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**U.S. Army
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FINAL

SITE INSPECTION REPORT

WOODBIDGE RESEARCH FACILITY, VIRGINIA

VOLUME I

MAY 1995

Prepared For:

**U.S. Army Environmental Center
Aberdeen Proving Ground, Maryland 21010**

Prepared By:

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1420 King Street, Suite 600
Alexandria, Virginia 22314**

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Site Inspection activities were completed at the Woodbridge Research Facility in Woodbridge, Virginia by the U.S. Army Environmental Center. This report details all sampling and analysis activities completed at 20 areas requiring environmental evaluation. Relevant information presented includes: site geology; facility background and use; sampling and analysis methodology; and, analytical results.

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AB	Ambient Blank
AR	Army Regulation
ARAR	Applicable or Relevant and Appropriate Requirement
AREE	Area Requiring Environmental Evaluation
ASTM	American Society for Testing and Materials
BATES	Biological Assessment of Threatened and Endangered Species
BCT	Base Cleanup Team
BDAT	Best Demonstrated Available Technology
bgs	Below Ground Surface
BRAC	Base Realignment and Closure
CENAB	Baltimore District, U.S. Army Corps of Engineers
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERFA	Community Environmental Response Facilitation Act
CHPPM	Center for Health Promotion and Preventive Medicine
CLP	Contract Laboratory Program
COD	Chemical Oxygen Demand
CONUS	Continental United States
CRL	Certified Reporting Limits
DOD	Department of Defense
EARTH TECH	The Earth Technology Corporation
EMI	Electromagnetic Induction
ENPA	Enhanced Preliminary Assessment
ESE	Environmental Science and Engineering, Inc.
GC/MS	Gas Chromatography/Mass Spectrometry
gpd	Gallons per day
gpm	Gallons per minute
GPR	Ground Penetrating Radar
HSA	Hollow Stem Auger
ICP	Inductively Coupled Plasma
IRDMIS	Installation Restoration Data Management Information System
IRP	Installation Restoration Program
LABCOM	Laboratory Command
LDR	Land Disposal Rule
LNAPL	Light Non-aqueous Phase Liquid
MERDC	Mobility Equipment Research and Development Center
mg/L	Milligrams per liter
mg/kg	Milligrams per kilogram
MHz	Mega Hertz
mL	Milliliter
mph	Miles per hour
MSL	Mean Sea Level
NCP	National Contingency Plan
NEPA	National Environmental Policy Act of 1969

LIST OF ACRONYMS

Continued

NFRAP	No Further Response Action Planned
NIST	National Institute for Standards and Technology
NPDES	National Pollutant Discharge Elimination System
NTAM	Non-THAMA Approved Method
NVCC	Northern Virginia Community College
O.D.	Outside Diameter
OWSD	Occoquan-Woodbridge Sanitation District
PCB	Polychlorinated Biphenyl
PID	Photoionization Detector
POC	Point-of-contact
POL	Petroleum, Oil, and Lubricant
ppb	Parts per billion
ppm	Parts per million
PVC	Polyvinyl Chloride
PWCSA	Prince William County Service Authority
QA/QC	Quality Assurance/Quality Control
QAP	Quality Assurance Plan
QAPP	Quality Assurance Project Plan
RB	Rinsate Blank
RCRA	Resource Conservation and Recovery Act
RD	Radio Detection
RI/FS	Remedial Investigation/Feasibility Study
RI	Remedial Investigation
RPD	Relative Percent Difference
SARM	Standard Analytical Reference Materials
SCR	Site Characterization Report
SI	Site Inspection
SOP	Standard Operating Procedure
SOV	Soil Organic Vapor
SSI	Supplemental Site Inspection
STORET	Storage and Retrieval
TB	Trip Blank
TBC	To-be-considered
TCLP	Toxicity Characteristic Leaching Procedure
TPH	Total Petroleum Hydrocarbon
$\mu\text{g/g}$	Micrograms per gram
$\mu\text{g/kg}$	Micrograms per kilogram
$\mu\text{g/L}$	Microgram per liter
USAEC	U.S. Army Environmental Center
USAECFB	U.S. Army Engineer Center and Fort Belvoir
USAMC	U.S. Army Materiel Command
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency

LIST OF ACRONYMS

Continued

USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VADEQ	Virginia Department of Environmental Quality
VEPCO	Virginia Electrical Power Company
VHWM	Virginia Hazardous Waste Management
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound
VWCB	Virginia Water Control Board
WRF	Woodbridge Research Facility

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EXECUTIVE SUMMARY

This "Final Site Inspection Report, Woodbridge Research Facility", summarizes an environmental investigation conducted by the U.S. Army Environmental Center (USAEC) for the U.S. Army Research Laboratory's Woodbridge, Virginia, Research Facility. USAEC's investigation focused on several areas within the facility which had been identified as requiring environmental evaluation due to past management--primarily storage and disposal--practices. This document reports USAEC's efforts to define site conditions to support the prioritization and scoping, if necessary, of a remedial investigation and/or removal actions.

This Site Inspection (SI) Report includes results from the Preliminary SI conducted in the Fall 1993 and the Phase I Supplemental Site Inspection (SSI) conducted in the Spring and Summer 1994. The Preliminary SI included 22 Areas Requiring Environmental Evaluation (AREEs). Due to inconclusive findings during the Preliminary SI at several AREEs, 8 AREEs were investigated further during the Phase I SSI.

The following summary table (Table ES-1) presents an overview of the environmental condition of Woodbridge Research Facility (WRF) based on the results of this SI. Data briefly introduced on this table and all necessary supporting information are presented in more detail in Sections 1.0 through 5.0, plus the Appendices, of this report.

Based on the findings of this report, each AREE was recommended for further study, no further response action planned (NFRAP), and/or removal action as shown below:

- **Further Study:** AREEs 1, 2, 3, 4, 5, 6A, 6B, 7, 8, 11, 12, 14, 18, 20, 22, 23, 25, 26, and 27
- **NFRAP:** AREEs 13, 19, and 21
- **Removal Action:** AREEs 11, 13, 14, and 26.

TABLE ES-1
SITE INSPECTION OVERVIEW WOODBRIDGE RESEARCH FACILITY

Site	Activity	Analyses	Results	Recommendation
Background	Surface soil samples	Metals	Expected range of concentrations	Wide distribution of sampling of each media for every analyte.
AREE 1	Geophysics, Trenching	None - Observation Only	Debris found	Further Study
	2 Subsurface Soil Samples	PCB/Pesticide	Significant PCB concentration	
	Groundwater Samples from 6 Existing Wells	VOC, PCB/Pesticide	Potential laboratory contamination	
AREE 2	4 Surface Water/Sediment Pairs	TPH, PCB/Pesticide	Low PCB concentration in sediment	Further Study
	5 Groundwater Samples from Existing Wells	VOC, PCB/Pesticide	ND	
AREE 3	Geophysics, Trenching	Observation	Debris found	Further Study
	1 Soil Sample	PCB/Pesticide	ND	
	2 Groundwater Samples from Direct Push	VOC, PCB/Pesticide	Potential laboratory contamination	
AREE 4	Geophysics, Trenching	Observation	Debris found	Further Study
	1 Subsurface Soil Sample	VOC, TPH, PCB/Pesticide	Significant TPH, PCB concentrations	
	1 Groundwater Sample from Direct Push	VOC, PCB/Pesticide	ND	
AREE 5	Geophysics, Trenching	Observation	Debris found	Further Study
	3 Subsurface Soil Samples	TPH, PCB/Pesticide	TPH, PCB/Pesticide detected	
	3 Groundwater Samples from Direct Push	VOC, PCB/Pesticide	PCB, acetone detected	
AREE 6A	Geophysics, Trenching	Observation	Debris found	Further Study
	2 Subsurface Soil Samples	PCB/Pesticide	ND	
	1 Groundwater Sample from Direct Push	PCB/Pesticide	ND	

TABLE ES-1
SITE INSPECTION OVERVIEW WOODBRIDGE RESEARCH FACILITY

Continued

Site	Activity	Analyses	Results	Recommendation
AREE 6B	Geophysics, Trenching	Observation	Surface debris found	Further Study
	2 Subsurface Soil Samples from Soil Boring	VOC, SVOC, TPH, PCB/Pesticide, metals	TPH detected, metals acceptable	
	2 Groundwater Samples from Direct Push	VOC, PCB/Pesticide	ND	
AREE 7	Excavation	Observation	Bullet identified	No Further Response Action Planned
	36 Surface and Subsurface Soil Samples	Metals	7 metals with significant concentrations	
AREEs 8/23	Geophysics, Trenching	Observation	Discolored soil, odor	Further Study
	5 Surface and Subsurface Soil Samples	TPH	Significant TPH concentration	
	2 Groundwater Samples from Existing Wells	TPH	TPH detected	
	1 Aqueous Sample from Condensate Return Tank	TPH	TPH detected	
AREE 11	Geophysics, Trenching	Observation	Separator leaking, discolored soil, odor	Removal Action, and Further Study
	1 Surface Water/Sediment Pair	VOC, SVOC, TPH, PCB/Pesticide	Significant PCB; VOC detected in sediment; VOC detected in surface water	
	1 Aqueous Sample from Separator	VOC, SVOC	ND	
	2 Subsurface Soil Samples	VOC, SVOC, TPH	Significant TPH concentrations, VOC, SVOC identified	
AREE 12	Geophysics, Excavation	Observation	None	Further Study
	2 Shallow Soil Samples	TPH, VOC, SVOC	VOC, TPH detected	
	10 Subsurface Soil Samples	VOC, SVOC, TPH, PCB/Pesticide, metals	VOC, TPH detected; metals acceptable	
AREE 13	Geophysics, Excavation	Observation	Tank intact	Removal Action, and No Further Response Action Planned
	4 Subsurface Soil Samples	Metals, pH	Metals acceptable, pH neutral	

TABLE ES-1
SITE INSPECTION OVERVIEW WOODBRIDGE RESEARCH FACILITY

Continued

Site	Activity	Analyses	Results	Recommendation
AREE 14	Geophysics, Excavation	Observation	Separator intact	Removal Action and Further Study
	1 Surface Water/Sediment Pair	VOC, SVOC, TPH	TPH detected in sediment; potential laboratory contamination	
	1 Aqueous Sample from Separator	VOC, SVOC	ND	
	2 Subsurface Soil Samples	VOC, SVOC, TPH	TPH detected	
AREEs 18/19	Geophysics, Excavation	Observation	None	Further Study at AREE 18, No Further Response Action Planned at AREE 19
	4 Soil Samples	VOC, SVOC, metals	Metals acceptable	
	2 Joint/Sealant Samples	VOC, SVOC, metals	Metals, VOC, SVOC identified	
AREE 20	Geophysics, Excavation	Observation	No evidence of former incinerator	Further Study
AREE 21	4 Surface Soil Samples	TPH, PCB/Pesticide	TPH identified	Further Study
	8 Subsurface Soil Samples	VOC, SVOC, TPH, PCB/Pesticides, metals	Metals acceptable	
AREE 22	4 Surface Water/Sediment Pairs	TPH	TPH detected in sediment	Further Study
AREE 25	6 Surface Soil Samples	Metals	Metals acceptable	No Further Response Action Planned
	12 Shallow/Subsurface Soil Samples	Metals, PCB/Pesticide	2 metals with significant concentrations	
AREE 26	Geophysics, Excavation	Observation	Hoses uncovered	Removal Action and Further Study
	6 Soil Samples	VOC, SVOC, TPH, PCB/Pesticide, metals, ethylene glycol	Ethylene glycol detected; metals acceptable	
	1 Aqueous Sample from Hoses	VOC, SVOC, TPH, PCB/Pesticide, metals, ethylene glycol	80% ethylene glycol	
AREE 27	6 Surface Soil Samples	Metals, PCB/Pesticide	Metals acceptable	No Further Response Action Planned

Key: AREE = Area Requiring Environmental Evaluation
PCB = Polychlorinated Biphenyl
VOC = Volatile Organic Compound

TPH = Total Petroleum Hydrocarbon
SVOC = Semivolatile Organic Compound
ND = Not Detected

SECTION 1.0

INTRODUCTION

In 1990 the Defense Base Closure and Realignment Act established the formal process to identify those Department of Defense (DOD) facilities which are suitable candidates for realignment. The 1990 Base Closure Act serves to accommodate the reduction in DOD forces by identifying which activities may be relocated and which DOD installations may be permanently closed, eventually allowing real property transfer at the closed installations according to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In July 1991 the Army Research Laboratory, Woodbridge Research Facility (WRF), Woodbridge, Virginia, was recommended for closure by 1991 Base Realignment and Closure (BRAC 91). As per BRAC 91, the U.S. Army closed WRF on 16 September 1994 and to plans dispose of the property before the 1 October 1997 deadline.

The U.S. Army Environmental Center (USAEC), Aberdeen Proving Ground, Maryland, directed EARTH TECH (The Earth Technology Corporation) to complete a Site Inspection (SI) of the WRF installation. This SI was conducted as part of the U.S. Army Installation Restoration Program (IRP) with all specific activities and project responsibilities as defined in contract number DAAA15-91-D-0009, Delivery Order 0001. Project-specific administration and technical supervision of this delivery order are provided by USAEC-Base Closure Division.

1.1 PURPOSE OF REPORT

This document, entitled "Site Inspection, Woodbridge Research Facility", describes all tasks performed in order to initially characterize and evaluate potentially contaminated sites at the WRF installation. This SI was prepared, and all activities specified herein, were completed in accordance with the National Environmental Policy Act of 1969 (NEPA) and Army Regulation (AR) 200-2.

As part of the IRP process, an Enhanced Preliminary Assessment (ENPA) was performed by Roy F. Weston, Inc. in September 1991 to document past activities and existing conditions at WRF. The objectives of the ENPA included identifying and characterizing all Areas Requiring Environmental Evaluation (AREEs) that may require a site investigation or immediate remedial action, and other actions that may be necessary to address and resolve all identified environmental problems. The results of the ENPA, delivered in March 1992, identified 29 AREEs and provided recommendations for appropriate actions.

In addition to the IRP, the Community Environmental Response Facilitation Act (CERFA) amendment to CERCLA provides a mechanism for installations designated

for closure to identify "clean" areas for property transfer purposes. A draft CERFA report for the WRF was published on 8 October 1993, and not only noted the 29 AREEs addressed in the Preliminary Assessment, but also identified two additional AREEs (AREEs 29 and 30).

The BRAC process also includes the development of a BRAC Cleanup Team (BCT) to assist in streamlining cleanup of installations with the underlying goal being the rapid transfer of "clean" properties to the public. This team consists of a DOD representative, an U.S. Environmental Protection Agency (USEPA) representative, and a Commonwealth of Virginia representative. One of the tasks assigned to the BCT is the completion of a "Bottom-Up Review" of all past activities at the installation to identify all possible concerns that may affect property transfer. During the "Bottom-Up Review" for the WRF, the BCT not only noted the 31 AREEs outlined in the Preliminary Assessment and CERFA report, but also identified additional AREEs.

USAEC identified 22 of the 29 AREEs defined in the ENPA as requiring further investigation, and the remaining seven AREEs were identified as either requiring no further response action planned (NFRAP) or involved actions to be performed by facility personnel to comply with regulatory requirements. This report presents the SI investigation activities and results for only these 22 AREEs. The findings of the ENPA and the associated SI activities that have been completed at the 22 AREEs are summarized in Table 1-1. The locations of the AREEs are included on Figures 1-1 and 1-2. Facility-wide AREEs are not shown due to their extensive presence across the installation.

A sampling program was conducted at these 22 AREEs beginning 10 September 1993 and ending 8 October 1993. This program will be referred to as the Preliminary SI throughout the remainder of this SI report. The intent of the Preliminary SI was to identify what, if any, contamination existed at the 22 AREEs being investigated. Advance recommendations based on the results of the Preliminary SI were provided by EARTH TECH to assist in a rapid decision-making process for the identification of necessary follow-up investigations.

The BCT in coordination with USAEC reviewed all information available for the 22 AREEs, including the advance recommendations provided by EARTH TECH from the Preliminary SI, to make determinations as to the type of remaining investigations required. Eight of the AREEs were identified as requiring Supplemental Site Inspections (SSIs) and the three AREEs identified as requiring Virginia Department of Environmental Quality (VADEQ) response actions. These AREEs were further investigated during a second sampling program conducted between 4 April 1994 and 11 August 1994. The intent of the second sampling program was to obtain additional information at several AREEs investigated during the Preliminary SI. The rationale for activities performed during the SSI are presented in Table 1-2.

**TABLE 1-1
AREES INCLUDED IN SITE INSPECTION**

AREE ⁽¹⁾ No.	Description ⁽¹⁾	Summary of Preliminary Assessment Findings ⁽¹⁾	Possible Chemicals of Concern ⁽²⁾	Site Inspection Activity
1	Former Dump No. 1	Dump contains metal, wire, concrete, wood, rubber tires, possible electrical capacitors. Covered with soil. Operated 1950s - 1973.	Metals, PCBs, petroleum products, asbestos	Groundwater sampling, soil sampling, geophysics, excavation, visual inspection, land surveying
2	Former Dump No. 2	Dump contained metal debris, wire, wood, miscellaneous refuse, capacitors and transformers containing PCBs. Capped with soil in 1973. Excavated in 1984. Contaminated material taken to Hazardous Materials Landfill.	PCBs, metals, petroleum products	Groundwater sampling, surface water sampling, sediment sampling, land surveying
3	Former Dump No. 3	Dump contains lead-containing wire, paper, plastic, wood. Covered with soil in 1973.	Metals, PCBs, petroleum products	Groundwater sampling, soil sampling, geophysics, excavation, visual inspection, direct push sampling, land surveying
4	Former Dump No. 4	Dump contains wire, trash, empty oil drums. Covered with soil in 1973. Operated 1950s - 1973.	Metals, PCBs, petroleum products	Groundwater sampling, soil sampling, geophysics, excavation, visual inspection, direct push sampling, land surveying
5	Former Dump No. 5	Dump contains metal debris. Covered before 1970.	Metals, PCBs, petroleum products	Groundwater sampling, soil sampling, geophysics, excavation, visual inspection, direct push sampling, land surveying
6A	Former Dump	Aerial photos indicate soil disturbance in 1960s and 1970s.	Metals, PCBs, petroleum products	Groundwater sampling, excavation, visual inspection, soil sampling, geophysics, direct push sampling, land surveying
6B	Former Dump	Aerial photos indicate soil disturbance in 1960s and 1970s.	Metals, PCBs, petroleum products	Groundwater sampling, soil sampling, excavation, visual inspection, geophysics, direct push sampling, land surveying
7	Pistol Range	Rounds fired into soil bank. Covered with soil in 1982.	Lead	Soil sampling, excavation, visual inspection, land surveying

**TABLE 1-1
AREES INCLUDED IN SITE INSPECTION**

Continued

AREE ⁽¹⁾ No.	Description ⁽¹⁾	Summary of Preliminary Assessment Findings ⁽¹⁾	Possible Chemicals of Concern ⁽²⁾	Site Inspection Activity
8/23	UST Leaks and Spills/ Former and Existing USTs	Area contained three 10,000-gallon USTs which were removed after leaking. Several major oil spills during UST filling and oil transfers. Water and oil seep into pit in nearby maintenance shop after rain. Six USTs have been removed, four as the result of failing leak tests conducted in 1990 and 1991, and two removed earlier after they were determined to be leaking. Two of the removed USTs were replaced with existing USTs.	Petroleum products	Groundwater sampling, aqueous sampling from tank, surface soil sampling, soil sampling, geophysics, excavation, visual inspection, land surveying
11	Oil/Water Separator	Waste oils from motor pool emptied into drains which ran to oil/water separator. Water discharged to grounds. Also vehicle Wash Rack drained to oil/water separator; Wash Rack drain plugged in 1990.	Petroleum products, VOCs, BNAs, PCBs	Surface water sampling, sediment sampling, aqueous sampling from separator, soil sampling, geophysics, excavation, visual inspection, land surveying
12	Drum Storage Area	Waste drums stored on pavement north of maintenance shop contained waste oil, paints, cleaning solvents, antifreeze, and brake fluid and are sent to Adelphi periodically.	Petroleum products, VOCs, BNAs	Soil sampling, geophysics, excavation, visual inspection, land surveying
13	Acid Neutralization Tank	Tank connected to drain in battery storage room in Building 211.	Acid, metals	Soil sampling, geophysics, excavation, visual inspection, land surveying
14	Oil/Water Separator (Building 211)	Separator connected to drain in work area in Building 211. Water drains to field east of building.	Petroleum products, VOCs, BNAs	Surface water sampling, sediment sampling, aqueous sampling from separator, soil sampling, geophysics, excavation, visual inspection, land surveying

**TABLE 1-1
AREES INCLUDED IN SITE INSPECTION**

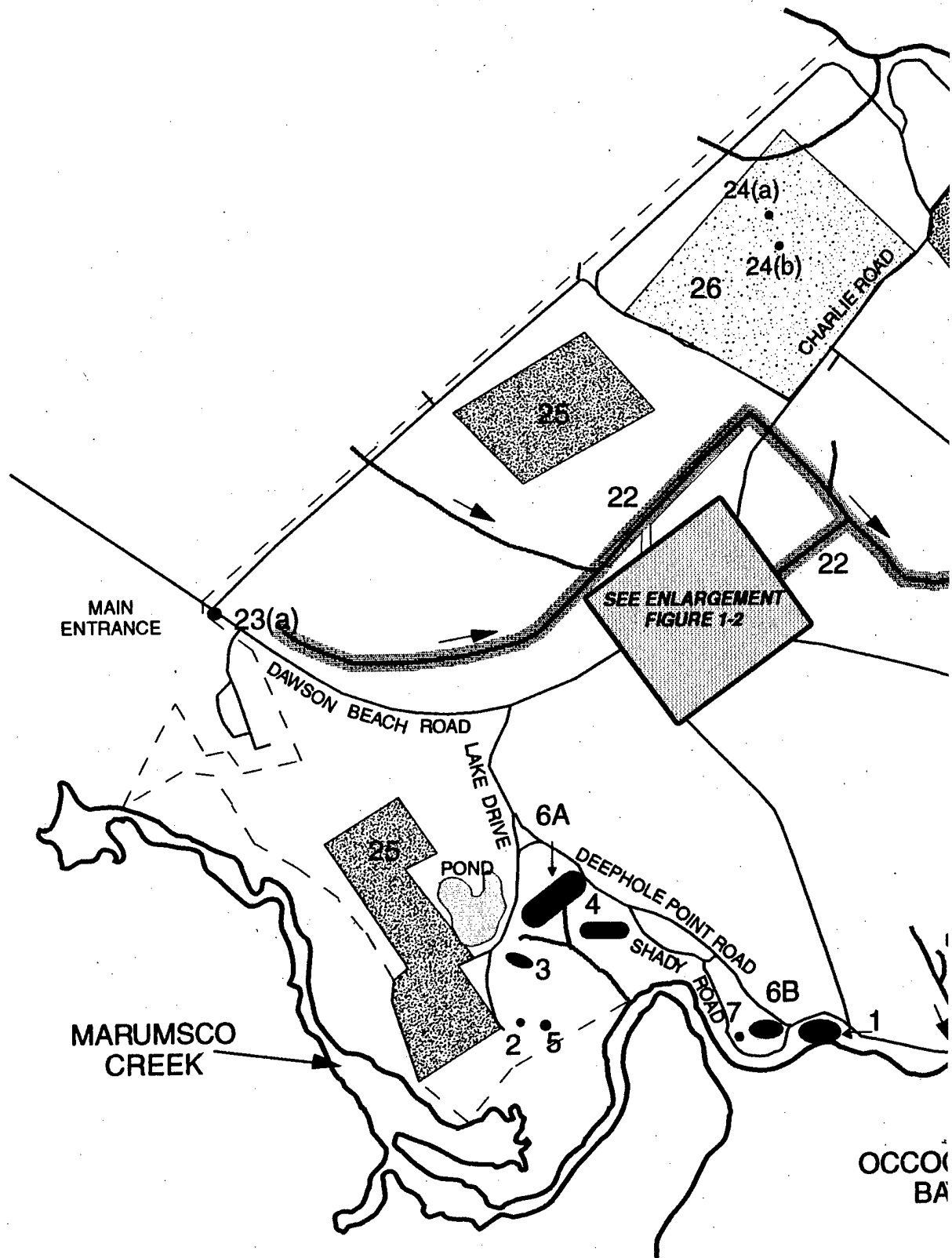
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AREE ⁽¹⁾ No.	Description ⁽¹⁾	Summary of Preliminary Assessment Findings ⁽¹⁾	Possible Chemicals of Concern ⁽²⁾	Site Inspection Activity
18	Flammable/Battery Storage (Building 204)	Storage building for batteries and drums containing flammable materials such as waste oil. Has concrete floor. Current battery storage area has safety shower and drain.	Metals, VOCs, BNAs	Surface soil sampling, soil sampling, geophysics, excavation, visual inspection, land surveying
19	Thermal Battery Storage	Metal containers stored thermal batteries along the eastern side of Building 204. Reportedly, the thermal batteries and metal storage containers were removed from the facility in March 1993.	Metals	Surface soil sampling, geophysics, visual inspection, land surveying
20	Former Incinerator	Metal box was used to burn paper from the 1950s to mid 1970s.	Metals	Geophysics, excavation, visual inspection, land surveying
21	Former Storage Area	Site partially covered by present Building 211. Reportedly stored transformers and capacitors in early 1970s.	PCBs, Petroleum products	Surface soil sampling, visual inspection, land surveying
22	Drainage Ditch	Oil spills may have drained to ditch. Contamination may have entered ditch from off- site.	Petroleum products	Surface water sampling, sediment sampling, visual inspection, land surveying
25	Sewage Injection Area	Sewage sludge injected into ground at depth of 2 feet in 1974.	Metals	Surface soil sampling, visual inspection, land surveying
26	Buried Antifreeze in Hoses	Ethylene glycol in rubber pipes in ground.	Ethylene glycol	Geophysics, soil sampling, excavation, visual inspection, land surveying
27	Buried Wire	Metal and plastic wire buried in ground for tests, could contain PCBs.	Lead, PCBs	Surface soil sampling, visual inspection

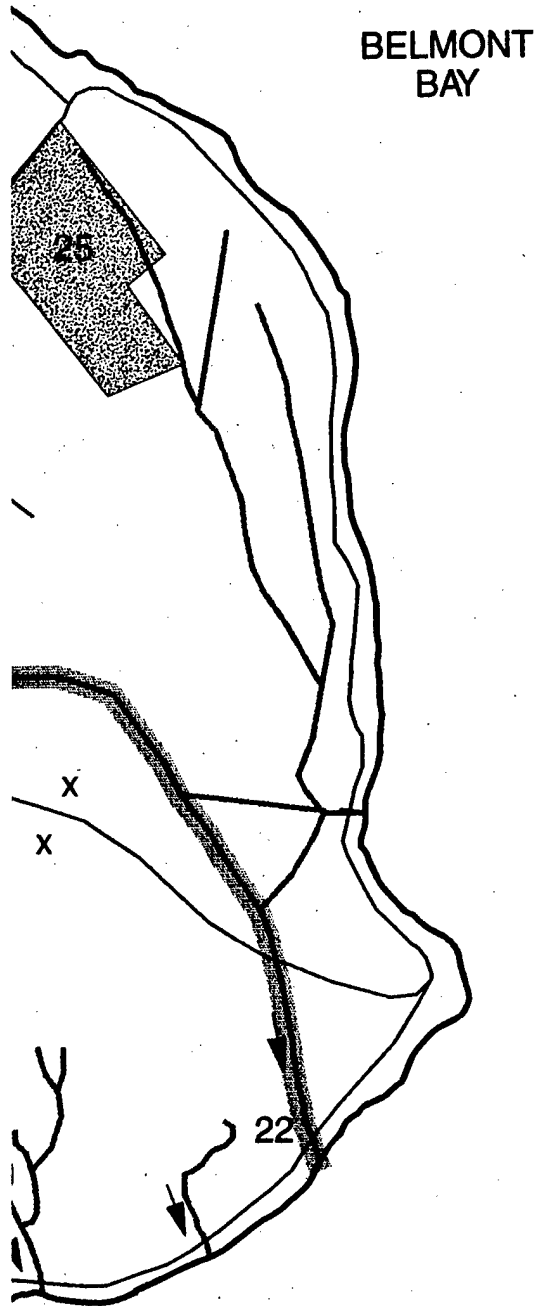
Key: AREE = Area Requiring Environmental Evaluation
 BNA = Base Neutral/Acid
 PCB = Polychlorinated Biphenyl
 UST = Underground Storage Tank
 VOC = Volatile Organic Compound

⁽¹⁾ Roy F. Weston, Incorporated, March 1992. Enhanced Preliminary Assessment, Woodbridge Research Facility.
⁽²⁾ Possible Chemicals of Concern as identified in Preliminary Assessment may or may not be present at the AREE.

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Former USTs (AREE 23)
 (a) One former 1,000-gal



KEY

- Facility Boundary
- Road
- ➔ Drainage and Flow Direction
- 6A AREE Number
- AREE 22
- ▨ AREE 25
- AREE 26
- X Supply Wells

AREE NUMBERS

1. Former Dump Number 1
2. Former Dump Number 2
3. Former Dump Number 3
4. Former Dump Number 4
5. Former Dump Number 5
6. Former Open Dump (2 Locations)
7. Pistol Range
22. Drainage Ditch
23. Former Underground Storage Tanks
24. Existing Underground Storage Tanks
25. Sewage Injection Areas
26. Buried Antifreeze Pipes (approximate location)
27. Buried Wire (throughout facility)

QUAN
IV

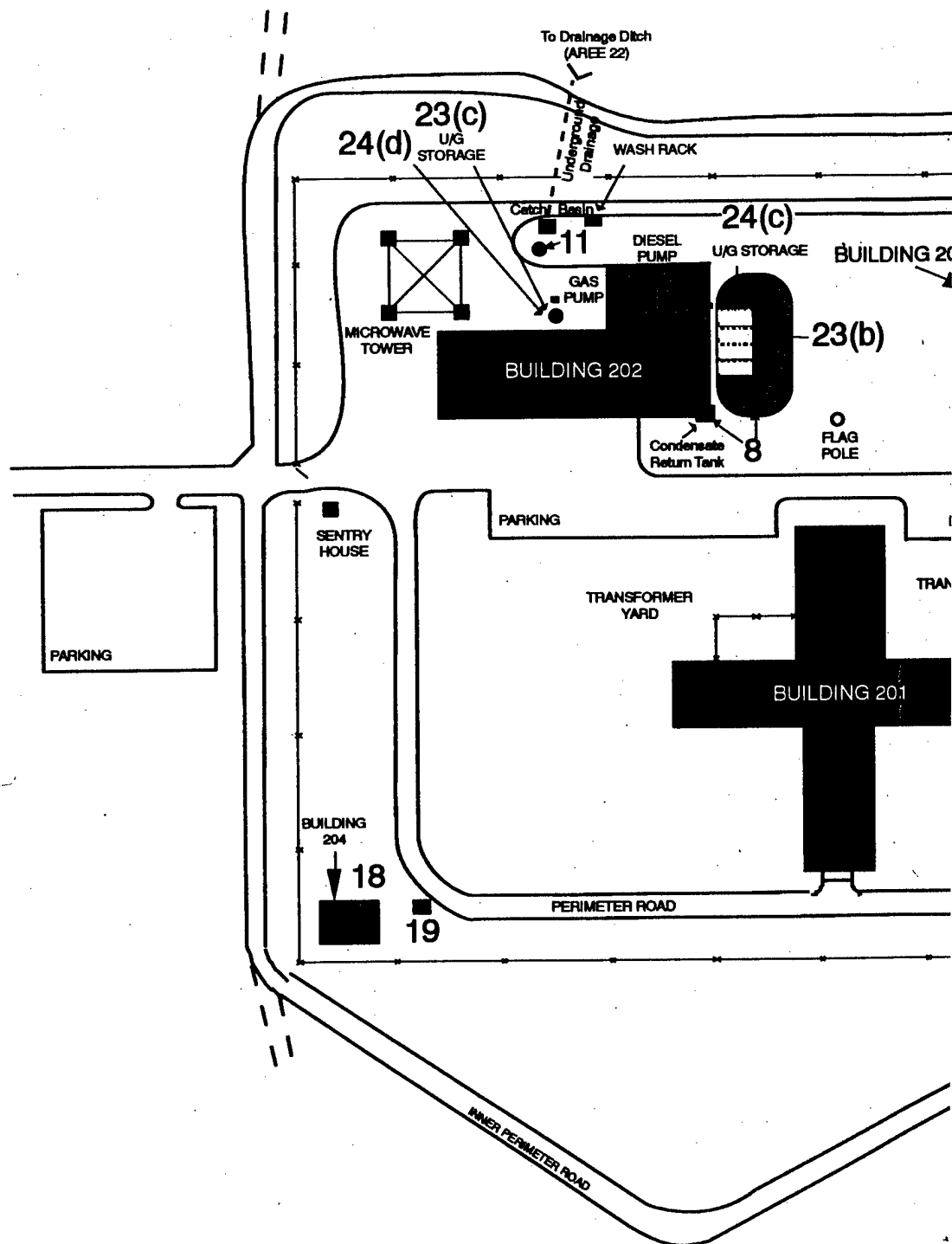


Ilon UST

Existing USTs (AREE 24)
(a) One existing 300-gallon UST
(b) One existing 300-gallon UST

EARTH TECH	FIGURE 1-1
Woodbridge Research Facility Areas Requiring Environmental Evaluation	

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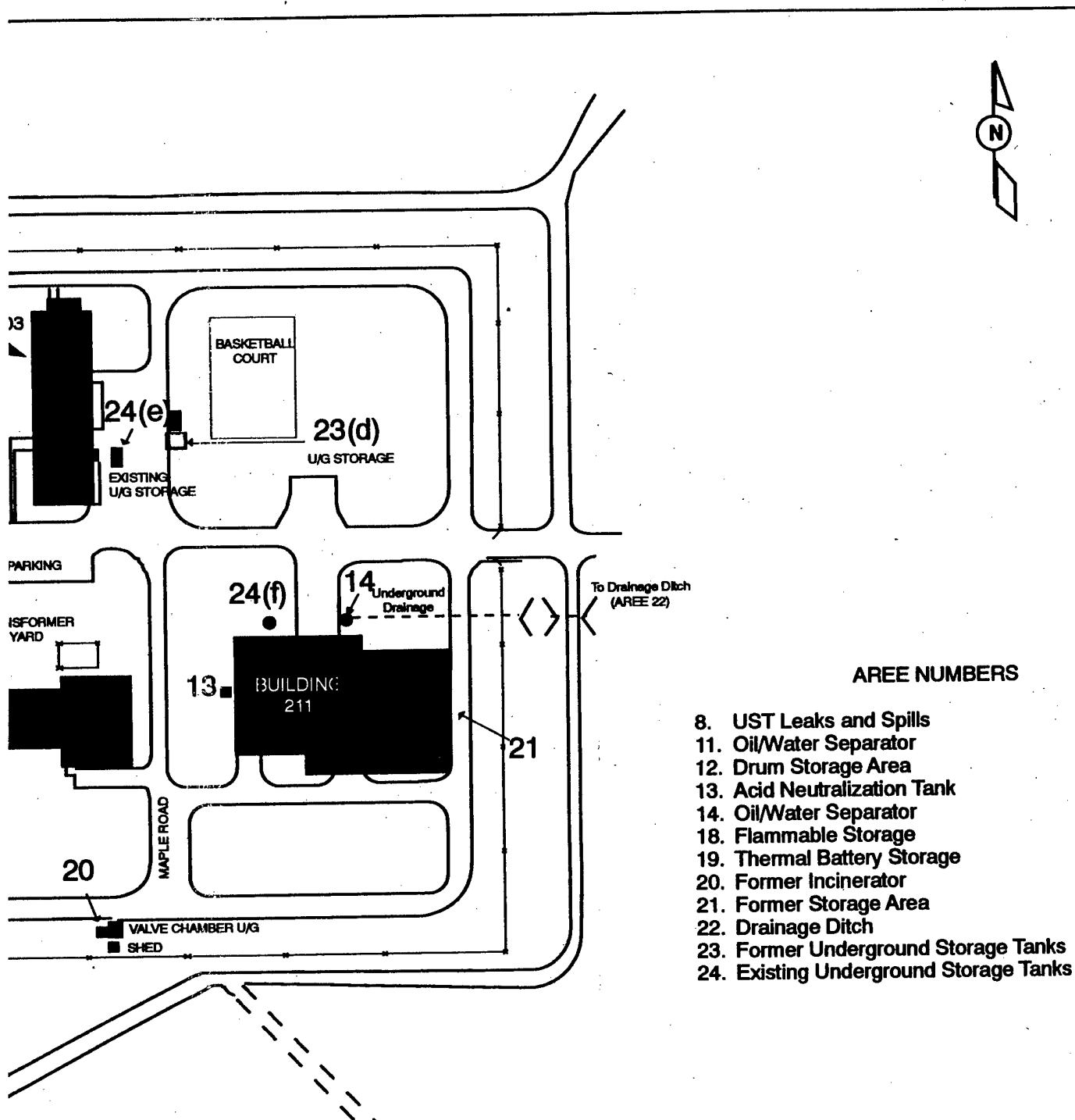


KEY

- Fence
- 6A AREE Number
- AREE
- > < Outfall

Former USTs (AREE 23)
 (b) Three former 10,000-gallon USTs.
 (c) One former 1,000-gallon UST.
 (d) One former 2,000-gallon UST.

Existing USTs (AREE 24)
 (c) One existing 2,000-gallon UST.
 (d) One existing 1,000-gallon UST.
 (e) One existing 10,000-gallon UST.
 (f) One existing 1,500-gallon UST.



NOTE: SEE FIGURE 1-1 FOR AREAS REQUIRING ENVIRONMENTAL EVALUATION OUTSIDE OF MAIN COMPOUND

EARTH TECH

FIGURE 1-2

**Woodbridge Research Facility
Areas Requiring Environmental
Evaluation
MAIN COMPOUND MAP**

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TABLE 1-2
AREES REQUIRING SUPPLEMENTAL SITE INSPECTION ACTIVITIES

AREE No.	Site Inspection Findings	Supplemental Site Inspection Activities	Supplemental Site Inspection Analyses
6B	Surface debris found; no soil samples collected.	Subsurface soil samples collected.	VOCs, SVOCs, TPH, PCB/Pesticides, Metals
7	One soil sample collected at 3 feet bgs; no bullets found.	Located bullets, subsurface soil samples collected.	Metals
12	2 shallow soil samples collected; acetone, 2-butanone, and TPH detected.	Four boreholes installed to collect subsurface soil samples.	VOCs, SVOCs, TPH, PCB/Pesticides, Metals
13	One subsurface soil sample collected and analyzed for pH only.	Three boreholes installed to collect subsurface soil samples.	Metals
18	Soils outside Building 204 collected.	Joint material inside Building 204 collected.	VOCs, SVOCs, Metals
21	Four composite surface soil samples collected and analyzed for TPH and PCB/Pesticides. TPH detected.	Four boreholes installed to collect subsurface soil samples.	VOCs, SVOC, TPH, PCB/Pesticides, Metals
25	Six surface soil samples collected and analyzed for metals.	Soil sample pairs collected (0.5 and 2 feet bgs).	PCB/Pesticides and Metals
26	No hoses were located. No samples were collected.	Hoses were found. Soil samples and an aqueous sample were collected.	VOC, SVOC, TPH, PCB/Pesticides, Metals, and Ethylene Glycol for Aqueous Sample, Metals and Ethylene Glycol for Soils

Key: PCB = Polychlorinated Biphenyl
 TPH = Total Petroleum Hydrocarbon
 VOC = Volatile Organic Compound
 SVOC = Semivolatile Organic Compound
 AREE = Area Requiring Environmental Evaluation

The results of the Preliminary SI and SSI are presented in this report for the 22 AREES investigated. The results of the VADEQ response actions conducted have been delivered in a Draft Site Characterization Report dated July 1994.

This SI was developed with information collected from a literature review which was conducted to establish both the installation history, the suspected nature and extent of any contamination potentially existing on-site, and results from sampling and analytical activities performed at WRF. The purpose of this SI is to initially characterize the surface and subsurface soil, sediment, surface water, and groundwater as appropriate at each AREE to accurately define what, if any, contamination exists at WRF as a result of past U.S. Army activities. The identification of the locations investigated, the investigative methods employed at each location, and the data quality objectives and rationale for the entire project are described in this SI Report. Completion of these environmental investigations is designed to support the Army's disposal of the facility in advance of the 1997 deadline.

1.2 PREVIOUS INVESTIGATIONS

Several environmental studies have been performed at the WRF. These investigations are briefly summarized below in chronological order of their completion.

In 1981, an Installation Assessment of ERADCOM Activities was completed by Environmental Science and Engineering, Inc. (ESE) for three facilities, one of which was the WRF. A records search and site visit were conducted. During the site visit several grave sites marked with the date 1695 were observed. A review of the on-site records indicated that WRF had not leased property to outside activities or been involved in any binding contracts. However, complaints relating to the WRF sewage disposal practices in 1974 were noted. At that time sewage sludge was injected into the WRF soil resulting in odor problems and possible groundwater contamination. Community objection to this practice resulted in its discontinuance. The records search identified five underground petroleum, oil, and lubricant (POL) storage tanks and one aboveground POL storage tank. These tanks were noted as having capacities ranging from 500 to 10,000 gallons. None of the tanks had been leak tested.

A summary of the waste management practices identified during the installation assessment is provided below. Waste oils generated by motor vehicle maintenance activities at the motor pool were stored in 55-gallon drums and transported to the Adelphi Laboratory Center at Adelphi, Maryland for disposal. During the previous 9 years approximately 100 gallons of waste oil had been generated. Effluent from the vehicle wash rack located behind Building 202 flowed through an oil separator and then into a stormwater drainage ditch. Oil removed from the wastewater was transported to the Adelphi Laboratory Center for disposal. No wastewater was treated at WRF. Sanitary sewage flowed by gravity from the main building complex to a sewage ejection station (Building 301) and then into the main sanitary sewer line (part of the Occoquan-Woodbridge Sanitation District (OWSD)) for off-site treatment.

Sanitary wastes generated at Building 306 flowed to a holding tank. Wastes from the tank were hauled to the OWSD system when the capacity of the tank was reached. No National Pollutant Discharge Elimination System (NPDES) permits existed for the Building 202 wash rack or the Building 301 ejection station overflow line (which drains into Occoquan Bay). There were no records indicating the existence of holding ponds at WRF.

Two solid waste disposal areas were identified on-site in the 1981 assessment. The first disposal area, referred to as Landfill No. 1 (or Former Dump No. 1), had been used as a dumping area for construction debris and scrap metal in an attempt to stop shore erosion. The half-acre area is bounded by Shady Road, Deephole Point Road, and Occoquan Bay. Before 1980, wooden boxes were buried in a 60 foot long trench in Landfill No. 1. The second disposal area at the south end of Lake Drive operated as an uncontrolled disposal site during the 1970s. The half-acre area once referred to as Landfill No. 2 and now referred to as Former Dump No. 2 was more recently used for the storage and collection of scrap metal.

No laboratory operations existed at WRF which generated hazardous waste. The 1981 assessment also provided review of hazardous material handling and storage practices and indicated that two polychlorinated biphenyl (PCB)-containing items were used at the facility. Both items were located in the transformer yard next to Building 201, were properly labeled, and periodically inspected.

Water quality data in the 1970-1980 records revealed no migration of toxic/hazardous materials into surface water or groundwater. Air emissions from all sources of fuel combustion did not significantly impact ambient air quality. All fuel combustion equipment (i.e. boilers) was maintained on a regular schedule according to Federal, State, and local regulations.

In 1984, a Plan for the Assessment of Contamination at Woodbridge Research Facility was completed by ESE to determine the extent of PCB contamination at a former waste disposal area (Landfill No. 2). The source of these items was the antennae fields that were dismantled in the early 1970s. A WRF employee had informed the installation in January 1984 that approximately 20 transformers and 70 capacitors containing PCBs were buried in a trench at Landfill No. 2. WRF excavated some test pits within the vicinity of the burial. PCB contamination was reported based on limited sampling and analysis of soil in the excavated area by Versar, Inc. In February 1984 ESE conducted further soil sampling at Landfill No. 2 in accordance with the 1982 U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) Quality Assurance/Quality Control (QA/QC) Program. The analyses confirmed PCB contamination. Concentrations of less than 0.6 to 200 micrograms per gram ($\mu\text{g/g}$) PCBs were detected in the trench soils sampled to a depth of approximately 4 feet. It was not determined whether groundwater contamination by PCBs existed, whether PCBs were migrating off the installation in the groundwater, or whether the potential for contaminant migration off the installation existed. Water quality data from 1970-1980 revealed no migration of toxic/hazardous materials, including PCBs, from WRF

into Occoquan or Belmont Bays. The data was recovered from the computerized Storage and Retrieval (STORET) database (USEPA STORET Data for 1981). Table 1-3 contains a summary of the data. Since the data were computer accessed, the reporting agency is unknown. Additionally, the significance of the 0.000 microgram per liter ($\mu\text{g/L}$) concentrations reported is unknown but is assumed to designate levels below the analytical detection limit. The records search which was conducted in 1981 indicated no presence of toxic/hazardous materials in the groundwater; however, no PCB analyses had been performed at that time.

Two on-site supply wells located at least 2,000 feet from Landfill No. 2 were sampled and analyzed; PCBs were not detected. The data was transmitted to USATHAMA in 1984. Originally the two water supply wells were used as the facility's potable water supply. Well No. 1 is abandoned with no pump and Well No. 2 has an inoperative 30 gallons per minute (gpm) pump. Well No. 2 contains a 6-inch distribution main leading to Building 205. At this location the 6-inch main is capped and connected to a 2-inch line leading to the pond. Each supply well is approximately 151 feet deep and both are located upgradient of AREE 2.

A Remedial Action Plan for the Woodbridge Research Facility PCB Disposal Site was completed by ESE in 1984 for the excavation and disposal of PCB-containing items and PCB-contaminated soil at Landfill No. 2. In 1985 a technical plan, Woodbridge Research Facility Remediation of PCB Contamination, for remediation of PCB contamination at Landfill No. 2 was prepared by Roy F. Weston, Inc.

The Closure Plan for Transformer/Capacitor Burial Trench-Harry Diamond Laboratories, Woodbridge Research Facility, Woodbridge, Virginia (1985) addressed exhumation activities for the disposal trench at Landfill No. 2. The closure work was completed by Roy F. Weston, Inc. Six transformers and 85 capacitors were removed from Landfill No. 2. Approximately 660 cubic yards of PCB-contaminated material were also removed from the site. Seventy-six composite soil samples, including duplicates, were submitted to the ESE laboratory. Sixty grab samples of the soil remaining in the trench were also collected and sent to the ESE laboratory for analysis. Analyses of total PCBs were performed in accordance with USATHAMA-certified analytical procedures. The composite soil samples indicated that the highest PCB concentrations were found at the burial of the transformers and capacitors. The closure plan did not indicate that the soil samples were tested for any hazardous constituents other than PCBs. Excavated soil containing total PCB concentrations greater than or equal to 3 parts per million (ppm) was disposed at a Chemical Waste Management, Inc. hazardous waste landfill facility. Soil from the side wall and floor of the excavated trench was sampled, analyzed, and considered "clean". Closure of Landfill No. 2 involved backfilling the excavated area with uncontaminated soil (less than 3 ppm PCBs).

TABLE 1-3
SUMMARY OF WATER QUALITY DATA FOR OCCOQUAN AND BELMONT
BAYS FOR 1970 TO 1980

Parameter	Concentration*	Number of Measurements	Water Quality Standards	
			Virginia Class II	Maryland Class I
Dissolved oxygen (DO) (mg/L)	6.8-13.8	99	4(5) +	5
pH (units)	7.3-10.0	63	6.0-8.5	6.5-8.5
Fecal coliform (MPN/100 mL)	<30-4,500	48	200	200
Arsenic (µg/L)	<5.0	5	NA	NA
Cadmium (µg/L)	<10.0	7	5	NA
Chromium (µg/L)	<10.0	8	100	NA
Manganese (µg/L)	70.0	1	100	NA
Iron (µg/L)	460.0	1	NA	NA
Nickel (µg/L)	<100.0	4	Note 1	NA
Copper (µg/L)	<10.0	9	Note 2	NA
Lead (µg/L)	<1.0-6.0	8	Note 1	NA
Zinc (µg/L)	<10.0-30	9	Note 1	NA
Mercury (µg/L)	<0.50	10	0.10	NA
Chlordane (µg/L)	0.000	2	0.004	NA
DDT (µg/L)	0.000	2	0.001	0.001
Aldrin (µg/L)	0.000	2	0.003	0.003
Dieldrin (µg/L)	0.000	2	0.003	0.003
Endrin (µg/L)	0.000	2	0.004	0.004
Methoxychlor (µg/L)	0.000	2	0.03	NA
PCBs (µg/L)	0.000	2	0	0.001

Note 1: 0.01 times the 96-hour LC₅₀ value as determined through continuous flow bioassay using the receiving or comparable water as the diluent and using a sensitive resident species.

Note 2: 0.1 times the 96-hour LC₅₀ value as determined through nonaerated, continuous flow bioassay, using the receiving water or comparable water as the diluent and using a sensitive resident species.

*Data were retrieved from the USEPA STORET system. Performers of the analyses were not identified.

+ Minimum level at any time (minimum daily average).

Key: mg/L = Milligrams per liter
 µg/L = Micrograms per liter
 MPN = Most Probable Number
 mL = Milliliters
 NA = Not applicable

Sources: State of Maryland, 1980
 Commonwealth of Virginia, 1980
 ESE, 1981

In 1985, the Remedial Investigation (RI) (Part I) and Feasibility Study (Part II) at Woodbridge Research Facility was finalized by ESE. The RI included installation of six monitoring wells (one upgradient and five downgradient) and the collection of sediment samples from the swampy area adjacent to Landfill No. 2. Two observation wells were also constructed upgradient of the landfill to better define the direction of groundwater flow. The results of composite soil core sampling during monitoring well drilling immediately downgradient of Landfill No. 2 indicated less than 0.6 $\mu\text{g/g}$ PCBs (the analytical detection limit). The sediment samples in the swampy area to the southeast of Landfill No. 2 did not show any detectable concentrations of PCBs with 0.2 $\mu\text{g/g}$ as the detection limit. Detectable levels of PCBs were not found in the groundwater samples from any of the monitoring wells. Groundwater, sediment, surface water, and soil samples collected in areas adjacent to Landfill No. 2 did not contain PCBs, suggesting that PCB contamination was confined to the landfill area. The detected values for PCBs in groundwater, surface water, sediment, and soil samples collected for the 1985 RI are shown in Table 1-4.

Landfill No. 1 had been a "debris" fill and was not used to bury transformers or capacitors. Three sediment samples and two surface water samples were collected at Landfill No. 1 during the RI. All of the sediment samples within the boundaries of Landfill No. 1 had concentrations of PCBs less than 5 $\mu\text{g/g}$. The source of PCB contamination at Landfill No. 1 is unknown. At the surface water sampling locations outside the west boundary of Landfill No. 1, PCBs were not detected. Due to the number of samples collected at Landfill No. 2 which had no detectable amount of PCBs, the samples were reanalyzed using a method that allows for a PCB detection limit in soil/sediment of 0.02 $\mu\text{g/g}$. All samples taken outside both landfills contained less than 0.02 $\mu\text{g/g}$ PCBs. Of the USEPA organic priority pollutants, low level concentrations of di-n-octyl phthalate (16 to 32 $\mu\text{g/L}$) and bis(2-ethylhexyl)phthalate (20 to 25 $\mu\text{g/L}$) were detected in the groundwater and surface water samples of Landfills No. 2 and 1, respectively. No USEPA human health standard has been established for di-n-octyl phthalate. Bis(2-ethylhexyl) phthalate is present at a concentration considerably less than the USEPA-established criterion for human health. Wire cable whose outer sheath is comprised of plastic and rubber has been buried in the landfills and could explain the presence of these compounds.

In 1985, An Archeological Overview and Management Plan for the Harry Diamond Laboratories-Woodbridge Research Facility was completed by Thunderbird Archeological Associates, Inc. and Envirosphere Co. This report was prepared as part of an interagency technical services agreement to develop facility-specific archeological overviews and management plans for U.S. Army Materiel Development and Readiness Command. A total of eleven prehistoric and historic sites (six known and five potential archeological resources) exist at locations within the WRF. Because WRF has remained relatively undisturbed, the potential significance of its archeological remains is of a high order. Recommendations were made for detailing, through further studies, archeological resources present on WRF.

TABLE 1-4
PCB CONCENTRATIONS IN SAMPLES COLLECTED DURING THE 1985 RI
FOR WOODBRIDGE RESEARCH FACILITY

Location	Sample Type	Date of Collection	Sampling Method	PCB Concentration (µg/L)	
				PCB 1016	PCB 1260
Landfill 2, MW 1	Groundwater	04/19/84	Bail	<3	<0.9
Landfill 2, MW 2	Groundwater	04/19/84	Bail	<3	<0.9
Landfill 2, MW 3	Groundwater	04/19/84	Bail	<3	<0.9
Landfill 2, MW 4	Groundwater	04/20/84	Bail	<3	<0.9
Landfill 2, MW 4(R)	Groundwater	04/20/84	Bail	<3	<0.9
Landfill 2, MW 5	Groundwater	04/20/84	Bail	<3	<0.9
Landfill 2, MW 6	Groundwater	04/19/84	Bail	<3	<0.9
Landfill 2, No. 7	Groundwater	04/20/84	Grab	<3	<0.9
Landfill 1, LF1W1	Surface Water	05/10/84	Grab	<3	<0.9
Landfill 1, LF1W2	Surface Water	05/10/84	Grab	<3	<0.9
Location	Sample Type	Date of Collection	Sampling Method	PCB Concentration (µg/g)	
				PCB 1016	PCB 1260
Landfill 2, MW 1	Soil	04/10/84	Core	<0.6	<0.6
Landfill 2, MW 2	Soil	04/12/84	Core	<0.6	<0.6
Landfill 2, MW 3	Soil	04/12/84	Core	<0.6	<0.6
Landfill 2, MW 4	Soil	04/11/84	Core	<0.6	<0.6
Landfill 2, MW 5	Soil	04/11/84	Core	<0.6	<0.6
Landfill 2, MW 6	Soil	04/12/84	Core	<0.6	<0.6
Landfill 2, MW 6(R)	Soil	04/12/84	Core	<0.6	<0.6
Landfill 2, No. 8	Sediment	04/13/84	Grab	<0.6	<0.6
Landfill 2, No. 9	Sediment	04/13/84	Grab	<0.6	<0.6
Landfill 1, LF1S1	Sediment	05/10/84	Grab	<0.6	1
Landfill 1, LF1S2	Sediment	05/10/84	Grab	<0.6	5
Landfill 1, LF1S3	Sediment	05/10/84	Grab	<0.6	<0.6

Key: PCB = Polychlorinated Biphenyl
RI = Remedial Investigation
µg/g = Micrograms per gram
µg/L = Micrograms per liter

Source: ESE, 1985

The Final Report for the Remediation of PCB Contamination at Woodbridge Research Facility was completed by Roy F. Weston, Inc. in 1986. The report details site preparation, removal and disposal operations for PCB contamination, and restoration at Landfill No. 2. The analytical results of composite soil sampling during remediation at Landfill No. 2 indicated that the highest PCB concentrations were found at the burial of the transformers and capacitors. Pursuant to the request of USATHAMA, all soil piles containing detectable PCB concentrations (greater than 0.6 $\mu\text{g/g}$) were removed from the site and disposed at the Chemical Waste Management hazardous waste landfill facility in Model City, New York. Groundwater sampling was performed at all monitoring well points adjacent to Landfill No. 1 and Landfill No. 2. The results of groundwater monitoring three months after closure of Landfill No. 2 indicated non-detectable levels of PCBs (less than 0.6 $\mu\text{g/L}$).

In 1986 Weston implemented a 5-year groundwater monitoring program for Landfill No. 2. PCB concentrations of up to 7 $\mu\text{g/L}$ were found in water samples from MW2 and MW3. The concentrations of PCB in the samples increased annually. PCB concentrations detected during this program are shown in Table 1-5 (IRDMIS, 1994). In January and February 1985, six monitoring wells were installed at Landfill No. 1. A groundwater sampling program for PCB analysis was then implemented (Weston, 1986), during which samples were collected over a 4-year period between 1987 and 1990. A review of the analytical data was conducted, and no detectable concentrations of PCBs were found in any of the groundwater samples collected (IRDMIS, 1991).

The Remedial Action Decision Document on Landfills 1 and 2 at Woodbridge Research Facility (1988) by USATHAMA is a post-closure assessment of a number of remedial action alternatives for PCB contamination. All of the previous documentation on WRF formed a database for this assessment.

An Environmental Assessment of the Woodbridge Research Facility Operations at Woodbridge, Virginia was completed by the U.S. Army Laboratory Command (LABCOM), Harry Diamond Laboratories at WRF, and LABCOM's Installation Support Activity in 1989. This assessment was required by the NEPA. Its purpose was to determine if the day-to-day operations at WRF have any significant impact on the surrounding environment. No samples were collected. The operations and maintenance activities were evaluated to assess resources, cultural resources, infrastructure, and safety. The continuation of operations at WRF was found to have no significant impact on the environment.

An Enhanced Preliminary Assessment, Woodbridge Research Facility, Virginia (1992) was prepared by Roy F. Weston, Inc. for the USATHAMA. Twenty-nine AREEs were identified. The AREEs include landfills (including Landfill No. 1 and Landfill No. 2), a pistol range, oil-contaminated areas, waste handling areas, storage areas, test areas, underground storage tanks (former and existing), transformers, oil/water separators, asbestos, drainage ditches, and spill areas. The report presents a summary of findings

TABLE 1-5
PCB CONCENTRATIONS DETECTED IN GROUNDWATER SAMPLES AT
LANDFILL 2 FROM 1985 TO 1990

Monitoring Well Number	Date Sampled	PCB 1016 (µg/L)	PCB 1221 (µg/L)	PCB 1223 (µg/L)
MW-2	08/25/88	1.94	ND	ND
	04/18/89	0.436	ND	ND
	06/07/90	ND	7S	ND
MW-3	03/10/87	0.496	ND	ND
	08/25/88	2.78	ND	ND
	04/18/89	0.775	ND	ND
	06/07/90	ND	ND	6 S
MW-4	08/25/88	0.254	ND	ND

Key: MW = Monitoring Well
 PCB = Polychlorinated Biphenyl
 ND = Not Detected
 µg/L = Micrograms per liter
 S = Flag for Non-target compound analyzed for and detected.

Source: IRDMIS.

for each AREE, environmental concerns due to the AREE hazardous materials, and recommendations for further action.

1.3 SITE INVENTORY

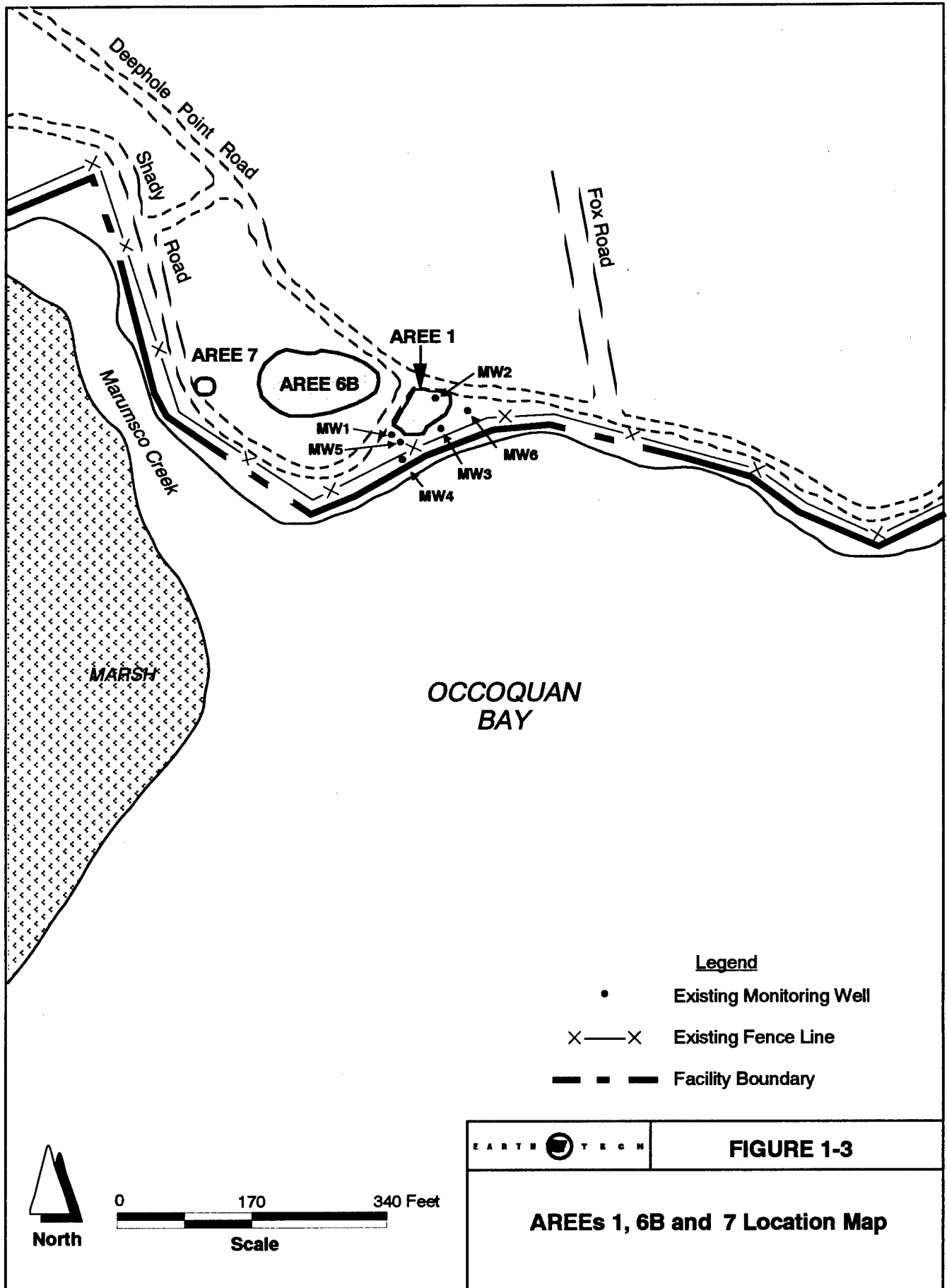
The focus of the activities presented in this report is 22 of the AREEs identified at the WRF. Provided in this section are brief site descriptions and histories for each of the 22 AREEs investigated during the SI. This information was obtained from a literature review conducted prior to the initiation of field activities.

1.3.1 AREE 1 - Former Dump No. 1

AREE 1 is a 0.4 acre former dump, previously referred to as Landfill No. 1, located at the intersection of Deephole Point Road and Shady Road as shown on Figure 1-3. The former dump was used as a dumping site for construction debris including concrete and scrap metal (ESE, 1981). The dumping was estimated beginning in the 1950s at this site; however, all dumping was stopped in 1973. In 1973, a trench approximately 60 feet long was bulldozed in order to bury wooden boxes along the slope of the shore. The reason for this activity was, at least in part, to provide shore erosion control (ESE, 1981; Weston, 1992). Additionally, some capacitors may have been dumped at the site prior to closure of the landfill (Weston, 1992).

An RI was completed for the former dump between January and May of 1984. The study showed that PCBs were detected at low concentrations in sediment samples taken from the former dump but not detected in surface water samples as shown in Table 1-4. In addition, bis(2-ethylhexyl) phthalate and di-n-octyl phthalate were detected in a surface water sample collected at the site (ESE, 1985). As a result of the RI, six monitoring wells were installed at the site between January and February of 1985. The locations of the wells are shown on Figure 1-3. During the Preliminary Assessment, additional materials were identified at the former dump including potential asbestos-containing material. Finally, the Virginia Water Control Board (VWCB) collected surface runoff samples at this former dump in March 1993 with PCBs detected at a level of 15 parts per billion (ppb) (Virginia Department of Environmental Quality—Office of Research and Standards, 1994).

A groundwater sampling program to monitor for PCB contamination was implemented at AREE 1; samples were collected over a 4-year period between 1987 and 1990. A review of the analytical data was conducted, and no detectable concentrations of PCBs were found in any of the groundwater samples collected (IRDMIS, 1991; Weston, 1992). These data are located in the Installation Restoration Data Management Information System (IRDMIS). In addition, although only nonhazardous materials have been disposed at Former Dump No. 1, the possibility exists that hazardous materials could have been disposed at all former dumps.



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1.3.2 AREE 2 - Former Dump No. 2

The former dump associated with AREE 2 was previously referred to as Landfill No. 2 and is located at the end of Lake Drive as shown on Figure 1-4. This was a disposal area for PCB-containing transformers and capacitors as well as other debris in the early 1970s. A Remedial Investigation/Feasibility Study (RI/FS) was completed for the former dump between January and May 1984. Six groundwater monitoring wells were installed as part of the RI. The locations of the wells are shown on Figure 1-4. The investigation identified PCB contamination within the former dump site; however, no PCBs were detected outside the disposal area. Soil and sediment samples had a detection limit of 1 $\mu\text{g/g}$ for PCB analysis. The RI concluded that PCBs had not migrated from within the disposal area, and the FS recommended removal and offsite disposal of contaminated material.

The removal and offsite disposal of contaminated material was completed in 1985. Six transformers and 85 capacitors were recovered, and PCB-contaminated soil was excavated until the soil remaining in the excavation tested as clean (less than 3 ppm PCBs). The closure plan did not indicate that the soil samples were tested for any hazardous constituents other than PCBs. The transformers, other debris, and soil were disposed at a hazardous waste landfill in New York (Weston, 1992).

Groundwater samples collected for the RI completed in 1984 did not contain detectable concentrations of PCBs as noted in Table 1-4. A 5-year groundwater sampling program was implemented from 1985 to 1990 to monitor for PCB contamination. The PCB concentrations have been increasing annually with concentrations up to 7 $\mu\text{g/L}$ detected in samples from MW2 and MW3 in 1990 (Weston, 1992).

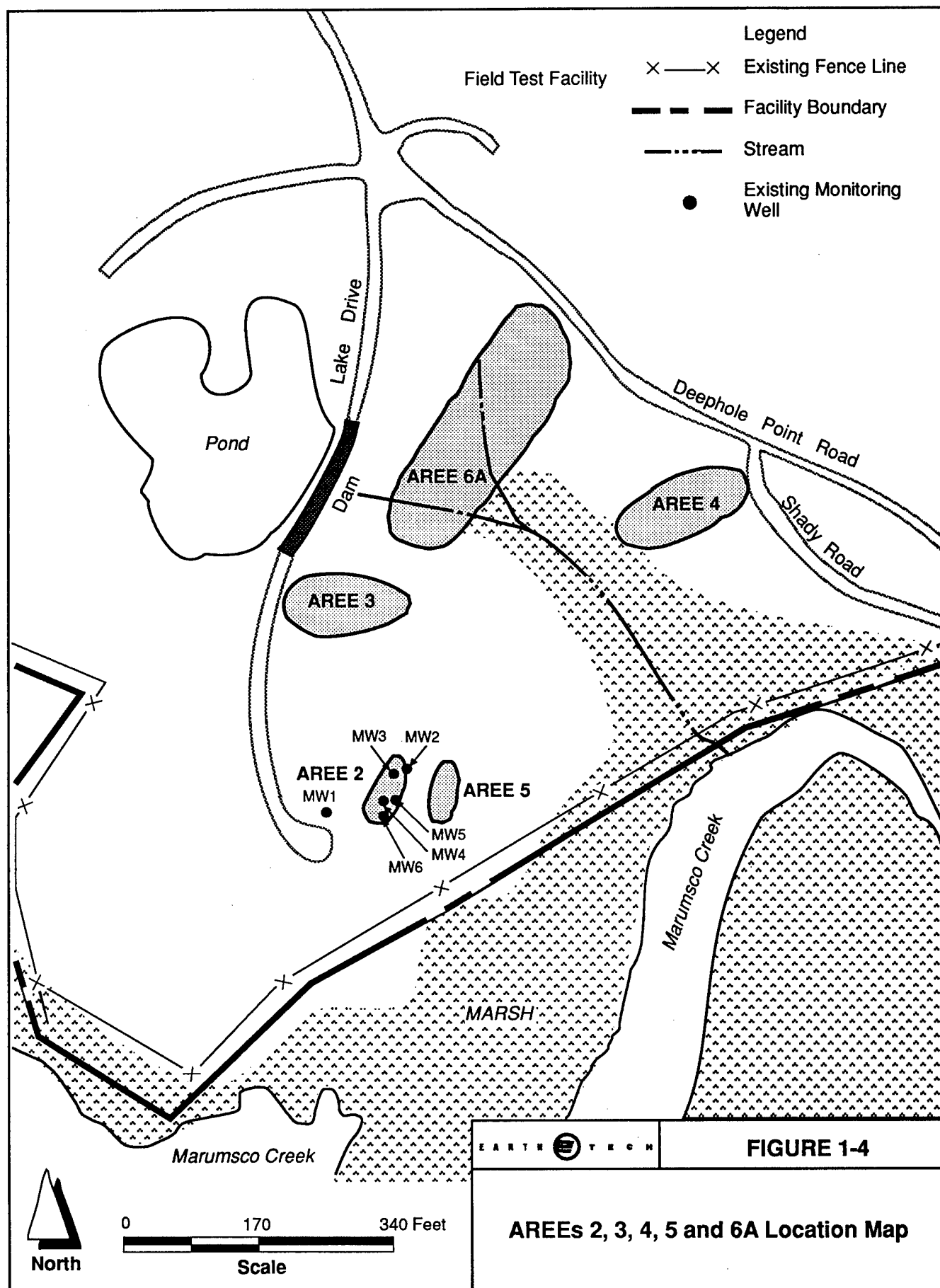
1.3.3 AREE 3 - Former Dump No. 3

AREE 3 is an former dump located just east of the pond on the east side of Lake Drive as shown on Figure 1-4. Approximate dimensions of the former dump were reported in the Preliminary Assessment as 100 feet by 25 feet by 10 feet deep (Weston, 1992). Debris such as wood, wire coated with lead, paper, and plastic were dumped at this site as early as 1966 until 1973 when the former dump was covered with soil (Weston, 1992). No previous investigations have been conducted at this site. Although only nonhazardous materials have been disposed at Former Dump No. 3, the possibility exists that hazardous materials could have been disposed at all former dumps.

1.3.4 AREE 4 - Former Dump No. 4

AREE 4 is an former dump located just south of Deephole Point Road and west of Shady Road as shown on Figure 1-4. Debris such as wire, wood, concrete, pipe insulation, and empty oil drums were dumped at this site from the late 1950s until 1973 when the former dump was covered with soil (Weston, 1992). No previous

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investigations have been conducted at this site. Although only nonhazardous materials have been disposed at Former Dump No. 4, the possibility exists that hazardous materials could have been disposed at all former dumps.

1.3.5 AREE 5 - Former Dump No. 5

AREE 5 is an former dump located just east of Former Dump No. 2 (AREE 2) as shown on Figure 1-4. Only metal debris was dumped at this site from the 1950s through the 1960s, and the former dump was closed before 1970 (Weston, 1992). No previous investigations have been conducted at this site. Although only nonhazardous materials have been disposed at Former Dump No. 5, the possibility exists that hazardous materials could have been disposed at all former dumps.

1.3.6 AREE 6A - Former Dump

AREE 6A is a former dump identified during the Preliminary Assessment (Weston, 1992). The former dump is situated west of Deep Hole Point Road and south of Lake Drive (just downstream of the pond) as shown on Figure 1-4. The former dump was identified based on ground scars and soil disturbances illustrated on aerial photographs for the facility taken in the 1960s and 1970s which were reviewed during the Preliminary Assessment. The Preliminary Assessment also reported the observation of debris located on the ground in the area of the former dump. No previous investigations have been conducted at this site. Although only nonhazardous materials are suspected to have been disposed at Former Dump No. 6A, the possibility exists that hazardous materials could have been disposed at all former dumps.

1.3.7 AREE 6B - Former Dump

AREE 6B is a former dump identified during the Preliminary Assessment. The former dump is situated at the intersection of Deephole Point Road and Shady Road across from AREE 1 as shown on Figure 1-3. The former dump was identified based on ground scars and soil disturbances illustrated on aerial photographs for the facility taken in the 1960s and 1970s which were reviewed during the Preliminary Assessment. The Preliminary Assessment also indicated the observation of debris located on the ground in the area of the former dump. No previous investigations have been conducted at this site. Although only nonhazardous materials are suspected to have been disposed at Former Dump No. 6B, the possibility exists that hazardous materials could have been disposed at all former dumps.

1.3.8 AREE 7 - Former Pistol Range

AREE 7 is a former pistol range site located on an open hillside between Deephole Point Road and Shady Road as shown on Figure 1-3. The hillside is situated approximately 75 yards west of the former dump identified in AREE 1. The range was used for qualifications of small arms firing on a semi-annual basis during the 1970s. This activity occurred for an unknown number of years before the firing range was

covered with backfill material and firing practice was stopped as a regular activity at WRF (Weston, 1992). No previous investigations have been conducted at this site.

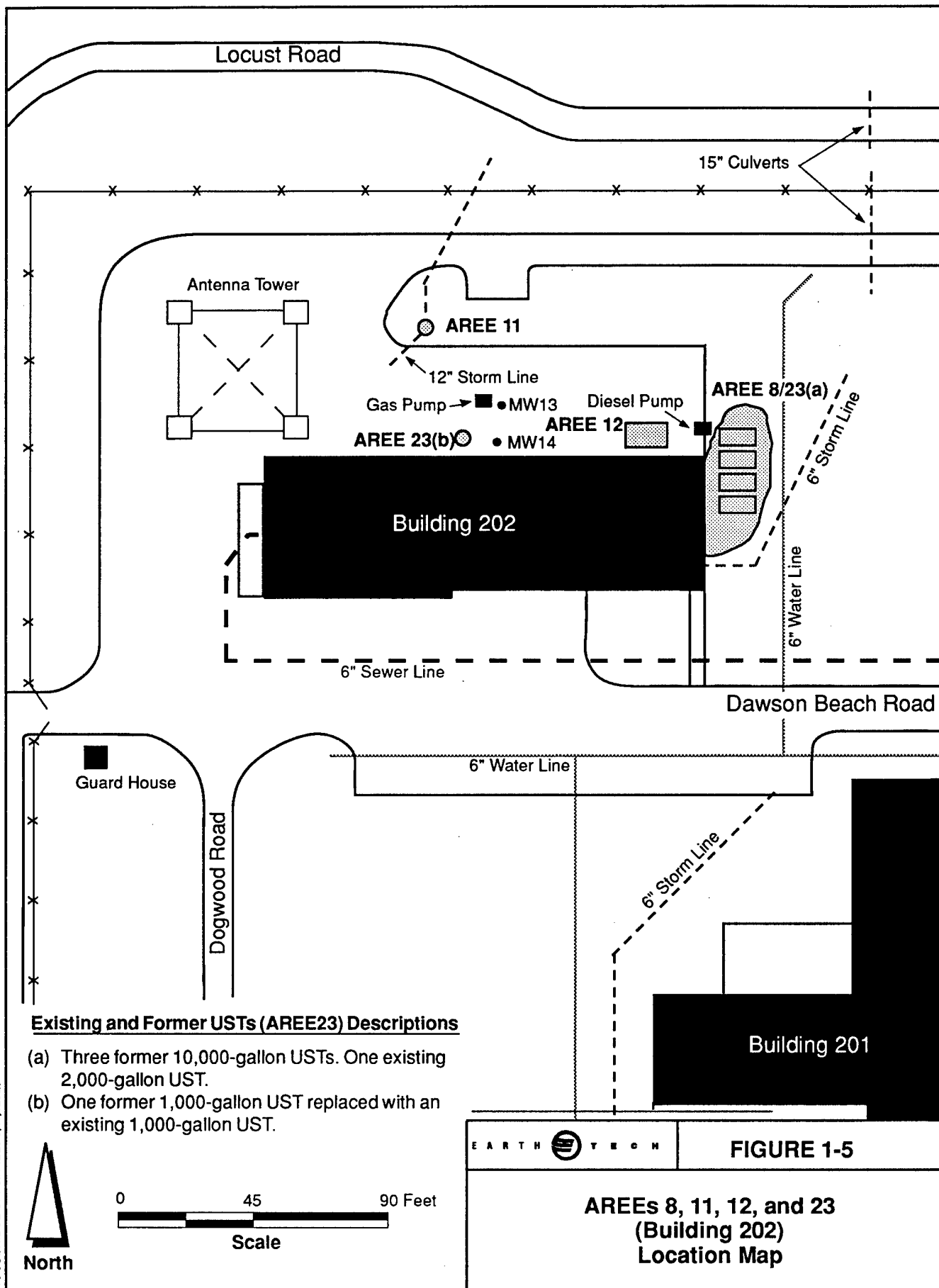
1.3.9 AREEs 8/23 - UST Leaks and Spills/Formers USTs

AREE 8 is located outside of the eastern wall of Building 202 as shown in Figure 1-5. There were three USTs, of steel construction, each with a 10,000 gallon capacity that were placed at this location in 1966. There is anecdotal information concerning uncontrolled releases of petroleum products relating to overfilling the USTs or spills while filling these USTs. In addition, water and oil seeps into the condensate return tank pit located in the electrical switch room in Building 202 (Weston, 1992). No investigations have been reported which specifically address these releases; the only soil analytical results found for this site relate to UST removal and closure testing.

AREE 23 includes the locations of former USTs and existing USTs at former UST areas. Table 1-6 contains a summary of the locations, size, content and history of the USTs which have been removed. Below are descriptions of the UST-related removal actions at WRF based on the nearest building to the UST(s).

One former UST was located at Building 101, the guardhouse, which is located at the main entrance to WRF on Dawson Beach Road as illustrated on Figure 1-1. The tank was of steel construction with steel piping and installed in 1966. The tank had a 1,000 gallon capacity and was used to contain #2 Fuel Oil. The tank failed a leak test in January 1991, and all product was reported promptly removed. The tank was removed in September 1991, with reported concentrations of total petroleum hydrocarbons (TPH) up to 230 ppm in the surrounding soil. Release response and corrective action procedures were followed with additional soil being removed from the excavation and disposed of with approval from the Virginia Solid Waste Management Division. Additional soil analyses detected TPH at concentrations below 100 ppm. No summary report of this action was identified.

Four USTs have been removed and two USTs installed near Building 202 as illustrated on Figure 1-2. Three of the four former USTs were located just east of Building 202 as mentioned above for AREE 8. These three USTs were of steel construction with steel piping and were installed in 1966. Each had a 10,000 gallon capacity with one containing diesel fuel and two containing #2 Fuel Oil. In 1981, the 10,000-gallon diesel fuel tank was removed and replaced with a 2,000-gallon, fiberglass, UST buried just north of the original location of the three 10,000-gallon USTs. The former 10,000-gallon diesel fuel tank at Building 202 was removed because it was leaking; however, no leak testing information was available for this tank. In addition, no closure report was available concerning the removal action. The existing 2,000-gallon diesel fuel tank which was installed to replace this 10,000-gallon tank was most recently leak tested in October 1994 and passed.



WOODBRIDGE/S/1-6, AREEs 8, 11, 12 & 23

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TABLE 1-6
FORMER UNDERGROUND STORAGE TANKS (AREE 23)

Nearest Building	Construction Material	Capacity (gallons)	Contents	Date Installed	Leak Tested	Results	Date Removed
101	Steel	1,000	#2 Fuel Oil	1966	Yes	Failed	1991
202	Steel	10,000	Diesel	Unknown	No	--	1981
202	Steel	10,000	#2 Fuel Oil	1966	Yes	Failed	1990
202	Steel	10,000	#2 Fuel Oil	1966	Yes	Failed	1990
202	Steel	1,000	Gasoline	Unknown	Yes	Failed	1990
203	Steel	2,000	#2 Fuel Oil	1966	No	--	1986 or 1987

Key: AREE = Areas Requiring Environmental Evaluation

The fourth former UST near Building 202 was located just north of the building as shown in Figure 1-2. The tank was of steel construction and installed at an unknown time. The tank had a 1,000 gallon capacity and was used to contain gasoline. In June 1990, this UST was removed and replaced with a 1,000-gallon, fiberglass, UST at the same location. Also installed at the same time as the new UST were two groundwater monitoring wells and spill/overflow protection.

The two former 10,000-gallon #2 Fuel Oil tanks and the former 1,000-gallon gasoline tank located at Building 202 were removed in June 1990 after failing leak tests in November 1989. The soil from the excavation of these USTs was analyzed with reported concentrations of TPH less than 25 ppm. Based on the above information, no further action was taken at these three former USTs. The existing 1,000-gallon gasoline tank which was installed to replace the former gasoline tank was leak tested in October 1994 and passed.

The last former UST was located east of Building 203 just beyond Maple Road as shown on Figure 1-2. The tank was of steel construction with a reported installation date of 1966. The tank had a 2,000 gallon capacity and was used to contain #2 Fuel Oil. The tank was removed in 1986 or 1987 with no record of leak testing or soil analyses at the time of removal.

1.3.10 *AREE 11 - Oil/Water Separator*

AREE 11 is located just north of the paved area north of Building 202 as shown on Figure 1-5. This structure formerly collected surface drainage from the storm sewer system for the paved area along the northern edges of the building. Several uncontrolled releases of petroleum products have occurred on this paved area, and there is a possibility that some portion of these releases eventually made it to this separator or beyond. Additionally, recent analyses of the liquid (light non-aqueous phase liquid (LNAPL) and water) and sediment in the separator indicated low concentrations of PCBs from an undetermined source. The oil/water separator was emptied of petroleum-contaminated water on 28 April 1993, and subsequently emptied of sediments and rendered visibly clean on 4 June 1993. In addition, there was no evidence of petroleum contamination seeping into the emptied separator.

1.3.11 *AREE 12 - Drum Storage Area*

AREE 12 is located on the paved area just north of Building 202 as shown on Figure 1-5. Building 202 houses the maintenance facilities as well as the vehicle repair facility for WRF. A wide range of organic and inorganic compounds and products were temporarily stored in drums, unprotected from the weather, on the pavement of this area. There is no record of large, uncontrolled releases of any of the products stored at this AREE. Visual inspection of the area has indicated worn and discolored asphalt at the surface of the site. The paved area is relatively flat, eventually draining to the oil/water separator which is AREE 11. No previous investigations have been conducted at this site.

1.3.12 *AREE 13 - Acid Neutralization Tank*

AREE 13 is a 1,000-gallon concrete underground acid neutralization tank located just west of Building 211 as shown on Figure 1-6. This location is adjacent to a battery room within the building. The tank was installed at the time of Building 211 construction in 1979. The purpose of the tank is to contain any spills that may originate in this battery room. The battery room is used for storage and charging of small lead/acid batteries. The room has a concrete floor and a safety shower. Spills or shower water drain to the tank via a floor drain. The tank has an overflow to the sanitary sewer but is large enough to contain expected spills. There is anecdotal information that while the tank does not currently contain neutralizing chemicals, twice a year an outside contractor added a neutralizing chemical to the contents of the tank and flushed the tank with water. There have been no significant spills reported in the battery room (Weston, 1992). No previous investigations have been conducted at this site.

1.3.13 *AREE 14 - Oil/Water Separator*

AREE 14 consists of the oil/water separator north of Building 211 as shown on Figure 1-6. The separator receives drainage from the work areas inside Building 211 and discharges to the grassy area to the east of the fenced compound. Based on the Preliminary Assessment, there have been no spills reported from the work areas inside Building 211, and no significant amounts of hazardous liquids are believed to have been handled there (Weston, 1992). No previous investigations have been conducted at this site.

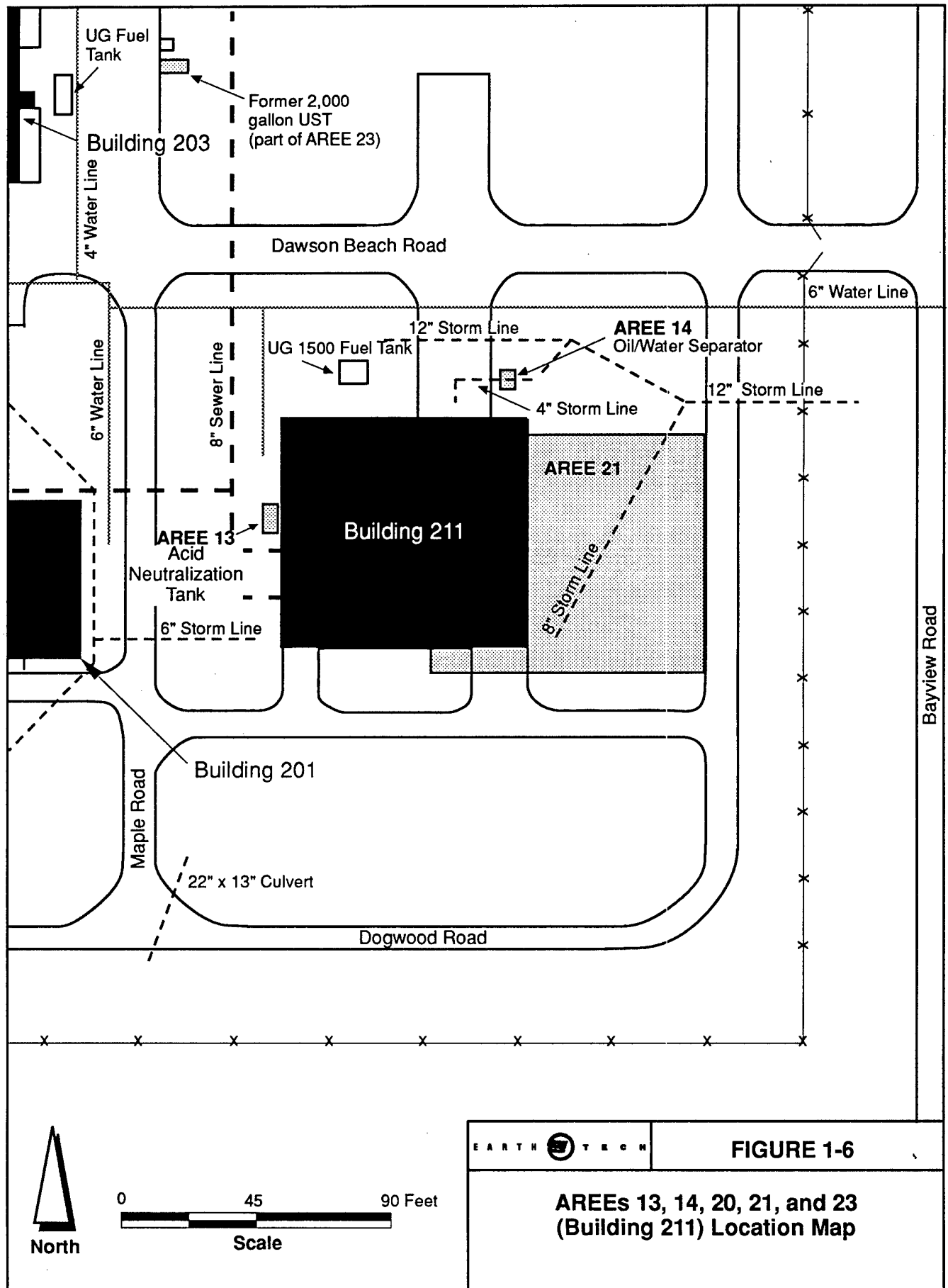
1.3.14 *AREEs 18/19 - Flammable/Battery Storage (Building 204)/Thermal Battery Storage*

AREEs 18 and 19 are illustrated on Figure 1-7. AREE 18 is Building 204 which is a small, two-room, concrete-floored structure used to store flammable materials in one room and vehicle batteries in the second room. The flammable storage room has a concrete floor with no drain and no curb at the door. The battery room has a concrete floor with a safety shower and drain in one corner. The shower does not have a curb which potentially could allow any acid spillage to flow into the drain. The discharge point of the drain is unknown.

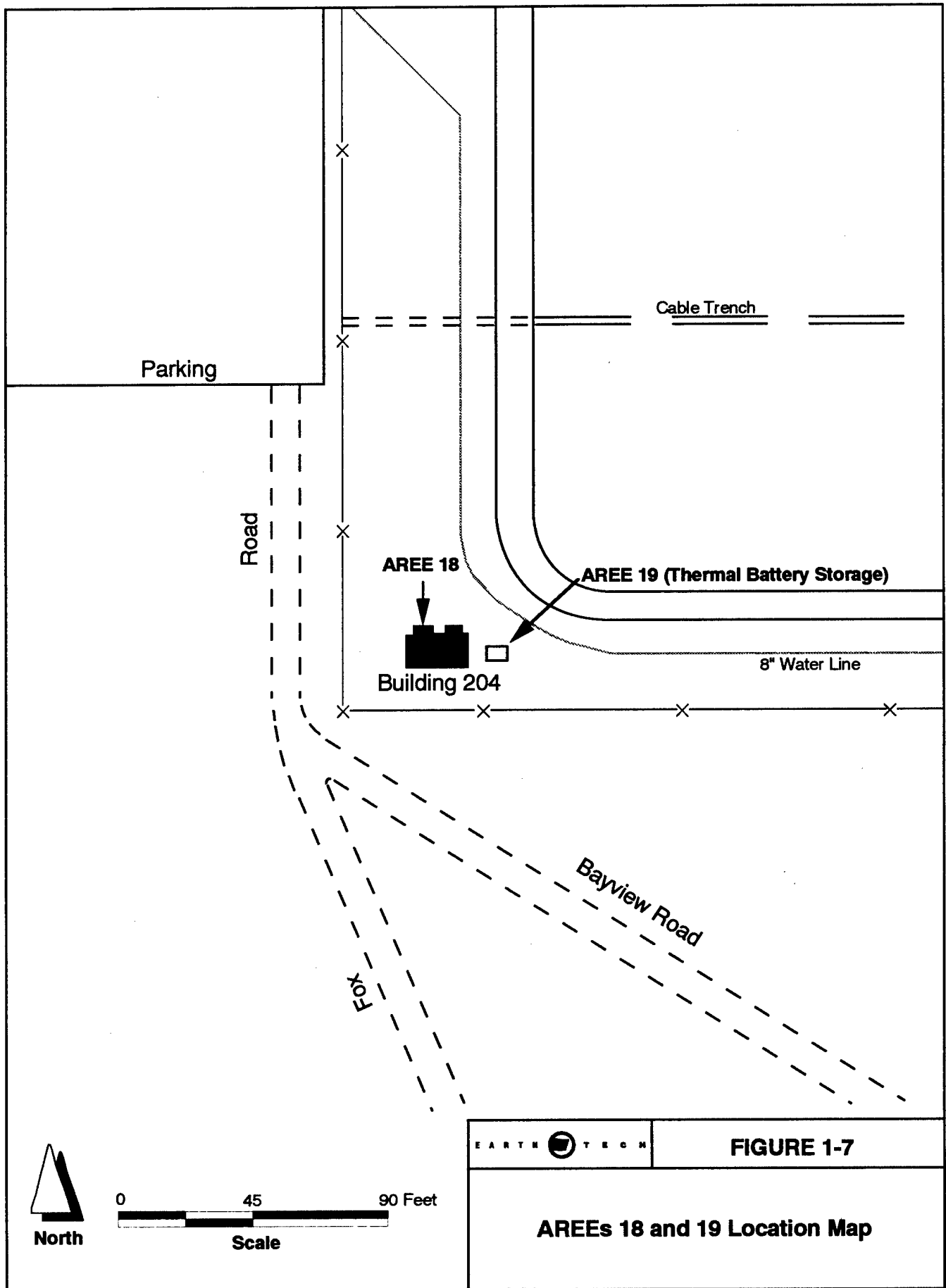
AREE 19 is the grassy area located along the eastern side of Building 204. The area was used to store two metal transport containers (i.e., CONEXs) containing thermal batteries. Thermal batteries were used to activate fuse components such as missiles and mortars. The batteries were hermetically sealed in metal cans and no evidence of leakage was detected during the Preliminary Assessment (Weston, 1992). The batteries typically contain an electrolyte of lithium chloride and potassium chloride, a cathode of calcium chromate or potassium chromate, and an anode of solid calcium. The batteries also contain a pyrotechnic heat source consisting of powdered zirconium and an ignitor such as a heated wire or a percussion primer. In addition, the batteries

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WOODBIDGE/S/I-6 AREEs 13, 14, 20, 21 & 23



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contain asbestos as an insulating material. The thermal batteries and metal storage containers were removed from the facility in March 1993. No previous investigations have been conducted at Building 204 or the surrounding area.

1.3.15 *AREE 20 - Former Incinerator*

A small incinerator (approximately 8 feet by 5 feet by 6 feet high) was located in the south area of the fenced compound. An approximate location of the incinerator is shown on Figure 1-2. The incinerator was used for burning classified documents from the 1950s until 1970 and was removed in 1972. The unit was mounted on a concrete base and consisted of an asbestos lining between inner and outer metal walls, a dust collector in the smoke stack to prevent release of ash out the stack, and a 100-gallon aboveground tank for heating oil, which was used as a fire starter. The incinerator was used frequently, sometimes daily. The ash was shoveled into drums and was disposed of at one of the on-site former dumps. When the incinerator was dismantled, it was disposed of in Former Dump No. 1 (Weston, 1992). No previous investigations have been performed for this site.

1.3.16 *AREE 21 - Former Storage Area*

AREE 21 is an area to the east of Building 211 which was used as a storage yard before Building 211 was built. This area is illustrated on Figure 1-6. Transformers and capacitors containing PCBs were stored in the area prior to disposal (Weston, 1992). No previous investigations have been conducted at this site.

1.3.17 *AREE 22 - Drainage Ditch*

A drainage ditch, shown in Figure 1-1, that enters WRF along the northern boundary and flows along the north and east sides of the inner fenced compound may have received contamination from the wash rack, the oil/water separators, various oil spills, and run-on from off-site properties to the north. Aerial photographs revealed possible stains and wet soil in the vicinity of the ditch during the 1960s, and tires and other debris were observed during the Preliminary Assessment. In March 1994, VADEQ collected several sediment samples from the ditch for PCB analysis. The results of this sampling are shown in Table 1-7. The sample locations are shown on Figure 1-8.

1.3.18 *AREE 25 - Sewage Injection Area*

In 1974, sanitary sewer sludge was injected into the ground throughout the northern part of the facility as shown on Figure 1-1. This practice was stopped after complaints from neighbors. The sludge was obtained from the Occoquan Sanitary District near Woodbridge and the Blue Plains sanitary treatment plant in Washington, D.C. Approximately 20,000 gallons per day (gpd) was injected to a depth of 18 inches over a 4-month period. Analyses of the sludge were not obtained, but only municipal sanitary sewage was processed at these plants (Weston, 1992). No previous investigations have been performed for this site.

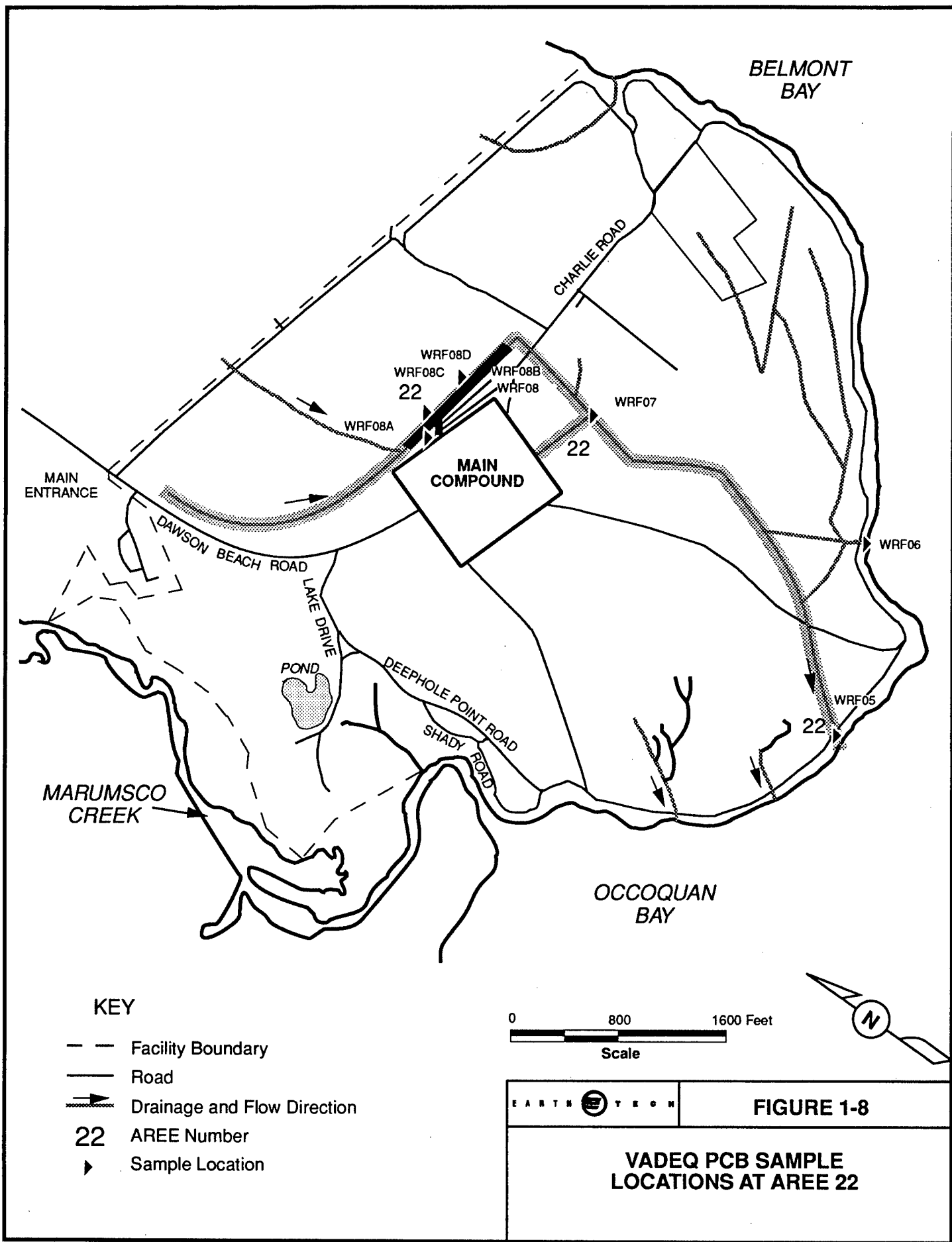
TABLE 1-7
SUMMARY OF AREE 22 SEDIMENT AND STORMWATER RUNOFF FROM
VADEQ DATA

Sample	Contaminant	Minimum Detection Level	Concentration	Units
STORMWATER				
WRF05	PCB-1260	1.0	ND	µg/L
WRF06	PCB-1260	1.0	ND	µg/L
WRF07	PCB-1260	1.0	ND	µg/L
WRF08	PCB-1260	1.00	1.50	µg/L

Sample	Contaminant	Minimum Detection Level	Concentration	Units
SEDIMENT				
WRF08A	PCB-1260	3,200	96,000	µg/kg
WRF08B	PCB-1260	3,200	100,000	µg/kg
WRF08C	PCB-1260	3,200	4,800	µg/kg
WRF08D	PCB-1260	3,200	7,600	µg/kg

Key: AREE = Areas Requiring Environmental Evaluation
VADEQ = Virginia Department of Environmental Quality
PCB = Polychlorinated Biphenyl
µg/L = Micrograms per liter
µg/kg = Micrograms per kilogram

Source: VADEQ's Bioaccumulation Initiative in Virginia's Coastal Zone Management Plan, March 31, 1994.



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1.3.19 *AREE 26 - Buried Antifreeze Pipes*

Antifreeze in rubber hoses was buried in the ground south of Building 306 as a test of a personnel intrusion and detection system. The antifreeze, which consisted mainly of ethylene glycol, was put in neoprene rubber hoses, which were cut to length, plugged at one end, filled with fluid, and sealed at the other end. The tubes were then buried at a depth of 1 foot to 3 feet. The tubes were placed from 6 to 20 feet apart in a random pattern over a square area approximately 2,000 feet on a side. The neoprene rubber hose varied from $\frac{3}{4}$ inch to 2 inches in diameter. The hose is uncovered from time to time during excavations in the area. When it is uncovered, it generally still contains antifreeze, which usually leaks from the hose into the ground during the excavation process. Most of the hose is still in the ground in the area shown on Figure 1-1 (Weston, 1992). No previous investigations have been performed for this site.

1.3.20 *AREE 27 - Buried Wire in Test Areas*

In the early 1950s, electrical cable was buried throughout the facility as part of an antenna system for a worldwide communication system. The antenna system was used until 1970. Subsequent tests have used buried cable to a lesser extent. The cable consists of a copper wire surrounded by a metal shield that contains copper, aluminum, or stainless steel, which is encased in a plastic outer coating. A limited amount of cable may have had a shield that contains lead and some of the cable could contain PCB-impregnated insulation material. Some of the cable has been dug up since 1970 during excavations, but most remains in the ground. Pieces of the cable are visible on the surface throughout the facility (Weston, 1992). No previous investigations have been performed for this site.

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SECTION 2.0

FACILITY BACKGROUND

This section describes the facility, including a discussion of the location and history of the property, and provides brief summaries of the surrounding demography, land use, and physical setting at the WRF.

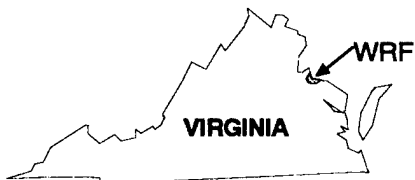
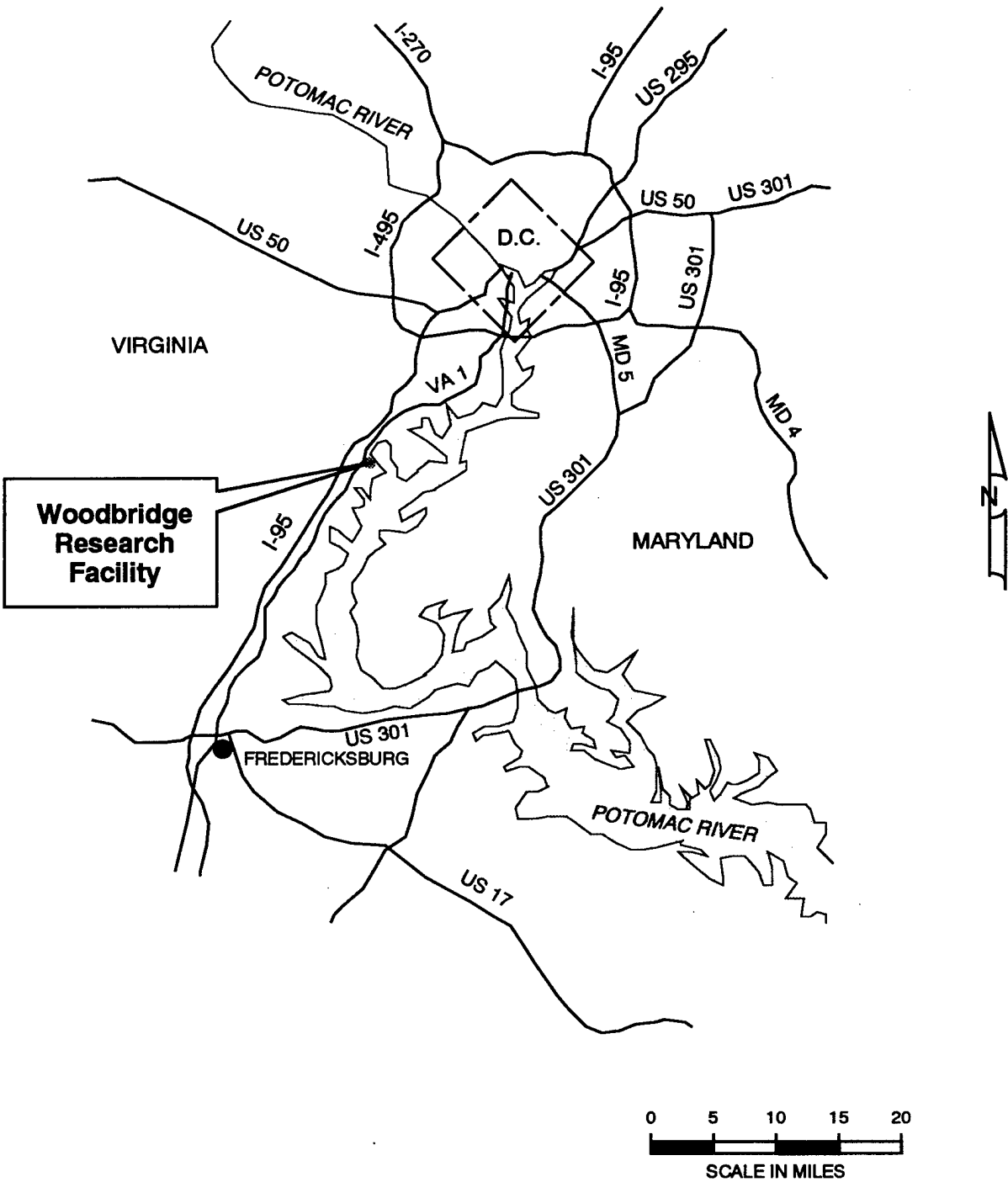
2.1 FACILITY DESCRIPTION AND HISTORY

WRF occupies approximately 579 acres of land in the town of Woodbridge in the easternmost portion of Prince William County, Virginia. The facility is located 22 miles southwest of Washington, D.C., as shown in Figure 2-1. Occoquan and Belmont Bays border WRF on the south and east respectively. Marumsco Creek, which is part of Marumsco National Wildlife Refuge, bounds the facility on the west side. The entrance to WRF is located on Dawson Beach Road, east of U.S. Route 1 in Woodbridge. Residential, commercial, and industrial areas are located north of the WRF. A facility location map is provided as Figure 2-2.

Historical records of the property which comprises the present-day WRF date back to the late 17th century when Martin Scarlet purchased approximately 700 acres (including the WRF site) from Captain Edward Streater. The land (referred to as Deep Hole Point) was used primarily for tobacco farming for nearly a century. In 1765 the land was transferred to Colonel John Taylor in whose name the property remained until the Civil War. During the Civil War, Confederate artillery batteries were constructed in the vicinity of the WRF. When the war ended, the WRF land returned to farming, and farm residences and outbuildings were present on the site. Fishing ports were also located along the southern shoreline. In 1908, J. Lindsay Dawson purchased the farmland for raising cattle. Cattle raising and commercial fishing ended in 1951 when the Army acquired title to approximately 648 acres of land for use as a military radio station.

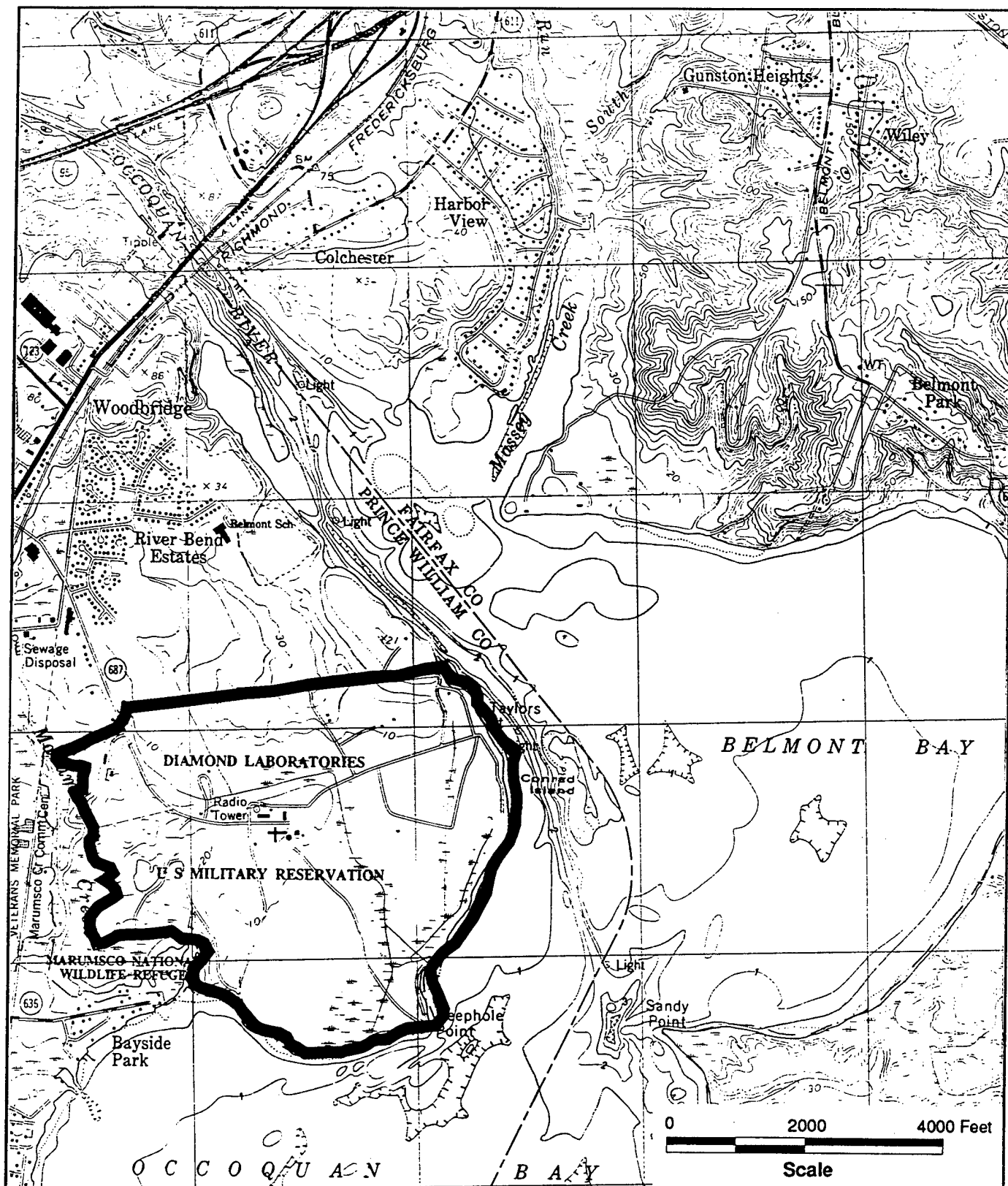
In 1952 the property was assigned to the U.S. Army Command and Administrative Communications Agency and designated the Army Transmitting Station. In 1962 the Station was reassigned to the U.S. Army Continental United States (CONUS) Regional Communications Command and redesignated the East Coast Radio Transmitting Station. In 1965, the Station was placed under the U.S. Army Strategic Communications Command, CONUS. The Station became inactive in July 1969. One year later, in July 1970, the U.S. Army Materiel Command (USAMC) acquired 642 acres of the site. The U.S. Army Mobility Equipment Research and Development Center (MERDC) administered the station. Concurrently, 7 acres reserved for housing were transferred to Fort Belvoir which is located approximately 6 miles northeast of

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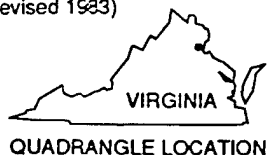


EARTH  TECH	FIGURE 2-1
LOCATION MAP WOODBIDGE RESEARCH FACILITY WOODBIDGE, VIRGINIA	

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SOURCE: USGS Fort Belvoir 7.5' Quadrangle, Virginia
(1965, photorevised 1993)



U.S. GOVERNMENT PRINTING OFFICE

FIGURE 2-2

WOODBIDGE RESEARCH
FACILITY
LOCATION MAP

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the WRF. In 1971 a consolidation of USAMC nuclear weapons effects research and test activities resulted in the transfer of 642 acres of the land to Harry Diamond Laboratories of Adelphi, Maryland. The site was designated the WRF, and in August 1973, 63 acres of the installation in the vicinity of Marumsco Creek were transferred to the U.S. Department of the Interior for use as a park and wildlife refuge (Marumsco National Wildlife Refuge) and the Electromagnetic Effects Laboratory was physically relocated from Fort Belvoir to WRF.

In 1991 the Defense Base Closure and Realignment Commission recommended realignment of the Army activities being conducted at WRF. Activities from the WRF have been relocated to White Sands, Aberdeen Proving Ground, Adelphi Laboratory Center, and Fort Belvoir. The mission of the facility was to support Army Research Laboratory in investigating nuclear weapons effects and army systems survivability. Scientists, engineers, and technical and administrative personnel were employed at WRF. The facility has studied the effects of electromagnetic pulses generated by exo-atmospheric nuclear weapons detonation on communications and other military systems. Testing activities were simulated utilizing on-site electromagnetic pulsers. The WRF closed as an active Army facility as of 16 September 1994.

2.2 SURROUNDING DEMOGRAPHY AND LAND USE

The population in Prince William County is 219,033 according to a 1991 estimate. The town of Woodbridge has a population of 30,860 (1991 estimate). U.S. Census Bureau Tract No. 9001.00, which encompasses WRF and the land immediately adjacent to the facility, contains an estimated 1,216 residents (1991). This tract is generally bounded by the RF&P railroad tracks on the west.

Until the construction of the WRF, the primary land use on the facility, especially the northern half was farming. Farm residences and outbuildings were present on the facility, and the land on this portion of the facility was probably plowed.

Generally, the land immediately adjacent to WRF is zoned either residential or heavy industrial to the north and residential or agricultural to the west and southwest around Marumsco Creek. More specifically, to the north of the facility and east of Dawson Beach Road lies residential property zoned either R-10 (Suburban Residential), R-T (Residential Townhouse), or RM-1 (Residential Multi-family). However, a large plot at the end of Taylor's Point Road, believed to be a private residence, is zoned M-1 (Heavy industrial use) according to the 1988 Prince Williams County Zoning Map.

To the west of Dawson Beach Road lies a heavily industrialized area. In the northwest corner of the facility site are nine military family housing units, administered by the U.S. Army Engineer Center and Fort Belvoir, (USAECFB), Fort Belvoir, Virginia.

To the west, the facility is bounded by Marumsco Creek and the Marumsco National Wildlife Refuge tidal wetlands. West of Marumsco Creek is Veteran's Memorial Park, a recreation area administered by Prince William County.

An outline of the cultural chronology is presented in Table 2-1.

2.3 PHYSICAL SETTING

This section describes the physical setting at the WRF. Provided below are detailed discussions on the following topics: climate, physiography, soils, geology, hydrogeology, and ecology.

2.3.1 Climate

The climate at WRF is influenced by the Chesapeake Bay and the Atlantic Ocean to the east and the Appalachian Mountains to the west. Under Koeppen classifications, the summers are characterized by maritime-tropical winds from the south and southwest, which bring warm, often humid air to the region. High-pressure systems often stagnate over the area, creating occasional air pollution episodes during the summer. Winter is characterized as mild, with dry continental-polar winds from the west and northwest.

The annual mean daily temperature for the area is 57°F. The monthly mean temperatures for the area range from an average high of 90°F in July to an average low of 29°F in January. The recorded high temperature was 106°F in July 1930, and a low of -15°F was recorded in February 1899. The growing season, based on average first and last killing frosts, is from April 15 to October 15 (ESE, 1981).

The average annual precipitation is 38.88 inches. Snowfall averages less than 10 inches per year. The maximum recorded snowfall of 25 inches fell in January 1922 (NRMP, 1991).

The winds are generally out of the south and southwest in the summer months and the west and northwest in the winter months. The average windspeed is 7.1 miles per hour (mph). The prevailing southerly flow associated with the Gulf Stream during the summer months often increases the potential for late afternoon/evening thunderstorms, which provide much of the precipitation during this period (LABCOM, 1989).

2.3.2 Physiography

The WRF lies entirely within the Coastal Plain physiographic province, less than 5 kilometers east of the Piedmont Province. WRF is located on a neck of land on the west side of the Potomac River between Occoquan Bay and Belmont Bay. Approximately 40 percent of WRF's shoreline borders on Belmont Bay, and the remaining 60 percent lies along Occoquan Bay. Marumsco Creek, which bounds the facility on the southwest side, empties into Occoquan Bay. The Occoquan River forms the boundary between Fairfax and Prince William Counties and empties into Belmont Bay on the facility's northeast side.

TABLE 2-1

A SUMMARY OF THE CULTURAL CHRONOLOGY OF THE AREA OF ARMY RESEARCH LABORATORY - WOODBIDGE RESEARCH FACILITY

Tradition	Cultural Unit		General Settlement Patterns	General Subsistence Systems	Kinds of Archeological Remains Representative of Period
	Period or Phase	Date			
American	Commercial	AD 1920 to Present	Rural small farms with large market focus (Washington), becoming more suburban residence related to Washington	Agriculture, tied to regional and national markets; light industry, often service oriented; national government employment	American manufactured goods; plastics; beverage bottles (bottle machine made); cans, crimped seam and seamless; pull tabs, aluminum foil; automobile parts; frame houses; ceramics--whitewares
	Post Civil War/Industrial	AD 1865 to 1920	Small farms with local focus; some small, locally focused industry; surplus traded to regional markets (Washington and Alexandria)	Agriculture; small service industry; overland trade by railroads and highways	Frame structures; rural outbuildings; mills; privies and trash pits on rural sites; ceramics--whitewares
	Pre Civil War/Early Industrial	AD 1820 to 1865	Small farms with local focus; some large farms; tenant farming; use of slaves; reduction in trade; local ports closed (silted up)	Agriculture; small local industry; trade by overland transport on roads	Frame structures/ruins; outbuildings/possible slave quarters; mills; wells, privies, trash pits; tobacco pipes ceramics--pearlware
	Post Revolution	AD 1781 to 1820	Mixed large farms and small farms/tenant farms; some use of slaves; local small industry; small port towns	Agriculture; reduction in tobacco and other exports; local industry; water transport increasingly replaced by over-land transport	Frame structures/foundations; outbuildings/ possible slave quarters; wells, privies, trash pits; tobacco pipes ceramics--pearlware, some creamware, salt-glazed stoneware
	Late Colonial	AD 1700 to 1781	Mixed large and small land-holding; flourishing plantations; tenant farms; some use of slaves, especially on large farms; tobacco as cash crop (trade to England); small trade towns/ports	Agriculture; cash crop of tobacco; small industries for local production and export; water transport	Foundations and house outlines of large and small frame structures; outbuildings; slave quarters, wells, privies, trash pits; tobacco pipes ceramics--salt-glazed stoneware, creamware, gray stoneware
Colonial	Early Colonial/Late Contact	AD 1600 to 1700	European: isolated large land-holdings; tenant farms; very small villages in southern Tidewater region	Agriculture; development of cash crop traded in international market	Farm sites, foundations and house outlines of frame structures; wells, privies, trash pits; tobacco pipes ceramics--lead-glazed red bodied earthenwares, slipwares, tin-glazed earthenwares, stoneware

TABLE 2-1
A SUMMARY OF THE CULTURAL CHRONOLOGY OF THE AREA OF ARMY RESEARCH LABORATORY -
WOODBIDGE RESEARCH FACILITY

Continued

Tradition	Cultural Unit		General Settlement Patterns	General Subsistence Systems	Kinds of Archeological Remains Representative of Period
	Period or Phase	Date			
Colonial (Continued)	Early Colonial/Late Contact (Continued)	AD 1600 to 1700	Aboriginal: major population depletion due to disease; major shifts in population; dislocation, fragmentation European: camps, trading posts, missions	Horticulture, hunting and gathering; trade with Europeans	Triangular and metal points; metal trade goods--axes and kettles; glass beads; European flint
	Discovery and Exploration	AD 1550 to 1600	Aboriginal: shifts in population due to trade; increased nucleation of settlements; increased warfare Larger sites, palisaded in later part; long term settlement/villages in areas near agricultural land and estuary resources; smaller inland sites (hunting?)	Sponsored exploration Horticulture/agriculture, hunting and gathering; trade of furs to international markets; regional trade of European goods	Small sites; metal and glass trade goods; tobacco pipes Triangular points; shell tempered pottery; European trade goods including glass beads, metal items; European flint; palisaded villages
	Late Woodland	AD 1000 to 1550	Camp sites near riverine/marine resources, especially near embayed estuaries of streams and rivers; small upland sites	Hunting and gathering; probably horticulture; shellfish and fish at river/estuary sites	Shell middens; camp sites; small upland sites; ceramics--Popes Creek, Albemarle, Mockley; points - Calvert, Rossville, Claggett, Selby Bay
Woodland	Middle Woodland	500 BC to AD 1000	Camp sites near riverine/marine resources, especially near embayed estuaries of streams and rivers; small upland sites	Hunting and gathering; seasonal resources; shellfish and fish at river/estuary sites	Shell middens; camp sites; small upland sites; ceramics-Marcey Creek, Selden Island, Accokeek-Point-Vernon, corner and side notched variants
	Early Woodland	1000 BC to 500 BC	Larger riverine/marine camp sites, especially at embayed estuaries of streams and rivers; small upland camps	Hunting and gathering; riverine focus--shellfish and fish; gathering includes hickory nuts and acorns	Shell middens; camp sites; smaller upland sites; points broadspear variants, fishtail points; steatite bowls
	Late Archaic (or Transitional)	2500 BC to 1000 BC			

TABLE 2-1
A SUMMARY OF THE CULTURAL CHRONOLOGY OF THE AREA OF ARMY RESEARCH LABORATORY -
WOODBIDGE RESEARCH FACILITY

Tradition	Cultural Unit		General Settlement Patterns	General Subsistence Systems	Kinds of Archeological Remains Representative of Period
	Period or Phase	Date			
Archaic (Continued)	Middle Archaic	6500 BC to 2500 BC	Many widely distributed small sites in most environmental zones; no quarry sites, no emphasis on quality of lithic raw material; many limited activity sites keyed to seasonally available resources	Hunting and gathering; emphasis on gathering/foraging, especially vegetal foods (acorns and nuts important)	Small camp sites; large sites where variety of resources; points - bifurcates (LeCroy, St. Albans, Kanawha), stemmed (Stanly, Morrow Mt., Guilford), side notched (Halifax); ground stone tools
	Early Archaic	8000 BC to 6500 BC	Expansion into more areas than Paleo-Indian, but still large camps near lithic sources; shift to deemphasis of lithic material and emphasis on seasonal resources	Hunting and gathering; shift to more foraging, especially seasonally available resources	Small camp sites; base camps/ large sites near desired resources; points--corner and side notched (Palmer, Kirk et al.)
Paleo-Indian	Late Paleo	7500 BC to 8000 BC	Fewer sites; large sites related to lithic procurement areas; hunting sites	Hunting and gathering	Quarry sites, stone tool manufacturing sites; small hunting sites; points--Dalton, Dalton/Hardaway
	Mid-Paleo	8500 BC to 8000 BC	Few sites; related to lithic procurement; small hunting sites	Hunting and gathering	Quarry sites, stone tool manufacturing sites; small hunting sites; point--Middle Paleo (small fluted point)
	Clovis	9500 BC to 8500 BC	Large camps related to lithic procurement areas; quarry sites at sources of crypto-crystalline rocks; hunting sites	Hunting and gathering; apparent emphasis on hunting technology	Quarry sites, stone tool manufacturing sites; base camps near sources of lithics; small hunting/extraction sites; point-Clovis

Continued

Source: An Archeological Overview and Management Plan for the Harry Diamond Laboratories - Woodbridge Research Facility, Thunderbird Archeological Associates, Incorporated, July 1985.

The southern portion of the WRF is marsh and is underlain by alluvium from Potomac River and Occoquan River terrace deposits. The northern portion of the facility is situated on slightly higher post-Pleistocene Potomac River terrace deposits. Topographic relief on the WRF is slight. Stream erosion is the primary cause of existing topographic relief in the region. The highest elevations on the installation (30 feet above mean sea level (MSL)) are found on a ridge along Marumsco Creek near the western boundary line of the WRF. Approximately two-thirds (387 acres) of the installation lies within the 100-year tidal floodplain (9.5 feet MSL).

2.3.3 Soils

According to the U.S. Department of Agriculture (USDA) Soil Survey for Prince William County issued in August 1989, the general soil association found in the eastern Woodbridge vicinity is the Dumfries-Lunt-Marr soil association. Less abundant units frequently found as part of this soil association are the Featherstone soils at low elevations, inundated by extreme high tides; Marumsco soils on low, nearly level terraces, with a high clay content; Neabsco soils at higher elevations, with a fragipan in the subsoil; Quantico soils, which are clayey, very deep, and well drained; and Codorus and Hatboro soils, moderately well drained to poorly drained soils on floodplains.

The six soil associations presently identified at WRF are described below (Weston, 1992). Figure 2-3 shows the distribution of soils at the WRF.

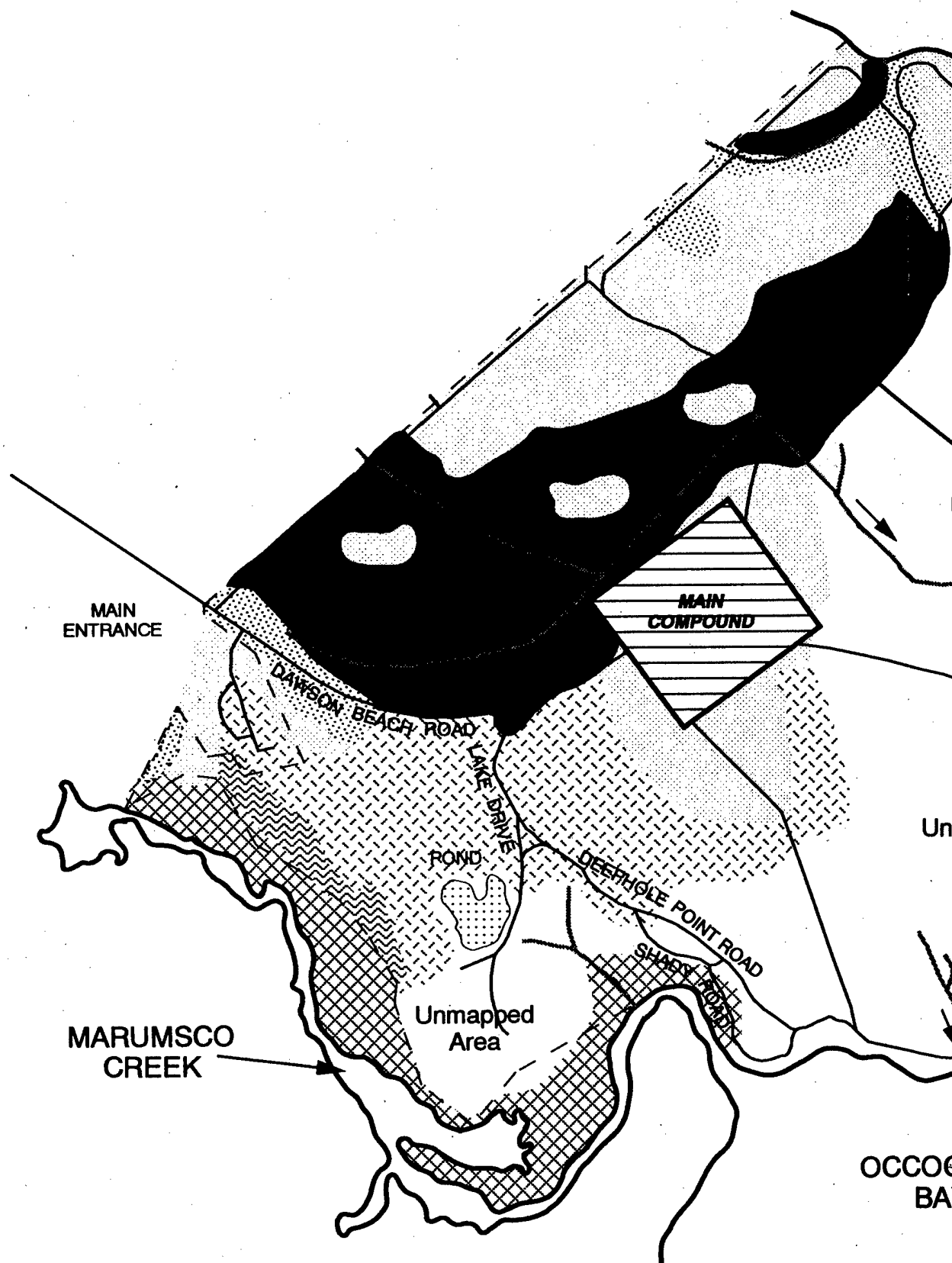
DELANCO SERIES. The soils of the Delanco series are very deep and moderately well drained. They formed in alluvial materials on low river terraces on the Piedmont Plateau. The soils are subject to rare flooding. Slopes range from 0 to 4 percent.

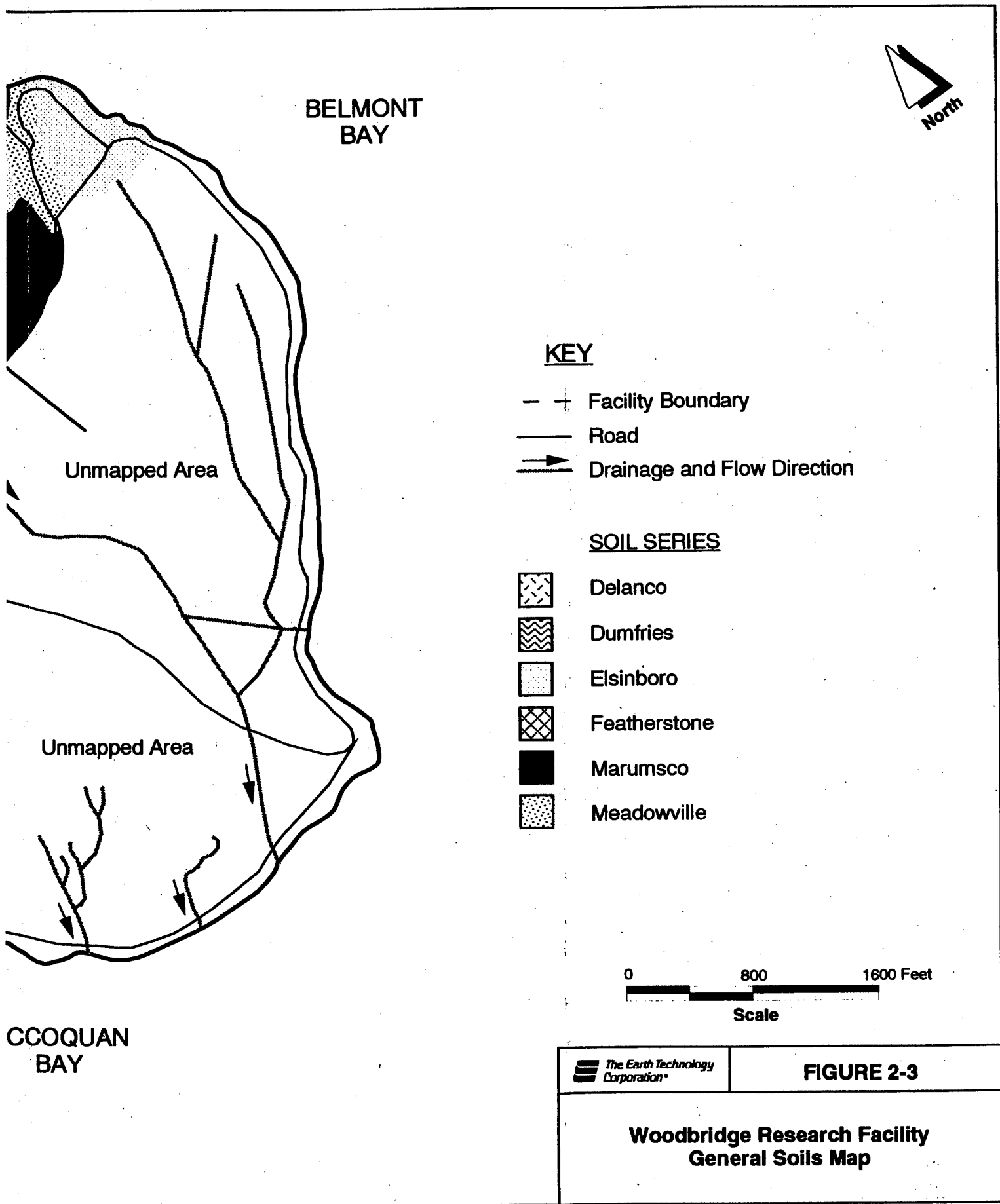
DUMFRIES SERIES. The soils of the Dumfries series are very deep and well drained. They formed in feldspathic sandy sediments of the Coastal Plain. The soils are on narrow ridges and side slopes. Slopes range from 7 to 50 percent.

EL SINBORO SERIES. The soils of the Elsinboro series are very deep and well drained. They formed in sediments dominantly derived from schist, gneiss, and granite of the northern Piedmont Plateau. They are on low stream terraces adjacent to floodplains. Flooding is rare. Slopes range from 2 to 7 percent.

FEATHERSTONE SERIES. The soils of the Featherstone series are very deep and very poorly drained. They formed in Coastal Plain sediments at an elevation of less than 2 feet. The water table is commonly at the surface, and most areas are subject to ponding. Slopes range from 0 to 1 percent.

MARUMSCO SERIES. The soils of the Marumsco series are very deep and moderately well drained to somewhat poorly drained. They formed in stratified marine sediments of the low Coastal Plain terraces. The soils are in depressional areas. Slopes range from 0 to 4 percent.





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MEADOWVILLE SERIES. The soils of the Meadowville series are very deep and well drained to moderately well drained. They formed partly in colluvial materials and partly in materials weathered from muscovite schist and gneiss. They are in depressional areas on toe slopes, along drainage ways, and in saddle positions in the northern part of the Piedmont Plateau. These soils are flooded for very brief periods after heavy rains. Slopes range from 0 to 5 percent.

2.3.4 Geology

The WRF is located within the Coastal Plain Physiographic Province which is comprised of sediments that dip and thicken toward the east to form a wedge. The sediments are principally gravels, sand, and clay of the Cretaceous-age Potomac group. The upper sediments include terrace and alluvial deposits of Pleistocene and Holocene (recent) ages. Underlying the Coastal Plain sediments are undifferentiated Paleozoic meta-sedimentary and meta-igneous rocks. Descriptions of the Potomac Group units as described by the U.S. Geological Survey (USGS) are given below.

2.3.4.1 Surface Geology

The Potomac Group (Lower Cretaceous) includes three different facies, listed below in order of abundance.

- Type 1** Type 1 deposits consist of medium to coarse feldspathic quartz sand, very light gray to pinkish gray in outcrop; fresh material in test borings may be greenish gray; locally oxidized to yellow, orange, and brown. Matrix is clay-silt that may constitute 40 percent or more of the sediment. Crossbedded sand units are generally 0.5 to 4 feet thick; trough crossbedding predominates. Gravelly sands contain pebbles and cobbles of vein quartz and quartzite or, less commonly, other metamorphic rock types. Intraformational conglomerate clasts are pebbles of clay and silt; locally, boulders of clay-silt are as much as 2 or 3 feet in maximum dimension. Type 1 sediments probably represent channel-lag and channel-bar or point-bar deposits.
- Type 2** Type 2 deposits consist of silty clay, clayey silt, and clayey fine sand; greenish gray; commonly mottled red or reddish brown; clay minerals are predominantly montmorillonite and illite; commonly forms clay-silt plugs 2 to 10 feet thick and 60 feet or more wide, within a dominantly medium to coarse sand sequence. Plugs are probably the result of filling of abandoned stream channels by fine sediments during flood stages. Coalified stems of plants, including trunk-size material 1 foot or more in diameter, are common in Types 1 and 2; silicified tree trunks are present but rare.
- Type 3** Type 3 deposits consist of dark yellowish-brown to olive-gray lignitic sandy silt and clay; contains well-preserved leaf and stem impressions

of ferns, cycads, and gymnosperms. Occurrences as thin to thick beds within Type 1 sediment suggest deposition in swampy areas of floodplains.

The Potomac Group thickens from a feather edge along the northwest margin of outcrop in Dale City and Agnewville to about 300 feet in Marumsco Woods area of Woodbridge. Analysis of pollen from the Potomac Group in Fort Belvoir, Occoquan, and Quantico quadrangles indicates a Lower Cretaceous (Aptian and Albian) age (Mixon and Seiders, 1981).

YOUNGER RIVER TERRACE DEPOSITS (PLEISTOCENE). Gravelly and sandy deposits (QT2 and QP2) underlie the lower two terraces of ancestral Potomac and Occoquan Rivers. These deposits occur under terraces in valleys of Pohick Creek and Giles Run graded to the same level as the more extensive Potomac River terraces in adjacent areas and units correlate with Potomac River deposits mapped in the Quantico quadrangle (Mixon *et al.*, 1972).

QT2 deposits consist of loose-crossbedded medium to coarse feldspathic quartz sand, pebbly in part, and massive to thick-bedded clayey and silty sand, commonly pale yellowish gray to reddish gray. Pebbles are mostly quartz, metamorphic rock of various types, and red shale and sandstone. The unit is very poorly exposed within the map area, but representative sections are well exposed in wave-cut cliffs bordering Occoquan Bay.

QP2 deposits consist of sandy gravel and feldspathic quartz sand very similar to QT2 deposits. Basal beds are commonly cobble gravel composed mainly of quartz, quartzite, and lesser amounts of chert and sandstone. These deposits are confined to small hilltop areas near the mouth of the Occoquan River and to the Gunston Heights area of Mason Neck. QP2 is much more extensive east and northeast of the map area in the northern part of Mason Neck, lower Pohick Creek and Accotink Creek drainage basin, and in the vicinity of Fort Belvoir.

ALLUVIUM (HOLOCENE). The alluvium consists of mud, sand, and gravel that form narrow floodplains along minor streams. This includes mud, muddy sand, and peat in swamps and marshes bordering tidal tributaries of the Potomac River and may include some colluvium.

2.3.4.2 Bedrock

As previously mentioned, undifferentiated Paleozoic meta-sedimentary and meta-igneous rocks underlie the Coastal Plain sediments. Well borings performed by the USGS indicate that bedrock depth ranges from approximately 94 to 105 feet below ground surface (bgs) less than one-fourth mile to the northwest of WRF. However, two wells drilled into the lower Potomac aquifer approximately one-half mile away in the central part of the WRF site indicated bedrock at a depth of approximately 150

feet bgs. The bedrock encountered consisted of a gray granite that was present to approximately 175 feet bgs which was the total depth drilled.

2.3.5 Hydrogeology

Surface water features are abundant with groundwater typically occurring near the ground surface over a large portion of the facility. Provided below are descriptions of the surface and subsurface hydrogeology at the WRF.

2.3.5.1 Surface

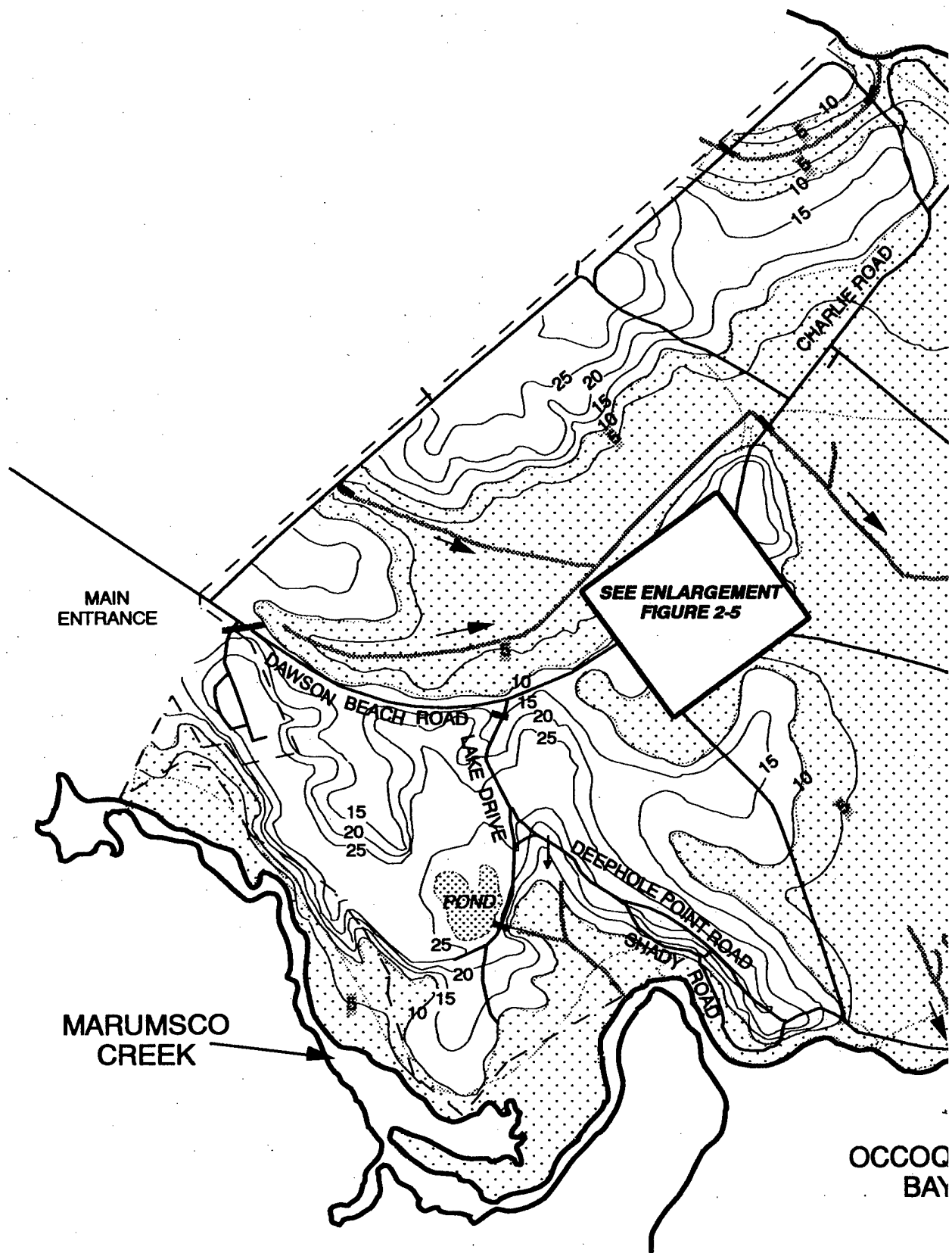
The facility is located in the Occoquan River drainage basin of the Occoquan watershed. Marumsco Creek, which bounds the facility on the southwest side, empties into Occoquan Bay. Occoquan Bay forms the southern boundary of the facility. Belmont Bay, which is on the facility's northeast side, is mainly fed by the Occoquan River. The facility is also bisected by an unnamed creek originating from residential and partly industrialized areas to the north. This creek flows around the main compound and is fed by several smaller drainage lines before eventually feeding to Belmont Bay. Several additional drainage ditches are also found on the property. These waters are tidal tributaries of the Potomac River and are classified by the Commonwealth of Virginia as Class II waters. Figures 2-4 and 2-5 depict the surface water drainage patterns and flow directions found at WRF.

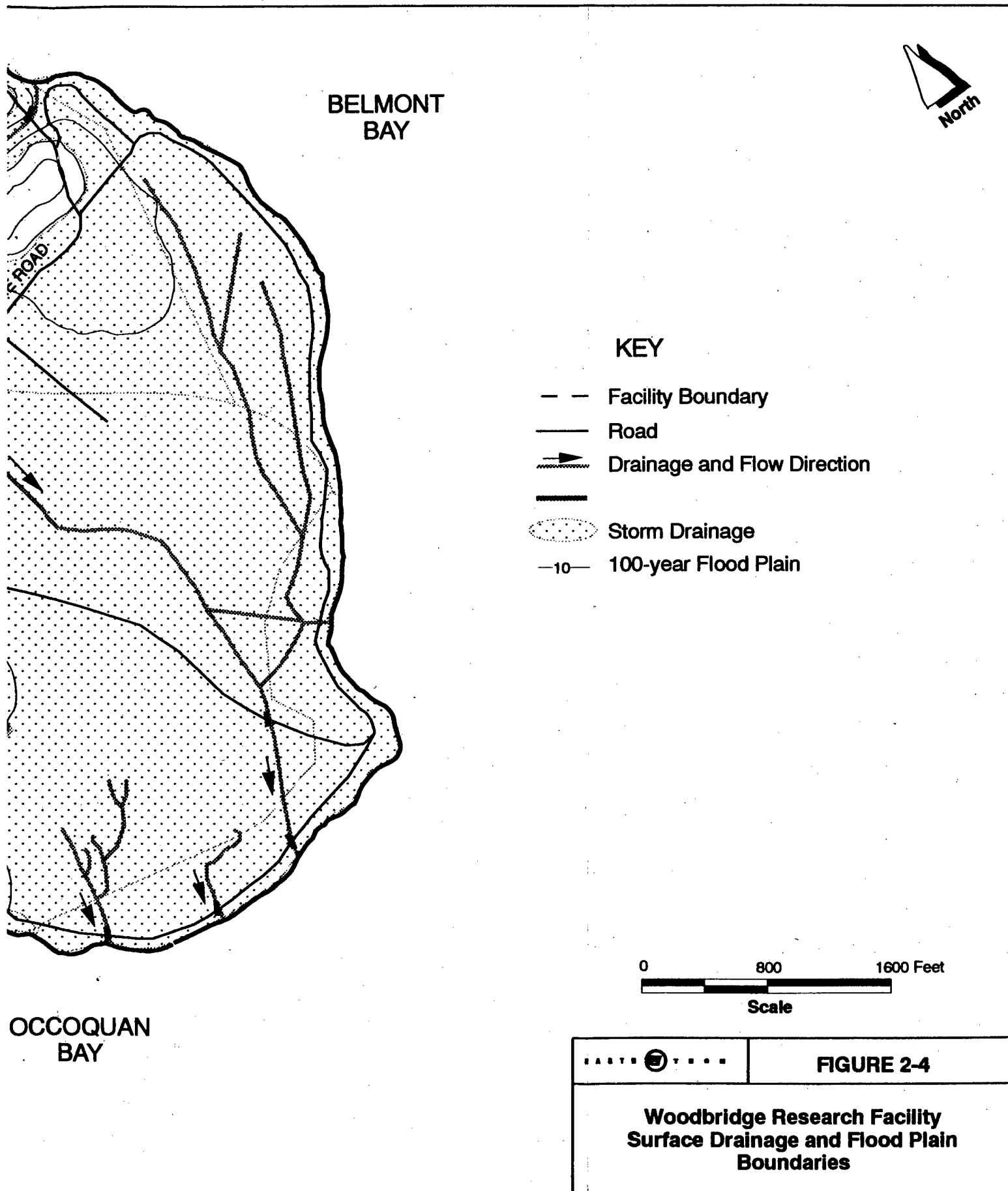
2.3.5.2 Subsurface

The surface of the shallow water table aquifer is rarely flat, usually displaying undulations conforming to the topography. The water table is higher under hills than under valleys. However, the relief of the water table surface is more subdued than the topographic relief. Therefore, the depth to the water table is greater under a hill than under a valley. The groundwater velocity ranges from a few inches per year to a few feet per day. The direction of groundwater flow in the shallow water table aquifer is topographically influenced and generally reflects the surface water drainage patterns depicted on Figure 2-4. The direction of groundwater flow is discussed on a site-specific basis in Section 4.0 of the SI due to the localized nature of the topography and resultant flow direction of the shallow water table aquifer.

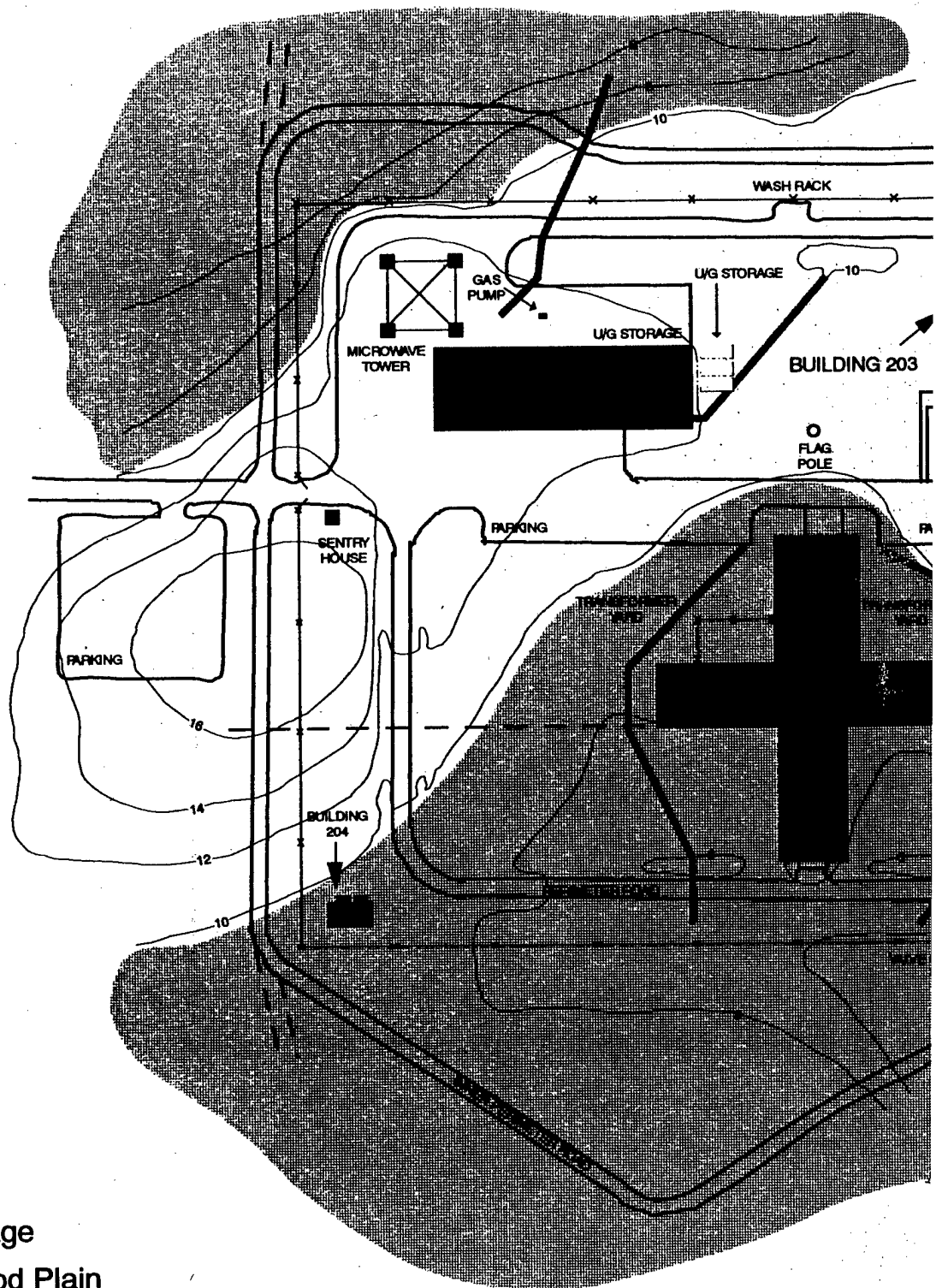
Due to the presence of laterally extensive sand beds, Coastal Plain sediments are good aquifers, although the limited areal extent and relative thinness of the sediments in Prince William County restrict the amount of water that can be developed. Sufficient yields for domestic or light industrial use (up to 50,000 gpd) are generally available at most locations in the Coastal Plain. Well yields averaging 250,000 gpd can be expected in the southeastern portion of the Coastal Plain. The highest water-yielding zones can be expected between 200 and 350 feet below sea level. However, the sand beds comprise a much smaller proportion of the sediments than the clay beds. The average yield for four wells drilled to less than 200 feet in the Coastal Plain is

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KEY

-  Fence
-  Storm Drainage
-  100-year Flood Plain
-  -10- Topographic Contour (ft)

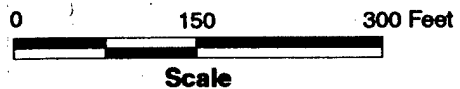
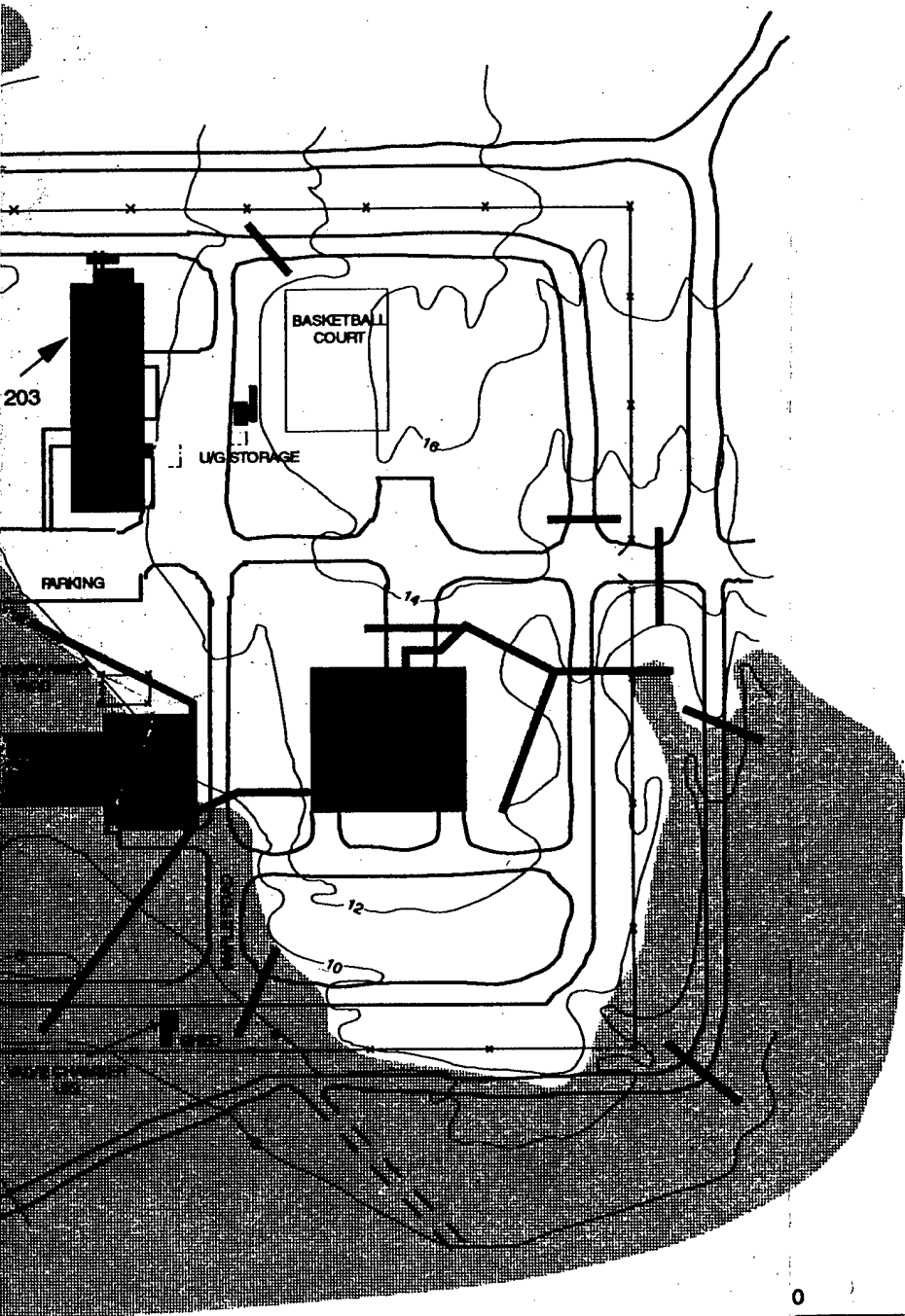


FIGURE 2-5

**Woodbridge Research Facility Surface
Drainage and Flood Plain Boundaries
MAIN COMPOUND MAP**

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101 gpm; for nine wells between 200 and 400 feet, 137 gpm; and for two wells from 400 to 600 feet, 211 gpm.

Groundwater from the Coastal Plain sediments is soft to moderately hard and contains low to moderate amounts of dissolved mineral matter. The water is harder along the western margin of the Coastal Plain near the Fall Line and is softer to the east. The iron content is commonly excessive and the water is acidic to slightly alkaline. Fluoride is often present but not in excessive amounts, and bicarbonate is the most common nonmetal ion. Sulfate, nitrate, and chloride may also be present (VWCB, 1991).

Water service is provided by the Prince William County Service Authority (PWCSA). Prior to obtaining water from the PWCSA the facility's water requirements were supplied by on-site wells. There are two deep wells located 1,400 feet southeast of the main compound. Reportedly, an abandoned in-place 4-inch water line connects Well No. 1 to Well No. 2 with an abandoned in-place 6-inch water line extending from Well No. 2 to the main compound. Well No. 1 is abandoned with no pump. Well No. 2 has an inoperative 30 gpm pump. From the Main Compound, an abandoned in-place 2-inch water line extends to the pond along Lake Drive. There is a potential for the wells to provide water only to the pond. The water is considered to be non-potable due to its recent history of disuse. There is no plan to upgrade the well system or to restore it as the facility's water source (LABCOM, 1989).

Depths to the water table are variable, ranging from at or near land surface in low marshy areas, to within 3 feet of land surface in the topographically flat areas, to an undetermined depth below land surface in the higher, better drained areas.

2.3.6 Ecology

The ecological environments at the WRF are extremely diverse. With a large portion of the facility being classified as wetlands, a great diversity of habitat types exist. Provided below are descriptions of the ecological setting at WRF, consisting of discussions on wetlands, flora, and fauna.

2.3.6.1 Wetlands

Approximately 150 acres of WRF are classified as wetlands on tidally influenced marshes or swamps (NRMP, 1991). The wetlands are diverse and support a wide variety of wildlife. Dominant wetland plants include:

- Broad-leaved Cattails (*Typha latifolia*)
- Pickerelweed (*Pontederia cordata*)
- Wild Rice (*Zizania aquatica*)
- Arrowarum (*Peltandra virginica*)
- Sword Grass (*Scirpus americanus*)
- Red Maple (*Acer rubrum*)

-
- Silver Maple (*Acer saccharinum*)
 - Red Cedar (*Juniperus virginiana*)
 - White Willow (*Salix*)
 - Burr Reed (*Sparganium eurycarpum*)
 - Yellow Pond Lily (*Nuphar variegatum*)

WRF is bordered on the west by Marumsco National Wildlife Refuge, a large wetland system that serves as a feeding and nesting area for many species of waterfowl including herons, black ducks, and wood ducks. The same species occur and perhaps nest at WRF as at Marumsco. From a joint program with the U.S. Fish and Wildlife Service (USFWS) and the Army Research Laboratory, a list has been developed of birds and other wildlife that have been sighted at WRF and Marumsco National Wildlife Refuge.

2.3.6.2 Flora and Fauna

WRF contains a great diversity of habitat types and resultant edge habitats. Habitat types include floodplain and upland forests, tidal marsh, wooded swamp, shrubland, open water, and disturbed habitat (mowed fields). WRF borders Marumsco National Wildlife Refuge, a large palustrine marsh system managed by the USFWS.

A fence around the installation controls immigration and emigration of large species (primarily white-tailed deer). The primary activities affecting populations at WRF are deer hunting, fishing, and pond stocking. Deer hunting had been discontinued for several years, resulting in a large population increase and an unhealthy herd. Hunting has been reinstituted and will be used as necessary to control the population. Following a post- and pre-harvest deer census, the number of hunting days and hunters will be determined. An effort will be made to keep the population at carrying capacity, estimated at 50 to 60 deer.

Other species are limited by food resources and other habitat considerations and by predation, mainly from birds of prey and foxes. According to the Natural Resource Management Plan (NRMP, 1991), largemouth bass, bluegill, gizzard shad, white perch, American eel, and perhaps channel catfish inhabit a two-acre pond at WRF.

Fishing is no longer permitted at the WRF due to concerns about PCB accumulation in the fish. In the past, employees of WRF and their immediate families were permitted to fish the pond as long as they possessed a Virginia fishing license and a WRF fishing permit. Permits and guidelines for the pond were developed in cooperation with the Office of Fishery Assistance and updated annually. Fish populations were monitored and creel limits were set to ensure a balanced population in the pond. The natural fish population in the pond remains relatively stable. Habitat, size of the pond, and food availability are the limiting factors for the fish population.

The Virginia Department of Agriculture and Consumer Services has jurisdiction over listed plant and insect species. The Virginia Department of Game and Inland Fisheries has jurisdiction over all other listed threatened or endangered species at the WRF.

To date, there are no state or Federal listed threatened or endangered plant or insect species known to occur at the WRF. The absence of data does not necessarily mean that no listed species occur in the area, but that the Bureau of Plant Protection and Pesticide Regulation files do not currently contain information to document their presence (Virginia Department of Agriculture and Consumer Services, 1995).

There are no documented occurrences of threatened or endangered animal species at the WRF. One listed species, the Bald Eagle (*Haliaeetus leucocephalus*) utilizes the WRF. Although no nests are known to occur there, eagles frequently perch and feed along the shorelines of the facility; they may also roost there. A major communal Bald Eagle roost is present on Mason Neck, just to the east of the facility and significant movement of eagles occurs between Mason Neck and the Woodbridge facility (USFWS, 1995). A Biological Assessment of Threatened and Endangered Species (BATES) survey conducted at the WRF between October 1991 and May 1992 sighted the Bald Eagle perched in trees on Conrad Island and on the installation in trees along Deephole Point Road. Data provided by USFWS volunteers indicate that these areas are used by juveniles and subadults on a weekly basis throughout the year. The Bald Eagle is listed as threatened on both the Virginia and Federal Lists of Threatened and Endangered Species.

The following state special concern birds are also known from the area; Great Egret (*Casmerodius albus egretta*), Yellow-crowned Night-heron (*Nyctannassa violaceus violaceus*), the Federal candidate, Cerulean Warbler (*Dendroica cerulea*) and the current state endangered and federal candidate, Loggerhead Shrike (*Lanius ludovicianus*) (VDGIF, 1995). As well, there is potential for the occurrence of the state threatened Wood Turtle (*Clemmys insculpta*) to occur at the research facility if habitat conditions are appropriate. Wood turtles are found predominantly near clear brooks and streams in deciduous woodlands, however, it also occurs in woodland bogs and marshy fields.

Information about fish and wildlife species was provided by the USFWS and generated from the VDGIF computerized Fish and Wildlife Information System, which describes animals that are known or may occur in a particular geographic area. "Candidate" species (those placed under review in the Federal Register to determine suitability for listing) are not legally protected under the Endangered Species Act and biological assessment and consultation requirements pursuant to that legislation do not apply to them. Additional information on candidate species may be obtained by contacting the VDGIF at (804) 367-8999 or the Virginia Division of Wetland Heritage at (804) 786-7951.

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SECTION 3.0

SITE INSPECTION ACTIVITIES

This section presents a summary of the activities performed for the SI. The activities are divided into field operations, analytical program, and data management with detailed discussions provided below. Also included in this section is a description of the methodology that will be used to evaluate the requirements for further action at each AREE.

3.1 FIELD OPERATIONS

A summary of SI field activities conducted at WRF is presented in Table 3-1. As previously mentioned, these activities were completed in two segments: the Preliminary SI which was conducted between 10 September 1993 and 8 October 1993; and the SSI which was conducted between 4 April 1994 and 11 August 1994. A chronology of the field activities completed during the SI at WRF is provided in Table 3-2.

3.1.1 Site Reconnaissance, Preparation, and Restoration

In general, site reconnaissance and preparation consisted of coordination with the Facility Manager and other personnel to minimize disruption of ongoing activities. Proposed sampling/drilling locations were reviewed and marked with the assistance of facility personnel prior to actual digging/drilling. Facility maps and facility personnel were consulted to initially obtain approximate locations of underground utilities in the proposed digging/drilling areas.

The Army Research Laboratory, in coordination with USAEC, provided the following assistance.

1. Accumulation points on the facility where drill cuttings, well purge water and decontamination material containers were placed.
2. Existing engineering plans, drawings, diagrams, aerial photographs, etc., to facilitate evaluation of tank or underground utility locations.
3. Personnel identification badges.
4. A secure staging area for storing equipment and supplies.
5. A paved decontamination area with an electrical supply and a potable water supply.

**TABLE 3-1
SUMMARY OF SITE INSPECTION ACTIVITIES**

Activity	AREE 1	AREE 2	AREE 3	AREE 4	AREE 5	AREE 6A	AREE 6B	AREE 7	AREE 8/23	AREE 11	AREE 12
Water Sampling											
Groundwater via Existing Wells	x	x							x		
Groundwater via Direct Push			x	x	x	x	x				
Surface Water		x	x	x	x	x				x	
Other Liquid									x	x	
Sediment/Soil Sampling											
Sediment		x	x	x	x	x				x	
Surface Soil ⁽¹⁾ , (2)									x		
Subsurface Soil via Excavation	x		x	x	x	x		x	x	x	x
Subsurface Soil via Borings							x	x			x
Field Operations											
Geophysics	x		x	x	x	x	x		x	x	x
Excavation	x		x	x	x	x	x	x	x	x	x
Borings							x	x			x
Direct Push			x	x	x	x	x				
Land Surveying	x	x	x	x	x	x	x	x	x	x	x

TABLE 3-1
SUMMARY OF SITE INSPECTION ACTIVITIES

Continued

Activity	AREE 13	AREE 14	AREE 18/19	AREE 20	AREE 21	AREE 22	AREE 25	AREE 26	AREE 27
Water Sampling									
Groundwater via Existing Wells									
Groundwater via Direct Push									
Surface Water		x				x			
Other Liquid		x						x	
Sediment/Soil Sampling									
Sediment		x				x			
Surface Soil ^{(1),(2)}			x	x	x		x		x
Subsurface Soil via Excavation	x	x	x					x	
Subsurface Soil via Borings	x				x				
Field Operations									
Geophysics	x	x	x	x				x	
Excavation	x	x	x	x				x	
Borings	x				x				
Direct Push									
Land Surveying	x	x	x	x	x	x	x	x	

Key: AREE = Area Requiring Environmental Evaluation
 x = Site Inspection Activities

- (1) Surface soil samples consist of those samples collected less than 2 feet below ground surface.
 (2) Includes soil excavated at AREE 20 for visual inspection, and the sampling of the joint material at AREE 18.

TABLE 3-2
CHRONOLOGY OF FIELD ACTIVITIES CONDUCTED DURING THE SITE
INSPECTION AT WOODBRIDGE RESEARCH FACILITY

Date	Activity
September 10, 1993	Mobilized to Woodbridge Research Facility for Preliminary Site Inspection. Set up trailer, unloaded equipment, purchased supplies, etc. Located existing monitoring wells to be sampled.
September 13, 1993 to September 18, 1993	Performed magnetic geophysical surveys at AREEs 6A and 1, and electromagnetic geophysical survey at AREE 1. Performed geophysical utility clearances at AREEs 13 and 14 using magnetometer and ground penetrating radar. Sampled existing monitoring wells at AREEs 1 and 2, and at the UST just north of Building 202. Collected background soil sample and water sample from hydrant used as decontamination water source. Completed surface water and sediment sampling for AREE 2 and AREE 22; surface soil sampling for AREEs 8, 18/19, and 21; surface water, sediment and aqueous sampling for AREEs 11 and 14. Collected 3 of 6 surface soil samples for AREE 27.
September 20, 1993 to September 25, 1993	Performed ground penetrating radar geophysical survey at AREE 6A. Performed magnetic and electromagnetic geophysical surveys at AREEs 3, 4, and 6B. Performed geophysical utility clearances and located former UST trenches at AREEs 11, 12, 18/19, and 23 using magnetometer and ground penetrating radar. Completed excavation and subsurface soil sampling at AREEs 11, 12, 13, 14, 18/19, and 23. Completed surface soil sampling for AREE 27. Collected an aqueous sample from condensate return tank pit in Building 202.
September 27, 1993 to October 2, 1993	Performed ground penetrating radar geophysical survey at AREEs 6B and 26. Performed magnetic and electromagnetic geophysical surveys at AREE 5. Extended magnetic and electromagnetic geophysical surveys for AREEs 3 and 4. Performed magnetic, electromagnetic and ground penetrating radar surveys at AREE 20. Completed excavation and subsurface soil sampling at AREEs 1, 4, 7, 6B, and 20. Began excavation and subsurface soil sampling at AREE 6A. Began sieve/metal detector analyses at AREE 7. Completed groundwater sampling via direct push at AREEs 3, 4, 5, 6A, and 6B. Collected surface soil samples for AREE 25.
October 4, 1993 to October 8, 1993	Completed excavation and subsurface soil sampling at AREEs 3, 5, 6A, and 26. Completed sieve/metal detector analysis at AREE 7. Collected second background soil sample. Completed surveying activities for the majority of points identified. Demobilized from facility. Trailer and all equipment removed from site.
December 12, 1993 to December 15, 1993	Completed all site restoration activities for Preliminary Site Inspection.

TABLE 3-2
CHRONOLOGY OF FIELD ACTIVITIES CONDUCTED DURING THE SITE
INSPECTION AT WOODBRIDGE RESEARCH FACILITY

Continued

Date	Activity
April 4, 1994 to April 11, 1994	Mobilized to Woodbridge Research Facility for Supplemental Site Inspection. Set up trailer, unloaded equipment, purchased supplies, etc. Staked out drilling/sampling locations.
April 18, 1994 to April 20, 1994	Performed utility clearance at soil boring locations. Drilled and sampled soil during drilling at the ten locations utilizing the hollow stem auger technique. Organized drums of drill cuttings, decontamination water, etc. at trailer.
April 21, 1994 to April 22, 1994	Collected soil sample with hand auger at AREE 13. Collected soil samples from ten locations at AREE 25.
April 28, 1994	Collected soil samples from remaining two locations at AREE 25. Collected soil samples with hand auger at two locations for AREE 7.
May 18, 1994	Collected water level measurements from all existing wells.
June 14, 1994	Collected water level measurements from all existing wells. Completed surveying activities for AREE 12.
July 11, 1994 to July 14, 1994	Staked out additional sampling locations.
July 19, 1994 to July 27, 1994	Completed the excavation and sampling activities at AREE 26.
August 9, 1994 to August 10, 1994	Collected soil samples with hand auger at two remaining locations for AREE 7 and the location at AREE 6B. Collected samples of joint material for AREE 18.

Key: AREE = Areas Requiring Environmental Evaluation
 UST = Underground Storage Tank

6. Keys for access to existing monitoring wells at the facility.

Areas were designated for setup of an office trailer, storage of equipment and supplies, decontamination, and storage of solid and liquid wastes generated during the field tasks. Access to electrical utilities was also provided for the office trailer.

Two areas were designated as Equipment Decontamination Areas. Both areas were constructed large enough to accommodate a backhoe and/or drill rig. Decontamination waters, mud, etc., were contained to be within the central sump. Water was periodically pumped from the sump into 55-gallon drums brought onsite for liquid storage. Solid wastes generated from equipment decontamination were also stored in 55-gallon drums.

Emergency equipment (e.g., fire extinguishers, personnel safety equipment, etc.) was kept in plain view in an easily accessible area at each site where work was being conducted. If available, each work crew was equipped with a mobile phone in case assistance was required.

The objective of site restoration is to leave the area of investigation essentially as it was originally. Soil cuttings, all unused materials, and stakes and flagging were removed from each site at the conclusion of work. Minimal disturbance of vegetation, or increases in erosion potential were anticipated and occurred as a result of this effort. Site restoration also included close coordination with WRF personnel to ensure that clean-up operations were in accordance with the overall management of their operations.

3.1.2 Geophysical Surveys

All geophysical activities were supervised by an experienced geophysicist and/or conducted in accordance with the manufacturers' operations manual. Data collection, reduction, and interpretation followed procedures described in Zohdy *et al.* (1974), Benson *et al.* (1984), and USEPA (1987). Equipment calibration procedures are described in Section 3.1.12.2. A detailed log of geophysical activities was maintained during field work.

Several surface geophysical techniques were used to detect buried utilities or other objects at appropriate sites and soil borehole locations. Results were used to locate the drilling sites and areas to excavate to avoid buried hazards and examine buried materials. The survey activities were coordinated with the Army Research Laboratory personnel and USAEC point-of-contact (POC).

The geophysical methods used for these surveys were electromagnetic induction (EMI), ground penetrating radar (GPR), and magnetic profiling. For EMI and magnetic profiling, discrete measurements are taken along traverse lines (profiles) at specific stations. The data collected at each point is then used to develop conductivity and magnetic contour maps under the EMI and magnetic techniques, respectively. With

GPR, measurements are collected along the entire profile producing a continuous cross-section of the subsurface for in-field analysis and data interpretation.

Technique efficiency depends on the targets of interest, site hydrogeology, and interference from surrounding cultural features. Several complementary techniques were used because underground utilities are made of many different materials (ferrous steel, aluminum, polyvinyl chloride (PVC), and ceramic). EMI profiling can detect changes in electrical properties. GPR responds to changes in dielectric properties. Magnetics can detect only ferrous objects. Using a combination of these techniques increases the confidence that buried hazards will either be detected and avoided, or if the desire is to investigate, detected and examined. Geophysical surveys can also be expanded beyond the limits set by the initial grid if the presence of anomalies are detected on the perimeter of the grid.

In EMI profiling, an alternating current in a transmitting coil magnetically induces an electric field in the ground. The amplitude of this field is measured with a receiving coil. The ratio of the received versus transmitted signal is proportional to soil conductivity. This method can detect lateral changes in soil conductivity related to changing soil types, groundwater, or man-made metal objects. EMI data were collected with a Radio Detection RD-600/400 system. Effective penetration depth was about 8 feet.

The GPR method uses the propagation and reflection of radar-frequency waves to locate changing dielectric conditions related to changing soil types and moisture conditions, trench locations, and buried man-made objects (i.e., storage tanks, 55-gallon drums, pipes, etc.). Electromagnetic waves are generated and received by a surface antenna. The received signals are reflected from subsurface dielectric interfaces. Penetration depth is very site-dependent and is greatly reduced by clay and/or shallow water. Data were collected with a Geophysical Survey System, Inc. Model 3 using the 300-Mega Hertz (MHz), and/or 500-MHz antennae depending on the desired penetration and target resolution. Effective penetration depth was usually approximately 10 feet.

In magnetic profiling, two vertically in-line magnetometers measure the vertical gradient of the earth's naturally occurring magnetic field. This field is locally disturbed by the presence of ferrous objects because they act as magnets (large magnetic susceptibility). This method can detect buried man-made steel and iron objects, such as storage tanks and pipelines. Data were collected with Schonstedt GA-72CV and GA-52C gradiometers. Effective penetration depth was about 10 feet. Geophysics results are presented in Appendix L.

3.1.3 Excavation

Excavation was used to locate the extent and depth of contamination at several sites. Trenches or test pits were dug to collect samples representative of the area.

Excavation was completed with a backhoe. The backhoe excavated from a stationary position which was beneficial to prevent cross contamination at a site.

The walls of the excavation were kept as near vertical as safety permitted. When excavating a trench, the width was not greater than the bucket width. The test pit at AREE 7 covered an area of 5 feet by 5 feet by 4 feet deep. At the Main Compound, all exhumed soil was placed on plastic in the event that the excavated soil was contaminated. At the sites outside the Main Compound, the heavy vegetation and variable terrain deterred the use of plastic except at AREE 7. In these cases, the exhumed soil was placed directly beside the excavated trenches. Samples were collected as described in Section 3.1.10.1. All activities were recorded on an Excavation Log Form (Appendix C). Air monitoring with a photoionization detector (PID) (HNU) was conducted continuously in the excavated areas and in the breathing zone. Trenches and test pits were backfilled with the exhumed soils upon completion.

3.1.4 Direct Push Sampling

The direct push method was used to collect groundwater samples for screening sites. The advantages of this method are that samples can be collected quickly (fifteen to twenty per day) and no cuttings are generated.

Prior to the collection of groundwater samples, all sampling equipment was decontaminated by washing with a non-phosphate, non-volatile cleaner and distilled water. A hydraulic probe was used to drive 1.25-inch diameter steel pipe to the prescribed depth (conditions permitting) at each sampling location. The probe was removed and a ½-inch diameter Schedule 40 PVC screen and riser were inserted into the hole created by the probe. The actual depth to groundwater was then measured. Samples of groundwater were collected with a teflon sampling tube or a stainless steel mini-bailer (for volatile organic compounds (VOCs)) lowered through the PVC riser. Water samples were stored in appropriate USEPA-clean amber glass containers as specified by the analysis to be performed. Containers were rinsed three times with sample location water prior to filling. Samples for VOCs were pH adjusted to inhibit microbial breakdown of contaminants. After sample collection the PVC screen and riser were removed and the holes were filled with bentonite.

Direct push is an efficient and cost-effective method for groundwater sampling; however, problems were encountered with the installation and sampling procedures. At AREE 6B, the holes were collapsing approximately 10 feet bgs after the probe was removed and before the PVC screen and riser were inserted into the hole. Several locations experienced problems with groundwater recovery and recharge. Clay clogged the screens at several direct push points blocking the flow of groundwater.

3.1.5 Drilling

This section describes the drilling methods and associated activities used for drilling the soil boreholes for collecting soil samples. Drilling and sampling activities were

supervised by a registered professional engineer. A detailed log of the drilling activities and materials encountered was maintained by the site geologist or engineer. Drilling and sampling methods followed procedures described in the *USATHAMA Geotechnical Requirements for Drilling, Monitor Wells, Data Acquisition, and Reports* (USATHAMA, 1987), the *Resource Conservation and Recovery Act (RCRA) Ground Water Monitoring Technical Enforcement Guidance Document* (USEPA, 1986b), and *A Compendium of Superfund Field Operations Methods* (USEPA, 1987).

The methods used to drill the soil boreholes were hollow stem auger (HSA) with no drilling fluids being utilized or hand auger. HSA involves the use of 5-foot sections of continuous-flight HSAs being forced into the ground while rotating. A special auger bit or cutter head is attached to the leading flight section to cut a hole for the flights to follow. The spiral action of the augers forces the cuttings to the ground surface along the exterior of the augers allowing continuous, undisturbed sampling immediately in advance of the lead auger.

A total of ten boreholes were drilled using the hollow stem technique during the SSI. In addition, six boreholes were drilled using a hand auger at locations where the drill rig could not be operated safely.

Boreholes were sampled continuously to the water table following procedures described in Section 3.1.10.1. Using the HSA technique, a 5.5-inch outside diameter (O.D.) hole was drilled for collection of soil samples to the depth of first groundwater. Drilling was performed to document hydrologic conditions, lithologically log the borehole, and allow collection of subsurface samples for chemical analyses. Drilling was performed from least to most contaminated sites when possible.

Boreholes were grouted after the borehole was logged and samples were collected. The grout slurry consisted of a mixture of Type I Portland cement and powdered sodium bentonite in approximately a 20:1 mixture, respectively, with a maximum of 8 gallons of potable water per 94 pound bag of cement. Grouting was completed after the augers had been removed without the use of a tremie pipe due to the shallow depth of the boreholes.

All soil cuttings generated during drilling were handled as described in Section 3.1.9. All downhole drilling equipment was decontaminated before use at a new drilling location as described in Section 3.1.8. Each borehole was permanently marked, including the boring number, with the location recorded on a project map for each specific site or area.

Drilling records were kept in the daily field logbook for the program and on logs for each borehole. The items included in the daily field logbook are described in Section 3.1.15. Information was also recorded on the field borehole log, as shown in Appendix C, in compliance with the existing USATHAMA (now USAEC) guidance.

Air monitoring was conducted during all drilling activities. A PID was used to monitor concentrations of total VOCs at various locations of the exclusion zone, in the breathing space at worker chest level, and down the borehole immediately below the ground surface. Air monitoring concentrations were recorded in the remarks column on the borehole logs.

3.1.6 Measurement of Potentiometric Water Levels

Water levels were measured in all existing monitoring wells and direct push points prior to sampling. Measurements were recorded as feet below the measuring point elevation (usually top of casing) to the nearest 0.01 foot and referenced to MSL. Measurements were taken prior to any well purging activities. The measurements were taken within as short a time period as practical so that water levels are representative of a given period and minimize the effects of tidal influence on the groundwater level.

The procedures used for measuring water levels were based on procedures described in the *RCRA Ground Water Monitoring Technical Enforcement Guidance Document* (USEPA, 1986b). The air above the well head was monitored to indicate toxic potential for workers. Action levels are listed in the Health and Safety Plan. The air monitoring may also indicate the presence of immiscible layers. There were no immiscible layers detected at any of the existing monitoring wells or direct push points. An electric sounder was used to measure the static water level depth. The sounder was then lowered to the bottom of the well to register the total depth of the well. The stick up (distance from ground to top of casing) was measured at each well with a calibrated tape. The electric sounder was decontaminated before use in each well. Decontamination procedures followed those for the water sampling equipment as described in Section 3.1.8.

3.1.7 Land Surveying

All surveyed points were referenced to standard horizontal and vertical control (third-order survey) by a licensed land surveyor. At least one location was surveyed along each geophysical grid except for utility clearances. For existing monitoring wells, elevations were surveyed at the ground surface adjacent to the well. Elevations of the ground surface were measured to the nearest 0.01 foot and referenced to MSL. The horizontal location of each surveyed point was surveyed to the nearest 0.01 foot. The survey used the same coordinate system as the previous surveys of the facility.

3.1.8 Equipment Decontamination

Decontamination of excavation and/or drilling equipment was performed prior to excavating each trench or test pit and/or each soil borehole. Decontamination information was recorded on a Decontamination Record form. All downhole drilling tools, bits, drill rods, augers, and drill equipment as well as the rig and excavating equipment were steam cleaned with USAEC-approved water prior to arrival on site.

Equipment was steam cleaned with USAEC-approved water prior to and between each trench and/or borehole.

Two decontamination areas were set up for all equipment decontamination. The abandoned wash rack on the Main Compound was converted to a temporary decontamination area to decontaminate the excavating and drilling equipment following use at the Main Compound sites. For decontamination after excavation at sites outside of the Main Compound, a temporary decontamination area was constructed at the intersection of Deephole Point and Shady Roads. Decontamination materials (solids and fluids) were collected and containerized in 55-gallon drums and were disposed in accordance with applicable regulations, following proper chemical characterization and evaluation of disposal options.

All sampling equipment was thoroughly decontaminated prior to use and after every sample was collected to avoid cross contamination. Sampling equipment was decontaminated by scrubbing and rinsing with distilled or USAEC-approved water. USAEC-approved water includes distilled water or water originating from an uncontaminated or untreated source or from a chemical supply company providing it is tested at a USAEC-approved laboratory for all analytes of concern. Sampling equipment was protected from ground surface contamination by being placed on plastic sheeting.

All measuring equipment (tapes, sounders, etc.) and apparatus were also thoroughly decontaminated prior to use and between sampling points to prevent cross contamination. Equipment such as PIDs were wiped clean with a moist towel at the end of each work day. Groundwater meters, such as the conductivity meter, were thoroughly rinsed with distilled water after each use. Discarded materials, including paper towels and decontamination fluids, were placed in 55-gallon drums for disposal in accordance with applicable regulations, following proper chemical characterization and evaluation of disposal options.

3.1.9 Waste Handling

Investigation-derived hazardous waste generated during this effort remained at WRF in a temporary storage area until they were characterized and properly disposed by EARTH TECH. The appropriate USEPA guidance documents, such as "Management of Investigation Derived Wastes During Site Inspection", were used for handling investigation derived waste.

Investigation-derived wastes include:

- 1) Materials identified as hazardous during the field activities
- 2) Cuttings from soil boreholes
- 3) Groundwater from purging prior to sampling monitoring wells
- 4) Decontamination fluids and disposable protective clothing and supplies.

These wastes are usually not hazardous. Based on the sampling results and field instrument readings, cuttings and groundwater can be spread around their holes or poured onto the ground next to the well, respectively.

VIRGINIA REGULATIONS. Because the Commonwealth of Virginia administers an authorized State RCRA program, the Virginia Hazardous Waste Management (VHWM) Regulations will serve as the governing regulations in place of the Federal RCRA regulations contained in the 40 CFR Parts, except for the Land Disposal Rule (LDR) of 51 CFR 40572. The identification and listing of hazardous waste is discussed in Part III of VR 672-10-1. The definition of hazardous waste in Part III of VR 672-10-1 matches the definition in the Federal regulations which defines a hazardous waste as a solid waste which, due to its quantity, concentration, or physical, chemical or infectious characteristics may represent a risk to human health or the environment if improperly managed. Wastes can be hazardous by virtue of listing, or if they are shown to exhibit one or more of the following characteristics: ignitability, corrosivity, reactivity, and toxicity.

- ★ ***Ignitability.*** A material is ignitable if a representative sample of the material has any of the following properties:
 - It is a liquid other than an aqueous solution containing less than 24 percent alcohol by volume and has a closed-cup flash point of less than 60°C (140°F)
 - It is not a liquid and is capable, under standard temperature and pressure, of causing fire through friction, absorption of moisture, or spontaneous chemical changes and, when ignited, burns so vigorously that it creates a hazard
 - It is an ignitable compressed gas
 - It is an oxidizer.
- ★ ***Corrosivity.*** A material is corrosive if a representative sample of the material has any of the following properties:
 - It is aqueous and has a pH less than or equal to 2, or greater than or equal to 12.5
 - It is a liquid that corrodes steel at a rate greater than 6.35 mm (0.25 inches) per year at a test temperature of 55°C (130°F).
- ★ ***Reactivity.*** A material is reactive if a representative sample of the material has any of the following properties:

-
- It is normally unstable and readily undergoes violent change without detonating
 - It forms potentially explosive mixtures with water
 - It reacts violently with water
 - When mixed with water, it generates toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment
 - It is a cyanide- or sulfur-bearing material which, when exposed to pH conditions between 2 and 12.5, can generate toxic gases, vapors or fumes in a quantity sufficient to present a danger to human health or the environment
 - It is capable of detonation or explosive reaction if it is subjected to a strong initiating source, or is heated under confinement
 - It is readily capable of detonation or explosive decomposition or reaction at standard temperature or pressure
 - It is a forbidden explosive or Class A or Class B explosive, as defined in 49 CFR 173.51, 173.53, or 173.88.
- ★ **Toxicity.** Wastes exhibit the toxicity characteristic under RCRA if an extract obtained using the Toxicity Characteristic Leaching Procedure (TCLP) from a representative sample of that waste exceeds the regulatory levels listed in Table 3-3. When the waste contains less than 0.5 percent filterable solids, the waste itself, after filtering as specified in the TCLP procedure, is considered to be the extract.

FEDERAL REGULATIONS. As mentioned previously, Federal Regulations for the LDR apply in the Commonwealth of Virginia. The LDR 51 CFR 40572 (November 7, 1986) limits the concentrations of hazardous constituents in wastes that can be disposed of on land. These limits are based on Best Demonstrated Available Technology (BDAT) for waste treatment and are specific for different industrial waste streams. For example, F006 refers to wastewater treatment sludges, and F007 refers to spent cyanide plating bath solutions. Since, the source of the waste is unknown, the LDR limits cannot be determined. In these cases, the USEPA has ruled that the TCLP limits be used as the disposal limits.

BOREHOLE SOIL CUTTINGS. Soil cuttings were generated in the course of drilling boreholes. Field screening was conducted on soil cuttings to evaluate whether they are contaminated. Screening consisted of monitoring using a PID and visual inspection. All cuttings were placed into 55-gallon drums and temporarily stored at

TABLE 3-3
MAXIMUM CONCENTRATION OF CONTAMINANTS FOR THE TOXICITY
CHARACTERISTICS

USEPA HW No. ¹	Contaminant	Regulatory Level (mg/L)
D004	Arsenic	5.0
D005	Barium	100.0
D018	Benzene	0.5
D006	Cadmium	1.0
D019	Carbon tetrachloride	0.5
D020	Chlordane	0.03
D021	Chlorobenzene	100.0
D022	Chloroform	6.0
D007	Chromium	5.0
D023	o-Cresol	³ 200.0
D024	m-Cresol	³ 200.0
D025	p-Cresol	³ 200.0
D026	Cresol	³ 200.0
D016	2,4-D	10.0
D027	1,4-Dichlorobenzene	7.5
D028	1,2-Dichloroethane	0.5
D029	1,1-Dichloroethylene	0.7
D030	2,4-Dinitrotoluene	² 0.13
D012	Endrin	0.02
D031	Heptachlor (and its epoxide)	0.008
D032	Hexachlorobenzene	² 0.13
D033	Hexachlorobutadiene	0.5
D034	Hexachloroethane	3.0
D008	Lead	5.0
D013	Lindane	0.4
D009	Mercury	0.2
D014	Methoxychlor	10.0
D035	Methyl ethyl ketone	200.0
D036	Nitrobenzene	2.0
D037	Pentachlorophenol	100.0
D038	Pyridine	² 5.0
D010	Selenium	1.0
D011	Silver	5.0
D039	Tetrachloroethylene	0.7
D015	Toxaphene	0.5
D040	Trichloroethylene	0.5
D041	2,4,5-Trichlorophenol	400.0
D042	2,4,6-Trichlorophenol	2.0
D017	2,4,5-TP (Silvex)	1.0
D043	Vinyl chloride	0.2

¹ Hazardous waste number.

² Quantitation limit is greater than the calculated regulatory level. The quantitation limit therefore becomes the regulatory level.

³ If o-, m-, and p-Cresol concentrations cannot be differentiated, the total cresol (D026) concentration is used. The regulatory level of total cresol is 200 mg/L.

Key: mg/L = Milligrams per liter

the drilling site. These containers were periodically moved to the investigation-derived waste storage area where the waste (soil cuttings) were stored prior to sampling and laboratory analyses.

Each drum was labeled identifying the sources of the cuttings in each container and the date of collection. Lids were fastened immediately after filling. The analytical results were compared with regulatory criteria and standards to assess if the cuttings must be classified as hazardous wastes. Because polychlorinated biphenyls (PCBs) were found at site, it was necessary to dispose of at least one drum as hazardous. All of the drums were handled and disposed by ChemWaste. A copy of the manifest is included in Appendix C.

WELL PURGE WATER. Water purged from groundwater monitoring wells prior to sample collection was presumed to be hazardous and was placed in 55-gallon drums. Drums were labeled, sealed, and transported by truck to the previously mentioned temporary storage area. The label describes the contents and the date of collection. One water sample was collected from each drum for chemical analyses at a fixed laboratory. The results of the laboratory analyses were submitted to the H.L. Mooney Wastewater Treatment Plant to assess if the well development/purge water must be classified as hazardous waste. The comparison with the criteria or standards indicated the water was nonhazardous so the water was disposed of via the sanitary sewer to the wastewater treatment plant.

DISPOSABLE PROTECTIVE CLOTHING AND SUPPLIES. A variety of wastes were generated as a result of sampling activities. These wastes include disposable clothing such as Tyveks, rags used to wipe equipment, plastic sheeting, and aluminum foil. All disposable protective clothing and supplies were presumed hazardous and were placed in 55-gallon drums. Drums were labeled, sealed, and transported to the previously mentioned temporary storage area. The label describes the contents and the date of collection.

3.1.10 *Field Sampling Procedures*

Soil, sediment, surface water, and groundwater samples were collected as part of the SI at WRF. The methodologies used in collecting these samples are discussed in the following subsections. A summary of the number of samples analyzed by each method is given in Tables 3-4 and 3-5.

3.1.10.1 Soil and Sediment Sampling

During soil and sediment sampling, all sample containers were filled using the following precautions.

- New gloves were worn at each sample location.
- The sampler did not lay the cap down or touch the inside of the cap.

TABLE 3-4
SUMMARY OF SOIL SAMPLE ANALYSES FOR SI ACTIVITIES

	Samples	Replicates	Trip Blanks	Rinsate Blanks	Total
Analysis					
Soil Moisture (D2216)	154	14	0	0	168
Metals by Inductively Coupled Argon Plasma (JS14)	110	11	0	8	129
Total Petroleum Hydrocarbons (E418.1)	49	3	0	2	54
Volatile Organic Compounds by Purge and Trap (LM33)	35	2	2	2	41
Acid & Base Neutrals (LM30)	34	2	0	2	38
Polychlorinated Biphenyls/Pesticides by Gas Chromatograph (LH19)	69	6	0	5	80
Ethylene Glycol by Gas Chromatograph (SW846 Method 8015)	6	1	0	1	8
pH (SW9045)	2	1	0	0	3

Key: SI = Site Investigation

Note: Surface, subsurface and sediment soil samples are included.

**TABLE 3-5
SUMMARY OF WATER SAMPLE ANALYSES FOR SI ACTIVITIES**

Analysis	Samples	Replicates	Rinsate Blanks	Trip Blanks	Ambient Blanks	Total
Metals by Inductively Coupled Argon Plasma (SS15)	2	0	10	NA	NA	12
Total Petroleum Hydrocarbons (E418.1)	11	1	0	NA	NA	12
Volatile Organic Compounds by Purge and Trap (UM05)	24	2	2	6	5	39
Acid & Base Neutrals (UM06)	4	1	0	NA	NA	5
Polychlorinated Biphenyls/Pesticides (UH21)	23	2	2	NA	NA	27
Ethylene Glycol by Gas Chromatograph (SW846 Method 8015)	2	0	1	NA	NA	3
Mercury (SB07)	2	0	10	NA	NA	12
Cyanide (TY03)	2	0	10	NA	NA	12

Note: Groundwater, surface water, and other liquid samples are included.

Key: NA = Not Applicable
SI = Site Investigation

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- The inside of the bottle did not come in contact with anything other than the sample.
 - After the sample volume was placed into the container, the cap was replaced carefully.
 - Sampling equipment was decontaminated between sample locations.
 - For volatile organic analysis (VOA), the containers were filled in a manner to minimize aeration of the samples so that no headspace existed in the container.

Following the collection of samples, containers were placed in a cooler (4°C), and the sample custody documentation and shipping procedures were completed as discussed in Sections 3.5.2 and 3.5.3 of the Work Plan. Samples were collected in containers that were cleaned according to protocols in Appendix F of the USATHAMA Quality Assurance Plan (QAP) (1990). The laboratory provided the appropriate containers.

SPLIT-SPOON SAMPLING TECHNIQUE. Soil samples were obtained through the hollow stem of the augers with a split-spoon sampler. The split-spoon method used to collect samples was the Standard Penetration Test (ASTM D-1586). This method consists of an 18-inch or 24-inch sampler being driven into the soil by dropping a 140-pound weight (also known as a hammer) a distance of 30 inches. All samples collected for this field effort utilized 24-inch samplers. The number of blows of the hammer needed to drive the sampler 6 inches in penetration was recorded onto the boring logs. Continuous split-spoons were obtained for the entire depth of the borings due to all borings being relatively shallow.

Upon reaching the surface, a PID was used to scan the split-spoon sampler for soil vapors. The use of the PID and visual observations assisted in making a field determination as to the presence of contamination in the subsurface. For soil being sent to the laboratory for chemical analysis, the sampler was opened and the sample extracted, peeled, and bottled in the shortest time possible. Replicates were put in separate sample containers using the same techniques as sample collection. Soils collected for head space analysis were agitated and aerated as little as possible prior to sealing the sample jar. The remaining soil was used for lithologic description according to the Unified Soil Classification System. The description included composition, color, stratification, condition, odors, and organic vapor measurements. Sample data was recorded on the field borehole logs and in the field logbook.

HAND AUGER SAMPLING TECHNIQUE. Soil samples obtained with the hand auger were collected directly from the auger. A stainless-steel hand auger was used to bore to the desired depth while periodically removing and depositing the soil cuttings near the hole but located such that loose material could not be accidentally reintroduced into the hole. The removed soil was used for lithologic description according to the Unified Soil Classification System. The description included composition, color, stratification,

condition, odors, and organic vapor measurements. Data was recorded on the field borehole logs and in the field logbook.

After reaching the desired depth for sampling for chemical analyses, the auger was slowly and carefully removed from the boring and the sample was collected directly from the auger. Soil at both ends of the auger was discarded, and the sample collected using the soil which was not in direct contact with the auger. Soil was transferred from the auger into the appropriate sample container with a stainless-steel spoon in the shortest time possible. Soils collected for head space analysis were agitated and aerated as little as possible prior to sealing the sample jar. Replicates were collected by splitting the samples into different jars. After all samples had been collected, the borehole was backfilled with the cuttings.

SOIL SAMPLING FROM EXCAVATED AREAS. Soil samples including replicates were collected from excavations. Disturbed samples, defined as those collected such that the in-situ physical structure of the soil has been disrupted, were collected from excavated areas. Disturbed samples were collected directly from a backhoe bucket during excavation. After making a cut, the operator set the full bucket in a safe location. Using a clean stainless steel trowel, the first 3 inches of soil were scraped out of the bucket. The sample was collected from the center of the bucket using a trowel or gloved hands. Replicates were collected from the same bucket.

SURFACE SOIL SAMPLING. Surface soil samples, including replicates, were collected. In general, surface soil samples were composite samples, except for the samples to be analyzed for volatile organics. The samples for VOA were agitated and aerated as little as possible prior to sealing the sample jar. Replicates were collected in the same manner as the corresponding sample. Composite samples were collected as follows.

- The sampling location was marked with a stake or flag.
- Soil at locations surrounding the stake, usually two locations 2-3 feet from the stake, was scooped into a stainless steel bowl with a stainless steel trowel. Surface soil samples were taken from the first 6 inches beneath the grass or vegetation.
- The soil was mixed in the bowl to homogenize the sample.
- The soil was distributed to sample jars which were labeled, placed in plastic bags, and stored in a cooler with ice.
- A sample was collected from the staked location for VOA if required by the Work Plan.
- Sample data obtained were recorded on a Soil/Sediment Sampling Record.

SEDIMENT SAMPLING. Sediment samples including replicates were collected by the following procedures to establish a uniform method for the collection of sediment samples.

- Sediment samples were collected at approximately the same location as the associated surface water sample. Surface water samples were obtained first to avoid excess suspended particles from the sediment sampling operations. To avoid the disturbance of the sampling area, sample locations in streams and other waterbodies were approached from the downstream side.
- Sediment sample jars were triple rinsed with the surface water from the sampling location prior to collecting the sediment sample. Sediment at the sample location was scooped into the sample jars using a stainless-steel trowel. If multiple aliquots were required, all aliquots were collected in the same location. Sediment samples for VOA were packed to maximum capacity to reduce headspace. Replicates were collected at the same time and location of the sample and in the same manner.

3.1.10.2 Water Sampling

During water sampling, field personnel used similar precautions as during soil sampling. In addition, water sample containers were rinsed three times with sample location water prior to filling the containers. The number of groundwater samples collected is presented in Table 3-5. The groundwater sampling methods discussed below follow procedures described in the *RCRA Ground Water Monitoring Technical Enforcement Guidance Document* (USEPA, 1986b) and *USATHAMA Geotechnical Requirements for Drilling, Monitor Wells, Data Acquisition, and Reports* (USATHAMA, 1987).

WELL PURGING. Since the water standing in the well may not be representative of site groundwater, it is necessary to purge the well prior to sampling in order to obtain a representative sample. Before purging the well, the static water level and any immiscible layer(s) were measured using an electric sounder. No immiscible layers were detected during the SI at WRF. The depth to the bottom of the well was measured using the weighted sounder.

After the static water level and well depth were measured, a bailer was used to purge the well. All wells were capable of yielding five borehole volumes within 24 hours. After purging the well, the pH and specific conductance of the groundwater were measured. Values of these parameters were recorded on the Groundwater Purge and Sampling Records.

GROUNDWATER SAMPLE WITHDRAWAL. Containers were rinsed three times with sample location water prior to filling. Samples were collected using a Teflon™ or stainless-steel bailer. A stainless-steel cable or Teflon™ - coated wire was used to lower

sampling equipment into the well. Samples were collected by placing the Teflon™ sampling nipple into the top of the bailer and allowing the sample to flow directly into the sample container(s) or by pouring directly into the larger containers. Duplicates were collected immediately after the sample by filling the bailer again or from the same bailer if possible.

Samples for VOA were collected in 40 milliliter (mL) glass bottles allowing no headspace. Headspace was checked by inverting the bottle and tapping the lid to see if any air bubbles were visible in the bottle. Samples collected for inorganic analysis were collected in the same manner as the organics, but were placed in plastic or glass containers filled to the top. Preservatives were added following sample collection. The samples were collected in order of decreasing volatilization as follows:

1. Volatile organics
2. Semivolatile organics
3. Other organics (i.e., PCBs)
4. Inorganics.

GROUNDWATER SAMPLING FROM DIRECT PUSH PROBES. Groundwater samples were collected from direct push locations in a manner similar to the collection of samples from existing wells. A Teflon™ sampling tube was placed down the pipe and groundwater was collected from the bottom of the hole. Samples were poured into bottles, labelled, and placed in a cooler to be sent to the laboratory for analysis.

SURFACE WATER SAMPLING. The following procedures describe how surface water samples were obtained from water bodies (i.e., ditches, marshes, and ponds). Surface water samples were collected after a rain storm to ensure that runoff was sampled.

- All sample containers were triple rinsed with the surface water prior to sample collection. The mouth of the sample container was oriented upstream, while the sampling personnel stood downstream so as not to disturb any sediment that could potentially contaminate the sample. Duplicates were collected immediately after the sample by repeating the procedure.
- All surface water samples were collected before sediment samples to avoid excess suspended particles from the sediment sampling locations.
- Preservatives were added after sample collection. The sample containers were placed in a temperature controlled (4°C) chest immediately after sampling.

3.1.11 Sample Handling

The sample containers, methods of preservation, and holding times are given in Table 3-6. The procedures for sample labeling are discussed below.

Unique field sample identification numbers were designated by a four-part number. For example:

03MW0201

where:	03	=	AREE Number (AREE 3)
	MW	=	Type of Sample Location (Monitoring Well)
	02	=	Sample Location Number (Monitoring Well 2)
	01	=	Sample Number (First Sample from MW02).

The following abbreviations were used for the sample location types:

AQ	=	Aqueous	BH	=	Borehole
DP	=	Direct Push Sample	SW	=	Surface Water
MW	=	Monitoring Well	SE	=	Sediment
SS	=	Surface Soil	EX	=	Excavation

The samples were also labelled with a site type and identification required by the IRDMIS to describe the sampling location. A complete list is given in Section 9.17 of the IRDMIS Data Dictionary (IRDMIS, 1993).

If multiple containers were collected from the same location on one day for different analyses, all containers were labelled with the same sample identification number. After collection and identification, the samples were maintained under chain-of-custody procedures as specified in Section 3.5.3 of the Work Plan (EARTH TECH, 1993).

Quality control samples were labeled sequentially with the sample type preceding the sample number. The abbreviations for sample type are TB for Trip Blanks, RB for Rinsate Blanks, and AB for Ambient Blanks. An example of a field identification number is TB01 (the first trip blank collected during the SI).

3.1.12 Field Measurements

The following sections discuss in detail the field measurements performed during the SI at WRF. Equipment calibration and maintenance are also discussed.

3.1.12.1 Field Parameters

Properties of water and soil were measured during the field activities. Geophysical techniques were used to measure changes in the subsurface electrical conductivity, magnetic, and dielectric properties of the soil. Temperature, specific conductance and

TABLE 3-6
RECOMMENDED SAMPLE CONTAINER, PRESERVATIVE, AND HOLDING TIMES
FOR SELECTED METHODS

Parameter	Container (a)	Volume Required		Preservation (b)		Maximum Holding Times (c)*
		Water (mL)	Soil (g)	Water	Soil	
pH	P	NA	50	NA	None	Analyze immediately
Total Petroleum Hydrocarbons	G	1,000	50	4°C HCl to pH < 2	4°	28 days
Metals	P	NA	50	NA	4°C	6 months
Soil Moisture Content (ASTM D2216)	G	NA	200 (For coarse sands or finer soil)	NA	Airtight Container	30 days
Organochlorine Pesticides/PCBs	G, Teflon™ screw cap	1,000	50	4°C	4°C	7 days until extraction, 40 days after extraction
Volatile Organics	G, Teflon™ lined septum	3 × 40	50	4°C HCl to pH < 2	4°C	14 days (7 days if not pH adjusted)
Semivolatile Organics	G, Teflon™ screw cap	1,000	50	4°C	4°C	7 days until extraction, 40 days after extraction
Mercury	P,G	1,000	200	4°C HNO ₃ to pH < 2	4°C	28 days
Cyanide	P,G	1,000	50	4°C NaOH to pH > 12	4°C	14 days
Ethylene Glycol	G	1,000	50	4°C	4°C	14 days

NOTE: * Extraction holding times are from date of sample collection; analysis times are from date of extraction.
 NA = Not Analyzed as part of the SI.

REFERENCE: This table includes the requirements of the U.S. Environmental Protection Agency, as published in the Code of Federal Regulations, Volume 49, Number 209, 40CFR 136, dated October 26, 1984, page 43260.

- (a) Polyethylene (P) or amber glass (G). Soil samples may be collected in either glass jars or stainless steel liners with both ends sealed with Teflon™ paper and plastic caps.
- (b) Sample preservation should be performed immediately upon sample collection. For composite chemical samples, each aliquot should be preserved at the time of collection. When use of an automatic sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting are completed.
- (c) Samples should be analyzed as soon as possible after collection. The times listed are maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods of time only if permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer time. Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter period if knowledge exists to show this is necessary to maintain sample stability.

pH were measured in the groundwater samples. In wells, the depth to water, volume of water purged, and depth of well were measured. Field parameters and the equipment used for the field measurements are presented in Table 3-7.

3.1.12.2 Equipment Calibration

Proper maintenance, calibration, and operation of each field instrument was the responsibility of the field personnel and the instrument technicians assigned to the project. All instruments and equipment used during the investigation were maintained, calibrated, and operated according to the manufacturers' guidelines and recommendations.

Field equipment was calibrated prior to use in the field as appropriate. The calibration procedures followed standard manufacturers' instructions to ensure that the equipment was functioning within established tolerances and as required by the project. Calibration frequencies are given in Table 3-8. A record of field calibration of analytical instruments was maintained in the calibration logbook by field personnel. All instruments were stored, transported, and handled with care to preserve equipment accuracy.

A brief summary of the calibration procedures for field measurement equipment is provided below.

- **Surface Geophysical Survey Equipment.** The EMI, GPR, and magnetic instruments are calibrated once by the factory and maintained according to manufacturers' specifications. Each instrument has built-in functional tests which were performed daily. Daily verification of the EMI, GPR, and magnetic instruments was performed at an established test site. Since these techniques are used to find buried objects, the tests consisted of locating a known buried object.
- **pH/Conductivity Meter.** Calibration for pH was performed prior to use at the beginning of the day using standard buffer solutions having pH values of 4, 7, and 10. Calibration knobs are used to set the meter to read the value of the standards. The meter was calibrated at the start of the sampling with pH buffers 4 or 10 and 7. The meter was also periodically checked during the sampling period using pH buffer 7. Conductivity was also calibrated for using the same procedure described above with conductivity standards.
- **Photoionization Detector (HNU and Photovac, Microtip).** The HNU Model 101 and Photovac, Microtip Model HL 2000 are initially calibrated at the factory. Additional calibrations were conducted at the beginning of each day of field work using calibration gas. Both instruments were equipped with a 10.2eV lamp and were calibrated using 100 ppm isobutylene in air.

TABLE 3-7
FIELD PARAMETERS AND MEASURING EQUIPMENT

Parameter	Equipment
Soil Electrical Conductivity	Radio Detection RD-600 System
Magnetic Field Variations	Schonstedt GA-52B and GA-52C Gradiometers
Radar Frequency Waves	Geophysical Survey System, Inc. Mode 3 System
Air Monitoring of Total Volatile Organic Compounds in Air	Photoionization Detector (HNU Photovac, Microtip)
Specific Conductance	Conductivity Meter
pH	pH Meter
Depth to Water and Bottom of Well	Electric Tape (Water Level Sounder)
Volume of Discharged Groundwater	Calibrated 5-gallon bucket
Temperature	Digital Thermometer

TABLE 3-8
CALIBRATION FREQUENCY FOR FIELD TEST EQUIPMENT

Equipment	Calibration Frequency
Surface Geophysical Equipment	One-time factory calibration
Photoionization Detector (HNU Photovac, Microtip)	Factory calibration. Field calibration check prior to use at the beginning of day.
pH/Conductivity Meter	Full calibration every 2 months. Field calibration check prior to use at the beginning of day.
Electric Tape (Water Level Sounder)	Every 12 months.
Container for Measuring Water Volume	Lifetime, except visual inspection.
Digital Thermometer	Factory calibration.

- **Digital Thermometer.** A digital thermometer was calibrated by the factory and maintained according to the manufacturer's specifications. Built-in functional tests were performed to validate effectiveness.
- **Electric Tape (Water Level Sounder).** The alarm function was checked by immersion in water. The length of tape was annually checked against a surveyor's steel tape.

3.1.13 Field QA/QC Program

The following section describes the preparation, collection, and use of the field QC samples in the field QC program. Discrepancies with the field QC samples are reported in Section 3.1.14.

TRIP BLANKS. A trip blank is a VOA sample bottle filled by the laboratory with Type II reagent grade water. The trip blank is transported to the sampling site, handled like a sample, and returned to the laboratory with samples submitted for VOA. The trip blank is not to be opened in the field. One trip blank was sent with every shipment of soil and water samples sent for VOA. The trip blanks were analyzed for the same VOCs as the samples.

AMBIENT CONDITIONS BLANKS. Ambient conditions blanks were prepared by pouring Type II reagent grade water into sample containers at the sampling site. These blanks were handled as samples and then sent to the laboratory for analysis. Ambient conditions blanks were collected every day a VOC sampling event for water occurred. Ambient conditions blanks were analyzed for VOCs only.

RINSATE BLANKS. After sampling equipment was decontaminated, rinsate blanks were prepared by pouring Type II reagent grade water through the sampling device (i.e., bailer, collection jar for groundwater sampling of PCBs via direct push) into the sample bottle. The blank was then transported to the laboratory for analysis. One rinsate blank was to be collected every day for every matrix per equipment type. The rinsate blanks were analyzed for the same parameters as the sample(s) taken that day.

DUPLICATES. Field duplicates are defined as two samples collected independently at a single sampling location during a single act of sampling. Duplicate water samples were to be collected at a rate of ten percent of the field samples. The actual numbers were 5 duplicates and 37 samples. Because not all water samples were analyzed by the same analyses, duplicates were taken so that each analysis contained 10 percent (see Table 3-5). The duplicates were collected immediately following sample collection using the same procedures.

REPLICATES. Field replicates were collected from the same locations as soil samples, and sediment samples. Field replicates, which were collected at a rate of ten percent of the total sample number, were collected for soil and sediment samples and analyzed for the same parameters. The actual ratio of soil samples to replicates

collected was 154 to 14, respectively. For sediment samples, the ratio of samples to replicates was 11 to 1.

3.1.14 *Field Nonconformances and Corrective Action*

During the course of the SI program at WRF, it was the responsibility of the Task Manager and sampling team members to see that all procedures were followed as specified and that measurement data met the prescribed acceptance criteria. When procedures were not followed as specified in the Work Plan, prompt action was taken to correct these procedures.

The number of blanks required with a shipment was not always correct. Several shipments with samples for VOC analysis were missing trip blanks due to the field crew running out of trip blanks. Delivery of additional trip blanks took a few days and VOC sampling could not be delayed. Ambient conditions blanks were sent with each of these shipments and contained no detections when analyzed. Additionally, one trip blank was included on the chain of custody but never placed in the cooler. Reminders were given to the field crew to include trip blanks in the cooler at the beginning of the day if VOC sampling was planned.

An incorrect definition of rinsate blanks was followed during the SI field activities resulting in the collection of rinsate blanks only during direct push sampling. Decontamination after each sampling event is documented.

Metals were detected in rinsate blanks RB06, RB07, RB08, RB09, RB10, RB11, RB19, and RB20 as illustrated on Table 3-9. Although several metals were detected in the above rinsate blanks, the metals detected from the environmental samples collected on the same day as the rinsate blanks were below or slightly exceeded naturally occurring levels for metals from the same geographic region.

Acetone was detected in rinsate blanks RB01, RB06, RB18, and trip blanks TB11 and TB13. The acetone detections in the above rinsate and trip blanks slightly exceeded the detection limit as shown in Table 3-9. In addition, the environmental samples collected on the same day as the above rinsate and trip blanks detected acetone slightly above the detection limit. Acetone is a common laboratory contaminant. Chloroform was detected in rinsate sample RB01 but was not detected in environmental samples collected on the same day.

One shipment of groundwater samples sent for VOC analysis did not contain an ambient conditions blank. This shipment did include a trip blank with no detections.

Several of the initial shipments did not contain temperature blanks. When the laboratory notified the field crew that temperature blanks were required, temperature blanks were prepared and sent with all subsequent shipments. Prior to notification, the laboratory reported the condition of the ice and samples rather than the temperature.

TABLE 3-9
FIELD QC SAMPLE DETECTABLE RESULTS ($\mu\text{g/L}$)

Sample	Analyte	Detection Limit	Concentration
RB01	Acetone	10	16
	Chloroform	5.0	5.7
RB06	Aluminum	107	3,420
	Barium	20.0	23.2
	Calcium	500	1,730
	Zinc	13.0	219
	Acetone	10.0	12.0 S
RB07	Thallium	3.00	9.50
	Calcium	500	1,290
	Zinc	13.0	161
RB08	Barium	20.0	30.2
	Calcium	500	1,970
	Zinc	13.0	244
RB09	Calcium	500	1,760
	Zinc	13.0	219
RB10	Calcium	500	2,660
	Zinc	13.0	323
RB11	Barium	20.0	21.2
	Calcium	500	2,840
	Zinc	13.0	374
RB18	Acetone	10.0	12.0 SV
RB19	Barium	20.0	28.2
RB20	Barium	20.0	26.2
	Zinc	13.0	13.2
TB11	Acetone	10.0	11.0 S
TB13	Acetone	10.0	12.0 S

Key: $\mu\text{g/L}$ = Micrograms per liter
 S = Non-target compound analyzed for and detected
 V = Sample was subject to unusual storage/preservation condition

3.1.15 *Recordkeeping*

3.1.15.1 Daily Logs

All information pertinent to the field work was recorded on the appropriate data sheets and/or in a project field logbook which is a waterproof, bound book with consecutively numbered pages. The bottom of each page in the logbook was signed by the person making the entries. Entries in the logbook were made in waterproof ink and included the following items:

- Name and address of field contact (on logbook cover).
- Names and affiliations of personnel on site.
- General description of each day's field activities.
- Documentation of weather conditions during sampling.
- Location of sampling (e.g., AREE number as description).

In addition to the information entered into the logbook, the following data sheets presented in Appendix C were prepared: Borehole Logs, Groundwater Purging and Sampling Sheets, Excavation Logs, Decontamination Records, Soil/Sediment Sampling Records, and Daily Quality Control Reports. Sampling information and observations were recorded on the appropriate form when activities took place. All data sheets and logbook entries were read, verified, and signed by a second individual. Originals of these forms were submitted to USAEC. Chain of custody forms were also completed when sampling occurred and are included in Appendix E.

3.1.15.2 Corrections to Documentation

All original data recorded in field logbooks, on sample labels, or in custody records, as well as other data sheet entries, were written with waterproof ink. If an error was made on the document, a single line was drawn through the error (in such a manner that the original entry can still be read), initialed and dated. The correct information was then entered.

3.1.15.3 Photographs

Photographs were recorded on the excavation logs. The photo log included as Appendix J includes information such as roll and exposure number, AREE number, and trench numbers.

3.2 ANALYTICAL PROGRAM

All samples were sent to Pace, Inc. for analysis. Analytical procedures concerning sample preparation, analysis, and reporting were in accordance with guidelines given in USATHAMA QAP and ER 1110-1-23. Performance demonstrated methods performed and the number of samples analyzed at Pace are given in Tables 3-4 and 3-5. Laboratory SOPs are available in the QA/QC Plan (April 1995).

Certified reporting limits (CRL) are required for all methods prior to sample analysis for USAEC projects in order to evaluate method performance. CRLs are based on all procedures and sample preparations used in the method. Therefore, if any procedures or sample preparations used in the method change, the method must be recertified. Analytical methods and their associated CRLs used at Pace for WRF are included in Appendix M. Analytical results are presented in Appendix H.

The purpose of the laboratory analyses is to identify the types and concentrations of contaminants in soil, sediment, surface water and groundwater. The analytical methods performed on soil and water samples collected during the SI at WRF were chosen based on the site history and the contaminants which have been identified during previous investigations. The contaminants of potential concern include fuels and their degradation products, PCBs, and various metals. Standard analytical methods used for the most sample analyses are approved by USAEC and are similar in scope to USEPA methods. Non-THAMA Approved Methods (NTAMs) were also used when lower detection limits were necessary and for the analysis of ethylene glycol. NTAMs are an IRDMIS acronym for USEPA (or SW846) methods that are not approved under the guidelines in the USATHAMA QAP.

A brief chronology of the lab analyses performed on the samples collected for the SI is presented in Table 3-10. The first samples were sent to Pace on 14 September 1993 and shipped through 10 August 1994. Table 3-10 provides a summary of starting and ending dates by analytical method.

3.2.1 Laboratory Sample Custody

Once samples arrive at the laboratory, all sample log-in, storage, and chain-of-custody documentation is the responsibility of the sample control supervisor. Any laboratory employee in sample control is authorized to sign for incoming samples. The sample control supervisor is responsible for retaining documents of shipment, and verifying data entered into the sample custody records. In addition, the sample control supervisor ensures that sample storage is secure and that samples are maintained at the proper temperature.

3.2.1.1 Sample Handling

Upon receipt in the laboratory the integrity of the shipping container was checked by verifying that the custody seal was not broken. The presence of ice was noted and the temperature measured. The samples were checked for breakage, leakage, and damage, and the contents of the shipping container were verified against the chain-of-custody documentation. Documentation of custody seal integrity, temperature or presence of ice, and sample preservations were made on the sample log-in form. Any problems were documented on the chain-of-custody and the EARTH TECH Analytical Program Manager was contacted immediately. Corrective actions taken due to sample handling are discussed in Section 3.2.7.

TABLE 3-10
CHRONOLOGY OF LABORATORY ANALYSIS

Soil Method	Earliest Analysis Date	Latest Analysis Date
Total Petroleum Hydrocarbons	10/05/93	08/31/94
pH	09/17/93	09/22/93
JS14 (Metals)	09/30/93	09/02/94
LH19 (Polychlorinated Biphenyls/Pesticides)	10/09/93	08/24/94
LM30 (Semi-volatile Organic Compounds)	10/06/93	08/31/94
LM33 (Volatile Organic Compounds)	09/28/93	08/23/94
Ethylene Glycol	08/05/94	08/05/94
Water Method	Earliest Analysis Date	Latest Analysis Date
UH21 (Polychlorinated Biphenyls)	10/02/93	08/28/94
UM05 (Volatile Organic Compounds)	09/23/93	08/04/94
UM06 (Semi-volatile Organic Compounds)	10/01/93	08/17/94
SS15 (Metals)	08/12/94	08/12/94
Total Petroleum Hydrocarbons	08/03/94	08/03/94
Ethylene Glycol	05/19/94	08/06/94

3.2.1.2 Sample Identification

Each sample was assigned a six-character identification code to label each sample in the USAEC database system (IRDMIS).

The first three characters of this code are alpha and represent the analytical lot code assigned by the lab and USAEC. Each analytical lot has a different set of alpha characters. For example a set of groundwater samples for metals analysis by inductively coupled plasma (ICP) would be designated AAA, while groundwater samples for organic gas chromatography/mass spectrometry (GC/MS) analysis would be designated BBB (multi-analyte methods, such as GC/MS, will have the same alpha designator for each analyte in a single sample). A fourth character can be added if all combinations have been used.

The second half of the six-character code consists of numeric characters that represent the individual samples within the lot (i.e., the third groundwater sample for metals analysis by ICP would be labeled as AAA003). Total lot size is determined and approved by the USAEC when the analytical method is approved.

3.2.1.3 Sample Custody Records

All samples were sent to the laboratory with a chain-of-custody record (Appendix E). A laboratory chain-of-custody was used to track the samples within the laboratory. All chain-of-custody records were filed permanently with the analytical data.

3.2.2 Laboratory Calibration

Prior to sample analysis, chemical calibration of each target analyte was performed to ensure analytical instrumentation was functioning properly within the established sensitivity range. Protocols defining the procedures and QC measurements for instrument calibration were in accordance with criteria specified in the 1990 USATHAMA QAP and the individual performance demonstrated methods.

Initial calibrations for the methods to be used in this project were performed routinely by Pace as part of the certified analytical protocol. New initial calibrations are not required unless the instrument fails the daily calibration test procedure. The initial calibration procedure also requires the analysis of a calibration check standard (in accordance with the 1990 USATHAMA QAP, Section 8.2) before sample analysis can begin.

3.2.3 Data Quality Objectives (DQOs)

DQOs are qualitative and quantitative statements developed by data users to specify the quality of data required from field and laboratory data collection activities to support specific decisions or regulatory actions. The DQOs describe what data are needed, why the data are needed, and how the data will be used to address the

problem being investigated. DQOs also establish numeric limits for the data to allow the data user (or reviewers) to determine whether data collected are of sufficient quality for use in their intended application.

3.2.3.1 General Description of DQOs

Five analytical quality control options are identified by CERCLA and described in the USEPA document *Data Quality Objectives for Remedial Response Activities Development Process* (USEPA, 1987b). These levels are based on the type of site to be investigated, the level of precision and accuracy required, and the intended use of the data.

The useability of the data collected during this investigation depends on its quality. Sample collection methods are as important to consider as sample analysis methods. Following standard operating procedures for both sample collection and analysis reduces sampling and analytical error. Complete chain-of-custody documentation, and adherence to required sample preservation techniques, holding times and proper shipment methods ensure sample integrity. Obtaining valid and comparable data also requires adequate QA/QC procedures and documentation, as well as established detection and control limits.

3.2.3.2 DQO Characteristics

Quality criteria address the following data characteristics: accuracy, precision, completeness, representativeness, and comparability.

ACCURACY. Accuracy is the degree of agreement of a measurement or average of measurements with an accepted reference or "true" value, and is a measure of bias in the system.

For this project, accuracy of the measurement data was assessed and controlled. Results for blank, matrix, and surrogate spikes are the primary indicators of accuracy. These results are used to control accuracy within acceptable limits by requiring that they meet specific criteria. As spiked samples are analyzed, spike recoveries are calculated and compared to pre-established laboratories acceptance limits. The calculation formula for percent recovery is:

$$\% \text{ spike recovery} = \frac{\text{value of sample plus spike} - \text{value of unspiked sample}}{\text{value of spike added}}$$

Acceptance limits are based upon previously established laboratory capabilities for similar samples using control chart techniques. In this approach, the control limits reflect the minimum and maximum recoveries expected for individual measurements for an in-control system. Recoveries outside the established limits indicate some assignable cause, other than normal measurement error, and possible need for

corrective action. This includes recalibration of the instrument, reanalysis of the QC sample, reanalysis of the samples in the batch, or flagging the data as suspect if the problems cannot be resolved.

PRECISION. Precision is a measure of mutual agreement among individual measurements of the same property under prescribed similar conditions. Precision of the measurement data for this project is based upon spike duplicates (replicability), control sample analyses (repeatability), and results for duplicate/replicate field samples (sampling replicability).

Field duplicates are defined as two samples collected independently at a single sampling location during a single act of sampling. Field duplicates were collected at greater than 10 percent of the original sample number. Field duplicates were collected for groundwater samples and analyzed for the same parameters. A field replicate is defined as a single sample that is collected, then divided into two equal parts for the purpose of analysis. Field replicates numbered 10 percent of the original sample number. Field replicates were collected for soil/sediment samples and analyzed for the same parameters. Discretely sampled field duplicates/replicates are useful in determining sampling variability. However, greater than expected differences between replicates may occur because of variability in the sample material. Field sample duplicates/replicates were used as a quality control measure to monitor precision relative to sample collection activities. Precision of duplicates may depend on sample homogeneity.

Analytical precision was evaluated by using duplicate spiked samples. In order to compare matrix spikes and spike duplicates, precision is calculated in terms of Relative Percent Difference (RPD), which is expressed as follows:

$$RPD = \frac{|X_1 - X_2|}{(X_1 + X_2)/2} \times 100$$

where X_1 and X_2 represent the individual values found for the target analyte in the two replicate analyses. RPDs must be compared to the laboratory-established RPD for the analysis. For concentrations less than 10 times the detection limit the RPD criteria are not valid and variations may be as great as 100 percent.

The analyst or his supervisor must investigate the cause of data outside stated acceptance limits. Follow-up action includes recalibration, reanalysis of QC samples, sample reanalysis, or flagging the data as suspect if problems cannot be resolved.

COMPLETENESS. Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount expected to be obtained under correct, normal conditions.

The target value for completeness of all parameters is 100 percent. Measurement data completeness is a measure of the extent to which the database resulting from a measurement effort fulfills objectives for the amount of data required. For this program, completeness was defined as the valid data percentage of the total tests requested.

$$\text{Completeness (\%)} = \frac{\text{No. of successful analyses}}{\text{No. of requested analyses}} \times 100$$

Successful analyses are defined as those where the sample arrived at the laboratory intact, properly preserved, in sufficient quantity to perform the requested analyses, and accompanied by a completed chain-of-custody. Furthermore, the sample must be analyzed within the specified holding time and in such a manner that analytical QC acceptance criteria are met.

Completeness for the entire project also involves completeness of field and laboratory documentation, whether all samples and analyses specified in the Statement of Work have been processed and the procedures specified in this document and laboratory standard operating procedures (SOPs) have been implemented.

REPRESENTATIVENESS. Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.

The characteristics of representativeness are usually not quantifiable. Subjective factors to be taken into account are as follows:

- Degree of homogeneity of a site
- Degree of homogeneity of a sample taken from one point in a site
- Available information on which a sampling plan is based.

Field duplication and field replication, as defined under precision, are also used to assess representativeness. Two samples which are collected at the same location and at the same time are considered to be equally representative of this condition, at a given point in space and time. Sampling locations were chosen so as to represent the areas of interest at the site. To maximize representativeness of results, sampling techniques, sample size and sample locations were carefully chosen so they provide laboratory samples representative of the site and the specific area. Precautions, such as not operating engines near a well during sampling, were taken so that introduction of extraneous compounds does not threaten the representativeness of the samples. Samples exhibiting obvious stratification or lithologic changes were not used as replicates. Within the laboratory, precautions were taken to extract from the sample container an aliquot representative of the whole sample. For samples requiring volatiles analysis, premixing or homogenizing was not permitted.

COMPARABILITY. Comparability expresses the confidence with which one data set can be compared to another data set measuring the same property. Comparability is ensured through the use of established and approved sample collection techniques and analytical methods, consistency in the basis of analysis (wet weight, volume etc.), consistency in reporting units, and analysis of standard reference materials.

Data comparability is achieved by using standard units of measure i.e., milligrams per liter (mg/L) for metals and inorganics in water samples, $\mu\text{g/L}$ for organics in water, and $\mu\text{g/g}$ (dry weight) for both inorganics and organics in soil samples.

The use of standard methods to collect and analyze samples (in this case American Society for Testing Materials [ASTM] and USAEC methods), along with instruments calibrated against Standard Analytical Reference Materials (SARM) which are National Institute for Standards and Technology (NIST)-traceable standards, also ensures comparability.

3.2.3.3 Reporting Precision, Accuracy, and Completeness

Project quality objectives for the various measurement parameters associated with site characterization efforts are not quantifiable for representativeness and comparability. Accuracy is specified for laboratory analyses as acceptance criteria specified in the 1990 USATHAMA QAP. For precision, relative percent differences of up to 40 percent for soil samples and 30 percent for water samples can be expected. A completeness factor of 90 percent is acceptable.

Control charts are used to monitor the variations in the precision and accuracy of routine analyses and detect trends in these variations. Control charts have been provided to the USAEC Geology and Chemistry Branch.

Results for blanks, matrix spikes, and surrogate spikes are checked by analysts at Pace and by the IRDMIS system. Data that are out of control are flagged by analysts and must be approved by the USAEC Project Chemist. Three samples had surrogate recoveries below the CRL due to dilutions. Overall, accuracy was within the acceptable range.

Precision is also checked by comparing results from spike duplicates, control samples, and field duplicates/replicates. Analysts at Pace check that recoveries from spike duplicates and control samples are within the acceptable limits. These results are also checked by the USAEC Project Chemist. Field duplicate and replicate results are reported in Table 3-11.

Table 3-12 indicates completeness by method. Although some analyses were not completed within sample holding times for extraction and preparation, no data were rejected.

TABLE 3-11
COMPARISON OF DUPLICATE/REPLICATE RESULTS WITH
SAMPLE RESULTS

Analyses	Sample Results		Duplicate/Replicate Results	
	Sample No.	Detected Analyte & Concentration	Duplicate/Replicate No.	Detected Analyte & Concentration
VOCs, PCBs, Pesticides	01MW0401	ND	01MW0402	ND
PCBs, Pesticides	02SW0201	ND	02SW0202	ND
VOCs	05DP0301	Acetone: 17 ppb	05DP0302	Acetone: 20 ppb
SVOCs	14SW0101	DNOP: 30 ppb BEHP: 1,180 ppb	14SW0102	ND
TPH	23AQ0101	TPH: 2 ppm	23AQ0102	TPH: 84 ppm
PCBs, Pesticides	01EX0201	PCB-1260: 31 ppm	01EX0202	PCB-1260: 74 ppm
TPH, VOCs, SVOCs	11EX0101	TPH: 4,250.0 ppm Fluorene: 0.2 ppm Phenanthrene: 0.45 ppm BEHP: 0.28 ppm	11EX0102	TPH: 4,936.7 ppm
TPH	14SE0101	TPH: 51.4 ppm	14SE0102	TPH: 52.7 ppm
PCBs, Metals, Pesticides	27SS0401	PCBs: ND Metals: See Table 4-62	27SS0402	PCBs: ND Metals: See Table 4-62
pH, Metals	BGSS0101	pH: 5.6 Metals: See Table 4-1	BGSS0102	pH: 6.1 Metals: See Table 4-1
Metals, TPH, VOCs, SVOCs, PCBs, Pesticides	21BH0205	TPH, VOCs, SVOCs, PCBs, Pesticides: ND Metals: See Table 4-52	21BH0269	TPH, VOCs, SVOCs, PCBs, Pesticides: ND Metals: See Table 4-52
PCBs, Pesticides, Metals	25SS0701	PCBs, Pesticides: ND Metals: See Table 4-55	25SS0769	PCBs, Pesticides: ND Metals: See Table 4-55
PCBs, Pesticides, Metals	25SS1402	PCBs, Pesticides: ND Metals: See Table 4-55	25SS1469	PCBs, Pesticides: ND Metals: See Table 4-55
PCBs, Pesticides, Metals	25SS1502	PCBs, Pesticides: ND Metals: See Table 4-55	25SS1569	PCBs, Pesticides: ND Metals: See Table 4-55
Metals	07BH0108	Metals: See Table 4-31	07BH0169	Metals: See Table 4-31
Metals	07BH0204	Metals: See Table 4-32	07BH0269	Metals: See Table 4-32
Metals	07BH0304	Metals: See Table 4-33	07BH0369	Metals: See Table 4-33
Metals	07BH0406	Metals: See Table 4-34	07BH0469	Metals: See Table 4-34
Metals, Ethylene Glycol	26EX0105	Ethylene Glycol: 690 ppm Metals: See Table 4-57	26EX0169	Ethylene Glycol: ND Metals: See Table 4-57

Key:	VOC = Volatile Organic Compound	ppb = Parts per billion
	PCB = Polychlorinated Biphenyl	ppm = Parts per million
	SVOC = Semi-volatile Organic Compound	BEHP = Bis(2-ethylhexyl)phthalate
	TPH = Total Petroleum Hydrocarbon	DNOP = Di-n-octyl phthalate
	ND = Not Detected	

TABLE 3-12
PERCENT COMPLETENESS SUMMARY

Methods Soil/Water (Parameter)	Percent Complete	
	Soil	Water
D2216 (Soil Moisture)	100	NA
LM33/UM05 (Volatile Organic Compounds)	100	100
LM30/UM06 (Semi-volatile Organic Compounds)	100	100
JS14/SS15 (Metals)	100	100
E418.1 (Total Petroleum Hydrocarbon)	100	100
LH19/UH21 (Pesticides/Polychlorinated Biphenyls)	100	100
SW9045 (pH)	100	NA
8015 (Ethylene Glycol)	100	100

Key: NA = Not Analyzed

3.2.3.4 Analytical Levels

USEPA Analytical Levels are summarized in Table 3-13. Field analysis data of qualitative or semi-quantitative nature are considered USEPA Level I quality. Data are obtained by use of approved field equipment, such as total organic vapor analyzers, dissolved oxygen meters, and geophysical survey instruments. Level I data may be used for the following: (1) delineation of contaminated zones; (2) gross determination of analytes in samples; or (3) health and safety screening. Level I data can provide information to the laboratory regarding expected concentration ranges.

Quantitative field instruments which are designed for in-situ measurements and analyses performed by mobile labs and fall under USEPA Level II protocols. Data from Level II are used for site characterization, evaluation of alternatives, engineering design, and monitoring during implementation or sampling. Data collected by use of analytical field procedures (e.g. temperature and pH) are considered to be Level II. Analytical programs for Soil Organic Vapor (SOV) surveys are also considered to be Level II.

Level III provides low detection limits, a wide range of calibrated analytes, matrix recovery information, laboratory process control information, and known precision and accuracy. USEPA-accepted methods, such as those in SW-846, the National Pollutant Discharge Elimination System (NPDES), and the Contract Laboratory Program (CLP) are used under Level III. USAEC-methods (Class 1, 1B, or 1A) would fall under Level III since they are based on USEPA methods. Level III can be used for risk assessment, site characterization, evaluation of alternatives, engineering design, and monitoring during implementation.

The samples collected as part of the SI at WRF were analyzed by USEPA Level I and III protocols. These results are for site characterization. Field equipment such as HNus and geophysical instruments were used initially to gather data at Level I. Soil, sediment, surface water and groundwater samples were sent to Pace for analysis at Level III by USAEC-approved methods or SW846 methods.

3.2.4 Quality Control For Laboratory Analyses

Internal quality control focuses on ensuring that each chemical measurement has the highest probability of exceeding method protocol in terms of precision and accuracy. Quality control samples such as method blanks, spikes, and duplicates are evaluated and documented on a routine basis. Spike and surrogate recoveries and relative percent difference, as appropriate, are calculated, and these quality control data are compared on an ongoing basis to laboratory-established control limits. SARMs are used for spiking compounds and surrogates. The following are laboratory QA/QC samples used by Pace, Inc.

TABLE 3-13
SUMMARY OF ANALYTICAL LEVELS APPROPRIATE TO DATA USES

Data Uses	Analytical Level	Type of Analysis	Limitations	Data Quality
Site Characterization; Monitoring During Implementation	Level I	Total organic/inorganic vapor detection using portable instruments Field test kits	Instruments respond to naturally-occurring compounds	If instruments calibrated and data interpreted correctly, can provide indication of contamination
Site Characterization; Evaluation of Alternatives; Engineering Design; Monitoring During Implementation	Level II	Variety of organics by GC; inorganics by AA; XRF Tentative ID; analyte-specific Detection limits vary from low ppm to low ppb	Tentative ID Techniques/instruments limited mostly to volatiles, metals	Dependent on QA/QC steps employed Data typically reported in concentration ranges
Risk Assessment; PRP Determination; Site Characterization; Evaluation of Alternatives; Engineering Design; Monitoring During Implementation	Level III	Organics/inorganics using USEPA procedures other than CLP; can be analyte-specific RCRA characteristics tests	Tentative ID in some cases Can provide data of same quality as Level IV	Similar detection limits to CLP Less rigorous QA/QC than Level IV
Risk Assessment; PRP Determination; Evaluation of Alternatives; Engineering Design	Level IV	HSL organics/inorganics by GC/MS; AA; ICP Low ppb detection limit Non-conventional parameters Method-specific detection limits Modification of existing methods Appendix 8 parameters	Tentative identification of Non-HSL Parameters Some time may be required for validation of packages May require method development/modification Mechanism to obtain services requires special lead time	Goal is data of known quality Rigorous QA/QC Method-specific
Risk Assessment; PRP Determination	Level V			

Key: PRP = Potentially Responsible Party
GC/MS = Gas Chromatography/Mass Spectrometry
AA = Atomic Absorption
XRF = X-Ray Fluorescence
ppm = Parts per million
ppb = Parts per billion

USEPA = U.S. Environmental Protection Agency
CLP = Contract Laboratory Program
RCRA = Resource Conservation and Recovery Act
ICP = Inductively coupled plasma
QA/QC = Quality Assurance/Quality Control

ANALYTICAL LOT. The basic unit for analytical quality control is the analytical lot. Samples in each lot should be of similar composition and include QC samples. Maximum lot size is defined as the number of samples, including QC samples, that can be processed through a step of the analytical method during a single time period (not to exceed 1 day) as determined by the time or by the equipment limiting step of the method.

METHOD BLANK. A method blank is an artificial, matrixless sample used to monitor the system for interferences and contamination from glassware, reagents, etc. The method blank is taken through the entire sample preparation process and is included with each lot of extractions/digestions prepared.

SPIKES. USAEC does not normally require the matrix spikes and matrix spikes duplicates required by the USEPA. The USEPA uses these samples to determine matrix effects and within day variability of the laboratory. In lieu of these, USAEC methods will include surrogates to determine matrix effects. If surrogates are not available and for NTAMs, matrix spikes will be performed at a rate of 1 per 20 samples.

SURROGATE COMPOUNDS. For Class 1A only, the analytical process includes the addition, subsequent detection, and recovery calculations of surrogate spiking compounds. Surrogate compounds are added to every sample at the beginning of the sample preparation, and the surrogate recovery is used to monitor matrix effects and sample preparation. Compounds that meet the following criteria are suitable surrogate compounds.

- Compounds not requested for analysis
- Compounds that do not interfere with the determination of required analytes
- Compounds that are not naturally occurring, yet are chemically similar to the required analytes.

METHOD OF STANDARD ADDITION. The method of standard addition is used in metals analysis for samples that exhibit matrix interferences. Matrix interferences are caused by, for instance, high concentrations of analytes other than those that are being analyzed. Standard addition analysis involves adding known amounts at different concentrations to the sample and reanalyzing. A plot of concentration versus absorbance will give the concentration of the unknown when extrapolated back to zero absorbance. The method of standard addition shall be applied to metals analysis at the rate of 5% or 1 per lot, whichever is greater.

REAGENTS. Laboratory reagent water that meets the requirements of ASTM Type II water, as described in the USATHAMA QAP, is checked daily. The resistivity of the

water is measured and recorded in a logbook. Blanks are routinely analyzed for purity and accompany each lot tested.

High-purity reagents are purchased as dictated by each test method and are documented by batch, lot number, and supplier, as well as time period of laboratory use (date opened, date depleted). SARMS should be acquired by the laboratory when analyzing samples under the USAEC program, and used whenever possible for internal QC and calibration samples. Standard soil samples are provided by the USAEC Geology and Chemistry Branch.

3.2.5 Laboratory Performance and Systems Audits

Performance and systems audits are used to monitor project activities to assure compliance with the QA objectives and procedures. Audits may be performed by USAEC or EARTH TECH. USATHAMA QAP describes external and internal audits. An external audit was performed by USAEC personnel on 27 September 1993. A letter documenting the findings is provided in Appendix K.

3.2.6 Preventive Maintenance

The primary objective of a preventive maintenance program is to help ensure the timely and effective completion of a measurement effort by minimizing the down time of crucial sampling and/or analytical equipment due to expected or unexpected component failure. In implementing this program, efforts are focused in three primary areas: maintenance responsibilities; maintenance schedules; and adequate inventory of critical spare parts and equipment.

Maintenance responsibilities for laboratory equipment are assigned to the respective laboratory managers. The laboratory managers then establish maintenance procedures and schedules for each major equipment item. These are contained in the maintenance logbooks assigned to each instrument.

The effectiveness of any maintenance program depends to a large extent on adherence to specific maintenance schedules for each major equipment item. A specific schedule is established for all routine maintenance activities. Other maintenance activities may also be identified as requiring attention on an as-needed basis. Manufacturers' recommendations and/or sample throughput provide the basis for the established maintenance schedules, and manufacturers' service contracts provide primary maintenance for many major instruments (e.g., GC/MS instruments, atomic absorption spectrometers, analytical balances, etc.). Maintenance activities for each instrument are documented in a maintenance log which indicates the required frequency for each procedure and provides for dated entries.

Along with a schedule for maintenance activities, an adequate inventory of spare parts is required to minimize equipment down time. This inventory emphasizes those parts (and supplies) which are subject to frequent failure, have limited useful lifetimes, or

cannot be obtained in a timely manner should failure occur. The respective laboratory managers are responsible for maintaining an adequate inventory of necessary spare parts. Sufficient equipment should be on hand to continue analyses in the event that an instrument encounters problems. In addition to backup instrumentation, a supply of spare parts such as gas chromatography columns, fittings, septums; atomic absorption lamps, mirrors, diaphragms; graphite furnace tubes; and other ancillary equipment should be maintained.

3.2.7 Laboratory Nonconformances and Corrective Action

Corrective action is dictated by the type and extent of the nonconformance. Corrective action may be initiated and carried out by nonsupervisory staff, but final approval and data review by laboratory management is necessary before reporting any information. All potentially affected data must be thoroughly reviewed for acceptance or rejection.

A nonconformance occurs whenever results fall outside of established laboratory limits. A nonconformance may result from a number of factors including method procedural problems, equipment malfunctions, and operator error. Regardless of the cause, any activity in the laboratory which adversely affects data quality is considered a nonconformance.

The nonconformances reported by Pace, Inc. and the subsequent corrective actions are described below.

- Two samples (22SW0301, 02SW0201) were received broken at the laboratory and one (01MW0301) was spilled in the laboratory. These samples were recollected and analyzed.
- Two samples (05DP0301, 05DP0201) sent for VOC analysis had a pH of 7 and therefore could not be considered preserved samples. These samples were analyzed after the holding time for unpreserved samples but due to sample collection procedures (direct push) could not be resampled.
- Sample 26AQ0101 sent for total petroleum hydrocarbon (TPH) and cyanide analyses had a pH of 7, and therefore could not be considered a preserved sample. This sample was discarded, recollected, and analyzed.
- Rinsate sample RB19 and trip blank sample TB20 sent for VOC analysis were erroneously never analyzed by the laboratory. Samples 18SD0101 and 18SD0102 were collected the same day and contained VOC detections.

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- Two coolers were not received at the laboratory within the acceptable temperature range of 2°C to 6°C. One cooler was received at 0.4°C and the other was received at 2°C. These samples were analyzed and flagged with a "V".
 - Several site types were not valid as written on the chain-of-custody. The laboratory notified the EARTH TECH Analytical Program Manager and the errors were corrected before the data were entered into IRDMIS.
 - Three lots were uploaded to Level III before errors in the header information and data results were discovered. The erroneous lots EWA, EVJ, and EVZ were deleted from Level III and the corrected lots were uploaded.
 - Several samples had holding times exceeded. Eight samples (01EX0101, 01EX0201, 01EX0202, 03EX0101, 05EX0101, 05EX0201, 05EX0301, and 6AEX0201) were extracted for PCBs/pesticides one day after the holding time. The laboratory staff performing extractions was reminded of USAEC's holding time requirements. The appropriate flag "K" was attached to the sample results.
 - Several IRDMIS lots contained errors that required clearance from the USAEC Project Chemist. Lots HKR, ICR, ICS, ILV, ILW, HPR, and HOL indicated no method blanks found for surrogate analytes. The surrogates were to be added to the method blank to determine method efficiency. Lots HDL and HDM contained surrogate compounds not within the certified range due to dilutions that were performed. Lot HDY experienced a QC failure in the ending calibration for the matrix in three compounds. Flags or qualifiers were attached to the results, where appropriate.
 - Several lots that initially failed group or record check due to surrogate or map file errors were corrected with the appropriate flags or changes to the map file, respectively.

3.2.8 Quality Assurance Reports

Effective management of a field sampling and analytical effort requires timely assessment and review of field and laboratory activities. This requires effective interaction and feedback between the field team members, the Project Manager, and the Laboratory Project Manager.

Sampling activities were reviewed by the onsite task leader to determine if the sampling quality control requirements, such as the proper numbers of blanks and duplicate samples were being fulfilled. All data sheets and logbooks were reviewed daily. Any needed corrective action was initiated and documented daily.

The laboratory project managers/QA officers have the responsibility of reviewing all laboratory analytical activities to ensure compliance with the QC requirements outlined in the Quality Assurance Project Plan (QAPP). This review serves as a control function in that it should be conducted frequently so deviations from method requirements will be immediately identified and corrected. Corrective actions are reported in Section 3.2.7.

3.3 DATA MANAGEMENT

3.3.1 Field Data Reduction, Validation, and Reporting

Field observations, direct reading instrument responses, and other measurements were recorded either in field logbooks or in the field data forms appropriate for the activity as discussed in Section 3.1.15. The forms used for field documentation are presented in Appendix C. The Task Manager was responsible for ensuring that all necessary data and information were incorporated into the logbooks and forms as each field activity occurred. On a daily basis, the Task Manager checked the logbooks and forms for completeness.

To present field data in this report, data in logbooks and on forms had to be summarized and transferred to tables, figures, maps, or logs. The Project Manager and Task Manager are responsible for the data transfer activities pertinent to their project roles. The QC Coordinator is responsible for performing spot checks of transfer activities and for ensuring the data transfers are performed accurately. The data were also entered into IRDMIS map file. IRDMIS map file was completed prior to sampling and updated when survey data were available.

3.3.2 Laboratory Data Reduction, Validation, and Reporting

3.3.2.1 Data Reduction

Chemical results in data packages have been submitted to the USAEC Geology and Chemistry Branch from the analytical laboratory. It is the responsibility of the laboratory data manager to check the raw laboratory data for completeness and accuracy. Raw laboratory data were transferred from the laboratory reports to the IRDMIS chemical data files.

It is the responsibility of the QA Coordinator and Data Manager to ensure that all data transferred to IRDMIS are transferred correctly. All data transferred were checked at least once for completeness and accuracy of transfer. IRDMIS data are record and group checked by the IRDMIS PC Data Entry and Validation System and submitted to Potomac Research, Incorporated when correct.

3.3.2.2 Data Validation/Review

Pace's system for ensuring valid data includes several levels of review. Each level commands specific action to prevent the unqualified release of erroneous data and to correct any problems discovered during the review process.

All analytical data generated at Pace are extensively checked for accuracy and completeness. The data validation process consists of data generation, reduction, and three levels of review to check sample preparation, analysis, and documentation. All data are ultimately compared to the criteria in 1990 USATHAMA QAP and the specific approved USAEC method.

If no problems are found with the data package, the review is considered complete. If any problems are found with the data package, an additional 10 percent of the samples are checked to the bench sheet. The process continues until no errors are found or until the data package has been reviewed in its entirety. The reviewed data are then approved for release and a final report is prepared.

Before the report is released, the Laboratory Project Manager who is responsible for interfacing directly with EARTH TECH reviews the report to ensure that the data meet the overall objectives of the project.

Each step of the review process involves evaluation of data quality based on both the results of the QC data and the professional judgement of those conducting the review. This application of technical knowledge and experience to the evaluation of the data is essential in ensuring that data of high quality are generated consistently.

In addition to the reviews discussed above, the USAEC Geology and Chemistry Branch validates the data packages when USAEC methods are used. Validation of data required that appropriate QA/QC and documentation steps were performed in both the lab and the field. USAEC chemists trained in validation procedures reviewed this information to assign data qualifiers. Qualifiers indicated data acceptance, potential limitations of data usage, or rejection when QA/QC criteria were not met. During the data validation process, the USAEC Project Chemist reviewed all flagging codes attributed by Pace and analytical protocols prior to assigning data qualifiers. Data qualifiers and flagging codes become a permanent part of the numeric data (i.e., a value of 7 qualified with an A is always represented as 7A). The following flagging codes were available for use during this effort.

- A Analyte found in trip blank as well as in field samples
- B Analyte found in the method blank or QC blank as well as the sample
- C Analysis was confirmed
- D Duplicate analysis
- F Sample filtered prior to analysis
- G Analyte found in rinse blank as well as field sample
- H Out-of-control but data accepted due to high recoveries

I	Interferences in sample make quantitation and/or identification to be suspect
J	Value is estimated
K	Reported results are affected by interferences or high background
L	Out-of-control, data rejected due to low recoveries
M	Duplicate (high) spike analysis not within control limits
N	Tentatively Identified Compound (TIC) (match greater than 70 percent)
P	Results less than reporting limit but greater than instrument detection limit (IDL)
Q	Sample interference obscured peak of interest
R	Nontarget compound analyzed for but not detected (GC/MS methods)
S	Nontarget compound analyzed for and detected (GC/MS methods)
T	Nontarget compound analyzed for but not detected (non-GC/MS methods).
U	Analysis is unconfirmed
V	Sample subjected to unusual storage/preservation conditions
W	Single analyte required from a multi-analyte method
X	Analyte recovery outside of certified range but within acceptable limits
Y	TIC (match less than 70 percent)
Z	Nontarget compound analyzed for and detected (non-GC/MS methods)
1	Result less than CRL but greater than chemical oxygen demand (COD)
2	Ending calibration not within acceptable limits
3	Internal standard(s) not within acceptable limits
7	Low spike recovery is not within control limits.

The "T" and "Z" flags were assigned to all PCB results because Pace is approved under Method LH19 and UH21 to perform pesticides but the PCBs that are analyzed with them are not USAEC-approved target compounds. In addition, the following qualifier codes were assigned to some results by the USAEC Chemist to indicate data acceptance or rejection based on validation findings.

I	The low-spike recovery is high.
J	The low-spike recovery is low.
K	Missed holding time for extraction and preparation.
L	Missed holding time for sample analysis.
M	The high-spike recovery is high.
N	The high-spike recovery is low.
P	High spike recoveries excessively different.
Q	Surrogate recovery is outside of normal limits (field samples only)
R	Datum is rejected.

Due to the necessity to use standard USEPA analytical methods on occasion, EARTH TECH validated all data associated with non-USAEC methods. The data validation consists of the verification that holding times have been met, calibration checks are adequate, qualitative and quantitative results are correct, documentation is complete, and QC results are complete and accurate. In addition, EARTH TECH validated 10 percent of data. EARTH TECH's validation efforts are summarized in Appendix I.

While qualifiers and flags were added to the data, none of the data were assigned the qualifier "R" for rejected.

PROCEDURES FOR HANDLING UNACCEPTABLE DATA. Control charts and calibration curves are used to review the data and identify outlying results. Quality control charts are prepared from spiked QC samples. Control limits are statistically calculated using a USAEC required software package. Out of control samples are investigated by the analysts.

Results which exceed the warning limits but not the control limits alert the analyst to a potential problem. Sample results are accepted when they fall between warning limits and control limits, but the procedures and standards are checked. If the laboratory control sample exceeds the control limit, the analyst stops work on the analysis. The analyst and supervisor should investigate potential causes of the problem. After the cause is determined and corrected, samples from the original set are rerun along with duplicate spiked samples and a laboratory control sample.

All QC information is recorded in the notebooks and printouts in the same format used for sample results. It is the analyst's responsibility to check the QC information against limits for the analysis. When an analysis of a QC sample (blank, spike, check standard, USEPA-traceable standard, replicate, or similar sample) shows that the analysis of that batch of samples is not in control, the analyst immediately brings the matter to the attention of the supervisor. The supervisor consults with the QA manager and/or the Laboratory Project Manager to determine whether the analysis can proceed, if selected samples should be rerun, or specific corrective action needs to be taken before analyzing additional samples. Out-of-control analyses must be documented by the supervisor. The analyst or supervisor files an "Anomaly Report" with the QA manager. Nonconformance data and resulting corrective actions are discussed in Section 3.2.7.

3.3.2.3 Laboratory Data Reporting

Reports from Pace include the following.

- A copy of the signed chain-of-custody form showing date and time of sample receipt in laboratory.
- Sample collection, extraction and analysis dates.
- A sample data summary (the analytical results for the sample).
- A QA/QC summary report, providing data on method blanks, check samples, surrogate recoveries, laboratory duplicates, matrix spikes, or matrix spike duplicates (whichever are applicable to the particular method). The QA/QC summary report shall also list laboratory control limits and discuss the corrective actions taken whenever laboratory control limits are exceeded.
- The required IRDMIS chemical data files.

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- A weekly list of the chemical lots analyzed and the IRDMIS files sent to Potomac Research, Incorporated.
 - The control charts sent to the USAEC Geology and Chemistry Branch.

A complete set of analytical results including flags and qualifiers is presented in Appendix H.

3.3.3 IRDMIS Data Management Plan

The IRDMIS computerized, environmental database was used to manage data collected during the SI. It is an interactive data management system that stores, checks, and manipulates laboratory analytical results and field data. The IRDMIS provides the advantage of electronic data management to help ensure data integrity, consistency, and completeness.

EARTH TECH and Pace coordinated field data collection and laboratory analysis to produce the IRDMIS files that were used to complete the SI. The following sections describe the data management used by EARTH TECH and Pace to produce the IRDMIS map, geotechnical, and chemical files.

3.3.3.1 Map Data File

The map data file is an integral component of IRDMIS that ensures chemical and geotechnical data correspond to sampling locations at WRF. The map file can also be used to help construct groundwater level elevation and isoconcentration maps.

EARTH TECH obtained the existing map data file for the WRF to identify any unique designators for locations that were sampled in past investigations. The existing wells to be sampled by EARTH TECH during the SI were not located in IRDMIS. The sample locations used in the SI were identified on a facility map and EARTH TECH constructed a new map file. EARTH TECH submitted this map file to USAEC and Pace. Once the sampling locations were surveyed by EARTH TECH, the new map file was updated with surveyed coordinates and submitted to USAEC.

Before any samples were sent to the laboratory for analysis, EARTH TECH field personnel were given the complete list of sampling location designators recorded in the new map file. These designators were used on chain-of-custody forms that accompanied all samples sent from the field to Pace. The map data file allowed Pace to perform the IRDMIS group checking on chemical data files. IRDMIS group checking requires that the sample designator assigned to an analytical result corresponds to a sample location recorded in the map data file.

3.3.3.2 Geotechnical Data Files

The following five geotechnical data files are included in the IRDMIS system:

- Field drilling file
- Well construction file
- Groundwater stabilized file
- Physical analysis file
- Aquifer analysis file.

A field drilling file was completed for this SI for all boreholes drilled. Data included in the field drilling file consists of the borehole drilling date, total depth of borehole, depth to groundwater (if encountered), and the borehole lithology as recorded on the borehole logs during drilling. No well construction was completed during the SI so the second file was not required. A groundwater stabilized data file was produced for all groundwater locations in the map file. The file contains the time and date the water level was taken and the measurement for each groundwater sampling point.

The last two files listed above, the physical analysis file and aquifer analysis file, were not completed for this SI. Although IRDMIS will accept and process these file types, guidance on the data necessary for the files have not been provided due to USAEC re-evaluating the need for the data to be retained in IRDMIS.

3.3.3.3 Chemical Data Files

Pace provided the analytical results in chemical data files to the IRDMIS database. These chemical data files contain all the IRDMIS-required information that results from the analysis of all environmental and QA/QC samples collected during the SI. The chemical files fully comply with all the IRDMIS requirements with regard to analytical methods, QA/QC information, duplicate and blank sample analyses, lot size, and data reporting. Pace used the data codes identified in the IRDMIS User's Guide, Volume II, Data Dictionary. The NTAM database was used for SW846 methods.

To construct the IRDMIS chemical data files, Pace interfaced its laboratory information management system with the IRDMIS to download laboratory data and used the IRDMIS PC Data Entry and Validation Subsystem to manually enter sampling data.

Pace used the IRDMIS PC Data Entry and Validation Subsystem to perform record and group checking on all constructed chemical data files before submittal to the IRDMIS. When performing group checking, Pace used the map data file that EARTH TECH constructed and submitted to the IRDMIS. If errors occurred during record and group checking, Pace worked with the USAEC Geology and Chemistry Branch to identify and correct acceptable and unacceptable errors. Once Pace corrected all unacceptable errors for a chemical data file, the chemical data file was submitted via modem to the IRDMIS.

3.4 EVALUATION METHODOLOGY

The general purpose of an SI is to determine whether contamination exists at a site and whether there is a potential threat to human health or the environment. An extensive evaluation of ARARs and background conditions is not specifically required for an SI, but such a comparison can be used to evaluate the need for additional investigative work and/or cleanup. Detailed discussions of ARARs and the establishment of background conditions are presented in the following sections.

3.4.1 Applicable or Relevant and Appropriate Requirements (ARARs)

Section 121 of CERCLA requires that site cleanups comply with Federal ARARs or state ARARs in cases where these requirements are more stringent than federal requirements. ARARs are derived from both federal and state laws. A requirement may be either "applicable" or "relevant and appropriate." "Applicable" requirements are those promulgated federal or state substantive cleanup standards, standards of control or requirements under federal or state environmental laws or facility siting laws that meet all jurisdictional prerequisites of a requirement and fully address the circumstances at the site or the proposed remedial activity. Applicable requirements are identified on a site-specific basis by determining whether the jurisdictional prerequisites of a requirement fully address the circumstances at the site or the proposed remedial activity.

In addition to ARARs, non-promulgated advisories or guidances, referred to as "to-be-considered" (TBC) materials, may also apply to the conditions found at a site. TBCs are not legally binding. However, they may be used to determine cleanup levels when ARARs do not exist or when ARARs alone would not be sufficiently protective of human health and the environment.

ARARs that govern actions at CERCLA sites fall into the following three broad categories, based on the site characteristics, chemicals present, and remedial alternatives for cleanup.

- ***Chemical-specific ARARs*** include those environmental laws and regulations which regulate the release to the environment of materials possessing certain chemical or physical characteristics or containing specified chemical compounds. These requirements generally set health- or risk-based concentration limits or discharge limits for specific hazardous substances. See Preamble to Proposed National Contingency Plan (NCP), 53 Federal Register at 51437. Chemical-specific ARARs are triggered by the specific chemical contaminants found at a particular site.
- ***Location-specific ARARs*** govern activities in certain environmentally sensitive areas. Examples of location-specific ARARs include protective

uses of floodplains, wetlands, endangered species habitat, or historically significant resources.

- **Action-specific ARARs** are restrictions that define acceptable treatment and disposal procedures for hazardous substances. These ARARs generally set performance, design or other similar action-specific controls or restrictions on particular kinds of activities related to management of hazardous substances or pollutants, such as RCRA regulations for waste treatment, storage and disposal. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy.

Potential Federal and Virginia chemical-, location-, and action-specific ARARs are reviewed in Tables 3-14 and 3-15, respectively. Potential soil and groundwater ARARs and TBCs for chemicals of concern at WRF are provided in Tables 3-16 through 3-18. Potential sediment TBCs for chemicals of concern included in Table 3-19.

3.4.2 Establishing Background

As a means to evaluate concentrations of inorganic analytes detected in soil and sediment samples collected as part of this SI, background concentration ranges of these analytes will be used for the WRF. Background concentration ranges were based on analytical results gathered from soil samples collected at the WRF in locations judged to be unaffected by past U.S. Army activities. In addition, USGS published concentration ranges for the analytes from surficial soil samples collected within the WRF geographical area were also obtained.

**TABLE 3-14
POTENTIAL FEDERAL ARARS - WOODBRIDGE RESEARCH FACILITY**

Requirement	Citation	Scope	Applicable/Relevant and Appropriate or TBC	Applicability to Cleanup at Woodbridge Research Facility
CHEMICAL-SPECIFIC				
National Primary Drinking Water Standards	40 CFR Part 141	Establishes health-based standards for public water systems (Maximum Contaminant Levels (MCLs))	Relevant & Appropriate	MCLs are not applicable because they address contaminants in drinking water systems, not groundwater aquifers. However, the NCP has deemed MCLs to be relevant and appropriate for groundwater cleanup standards.
National Secondary Drinking Water Standards	40 CFR Part 143	Establishes welfare-based standards for the aesthetic quality of public water supplies (Secondary Maximum Contaminant Levels (SMCLs))	No	SMCLs are not legally enforceable, and are thus not ARAR. Site contaminants have not affected secondary standards. Background levels of some contaminants exceed secondary MCLs.
Maximum Contaminant Level Goals (MCLGs)	40 CFR Part 141	Establishes drinking water quality goals at no known or anticipated adverse health effects with an adequate margin of safety	No	NCP states that where MCLGs are greater than zero the MCLGs are relevant and appropriate for site cleanup. MCLGs for site contaminants either equal MCL or are zero; therefore MCLGs are not ARAR.
Federal Ambient Water Quality Criteria	40 CFR Part 131	Sets criteria for water quality based on toxicity to aquatic organisms and human health	TBC	Water quality criteria are non-enforceable; Virginia Water Quality Standards are based on these criteria.
Identification and Listing of a Hazardous Waste	40 CFR Part 261	Establishes criteria for the identification and listing of a hazardous waste	No	The Commonwealth of Virginia RCRA regulations are more stringent than Federal RCRA regulations. See Table 3-15 for Virginia RCRA regulations.

TABLE 3-14
POTENTIAL FEDERAL ARARS - WOODBRIDGE RESEARCH FACILITY

Continued

Requirement	Citation	Scope	Applicable/Relevant and Appropriate or TBC	Applicability to Cleanup at Woodbridge Research Facility
CHEMICAL-SPECIFIC (CONTINUED)				
RCRA Corrective Action Levels for SWMUs	40 CFR 264.52 Proposed Rule	Establishes concentrations at or above which corrective action is triggered	TBC	These levels can be used as input in developing soil cleanup levels.
USEPA Risk-based Concentrations	Risk-based Concentration Table, Fourth Quarter 1993	Establishes risk-based concentrations above which further risk characterization is recommended.	TBC	Useful as a risk-based screen for Superfund sites, but is not considered a source of site-specific cleanup levels.
USEPA Guidance on Remedial Actions for Superfund Sites with PCB Contamination	OSWER Directive No. 9355.4-01 August 1990	Recommends action levels of 1 ppm (residential) and 10-25 ppm (industrial) in soils	TBC	PCB-contaminated soils exist at the Woodbridge Research Facility.
LOCATION-SPECIFIC				
Endangered Species Act	50 CFR 16 USC, Section 1531, Parts 12 and 17.11	Requires action to protect endangered species and critical habitats upon which endangered species depend	Applicable	Twelve endangered or threatened species have been observed at Woodbridge Research Facility.
Executive Order on Flood Plain Management	Executive Order No. 11988	Requires federal agencies to evaluate the potential effects of actions they may take in a flood plain to avoid adverse impacts associated with direct and indirect development of a floodplain.	Applicable	Approximately two-thirds (387 acres) of the installation lies within the 100-year floodplain.

**TABLE 3-14
POTENTIAL FEDERAL ARARS - WOODBRIDGE RESEARCH FACILITY**

Continued

Requirement	Citation	Scope	Applicable/Relevant and Appropriate or TBC	Applicability to Cleanup at Woodbridge Research Facility
LOCATION-SPECIFIC (CONTINUED)				
National Historic Preservation Act	16 USC Section 470 et seq. 36 CFR Part 800	Requires federal agencies to consider the effect of any federally assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places	Applicable	No prehistoric archeological or historic sites are considered eligible for the National Register of Historic Places. The Army is currently evaluating the status of buildings and laboratories for inclusion on the NRHP.
Clean Water Act, Section 404(b)(1) and Executive Order 11990 "Protection of Wetlands"	40 CFR Section 230.10 and Executive Order 11990	Requires permit from the U.S. Army Corps of Engineers for construction activities in wetlands and alternatives analysis to ensure selection of the least damaging practicable alternative. Action must be taken to minimize adverse impacts on wetlands.	Applicable	Approximately 150 acres of Woodbridge Research Facility are described as wetlands.
ACTION-SPECIFIC				
National Pretreatment Standards	40 CFR Part 403	Sets standards to control pollutants that pass through or interfere with treatment processes in publicly-owned treatment works or which may contaminate sewage sludge.	Applicable	Applicable if purge water or treated effluent is sent offsite to a Publicly Owned Treatment Works (POTW) for treatment.
National Pollutant Discharge Elimination System	40 CFR Parts 122-125	Requires permits for the discharge of pollutants from any point source into the waters of the United States	Applicable	Applicable if treated effluent is discharged to surface water.

**TABLE 3-14
POTENTIAL FEDERAL ARARS - WOODBRIDGE RESEARCH FACILITY**

Continued

Requirement	Citation	Scope	Applicable/Relevant and Appropriate or TBC	Applicability to Cleanup at Woodbridge Research Facility
ACTION-SPECIFIC (CONTINUED)				
Resource Conservation and Recovery Act (RCRA)				
• Standards for Interim Status Facilities	40 CFR Part 265	Adds closure and post-closure care and groundwater monitoring	No	The Commonwealth of Virginia regulations now operate instead of Federal regulations, since the Virginia RCRA program has been authorized by USEPA. See Table 3-15 for Virginia RCRA regulations.
• Standards Applicable to Transporters of Hazardous Waste	40 CFR Part 263	Establishes standards for persons transporting hazardous wastes in the U.S.	No	
• Land Disposal Restrictions	40 CFR Part 268	Establishes treatability limits for listed and some characteristic wastes for land disposal.	Applicable	Federal Land Disposal Restrictions are applicable since Virginia has not yet promulgated these standards.
Underground Injection Control Program	40 CFR Parts 144-146	Protects groundwater from contamination by subsurface emplacement of fluids	Applicable	Reinjection of treated groundwater may be proposed.
New Source Performance Standards	Clean Air Act, Section III	Establishes standards for new sources of air emissions to ensure that emissions from new sources are minimized. The emission central technology on which the NSPSs are based is the best demonstrated technology.	No	NSPSs are source specific and not applicable to groundwater treatment technologies.

TABLE 3-14
POTENTIAL FEDERAL ARARS - WOODBRIDGE RESEARCH FACILITY

Continued

Requirement	Citation	Scope	Applicable/Relevant and Appropriate or TBC	Applicability to Cleanup at Woodbridge Research Facility
ACTION-SPECIFIC (CONTINUED)				
Statement of Policy on Control of Air Stripper Emissions	OSWER Directive 9355.028	Limits VOC emissions from Air Stripper Towers to less than 3 pounds per hour or 10 tons per year total VOCs	TBC	The policy statement was developed for controlling air stripper emissions at CERCLA sites, such as Woodbridge Research Facility.

Key:

TBC	= To Be Considered
ARAR	= Applicable or Relevant and Appropriate Requirement
NCP	= National Contingency Plan
SMCL	= Secondary Maximum Contaminant Level
SWMU	= Solid Waste Management Unit
OSWER	= Office of Solid Waste and Emergency Response
ppm	= Parts per million
NRHP	= National Register of Historic Places
NSPS	= New Source Performance Standard
VOC	= Volatile Organic Compound
CERCLA	= Comprehensive Environmental Response, Compensation, and Liability Act
MCL	= Maximum Contaminant Level
MCLG	= Maximum Contaminant Level Goal
RCRA	= Resource Conservation and Recovery Act
USEPA	= U.S. Environmental Protection Agency

TABLE 3-15
POTENTIAL VIRGINIA ARARS - WOODBRIDGE RESEARCH FACILITY

Requirement	Citation	Scope	Applicable/Relevant and Appropriate or TBC	Applicability to Cleanup at Woodbridge Research Facility
CHEMICAL-SPECIFIC				
Water Works Regulations - Inorganic and Organic Chemicals	VR 355-18-000	Establishes maximum contaminant levels (MCLs) for public water systems.	Relevant & Appropriate	These requirements are not directly applicable, but are relevant and appropriate, since groundwater aquifers at Woodbridge are considered potential sources of drinking water. State MCLs that are more stringent than Federal MCLs are relevant and appropriate.
Virginia Water Quality Standards	VR 680-21-00 to VR 680-21-08	Establishes numeric standards for surface and groundwater. These standards are not effluent ("end-of-pipe") limitations; instead the discharger can dilute his wastewater in a small area of the receiving water, so long as concentrations in this "mixing zone" do not interfere with or cause acute lethal effects upon, passing or drifting aquatic life.	Applicable	These standards would be applicable to discharges of treated effluent to ground or surface water.
Antidegradation Policy for Surface Waters	VR 680-21	Water whose existing quality is better than the established standards must be maintained at existing quality, except when the charge is justifiable to provide necessary economic or social development in the area where the waters are located.	TBC	A consideration for discharge of treated effluent or purge water to surface waters.
Soil Cleanup Levels for Underground Storage Tanks	Unpublished DEQ Guidance	Recommends level of 100 ppm as soil cleanup levels; if TPH is primarily BTEX, 25 ppm is the cleanup level.	TBC	A consideration for cleanup of POL-contaminated soil.

**TABLE 3-15
POTENTIAL VIRGINIA ARARS - WOODBRIDGE RESEARCH FACILITY**

Continued

Requirement	Citation	Scope	Applicable/Relevant and Appropriate or TBC	Applicability to Cleanup at Woodbridge Research Facility
CHEMICAL-SPECIFIC (CONTINUED)				
Criteria for Identifying and Listing Hazardous Wastes	VR 672-10-01; Part III	Presents criteria for testing and identifying RCRA hazardous wastes.	Applicable	These criteria are applicable to characterization of excavated soils, cuttings, spent carbon or other wastes generated by remedial activities at Woodbridge Research Facility.
LOCATION-SPECIFIC				
Floodplain Management	VR 672-10-1, 8	RCRA hazardous waste, treatment, storage or disposal facilities must be designed, constructed and operated to withstand a 100-year flood.	Applicable	Approximately two-thirds of the installation (387 acres) lies within the 100-year floodplain.
Hazardous Waste Facility Siting Criteria	VR 672-01-5 Part II	Hazardous waste storage, treatment, and disposal facilities must be located so as to avoid adverse impacts on the environment. Siting facilities in wetlands or 100-year floodplains is prohibited.	Applicable	Substantive requirements could apply if hazardous waste is treated and stored in tanks, or if land treatment or disposal of soils occurs.
Chesapeake Bay Preservation Act	Virginia Code Section 10.1-2100	Establishes criteria for land use and development in environmentally sensitive areas, called Chesapeake Bay Preservation Areas (CBPA); criteria are established on a state-wide basis, but implemented locally.	Applicable	More than 50% (approximately 300 acres) of the installation is within a Resource Protection Area, the most sensitive part of a CBPA. Remedial activities must minimize impacts on soils, vegetation wetlands, and water quality.
Virginia Endangered Species	Virginia Code Section 29.563 et seq.	Prohibits acts which directly, or indirectly, harm or injure a threatened or endangered species. Protects critical wildlife habitat.	Applicable	Applicable if remedial actions occur in locations where endangered or threatened species or this habitat can be affected.

**TABLE 3-15
POTENTIAL VIRGINIA ARARS - WOODBRIDGE RESEARCH FACILITY**

Continued

Requirement	Citation	Scope	Applicable/Relevant and Appropriate or TBC	Applicability to Cleanup at Woodbridge Research Facility
ACTION-SPECIFIC				
Resource Conservation and Recovery Act				
Standards Applicable to Generators of Hazardous Waste	VR 672-10-1	Establishes hazardous waste determination, manifesting, pre-transport, recordkeeping and reporting requirements.	Applicable	Substantive requirements are applicable if excavated soils or treatment residuals exceed RCRA hazardous waste thresholds.
- Standards for Permitted Hazardous Waste Facilities: - Storage in Containers & Tanks - Closure & Post-closure	VR 672-10-1 Sections 10.8 and 10.9 VR 672-10-1 Section 10.6	Regulates the storage of hazardous wastes in containers and in tanks. Establishes process-specific closure requirements for landfills, surface impoundments, and waste piles.	Relevant & Appropriate Relevant & Appropriate	Pertinent if hazardous waste is stored in containers or tanks. Not directly applicable because remedial action sites are not permitted facilities. These requirements would be relevant if landfills are being clean-closed or capped.
Standards Applicable to Transporters of Hazardous Waste	VR 672-10-1 Part VII	Establishes standards that apply to persons transporting wastes in Virginia.	No	These regulations apply to offsite activities, and are therefore, by definition, not ARAR. Nonetheless these requirements must be fully complied with when transporting hazardous waste offsite.

**TABLE 3-15
POTENTIAL VIRGINIA ARARS - WOODBRIDGE RESEARCH FACILITY**

Continued

Requirement	Citation	Scope	Applicable/Relevant and Appropriate or TBC	Applicability to Cleanup at Woodbridge Research Facility
ACTION-SPECIFIC (CONTINUED)				
Virginia Solid Waste Regulations Soil, Debris, and Sludge Deposit Requirements	VR 672-20-10 Part VIII	Regulates "special wastes." Soil containing less than 50 ppm TPH and 10 ppm BTEX may be clean-filled, soils with contaminants exceeding this level, but not more than 500 ppm TPH must be placed in a sanitary landfill.	Applicable	Solid wastes from the cleanup or investigation of an area where hazardous wastes have been disposed of or released are "special wastes".
Virginia Pollutant Discharge Elimination System	VR 680-14-01	Establishes the NPDES program in Virginia. Regulates point source discharges to surface waters of the state.	Applicable	Would be applicable to discharges of treated effluent or purge water to surface waters.
Virginia Pretreatment Standards	Permit Regulation, Part VIII	Imposes general standards and categorical standards on industrial dischargers to POTWs.	Applicable	Applicable if treated effluent or purge water is "discharged to a POTW".
Virginia Air Toxics Program	VR 120-01 State Air Pollution Control Board (SA PCB) Regulations Section 120-04-0301-0307	The program sets standards for new and existing sources. The standards provide for maximum allowable ambient air concentrations for air toxics.	No	It is unlikely limits for any toxic pollutants would be exceeded.

**TABLE 3-15
POTENTIAL VIRGINIA ARARS - WOODBRIDGE RESEARCH FACILITY**

Continued

Requirement	Citation	Scope	Applicable/Relevant and Appropriate or TBC	Applicability to Cleanup at Woodbridge Research Facility
ACTION-SPECIFIC (CONTINUED)				
Permits for New and Modified Sources of Air Emissions	SAPCBBR Section 120-08-01	These regulations require all new and modified sources of air emissions to obtain a permit prior to construction or modification.	No	Treatment units would likely be exempt based on threshold emission rates.

Key:

TBC	=	To Be Considered
ARAR	=	Applicable or Relevant and Appropriate Requirement
ppm	=	Parts per million
POL	=	Petroleum, Oil, and Lubricant
RCRA	=	Resource Conservation and Recovery Act
TPH	=	Total Petroleum Hydrocarbon
BTEX	=	Benzene, Toluene, Ethylbenzene, and Xylenes
NPDES	=	National Pollutant Discharge Elimination System
POTW	=	Publicly Owned Treatment Works

TABLE 3-16
POTENTIAL SOIL TBCs⁽¹⁾ FOR INORGANIC CHEMICALS OF CONCERN AT
WOODBIDGE RESEARCH FACILITY

Analytes	Potential TBCs (all concentrations in mg/kg)		
	USEPA Proposed RCRA Corrective Action Level ⁽²⁾	USEPA Region III Risk-based Concentrations in Soil ⁽³⁾	
		Commercial	Residential
Aluminum		1,000,000	78,000
Barium		72,000	5,500
Beryllium	0.2	0.67	0.15
Calcium			
Cadmium	40	510	39
Cobalt		61,000	4,700
Chromium	400 ⁽⁴⁾	5,100 ⁽⁴⁾	390 ⁽⁴⁾
Copper		38,000	2,900
Iron			
Potassium			
Magnesium			
Manganese		5,100	390
Mercury		310	23
Molybdenum			
Sodium			
Nickel	2,000	20,000 ⁽⁵⁾	1,600 ⁽⁵⁾
Lead (tetraethyl)		0.1	0.0078
Antimony	30	410	31
Selenium		5,100	390
Thallium			
Vanadium		7,200	550
Zinc		310,000	23,000
Arsenic	80	1.6	0.37

Key: TBC = To Be Considered RCRA = Resource Conservation and Recovery Act
 USEPA = U.S. Environmental Protection Agency mg/kg = Milligrams per kilogram

⁽¹⁾ No Federal or State ARARs exist for soil cleanup in Virginia. According to the Virginia Department of Environmental Quality (VADEQ) standards for surface soil are to be based on human health risk, while subsurface cleanup standards are to be based on soil concentrations that are protective of both ground and surface waters as measured by Maximum Contaminant Levels.

⁽²⁾ USEPA Proposed RCRA Corrective Action Levels for SWMUs at Hazardous Waste Management Facilities (40 CFR 264-52 Proposed Rule; 55 FR 30867, July 27, 1990). These are TBC for cleanup at Woodbridge Research Facility.

⁽³⁾ USEPA Region III Risk-based Concentrations (October 15, 1993). These are levels above which further risk characterization is recommended; they are TBC. They are based upon a hazard quotient of 1 or a lifetime cancer risk of 10⁻⁶.

⁽⁴⁾ Chromium VI.

⁽⁵⁾ Soluble salts.

TABLE 3-17
POTENTIAL SOIL TBCs⁽¹⁾ FOR ORGANIC CHEMICALS OF CONCERN AT
WOODBRIIDGE RESEARCH FACILITY

Organic Analytes	Potential TBCs (all concentrations in mg/kg)				
	Proposed USEPA RCRA Corrective Action Level ⁽²⁾	USEPA Region III Risk-based Concentrations in Soil ⁽³⁾		Virginia UST Program Action Level in Soil ⁽⁴⁾	USEPA Recommended Soil Action Levels for PCBs ⁽⁵⁾
		Commercial (Industrial)	Residential		
1,2,4-Trichlorobenzene	2,000	10,000	780		
1,2-Dichlorobenzene		9,200	7,000		
1,4-Dichlorobenzene		120	27		
4,4'-DDD	3	12	2.7		
4,4'-DDE	2	8.4	1.9		
4,4'-DDT	2	8.4	1.9		
a-Chlordane	0.5				
Acetone	8,000	100,000	7,800		
Bis(2-ethylhexyl)phthalate	50	200	46		
Bromodichloromethane	0.5	46	10		
Chlorobenzene	2,000	20,000	1,600		
Chloroform	100	470	100		
Chloromethane		220	49		
Di-n-octyl phthalate					
Dieldrin	0.04	0.18	0.04		
Ethylbenzene	8,000	100,000	7,800		
Ethylene Glycol		1,000,000	160,000		
Fluorene					
Methyl Ethyl Ketone (2-butanone)	4,000	610,000	47,000		
PCB-1242	0.09	0.37	0.083		1
PCB-1254	0.09	0.37	0.083		1
PCB-1260	0.09	0.37	0.083		1
Phenanthrene					
Toluene	20,000	200,000	16,000		
Total Petroleum Hydrocarbon				100	

Key: TBC = To Be Considered UST = Underground Storage Tank
RCRA = Resource Conservation and Recovery Act PCB = Polychlorinated Biphenyl
USEPA = U.S. Environmental Protection Agency

⁽¹⁾ No Federal or State ARARs exist for soil cleanup in Virginia. According to the Virginia Department of Environmental Quality (VADEQ) standards for surface soil are to be based on human health risk, while subsurface cleanup standards are to be based on soil concentrations that are protective of both ground and surface waters as measured by Maximum Contaminant Levels.

⁽²⁾ Proposed Rules for Corrective Action Levels (40 CFR 264.52; 55 FR 30867, July 27, 1990). This is a "trigger" level for a RCRA Corrective Measures Study and is not a cleanup level.

⁽³⁾ USEPA Region III Risk-based Concentrations (October 15, 1993). These levels are to be used as markers for additional study; they are not enforceable cleanup levels.

⁽⁴⁾ Risk-based Action Levels in Soil, Virginia Underground Storage Tank Program. These are screening levels below which no action is required; at or above these levels further risk characterization is required.

⁽⁵⁾ Guidance on Remedial Actions for Superfund Sites with PCB contamination (USEPA, 1990). This is based on a 10⁻⁵ risk level assuming future residential use. The Toxic Substances Control Act also requires cleanup and disposal of soils with 50 ppm or greater concentrations of PCBs. The Toxic Substances Control Act regulations are ARARs, not TBCs.

TABLE 3-18
POTENTIAL WATER QUALITY RELATED ARARs AND TBCs FOR
GROUNDWATER CONTAMINANTS OF CONCERN AT
WOODBIDGE RESEARCH FACILITY

Analyte	Potential ARARs and TBCs (all concentrations in ppb)									
	Federal Maximum Contaminant Level ⁽¹⁾	Virginia Maximum Contaminant Level ⁽²⁾	Federal Ambient Water Quality Criteria ⁽³⁾			Virginia Water Quality Standards ⁽⁴⁾			USEPA Risk- based Concentrations in Drinking Water ⁽⁵⁾	Virginia Groundwater Standards ⁽⁶⁾
			Fresh	Salt	Water & Fish Ingestion	Fresh	Salt	Water & Fish Ingestion		
Acetone									3,700	
PCB-1260	0.5 ⁽¹⁴⁾		0.014	0.03	7.9E-05	0.014	0.03	0.00044	0.0087	
PCB-1254	0.5 ⁽¹⁴⁾		0.014	0.03	7.9E-05	0.014	0.03	0.00044	0.0087	
BEHP	6				15,000				4.8	
Di-n-octyl phthalate										
TPH										
Aluminum										1,000
Barium	2,000	1,000			1,000			2,000	2,600	1,000
Beryllium	4				0.0068				0.016	
Calcium										
Cadmium	5	10	1.1 ⁽¹⁵⁾	9.3	10	(9)	9.3	16	18	0.4
Copper			12 ⁽¹⁵⁾	2.9		(10)	2.9	1,300	1,400	1,000
Iron			1,000		300					300
Potassium										
Magnesium										
Manganese					50				180	50
Molybdenum									180	
Sodium										100,000
Nickel	100		160	8.3	13.4	(11)	8.3	607	730	
Lead		50	3.2 ⁽¹⁵⁾	5.6	50	(12)	8.5		0.0037	50

TABLE 3-18
POTENTIAL WATER QUALITY RELATED ARARS AND TBCs FOR
GROUNDWATER CONTAMINANTS OF CONCERN AT
WOODBIDGE RESEARCH FACILITY

Continued

Analyte	Potential ARARs and TBCs (all concentrations in ppb)									
	Federal Maximum Contaminant Level ⁽¹⁾	Virginia Maximum Contaminant Level ⁽²⁾	Federal Ambient Water Quality Criteria ⁽³⁾			Virginia Water Quality Standards ⁽⁴⁾			USEPA Risk-based Concentrations in Drinking Water ⁽⁵⁾	Virginia Groundwater Standards ⁽⁶⁾
			Fresh	Salt	Water & Fish Ingestion	Fresh	Salt	Water & Fish Ingestion		
Antimony	6		30	500	146				15	
Selenium	50	10	35	54	10	5	71	11,200	180	10
Thallium	2	40			13					
Vanadium									260	
Zinc			110 ⁽¹⁵⁾	86		(13)	86	5,000	11,000	50
Arsenic (carcinogen)	50				0.002			50	0.038	50

Key: ARAR = Applicable or Relevant and Appropriate Requirement

TBC = To Be Considered

USEPA = U.S. Environmental Protection Agency

MCL = Maximum Contaminant Level

PCB = Polychlorinated Biphenyl
BEHP = Bis(2-ethylhexyl)phthalate
TPH = Total Petroleum Hydrocarbon
ppb = Parts per billion

Note: Compounds not addressed do not have assigned standards, under Virginia Groundwater Standards, concentrations of these compounds should not exceed natural background levels. For non-naturally occurring compounds, the standard would be non-detect.

⁽¹⁾ Primary Maximum Contaminant Levels; 40 CFR 141. These standards are relevant and appropriate for cleanup at the Woodbridge Research Facility.

⁽²⁾ Commonwealth of Virginia, State Board of Health, Water Works Regulations (VR-355-18-000). These values are relevant and appropriate to the cleanup at Woodbridge Research Facility.

⁽³⁾ Water Quality Criteria, USEPA Office of Water, 1986. "Chronic" values. These are TBC only.

⁽⁴⁾ Virginia Water Quality Standards for Protection of Aquatic Life and Human Health (VR 680-21-40-3). "Chronic" values. These would be applicable to discharge of treated effluent to surface water. "Fish" criteria are for human ingestion of fish. These are not effluent (end-of-pipe) standards; the discharge has the opportunity to dilute the wastewater in a small area of the receiving stream, as long as elevated concentrations in this "mixing zone" do not interfere with, or cause acute lethal effects on passing or drifting aquatic life.

⁽⁵⁾ USEPA Region III Risk-based Concentrations (Tap Water) (October 15, 1993). These levels were developed by USEPA Region III as a threshold to determine whether additional investigation is necessary to characterize risk. They are non-enforceable and are not cleanup levels. These are TBC.

⁽⁶⁾ Water Quality Standards for Groundwater (VR 680-21-05.1). These are enforceable standards and are therefore applicable to the cleanup at the Woodbridge Research Facility. Mixing provisions apply (see Footnote 4).

⁽⁷⁾ Secondary Maximum Contaminant Levels (40 CFR 143.3). These are non-enforceable aesthetic standards, and are therefore TBC.

⁽⁸⁾ Commonwealth of Virginia, State Board of Health, Water Works Regulations (VR-355-18-000). These are non-enforceable, and are therefore TBC.

⁽⁹⁾ 0.7852 in (hardness as 25 - 400 mg/L CaCO₃) - 3.4901).

⁽¹⁰⁾ 0.8545 in (hardness as 25 - 400 mg/L CaCO₃) - 1.465).

⁽¹¹⁾ 0.8460 in (hardness as 25 - 400 mg/L CaCO₃) + 1.645).

⁽¹²⁾ 1.273 in (hardness as 25 - 400 mg/L CaCO₃) - 4.705).

⁽¹³⁾ 0.8473 in (hardness as 25 - 400 mg/L CaCO₃) + 0.7614).

⁽¹⁴⁾ 0.5 is value for total PCB concentrations, not individual PCB concentrations.

⁽¹⁵⁾ Hardness value of 100 mg/L used; site-specific value not available.

TABLE 3-19
POTENTIAL SEDIMENT TBCs⁽¹⁾ FOR CHEMICALS OF CONCERN AT
WOODBRIIDGE RESEARCH FACILITY

Analytes	Potential TBCs (concentrations in ppb)	
	Effects Range Low	Effects Range Median
Chlorobenzene	--	--
1,4-Dichlorobenzene	--	--
1,2-Dichlorobenzene	--	--
Polychlorinated Biphenyls	22.7	180

Key: TBC = To Be Considered
 ppb = Parts per billion

Source: Long and Morgan, 1990.

SECTION 4.0

SITE INSPECTION RESULTS

The results of the sampling and analysis program completed during the SI are discussed below. Samples were collected from background locations as well as individual AREEs identified in the Enhanced Preliminary Assessment.

4.1 BACKGROUND

The sampling program for the SI at WRF included the collection of background surface soil samples. Two locations, BGSS01 and BGSS02 as illustrated on Figure 4-1, were chosen off the main road at the top of a hill in an area judged to be unaffected by past U.S. Army activities. These locations were selected after a review of historical records, maps, aerial photographs, and an assessment of potential contaminant sources and migration pathways. The review indicated that the area chosen for background sample collection had not been affected by past activities.

The soil samples were collected for chemical analysis to establish a range of naturally occurring concentrations of metals in the soil at WRF. Organic analytes are not expected to occur naturally in the soils at WRF at concentrations which are detectable by the standard methods employed during the analytical program. The detection of these target organic analytes will be considered as an identification of a contaminant of concern. The CRLs for all the organic analytes targeted in the analytical program completed during the SI are listed in Appendix M. The background analytical data collected can be compared to data from AREEs to determine if contamination is present at an AREE. A detailed discussion of background levels is presented in the following sections.

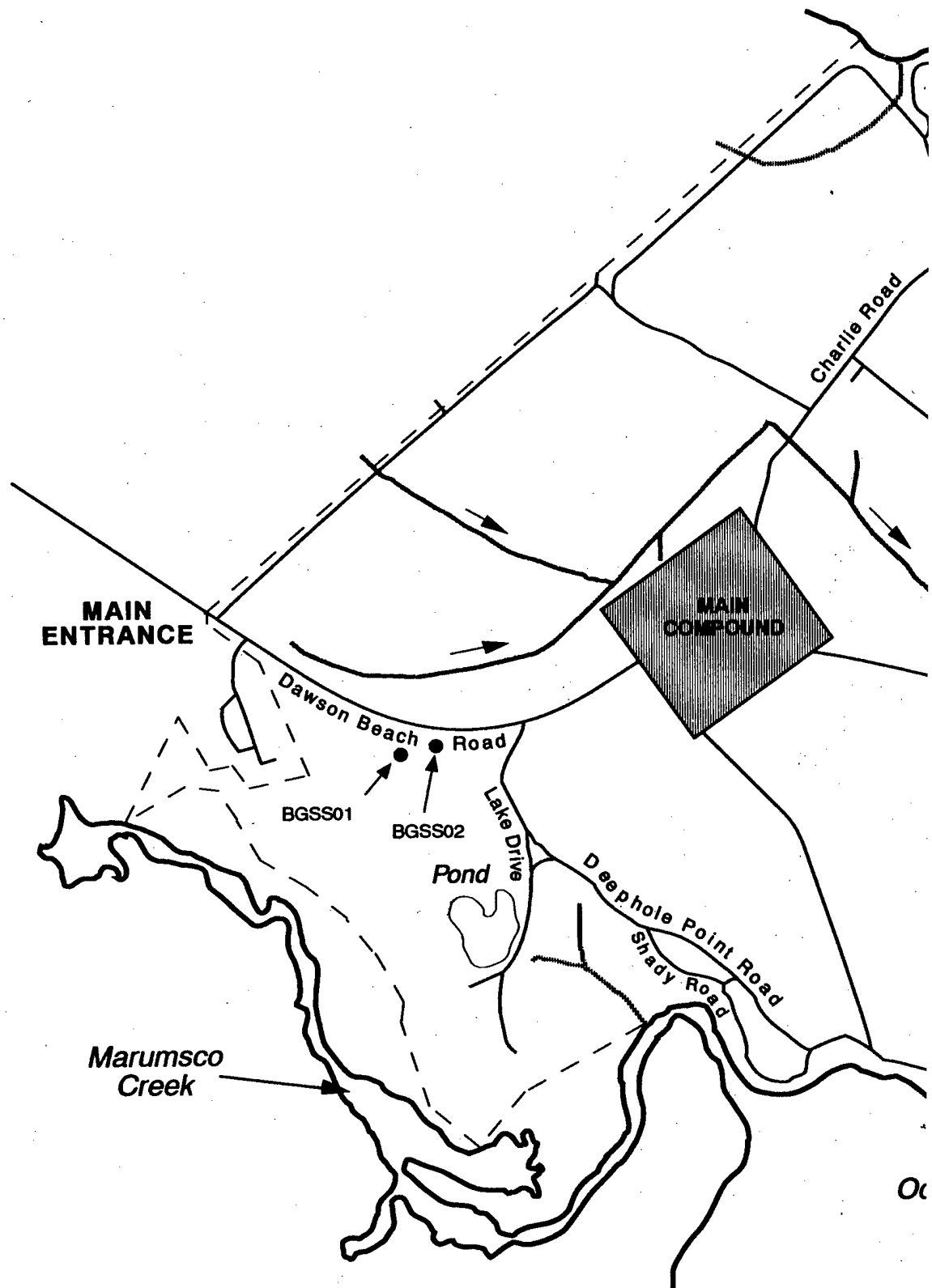
4.1.1 Summary of Field Activities and Analytical Program

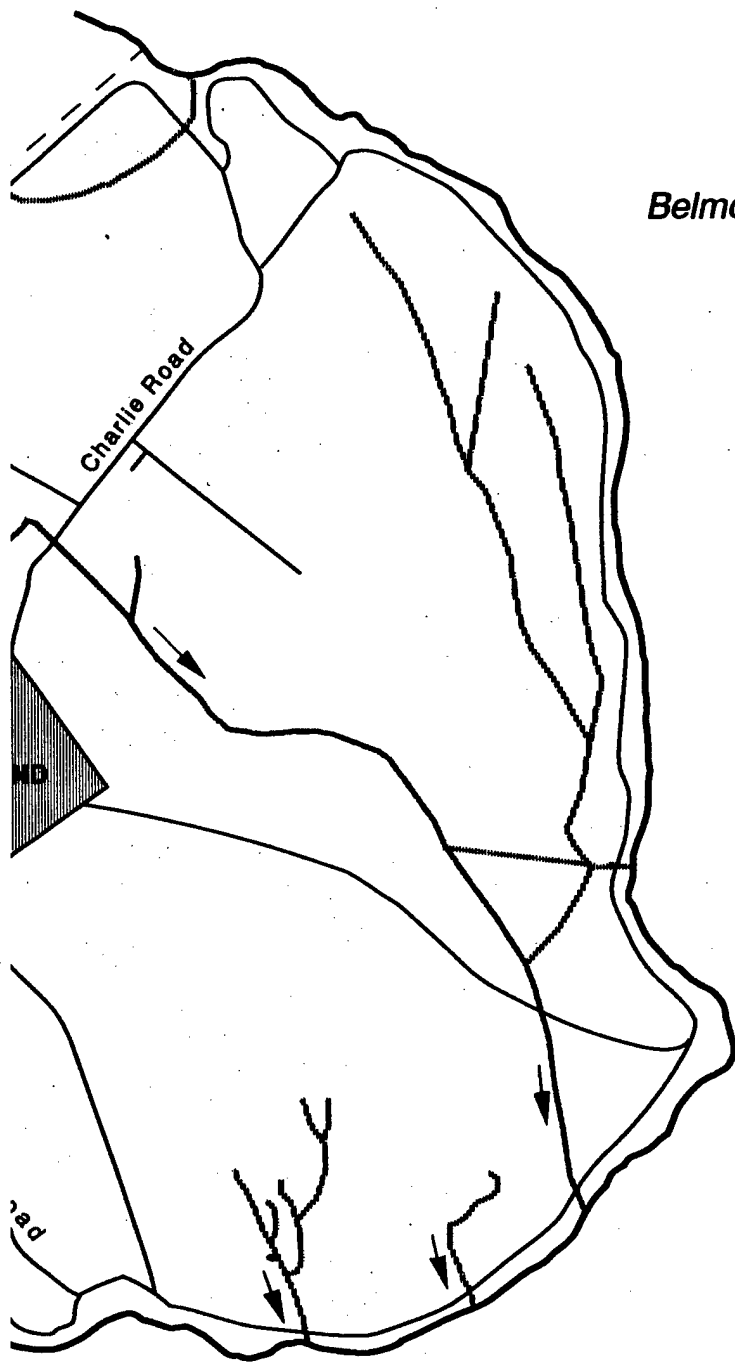
One background soil sample was collected at each of the two locations shown on Figure 4-1. In addition, a replicate sample was collected at location BGSS01 as part of the QA/QC program for the investigation. Both soil samples and the replicate were collected at a depth of approximately 0.5 feet bgs using a stainless-steel scoop. Both soil samples and the replicate were analyzed for metals and soil moisture; the soil sample and replicate collected at location BGSS01 were also analyzed for pH.

4.1.2 Data Summary

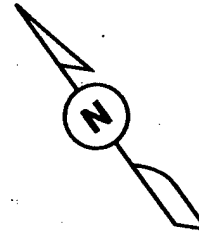
A summary of the analytical results for the analyses performed on the background soil samples and replicate are provided in Table 4-1. The soil moisture determined in the laboratory was used to convert soil analytical results to a dry-weight basis. The concentrations provided in Table 4-1 are reported on a dry-weight basis.

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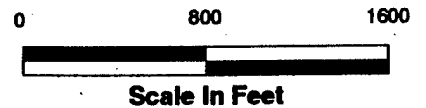


Belmont Bay



KEY

- — Facility Boundary
- Road
- > Drainage and Flow Direction
- Sample Points



Occoquan Bay

EARTH TECH

FIGURE 4-1

Background Sampling Locations

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TABLE 4-1
BACKGROUND SOIL SAMPLING RESULTS AND USGS SOIL DATA

Analyte ⁽²⁾	Method Detection Limit	Background Soil Data			USGS Regional Data ⁽¹⁾	
		Sample Number			Range	Range
		BGSS0101 @ 0.5 feet bgs	BGSS0102 ⁽³⁾ @ 0.5 feet bgs	BGSS0201 @ 0.5 feet bgs		
pH	0.1	5.6	6.1	--	5.6 - 6.1	--
Aluminum	10.7	14,000	14,000	10,000	10,000 - 14,000	50,000-100,000
Arsenic	12.7	NA	NA	NA	NA	2.6-6.5
Barium	4.9	70.9	71.4	61.6	61.6 - 71.4	300-700
Beryllium	0.3	0.802	0.668	0.572	0.572 - 0.802	≤1
Calcium	109	1,280	1,360	1,720	1,280 - 1,720	3,500-5,200
Cadmium	0.4	ND	ND	ND	ND	--
Cobalt	2.5	3.42	ND	13.8	ND - 13.8	3-7
Chromium	1.0	23.9	21.9	21.3	21.3 - 23.9	30-70
Copper	3.4	5.62	5.75	6.67	5.62 - 6.67	20-30
Iron	12.0	18,000	18,000	16,000	16,000 - 18,000	20,000-50,000
Potassium	142	428	408	477	408 - 477	6,800-16,000
Magnesium	138	1,270	1,310	1,120	1,120 - 1,310	20,000-30,000
Manganese	0.5	112	107	300	107 - 300	200-300
Mercury	--	NA	NA	ND	ND	0.082 - 0.13
Molybdenum	4.0	ND	ND	ND	ND	≤3
Sodium	50.0	ND	ND	ND	ND	500-2,000
Nickel	7.5	ND	ND	ND	ND	10-20
Lead	10.0	17.7	18.8	22.1	17.7 - 22.1	15-150
Antimony	82.9	ND	ND	ND	ND	≤1
Selenium	12.4	ND	ND	ND	ND	0.1-5
Thallium	12.5	ND	ND	ND	ND	--
Vanadium	2.0	49.2	47.1	38.1	38.1 - 49.2	70-150
Zinc	4.0	42.3	41.4	37.4	37.4 - 42.3	28-74

Key: USGS = United States Geological Survey
 NA = Not Analyzed
 ND = Not Detected
 -- = Not Available
 bgs = Below Ground Surface

Notes: ⁽¹⁾ U.S. Geological Survey, 1984.

⁽²⁾ Inorganic concentrations reported in micrograms per gram (µg/g) and pH concentrations reported in pH units.

⁽³⁾ Replicate.

All analytes were detected at concentrations above their appropriate detection limits in at least one sample except for antimony, cadmium, mercury, molybdenum, nickel, selenium, sodium, and thallium. The detected concentrations were used to establish a background concentration range for each analyte which is also provided in Table 4-1. In addition, Table 4-1 includes the concentration ranges for the analytes as published by the USGS (USGS, 1984) for surficial soil samples collected within the WRF geographical area. It should be noted that no USGS data are available for cadmium and thallium as indicated in the table.

4.1.3 Evaluation

The purpose of background sample collection and analysis is to establish a range of naturally occurring concentrations for compounds that may be found in the soil at the WRF. As discussed above, background soil samples were collected and analyzed for the purposes of establishing this range of concentrations which is shown on Table 4-1 for each analyte. To assure that the detected concentrations for each analyte can be considered naturally occurring, a comparison to published regional data can be performed.

When the background metals concentrations ranges are compared to the regional USGS metals concentrations ranges, cobalt was the only inorganic to exceed the regional USGS ranges. The detected background range for cobalt is 3.42 to 13.8 $\mu\text{g/g}$ and the detected USGS range for cobalt is 3 to 7 $\mu\text{g/g}$.

4.1.4 Conclusions

Since background metals concentrations are either within or only slightly in excess of the regional USGS values, it is assumed that the background samples were collected from areas which were unaffected by past U.S. Army activities and are representative of naturally occurring conditions. In addition, the background sample results and USGS data are considered to be adequate to evaluate potential metals contamination in soil at individual AREEs.

4.2 AREE 1 (FORMER DUMP No. 1)

4.2.1 Summary of Field Activities and Analytical Program

During the site reconnaissance conducted at AREE 1, WRF facility personnel: identified the approximate location and orientation of the former disposal trenches at this former dump; reported these disposal trenches were estimated, and reported the former dump consisted of at least two trenches. The trenches were estimated existing parallel to each other in the slope of the hill along an approximate north-south orientation.

After site reconnaissance, geophysical surveys were performed at AREE 1 to establish the limits of the past trenches of the former dump. Two geophysical survey

techniques were utilized; magnetic and EMI profiling. Based on the information gathered during the site reconnaissance, a grid was established for the surveys. Profile lines were laid out along an east-west orientation with a grid spacing of 20 feet. Readings were collected at 10-foot intervals along the profile lines. The grid boundary of the geophysical surveys for AREE 1 is shown on Figure 4-2.

Five anomalies were identified by the geophysical surveys as shown on Figure 4-2. Three of the five anomalies were detected in the areas identified by facility personnel as the approximate former disposal trench locations. The subsequent excavation and soil sampling activities focused on these three anomalies.

Four trenches were excavated by a backhoe to investigate the anomalies at the locations shown on Figure 4-2. A summary of the excavation and soil sampling activities for AREE 1 is provided in Table 4-2.

TABLE 4-2
AREE 1 EXCAVATION AND SOIL SAMPLING ACTIVITIES SUMMARY

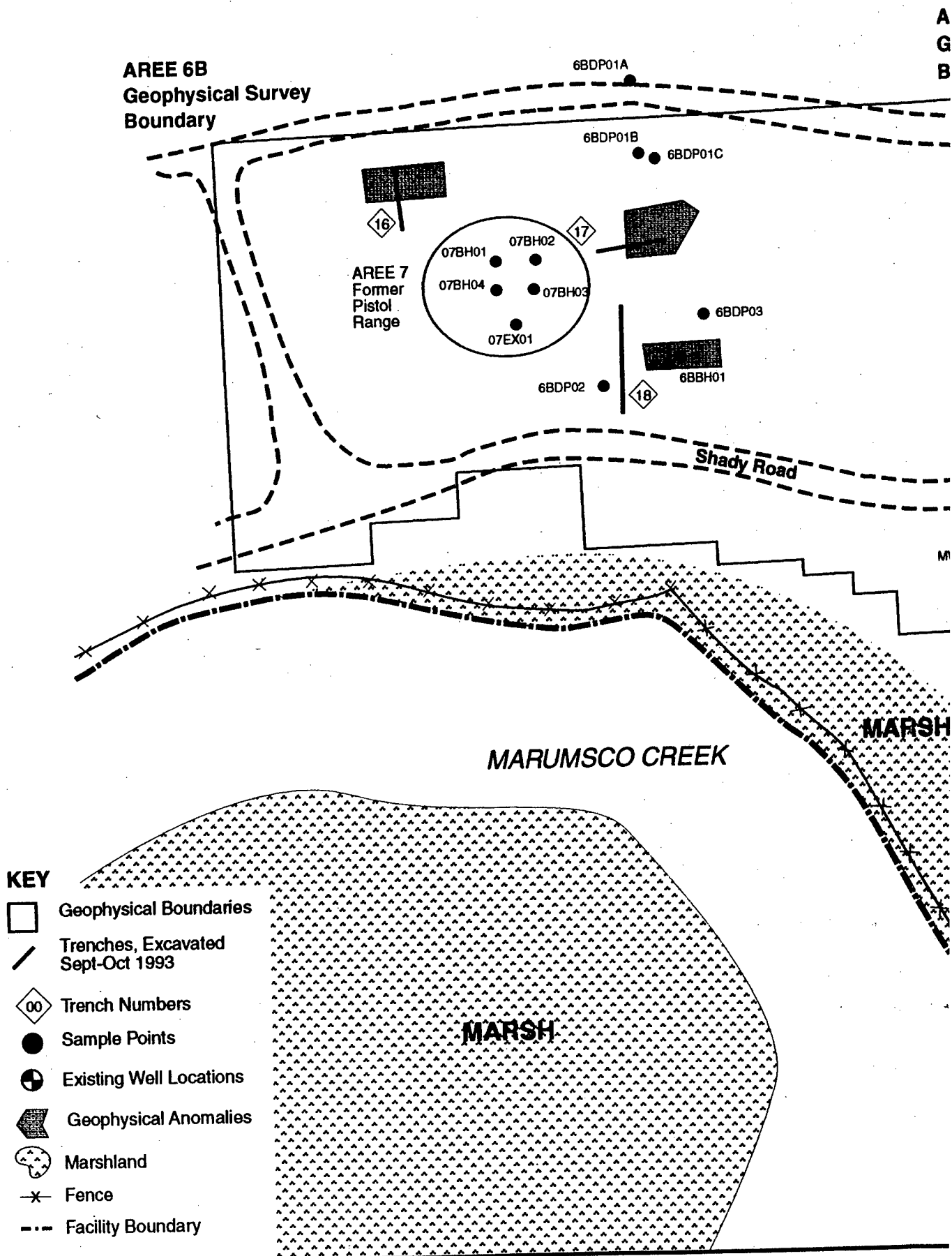
Trench Number	Date Excavated	Trench Length (feet)	Trench Depth (feet)	Debris Found	Sample Collected	Sample Location	Sample Number	Analyses
19	09/29/93	30	5	No	No	NA	NA	NA
20	09/28/93	100	6	Yes	Yes	01EX01	01EX0101	PCBs/ Pesticides
21	09/29/93	65	6	Yes	Yes	01EX02	01EX0201 01EX0202 ⁽¹⁾	PCBs/ Pesticides PCBs/ Pesticides
22	09/29/93	9	4.5	No	No	NA	NA	NA

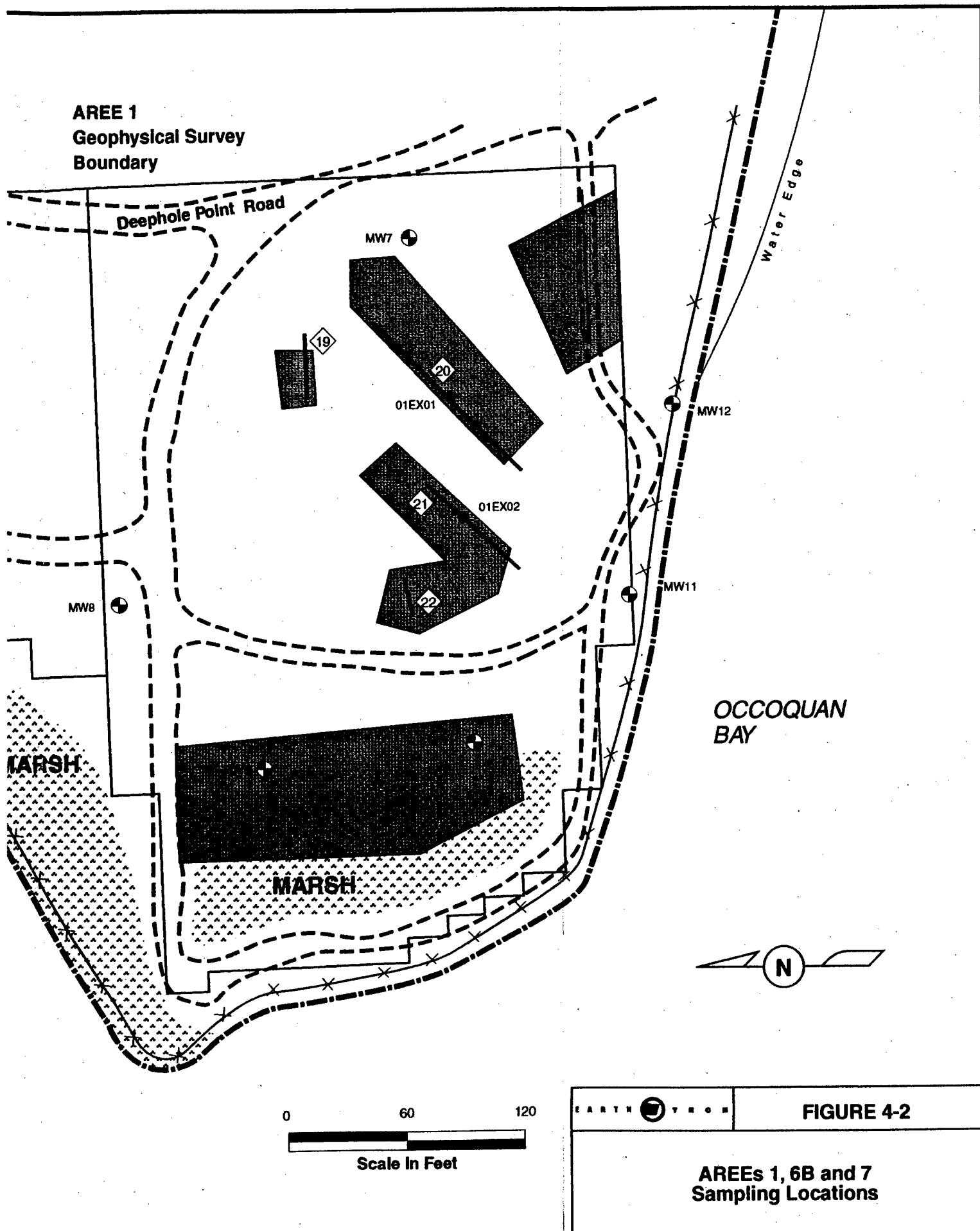
Key: AREE = Area Requiring Environmental Evaluation
PCB = Polychlorinated Biphenyl
NA = Not Applicable

Note: ⁽¹⁾ Replicate.

Trench 19 was approximately 30 feet long and 5 feet deep. No debris was encountered during the excavation. Trench 20 was approximately 100 feet long and 6 feet deep. Debris consisting of metal wires, cables, a "telephone" pole, scrap metal, plastic, concrete, and metal rods was found during the excavation of Trench 20. Trench 21 was approximately 65 feet long and 6 feet deep. Debris was also found during the excavation of Trench 21. Trench 21 uncovered wire screens, a plastic drop cloth, riveted sheet metal, timbers, and a drainage culvert section. Trench 22 was approximately 9 feet long and 4.5 feet deep, with no debris encountered.

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During the excavation of all of these trenches, air monitoring was performed, and no elevated readings were observed with the HNu. At one point during the excavation of Trench 20, an odor that smelled of creosote was noted; however, only a maximum reading of 1.5 ppm was recorded with the HNu.

The presence of the debris prompted the collection of soil samples from Trenches 20 and 21. One soil sample was collected from each of the two trenches at a depth of approximately 6 feet at the locations shown on Figure 4-2. In addition, a replicate sample was collected at location 01EX02 at the same depth as the sample. The soil samples and replicate were analyzed for PCBs/pesticides as well as soil moisture.

SI activities at AREE 1 also included the sampling of the six existing monitoring wells illustrated on Figure 4-2 (MW7 through MW12). One sample was collected from each existing well with a duplicate sample collected at MW10. All groundwater samples were analyzed for VOCs and PCBs/pesticides.

As part of the groundwater sampling procedures, the water levels were measured in each well prior to purging and sampling. Water levels were also measured on two other occasions in an attempt to determine groundwater flow directions.

All sampling locations, the ends of excavated trenches, and geophysical grid corners were surveyed. Surveying activities for each point included the determination of the elevation with respect to MSL and the calculation of the State Plane coordinates.

4.2.2 Data Summary

The results from the geophysical surveys were used to prepare magnetic and conductivity contour maps which are presented in Appendix L. These contour maps were then used to delineate anomalies that represented areas of suspected buried material. The five anomalies identified by the geophysical surveys are illustrated on Figure 4-2.

A summary of the analytical results for the soil samples collected at AREE 1 is provided in Table 4-3. Only those analytes that were detected above their appropriate detection limit are included in Table 4-3 with the concentrations reported on a dry-weight basis. As noted in the table, PCB-1242 was detected in soil sample 01EX0101 at a concentration of 0.244 $\mu\text{g/g}$, and PCB-1260 was detected in soil sample 01EX0201 and replicate 01EX0202 at concentrations of 74 $\mu\text{g/g}$ and 31 $\mu\text{g/g}$, respectively. These data were qualified with a "K" due to the sample extraction and preparation being performed one day beyond the holding times for the parameters.

The groundwater samples collected from the existing wells at AREE 1 were analyzed for VOCs and PCBs/pesticides. The only VOC detected in any of the groundwater samples was acetone, detected at a concentration of 13 $\mu\text{g/L}$ from the sample collected at MW11. This result was qualified due to a low spike recovery from the sample. No PCBs or pesticides were detected in any of the groundwater samples.

TABLE 4-3
AREE 1 SOIL SAMPLING RESULTS SUMMARY

Analytes ⁽¹⁾	Detection Limit	01EX0101 @6.0 feet bgs	01EX0201 @6.0 feet bgs	01EX0202 ⁽²⁾ @6.0 feet bgs
PCB-1242	0.04	0.244 K	ND K	ND K
PCB-1260	0.04	ND K	74 K	31 K

Key: PCB = Polychlorinated Biphenyl ND = Not Detected
 AREE = Area Requiring Environmental Evaluation K = Qualifier for missed
 bgs = Below ground surface holding times for extraction and preparation

Notes: ⁽¹⁾Concentrations reported in micrograms per gram ($\mu\text{g/g}$).

⁽²⁾ Replicate.

Table 4-4 provides the water level measurements from the existing wells at AREE 1. Three sets of water level measurements are presented: one set of measurements collected prior to purging and sampling and two sets collected on separate occasions to determine groundwater flow directions. All water levels are provided as depths bgs as well as groundwater elevations referenced to MSL.

Surveying data are provided in Appendix D. The data include elevations with respect to MSL and the State Plane coordinates of all sampling locations, ends of trenches, and geophysical grid corners.

4.2.3 Evaluation

Buried material was found at two of the three anomalies investigated via excavation. The anomaly at which Trench 19 was excavated may have been caused by surface debris. Additionally, the portion of the anomaly at which Trench 22 was excavated may have been caused by surface debris as no buried material was discovered while excavating Trench 22.

The purpose of the soil sampling at AREE 1 was to identify possible soil contamination projected to be caused by releases from buried material. For this reason, soil samples were only collected in trenches that uncovered buried debris. The analyses of the soil samples and replicate identified PCB contamination in the soil near the buried debris.

The levels of PCB contamination in the soil sample and replicate collected from 01EX02 are above potential soil TBCs for PCBs as presented in Table 3-15. The detected value of PCBs in the replicate and a soil sample from this site are above the 1 $\mu\text{g/g}$ USEPA-recommended soil action level. The detected value of PCBs in sample 01EX01 is less than the 1 $\mu\text{g/g}$ USEPA recommended soil action level and the 0.37 $\mu\text{g/g}$ USEPA Region III risk-based concentration for commercial (industrial) sites. The

TABLE 4-4
AREE 1 WATER LEVEL MEASUREMENTS

Well Number	Date Measured	Time Measured	Depth to Water (feet bgs)	Ground Elevation (feet MSL)	Groundwater Elevation (feet MSL)
7	9/16/93	1325	24.55	25.91	1.36
8	9/16/93	1105	6.95	8.46	1.51
9	9/16/93	1005	1.85	2.65	0.80
9	10/2/93	0915	1.05	2.65	1.60
10	9/16/93	0845	2.39	3.40	1.01
11	9/15/93	1022	2.06	3.50	1.44
12	9/14/93	1545	3.92	5.20	1.28
7	5/18/94	1517	24.86	25.91	1.05
8	5/18/94	1447	6.89	8.46	1.57
9	5/18/94	1451	2.40	2.65	0.25
10	5/18/94	1455	3.09	3.40	0.31
11	5/18/94	1459	2.99	3.50	0.51
12	5/18/94	1504	3.91	5.20	1.29
7	6/14/94	1505	24.74	25.91	1.17
8	6/14/94	1511	6.76	8.46	1.70
9	6/14/94	1515	2.00	2.65	0.65
10	6/14/94	1520	2.62	3.40	0.78
11	6/14/94	1524	2.60	3.50	0.90
12	6/14/94	1528	3.73	5.20	1.47

Key: AREE = Area Requiring Environmental Evaluation
bgs = Below Ground Surface
MSL = Mean Sea Level

detected value of 0.244 $\mu\text{g/g}$ in 01EX01 is higher than the 0.083 USEPA Region III risk-based concentration for residential sites. The qualifier "K" is necessary due to the missed holding time, however one day does not interfere with the validity of the results.

Groundwater sampling at AREE 1 was completed to identify possible contamination that may have leached from any buried material to the groundwater. Although acetone was detected in the sample collected from MW11, this analyte is a typical laboratory contaminant. In addition, the detected value of 13 $\mu\text{g/L}$ is well below the 3,700 $\mu\text{g/L}$ USEPA risk-based concentration in drinking water for acetone. No other VOCs, PCBs or pesticides were detected in any of the groundwater samples.

Since the water levels measured at the time of groundwater purging and sampling were collected over a period of a few days, these data are not directly usable for the determination of groundwater flow directions. However, the other two sets of data can be utilized to estimate the direction of groundwater flow. Figure 4-3 illustrates the groundwater elevations and contours determined from the 18 May 1994 water levels measured. The data collected in June 1994 exhibits similar contours. From the contours shown on the figure, groundwater at AREE 1 appears to be converging from the southeast and northeast to ultimately flow in a westward direction.

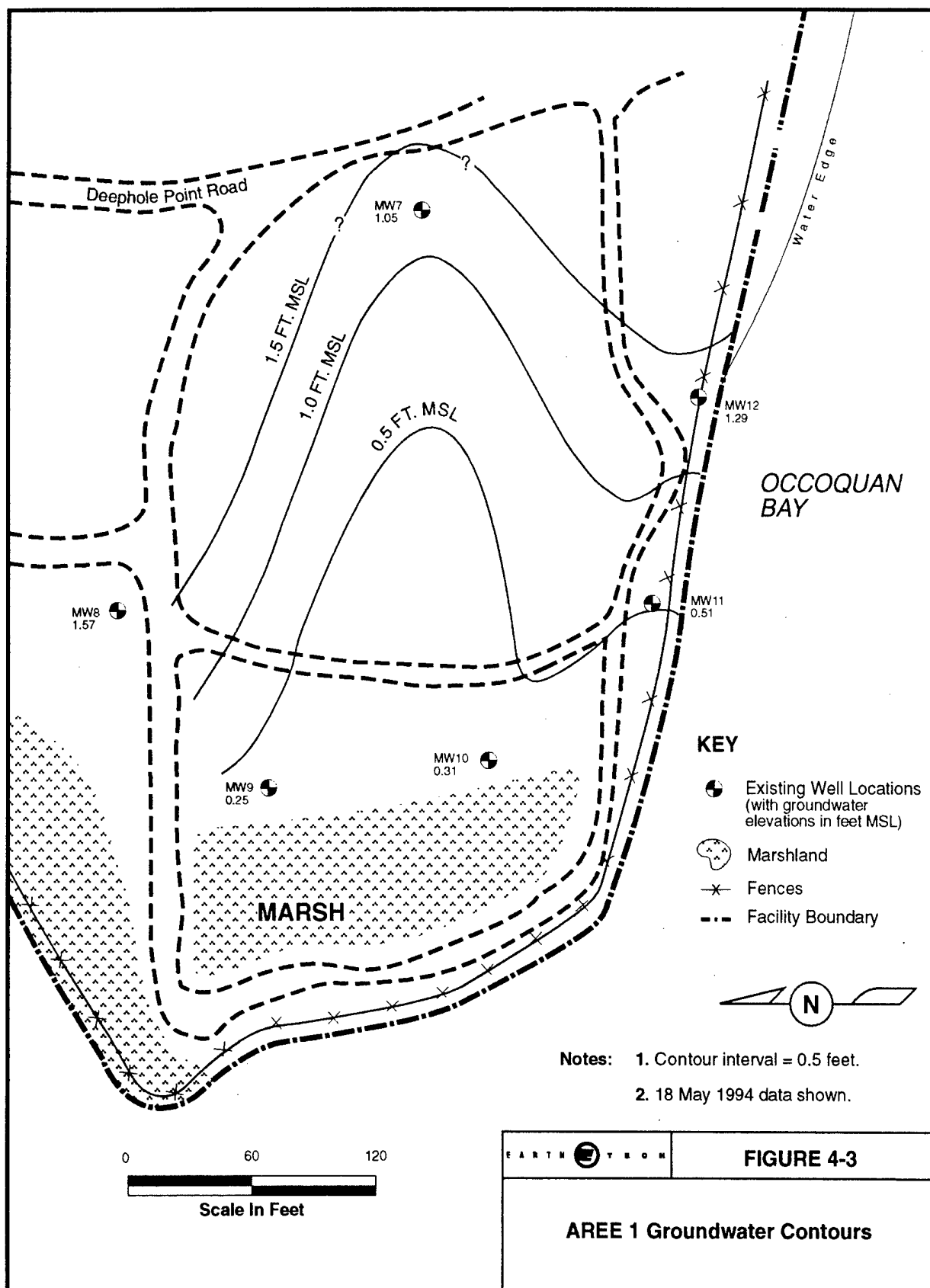
4.2.4 Conclusions

The geophysical survey anomaly where Trench 19 was completed should not require any further action since buried debris was not encountered; the anomaly was most likely the result of the observed surface debris.

The other four anomalies identified with the geophysical surveys require further evaluation. Two anomalies investigated via excavation and soil sampling identified buried material and soil contamination. The two anomalies not investigated via excavation should be examined to determine their potential as sources of contamination.

Analytical results did not indicate groundwater contamination in the existing wells surrounding AREE 1.

Based on results of a surface water sampling program conducted by the State of Virginia, contamination may be migrating from AREE 1 via a pathway not investigated under this SI. Possible contaminant migration pathways that need to be evaluated at AREE 1 include surface water, sediment, and biota.



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4.3 AREE 2 (FORMER DUMP NO. 2)

4.3.1 Summary of Field Activities and Analytical Program

The SI at AREE 2 was planned to include the sampling of six existing wells illustrated on Figure 4-4. Existing well MW6, however, was damaged and inaccessible. The stickup for MW6 was bent at such an angle that the bailer being used for groundwater sampling could not be inserted into the well. One sample was collected from each of the five accessible existing wells. All groundwater samples were analyzed for VOCs and PCBs/pesticides. Water levels were measured in each well prior to purging and sampling. Water levels were also measured on two other occasions to aid the determination of groundwater flow directions.

Included in the SI activities at AREE 2 was the sampling of surface water and sediment to identify potential contamination possibly migrating via runoff from the area bounded by Lake Drive and Deephole Point Road. A surface water and sediment sample pair was collected at each of four separate locations. The surface water and sediment pair locations are illustrated on Figure 4-4 as 02SW01/02SE01, 02SW02/02SE02, 02SW03/02SE03, and 02SW04/02SE04. A duplicate surface water sample was also collected at location 02SW02.

All surface water and sediment sampling was conducted immediately after a rainfall event. The surface water and sediment samples were analyzed for TPHs and PCBs/pesticides with the sediment samples also being analyzed for soil moisture. The duplicate surface water sample was analyzed only for PCBs/pesticides.

All sampling locations at AREE 2 were surveyed. Surveying activities for each point included the determination of the elevation with respect to MSL and the calculation of the State Plane coordinates for each location.

4.3.2 Data Summary

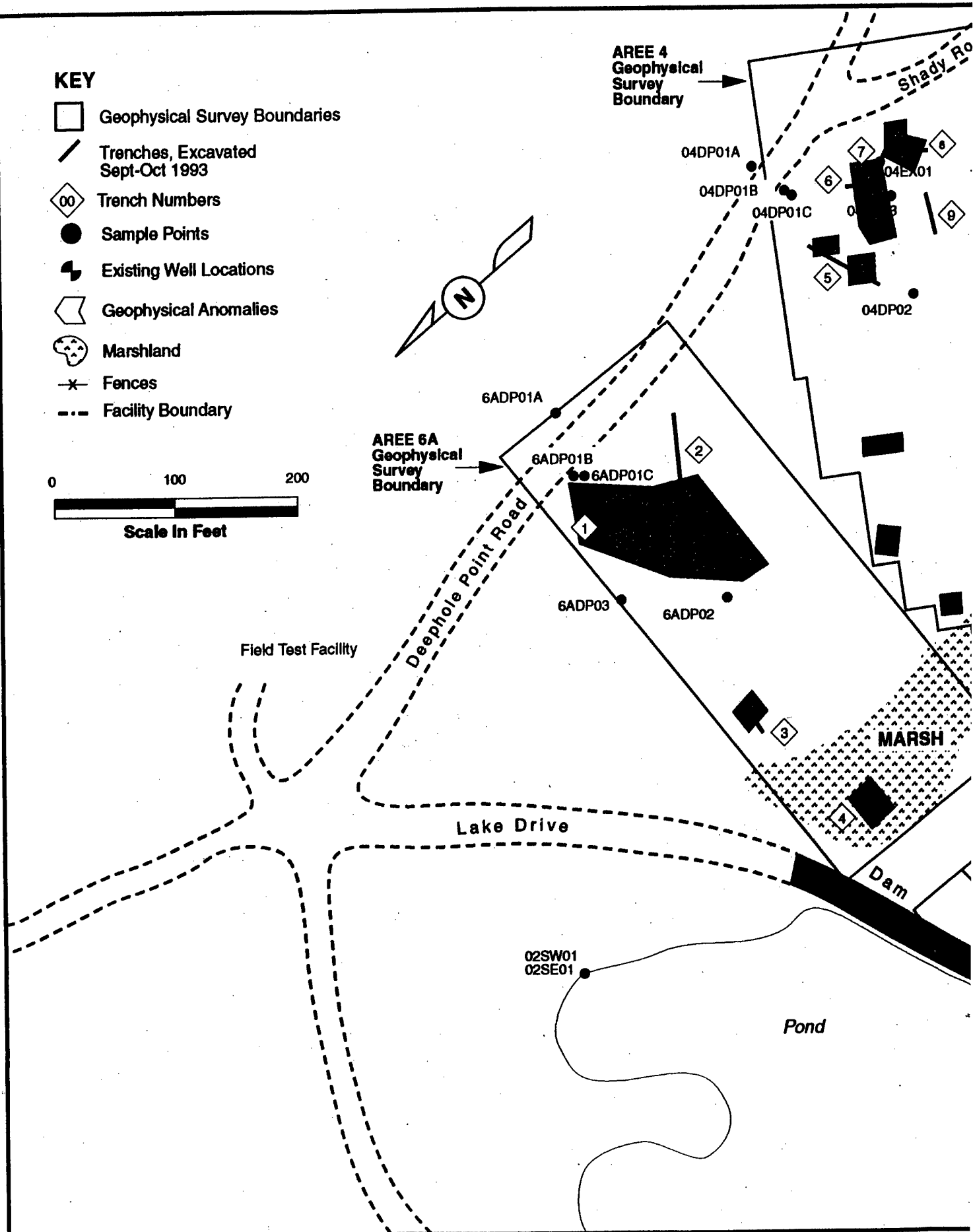
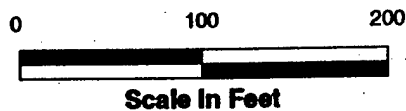
The groundwater samples collected from the existing wells at AREE 2 were analyzed for VOCs and PCBs/pesticides. None of these analytes were reported at concentrations above the detection limit in any of the groundwater samples.

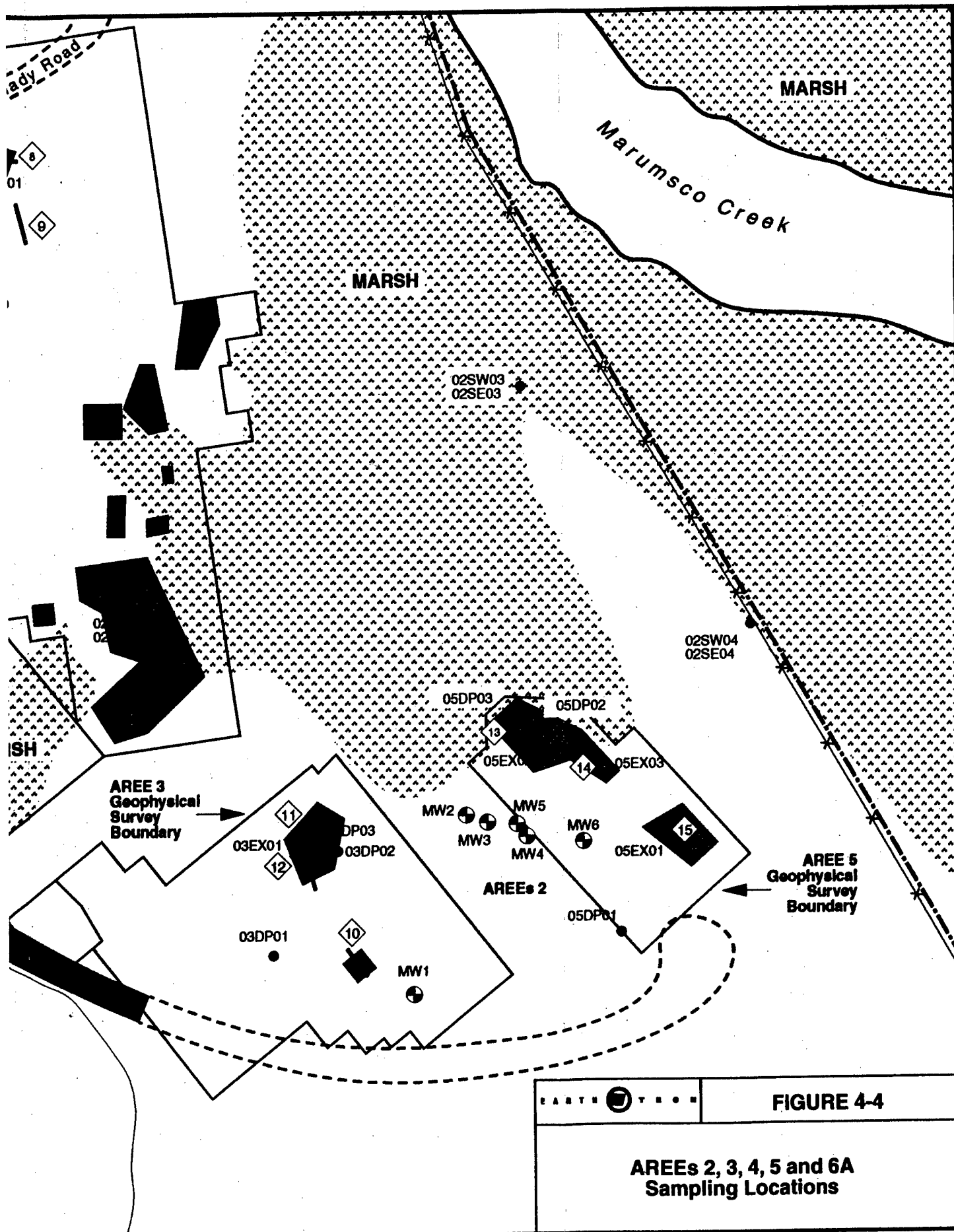
The surface water samples and duplicate collected at AREE 2, were analyzed for TPH and PCBs/pesticides. None of these analytes were reported at concentrations above the detection limit in the surface water samples. TPHs were not detected in any sediment sample collected at AREE 2. However, PCB-1260 was detected in three of the four sediment samples. Table 4-5 provides a summary of the PCB results for the sediment samples collected as part of AREE 2. The concentrations reported in Table 4-5 are on a dry-weight basis with only those analytes detected above their appropriate detection limit listed. As shown on Table 4-5, the detected concentrations of PCB-1260 were 0.14 $\mu\text{g/g}$, 0.13 $\mu\text{g/g}$, and 0.07 $\mu\text{g/g}$ in sediment samples collected from 02SE01, 02SE02, and 02SE04, respectively.

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KEY

- Geophysical Survey Boundaries
- Trenches, Excavated Sept-Oct 1993
- Trench Numbers
- Sample Points
- Existing Well Locations
- Geophysical Anomalies
- Marshland
- Fences
- Facility Boundary





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TABLE 4-5
AREE 2 SEDIMENT SAMPLING RESULTS SUMMARY

Analytes ⁽¹⁾	Detection Limit	Sample Location			
		02SE01	02SE02	02SE03	02SE04
PCB-1260	0.04	0.14 S	0.13 S	ND T	0.07 S

Key: AREE = Area Requiring Environmental Evaluation
PCB = Polychlorinated Biphenyl
ND = Not Detected
S = Flag for non-target compound analyzed for and detected
T = Flag for non-target compound analyzed for and not detected

Note: ⁽¹⁾ Concentrations reported in micrograms per gram ($\mu\text{g/g}$).

The water level measurements from the existing wells at AREE 2 are provided in Table 4-6. Three sets of water level measurements are presented: one set collected prior to purging and sampling and two sets collected on separate occasions to determine groundwater flow direction. All water levels are provided as depths bgs as well as groundwater elevations referenced to MSL. Appendix C includes all purging and groundwater sampling records.

Survey data activities are provided in Appendix D. The data include elevations with respect to MSL and the State Plane coordinates of all sampling locations.

4.3.3 Evaluation

The groundwater sampling at AREE 2 was completed to identify possible contamination resulting from past disposal actions. The analytical results for the groundwater samples from AREE 2 indicated no detection of VOCs, PCBs, or pesticides.

The analytical results for the surface water samples from AREE 2 reported no detection of TPHs, PCBs, or pesticides. However, PCBs were detected in three of the four sediment samples collected at concentrations which are below both the $1 \mu\text{g/g}$ USEPA-recommended soil action level and the $0.37 \mu\text{g/g}$ USEPA Region III risk-based concentration for commercial (industrial) sites. However, while only two of the three reported PCB concentrations are greater than the $0.083 \mu\text{g/g}$ USEPA Region III risk-based concentration for residential sites, all three were below the sediment TBC range of 22.7 to $180 \mu\text{g/g}$. The highest detected value of PCB contamination was identified in the sediment sample collected from the pond. Following the surface runoff, concentrations decreased from the pond to Marumsco Creek.

TABLE 4-6
AREE 2 WATER LEVEL MEASUREMENTS

Well Number	Date Measured	Time Measured	Depth to Water (feet bgs)	Ground Elevation (feet MSL)	Groundwater Elevation (feet MSL)
1	9/14/93	1440	10.71	12.64	1.93
2	9/14/93	1403	7.25	7.56	0.31
3	9/14/93	1340	5.85	7.22	1.37
4	9/14/93	1640	6.10	7.47	1.37
5	9/16/93	1550	6.14	7.18	1.04
5	9/14/93	--	5.38	7.18	1.80
6	9/14/93	--	6.87	8.39	1.52
1	5/18/94	1408	9.77	12.64	2.87
2	5/18/94	1417	5.57	7.56	1.99
3	5/18/94	1420	5.25	7.22	1.97
4	5/18/94	1423	5.56	7.47	1.91
5	5/18/94	1426	4.97	7.18	2.21
6	5/18/94	1430	6.41	8.39	1.98
1	6/14/94	1434	10.20	12.64	2.44
2	6/14/94	1439	6.05	7.56	1.51
3	6/14/94	1442	5.75	7.22	1.47
4	6/14/94	1445	6.08	7.47	1.39
5	6/14/94	1448	5.30	7.18	1.88
6	6/14/94	1452	6.90	8.39	1.49

Key: AREE = Area Requiring Environmental Evaluation
bgs = Below Ground Surface
MSL = Mean Sea Level
-- = Not Available

Since the water levels measured at the time of groundwater purging and sampling were collected over a period of a few days, these data are not directly usable for the determination of groundwater flow direction. In addition, since wells MW2 through MW6 are located close together, an accurate depiction of the groundwater flow direction is difficult with the 18 May 1994 and 14 June 1994 data. For this reason, a groundwater contour map was not generated with these data. The data indicate, however, that the water level in well MW1 is roughly 0.9 feet higher than the water levels in wells MW2 through MW6.

4.3.4 Conclusions

Analytical results did not indicate groundwater contamination in the existing wells surrounding AREE 2.

The results of the surface water and sediment sampling conducted at AREE 2 indicate low (less than 0.15 $\mu\text{g/g}$) concentrations of PCB contamination in the sediment in the vicinity of the former dumps. A well-defined source and an accurate migration pathway of the PCB contamination is still in question.

4.4 AREE 3 (FORMER DUMP NO. 3)

4.4.1 Summary of Field Activities and Analytical Program

During the site reconnaissance conducted at AREE 3, WRF facility personnel identified the approximate location and orientation of the former disposal trench at this former dump. WRF personnel reported that the former dump consisted of only one trench that was excavated just north of, and parallel to, the existing treeline.

After site reconnaissance, geophysical surveys were performed at AREE 3 to establish the limits of the past trench of the former dump. Two geophysical survey techniques were utilized: magnetic and EMI profiling. Based on the information gathered during the site reconnaissance, a grid was established for the surveys. Profile lines were laid out along an east-west orientation with a grid spacing of 20 feet. Readings were collected at 10-foot intervals along the profile lines. The grid boundary of the geophysical surveys for AREE 3 is shown on Figure 4-4.

Three anomalies were identified by the geophysical surveys as shown on Figure 4-4. One of the three anomalies was detected in the area initially identified by facility personnel as the approximate trench location. The second anomaly was detected west of this area, just east of well MW1. The third anomaly was detected in the northeast corner of the geophysical grid, along the downgradient slope of the dam for the pond. The subsequent excavation and soil sampling activities focused on the first two anomalies. The third anomaly was identified in an area where it is geotechnically unsound to excavate (in the dam for the pond).

Three trenches were excavated by a backhoe to investigate the anomalies at the locations shown on Figure 4-4. A summary of the excavation and soil sampling activities for AREE 3 is provided in Table 4-7.

TABLE 4-7
AREE 3 EXCAVATION AND SOIL SAMPLING ACTIVITIES SUMMARY

Trench Number	Date Excavated	Trench Length (feet)	Trench Depth (feet)	Debris Found	Sample Collected	Sample Location	Sample Number	Analyses
10	10/05/93	20	6	Yes	No	NA	NA	NA
11	10/05/93	50	6	Yes	No	NA	NA	NA
12	10/05/93	30	6	Yes	Yes	03EX01	03EX0101	PCBs/ Pesticides

Key: AREE = Area Requiring Environmental Evaluation
PCB = Polychlorinated Biphenyl
NA = Not Applicable

Trench 10 was approximately 20 feet long and 6 feet deep. The only debris uncovered was one 3-foot length of 1½-inch diameter metal pipe found near the surface. Trenches 11 and 12 were excavated at approximate lengths of 50 feet and 30 feet, respectively, and each was 6 feet deep. These trenches were excavated perpendicular to each other. Various debris such as a tractor tire, sheet metal, and automobile body parts were uncovered at the intersection of the two trenches. During the excavation of the three trenches at AREE 3, air monitoring was performed with an HNu-brand PID. No elevated readings were reported.

Due to the limited quantity of debris uncovered during the excavation of Trench 10, a soil sample was not collected from the trench. However, the presence of the debris found at the intersection of Trenches 11 and 12 prompted the collection of a soil sample at that location (03EX01). The soil sample was collected from the trench floor at a depth of approximately 6 feet bgs at the intersection of the trenches. Sample location 03EX01 is shown on Figure 4-4. The soil sample was analyzed for PCBs/pesticides and soil moisture as noted in Table 4-7 as well as soil moisture.

SI activities at AREE 3 also included groundwater sampling via the direct push technique. Groundwater samples were to be collected at one location upgradient of the suspected former dump (03DP01) and two downgradient locations (03DP02 and 03DP03) (see Figure 4-4). A summary of the direct push point installation and sampling activities at AREE 3 is provided in Table 4-8. As noted in Table 4-8, groundwater samples could only be collected from points 03DP01 and 03DP02; point

03DP03 was dry at the time of sampling. Both groundwater samples were analyzed for VOCs and PCBs/pesticides.

TABLE 4-8
AREE 3 DIRECT PUSH POINT INSTALLATION AND GROUNDWATER
SAMPLING SUMMARY

Direct Push Point	Installation		Sampling			Analyses
	Date	Depth (feet bgs)	Date	Depth to Water (feet bgs)	Sample Number	
03DP01	09/28/93	16.7	09/30/93	12.7 ⁽¹⁾	03DP0101	VOCs, PCBs/Pesticides
03DP02	09/30/93	14.1	09/30/93 10/01/93	9.0 ⁽¹⁾ 10.0 ⁽²⁾	03DP0201 03DP0201	VOCs PCBs/Pesticides
03DP03	09/30/93	14.0 ⁽³⁾	10/01/93	Dry to 14.0 ⁽²⁾	NA	NA

Key: AREE = Area Requiring Environmental Evaluation
VOC = Volatile Organic Compound
PCB = Polychlorinated Biphenyl
bgs = Below Ground Surface
NA = Not Applicable

Notes: ⁽¹⁾ Depth to water measured at time of installation.
⁽²⁾ Depth to water measured at time of sampling.
⁽³⁾ Approximate installation depth; measured installation depth not recorded.

Water levels were measured at both direct push locations. The water levels were collected to verify that the reported points were installed at their appropriate upgradient/downgradient locations with respect to the former dump.

All sampling locations, the ends of the newly excavated trenches, and the geophysical grid corners at AREE 3 were surveyed. Surveying activities for each location included the determination of the elevation with respect to MSL and the calculation of the State Plane coordinates for the location.

4.4.2 Data Summary

The results from the geophysical surveys were used to prepare magnetic and conductivity contour maps which are presented in Appendix L. These contour maps were then used to delineate anomalies that represented areas of suspected buried material. Three anomalies were identified by the geophysical surveys and are illustrated on Figure 4-4.

The soil sample collected at location 03EX01 was analyzed for PCBs/pesticides. These analytes were not detected in the soil sample.

The groundwater samples collected from the two direct push points at AREE 3 were analyzed for VOCs and PCBs/pesticides. The only VOC detected in either groundwater sample was acetone, detected at a concentration of 18 $\mu\text{g/L}$ from the sample collected at 03DP02 (see Table 4-9). No PCBs or pesticides were detected in either of the groundwater samples.

Table 4-10 provides the water level measurements from the direct push points at AREE 3. All water levels are provided as depths bgs as well as groundwater elevations referenced to MSL.

Survey data activities are provided in Appendix D. The data include elevations with respect to MSL and the State Plane coordinates of all sampling locations, ends of trenches, and geophysical grid corners.

4.4.3 Evaluation

Buried material was found at both anomalies investigated via excavation. A 3-foot length of 1 1/2-inch diameter metal pipe was uncovered at the anomaly where Trench 10 was excavated. This pipe may have been the cause of the anomaly. A greater volume and assortment of debris was uncovered at the other anomaly which was in the area identified by facility personnel as the approximate location of the former dump.

For the anomaly at which no excavation was completed, both the magnetic and conductivity contour maps provided in Appendix L illustrate readings indicative of buried material. In addition, during the site reconnaissance facility personnel suggested various materials such as a water heater and pipe parts may have been used as fill material for the dam. However, this anomaly is located in a disadvantageous geotechnical position along the downgradient slope of the dam for the pond.

The presence of only one 3-foot section of 1 1/2-inch diameter metal pipe did not warrant the collection of a soil sample from Trench 10. The only soil sample collected at AREE 3 was in the area near the intersection of Trenches 11 and 12. The analytical results for this soil sample indicated no detection of PCBs or pesticides.

Acetone was detected in one groundwater sample collected at 03DP02 (this analyte is a typical laboratory contaminant) at a concentration of 18 $\mu\text{g/L}$, below the 3,700 $\mu\text{g/L}$ USEPA risk-based concentration in drinking water for acetone. No other VOCs, PCBs or pesticides were detected in the groundwater samples collected for AREE 3.

TABLE 4-9
AREE 3 GROUNDWATER SAMPLING RESULTS SUMMARY

Analytes ⁽¹⁾	Detection Limit	03DP0101	03DP0201
Acetone	10	ND R	18.0 S

Key: AREE = Area Requiring Environmental Evaluation
 S = Flag for non-target compound analyzed for and detected
 R = Flag for non-target compound analyzed for but non-detected
 ND = Not Detected

Note: ⁽¹⁾ Concentrations reported in micrograms per liter ($\mu\text{g/L}$).

TABLE 4-10
AREE 3 WATER LEVEL MEASUREMENTS

Direct Push Point	Date Measured	Time Measured	Depth to Water (feet bgs)	Ground Elevation (feet MSL)	Groundwater Elevation (feet MSL)
03DP01	09/28/93	1627	12.7 ⁽¹⁾	19.27	6.57
03DP02	09/30/93	1015	9.0 ⁽¹⁾	11.88	2.88
03DP02	10/01/93	0922	10.0 ⁽²⁾	11.88	1.88
03DP03	10/01/93	0924	Dry to 14.0 ⁽²⁾	13.65	NA

Key: AREE = Area Requiring Environmental Evaluation
 bgs = Below Ground Surface
 MSL = Mean Sea Level
 NA = Not Applicable

Notes: ⁽¹⁾ Depth to water measured at time of installation.
⁽²⁾ Depth to water measured at time of sampling.

In general, the direct push technique was also determined to be an unsatisfactory method for the collection of groundwater samples at the WRF. Two major shortcomings were identified with the technique for groundwater sampling. First, knowledge of the groundwater elevation at a proposed location is required prior to installation. Second, the soil conditions at WRF made successful sample collection difficult. The presence of low permeability clay layers resulted in dry sampling points. In addition, the presence of sands resulted in the inability to install points at their desired depths.

Since the water levels measured at the direct push points were collected over a period of a few days, these data are not directly usable for the determination of groundwater flow directions. However, the data confirm the assumption that the points were installed at their appropriate upgradient/downgradient locations with respect to the buried material.

4.4.4 Conclusions

The excavation of Trench 10 uncovered a metal pipe whose size and makeup are consistent with the magnitude of the anomaly identified by the geophysical surveys. Therefore, no further action should be required at this anomaly.

The other anomaly at AREE 3 identified by the geophysical surveys and investigated via excavation is in the reported location of the former disposal trench for the former dump. Although no PCBs or pesticides were detected in the soil sample collected in the vicinity of the buried material, metals may also be a contaminant of concern based on the debris encountered.

The geophysical anomaly identified along the downgradient slope of the dam for the pond may also require further evaluation. Anecdotal information suggests that various materials were used as fill for the dam. A determination of whether the dam should be examined as a potential source of contamination must include a geotechnical analysis of the stability/strength of the dam.

Based on the groundwater sampling and analyses performed, VOCs, PCBs, and pesticides were not identified in the groundwater at AREE 3. The detection of acetone in the sample collected at O3DP02 is most likely attributed to laboratory contamination during analysis. However, contamination may exist in the groundwater beyond the limited area investigated by the direct-push sampling at AREE 3. In addition, future use of the direct push technique for the collection of groundwater samples at AREE 3 may not be appropriate due to the presence of low permeability clay layers in the area.

4.5 AREE 4 (FORMER DUMP NO. 4)

4.5.1 Summary of Field Activities and Analytical Program

During the site reconnaissance conducted at AREE 4, facility personnel identified the approximate location and orientation of the former trenches at this former dump. At that time, facility personnel estimated that the former dump consisted of only one disposal trench with an approximate north-south orientation that had been excavated just west of, and parallel to, Deephole Point Road near its intersection with Shady Road.

After site reconnaissance, geophysical surveys were performed at AREE 4 to establish the limits of the former disposal trench of the former dump. Two geophysical survey techniques were utilized: magnetic and EMI profiling. Based on the information gathered during the site reconnaissance, a grid was established for the surveys. Profile lines were laid out along a southwest-northeast orientation with a grid spacing of 20 feet. Readings were collected at 10-foot intervals along the profile lines. The detection of anomalies west of the area identified by facility personnel as the former dump location prompted the extension of the geophysical survey grid further northwest. The grid boundary of the geophysical surveys for AREE 4 is shown on Figure 4-4.

Numerous anomalies were identified by the geophysical surveys as shown on Figure 4-4. Four of the anomalies were detected in the area tentatively identified by facility personnel as the approximate former disposal trench location. For this reason, the majority of excavation and soil sampling activities at AREE 4 focused on these anomalies.

Five trenches were excavated by a backhoe to investigate the area in the vicinity of the four anomalies (see Figure 4-4). A summary of the excavation and soil sampling activities for AREE 4 is provided in Table 4-11.

The SI included the excavation of four trenches at AREE 4 to investigate anomalies in the area suspected to be the former dump. Trench 5 was approximately 65 feet long and 6 feet deep; no debris was encountered during its excavation. Trench 6 was approximately 20 feet long and 6 feet deep with only a piece of lumber and a piece of styrofoam being found during excavation. Trench 7 was approximately 40 feet long and 6 feet deep. Debris consisting of wood, metal cable, plastic, and barbed wire was found during the excavation of Trench 7. Trench 8 was approximately 30 feet long and 7 feet deep; no debris was encountered during its excavation.

Trench 9 was approximately 45 feet long and 6 feet deep and was located in the area southwest of the anomalies suspected to be the former dump. Although no geophysical anomaly was clearly defined in this area, this trench was excavated due to the presence of mounded soil that is representative of a trench that had been overfilled to offset the likely settlement of backfilled soil. However, neither the

TABLE 4-11
AREE 4 EXCAVATION AND SOIL SAMPLING ACTIVITIES SUMMARY

Trench Number	Date Excavated	Trench Length (feet)	Trench Depth (feet)	Debris Found	Sample Collected	Sample Location	Sample Number	Analyses
5	09/30/93	65	6	No	No	NA	NA	NA
6	09/30/93	20	6	Yes	No	NA	NA	NA
7	09/30/93	40	6	Yes	Yes	04EX01	04EX0101	PCBs/ Pesticides, VOCs, TPHs
8	09/30/93	30	7	No	No	NA	NA	NA
9	09/30/93	45	6	No	No	NA	NA	NA

Key: AREE = Area Requiring Environmental Evaluation VOC = Volatile Organic Compound
 PCB = Polychlorinated Biphenyl TPH = Total Petroleum Hydrocarbon
 NA = Not Applicable

indication of a backfilled trench, nor debris were encountered during the excavation of Trench 9.

During the excavation of all trenches, continuous air monitoring was performed using a HNu-brand PID. No elevated readings were recorded with the HNu in Trenches 5, 6, 8, and 9. During the excavation of Trench 7, low readings (1 to 2 ppm) were recorded with the HNu; however, at one point a maximum reading of 100 ppm was recorded at the same time that an odor which smelled of paint thinner was noted.

As the only material found in Trench 6 was a piece of lumber and a piece of styrofoam, a soil sample was not collected from the trench. The more extensive presence of debris uncovered during the excavation of Trench 7 prompted the collection of a soil sample from this trench. One soil sample was collected from the floor of Trench 7 at a depth of approximately 5.5 feet at the location shown on Figure 4-4. The soil sample was analyzed for PCBs/pesticides, VOCs, and TPHs as noted in Table 4-11; a soil moisture analysis was also completed.

SI activities at AREE 4 also included groundwater sampling via the direct push technique. Groundwater samples were projected to be collected at three locations surrounding the former dump, one upgradient and two downgradient locations. Due to problems arising from the collection of the upgradient sample, a cluster of three points were installed in an attempt to collect the sample. Therefore, a total of five points were installed for AREE 4 (as shown on Figure 4-4): 04DP01A, 04DP01B, and 04DP01C for the upgradient locations, and 04DP02 and 04DP03 for the

downgradient locations. A summary of the direct push point installation and sampling activities for AREE 4 is provided in Table 4-12. As noted in Table 4-12, a groundwater sample could only be collected from 04DP03 due to the other points either being dry at the time of sampling or having insufficient recharge to collect the required amounts of water for the entire suite of analyses which were to be completed on these groundwater samples. The groundwater sample collected at 04DP03 was analyzed for VOCs and PCBs/pesticides.

As part of the direct push point groundwater sampling, the water levels were measured at each location. Water levels were collected to verify that the points were installed at their appropriate upgradient/downgradient locations.

All sampling locations, the ends of the newly excavated trenches, and geophysical grid corners at AREE 4 were surveyed. Surveying activities for each location included the determination of the elevation with respect to MSL and the calculation of the State Plane coordinates.

4.5.2 Data Summary

The results from the geophysical surveys were used to prepare magnetic and conductivity contour maps which are presented in Appendix L. These contour maps were then used to delineate anomalies that represented areas of suspected buried material. Numerous anomalies were identified by the geophysical surveys and are illustrated on Figure 4-4.

The soil sample collected at location 04EX01 was analyzed for PCBs/pesticides, VOCs, and TPHs. PCB-1260 was detected at a concentration of $0.85 \mu\text{g/g}$ and TPH was detected at a concentration of 220.7 milligrams per kilogram (mg/kg). These results are reported on a dry-weight basis and are shown in Table 4-13.

The groundwater sample collected from direct push point 04DP03 was analyzed for VOCs and PCBs/pesticides. None of these analytes were detected in this groundwater sample.

Table 4-14 provides the water level measurements from the direct push points at AREE 4. All water levels are provided as depths bgs; groundwater elevations are referenced to MSL.

Survey data are provided in Appendix D. The data include elevations with respect to MSL and the State Plane coordinates of all sampling locations, ends of trenches, and geophysical grid corners.

TABLE 4-12
AREE 4 DIRECT PUSH POINT INSTALLATION AND GROUNDWATER
SAMPLING SUMMARY

Direct Push Point	Installation		Sampling			Analyses
	Date	Depth (feet bgs)	Date Sampled	Depth to Water ⁽¹⁾ (feet bgs)	Sample Number	
04DP01A	09/28/93	28 ⁽²⁾	09/28/93	Dry	NA	NA
04DP01B	09/30/93	9.1	10/01/93	Dry	NA	NA
04DP01C	09/30/93	11.9	10/01/93	11.8	NA	NA
04DP02	09/30/93	16.6	10/01/93	15.2	NA	NA
04DP03	09/30/93	22.2	10/01/93	20.2	04DP0301	VOCs, PCBs/ Pesticides

Key: AREE = Area Requiring Environmental Evaluation
VOC = Volatile Organic Compound
PCB = Polychlorinated Biphenyl
bgs = Below Ground Surface
NA = Not Applicable

Notes: ⁽¹⁾ Depth to water measured at time of sampling.
⁽²⁾ Approximate installation depth; measured installation depth not recorded.

TABLE 4-13
AREE 4 SOIL SAMPLING SUMMARY

Analytes	Detection Limit	04EX0101 @ 5.5 feet bgs
PCB-1260	0.040 µg/g	0.850 µg/g S
Total Petroleum Hydrocarbons	10.0 mg/kg	220.7 mg/kg

Key: AREE = Area Requiring Environmental Evaluation
PCB = Polychlorinated Biphenyl
bgs = Below Ground Surface
µg/g = Micrograms per gram
mg/kg = Milligrams per kilogram
S = Flag for non-target compound analyzed for and detected

TABLE 4-14
AREE 4 WATER LEVEL MEASUREMENTS

Direct Push Point	Date Measured	Time Measured	Depth to Water (feet bgs)	Ground Elevation (feet MSL)	Groundwater Elevation (feet MSL)
04DP01A	09/28/93	1530	Dry	27.32	NA
04DP01B	10/01/93	1016	Dry	26.49	NA
04DP01C	10/01/93	1016	11.8	26.60	14.87
04DP02	10/01/93	1208	15.55	17.42	1.87
04DP03	10/01/93	1200	20.12	21.03	0.91

Key: AREE = Area Requiring Environmental Evaluation
bgs = Below Ground Surface
MSL = Mean Sea Level
NA = Not Applicable

4.5.3 Evaluation

Buried material was found during the excavation activities associated with the two southeasternmost anomalies. This area corresponds closely to the reported location of the former dump as identified by facility personnel. A considerable amount of debris was uncovered at this location. The two anomalies through which Trench 5 was excavated may have been caused by observed surface debris.

Additionally, at AREE 4 four large anomalies and several smaller anomalies were identified in areas of no reported past disposal activities. No excavations were completed at these locations. Both the magnetic and conductivity contour maps are provided in Appendix L. For the larger anomalies, these illustrate readings which may be indicative of buried material. The six smaller anomalies were identified only on the magnetic contour map and may have been caused by surface debris.

The presence of only a piece of lumber and a piece of styrofoam did not warrant the collection of a soil sample from Trench 6. Only one soil sample was collected during the SI at AREE 4. This soil sample was collected from Trench 7. The analyses of the soil sample identified PCBs and TPHs in the soil near the buried debris.

The detected concentration of PCB-1260 in this soil sample is less than the 1 $\mu\text{g/g}$ USEPA-recommended soil action level. However, the detected concentration is above both the 0.083 $\mu\text{g/g}$ and 0.37 $\mu\text{g/g}$ USEPA Region III risk-based concentrations for residential and commercial (industrial) sites, respectively. In addition, the detected

concentration of TPHs in this soil sample is more than twice the 100 mg/kg Virginia UST Program Action Level which is the potential TBC value for TPHs in soil.

The analytical results for the groundwater sample at AREE 4 indicated no detection of VOCs, PCBs, or pesticides.

As mentioned previously, the direct push technique was determined to be an unsatisfactory method for the collection of groundwater samples at the WRF. Two major shortcomings were identified with the technique for groundwater sampling. First, knowledge of the groundwater elevation at a proposed location is required prior to installation. This is due to the need to know what depth to install the bottom of the point. Second, the soil conditions at WRF made successful sampling more difficult. The presence of low permeability clay layers resulted in dry sampling points. In addition, the presence of sands resulted in the inability to install points at their desired depths.

Since the water levels measured at the direct push points were collected over a period of a few days, these data are not directly usable for the determination of groundwater flow directions. In addition, a determination as to whether the points were installed at upgradient/downgradient locations of the trenches could not be made.

4.5.4 Conclusions

The anomalies through which Trench 5 was excavated appeared to be clear of buried material; therefore, the anomalies were most likely caused by surface debris.

Several of the remaining anomalies identified by the geophysical surveys at AREE 4 may require further evaluation. The excavation and soil sampling in Trench 7 showed the presence of buried material and soil contamination. These excavation activities appear to indicate that the buried material is located in the area where two anomalies are closely spaced. The debris encountered during the trench excavations suggests metals may be present as a contaminant of concern. The anomalies not investigated via excavation should be examined to determine their potential as sources of contamination.

No contaminants were detected in the one groundwater sample which was collected for limited chemical analysis. Currently, the hydrogeologic and chemical information for AREE 4 is not adequate to determine whether the groundwater is or is not contaminated. Future use of the direct push technique for the collection of groundwater samples at AREE 4 does not appear to be appropriate due to the presence of low permeability clay layers in the area.

4.6 AREE 5 (FORMER DUMP NO. 5)

4.6.1 Summary of Field Activities and Analytical Program

During the site reconnaissance conducted at AREE 5, facility personnel identified the approximate location and orientation of the former disposal trenches at this former dump. At that time, facility personnel estimated that the former dump consisted of at least two areas that were used for debris disposal. The first area was a disposal trench which had been excavated near the end of Lake Drive. The second was an area east of this former trench where material was dumped directly into the marsh then covered with soil.

After site reconnaissance, geophysical surveys were performed at AREE 5 to establish the limits of the past former dump. Two geophysical survey techniques were utilized: magnetic and EMI profiling. Based on the information gathered during the site reconnaissance, a grid was established for the surveys. Profile lines were laid out along an east-west orientation with a grid spacing of 20 feet. Readings were collected at 10-foot intervals along the profile lines. The grid boundary of the geophysical surveys for AREE 5 is shown on Figure 4-4.

As shown on Figure 4-4 the geophysical surveys identified two anomalies which were detected in the areas identified by facility personnel as the approximate disposal locations. Subsequent excavation and soil sampling activities at AREE 5 focused on these anomalies.

Three trenches were excavated by a backhoe to investigate the anomalies shown on Figure 4-4. A summary of the excavation and soil sampling activities for AREE 5 is provided in Table 4-15.

TABLE 4-15
AREE 5 EXCAVATION AND SOIL SAMPLING ACTIVITIES SUMMARY

Trench Number	Date Excavated	Trench Length (feet)	Trench Depth (feet)	Debris Found	Sample Collected	Sample Location	Sample Number	Analyses
13	10/06/93	40	6	Yes	Yes	05EX02	05EX0201	PCBs/ Pesticides, TPHs
14	10/06/93	40	6	Yes	Yes	05EX03	05EX0301	PCBs/ Pesticides, TPHs
15	10/06/93	10	6	Yes	Yes	05EX01	05EX0101	PCBs/ Pesticides, TPHs

Key: AREE = Area Requiring Environmental Evaluation PCB = Polychlorinated Biphenyl
TPH = Total Petroleum Hydrocarbon

Trenches 13 and 14 were each approximately 40 feet long and 6 feet deep. Trench 15 was approximately 10 feet long and 6 feet deep. Buried debris was found during the excavation of the three trenches. A car chassis, timber, angle iron, metal cable, and sheet metal were identified in Trench 13. Metal objects, wire, and plastic were identified in Trench 14. Timber, metal, plastic, a "telephone" pole, and wire springs were identified at Trench 15. In addition, during the excavation of Trench 14, a 55-gallon drum which was only partially buried was also noted. This drum appeared to be intact and was filled with a solid material.

During the excavation of all trenches, continuous air monitoring was performed. No elevated readings were recorded with the HNu. The highest reading was 3 ppm which was recorded with the HNu during the excavation of Trench 13. In addition, at one point during the excavation of Trench 15, an odor that smelled of fuel was noted; however, a reading of 0 ppm was recorded with the HNu.

The extensive presence of debris prompted the collection of soil samples from each of the trenches. One soil sample was collected from each of the three trenches at a depth of approximately 6 feet bgs. The sampling locations are shown on Figure 4-4. The three locations represent: the point at which the highest HNu reading was recorded in Trench 13; the vicinity at which the 55-gallon drum was found at Trench 14; and, the point at which the fuel odor was noted in Trench 15. The soil samples were analyzed for PCBs/pesticides and TPHs as noted in Table 4-15, as well as soil moisture.

SI activities at AREE 5 also included groundwater sampling via the direct push technique. Groundwater samples were to be collected from one upgradient (05DP01) and two downgradient locations (05DP02 and 05DP03) (see Figure 4-4). A summary of the direct push point installation and sampling activities for AREE 5 is provided in Table 4-16. As noted in Table 4-16, groundwater samples were collected from the three points for VOC analysis. However, a sufficient volume of groundwater necessary to complete the PCBs/pesticides analyses could only be collected from points 05DP01 and 05DP03 (due to poor groundwater recharge at point 05DP02). In addition, a duplicate sample was collected at point 05DP03 for VOC analysis; however, a duplicate sample volume for PCB/pesticide analyses could not be collected at this location due to poor groundwater recharge.

As part of the direct push point installation and/or groundwater sampling from the points, the water levels were measured at each location. The water levels were collected to verify that the points were installed at their appropriate upgradient/downgradient locations.

All sampling locations, the ends of newly excavated trenches, and the geophysical grid corners at AREE 5 were surveyed. Surveying activities for each location included the determination of the elevation with respect to MSL and the calculation of the State Plane coordinates.

TABLE 4-16
AREE 5 DIRECT PUSH POINT INSTALLATION AND GROUNDWATER
SAMPLING SUMMARY

Direct Push Point	Installation		Sampling			Analyses
	Date	Depth (feet bgs)	Date	Depth to Water (feet bgs)	Sample Number	
05DP01	09/28/93	11.1	09/30/93	5.5 ⁽¹⁾	05DP0101	VOCs, PCBs/ Pesticides
05DP02	09/30/93	6.5	09/30/93	4.8 ⁽²⁾	05DP0201	VOCs
05DP03	09/30/93	6.98	09/30/93 09/30/93 10/01/93	0.22 ⁽³⁾	05DP0301 05DP0302 ⁽⁴⁾ 05DP0301	VOCs VOCs PCBs/ Pesticides

Key: AREE = Area Requiring Environmental Evaluation PCB = Polychlorinated Biphenyl
VOC = Volatile Organic Compound bgs = Below Ground Surface

Notes: ⁽¹⁾ Depth to water measured at time of installation.
⁽²⁾ Depth to water measured approximately 17 hours after sampling.
⁽³⁾ Depth to water measured at time of sampling on October 1, 1993.
⁽⁴⁾ Duplicate.

4.6.2 Data Summary

The results from the geophysical surveys were used to prepare magnetic and conductivity contour maps which are presented in Appendix L. These contour maps were then used to delineate anomalies that represented areas of suspected buried material.

Provided in Table 4-17 is a summary of the analytical results for the soil samples collected at AREE 5. Only those analytes that were reported above their appropriate detection limit are included in Table 4-17. Chemical concentrations are reported on a dry-weight basis. As noted in the table, PCB-1254 was detected in soil sample 05EX0101 at a concentration of 0.33 $\mu\text{g/g}$ and PCB-1260 was detected in soil sample 05EX0301 at a concentration of 0.14 $\mu\text{g/g}$. Pesticides were also detected in two of three soil samples. The pesticides 4,4'-DDD and 4,4'-DDE were detected in soil sample 05EX0101 at concentrations of 0.0123 $\mu\text{g/g}$ and 0.048 $\mu\text{g/g}$, respectively. The pesticides 4,4'-DDE, 4,4'-DDT, dieldrin, and α -chlordane were detected in soil sample 05EX0201 at concentrations of 0.032 $\mu\text{g/g}$, 0.035 $\mu\text{g/g}$, 0.012 $\mu\text{g/g}$, and 0.005 $\mu\text{g/g}$, respectively. TPHs were also detected in soil samples 05EX0101, 05EX0201, and 05EX0301 at concentrations of 35.1 mg/kg, 27.2 mg/kg, and 19.4 mg/kg, respectively. The PCBs/pesticides results were qualified due to the sample extraction and preparation being performed beyond the required maximum holding

TABLE 4-17
AREE 5 SOIL SAMPLING RESULTS SUMMARY

Analytes ⁽¹⁾	Detection Limit	05EX0101 @ 6.0 feet bgs	05EX0201 @ 6.0 feet bgs	05EX0301 @ 6.0 feet bgs
PCB-1254	0.10	0.33 K S	ND K T	ND K T
PCB-1260	0.10	ND K T	ND K T	0.14 K S
4,4'-DDD	0.0112	0.0123 K	ND K	ND K
4,4'-DDE	0.0142	0.048 K	0.032 K	ND K
4,4'-DDT	0.0096	ND K	0.035 K	ND K
Dieldrin	0.0078	ND K	0.012 K	ND K
a-Chlordane	0.0040	ND K	0.005 K 1	ND K
TPH ⁽²⁾	10.0	35.1	27.2	19.4

Key: AREE = Area Requiring Environmental Evaluation
PCB = Polychlorinated Biphenyl
TPH = Total Petroleum Hydrocarbon
bgs = Below Ground Surface
ND = Not Detected
K = Qualifier for missed holding times for extraction and preparation
T = Flag for non-target compound analyzed for and not detected
S = Flag for non-target compound analyzed for and detected
1 = Flag for result less than CRL but greater than COD

Notes: ⁽¹⁾ Concentrations reported in micrograms per gram ($\mu\text{g/g}$).

⁽²⁾ Concentrations reported in milligrams per kilogram (mg/kg).

times for the parameters. Since PCBs/pesticides are not highly volatile, the exceedance does not alter the validity of the results.

The groundwater samples (and the corresponding duplicate) collected from the direct push points at AREE 5 were analyzed for VOCs and PCBs/pesticides as shown in Table 4-16. PCB-1254 was detected in one groundwater sample from AREE 5. PCB-1254 was reported in groundwater sample 05DP0101 at a concentration of 0.140 $\mu\text{g/L}$. The only VOC detected in the groundwater samples was acetone, reported at concentrations of 17.0 $\mu\text{g/L}$ and 20.0 $\mu\text{g/L}$ from the sample and duplicate, respectively, collected at 05DP03. Groundwater sample results are summarized in Table 4-18.

Table 4-19 provides the water level measurements from the direct push points at AREE 5. All water levels are provided as depths bgs; groundwater elevations are referenced to MSL.

TABLE 4-18
AREE 5 GROUNDWATER SAMPLING RESULTS SUMMARY

Analytes ⁽¹⁾	Detection Limit	05DP0101	05DP0201	05DP0301	05DP0302
PCB-1254	0.100	0.140 S	NA	ND T	NA
Acetone	10	ND R	ND	17.0 S	20.0 S

Key: AREE = Area Requiring Environmental Evaluation
 PCB = Polychlorinated Biphenyl
 NA = Not Analyzed
 ND = Not Detected
 S = Flag for non-target compound analyzed for and detected
 T = Flag for non-target compound analyzed for and not detected
 R = Flag for non-target compound analyzed for and not detected

Note: ⁽¹⁾ Concentrations reported in micrograms per liter ($\mu\text{g/L}$).

TABLE 4-19
AREE 5 WATER LEVEL MEASUREMENTS

Direct Push Point	Date Measured	Time Measured	Depth to Water (feet bgs)	Ground Elevation (feet MSL)	Groundwater Elevation (feet MSL)
05DP01	09/28/93	1638	5.5 ⁽¹⁾	8.08	2.58
05DP02	10/01/93	0846	4.8 ⁽²⁾	1.80	-3.00
05DP03	10/01/93	0850	0.22 ⁽³⁾	2.01	1.79

Key: AREE = Area Requiring Environmental Evaluation
 bgs = Below Ground Surface
 MSL = Mean Sea Level

Notes: ⁽¹⁾ Depth to water measured at time of installation.
⁽²⁾ Depth to water measured approximately 17 hours after sampling.
⁽³⁾ Depth to water measured at time of sampling.

Survey data activities are provided in Appendix D. The data include elevations with respect to MSL and the State Plane coordinates of all sampling locations, ends of trenches, and geophysical grid corners.

4.6.3 Evaluation

Buried material was found at both anomalies identified by the geophysical surveys and investigated via excavation. As previously mentioned, the anomalies were identified in the areas that correspond closely to the approximate former disposal locations identified by facility personnel.

A soil sample was collected from each trench that was excavated during the SI. The analyses of the soil samples identified PCB, pesticide, and/or TPH contamination in the soil which was collected near the buried debris.

The detected PCB concentrations in soil are less than the 1 $\mu\text{g/g}$ USEPA recommended soil action level and the 0.37 $\mu\text{g/g}$ USEPA Region III risk-based concentration for commercial (industrial) sites. However, the detected PCB concentrations are above the 0.083 $\mu\text{g/g}$ USEPA Region III risk-based concentration for residential sites. All detected values of pesticides are less than their appropriate USEPA recommended soil action levels and USEPA Region III risk-based concentrations for commercial (industrial) and residential sites. All detected values of TPHs are less than the 100 mg/kg Virginia UST Program Action Level which is the potential TBC value for TPHs in soil.

The single detection of PCB-1254 in groundwater is reported at a concentration lower than the 0.5 $\mu\text{g/L}$ Federal MCL which is the only ARAR for PCBs in groundwater; however, the detected PCB-1254 concentration of 0.14 $\mu\text{g/L}$ is higher than all the TBCs for PCBs in groundwater. The detected values of acetone are well below the 3,700 $\mu\text{g/L}$ USEPA risk-based concentration in drinking water for acetone.

As mentioned previously, the direct push technique was determined to be an unsatisfactory method for the collection of groundwater samples at the WRF. Two major shortcomings were identified with the technique for groundwater sampling. First, knowledge of the groundwater elevation at a proposed location is required prior to installation. This is due to the need to know what depth to install the bottom of the point. Second, the soil conditions at WRF made successful sampling more difficult. The presence of low permeability clay layers resulted in dry sampling points. In addition, the presence of sands resulted in the inability to install points at their desired depths.

Since the water levels measured at the direct push points were collected over a period of a few days, these data are not directly usable for the determination of groundwater flow direction. In addition, it is difficult to determine whether the points were installed at their appropriate upgradient/downgradient locations with respect to the buried material.

4.6.4 Conclusions

Two anomalies identified by the geophysical surveys appear to be at the anecdotal locations of the former disposal areas at AREE 5. The extensive presence of buried material and the presence of soil contamination warrant further evaluation. The debris encountered during the trench excavations suggests metals may be present as a contaminant of concern.

Groundwater contamination was identified in the vicinity of AREE 5, although the extent of groundwater contamination was not established. The source of the groundwater contamination was not determined due to the uncertainties of the groundwater flow direction and rate. The contamination detected in the direct push point considered upgradient of AREE 5 may be caused by buried material not associated with this former dump. In addition, future use of the direct push technique for the collection of groundwater samples at AREE 5 may not be appropriate due to the presence of low permeability clay layers in the area.

4.7 AREE 6A (FORMER DUMP)

4.7.1 Summary of Field Activities and Analytical Program

During the site reconnaissance conducted at AREE 6A, facility personnel indicated no knowledge of any former trenches or past disposal associated with this former dump. A visual examination of the AREE identified the presence of surface debris and mounded soil just west of Deephole Point Road and north of AREE 4. Due to the limited evidence that the area was used for disposal purposes, a determination was made that the investigation at AREE 6A be completed over as large an area as practical.

After site reconnaissance, geophysical surveys were performed at AREE 6A in an attempt to identify any buried material that could be associated with the former dump. Three geophysical survey techniques were utilized: magnetic, EMI and GPR profiling. Based on the information gathered during the site reconnaissance, a grid was established for the surveys. Profile lines were laid out along an east-west orientation with a grid spacing of 30 feet. Readings were collected at 10-foot intervals along the profile lines. The grid boundary of the geophysical surveys for AREE 6A is shown on Figure 4-4.

As shown on Figure 4-4 the geophysical surveys identified three anomalies. One of the three anomalies was detected in the area that the surface debris and mounded soil was observed. The second anomaly was located west of the first anomaly, just east of the marsh area downgradient of the pond. The third anomaly was detected within the marsh area downgradient of the pond. Subsequent excavation and soil sampling activities at AREE 6A focused on the three anomalies.

Four trenches were excavated by a backhoe to investigate the anomalies at the locations shown on Figure 4-4. A summary of the excavation and soil sampling activities for AREE 6A is provided in Table 4-20.

Trench 1 was approximately 90 feet long and 6 feet deep. Debris consisting of metal cable, timber, barbed wire, and an empty 55-gallon drum was found during the excavation of Trench 1. Trench 2 was approximately 140 feet long and 7 feet deep. Debris was found during the excavation of Trench 2. This debris consisted of plastic sheeting, wood, barbed wire, steel cable, and a utility pole. Trench 3 was approximately 20 feet long and 8 feet deep. No debris was encountered during the excavation. Trench 4 was approximately 20 feet long and 6 feet deep with no debris found during excavation; however, a 15-foot by 15-foot piece of metal was noted at the ground surface near the trench. During the excavation of all trenches, air monitoring was performed with no elevated readings recorded with the HNu.

The presence of the debris prompted the collection of soil samples from Trenches 1 and 2. A soil sample was not collected from Trench 4 as only the single, large piece of metal was found at the ground surface near Trench 4. One soil sample was collected from Trench 1 at a depth of approximately 6 feet and one soil sample was collected from Trench 2 at a depth of approximately 7 feet. The sample locations are shown on Figure 4-4. Both soil samples were analyzed for PCBs/pesticides as noted in Table 4-20; a soil moisture measurement was conducted on both soil samples.

SI activities at AREE 6A also included groundwater sample collection via the direct push technique. Groundwater samples were to be collected at one upgradient and two downgradient locations. Due to problems arising during the collection of the upgradient sample, three points were installed in an attempt to assure the collection of the sample. As shown on Figure 4-4, a total of five points were installed for AREE 6A. Points 6ADP01A, 6ADP01B, and 6ADP01C were complete for the upgradient locations and points 6ADP02 and 6ADP03 for the downgradient locations. A summary of the direct push point installation and sampling activities for AREE 6A is provided in Table 4-21. As noted in Table 4-21, a groundwater sample could only be collected from 6ADP03 due to the other points either being dry at the time of sampling or having insufficient recharge to allow the collection of the required volumes of groundwater for the proper completion of the projected analyses. The single groundwater sample which was collected was analyzed only for PCBs/pesticides; the groundwater was too turbid to allow proper collection of samples for VOC analyses as proposed.

As part of the direct push point installation and/or groundwater sampling from the points, the water levels were measured at each location. The water levels were collected to verify that the points were installed at their appropriate upgradient/downgradient locations with respect to the buried material.

TABLE 4-20
AREE 6A EXCAVATION AND SOIL SAMPLING ACTIVITIES SUMMARY

Trench Number	Date Excavated	Trench Length (feet)	Trench Depth (feet)	Debris Found	Sample Collected	Sample Location	Sample Number	Analyses
1	10/05/93	90	6	Yes	Yes	6AEX02	6AEX0201	PCBs/ Pesticides
2	10/01/93	140	7	Yes	Yes	6AEX01	6AEX0101	PCBs/ Pesticides
3	10/05/93	20	8	No	No	NA	NA	NA
4	10/05/93	20	6	Yes ⁽¹⁾	No	NA	NA	NA

Key: AREE = Area Requiring Environmental Evaluation
PCB = Polychlorinated Biphenyl
NA = Not Applicable

⁽¹⁾ Debris found on surface near trench.

TABLE 4-21
AREE 6A DIRECT PUSH POINT INSTALLATION AND GROUNDWATER SAMPLING SUMMARY

Direct Push Point	Installation		Sampling			Analyses
	Date	Depth (feet bgs)	Date Sampled	Depth to Water ⁽¹⁾ (feet bgs)	Sample Number	
6ADP01A	09/28/93	9.2	10/01/93	8.5	NA	NA
6ADP01B	09/30/93	15 ⁽²⁾	10/01/93	Dry	NA	NA
6ADP01C	10/01/93	17.5	10/01/93	Dry	NA	NA
6ADP02	09/30/93	13.5	10/01/93	10.8	NA	NA
6ADP03	09/30/93	14.2	10/01/93	12.9	04DP0301	PCBs/ Pesticides

Key: AREE = Area Requiring Environmental Evaluation
PCB = Polychlorinated Biphenyl
bgs = Below Ground Surface
NA = Not Applicable

Notes: ⁽¹⁾ Depth to water measured at time of sampling.

⁽²⁾ Approximate installation depth; measured installation depth not recorded.

All sampling locations, the ends of the newly dug trenches, and geophysical grid corners at AREE 6A were surveyed. Surveying activities for each point included the determination of the elevation with respect to MSL and the calculation of the State Plane coordinates.

4.7.2 Data Summary

The results from the geophysical surveys were used to prepare magnetic and conductivity contour maps which are presented in Appendix L. These contour maps were then used to delineate anomalies that represented areas of suspected buried material.

The soil samples collected at location 6AEX01 and 6AEX02 were analyzed for PCBs/pesticides. These analytes were not detected in the soil samples.

The groundwater sample collected from direct push point 6ADP03 was analyzed for PCBs/pesticides. None of these analytes were detected in the groundwater sample.

Table 4-22 provides the water level measurements from the direct push points at AREE 6A. All water levels are provided as depths bgs as well as groundwater elevations referenced to MSL.

TABLE 4-22
AREE 6A WATER LEVEL MEASUREMENTS

Direct Push Point	Date Measured	Time Measured	Depth to Water (feet bgs)	Ground Elevation (feet MSL)	Groundwater Elevation (feet MSL)
6ADP01A	10/01/93	1006	8.5	27.74	19.24
6ADP01B	10/01/93	1008	Dry	25.61	NA
6ADP01C	10/01/93	1216	Dry	25.60	NA
6ADP02	10/01/93	0948	10.8	12.94	2.14
6ADP03	10/01/93	0930	12.9	14.85	1.95

Key: AREE = Area Requiring Environmental Evaluation
bgs = Below Ground Surface
MSL = Mean Sea Level
NA = Not Applicable

Survey data are provided in Appendix D. The data include elevations with respect to MSL and the State Plane coordinates of all sampling locations, ends of trenches, and geophysical grid corners.

4.7.3 Evaluation

Buried material was found during the excavation activities which focused on the large anomaly located just west of Deephole Point Road. This area corresponds to the location that surface debris and mounded soil was observed during a visual examination of the AREE. The other two anomalies identified during the geophysical surveys may have been caused by surface debris, such as the 15-foot by 15-foot piece of metal which was found at the ground surface near Trench 4.

The purpose of the soil sampling at AREE 6A was to identify possible subsurface soil contamination resulting from the past burial of waste materials. Therefore, the presence of the 15-foot by 15-foot piece of metal found at the ground surface did not warrant the collection of a soil sample from Trench 4. Soil samples were only collected from Trenches 1 and 2. The analytical results for the soil samples indicated no detection of PCBs or pesticides.

The analytical results for the single groundwater sample collected at AREE 6A indicated no detection of PCBs or pesticides.

As mentioned previously, the direct push technique was determined to be an unsatisfactory method for the collection of groundwater samples at the WRF. Two major shortcomings were identified with the technique for groundwater sampling. First, knowledge of the groundwater elevation at a proposed location is required prior to installation. This is due to the need to know what depth to install the bottom of the point. Second, the soil conditions at WRF made successful sampling more difficult. The presence of low permeability clay layers resulted in dry sampling points. In addition, the presence of sands resulted in the inability to install points at their desired depths.

Since the water levels measured at the direct push points were collected over a period of a few days, these data are not directly usable for the determination of groundwater flow directions. In addition, it is difficult to determine whether the points were installed at upgradient/downgradient locations with respect to the buried material.

4.7.4 Conclusions

Two of the anomalies identified by the geophysical surveys should not require any further action. The anomaly at which Trench 3 was excavated appeared to be clear of buried material; therefore, the anomaly was most likely caused by surface debris. The anomaly at which Trench 4 was excavated appears to have been caused by the large piece of metal that was discovered at the ground surface during the excavation. Therefore, no further action should be required at this anomaly.

The remaining anomaly identified by the geophysical surveys may require further evaluation. No PCBs or pesticides were detected in the soil samples collected where the buried debris was identified.

Although no contamination was detected in the one groundwater sample collected, existing information is not adequate to determine whether the groundwater in the vicinity of AREE 6A is or is not contaminated. Future use of the direct push technique for the collection of groundwater samples at AREE 6A does not appear to be appropriate due to the presence of low permeability clay layers in the area.

4.8 AREE 6B (FORMER DUMP)

4.8.1 Summary of Field Activities and Analytical Program

During the site reconnaissance conducted at AREE 6B for the SI, facility personnel indicated no knowledge of any former disposal trenches associated with this former dump. A visual examination of the AREE was then completed. Surface debris was observed scattered throughout the area. Due to limited anecdotal evidence that the area was or was not used for disposal purposes, a determination was made that the investigation at AREE 6B be completed over as large an area as practical.

After site reconnaissance, geophysical surveys were performed at AREE 6B in an attempt to identify any buried material that could be associated with the former dump. Three geophysical survey techniques were utilized: magnetic, EMI and GPR profiling. Based on the information gathered during the site reconnaissance, a grid was established for the surveys. Profile lines were laid out along an east-west orientation with a grid spacing of 20 feet. Readings were collected at 10-foot intervals along the profile lines. The grid boundary of the geophysical surveys for AREE 6B is shown on Figure 4-2.

As shown on Figure 4-2 the geophysical survey identified three anomalies. The three anomalies were detected in the area between Deephole Point Road and Shady Road located north of AREE 1. Subsequent excavation and soil sampling activities at AREE 6B focused on the three anomalies.

Three trenches were excavated by a backhoe to investigate the vicinity of the anomalies shown on Figure 4-2. A summary of the excavation and soil sampling activities for AREE 6B is provided in Table 4-23.

TABLE 4-23
AREE 6B EXCAVATION AND SOIL SAMPLING ACTIVITIES SUMMARY

Trench Number	Date Excavated	Trench Length (feet)	Trench Depth (feet)	Debris Found	Sample Collected	Sample Location	Sample Number	Analyses
16	09/29/93	30	6	No	No	NA	NA	NA
17	09/30/93	35	6	No	No	NA	NA	NA
18	09/30/93	50	6	No	No	NA	NA	NA

Key: AREE = Area Requiring Environmental Evaluation NA = Not Applicable

All trenches were excavated to a depth of approximately 6 feet with trench lengths of approximately 30 feet, 35 feet, and 50 feet for Trenches 16, 17, and 18, respectively. No debris was encountered during the excavation of the three trenches. Since no debris was uncovered during the excavation of the trenches, no soil samples were collected from the trenches. During the excavation of all trenches, air monitoring was performed, and no elevated readings were recorded with the HNu.

SI activities at AREE 6B also included groundwater sampling via the direct push technique. Groundwater samples were to be collected at one upgradient and two downgradient locations. Due to problems arising during the collection of the upgradient sample, three points were installed in an attempt assure to collection of the sample. As shown on Figure 4-2, five points were installed for AREE 6B: 6BDP01A, 6BDP01B, and 6BDP01C for the upgradient locations and 6BDP02 and 6BDP03 for the downgradient locations. A summary of the direct push point installation and sampling activities for AREE 6B is provided in Table 4-24. As noted in Table 4-24, groundwater samples could only be collected from 6BDP02 and 6BDP03 due to the other points being dry at the time of sampling. The two groundwater samples collected at AREE 6B were analyzed for VOCs and PCBs/pesticides.

TABLE 4-24
AREE 6B DIRECT PUSH POINT INSTALLATION AND GROUNDWATER
SAMPLING SUMMARY

Direct Push Point	Installation		Sampling			Analyses
	Date	Depth (feet bgs)	Date Sampled	Depth to Water ⁽¹⁾ (feet bgs)	Sample Number	
6BDP01A	09/28/93	24.5	09/28/93	Dry	NA	NA
6BDP01B	09/30/93	8.4	10/01/93	Dry	NA	NA
6BDP01C	09/30/93	14.26	10/01/93	Dry	NA	NA
6BDP02	09/30/93	10.39	10/01/93	8.03	6BDP0201	VOCs, PCBs/Pesticides
6BDP03	09/30/93	15.17	10/01/93	12.90	6BDP0301	VOCs, PCBs/Pesticides

Key: AREE = Area Requiring Environmental Evaluation
VOC = Volatile Organic Compound
PCB = Polychlorinated Biphenyl
bgs = Below Ground Surface
NA = Not Applicable

Note: ⁽¹⁾ Depth to water measured at time of sampling.

As part of the direct push point groundwater sampling, water levels were measured at each location. The water levels were measured to verify that the points were installed at their appropriate upgradient/downgradient locations.

During the Preliminary SI at AREE 6B all sampling locations, the ends of the newly excavated trenches, and geophysical grid corners were surveyed. Surveying activities for each point included the determination of the elevation with respect to MSL and the calculation of the State Plane coordinates.

Upon completion of the Preliminary SI field activities, the BCT requested that additional investigations be performed at AREE 6B as part of a SSI. The SSI at AREE 6B began with another site reconnaissance attended by the DOD representative of the BCT, the VADEQ representative of the BCT, the USAEC Project Officer, and EARTH TECH representatives. At that time, a decision was made to collect soil samples from a borehole in the vicinity of surface debris located at the westernmost anomaly identified by the geophysical surveys.

As shown on Figure 4-2 one hand-augered borehole was completed at location 6BBH01. Two soil samples were collected from the borehole and both were analyzed for metals, TPH, VOCs, SVOCs, PCBs/pesticides, and soil moisture. Sample 6BBH0101 was collected from 0.5 to 1.5 feet bgs and sample 6BBH0103 was collected from 4.5 to 5.5 feet bgs.

4.8.2 Data Summary

The results from the geophysical surveys were used to prepare magnetic and conductivity contour maps which are presented in Appendix L. These contour maps were then used to delineate anomalies that represented areas of suspected buried material.

The groundwater samples collected from direct push points 6BDP02 and 6BDP03 were analyzed for VOCs and PCBs/pesticides. None of these analytes were detected in either of the groundwater samples.

Table 4-25 provides the water level measurements from the direct push points at AREE 6B. All water levels are provided as depths bgs as well as groundwater elevations referenced to MSL.

Survey data are provided in Appendix D. The data include elevations with respect to MSL and the State Plane coordinates of all sampling locations, ends of trenches, and geophysical grid corners.

The soil samples collected at borehole 6BBH01 were analyzed for TPHs, VOCs, SVOCs, PCBs/pesticides, and metals. TPHs were detected in samples 6BBH0101 and 6BBH0103 at concentrations of 28 mg/kg and 61.4 mg/kg, respectively as shown in Table 4-26. No VOCs, SVOCs, PCBs, or pesticides were detected in either sample.

TABLE 4-25
AREE 6B WATER LEVEL MEASUREMENTS

Direct Push Point	Date Measured	Time Measured	Depth to Water (feet bgs)	Ground Elevation (feet MSL)	Groundwater Elevation (feet MSL)
6BDP01A	09/28/93	1510	Dry	24.86	NA
6BDP01B	10/01/93	1037	Dry	23.34	NA
6BDP01C	10/01/93	1041	Dry	23.47	NA
6BDP02	09/30/93	1700	8.05	10.84	2.79
6BDP02	10/01/93	1055	8.03	10.84	2.81
6BDP03	09/30/93	1710	12.92	13.93	1.01
6BDP03	10/01/93	1045	12.90	13.93	1.03

Key: AREE = Area Requiring Environmental Evaluation
bgs = Below Ground Surface
MSL = Mean Sea Level
NA = Not Applicable

TABLE 4-26
AREE 6B ORGANIC SOIL SAMPLING SUMMARY

Analytes ⁽¹⁾	Detection Limit	6BBH0101 @ 0.5 feet bgs	6BBH0103 @ 4.5 feet bgs
Total Petroleum Hydrocarbons	20.0	28.0	61.4

Key: AREE = Area Requiring Environmental Evaluation
bgs = Below Ground Surface

Note: ⁽¹⁾ Concentrations reported in milligrams per kilogram (mg/kg).

A summary of the analytical results for the inorganic analyses performed on the soil samples are provided in Table 4-27 and are reported on a dry-weight basis. All analytes were detected at concentrations above their appropriate detection limits in at least one sample except for mercury, molybdenum, thallium, antimony, cadmium, selenium, and cyanide.

4.8.3 Evaluation

No buried material was found during the excavation activities associated with AREE 6B. However, surface debris was observed scattered throughout the area.

The analytical results for the groundwater sample collected at AREE 6B indicated no detection of VOCs, PCBs, or pesticides.

As mentioned previously, the direct push technique was determined to be an unsatisfactory method for the collection of groundwater samples at the WRF. Two major shortcomings were identified with the technique for groundwater sampling. First, knowledge of the groundwater elevation at a proposed location is required prior to installation. This is due to the need to know what depth to install the bottom of the point. Second, the soil conditions at WRF made successful sampling more difficult. The presence of low permeability clay layers resulted in dry sampling points. In addition, the presence of sands resulted in the inability to install points at their desired depths.

Since the water levels measured at the direct push points were collected over a period of a few days, these data are not directly usable for the determination of groundwater flow directions. In addition, it is difficult to determine whether the points were installed at their appropriate upgradient/downgradient locations.

The analyses of the soil samples collected from borehole 6BBH01 identified TPHs in the soil. However, the detected values of TPHs are less than the 100 mg/kg Virginia UST Program Action Level which is the potential TBC value for TPHs in soil.

Table 4-28 provides ranges for the inorganic results from the metals analyses performed on the soil samples collected at borehole 6BBH01. The table also includes the background soil ranges and the ranges for the analytes as published by the USGS (USGS, 1984) for surficial soil samples collected within the WRF geographical area. It should be noted that no USGS data are available for cadmium, thallium, and cyanide as indicated in the table. In addition, the SI values for aluminum, barium, iron, and chromium are not directly comparable with the USGS values due to analytical method differences.

For the following analytes detected in the soil samples collected in borehole 6BBH01 the upper limit of the range was higher than the onsite background soil ranges but lower than the USGS ranges: iron, magnesium, nickel, potassium, sodium, barium, beryllium, chromium, cobalt, copper, and zinc. Cobalt was the only analyte in which

TABLE 4-27
AREE 6B INORGANIC RESULTS IN SOIL

Analytes ⁽¹⁾	Detection Limit	6BBH0101 @ 0.5 feet bgs	6BBH0103 @ 4.5 feet bgs	AREE 6B Range
Aluminum	10.7	11,000	10,000	10,000 - 11,000
Antimony	82.9	ND J	ND J	ND
Arsenic	0.200	2.75	ND	ND-2.75
Barium	4.87	37.1 I	72.6 I	37.1 - 72.6
Beryllium	0.250	0.939	0.619	0.619 - 0.939
Cadmium	0.427	ND	ND	ND
Calcium	109	451	733	451 - 733
Chromium	0.974	24.6	32.8	24.6 - 32.8
Cobalt	2.50	3.81	14.2	3.81 - 14.2
Copper	3.38	14.8	8.60	8.60 - 14.8
Cyanide	1.22	ND	ND	ND
Iron	12.0	22,000	15,000	15,000-22,000
Lead	0.700	13 B	6.6 B	6.6 - 13.0
Magnesium	138	2,090	3,370	2,090 - 3,370
Manganese	0.511	124	135	124 - 135
Mercury	0.0870	ND	ND	ND
Molybdenum	4.00	ND	ND	ND
Nickel	7.50	ND	16.0	ND - 16.0
Potassium	142	823	980	823 - 980
Selenium	12.4	ND	ND	ND
Sodium	50.0	192	549	192 - 549
Thallium	12.5	ND	ND	ND
Vanadium	2.00	47.1	30.4	30.4 - 47.1
Zinc	4.00	41.8	42.6	41.8 - 42.6

Key: AREE = Area Requiring Environmental Evaluation
bgs = Below Ground Surface
B = Flag for analyte found in the method blank or QC blank as well as the sample
I = Qualifier for the low spike recovery is high
J = Qualifier for the low spike recovery is low
ND = Not Detected

⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).

TABLE 4-28
COMPARISON OF INORGANIC RESULTS IN SOIL FOR AREE 6B,
BACKGROUND SAMPLES, AND USGS RANGES

Analyte ⁽¹⁾	AREE 6B Range ⁽²⁾	Background Range	USGS Range ⁽³⁾
Aluminum	10,000 - 11,000	10,000 - 14,000	50,000 - 100,000
Antimony	ND	ND	≤ 1
Arsenic	ND - 2.75	NA	2.6 - 6.5
Barium	37.1 - 72.6	61.6 - 71.4	300 - 700
Beryllium	0.619 - 0.939	0.572 - 0.802	≤ 1
Cadmium	ND	ND	--
Calcium	451 - 733	1,280 - 1,720	3,500 - 5,200
Chromium	24.6 - 32.8	21.3 - 23.9	30 - 70
Cobalt	3.81 - 14.2	ND - 13.8	3 - 7
Copper	8.60 - 14.8	5.62 - 6.67	20 - 30
Cyanide	ND	NA	--
Iron	15,000 - 22,000	16,000 - 18,000	20,000 - 50,000
Lead	6.6 - 13.0	17.7 - 22.1	15 - 150
Magnesium	2,090 - 3,370	1,120 - 1,310	20,000 - 30,000
Manganese	124 - 135	107 - 300	200 - 300
Mercury	ND	ND	0.082 - 0.13
Molybdenum	ND	ND	≤ 3
Nickel	ND - 16.0	ND	10 - 20
Potassium	823 - 980	408 - 477	6,800 - 16,000
Selenium	ND	ND	0.1 - 5
Sodium	192 - 549	ND	500 - 2,000
Thallium	ND	ND	--
Vanadium	30.4 - 47.1	38.1 - 49.2	70 - 150
Zinc	41.8 - 42.6	37.4 - 42.3	28 - 74

Key: AREE = Area Requiring Environmental Evaluation
 USGS = U.S. Geological Survey
 NA = Not Analyzed
 ND = Not Detected
 -- = Not Available

Notes: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).

⁽²⁾ Shaded results indicate where the AREE 6B range exceeds background and/or USGS range.

⁽³⁾ U.S. Geological Survey, 1984.

the upper limit of the range for the soil samples collected at borehole 6BBH01 was also higher than the background soil range and the USGS range. However, there are no ARARs or potential TBCs for cobalt in soil.

4.8.4 Conclusions

Two of the anomalies identified by the geophysical surveys should not require any further action. The anomalies at which Trenches 16 and 17 were excavated appeared to be clear of buried material. The anomalies were most likely caused by surface debris.

The third anomaly identified at AREE 6B by the geophysical surveys was investigated by completing borehole 6BBH01 to collect subsurface soil data. Although TPHs were detected in the soil samples collected from the borehole, the level of contamination is below the potential TBC value for TPHs in soil. Furthermore, cobalt was the only metal that is above the reported background range for WRF and regional USGS data; however, there are no ARARs or potential TBCs for this analyte in soil.

Based on the limited groundwater sampling performed, the groundwater at AREE 6B does not appear to be contaminated with VOCs, PCBs, or pesticides. Future use of the direct push technique for the collection of groundwater samples at AREE 6B does not appear to be appropriate due to the presence of low permeability clay layers and sands in the area. This AREE is recommended for further study, not as a source but to further investigate the extent of contamination from AREE 1.

4.9 AREE 7 (FORMER PISTOL RANGE)

4.9.1 Summary of Field Activities and Analytical Program

During the site reconnaissance conducted at AREE 7, the approximate location of the former pistol range was identified by facility personnel. This location corresponded to the area identified in the Preliminary Assessment as the location of the pistol range.

After site reconnaissance, a 5 foot $\times$ 5 foot area was excavated to a depth of 5 feet at the location shown in Figure 4-2 as 07EX01. A backhoe excavated the soil which was placed on plastic sheeting, sieved, and examined for bullets visually and with a metal detector. No bullets were found.

One soil sample was collected at location 07EX01 from the bucket of the backhoe at a depth of approximately 3 feet in the center of the excavated area and analyzed for metals as well as soil moisture. The center of the excavation was surveyed (Appendix D). The locations of the pistol range and sampling location are shown on Figure 4-2.

A second site reconnaissance completed on 7 April 1994 revealed that according to a facility representative, the impact area for the pistol range is under approximately

15 feet of fill. Therefore, during the SSI, four boreholes were hand augered at locations 07BH01, 07BH02, 07BH03, and 07BH04 as shown on Figure 4-2.

Four boreholes were hand augered approximately 15 feet east and uphill from the test pit excavated at location 07EX01. The four boreholes form a square at the location where facility personnel suggested the bullets should have penetrated the soil. Each borehole is spaced approximately 15 feet apart.

Nine soil samples were collected from each borehole from depths of 1, 2, 3, 4, 8, 12, 13, 14, and 15 feet. All 36 soil samples were analyzed for metals. In addition, one replicate sample was collected with one of the soil samples from each borehole. Table 4-29 provides a summary of the soil samples and replicates collected from the boreholes.

TABLE 4-29
AREE 7 BOREHOLE SAMPLE COLLECTION SUMMARY

Depth (feet)	Location 07BH01	Location 07BH02	Location 07BH03	Location 07BH04
1	07BH0101	07BH0201	07BH0301	07BH0401
2	07BH0102	07BH0202	07BH0302	07BH0402
3	07BH0103	07BH0203	07BH0303	07BH0403
4	07BH0104	07BH0204 & 07BH0269	07BH0304 & 07BH0369	07BH0404
8	07BH0105	07BH0205	07BH0305	07BH0405
12	07BH0106	07BH0206	07BH0306	07BH0406 & 07BH0469
13	07BH0107	07BH0207	07BH0307	07BH0407
14	07BH0108 & 07BH0169	07BH0208	07BH0308	07BH0408
15	07BH0109	07BH0209	07BH0309	07BH0409

Key: AREE = Area Requiring Environmental Evaluation

In addition, the hand auger cuttings were examined in an effort to locate bullets. A bullet was encountered at an approximate depth of 1.5 feet while hand augering the northeast borehole (07BH01). Also, a shell casing was found in borehole 07BH04 at an approximate depth of 1 foot.

4.9.2 Data Summary

A summary of the analytical results for the analyses performed on the soil sample collected from the excavation of the test pit at AREE 7 are provided in Table 4-30. Tables 4-31 through 4-34 provide summaries of the analytical results for the analyses performed on the soil samples and replicates collected from the boreholes at AREE 7. The soil moisture determined in the laboratory was used to convert soil analytical results to a dry-weight basis. The concentrations provided in Table 4-30 through 4-34 are reported on a dry-weight basis.

For sample 07EX0101, all analytes were detected at concentrations above their appropriate detection limits except for cadmium, molybdenum, antimony, selenium, and thallium. Mercury, molybdenum, thallium, antimony, cadmium, selenium, and cyanide were not reported above detection limits for any of the soil samples collected from the boreholes at AREE 7.

4.9.3 Evaluation

The investigation for AREE 7 focussed on an area identified by facility personnel as the location of the former pistol range. Evidence was found during the investigation to support this identification.

Table 4-35 provides ranges for the inorganic results from the metals analyses performed on the soil samples collected at AREE 7. The table also includes the background soil ranges and the ranges for the analytes as published by the USGS (USGS, 1984) for surficial soil samples collected within the WRF geographical area. It should be noted that no USGS data are available for cadmium, thallium, and cyanide as indicated in the table. In addition, the SI values for aluminum, barium, iron, and chromium are not directly comparable with the USGS values due to analytical method differences.

The upper limit of the range of concentrations detected in soil samples at AREE 7 for the following analytes was higher than WRF background soil concentration ranges, but lower than the USGS regional ranges: aluminum, barium, calcium, chromium, magnesium, potassium, sodium, and vanadium. The upper limit of the range of concentrations detected in soil samples at AREE 7 for the following analytes was higher than both background soil concentration ranges and the USGS regional ranges: beryllium, cobalt, copper, iron, manganese, nickel, and zinc. For these seven analytes, there are no ARARs for soil. For iron and cobalt in soil there are no potential TBCs. However, there are potential soil TBCs for the remaining five analytes.

The analytical results for AREE 7 show that none of the samples detected nickel, copper, and zinc above their appropriate potential TBCs. The analytical results show that only two samples, 07BH0107 and 07BH0305, detected manganese above the TBC value of 390 $\mu\text{g/g}$ which is the USEPA Region III risk-based concentration for residential sites. Neither sample detected manganese above the TBC value of 5,100

TABLE 4-30
AREE 7 INORGANIC RESULTS IN SOIL FOR EXCAVATION
LOCATION 07EX01

Analytes ⁽¹⁾	Detection Limits	07EX0101 @ 4.5 feet bgs
Aluminum	10.7	21,000
Antimony	82.9	ND
Arsenic	NA	NA
Barium	4.87	68.5
Beryllium	0.250	1.80
Cadmium	0.427	ND
Calcium	109	830
Chromium	0.974	65.3
Cobalt	2.50	19.6
Copper	3.38	38.4
Iron	12.0	15,000
Lead	0.700	18.6
Magnesium	138	75.1
Manganese	0.511	7,510
Mercury	NA	NA
Molybdenum	4.00	ND
Nickel	7.50	32.3
Potassium	142	1,120
Selenium	12.4	ND
Sodium	50.0	1,100
Thallium	12.5	ND
Vanadium	2.00	84.3
Zinc	4.00	128

Key: AREE = Area Requiring Environmental Evaluation
 ND = Not Detected
 NA = Not Analyzed
 bgs = Below Ground Surface

Note: ⁽¹⁾ Concentrations reported in micrograms per gram ($\mu\text{g/g}$).

TABLE 4-31
AREE 7 INORGANIC RESULTS IN SOIL FOR LOCATION 07BH01

Analytes ⁽¹⁾	Detection Limits	07BH0101 @ 1.0 feet bgs	07BH0102 @ 2.0 feet bgs	07BH0103 @ 3.0 feet bgs	07BH0104 @ 4.0 feet bgs	07BH0105 @ 8.0 feet bgs	07BH0106 @ 12.0 feet bgs	07BH0107 @ 13.0 feet bgs	07BH0108 @ 14.0 feet bgs	07BH0109 @ 15.0 feet bgs	07BH0169 @ 14.0 feet bgs
Aluminum	10.7	10,000	9,700	12,000	9,900	8,200	9,100	12,000	6,900	6,800	6,000
Antimony	82.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.200	1.80	1.60	2.50	1.40	0.670	0.350	1.10	1.40	1.20	1.40
Barium	4.87	65.7	58.0	42.5	60.7	116	54.5	64.4	46.5	45.3	41.0
Beryllium	0.250	0.684	0.823	1.24	0.664	1.53	0.630	1.02	0.523	0.515	0.518
Cadmium	0.427	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	109	482	267	191	313	803	641	1,010	754	842	676
Chromium	0.974	19.1	18.2	29.8	16.5	24.4	24.4	42.5	27.2	25.8	25.7
Cobalt	2.50	10.2	9.61	ND	6.16	12.9	8.23	4.84	26.4	36.1	9.80
Copper	3.38	13.3	13.6	20.5	13.5	18.0	10.0	19.9	8.13	8.71	6.99
Cyanide	1.22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	12.0	15,000	19,000	45,000	17,000	5,000	16,000	49,000	16,000	11,000	14,000
Lead	0.700	14.0 B	12.0 B	13.0 B	10.0 B	12.0 B	7.70 B	8.60 B	5.70 B	5.70 B	4.80 B
Magnesium	138	2,320	2,430	2,630	2,850	3,060	3,300	3,950	2,470	2,570	2,230
Manganese	0.511	136	103	121	93.1	40.6	157	500	199	172	120
Mercury	0.0870	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum	4.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	7.50	11.5	12.4	10.8	11.0	20.4	12.4	21.2	12.5	14.3	11.0
Potassium	142	664	647	686	724	544	980	1,040	649	682	580
Selenium	12.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	50.0	126	185	235	293	793	441	571	334	326	304
Thallium	12.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	2.00	38.4	35.5	46.9	33.6	41.0	40.3	52.8	35.6	30.9	31.7
Zinc	4.00	41.3	42.7	48.6	46.1	61.6	34.6	61.8	33.2	44.8	28.9

Key: AREE = Area Requiring Environmental Evaluation
ND = Not Detected

= = Flag for analyte found in the method blank or QC blank as well as the sample.
B = Below Ground Surface
bgs

Note: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).

TABLE 4-32
AREE 7 INORGANIC RESULTS IN SOIL FOR LOCATION 07BH02

Analytes ⁽¹⁾	Detection Limits	07BH0201 @ 1.0 feet bgs	07BH0202 @ 2.0 feet bgs	07BH0203 @ 3.0 feet bgs	07BH0204 @ 4.0 feet bgs	07BH0205 @ 8.0 feet bgs	07BH0206 @ 12.0 feet bgs	07BH0207 @ 13.0 feet bgs	07BH0208 @ 14.0 feet bgs	07BH0209 @ 15.0 feet bgs	07BH0269 @ 4.0 feet bgs
Aluminum	10.7	11,000	7,200	12,000	13,000	12,000	5,800	11,000	11,000	14,000	13,000
Antimony	82.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.200	1.50	1.30	1.80	0.540	0.710	ND	0.940	1.60	1.40	1.60
Barium	4.87	78.6	71.1	78.6	61.2	177	24.5	62.5	61.3	108	58.3
Beryllium	0.250	1.25	0.712	0.826	0.833	1.55	0.376	0.840	0.654	0.967	0.841
Cadmium	0.427	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	109	547	543	433	359	905	499	958	1,020	1,360	326
Chromium	0.974	28.9	22.8	18.9	19.6	26.0	20.2	39.6	34.4	54.1	20.2
Cobalt	2.50	6.18	9.98	11.2	9.46	23.8	ND	7.55	14.5	8.37	8.49
Copper	3.38	19.4	13.4	14.0	14.1	18.8	6.08	16.5	11.5	21.0	14.2
Cyanide	1.22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	12.0	24,000	9,400	18,000	19,000	8,400	13,000	30,000	19,000	27,000	21,000
Lead	0.700	13.0 B	9.70 B	12.0 B	12.0 B	13.0 B	5.00 B	8.00 B	6.70 B	9.50 B	11.0 B
Magnesium	138	2,480	2,640	2,510	3,340	3,640	2,350	3,730	3,180	4,380	3,270
Manganese	0.511	75.2	87.6	117	147	70.6	101	270	130	133	157
Mercury	0.0870	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum	4.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	7.50	13.4	16.6	13.3	13.4	25.5	ND	15.6	15.6	23.3	13.7
Potassium	142	682	473	805	914	682	652	991	1,040	1,100	939
Selenium	12.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	50.0	163	186	201	251	802	280	530	394	568	234
Thallium	12.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	2.00	42.8	32.8	36.2	39.2	45.6	31.0	49.2	47.3	63.6	43.6
Zinc	4.00	48.1	41.9	45.1	54.7	69.5	26.9	47.0	41.4	62.4	50.3

Key: AREE = Area Requiring Environmental Evaluation
ND = Not Detected

B = Flag for analyte found in the method blank or QC blank as well as the sample.
bgs = Below Ground Surface

Note: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).

TABLE 4-33
AREE 7 INORGANIC RESULTS IN SOIL FOR LOCATION 07BH03

Analytes ⁽¹⁾	Detection Limits	07BH0301 @ 1.0 feet bgs	07BH0302 @ 2.0 feet bgs	07BH0303 @ 3.0 feet bgs	07BH0304 @ 4.0 feet bgs	07BH0305 @ 8.0 feet bgs	07BH0306 @ 12.0 feet bgs	07BH0307 @ 13.0 feet bgs	07BH0308 @ 14.0 feet bgs	07BH0309 @ 15.0 feet bgs	07BH0369 @ 4.0 feet bgs
Aluminum	10.7	13,000	15,000	19,000	19,000	12,000	11,000	462	20,000	20,000	19,000
Antimony	82.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.200	2.25	2.77	ND	ND	ND	1.98	ND	ND	ND	ND
Barium	4.87	85.6 l	83.3 l	120 l	91.9 l	124 l	74.4 l	69.5 l	393 l	94.5 l	119 l
Beryllium	0.250	1.04	1.16	0.814	1.48	0.391	0.777	0.648	1.32	1.20	1.61
Cadmium	0.427	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	109	695	570	598	799	721	1,220	1,210	2,230	1,940	800
Chromium	0.974	31.8	28.8	34.3	38.5	27.6	41.5	45.0	48.2	46.9	41.1
Cobalt	2.50	9.95	7.67	8.35	15.3	38.7	9.07	5.77	33.8	13.9	14.3
Copper	3.38	18.9	19.1	16.8	24.0	9.88	12.0	12.2	33.4	28.2	22.3
Cyanide	1.22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	12.0	24,000	26,000	16,000	9,400	23,000	20,000	13,000	27,000	36,000	9,100
Lead	0.700	14.2 B	15.3 B	12.0 B	15.5 B	9.30 B	7.80 B	7.90 B	18.1 B	14.8 B	14.0 B
Magnesium	138	3,110	2,890	3,810	3,560	3,660	3,020	3,300	370	6,050	3,470
Manganese	0.511	144	113	68.6	54.9	1,800	114	88.5	14.1	213	57.2
Mercury	0.0870	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum	4.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	7.50	16.1	15.0	14.7	22.2	21.2	15.8	16.5	36.0	32.3	24.3
Potassium	142	1,020	1,150	1,430	1,480	1,070	1,170	863	1,540	1,550	1,460
Selenium	12.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	50.0	198	264	494	691	681	421	401	827	701	649
Thallium	12.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	2.00	56.4	51.8	44.2	60.6	38.5	62.0	46.0	74.2	69.2	62.6
Zinc	4.00	56.5	57.5	54.0	83.1	41.0	39.4	40.2	88.9	82.4	89.1

Key: AREE = Area Requiring Environmental Evaluation
ND = Not Detected

B = Flag for analyte found in the method blank or QC blank as well as the sample.
bgs = Below Ground Surface

Note: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).

TABLE 4-34
AREE 7 INORGANIC RESULTS IN SOIL FOR LOCATION 07BH04

Analytes ⁽¹⁾	Detection Limits	07BH0401 @ 1.0 feet bgs	07BH0402 @ 2.0 feet bgs	07BH0403 @ 3.0 feet bgs	07BH0404 @ 4.0 feet bgs	07BH0405 @ 8.0 feet bgs	07BH0406 @ 12.0 feet bgs	07BH0407 @ 13.0 feet bgs	07BH0408 @ 14.0 feet bgs	07BH0409 @ 15.0 feet bgs	07BH0469 @ 12.0 feet bgs	AREE 7 Range
Aluminum	10.7	20,000	26,000	23,000	25,000	38,000	15,000	18,000	19,000	25,000	16,000	462 - 38,000
Antimony	82.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.200	1.36	0.840	1.78	1.60	4.67	1.48	ND	ND	ND	5.84	ND - 5.84
Barium	4.87	71.4	63.7	222	65.8	86.4	64.4	62.8	42.7	111	72.5	24.5 - 393
Beryllium	0.250	1.04	1.19	1.48	2.79	1.57	0.774	0.980	0.794	1.30	0.775	0.376 - 2.79
Cadmium	0.427	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	109	579	348	359	466	1,180	1,100	1,560	2,450	1,920	1,210	191 - 2,450
Chromium	0.974	30.7	32.3	38.9	63.0	60.0	37.1	46.6	48.4	59.2	39.6	16.5 - 63.0
Cobalt	2.50	13.8	11.9	9.17	4.63	29.3	13.9	18.6	9.39	15.3	12.0	ND - 38.7
Copper	3.38	17.0	17.4	23.5	37.7	28.3	10.1	19.1	16.1	34.4	10.6	6.08 - 37.7
Cyanide	1.22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	12.0	ND	30,000	44,000	86,000	26,000	21,000	28,000	18,000	26,000	21,000	ND - 86,000
Lead	0.700	15.0	13.0	15.7	17.0	16.0	6.50	10.0	7.80	13.0	7.4	4.80 - 17.0
Magnesium	138	3,150	3,670	3,580	3,230	6,520	3,050	4,920	3,950	6,360	3,260	307 - 6,520
Manganese	0.511	121	127	158	165	122	166	175	108	131	167	14.1 - 1,800
Mercury	0.0870	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum	4.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	7.50	14.7	15.1	13.8	16.7	42.0	13.8	23.1	18.4	32.4	14.3	ND - 42.0
Potassium	142	1,560	2,310	2,030	2,050	2,700	1,810	1,660	2,400	2,330	2,060	473 - 2,700
Selenium	12.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	50.0	175	219	292	453	1,330	421	568	661	625	452	126 - 1,330
Thallium	12.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	2.00	49.7	52.6	64.2	68.2	101	50.8	71.4	60.4	78.8	51.5	30.9 - 101
Zinc	4.00	50.3	53.4	57.6	69.8	99.5	36.5	60.6	46.0	75.0	40.2	26.9 - 117

Key: AREE = Area Requiring Environmental Evaluation bgs = Below Ground Surface
 ND = Not Detected

Note: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).

TABLE 4-35
COMPARISON OF INORGANIC RESULTS IN SOIL FOR AREE 7, BACKGROUND
SAMPLES, AND USGS RANGES

Analyte ⁽¹⁾	AREE 7 Range ⁽²⁾	Background Range	USGS Range ⁽³⁾
Aluminum	462 - 38,000	10,000 - 14,000	50,000 - 100,000
Antimony	ND	ND	≤ 1
Arsenic	ND - 5.84	NA	2.6 - 6.5
Barium	24.5 - 393	61.6 - 71.4	300 - 700
Beryllium	0.376 - 2.79	0.572 - 0.802	≤ 1
Cadmium	ND	ND	--
Calcium	191 - 2,450	1,280 - 1,720	3,500 - 5,200
Chromium	16.5 - 63.0	21.3 - 23.9	30 - 70
Cobalt	ND - 38.7	ND - 13.8	3 - 7
Copper	6.08 - 37.7	5.62 - 6.67	20 - 30
Cyanide	ND	NA	--
Iron	ND - 86,000	16,000 - 18,000	20,000 - 50,000
Lead	4.80 - 17.0	17.7 - 22.1	15 - 150
Magnesium	307 - 6,520	1,120 - 1,310	20,000 - 30,000
Manganese	14.1 - 1,800	107 - 300	200 - 300
Mercury	ND	ND	0.082 - 0.13
Molybdenum	ND	ND	≤ 3
Nickel	ND - 42.0	ND	10 - 20
Potassium	473 - 2,700	408 - 477	6,800 - 16,000
Selenium	ND	ND	0.1 - 5
Sodium	126 - 1,330	ND	500 - 2,000
Thallium	ND	ND	--
Vanadium	30.9 - 101	38.1 - 49.2	70 - 150
Zinc	26.9 - 117	37.4 - 42.3	28 - 74

Key: USGS = U.S. Geological Survey NA = Not Analyzed
AREE = Area Requiring Environmental Evaluation ND = Not Detected
-- = Not Available

Notes: (1) Concentrations reported in micrograms per gram (µg/g)
(2) Shaded results indicate where the AREE 7 range exceeds the background and/or USGS range.
(3) U.S. Geological Survey, 1984.

$\mu\text{g/g}$ which is the USEPA Region III risk-based concentration for commercial sites. The analytical results show that the majority (78%) of the samples detected beryllium above the potential TBCs.

4.9.4 Conclusions

Due to the facility personnel identifying the location of the pistol range and the evidence found during the investigation, the area under investigation for AREE 7 was determined to be the former pistol range.

The soil sampling completed identified seven metals detected above naturally occurring levels; however, there are no ARARs or potential TBCs for two of the seven analytes. The analytical results showed three of the five remaining analytes as detected below their appropriate potential TBCs.

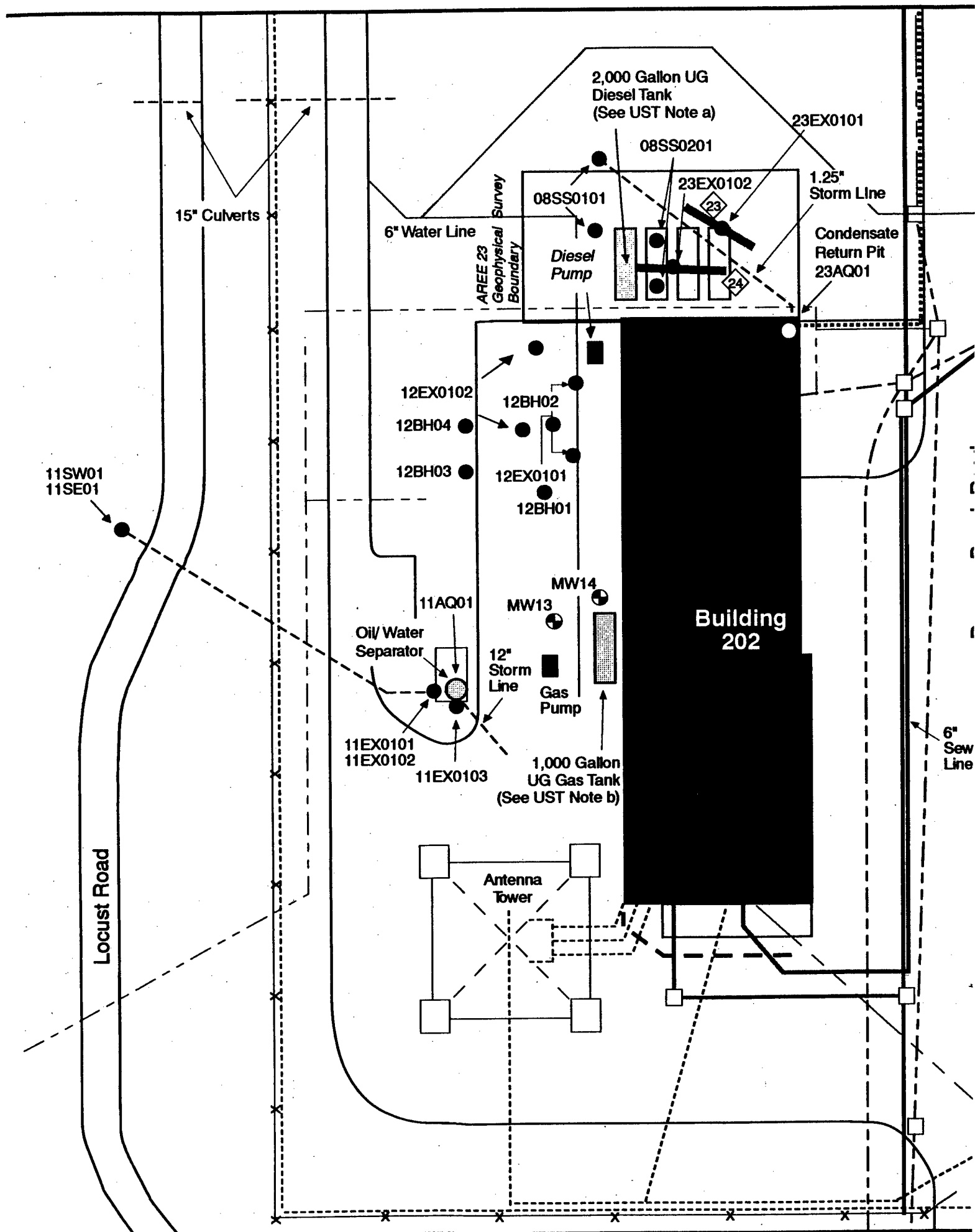
4.10 AREEs 8/23 (UST LEAKS AND SPILLS/EXISTING AND FORMER USTs)

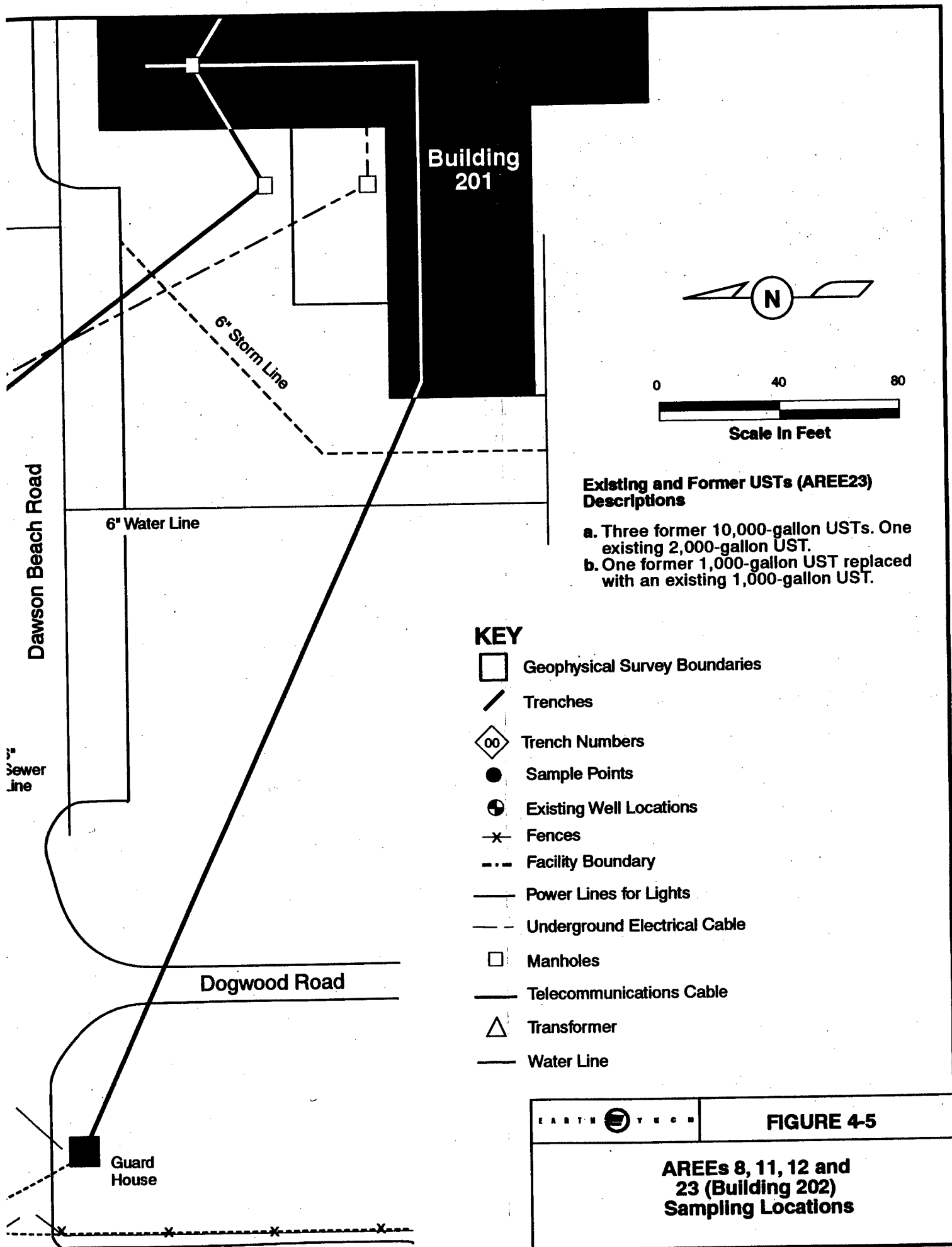
4.10.1 Summary of Field Activities and Analytical Program

Geophysical activities performed at AREEs 8/23 included magnetic and GPR profiling to locate the trench for the former tanks, the existing tank, and any subsurface utilities in the area. Three trenches were excavated, Trenches 23 and 24 at the former UST locations at Building 202 (Figure 4-5), and Trench 25 at the former UST location by Building 203 (Figure 4-6). Trenches 23 and 24 were excavated to a depth of approximately 8 feet and contained dark, discolored soil with an odor (Appendix C). Trenches 23 and 24 had excavated soil HNu readings of 4 and 13 ppm, respectively. Trench 25 contained no debris, discoloring, or odor. The excavated soil and ambient air HNu readings were 0 ppm.

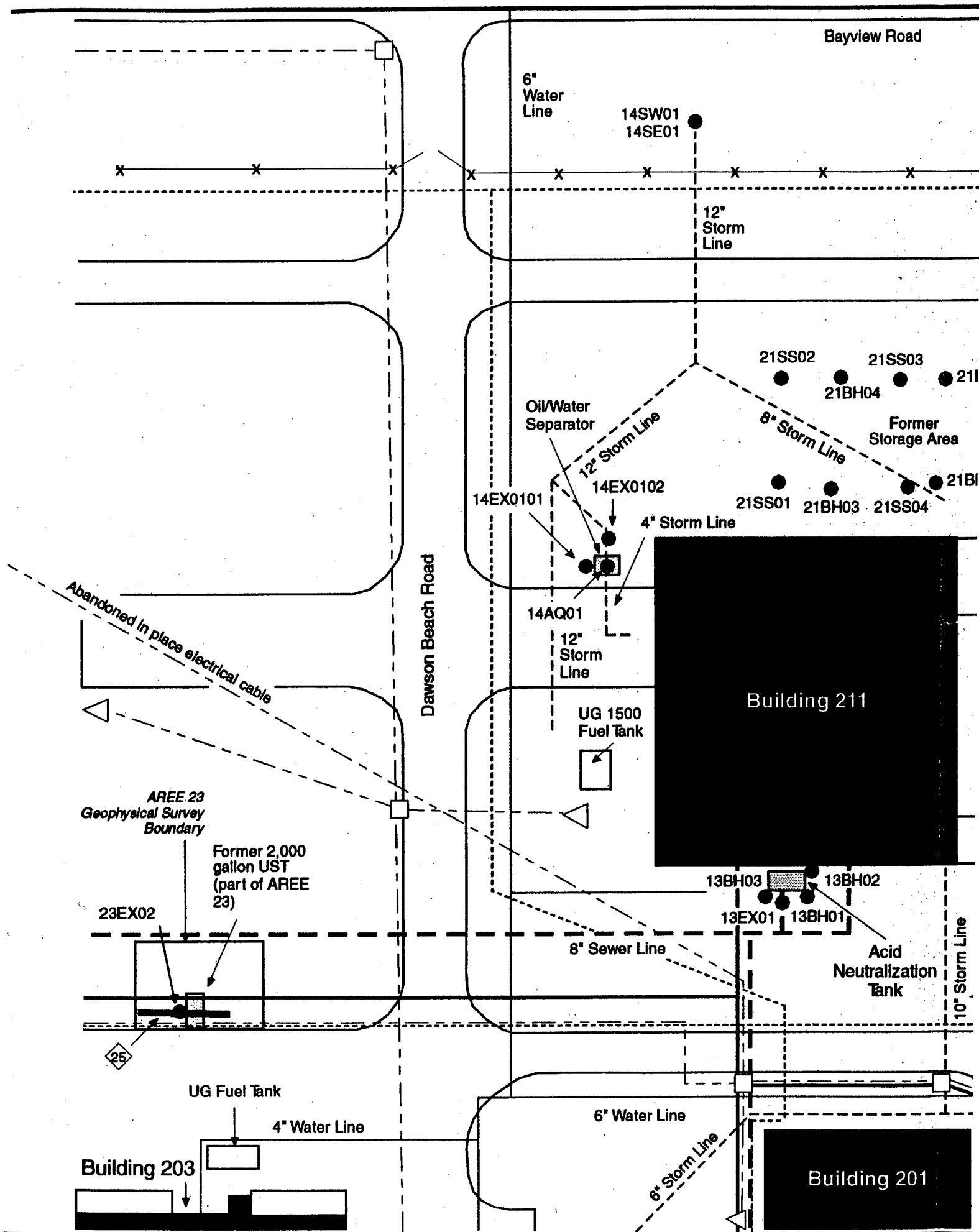
Two composite surface soil samples 08SS0101 and 08SS0201 were collected from the spill area (AREE 8). Soil samples 23EX0101 and 23EX0102 were collected at 7.5 feet bgs from Trenches 23 and 24, respectively, as shown on Figure 4-5. Soil sample 23EX0201 was collected at 10 feet bgs from Trench 25 as illustrated on Figure 4-6. TPH analyses were performed on all samples. The two existing wells, MW13 and MW14, located just north of Building 202 were purged and sampled (Appendix C). An aqueous sample and duplicate were collected from the condensate return pit inside Building 202, designated 23AQ01 on Figure 4-5. All water/aqueous samples were analyzed for TPHs.

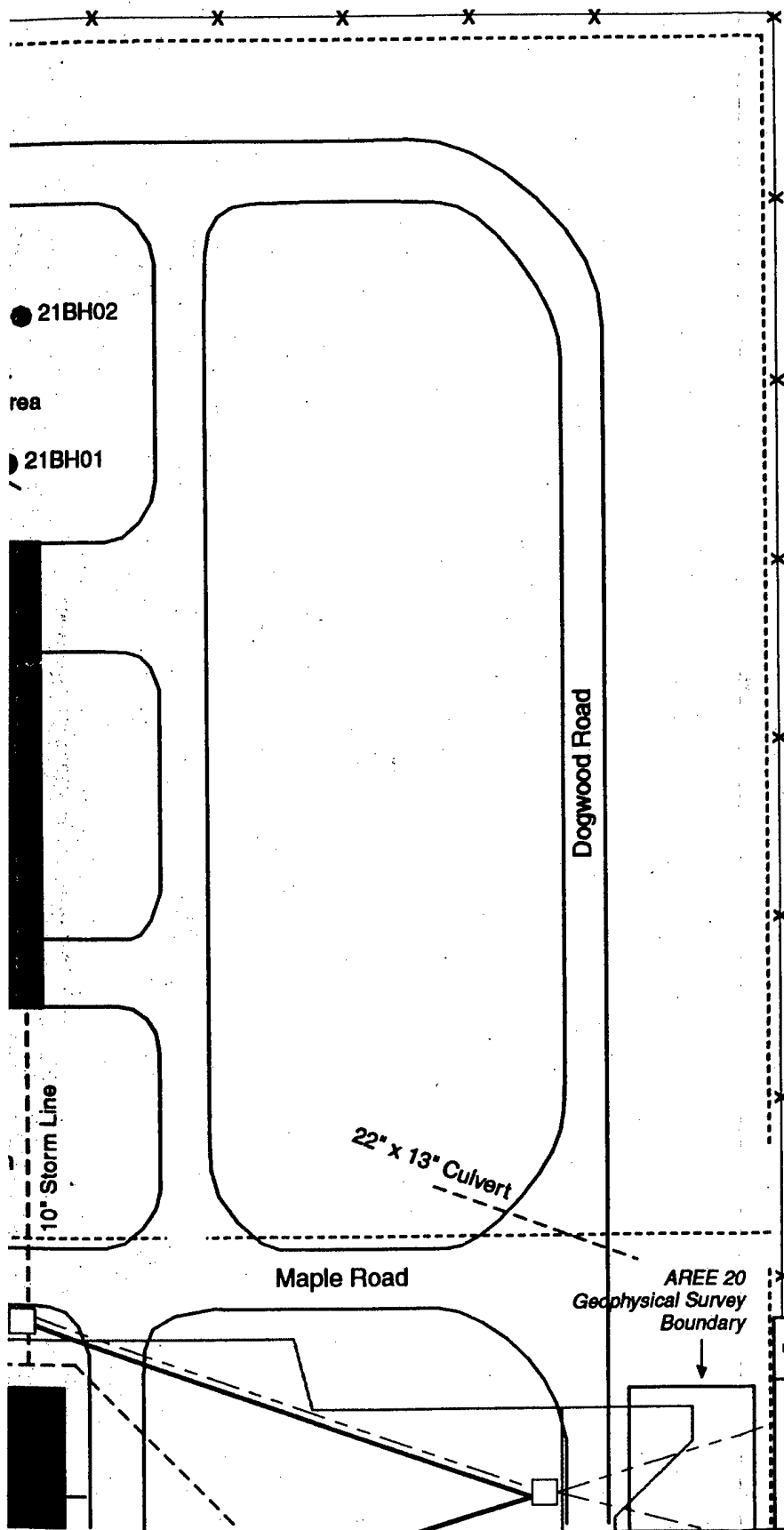
Points surveyed include sampling locations, ends of trenches, and geophysics grid corners (Appendix D). Locations of all sampling points for AREEs 8/23 are shown on Figures 4-5 and 4-6.





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KEY

- Geophysical Survey Boundaries
- Trenches
- Sample Points
- Power Lines for Lights
- Underground Electrical Cable
- Manholes
- Telecommunications Cable
- Transformer
- Water Line
- Trench Numbers



EARTH SYSTEMS

FIGURE 4-6

**AREEs 13,14, 20, 21 and
23 (Building 211)
Sampling Locations**

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4.10.2 *Data Summary*

TPHs were detected in all soil samples collected as illustrated in Table 4-36. For the two composite surface soil samples, 08SS0101 and 08SS0201, TPHs were detected at concentrations of 14 mg/kg and 42 mg/kg, respectively. For the three soil samples collected from the excavated trenches, 23EX0101, 23EX0102 and 23EX0201, TPHs were detected at concentrations of 209 mg/kg, 302 mg/kg, and 30 mg/kg, respectively.

TPHs were also detected in the groundwater sample collected at MW13 (see Table 4-37). The detected concentration in this sample was 1 μ g/L which is equal to the detection limit for this analyte in water. TPHs were not detected in the groundwater sample collected at MW14.

The aqueous sample and duplicate collected from the condensate return tank pit also contained detectable concentrations of TPHs. TPHs were detected at concentrations of 2 μ g/L and 84 μ g/L for the aqueous sample 23AQ0101 and duplicate 23AQ0102 as shown in Table 4-37.

4.10.3 *Evaluation*

TPHs were detected in all soil samples collected for AREEs 8/23; however, only those samples collected during the excavation near the former USTs just east of Building 202 contained TPHs above the 100 mg/kg Virginia UST Program Action Level which is the TBC for TPHs in soil.

Only one of the two wells sampled in conjunction with AREEs 8/23 contained a detectable level of TPHs. The detected concentration of 1 μ g/L is less than the Virginia Groundwater Standard for TPHs. The aqueous sample and duplicate also detected TPHs at levels lower than this TBC value.

4.10.4 *Conclusions*

Based on the soil sampling performed for AREEs 8/23, the surface soil east of Building 202 does not appear to be contaminated by TPHs at concentrations at, or a approaching, VADEQ action levels. This is also true for subsurface soil in the vicinity of the former UST located east of Building 203. However, the subsurface soil in the vicinity of the former USTs located east of Building 202 appears to be contaminated at concentrations above action levels.

The water sampling conducted for AREEs 8/23 also suggests possible groundwater contamination in the vicinity of Building 202. The groundwater samples collected from the existing wells north of Building 202 may indicate possible contamination from the former and/or existing USTs located near the wells. In addition, the aqueous samples collected from the condensate return tank pit located at the southeast corner

TABLE 4-36
AREEs 8/23 SOIL SAMPLING RESULTS SUMMARY

Analytes ⁽¹⁾	Detection Limit	08SS0101 @ 2 inches	08SS0201 @ 2 inches	23EX0101 @ 2.5 feet bgs	23EX0102 @ 7.5 feet bgs	23EX0201 @ 10.0 feet bgs
TPHs	10	14.0	42.0	209	302	30.0

Key: AREE = Area Requiring Environmental Evaluation
 TPH = Total Petroleum Hydrocarbon
 bgs = Below Ground Surface

Note: ⁽¹⁾ Concentrations reported in milligrams per kilogram (mg/kg).

TABLE 4-37
AREEs 8/23 GROUNDWATER AND AQUEOUS SAMPLING RESULTS SUMMARY

Analytes ⁽¹⁾	Detection Limit	MW13	MW14	23AQ0101	23AQ0102
TPHs	1	1	ND	2	84

Key: AREE = Area Requiring Environmental Evaluation
 TPH = Total Petroleum Hydrocarbon
 ND = Not Detected

Note: ⁽¹⁾ Concentrations reported in micrograms per liter (µg/L).

of Building 202 may indicate possible contamination from the former and/or existing USTs located just east of the building.

The Draft Site Characterization Report for Building 202, (EARTH TECH, July 1994), summarizes additional actions that have been performed at AREEs 8/23.

4.11 AREE 11 (OIL/WATER SEPARATOR)

4.11.1 *Summary of Field Activities and Analytical Program*

Geophysical activities performed at AREE 11 included magnetic and GPR profiling to locate subsurface utilities. Four trenches were excavated to expose the sides of the oil/water separator. During the excavation the separator appeared to be leaking along the north and west sides of the separator. The soil surrounding the separator was discolored and had a fuel odor. HNu readings on the excavated soil were approximately 13 ppm. During the excavation of the south side of the separator, a fuel odor was encountered, but no leaks were observed. No apparent leaks or odors were observed during the excavation along the eastern side of the separator.

One surface water sample and one sediment sample were collected from the separator outfall, and an aqueous sample was collected from inside the separator. The surface water and sediment sampling location is designated 11SW01/11SE01 and the aqueous sample location is designated 11AQ01 as shown on Figure 4-5. The surface water sample and aqueous sample were analyzed for VOCs and SVOCs. The sediment sample was analyzed for VOCs, SVOCs, TPHs, and PCBs/pesticides.

Soil sample 11EX0101 and replicate 11EX0102 were collected at 5 feet bgs from the trench along the north side of the separator. Soil sample 11EX0103 was collected at 5 feet bgs from the excavation along the west side of the separator. The two soil samples and replicate were analyzed for VOCs, SVOCs, and TPHs. All sampling locations were surveyed and are shown in Figure 4-5.

4.11.2 *Data Summary*

The analytical results for the sediment sample collected at the outfall (11SE0101) reported detectable concentrations of 1,4-dichlorobenzene, 1,2-dichlorobenzene, 1,2,4-trichlorobenzene, PCB-1260, and chlorobenzene at 39 $\mu\text{g/g}$, 8.6 $\mu\text{g/g}$, 260 $\mu\text{g/g}$, 1,170 $\mu\text{g/g}$, and 1.6 $\mu\text{g/g}$, respectively (see Table 4-38). TPHs were detected in the soil sample and replicate at concentrations over 4,200 mg/kg as shown in Table 4-38. Soil sample 11EX0101 from the excavation also contained fluorene, phenanthrene, and bis(2-ethylhexyl)phthalate at 0.20 $\mu\text{g/g}$, 0.45 $\mu\text{g/g}$, and 0.28 $\mu\text{g/g}$, respectively. None of these analytes were detected in the replicate sample. Soil sample 11EX0103 contained ethylbenzene, 2-butanone, and phenanthrene at 0.0042 $\mu\text{g/g}$, 0.006 $\mu\text{g/g}$, and 0.22 $\mu\text{g/g}$, respectively and TPHs at 145 mg/kg. The surface water sample (11SW0101) contained acetone at 150 $\mu\text{g/L}$ as shown in Table 4-39. VOCs and

TABLE 4-38
AREE 11 SOIL AND SEDIMENT SAMPLING RESULTS SUMMARY

Analytes ⁽¹⁾	Detection Limit	11EX0101 @ 5 feet bgs	11EX0102 ⁽²⁾ @ 5 feet bgs	11EX0103 @ 5 feet bgs	11SE0101
Bis(2-ethylhexyl)phthalate	0.19	0.28	ND	ND	ND
Fluorene	0.17	0.20 1	ND	ND	ND
Phenanthrene	0.17	0.45	ND	0.22	ND
Ethylbenzene	0.0025	ND	ND	0.0042	ND
2-Butanone	0.0051	ND	ND	0.006	ND
1,2,4-Trichlorobenzene	29	ND	ND	ND	260
1,2-Dichlorobenzene	3.2	ND	ND	ND	8.6
1,4-Dichlorobenzene	17	ND	ND	ND	39
Chlorobenzene	1.2	ND	ND	ND	1.6
PCB-1260	0.04	NA	NA	NA	1,170
Total Petroleum Hydrocarbons	9	4,250	4,937	145	ND

Key: AREE = Area Requiring Environmental Evaluation
PCB = Polychlorinated Biphenyl
bgs = Below Ground Surface
ND = Not Detected
NA = Not Analyzed
1 = Flag for result less than CRL but greater than COD

Notes: ⁽¹⁾ All concentrations reported in micrograms per gram ($\mu\text{g/g}$) except for Total Petroleum Hydrocarbons which are reported in milligrams per kilogram (mg/kg).
⁽²⁾ Replicate of 11EX0101.

TABLE 4-39
AREE 11 SURFACE WATER SAMPLING RESULTS SUMMARY

Analytes ⁽¹⁾	Detection Limit	11SW0101
Acetone	10	150 S

Key: AREE = Area Requiring Environmental Evaluation
S = Flag for non-target compound analyzed for and detected.

Note: ⁽¹⁾ Concentrations reported in micrograms per liter ($\mu\text{g/L}$).

SVOCs were not detected in the aqueous sample. Appendix H contains the complete results of all analyses.

4.11.3 *Evaluation*

The purpose of the sampling program conducted at AREE 11 was to identify possible contamination that could have been caused by the past use of the oil/water separator. The analytical results from the sampling indicate that the soil immediately adjacent to the oil/water separator and the sediment at the outfall for the separator is contaminated with VOCs, SVOCs, TPH, and/or PCBs.

The majority of the detected compounds are below their appropriate potential TBCs as provided in Table 3-15. The detected value of 1,4-dichlorobenzene is lower than the 120 $\mu\text{g/g}$ USEPA Region III risk-based concentration for commercial (industrial) sites but slightly higher than the 27 $\mu\text{g/g}$ USEPA Region III risk-based concentration for residential sites. However, the detected values of PCB-1260 and TPHs are much higher than their appropriate potential TBCs.

Although acetone was detected in the surface water sample collected at the outfall from the oil/water separator, this analyte is a typical laboratory contaminant. In addition, the detected value of 150 $\mu\text{g/L}$ is well below the 3,700 $\mu\text{g/L}$ USEPA risk-based concentration in drinking water for acetone which is the potential TBC for this analyte. No other VOCs nor SVOCs were detected in the surface water or aqueous sample.

4.11.4 *Conclusions*

During the excavation activities, the oil/water separator was noted to have leaks, and the soil surrounding the separator was observed as discolored with a fuel odor. Based on the sampling performed, the soil in the vicinity of the separator and the sediment at the outfall from the separator are contaminated and will require additional investigation to identify the extent of soil contamination and a removal action. Investigation of possible groundwater contamination beneath the separator and at the outfall are recommended.

4.12 AREE 12 (DRUM STORAGE AREA)

4.12.1 *Summary of Field Activities and Analytical Program*

Geophysical activities performed at AREE 12 included magnetic, EMI, and GPR profiling to locate subsurface utilities. During the Preliminary SI four areas approximately 2 feet by 3 feet wide were excavated to a depth of 1.5 feet immediately beneath the pavement. The locations chosen for the excavation were based on stains on the pavement and cracks in the asphalt which were considered the most likely route for contamination migration.

Two composite soil samples were collected from the shallow excavations (1 foot bgs) immediately under the pavement. Soil sample 12EX0101 was collected beneath the two southern pavement excavations, and soil sample 12EX0102 was collected beneath the two northern pavement excavations. Sampling locations were surveyed and are shown on Figure 4-5. Both soil samples were analyzed for TPHs, VOCs, and SVOCs.

Subsequent to the Preliminary SI, the BCT requested additional sampling to be conducted as part of a SSI. During the SSI, two boreholes (12BH01 and 12BH02) were drilled through the asphalt pavement and two boreholes (12BH03 and 12BH04) were drilled approximately 2 feet north of the asphalt pavement as illustrated in Figure 4-5. The two boreholes located on the asphalt pavement were completed to a depth of 12 feet, and the two boreholes drilled north of the asphalt were completed to a depth of 10 feet.

Subsurface soil samples 12BH0101, 12BH0103, and 12BH0105 were collected from location 12BH01 at depths of 1, 5, and 10 feet, respectively. Subsurface soil samples 12BH0201, 12BH0203, and 12BH0205 were collected from location 12BH02 at depths of 1, 5, and 10 feet, respectively. Subsurface soil samples 12BH0302 and 12BH0305 were collected from location 12BH03 at depths of 2 and 8 feet, respectively, and subsurface soil samples 12BH0402 and 12BH0405 were collected from location 12BH04 at depths of 2 and 8 feet, respectively. All of the soil samples collected at AREE 12 during the SSI were analyzed for metals, TPHs, VOCs, SVOCs, PCBs, and pesticides.

4.12.2 Data Summary

Acetone, 2-butanone, and TPHs were detected in both composite soil samples collected during the Preliminary SI from the excavated areas. Samples 12EX0101 and 12EX0102 contained 0.100 $\mu\text{g/g}$ and 0.070 $\mu\text{g/g}$ of acetone, respectively, and 0.012 $\mu\text{g/g}$ and 0.008 $\mu\text{g/g}$ of 2-butanone, respectively. The TPH concentration in 12EX0101 was 40.5 mg/kg and 66.3 mg/kg in 12EX0102. A summary of the analytical results is provided in Table 4-40.

The analytical results for organic compounds for the samples collected from the boreholes completed during the SSI are also summarized in Table 4-40. TPHs, acetone, and 2-butanone were detected in sample 12BH0101 at 25.9 mg/kg, 0.069 $\mu\text{g/g}$, and 0.005 $\mu\text{g/g}$, respectively. No organics were detected in samples 12BH0103 and 12BH0105. Sample 12BH0201 contained 0.086 $\mu\text{g/g}$ of acetone. No organics were detected in sample 12BH0205. Samples 12BH0203, 12BH0302, 12BH0305, and 12BH0402 contained concentrations less than the CRL, 0.180 $\mu\text{g/g}$, 0.250 $\mu\text{g/g}$, 0.160 $\mu\text{g/g}$, and 0.270 $\mu\text{g/g}$, of di-n-octyl phthalate, respectively. No pesticides or PCBs were detected in any samples from the boreholes at AREE 12.

TABLE 4-40
AREE 12 SUMMARY OF ORGANIC SOIL SAMPLE RESULTS⁽¹⁾

Analytes ⁽²⁾	Detection Limit	12EX0101 ⁽²⁾ @ 1.0 feet bgs	12EX0102 ⁽³⁾ @ 1.0 feet bgs	12BH0101 @ 1.0 feet bgs	12BH0201 @ 1.0 feet bgs	12BH0203 @ 5.0 feet bgs	12BH0302 @ 2.0 feet bgs	12BH0305 @ 8.0 feet bgs	12BH0402 @ 2.0 feet bgs
Acetone	0.00446	0.100	0.070	0.069	0.086	ND	ND	ND	ND
2-Butanone	0.00510	0.012	0.008	0.005	ND	ND	ND	ND	ND
Total Petroleum Hydrocarbons	20.0	40.5	66.3	25.9	ND	ND	ND	ND	ND
Di-n-octyl Phthalate	0.220	NA	NA	ND	ND	0.180 1	0.250 1	0.160 1	0.270 1

Key: AREE = Area Requiring Environmental Evaluation
bgs = Below Ground Surface
ND = Not Detected
NA = Not Analyzed
1 = Flag for result less than CRL but greater than COD.

Notes:
⁽¹⁾ Included samples have positive detections. Additional soil samples were collected but did not contain any organic compounds.
⁽²⁾ All concentrations reported in micrograms per gram (µg/g) except for Total Petroleum Hydrocarbons which are reported in milligrams per kilogram (mg/kg).
⁽³⁾ These samples have a detection limit of 9 mg/kg for Total Petroleum Hydrocarbons.

Inorganics were detected in all AREE 12 soil samples. A summary of AREE 12 inorganic soil sample results is provided in Table 4-41. Inorganics not detected in any samples from borehole locations 12BH01, 12BH02, 12BH03, or 12BH04 include mercury, molybdenum, thallium, antimony, cadmium, and selenium.

4.12.3 *Evaluation*

The purpose of the soil sampling program conducted at AREE 12 was to identify possible contamination that could have been caused by improper past management of materials at this area. The analytical results for the soil sampling indicate both organic and inorganic compounds detected in the soil beneath the pavement. The detected values of all organic compounds are below their appropriate potential TBCs as provided in Table 3-15.

Table 4-42 presents a comparison between the inorganic results obtained from the soil sampling at AREE 12 and the background sampling as well as the USGS regional data. The upper limit of the AREE 12 soil sampling results was higher than the background concentration range but lower than the USGS range for the following analytes: aluminum, iron, magnesium, nickel, potassium, sodium, barium, beryllium, chromium, copper, vanadium, and zinc. In addition, the upper limit for cobalt was higher than the USGS range but lower than the background range.

Only manganese had at least one detection above both the background and USGS concentration ranges. When compared to the potential TBCs as provided in Table 3-14, only one sample detected manganese above the 390 $\mu\text{g/g}$ USEPA Region III risk-based concentration for residential sites but lower than the 5,100 $\mu\text{g/g}$ USEPA Region III risk-based concentration for commercial sites. There were no potential TBCs identified or background levels for cyanide in soil; however, cyanide was detected in one soil sample.

4.12.4 *Conclusions*

Although both organic and inorganic compounds were detected in the soil beneath the pavement at AREE 12, the level of contamination does not appear to be significant. However, since AREE 12 is near the oil/water separator, any subsequent investigation at this general area should be considered in conjunction with any future activities proposed at the separator.

4.13 AREE 13 (ACID NEUTRALIZATION TANK)

4.13.1 *Summary of Field Activities and Analytical Program*

Geophysical activities performed at AREE 13 included magnetic and GPR profiling to locate subsurface utilities. During Preliminary SI activities two sides of the tank were exposed by excavation and no leaks or stained soil were observed. The excavation was completed to a depth of 10 feet to the west of the tank and to a depth of 4 feet

to the north of the tank. The bottom of the tank was discovered to be at approximately 6.0 feet. A soil pH meter was used during the excavation with approximate readings of 6.4 obtained throughout the excavation.

Soil sample 13EX0101 was collected from location 13EX01 at a depth of 10 feet in the excavation to the west of the tank. This sampling location was surveyed and is shown in Figure 4-6. The sample was sent to a fixed laboratory for a pH analysis.

Subsequent to the Preliminary SI, the BCT requested additional sampling to be conducted as part of a SSI. Three boreholes were drilled during the SSI at locations shown in Figure 4-6. Two boreholes were drilled approximately 3 feet west of the tank at locations 13BH01 and 13BH03. Both boreholes were drilled to a depth of 8 feet. Borehole 13BH02 was hand augered 1 foot southeast of the tank to a depth of 6.5 feet. A hand augered borehole was attempted on the northeast side of the tank; however, the desired depth could not be reached due to the presence of concrete at approximately to a depth of 3 feet.

One sample was collected from each borehole at approximately 6 feet deep (the bottom of the tank). Sample 13BH0104 was collected from location 13BH01, sample 13BH0204 was collected from location 13BH02, and sample 13BH0304 was collected from location 13BH03. All samples were analyzed for inorganic compounds.

4.13.2 *Data Summary*

The soil sample collected during the excavation activities was analyzed for pH. The laboratory-determined pH was 6.5 which is only 0.1 pH unit different than the field-determined pH.

A summary of the inorganics results for the samples collected at the boreholes is provided in Table 4-43. Mercury, molybdenum, nickel, thallium, antimony, cadmium, selenium, and cyanide were not detected in any of the borehole samples at AREE 13.

4.13.3 *Evaluation*

The presence of the investigation conducted at AREE 13 was to identify possible contamination that could have been caused by the past use of the acid neutralization tank. The excavation activities showed the tank to be structurally sound with no indication of leaking or contaminated soil.

Based on the soil sampling, the soil in the vicinity of the acid neutralization tank does not appear to be contaminated. The pH recorded in the field as well as the pH determined in the laboratory showed the soil to be less acidic than the average background pH value of 5.8 as determined from Table 4-1. A comparison between the inorganic results obtained from the borehole samples at AREE 13 and the background sampling as well as the USGS regional data is provided in Table 4-44. The upper limit of the AREE 13 soil sampling results was higher than the background

TABLE 4-43
AREE 13 INORGANIC RESULTS IN SOIL

Analytes ⁽¹⁾	Detection Limits	13BH0104 @ 6.0 feet bgs	13BH0204 @ 6.0 feet bgs	13BH0304 @ 6.0 feet bgs	AREE 13 Range
Aluminum	10.7	7,300	4,720	6,600	4,720 - 7,300
Antimony	82.9	ND	ND	ND	ND
Arsenic	0.200	0.710	0.830	0.960	0.710 - 0.960
Barium	4.87	24.5	22.8	32.0	22.8 - 32.0
Beryllium	0.250	0.382	0.382	0.393	0.382 - 0.393
Cadmium	0.427	ND	ND	ND	ND
Calcium	109	329	361	293	293 - 361
Chromium	0.974	7.34	6.04	7.91	6.04 - 7.91
Cobalt	2.50	ND	3.86	3.47	ND - 3.86
Copper	3.38	4.43	ND	ND	ND - 4.43
Cyanide	1.22	ND	ND	ND	ND
Iron	12.0	7,600	6,800	7,000	6,800 - 7,600
Lead	0.700	2.40 B	2.80 B	3.20 B	2.40 - 3.20
Magnesium	138	758	543	693	543 - 758
Manganese	0.511	119	177	250	119 - 250
Mercury	0.0870	ND	ND	ND	ND
Molybdenum	4.00	ND	ND	ND	ND
Nickel	7.50	ND	ND	ND	ND
Potassium	142	334	199	297	199 - 334
Selenium	12.4	ND	ND	ND	ND
Sodium	50.0	ND	ND	108	ND - 108
Thallium	12.5	ND	ND	ND	ND
Vanadium	2.00	14.8	11.5	14.1	11.5 - 14.8
Zinc	4.00	21.3 B	11.7	21.4 B	11.7 - 21.4

Key: AREE = Area Requiring Environmental Evaluation
 ND = Not Detected
 bgs = Below Ground Surface
 B = Flag for analyte found in method blank or QC blank as well as the sample

Notes: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).

TABLE 4-44
COMPARISON OF INORGANIC RESULTS IN SOIL FOR AREE 13,
BACKGROUND SAMPLES, AND USGS RANGES

Analyte ⁽¹⁾	AREE 13 Range ⁽²⁾	Background Range	USGS Range ⁽³⁾
Aluminum	4,720 - 7,300	10,000 - 14,000	50,000 - 100,000
Antimony	ND	ND	≤ 1
Arsenic	0.710 - 0.960	NA	2.6 - 6.5
Barium	22.8 - 32.0	61.6 - 71.4	300 - 700
Beryllium	0.382 - 0.393	0.572 - 0.802	≤ 1
Cadmium	ND	ND	--
Calcium	293 - 361	1,280 - 1,720	3,500 - 5,200
Chromium	6.04 - 7.91	21.3 - 23.9	30 - 70
Cobalt	ND - 3.86	ND - 13.8	3 - 7
Copper	ND - 4.43	5.62 - 6.67	20 - 30
Cyanide	ND	NA	--
Iron	6,800 - 7,600	16,000 - 18,000	20,000 - 50,000
Lead	2.40 - 3.20	17.7 - 22.1	15 - 150
Magnesium	543 - 758	1,120 - 1,310	20,000 - 30,000
Manganese	119 - 250	107 - 300	200 - 300
Mercury	ND	ND	0.082 - 0.13
Molybdenum	ND	ND	≤ 3
Nickel	ND	ND	10 - 20
Potassium	199 - 334	408 - 477	6,800 - 16,000
Selenium	ND	ND	0.1 - 5
Sodium	ND - 108	ND	500 - 2,000
Thallium	ND	ND	--
Vanadium	11.5 - 14.8	38.1 - 49.2	70 - 150
Zinc	11.7 - 21.4	37.4 - 42.3	28 - 74

Key: AREE = Area Requiring Environmental Evaluation ND = Not Detected
USGS = U.S. Geological Survey -- = Not Available
NA = Not Analyzed

Notes: (1) Concentrations reported in micrograms per gram (µg/g).
(2) Shaded results indicate where the AREE 13 range exceeds the background and/or USGS range.
(3) U.S. Geological Survey, 1984.

concentration range but lower than the USGS range for sodium. All analytes were detected within the USGS background ranges.

4.13.4 Conclusions

The activities conducted at AREE 13 suggest no evidence of soil contamination. The acid neutralization tank appeared to be in good condition and the field and laboratory determined pHs do not indicate acidic contamination. In addition, the inorganic analyses of the soil collected from the boreholes resulted in no analytes being detected above naturally occurring levels. Therefore, no further action should be appropriate for this AREE. The BCT has recommended the removal of the tank.

4.14 AREE 14 (OIL/WATER SEPARATOR)

4.14.1 Summary of Field Activities and Analytical Program

Geophysical activities performed at AREE 14 included magnetic, EMI, and GPR surveys to locate subsurface utilities. Four trenches were excavated to expose each side of the separator and no leaks or odors were observed. The trenches to the north and east were excavated to a depth of 9 feet, and the trenches to the south and west were excavated to a depth of 3 feet. All trenches had ambient air and excavated soil headspace HNu readings of 0 ppm.

One surface water sample and one sediment sample as well as duplicate surface water and replicate sediment samples were collected from the separator outfall. This location is designated 14SW01/14SE01 as shown on Figure 4-6. The surface water sample was analyzed for VOCs and SVOCs with the duplicate sample being analyzed for only SVOCs. The sediment sample was analyzed for VOCs, SVOCs, and TPHs with the replicate being analyzed for only TPHs. An aqueous sample was collected from inside the separator and is designated as location 14AQ01 on Figure 4-6. The aqueous sample was analyzed for VOCs and SVOCs. Soil samples 14EX0101 and 14EX0102 were collected from the excavations at 9 feet bgs and were analyzed for VOCs, SVOCs, and TPHs. All sampling locations were surveyed as shown on Figure 4-6.

4.14.2 Data Summary

Bis(2-ethylhexyl)phthalate and di-n-octyl phthalate were detected at concentrations of 1,000 $\mu\text{g/L}$ and 30 $\mu\text{g/L}$, respectively, in surface water sample 14SW0101 collected from the outfall; the duplicate sample 14SW0102 did not contain these compounds. Results are summarized in Table 4-45. No VOCs were detected in the surface water sample or the duplicate. TPHs were detected in sediment sample 14SE0101 and replicate 14SE0102 collected from the outfall at concentrations of 51 mg/kg and 53 mg/kg, respectively, as shown in Table 4-46. No VOCs or SVOCs were detected in the sediment sample. In addition, no VOCs or SVOCs were detected in the aqueous sample collected from the oil/water separator. The two soil samples

TABLE 4-45
AREE 14 SURFACE WATER AND AQUEOUS SAMPLING
RESULTS SUMMARY

Analytes ⁽¹⁾	Detection Limit	14SW0101	14SW0102 (Duplicate)	14QA0101
Bis(2-ethylhexyl)phthalate	10	1,000 S	ND R	ND
Di-n-octyl phthalate	10	30 S	ND R	ND

Key: AREE = Area Requiring Environmental Evaluation
 ND = Not Detected
 S = Flag for non-target compound analyzed for and detected.
 R = Flag for non-target compound analyzed for and not detected.

Note: ⁽¹⁾ Concentrations reported in micrograms per liter ($\mu\text{g/L}$).

TABLE 4-46
AREE 14 SOIL AND SEDIMENT SAMPLING RESULTS SUMMARY

Analytes ⁽¹⁾	Detection Limit	14SE0101	14SE0102 (Replicate)	14EX0101 @ 9.0 feet bgs	14EX0102 @ 9.0 feet bgs
TPHs	10	51	53	55	65

Key: AREE = Area Requiring Environmental Evaluation
 TPH = Total Petroleum Hydrocarbon
 bgs = Below Ground Surface

Note: ⁽¹⁾ Concentrations reported in milligrams per kilogram (mg/kg).

collected during the excavation activities adjacent to the oil/water separator also had detectable concentrations of TPH at 55 mg/kg and 65 mg/kg for samples 14EX0101 and 14EX0102, respectively. No VOCs or SVOCs were detected in the samples collected from the excavation adjacent to the separator.

4.14.3 *Evaluation*

Although two SVOCs were detected in the surface water sample collected at the outfall for the oil/water separator, the results for this sample are questionable since the compounds were not detected in the duplicate sample. No potential ARARs or TBCs exist for the two SVOCs reported in water.

The only analytes detected in the sediment, replicate, and soil samples were TPHs. However, the detected value of TPHs in these samples are below the 100 mg/kg Virginia UST Program Action Level which is the TBC for TPHs in soil. There are no TBCs for TPH in sediment.

4.14.4 *Conclusions*

Based on the sampling performed for AREE 14, the low levels of contamination detected do not appear to be significant. However, with two SVOCs being detected in the surface water sample but not in the duplicate these data are questionable. Further study may occur to confirm the presence or absence of the SVOCs. The BCT has also recommended the removal of the oil/water separator.

4.15 AREEs 18/19 (FLAMMABLE/BATTERY STORAGE (BUILDING 204)/THERMAL BATTERY STORAGE) DESCRIPTION

4.15.1 *Summary of Field Activities and Analytical Program*

The Preliminary SI included geophysical activities at AREEs 18/19 including magnetic, EMI, and GPR surveys to locate subsurface utilities. An excavation was performed to expose the outfall of the drain pipe from Building 204. The drain pipe terminated at an underground gravel sump at an approximate depth of 3 feet just east of Building 204. No evidence of stains or liquid were found at the outfall.

Three surface soil samples at AREEs 18/19 and one subsurface soil sample at the drain outfall were collected. The locations of the surface soil samples are designated as 18SS01, 18SS02, and 18SS03, and location of the subsurface soil sample at the drain outfall is designated 18EX01. All sampling locations are shown on Figure 4-7. All soil samples were analyzed for VOCs, SVOCs, and metals. Sampling locations were surveyed upon completion of the sampling activities.

Subsequent to the Preliminary SI, the BCT requested additional sampling to be conducted as part of a SSI. A site reconnaissance completed on 7 April 1994 revealed that contaminants resulting from the flammable/battery storage (Building

204) could potentially be present in the joint material of the building as well as the drain outfall. During the SSI two samples of the building's joint material which filled the space between the floor and the walls were collected.

Sample 18SD0101 was collected from the material in the west room and sample 18SD0102 was collected from the east room of Building 204. Both samples consisted of the joint material that was chipped out with a screw driver. These samples were analyzed for metals, VOCs, and SVOCs.

4.15.2 Data Summary

A summary of the analytical results for the inorganic analyses conducted on the three surface soil samples and the soil sample collected at the drain outfall is provided in Table 4-47. Inorganics not detected in any of the four soil samples collected include cadmium, cobalt, molybdenum, antimony, selenium, and thallium. Toluene was detected at 0.00310 $\mu\text{g/g}$ in the surface soil sample collected at location 18SS01. No other VOCs or SVOCs were detected in the surface soil samples or the sample collected at the drain outfall.

Samples 18SD0101 and 18SD0102 were collected at the locations shown on Figure 4-7. Organic contaminants detected in these samples are listed in Table 4-48. Acetone, methylene chloride, toluene, 2-butanone, total xylenes, bis(2-ethylhexyl)phthalate, and dimethyl phthalate were detected at 18SD0101 with concentrations of 0.140, 0.024, 0.018, 0.010, 0.024, 2.0 and 5.0 $\mu\text{g/g}$, respectively. Sample 18SD0102 results indicated acetone at 0.056 $\mu\text{g/g}$ and methylene chloride at 0.035 $\mu\text{g/g}$. Inorganic results for samples 18SD0101 and 18SD0102 are presented in Table 4-47 along with previous inorganic results from the Preliminary SI. Inorganics not detected in either one of the joint samples include antimony, beryllium, cobalt, cyanide, molybdenum, selenium, and thallium.

4.15.3 Evaluation

Table 4-49 provides a comparison of the inorganic results for the soil samples collected at AREEs 18/19 with the ranges of concentrations from the background sampling and the USGS regional data. The upper limit of the ranges for the AREE 18/19 soil samples are higher than the background soil sample ranges but within the USGS ranges for the following analytes: aluminum, barium, calcium, chromium, copper, iron, potassium, magnesium, sodium, nickel, lead, and zinc. Manganese was the only analyte detected above the both the background and USGS ranges. When compared to the potential TBCs listed in Table 3-14, the detected values of manganese are below the 5,100 $\mu\text{g/g}$ USEPA Region III risk-based concentration for commercial sites, and only one sample contained detectable concentrations of manganese above the 390 $\mu\text{g/g}$ USEPA Region III risk-based concentration for residential sites.

TABLE 4-47
AREES 18/19 INORGANIC RESULTS IN SOIL AND JOINT MATERIAL

Analytes ⁽¹⁾	Detection Limits	18SS0101 ⁽²⁾ @ 0.2 feet bgs	18SS0201 ⁽²⁾ @ 0.2 feet bgs	18SS0301 ⁽²⁾ @ 0.2 feet bgs	18EX0101 ⁽²⁾ @ 2.5 feet bgs	18SD0101	18SD0102	AREE 18/19 Range ⁽³⁾
Aluminum	10.7	7,800	6,400	14,000	19,000	1,880	3,240	6,400 - 19,000
Antimony	82.9	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.200	NA	NA	NA	NA	270	120	ND
Barium	4.87	81.5	52.1	85.7	106	25.0	23.4	52.1 - 106
Beryllium	0.250	0.634	0.382	0.684	0.821	ND	ND	0.382 - 0.821
Cadmium	0.427	ND	ND	ND	ND	1.70	1.57	ND
Calcium	109	2,940	2,410	567	976	37,000	5,240	567 - 2,940
Chromium	0.974	12.4	17.3	24	25.7	9.96	19.0	12.4 - 25.7
Cobalt	2.50	ND	ND	ND	ND	ND	ND	ND
Copper	3.38	6.15	16	22.4	14.3	14.3	714	6.15 - 22.4
Cyanide	1.22	NA	NA	NA	NA	ND	ND	ND
Iron	12.0	7,800	10,000	22,000	16,000	3,500	3,500	7,800 - 22,000
Lead	0.700	25	68.3	42.2	ND	23.0	4,500 by JS14	ND - 68.3
Magnesium	138	1,660	1,760	1,430	1,940	996	475	1,430 - 1,940
Manganese	0.511	470	310	540	360	59.3	81.3	310 - 540
Mercury	0.0870	NA	NA	NA	NA	0.131	0.207	NA
Molybdenum	4.00	ND	ND	ND	ND	ND	ND	ND
Nickel	7.50	ND	ND	11.7	13.4	18.3	31.9	ND - 13.4
Potassium	142	726	819	555	785	2,390	271	555 - 819
Selenium	12.4	ND	ND	ND	ND	ND	ND	ND
Sodium	50.0	ND	58.5	ND	ND	551	81.7	ND - 58.5
Thallium	12.5	ND	ND	ND	ND	ND J	ND J	ND
Vanadium	2.00	18.6	21.6	34	38.6	41.4	86.6	18.6 - 38.6
Zinc	4.00	44.8	42.8	58.8	50.4	67.3	137	42.8 - 58.8

Key: AREE = Area Requiring Environmental Evaluation
 ND = Not Detected
 NA = Not Analyzed
 bgs = Below Ground Surface
 J = Qualifier for the low spike recovery is low

Notes: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).
⁽²⁾ These samples have a detection limit of 10.0 µg/g for lead.
⁽³⁾ Only for soil samples.

TABLE 4-48
AREEs 18/19 ORGANIC RESULTS IN JOINT MATERIAL

Analyte ⁽¹⁾	Detection Limit	18SD0101	18SD0102
Acetone	0.0446	0.140	0.056
Methylene Chloride	0.00616	0.024	0.035
Toluene	0.00250	0.018	ND
2-Butanone	0.00510	0.010	ND
Total Xylenes	0.00596	0.024	ND
Bis(2-ethylhexyl)phthalate	0.190	2.0	ND
Dimethyl Phthalate	0.350	5.0	ND

Key: AREE = Area Requiring Environmental Evaluation
ND = Not Detected

Note: ⁽¹⁾ All concentrations reported in micrograms per gram ($\mu\text{g/g}$).

TABLE 4-49
COMPARISON OF INORGANIC RESULTS IN SOIL FOR AREEs 18/19,
BACKGROUND SAMPLES, AND USGS RANGES

Analytes ⁽¹⁾	AREEs 18/19 Range ⁽²⁾	Background Range	USGS Range ⁽³⁾
Aluminum	6,400 - 19,000	10,000 - 14,000	50,000 - 100,000
Antimony	ND	ND	≤ 1
Arsenic	ND	NA	2.6 - 6.5
Barium	52.1 - 106	61.6 - 71.4	300 - 700
Beryllium	0.382 - 0.821	0.572 - 0.802	≤ 1
Cadmium	ND	ND	--
Calcium	567 - 2,940	1,280 - 1,720	3,500 - 5,200
Chromium	12.4 - 25.7	21.3 - 23.9	30 - 70
Cobalt	ND	ND - 13.8	3 - 7
Copper	6.15 - 22.4	5.62 - 6.67	20 - 30
Cyanide	ND	NA	--
Iron	7,800 - 22,000	16,000 - 18,000	20,000 - 50,000
Lead	ND - 68.3	17.7 - 22.1	15 - 150
Magnesium	1,430 - 1,940	1,120 - 1,310	20,000 - 30,000
Manganese	310 - 540	107 - 300	200 - 300
Mercury	NA	ND	0.082 - 0.13
Molybdenum	ND	ND	≤ 3
Nickel	ND - 13.4	ND	10 - 20
Potassium	555 - 819	408 - 477	6,800 - 16,000
Selenium	ND	ND	0.1 - 5
Sodium	ND - 58.5	ND	500 - 2,000
Thallium	ND	ND	--
Vanadium	18.6 - 38.6	38.1 - 49.2	70 - 150
Zinc	42.8 - 58.8	37.4 - 42.3	28 - 74

Key: AREE = Area Requiring Environmental Evaluation
 USGS = U.S. Geological Survey
 NA = Not Available
 ND = Not Detected

Notes: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).
⁽²⁾ Shaded results indicate where the AREEs 18/19 range exceeds the background and/or USGS range.
⁽³⁾ U.S. Geological Survey, 1984.

TABLE 4-50
SUMMARY OF SUBSURFACE SOIL SAMPLES COLLECTED FOR CHEMICAL
ANALYSES AT AREE 21

Sample Number	Borehole Number	Sampling Interval (feet bgs)
21BH0102	21BH01	2-4
21BH0105	21BH01	8-10
21BH0202	21BH02	2-4
21BH0205	21BH02	8-10
21BH0269 ⁽¹⁾	21BH02	8-10
21BH0302	21BH03	2-4
21BH0305	21BH03	8-10
21BH0402	21BH04	2-4
21BH0405	21BH04	8-10

Key: AREE = Area Requiring Environmental Evaluation
bgs = Below Ground Surface

Notes: ⁽¹⁾ Replicate

4.17.2 Data Summary

TPHs were detected at all four surface soil sampling locations completed during the Preliminary SI as illustrated in Table 4-51. The TPHs concentrations were 55 mg/kg, 30 mg/kg, 42 mg/kg, and 35 mg/kg at locations 21SS01, 21SS02, 21SS03, and 21SS04, respectively. No PCBs nor pesticides were detected in any of the surface soil samples.

**TABLE 4-51
AREE 21 ORGANIC RESULTS IN SOIL**

Analytes ⁽¹⁾	Detection Limit	21SS0101 @ 0.2 feet bgs	21SS0201 @ 0.2 feet bgs	21SS0301 @ 0.2 feet bgs	21SS0401 @ 0.2 feet bgs
TPHs	10	55	30	42	35

Key: AREE = Area Requiring Environmental Evaluation
TPH = Total Petroleum Hydrocarbon
bgs = Below Ground Surface

Note: ⁽¹⁾ Concentrations reported in milligrams per kilogram (mg/kg).

The only organic analyte detected in samples collected during the SSI was di-n-octyl phthalate at a concentration of 0.23 $\mu\text{g/g}$ in the subsurface soil sample collected from 21BH01 at the 2- to 4-foot interval. In addition, no TPHs, VOCs, PCBs, nor pesticides were detected in any of the subsurface soil samples.

A summary of the inorganic results for the samples collected from the boreholes is provided in Table 4-52. Mercury, molybdenum, nickel, thallium, antimony, cadmium, selenium, and cyanide were not detected in any of the samples from locations 21BH01, 21BH02, 21BH03, and 21BH04.

4.17.3 Evaluation

TPH contamination was detected in the surface soil samples. All detected values of TPHs in the surface soil samples are below the 100 mg/kg Virginia UST Program Action Level for TPHs in soil. No PCB or pesticide contamination was detected in any of the surface soil samples.

TABLE 4-52
AREE 21 INORGANIC RESULTS IN SOIL

Analytes ⁽¹⁾	Detection Limits	21BH0102 @ 2.0 feet bgs	21BH0105 @ 8.0 feet bgs	21BH0202 @ 2.0 feet bgs	21BH0205 @ 8.0 feet bgs	21BH0269 ⁽²⁾ @ 8.0 feet bgs	21BH0302 @ 2.0 feet bgs	21BH0305 @ 8.0 feet bgs	21BH0402 @ 2.0 feet bgs	21BH0405 @ 8.0 feet bgs	AREE 21 Range
Aluminum	10.7	12,000	2,220	4,610	2,130	2,940	9,800	1,980	7,400	1,840	1,840 - 12,000
Antimony	82.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.200	1.10	0.410	ND	0.440	0.390	0.920	0.350	0.400	ND	ND - 1.10
Barium	4.87	42.3	11.9	16.5	8.73	10.1	32.3	9.56	20.9	6.83	6.83 - 42.3
Beryllium	0.250	0.675	ND	ND	ND	ND	0.395	ND	ND	ND	ND - 0.675
Cadmium	0.427	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	109	385	ND	240	ND	ND	230	ND	140	ND	ND - 385
Chromium	0.974	14.8	3.20	6.93	5.21	4.98	13.6	2.91	9.94	6.37	2.91 - 14.8
Cobalt	2.50	7.54	ND	3.72	ND	ND	5.73	ND	ND	ND	ND - 7.54
Copper	3.38	6.79	ND	ND	ND	ND	5.30	ND	ND	ND	ND - 6.79
Cyanide	1.22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	12.0	14,000	3,100	5,800	4,700	5,600	11,000	3,200	7,400	4,900	3,100 - 14,000
Lead	0.700	5.20	0.820	1.90	1.20 B	1.40 B	4.50 B	1.50 B	3.00 B	1.40 B	0.820 - 5.20
Magnesium	138	1,940	317	657	290	354	1,250	278	818	271	271 - 1,940
Manganese	0.511	164	166	117	153	201	179	83.5	133	113	83.5 - 201
Mercury	0.0870	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum	4.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	7.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	142	372	ND	258	ND	ND	384	ND	295	ND	ND - 384
Selenium	12.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	50.0	61.5	ND	ND	ND	ND	ND	ND	ND	ND	ND - 61.5
Thallium	12.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	2.00	30.8	5.41	12.4	7.19	7.58	24.9	6.07	17.3	7.25	5.41 - 30.8
Zinc	4.00	29.4 B	11.9 B	16.7 B	7.73 B	14.9 B	21.9 B	7.18 B	21.5 B	8.51 B	7.18 - 29.4

Key: AREE = Area Requiring Environmental Evaluation B = Flag for analyte found in the method blank or QC blank as well as the sample
ND = Not Detected bgs = Below Ground Surface

Notes: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).
⁽²⁾ Replicate of sample 21BH0205.

The only organic detected in any of the subsurface soil samples was di-n-octyl phthalate which was only found in one sample. There are no potential TBCs for this analyte in soil. In addition, the detected value was just above the 0.22 $\mu\text{g/g}$ detection limit. No TPH, VOC, PCB, nor pesticide contamination was detected in any of the subsurface soil samples.

Table 4-53 provides a comparison of the inorganic results for the subsurface soil samples collected at AREE 21 with the ranges of concentrations from the background sampling and the USGS regional data. The upper limit of the ranges for the AREE 21 subsurface soil samples are higher than the background soil sample ranges but within the USGS ranges for the following analytes: copper, sodium, and magnesium. Cobalt was the only analyte detected above the USGS range but within the background soil sample range.

4.17.4 Conclusions

Although the surface soil sampling at AREE 21 suggests possible TPH contamination, the level of contamination is lower than the potential TBCs for TPHs in soil. In addition, the detection of only one organic analyte in a subsurface soil sample, near the detection limit would imply a small concern if any for organic contamination at the AREE. The soil sampling results also suggest no PCB or pesticide contamination at the AREE as well as no SVOC contamination in the subsurface. Finally, from the discussion of the inorganic results obtained from the subsurface soil sampling, all inorganic analytes at the AREE appear to be found at their naturally occurring levels. Therefore, no further action at this AREE should be appropriate.

4.18 AREE 22 (DRAINAGE DITCH)

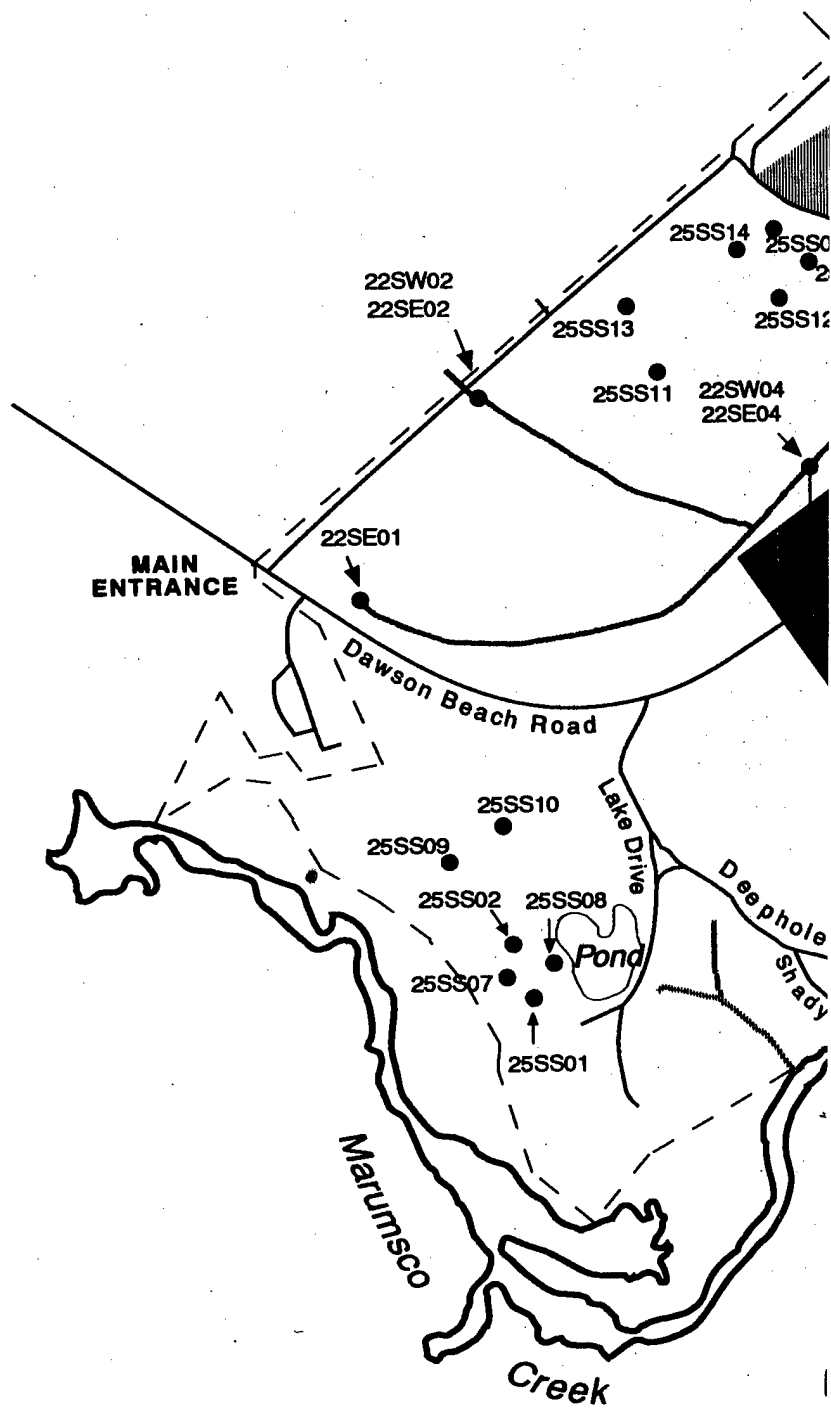
4.18.1 Summary of Field Activities and Analytical Program

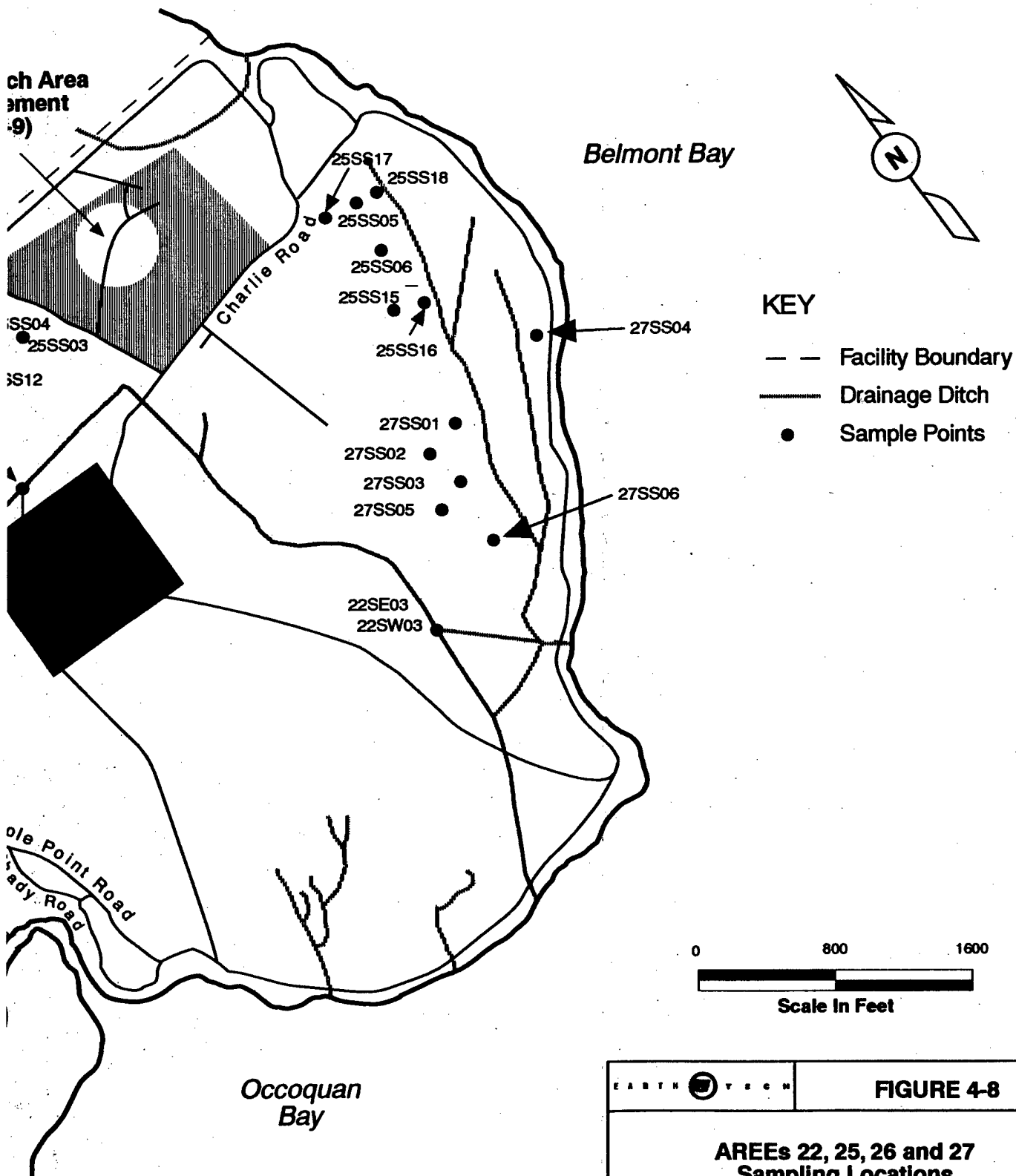
During the Preliminary SI, three surface water and four sediment samples were collected from four locations along the drainage ditch. The locations are designated as 22SE01, 22SE02/22SW02, 22SE03/22SW03, and 22SE04/22SW04 as illustrated on Figure 4-8. The samples were collected after a rainfall event in an attempt to characterize contaminant migration during maximum surface runoff. All samples were analyzed for TPHs. All sampling locations were surveyed; the survey data are provided in Appendix D.

4.18.2 Data Summary

TPHs were detected in two of the four sediment samples. The sediment collected at locations 22SE01 and 22SE02 was reported to have TPH concentrations of 18 mg/kg and 14 mg/kg, respectively. TPHs were not detected in any of the three surface water samples collected.

AREE 26 Trench
(See enlargement
Figure 4-9)





EARTH TECH	FIGURE 4-8
AREEs 22, 25, 26 and 27 Sampling Locations	

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TABLE 4-53
COMPARISON OF INORGANIC RESULTS IN SOIL FOR AREE 21,
BACKGROUND SAMPLES, AND USGS RANGES

Analyte ⁽¹⁾	AREE 21 Range ⁽²⁾	Background Range	USGS Range ⁽³⁾
Aluminum	1,840 - 12,000	10,000 - 14,000	50,000 - 100,000
Antimony	ND	ND	≤ 1
Arsenic	ND - 1.10	NA	2.6 - 6.5
Barium	6.83 - 42.3	61.6 - 71.4	300 - 700
Beryllium	ND - 0.675	0.572 - 0.802	≤ 1
Cadmium	ND	ND	--
Calcium	ND - 385	1,280 - 1,720	3,500 - 5,200
Chromium	2.91 - 14.8	21.3 - 23.9	30 - 70
Cobalt	ND - 7.54	ND - 13.8	3 - 7
Copper	ND - 6.79	5.62 - 6.67	20 - 30
Cyanide	ND	NA	--
Iron	3,100 - 14,000	16,000 - 18,000	20,000 - 50,000
Lead	0.820 - 5.20	17.7 - 22.1	15 - 150
Magnesium	271 - 1,940	1,120 - 1,310	20,000 - 30,000
Manganese	83.5 - 201	107 - 300	200 - 300
Mercury	ND	ND	0.082 - 0.13
Molybdenum	ND	ND	≤ 3
Nickel	ND	ND	10 - 20
Potassium	ND - 384	408 - 477	6,800 - 16,000
Selenium	ND	ND	0.1 - 5
Sodium	ND - 61.5	ND	500 - 2,000
Thallium	ND	ND	--
Vanadium	5.41 - 30.8	38.1 - 49.2	70 - 150
Zinc	7.18 - 29.4	37.4 - 42.3	28 - 74

Key: AREE = Area Requiring Environmental Evaluation ND = Not Detected
USGS = U.S. Geological Survey -- = Not Available
NA = Not Analyzed

Notes: (1) Concentrations reported in micrograms per gram (µg/g).
(2) Shaded results indicate where the AREE 21 range exceeds the background and/or USGS range.
(3) U.S. Geological Survey, 1984.

4.18.3 *Evaluation*

TPH contamination was detected in two of the sediment samples collected. Both detected values are below the 100 mg/kg Virginia UST Program Action Level for TPHs in soil. No action levels exist for TPH in sediment. No TPH contamination was detected in any of the surface water samples collected.

4.18.4 *Conclusions*

Although the sediment sampling suggests possible TPH contamination at the upstream portions of the stream, the level of contamination is lower than the potential TBC for TPHs in soil. In addition, no TPH contamination was detected during the surface water sampling.

However, PCBs were detected in AREE 22 drainage ditch as part of a VADEQ sampling effort. These results shown on Table 1-6 prompted the BCT to request further study at AREE 22.

4.19 AREE 25 (SEWAGE INJECTION AREA)

4.19.1 *Summary of Field Activities and Analytical Program*

During the site reconnaissance conducted for the Preliminary SI at AREE 25, facility personnel identified the three areas at which the sewage injection activities had reportedly occurred. These areas are illustrated on Figure 4-8. Based on this information, two surface soil samples were collected from each of the three sewage injection areas. The sampling locations are designated as 25SS01 through 25SS06 as shown on Figure 4-8. Table 4-54 presents a summary of the soil samples collected for chemical analysis. All soil samples were analyzed for metals. Sampling locations were surveyed with the survey data provided in Appendix D.

Subsequent to the Preliminary SI, the BCT requested additional sampling to be conducted as part of an SSI. The SSI activities consisted of the collection four sample pairs and a replicate from each of the three previously identified sewage injection areas. Each sample pair consisted of a soil sample collected from a depth of 0.5 feet and a second sample from 2 feet. Figure 4-8 illustrates the locations of the sample pairs as 25SS07, 25SS08, 25SS09, 25SS10, 25SS11, 25SS12, 25SS13, 25SS14, 25SS15, 25SS16, 25SS17, and 25SS18. A summary of the soil samples and replicates collected for the SSI are also included in Table 4-54. All samples were analyzed for metals, PCBs, and pesticides.

TABLE 4-54
SUMMARY OF SOIL SAMPLES AND REPLICATES COLLECTED
FOR CHEMICAL ANALYSES AT AREE 25

Sample Location	Sample Number	Sampling Depth (feet bgs)
25SS01	25SS0101	0.5
25SS02	25SS0201	0.5
25SS03	25SS0301	0.5
25SS04	25SS0401	0.5
25SS05	25SS0501	0.5
25SS06	25SS0601	0.5
25SS07	25SS0701	0.5
25SS07	25SS0702	2.0
25SS07	25SS0769 ⁽¹⁾	0.5
25SS08	25SS0801	0.5
25SS08	25SS0802	2.0
25SS09	25SS0901	0.5
25SS09	25SS0902	2.0
25SS10	25SS1001	0.5
25SS10	25SS1002	2.0
25SS11	25SS1101	0.5
25SS11	25SS1102	2.0
25SS12	25SS1201	0.5
25SS12	25SS1202	2.0
25SS13	25SS1301	0.5
25SS13	25SS1302	2.0
25SS14	25SS1401	0.5
25SS14	25SS1402	2.0
25SS14	25SS1469 ⁽¹⁾	2.0
25SS15	25SS1501	0.5
25SS15	25SS1502	2.0
25SS15	25SS1569 ⁽¹⁾	2.0
25SS16	25SS1601	0.5
25SS16	25SS1602	2.0
25SS17	25SS1701	0.5
25SS17	25SS1702	2.0
25SS18	25SS1801	0.5
25SS18	25SS1802	2.0

Key: AREE = Area Requiring Environmental Evaluation
bgs = Below Ground Surface

Notes: ⁽¹⁾ Replicate

4.19.2 *Data Summary*

No PCBs or pesticides were detected in any of the soil samples collected. Inorganics were detected in all AREE 25 soil samples and are illustrated in Table 4-55. Inorganic analytes which were not detected in any of the soil samples collected at AREE 25 include antimony, cadmium, cyanide, molybdenum, mercury, selenium, and thallium.

4.19.3 *Evaluation*

Table 4-56 provides a comparison of the inorganic results for the soil samples collected at AREE 25 with the ranges of concentrations from background sampling and USGS regional data. The upper limit of the ranges for the AREE 25 soil samples are higher than the background soil sample ranges but within the USGS ranges for the following analytes: aluminum, barium, chromium, copper, iron, magnesium, nickel, potassium, sodium, vanadium, and zinc. The AREE 25 upper limit of soil sample ranges for manganese, beryllium, and cobalt exceed the background sample ranges and the regional USGS ranges.

The inorganic analytical results for the AREE 25 soil samples can also be compared to the potential TBCs listed in Table 3-14. The detected values for manganese are below the 5,100 $\mu\text{g/g}$ USEPA Region III risk-based concentration for commercial sites; however, the majority (82%) of the samples contained detectable concentrations of manganese above the 390 $\mu\text{g/g}$ USEPA Region III risk-based concentration for residential sites. Sixty-four percent of the samples contained detectable concentrations of beryllium above the 0.67 $\mu\text{g/g}$ USEPA Region III risk-based concentration for commercial sites, and all detected values for beryllium were above the 0.2 $\mu\text{g/g}$ USEPA proposed RCRA Corrective Action Level and the 0.15 USEPA Region III risk-based concentration for residential sites. There are no potential soil TBCs for cobalt; however, the highest AREE 25 level of cobalt exceeded the highest background level of cobalt by a factor of three.

4.19.4 *Conclusions*

Manganese and beryllium at the former sewage injection areas were detected at concentrations in the surface soil which exceed the albeit limited background inorganic concentrations. However, these two analytes may occur naturally in high levels at different parts of the WRF due to the site conditions of the facility (e.g., the area being predominantly tidally influenced wetlands). More pervasive background sampling should be completed across all parts of the facility to determine the natural occurrence of all analytes at the WRF.

TABLE 4-55
AREE 25 INORGANIC RESULTS IN SOIL

Analyte ⁽¹⁾	Detection Limits	25SS0101 @ 0.5 feet bgs	25SS0201 @ 0.5 feet bgs	25SS0301 @ 0.5 feet bgs	25SS0401 @ 0.5 feet bgs	25SS0501 @ 0.5 feet bgs	25SS0601 @ 0.5 feet bgs
Aluminum	10.7	11,000	12,000	16,000	9,400	8,300	10,000
Antimony	82.9	ND	ND	ND	ND	ND	ND
Arsenic	12.7	NA	NA	NA	NA	NA	NA
Barium	4.9	45	78.7	80.6	93.9	87.6	91.5
Beryllium	0.3	0.561	0.71	0.737	0.884	0.727	.862
Cadmium	0.4	ND	ND	ND	ND	ND	ND
Calcium	109	211	1,100	649	574	837	988
Chromium	1.0	18.4	22.2	27.9	22.1	25.2	25.8
Cobalt	2.5	13.1	11.8	15.8	11.2	12.3	13.6
Copper	3.4	6.54	4.41	7.41	ND	9.98	10.3
Iron	12.0	13,000	20,000	20,000	15,000	19,000	21,000
Lead	10.0	21.6	16.3	16.1	15.4	20.8	21.6
Magnesium	138	956	1,090	1,670	1,080	1,240	1,320
Manganese	0.5	430	16.5	680	1,200	920	1,100
Molybdenum	4.0	ND	ND	ND	ND	ND	ND
Nickel	7.5	ND	ND	ND	ND	ND	ND
Potassium	142	583	345	869	441	468	534
Selenium	12.4	ND	ND	ND	ND	ND	ND
Sodium	50.0	ND	74.9	75	ND	69.9	ND
Thallium	12.5	ND	ND	ND	ND	ND	ND
Vanadium	2.0	33.6	41.9	49.4	35.2	56.6	62.2
Zinc	4.0	33.7	37.2	46.8	33.1	38.7	43.5

Key: AREE = Area Requiring Environmental Evaluation bgs = Below Ground Surface
ND = Not Detected NA = Not Analyzed

Note: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).

TABLE 4-55
AREE 25 INORGANIC RESULTS IN SOIL

Analytes ⁽¹⁾	Detection Limits	25SS0701	25SS0702	25SS0769	25SS0801	25SS0802	25SS0901	25SS0902	25SS1001	25SS1002
		@ 0.5 feet bgs	@ 2.0 feet bgs	@ 0.5 feet bgs	@ 0.5 feet bgs	@ 2.0 feet bgs	@ 0.5 feet bgs	@ 2.0 feet bgs	@ 0.5 feet bgs	@ 2.0 feet bgs
Aluminum	10.7	13,000	18,000	10,000	6,600	7,300	13,000	17,000	11,000	8,900
Antimony	82.9	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.200	3.60	2.80	3.20	1.80	2.80	3.10	3.60	1.60	3.70
Barium	4.87	71.7	77.6	72.7	25.5	19.1	92.0	53.3	124	74.7
Beryllium	0.250	0.717	1.02	0.715	0.407	0.692	1.00	0.587	2.07	0.915
Cadmium	0.427	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	109	887	416	744	617	197	1,230	612	675	554
Chromium	0.974	24.5	32.8	23.9	13.5	15.0	28.9	27.6	11.9	17.4
Cobalt	2.50	9.09	38.1	14.6	ND	ND	16.8	17.5	26.4	25.1
Copper	3.38	4.46	8.91	ND	5.96	9.36	5.89	7.52	ND	ND
Cyanide	1.22	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	12.0	24,000	30,000	20,000	22,000	32,000	19,000	26,000	14,000	15,000
Lead	0.700	14.0 B	15.0 B	14.0 B	5.90 B	7.10 B	15.0 B	13.0 B	18.0 B	17.0 B
Magnesium	138	1,070	2,100	921	606	641	1,180	1,530	736	886
Manganese	0.511	310	950	500	56.1	34.1	1,100	610	2,600	750
Mercury	0.0870	ND	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum	4.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	7.50	ND	ND	ND	ND	ND	10.7	ND	11.7	ND
Potassium	142	316	377	315	261	270	437	475	304	345
Selenium	12.4	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	50.0	ND	74.6	ND	ND	76.9	ND	ND	ND	ND
Thallium	12.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	2.00	46.4	64.7	39.2	26.4	25.0	40.3	51.6	25.7	35.0
Zinc	4.00	27.6	39.9	25.7	30.7	27.1	36.0 B	35.5	30.6	31.5

Continued

Key: AREE = Area Requiring Environmental Evaluation B = Flag for analyte found in the method blank or QC blank as well as the sample
ND = Not Detected bgs = Below Ground Surface

Note: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).

TABLE 4-55
AREE 25 INORGANIC RESULTS IN SOIL

Analytes ⁽¹⁾	Detection Limits	25SS1101	25SS1102	25SS1201	25SS1202	25SS1301	25SS1302	25SS1401	25SS1402	25SS1469
		@ 0.5 feet bgs	@ 2.0 feet bgs	@ 0.5 feet bgs	@ 2.0 feet bgs	@ 0.5 feet bgs	@ 2.0 feet bgs	@ 0.5 feet bgs	@ 2.0 feet bgs	@ 2.0 feet bgs
Aluminum	10.7	7,700	16,000	11,000	17,000	8,100	15,000	8,600	16,000	16,000
Antimony	82.9	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.200	2.00	2.50	2.00	2.30	2.40	2.30	2.50	2.00	2.00
Barium	4.87	67.7	66.9	88.4	69.9	64.8	53.3	112	67.3	65.9
Beryllium	0.250	0.675	0.559	0.550	0.835	0.683	0.553	0.809	0.694	0.685
Cadmium	0.427	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	109	783	783	928	1,220	447	783	954	1,250	1,180
Chromium	0.974	18.1	19.5	19.2	22.9	17.9	18.8	18.7	19.2	16.9
Cobalt	2.50	8.95	11.8	8.98	8.83	8.4	9.04	10.5	11.6	15.6
Copper	3.38	ND	6.78	5.91	9.80	ND	5.82	5.18	7.87	7.02
Cyanide	1.22	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	12.0	14,000	21,000	18,000	25,000	13,000	19,000	16,000	20,000	20,000
Lead	0.700	11.0 B	8.30 B	12.0 B	8.40 B	11.0 B	7.20 B	13.0 B	8.30 B	8.90 B
Magnesium	138	1,040	2,030	1,290	2,140	996	1,480	940	1,790	1,730
Manganese	0.511	560	400	510	330	570	270	940	420	600
Mercury	0.0870	ND	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum	4.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	7.50	ND	ND	ND	10.1	ND	ND	ND	ND	ND
Potassium	142	350	414	467	555	305	397	684	515	523
Selenium	12.4	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	50.0	ND	158	ND	66.9	ND	ND	ND	ND	ND
Thallium	12.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	2.00	29.6	45.7	36.8	54.0	26.8	38.0	33.8	43.6	41.3
Zinc	4.00	36.7	37.2	30.3	40.0	28.7	29.5	28.9	35.9	34.6

Continued

Key: AREE = Area Requiring Environmental Evaluation B = Flag for analyte found in the method blank or QC blank as well as the sample
ND = Not Detected = Below Ground Surface
Note: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).

TABLE 4-55
AREE 25 INORGANIC RESULTS IN SOIL

Analytes ⁽¹⁾	Detection Limits	Continued									
		25SS1501 @ 0.5 feet bgs	25SS1502 @ 2.0 feet bgs	25SS1569 @ 2.0 feet bgs	25SS1601 @ 0.5 feet bgs	25SS1602 @ 2.0 feet bgs	25SS1701 @ 0.5 feet bgs	25SS1702 @ 2.0 feet bgs	25SS1801 @ 0.5 feet bgs	25SS1802 @ 2.0 feet bgs	AREE 25 Range
Aluminum	10.7	8,200	8,100	10,000	14,000	9,300	11,000	8,800	10,000	9,200	6,600 - 18,000
Antimony	82.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.200	1.60	1.80	1.70	2.40	2.40	1.80	2.30	1.90	2.40	ND - 3.70
Barium	4.87	76.2	53.3	148	80.0	31.8	134	49.6	157	69.5	19.1 - 157
Beryllium	0.250	0.769	0.617	0.758	0.834	0.527	1.10	0.738	0.990	0.653	0.500 - 2.07
Cadmium	0.427	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	109	410	488	540	977	634	1,110	737	1,190	864	197 - 1,250
Chromium	0.974	26.2	33.9	38.6	24.8	30.4	23.3	20.3	26.4	37.0	11.9 - 38.6
Cobalt	2.50	9.95	12.1	15.8	18.4	19.3	15.4	11.9	15.9	19.8	ND - 38.1
Copper	3.38	10.7	18.6	15.4	13.2	12.5	10.7	8.23	21.6	14.6	ND - 21.6
Cyanide	1.22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	12.0	21,000	26,000	36,000	26,000	23,000	23,000	22,000	22,000	24,000	13,000 - 36,000
Lead	0.700	14.0 B	8.30 B	11.0 B	11.0	6.70	14.0 B	8.60 B	15.0 B	9.10	5.90 - 19.6
Magnesium	138	1,130	1,120	1,410	1,870	1,500	1,400	1,240	1,450	1,610	606 - 2,140
Manganese	0.511	920	700	1,500	820	490	1,500	640	1,500	570	34.1 - 2,600
Mercury	0.0870	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum	4.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	7.50	9.55	10.8	13.3	12.0	11.1	11.1	ND	ND	9.98	ND - 13.4
Potassium	142	313	434	376	691	474	439	435	438	597	261 - 759
Selenium	12.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	50.0	ND	ND	ND	ND	ND	ND	ND	ND	64.7	ND - 158
Thallium	12.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	2.00	55.0	78.4	93.9	58.5	60.2	58.2	53.1	51.1	65.8	25.0 - 93.9
Zinc	4.00	32.1	24.6	42.1	63.5 B	31.4 B	38.6	29.1	50.7	30.1	24.6 - 63.5

Key: AREE = Area Requiring Environmental Evaluation B = Flag for analyte found in the method blank or QC blank as well as the sample
ND = Not Detected bgs = Below Ground Surface

Note: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).

TABLE 4-56
COMPARISON OF INORGANIC RESULTS IN SOIL FOR AREE 25,
BACKGROUND SAMPLES, AND USGS RANGES

Analyte ⁽¹⁾	AREE 25 Range ⁽²⁾	Background Range	USGS Range ⁽³⁾
Aluminum	6,600 - 18,000	10,000 - 14,000	50,000 - 100,000
Antimony	ND	ND	≤ 1
Arsenic	ND - 3.70	NA	2.6 - 6.5
Barium	19.1 - 157	61.6 - 71.4	300 - 700
Beryllium	0.500 - 2.07	0.572 - 0.802	≤ 1
Cadmium	ND	ND	--
Calcium	197 - 1,250	1,280 - 1,720	3,500 - 5,200
Chromium	11.9 - 38.6	21.3 - 23.9	30 - 70
Cobalt	ND - 38.1	ND - 13.8	3 - 7
Copper	ND - 21.6	5.62 - 6.67	20 - 30
Cyanide	ND	NA	--
Iron	13,000 - 36,000	16,000 - 18,000	20,000 - 50,000
Lead	5.90 - 19.6	17.7 - 22.1	15 - 150
Magnesium	606 - 2,140	1,120 - 1,310	20,000 - 30,000
Manganese	34.1 - 2,600	107 - 300	200 - 300
Mercury	ND	ND	0.082 - 0.13
Molybdenum	ND	ND	≤ 3
Nickel	ND - 13.4	ND	10 - 20
Potassium	261 - 759	408 - 477	6,800 - 16,000
Selenium	ND	ND	0.1 - 5
Sodium	ND - 158	ND	500 - 2,000
Thallium	ND	ND	--
Vanadium	25.0 - 93.9	38.1 - 49.2	70 - 150
Zinc	24.6 - 63.5	37.4 - 42.3	28 - 74

Key: AREE = Area Requiring Environmental Evaluation ND = Not Detected
USGS = U.S. Geological Survey -- = Not Available
NA = Not Analyzed

Notes: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).
⁽²⁾ Shaded results indicate where the AREE 25 range exceeds the background and/or USGS range.
⁽³⁾ U.S. Geological Survey, 1984.

4.20 AREE 26 (BURIED ANTIFREEZE HOSES)

4.20.1 *Summary of Field Activities and Analytical Program*

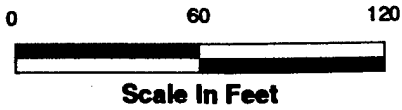
During the site reconnaissance conducted at AREE 26, facility personnel identified the approximate location of the buried hoses containing antifreeze. At that time, facility personnel indicated that the hoses could probably be found anywhere within the large area shown on Figure 4-8. Facility personnel also identified the approximate location where they had relatively recently encountered hoses during excavation activities associated with the installation of a utility line. This location was just north of the access road and near the test facility located in the area.

Based on the information gathered during the site reconnaissance, the Preliminary SI investigation focused on the area just north of the utility line installed, near the location where facility personnel reported encountering the hoses. Geophysical surveys were performed at AREE 26 in an attempt to locate the buried hoses. Three geophysical survey techniques were utilized: magnetic, EMI, and GPR profiling. Anecdotal information reported the hoses were buried at depths ranging from 1 to 3 feet and placed from 6 to 20 feet apart in apparent random patterns. Based on this information, the grid used for the geophysical surveys consisted of profiles laid out in an east-west orientation at a spacing of 3 feet with readings collected at 3 foot stations along the profiles. The grid boundary of the geophysical surveys for AREE 26 is shown on Figure 4-9.

The geophysical surveys did not detect the buried hoses. Excavation activities during the Preliminary SI were conducted not only within the area that geophysics had been performed, but also in adjacent areas. Nine trenches were excavated in an attempt to locate the buried antifreeze hoses. The locations of the nine trenches, designated as Trenches 41 through 49, are illustrated on Figure 4-9. No hoses were encountered during the Preliminary SI excavation activities; therefore, no samples were collected at that time.

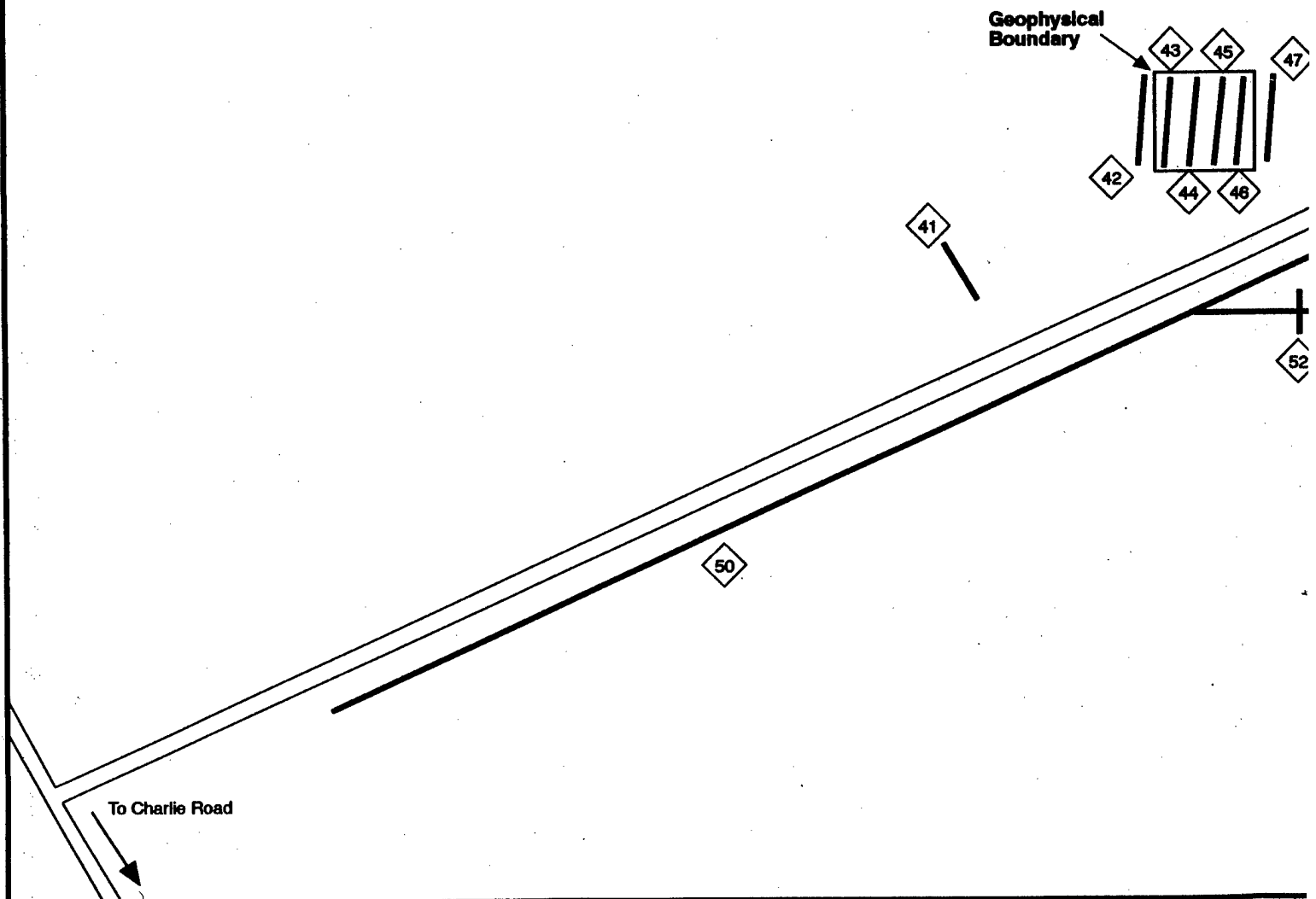
At the completion of the Preliminary SI, the ends of the excavated trenches and the geophysical grid corners were surveyed. Surveying activities for each point included the determination of the elevation with respect to MSL and the calculation of the State Plane coordinates.

Subsequent to the Preliminary SI, the BCT requested that this AREE be further investigated under an SSI. The SSI began with a second site reconnaissance conducted with Army Research Laboratory personnel. At that time, Army Research Laboratory instructed EARTH TECH to excavate a trench beginning approximately 5 to 10 feet south of the western intersection of the road to the test facility and continuing parallel to the road, along an eastward bearing.



KEY

-  Trenches
-  Geophysical Boundaries
-  Trench Numbers
-  Sample Points



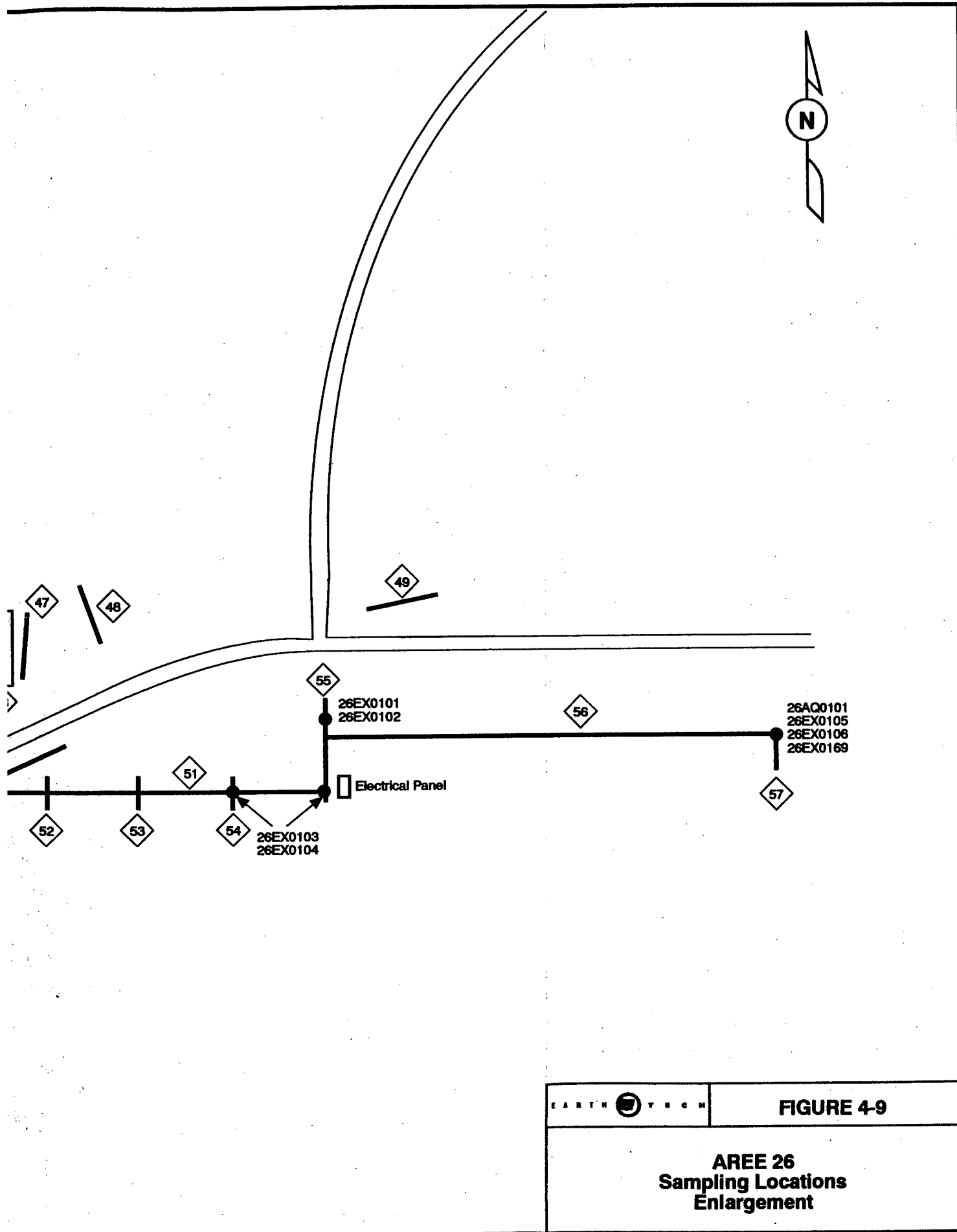


	FIGURE 4-9
AREE 26 Sampling Locations Enlargement	

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A total of eight trenches were excavated with a backhoe during the SSI in an effort to locate the buried hoses. These trenches are designated Trenches 50 through 57 as illustrated on Figure 4-9.

Trench 50 was excavated approximately 10 feet south and parallel to the road leading to the test facility. Trench 50 was approximately 450 feet long and 5 feet deep. Several abandoned phone wires and seven of the targeted "antifreeze" hoses were encountered during the excavation. The seven flexible reinforced rubber hoses were found at depths between 1 and 2 feet with four hoses having 1-inch inside diameters and three hoses having 1.5-inch inside diameters. The seven hoses ranged from 5 to 10 feet apart and were in good condition.

Trench 51 was excavated to uncover a 1-inch diameter hose identified during the excavating of Trench 50. Trench 51 was excavated from Trench 50 several hundred feet to an electrical panel as shown on Figure 4-9. The 1-inch diameter hose had been severed at the electrical panel. Trench 51 was continued 10 feet east of the electrical panel in an attempt to find the other end of the hose. A second apparent once-connected section of hose was found. This hose appeared to have been broken for the installation of the electrical panel and the gravel pad surrounding it. Trench 51 was then continued to be excavated for approximately 160 feet at the 1 to 1.5 feet depth of the hose.

Trenches 52, 53, and 54 were each approximately 15 feet long and 1.5 feet deep perpendicular to Trench 51 to confirm that the other buried hoses paralleled the hose entirely uncovered by Trench 51. Trench 55 was approximately 40 feet long and 1.5 feet deep and perpendicular to Trench 51 to confirm the presence of the seven hoses in the vicinity of the electrical panel.

Trench 56 was excavated approximately to 1.5 feet deep to uncover a length of one of the 1.5-inch diameter hoses. The trench was excavated from the electrical panel to approximately 170 feet east of the panel where the hose was found to be severed. Trench 57 was excavated perpendicular to Trench 56 for approximately 25 feet and was 1.5 feet deep. At least five of the seven hoses appeared to continue east of Trench 57.

Six soil samples, a replicate soil sample, and an aqueous sample of the liquid in a hose were collected (see Figure 4-9). The seven soil samples and replicate were analyzed for metals and ethylene glycol. The aqueous sample was analyzed for metals, TPHs, VOCs, SVOCs, PCBs, pesticides, and ethylene glycol. Soil samples 26EX0101 and 26EX0102 were collected at depths of 0.5 feet and 2 feet, respectively beneath a connection in a hose in Trench 55 as shown on Figure 4-9. Soil samples 26EX0103 at a depth of 0.5 feet and 26EX0104 at a depth of 2 feet were composite samples collected from two locations as shown in Figure 4-9. Soil samples 26EX0105 and 26EX0106 were collected at depths of 0.5 feet and 2 feet beneath the severed end of the hose in the east end of Trench 56 as shown on Figure 4-9. Replicate 26EX0169 was also collected at this location.

The liquid inside the 1.5-inch diameter hose in Trench 56 was collected as aqueous sample 26AQ0101. The liquid inside this hose was collected in sample containers when the hose was removed from the trench. All trenches were backfilled with the excavated soil, the identified hoses remained in the backfilled trenches.

4.20.2 *Data Summary*

Inorganic results for all soil samples are summarized in Table 4-57. Inorganic analytes which were not detected in any of the soil samples collected at AREE 26 include mercury, molybdenum, thallium, antimony, cadmium, selenium, and cyanide. Ethylene glycol was detected in the soil samples collected at AREE 26 at 690 $\mu\text{g/g}$ and 54.8 $\mu\text{g/g}$ in samples 26EX0105 and 26EX0106, respectively, as shown in Table 4-58.

Organic and inorganic analytical results for liquid sample 26AQ0101 are provided in Table 4-59. Inorganic analytes not detected in liquid sample 26AQ0101 include beryllium, chromium, cobalt, copper, cyanide, mercury, magnesium, molybdenum, nickel, silver, thallium, and vanadium. Organic compounds detected include acetone, 2,4-dimethylphenol, and ethylene glycol at 100 $\mu\text{g/L}$, 90 $\mu\text{g/L}$, and 800,000,000 $\mu\text{g/L}$, respectively.

4.20.3 *Evaluation*

A comparison between the inorganic results obtained for the soil samples collected at AREE 26 and the WRF background soil sampling as well as the USGS regional data is provided in Table 4-60. The upper limit of the AREE 26 soil sampling results was higher than the background range but lower than the USGS range for the following analytes: aluminum, barium, chromium, copper, iron, magnesium, nickel, potassium, and sodium. Cobalt was detected at concentrations higher than the USGS range but within the background sampling range. Beryllium, manganese, and zinc were detected at concentrations higher than both the background and USGS ranges.

Manganese was detected in all samples at levels below the 5,100 $\mu\text{g/g}$ USEPA Region III risk-based concentration for commercial sites but higher than the 390 $\mu\text{g/g}$ USEPA Region III risk-based concentration for residential sites. In addition, beryllium was detected in all samples at concentrations higher than potential TBCs listed. However, zinc was detected in all samples at levels below the potential TBCs.

The only organic compound detected in the soil samples was ethylene glycol. The detected concentration of ethylene glycol in sample 26EX0105 was 69 $\mu\text{g/g}$; however, this result is suspect due to the compound not being detected in the replicate collected at the same time and location as 25EX0105. Furthermore, the results of the soil sampling indicate that there is no TPH, VOC, SVOC, PCB, nor pesticide contamination in those areas of the soil adjacent to the hoses at which the samples were collected.

TABLE 4-57
AREE 26 INORGANIC RESULTS IN SOIL

Analytes ⁽¹⁾	Detection Limits	26EX0101 @ 0.5 feet bgs	26EX0102 @ 1.5 feet bgs	26EX0103 @ 0.5 feet bgs	26EX0104 @ 1.5 feet bgs	26EX0105 @ 0.5 feet bgs	26EX0106 @ 1.5 feet bgs	26EX0169 @ 0.5 feet bgs	AREE 26 Range
Aluminum	10.7	15,000 V	15,000 V	16,000 V	14,000 V	13,000 V	15,000 V	15,000 V	13,000 - 16,000
Antimony	82.9	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.200	2.40 V	2.60 V	ND	ND	ND	ND	ND	ND - 2.60
Barium	4.87	93.7 VI	93.1 VI	123 VI	117 VI	109 VI	120 VI	130 VI	93.1 - 130
Beryllium	0.250	0.847 V	0.848 V	1.13 V	1.13 V	0.992 V	1.15 V	1.14 V	0.847 - 1.15
Cadmium	0.427	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	109	886 V	981 V	943 V	911 V	809 V	896 V	1,030 V	809 - 1,030
Chromium	0.974	24.9 V	25.8 V	27.7 V	27.8 V	22.9 V	28.2 V	25.9 V	22.9 - 28.2
Cobalt	2.50	6.28 V	8.03 V	7.88 V	7.60 V	6.57 V	6.78 V	7.40 V	6.28 - 8.03
Copper	3.38	6.85 V	7.37 V	6.32 V	5.54 V	7.39 V	7.33 V	7.80 V	5.54 - 7.80
Cyanide	1.22	ND	ND	ND	ND	ND	ND	ND	ND
Iron	12.0	20,000 V	19,000 V	20,000 V	21,000 V	15,000 V	17,000 V	17,000 V	15,000 - 21,000
Lead	0.700	12.0 VB	14.0 VB	13.0 VB	12.0 VB	14.0 VB	15.0 VB	16.0 VB	12.0 - 16.0
Magnesium	138	1,780 V	1,810 V	1,940 V	1,790 V	1,730 V	1,800 V	1,850 V	1,730 - 1,940
Manganese	0.511	720 V	720 V	1,200 V	1,100 V	1,000 V	450 V	1,300 V	450 - 1,300
Mercury	0.0870	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum	4.00	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	7.50	ND	ND	11.2 V	ND	10.4 V	11.2 V	12.0 V	ND - 12.0
Potassium	142	633 V	666 V	767 V	668 V	740 V	842 V	842 V	633 - 842
Selenium	12.4	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	50.0	ND	ND	ND	63.4 V	157 V	156 V	105 V	ND - 157
Thallium	12.5	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	2.00	41.0 V	42.9 V	45.1 V	47.1 V	37.4 V	42.6 V	40.6 V	37.4 - 47.1
Zinc	4.00	46.0 V	47.0 V	55.2 V	45.8 V	54.8 V	90.8 V	54.1 V	45.8 - 90.8

Key: AREE = Area Requiring Environmental Evaluation

ND = Not Detected

B = Flag for analyte found in the method blank or QC blank as well as the sample

I = Qualifier for the low-spike recovery is high.

V = Flag for sample subjected to unusual storage/preservation conditions

bgs = Below Ground Surface

Notes: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).

TABLE 4-58
AREE 26 SOIL SAMPLING RESULTS SUMMARY⁽¹⁾

Analytes⁽²⁾	Detection Limit	26EX0105 @ 0.5 feet bgs	26EX0106 @ 1.5 feet bgs
Ethylene Glycol	25	690	54.8

Key: AREE = Area Requiring Environmental Evaluation
bgs = Below Ground Surface

Note: ⁽¹⁾ Only soil samples with positive detections included.

⁽²⁾ Concentrations reported in micrograms per gram ($\mu\text{g/g}$).

TABLE 4-59
AREE 26 ORGANIC AND INORGANIC RESULTS FOR AQUEOUS SAMPLE

Analytes ⁽¹⁾	Detection Limits	26AQ0101
2,4-Dimethylphenol	10.0	90.0 SV
Acetone	10.0	100 SV
Aluminum	107	793 V
Antimony	3.00	130 V
Arsenic	3.00	270 V
Barium	20.0	52.4 V
Beryllium	2.50	ND
Cadmium	5.00	9.18 V
Calcium	500	2,790 V
Chromium	15.0	ND
Cobalt	25.0	ND
Copper	20.0	ND
Cyanide	8.17	ND
Ethylene Glycol	5,000	800,000,000
Iron	120	18,000 V
Lead	4.00	150 V
Magnesium	500	ND
Manganese	5.11	226 V
Mercury	0.740	ND
Molybdenum	30.9	ND
Nickel	63.1	ND
Potassium	1,250	17,800 V
Selenium	2.00	600 V
Silver	13.0	ND
Sodium	500	1,500,000 V
Thallium	2.00	ND
Vanadium	20.0	ND
Zinc	13.0	19,000 V

Key: AREE = Areas Requiring Environmental Evaluation
 ND = Not Detected
 V = Flag for sample subjected to unusual storage/preservation conditions
 S = Flag for non-target compound analyzed for and detected

Note: ⁽¹⁾ Concentrations reported in micrograms per liter (µg/L).

TABLE 4-60
COMPARISON OF INORGANIC RESULTS IN SOIL FOR AREE 26,
BACKGROUND SAMPLES, AND USGS RANGES

Analyte ⁽¹⁾	AREE 26 Range ⁽²⁾	Background Range	USGS Range ⁽³⁾
Aluminum	13,000 - 16,000	10,000 - 14,000	50,000 - 100,000
Antimony	ND	ND	≤ 1
Arsenic	ND - 2.60	NA	2.6 - 6.5
Barium	93.1 - 130	61.6 - 71.4	300 - 700
Beryllium	0.847 - 1.15	0.572 - 0.802	≤ 1
Cadmium	ND	ND	--
Calcium	809 - 1,030	1,280 - 1,720	3,500 - 5,200
Chromium	22.9 - 28.2	21.3 - 23.9	30 - 70
Cobalt	6.28 - 8.03	ND - 13.8	3 - 7
Copper	5.54 - 7.80	5.62 - 6.67	20 - 30
Cyanide	ND	NA	--
Iron	15,000 - 21,000	16,000 - 18,000	20,000 - 50,000
Lead	12.0 - 16.0	17.7 - 22.1	15 - 150
Magnesium	1,730 - 1,940	1,120 - 1,310	20,000 - 30,000
Manganese	450 - 1,300	107 - 300	200 - 300
Mercury	ND	ND	0.082 - 0.13
Molybdenum	ND	ND	≤ 3
Nickel	ND - 12.0	ND	10 - 20
Potassium	633 - 842	408 - 477	6,800 - 16,000
Selenium	ND	ND	0.1 - 5
Sodium	ND - 157	ND	500 - 2,000
Thallium	ND	ND	--
Vanadium	37.4 - 47.1	38.1 - 49.2	70 - 150
Zinc	45.8 - 90.8	37.4 - 42.3	28 - 74

Key: AREE = Area Requiring Environmental Evaluation ND = Not Detected
USGS = U.S. Geological Survey -- = Not Available
NA = Not Analyzed

Notes: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).
⁽²⁾ Shaded results indicate where the AREE 26 range exceeds the background and/or USGS range.
⁽³⁾ U.S. Geological Survey, 1984.

The sampling of the liquid inside the hoses revealed that the liquid appears to be 80% ethylene glycol. No PCBs or TPHs were detected in the liquid sample.

4.20.4 *Conclusions*

Magnesium, beryllium, and ethylene glycol were identified in the soil at AREE 26. The detection of magnesium and beryllium may be attributed to site-wide conditions. The aqueous sampling also confirmed that the hoses are filled with an 80% ethylene glycol solution.

The hoses appeared to be in good condition, but the extent of contamination was not fully investigated. Consideration may be given to the removal of the hoses; however, the potential for releases of the liquid inside the hoses at the time of removal must be considered. The extent and impact of possible decontamination on human health and the environment should be determined.

4.21 AREE 27 (BURIED WIRE)

4.21.1 *Summary of Field Activities and Analytical Program*

Six surface soil samples were collected from locations 27SS01, 27SS02, 27SS03, 27SS04, 27SS05, 27SS06 as shown on Figure 4-8. In addition, a replicate sample was also collected at location 27SS04. A summary of the soil samples and replicate collected for AREE 27 is provided in Table 4-61. These locations were selected based on the presence of partially buried wire found exposed at the ground surface. All samples were analyzed for metals and PCBs/pesticides.

4.21.2 *Data Summary*

The six soil samples and the replicate were analyzed for metals and PCBs/pesticides. The inorganic analytes which were not detected in any of the seven soil samples collected at AREE 27 include antimony, cadmium, molybdenum, selenium, and thallium. All inorganic concentrations for AREE 27 are provided in Table 4-62. No PCBs/pesticides were detected in any of the soil samples or replicate.

4.21.3 *Evaluation*

A comparison between the inorganic results obtained from the soil samples collected at AREE 27 and the background sampling as well as the USGS regional data is provided in Table 4-63. The upper limit of the AREE 27 soil sampling results was higher than the background concentration range but lower than the USGS range for the following analytes: aluminum, barium, copper, lead, magnesium, nickel, potassium, sodium, and vanadium. The following analytes were detected above both the background range and the USGS range: beryllium, calcium, chromium, cobalt, iron, manganese, and zinc.

TABLE 4-61
AREE 27 SUMMARY OF SOIL SAMPLES AND REPLICATE COLLECTED

Sample Location	Sample Number	Depth (feet bgs)
27SS01	27SS0101	0.5
27SS02	27SS0201	0.5
27SS03	27SS0301	0.5
27SS04	27SS0401	0.5
27SS04	27SS0402 (replicate)	0.5
27SS05	27SS0501	0.5
27SS06	27SS0601	0.5

Key: AREE = Area Requiring Environmental Evaluation
bgs = Below Ground Surface

TABLE 4-62
AREE 27 INORGANIC RESULTS IN SOIL

Analyte ⁽¹⁾	Detection Limits	27SS0101 @ 0.2 feet bgs	27SS0201 @ 0.2 feet bgs	27SS0301 @ 0.2 feet bgs	27SS0401 @ 0.5 feet bgs	27SS0402 ⁽²⁾ @ 0.5 feet bgs	27SS0501 @ 0.5 feet bgs	27SS0601 @ 0.5 feet bgs	AREE 27 Range
Aluminum	10.7	11,000	11,000	12,000	15,000	14,000	11,000	11,000	11,000 - 15,000
Antimony	82.9	ND	ND	ND	ND	ND	ND	ND	ND
Barium	4.9	119	98.7	83.2	184	165	63	89.4	63 - 184
Beryllium	0.3	0.676	ND	0.945	1.26	1.1	0.692	0.7784	ND - 1.26
Cadmium	0.4	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	109	1,400	1,270	1,150	6,150	8,200	965	760	760 - 8,200
Chromium	1.0	19.5	23.7	195	31.2	28.1	21.9	24.2	19.5 - 195
Cobalt	2.5	ND	ND	ND	19.4	16.4	16	14	ND - 19.4
Copper	3.4	22.6	18.4	20.2	27.8	20.6	14.3	11.7	11.7 - 27.8
Iron	12.0	19,000	18,000	55,000	32,000	28,000	19,000	22,000	18,000 - 55,000
Lead	10.0	21.5	26.9	22.2	28.1	31.2	38.6	20.4	20.4 - 38.6
Magnesium	138	2,170	1,490	1,390	2,150	1,920	1,640	1,250	1,250 - 2,170
Manganese	0.5	1,400	840	830	1,500	1,300	600	1,000	600 - 1,500
Molybdenum	4.0	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	7.5	13.4	11.2	11.1	14.4	11.9	ND	9.37	ND - 14.4
Potassium	142	541	420	497	1,040	807	650	515	420 - 1,040
Selenium	12.4	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	50.0	168	83.2	ND	239	179	70.3	76.7	ND - 239
Thallium	12.5	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	2.0	50.4	55.8	125	80.3	71	53.9	56.7	50.4 - 125
Zinc	4.0	171	292	223	98.1	100	73.7	53.8	53.8 - 292

Key: AREE = Area Requiring Environmental Evaluation bgs = Below Ground Surface
ND = Not Detected

Notes: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).

⁽²⁾ Replicate of sample 27SS0401.

TABLE 4-63
COMPARISON OF INORGANIC RESULTS IN SOIL FOR AREE 27,
BACKGROUND SAMPLES, AND USGS RANGES

Analytes ⁽¹⁾	AREE 27 Range ⁽²⁾	Background Range	USGS Range ⁽³⁾
Aluminum	11,000 - 15,000	10,000 - 14,000	50,000 - 100,000
Antimony	ND	ND	≤1
Barium	63 - 184	61.6 - 71.4	300 - 700
Beryllium	ND - 1.26	0.572 - 0.802	≤1
Cadmium	ND	ND	--
Calcium	760 - 8,200	1,280 - 1,720	3,500 - 5,200
Chromium	19.5 - 195	21.3 - 23.9	30 - 70
Cobalt	ND - 19.4	ND - 13.8	3 - 7
Copper	11.7 - 27.8	5.62 - 6.67	20 - 30
Iron	18,000 - 55,000	16,000 - 18,000	20,000 - 50,000
Lead	20.4 - 38.6	17.7 - 22.1	15 - 150
Magnesium	1,250 - 2,170	1,120 - 1,310	20,000 - 30,000
Manganese	600 - 1,500	107 - 300	200 - 300
Molybdenum	ND	ND	≤3
Nickel	ND - 14.4	ND	10 - 20
Potassium	420 - 1,040	408 - 477	6,800 - 16,000
Selenium	ND	ND	0.1 - 5
Sodium	ND - 239	ND	500 - 2,000
Thallium	ND	ND	--
Vanadium	50.4 - 125	38.1 - 49.2	70 - 150
Zinc	53.8 - 292	37.4 - 42.3	28 - 74

Key: AREE = Area Requiring Environmental Evaluation ND = Not Detected
 USGS = U.S. Geological Survey -- = Not Available
 NA = Not Analyzed

Notes: ⁽¹⁾ Concentrations reported in micrograms per gram (µg/g).
⁽²⁾ Shaded results indicate where the AREE 27 range exceeds the background and/or USGS range.
⁽³⁾ U.S. Geological Survey, 1984.

The detected concentrations can also be compared to the potential TBCs as provided in Table 3-14. There are no potential TBCs for the following analytes detected above the background and USGS ranges: calcium, cobalt, and iron. The detected values for chromium and zinc are well below the potential TBCs for these analytes. The concentrations of beryllium detected in four soil samples were above the 0.67 $\mu\text{g/g}$ USEPA Region III risk-based concentration for commercial sites; however, beryllium was detected in all soil samples above the 0.2 $\mu\text{g/g}$ USEPA proposed RCRA corrective action level and 0.15 $\mu\text{g/g}$ USEPA Region III risk-based concentration for residential sites. The concentrations of manganese detected in all soil samples were below the 5,100 $\mu\text{g/g}$ USEPA Region III risk-based concentration for commercial sites but above the 390 $\mu\text{g/g}$ USEPA Region III risk-based concentration for residential sites.

The soil samples were also analyzed for PCBs and pesticides, which were not detected in the soil samples collected for AREE 27.

4.21.4 *Conclusions*

Based on the evaluation of the analytical results, the surface soil in the vicinity of the buried wire does not appear to be contaminated with PCBs or pesticides but contains concentrations of beryllium and manganese above the limited site background ranges. However, the high concentrations detected for these two analytes may be naturally occurring caused by site conditions (e.g., due to the site including tidally influenced wetlands). Additional background sampling may be considered to determine the concentrations of beryllium and manganese across all portions of WRF. The impact of these concentrations to potential receptors may also be determined.

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SECTION 5.0

RECOMMENDATIONS

The following future actions are recommended for each of the AREEs investigated by this SI:

- Further Study
- No Further Response Action Planned
- Removal Action.

5.1 AREEs RECOMMENDED FOR FURTHER STUDY

The following AREEs investigated are recommended for further study: 1, 2, 3, 4, 5, 6A, 6B, 7, 8, 11, 12, 14, 18, 20, 22, 23, 25, 26, and 27.

The area encompassing AREEs 1 through 7 should be investigated as a single unit due to the proximity of the AREEs and the similar contaminant source types. A wide range of debris appears to be buried in this area; this debris is the likely source for the contamination identified during the SI. Groundwater (chemical concentrations, hydrogeologic characteristics, and connection to the nearby Belmont Bay) must be better characterized in this area to determine if the buried debris is a potential source of contamination which may migrate from the area. The extent of soil contamination in this area should be evaluated to determine if soil may be a source of risk to human health or the environment. Particular contaminants of concern include PCBs, VOCs, and TPHs. Inorganics of concern cannot be determined until background concentrations of metals are better established.

The extent of any soil and groundwater contamination on the north side of Building 202 (AREEs 8, 11, 12, and 23) should be examined. This investigation should identify what, if any, migration pathways exist which may transport contamination from this area. The leaking oil/water separator and all related piping should be removed. The oil/water separator at Building 211 (AREE 14) may also be removed even though it was reported in good condition, and the area investigated further.

AREEs 18 and 20 are also included for further study. The conditions under Building 204 are recommended for further study. At AREE 20, soil sampling is recommended.

Any present impact which is the result of past upstream uncontrolled releases into the environment along AREE 22 should be established. This requires additional surface water and sediment sampling as well as indigenous biota sampling. A comprehensive evaluation of potential risk to human health and the environment which may exist in this area should be completed.

AREEs 25, 26, and 27 may not require additional sampling but the impact on human health and the environment should be determined based on existing data. An evaluation of potential risk to human health and the environment existing at AREE 26 because of the presence of ethylene glycol should be completed. This evaluation will require a measurement of the amount of ethylene glycol remaining in the buried hoses and an estimate of total hose, to establish the volume likely released into the soil.

5.2 AREEs RECOMMENDED FOR NFRAP

For AREEs 13, 19, and 21 the SI located the site of a feature (or former feature) that was suggested to require environmental evaluation. A prudent, technically sound investigation of each of these AREEs did not yield any indication that past U.S. Army activities may have had a negative impact on human health and the environment.

5.3 AREEs RECOMMENDED FOR REMOVAL ACTION

AREEs 11, 14, and 26 are recommended for a removal action in addition to further study. AREE 13 is recommended for a removal action and then no further response action.