site is forested with a moderate amount of underbrush and extensive ground cover (fallen leaves), which would effectively restrict windblown transport. There appears to be sufficient ground cover in the eastern, western, and central portions of the site to effectively limit this transport mechanism.

5.2.2 Soil/Sediment Transport by Storm Water Runoff

Water can erode exposed soil/sediment particles during precipitation events. Site topography, amount and rate of precipitation, soil/sediment particle size/density, cohesion of soil/sediment, and vegetative cover influence the rate of erosion. Similar to windblown transport, vegetative cover at the site limits the surface area of soil/sediment that may be subject to erosion by storm water runoff. Also, the high permeability of the soil/sediment present at the site effectively reduces the volume of storm water runoff. Based on the factors that influence transport by storm water runoff, contaminant transport by this mechanism would be limited.

5.2.3 Soil/Surface Water to Air Transport

The primary mechanism of contaminant transport from soil and surface water to air is volatilization. Volatile soil contaminants, including some PCBs with sufficiently high Henry's Law Constants such as Aroclor 1254 and 1260, can migrate up through soil pore spaces and diffuse into the atmosphere. Nonvolatile contaminants such as metals generally can be transported to air only if adhered to airborne particulate matter.

5.2.4 Surface Water to Sediment Transport

Some important mechanisms that control contaminant migration from surface water to sediment are:

- **Seepage**: Contaminated storm water can flow through sediment under hydraulic head, potentially transporting dissolved contaminants to sediment.
- **Gravity Settling**: Gravity settling is a mechanism for separating particles with sorbed metals and organic chemicals from surface water.

- **Adsorption**: Depending on the chemistry of the surface water and sediment and the physical interactions between surface water and sediments, adsorption can be a mechanism for transporting contaminants in water to sediment.
- **Dissolution/Precipitation**. The chemical process by which a material is dissolved in a liquid solvent such as water. Precipitation is the reverse process of dissolution.

5.2.5 Sediment to Surface Water Transport

The primary mechanisms for transporting contaminants from sediment to surface water are desorption, dissolution, and ion exchange. This process is influenced by the physical and chemical properties of the contaminant, the sediment particle, the surface water and turbulence during transport.

5.2.6 Soil/Vadose Zone to Shallow Groundwater Transport

The primary mechanism of contaminant transport from the soil/vadose zone to groundwater is through dissolution and transport of constituents via infiltration of rainwater. VOCs, in particular, have a strong propensity to migrate to groundwater. Infiltration can effectively transport soluble contaminants. Because of the high annual precipitation (45.7 in/yr) at FGGM and the highly permeable soils present at the site, and since the site contains interbedded layers of fine to medium sand, silt, and relatively thin clay layers, the infiltration rate could be high. However, at the central and western wooded areas of the site, the rate would be reduced due to ground cover. Some areas at FGGM have significantly reduced the potential for infiltration due to localized low-permeability features (e.g., pavement and buildings).

5.2.7 Shallow Groundwater to Soil/Vadose Zone Transport

There are several mechanisms of contaminant transport from groundwater to the vadose zone. VOCs in groundwater can volatilize into the unsaturated pore space in the vadose zone. At the capillary fringe, groundwater contaminants can be transported to unsaturated soil via precipitation, adsorption, and ion exchange.

5.2.8 Shallow Groundwater to Surface Water Transport

Contaminants are present in groundwater in either a dissolved state or as a separate fluid phase (non-aqueous phase liquid or NAPL). NAPLs are not a contaminant of concern at the LOC parcel; therefore, they will not be discussed further. As impacted groundwater flows to discharge areas, contaminants may be transported to surface water bodies and wetlands.

The transport of dissolved contaminants is most strongly influenced by advection along the hydraulic gradient present at the site. Dispersion and spreading during transport results in dilution of contaminants hydraulically downgradient of the source area. Generally speaking, dispersion is greater along the direction of groundwater flow than it is transverse to the flow direction. In low permeability formations (e.g., unfractured clays), diffusive transport may be large compared to advective transport.

Retardation of dissolved contaminants occurs as a result of adsorption, partitioning, ion exchange, and other processes that occur along the groundwater flow path. As a result of retardation, contaminants are distributed between the aqueous phase and aquifer solids,

contaminant concentrations in the aqueous phase decrease, and migration of the aqueous phase is reduced relative to groundwater flow.

5.2.9 Shallow Groundwater to Deep Groundwater

Shallow groundwater encountered on the LOC parcel (Patapsco Aquifer) is separated from deep groundwater (Patuxent Aquifer) by a 150-250 foot thick clay layer known as the Arundel Formation (see Section 3). This clay layer sufficiently isolates the deep groundwater aquifer in the vicinity of the LOC parcel and thus contaminant transport between the shallow and deep aquifers is considered negligible.

5.3 SITE FATE AND TRANSPORT

This section discusses the fate and transport for the LOC parcel. The conceptual fate and transport model presented in this section provides a qualitative analysis of the environmental mechanisms, site characteristics, and physical/chemical properties of contaminants that have influenced, or currently influence, contaminant fate and transport at the LOC parcel. **Table 5-3** and **Table 5-5** presents the transport mechanisms applicable to the individual transport pathways and the transport pathways identified for the site are presented in **Table 5-6.** Based on the fate and transport properties of the general type of chemical(s) present at the site and the site conditions, a conceptual model for the site is presented. A graphical presentation of the conceptual model for the site is presented on **Figure 5-1**.

Table 5-6: Transport Pathways

Transport Pathways	LOC Site Pathway Present?
S to Air	Yes
SW to Air	No
SW to Sed	Yes
Sed to SW	No
S/VZ to GW	Yes
GW to S/VZ	No
GW	Yes (horizontal but not vertical)

S to Air - Soil to Air
SW to Air - Surface Water to Air
SW to Sed - Surface Water to Sediment
Sed to SW - Sediment to Surface Water
S/VZ to GW - Soil/Vadose Zone to Groundwater
GW to S/VZ - Groundwater to Soil/Vadose Zone
GW - Groundwater

The possible transport pathways identified for the site that are considered to be minor pathways due to mitigating site conditions or contaminant properties include the following:

- Migration of pesticides in groundwater via advection, diffusion, and dispersion. Pesticides would not be readily transported by this mechanism due to their low aqueous solubility.
- Migration, enhanced by infiltrating rainwater, of pesticides through the vadose zone to groundwater. Pesticides strongly adsorb to soil/sediments and are not readily leached to groundwater due to their low aqueous solubility.
- Migration of soil particles with adsorbed contaminants due to winds (as dust). This pathway would be limited since the majority of the LOC parcel is covered with buildings, paved areas, and vegetation.

The major transport pathways identified for the site include:

- Transport of VOCs (such as toluene and PCE) and SVOCs (such as naphthalene and 2-methylnaphthalene) between subsurface soils and shallow groundwater via volatilization (from groundwater to soils) and downward migration (from soils to groundwater) enhanced by infiltrating precipitation.
- Transport of VOCs and SVOCs to air via volatilization and adsorption to airborne particles.
- Migration of SVOCs and VOCs through groundwater via advection, diffusion and dispersion mechanisms. This may be mitigated by adsorption of these contaminants to aquifer solids and biodegradation of the contaminants.
- Transport of metals (such as arsenic and iron) from soils to groundwater via leaching.
- Migration of metals (such as arsenic and iron) through groundwater via advection, diffusion and dispersion mechanisms. This may be mitigated by adsorption of metals to aquifer solids. Although a number of other inorganic contaminants were detected in unfiltered groundwater samples at concentrations above their ARARs and TBCs, the corresponding concentrations in the filtered samples were generally below levels of concern.
- Migration of pesticides from soil to sediments via stormwater runoff.
- Migration of metals from shallow groundwater to surface water via groundwater discharge.

Soils

No VOCs were detected above their respective EPA RBCs for residential or industrial soil. Considering the low concentrations detected, migration of VOCs is only a concern for those contaminants found in both soil and groundwater samples such as toluene and PCE. It should also be noted that detections of benzene, toluene, ethylbenzene, and xylenes (BTEX) were co-located with SVOCs of concern in sample SB02-DPT/GW-02, suggesting that petroleum contamination is present at this location. The highest concentrations of VOCs were detected at this location. According to the log K_{oc} values for toluene and PCE, these contaminants are classified as slightly mobile. Therefore, toluene and PCE will readily leach from soils with a low organic content, providing a transport mechanism from soil to shallow groundwater. Leaching at the site is expected to be limited, however, because a high percentage of the LOC parcel is covered by buildings, paved areas, and vegetation which help prevent infiltration.

The SVOCs detected in the soil samples were primarily PAHs. The SVOCs with the highest detected soil concentrations include naphthalene (up to 6,100J ug/kg) and 2-methylnaphthalene (up to 31,000 ug/kg). These two compounds were also detected in groundwater at levels of concern. PAHs strongly adsorb to soil with high organic carbon concentrations and remain in the soil column at the source area, but they can slowly leach to groundwater. Leaching at the site is expected to be limited, however, because a high percentage of the LOC parcel is covered by buildings, paved areas, and vegetation which help prevent infiltration. Naphthalene and 2-methylnaphthalene may biodegrade in soil under aerobic conditions.

Numerous metals were detected on-site. Except for arsenic and iron, the detected concentrations of metals are generally comparable to expected regional background concentrations. Both arsenic and iron were detected at concentrations above industrial RBCs in most locations across the site. Potential sources of arsenic include treated rail ties and possible historic application of arsenical herbicides to control vegetation along the rail alignment. Arsenic and iron may be transported through soil to groundwater via leaching mechanisms.

Pesticides were detected in the soil samples below RBCs. The most frequent detections were DDT and its breakdown products. Pesticides are persistent and relatively immobile compounds. DDT can biodegrade to DDE under aerobic and anaerobic conditions. These compounds would not be expected to leach to groundwater or to surface water due to their high propensity to adsorb to soils. DDT, DDE, and DDD can migrate while adsorbed to soil particles when transported by storm water runoff to sediment via surface water.

Sediments

The only VOC detected in sediment was acetone, a common laboratory contaminant at concentrations ranging from 65J to 88J ug/kg.

The only SVOC detected in sediment was bis(2-ethylhexyl)phthalate, a plasticizer present in disposable gloves used to collect environmental samples and also a common laboratory contaminant. The detected concentrations were qualified "B" and subsequently were not used in the data analysis.

Low concentrations of pesticides were detected in each sediment sample. The compounds detected in one or more samples were alpha- and gamma-chlordane, DDT, DDD, DDE, and endrin aldehyde. Migration of DDT, DDD, DDE would primarily occur when pesticides that are sorbed to soil particles are transported to sediments via storm water runoff. Biodegradation for these compounds is not a significant mechanism since DDT, DDD, and DDE are relatively persistent in the environment.

Aluminum, barium, iron, and lead were above the EPA Region III BTAG screening level for freshwater sediment. Metals may be transported from groundwater to sediment via discharge to surface water.

Surface Water

No targeted VOCs, SVOCs, pesticides, or PCBs were detected in surface water.

Most metals were detected in all surface water samples and concentrations varied for each compound with distance downstream. Metals may be transported via groundwater discharge (groundwater to surface water) and sorption to sediment particles (surface water to sediment).

Groundwater

VOCs, toluene and PCE, were detected in groundwater samples at concentrations above the EPA Region III RBC Criteria for Tap Water. These compounds were also detected in soil samples, though at levels less than the applicable RBCs, suggesting that these contaminants may be transported via leaching (soil to groundwater) and volatilization (groundwater to soil). In addition, the contaminants may be transported with groundwater via advection, diffusion, and dispersion (except to the degree that their mobility may be retarded by adsorption to aquifer solids).

Carbon tetrachloride and chloroform were detected in groundwater samples at concentrations above the EPA Region III RBC Criteria for Tap Water. However, these compounds were not detected in soil samples, suggesting that these contaminants are transported via groundwater. The contaminants may be transported with groundwater via advection, diffusion, and dispersion (except to the degree that their mobility may be retarded by adsorption to aquifer solids). Additionally, the carbon tetrachloride groundwater plume was previously delineated as discussed in Section 1.2.5.3, and the source of the plume has not been identified.

The SVOCs naphthalene and 2-methylnaphthalene were detected in three groundwater samples at concentrations above their EPA RBC criteria, including location GWO2-DPT, where BTEX compounds and PAHs were also detected in the subsurface soils, suggesting the presence of petroleum contamination. Naphthalene and 2-methylnaphthalene were detected in the soil samples at SB02-DPT/GW, suggesting that these contaminants may be transported via leaching (soil to groundwater) and volatilization (groundwater to soil). In addition, the contaminants may be transported with groundwater via advection, diffusion, and dispersion (except to the degree that their mobility may be retarded by adsorption to aquifer solids).

Numerous metals were detected in groundwater. Only arsenic and iron are considered to be potential concerns for the site. In the groundwater samples collected from fixed monitoring wells, the total and dissolved concentrations of arsenic detected were comparable. In the groundwater samples collected via DPT, the concentrations were significantly higher in the unfiltered samples, suggesting that arsenic-contaminated solids were present in the groundwater samples. The highest concentrations of arsenic in groundwater were detected in the western portion of the LOC parcel, generally proximal to soil sampling location DPT-11, where the highest concentration of arsenic in soil was detected. Arsenic and iron may migrate through groundwater via advection, diffusion and dispersion mechanisms. This may be mitigated by adsorption of metals to aquifer solids. These metals may also be transported via discharge (groundwater to surface water) and sorption to sediments (surface water to sediment).

6 HUMAN HEALTH RISK ASSESSMENT

6.1 INTRODUCTION

This section presents an assessment of potential human health risks associated with chemicals detected in soil, groundwater, surface water, and sediment at the 100-acre LOC parcel. The human health risk assessment (HHRA) follows guidance outlined in the EPA's *Risk Assessment Guidance for Superfund* (RAGS), *Volume I: Human Health Evaluation Manual* and other EPA and EPA Region III guidance. Analytical data collected for the RI during two sampling events (2000/2001 and 2004/2005) were used in the HHRA, as described below.

6.1.1 Objectives

The overall objectives of the HHRA are to: (1) provide an analysis of baseline risk, currently and in the future, in the absence of any major action to control or mitigate site contamination, and (2) assist in determining the need for and extent of remediation. Specific objectives include:

- Provide an analysis of baseline human health risks and help determine the need for remedial action at the site.
- Provide a basis for determining levels of chemicals that can remain at the site and still be adequately protective of public and FGGM personnel health.
- Provide a consistent process for evaluating and documenting public health threats at the site.

6.1.2 Overview of the Human Health Risk Assessment Process

There are four components to the HHRA process: (1) data evaluation; (2) exposure assessment; (3) toxicity assessment; and (4) risk characterization. In the data evaluation, relevant data are compiled and analyzed to determine the usability of the data and to select COPCs that are representative of the contamination detected at or emanating from the source. In the exposure assessment, actual or potential chemical release and transport mechanisms are identified; potentially exposed human populations and possible exposure pathways and routes of exposure are described; concentrations of the COPCs at potential points of human exposure are determined; and human exposures to the COPCs are estimated. In the toxicity assessment, quantitative and/or qualitative toxicity data for each COPC are summarized and toxicological criteria used to characterize risks are identified. The likelihood and magnitude of adverse health risks are estimated in the risk characterization, in the form of excess lifetime cancer risks and non-cancer hazard quotients (HQ). Sources of uncertainty in the evaluation are then noted and discussed. This stepwise process is used in the following sections to evaluate potential human health risks that may be associated with exposure to chemicals at or emanating from the source.

6.2 DATA EVALUATION

The HHRA focuses on the compilation of usable data and the selection of COPCs. Data summary tables showing chemicals detected in soil, groundwater, surface water, and sediment from selected locations are presented and discussed in the following sections. The tables also present the criteria (e.g., screening toxicity values and frequency of detection) used to select COPCs. This process, described below, identifies COPCs that, if contacted, pose potential risks to human health. **Figure 2-1** shows all sample locations.

All field work and environmental sampling were conducted in accordance with the Scopes of Work developed by the USACE, with field investigation procedures further developed in the *Final Work Plan* (Malcolm Pirnie, Inc., 2000), the *Revised Final Work Plan Addendum* (Malcolm Pirnie, Inc., 2000), and the *Final Site Specific Work Plan* (Malcolm Pirnie, Inc., 2004). Samples from 2000/2001 were analyzed by STL of Savannah, GA; samples from 2004/2005 were analyzed by GPL Laboratories of Frederick, MD. Laboratory analytical methods and data validation procedures were selected to meet the data quality objectives identified in the QAPP. Only validated analytical data are used in the assessment of the potential for human health risks.

The decision process for the selection of COPCs in sampled environmental media is dictated by relevant EPA (EPA, 1989) and EPA Region III (EPA, Region III, 1993a) guidance. A risk-based screen of detected chemical concentrations is implemented, using the EPA, Region III RBCs (EPA, 2005b) as primary screening toxicity values. Chemicals with maximum concentrations greater than these screening toxicity values are selected as COPCs. All chemicals regarded by the EPA as Class A carcinogens are automatically selected as COPCs, regardless of the detected concentration relative to the screening toxicity value. Where no EPA Region 3 RBCs for detected chemicals are available, the chemical is selected as a COPC and the potential toxicity from human exposure is evaluated qualitatively in the risk characterization section. For sample sizes greater than 20, chemicals are eliminated as COPCs based on low frequency of detection (< 5%). Lastly, the essential nutrients (i.e., calcium, magnesium, potassium, and sodium) are categorically eliminated as COPCs from all sampled environmental media.

All tabular presentations of data summaries and risk estimates are in RAGS, Part D (EPA, 2001) format and are presented in Appendix D.

6.2.1 Soil

Surface and subsurface soil data are available from two sampling periods, as discussed in Section 2. For the purposes of this HHRA, soil data from 0-2 feet below ground surface (bgs) are considered surface soil and are summarized to facilitate an evaluation of outdoor site worker exposure to soil. Soil samples collected from greater than 2 feet bgs are considered subsurface soil data. Surface and subsurface soil data are combined to create an “all soils” database, to be used in the evaluation of construction/utility worker and construction worker exposure to soil.

6.2.1.1 Surface Soil

From the 2000/2001 sampling event, surface soil data are available from 52 samples collected on the site, 10 of which were collected at known or potential transformer locations and analyzed

for PCBs only, and 4 duplicates. For the duplicate samples, the results of the original and the duplicate samples were averaged. Twenty-eight samples (and three duplicates) were analyzed for VOCs, SVOCs, pesticides/PCBs, and total metals. VOC results from one replacement sample (SB17-DPTR-02) were substituted for the VOC results of the original sample (SB17-DPT-02). Two samples (SS05-LOC-01 and SS06-LOC-01) were analyzed only for VOCs, while two samples (SS05-LOC-02 and SS06-LOC-02) were not analyzed for VOCs. The duplicate sample (SS05-LOCD-01) was analyzed for VOCs, SVOCs, pesticides/PCBs, and total metals. Therefore, the VOC results of the duplicate and original sample were averaged, and the results from the duplicate sample for all other parameters were accepted as though they were from the original sample.

From the 2004/2005 sampling event, data are available from 25 surface soil samples and three duplicates. Samples were analyzed for the following parameters: 11 samples for VOCs, SVOCs, pesticides/PCBs, and metals; 10 samples for metals only; 2 samples for arsenic only; 2 samples for arsenic and mercury only; 2 samples for lead only; and 1 sample for arsenic and lead only. As with the surface soil data from the previous round, one sample original (AOC-SS-41) was analyzed for arsenic and lead only, while its duplicate (41-DUP) was analyzed for all metals. Therefore, the results for arsenic and lead from the original and duplicate samples were averaged, while for all other metals, the results from the duplicate were accepted as though they were from the original sample.

Appendix D, Table 2.1 presents combined summary statistics for surface soil data from both sampling events. The range of detected concentrations, the frequency of detection, the location of the maximum detected concentration, and the range of detection limits for non-detects are presented. For the 2000/2001 data, STL reported the sample quantitation limits (SQL) for all non-detected organic and inorganic chemicals. For the 2004/2005 data, GPL reported the SQL for non-detected organic chemicals and the adjusted method detection limit for non-detected inorganic chemicals, to account for adjustments (e.g., to account for dilution) to the preparation or analytical method used. Data from three surface soil samples collected from off-site, north of Rock Avenue (SB05-HSA-02, SB06-HSA-02, and SB07-HSA-02) were not included in the surface soil data summary. The background ranges of detected metals concentrations were adapted from Table 4-1, Surface Soil Summary Statistics, from the Final Soil Background Concentration Report of Fort George G. Meade, Maryland (Malcolm Pirnie, Inc., 2001).

The EPA, Region III RBCs for residential soils (EPA, 2005b) are used as primary screening toxicity values. EPA, Region III RBCs based on non-cancer health effects were reduced by one-tenth to represent a target HQ of 0.1 and account for additive health effects.

The COPC flag and rationale for chemical deletion or selection are provided for each detected chemical. The following chemicals were selected as COPCs in surface soil:

- Three SVOCs: benzo(a)pyrene, benzo(b)fluoranthene, and phenanthrene.
- Six metals: arsenic, chromium, iron, manganese, mercury, and vanadium.

6.2.1.2 Subsurface Soil

From the 2000/2001 sampling event, subsurface soil data are available from 49 samples and 7 duplicates collected on the site. All samples were collected from depths between 9 and 41 feet bgs and were analyzed for VOCs, SVOCs, pesticides/PCBs, and total metals. VOC results from

one replacement sample (SB17-DPTR-09) were substituted for the VOC results of the original sample (SB17-DPT-09).

From the 2004/2005 sampling event, subsurface soil data are available from 21 samples and 1 duplicate collected on the site. Twelve samples and one duplicate were analyzed for VOCs, SVOCs, pesticides/PCBs, and total metals. Eight samples were analyzed for metals only, while one sample was only analyzed for arsenic only. All samples were collected from depths between 5 and 10 feet bgs.

Appendix D, Table 2.2 presents summary statistics for combined surface and subsurface soil data from both sampling events. The range of detected concentrations, frequency of detection, the location of the maximum detected concentration, and the range of detection limits for non-detects are presented. For the 2004/2005 data, GPL reported the SQL for non-detected organic chemicals and the adjusted method detection limit for non-detected inorganic chemicals, to account for adjustments (e.g., to account for dilution) to the preparation or analytical method used. Data from six subsurface soil samples and one duplicate sample collected off-site, north of Rock Avenue, were not included in the subsurface soil data summary. The background ranges of detected metals concentrations reflect the combined background surface and subsurface datasets, presented in Tables 4-1 and 4-2, Surface Soil Summary Statistics and Subsurface Soil Summary Statistics (Malcolm Pirnie, Inc., 2001).

Direct Contact

As with surface soil, the EPA, Region III RBCs for residential soils are used as primary screening toxicity values. EPA, Region III RBCs based on non-cancer health effects were reduced by one-tenth to represent a target HQ of 0.1 and account for additive health effects.

The COPC flag and rationale for chemical deletion or selection are provided for each detected chemical. The following chemicals were selected as COPCs in subsurface soil:

- Two VOCs: cyclohexane and methylcyclohexane.
- One SVOC: phenanthrene.
- Nine metals: antimony, arsenic, beryllium, chromium, iron, lead, manganese, mercury, and vanadium.

Vapor Intrusion

Consideration was also given to the potential for subsurface vapor intrusion of volatile chemicals in surface and subsurface soil into current or future buildings on the site. As indicated above, comparison of the combined surface and subsurface soil data to the EPA, Region III RBCs for residential soil resulted in the selection of just three volatile chemicals (defined by the EPA as having a Henry's Law Constant greater than 10-5 atm-m^3/mol and a molecular weight less than 200 g/mol) as COPCs: cyclohexane, methylcyclohexane, and phenanthrene. All three chemicals were selected due to the lack of screening toxicity values.

6.2.2 Groundwater

Groundwater data are summarized in Section 4. Groundwater data from only the most recent (2004/2005) sampling event are used for the purposes of the HHRA, based on the assumption that they are most reflective of current groundwater quality. Only groundwater data from the following sixteen fixed monitoring wells are used: NW-1 through NW-14 (except NW-3), EW-2, EW-3, and MW-7. The sample from MW-7 was analyzed for VOCs only. The remainder of the samples were analyzed for VOCs, SVOCs, pesticides/PCBs, and metals (total and dissolved), as described previously. Dissolved metals data are not included in the data evaluation for the HHRA; only total metals data are used. Two sample duplicates (NW-2-DUP and NW-9-DUP) were collected and are included in the HHRA analysis by averaging the results of the original and the duplicate samples.

The site groundwater data included in the HHRA are summarized in Appendix D, Table 2.3. The frequency of detection, range of detected concentrations, data qualifiers, location of the maximum detected concentration, and the range of detection limits for non-detects are presented. For all groundwater data, the detection limit is equal to the SQL. Upgradient groundwater data are from the three monitoring wells (NW-5, NW-6, and NW-7) located off the site, north of Rock Avenue.

Direct Contact

The COPC selection process is documented in Appendix D, Table 2.3 by the inclusion of the screening toxicity values. The EPA Region III RBCs for tap water were used as primary screening toxicity values. The screening toxicity value for lead (15 ug/L) is equal to the action level under the Safe Drinking Water Act. EPA, Region III RBCs based on non-cancer health effects were reduced by one-tenth to represent a target HQ of 0.1 and account for additive health effects.

The COPC flag and rationale for chemical deletion or selection are provided for each detected chemical. Applying these selection criteria, the following chemicals were selected as COPCs in groundwater due to the potential for health risks posed by direct contact exposure:

- Five VOCs: benzene, carbon tetrachloride, chloroform, methylene chloride, and methyl tert-butyl ether.
- Four SVOCs: bis(2-ethylhexyl)phthalate, carbazole, 2-methylnaphthalene, and naphthalene.
- Twelve metals: aluminum, arsenic, beryllium, cadmium, chromium, cobalt, iron, lead, manganese, nickel, vanadium, and zinc.

Vapor Intrusion

Consideration was also given to the potential for subsurface vapor intrusion of volatile chemicals in groundwater into current or future buildings on the site.

Fifteen volatile chemicals (as defined by the EPA) were detected in groundwater. These chemicals were detected infrequently, generally in only 1 or 2 of 13 groundwater monitoring well samples and at relatively low concentrations. Most of the detections were along the western boundary of the site, in the vicinity of the TMP. To assess the potential for subsurface vapor intrusion, the data for these chemicals were compared to target groundwater concentrations for a commercial/industrial setting using the overall methodology employed by the EPA in their *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils* (EPA, 2002) and exposure parameters and toxicity values used by the EPA, Region III in the development of their RBCs (EPA, 2005), as noted in Table 2.4. Consistent with EPA (2002), a conservative attenuation factor (alpha) of 0.001 was assumed. The target groundwater concentrations were derived based on a target HQ of 0.1 and/or a target risk of 10^{-6}; the derivation is provided in Appendix F.

Comparison of the groundwater data to the target groundwater concentrations is presented in Appendix D, Table 2.4. Carbon tetrachloride was detected in groundwater from two monitoring wells (MW-7 and NW-4) at concentrations greater than the target groundwater concentration. In addition, benzene (EW-2), chloroform (MW-7), and isopropylbenzene (NW-1 and EW-2) were detected in one or two groundwater samples at concentrations slightly greater than the target groundwater concentrations. No screening values were available for cyclohexane, 1,1'-biphenyl, and 2-methylnaphthalene.

Based on the above evaluation, the following chemicals were selected as COPCs in groundwater due to the potential for vapor intrusion to indoor air:

- VOCs – benzene, carbon tetrachloride, chloroform, cyclohexane, isopropylbenzene, 1,1'-biphenyl, and 2-methylnaphthalene.

6.2.3 Surface Water

Surface water sampling was conducted in 2000/2001 to evaluate the nature of contamination in the surface water that flows in Rogue Harbor Branch from north to south across the site. Three surface water samples and one duplicate sample were collected during the field investigation. The sample "SW-UPR" was located near the site's northern boundary, while the sample "SW-LWR" was collected near the site's southern boundary. All surface water samples were analyzed for VOCs, SVOCs, pesticides/PCBs, and metals, as indicated in Section 4.3.4.

Appendix D, Table 2.4 presents the surface water data; data for SW-UPR appear as "upstream values" in the table. Sample results from the duplicate sample were averaged with the original (SW-LWR). No VOCs, SVOCs, pesticides, or PCBs were detected in any of the three surface water samples. Appendix D, Table 2.5 therefore presents the total metals data only.

There are no risk-based surface water screening toxicity values for human health risk assessment available. Even though ingestion of surface water by an adolescent recreationist is not anticipated, detected chemical concentrations in surface water are compared to EPA, Region III RBCs for tap water. EPA, Region III RBCs based on non-cancer health effects were reduced by one-tenth to represent a target HQ of 0.1 and account for additive health effects.

For lead, no RBC is available; therefore, the action level (15 µg/L) under the Safe Drinking Water Act was substituted.

The COPC flag and rationale for chemical deletion or selection are provided for each detected chemical. Applying these selection criteria, the following chemicals were selected as COPCs in surface water:

- Four metals: iron, lead, manganese, and vanadium.

6.2.4 Sediment

Sediment sampling was conducted to evaluate the nature and extent of contamination in the sediment in Rogue Harbor Branch. Three sediment samples were collected from depths of 0-6 inches. All three samples were analyzed for VOCs, SVOCs, pesticides/PCBs, and metals, as indicated in Section 4.3.3. Appendix D, Table 2.6 presents the sediment data; data for SED-UPR appear as "upstream values" in the table.

There are no risk-based sediment screening toxicity values for human health risk assessment available. EPA, Region III RBCs for residential soil are substituted in Appendix D, Table 2.5 for the purposes of the screen, with the assumption that RBCs protective of resident exposures to soil are also protective of adolescent recreationist exposures from ingestion and dermal contact with sediment. Region III RBCs based on non-cancer health effects were reduced by one-tenth to represent a target HQ of 0.1 and account for additive health effects.

The COPC flag and rationale for chemical deletion or selection are provided for each detected chemical. Applying these selection criteria, the following chemicals were selected as COPCs in sediment:

- Two metals: arsenic and iron.

6.3 EXPOSURE ASSESSMENT

The objective of the exposure assessment is to estimate the type and magnitude of human exposure to COPCs present at or migrating from the site. The first step of the exposure assessment is to identify the potentially exposed human populations at or near the site, with regard to the current and potential future land uses. Potentially complete exposure pathways are then identified between selected human receptors and COPCs in soil, groundwater, surface water, and sediment at the site. Lastly, an estimate of chemical intake is calculated from representative exposure point concentrations (EPC) and exposure parameters that are specific to, respectively, sampled environmental media and identified receptor populations. The results of the exposure assessment are combined with the toxicity assessment to characterize the potential for human health risks in Section 6.5.

6.3.1 Human Receptors

The site is currently a mixture of various types of industrial activities, including transportation maintenance, petroleum fueling, and material storage. Numerous underground utility lines are located on the site, including a water distribution system, a sanitary sewer system, an electrical

system, and a mechanical branch system for heating/cooling. Future site land use will be as an LOC Campus Facility. Potential current and future human receptors therefore include: LOC workers in the storage facilities, FGGM site workers at the TMP or performing maintenance work at the site, construction/utility workers performing routine maintenance or repair operations, and construction workers performing construction activities related to site redevelopment.

Base housing is located directly north of the site. While residents are not expected to be present on the LOC parcel, it is possible that resident adolescents may recreate along Rogue Harbor Branch, resulting in exposure to surface water and sediment. According to future LOC plans for the site, the eastern and western portions of the site, corresponding to the TMP and Warehouse Area, respectively, will be fenced. Therefore, resident adolescents are not expected to be present in those areas of concern.

FGGM is a fenced and routinely patrolled installation, with limited visitor access. It is highly unlikely that trespassers would be present on the post property, so trespassers are not considered a potential human receptor population for this site.

Previous reports indicate there are six production wells, screened between 500 and 800 feet below ground surface, located on FGGM. Production wells PW-1 and PW-2 are located on the FGGM cantonment area north of MD Route 32, and wells PW-3 through PW-6 are located along Range Road. These wells are not located near the LOC parcel and are installed in the deep aquifer, below at least one confining layer. Under the current land use scenario, there are no nearby drinking water wells, and there is no potential for exposure to groundwater from potable use. However, given the current groundwater classification on FGGM, there is the possibility that future use of the groundwater in the vicinity of the site may include potable water supply. Residents (adults and children) living in the vicinity of the site who may consume or utilize local groundwater or whose property is, or could be, underlain by contaminated groundwater in the future are included as potential human receptors in this HHRA. Therefore, a residential exposure scenario was included to estimate exposure to COPCs in groundwater.

Based on the above rationale, under the current and future land use scenarios, potentially exposed human populations are indoor and outdoor site workers, construction workers, construction/utility workers, and recreationists (off-site resident adolescents). The two categories of construction workers consider large-scale redevelopment (construction workers) and utility maintenance or repair (construction/utility workers). Additional potential future human receptors are off-site residents (adults and children) who may utilize groundwater for potable water supply.

6.3.2 Exposure Pathways

Potentially complete exposure pathways consist of four elements: a) a source and mechanism of COPC release, 2) a retention or transport mechanism, 3) a point of potential human contact with the contaminated medium, and 4) an exposure route at the contact point (EPA, 1989).

Exposure pathways between COPCs in source media and potential human receptors at the FGGM site are illustrated through a conceptual site model, presented in Figure 6-1 (provided at the end of Section 6). Exposure media are surface and subsurface soil, groundwater, surface water, and sediment at the site. Although no environmental samples were collected, air is identified as an additional exposure medium due to the potential exposure pathways described

below. Exposure routes to human receptors are therefore incidental ingestion, dermal contact, and inhalation. A discussion of the potentially complete exposure pathways identified for each medium of concern is presented below.

Soil

There is the potential for indoor and outdoor site workers to be exposed to COPCs in surface soil via dermal contact with and incidental ingestion of soil during outdoor activities. There is the potential for construction and construction/utility workers to be exposed to COPCs in surface and subsurface soil through dermal contact with and incidental ingestion of soil during construction and utility work.

Due to the presence of moderate vegetation and gravel, minimal inhalation exposure to outdoor site workers from windblown dust is anticipated. However, there is the potential for indoor site workers to be exposed to volatile COPCs in subsurface vapors released from soil and transported to indoor air in on-site buildings. In the event of intrusive utility maintenance and repair activities, there is the potential for construction/utility workers to inhale volatile COPCs released from the soil and COPCs as respirable particulates released from the soil during soil excavation. In addition, there is the potential for construction workers to inhale volatile COPCs released from soil and COPCs as respirable particulates released from the soil from vehicle traffic on temporary unpaved roads. According to the EPA (2002a), respirable particulate emissions from vehicle traffic on unpaved roads is potentially greater than wind-driven or construction activity-driven emissions.

Groundwater

Depth to groundwater has been characterized as variable across the site; boring logs recorded measurements as shallow as 5 feet bgs near Rogue Harbor Branch and as deep as 45 feet bgs in the northeast corner of the site. There is a potentially complete exposure pathway identified for construction/utility workers, from dermal contact with COPCs in and inhalation of volatile COPCs released to outdoor air from shallow groundwater, in the event that soil excavation and trenching activities result in pooling of shallow groundwater in the bottom of the excavation/trench. There is also the potential for indoor site workers to inhale volatile COPCs in subsurface vapors released from groundwater and transported to indoor air in on-site buildings.

Given the current groundwater classification on FGGM, there is the possibility that future use of the groundwater in the vicinity of the site may include potable water supply. Off-site residents (adults and children) may be exposed to COPCs in groundwater through ingestion, dermal contact, and inhalation of volatiles in groundwater released to indoor air during showering or bathing. In addition, there is the potential for off-site residents to inhale chemicals in subsurface vapors released from groundwater and transported to indoor air in off-site residences.

Surface Water

Rogue Harbor Branch runs north-south through a forested portion of the 100-acre site. Field observations indicate the stream is 10-20 feet wide, with a shallow water depth of 1-3 feet and an average flow of less than 10 cubic feet per second. Surface water is not used for drinking water or fishing. FGGM site workers do not work near the stream, and no construction occurs at the stream. Therefore, no potentially complete exposure pathways are identified from COPCs in surface water to site workers, construction/utility workers, or construction workers under the current land use scenario.

Base housing is located north of the site. While residential adolescents are not expected to frequent Rogue Harbor Branch on a routine basis, it is possible that resident adolescents may recreate near the stream, resulting in exposure to surface water and sediment. Potential exposure pathways are therefore identified for the recreationist, characterized as resident adolescents, through the dermal contact route of exposure.

Sediment

Potential exposure pathways associated with sediment of Rogue Harbor Branch are essentially the same as those for surface water. Site workers do not work near the stream, and no construction occurs at the stream, so exposure to sediment is not expected to site workers, construction/utility workers, or construction workers under the current land use scenario.

However, a potentially complete exposure pathway is identified between COPCs in sediment and recreationists, characterized as resident adolescents, through dermal contact and incidental ingestion routes of exposure.

Based on the above discussion, a summary of the exposure pathways selected for inclusion in the estimation of the potential for human health risks associated with environmental impacts at the LOC parcel appear in Appendix D, Table 1. The scenario time frame, medium, exposure medium, exposure point, receptor population, receptor age, exposure route, type of analysis (quantitative or qualitative), and rationale for inclusion of the exposure pathway are provided.

6.3.3 Data Utilization

In utilizing the analytical data to derive representative EPCs, duplicate samples were averaged with results of the originals, as indicated above. If a COPC was not detected in a sample, it was assumed to be present at one-half its detection limit. Using one-half the detection limit as conservative “proxy” concentrations assumes that a chemical may be present at a concentration above zero but below the reported detection limit and may tend to overestimate the EPC. Data assigned a qualifier indicating the numerical value is an estimated quantity, or that the identity and quantity are based on presumptive evidence, were treated the same way as data without such qualifiers.

In order to determine the COPC concentrations to which an individual might be exposed over many years, representative EPCs were calculated from the available/usable data sets described earlier in Section 6.2. The EPA (2002a, 1991b, 1989) recommends that the arithmetic average concentration of the data be used for evaluating long-term exposure and that, because of the uncertainty associated with estimating the true average concentration at a site, the 95% upper

confidence limit (UCL) on the arithmetic average be used as the EPC. The 95% UCL on the arithmetic average concentration provides reasonable confidence that the true average will not be underestimated. The EPA (2002a, 1991b) also indicates that, in calculating a 95% UCL on the arithmetic average concentration, where there is a question about the distribution of the data set, a statistical test should be used to identify the best distributional assumption for the data set. The ProUCL Version 3.0 program developed by Lockheed Martin for the EPA, Region III through the EPA's Technology Support Center for Monitoring and Site Characterization was used to test the distributional assumptions and calculate the 95% UCLs.

In a few cases where the 95% UCL on the arithmetic average concentration is greater than the maximum detected concentration, the maximum detected concentration is used as the EPC. Despite the large amount of censored (non-detected) data in soil and groundwater samples, the 95% UCLs were calculated the same way, whether the frequency of detection was greater or less than 85%. For surface water and sediment samples, the maximum detected concentration is the EPC, because the data sets are comprised of less than 10 samples.

The EPCs for the COPCs in sampled environmental media, based on the data sets described above, are presented in Appendix D, Tables 3.1 to 3.5. The ProUCL output sheets for the individual COPCs are provided in Appendix E.

The EPCs for the volatile and non-volatile COPCs in outdoor or indoor air following release from groundwater or soil were estimated based on the EPCs for the COPCs in those media. The various techniques used to estimate COPC emissions and COPC concentrations in outdoor or indoor air are outlined below, by medium, and presented in greater detail in Appendix F.

Soil

Concentrations of the COPCs in outdoor air over an excavation (to evaluate potential exposure of construction/utility workers) were estimated using emissions equations recommended by the EPA for respirable particulates (EPA, 1993b) and vapors (EPA, 1992a). Emissions of the non-volatile COPCs in soil were estimated under the assumption that COPCs associated with respirable particulates are released to outdoor air during the digging of the excavation. In addition, emissions of the volatile COPCs in soil were estimated under the assumption that the chemicals are released from the soil pore space during the digging of the excavation and that the chemicals diffuse through the sidewalls of the excavation once completed. Resulting non-volatile and volatile COPC concentrations in outdoor air over an excavation were estimated using the EPA-approved SCREEN3 model (EPA, 1995b) and Point, Area, and Line source model (PAL2.1, EPA, 1992b), respectively.

Concentrations of the COPCs in outdoor air during larger-scale construction (to evaluate potential exposure of construction workers) were estimated following EPA guidance (EPA, 2002d) through derivation of a particulate emissions factor (PEF) for emissions of non-volatile COPCs from vehicle traffic on temporary unpaved roads and volatilization factors (VFs) for volatile COPCs released from the soil surface.

Groundwater

Concentrations of the volatile COPCs in shower and bathroom air during and following showering (to evaluate potential exposure of resident adults and children) were estimated using the "Schaum model" (Schaum et al., 1992).

Concentrations of the volatile COPCs in outdoor air (to evaluate potential exposure of construction/utility workers) were estimated using an emissions equation recommended by the EPA (1995b), under the assumption that shallow groundwater infiltrates an excavation and the volatile COPCs are released from pooled water at the bottom of the excavation, and the EPA-approved PAL2.1 model (EPA, 1992b). Since the depth to the water table ranges from 5 to 45 feet bgs, scenarios where the water table is deeper than the assumed depth of an excavation are possible. Under these conditions, volatile COPCs could be released from the water table and diffuse through the overlying soil before infiltrating an excavation. Since evaluation of the pooled water scenario should be adequately protective of deeper water table conditions, deeper water table conditions were not evaluated further.

Concentrations of the volatile COPCs in indoor air in current and future buildings built on a slab (to evaluate potential exposure of indoor workers), were estimated using the Johnson and Ettinger model (J&E model) for subsurface vapor intrusion into buildings, as described in Appendix F. The EPA's User's Guide (EPA, 2004d) and software were used to facilitate this analysis. Available site-specific data for the southwest area of the site, as represented by conditions in monitoring well NW-4, were used in the analysis. As shown on Figure 3-2, a depth to groundwater of approximately 22 feet and three overlying soil strata were input to the J&E model including, in descending order: sand (19 feet thick), clay (2 feet thick), and sand (1 foot thick). Where site-specific data were not available, default values provided in the EPA's User's Guide that are appropriate for the assumed soil types were used. The current building was represented by the dimensions of Building 68; due to the age of construction, an air exchange rate of 2/hour was assumed. The future building was represented by the dimensions of Buildable Area 1b which is designated for possible administrative or warehouse use (Greenhorne & O'Mara, Inc., 2005); an air exchange rate of 1/hour for newer construction was assumed.

6.3.4 Estimates of Chemical Intake / Exposure

Estimates of chemical intake and exposure were developed to portray reasonable maximum exposure (RME) that might be expected to occur under current and future exposure scenarios. Thus, the highest exposure that might reasonably be expected to occur in the vicinity of the LOC parcel, one that is well above the average case of exposure but within the range of possibilities, was considered.

The exposure equations for estimating chemical intakes and dermally absorbed doses, as well as the parameter values used in the equations, are presented in Appendix D, Tables 4.1 through 4.12 and described below. Application of the exposure equations results in chronic daily intake (CDI) or, for dermal contact exposure, dermally absorbed dose, expressed in mg per kg of body weight per day (mg/kg-day). The CDI is the amount of chemical at the exchange boundary. A fundamental assumption in the estimate of the dermally absorbed dose is that absorption continues long after the exposure has ended (EPA, 2004b); thus, the final absorbed dose (DA_{event}) is estimated to be the total dose dissolved in the skin at the end of the exposure.

All of the exposure equations require a chemical concentration or the 'average' concentration contacted over the exposure period (e.g., mg/L groundwater), termed the EPC. In practice, this is the 95% upper confidence level (UCL) on the arithmetic average concentration or the maximum detected concentration, as described above. The equations also require a contact rate, which is the amount of contaminated medium contacted per unit time or event (e.g., 1 L water/day), body weight, which is the average body weight (kg) over the exposure period, and an averaging time, which is the time period (days) over which exposure is averaged. For all adult exposure scenarios, an average body weight (BW) of 70 kg is used (EPA, 1991a).

The averaging time (AT) depends on the type of toxic effect being assessed. When evaluating exposures for potential long-term, non-cancer health effects, intakes are calculated by averaging over the period of exposure. This is equal to the exposure duration (ED) multiplied by 365 days/year. When evaluating potential excess lifetime cancer risks, intakes are calculated by prorating the total cumulative intake over a lifetime (i.e., lifetime average daily intake). For calculation purposes, this is equal to 70 years multiplied by 365 days/year (or 25,550 days). This distinction is consistent with the hypothesis that the mechanism of action for each of these health effects endpoints is different. The approach for carcinogens is based on the assumption that a high dose received over a short period of time is equivalent to a corresponding low dose spread over a lifetime. These and other COPC-related, population-related, and evaluation-determined parameters are discussed below, by medium and receptor population.

Outdoor Site Workers

The exposure parameters necessary to estimate COPC intakes by adult outdoor site workers, via incidental ingestion of and dermal contact with COPCs in surface soil, are as follows.

The exposure frequency (EF) is 225 days/year and an exposure duration (ED) of 25 years is assumed. An average ingestion rate (IR-S) of 100 mg/day is used to evaluate incidental ingestion (i.e., as might result from hand-to-mouth behavior) of soil by site workers (EPA, 2002a). A "fraction ingested" (FI) (i.e., the fraction of the total amount of contacted soil that is presumed to be contaminated) of 1 is used in this evaluation, with the assumption that 100% of the soil ingested is contaminated with concentrations equivalent to the estimated EPCs.

Several parameters for evaluating dermal exposure by estimating the absorbed dose per event (DA_{event}) are needed. Consistent with EPA (2004b) and EPA Region III (2003b, 1995a) guidance for dermal risk assessment (EPA, 2003, 1995), dermal contact with soil (and sediment) is estimated using chemical-specific dermal absorption factors, as listed on Table F-12 in Appendix F. In the absence of chemical-specific dermal absorption factors, chemical class-specific factors are used, consistent with EPA guidance. For the calculation of dermally absorbed dose, a skin surface area (SA) of 3,300 cm^2 and a soil-to-skin adherence factor (AF) of 0.2 mg/cm^2-event are used (EPA, 2002a).

Indoor Site Workers

The exposure parameters necessary to estimate COPC intakes by adult workers, via potential inhalation of volatile COPCs in subsurface vapors released from groundwater and transported to indoor air in on-site buildings, are as follows.

The EF for an indoor worker is 250 days/year (5 days/week for 50 weeks/year), and an ED of 25 years was assumed. An exposure time (ET) of 8 hours/day and an inhalation rate (IR_i) of 20 m^3/day (EPA, 2002a), or 0.83 m^3/hr, were used.

Construction / Utility Workers

The exposure parameters necessary to estimate COPC intakes by construction/utility workers, via potential ingestion, dermal contact, and inhalation exposures to COPCs in all soil and via dermal contact with and exposure to COPCs in groundwater are as follows. An IR-S of 330 mg/day and an FI of 1 were used. An SA of 3,300 cm^2 and an AF of 0.3 mg/cm^2-event were assumed (EPA, 2002a). An IR_i of 20 m^3/day, or 0.83 m^3/hr, was used to assess inhalation of volatile COPCs released to outdoor around an excavation from soil and/or groundwater and COPCs sorbed to dust particulates released to outdoor air from soil around an excavation. An ET of 8 hours/day is assumed. An EF of 60 days/year (5 days/week and 4 weeks/month for 3 months/year), and an ED of 1 year were assumed, because construction/utility work is limited in duration.

For soil, dermal contact exposure was estimated as described above for an outdoor site worker. Chemical-specific dermal absorption factors are listed on Table F-13 in Appendix F. For groundwater, parameters needed to calculate DA_{event} include chemical-specific parameters, such as a fraction absorbed (FA), a dermal permeability coefficient (Kp), and a lag time per event (tau-event). The Kp reflects movement across the skin to the underlying skin layers and into the bloodstream. The chemical-specific parameter for the ratio of the permeability coefficient (Kp) of a chemical through the stratum corneum relative to its permeability coefficient across the viable epidermis (B) does not appear in the equation for DA_{event} for short exposure times, because DA_{event} is not a function of B at short exposure times. For short exposure times, the amount of chemical absorbed depends only on permeability of the stratum corneum (Kp). Sources of chemical-specific values used in this exposure assessment are the *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (EPA, 2002a) and the Syracuse Research Corporation's ChemFate database, recommended by the Superfund Chemical Data Matrix Methodology (EPA, 2004c). Chemical-specific factors used in the calculation of DA_{event} for the construction/utility worker appear in Table F-14 of Appendix F.

Construction Worker

The exposure parameters necessary to estimate COPC intakes by construction workers, via potential ingestion, dermal contact, and inhalation exposures to COPCs in all soil are as follows. An IR-S of 330 mg/day and an FI of 1 were used. An SA of 3,300 cm^2 and an AF of 0.3 mg/cm^2-event were assumed (EPA, 2002a). An IR_i of 20 m^3/day, or 0.83 m^3/hr, was used to assess inhalation of volatile and non-volatile COPCs released from soil to outdoor air during construction. In accordance with EPA (2002a) guidance, an exposure time ET of 8 hours/day, an EF of 250 days/year (5 days/week for 50 weeks/year), and an ED of 1 year were assumed.

Dermal contact with soil was evaluated as described above for the outdoor site worker. Chemical-specific dermal absorption factors are listed on Table F-13 in Appendix F. As described above, Inhalation of volatile and non-volatile COPCs in outdoor air was evaluated using chemical-specific VFs and a PEF.

Residents- Adults and Children

The potential for off-site residents to inhale chemicals in subsurface vapors released from groundwater and transported to indoor air in off-site residences was identified earlier as a potential exposure pathway. However, future residential development downgradient of the site is unlikely, considering the presence of a county airport and a wildlife refuge southeast of the site. Therefore, the only exposure scenario evaluated assumes hypothetical future use of the groundwater for potable and other household purposes by off-site resident adults and children. In this way, the inclusion of a residential scenario is intended to supplement the groundwater data analysis, without reflecting actual potential future use.

The exposure parameters necessary to estimate COPC intakes by resident adults and children, via potential ingestion of, dermal contact with, and inhalation of COPCs in tap water are as follows. Ingestion rates (IR-W) of 2 liters/day and 1 liter/day were assumed for adults and children, respectively; they represent the 90th percentile values for daily water consumption for adults and infants (EPA, 2002a).

Since the greatest, but not exclusive, opportunity for dermal exposure in the home is during showering or bathing, the entire surface area of the body was used to evaluate dermal exposure. Skin SAs of 18,000 cm^2 and 6,600 cm^2 were used for adults and children, respectively. These values represent the average of 50th percentile total body surface areas for adult males and females and a time-weighted average surface area for a 0 to 6-year old child using 50th percentile total body surface areas for male and female children, respectively (EPA, 2004).

The EPA (2004b) recommends the use of a screening procedure for evaluating dermal contact with water where the receptor is also exposed via ingestion (i.e., resident adults and children and workers). Typically following this screening procedure, a COPC is evaluated for the dermal contact exposure route only if intake from dermal contact exceeds 10% of the intake from ingestion. However, dermal contact is evaluated with all COPCs, consistent with EPA Region III guidance (EPA, 2003b). In addition, for dermal contact with the volatile COPCs, the EPCs in groundwater were adjusted by a factor of 0.6. This adjustment accounts for the fact that as the volatile COPCs are released from the water to air, less of the VOCs are available for dermal contact. Based on a generalized volatilization factor for VOCs in shower water of about 75% (over a range of 50% to 90% depending on the VOC) and the assumption that volatilization occurs linearly over time, Schaum et al. (1992) recommend that the average concentration of a VOC dissolved in the water be estimated as 60% of the initial VOC concentration. Otherwise, dermal contact with groundwater was as described above. Chemical-specific factors used in the calculation of DA_{event} for the residential adults and children appear in Tables F-15 and F-16 of Appendix F.

An IR_i of 0.83 m^3/hour was assumed in evaluating exposure of resident adults to vapor-phase chemicals released from the water; this represents an average inhalation rate for an average adult (EPA, 1991a). For a child, age 6, an IR_i of 0.3 m^3/hour during rest activities was assumed (EPA, 1997a).

Exposure times for dermal contact of 0.2 hours/event (i.e., 12 minutes/event) for adults during showering and 0.33 hours/day (i.e., 20 minutes/day) for children during bathing were used (EPA, 2003b). The ETs for inhalation during and after showering/bathing while in the bathroom

of 0.33 hours/event (i.e., 20 minutes/event) for adults and 0.5 hours/event (i.e., 30 minutes/event) for children were assumed.

An EF of 350 days/year was used for residents, assuming 15 days away from the home over the course of a year (EPA, 1991a). The ED used was 30 years (the 90th percentile time at one residence) for adults and 6 years for children. However, in evaluating excess lifetime cancer risks for resident adults, the ED of 30 years is based on 6 years at the child's rate of exposure and 24 years at the adult's rate of exposure (EPA, 1991a). The average BW of an adult is 70 kg, while that of a child (ages 0-6 years) is 15 kg (EPA, 1989).

Recreationist

The recreationist exposure scenario is modeled through contact of resident adolescents, ages 12-18 years, with surface water and sediment. The exposure parameters necessary to estimate COPC intakes are as follows.

An EF of 50 days/year is used for resident adolescents, assuming contact once a week throughout the year or twice a week during the six warmer months of the year. An ED of 6 years accounts for adolescents between the ages of 12 and 18 years. The average BW of an adolescent is 61 kg, calculated as the average of the mean male and female body weights, for ages 12-18 years (EPA, 2002a).

To estimate exposure via incidental ingestion (i.e., as might result from hand-to-mouth behavior), a sediment ingestion rate (IR_{sed}) of 100 mg/day was adapted from EPA recommendations on the IR-S for estimating residential exposure to soil (EPA, 2002a). An FI of 1 was used, with the assumption that 100% of the sediment ingested is contaminated with concentrations equivalent to the estimated EPCs.

For dermal contact exposures, an SA of 7,224 cm^2 (EPA, 2002b) was calculated by taking a percent of the average 90th percentile total body surface areas for males and females. The percent of total body surface area is based on the sum of "percentage total body area" for the face (half the head), forearms (half the arms), lower legs (half the legs), hands, and feet. An AF of 0.2 mg/cm^2-event was adapted from EPA recommendations on parameters to be used for estimating child exposures to wet soil (EPA, 2002a). The event time (t-event) is assumed to be 2 hours/day spent near Rogue Harbor Branch.

Dermal contact with surface water and sediment was evaluated as described above for groundwater and soil. Chemical-specific factors used in the calculation of DA_{event} for the recreationist appear in Tables F-17 and F-18 of Appendix F.

6.4 TOXICITY ASSESSMENT

The toxicity assessment, also termed the dose-response assessment, serves to characterize the relationship between the magnitude of exposure and the potential that an adverse effect will occur. It involves determining whether exposure to a chemical can cause an increase in the incidence of a particular adverse health effect, and characterizing the nature and strength of the evidence of causation. The toxicity information is then quantitatively evaluated and the

relationship between the dose of the chemical received and the incidence of adverse effects in the exposed population is evaluated.

The EPA and other regulatory agencies have performed toxicity assessments for numerous chemicals and the guidance they provide are used in this risk assessment. These include verified reference doses (RfDs) or verified reference concentrations (RfCs) for the evaluation of noncarcinogenic health effects from chronic exposure to chemicals and cancer potency slope factors for the evaluation of excess cancer risk from lifetime exposure to chemicals. Sources of toxicological information and toxicity values, in order of preference consistent with current EPA guidance (EPA, 2003a), include:

- Tier 1: IRIS (Integrated Risk Information System), which is an on-line EPA database containing current toxicity criteria for many chemicals that have gone through a peer review and EPA consensus review process (EPA, 2005c).
- Tier 2: Provisional Peer-Reviewed Toxicity Values (PPRTVs) developed by the EPA Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center [Presently, available PPRTVs were obtained from the EPA, Region III RBC Table (EPA, 2005b)].
- Tier 3: Additional EPA and non-EPA sources of toxicity information, including but not limited to the California Environmental Protection Agency toxicity values, the ATSDR minimum risk levels, and toxicity values published in the EPA Health Effects Assessment Summary Tables (HEAST) (EPA, 1997b). [Presently, available provisional toxicity values derived by the EPA National Center for Environmental Assessment were obtained from the EPA, Region III RBC Table (EPA, 2005b)].

6.4.1 Non-cancer Health Effects from Chronic Exposure

The potential for non-cancer health effects associated with chemical exposure is evaluated by comparing an estimated intake (such as CDI) over a specified time period with a reference dose (RfD) derived for a similar exposure period. The RfD is an estimate of a daily exposure level for the human population, including sensitive subpopulations that are likely to be without an appreciable risk of deleterious effects during a lifetime. According to the EPA, RfDs often have an uncertainty spanning perhaps an order of magnitude or greater. Chronic RfDs used in this risk assessment are specifically developed to be protective of long-term exposure to a chemical. For construction/utility workers whose exposure was assumed to have occurred over a one-year period, sub chronic RfDs are the more appropriate criteria. However, since sub chronic RfDs are often lacking or in some cases set equal to chronic RfDs, chronic RfDs are used as conservative approximations.

The RfDs for the characterization of potential chronic non-cancer health effects via oral and inhalation exposures are presented in Appendix D, Tables 5.1 and 5.2, respectively, along with the primary target organ, the source of the RfD, and combined uncertainty and modifying factors used in the derivation of the RfD. Generally, order-of-magnitude (i.e., in increments of 10) uncertainty factors reflect the various types of data (e.g., a No Observable Adverse Effect Level from a valid chronic study in humans) used to estimate the RfDs. Modifying factors, which can range from greater than zero to 10, reflect qualitative professional judgment regarding scientific uncertainties (e.g., the completeness of the overall database) not covered by the uncertainty factor.

RfDs for oral exposure are available for most of the COPCs. RfDs are not available, however, for dermal exposure. In their absence, oral RfDs are used and adjusted as per EPA guidance (EPA, 2004b, 1989) to reflect absorbed dose. This allows for comparison between exposures estimated as absorbed doses and toxicity values expressed as absorbed doses. The oral-to-dermal adjustment factors and the adjusted RfDs are presented in Table 5.1.

A limited number of reference concentrations (RfCs) for inhalation exposure are available. The available RfCs were converted into RfDs based on a standard inhalation rate of 20 m^3/day and standard body weight of 70 kg.

The potential for noncarcinogenic health effects is evaluated using the ratio of the CDI to the RfD (i.e., CDI/RfD), termed a HQ. The HQ assumes that there is a level of exposure (i.e., the RfD) below which it is unlikely for even sensitive subpopulations to experience adverse health effects. If the HQ exceeds 1, then there may be concern for potential non-cancer health effects. The greater the HQ is above 1, the greater the level of concern.

6.4.2 Carcinogenic Risks from Lifetime Exposure

Regardless of the mechanism of effect, risk evaluation methods employed by the EPA generally derive from the hypothesis that thresholds for cancer induction by carcinogens do not exist and that the dose-response relationship is linear at low doses. Based on this hypothesis, the EPA has derived estimates of excess cancer risk from lifetime exposure to potential carcinogens. Generally, the EPA establishes the carcinogenic potency of the chemical through critical evaluation of the various test data and fitting dose-response data to a low-dose extrapolation model. The slope factor, which describes the dose-response relationship at low doses, is expressed as a function of intake [i.e., (mg/kg-day)-1].

The oral and inhalation slope factors for the carcinogenic COPCs presented in Appendix D, Tables 6.1 and 6.2, respectively, were used to estimate finite, upper limits of risk at low dose levels administered over a lifetime. For children, the estimated cancer risk reflects the potential risk over a lifetime due to childhood exposure. The weight-of-evidence classification for carcinogenicity and the basis and source of slope factor are also presented in Appendix D, Tables 6.1 and 6.2.

Excess lifetime cancer risks are estimated by multiplying the CDI averaged over 70 years by the slope factor. The resulting risk estimate is expressed as a unitless probability (e.g., 2 x 10-5 or 2 in 100,000) of an individual developing cancer. This linear equation is valid only at low risk levels (i.e., below estimated risks of 10-2). When intakes may be high (i.e., estimated risks above 10-2), the EPA (1989) recommends an alternate calculation (using the one-hit equation) that is also consistent with the linear low-dose model. According to the EPA, this overall approach for estimating excess lifetime cancer risk does not necessarily give a realistic prediction of risk. The true value of the risk at trace ambient concentrations is unknown, and may be as low as zero.

As with RfDs, the EPA has not derived slope factors for dermal exposure. In their absence, slope factors for oral exposure were used and adjusted as per EPA guidance to reflect absorbed dose. This allows for risk estimation based on exposures estimated as absorbed doses and slope factors expressed as absorbed doses. The oral-to-dermal adjustment factors and the adjusted slope factors are presented in Appendix D, Table 6.1.

6.4.3 Chemical Mixtures

EPA guidance was also used to evaluate the overall potential for non-cancer health effects and cancer risks posed by multiple chemicals. For the evaluation of non-cancer health effects, EPA guidance assumes that sub threshold exposures to several chemicals at the same time could result in an adverse health effect. The sum of the HQs (for individual chemicals, exposure routes, exposure pathways, or potentially-exposed populations) is the hazard index (HI). When the HI exceeds 1, there may be concern for potential health effects. Generally, HIs are only used in the evaluation of a mixture of chemicals that induce the same effect by the same mechanism of action. In this evaluation, the HIs of mixtures of chemicals that can have different effects were used as a screening-level approach, as recommended by the EPA (1989). This approach may overestimate the likelihood of adverse, non-cancer health effects. Then, for HIs that were greater than the EPA acceptable level, toxic endpoint-specific hazard indices were calculated based on the toxicological endpoint used to derive the RfD.

For the evaluation of excess lifetime cancer risks, EPA guidance indicates that the individual risks associated with exposure to each chemical can be summed. This approach, which is used in this evaluation, assumes independence of action by the chemicals involved (i.e., that there are no synergistic or antagonistic chemical interactions and that all chemicals produce the same effect: cancer).

6.4.4 Lead

The EPA has not developed reference doses or slope factors for lead. Rather, the potential for adverse health effects from exposure to lead in soil and groundwater is evaluated through comparison of predicted blood lead (PbB) levels to a health-protective target PbB level. For adult workers exposed to lead in soil, this evaluation is facilitated through the use of the EPA's Adult Lead Methodology (EPA, 2003) and Adult Lead Model (ALM). For resident children exposed to lead in groundwater, this evaluation is facilitated through the use of the EPA's Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) (USEPA, 2002e, 1994). The models were accessed at: www.epa.gov/superfund/programs/lead/products.htm. The soil and groundwater evaluations are presented in Section 6.5 Risk Characterization.

6.4.5 Qualitative Assessment of COPCs without Toxicity Criteria

EPA-derived toxicity criteria were not available to quantitatively assess the potential for human health risks for 1,1'-biphenyl, carbazole, methylcyclohexane, and phenanthrene. Possible health implications that may be associated with exposure to these COPCs are described in Section 6.5 Risk Characterization.

6.5 RISK CHARACTERIZATION

As indicated previously, the likelihood and magnitude of adverse health risks are estimated in the risk characterization, in the form of non-cancer HQs and HIs and excess lifetime cancer risks. The toxicity of COPCs without toxicity values and sources of uncertainty in the risk assessment are also noted and briefly discussed.

6.5.1 Risk Estimation

The COPC and exposure route specific non-cancer HQs and excess lifetime cancer risks associated with potential exposure to the receptors considered in this risk assessment are presented in Appendix D, Tables 7.1 to 7.10. The total non-cancer hazard indices and excess lifetime cancer risks for the COPCs summed for all exposure routes, and the total pathway non-cancer hazard indices and excess lifetime cancer risks (i.e., summed for all COPCs and exposure routes), are presented in Appendix D, Tables 9.1 to 9.8 and discussed below. (Note that there is no Table 8 series as those tables are reserved for radionuclide in the EPA's RAGS Part D format.) To be inclusive of both indoor and outdoor exposure scenarios, the risk estimates for the outdoor site workers' exposure to surface soil were added to the indoor workers' exposure to groundwater COPCs in indoor air. The combined risk estimates, under the current and future exposure scenarios, are presented in Appendix D, Tables 9.2 and 9.3.

The estimated risks are compared to the EPA acceptable levels specified in their National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (EPA, 1990). For non-cancer health effects, the NCP states that acceptable exposure levels shall represent concentration levels to which the human population, including sensitive subgroups, may be exposed without adverse effect during a lifetime or part of a lifetime, incorporating an adequate margin of safety. In practice, the EPA defines this as both HQs and hazard indices less than or equal to 1. For known or suspected carcinogens, the NCP states that acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual which range from 10^{-6} (i.e., 1E-06 or 1 in 1,000,000) to 10^{-4} (i.e., 1E-04 or 1 in 10,000).

Where the total HI or total excess lifetime cancer risk is greater than the EPA acceptable level of 1E-04, the COPCs that are the predominant contributors to the risk estimates are presented in Appendix D, Tables 10.1 to 10.2. The risks for those COPCs identified as predominant contributors are either greater than the EPA acceptable level or contribute significantly to total risks greater than the EPA acceptable level. Where a total hazard index is greater than the EPA acceptable level of 1, toxic endpoint-specific hazard indices were calculated and presented in Appendix D, Tables 9.1 to 9.6 and 10.1 to 10.2.

Current/Future Outdoor Site Workers

This scenario assumes exposure to surface soil across the site by outdoor site workers. The total HI (Appendix D, Table 9.1) for potential exposure of outdoor workers to the COPCs in surface soil from incidental ingestion and dermal contact is 1E-01 (i.e., 0.1); this HI is less than the EPA acceptable level of 1, indicating that adverse, non-cancer health effects from such exposure are unlikely. The estimated total excess lifetime cancer risk (Appendix D, Table 9.1) is 8E-06 (8 in 1,000,000), within the EPA acceptable risk range.

Current/Future Indoor Site Workers

This scenario assumes inhalation exposure of indoor site workers to volatile COPCs in subsurface vapors released from groundwater and transported to indoor air in on-site buildings. As shown on Appendix D, Tables 7.1 and 7.2, the total HIs estimated under the current and future use scenarios are 1E-02 and 2E-02 (i.e., 0.01 and 0.02), respectively; these HIs are less than the EPA acceptable level of 1, indicating that adverse, non-cancer health effects from such

exposure are unlikely. The estimated total excess lifetime cancer risks (Appendix D, Tables 7.1 and 7.2) under both current and future use scenarios are 1E-06 (1 in 1,000,000), at the lower end of the EPA acceptable risk range.

Tables 9.2 and 9.3 in Appendix D present the sums of HQs and incremental cancer risks per chemical for indoor site workers' exposure to indoor air and outdoor site workers' exposure to surface soil. As stated earlier, to evaluate site workers' exposure to surface soil, outdoor worker parameters were used, assuming the evaluation would be protective of indoor workers' exposure to surface soil as well. As shown on Tables 9.2 and 9.3, the HIs estimated under the current and future use scenarios are 2E-01 (i.e., 0.2); this HI is less than the EPA acceptable level of 1, indicating that adverse, non-cancer health effects from such exposure are unlikely. The estimated total excess lifetime cancer risks (Appendix D, Tables 9.2 and 9.3) under current and future use scenarios are 9E-06 and 1E-05 (i.e., 9 in 1,000,000 and 1 in 100,000), respectively. These risk estimates are within the EPA acceptable risk range.

Although the three volatile COPCs in soil (i.e., cyclohexane, methylcyclohexane, and phenanthrene) were not evaluated, due to a lack of toxicity screening values, cyclohexane and methylcyclohexane were detected in only 1 of 12 and 2 of 12 samples, respectively, near Building 15 in the warehouse area. Phenanthrene was detected in 5 of 52 samples, most often near the commissary warehouses. Since this soil contamination is not widespread across the site, it is unlikely that these chemicals, at the frequencies and concentrations detected, would pose a significant potential for exposure via subsurface vapor intrusion.

Current/Future Construction/Utility Workers

This scenario assumes exposure to all soil (i.e., at all depths sampled) and shallow groundwater by construction/utility workers during work in the vicinity of an excavation (of assumed size) for utility maintenance and/or repair. The total HI (Appendix D, Table 9.4) for potential exposure of construction/utility workers to the COPCs in all soil from incidental ingestion, dermal contact, inhalation of volatile COPCs released to outdoor air, and inhalation of non-volatile COPCs on respirable particulates released to outdoor air and to the COPCS in groundwater from dermal contact and inhalation of volatile COPCs released to outdoor air is 1E+00 (i.e., 1); this HI is equal to the EPA acceptable level of 1. The estimated total excess lifetime cancer risk (Appendix D, Table 9.2) is 1E-06 (1 in 1,000,000), at the lower end of the EPA acceptable risk range.

Current/Future Construction Workers

This scenario assumes exposure to all soil (i.e., at all depths sampled) by construction workers around a construction site. The total HI (Appendix D, Table 9.5) for potential exposure of construction workers to the COPCs in all soil from incidental ingestion, dermal contact, inhalation of volatile COPCs released to outdoor air, and inhalation of non-volatile COPCs adsorbed on fugitive dust particles released to outdoor air is 6E-01 (i.e., 0.6); this HI is below the EPA acceptable level of 1, indicating that non-cancer health effects from such exposure are unlikely. The estimated total excess lifetime cancer risk (Appendix D, Table 9.5) is 1E-06 (1 in 1,000,000), at the lower end of the EPA acceptable risk range.

Future Residents

This scenario assumes exposure during future use of the groundwater for potable and other household purposes by off-site resident adults and children.

The total HI (Appendix D, Table 9.6) for potential exposure of resident adults to the COPCs in groundwater from ingestion, dermal contact, and inhalation of volatile COPCs released to indoor air while showering/bathing is 2E+01 (i.e., 20); this HI is greater than the EPA acceptable level of 1, indicating a potential for adverse, non-cancer health effects from such exposure. Iron, arsenic, and vanadium are the predominant contributors to the total HI. The estimated total excess lifetime cancer risk (Appendix D, Table 9.6) is 9E-04 (9 in 10,000), greater than the EPA acceptable risk range. Arsenic is the predominant contributor to the total risk estimate.

The total HI (Appendix D, Table 9.7) for potential exposure of resident children to the COPCs in groundwater from ingestion, dermal contact, and inhalation of volatile COPCs released to indoor air while showering/bathing is 3E+01 (i.e., 30); this HI is greater than the EPA acceptable level of 1, indicating a potential for adverse, non-cancer health effects from such exposure. Iron, arsenic, vanadium, and chromium (evaluated as hexavalent chromium) are the predominant contributors to the total HI. The estimated total excess lifetime cancer risk (Appendix D, Table 9.7) is 3E-04 (3 in 10,000), greater than the EPA acceptable risk range. Arsenic is the predominant contributor to the total risk estimate.

However, the EPCs used to evaluate potential exposure to iron, vanadium, and chromium are within the concentration ranges detected in up-gradient groundwater. Further, chromium, which was reported as total chromium, was evaluated as if it were hexavalent chromium.

Current/Future Recreationists

This scenario assumes exposure to surface water and sediment by adolescent recreationists while wading and otherwise recreating in Rogue Harbor Branch. The total HI (Appendix D, Table 9.8) for potential exposure of adolescent recreationists to the COPCs in surface water dermal contact and to the COPCs in sediment from incidental ingestion and dermal contact is 3E-02 (i.e., 0.03); this HI is less than the EPA acceptable level of 1, indicating that adverse, non-cancer health effects from such exposure are unlikely. The estimated total excess lifetime cancer risk (Appendix D, Table 9.8) is 5E-08 (5 in 100,000,000), less than the EPA acceptable risk range.

6.5.2 Lead

As indicated previously, the potential for adverse health effects from exposure to lead in soil and groundwater is evaluated through comparison of predicted blood lead (PbB) levels to a health-protective target PbB level. The U.S. Centers for Disease Control and the Agency for Toxic Substances and Disease Registry have designated, and the EPA has adopted, 10 micrograms per deciliter (µg/dL) as a PbB level of concern to protect sensitive populations (e.g., neonates, infants, and children). The EPA's stated goal for lead is that children have no more than a 5 percent probability of exceeding a PbB level of 10 ug/dL. As such, this level is assumed to also provide protection for adults.

For potential exposure adult workers to lead in soil, the evaluation is facilitated through the use of the EPA's Adult Lead Methodology (EPA, 2003b) and ALM. In this regard, the EPA has indicated that in a commercial/industrial setting, the most sensitive receptor is the fetus of a worker who develops a body burden as a result of non-residential exposure to lead and that this body burden is available to transfer to the fetus for several years after exposure ends.

The ALM estimates PbB levels in the two most sensitive receptor populations: women of child-bearing age and an unborn fetus. The model to estimate PbB levels in the adult includes a typical, baseline PbB level in the absence of site-related exposure, a constant biokinetic slope factor (BKSF) that relates the increase in typical PbB level to average daily lead uptake, and a site-specific estimate of average daily uptake of lead through ingestion of soil. The model to estimate PbB levels in the fetus includes a normalized adult PbB level and a constant of proportionality between fetal and maternal PbB levels. Since lead in soil was selected as a COPC in all soil only, exposure evaluations were conducted for construction workers and construction/utility workers as detailed in the Adult Lead Worksheets, provided in Appendix F. Since an EF of 60 days/year during a 3-month period was assumed for construction/utility workers, an averaging time of 90 days/year was used. The equations for estimating PbB levels, and the results of the evaluations, are presented in the ALM output files, provided in Appendix F. RAGS, Part D Adult Lead Model Worksheets are also provided in Appendix F.

Consistent with the EPA methodology, a range of both maternal and fetal PbB levels was estimated for both worker populations based on default parameter values (e.g., baseline PbB levels and geometric standard deviation PbB levels) for both homogeneous (expected to have a low geometric standard deviation) and heterogeneous populations. The arithmetic mean lead concentration in all soil was used as the exposure point concentration, consistent with EPA methodology.

For construction/utility workers, the geometric mean PbB level is 2.3 to 2.5 ug/dL, the 95th percentile PbB level among fetuses of those workers is 6.9 to 8.7 ug/dL, and the probability that the fetal PbB level exceeds the target PbB level is 1.6 to 3.5 percent based on the ALM evaluation. For construction workers, the geometric mean PbB level is also 2.3 to 2.5 ug/dL, the 95th percentile PbB level among fetuses of those workers is 7.0 to 8.8 ug/dL, and the probability that the fetal PbB level exceeds the target PbB level is 1.6 to 3.6 percent based on the ALM evaluation. Therefore, lead-impacted soil should not pose a health risk to future on-site construction or construction/utility workers.

For potential exposure of resident children to lead in groundwater, the evaluation is facilitated through the use of the EPA's IEUBK model. The focus of the IEUBK model is the prediction of PbB levels in young children exposed to lead from several sources and by several routes. The model utilizes four interrelated modules (exposure, uptake, biokinetic, and probability distribution) to mathematically and statistically link environmental lead exposure to PbB levels for a population of young children (0-84 months of age). A plausible distribution of PbB levels, centered on a geometric mean PbB level, is predicted and used to estimate the probability that a child's or a population of children's PbB levels will exceed the target PbB level. The IEUBK output files and the RAGS, Part D IEUBK Lead Worksheet are also provided in Appendix F.

For resident children, the geometric mean PbB level is 4.47 ug/dL and the probability that the PbB level exceeds the target PbB level is 4.3 percent based on the IEUBK model. Therefore, the lead concentrations in groundwater should not pose a health risk should groundwater be used in the future for potable and other household purposes by off-site residents.

6.5.3 Qualitative Assessment of COPCs without Toxicity Criteria

The following section includes statements about the potential toxicity and known health effects of COPCs without toxicity criteria.

1,1'-Biphenyl

1,1'-Biphenyl is known to be a skin irritant, moderately toxic by ingestion, and a powerful inhalation irritant in humans (Lewis, 1992). Exposure to the skin may cause dermatitis. Inhalation of very small amounts by humans can cause flaccid paralysis, nausea, vomiting, and other unspecified gastrointestinal effects. Per the EPA (2005c), 1,1'-biphenyl is not classifiable as to human carcinogenicity.

Carbazole

Carbazole is regarded as moderately toxic by ingestion (Lewis, 1992).

Methylcyclohexane

Methylcyclohexane is regarded as moderately toxic by ingestion and mildly toxic by inhalation (Lewis, 1992). At high concentrations in air, exposure can cause narcosis and anesthesia. It is believed to be more toxic than hexane.

Phenanthrene

Phenanthrene is among the 17 PAHs typically analyzed for and evaluated at hazardous waste sites; the 17 PAHs often occur together in the environment and many have similar environmental fate and toxicological characteristics (ATSDR, 1995). However, reliable environmental fate and toxicological information exists for only a few of the 17 PAHs and the potential health effects of the other less well-studied PAHs must be inferred from this information (ATSDR, 1995). The EPA (2005) regards phenanthrene as not classifiable as to carcinogenicity.

6.5.4 Uncertainty Evaluation

Some uncertainty is inherent in the process of conducting predictive, quantitative risk assessment. Environmental sampling and analysis, fate and transport modeling, and human exposure modeling are all prone to uncertainty, as are the available toxicity data used to characterize risks.

Environmental Sampling and Analysis

Uncertainty associated with environmental sampling is generally related to the limitations of the sampling in terms of the number and distribution of samples, while uncertainty associated with the analysis of samples is generally associated with systematic or random errors (i.e., false positive or negative results). Thus, exposure may be overestimated or underestimated depending on how well the environmental medium is characterized.

The samples collected at FGGM represent a biased sample group. The sampling locations are biased because the locations were selected at areas that would be most likely to contain contaminants due to past activities. For the outdoor worker and resident receptors, this may result in higher risk estimates than if a true average was established across the LOC parcel.

Fate and Transport Modeling

Constituent release and transport modeling were used to estimate EPCs for the COPCs in shower/bathroom air for the shower scenarios and in outdoor air over an excavation for the construction/utility worker scenario. Uncertainty associated with such modeling is related to the accuracy with which environmental conditions and processes, and the characteristics of the shower/bathroom flow/dimensions and excavation, are modeled.

COPC release and transport were evaluated based on screening-level emissions and atmospheric dispersion models that, due to their relative simplicity, tend to overestimate these processes. For example, source depletion over time (e.g., through COPC release or environmental degradation) was not taken into account. For the evaluation of construction worker inhalation exposures to volatile and non-volatile COPCs in soil, estimation of VFs and PEF was based on a site acreage of 2.1 acres; the actual area of construction at one time may be greater or less than this acreage. Overall, the potential inhalation exposure scenarios were modeled in ways that likely overestimated exposure and risk.

The predicted indoor air concentrations for the vapor intrusion scenarios were based on subsurface conditions (i.e., depth to groundwater and overlying soil stratigraphy) determined at monitoring well NW-4 in the southwest corner of the site and generic assumed building parameters (e.g., dimensions of the future building and air exchange rates in the current and future buildings). As such, the evaluations may result in over- or underestimated risks.

Human Exposure Modeling

The number of non-detects for the organic COPCs in the datasets used to compute the EPCs for surface soil, all soil, and groundwater is quite large (see Appendix D, Tables 2.1 to 2.3). A large amount of “censored” data, and the treatment of non-detects in this evaluation (i.e., substitution of one-half the detection limit), may result in uncertainty in the 95% UCL on the arithmetic average concentrations used to represent the EPCs. The EPA (2002a) indicates that:

- There is no general rule about which substitution method will yield an appropriate 95% UCL on the arithmetic average concentration,
- The uncertainty associated with the substitution method increases as the number of non-detects in the data increases, and

- If the proportion of non-detects is high (> 75%), no substitution method will work reliably well.

As a result, the EPCs may be underestimated or overestimated.

Assumptions and model input parameters that result in RME estimates were used in the exposure assessment; the actual frequencies and durations of exposure would probably be less than evaluated so that long-term exposure should be overestimated.

Potential exposure to chemicals in groundwater from dermal contact during showering (or bathing/washing) is based on data from unfiltered water samples and, as chemicals adsorbed to particulates in the water may be unavailable for dermal absorption, exposure may be overestimated. According to the EPA (2004b), the final dermally absorbed doses and dermal contact risk estimates should be considered highly uncertain. In the dermally absorbed dose equation, Kp is the most uncertain variable, with measured values spanning an order of magnitude. In addition, the FA is obtained from a graph to the nearest one significant figure, contributing to the uncertainty in the dermally absorbed dose for water.

While aspects of the exposure assessment methodology can result in overestimation or underestimation of long-term exposure, exposure is probably overestimated, overall, for the potentially exposed populations evaluated. The EPCs used in the exposure assessment (i.e., the 95% UCL on the arithmetic average concentration or the maximum detected concentration) were estimated without consideration of environmental migration, transformation, degradation, or loss and should result in overestimates of long-term exposure. The future scenario that considers potable use of the groundwater by off-site residents may be unlikely as the presence of a wildlife refuge downgradient of the site should preclude residential or commercial/industrial development.

In the surface soil or all soil datasets presented in Appendix D, Table 2.1 and 2.2, the following chemicals were not selected as COPCs due to their infrequent detection even though their maximum detected concentrations exceeded the screening toxicity values:

- Thallium at SS01-LOC-02,
- Benzo(a)pyrene and benzo(b)fluoranthene at AOC-SB-32, and
- Aroclor 1248 and Aroclor 1260 at SB07-DPT-09 and SB08-DPT-02, respectively.

Therefore, there may be a potential for greater risks to construction/utility workers contacting soils in excavations at these specific locations on the site than otherwise indicated in this risk assessment.

Available Toxicity Values

The derivation of the toxicity criteria that form the basis of the risk characterization can result in overestimates or underestimates of potential health risks. In most cases, the toxicity criteria are derived from extrapolation from laboratory animal data to humans, with the inclusion of modifying and/or uncertainty factors. RfDs and cancer slope factors for oral exposure were adjusted and used to assess exposure from dermal absorption. While the criteria for oral exposure are adjusted for such use following EPA guidance, oral absorption for the organic COPCs was assumed to be 100%; this may underestimate dermal contact exposure for some

chemicals. For those chemicals with specific oral absorption factors, consideration was not given to the absorption efficiency of the exposure vehicle used in the studies on which the toxicity factors are based; this may overestimate or underestimate dermal contact risks for some chemicals.

For benzene, where the EPA provides a range of cancer potency, the more conservative (i.e., health protective) oral and inhalation cancer slope factors were used. Finally, for some chemicals, health criteria are insufficient to determine RfDs or slope factors for oral and/or inhalation exposure.

6.6 SUMMARY AND CONCLUSIONS

The human health evaluation indicates a potential for health risks to off-site resident adults and children should groundwater be used for potable purposes in the future in the absence of remedial action. The non-cancer HIs for adults (2E+01) and children (3E+01) are greater than the EPA acceptable level (1). As indicated in Appendix D, Tables 10.1 and 10.2, these HIs are predominantly due to arsenic, iron, chromium, and vanadium. Chromium, which was reported as total chromium, was evaluated as if it were hexavalent chromium. The excess lifetime cancer risks for adults (9E-04) and children (3E-04) are greater than the EPA acceptable risk range (1E-04 to 1E-06). As also indicated in Appendix D, Tables 10.1 and 10.2, these excess lifetime cancer risks are predominantly due to arsenic. Lead was detected in elevated or slightly elevated concentrations in groundwater relative to the EPA action level for lead in drinking water at three locations on the site. As stated in Section 6.3.4, the potential for off-site residents to inhale chemicals in subsurface vapors released from groundwater and transported to indoor air in off-site residences was not evaluated.

The human health evaluation indicates that, currently and in the future in the absence of remedial action, adverse, non-cancer health risks are unlikely and excess lifetime cancer risks are less than or within the EPA acceptable risk range for the following exposure scenarios:

- outdoor site workers' exposure to surface soil;
- indoor site workers' exposure to surface soil and vapors transported from groundwater to indoor air;
- construction/utility workers' exposure to surface and subsurface soil,, groundwater, and outdoor air;
- construction workers' exposure to surface and subsurface soil and outdoor air; and
- adolescent recreationists' exposure to surface water and sediment in Rogue Harbor Branch.

Lead concentrations in soil should not pose a risk to construction or construction/utility workers at the site and lead concentrations in groundwater should not pose a risk to off-site residents if groundwater is used for potable purposes in the future.

7 SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

This section presents an assessment of potential ecological risks associated with chemicals detected at the LOC site (the site) and potentially affected areas. The screening-level ecological risk assessment (SLERA) follows relevant EPA (EPA, 1997c) and EPA Region III guidance (EPA, 2005d).

7.1 OBJECTIVES AND OVERVIEW

The primary objective of the SLERA is to identify and characterize the potential for health risks to ecological communities and wildlife receptors as a result of chemical releases at the site. Secondary objectives are: to document dominant flora and fauna associated with the site; to determine the COPC being released from the site; to identify potential pathways for receptor exposure; and to determine if any further action might be necessary to refine the ecological risk assessment.

According to current EPA (1997c) guidance, the following steps were completed for this SLERA:

- Problem formulation, including qualitative characterization of natural resources, identification of ecological assessment and measurement endpoints, and the identification of potential exposure pathways
- Exposure assessment providing quantitative exposure scenarios for selected ecological receptors
- Characterization of the potential for ecological risk
- Discussion of uncertainties associated with risk estimation, identification of the general assumptions employed, and presentation of a refinement to exposure parameters and risk estimates for chemicals where the potential for risk is initially identified

As preceding sections of this RI Report indicate, a substantial amount of site-specific chemical and physical information was developed to characterize the types, location, and concentrations of chemicals in the environmental media. Information on site chemicals, geology, hydrology, soil types and other characteristics of the site are provided in earlier sections of this RI Report. Data are available from soil, groundwater, surface water, and sediment samples collected for the RI at the site and in Rogue Harbor Branch. Only validated chemical analytical results were used in this SLERA.

The SLERA evaluates the potential for ecological risks to the following biological groups and resources associated with the area: vascular vegetation, soil invertebrates, aquatic fauna, benthic invertebrates, and terrestrial and semi-aquatic small mammals and birds. Significant habitats and wetlands in the site vicinity are also identified.

7.2 Problem Formulation

Problem formulation is based on information collected during the RI and establishes the goals, breadth, and focus of the SLERA (EPA, 1997c). The process involves a series of steps to characterize the environmental setting, identify potential physical and chemical stressors present at the site, identify appropriate ecological assessment and measurement endpoints, and outline potentially complete exposure pathways between stressors and receptors, as illustrated through a conceptual site model.

7.2.1 Site Characterization

The ecology of the site was characterized based on existing information collected for other aspects of the FGGM site and review of available mapping and aerial photography of the site vicinity.

Site Description

The site is located on a 100-acre parcel of land at the southern end of the FGGM. It is bounded to the south by MD Route 32 (Patuxent Highway), to the north by Rock Avenue, and to the east and west by Pepper Road and Remount Road, respectively. Currently, much of the site is used for warehouse storage, making use of the large warehouse buildings in the eastern portion of the site. The DRMO and TMP are located in the western portion of the site. Thus, the easternmost and westernmost portions of the site contain warehouses and other buildings, including paved areas and improvements associated with the DRMO and TMP. Rogue Harbor Branch traverses the site in a north-south direction, as shown in **Figure 2-1**. East of Rogue Harbor Branch are a fenced parking lot for tractor-trailer and vehicle storage, a fenced 13 kV electrical substation, and a sewage pump station. The area between the TMP and the electrical substation area, on each side of Rogue Harbor Branch, is mostly woodland. Another small wooded area exists between the warehouse area and the vehicle storage area.

Description of Natural Resources

Flora and Fauna

A variety of ecological communities are present at FGGM, including pine and mixed pine/hardwood woodlands and wetlands. Woodland species that have been previously identified at FGGM include:

- Dogwood (*Cornus florida*)
- Beech (*Fagus grandifolia*)
- Tulip tree (*Liriodendron tulipifera*)
- Eastern white pine (*Pinus strobus*)
- Loblolly pine (*Pinus taeda*)
- Virginia pine (*Pinus virginiana*)
- White oak (*Quercus alba*)

- Chestnut oak (*Quercus prinus*)
- Northern red oak (*Quercus rubra*)

Shrub layers in the area have been reported to contain mountain laurel (*Kalmia latifolia*) and lowbush blueberry (*Vaccinium vacillans*), as well as beech and flowering dogwood. The woodlands and shrub layers provide adequate vegetative cover to support wildlife, although species of wildlife have not been recorded.

Wildlife likely to occur in the site vicinity include mammals such as white-tailed deer (*Odocoileus virginiana*), raccoon (*Procyon lotor*), groundhog (*Marmota monax*), red fox (*Vulpes vulpes*) and Eastern cottontail (*Sylvilagus floridanus*). Small birds such as the common flicker (*Colaptes auratus*), American robin (*Turdus migratorius*), common crow (*Corvus brachyrynchos*), mourning dove (*Zenaida macroura*) and other wildlife may inhabit the site vicinity as well. Amphibians (e.g., frogs) may inhabit areas near Rogue Harbor Branch, and reptiles (e.g., snakes) may be present in the wooded and brush-covered portions of the site as well. Fish known to be present in Rogue Harbor Branch are species common to Coastal Plain fish assemblages and include bluespotted sunfish (*Enneacanthus gloriosus*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), American eel (*Anguilla rostrata*), Eastern mudminnow (*Umbra pygmaea*), and creek chubsucker (*Erimyzon oblongus*).

Surface Waters and Wetlands

Based on information from the NWI and prior field investigations, limited wetlands are present within the site. Rogue Harbor Branch is classified as a riverine ecological system and is a permanent lower perennial open water stream (RK&K 1994). The junction of Rogue Harbor Branch and MD Route 32 is marshy, and some wetland vegetation is evident. This area is classified as PSS1 (palustrine scrub-shrub broad-leaved deciduous) and PUB (palustrine unconsolidated bottom), as shown in **Figure 7-1**. There are no other mapped wetlands within the site. Areas east of Rogue Harbor Branch and north of the old railroad alignment have been reported to contain standing water.

Two ecosystems of concern are evaluated in this SLERA: the wooded upland portions of the site and the portion of Rogue Harbor Branch and associated wetlands that lies within the site.

Potential Physical and Chemical Stressors

Both physical and chemical stressors exist at the site. Physical stress may be caused by the current and former use of the active portions of the site. Activities, such as vehicle movement, maintenance, and outdoor storage of equipment, cause disturbance to vegetation and prevent natural succession from occurring. However, wildlife inhabiting the site would likely avoid the active areas of the site and, therefore, would not be adversely affected by these activities. Thus, physical stressors are not addressed further in this SLERA.

Potential chemical stressors are considered all chemicals detected in sampled environmental media at the site. For this SLERA, chemicals in surface soil, surface water, and sediment are evaluated two ways: the potential for ecological risks posed to vegetative and invertebrate/benthic communities and the potential for bioaccumulative risks to upper trophic level avian and mammalian wildlife. It is assumed that environmental samples collected at areas of concern represent conditions across the site and that chemicals are 100% bioavailable.

Further, maximum detected chemical concentrations are used as conservative estimates of concentrations in environmental media at the points of exposure.

7.2.2 Ecological Endpoints

Based on the site characterization and descriptions of habitat, the following general classes of ecological receptors may potentially be exposed to chemicals at the site.

- Terrestrial plants growing within the wooded areas and semi-aquatic plants growing in the wetlands associated with Rogue Harbor Branch;
- Terrestrial invertebrates living in surface soils and benthic or other aquatic invertebrates in the wetland area;
- Birds that forage or nest within the wooded and aquatic/wetland areas; and
- Small mammals that reside and/or feed in the vicinity of the site.

Adverse health effects (e.g., reduced vigor or population decline) in vegetation, invertebrates, small mammals and birds were selected as assessment endpoints for the site. The evaluation of the potential for adverse health effects in vegetative and invertebrate communities due to chemicals at the site was based on the comparison of maximum detected chemical concentrations to conservative ecotoxicity screening benchmarks. The benchmarks represent conservative thresholds for adverse ecological effects (EPA, 1997c), and are therefore, also called threshold reference values (TRVs) at later stages of the SLERA. It is assumed that a lack of a screening benchmark indicates a chemical may pose ecological health risks. The benchmarks for soil, surface water, and sediment are presented subsequently, in Sections 7.3.1, 7.3.2, and 7.3.3, respectively.

For the evaluation of the bioaccumulative potential of chemicals detected at the site, estimates of dietary exposure were calculated and then compared to conservative TRVs, derived from dose-response studies found in literature sources. Receptor species representative of the local upper trophic level wildlife populations that may frequent the site are identified below. These species were selected based on their potential exposure (i.e., site usage, food habitats, home range) and susceptibility to adverse effects of the COPC.

Terrestrial Assessment and Measurement Endpoints

Following is a brief description of the habitat requirements and diet of the terrestrial receptor species selected for the wooded portions of the site. The reasons for selection of these species are also discussed. It is assumed that the home range of each of the species is less than or equal to the site area and that no seasonal migration occurs.

Herbaceous Vegetation. Plants that occur in old field, wooded and disturbed areas of the northeastern United States are likely to occur at the site. These plants are woody and herbaceous species that serve as an important food source and cover for songbirds and small herbivores. The measurement endpoints for terrestrial vegetation are published plant benchmarks.

Soil Invertebrates. Invertebrates that are common in central Maryland are likely to occur within the site. These invertebrates are an important food source for ground gleaning birds and small

mammals. The measurement endpoints for soil invertebrates are published benchmarks for soil invertebrates (e.g., earthworms).

Eastern Cottontail (*Sylvilagus floridanus*). The Eastern cottontail is the most widely distributed of the medium-sized rabbits found over most of the eastern half of the United States and southern Canada and widely introduced in the western United States. Cottontails inhabit a large variety of habitats, including glades and woodlands, deserts, swamps, prairies, hardwood forests, and boreal forests. The Eastern cottontail eats herbaceous vegetation during the summer and woody vines, trees and shrubs during the winter. Home ranges can vary widely depending on vegetative cover and season (EPA, 1993d).

The Eastern cottontail, as an herbivore, has been selected to represent the terrestrial small mammal community at the site. Measurement endpoints for the Eastern cottontail are derived from mammalian toxicity data taken from published dose-response studies that relate chemical exposure or uptake effects on individual organisms.

Short-tailed Shrew (*Blarina brevicauda*). The short-tailed shrew ranges throughout the north-central and eastern United States and into southern Canada. This species occurs in a wide variety of habitats, preferring those that are cool and moist and areas with abundant cover. The short-tailed shrew is primarily carnivorous, concentrating on insects, earthworms, slugs, and snails when available. However, it will also eat plants, fungi, millipedes, arachnids, and small mammals. The winter, non-breeding home range of the short-tailed shrew can vary from 0.03 to 0.07 hectares. The short-tailed shrew is an important prey species for many raptors and carnivorous mammals (EPA, 1993d).

The short-tailed shrew, as a carnivore, has been selected to represent the terrestrial small mammal community at the site. Measurement endpoints for the short-tailed shrew are derived from mammalian toxicity data taken from published dose-response studies that relate chemical exposure or uptake effects on individual organisms.

American Robin (*Turdus migratorius*). The American robin occurs throughout most of the continental United States during the breeding season and winters in the southern half of the United States and in Mexico and Central America. Robins forage on the ground in open areas, along habitat edges, or the edges of streams. They forage by hopping along the ground in search of ground-dwelling invertebrates and by searching for fruit and insects in shrubs and low tree branches. Foraging home ranges of 0.16 to 0.81 hectares have been measured. In the months preceding and during the breeding season, robins feed mainly (greater than 90 percent by volume) on invertebrates and on some fruits; during the remainder of the year, their diet consists primarily (over 80 to 99 percent by volume) of fruits (EPA, 1993d).

The American robin has been selected to represent the terrestrial songbird community at the site. Although other small bird species are known to occur at the site, the American robin represents herbivorous and insectivorous small birds in the site vicinity. Measurement endpoints for the American robin are derived from avian toxicity data taken from published dose-response studies that relate chemical exposure or uptake to effects on individual organisms.

Aquatic Assessment and Measurement Endpoints

Following is a brief description of the habitat requirements and diet of the semi-aquatic receptor species selected for Rogue Harbor Branch. In addition, the reasons for selection of these species are discussed.

Aquatic/Wetland Plants. Rogue Harbor Branch and its associated wetlands may support a variety of aquatic/wetland plants. These plants serve as important cover and forage for wildlife species using the area. Therefore, the community of aquatic/wetland plants was selected as an assessment endpoint. Since there are no published TRVs for aquatic/wetland plants, the measurement endpoints are published sediment benchmarks for flora.

Benthic Invertebrates. Rogue Harbor Branch may support communities of benthic invertebrates. Aquatic invertebrates form the base of the aquatic food chain and are sensitive indicators of environmental contamination. Therefore, the community of aquatic invertebrates was selected as an assessment endpoint. The measurement endpoints for aquatic invertebrates are published sediment benchmarks for fauna.

Muskrat (*Ondatra zibethicus*). Muskrats are common throughout most of the United States, except in the extreme southeast, central Texas, and most of California. They inhabit fresh, brackish or saltwater marshes, ponds, lakes, rivers and canals. Muskrats are primarily herbivorous, but some populations are more omnivorous. The roots and basal portions of aquatic plants make up most of the muskrat's diet, although shoots, bulbs, tubers, stems, and leaves are also eaten. Crayfish, fish, frogs, turtles, young birds and molluscs are also known to be consumed with less frequency by muskrats (EPA, 1993d). The home range of the muskrat is estimated as 0.05 to 0.17 hectares.

The muskrat has been chosen to represent the semi-aquatic, herbivorous, small mammal community at the site. Measurement endpoints for the muskrat are derived from the mammalian toxicity data taken from published dose-response studies that relate chemical exposure or uptake to effects on individual organisms.

Mallard (*Anas platyrynchos*). The mallard is the most abundant of United States ducks. This species consumes aquatic plants, seeds, and aquatic invertebrates, depending on the season, and forages in ponds and wetlands by dabbling and filtering through sediments (EPA, 1993d). The home range of the mallard ranges from 38 to 1,440 hectares.

The mallard has been selected to represent the semi-aquatic avian community at the site. It is an omnivorous species that may be associated with Rogue Harbor Branch. Measurement endpoints for the mallard are derived from avian toxicity data taken from published dose-response studies that relate chemical exposure or uptake to effects on individual organisms.

7.2.3 Exposure Pathways

Several ecologically relevant migration pathways for chemicals exist at the site. Wildlife may have incidental contact with or ingest chemicals in the surface soil, surface water, and/or sediment while foraging, nesting, or engaging in other activities in the terrestrial and wetland portions of the site. Chemicals can also adversely affect wildlife in surrounding habitats via the food chain. This SLERA addresses incidental contact and ingestion, as well as uptake of chemicals in the food chain, for both upland and wetland ecosystems.

Upon their release, some site chemicals are persistent and may be transformed to more bioavailable forms and mobilized in the food chain. Mobilization of chemicals in the terrestrial and wetland food chains could occur through the following pathways:

- Root uptake from soil and sediment by herbaceous plants;
- Contact and absorption, incidental ingestion, and feeding by invertebrates;
- Drinking of surface water by wildlife; and
- Bioaccumulation from vegetation or animal prey at the base of the food chain by wildlife.

Following EPA guidance (EPA, 1997c), a conceptual site model was developed to evaluate how chemical stressors from the site may affect ecological components of the natural environment (see **Figure 7-2**). This model illustrates the relationship between the ecosystem potentially at risk, including the receptor species and the chemical stressors. Contaminated media, exposure routes, and environmental transport mechanisms are identified in the conceptual site model.

7.3 DATA EVALUAITON

In the data evaluation section, COPCs are identified in surface soil, surface water, and sediment. Chemicals detected in subsurface soil and groundwater were not evaluated in this SLERA because of the lack of wildlife exposure to these media. All subsurface soil samples were collected from depths greater than 5 feet below ground surface.

COPCs are identified through the comparison of detected chemical concentrations to ecotoxicity screening benchmarks that are considered protective of detrimental effects on vegetative and invertebrate communities. If the maximum detected concentration exceeded the screening benchmark, or if no benchmark was available, the chemical was identified as a COPC for that particular medium. Further, all chemicals that are bioaccumulative were identified as COPCs, regardless of the comparison of detected concentrations to risk-based screening benchmarks.

While the ecotoxicity benchmarks are conservative, they provide initial levels with which to screen chemicals. A low frequency of detection (<5% detection frequency) in the sampled environmental medium was also considered reason for eliminating a chemical as a COPC.

A detailed description of the extent of sampling conducted at the site and the analytical results for each medium sampled are provided in previous sections of this RI Report. The identification of COPCs for each medium is discussed below.

7.3.1 Surface Soil

Surface soil samples were collected at 66 locations within the site. Six sample duplicates were included in the data evaluation, by taking the greater of the detected concentrations in the original and duplicate sample, in accordance with EPA Region III guidance (EPA, 2005d). Samples were analyzed for different parameters, depending on the selected data analysis, as described in previous sections of the RI.

The EPA Region III BTAG Draft Screening Levels for terrestrial plants and invertebrates (EPA, 1995) were used to screen chemicals and identify COPCs. If EPA Region III BTAG Screening

Levels were not available for a chemical, then EPA Ecological Soil Screening Levels (ECO-SSLs) were used (EPA, 2005e). If ECO-SSLs were not available, screening levels generated by the U.S. Department of Energy (USDOE) (Efroymson et al., 1997a and 1997b) were used.

Terrestrial Plants

As shown in **Table 7-1**, the following chemicals were selected as COPCs based on maximum detected concentrations greater than the soil benchmarks that are protective of terrestrial plants or due to the lack of such benchmarks:

- Two VOCs: acetone and xylenes.
- Fourteen SVOCs: anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, 1,1'-biphenyl, bis(2-ethylhexyl)phthalate, caprolactam, chrysene, dibenzofuran, di-n-butylphthalate, fluoranthene, naphthalene, phenanthrene, and pyrene.
- Two pesticides: 4.4'-DDT and 4.4'-DDE.
- Fifteen metals: aluminum, antimony, beryllium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, silver, thallium, vanadium, and zinc.

The following chemicals were not selected as COPCs since they were detected with less than 5% frequency: benzo(g,h,i)perylene, benzyl butyl phthalate, indeno(1,2,3-cd)pyrene, and Aroclor 1260.

Terrestrial Invertebrates

As shown in **Table 7-1**, the following chemicals were selected as COPCs based on maximum detected concentrations greater than the soil benchmarks that are protective of terrestrial invertebrates or due to the lack of such benchmarks:

- One VOC: acetone.
- Fourteen SVOCs: anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, 1,1'-biphenyl, bis(2-ethylhexyl)phthalate, caprolactam, chrysene, dibenzofuran, di-n-butylphthalate, fluoranthene, naphthalene, phenanthrene, and pyrene.
- Two pesticides: 4.4'-DDT and 4.4'-DDE.
- Ten metals: aluminum, arsenic, chromium, cobalt, iron, lead, manganese, mercury, silver, and thallium.

The following chemicals were not selected as COPCs since they were detected with less than 5% frequency: benzo(g,h,i)perylene, benzyl butyl phthalate, indeno(1,2,3-cd)pyrene, methoxychlor, Aroclor 1248, and Aroclor 1260.

Potential for Bioaccumulation

As shown in **Table 7-1**, the following chemicals were selected as COPCs, regardless of their concentrations or frequency of detection, due to their potential to bioaccumulate:

- Nine SVOCs: anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chyrsene, fluoranthene, indeno(1,2,3-cd)pyrene, and pyrene.
- Seven pesticides/PCBs: 4.4'-DDT, 4.4'-DDE, 4'4-DDD, endrin ketone, methoxychlor, Aroclor 1248, and Aroclor 1260.
- Nine metals: arsenic, cadmium, chromium, copper, lead, nickel, selenium, silver, and zinc.

7.3.2 Surface Water

Three surface water samples were collected from Rogue Harbor Branch within the boundaries of the site, as shown in **Figure 2-1**. All of the samples were analyzed for VOCs, SVOCs, pesticides, PCBs, and metals. Metals were the only analytes detected in any of the samples.

Chemicals detected in surface water were compared with the EPA Region III BTAG freshwater screening benchmarks (EPA, 2005f). As shown in **Table 7-2**, the following chemicals were selected as COPCs based on maximum detected concentrations greater than the freshwater benchmarks:

- Six metals: aluminum, barium, copper, iron, lead, and manganese.

Also shown in **Table 7-2**, the following chemicals were selected as COPCs due to their potential to bioaccumulate:

- Four metals: copper, lead, nickel, and zinc.

7.3.3 Sediment

Three sediment samples were collected from Rogue Harbor Branch, within the boundaries of the site, as shown in **Figure 2-1**. All of the samples were analyzed for VOCs, SVOCs, pesticides, PCBs, and metals.

Chemicals detected in sediment were compared to the EPA, Region III freshwater sediment screening benchmarks (EPA, 2005g). As shown in **Table 7-3**, the following chemicals were selected as COPCs based on maximum detected concentrations greater than the sediment benchmarks or the lack of such benchmarks:

- One VOC: acetone.
- One SVOC: bis(2-ethylhexyl)phthalate.
- Four metals: aluminum, barium, beryllium, and vanadium.

Also shown in **Table 7-3**, the following chemicals were selected as COPCs due to their potential to bioaccumulate:

- Six pesticides: alpha-Chlordane, gamma-Chlordane, 4,4'-DDT, 4,4'-DDE, 4'4-DDD, and endrin aldehyde.
- Six metals: arsenic, cadmium, copper, lead, nickel, and zinc.

7.4 EXPOSURE ASSESSMENT

This section presents site-specific information pertinent to the assessment of the potential for risks from bioaccumulative COPCs present in environmental media at the site.

7.4.1 Exposure Scenarios and Pathways

The exposure scenarios involving direct contact with chemicals in the various media are evaluated in the risk characterization section, Section 7.5. These include terrestrial plants and invertebrates in surface soil, aquatic fauna in surface water, and aquatic/wetland plants and benthic invertebrates in sediment.

Three scenarios involving food chain transfer of bioaccumulative chemicals were selected for the wooded portions of the site:

- A small herbivorous mammal consuming vegetation from the wooded portions of the site (Eastern cottontail);
- A small carnivorous mammal consuming soil invertebrates (e.g., earthworms) from the wooded portions of the site (short-tailed shrew); and
- An omnivorous bird consuming both vegetation and soil invertebrates from the wooded portions of the site (American robin).

Two wildlife scenarios involving food chain transfer of bioaccumulative chemicals were selected for Rogue Harbor Branch and associated wetlands:

- Herbivorous semi-aquatic mammal consuming vegetation growing along the banks of Rogue Harbor Branch (muskrat); and
- Omnivorous semi-aquatic bird consuming both vegetation growing along the banks of Rogue Harbor Branch and benthic invertebrates living in the sediment of Rogue Harbor Branch (mallard).

7.4.2 Exposure Estimates

Exposure estimates for terrestrial and semi-aquatic wildlife were calculated based on the following assumptions. The estimated maximum exposure (expressed as daily dosage) through ingestion of soil/sediment, water, and food for each of the wildlife receptors is given in **Tables G-1 to G-5** of **Appendix G**.

Terrestrial Wildlife

The Eastern cottontail, short-tailed shrew and American robin were assumed to confine their feeding activities to the uplands, but to stray into the aquatic/wetland area to drink surface water from Rogue Harbor Branch. Therefore, these receptors could be exposed either directly or indirectly via the food chain to COPCs in soil from the wooded portions of the site and surface water from Rogue Harbor Branch. It was assumed that the terrestrial receptors spend all of their time at the site (i.e., area use factors equal 100%). Exposure from ingestion and diet was calculated for COPCs in each medium for each receptor. The exposure estimates were summed to obtain the total exposure.

Semi-Aquatic Wildlife

The muskrat and mallard were assumed to confine their feeding activities to Rogue Harbor Branch. Therefore, these receptors could be exposed either directly or indirectly through the food chain to COPCs in Rogue Harbor Branch sediment. It was assumed that the semi-aquatic receptors spend all of their time at the site (i.e., area use factors equal 100%). Exposure from ingestion and diet was calculated for each medium for each receptor. The exposure estimates were summed to obtain total exposure.

Exposure Point Concentrations

The estimated exposures (EE) for terrestrial herbaceous vegetation, terrestrial invertebrates, aquatic fauna, aquatic/wetland plants, and aquatic invertebrates were derived from maximum concentrations of the COPCs detected in surface soil, surface water or sediment. Exposure point concentrations for the COPCs in surface soil, surface water, and sediment are presented in **Table 7-4.**

Exposure Parameters

The parameters used to estimate potential wildlife exposure through incidental ingestion of soil and sediment, ingestion of water, and exposure through the food-chain are provided in **Table 7-5**. The exposure parameters were obtained or derived from published sources. The ingestion rates (IR) of food for the various receptors were estimated from the receptors' body weight (BW), using the following equations provided in the *Wildlife Exposure Factors Handbook* (EPA, 1993d):

Birds: IR_{total} (kg/day) = 0.0582 $BW^{0.651}$ (kg)

Mammals: IR_{total} (kg/day) = 0.0687 $BW^{0.822}$ (kg)

The normalized ingestion rate (NIR) is the IR divided by the receptor's BW.

Where soil or sediment IRs were unknown, IRs for species with similar foraging habits were utilized. No estimates of soil or sediment IRs were directly appropriate for the short-tailed shrew. However, the EPA (1993d) gives estimates of soil in diet for various invertebrate-consuming species. It was assumed that the use of the high end of this range would be appropriate for the short-tailed shrew since this animal's diet consists mostly of organisms that live in soil or sediment. Therefore, a conservative soil/sediment IR of 10% was used in the exposure calculations for the short-tailed shrew.

Exposure Estimate Equations

Dietary exposure and exposure from incidental ingestion of soil or sediment and direct ingestion of surface water for the wildlife receptor species (small birds and small mammals) were also calculated using equations provided in the *Wildlife Exposure Factors Handbook* (EPA, 1993d).

The following equations were used to estimate exposure to COPCs in soil/sediment via ingestion:

$$EE_{soil/sediment} = [EPC \times FS \times IR_{total}(\text{dry weight}) \times FR] / BW$$

where:

$EE_{soil/sediment}$ = Estimated exposure through ingestion of soil/sediment (mg/kg BW-day)

EPC = Exposure point concentration in soil/sediment in the area of concern (mg/kg dry weight)

FS = Fraction of soil/sediment in diet (as percentage of diet on a dry-weight basis divided by 100; unitless)

IR_{total} = Food ingestion rate on a dry-weight basis (kg/day)

FR = Fraction of total food intake from the area of concern (unitless)

BW = Body weight (kg)

The IR_{total} on a dry-weight basis was estimated based on body weight, as discussed previously. The FR from the area of concern was conservatively assumed to be 100%, or 1.

Estimates of exposure to COPCs via dietary sources were made for the receptors using the following equation:

$$EE_{diet} = \sum_{k=1}^{m} (EPC_k \times FR_k \times NIR_k)$$

where:

EE_{diet} = Estimated exposure through diet (mg/kg BW-day)

EPC_k = Exposure point concentration in the kth type of food (mg/kg dry weight).

FR_k = Fraction of intake of the kth food type that is contaminated (unitless).

NIR = Normalized ingestion rate of the kth food type on a dry weight basis (g/g-day).

m = Number of contaminated food types

EPC_k = EPC (mg/kg) x Uptake Factor (unitless)

To estimate exposure through the terrestrial and wetland food chains, uptake factors (UFs) for terrestrial plants (plant uptake factors or PUFs) and soil/sediment invertebrates (invertebrate uptake factors or IUFs) were obtained from published sources. UFs relate the chemical concentration in the organism (e.g., vegetation, earthworm tissue) to the chemical concentration in the exposure medium (e.g., soil) as follows:

$$UF = \frac{\text{Concentration in organism}}{\text{Concentration in Medium}}$$

If published PUFs and IUFs were not available, they were calculated based on octanol-water partition coefficients (K_{ow}), as follows:

logPUF (dry weight) = 1.588 – 0.578 x log Kow (Travis and Arms, 1988)

logIUF (wet weight) = 0.819 x log Kow – 1.146 (EPA, 1999)

PUFs and IUFs are given in **Tables 7-6 and 7-7,** respectively**.** Since the calculated IUFs are based on wet weights of earthworms or benthic invertebrates, the IUFs were converted to dry weight values prior to their use in the exposure calculations, as shown in **Table 7-7.** A water content of 84% was assumed for earthworms and 79% for benthic invertebrates (EPA, 1993d). Using these UFs, chemical levels in the tissue of prey items of the receptor species were calculated (the EPC_k value shown above).

Estimates of exposure to COPCs in surface water via ingestion were made by using the following equation:

$$EE_{water} = EPC \times FR \times NIR$$

where:

EE_{water}	=	Estimated exposure through ingestion of water (mg/kg BW-day).
EPC	=	Exposure point concentration in a single water source (mg/l).
FR	=	Fraction of total water ingestion from the water source (unitless)
NIR	=	Normalized water ingestion rate (i.e., fraction of body weight consumed as water per unit time; g/g-day).

7.4.3 Toxicity Reference Values

Toxicity reference values are used to measure the potential for adverse health effects in either ecological communities or particular receptor species, as a result of, respectively, maximum detected chemical concentrations in a medium or an estimated dietary exposure. TRVs for terrestrial plants, soil invertebrates, aquatic fauna, aquatic/wetland plants, and benthic invertebrates are the benchmarks provided in **Tables 7-1** through **7-3**.

TRVs for small mammals and birds chosen as receptor species were derived based on methodology presented by Sample et al. (1996). This general method is based on EPA methodology for deriving human toxicity values from animal data. In this method, experimentally derived no observed adverse effect levels (NOAELs) are used to estimate NOAELs for wildlife by adjusting the dose according to differences in body size. NOAELs for laboratory species, obtained from the literature, were converted to receptor species NOAELs as follows (Sample et al., 1996):

$$NOAEL_r = NOAEL_t \, (BW_t / BW_r)^{1/4}$$

where:
$NOAEL_r$ = receptor species NOAEL
$NOAEL_t$ = test species NOAEL
BW_r = receptor body weight
BW_t = test species body weight

Recent research suggests that physiological scaling factors developed for mammals may not be appropriate for interspecies extrapolation among birds. Based on one study, scaling factors for the majority of pesticides evaluated (29 of 37) were not significantly different from 1. A scaling factor of 1 was, therefore, considered most appropriate for interspecies extrapolation among birds (Sample et al., 1996). NOAELs for an avian test species obtained from the literature were converted to NOAELs for the American robin as follows:

$$NOAEL_r = NOAEL_t \, (BW_t / BW_r)^{0} = NOAEL_t \, (1) = NOAEL_t$$

The mammalian and avian test species and receptor species NOAELs are provided for each of the COPCs in **Tables 7-8** and **7-9,** respectively.

7.5 RISK CHARACTERIZATION

In this section, potential ecological risks posed by COPCs at the site are identified and summarized. Risk characterization involves two major steps: risk estimation and risk description (EPA, 1997c). The risks to vegetative and invertebrate communities are estimated using general comparisons and HQs calculated with EPCs and the selected TRVs. The potential for risks to wildlife receptors are estimated using HQs calculated with EEs and TRVs for each receptor. The HQs are summarized, and the principal uncertainties of the assessment are discussed in Section 7.5.2. The ecological significance of the risk estimates is discussed in Section 7.6.

7.5.1 Discussion of Risk Estimates

The HQ is the ratio of a single substance exposure level to the TRV selected for the risk assessment (EPA, 1997c). An HQ greater than 1.0 indicates that the COPC may have the potential to pose a risk to the receptor evaluated. An HQ less than 1.0 indicates that the COPC is unlikely to pose a risk to the receptor evaluated. To take into account the conservative nature of this SLERA, the risk characterization also singles out those COPCs that have HQs greater and less than 10.

Wooded Areas

The maximum concentrations of all of the COPCs in soil exceed the plant TRVs (i.e., the HQs are greater than 1). As shown in **Table 7-10**, the HQs for pyrene, lead, mercury, nickel, and vanadium are greater than 10 and the HQs for aluminum, beryllium, chromium, cobalt, silver, and thallium are greater than 100. The ranges of reported background metals concentrations in surface soil at FGGM (Malcolm Pirnie Inc., 2001) also appear in **Table 7-10**. The maximum detected concentrations of chromium, silver, and vanadium are within the reported range of background surface soil concentrations at FGGM.

The maximum concentrations of all of the COPCs in soil exceed the soil invertebrate TRVs (i.e., the HQs are greater than 1), where available. Soil invertebrate TRVs were unavailable for 1,1'-biphenyl, di-n-butylphthalate, aluminum, and thallium. HQs for pyrene, cobalt, and mercury are greater than 10 and the HQs for chromium, iron, and lead are greater than 100. Again, as shown on **Table 7-10**, the maximum detected chromium concentration is within the range of reported background surface soil chromium concentrations at FGGM.

The results of the risk characterization for the Eastern cottontail, short-tailed shrew and American robin are given in **Table 7-11**. For the Eastern cottontail and short-tailed shrew, the only HQs greater than 1 are for arsenic. For the American robin, the HQs for 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, lead, and zinc are greater than 1. TRVs for avian receptors were not available for a number of COPCs. Therefore, HQs were not estimated under this exposure scenario for all bioaccumulative COPCs in soil.

Rogue Harbor Branch

The maximum concentrations of all of the COPCs in surface water exceed the surface water TRVs (i.e., the HQs are greater than 1). As shown in **Table 7-12**, the HQs for aluminum, barium, and iron are greater than 10. The EPCs for surface water were the maximum detected metals concentrations, all of which occurred at the mid-stream sample location.

Also shown in **Table 7-12**, no HQs for the sediment COPCs are greater than 1, although sediment guidelines were not available for any of the chemicals except bis(2-ethylhexyl)phthalate. Therefore, the potential risk to aquatic/wetland plants and benthic invertebrates were not evaluated for these COPCs.

The results of the risk characterization for the muskrat and mallard are given in **Table 7-13**. For both of these aquatic wildlife receptors, using the maximum detected concentrations as the EPCs, none of the HQs are greater than 1. However, the potential for ecological health risks due to endrin aldehyde could not be quantified.

7.5.2 Uncertainty Analysis

Uncertainty in the risk estimates may arise during any stage in the SLERA process. Incorrect assumptions may be made regarding the potential effects of a stressor, the ecosystems of concern, or the species residing within those ecosystems. Generally, care was taken to fully assess and incorporate existing information concerning the site into problem formulation, in order to minimize the impacts of these uncertainties on the SLERA results.

General Sources of Uncertainty

Uncertainty associated with environmental sampling is generally related to the limitations of the sampling program in terms of the number and distribution of samples, while uncertainty associated with the analysis of the samples is generally related to systematic or random errors. The limited number of surface water and sediment samples collected at the site adds uncertainty to the EPCs used in the exposure assessment.

The principal uncertainties in the dietary exposure assessment have to do with quantitative estimates of the various uptake and exposure parameters. These parameters typically are chemical, species, and site-specific. Uptake and exposure parameters for COPCs were taken from the literature or calculated from literature data. Data on chemicals in wild animals, as opposed to domestic or laboratory animals, were used, where available. In addition, the average weights and daily intakes used for the receptor species do not take into account smaller and larger individuals or young of the species, which may be more or less sensitive to chemicals than average-sized adults. Generally, the maximum exposure case was assumed to provide a conservative estimate of potential exposure and risk.

Another point of uncertainty lies in the assumption that each of the wildlife receptor species feeds exclusively upon food items found within the site. For the majority of the species chosen, this assumption is likely to be close to actuality, because of their small home ranges. However, the mallard's reported home range is five times larger than the size of the LOC parcel. In addition, the American robin is a migratory species. A seasonality factor was not employed in this SLERA, because resident populations of robins may be present at Fort Meade. The mallard and the American robin may consume food sources other than those considered in the assessment, the exclusion of which could either over- or underestimate potential exposure and risk. The assumption that soil and sediment invertebrate uptake of COPCs would be equal to published invertebrate uptake factors may also result in an over- or underestimation of potential risk. The amount of a chemical that is taken up by invertebrates from soil or sediment depends, in part, on site-specific soil and sediment conditions, such as organic content, chemical concentration, and presence of other chemicals in the soil or sediment. Uptake of chemicals by soil and sediment invertebrates may occur at different rates or under different conditions at the site other than those estimated by the IUFs. Similarly, uptake of chemicals by vegetation is dependent on the type of chemical, soil type, plant species, and other environmental factors.

Uncertainty arises when using any published toxicity results as TRVs. These uncertainties include extrapolating from acute or subchronic exposures to chronic exposure durations and extrapolating across different species, genera, orders, and families.

Overall, the SLERA is likely to overestimate rather than underestimate the risks of adverse ecological effects at the site, because of the conservative nature of the assumptions used. A generally conservative approach was taken in the evaluation to minimize the possibility of actual risk being greater than that predicted. In summary, these assumptions included:

- Environmental samples collected at areas of concern represent conditions across the site;
- Conservative benchmarks are thresholds of the potential for ecological risk at Fort Meade, Maryland;
- A lack of a screening benchmark indicates a chemical may pose ecological health risks;

- EPCs are equal to maximum chemical concentrations;
- Chemicals are 100% bioavailable; and
- A receptor species' home range is less than or equal to the site area, and no migration of the American robin occurs.

SLERA Refinement

As an illustration of the conservatisms inherent in the results of the SLERA, a further evaluation was carried out for the surface soil COPCs and terrestrial receptors where the potential for ecological risks was determined to be present. No further refinements were made to the surface water and sediment evaluation, due to the limited number of samples collected, the lack of alternative screening values for community-level assemblages, and the fact that no elevated HQs for aquatic receptors were originally estimated.

First, instead of using the maximum detected concentration for surface soil EPCs, the 95% UCL on the arithmetic average concentration was calculated. The 95% UCL represents the highest that the arithmetic average concentration is likely to be, with 95% confidence. The EPA (2002a, 1991b) indicates that, in calculating a 95% UCL on the arithmetic average concentration, where there is a question about the distribution of the data set, a statistical test should be used to identify the best distributional assumption for the data set. ProUCL Version 3.0, developed for the EPA, Region III through the EPA's Technology Support Center for Monitoring and Site Characterization, was used to test the distributional assumptions and calculate the 95% UCLs.

Appendix E contains the ProUCL output sheets for each surface soil COPC that yielded an HQ greater than 1. In a few cases where the 95% UCL on the arithmetic average concentration is greater than the maximum detected concentration, the maximum detected concentration was retained as the EPC. **Table 7-14** shows the alternate risk characterization for terrestrial plants and soil invertebrates, using the 95% UCLs for each COPC. As shown, the HQs for 4,4'-DDE and manganese drop below 1. The HQs for pyrene, lead, mercury, and nickel drop below 10, while that for vanadium remains greater than 10. The HQs for aluminum, chromium, silver, and thallium are still greater than 100, while that for cobalt drops from 160 to 17.

An additional refinement was made to the dietary exposure assessment of bioaccumulative COPCs. Lowest-Observed-Adverse-Effect-Levels (LOAELs), obtained from Sample et al. (1996), were substituted for NOAELs as the selected TRVs for terrestrial wildlife receptors. LOAELs are also based on clinical dose-response studies, but represent the lowest level at which an effect is observed in the species tested. Where NOAELs are not available for a specific chemical, the EPA (1997) recommends that a NOAEL be estimated from a LOAEL by dividing by 0.1.

Table 7-15 shows the derivation of the LOAEL-based TRVs for arsenic, the only COPC with elevated HQs calculated under the cottontail rabbit and short-tailed shrew exposure scenarios. **Table 7-16** shows the derivation of the LOAEL-based TRVs for 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, lead, and zinc, which were the COPCs with elevated HQs for the American robin. **Tables G-6 to G-8** in **Appendix G** contain the revised calculation of total estimated exposure as dietary dosage, based on the 95% UCL concentrations, and the hazard quotients, based on the comparison to LOAELs, for the three terrestrial receptor species. As shown on **Table 7-17**, the only HQ greater than 1, that results from this alternate evaluation, is for 4,4'-DDT exposure to the American robin (2E+00). Again, no seasonality factor was used to account for the migration

of the American robin; therefore, the risk estimate represents a portion of its exposure and not its total exposure.

7.6 SUMMARY AND CONCLUSIONS

A number of COPCs in surface soil, predominantly metals, pose the potential for adverse ecological effects in terrestrial plants and soil invertebrates based on the comparison of the maximum detected chemical concentrations to conservative benchmarks. The results of the comparison of dietary exposure estimates to TRVs for upper trophic level terrestrial wildlife indicate that 4,4'-DDT and its derivatives (4,4'-DDD and 4,4'-DDE) and a few metals (arsenic, lead, and zinc) may pose the potential for adverse ecological health effects. Consideration should be given to areas from which these samples were collected, with the thought that the areas of concern known to be associated with former industrial activities are also less likely to be used by wildlife receptors with the same frequency and intensity as the exposure assessment parameters would indicate.

Similarly, a number of metals in surface water and/or sediment pose the potential for adverse ecological effects in aquatic organisms and benthic invertebrates, based on the comparison of the maximum detected chemical concentrations to conservative benchmarks. Based on the dietary exposure estimates for upper trophic level semi-aquatic wildlife, there is little to no potential for adverse health risks.

Overall, the SLERA process is designed to result in over-estimation of the potential for adverse ecological effects. Using the maximum detected concentrations as the EPCs and the NOAEL-based TRVs in the risk estimates contributes to over-estimation of the potential for actual ecological risks present at the site. As an illustration, the alternate exposure assessment presented above resulted in lower plant and soil invertebrate HQs. For the evaluation of bioaccumulative COPCs in soil, the only HQ above 1 was for 4,4'-DDT exposure to the American robin.

Based on these results, and consistent with EPA (1997c), a more thorough assessment of the potential for ecological risk may be warranted.

Section 7 Tables

Table 7-1: Surface Soil Data Summary

Table 7-2: Surface Water Data Summary

Table 7-3: Sediment Data Summary

Table 7-4: Exposure Point Concentrations

Table 7-5: Exposure Factors for Ecological Receptors

Table 7-6: Summary of Plant Uptake Factors

Table 7-7: Summary of Invertebrate Uptake Factors

Table 7-8: Toxicity Information for Eastern Cottontail Rabbit, Short-tailed Shrew and Muskrat

Table 7-9: Toxicity Information for American Robin and Mallard

Table 7-10: Risk Characterization for Terrestrial Plants and Soil Invertebrates

Table 7-11: Risk Characterization for Eastern Cottontail Rabbit, Short-tailed Shrew and American robin

Table 7-12: Risk Characterization for Aquatic Organisms

Table 7-13: Risk Characterization for Muskrat and Mallard

Table 7-14: Alternate Risk Characterization for Terrestrial Plants and Soil Invertebrates

Table 7-15: Toxicity Information for Eastern Cottontail Rabbit and Short-tailed Shrew

Table 7-16: Toxicity Information for American Robin

Table 7-17: Alternate Risk Characterization for Eastern Cottontail Rabbit, Short-tailed Shrew and American robin

8 SUMMARY AND CONCLUSIONS

A summary of the nature and extent of contamination, fate and transport characteristics, and the baseline risk assessment for the LOC parcel is provided in the following sections.

8.1 NATURE AND EXTENT OF CONTAMINATION

8.1.1 Soils

A summary of the nature and extent of soil contamination is provided as follows:

VOCs

- Sixteen VOCs were identified in several surface and subsurface soil samples collected at the site, but due to the limited number of VOC detections and relatively low concentrations no discernable distribution pattern can be identified for VOCs in soil. All VOC detections were located in areas with previous industrial activity.
- No VOCs were detected above their respective residential or industrial EPA RBCs. However, several VOCs (bromomethane, ethylbenzene, xylenes, benzene, vinyl chloride, and PCE) were detected above the EPA SSLs.
- VOCs associated with petroleum compounds were detected in surface and subsurface soils. The petroleum compounds were detected in areas with former operations involving petroleum compounds (i.e., USTs) and in the associated runoff locations.

SVOCs

- PAHs and phthalates were detected in numerous surface and subsurface soil samples on-site. There were no discernible patterns to the surficial SVOC contamination, indicating that multiple small sources (e.g., fuel spills, combustion sources) may have been present, and there does not appear to have been any significant, ongoing spills, leaks, or sources. SVOC concentrations did not vary greatly with increasing depth in the soil borings on-site.
- Three SVOCs were detected above the residential soil RBC (benzo(b)fluoranthene, dibenzo(a,h)anthracene, and benzo(a)pyrene), but only benzo(a)pyrene exceeded the industrial soil EPA RBC. Several other SVOCs also exceeded the EPA SSLs.

PCBs

- Two PCBs (Aroclor-1248 and Aroclor-1260) were detected in the surface and subsurface soil samples collected at the site. One detection of Aroclor-1260 exceeded the EPA RBC for residential soil, and one detection of Aroclor-1248 equaled the EPA RBC for residential soil.
- The PCB detections were identified during the 2000/2001 sampling event, and no PCB detections were identified during the 2004/2005 sampling event which included sample locations in the vicinity of SB07-DPT-02 and SB08-DPT-02. Thus, the PCB detections in surface soil are isolated (i.e., three sample locations) and therefore, no distribution pattern can be identified.

Pesticides

- Several pesticides, including alpha-Chlordane, DDD, DDE, DDT, toxaphene, endosulfan I, endrin ketone, and methoxychlor, were detected in soil samples collected at the site. No pesticides were detected above the EPA RBCs or EPA SSLs.
- DDE and DDT were detected in several soil samples collected on-site. The highest concentrations of these compounds were detected in surface soils on-site at locations in the central portions of the site. These detections are typical of areas of similar industrial usage. DDE and DDT concentrations did not change significantly with increasing depth in the soil borings on-site.

Inorganics

- The highest concentrations of arsenic were detected in surface soils along the former railroad bed (e.g., DPT-11, DPT-25, and DPT-27) and may be attributable to the use of arsenical herbicides to control vegetation in the rail alignment, or the use of arsenic-treated railroad ties.
- The highest concentrations of lead were detected in the subsurface soils at Building 39 (DPT33) and at the Electrical Substation (DPT/GW29) and in the surface soils at the Warehouse Area (DPT41) and the Electrical Substation (DPT/GW-29). The higher lead concentrations in the surface soil and subsurface soil indicate potential site influences from lead-based paint adjacent to the buildings and potential industrial fill material at other locations.
- Numerous metals, including aluminum, arsenic, barium, beryllium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, selenium, vanadium and zinc, were detected in most surface and subsurface soil samples. Other metals, including antimony, cadmium, sodium, mercury, selenium, and thallium, were detected in some of the other surface and subsurface soil samples collected at the site. Due to the variations in inorganics concentrations observed in soil samples collected across the site, no specific source areas could be identified at the site.

8.1.2 Sediment

A summary of the nature and extent of sediment contamination is as follows:

VOCs

- Acetone was detected in two of three sediment samples, but at concentrations approximately six to seven orders of magnitude less than EPA Region III BTAG Freshwater Sediment Screening Benchmark.

Pesticides

- Pesticides were detected in all three sediment samples (upstream, mid-point, and downstream) collected from Rogue Harbor Branch, with chlordane, DDD, DDE, and DDT being the primary compounds detected. The concentrations detected were below the EPA Region III BTAG Freshwater Sediments Screening Benchmark with the exception of DDD in one sample. Of the three sediment samples collected, no discernable pattern of pesticide impact could be identified in the sediments.

one sample. Of the three sediment samples collected, no discernable pattern of pesticide impact could be identified in the sediments.

Inorganics

- Numerous metals were detected in the three sediment samples collected at the site. Aluminum, barium, iron, and lead exceeded the EPA Region III BTAG Freshwater Sediments Screening Benchmark. There was minimal variation in the metals concentrations in the sediment samples collected at the site.

8.1.3 Surface Water

A summary of the nature and extent of surface water contamination is provided below:

Organics

- No VOCs, SVOCs, PCBs, or pesticides were detected in the surface water samples collected from Rogue Harbor Branch.

Inorganics

- Most metals were detected in the three (upstream, midpoint, and downstream) surface water samples. Aluminum, barium, iron, lead, and manganese concentrations in the surface water were greater than the EPA Region III BTAG Freshwater Screening Benchmark. There was minimal variation in metals concentrations in the surface water samples collected at the site.

8.1.4 Groundwater

A summary of the nature and extent of ground water contamination is provided:

VOCs

- VOCs were identified in several DPT and monitoring well groundwater samples collected at the site. With the exception of PCE, carbon tetrachloride, chloroform, and petroleum compounds, no discernable distribution pattern can be identified for VOCs in groundwater. All VOC detections were located in areas with previous industrial activity.

- VOCs associated with petroleum compounds (benzene, cyclohexane, ethylbenzene, isopropylbenzene, methylcyclohaxane, MTBE, and xylenes) were detected in DPT and monitoring well groundwater samples. Some petroleum compounds exceeded the EPA RBC for tap water and EPA MCLs. The petroleum compounds were detected in areas with former operations involving petroleum compounds (USTs) and in the associated runoff locations.

- PCE was detected at four groundwater sampling locations (West of Rogue Harbor Branch, Gravel Fill Area, and Suspected Fill Area). The PCE detections exceeded the EPA RBCs for tap water and the EPA MCLs. With the exception of NW-10, PCE was not detected in the samples collected from the monitoring well located on the downgradient boundary of the site (i.e., NW-8, NW-13, and NW-14). The source of the PCE detections is unknown, but the detections are consistent with industrial activities.

- Carbon tetrachloride and chloroform were detected in the southwestern corner of the site in two monitoring wells; however, these compounds can be attributed to off-site impacts located west of the site.

SVOCs

- Several SVOCs were detected in the groundwater at this site. Bis(2-ethylhexyl)phthalate, 2-Methylnaphthalene, carbazole, and naphthalene exceeded the RBC for tap water and EPA MCLs. The remaining SVOCs did not exceed their respective screening criteria. With the exception of the SVOCs detected in the vicinity of the former USTs, there is no discernible pattern of SVOC contamination in the site groundwater.

Pesticides

- The pesticides chlordane and heptachlor epoxide were each detected in the groundwater at one location (GW12-LOC). Heptachlor epoxide exceeded the EPA RBC for tap water, but was below the EPA MCLs. Chlordane was detected at a concentration below the screening criteria.

Inorganics

- Total metals concentrations in the DPT groundwater samples and the monitoring well groundwater samples are comparable for most metals; however, concentrations in the total metals samples for the upgradient groundwater monitoring well samples (i.e., NW-5, NW-6, and NW-7) are generally higher for specific total metals (aluminum, arsenic, chromium, and selenium).

- Elevated metals concentrations (i.e., arsenic and iron) were detected in the surface soil and subsurface soil throughout the site. Based on these results and since potential site sources can not be differentiated from potential upgradient sources, correlations between these elevated metals in the site groundwater and the surrounding soils can not be made conclusively.

- No discernible distribution pattern was indicated based on the dissolved groundwater data. Dissolved metals, some of which were detected above EPA RBCs, including arsenic, iron, manganese, nickel, and silver were detected throughout the site, but in no specific lateral pattern, indicating that these metals may be naturally occurring.

- Evaluation of the data does not suggest the presence of a significant dissolved metals contaminant plume beneath the LOC site.

8.2 Fate and Transport

A summary of the fate and transport for the site contaminants is provided in the following sections.

8.2.1 Transport Pathways

The possible transport pathways identified for the site that are considered to be minor pathways due to mitigating site conditions or contaminant properties include the following:

- Migration of pesticides in groundwater via advection, diffusion, and dispersion. Pesticides would not be readily transported by this mechanism due to their low aqueous solubility.
- Migration, enhanced by infiltrating rainwater, of pesticides through the vadose zone to groundwater. Pesticides strongly adsorb to soil/sediments and are not readily leached to groundwater due to their low aqueous solubility.
- Migration of soil particles with adsorbed contaminants due to winds (as dust). This pathway would be limited since the majority of the LOC parcel is covered with buildings, paved areas, and vegetation.

The major transport pathways identified for the site include:

- Transport of VOCs (such as toluene and PCE) and SVOCs (such as naphthalene and 2-methylnaphthalene) between subsurface soils and shallow groundwater via volatilization (from groundwater to soils) and downward migration (from soils to groundwater) enhanced by infiltrating precipitation.
- Transport of VOCs and SVOCs to air via volatilization and adsorption to airborne particles.
- Migration of SVOCs and VOCs through groundwater via advection, diffusion and dispersion mechanisms. This may be mitigated by adsorption of these contaminants to aquifer solids and biodegradation of the contaminants.
- Transport of metals (such as arsenic and iron) from soils to groundwater via leaching.
- Migration of metals (such as arsenic and iron) through groundwater via advection, diffusion and dispersion mechanisms. This may be mitigated by adsorption of metals to aquifer solids. Although a number of other inorganic contaminants were detected in unfiltered groundwater samples at concentrations above their ARARs and TBCs, the corresponding concentrations in the filtered samples were generally below levels of concern.
- Migration of pesticides from soil to sediments via stormwater runoff.
- Migration of metals from shallow groundwater to surface water via groundwater discharge.

8.2.2 Fate and Transport of Contaminants in Specific Media

A summary of the fate and transport for the site contaminants in specific media is provided in the following sections.

Soils and Sediments

PAHs, metals, and pesticides remain in the soil column because these compounds strongly adsorb to soil, especially the fine fraction (silt and clay). Thus, these compounds tend to remain at the source area with little migration. Biodegradation is expected to be an important fate process for PAHs and pesticides at the site. Due to the potential for transport of soil particles by

storm water runoff or surface water, these compounds can migrate when adsorbed to soil or sediment particles. It is expected that transport from on-site to downgradient locations is accomplished by these mechanisms.

Groundwater

VOCs were infrequently detected in groundwater samples from the site. Due to the relatively flat gradient, the probability of further significant migration appears to be limited. However, the carbon tetrachloride plume in the southwest corner of the LOC parcel has been delineated during a previous investigation and is traveling in a southeasterly direction.

PAHs were the most frequent SVOCs detected in the groundwater. Transport of these compounds is expected to occur as a slow leaching from the soil column to groundwater. Biodegradation would occur more rapidly under aerobic conditions. It is expected that the while the compounds could be transported along with groundwater to discharge points, this transport would be extremely slow (due to the flat gradient and fine particle size) and likely insignificant due to the compounds' affinity for soil particles.

Numerous metals were detected in groundwater; however, the constituents most frequently detected over the RBCs were aluminum, arsenic, iron, chromium, manganese, and vanadium. Dissolved phase inorganics will be transported with flowing groundwater but likely will not migrate as rapidly as the organics.

Chlordane and heptachlor epoxide were the only pesticides detected in the groundwater monitoring wells. However, Chlordane and heptachlor epoxide were each only detected in one groundwater sample; therefore, pesticides in groundwater are not of significant concern due to their infrequent detection and when considered in conjunction with the relatively flat gradient.

8.3 RISK ASSESSMENT

8.3.1 Human Health Risk Assessment

A summary of the estimated hazard indices for non-carcinogenic health effects and excess lifetime cancer risks is provided in **Table 8-1**.

Table 8-1: Human Health Risk Assessment Summary

Receptor Population	Scenario Time Frame	Exposure Pathway	Non-Cancer Hazard Hazard Indices		Cancer Risk Cancer Risks	
			Pathway	Total	Pathway	Total
Recreationist (Adolescent)	Current/Future	Ingestion of Sediment	4E-03	3E-02	3E-08	5E-08
		Dermal Contact with Sediment	2E-03		2E-08	
		Dermal Contact with Surface Water	3E-02		N/A	
Outdoor Site Worker	Current/Future	Ingestion of Surface Soil	9E-02	1E-01	7E-06	8E-06
		Dermal Contact with Surface Soil	5E-02		2E-06	
Indoor Site Worker	Current	Inhalation of VOCs in GW, migrated to indoor air	1E-02	2E-01	1E-02	9E-06
		Ingestion of Surface Soil	9E-02		7E-06	
		Dermal Contact with Surface Soil	5E-02		2E-06	
Indoor Site Worker (Future)	Future	Inhalation of VOCs in GW, migrated to indoor air	2E-02	2E-01	1E-06	1E-05
		Ingestion of Surface Soil	9E-02		7E-06	
		Dermal Contact with Surface Soil	5E-06		2E-06	
Construction Worker	Current/Future	Ingestion of Soil	3E-01	6E-01	6E-07	1E-06
		Dermal Contact with Soil	1E-01		5E-08	
		Inhalation of Soil VOCs and Particulates	3E-01		4E-07	
Residential Adult	Future	Ingestion of Groundwater	1E+01	2E+01	9E-04	9E-04
		Dermal Contact with GW	2E+00		1E-05	
		Inhalation of Vapors from GW	6E-02		5E-06	
Residential Child	Future	Ingestion of Groundwater	3E+01	3E+01	3E-04	3E-04
		Dermal Contact with GW	1E+00		2E-06	
		Inhalation of Vapors from GW	3E-01		3E-06	

Receptor Population	Scenario Time Frame	Exposure Pathway	Non-Cancer Hazard Hazard Indices		Cancer Risk Cancer Risks	
			Pathway	Total	Pathway	Total
Construction/Utility Workers	Current/Future	Ingestion of Soil	6E-02	1E+00	1E-07	1E-06
		Dermal Contact with Soil	3E-02		1E-08	
		Inhalation of Soil VOCs and Particulates	1E-01		7E-07	
		Dermal Contact with GW	1E+00		3E-07	
		Inhalation of Vapors from GW	3E-05		5E-11	

For Non-Carcinogens:
Criterion of 1.0 is used to determine if adverse health effects are possible or unlikely.
For Carcinogens:
USEPA acceptable risk range of 10^{-4} to 10^{-6} used to assess carcinogenic risk.
Shaded cells indicate either the total hazard index for the receptor population is greater than 1.0 or the total cancer risk for the receptor population is greater than 10^{-4}.

Elevated human health risks relative to the EPA acceptable levels are limited to hypothetical future residential exposure to shallow groundwater. The hazard indices for non-carcinogenic health effects for residential exposure to shallow groundwater are predominantly due to arsenic, iron, chromium, and vanadium. The excess lifetime cancer risks are predominantly due to arsenic.

Lead in soil should not pose a risk to construction and construction/utility workers at the site and lead in groundwater should not pose a risk to off-site residents if groundwater is used for potable purposes in the future. However, the LOC parcel is not currently used for or planned to be used for residential purposes. Furthermore, shallow groundwater is not currently used or planned to be used for potable use at the LOC parcel, and downgradient properties consist of a closed sanitary landfill and a wildlife refuge. These areas are not likely to be used for residential purposes, in particular residences with shallow groundwater as a potable supply. Therefore, the consideration of the residential use scenario is considered to be very conservative.

8.3.2 Ecological Risk Assessment

Based on the comparison of maximum detected chemical concentrations in surface soil to ecotoxicity screening benchmarks, a number of COPCs, predominantly metals, pose the potential for adverse ecological effects in terrestrial plants and soil invertebrates. Specifically, maximum concentrations of aluminum, beryllium, chromium, cobalt, silver, and thallium contribute most to elevated risk estimates for terrestrial plant communities. Chromium, iron, and lead contribute most to risk estimates for soil invertebrates.

Based on the assessment of dietary exposures to upper trophic level terrestrial wildlife, the maximum detected concentrations of a few pesticides (i.e., 4,4'-DDT, 4,4'-DDD, 4,4'-DDE) and metals (i.e., arsenic, lead, and zinc) pose potential risks for adverse health effects in the receptor populations evaluated. Consideration should be given to areas from which these samples were collected, with the thought that the areas of concern, known to be associated with former industrial activities, are also less likely to be used by wildlife receptors with the same frequency and intensity as the exposure assessment parameters would indicate.

Based on the comparison of maximum detected chemical concentrations in surface water and sediment to ecotoxicity screening benchmarks protective of aquatic/semi-aquatic communities, a number of metals pose potential risks for adverse health effects in aquatic organisms and benthic invertebrates. Specifically, maximum concentrations of aluminum, barium, and iron contribute most to elevated risk estimates for aquatic/semi-aquatic communities. These estimates are based on the comparison to surface water ecotoxicity screening values.

The assessment of dietary exposures to upper trophic level semi-aquatic wildlife indicates there is little to no potential for adverse health risks in the receptor populations evaluated.

Overall, the SLERA process is designed to result in over-estimation of the potential for adverse ecological effects. However, based on the results of this SLERA and consistent with EPA (1997c), a more thorough assessment of the potential for ecological risk may be warranted.

8.4 RECOMMENDATIONS

The recommendations for the site are based on the nature and extent of contamination, fate and transport characteristics and the results of the human health and ecological risk assessments.

The HHRA indicates a potential for health risks to off-site resident adults and children should groundwater be used for potable purposes in the future in the absence of remedial action. However, future residential development downgradient of the site is highly unlikely, considering the presence of a county airport and a wildlife refuge southeast of the site. Therefore, the results of the HHRA indicate that the potential for unacceptable human health risks to the most likely current and future receptor populations evaluated is not likely. Based on the results of the ecological risk assessment and consistent with EPA (1997c), a more thorough assessment of the potential for ecological risk may be warranted.

Based on the results presented in this RI Report, it appears that further evaluation is required in the form of a Feasibility Study to support the selection of viable alternatives for mitigating the identified potential risks to human health and the environment.

9 REFERENCES

Achmad, G. 1991. Simulated hydrologic effects of the development of the Patapsco Aquifer System in Glen Burnie, Anne Arundel County, Maryland, Maryland Geological Survey Report of Investigations No. 54.

Agency for Toxic Substances and Disease Registry. 1999. Toxicological Profile for Lead. U.S. Department of Health & Human Services, Public Health Service, Atlanta, GA. (July 1999)

Agency for Toxic Substances and Disease Registry. 1995. Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs). U.S. Department of Health & Human Services, Public Health Service, Atlanta, GA. (August 1995)

Andreasen, D.C. 1999. The geohydrology and water-supply potential of the Lower Patapsco aquifer and Patuxent aquifers in the Indian Head-Bryans Road area, Charles County, Maryland: Maryland Geological Survey Report of Investigations No. 69.

Baes, C.F., R.D. Sharp, A.L. Sjoreen and R.W. Shor. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture. ORNL-5786. Oak Ridge National Laboratory. Oak Ridge, TN.

Bennett, R.R. and R.R. Meyer. 1952. Geology and groundwater resources of the Baltimore area: Maryland Geological Survey Bulletin No. 4.

Bolton, D.W. and M.A. Hayes. 1999. Pilot study of carcinogens in well water in Anne Arundel County, Maryland: Maryland Geological Survey, Open-File Report No. 99-02-10.

Booz, Allen, Hamilton. October 2003. Architect of the Capitol, Environmental, Occupational Health and Safety Baseline Assessment, Final Report, Fort Meade Warehouses, Fort Meade, MD.

Chapelle, F.H. 1985. Hydrogeology, digital solute-transport simulation, and geochemistry of the Lower Cretaceous aquifer system near Baltimore, Maryland: Maryland Geological Survey Report of Investigations No. 43.

Chapelle, F.H., and D.D. Drummond. 1983. Hydrogeology, digital simulation, and geochemistry of the Aquia and Piney Point-Nanjemoy aquifer system in Southern Maryland: Maryland Geological Survey Report of Investigations No. 38.

Clark, W.B., and E.W. Berry. 1911. Lower Cretaceous: Maryland Geological Survey.

Clark, W.B., Mathews, E.B., and E.W. Berry. 1918. The surface and underground water resources of Maryland, including Delaware and the District of Columbia: Maryland Geological Survey, v. 10, Part 2.

Efroymson, R.A., M.E. Will, G.W. Suter II and A.C. Wooten. 1997a. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1997 Revision. ES/ER/TM-85/R3. Environmental Sciences Division, Oak Ridge National Laboratory.

Oak Ridge, TN.

Efroymson, R.A., M.E. Will and G.W. Suter II. 1997b. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. ES/ER/TM-126/R2. Environmental Sciences Division, Oak Ridge National Laboratory. Oak Ridge, TN.

E.A. Engineering Science and Technology, Inc. November 1991. Fort Meade Site inspection DPDO salvage Yard Land Cover.

EM Federal Corporation. Generic Field Sampling Plan, Fort George G. Meade, Final Document. March 2003.

EM Federal Corporation. Generic Quality Assurance Project Plan, Fort George G. Meade, Final Document. March 2003.

EM Federal Corporation. Generic Health and Safety Plan, Fort George G. Meade, Final Document. June 2003.

Fleck, W.B. and D.A. Vroblesky. 1996. Simulation of groundwater flow of the Coastal Plain aquifers in parts of Maryland, Delaware, and the District of Columbia: U.S. Geological Survey Professional Paper 1404-J.

Fleck, W.B. and D.C. Andreasen. 1996. Geohydrologic framework, groundwater quality and flow, and brackish-water intrusion in east-central Anne Arundel County, Maryland: Maryland Geological Survey Report of Investigations No. 62.

Fort George G. Meade Environmental Office. August 1994. Land Transfer to the Architect of the Capital, Preliminary Assessment Screening.

Gascoyne Laboratories, Inc. 1989. Report of Analysis, 89-05-518.

Glaser, J.D. 1969. Petrology and origin of Potomac and Magothy (Cretaceous) Sediments, Middle Atlantic Coastal Plain: Maryland Geological Survey Report of Investigations No.11.

Glaser, J.D. 1968. Coastal Plain geology of Southern Maryland: Maryland Geological Survey Guide Book No.1.

Glaser, J.D. 1973. Bowie Quadrangle, Geologic and Environmental Atlas: Maryland Geological Survey.

Glaser. J.D. 1976. Geologic map of Anne Arundel County: Maryland Geological Survey.

Greenhorne & O'Mara, Inc. January 2005. Master Plan Congressional Campus at Fort George G. Meade, MD, 90% Submittal.

Hansen, H.J. 1968. Geophysical log cross-section network of the Cretaceous sediments of southern Maryland, Maryland Geological Survey Report of Investigations No. 7.

Hansen, H.J. 1969. Depositional environments of subsurface Potomac Group in Southern Maryland: American Association of Petroleum Geologists Bulletin, vol. 53, no. 9.

Hansen, H.J. 1974. Sedimentary facies of the Aquia Formation in the subsurface of the Maryland Coastal Plain: Maryland Geological Survey Report of Investigation No. 21.

Hazardous Waste Management Division, Philadelphia, Pennsylvania. Assessment Guidelines. July 27, 1994.

Lewis, R.J., Sr. 1992. Sax's Dangerous Properties of Industrial Materials. Eighth Edition. Van Nostrand Reinhold, New York, NY.

Lucas, R.C. 1976. Anne Arundel County groundwater information: selected well records, chemical-quality data, pumpage, appropriation data, and selected well logs: Maryland Geological Survey Water Resources Basic Data Report No. 8.

Mack, F.K. 1976. Preliminary analysis of geohydrologic data from test wells drilled near Chalk Point, Prince Georges County, Maryland: U.S. Geological Survey Open-File Report 76-322.

Mack, F.K., and G. Achmad. 1986. Evaluation of the water-supply potential of aquifers in the Potomac Group of Anne Arundel County, Maryland: Maryland Geological Survey Report of Investigations No. 46.

Mack, F.K., and R.J. Mandle. 1977. Digital simulation and prediction of water levels in the Magothy aquifer in Southern Maryland: Maryland Geological Survey Report of Investigations No. 28.

Malcolm Pirnie, Inc. 2000. Final Work Plan, Quality Assurance Project Plan Part II, Remedial Investigation Library of Congress Campus Facility, Reference Sampling and Analysis, Fort George G. Meade, Maryland. March 2000.

Malcolm Pirnie, Inc. 2000. Final Work Plan, Site Safety and Health Plan Part III, Remedial Investigation Library of Congress Campus Facility, Reference Sampling and Analysis, Fort George G. Meade, Maryland. March 2000.

Malcolm Pirnie, Inc. 2000. Revised Final Work Plan, Field Sampling Plan Part I, Remedial Investigation Library of Congress Campus Facility, Reference Sampling and Analysis, Fort George G. Meade, Maryland. November 2000.

Malcolm Pirnie, Inc. 2001. Final Soil Background Concentration Report of Fort George G. Meade, Maryland. July 2001.

Malcolm Pirnie, Inc. 2002. Draft Final Remedial Investigation Library of Congress Campus Facility, Fort George G. Meade, Maryland. April 2002.

Malcolm Pirnie, Inc. 2004. Final Site Specific Work Plan, Remedial Investigation Library of Congress Campus Facility, Reference Sampling and Analysis, Fort George G. Meade, Maryland. October 2004.

Rummel, Klepper & Kahl. 1994. Initial Phase I LOC Campus Facility, Fort George . Meade, Maryland. (May 1994)

Sample, B.E., D.M. Opresko, and G.W. Suter. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. ES/ER/TM-86/R3. Oak Ridge National Laboratory. Oak Ridge, Tennessee.

Schaum, J., K. Hoang, R. Kinerson, and J. Moya. 1992. Estimating Dermal and Inhalation Exposure to Volatile Chemicals in Domestic Water. California Environmental Protection Agency, Sacramento, CA. April 2, 1992.

Syracuse Research Corporation. 2005. ChemFate Chemical Search. Access online: http://www.syrres.com/esc/chemfate.htm

State of Maryland, Department of the Environment. Cleanup Standards for Soil and Groundwater, Interim Final Guidance. August 2001.

State of Maryland, Maryland Department of the Environment. COMAR 26.08.02.03-2 Numerical Criteria for Toxic Substances in Surface Waters. Accessed July 2005.
http://www.dsd.state.md.us/comar/26/26.08.02.03%2D2.htm

Travis, C.C. and A. Arms. 1988. Bioconcentration of Organics in Beef, Milk, and Vegetation. Environmental Science and Technology. 22(3): 271-274.

U.S. Army Environmental Hygiene Agency, February 1994, Phase 3 Pre-Construction Study No. 37-26-J182-94, PCB Release Evaluation, Defense Reutilization and Marketing Office, Fort George G. Meade, Maryland.

U.S. Army Corps of Engineers, August 1994, Monitoring Well Design, Installation, and Documentation at Hazardous and/or Toxic Waste Sites, EM 1110-1-4000.

U.S. Environmental Protection Agency, 1996. Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. Technical Review Workgroup for Lead. (December 1996)

U.S. Army Corps of Engineers, Baltimore District, 2004, Southeast Area Conceptual Site Model, Fort George G. Meade, Anne Arundel County, Maryland. June 2004.

U.S. Department of Agriculture, Soil Conservation Service, 1973. Soil Survey of Anne Arundel County, Maryland. February 1973.

United States Department of Energy. 2005. Risk Assessment Information System. Oak Ridge National Laboratory, Oak Ridge, TN. Access online: http://risk.lsd.ornl.gov/index.shtml

U.S. Environmental Protection Agency. 2005a. List of Drinking Water Contaminants & MCLs. Accessed July 2005. http://www.epa.gov/waterscience/criteria/wqcriteria.html

U.S. Environmental Protection Agency. 2005b. Risk-Based Concentration Table, U.S. EPA Region III, Philadelphia, PA, Office of RCRA Technical & Program Support Branch, Philadelphia, PA. April 7, 2005.

U.S. Environmental Protection Agency, Region III. 2005c. Integrated Risk Information System. Database for Risk Assessment. Access Online: http://www.epa.gov/IRIS/

U.S. Environmental Protection Agency, Region III. 2005d. Ecological Risk Assessment Guidance: Frequently Asked Questions.
Access online: http://www.epa.gov/reg3hwmd/risk/eco/index.htm

U.S. Environmental Protection Agency. 2005e. Ecological Soil Screening Levels.
Access online: http://www.epa.gov/ecotox/ecossl/

U.S. Environmental Protection Agency, Region III. 2005f. Region III BTAG Freshwater Screening Benchmarks.
Access online: http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fw/screenbench.htm

U.S. Environmental Protection Agency, Region III. 2005g. Region III BTAG Freshwater Sediment Screening Benchmarks.
Access online: http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fwsed/screenbench.htm

U.S. Environmental Protection Agency. 2004a. National Recommended Water Quality Criteria. Washington, DC. Office of Water, Office of Science and Technology.

U.S. Environmental Protection Agency. 2004b. Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual (Part E: Supplemental Guidance for Dermal Risk Assessment). Final. EPA/540/R/99/005. Office of Emergency and Remedial Response, Washington, D.C. (August 2004)

United States Environmental Protection Agency. 2004c. Superfund Chemical Data Matrix Methodology. (January 2004) Access Online: http://www.epa.gov/superfund/sites/npl/hrsres/tools/scdm.htm

U.S. Environmental Protection Agency. 2003a. Human Health Toxicity Values in Superfund Risk Assessments. OSWER Directive 9285.7-53. Office of Solid Waste and Emergency Response, Washington, DC. (December 5, 2003)

U.S. Environmental Protection Agency. 2003b. Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. EPA-540-R-03-001. Technical Review Workgroup for Lead, Washington, DC. (January 2003)

U.S. Environmental Protection Agency. 2003c. Region III Technical Guidance Manual, Risk Assessment. Updated Dermal Exposure Assessment Guidance. EPA Region III, Mid-Atlantic Risk Assessment. (June 2003) Access online: www.epa.gov/reg3hwmd/risk/human/info/dermalag.htm

U.S. Environmental Protection Agency. 2002a. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10. Office of Emergency and Remedial Response, Washington, DC. (December 2002)

U.S. Environmental Protection Agency. 2002b. Child-Specific Exposure Factors Handbook. Interim Report. Office of Research and Development, Washington, D.C. (September 2002)

U.S. Environmental Protection Agency. 2002c. Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils. EPA530-F-02-052. Office of Solid Waste and Emergency Response, Washington, DC. (November 2002)

U.S. Environmental Protection Agency. 2002d. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24. Office of Solid Waste and Emergency Response, Washington, D.C. (December 2002)

U.S. Environmental Protection Agency. 2002e. User's Guide for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) Window® Version – 32 Bit Version. EPA540-K-01-005. Office of Solid Waste and Emergency Response, Washington, DC. (May 2002)

U.S. Environmental Protection Agency. 2001. Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual (Part D, Standardized Planning, Reporting and Review of Superfund Risk Assessments). Final. Publication 9285.7-01D. Office of Emergency and Remedial Response, Washington, D.C. (December 2001)

U.S. Environmental Protection Agency. 2000. Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment: Status and Needs. Office of Water and Solid Waste. Washington, D.C. February 2000.

U.S. Environmental Protection Agency. 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities. Peer Review Draft. EPA530-D-99-001C. Office of Water and Solid Waste and Emergency Response. Washington, D.C. August 1999.

U.S. Environmental Protection Agency. 1997a. Exposure Factors Handbook. Volume I: General Factors. EPA/600/P-95/002Fa. Office of Research and Development, Washington, D.C. (August 1997)

U.S. Environmental Protection Agency. 1997b. Health Effects Assessment Summary Tables. FY 1997 Update. EPA-540-R-97-036. Office of Solid Waste and Emergency Response, Washington, DC. (July 1997)

U.S. Environmental Protection Agency, 1997c. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final. EPA, Environmental Response Team, Edison, NJ. EPA 540-R-97-006.

United States Environmental Protection Agency. 1996. Soil Screening Guidance: Technical Background Document. EPA/540/R-95/128. Office of Solid Waste and Emergency Response, Washington, D.C. (May 1996)

U.S. Environmental Protection Agency, 1995a. U.S. EPA Region III. Region III Technical Guidance Manual Risk Assessment. Assessing Dermal Exposure from Soil, EPA/903-K-95-003, Philadelphia, PA. (December 1995)

U.S. Environmental Protection Agency, 1995b. Guideline for Predictive Baseline Emissions Estimation for Superfund Sites. Interim Final. EPA-451/R-96-001. Air/Superfund National Technical Guidance Study Series. Office of Air Quality Planning and Standards, Research Triangle Park, NC. (November 1995)

U.S. Environmental Protection Agency. 1995c. SCREEN3 Model and Users Guide. EPA-454/B95-004. Research Triangle Park, NC.

U.S. Environmental Protection Agency. 1995d. Region III BTAG Screening Levels.

U.S. Environmental Protection Agency. 1994. Guidance Manual for the IEUBK Model for Lead in Children. OSWER #9285.7-15-1. Office of Solid Waste and Emergency Response, Washington, DC. (February 1994)

U.S. Environmental Protection Agency. 1993a. Selecting Exposure Routes and Contaminants of Concern by Risk Based Screening. EPA/903/R-93-001. U.S. EPA Region III, Philadelphia, PA, Office of Superfund Programs. (January 1993)

U.S. Environmental Protection Agency. 1993b. Estimation of Air Impacts from Area Sources of Particulate Matter Emission at Superfund Sites. EPA-451/R-93-004. Air/Superfund National Technical Guidance Study Series. Office of Air Quality Planning and Standards, Research Triangle Park, NC. (April 1993)

U.S. Environmental Protection Agency. 1993b. Air/Superfund National Technical Guidance Study Series. Estimation of Air Impacts from Area Sources of Particulate Matter Emission at Superfund Sites. EPA-451/R-93-004. Office of Air Quality Planning and Standards, Research Triangle Park, NC. (April 1993)

U.S. Environmental Protection Agency. 1993c. Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risk Associated with Adult Exposures to Lead in Soil. Final. EPA-540-R-03-001. Technical Review Workgroup for Lead, Washington, DC. (January 1993)

U.S. Environmental Protection Agency, 1993d. Wildlife Exposure Factors Handbook. EPA/600/R-93/187a. Office of Research and Development. Washington, D.C. (December 1993)

U.S. Environmental Protection Agency. 1992a. Estimation of Air Impacts for the Excavation of Contaminated Soil. EPA-450/1-92-004. Air/Superfund National Technical Guidance Study Series. Office of Air Quality Planning and Standards, Research Triangle Park, NC. (March 1992).

U.S. Environmental Protection Agency. 1992b. PAL2.1: A Gaussian-Plume Algorithm for Point, Area, and Line Sources. Version 89272.

U.S. Environmental Protection Agency. 1991a. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual. Supplemental Guidance. “Standard Default Exposure Factors.” Interim Final. OSWER Directive: 9285.6-03. Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency. 1991b. Region III Technical Guidance Manual, Risk Assessment. Exposure Point Concentrations in Groundwater. EPA/903/8-91/002. EPA Region III, Mid-Atlantic Risk Assessment.
Access online: http://www.epa.gov/reg3hwmd/risk/human/info/guide5.pdf

U.S. Environmental Protection Agency. 1991c. Region III Technical Guidance Manual, Risk Assessment. Guidance on Handling Chemical Concentration Data Near the Detection Limit in Risk Assessments. EPA Region III, Mid-Atlantic Risk Assessment. (November 1991) Access online: http://www.epa.gov/reg3hwmd/risk/human/info/guide3.htm

U.S. Environmental Protection Agency. 1990. National Oil and Hazardous Substances Pollution Contingency Plan; Final Rule. 40 CFR Part 300. Federal Register. 55(46): 866-8865.

U.S. Environmental Protection Agency. 1989. Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual (Part A). Interim Final. EPA/540/1-89/002. Office of Emergency and Remedial Response, Washington, D.C. (December 1989)

U.S. Environmental Protection Agency. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Interim Final. EPA/540/G-89/004. Washington, DC. Office of Emergency and Remedial Response.

URS. February 2001. Final Summary Report Source Area Delineation of Carbon Tetrachloride DRMO Facility, Fort George Meade, MD.

URS. July 10, 2003. Final Remedial Investigation and Baseline Risk Assessment, DRMO Site, Fort George G. Meade, Maryland.

URS. June 23, 2003. Final CTT Inventory Report, Fort George G. Meade BRAC Property, Maryland.

URS. February, 2004. Draft Focused Feasibility Study, Defense Reutilization and Marketing Office Site.

Weaver, K.N., Cleaves, E.T., Edwards, J., and Glaser, J.D., 1968, Geologic map of Maryland: Maryland Geological Survey, Baltimore, Maryland.

Wentsel, R.S., R.T. Checkai, T.W. LaPoint, M. Shimini, D. Ludwig, and L. Brewer. 1994.

Wilson, J.M. and Achmad, G., 1995, Delineation of wellhead protection areas using particle tracking analysis and hydrogeologic mapping, Northern Anne Arundel County, Maryland: Maryland Geological Survey Report of Investigations No. 61.

Wilson, J.M., and Fleck, W.B., 1990, Geology and hydrogeologic assessment of coastal plain aquifers in the Waldorf area, Charles County, Maryland: Maryland Geological Survey Report of Investigations No. 53.