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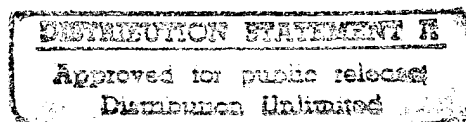
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Volume 1 of 2

FINAL

SITE CHARACTERIZATION REPORT (BUILDING 202)

WOODBIDGE RESEARCH FACILITY
VIRGINIA



April 1996

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Approved for Public Release

Prepared for:

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

Prepared by:

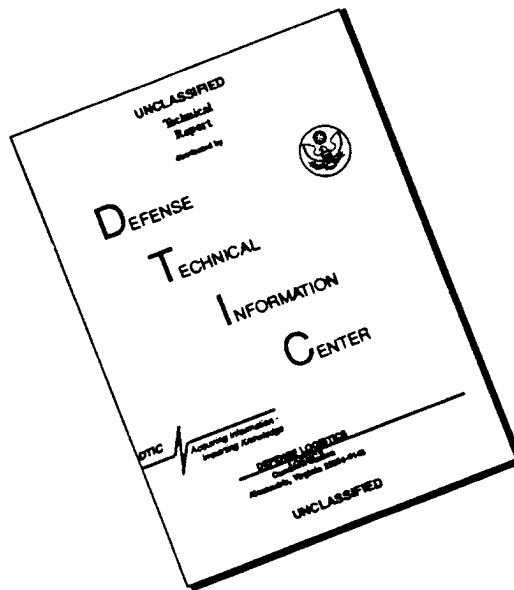
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SITE CHARACTERIZATION REPORT REVISION

COVER SHEET

This cover sheet must accompany the Site Characterization Report

To: Department of Environmental Quality
Groundwater Section
Attn: William von Till
1519 Davis Ford Road, Suite 14
Woodbridge, Virginia 22192

From: Army Research Laboratory
Attn: AMSRL-OP-RK, Bob Craig
2800 Powder Mill Road
Adelphia, Maryland 20783-1197

PC#: 92-0524

Site Address: Woodbridge Research Facility
Building 202
UST Investigation
AREE 23

Due Date: January 3, 1994

Case Officer: William von Till

SITE CHARACTERIZATION REPORT CHECKLIST

Site: Woodbridge Research Facility (Building 202) PC#: 92-0524

Region: Woodbridge

The following checklist must be filled out by the Responsible Party and/or the Responsible Party's Consultant and included in the Site Characterization Report. Indicate on the checklist the page and section number where each item is addressed in the attached report. Also indicate on the checklist the section and page number where justification is given for items omitted from the attached report. The contents of the report should reflect and be commensurate with the nature of the release, degree of contamination and complexity of the site investigation.

A copy of the Initial Abatement Measures Report must be attached to or included in the Site Characterization Report.

Items marked with an asterisk (*) are required as part of the CAP Permit Application.

1. SITE ASSESSMENT

Page	/	Section	
<u>320</u>	/	<u>3.3</u>	Nature and quantity of release
<u>4-3</u>	/	<u>4.0</u>	*Physical and chemical properties of released product
<u>NA</u>	/	<u>NA</u>	Free Product Removal Report
<u>3-20</u>	/	<u>3.3</u>	Tank Information (capacity, location, contents)
<u>1-11</u>	/	<u>1.3</u>	Geologic/hydrogeologic site information
<u>1-11</u>	/	<u>1.3.1</u>	Site Geology
<u>1-29</u>	/	<u>1.3.5</u>	Subsurface conditions (fractures, solution cavities, lenses, depth to groundwater)
<u>NA</u>	/	<u>NA</u>	Pumping/Injection Wells
<u>Appendix</u>	/	<u>B</u>	Drillers/geologic logs and construction details for all wells and boreholes
<u>1-29</u>	/	<u>1.3.5</u>	Aquifer Characteristics
<u>1-29</u>	/	<u>1.3.5</u>	Name
<u>1-37</u>	/	<u>1.3.5</u>	Thickness
<u>1-37</u>	/	<u>1.3.5</u>	Conductivity
<u>1-37</u>	/	<u>1.3.5</u>	Transmissivity
<u>1-30</u>	/	<u>1.3.5</u>	Hydraulic Gradient
<u>1-37</u>	/	<u>1.3.5</u>	Flow Velocity/Direction
<u>1-35</u>	/	<u>1.3.5</u>	Hydrogeologic Cross Section
<u>1-30</u>	/	<u>1.3.5</u>	Information as to water resources within 1,000 feet of site (wells, springs, surface water)

Page	/	Section	
<u>1-11</u>	/	<u>1.2.2</u>	Information as to adjacent property owners and potentially affected ground and surface water users (names, addresses, telephone numbers)
<u>3-20</u>	/	<u>3.3</u>	Information on historical releases at the site as well as historical releases from USTs located on adjacent property
<u>NA</u>	/	<u>NA</u>	Construction information on potentially affected wells
<u>1-39</u>	/	<u>1.3.5</u>	Current and projected groundwater/land use
<u>3-1</u>	/	<u>3.0</u>	Description of vertical and lateral extent of contamination
<u>NA</u>	/	<u>NA</u>	Free Product Phase
<u>NA</u>	/	<u>NA</u>	Dissolved Phase
<u>4-3</u>	/	<u>4.0</u>	Residual Phase
<u>4-3</u>	/	<u>4.0</u>	Vapor Phase SCR Checklist
<u>NA</u>	/	<u>NA</u>	Plume Migration Direction and Rate
<u>3-1</u>	/	<u>3.0</u>	*Sampling/monitoring Results

Note: All lab sheets and tables submitted in SCR must have sample media, analytical method used, detection limit method, unit of measure, sample depths, and sample locations. Sampling results from BTEX analysis must be reported individually and totaled.

Site maps/sketches (combined when appropriate and to scale when possible).

<u>1-3</u>	/	<u>1.2.1</u>	*Locus map on 7½ min. quad. or county highway map
<u>1-9</u>	/	<u>1.2.1</u>	*Base map with property lines and physical features (buildings, roads, etc.)
<u>1-9</u>	/	<u>1.2.1</u>	*Location of Source(s) of Contamination at Site
<u>3-21</u>	/	<u>3.0</u>	Sample Locations (water, vapor, and/or soil)
<u>3-21</u>	/	<u>3.0</u>	Excavation Pits
<u>3-21</u>	/	<u>3.0</u>	Surficial Soils
<u>3-21</u>	/	<u>3.0</u>	Surface Waters
<u>1-9</u>	/	<u>1.0</u>	Basements/Conduits (and/or soil vapor surveys)
<u>3-21</u>	/	<u>3.0</u>	Monitoring Wells
<u>NA</u>	/	<u>NA</u>	Domestic Wells
<u>NA</u>	/	<u>NA</u>	Public Supply Wells
<u>NA</u>	/	<u>NA</u>	Springs
<u>3-21</u>	/	<u>3.0</u>	Boring Locations
<u>NA</u>	/	<u>NA</u>	Observation Well Locations
<u>1-33</u>	/	<u>1.3.5</u>	Groundwater Flow Direction Map
<u>1-9</u>	/	<u>1.2.1</u>	Subsurface Conduits (telephone, water, sewer, power, dispenser piping)
<u>NA</u>	/	<u>NA</u>	*Potentially Affected Wells/Streams/Springs
<u>1-31</u>	/	<u>1.3.5</u>	*Floodplain Designation
<u>Figure 4-1</u>	/	<u>4.0</u>	Isoconcentration or plume delineation map for each affected aquifer and/or soil zone for all phases present (cross-sectional and map view)
<u>NA</u>	/	<u>NA</u>	Free Product
<u>NA</u>	/	<u>NA</u>	Dissolved
<u>Figure 4-1</u>	/	<u>4.0</u>	Residual
<u>NA</u>	/	<u>NA</u>	Vapor

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Deficiencies: _____

2. Risk Assessment

Page	/	Section	
<u>4-9</u>	/	<u>4.5.1</u>	Description of Demographics (population)
<u>4-9</u>	/	<u>4.5.1</u>	Impacted and potentially impacted receptors (human/wildlife/forestry, etc.)
<u>4-11</u>	/	<u>4.5.2</u>	Exposure pathways for receptors
<u>4-11</u>	/	<u>4.5.2.1</u>	Ingestion
<u>4-11</u>	/	<u>4.5.2.2</u>	Dermal Contact
<u>4-12</u>	/	<u>4.5.2.3</u>	Inhalation
<u>NA</u>	/	<u>NA</u>	Other
<u>4-9</u>	/	<u>4.5</u>	Exposure levels for receptors
<u>4-9</u>	/	<u>4.5</u>	Exposure level determination
	/	<u>NA</u>	Tap Water Sample
	/	<u>NA</u>	Direct Well Sample
	/	<u>NA</u>	Surface Water Sample
	/	<u>NA</u>	OVA and Location of Measurement
	/	<u>NA</u>	Extrapolation
	/	<u>NA</u>	Other
<u>4-4</u>	/	<u>4.4</u>	Evaluation of existing/potential risk to receptors (based on contaminant levels, exposure levels, frequency of exposure)
<u>4-4</u>	/	<u>4.4</u>	Evaluation of existing/potential risk to environment (based on contaminant levels, fate & transport, etc.)
<u>NA</u>	/	<u>NA</u>	Evaluation/provision of alternate water supply

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Deficiencies: _____

3. Remediation Assessment

Page	/	Section	
NA	/	NA	Remediation Feasibility
NA	/	NA	Projected remediation endpoints based on site, risk, and remediation assessments
	/		Free Product
	/		Dissolved
	/		Residual
	/		Vapor
NA	/	NA	Description & evaluation of applicable technologies
	/		Design for each applicable technology
	/		Timeframe for implementation and duration for each applicable technology to achieve projected remediation endpoints
	/		Projected cost for each applicable technology to achieve projected remediation endpoints
	/		Achievable endpoints for each applicable technology
	/		Free Product
	/		Dissolved
	/		Residual
	/		Vapor
	/		Estimated timeframe for achieving endpoints for each applicable technology
	/		Free Product
	/		Dissolved
	/		Residual
	/		Vapor
	/		Immediate/future beneficial results for each applicable technology
NA	/	NA	Recommendation of most appropriate technologies with costs
NA	/	NA	Site Characterization Report submitted within 45 days of release conformation or extension granted.

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Comments: _____

Deficiencies: _____

Reviewed By: _____ Date: _____

DRAFT FINAL

**SITE CHARACTERIZATION
REPORT
(BUILDING 202)**

**WOODBIDGE RESEARCH FACILITY
VIRGINIA**

AUGUST 1995

Prepared for:

**U.S. ARMY ENVIRONMENTAL CENTER
Aberdeen Proving Ground, Maryland 21010**

Prepared By:

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

Under Contract Number DAAA15-91-D-0009, Delivery Order 0001

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LIST OF ACRONYMS AND ABBREVIATIONS

API	American Petroleum Institute
ARAR	Applicable or Relevant and Appropriate Requirements
AREE	Areas Requiring Environmental Evaluation
ATSDR	Agency for Toxic Substances and Disease Registry
BATES	Biological Assessment of Threatened and Endangered Species
BDAT	Best Demonstrated Available Technology
bgs	Below Ground Surface
BRAC	Base Realignment and Closure
C/SS	Calibration/Service Specification
COD	Chemical Oxygen Demand
CONUS	Continental United States
CRL	Certified Reporting Limit
DOD	Department of Defense
DOI	Department of the Interior
DQO	Data Quality Objective
EMI	Electromagnetic Induction
ENPA	Enhanced Preliminary Assessment
GC/MS	Gas Chromatograph/Mass Spectrometry
gpd	Gallons per day
gpm	Gallons per minute
GPR	Ground Penetrating Radar
HSA	Hollow-stem Auger
ICP	Inductively Coupled Plasma
IDL	Instrument Detection Limit
IRDMIS	Installation Restoration Data Management Information System
IRP	Installation Restoration Program
K _{oc}	Organic carbon adsorption coefficients
K _{ow}	Octanol-water partition coefficients
L/kg	Liters per kilogram
LCL	Lower Control Limit
LDR	Land Disposal Rule
LIMS	Laboratory Information Management System
LWL	Lower Warning Limit
MCL	Maximum Concentration Limit
MDL	Method Detection Limit
MERDC	Mobility Equipment Research and Development Center
mg/L	Milligrams per liter
MHz	Mega Hertz
mL	Milliliter
mph	Miles per hour
MSL	Mean Sea Level

LIST OF ACRONYMS AND ABBREVIATIONS

Continued

NCP	National Contingency Plan
NEIC	National Enforcement Investigations Center
NIST	National Institute of Standards and Technology
NO ₃	Nitrate
NTAM	non-THAMA Approved Methods
PCB	Polychlorinated Biphenyl
PID	Photoionization Detector
POC	Point-of-Contact
ppb	Parts per billion
ppm	Parts per million
PRI	Potomac Research, Inc.
PVC	Polyvinyl Chloride
PWCSA	Prince William County Service Authority
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RD	Radio Detection
RDL	Required Detection Level
RPD	Relative Percent Difference
SARM	Standard Analytical Reference Material
SCR	Site Characterization Report
SI	Site Inspection
SQL	Standard Query Language
SVOC	Semivolatile Organic Compound
TBC	To-be-considered
TCLP	Toxicity Characteristic Leaching Procedure
TIC	Tentatively Identified Compound
TPH	Total Petroleum Hydrocarbon
UCL	Upper Control Limit
µg/g	Micrograms per gram
µg/L	Micrograms per liter
USACE	U.S. Army Corps of Engineers
USAEC	U.S. Army Environmental Center
USAECFB	U.S. Army Engineer Center and Fort Belvoir, Fort Belvoir
USAMC	U.S. Army Materiel Command
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	Underground Storage Tank

LIST OF ACRONYMS AND ABBREVIATIONS

Continued

UWL	Upper Warning Limit
VADEQ	Virginia Department of Environmental Quality
VHWM	Virginia Hazardous Waste Management
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound
VR	Virginia Regulation
VWCB	Virginia State Water Control Board
WRF	Woodbridge Research Facility

EXECUTIVE SUMMARY

In July 1991 the U.S. Army Research Laboratory, Woodbridge Research Facility (WRF), Woodbridge, Virginia, was recommended for closure by 1991 Base Realignment and Closure (BRAC 91). The WRF officially closed on 16 September 1994. No property has yet been disposed at the WRF. Public Law 103-307 was signed by the President of the United States on 23 August 1994. This law mandated the transfer of the entire installation from the U.S. Army to the Department of the Interior (DOI). As of July 1995, negotiations of the terms of the property transfer are in progress. A property transfer date has not yet been announced. It has been determined that the U.S. Fish and Wildlife Service (USFWS), an organization within the DOI, will designate the property as a component of the National Wildlife Refuge system. Representatives of the USFWS have announced that the main compound area at the WRF will be utilized for administrative and educational purposes. The remainder of the installation is to be maintained as habitat for the wildlife and flora at the WRF.

The U.S. Army Environmental Center (USAEC), Aberdeen Proving Ground, Maryland, directed EARTH TECH to complete a Draft Site Characterization Report (SCR) for past and present underground storage tank (UST) sites at and adjacent to Building 202 at WRF. A Draft SCR was submitted to Virginia Department of Environmental Quality (VADEQ) for review and comment on August 4, 1994. VADEQ comments to the Draft SCR requested an additional investigation be presented in an Draft Final SCR to provide the following items:

- Additional investigation beneath Building 202 in the vicinity of the "sump-pump" including soil and groundwater sampling to assess possible petroleum hydrocarbon concentrations.
- Submittal of a risk assessment regarding potential future environmental impacts to the wetland from petroleum leaching into the sump-pump and discharging into the wetland.
- Based on the above mentioned investigation, a submittal of a remediation assessment outlining what remedial efforts are necessary to protect human health and the environment (wetlands).

This document, entitled "Draft Final Site Characterization Report (Building 202)", describes all tasks performed to evaluate the extent and potential impact of potentially petroleum-contaminated media at and adjacent to Building 202. A risk and remediation assessment based on the results of the investigation is provided. This SCR was prepared, and all activities specified herein were completed, in accordance with the Virginia UST regulations (Virginia Regulation (VR) 680-13-02) under Article

9 of the State Water Control Law and Army Regulation 200-2. Project-specific administration and technical supervision of this SCR was provided by USAEC-Base Closure Division. This SCR was completed by EARTH TECH 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, Modification 2.

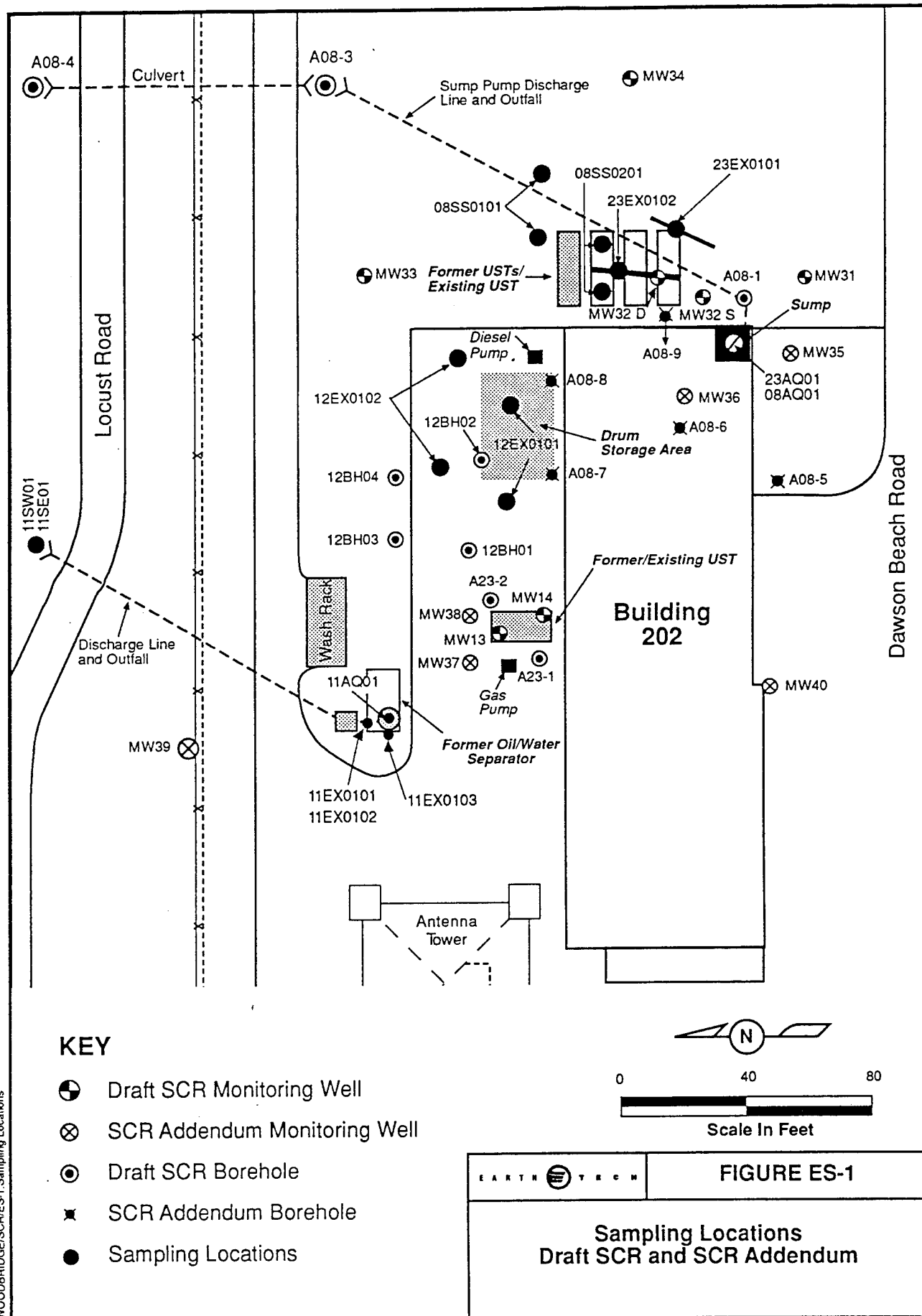
The SCR focused on two former/existing UST areas at Building 202. The analytical result of three other potentially contaminated areas at Building 202, investigated as part of a facility-wide inspection (Site Inspection (SI)), are also summarized to further define possible migration of contaminants from USTs at Building 202. The sampling program and constituents detected at significant concentrations above established regulatory guidelines are summarized below. A comprehensive discussion of the sampling program and all analytical results are provided in Section 3.0, Site Assessment. A site map indicating the sampling locations discussed below is provided as Figure ES-1.

FORMER USTs / EXISTING UST EAST OF BUILDING 202. Four former UST(s) were located at Building 202. Three of UST(s) were located outside of the eastern wall of Building 202. An existing 2,000-gallon UST is located north of the original location of the three former UST(s). The SCR sampling program and results are described below. In addition, soil analytical results from the downgradient drum storage area and Building 202 sump sampling are summarized to further define possible migration from the USTs east of Building 202.

Two trenches were excavated into the former UST(s) trench and composite subsurface soil samples (23EX0101, 23EX0102) obtained. The soil samples were analyzed for total petroleum hydrocarbon (TPH). Two surface soil samples (08SS0101, 08SS0201) were also collected from a reported overfill/spill area at the UST(s) east of Building 202. The surface soils were analyzed for TPH.

Five boreholes (BH-31, BH-32D, BH-32S, BH-33, BH-34) were drilled for subsurface soil collection and monitoring well installation at the former/existing UST(s) during the Draft SCR. All of the soil samples from these boreholes collected during the Draft SCR were analyzed for TPH, benzene, toluene, ethylbenzene, xylene (BTEX), polychlorinated biphenyl (PCB)/pesticides, and lead.

Seven additional boreholes (A08-5, A08-6, A08-7, A08-8, A08-9, BH-35, BH-36) were drilled during the Draft Final SCR relative to the former/existing UST(s) east of Building 202. The soil samples from these boreholes were analyzed for volatile organic compound (VOC), semivolatile organic compound (SVOC), TPH, PCB/pesticide, and metals. Boreholes BH-35 and BH-36 were converted to monitoring wells (MW-35, MW-36) from which groundwater samples were collected.



The soil analytical results indicated TPH concentrations above regulatory criteria within and immediately adjacent to the former UST(s) trench. Borehole BH-32D indicated the highest TPH concentrations, ranging from 2,166 parts per million (ppm) at 6-8 feet below ground surface (bgs) to 149 ppm at 10-12 feet bgs. Other soil results from the UST(s) trench area indicated 143 ppm TPH at borehole A08-9 and 209 ppm to 302 ppm TPH in the trench excavations.

The soil investigation indicated TPH concentrations are localized in subsurface soil at and adjacent to the former UST(s) trench based on soil sample results at downgradient boreholes installed during the SCR which did not report TPH or other significant contamination. In addition, no TPH or significant contaminants were detected in soils at the downgradient drum storage area collected during the SI. Only one downgradient borehole (A08-3), located at a surface water drainage culvert, indicated TPH concentrations above regulatory criteria at 109 ppm at 4 to 6 feet bgs (and non-detect at 8 to 10 feet bgs).

Monitoring wells MW-31 through MW-34, installed at and downgradient of the former USTs east of Building 202, were sampled for groundwater analysis in May 1994 for the Draft SCR and resampled in April 1995 for the Draft Final SCR. Monitoring wells MW-35 and MW-36, installed during the Draft Final SCR for further characterization, were also sampled. Groundwater samples obtained in May 1994 during the Draft SCR were analyzed for TPH, BTEX, and Lead. Groundwater samples obtained in April 1995 for the Draft Final SCR were analyzed for VOCs, SVOCs, TPH, PCB/pesticides, and metals.

Groundwater results of the May 1994 sampling event indicated 0.653 parts per billion (ppb) ethylbenzene at MW-32S which is located within the former UST(s) trench area. Groundwater results of the April 1995 sampling event did not detect VOCs, SVOCs, TPH, PCB/Pesticides, or elevated metals at monitoring wells MW-31 through MW-36. In summary, the result of the groundwater investigation did not indicate significant groundwater contamination at former/existing UST(s) east of Building 202. The ethylbenzene detected in the May 1994 event is well below regulatory criteria for the analyte in groundwater.

In association with the USTs east of Building 202, the Building 202 sump and discharge were investigated to detect any contaminant migration from the USTs toward the sump under the influence of the former sump-pump operation. A water sample and duplicate (23AQ01) were collected from the Building 202 sump during the SI and analyzed for TPH. A water sample and duplicate (08AQ01) were also collected from the sump for the Draft SCR and analyzed for BTEX, TPH, and lead.

Boreholes A08-6 and BH-36 were located inside and drilled beneath Building 202 to respond to VADEQ comments and further investigate any possible contaminant migration. Soil was collected from each borehole. BH-36 was converted to a monitoring well (MW-36) from which a groundwater sample was collected. Soil and groundwater samples were analyzed for VOC, SVOC, TPH, PCB/pesticide, and metals.

Three boreholes (A08-1, A08-3, A08-4) were also drilled at the former sump-pump discharge line and outfall. Soil samples from these boreholes obtained during the Draft SCR were analyzed for TPH, BTEX, PCB/pesticides, and lead.

The results of the water sample and duplicate collected during the preliminary SI at the sump indicated TPH concentrations of 2 ppm and 84 ppm, respectively. A resample of the sump during the Draft SCR did not indicate BTEX, TPH, or lead (filtered). No significant contamination was identified in soil or groundwater samples taken below Building 202 (A08-6 and MW-36) in close proximity to the sump.

Soil analysis at A08-1 and A08-4, located along the former sump-pump discharge line and downgradient of the outfall, respectively, did not indicate TPH, BTEX, PCB/pesticide, or lead. Soil sample results at borehole A08-3, located in a culvert at the former sump-pump discharge outfall, indicated TPH (109 ppm) at 4 to 6 feet bgs and non-detect at 8 to 10 feet bgs.

Based on the chemical analyses of soil and groundwater, no ecological or human health threats were expected from residual TPH identified in subsurface soil media at former UST(s) to human and environmental receptors. Only one downgradient borehole (A08-3), located at a surface water drainage culvert, indicated TPH concentrations at 109 ppm at 4 to 6 feet bgs (and non-detect at 8 to 10 feet). The shallow TPH concentrations may be attributable to the former sump-pump discharge or surface water runoff containing residual TPH concentrations directed toward the culvert over a large portion of the compound. With the exception of one ethylbenzene detection at 0.653 ppb, no BTEX and TPH were found in two groundwater sampling events at the site. In short, no health threats are estimated from the present level of contamination onsite. The site is considered a good candidate for a request to the VADEQ for UST closure under the no further action option.

FORMER UST/EXISTING UST NORTH OF BUILDING 202. A 1,000-gallon fiberglass UST is currently located north of Building 202, installed to replace a steel 1,000-gallon former UST at the same location. Boreholes A23-1, A23-2, BH-37, and BH-38 were drilled for subsurface soil collection adjacent to the former/existing UST. Borehole BH-39 was drilled at approximately 100 feet downgradient of the former/existing UST location. Borehole BH-40 was drilled and sampled at a background location immediately south of Building 202. Soil samples at borings A23-1 and A23-2 were analyzed for TPH, BTEX, PCB/pesticides, and lead during the Draft SCR. Soil samples at BH-37, BH-38, BH-39, and BH-40 were obtained and analyzed for VOCs, SVOCs, TPH, PCBs/pesticides, and metals during the SCR.

Groundwater samples at two existing wells (MW-13, MW-14) were collected and analyzed for TPH, BTEX, and lead during the Draft SCR. Boreholes BH-37, BH-38, BH-39, and BH-40 were converted to monitoring wells (MW-37, MW-38, MW-39, and MW-40) and groundwater samples analyzed for VOC, SVOC, TPH, PCB/pesticide, and metals during the SCR.

Soil sample results indicated TPH concentrations at A23-1 (353 ppm) and A23-2 (75 ppm) at 4 to 6 feet bgs. No TPH were detected at 8 to 10 feet bgs in either boring. TPH concentrations were also detected at BH-37 (159 ppm) and BH-38 (82 ppm) at 6 to 10 feet bgs. No TPH was detected at BH-39. No BTEX were detected at A23-1 or A23-2 and no VOCs, SVOCs, or PCB/pesticides, were detected above regulatory criteria at BH-37, BH-38, BH-39, and BH-40.

Groundwater results at MW-13 and MW-14 did not detect BTEX or TPH. Groundwater analyses at MW-37, MW-38, and MW-40 did not detect VOCs, SVOCs, PCB/pesticide, TPH, or elevated metals concentrations. Based on the analytical results of these groundwater samples located immediately downgradient and adjacent to the UST, residual TPH in soils at the UST trench do not appear to be leaching to the shallow aquifer.

The groundwater sample obtained at MW-39 indicated no TPHs or PCB/pesticides, however, organic concentrations of acetone (11 ppb) and chlorobenzene (26 ppb) were detected in the groundwater. The organic concentrations of acetone (11 ppb) and chlorobenzene (26 ppb) detected in groundwater at the well do not exceed U.S. Environmental Protection Agency (USEPA) Region III risk-based concentration for tap water. Metals analysis of groundwater reported elevated levels of zinc (93 parts per billion (ppb)) and manganese (346 ppb). The zinc concentration exceeds Virginia groundwater standards (50 ppb) but not USEPA risk-based concentrations nor Virginia surface water quality standards or secondary maximum concentration limits (MCLs).

MW-39 is located approximately 50 feet downgradient of a former oil/water separator as shown on Figure ES-1. The oil/water separator is located just north of the paved area north of Building 202. This structure formerly collected surface drainage from the storm sewer system for the paved area north of the building. TPH concentrations identified in soils adjacent to the oil/water separator and elevated PCB concentrations detected at the separator outfall in SI sampling prompted the USAEC to initiate removal action and possible additional study. The oil/water separator is scheduled to be excavated as part of a concurrent removal action conducted by the Omaha Corp of Engineers. The USAEC is working closely with the appropriate regulatory agencies in the removal action and any possible additional study.

Based on the chemical analyses of soil and groundwater, no ecological or human health threats were expected from residual TPH identified at former UST(s) soil media for human and environmental receptors. No health threats are expected from the present level of contamination onsite. Additional quarterly sampling for BTEX and TPH are recommended for MW-32D, MW-32S, and the sump for one year to monitor migration. The site will be considered a good candidate for a request to VADEQ for UST closure under the no further action option if the additional sampling results are clean. A risk assessment of the TPH in subsurface soils to receptors is further discussed in Section 4.0, Risk Assessment.

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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 U.S. Army Research Laboratory, Woodbridge Research Facility (WRF), Woodbridge, Virginia, was recommended for closure by 1991 Base Realignment and Closure (BRAC 91). The WRF officially closed on 16 September 1994. No property has yet been disposed at the WRF. Public Law 103-307 was signed by the President of the United States on 23 August 1994. This law mandated the transfer of the entire installation from the U.S. Army to the Department of the Interior (DOI). As of July 1995, negotiations of the terms of the property transfer are in progress. A property transfer date has not yet been announced. It has been determined that the U.S. Fish and Wildlife Service (USFWS), an organization within the DOI, will designate the property as a component of the National Wildlife Refuge system. Representatives of the USFWS have announced that the main compound area at the WRF will be utilized for administrative and educational purposes. The remainder of the installation is to be maintained as habitat for the wildlife and flora at the WRF.

Initiating the Installation Restoration Program (IRP) process, an Enhanced Preliminary Assessment (ENPA) was performed at the WRF in September 1991, which intended to document past activities and current conditions at the installation. The ENPA recommendations are documented in a final report dated March 1992. Twenty-nine Areas Requiring Environmental Evaluation (AREEs) were identified in the ENPA Report. Site Inspection (SI) physical sampling activities occurred at a selected number of these initial 29 AREEs in September and October 1993. AREEs investigated at Building 202 in the SI included: Underground Storage Tank (UST) Leaks and Spills, Former and Existing USTs, an Oil/Water Separator, and Drum Storage Area. In order to evaluate all data available for site characterization, the sampling program and analytical results obtained at the oil/water separator and drum storage area are included with the UST(s) evaluation.

The U.S. Army Environmental Center (USAEC), Aberdeen Proving Ground, Maryland, directed EARTH TECH to complete a Draft Site Characterization Report (SCR) for past and present UST sites at Building 202. The Draft SCR was submitted to Virginia Department of Environmental Quality (VADEQ) for review and comment on August

4, 1994. VADEQ comments on the Draft SCR requested additional investigation in the area of Building 202, a risk and remedial assessment based on the investigation, and submittal of an SCR presenting the results.

This SCR is separated into five sections: the introduction; site characterization activities, site characterization; the risk assessment; and the remediation assessment. The introduction provides the purpose of the report, the general background of the entire facility, and the physical setting. The site characterization activities provide assessment methods, analytical program, data management, and data evaluation protocol. The site characterization section presents objectives for the field investigation, field sampling and analytical program, data summary, and an evaluation of the data. The risk assessment provides a description and evaluation of existing/potential risk to receptors from potential contamination at Building 202. The remediation assessment consists of a feasibility study to describe and evaluate applicable technologies to achieve projected remediation endpoints.

1.1 PURPOSE OF REPORT

The purpose of this report is to characterize the environmental condition of surface and subsurface soil, sediments, surface water, and groundwater at former and existing petroleum storage sites at Building 202, and address VADEQ comments to the Draft SCR. This SCR will identify the extent of contamination, if any, which may exist at current and former petroleum storage sites at Building 202 as a result of past U.S. Army activities. A risk and remedial assessment based on the investigation is provided.

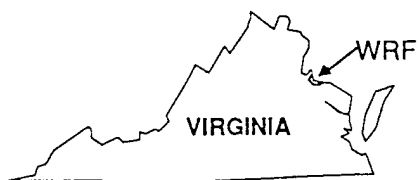
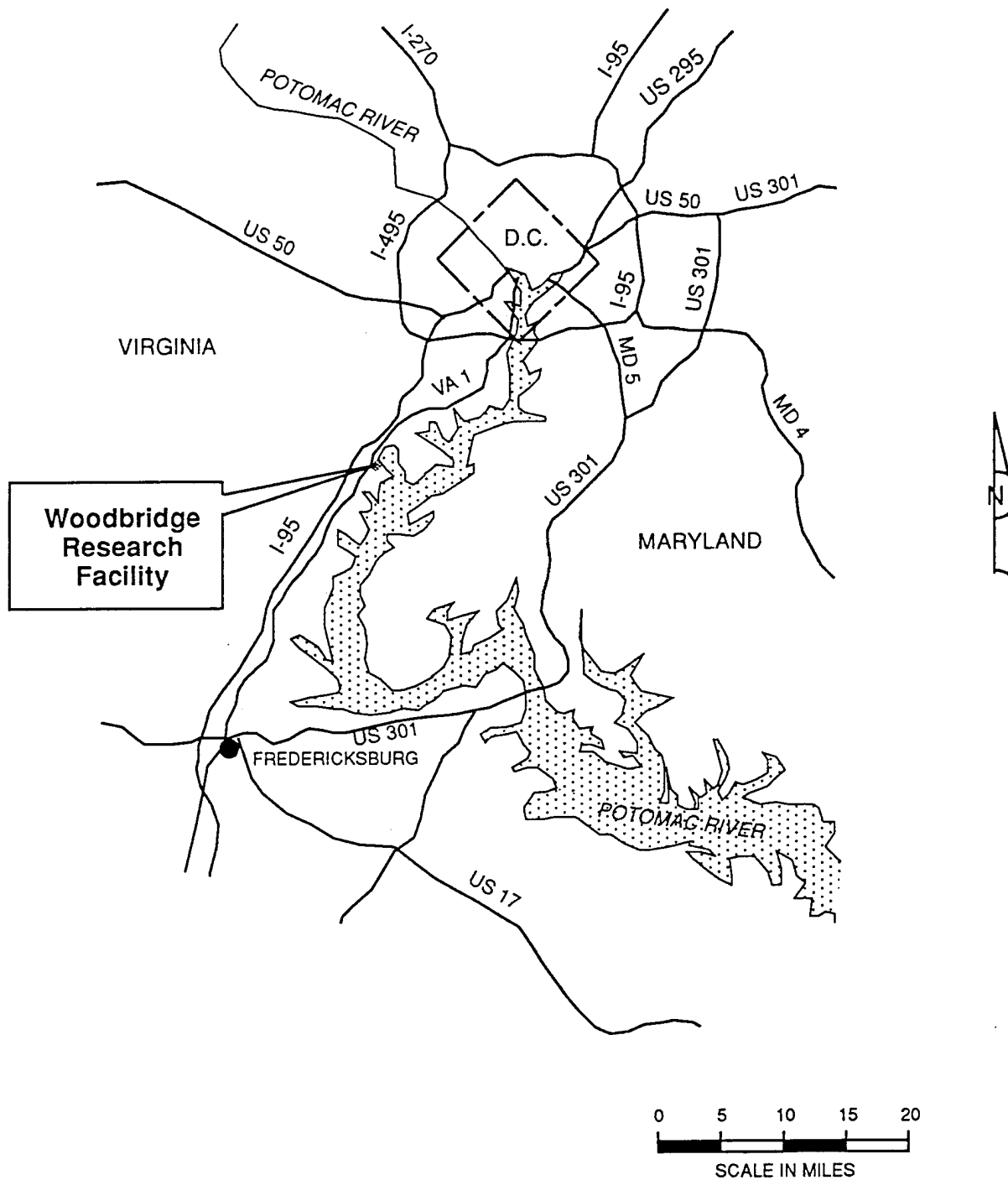
This SCR was prepared, and all activities specified herein were completed, in accordance with the Virginia UST regulations under Article 9 of the State Water Control Law and Army Regulation 200-2. Article 9 of the State Water Control Law consists of the Virginia UST regulations (Virginia Regulation (VR) 680-13-02) which regulates all USTs (except heating oil tanks with a capacity of 5,000-gallons or less).

1.2 FACILITY BACKGROUND

The subject of facility background consists of a description of the facility including a discussion of the location and history of the property.

1.2.1 Facility Description and History

WRF occupies approximately 579 acres of land in Woodbridge, Virginia in the easternmost portion of Prince William County. The facility is located 22 miles southwest of Washington, D.C., as shown in Figure 1-1. 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



EARTH  TECH

FIGURE 1-1

LOCATION MAP
WOODBIDGE RESEARCH FACILITY
WOODBIDGE, VIRGINIA

WRF. A facility location map based on the U.S. Geological Survey (USGS) Fort Belvoir Quadrangle Map is provided as Figure 1-2. Building 202 formerly housed the maintenance facilities as well as the vehicle repair facility for WRF. Figure 1-3 depicts Building 202 and all utilities in the area of the building.

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 641 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 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.

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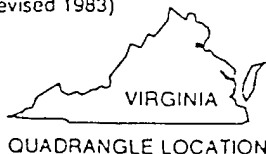


SOURCE: USGS Fort Belvoir 7.5' Quadrangle, Virginia
(1965, photorevised 1983)

MAP



North

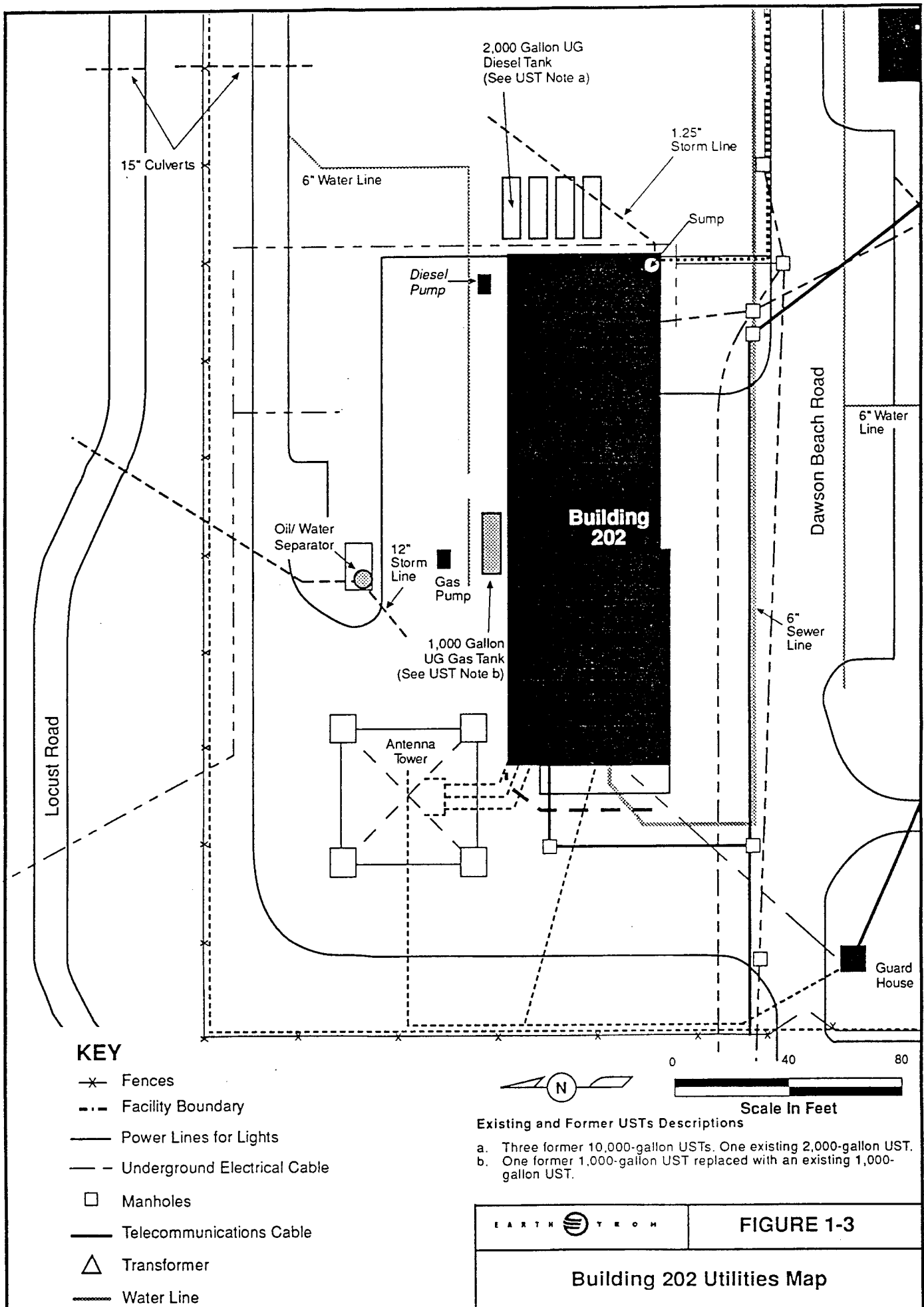


QUADRANGLE LOCATION

The Earth Technology Corporation

FIGURE 1-2

WOODBIDGE RESEARCH
FACILITY
LOCATION MAP



1.2.2 Surrounding Demography and Land Use

The population in Prince William County is 219,033 according to a 1991 estimate. The population of Woodbridge is 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, Fort Belvoir (USAECFB), 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.

1.3 PHYSICAL SETTING

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

1.3.1 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.

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).

1.3.2 Regional 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 1-4 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.

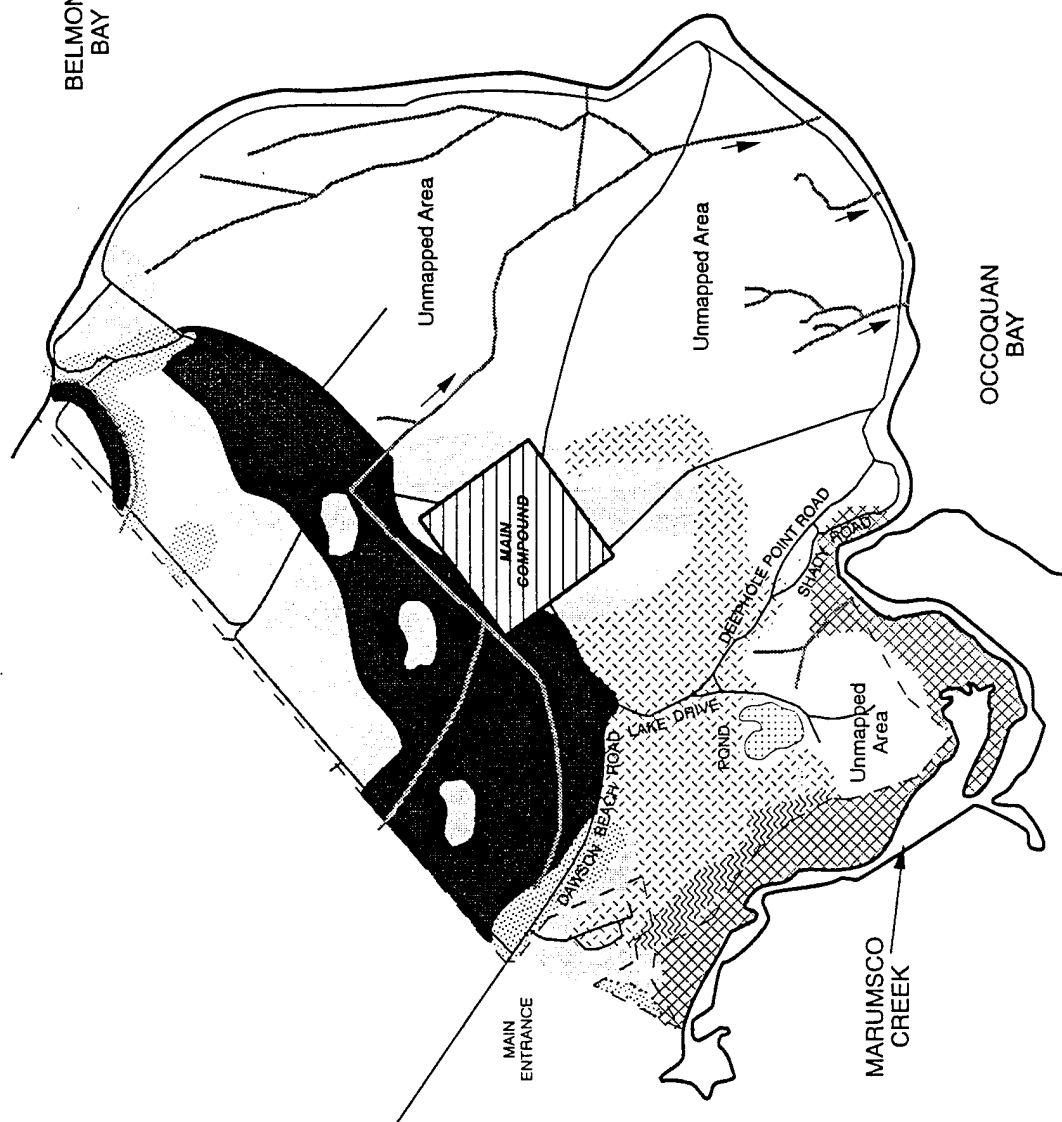
EL SINBORO SERIES. The soils of the Elsinboro series are very deep and well drained. They formed in sediments dominantly derived from schist, gneiss, and granite of the northern Piedmont Plateau. They are on low stream terraces adjacent to floodplains. Flooding is rare. Slopes range from 2 to 7 percent.

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.



BELMONT
BAY



KEY

- Facility Boundary
- Road
- Drainage and Flow Direction

SERIES

- | SOIL | SERIES |
|------------------------------|--------------|
| [Dark Gray] | Delanco |
| [Light Gray] | Dumfries |
| [Medium Gray] | Elsinboro |
| [Dark Gray with Cross-hatch] | Featherstone |
| [Dark Gray with Dots] | Marumsko |
| [Light Gray with Dots] | Meadowville |

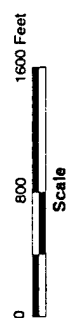


FIGURE 1-4

Woodbridge Research Facility
General Soils Map

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.

1.3.3 Regional 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. The Potomac Group (Lower Cretaceous) includes three different facies, listed below in order of abundance as described by the USGS.

- 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.

1.3.4 Site Geology

During completion of the Draft SCR and SCR, twenty boreholes were drilled at Building 202 using the hollow-stem auger (HSA) technique. Eleven of the boreholes were converted to monitoring wells. In addition, one borehole was drilled using a hand auger at a location where the drill rig could not be operated safely. Table 1-1 provides the borehole drilling information. The locations of the boreholes and geologic cross sections described below are shown in Figure 1-5.

Boreholes were sampled continuously to the water table following procedures described in Section 2.1. Drilling was performed to document hydrologic conditions, lithologically log the borehole, allow collection of subsurface samples for chemical analyses, and monitoring well installation.

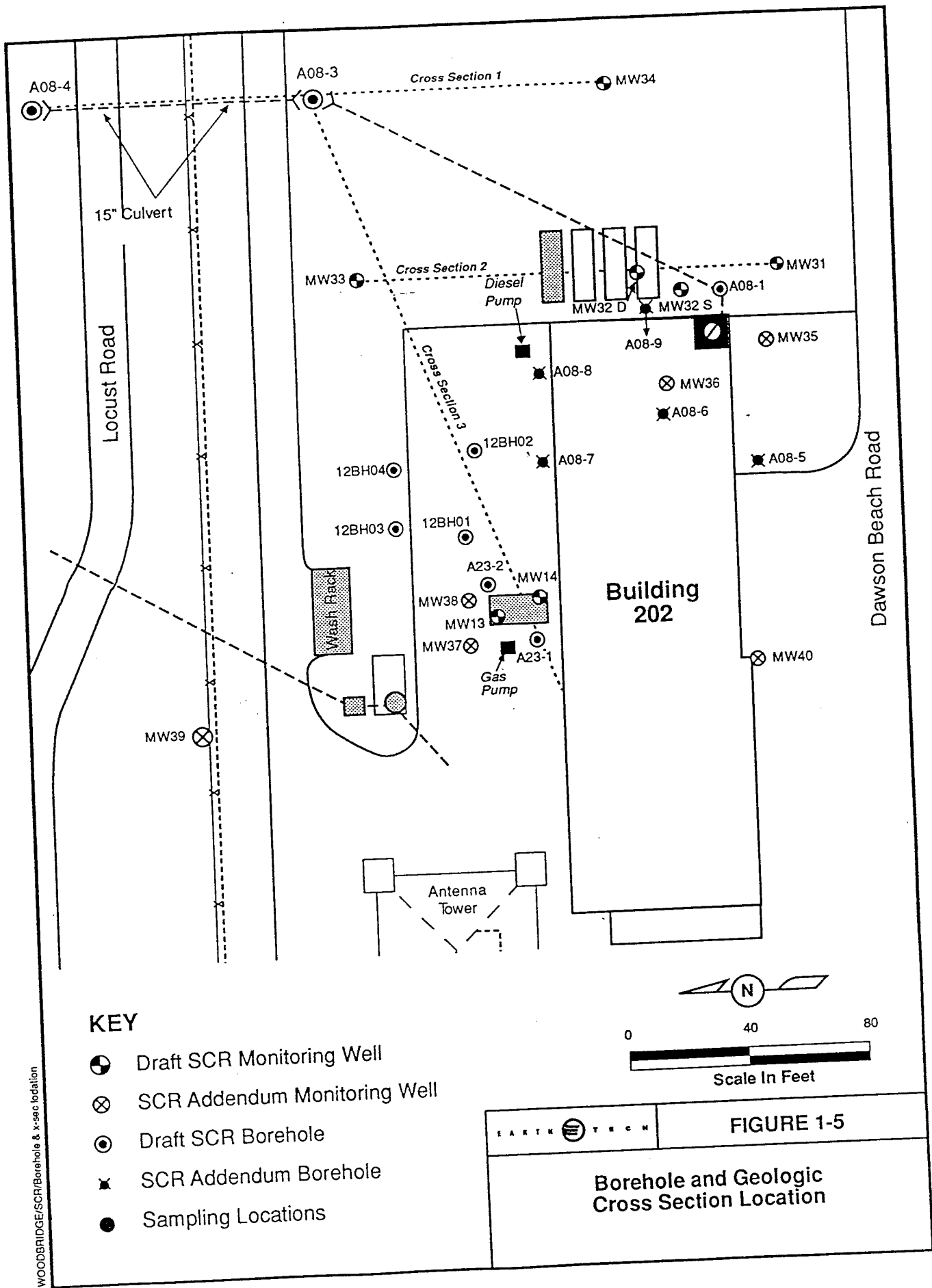
TABLE 1-1
BOREHOLE DATA

Borehole Number	Date Drilled	Depth to Water (feet bgs)	Total Depth (feet)
BH-31	April 12, 1994	6.25	15.0
BH-32S	April 15, 1994	7.0	15.0
BH-32D	April 14, 1994	10.0	27.0
BH-33	April 14, 1994	6.7	15.5
BH-34	April 12, 1994	4.5	13.5
A08-1	April 18, 1994	9.4	10.0
A08-3	April 18, 1994	7.0	10.0
A08-4*	April 21, 1994	2.1	5.0
A23-1	April 18, 1994	9.0	10.0
A23-2	April 18, 1994	9.0	10.0
A08-6	March 2, 1995	9.0	10.0
A08-7	March 2, 1995	9.0	11.0
A08-8	March 2, 1995	9.0	11.0
A08-9	March 2, 1995	7.7	10.0
BH-35	March 2, 1995	9.6	17.0
BH-36	March 2, 1995	9.0	15.0
BH-37	March 2, 1995	9.0	15.0
BH-38	March 2, 1995	9.0	15.0
BH-39	March 3, 1995	6.0	14.5
BH-40	March 2, 1995	9.5	16.5

*Borehole drilled with hand auger.

Key: bgs = Below Ground Surface

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Three cross sections have been constructed based on the lithology identified in the borehole logs prepared during drilling. The locations of the cross sections are depicted on Figure 1-5. The first cross section runs in a north-south direction and connects borings BH-34, A08-3, and A08-4 (Figure 1-6). The second cross section also runs in a north-south direction consisting of BH-31, BH-32S, and BH-33 (Figure 1-7). Boring A08-1 was not included in this section due to fill material encountered to a depth of approximately 9.4 feet below ground surface (bgs) presumably associated with the construction of Building 202. Similarly, boring BH-32D was not included in this section due to artificial fill material encountered to a depth of approximately 13.5 feet bgs associated with previously USTs located in this area. The third cross section is orientated in an east-west direction and connects borings A23-1, A23-2, BH-33, and A08-3 (Figure 1-8).

The first cross section depicts topsoil in the upper two to three inches. The interval beneath the topsoil was considered to extend to approximately 6.5 feet bgs in BH-34 and A08-3 and approximately 4.5 feet bgs in A08-4. In the shallow portion of this interval, the soil tended to be a clay with some silt. The silt content increased with depth grading at times to be higher in silt content than clay. Towards the bottom of the interval, fine sand began to grade into the clay/silt layer. Below this interval the soil tended to be a fine to medium-grained sand with some silt and clay in the shallow portion of the interval.

The second cross section which consists of borings BH-31, BH-32S, and BH-33 is illustrated in Figure 1-7. This cross section also begins with approximately two to three inches of topsoil. Directly beneath the topsoil, a silt layer with some fine sand and clay was encountered to a depth ranging from 2 to 3 feet bgs. Below the silt layer, a clay layer with some silt and fine sand was found to a depth ranging from 8.5 to 9.0 feet bgs. The final layer encountered was a sand with some silt that graded from fine-grained to coarse-grained with depth.

The third cross section that connects borings A23-1, A23-2, BH-33, and A08-3 is composed of two distinct portions and is shown in Figure 1-8. The first portion cuts through the paved area north of Building 202 and the second portion cuts through the grass area northeast of the building. The pavement and base coarse for the pavement extended to approximately 2 feet bgs. Below the base coarse for the pavement, the soil consisted of a silt and fine sand with some clay, with the fine sand becoming more prominent at approximately 10 feet bgs. In traveling east along the cross section, this silt and fine sand layer with some clay occurred only to a depth of approximately 2 feet bgs at boring BH-33, with a clay layer with trace silt and fine sand encountered beneath to a depth of approximately 8.5 feet bgs. Below this clay layer, fine to medium sand with some silt was encountered. Continuing east along the cross section, the silt layer found in the western portion of the cross section was not encountered in boring A08-3. In addition, the clay layer found in boring BH-33 to 8.5 feet bgs was only encountered to approximately 6.2 feet bgs in boring A08-3. Beneath the clay layer, the sand layer was once again found to the bottom of boring A08-3 at 10 feet bgs.

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A08-4

A08-3

MW34

15' MSL

10' MSL

5' MSL

0' MSL

-5' MSL

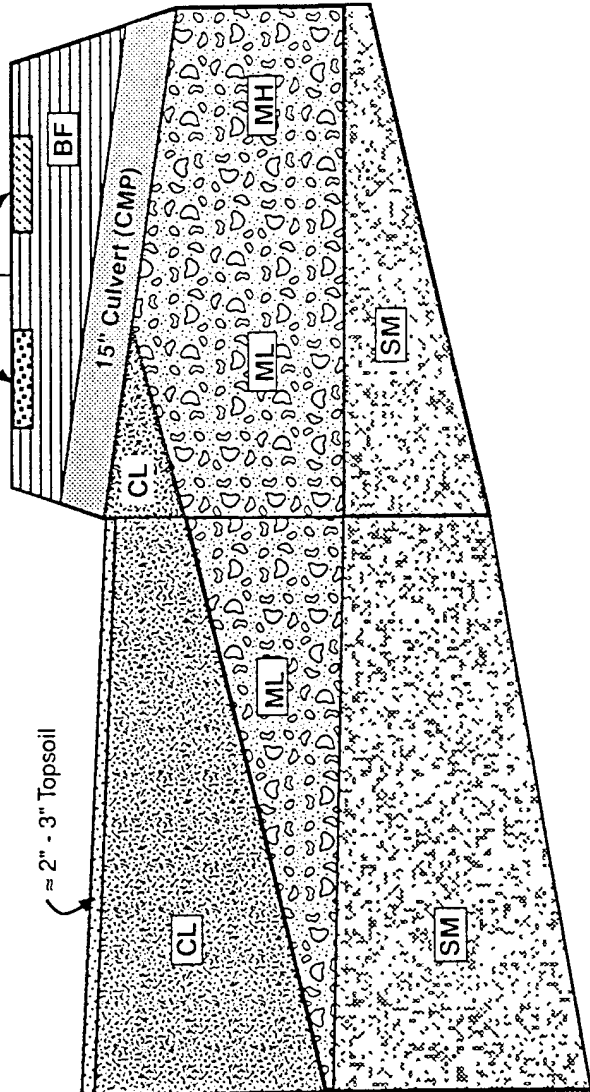
6' Chain-Link Fence

Tower Road (Paved)

Locust Road (Gravel)

≈ 2" - 3" Topsoil

15" Culvert (CMP)



Key:

- TS = Topsoil
- PV = Pavement
- GV = Gravel
- BF = Backfill
- CL = Clay with some Silt
- ML & MH = Silt and Fine Sand with some Clay
- SM = Sand with some Silt

Scale:

Hor. 1" = 30'

Vert. 1" = 5'

FIGURE 1-6

EARTH T E C H N

Cross Section 1

MW33

MW32S

MW31

15' MSL

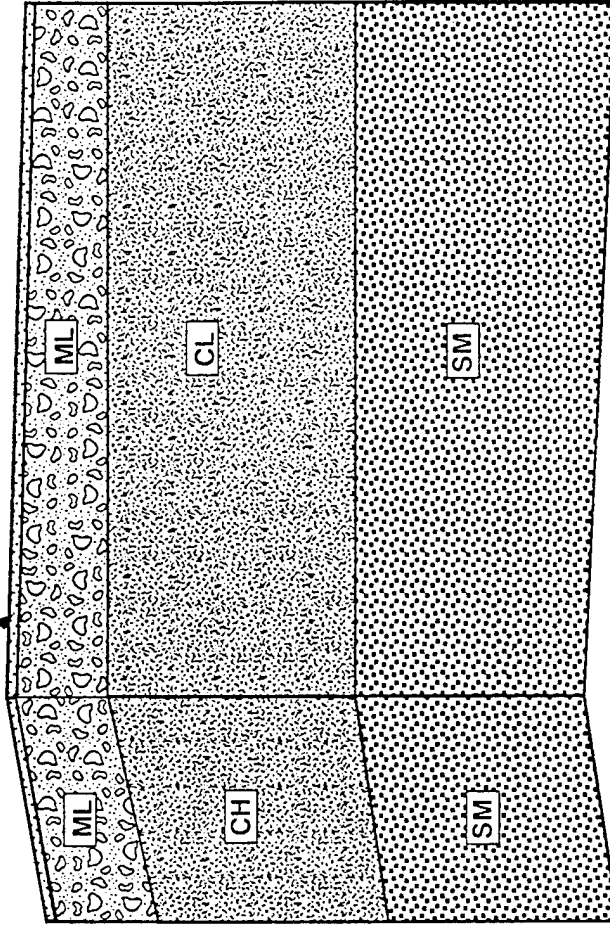
10' MSL

5' MSL

0' MSL

-5' MSL

≈ 1" - 3" Topsoil



Key:



Scale:

Hor. 1" = 30'

Vert. 1" = 5'

FIGURE 1-7

EARTH TECH

Cross Section 2

A08-3

MW33

A23-2

A23-1

15' MSL

10' MSL

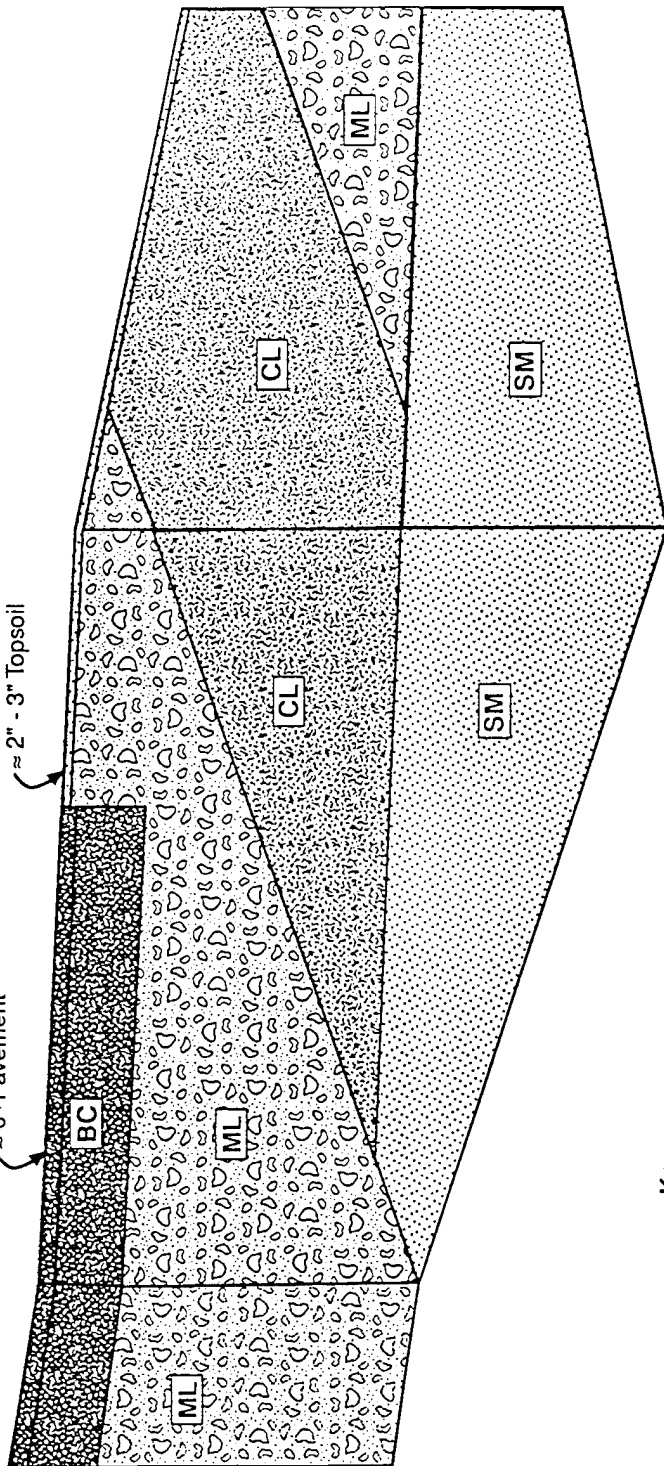
5' MSL

0' MSL

-5' MSL

≈ 6" Pavement

≈ 2" - 3" Topsoil



Key:

- TS = Topsoil
- BC = Base Coarse for Pavement
- CL = Clay with some Silt
- ML = Silt and Fine Sand with some Clay
- SM = Sand with some Silt

Scale:

Hor. 1" = 30'

Vert. 1" = 5'

FIGURE 1-8



Cross Section 3

As previously mentioned, borings A08-1 and BH-32D were not included in any of the cross sections due to the indication that the materials encountered in the borings were artificial fill to considerable depth. In boring A08-1, the fill material appeared as a silty fine sand to a depth of approximately 9.4 feet bgs. Below this layer, the sand layer encountered in adjacent borings was also found in boring A08-1. In boring BH-32D, the fill material also appeared as a sand, but more a medium to fine sand with some silt, and extended to a depth of 13.5 feet bgs. Also noted during drilling through the fill material was a petroleum odor in the soil beginning at approximately 6 feet bgs and continuing to 13.5 feet bgs, with the odor becoming heavier with depth. The interval from 13.5 to 15 feet bgs was concrete, believed to be the pad for the former USTs previously located in this area. Below the concrete pad, a silt with some fine sand was found to approximately 16.5 feet bgs. This silt layer was assumed to be the base coarse for the concrete pad due to a distinctive change to next lithological interval which was a clay with some silt to a depth of approximately 19 feet bgs. Below the clay layer, another silt layer was encountered to a depth of approximately 26 feet bgs. From 26 to 26.5 feet bgs, a medium-grained sand layer with some silt was found and from 26.5 to 27 feet bgs, a highly organic peat layer was encountered.

BEDROCK. 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 bgs less than one-fourth mile to the northwest of WRF. However, two wells drilled into the lower Potomac aquifer 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.

Boreholes drilled for the purpose of soil sample collection, lithologic logging, and not monitoring well installation, were grouted after the borehole was logged and samples were collected. The grout slurry consisted of a mixture of Type II 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 downhole drilling equipment was decontaminated before use at a new drilling location and all soil cuttings generated during drilling were handled as described in Section 2.3. Each borehole was permanently marked, including the boring number, with the location recorded on a project map for each specific site or area.

1.3.5 Site 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.

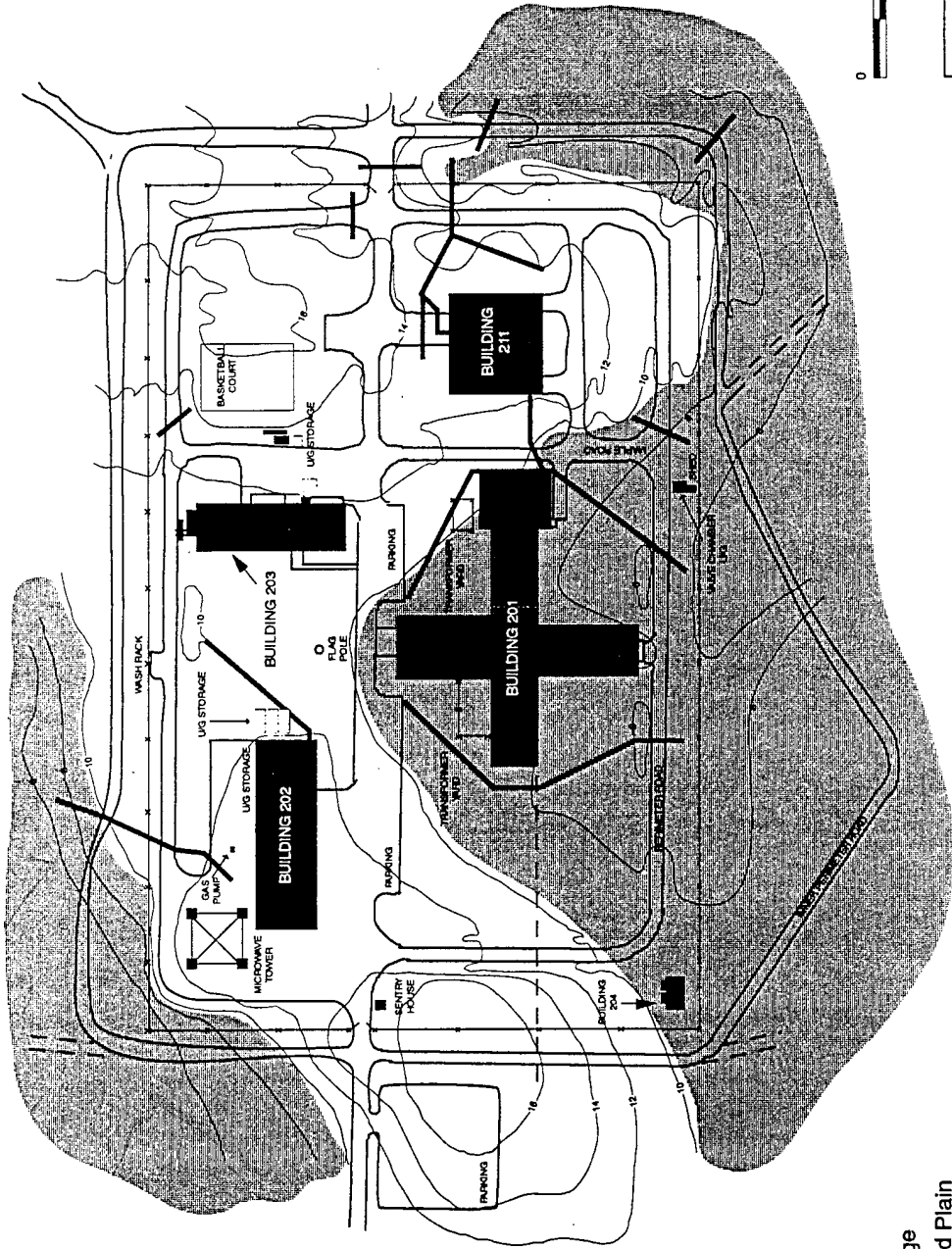
SURFACE WATER. The facility is located in the Occoquan River drainage basin of the Occoquan watershed. Marumsco Creek, which bounds the facility on the southwest side, empties into Occoquan Bay. Occoquan Bay forms the southern boundary of the facility. Belmont Bay, which is on the facility's northeast side, is mainly fed by the Occoquan River. The facility is bisected by an unnamed drainage channel originating from residential and partly industrialized areas to the north. The channel flows west to east across the facility and approximately 200 feet north and downgradient of Building 202. Surface water at Building 202 flows in a northerly direction toward the drainage channel with the ground surface grade. This channel flows easterly beyond the main compound and is fed by several smaller drainage lines before turning south and eventually feeding to Belmont Bay southeast of the main compound. 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. Figure 1-8 depicts the surface water drainage patterns and flow directions found at Building 202 and the WRF.

GROUNDWATER. 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 1-9. Depths to the water table ranged from 6.8 feet bgs at downgradient monitoring well MW-39 to 8.0 at upgradient monitoring well MW-40, south of Building 202. The groundwater gradient varies 0.59 feet from 5.15 feet MSL at MW-40 to 4.56 feet MSL at MW-39. The gradient of the water table indicates that the water table is at or near land surface and likely discharges to the drainage channel and adjacent low marshy areas downgradient of Building 202. The direction of groundwater flow at Building 202 is depicted on Figure 1-10.

Eleven of the twenty boreholes drilled at Building 202 were converted to monitoring wells as depicted on Figure 1-5. Well construction information for the eleven wells installed under this effort are provided on Figure 1-10 as Table 1-2. The table includes well number, total depth, screened interval, ground surface elevation, height of stick-up, casing rim elevation, depth to water, and water surface elevation.

To detect floating hydrocarbons on the groundwater surface, ten of the eleven monitoring wells were installed with sufficient well screen placed above the water table to accommodate water level fluctuations. One monitoring well (MW-32D) was screened beneath a 1.5-foot thick concrete layer encountered at approximately 13.5 feet bgs which, according to facility diagrams, is a concrete pad for the former USTs previously located at this site. A hydrogeologic cross section based on the lithology of these wells is presented as Figure 1-11.

All wells were screened within unconsolidated alluvial sediments beneath the site. The sediments encountered at Building 202 consist of silty clay, clayey silt, thin crossbedded silty sand units, and grey clay east of Building 202. A discontinuous fine to medium sand was encountered above a gravel-sand-silt deposit with clay silt matrix. The shallow water table aquifer was intercepted in the discontinuous sand and gravel-sand-silt deposits.



KEY

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

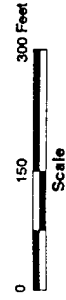
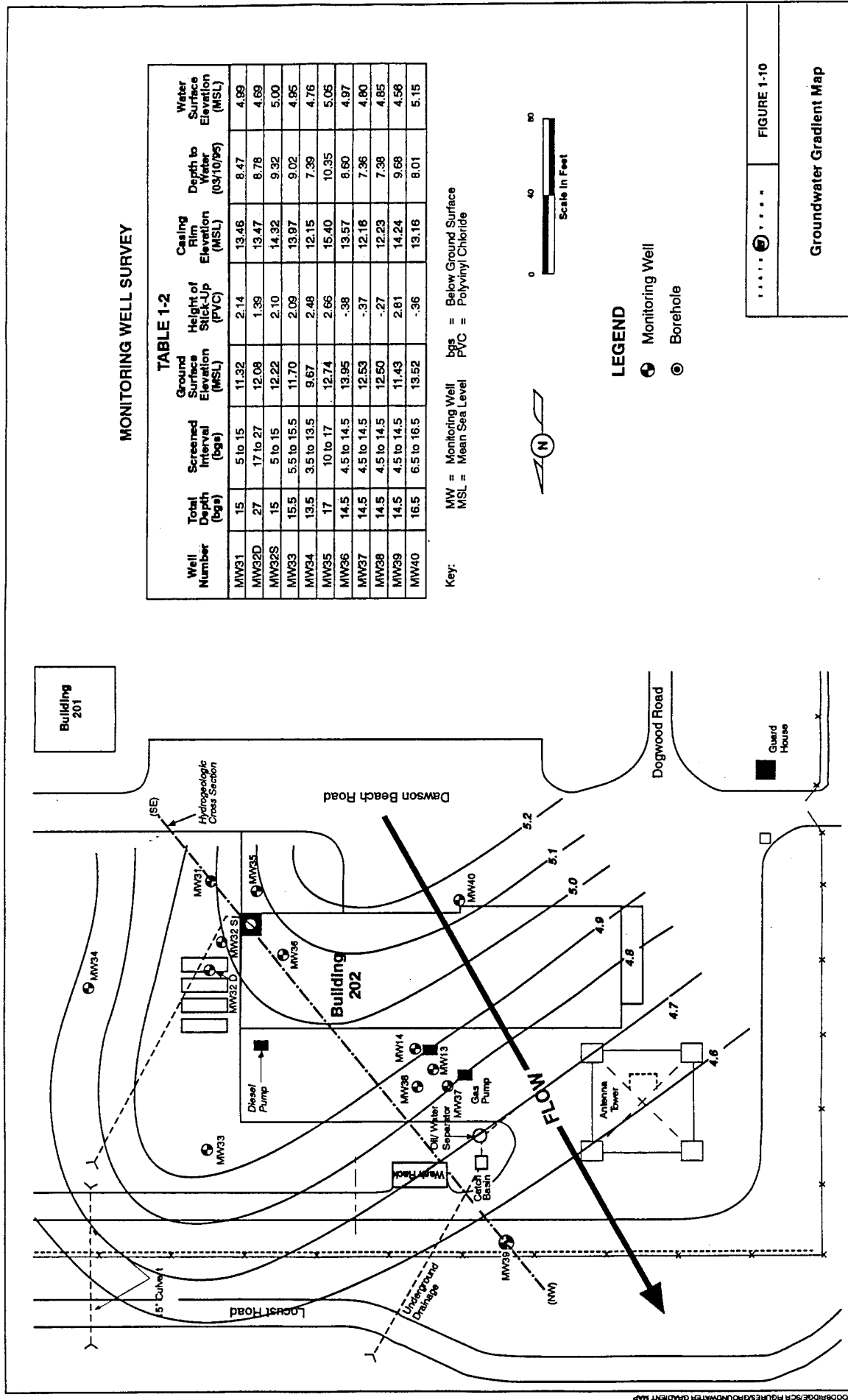
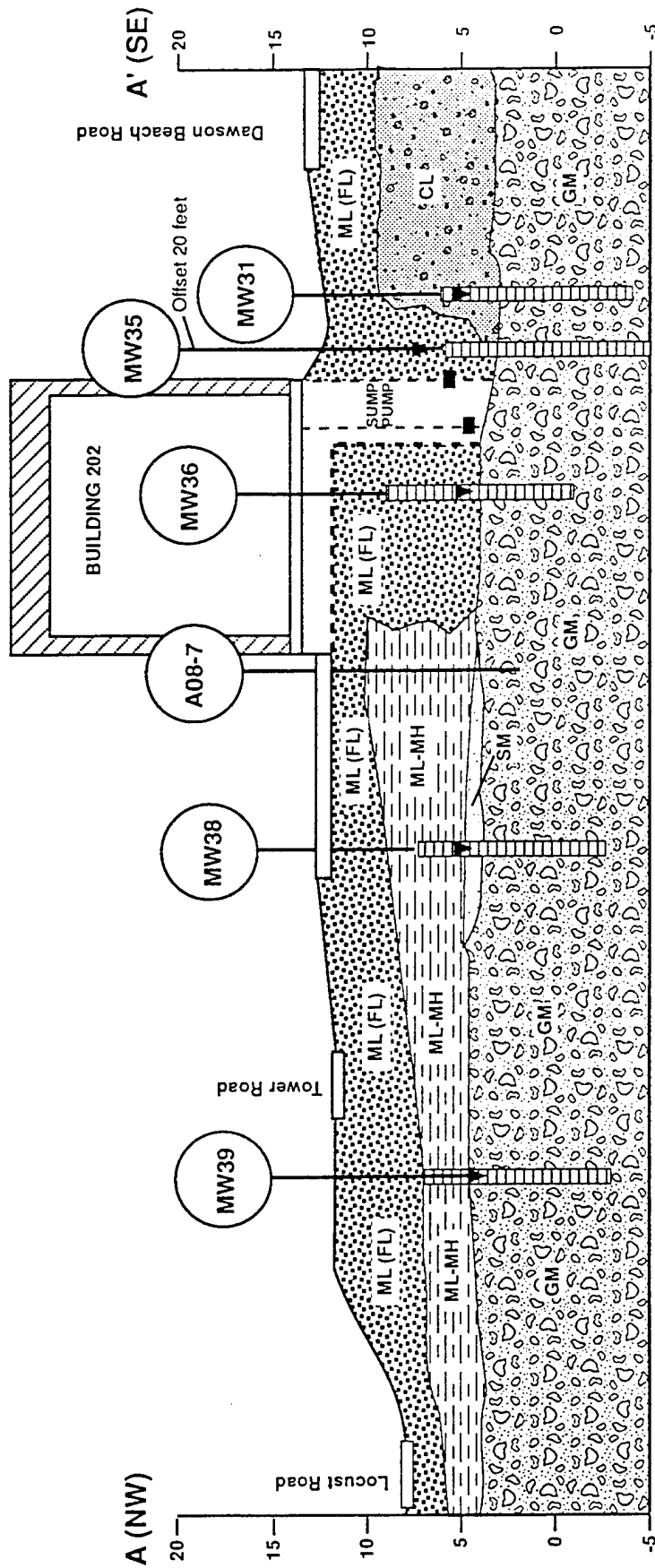


FIGURE 1-9

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



WOODBRIDGE/SCARBOURGH REGIONAL WASTE WATER TREATMENT PLANT



Key

- GM - Gravel-Sand-Silt
- SM - Sand with some Silt
- ML-MH - Silt and Fine Sand with Clay
- ML - Silt and Fine Sand trace Clay
- CL - Clay with Silt and Fine Sand
- (FL) - Fill Material
- Screened Interval
- Groundwater Elevations

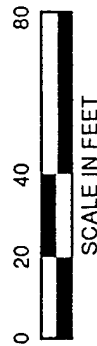


Figure 1-11

Hydrogeologic Cross-Section NW-SE

Slug tests were performed on all wells installed at Building 202 to determine aquifer properties at the site. Hydraulic conductivity, K , (often referred to as permeability) is the rate at which groundwater flows through a unit area of aquifer under a unit hydraulic gradient. Falling head and rising head methods of slug testing were performed by instantaneously introducing/removing a predetermined volume at the well via a polyvinyl chloride (PVC)-encased concrete slug and measuring the change in hydraulic head with a Hermit SE 2000 data logger. Slug tests were conducted until the hydraulic head had recovered to 90% of the static water level that was gauged just before the start of the test. Falling head hydraulic conductivities ranged from 3.35×10^{-4} feet/minute at MW-32D to 2.11×10^{-3} feet/minute at MW-39. Rising head hydraulic conductivities ranged from 8.29×10^{-3} feet/minute at MW36 to 1.12×10^{-2} feet/minute at MW-39. The result of the slug tests indicated the lowest conductivity at wells located in clay northeast of Building 202 and highest conductivity in wells completed with less clay and downgradient of Building 202. The results of the tests are shown in Table 1-3. All data, plots, and calculations are provided in Appendix D.

If the hydraulic conductivity (K) and hydraulic gradient (dh/dl) are known, the apparent groundwater velocity can be computed using Darcy's Law:

$$v = K \frac{dh}{dl}$$

Utilizing the most permeable value obtained at MW-39 (1.12×10^{-2}) and the hydraulic gradient between downgradient monitoring well MW-39 and upgradient monitoring well MW-40, an apparent groundwater velocity of 17 feet/year can be obtained.

The aquifer testing equipment (slug, pressure transducers, etc.) that were used for aquifer testing was decontaminated prior to testing each monitoring well to prevent the introduction of potential contamination. USAEC approved water was used for the wash and rinse decontamination procedure.

According to a drilling log available for one of two former water supply wells at the facility, sand and gravel were similarly encountered at approximately 9 feet bgs and extended to 49 feet bgs. A gray clay was encountered from 49 to 60 feet bgs. Sand and gravel were again encountered to 64 feet bgs where the formation graded into gray clay and gravel to 118 feet bgs. The supply well intercepted bedrock at 151 feet bgs and was completed in bedrock to 174 feet bgs. In general, the log indicates coarse material dominates the upper 45 feet and fine sediments dominate the lower 90 feet. The presence of thick clay units at 49 and 64 feet bgs indicate the shallow ground water table is confined to the upper sediments.

TABLE 1-3
CALCULATED HYDRAULIC CONDUCTIVITIES FROM SLUG TESTS

Well Number	Falling Head Hydraulic Conductivity (feet/minute)	Rising Head Hydraulic Conductivity (feet/minute)
MW-31	3.15×10^{-3}	3.66×10^{-3}
MW-32S	3.82×10^{-3}	4.44×10^{-3}
MW-32D	3.35×10^{-4}	2.15×10^{-4}
MW-33	2.14×10^{-3}	2.32×10^{-3}
MW-34	1.37×10^{-3}	1.70×10^{-3}
MW-31 *	2.18×10^{-3}	2.88×10^{-3}
MW-35	1.93×10^{-3}	2.98×10^{-3}
MW-36	6.47×10^{-3}	8.29×10^{-3}
MW-37	1.84×10^{-3}	1.23×10^{-3}
MW-38	2.86×10^{-3}	8.75×10^{-4}
MW-39	2.11×10^{-3}	1.12×10^{-2}
MW-40	1.28×10^{-3}	1.37×10^{-3}

Note: MW-31 retested to correlate with previous slug tests, MW-31 through MW-34 tested during Draft SCR, MW-31, MW-35 through MW-40 tested during SCR.

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 gallons per day (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 101 gallons per minute (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 (Virginia State Water Control Board (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. The two former deep water supply wells are located 1,400 feet southeast of the main compound. Well No. 1 is abandoned with no pump. Well No. 2 has an inoperative 30 gpm pump. There is a potential for the wells to provide water to the pond via in place water lines. 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).

1.3.6 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).

1.3.7 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.

1.3.7.1 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 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.

1.3.7.2 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). 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 channel catfish inhabit a two-acre pond at WRF.

Fishing is no longer permitted at the WRF due to concerns about polychlorinated biphenyl (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.

SECTION 2.0

SITE CHARACTERIZATION METHODS

This section describes the procedures used throughout the SCR sampling, analysis, and data management program at the WRF. The Quality Assurance/Quality Control (QA/QC) procedures were developed in accordance with USAEC requirements and applicable regulatory agencies to provide ongoing control and review of data collected for the SCR effort. Both laboratory and field procedures are discussed in this section. The overall project goal was to document that the data collected were valid and defensible for the intended use and representative of the *in-situ* environmental conditions measured. This section was prepared in accordance with the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) Quality Assurance Project Plan (QAPP) (1990). An overview of sample collection, field operations, analytical parameters, QA/QC procedures, data quality evaluation, and data management are presented.

2.1 FIELD OPERATIONS

A chronology of SCR field activities conducted at Building 202 is presented in Table 2-1. As previously mentioned, these activities were completed in two segments: the Draft SCR which was conducted between 4 April 1994 and 14 June 1994; and the SCR which was conducted between 1 March 1995 and 27 April 1995.

2.1.1 Site Reconnaissance, Preparation, and Restoration

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. A secure staging area for storing equipment and supplies.
4. A paved decontamination area with an electrical supply and a potable water supply.

TABLE 2-1
CHRONOLOGY OF FIELD ACTIVITIES CONDUCTED

Date	Activity
Draft Site Characterization Report	
April 4, 1994 to April 11, 1994	Mobilized to Woodbridge Research Facility. Set up trailer, unloaded equipment, purchased supplies, etc. Staked out drilling/sampling locations.
April 12, 1994 to April 18, 1994	Performed utility clearance at well/boring locations. Drilled, sampled soil during drilling, and installed the five monitor wells (MW-31, MW-32S, MW-32D, MW-33, and MW-34). Drilled and sampled soil during drilling of four boreholes (A08-1, A08-3, A23-1, and A23-2).
April 20, 1994 to April 21, 1994	Organized drums of drill cuttings, decontamination water, etc. at trailer. Installed the surface completion for the five newly constructed monitor wells. Hand augered and collected soil sample at A08-4.
April 25, 1994 to April 27, 1994	Completed surging and development of the five newly constructed wells.
May 3, 1994	Painted protective casings and guard posts for the five newly constructed wells.
May 11, 1994 to May 18, 1994	Completed purging and sampling of groundwater at the five newly constructed wells and at the two previously existing wells by the underground storage tank (UST) north of Building 202 (MW-13 and MW-14). Collected aqueous sample from condensate return tank pit inside Building 202.
May 24, 1994 to May 26, 1994	Recollected groundwater samples (purging and sampling) at MW-14 due to sample container arriving at laboratory broken on May 18, 1994, and AEC rejecting samples collected on May 24, 1994. Attempted to perform aquifer tests but equipment was malfunctioning.
June 6, 1994 to June 7, 1994	Completed aquifer tests at the five newly constructed wells. Attempted to perform aquifer tests at the two previously existing wells by the UST north of Building 202 (MW-13 and MW-14) but could not complete due to poor well construction.
June 14, 1994	Completed surveying activities for sampling locations.
Site Characterization Report Addendum	
March 1, 1995 to March 3, 1995	Drilled, sampled, constructed A08-5, A08-6, A08-7, A08-8, A08-9, MW-35, MW-36, MW-37, MW-38, MW-39, MW-40.
April 17, 1995 to April 24, 1995	Purge and sample MW-31, MW-32D, MW-32S, MW-33, MW-34, MW-36, MW-38, MW-39, MW-40.
April 26, 1995 to April 27, 1995	Perform aquifer tests at all new wells and retest existing well MW-31.
May 3, 1995 to May 5, 1995	Completed surveying activities for sampling locations.

5. 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. Plastic sheeting and berms were used to contain decontamination waters, mud, etc. Water was periodically pumped from the area 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. Site restoration also included close coordination with WRF personnel to ensure that clean-up operations were in accordance with the overall management of their facility.

2.1.2 Geophysical Surveys

All geophysical activities were supervised by an experienced geophysicist and 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 U.S. Environmental Protection Agency (USEPA) (1987). Equipment calibration procedures are described in Section 2.1.12.2. A detailed log of geophysical activities was maintained during field work.

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, 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.

2.1.3 Excavation

Excavation was used to locate the extent and depth of contamination. Trenches 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. All exhumed

soil was placed on plastic in the event that the excavated soil was contaminated. Samples were collected as described in Section 2.1.9.1. All activities were recorded on an Excavation Log Form. 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.

2.1.4 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 HSA 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 utilizing split-spoon soil samplers.

Soil samples were collected continuously using the HSA technique 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.

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. Type II Portland cement was utilized in SCR activity in the same manner as above per USAEC directive. 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 downhole drilling equipment was decontaminated before use at a new drilling location. 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. Information was also recorded on the field borehole log in compliance with the existing USAEC guidance.

Air monitoring was conducted during all drilling activities. A PID was used to detect concentrations of total volatile organic compounds (VOCs) 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.

2.1.5 Land Surveying

All surveyed points were referenced to standard horizontal and vertical control (third-order survey). 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.

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

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 Building 202. 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.

2.1.7 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 2-2. When the waste contains less than

TABLE 2-2
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

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 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.

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. The results of monitoring well analyses and representative water samples from the drums were submitted to the H.L. Mooney Wastewater Treatment Plant to assess if the well development/purge water must be classified as hazardous waste. A comparison with regulatory criteria indicated the water was nonhazardous and 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.

2.1.8 Field Sampling Procedures

Soil, sediment, surface water, and groundwater samples were collected as part of the SCR at Building 202. The methodologies used in collecting these samples are discussed in the following subsections.

2.1.8.1 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.
- 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. Samples were collected in containers that were cleaned according to protocols in Appendix F of the USATHAMA QAPP (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 all borings.

Due to height restrictions inside Building 202, precluding use of the split-spoon hammer, borings BH-36 and A08-6 were sampled with 5 foot continuous split-spoon samplers pushed into the ground by the drill rig table. Due to the increased soil volume required by SCR analyte sampling scheme, three- to four-intervals were sampled from the borehole dependent on soil sample recovery.

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 were 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 were 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 were collected with stainless steel hand augers. The samples for VOC analysis were agitated and aerated as little as possible prior to sealing the sampling jar. Surface soil samples were collected with a hand auger. Duplicate soil samples were collected immediately adjacent to the soil sample. Samples from augers were placed directly in the sample jar from the auger. The jar

was completely filled to eliminate headspace. All sample data were recorded on a Soil/Sediment Sampling Record.

SEDIMENT SAMPLING. All sample data were recorded in a soil/sediment sampling record. The following procedures were used for the collection of sediment samples:

- The farthest downstream sample location was sampled first. Sediment samples collected in upstream and downstream locations were obtained in areas of similar environment, and whenever possible, were obtained from slow-moving pool areas. To avoid the disturbance of the sampling area, sample locations in streams and other waterbodies were always approached from the downstream side.
- The sediment sampling device was selected based on site-specific sediment properties. If possible, a stainless steel hand auger was used. If auger recovery was insufficient to collect a sample, a stainless steel scoop was used to collect sediment and transfer the sample into the sample jars. Sediment sample jars were tripled rinsed with the surface water from slightly downstream of the sampling location prior to collecting the sediment sample. Sediment VOC samples were packed to eliminate headspace and shipped in coolers filled with ice.
- Duplicates were collected directly adjacent to the sample location. If a auger or stainless steel scoop were used, undisturbed sediment from adjacent locations was placed in jars for analysis.

2.1.8.2 Groundwater Sampling

Field personnel filled all sample containers using the same precautions as for soil sampling. In addition, water sample containers were rinsed three times with sample location water prior to filling the containers. Samples were collected from the wells installed during the SCR no sooner than 14 days following well development. This 14-day waiting period allows the groundwater in the well to reach equilibrium conditions. In general, groundwater samples were collected from the least likely contaminated well locations to the most likely contaminated well locations in order to lower the possibility of cross contamination. The groundwater sampling methods discussed below followed procedures described in the *RCRA Ground Water Monitoring Technical Enforcement Guidance Document* (USEPA, 1986) and *USATHAMA Geotechnical Requirements for Drilling, Monitor Wells, Data Acquisition, and Reports* (USATHAMA, 1987).

MEASUREMENT OF POTENTIOMETRIC WATER LEVELS. Water levels were measured in all monitoring wells just prior to purging for sampling. Measurements were recorded as feet below the measuring point elevation (usually top of casing) to the nearest 0.01 foot and were referenced to MSL. Measurements were taken after wells had been developed and prior to any well purging activities. The measurements were taken

within as short a time period as practical so that water levels were representative of a given period.

The procedures for water level measurement are based on methods described in the *RCRA Ground Water Monitoring Technical Enforcement Guidance Document* (USEPA, 1986) and are as follows:

1. Locking and protective caps were removed.
2. The air was sampled in the well head for the presence of organic vapors using a PID.
3. Visual surveys were conducted of the well.
4. The static water level depth was determined from the top of the inside casing (surveyed measuring point) to the nearest 0.01 foot using an electric sounder.
5. The total depth was measured in the well.

The water level probe was decontaminated before use in each well. Decontamination procedures followed those for the water sampling equipment as described in the approved Work Plan.

WELL PURGING. Before purging the well, the static water level and total well depth were measured using an electric sounder as described above.

After the static water level and well depth were measured, the well was purged using a PVC bailer or submersible pump. At least five well volumes, including the saturated annulus, were purged from the well. If the well was approaching dryness, the pump was turned off or bailing discontinued to allow the well to recover. A Whaler Supersub submersible pump equipped with a stainless steel check valve was used for purging the wells. Before, during, and after purging, a water sample was collected and pH, turbidity, specific conductance, and temperature were measured. Color and odor of the water were noted. Samples were measured quickly in order to minimize contact with the atmosphere.

SAMPLE WITHDRAWAL. Sample containers were rinsed three times with sample location water prior to filling. Samples were collected using a Teflon™ bailer and Whaler Supersub submersible pump. A Teflon™-coated wire or medical grade PVC tubing was used to lower sampling equipment into the well. Samples were collected by pouring the water from the bailer or tubing directly into the sample container(s). Duplicates were collected concurrently.

Samples for VOC analysis were collected in 40 milliliter (mL) glass VOC vials fitted with Teflon™ septa, allowing no headspace. VOC samples were collected first,

followed by semivolatile organic compound (SVOC), pesticide/PCB, and inorganics (inductively coupled plasma (ICP) metals, mercury, and cyanide) as appropriate. Preservatives were added at the time of sample collection. 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 analyses were collected in the same manner as the organic samples but were placed in plastic or glass containers. Preservatives were added at the time of sample collection. Samples collected for dissolved metals analysis were filtered through a 0.45- μ m membrane filter using an in-line positive pressure filter within 15 minutes of sampling and prior to sample preservation.

2.1.8.3 Decontamination

Water used for rinsing field equipment was taken from an USAEC-approved source as discussed in Section 2.1.1.4. Soil, sediment, and groundwater, equipment was decontaminated between each use to prevent cross-contamination. Equipment was scrubbed and rinsed with water from the AEC-approved source. Sampling equipment was protected from recontamination by wrapping with aluminum foil or placement in a Ziplock™ bag.

The submersible pump, was decontaminated by scrubbing and flushing/pumping 10 gallons of USAEC-approved water through the components. Dedicated medical grade PVC tubing was also utilized at each well.

The drill rig was steam cleaned at the decon pad between boreholes. All measurement equipment (tapes, sounders, etc.) was also thoroughly decontaminated prior to use and between sampling points by washing and rinsing with water. Monitoring equipment, such as the PID, was wiped clean with a moist towel at the end of each work day. Discarded materials, including paper towels and decontamination fluids, were disposed in accordance with applicable regulations.

2.1.9 Sample Handling

Sample containers were selected in accordance with USEPA and Appendix F of ER 1110-1-263. The USEPA-recommended preservation techniques for the parameters of concern as listed on Table 2-3 were followed. Preservation of samples is required to retain sample integrity. Minimum sample volumes required for each analysis are also specified and were observed. Pre-cleaned sample containers for soil and groundwater samples were provided by the laboratory accompanied with a certificate indicating that the bottles are analyte free. In general, amber glass bottles with Teflon™ lids were used for organic samples while polypropylene bottles were used for metals and other inorganics.

TABLE 2-3
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	
Total Petroleum Hydrocarbons	G	1,000	50	4°C HCl to pH < 2	4°	28 days
Metals	P	1,000	50	4°C HNO ₃ to pH < 2	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 including BTEX	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

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

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.

All Federal, State, and local regulations were carefully observed when shipping each type of sample. Shipping containers (Coleman coolers) were secured using tape and custody seals to ensure that samples were not disturbed during transport. The sample packaging protocols listed below were followed during the SI effort:

- Sample bottle lids were not mixed. All sample lids stayed with the original containers.
- If the sample volume level was low because of limited sample availability, the level was marked on the outside of the container with a grease pencil.
- All sample containers were placed in individual plastic bags. All glass sample bottles were placed in plastic bags and wrapped in bubble pack to minimize the potential for breakage and contamination during shipment. Plastic bottles and brass sleeves were not wrapped in bubble pack but were placed in plastic bags. All individually bagged bottles were placed in a large plastic trash bag within the cooler.
- All samples were cooled using ice. The sample containers were packed in Coleman coolers. A layer of vermiculite was placed at the bottom of each cooler to act as an absorbent material in case of breakage. Empty space around the samples were filled with inert packing material. The coolers were then filled with ice packed in Ziplock™ bags.
- The chain-of-custody record was rechecked and placed in a plastic bag and taped to the inside of the cooler lid.
- All shipping containers were taped and custody seals secured prior to shipment to the laboratory. Custody seals were placed on two sides of the shipping container. The custody seal consisted of either a plastic or a regular paper custody seal and filament tape wrapped around the shipping container at least twice.

Samples were sent to the laboratory for analysis within 48 hours after collection to minimize holding time exceedance. The holding time began from the time of collection in the field. Preservatives were added in the field.

Two sample coolers that were shipped on July 8 and July 9, 1994, were delayed by the overnight air courier, Federal Express. As a result of the delay, the laboratory was instructed not to analyze the samples pending review by the AEC Chemist. As described in Section 5.0, the majority of the samples were recollected at the expense of Federal Express and analyzed according to the original chain-of-custody request. An "R" was added to the field sample identification number to indicate the sample had been recollected.

2.1.10 Field Sample Identification

Unique field sample identification numbers were designated by a four-part code. The first three digits represent the AREE number, the middle three digits designate the sampling location (type of sample location and its number), and the last two digits state the sample number taken sequentially from the location. Sample numbers were labeled consecutively as they were collected at a location. An example of the sample identification is described below:

003M0201

Where:	003	=	The AREE Number (AREE 3)
	M	=	Type of Sample Location (Monitoring Well)
	02	=	Sample Location Number (Monitoring Well 2)
	01	=	Sample Number (First Sample from M02).

The following abbreviations were used for the sample location types:

B	=	Borehole	A	=	Hand Augered Surface Soil
M	=	Monitor Well	T	=	Tank
O	=	Surface Soil	S	=	Sediment.

Every sample collected for laboratory analysis was labeled with identification information. In addition to the field sample number described above, each label contained Installation Restoration Data Management Information System (IRDMIS) codes for the installation name, site type, and media type. Blind duplicates were sent to the laboratory (i.e., the sample label did not identify which samples were duplicates). The duplicate was assigned a false sample number and then corrected and flagged using a "D" flagging code in the IRDMIS database following analysis.

If more than one container was collected from the same location on one day to provide the laboratory with sufficient sample volume or due to different analytical requirements, all containers were labeled with the same identification number. The sample number, along with the date and time the sample was obtained, were recorded in the field log and written on the sample label. After collection and identification, the samples were maintained under chain-of-custody procedures.

QC samples were labeled using a three part numbering system. The first part was a one-digit letter as follows:

T	=	Trip Blank
R	=	Rinse Blank
A or F	=	Ambient Condition or Field Blank.

The second part was one-digit number, consecutively, numbered each day, beginning with one. The third part was a six-digit number that represents the date of sample collection. The following two examples illustrate a typical QC sample ID:

T1031794 = First trip blank collected on March 17, 1994
R3040394 = Third rinse blank collected on April 3, 1994.

2.1.11 Sample Custody

All samples collected followed strict chain-of-custody procedures to maintain and document sample possession, as described below.

FIELD CUSTODY PROCEDURES. EARTH TECH field personnel were responsible for the care and custody of the samples until they were shipped to Pace, Inc. Samples were either in the possession of the field crew or locked in the EARTH TECH trailer. All sample label information was inscribed using waterproof ink.

Custody seals were used whenever samples were not in EARTH TECH's possession. When shipping samples to Pace, custody seals were covered with clear filament tape that was wrapped around individual shipping containers.

TRANSFER OF CUSTODY. A chain-of-custody form was completed before shipping. When transferring the possession of samples the persons relinquishing and receiving the samples signed, dated, and noted the time on the form. The chain-of-custody form documents sample custody from the field sample acquisition to the person responsible for packaging and finally through the laboratory separate laboratory custody procedures were maintained. When samples were relinquished to an overnight carrier, shipping containers were sealed with custody seals by the person relinquishing custody. Upon receipt at the analytical laboratory, the laboratory sample custodian who opened the shipping container signed the chain-of-custody form, accepting custody of the samples. The original chain-of-custody form accompanied the shipment to the laboratory. A copy was retained by EARTH TECH.

LABORATORY CUSTODY PROCEDURES. A designated laboratory sample custodian accepted custody of the samples and verified that the information on the individual sample labels matched the information on the chain-of-custody. Important information regarding the shipment was documented by the sample custodian. This information included the condition of the custody seals, and the condition of the sample bottles, including bottle breakage or samples received which exceeded accepted temperatures. If discrepancies were discovered between the chain-of-custody, sample label, and requested analyses, the sample custodian immediately notified EARTH TECH.

The field identification numbers for the samples were then entered into the Laboratory Information Management System (LIMS) which documented sample receipt. Each sample was then assigned a unique Pace number for tracking through the laboratory. The laboratory sample custodian then distributed samples to the appropriate analysts.

The analysts were responsible for the care and custody of the samples until the samples were either depleted during analysis or returned to the laboratory sample custodian.

2.2 ANALYTICAL PROCEDURES

All samples were analyzed according to either approved, laboratory validated USAEC analytical methods or other published methods (e.g., USEPA SW846 methods) approved for use by USAEC. The following sections describe equipment calibration, analytical method selection, sample batching, and method detection limits (MDLs).

2.2.1 Calibration Procedures

This section describes field and laboratory equipment calibration procedures.

CALIBRATION PROCEDURES AND FREQUENCIES FOR FIELD TEST EQUIPMENT. Field equipment was calibrated prior to use in the field as appropriate. The calibration procedures followed standard manufacturers' instructions and EARTH TECH's calibration/service specifications (C/SS) to ensure that the equipment functioned within tolerances established by the manufacturers and required by the project. In addition to regularly scheduled calibration, some instruments, such as pH meters, required calibration checks immediately before use. All instruments were monitored for evidence of nonreproducible or erratic readings, and recalibration was performed as required. A daily record of field analytical instrument (e.g., pH meter, conductivity meter, and PID) calibration was maintained in the field logbook by field personnel. In addition, any notes on unusual results, changing of standards, battery charging, and operation and maintenance were included in the logbook.

LABORATORY INSTRUMENT CALIBRATION. On a daily basis, 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 USATHAMA QAPP (1990).

Initial calibration for all methods used during this project were performed routinely by Pace, Inc. as part of the validated analytical protocol. Recalibration was not required unless the instrument failed the daily calibration test procedure. The initial calibration procedure also required the analysis of a calibration check standard at the MDL and one standard at the upper reporting limit.

2.2.2 Analytical Methods

An analytical method is a series of procedures that must be performed to determine the identity and quantity of an analyte in a sample. USAEC divides analytical methods into four classes for determining the number and types of QC samples per lot. The USAEC method classes are as follows:

-
- **Class 1 Methods.** These are methods for the analysis of selected organic parameters and for the analysis of inorganic parameters. Methods 9045 (pH), mercury, 418.1 (total petroleum hydrocarbon (TPH)), cyanide and ICP metals are representative of this class.
 - **Class 1M Methods.** These are gas chromatograph/mass spectrometry (GC/MS) methods for the analysis of VOCs and SVOCs.
 - **Class 1P Methods.** This class is restricted to methods for the analysis of pesticide and PCBs by GC.
 - **Class 2 Methods.** This class is reserved for screening type methods, which give only a qualitative (i.e. yes/no) result. Soil gas and geophysical surveys are representative of this class.

In addition to USAEC approved methods, non-THAMA Approved Methods (NTAM) were used to analyze arsenic, selenium, lead, and thallium. Data validation was performed in accordance with the June 1991 "USEPA Region III Modification to National Functional Guidelines for evaluating Inorganic Analyses". Data validation reports are presented in Appendix G-3. The analytical methods performed on samples collected during the SCR were chosen based on the site history and the contaminants which have been identified during previous investigations. The contaminants of potential concern included TPH, BTEX, PCBs, pesticides, and various metals. Class 1, Class 2, Class 1M, Class 1P, and SW-846 methods were selected for this SCR.

2.2.3 Tentatively Identified Compounds (TICs)

In addition to the compounds of interest, Pace, Inc., tentatively identified all noncertified compounds represented by peaks which had a response 10 percent or greater than the response of the internal standard. Unknowns which accounted for 10 percent or more of the total ion current were also tentatively identified. For each sample, Pace conducted a mass spectral search of the National Institute of Standards and Technology (NIST) library and reported the possible identity of the compound. Prior to qualitatively identifying a compound, a visual comparison and interpretation of the sample spectra with the spectra generated by the GC/MS library search was performed. Chromatograms of blank samples were examined to verify that TIC peaks present in the samples were not found in the blanks. Mass spectra of the unknown compounds and of the three "best fit" compounds were provided in the final data packages submitted to the USAEC Project Chemist. These TICs were reported to IRDMIS as unknowns in accordance with IRDMIS reporting requirements.

2.2.4 Sample Analysis/Lots

All samples were analyzed by lot. A lot is the maximum number of samples including QC samples, that can be processed through the rate limiting step of the method during a single time period, not to exceed one 24-hour day. The time period for a lot

does not include the initial or daily lot calibrations, provided that sample analyses begins immediately following completion of the calibration. The rate of sample collection or shipment did not determine the maximum lot size, although it did limit the number of samples available for analysis at a given time.

2.2.5 Sample Identification

The USAEC analytical reporting system uses a seven-character identification code to identify each sample. The first four characters of this code were alpha and represented the analytical lot code assigned by the laboratory and USAEC. Each analytical lot had a unique set of alpha characters. For example, a set of groundwater samples for metals analysis by ICP would be designated AAAA, while groundwater samples for organic GC/MS analysis would be designated BBBB (multi-analyte methods, such as GC/MS, were the same alpha designator for each analyte in a single sample). The second half of the seven-character code was 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 AAAA003). The lot size was determined and approved by USAEC when the analytical method was approved. Laboratory lots were used by the laboratory USAEC and EARTH TECH for data control.

2.2.6 Detection Limits

MDLs were established by the laboratory and were approved by USAEC for all methods prior to sample analysis. The approved MDL was equal to or less than the Required Detection Level (RDL). RDLs are project-specific certified reporting limits (CRLs) established by USAEC. MDLs for inorganics were verified quarterly. MDLs for organics were verified annually. Analytical methods and their associated CRLs used at Pace for the SCR are listed in Appendix G.

2.3 QUALITY ASSURANCE/QUALITY CONTROL

EARTH TECH in conjunction with Pace, Inc. established a quality assurance program with the objective of providing analytical data of documented and acceptable quality. This program incorporated quality control procedures, any necessary corrective action, and all documentation required during sample collection and data analysis to ensure acceptable data were obtained. The strength of this partnership was the ongoing communication between EARTH TECH and Pace to identify and resolve incidents as they occurred.

This section describes the procedures that were implemented in accordance with USATHAMA QAPP (1990).

2.3.1 Quality Assurance Reporting Procedure

The Laboratory Project Managers and appropriate project team members were responsible for keeping the EARTH TECH Project Manager, Project Chemist and Field

Team Leader informed regarding the status of their respective tasks so that quick and effective solutions could be implemented when data quality problems arose. Sampling activities were reviewed on a daily basis by the Field Team Leader to determine if the sampling quality control requirements were fulfilled, such as ensuring the proper numbers of blanks and duplicate samples were taken for each parameter sampled. Efforts were made to review all data sheets and logbooks on a daily basis. Any needed corrective action was initiated and documented daily.

The laboratory project managers/QA officer were responsible for reviewing all laboratory analytical activities to ensure compliance. This review served as an ongoing control function in that it was conducted frequently so deviations from method requirements were immediately identified and corrected. The Field Team Leader, Project Chemist, and Laboratory Project Manager reconfirmed information daily by telephone and facsimile.

2.3.2 Laboratory Certification

Pace, Inc. performed the chemical analyses for the SCR. Pace, Inc. is approved by USAEC and validated by the Missouri River District of the U.S. Army Corps of Engineers (USACE). In addition to sample analysis, Pace was responsible for generating the IRDMIS chemical data files.

Prior to performing analyses on a USAEC project, Pace demonstrated the ability to perform various analytical methods. This was achieved through the use of a method certification process as outlined. The certification process involved two steps: the data submission and approval from precertification calibration standards, and data submission and approval of performance samples. The laboratory's certification was also dependent upon satisfactory laboratory audits and adherence to the USAEC's QA Program Plan. In addition, control charts were submitted and reviewed by USAEC and EARTH TECH throughout the analytical effort.

2.3.3 Internal Quality Control Checks

Internal QC checks refer to both laboratory and field QC samples. The primary purpose of QC check samples was to ensure that each chemical measurement had the highest probability of exceeding method protocols in terms of precision and accuracy and to identify potential false positive results through the analysis of blank contaminants. Laboratory QC samples such as method blanks, spikes, and duplicates were evaluated and documented on a routine basis. Spike and surrogate recoveries, as appropriate, were calculated, and these QC data were compared on an ongoing basis with USAEC control limits. Field QC samples included trip blanks, rinse blanks, field blanks, and duplicate samples. The definition and use of laboratory and field QC samples is discussed below.

2.3.3.1 Laboratory Quality Control Samples

QC samples were those samples containing known concentrations of analytes that were introduced into the analytical run sequence to monitor the performance of the analytical system and to identify acceptable levels of precision, accuracy, and possible carry over, resulting in method blank contamination. The types of laboratory QC samples analyzed for this effort are described below.

METHOD BLANK. A method blank is an artificial sample used to monitor the system for interferences and contamination from glassware, reagents, etc. The method blank was taken through the entire sample preparation process and was included with each lot of extractions/digestions prepared, regardless of the method. Appendix G-2 presents the method blank analysis.

SPIKES. USAEC does not normally require matrix spikes and matrix spike duplicates that are required by USEPA. The USEPA uses these samples to determine matrix effects and within day variability of the laboratory. In lieu of these, matrix effects were determined using surrogates in each field sample if appropriate surrogates were available. If surrogates were not available, then natural matrix spikes were performed at a rate of 1 per 20 samples. Depending on the method class, standard matrix spikes were used in each lot. The spiking levels and frequency depended upon the method class.

SURROGATE COMPOUNDS. For all method classes except Class 2, the analytical process included the addition, subsequent detection, and recovery calculations of surrogate spiking compounds. Surrogate compounds were added to every sample at the beginning of the sample preparation, and the surrogate recovery was used to monitor matrix effects and sample preparation. Compounds that met the following criteria were suitable surrogate compounds:

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

When available, a Standard Analytical Reference Material (SARM) was used for the surrogate.

METHOD OF STANDARD ADDITION. The method of standard addition was used in metals analysis for samples that exhibit matrix interferences. Matrix interferences can be caused by high concentrations of target or nontarget analytes. Standard addition analysis involved adding known concentrations to the sample and reanalyzing. A plot of concentration versus absorbance gave the concentration of the unknown when

extrapolated back to zero absorbance. The method of standard addition was applied to metals analysis at the rate of 5 percent or 1 per lot, whichever was greater.

2.3.3.2 Field Quality Control Samples

Four types of field QC samples were collected and used for this effort as described below:

TRIP BLANKS. Trip blanks were used to determine if VOC samples were being contaminated during shipping and storage. A trip blank consisted of a VOC analysis sample bottle filled by the laboratory with ASTM Type II reagent grade water and HCl preservative. The trip blank was transported to the sampling site, handled like a sample, and returned to the laboratory with samples submitted for VOC analysis. The trip blank was not opened in the field. One trip blank accompanied every shipment of soil and water samples sent for VOC analysis. The trip blank was analyzed for the same target compound VOCs as the samples.

Acetone was detected at low levels in three trip blanks. Acetone is a known laboratory contaminant and should be viewed with suspicion.

FIELD BLANKS. A field blank is a approved source water to which no analyte of interest has been added, that was prepared in the field to assess ambient contaminants. Field blanks are prepared by pouring water into sample containers at a sampling site. These blanks are handled as samples and then sent to the laboratory for analysis.

RINSE BLANKS. A rinse blank is analyte-free water which was poured over cleaned equipment and collected for analysis. The results were used to verify the efficiency of the equipment cleaning procedures. After sampling equipment was decontaminated, rinse blanks were prepared by pouring water through the sampling device into the sample bottle. The blank was then transported to the laboratory for analysis. One rinse blank was collected per day per equipment type. The rinse blanks were analyzed for the same parameters as the sample(s) taken using that equipment. Rinse blank samples taken during the conduct of the SCR are listed on Table 2-4.

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 collected at a rate of 5 percent of the field samples. A minimum of one duplicate was collected per site; duplicates were not collected from the background site. The sample and the duplicate were analyzed for the same parameters. The duplicates were collected by the same procedures as the sample immediately following its collection. Duplicates obtained during the SCR are listed on Table 2-5.

TABLE 2-4
FIELD QC SAMPLES

Date	Rinse Blank	Trip Blank
April 12, 1994	RB03, PCB/Pesticide	TB09, BTEX
April 14, 1994	RB04, BTEX, TPH, PCB/Pesticides, Lead	TB10, BTEX
April 18, 1994	RB05, Metals, TPH, VOCs, PCB/Pesticides	TB11, VOCs
April 21, 1994	RB09, Metals, TPH, BTEX, PCB/Pesticides, Lead	TB14, BTEX
May 12, 1994	RB12, TPH, BTEX, Lead	TB15, BTEX
May 16, 1994	RB13, TPH, BTEX, Lead	TB16, BTEX
May 17, 1994	RB14, TPH, BTEX, Lead	TB17, BTEX
May 18, 1994	RB15, TPH, BTEX, Lead	TB18, BTEX
May 18, 1994	RB16, PCB/Pesticides	--
May 24, 1994	RB17, TPH	--
May 26, 1994	RB17, TPH	--
March 1, 1995	--	TB3195, VOA
March 2, 1995	FB3295, VOA, SVOA, PCB/Pesticides, Metals, TPH	TB3295, VOA
March 3, 1995	RB3395, VOA, SVOA, PCB/Pesticides, Metals, TPH	TB3395, VOA
April 17, 1995	RB41795, VOA, SVOA, PCB/Pesticides, Metals, TPH	TB41795, VOA
April 18, 1995	RB41895, VOA, SVOA, PCB/Pesticides, Metals, TPH	TB41895, VOA
April 20, 1995	RB42095, VOA, SVOA, PCB/Pesticides, Metals, TPH	TB42095, VOA
April 21, 1995	RB42195, VOA, SVOA, PCB/Pesticides, Metals, TPH	TB42195, VOA
April 24, 1995	RB42495, VOA, SVOA, PCB/Pesticides, Metals, TPH	TB42495, VOA

Key: QC = Quality Control
 PCB = Polychlorinated Biphenyl
 BTEX = Benzene, Toluene, Ethylbenzene, Xylene
 TPH = Total Petroleum Hydrocarbon
 VOC = Volatile Organic Compounds
 VOA = Volatile Organic Analysis
 SVOA = Semivolatile Organic Analysis

TABLE 2-5
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
TPH, PCBs, Pesticides, BTEX, lead	08BH0305	Lead 1 (µg/g)	08BH0369	Lead 7 (µg/g)
VOC, SVOCs, TPH, PCB/Pesticides, metals	08BH0608	ND Metals: See Table 2-10	08BH0609	ND Metals: See Table 2-10
VOC, SVOCs, TPH, PCB/Pesticides, metals	08BH3608	ND Metals: See Table 2-10	08BH3609	ND Metals: See Table 2-10
TPH, BTEX, Lead	08MW3210	Ethylbenzene 0.653 (µg/g)	08MW3212	ND
VOC, SVOC, TPH, PCB/Pesticides, Metals	08MW3601	ND Metals: See Table 2-11	08MW3609	ND Metals: See Table 2-11
TPH, BTEX, Lead (filtered, unfiltered)	08AQ01 08AQ02	40 ppb lead (unfiltered)	08AQ0103 08AQ0104	69 ppb lead (unfiltered)

Key:

VOC	=	Volatile Organic Compound
PCB	=	Polychlorinated Biphenyl
SVOC	=	Semi-volatile Organic Compound
TPH	=	Total Petroleum Hydrocarbon
BTEX	=	Benzene, Toluene, Ethylbenzene, Xylenes
µg/g	=	Micrograms per gram
ppb	=	Parts per billion
ND	=	Not Detected

2.3.3.3 Reagents

Reagents used by the analytical laboratory and field team are discussed in this Section. Laboratory reagent water that met the requirements of ASTM Type II water. ASTM Type I Water was used for inorganic methods. The resistivity of the water was measured and recorded in a logbook. Blanks were routinely analyzed for purity and accompanied each lot tested.

High-purity reagents were 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 were acquired by the laboratory and used for internal QC and calibration samples. Standard soil samples were provided by the USAEC Geology Branch.

2.3.3.4 Control Charts

Data generated from the control samples were plotted on control charts, which were used to monitor day-to-day variations in routine analyses for Class 1, Class 1P, and Class 1M certified methods. Control charts included the analyte, method number, Pace, Inc. code (UB), spike concentration, matrix chart title, lot designation, percent recovery, and mean and control limits. All data presented on a control chart were also presented in tabular form. Examples of control charts utilized for the SCR are presented in Appendix G-4. The basis of this program was to demonstrate that the laboratory method for sample preparation and analysis was in control. The method blank spike data which consisted of ASTM Type II or Type I water (as appropriate for the method) spiked with known compounds, was plotted on a daily basis for each method and matrix. By plotting the results of the method blank spike, control charts give a picture of the actual process of sample analysis, with fewer interferences from matrix effects and sample in homogeneity. This information was used in conjunction with matrix spike and surrogate recoveries, to assist in determining whether an out of control situation was due to the laboratory or matrix.

The analytes selected for spiking were representative of the compound class. Surrogates were used for VOC and SVOCs analyses as control compounds for the GC/MS methods. In addition to surrogates for the analysis of pesticide/PCB by GC, standard matrices were spiked with the required compounds. For ICP water methods, due to interelement factors, all analytes were spiked into the control samples. However, only those analytes which were reported were used in preparing control charts. The same procedure was used for soil methods, however aluminum, barium, calcium, cyanide, iron, magnesium, manganese, and sodium were not used for spiking analytes. For wet analytical chemistry methods such as cyanide, a single spike of an appropriate control for each method was used. The scheduled laboratory quality control and calibration is presented as Appendix G-5.

PROCEDURES FOR HANDLING OUT-OF-CONTROL SITUATIONS. Control charts were used to review the data and identify outlying results. Control limits were statistically

calculated using the USAEC required software package. The following charts were selected from the USAEC-supplied computer control chart program:

1. Single-Day X-Bar Control Chart — High Spike Concentration.
2. Single-Day X-Bar Control Chart — Low Spike Concentration.
3. Single-Day Range Control Chart — High Spike Concentration.
4. Single-Day Range Control Chart — Low Spike Concentration.
5. Three-Day X-Bar Control Chart — Low Spike Concentration.
6. Three-Day Range Control Chart — Low Spike Concentration.

The analyst quantified control analytes in the method blank and spiked QC samples each day of analysis to verify that the analytical system was within control limits. Processing of subsequent lots would not occur until the QC results of the current lot had been evaluated and the analytical method was shown to be in control.

A possible out-of-control situation was indicated by any of the following criteria: a value outside the control limits or classified as an outlier by a statistical test; a series of seven successive points on the same side of the mean; a series of five successive points going in the same direction; a cyclical pattern of control values; or two consecutive points between the Upper Warning Limit (UWL) and Upper Control Limit (UCL) or the Lower Warning Limit (LWL) and Lower Control Limit (LCL). For USAEC 3-day control charts the actual data point rather than the average was evaluated for trend-control situations. This evaluation was in relationship to other data points rather than against the control limits, which were calculated from averages.

If the points for at least two-thirds of the control analytes for a multi-analyte method were classified as in control, the method was considered in control and the sample results were reported. However, if one analyte had two consecutive points outside of control limits, the method was investigated. If data points for fewer than two-thirds of the control analytes were classified as in control, the lot was considered to be out of control, and the data in that lot were not reported without being investigated and approved by the USAEC Project Chemist.

All QC information was recorded in notebooks and printouts in the same format used for sample results. It was the analyst's responsibility to check the QC information against acceptable limits for the analysis. When an analysis of a QC sample (blank, spike, check standard, USEPA-traceable standard, duplicate, or similar sample) showed that the analysis of that batch of samples was not in control, the analyst immediately brought the matter to the attention of the Laboratory Project Manager. The Laboratory Project Manager consulted with the USAEC Project Chemist to determine whether the analysis could proceed, if selected samples should be rerun, or if specific corrective actions were needed before analyzing additional samples. Out-of-control analyses were documented by the supervisor. The analyst or supervisor filed an "Anomaly Report" with the Laboratory QA Officer. Copies of all Anomaly Reports are kept in the project file at Pace, Inc.

2.3.3.5 Preventive Maintenance

The primary objective of a preventive maintenance program was 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 were focused in three primary areas for field equipment and laboratory equipment heads: maintenance responsibilities, maintenance schedules, and adequate inventory of critical spare parts and equipment.

2.3.3.5.1 Maintenance Responsibilities. Maintenance responsibilities for field equipment were coordinated through the Field Team Leader who had responsibility for ensuring that available equipment and instrumentation were ready for use, and that returned equipment was checked, serviced, and returned to available inventory in a timely manner. Maintenance during use was the responsibility of the project team using the equipment, who were trained in the use of the field equipment.

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

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

2.3.3.5.3 Spare Parts. Along with a schedule for maintenance activities, an adequate inventory of spare parts was required to minimize equipment down time. This inventory emphasized those parts (and supplies) which were subject to frequent failure, had limited useful lifetimes, or could not be obtained in a timely manner should failure occur. Backup equipment, spare parts, and other supplies were brought to the field as possible.

2.3.3.6 Corrective Action

This section provides a discussion of corrective action procedures for both field and laboratory activities.

2.3.3.6.1 Laboratory Activities. Corrective action was dictated by the type and extent of the nonconformance. Corrective action was initiated and carried out by nonsupervisory staff, but final approval and data review by management was necessary before reporting any information. All potentially affected data were thoroughly reviewed for acceptance or rejection.

A nonconformance was any event which results fell outside established laboratory limits. A nonconformance can 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 affected data quality was considered a nonconformance.

Spike recovery (accuracy) and replicability (precision) plotted on control charts were a means of determining a nonconforming situation. A single mean outside of the modified limits constitutes a nonconformance.

A nonconformance/corrective action report was required to document any nonconforming situation and the corrective actions taken. The documentation included:

- Definition of the out-of-control event and identification of all affected samples.
- Description of where the out-of-control incident occurred (department and test name)
- Date of occurrence
- Corrective action taken
- Verification of corrective action and reestablishment of control
- Initials of operating analyst, supervisor, and laboratory QA officer.

Corrective action may take several forms, but the following steps were included where appropriate:

1. Recheck the calculations.
2. Recheck that the instrument was properly setup.
3. Reanalyze the control item.

All data generated during an out-of-control situation were flagged, and when control had been reestablished, a decision was made as to whether the data could be used or if reanalysis was required. The decision was documented on the nonconformance/corrective action report which was provided to the Laboratory QA Officer, USAEC Project Chemist, and the EARTH TECH Project Manager.

For out-of-control incidents, the nature of the incident and the corrective actions taken to assure the system was back in control was documented. A copy of the control charts or other data describing the out-of-control conditions was included in the corrective action report. All out-of-control incident documentation and copies of the

corrective action reports were included in the final deliverable package and placed in Pace, Inc. quality assurance file of corrective actions.

2.3.3.6.2 Field Activities. During the course of the SCR, the Field Team Leader and sampling team members were responsible for documenting that all procedures were followed as specified in the Work Plan and that measurement data met the prescribed acceptance criteria. In the event a problem arose, prompt action was taken to correct the problem.

All field measurement data was reviewed by the Field Team Leader, usually on a daily basis. Nonconformances were evaluated with the sampling crew and project manager, as appropriate.

A nonconformance existed if there was a deviation from or noncompliance with contract specifications, the QA program, approved procedures, the Work Plan or EARTH TECH SOPs. Any field nonconformances were recorded in the field logbooks. Section 3.9 discusses deviations from the Work Plan.

2.3.4 Data Reduction, Validation, and Reporting

This section presents both field and laboratory data reduction, validation, and reporting information.

2.3.4.1 Laboratory Data Reduction, Validation, and Reporting

This section provides a summary of data reduction, data validation/review, and laboratory data reporting.

2.3.4.1.1 Data Reduction. Pace, Inc. used the IRDMIS PC Data Entry and Validation Subsystem to generate the chemical lot files. The LIMS system and electronic download from the auto analyzers were used to transfer data electronically. Prior to submission to IRDMIS, Pace, Inc. performed a record and group check on each chemical lot file. The header information from these chemical files was reviewed by EARTH TECH prior to IRDMIS transfer. EARTH TECH submitted the map files and geotechnical files directory to IRDMIS.

When errors were detected by the IRDMIS system or by EARTH TECH, Pace made the necessary corrections to the files. In some cases, error codes from the IRDMIS system persisted and Pace wrote to the USAEC Project Chemist explaining the particular error. Pre-approval by the AEC Project Chemist was required before Pace could resubmit chemical files to IRDMIS in which errors existed. For example, the surrogate spiking level for a pesticide or PCB was in excess of method specifications. Lots associated with this method conformance were denied to the IRDMIS database (Level 3) and an error code was generated by the system. Following review and approval by the USAEC Project Chemist, these lots were uploaded into the IRDMIS database (Level 3).

2.3.4.1.2 Data Validation. An integral part of any QA Program is the review of data and subsequent validation. Record checking was the first validation step to ensure the chemical data entered were valid. Each field of each record in the specified lot(s) was checked to determine whether it had an acceptable entry or, in the case of a numerical field, whether the value was within an acceptable range.

Group checking was the second step to ensure the chemical data entered was valid. Records that had been previously record checked were analyzed in a group to determine that all sites in the lot were valid sites in the map file. The group checking process utilized the map data base file located in the IRMAP subdirectory which was generated by EARTH TECH. Each installation/IR installation had its own map data base file.

The primary responsibility for data for the SCR data review and validation was with Pace, Inc. and the USAEC Project Chemist. The Project Chemist was responsible for approving the method via a control chart review, validating sample results, and assigning any necessary data qualifiers. Data qualifiers were assigned electronically and only the USAEC Project Chemist had the authority to assign or change qualifiers in the IRDMIS database.

2.3.4.1.3 Laboratory Data Reporting. Reports from Pace, Inc. to EARTH TECH included the following:

- A copy of the signed chain-of-custody forms showing date and time of sample receipt at the laboratory
- An electronic copy of the required IRDMIS chemical data files
- A weekly list of the chemical lots analyzed and the IRDMIS files sent to Potomac Research, Inc. (PRI)
- A weekly list of control charts sent to the USAEC Geology Branch
- A list of field sample numbers contained in each lot.

IRDMIS error codes were generated by PRI and sent electronically to EARTH TECH and Pace, Inc.

2.3.4.2 Field Data Reduction, Validation, and Reporting

Field observations, direct read instrument responses, and other measurements were recorded either directly into field logbooks or on the field data forms appropriate for the activity. The Field Team Leader was responsible for ensuring that all necessary data were incorporated into the log books and forms as each field activity occurred. On a daily basis, the Field Team Leader or a Task Manager checked the log books and

forms for completeness. The EARTH TECH Project Manager and USAEC Project Manager were notified daily of the field team's progress by the Field Team Leader.

Field measurement data review was the responsibility of the Field Team Leader. Criteria considered during the review of measurement data includes the following review of calibration information in log books, and reasonableness of results based on what was known for the site relative to the magnitude and implications of the result.

Data recorded in log books and on forms were summarized and transferred to tables, figures, maps, or logs for inclusion in this SI report. The Field Team Leader was responsible for the data transfer activities and for performing spot checks of data transfer activities to ensure accuracy. The field data were also entered by EARTH TECH into the IRDMIS map and geotechnical files. IRDMIS map files were completed prior to sampling and updated as needed following the land survey.

2.4 DATA QUALITY EVALUATION

The process of generating data of known quality began in the planning stages when data quality objectives (DQOs) were established, and continued during sample collection activities and laboratory analysis. Data reduction and validation completes the data useability determination. 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, Inc. 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 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.

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.

The documentation provided by Pace, Inc. in conjunction with EARTH TECH field records were used to evaluate the following data quality indicators:

- Integrity and stability of the samples
- Instrument performance during sample analyses
- Precision
- Accuracy
- Representativeness
- Completeness
- Comparability.

INTEGRITY AND STABILITY. Handling, storage, shipping, holding times, preservation, and chain of custody procedures of field and laboratory samples were performed according to required protocols specified in National Enforcement Investigations Center (NEIC) Policies and Procedures (EPA-300/9-78-001-R) to prevent damage, loss, deterioration, and interferences.

INSTRUMENT PERFORMANCE AND MAINTENANCE. All analytical instrumentation and other sampling, measuring, and testing equipment used for activities affecting quality were controlled appropriately and calibrated to maintain accuracy within specified limits. Calibration was conducted using standards which bracketed the expected range of the samples and was analyzed to meet calibration requirements. Documentation of calibration was maintained and was traceable to each instrument. Periodic preventive and corrective maintenance of measurement devices and analytical instrumentation was performed to ensure satisfactory performance.

PRECISION. Precision was an estimate measure of mutual agreement among individual measurements of the same property under prescribed similar conditions. Precision was independent of the error (accuracy) of the analyses and reflected only the degree to which the measurements agreed with one another, not the degree to which they agreed with the "true" value for the parameter measured. Precision of the measurement data for this project was based upon duplicate analyses (replicability), control sample analyses (repeatability), and results for duplicate field samples (sampling replicability). Field duplicates were defined as two samples collected independently at a single sampling location during a single act of sampling. Field duplicates numbered 5 percent of the original sample number.

Discretely sampled field duplicates were useful in determining sampling variability. However, greater than expected differences between duplicates occurred because of variability in the sample material. In these instances a visual examination of the sample material was performed in order to document the reason for the difference. Field sample duplicates were used as a QC measure to monitor precision relative to sample collection activities. Field duplicates samples were collected at each site investigated by media as discussed in Section 4.3.3.1. Each duplicate sample was analyzed for the same suite of analytes as the corresponding original sample. The Relative Percent Difference (RPDs) between the original sample and the corresponding duplicate were calculated for the target compounds. Water matrices are more homogenous than soil and therefore, lower RPD values were expected. Analytical precision was evaluated by using duplicate spiked samples using the following relationship:

$$RPD = \frac{(C_1 - C_2)}{(C_1 + C_2)/2} \times 100$$

Where: C₁ = Larger of the two observed values
 C₂ = Smaller of the two observed values
 RPD = Relative Percent Difference

As part of the method approval process, precision was calculated using USAEC software, for Method Classes 1 and 1P. Precision was tracked for a specific method using a range (R) control chart on a daily basis. The formula used to establish and maintain control charts for duplicates is as follows:

$$\bar{R} = \frac{\sum R}{K}$$

Where: R = Within group difference between recoveries for data pairs.
K = Cumulative number of pairs in database.

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 blanks, laboratory control spikes, and surrogate spikes were the primary indicators of accuracy. In certain methods such as pesticides/PCBs, volatiles, and semivolatiles, all environmental and QC samples are spiked with surrogate compounds. The percent recovery of these surrogates are calculated, and surrogate accuracy is evaluated based on a preestablished set of recovery control limits. 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. The reanalysis of the samples in the batch, or flagging the data as suspect if the problems cannot be resolved. For highly contaminated samples, recovery of matrix spikes may depend on sample dilution. The calculation formula for percent recovery is:

$$\text{Percent spike recovery} = \frac{\text{found concentration}}{\text{value of spike added}} \times 100$$

Control charts were submitted by analytical lot to the USAEC Project Chemist and EARTH TECH to determine if a method was in control. As discussed in Section 4.3.4.1 data qualifiers were assigned by the USAEC Project Chemist as appropriate, for out-of-control events.

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

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

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

Field duplicate samples were also used to assess representativeness. Two samples which were collected at the same location and at the same time were considered to

be equally representative of this condition, at a given point in space and time. However, to be conservative, the maximum concentration of any chemical found in a sample or sample duplicate was used to represent the point, and not an average of the two points.

Soil boreholes and well locations were selected to represent the areas of interest at the site. To maximize representativeness of results, sampling techniques, sample size and sample locations were carefully chosen to provide laboratory samples representative of the site and the specific area.

Properly installed monitoring wells ensured that the water being sampled originated from the aquifer of concern. Care was taken to ensure proper stabilization of measured water parameters, clarity and color before groundwater samples were taken.

Soil and sediment samples were even less homogeneous than water, and thus it was important for the sampler and analyst to exercise good judgment when removing a sample. Samples exhibiting obvious stratification or lithologic changes were not used as duplicates. Within the laboratory, precautions are taken to extract from the sample container an aliquot representative of the whole sample.

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

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

The use of standard method to collect and analyze samples along with instruments calibrated against SARM which are NIST-traceable standards, also enhance comparability.

Comparability also depends on the other data quality characteristics. Only when data was judged to be representative of the environmental conditions, and when precision and accuracy were known, could data sets be compared with confidence.

COMPLETENESS. Completeness was reported as the percentage of all measurements whose results are judged to be valid. The following formula was used to estimate completeness:

$$\text{Completeness} = \frac{\text{Number of successful analyses}}{\text{Number of requested analyses}} \times 100$$

Successful analyses were 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 have been analyzed within the specified holding time and in such a manner that analytical QC acceptance criteria were met.

A project completeness goal of 90 percent was established in the Work Plan (June, 1994). This goal was met with a completeness value of 100 percent. All of the requested analyses were completed by the laboratory. No holding times were exceeded, and all QC sample acceptance criteria were within limits specified by USAEC.

The values of completeness do not represent the percentage of useable data. Data qualified due to blank contamination were considered successful for completeness calculations since the analyses were successful.

2.5 DATA MANAGEMENT

Data management procedures included protocols specifying the acquisition or entry, update, correction, deletion, storage and security of data files.

EARTH TECH generated the map and geotechnical files for sampling locations at Building 202. The map files contain the sampling site location names as defined by IRDMIS and the surveyed X, Y, and Z coordinates of each sampling location. The geotechnical files contain specific information from the bore and well-construction logs for each new boring or well. Pace, Inc. created the chemical data files for the analytical results using IRDMIS codes provided on the EARTH TECH Chain-of-Custody form.

There are three levels of data recognized in IRDMIS. EARTH TECH and Pace, Inc. generate Level I data files using the IR PC Tool Data Entry and Validation Subsystem. After the files have been successfully entered and pass the IR PC Tool error checking program they are forwarded to PRI, AEC's data processing subcontractor. Occasionally a file will generate an error from the IR PC Tool that requires approval from either the AEC Project Geologist, Chemist or Manager. These files are also forwarded to PRI for AEC approval.

Once received at PRI, the files are considered to be at Level II. At this level the files are logged as received, rechecked using the IR PC Tool, and archived. Files that are error free are loaded into the IRDMIS Level III database. If the file has an error requiring AEC approval it is forwarded by PRI to the appropriate AEC personnel. If a file has an error that AEC does not approve, it must be corrected by the originator (either Pace, Inc. or EARTH TECH) and resubmitted to PRI.

Once loaded into the Level III database the data is considered eligible for report generation. Changes may only be made to the Level III database with the written

authorization of the AEC Project Manager. The data may be retrieved either using the IRDMIS Level III Menu System or using Standard Query Language (SQL). EARTH TECH used a combination of these two options, generating several reports from the IRDMIS Level III menu system as well as downloading the data into a PC based dBase system for further manipulation, analysis and custom reporting.

This section discusses the general methodologies used during field operations for the SCR at WRF. Methods described include: geophysical techniques, soil gas sampling, drilling techniques, borehole logging, well installation, well development, well abandonment, environmental sampling, land surveying, and the disposal of investigation-derived wastes.

2.6 EVALUATION METHODOLOGY

An extensive evaluation of applicable or relevant and appropriate requirements (ARARs) and background conditions is not specifically required for an SCR, 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.

2.6.1 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), 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 2-6 and 2-7, respectively. Potential soil and groundwater ARARs and TBCs for chemicals of concern at WRF are provided in Tables 2-8 through 2-10. Potential sediment TBCs for chemicals of concern included in Table 2-11.

2.6.2 Establishing Background

As a means to evaluate concentrations of inorganic analytes detected in soil and sediment samples collected as part of this SCR, 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 2-6
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 2-6
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	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 2-6
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 2-6
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	
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 2-6

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 2-7
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 2-7
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 2-7
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 2-7
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 2-7
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	SAPCBR 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 2-8
POTENTIAL SOIL TBCs⁽¹⁾ FOR INORGANIC CHEMICALS OF CONCERN AT
WOODBRIIDGE 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 Solid Waste Management Units (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 2-9
POTENTIAL SOIL TBCs⁽¹⁾ FOR ORGANIC CHEMICALS OF CONCERN AT
WOODBRIAGE 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		
α-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 2-10
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⁾	Federal Secondary MCL ⁽⁷⁾	Virginia Secondary MCL ⁽⁸⁾
			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												
Chlorobenzene												
TPH									39			
Aluminum										1,000		
Barium	2,000	1,000			1,000			2,000	110,000		50-200	
Beryllium	4				0.0068				2,600	1,000		
Calcium									0.016			
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	1,000	1,000
Iron			1,000		300					300	300	300
Potassium												
Magnesium												
Manganese					50				180	50	50	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 2-10
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
										5,000
										5,000

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 discharger 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 - 3.49011.

⁽¹⁰⁾ 0.8545 in hardness as 25 - 400 mg/L CaCO₃ - 1.4651.

⁽¹¹⁾ 0.8460 in hardness as 25 - 400 mg/L CaCO₃ + 1.6451.

⁽¹²⁾ 1.273 in hardness as 25 - 400 mg/L CaCO₃ - 4.7051.

⁽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 2-11
POTENTIAL SEDIMENT TBCs⁽¹⁾ FOR CHEMICALS OF CONCERN AT
WOODBRIE 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 3.0

SITE CHARACTERIZATION

The sampling program focused on two former/existing UST locations at Building 202. The analytical result of additional potentially contaminated areas at Building 202, investigated as part of a facility-wide inspection (SI), are summarized to further define possible migration of contaminants from USTs at Building 202. A summary of the field activities and analytical program, data summary, evaluation, and conclusions are provided. The two former/existing UST locations and sites investigated in the SI at Building 202 are depicted on Figure 3-1. A comprehensive presentation of field operations, analytical program, data management, and evaluation methodology is provided in Section 2.0, Site Characterization Methods.

3.1 FORMER UST(S) AND EXISTING UST EAST OF BUILDING 202

3.1.1 SITE DESCRIPTIONS & HISTORY

Four former USTs were located at Building 202. Three of the USTs were located outside of the eastern wall of Building 202. The three former USTs, of steel construction, were placed at this location in 1966. Each had a 10,000 gallon capacity with one containing diesel fuel and two containing #2 Fuel Oil. An existing 2,000-gallon, fiberglass UST is located north of the original location of the three former USTs. Former and existing UST(s) and associated sampling locations are depicted on Figure 3-1. Table 3-1 contains a summary of the locations, size, content and history of USTs at Building 202.

There is anecdotal information concerning uncontrolled releases of petroleum products relating to overfilling or spills while filling former USTs east of Building 202 (Weston, 1992). No investigations have been reported which specifically address these releases; the only historical soil analytical results found for this site relate to UST removal and closure testing. Below are descriptions of the UST-related removal actions.

In 1981, the 10,000-gallon diesel fuel tank was removed and replaced with the 2,000-gallon, fiberglass UST, buried just north of the former USTs. The 10,000-gallon diesel fuel tank 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.

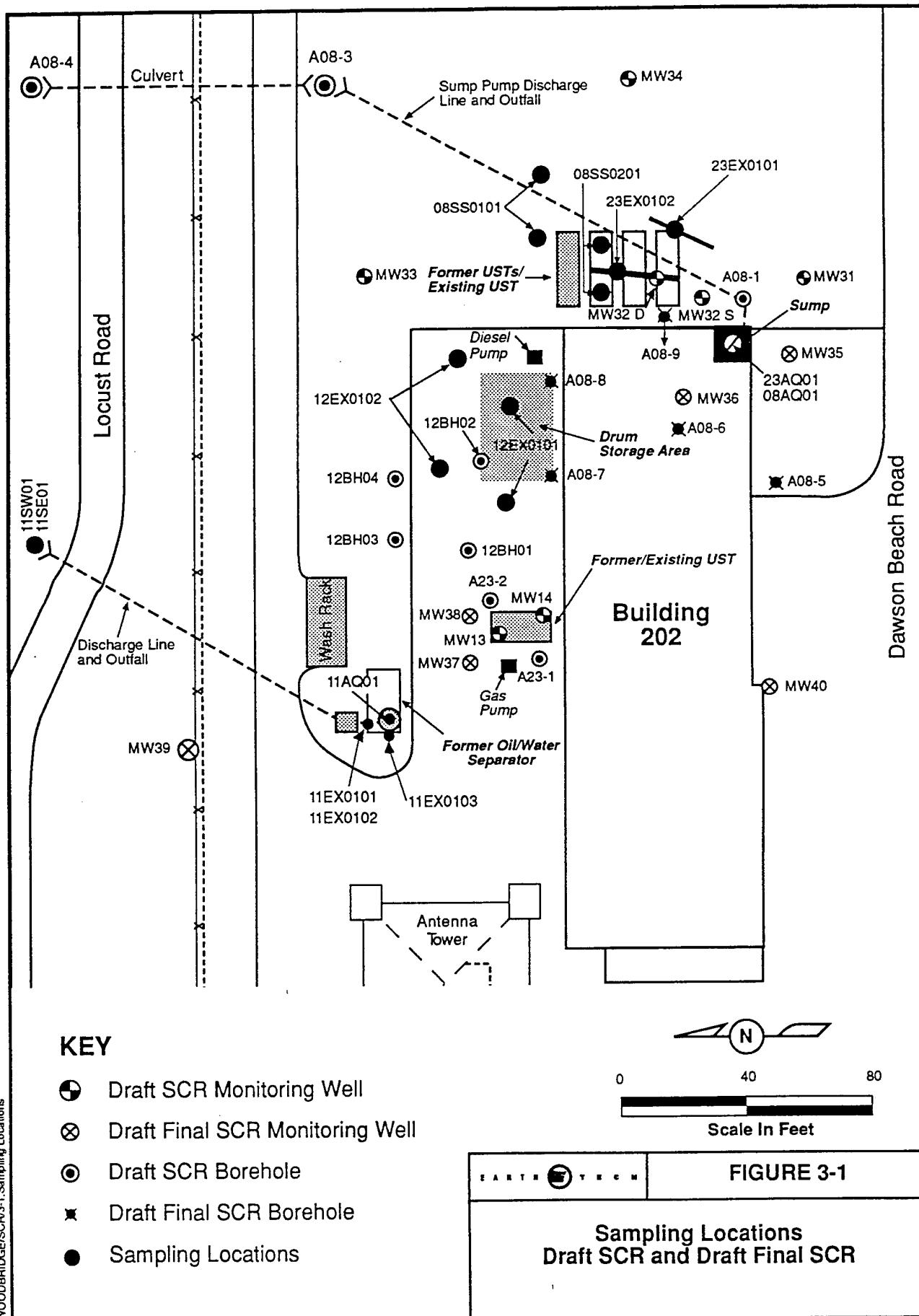


TABLE 3-1
UNDERGROUND STORAGE TANKS

Nearest Building	Type	Capacity (gallons)	Contents	Installation Date	Tightness Tested	Results	Date Removed	Regulatory Program
East 202	Steel	10,000	Diesel	1966	No	--	1981	Article 9
East 202	Steel	10,000	#2 Fuel Oil	1966	Yes	Failed	1990	Article 9
East 202	Steel	10,000	#2 Fuel Oil	1966	Yes	Failed	1990	Article 9
North 202	Steel	1,000	Gasoline	Unknown	Yes	Failed	1990	Article 9
East 202	Fiberglass	2,000	Diesel	1981	Yes	Passed	Existing	Article 9
North 202	Fiberglass	1,000	Gasoline	1990	Yes	Passed	Existing	Article 9

The two remaining 10,000-gallon #2 Fuel Oil tanks 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 TPHs less than 25 parts per million (ppm). Based on the above information, no further action was taken at these three former USTs.

3.1.2 Summary of Field Sampling and Analytical Program

A geophysical survey at Building 202 included magnetic and GPR profiling to locate the trench of the former tanks, the existing tank, and any subsurface utilities in the area. Trenches 23 and 24 were excavated at former UST locations east of Building 202 following the geophysical survey. Trenches 23 and 24 were excavated to a depth of approximately 8 feet and contained dark, discolored soil with an odor and excavated soil HNu readings of 4 and 13 ppm, respectively. Soil samples 23EX0101 and 23EX0102 were collected at 7.0 and 7.5 feet bgs from Trenches 23 and 24, respectively. The soil samples were analyzed for TPHs.

Two composite surface soil samples 08SS0101 and 08SS0201 were collected from the reported spill area at the former USTs. The soil samples were analyzed for TPHs.

Five boreholes (BH-31, BH-32D, BH-32S, BH-33, BH-34) were drilled for subsurface soil collection and monitoring well installation at the UST(s) during the Draft SCR. Boreholes BH-32D and BH-32S were drilled within the former UST(s) trench. Boreholes BH-31, BH-33, and BH-34 were drilled downgradient from the existing/former UST(s) trench. Three boreholes (A08-1, A08-3, A08-4) were drilled in the area of the UST(s), in association with the former sump-pump discharge from Building 202. All of the soil samples from these boreholes collected during the Draft SCR were analyzed for TPHs, BTEX, PCB/pesticides, and lead.

Seven boreholes (A08-5, A08-6, A08-7, A08-8, A08-9, BH-35, BH-36) were drilled during the Draft Final SCR relative to the UST(s) east of Building 202. Boreholes A08-7, A08-8, A08-9, were installed around the northeastern perimeter of Building 202. Borehole A08-9 is also located between the former UST(s) trench and the

eastern wall of Building 202. Boreholes A08-6 and BH-36 were drilled inside Building 202, to investigate any possible migration of contaminants beneath the building from the former UST(s). Boreholes A08-5 and BH-35 are located upgradient of the former UST(s). The soil samples from these boreholes were analyzed for VOC, SVOC, TPHs, PCB/pesticide, and metals. Boreholes BH-35 and BH-36 were converted to monitoring wells (MW-35, MW-36) and groundwater sampled for the above analytes.

Monitoring wells MW-31 through MW-34 were sampled for groundwater analysis in May 1994 for the Draft SCR and resampled in April 1995 for the Draft Final SCR. Newly installed monitoring wells MW-35 and MW-36 were also sampled. Groundwater samples obtained in May 1994 during the Draft SCR were analyzed for TPHs, BTEX, and Lead. Groundwater samples obtained in April 1995 for the Draft Final SCR were analyzed for VOCs, SVOCs, TPHs, PCB/pesticides, and metals.

Table 3-2 provides a summary of the soil samples collected for chemical analysis at UST(s) east of Building 202. Table 3-3 provides a summary of water samples collected and analysis performed.

3.1.3 Evaluation

The soil investigation results indicated TPHs concentrations above regulatory criteria within and immediately adjacent to the former UST(s) trench. The soil at borehole location BH-32D indicated the highest TPHs concentrations, ranging from 2,166 ppm at 6 to 8 feet bgs to 149 ppm at 10 to 12 feet bgs. Other soil results from the UST(s) trench area indicated 143 ppm TPHs at borehole A08-9 and 209 ppm to 302 ppm TPHs at the trench excavations. Surface soil sample results at the reported spill area indicated TPHs concentrations below regulatory guidance, ranging from 14 ppm to 42 ppm. Only one downgradient borehole (A08-3), located at a surface water drainage culvert, indicated 109 ppm of TPHs at 4 to 6 feet bgs and nondetect at 8 to 10 feet bgs. The TPHs in near surface soil at A08-3 may be attributable to the former sump-pump discharge or residual TPHs in surface water flow to the culvert. Table 3-4 presents a summary of organic soil results. A tabular summary of all inorganic sample results is presented in Appendix H as Table H-1.

Soil sampling was also conducted during SI activity at the former drum storage area, located on the paved area north of Building 202, and downgradient of the UST(s) east of Building 202. Surface soil and subsurface soil samples were collected and analyzed for VOCs, SVOCs, TPHs, PCBs/pesticides, and metals. Based on the soil sampling data, no significant contamination was identified at the former drum storage area. Relatively low levels of organic compounds below their appropriate regulatory criteria were detected in three near surface soil samples at 1 to 2 feet bgs. Samples taken in the same location at deeper depth did not identify organic compounds. Inorganic analyses of soil samples indicated concentrations consistent with background and regional data. The soils do not appear to be impacted by any possible migration of petroleum from upgradient UST(s) east of Building 202 (SI Report, EARTH TECH, May 1995).

TABLE 3-2
SUMMARY OF SOIL SAMPLES COLLECTED FOR CHEMICAL ANALYSES AT
EXISTING/FORMER UST(S) EAST OF BUILDING 202

Sample Number	Location	Sampling Interval (feet bgs)	Analyses
Draft SCR			
08SS0101	Surface Soil	0.2	TPH
08SS0201	Surface Soil	0.2	TPH
23EX0101	Trench	7.5	TPH
23EX0102	Trench	7.5	TPH
08BH3105	BH-31	8-10	TPH, BTEX, PCB/pesticide, lead
08BH3204	BH-32D	6-8	TPH, BTEX, PCB/pesticide, lead
08BH3206	BH-32D	10-12	TPH, BTEX, PCB/pesticide, lead
08BH3305	BH-33	8-10	TPH, BTEX, PCB/pesticide, lead
08BH3405	BH-34	8-10	TPH, BTEX, PCB/pesticide, lead
08BH0103	A08-1	4-6	TPH, BTEX, PCB/pesticide, lead
08BH0105	A08-1	8-10	TPH, BTEX, PCB/pesticide, lead
08BH0303	A08-3	4-6	TPH, BTEX, PCB/pesticide, lead
08BH0305	A08-3	8-10	TPH, BTEX, PCB/pesticide, lead
08BH0369 ⁽¹⁾	A08-3	8-10	TPH, BTEX, PCB/pesticide, lead
08BH0402 ⁽²⁾	A08-4	2-4	TPH, BTEX, PCB/pesticide, lead
Draft Final SCR			
08BH0506	A08-5	6.5-9.5	VOC, SVOC, TPH, PCB/pesticide, metal
08BH0608	A08-6	8-10	VOC, SVOC, TPH, PCB/pesticide, metal
08BH0609 ⁽¹⁾	A08-6	8-10	VOC, SVOC, TPH, PCB/pesticide, metal
08BH0705	A08-7	5-9	VOC, SVOC, TPH, PCB/pesticide, metal
08BH0805	A08-8	5-9	VOC, SVOC, TPH, PCB/pesticide, metal
08BH0906	A08-9	6-9.5	VOC, SVOC, TPH, PCB/pesticide, metal
08BH3506	MW-35	6-9.5	VOC, SVOC, TPH, PCB/pesticide, metal
08BH3608	MW-36	8-10	VOC, SVOC, TPH, PCB/pesticide, metal
08BH3609 ⁽¹⁾	MW-36	8-10	VOC, SVOC, TPH, PCB/pesticide, metal

Key: bgs = Below Ground Surface
 TPH = Total Petroleum Hydrocarbon
 BTEX = Benzene, Toluene, Ethylbenzene, Xylene
 PCB = Polychlorinated Biphenyl
 VOC = Volatile Organic Compound
 SVOC = Semivolatile Organic Compound

Notes: ⁽¹⁾ Duplicate.
 ⁽²⁾ Sample collected with hand auger.

TABLE 3-3
SUMMARY OF WATER SAMPLES COLLECTED AT EXISTING/FORMER
UST(S) EAST OF BUILDING 202

Sample Number	Location	Analyses
Draft SCR		
08MW3101	MW-31	TPH, BTEX, Lead (Unfiltered)
08MW3102	MW-31	Lead (Filtered)
08MW3201	MW-32D	TPH, BTEX, Lead (Unfiltered)
08MW3202	MW-32D	Lead (Filtered)
08MW3210	MW-32S	TPH, BTEX, Lead (Unfiltered)
08MW3211	MW-32S	Lead (Filtered)
08MW3212 ⁽¹⁾	MW-32S	TPH, BTEX, Lead (Unfiltered)
08MW3213 ⁽¹⁾	MW-32S	Lead (Filtered)
08MW3301	MW-33	TPH, BTEX, Lead (Unfiltered)
08MW3302	MW-33	Lead (Filtered)
08MW3401	MW-34	TPH, BTEX, Lead (Unfiltered)
08MW3402	MW-34	Lead (Filtered)
Draft Final SCR		
08MW3102	MW-31	VOCs, SVOCs, PCB/Pesticide, Cyanide, TPH, and Filtered/Metals
08MW32D2	MW-32D	VOCs, SVOCs, PCB/Pesticide, Cyanide, TPH, and Filtered/Metals
08MW32S2	MW-32S	VOCs, SVOCs, PCB/Pesticide, Cyanide, TPH, and Filtered/Metals
08MW3302	MW-33	VOCs, SVOCs, PCB/Pesticide, Cyanide, TPH, and Filtered/Metals
08MW3402	MW-34	VOCs, SVOCs, PCB/Pesticide, Cyanide, TPH, and Filtered/Metals
08MW3501	MW-35	VOCs, SVOCs, PCB/Pesticide, Cyanide, TPH, and Filtered/Metals
08MW3601	MW-36	VOCs, SVOCs, PCB/Pesticide, Cyanide, TPH, and Filtered/Metals
08MW3609 ⁽¹⁾	MW-36	VOCs, SVOCs, PCB/Pesticide, Cyanide, TPH, and Filtered/Metals

Key: TPH = Total Petroleum Hydrocarbons
BTEX = Benzene, Toluene, Ethylbenzene, Total Xylenes
VOC = Volatile Organic Compound
SVOC = Semivolatile Organic Compound
PCB = Polychlorinated Biphenyl

Note: ⁽¹⁾ Duplicate.

TABLE 3-4
SUMMARY OF ANALYTICAL RESULTS FOR SCR SOIL SAMPLES
AT EXISTING/FORMER UST(S) EAST OF BUILDING 202

Sample Number	Borehole Number	Sampling Interval (feet bgs)	TPH (µg/g)	PCBs (µg/g)	PPDDE (µg/g)	PPDDD (µg/g)	Benzene (µg/g)	Toluene (µg/g)	Ethylbenzene (µg/g)	Total Xylenes (µg/g)	Lead (µg/g)
08BH3105	BH-31	8-10	ND	ND	ND	ND	ND	ND	ND	ND	7
08BH3204	BH-32D	6-8	2,166	ND	0.017	ND	ND	ND	ND	ND	13
08BH3206	BH-32D	10-12	149	ND	0.0039	ND	ND	ND	ND	ND	8
08BH3305	BH-33	8-10	ND	ND	ND	ND	ND	ND	ND	ND	5
08BH3405	BH-34	8-10	ND	ND	ND	ND	ND	ND	ND	ND	7
08BH0103	A08-1	4-6	ND	ND	ND	ND	ND	ND	ND	ND	11
08BH0105	A08-1	8-10	ND	ND	ND	ND	ND	ND	ND	ND	4
08BH0303	A08-3	4-6	109	ND	ND	ND	ND	ND	ND	ND	8
08BH0305	A08-3	8-10	ND	ND	ND	ND	ND	ND	ND	ND	1
08BH0369 ⁽¹⁾	A08-3	8-10	ND	ND	ND	0.0044	ND	ND	ND	ND	7
08BH0402 ⁽²⁾	A08-4	2-4	ND	ND	ND	ND	ND	ND	ND	ND	7
08BH0906	A08-9	6-10	143	ND	ND	ND	ND	ND	ND	ND	3
		Detection Limit	20	0.03	0.0033	0.0033	0.05	0.04	0.04	0.05	0.3

Key: bgs = Below Ground Surface PPDDD = 1,1-Dichloro-2,2-bis(p-chlorophenyl)ethane
 TPH = Total Petroleum Hydrocarbon µg/g = Micrograms per gram equivalent to parts per million (ppm)
 PCB = Polychlorinated Biphenyl ND = Not Detected
 PPDDE = 2,2-Bis(p-chlorophenyl)-1,1-dichloroethane

Notes: ⁽¹⁾ Replicate
⁽²⁾ Sample collected with hand auger

Groundwater results of the May 1994 sampling event indicated 0.653 parts per billion (ppb) ethylbenzene at MW-32S. Monitoring well MW-32S is located at the former UST(s) trench area. Downgradient monitoring wells did not detect TPHs or any other significant contamination. Groundwater results of the April 1995 sampling event did not detect VOCs, SVOCs, TPHs, PCB/Pesticides, or elevated inorganics. The result of water samples obtained at the former/existing UST(s) east of Building 202 are summarized on Table 3-5. A tabular summary of all inorganic results for water samples obtained during the SCR is presented as Table H-2 in Appendix H.

3.1.4 Conclusions

The result of the soil analysis indicated TPHs concentrations in subsurface soils exceeding the regulatory guidelines at the former UST trench east of Building 202. Soil samples obtained downgradient of the trench did not report contamination, indicating the TPHs concentrations are localized within the former trench area.

The result of the groundwater investigation did not indicate significant groundwater contamination at UST(s) east of Building 202. The ethylbenzene (0.653 ppb) detected in the May 1994 event may be attributable to localized contaminated fill within the former UST(s) trench mobilized during drilling activity. The organic was not detected in the April 1995 sampling.

No health threats are expected from residual TPHs identified at former UST(s) subsurface soil media for human and environmental receptors. With the exception of one ethylbenzene detection, hydrocarbons were not found in groundwater at the site. Monitoring wells MW-32D and MW-32S are recommended for quarterly sampling for BTEX and TPH for one year to ensure that soil contamination does not impact the groundwater. If sampling results are clean, the site may be considered for a request to VADEQ for UST closure under the no further action option. An assessment of the risk presented by the TPHs identified in subsurface soil at the UST(s) trench is presented in Section 4.0.

3.2 BUILDING 202 SUMP AND DISCHARGE

3.2.1 Site Description and History

The sump inside Building 202 is located in the southeast corner of the building. The sump houses the condensate return tank and has a sump-pump which discharges via an underground conduit to a culvert northeast of Building 202. The sump is constructed of cinder block approximately 4 feet square and 10 feet deep.

3.2.2 Summary of Field Activities and Analytical Program

In association with the USTs east of Building 202, the Building 202 sump and discharge were investigated to detect any contaminant migration from the USTs toward the sump under the influence of the former sump-pump operation. A water sample and duplicate (23AQ01) were collected from the Building 202 sump during the SI and analyzed for TPH. A water sample and duplicate (08AQ01) were also collected from the sump for the Draft SCR and analyzed for BTEX, TPH, and lead.

TABLE 3-5
SUMMARY OF ANALYTICAL RESULTS FOR SCR WATER SAMPLES
AT EXISTING/FORMER UST(S) EAST OF BUILDING 202

Sample ⁽²⁾ Number	Location	TPHs (µg/L)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	Lead (unfiltered) (µg/L)	Lead (filtered) (µg/L)
08MW3401	MW-34	ND	ND	ND	ND	ND	ND	NA
08MW3402	MW-34	NA	NA	NA	NA	NA	NA	ND
08MW3301	MW-33	ND	ND	ND	ND	ND	9.1	NA
08MW3302	MW-33	NA	NA	NA	NA	NA	NA	ND
08MW3101	MW-31	ND	ND	ND	ND	ND	4.0	NA
08MW3102	MW-31	NA	NA	NA	NA	NA	NA	ND
08MW3201	MW-32D	ND	ND	ND	ND	ND	5.3	NA
08MW3202	MW-32D	NA	NA	NA	NA	NA	NA	ND
08MW3210	MW-32S	ND	ND	ND	ND	ND	ND	NA
08MW3211	MW-32S	NA	NA	NA	NA	NA	NA	ND
08MW3212 ⁽¹⁾	MW-32S	ND	ND	ND	0.653	ND	ND	NA
08MW3213 ⁽¹⁾	MW-32S	NA	NA	NA	NA	NA	NA	ND
	Detection Limit	1.00	0.5	0.8	0.3	1.0	3.0	3.0

Key: TPHs = Total Petroleum Hydrocarbon µg/L = Micrograms per liter equivalent to parts per billion (ppb)
 ND = Not Detected NA = Not Analyzed

Note: ⁽¹⁾ Duplicate.

⁽²⁾ Groundwater sample results shown above for May 1994 sampling event. Groundwater sample results for above wells and MW-36 obtained in April 1995 did not detect VOCs, SVOCs, TPH, PCB/Pesticides, or elevated metals. See Appendix H, Table H-2 for a summary of inorganic concentrations in April 1995 groundwater samples.

Boreholes A08-6 and BH-36 were located inside and drilled beneath Building 202 to respond to VADEQ comments and further investigate any possible contaminant migration. Soil was collected from each borehole. BH-36 was converted to a monitoring well (MW-36) from which a groundwater sample was collected. Soil and groundwater samples were analyzed for VOC, SVOC, TPH, PCB/pesticide, and metals. Three boreholes (A08-1, A08-3, A08-4) were also drilled at the former sump-pump discharge line and outfall. Soil samples from these boreholes obtained during the Draft SCR were analyzed for TPH, BTEX, PCB/pesticides, and lead.

3.2.3 Evaluation

The water sample and duplicate collected from the sump during the preliminary investigation (SI) indicated TPHs concentrations of 2 ppm and 84 ppm, respectively. A resample of the sump during the Draft SCR did not indicate BTEX, TPHs, or lead (filtered). The concentrations of TPHs identified in the standing water in the sump most likely represent floating residual oil and grease from Building 202 floor drainage.

Soil analysis at A08-1 and A08-4 located along the former sump-pump discharge line and downgradient of the discharge outfall, respectively, did not indicate TPHs, BTEX, or lead. Soil sample results at borehole A08-3, located in a culvert at the former sump-pump discharge outfall, indicated TPHs (109 ppm) at 4 to 6 feet bgs and non-detect at 8 to 10 feet bgs. The shallow TPHs concentrations may be attributable to the former sump-pump discharge or stormwater containing residual TPHs concentrations which flows toward the culvert over a large portion of the compound. Residual contamination from former spills could also contribute to TPHs concentrations in surface water flow collected at the culvert. Borehole A08-4, located further downstream of the sump-pump discharge outfall did not report TPHs, BTEX, PCB/pesticide, or lead.

No significant contaminant concentrations were identified in soil or groundwater samples taken below Building 202 (A08-6 and MW-36) in close proximity to the sump.

3.2.4 Conclusions

Based on water samples from the sump and the soil and groundwater samples described above, the sump and former discharge from Building 202 does not appear to contribute significant contamination at the site. Quarterly sampling for BTEX and TPH of the sump is recommended for one year. When sampling the sump, standing water must be removed to obtain a representative groundwater sample.

3.3 FORMER/EXISTING UST NORTH OF BUILDING 202

3.3.1 Site Description and History

The former UST near Building 202 was located just north of the building as shown in previous Figure 3-1. 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 (MW-13 and MW-14) and spill/overflow protection.

3.3.2 Summary of Field Sampling and Analytical Program

Boreholes A23-1, A23-2, BH-37, BH-38, BH-39, and BH-40 were drilled for subsurface soil collection. Boreholes A23-1, A23-2, BH-37, and BH-38 were drilled adjacent to the UST north of Building 202. Borehole BH-39 was drilled approximately 100 feet downgradient of the UST and borehole BH-40 was drilled at a background location immediately south of Building 202. Soil samples at borings A23-1 and A23-2 were analyzed for TPHs, BTEX, PCB/pesticide, and lead during the Draft SCR. Soil samples at BH-37, BH-38, and BH-40 were obtained and analyzed for VOCs, SVOCs, TPHs, PCBs/pesticides, and metals during the Draft Final SCR. A summary of soil samples collected for chemical analysis is presented as Table 3-6.

Groundwater at the two existing wells (MW-13, MW-14) was sampled and analyzed for TPHs during the Draft SCR. Boreholes BH-37, BH-38, BH-39, and BH-40 were converted to monitoring wells (MW-37, MW-38, BH-39, and MW-40) and groundwater samples analyzed for VOC, SVOC, TPHs, PCB/pesticide, and metals during the Draft Final SCR. A summary of water samples collected for chemical analysis is presented as Table 3-7.

3.3.3 Evaluation

Soil sample results indicated TPHs concentrations at A23-1 (353 ppm) and A23-2 (75 ppm) at 4 to 6 feet bgs. No TPHs was detected at 8 to 10 feet bgs in either boring. TPHs concentrations were also detected at BH-37 (159 ppm) and BH-38 (82 ppm) at 6 to 10 feet bgs. Results of soil analysis taken at Borehole BH-37 also indicated organic concentrations of phenanthrene (0.42 ppm), naphthalene/tarcamphor (0.48 ppm), 2-methylnaphthalene (0.36 ppm) and acetone (0.026 ppm). No organics were detected in soil samples obtained at BH-38, BH-39, or BH-40. No elevated concentrations of inorganics were detected in soil samples. A summary of SCR soil results is presented as Table 3-8. SCR inorganic soil results are summarized in Table H-3, Appendix H.

No TPHs or BTEX compounds were detected in the groundwater samples collected at MW-13 or MW-14. Lead was detected in the two unfiltered samples at concentrations of 3.6 ppb and 7.2 ppb, respectively; however, lead was not detected in either of the filtered samples collected for this area. Groundwater analysis at MW-37, MW-38, and MW-40 did not detect VOCs, SVOCs, PCB/pesticide, TPHs, or elevated metals concentrations. A summary of the analytical results of groundwater samples is presented in Table 3-9. A summary of inorganic results is presented in Table H-4, Appendix H.

TABLE 3-6
SUMMARY OF SOIL SAMPLES COLLECTED FOR CHEMICAL ANALYSIS AT
EXISTING/FORMER UST NORTH OF BUILDING 202

Sample Number	Location	Sample Interval (feet bgs)	Analysis
23BH0102	A23-1	4 to 6	TPHs, BTEX, PCB/Pesticide, Lead
23BH0104	A23-1	8 to 10	TPHs, BTEX, PCB/Pesticide, Lead
23BH0202	A23-2	4 to 6	TPHs, BTEX, PCB/Pesticide, Lead
23BH0204	A23-2	8 to 10	TPHs, BTEX, PCB/Pesticide, Lead
08BH3706	BH-37	6 to 10	VOC, SVOC, TPHs, PCB/Pesticide, Metals
08BH3806	BH-38	6 to 10	VOC, SVOC, TPHs, PCB/Pesticide, Metals
08BH3906	BH-39	6 to 10	VOC, SVOC, TPHs, PCB/Pesticide, Metals
08BH4006	BH-40	6 to 10	VOC, SVOC, TPHs, PCB/Pesticide, Metals

Key: bgs = Below Ground Surface
 TPHs = Total Petroleum Hydrocarbon
 BTEX = Benzene, Toluene, Ethylbenzene, Xylene
 PCB = Polychlorinated Biphenyl
 VOC = Volatile Organic Compound
 SVOC = Semivolatile Organic Compound

TABLE 3-7
SUMMARY OF WATER SAMPLES COLLECTED FOR CHEMICAL ANALYSIS AT
EXISTING/FORMER UST NORTH OF BUILDING 202

Sample Number	Location	Analysis
23MW1301	MW-13	TPHs, BTEX, lead
23MW1401	MW-14	TPHs, BTEX, lead
08MW3701	MW-37	VOC, SVOC, TPHs, PCB/Pesticide, Metals
08MW3801	MW-38	VOC, SVOC, TPHs, PCB/Pesticide, Metals
08MW3901	MW-39	VOC, SVOC, TPHs, PCB/Pesticide, Metals
08MW4001	MW-40	VOC, SVOC, TPHs, PCB/Pesticide, Metals

Key: TPHs = Total Petroleum Hydrocarbon
 BTEX = Benzene, Toluene, Ethylbenzene, Xylene
 PCB = Polychlorinated Biphenyl
 VOC = Volatile Organic Compound
 SVOC = Semivolatile Organic Compound

TABLE 3-8
SUMMARY OF ANALYTICAL RESULTS FOR SCR SOIL SAMPLES
AT EXISTING/FORMER UST NORTH OF BUILDING 202

Sample Number	Borehole Number	Sampling Interval (feet bgs)	TPHs (µg/g)	PCBs (µg/g)	PPDDE (µg/g)	PPDDD (µg/g)	Benzene (µg/g)	Toluene (µg/g)	Ethylbenzene (µg/g)	Total Xylenes (µg/g)	Lead (µg/g)
23BH0102	A23-1	4 to 6	353	ND	ND	ND	ND	ND	ND	ND	13
23BH0104	A23-1	8 to 10	ND	ND	ND	ND	ND	ND	ND	ND	8
23BH0202	A23-2	4 to 6	75	ND	ND	ND	ND	ND	ND	ND	12
23BH0204	A23-2	8 to 10	ND	ND	ND	ND	ND	ND	ND	ND	5
08BH3706	BH-37	6 to 10	159	ND	ND	ND	ND	ND	ND	ND	6
08BH3806	BH-38	6 to 10	82	ND	ND	ND	ND	ND	ND	ND	8
		Detection Limit	20	0.03	0.0033	0.0033	0.05	0.04	0.04	0.05	0.3

Key: bgs = Below Ground Surface
 TPHs = Total Petroleum Hydrocarbon
 PCB = Polychlorinated Biphenyl
 PPDDE = 2,2-Bis(p-chlorophenyl)-1,1-dichloroethane
 PPDDD = 1,1-Dichloro-2,2-bis(p-chlorophenyl)ethane
 µg/g = Micrograms per gram equivalent to parts per million (ppm)
 ND = Not Detected

TABLE 3-9
SUMMARY OF ANALYTICAL RESULTS FOR SCR WATER SAMPLES
AT EXISTING/FORMER UST NORTH OF BUILDING 202

Sample Number	Location	TPHs (µg/L)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	Lead (unfiltered) (µg/L)	Lead (filtered) (µg/L)
23MW1301	MW-13	ND	ND	ND	ND	ND	3.6	NA
23MW1302	MW-13	NA	NA	NA	NA	NA	NA	ND
23MW1401	MW-14	ND	ND	ND	ND	ND	7.2	NA
23MW1402	MW-14	NA	NA	NA	NA	NA	NA	ND
Sample Number	Location	Acetone (µg/L)	Chloro-benzene (µg/L)	Zinc (µg/L)	Manganese (µg/L)			
08MW3902 ⁽¹⁾	MW-39	11	26	93	346			

Key: TPHs = Total Petroleum Hydrocarbon µg/L = Micrograms per liter equivalent to parts per billion (ppb)
 ND = Not Detected
 NA = Not Analyzed

Note: ⁽¹⁾ MW-39 analyzed for SVOC, VOC, PCB, pesticide, and metals. Organic detections and elevated inorganics shown only.

The groundwater sample obtained at MW-39 indicated no TPHs or PCB/pesticides, however, organic concentrations of acetone (11 ppb) and chlorobenzene (26 ppb) were detected in the groundwater. Metals analysis of groundwater reported elevated levels of zinc (93 ppb) and manganese (346 ppb). The organic concentrations of acetone (11 ppb) and chlorobenzene (26 ppb) detected in groundwater at the well do not exceed USEPA Region III risk-based concentration for tap water. Metals analyses of groundwater at MW-39 indicated elevated levels of manganese (325 ppb) and zinc (91 ppb). The zinc concentration exceeds Virginia groundwater standards (50 ppb) but not USEPA risk-based concentrations nor Virginia surface water quality standards or secondary maximum concentration limits (MCLs).

3.3.4 Conclusions

Soils analysis indicated TPHs concentrations above the regulatory guideline in soils at the former UST trench. The TPHs concentrations decreased with vertical and horizontal distance from the trench.

Groundwater results at MW-13 and MW-14 did not detect BTEX or TPH. Groundwater analyses at MW-37, MW-38, and MW-40 did not detect VOCs, SVOCs, PCB/pesticide, TPH, or elevated metals concentrations. Based on the analytical results of these groundwater samples located immediately downgradient and adjacent to the UST, residual TPH in soils at the UST trench do not appear to be leaching to the shallow aquifer.

MW-39 is located approximately 50 feet downgradient of a former oil/water separator as shown on previous Figure 3-1. The oil/water separator is located just north of the paved area north of Building 202. This structure formerly collected surface drainage from the storm sewer system for the paved area north of the building. TPH concentrations identified in soils adjacent to the oil/water separator and elevated PCB concentrations detected at the separator outfall in SI sampling prompted the USAEC to initiate removal action and possible additional study. The oil/water separator is scheduled to be excavated as part of a concurrent removal action conducted by the Omaha Corp of Engineers. The USAEC is working closely with the appropriate regulatory agencies in the removal action and any possible additional study. It is most likely that analytes identified below regulatory levels at MW-39 are associated with the oil/water separator.

Based on the chemical analyses of soil and groundwater, no ecological or human health threats were expected from residual TPH identified at former UST(s) soil media for human and environmental receptors. No health threats are expected from the present level of contamination onsite. The site is considered a good candidate for a request to VADEQ for UST closure under the no further action option. A risk assessment of the TPH in subsurface soils to receptors is further discussed in Section 4.0, Risk Assessment.

SECTION 4.0

QUALITATIVE RISK EVALUATION

The purpose of this qualitative risk evaluation is to identify any potential human health and environmental impacts which may exist as a result of potential exposures to those compounds identified during the field sampling analysis program detailed in Sections 2.0 and 3.0 for Building 202 located in the WRF, Woodbridge, Virginia (Section 1.0, Figures 1-1, 1-2, and 1-3). The evaluation of potential risk is to be used to provide a basis for determining if site-specific remediation is necessary; provide recommendations for remedial alternatives; and if necessary to develop health-based cleanup levels in soil and groundwater.

This qualitative risk evaluation was completed according to VADEQ, Water Division Guidance. This qualitative risk evaluation includes the following components.

- Site characterization (site description, physiography, nature and extent of contamination, and identification of chemicals of concern);
- Fate and transport analysis (contaminant migration to potential receptor points);
- Exposure assessment (receptor populations, pathways, exposure concentrations, chemical intakes);
- Risk characterization; and,
- Summary (recommendations and remedial assessment, if necessary).

In general, site characterization involves a detailed literature and data review to understand the history and dynamics of the site and surroundings (e.g., physical, chemical, and biological changes) and to identify the site-related chemicals that are expected to pose the most significant health concerns. This information establishes a chronology of events and provides insight into the cause-and-effect of the environmental problems such that remedial response, if necessary, focuses on the source and contaminants of primary health concern rather than the present status of the contamination at a site. A summary of the site characterization components is described in the following paragraphs.

4.1 SITE DESCRIPTION AND HISTORY

The site description and history have been described in detail in Section 1.0 of this SCR. The site is a vacant single-story glass and brick building identified as Building

202 within the main compound at the WRF. Two USTs (one 1,000-gallon UST north of the building, and one 2,000-gallon UST east of the building) currently exist at the site. Four USTs (three 10,000-gallon USTs east of the building, and one 1,000-gallon UST north of the building) were removed from the site. Table 4-1 lists existing and former USTs at Building 202.

TABLE 4-1
UNDERGROUND STORAGE TANKS

Nearest Building	Type	Capacity (Gallons)	Contents	Installation Date	Tightness Tested	Results	Date Removed	Regulatory Program
East 202	Steel	10,000	Diesel	1966	No	--	1981	Article 9
East 202	Steel	10,000	#2 Fuel Oil	1966	Yes	Failed	1990	Article 9
East 202	Steel	10,000	#2 Fuel Oil	1966	Yes	Failed	1990	Article 9
North 202	Steel	1,000	Gasoline	Unknown	Yes	Failed	1990	Article 9
East 202	Fiberglass	2,000	Diesel	1981	Yes	Passed	Existing	Article 9
North 202	Fiberglass	1,000	Gasoline	1990	Yes	Passed	Existing	Article 9

The WRF is located on approximately 579 acres of land in the easternmost portion of Prince William County, Virginia, within the town of Woodbridge. The primary mission of the facility, until its closure in September 1994, was to support the U.S. Army Research Laboratory in a variety of programs involving nuclear weapons effects and U.S. Army systems survivability. For the closure of the WRF, emphasis is given to ecological aspects at the installation due to the presence of numerous sensitive natural resource habitats. The great diversity of habitat types include upland forests, tidal marsh, and wooded swamp. In addition, the habitat for endangered and threatened species, including the bald eagle, is present on the facility.

The WRF officially closed on 16 September 1994. No property has yet been disposed at the WRF. Public Law 103-307 was signed by the President of the United States on 23 August 1994. This law mandated the transfer of the entire installation from the U.S. Army to the DOI. As of July 1995, negotiations of the terms of the property transfer are in progress. A property transfer date has not yet been announced.

The real property transfer actions are being administered for the U.S. Army by the USACE, Baltimore District. Reportedly, the USFWS, an organization within the DOI, will designate the property as a component of the National Wildlife Refuge system. Representatives of the USFWS have announced that the main compound area at the WRF will be utilized for administrative and educational purposes. The remainder of the installation is to be maintained as habitat for the wildlife and flora at the WRF.

4.2 PHYSIOGRAPHIC SETTING

Regional geology, site geology, site topography, site hydrogeology, climate, and demographics have been described in Section 1.0 of this SCR.

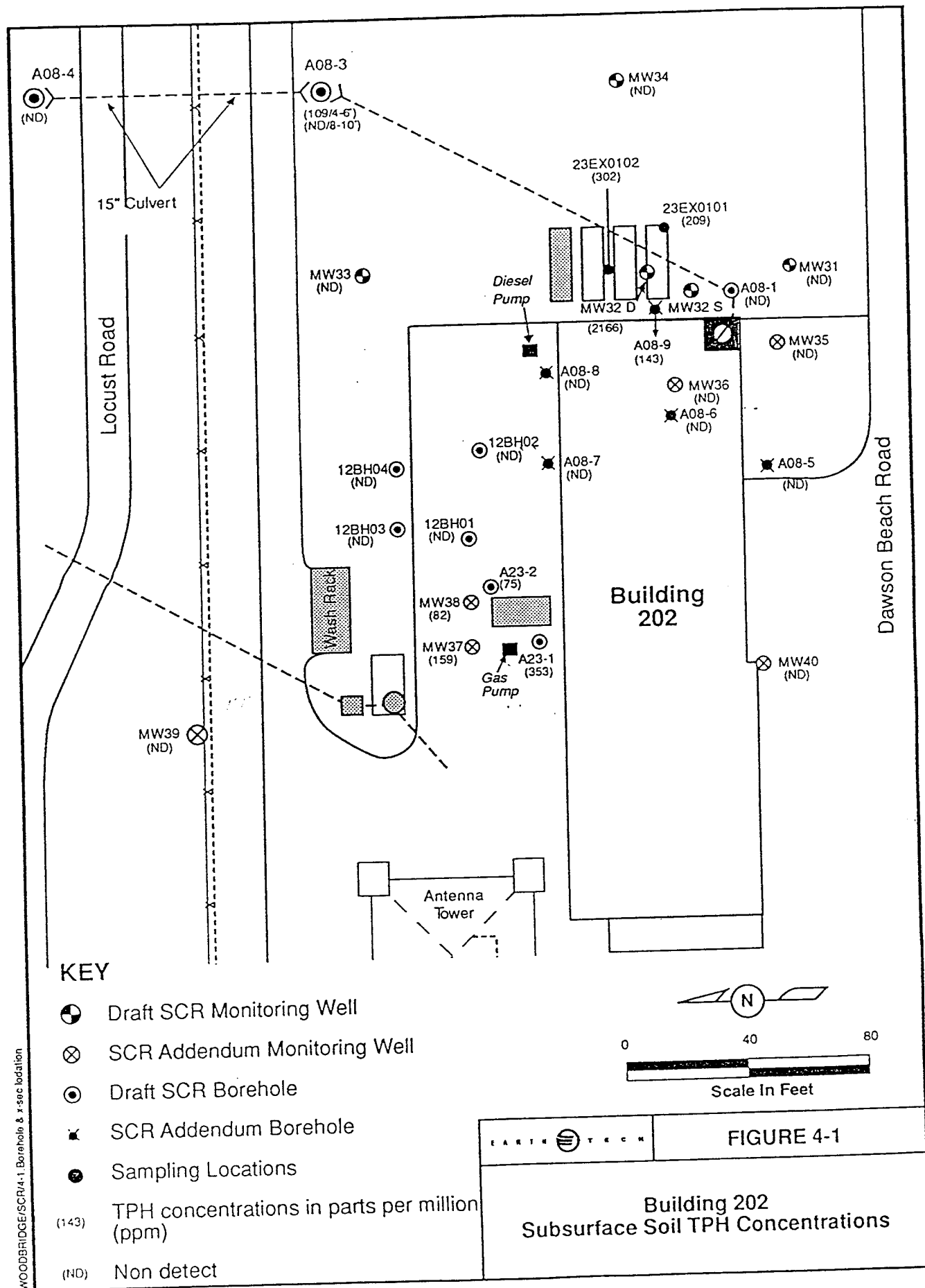
4.3 NATURE AND EXTENT OF CONTAMINATION

Twenty-five borings were completed in and around two former UST(s) trench locations at Building 202. Eleven boreholes were converted to monitor wells. Site characterization investigations included collecting continuous soil boring samples at each boring. Each soil sample was screened for soil gas as a preliminary indicator of the extent of soil hydrocarbon contamination. The soil sample with the highest OVA reading per boring (or closest to groundwater in the event of negligible OVA readings) was sent for laboratory analysis. Soil samples were analyzed for BTEX, TPHs, and lead during the Draft SCR. Soil samples collected during SCR sampling were analyzed for VOC, SVOC, TPHs, and metals in accordance with USEPA Methods. The location of subsurface soil sampling is depicted on Figure 4-1.

The soil investigation at former UST(s)/existing UST east of Building 202 indicated TPHs concentrations above regulatory criteria within and immediately adjacent to the former UST(s) trench. Borehole BH-32D indicated the highest TPHs concentrations, ranging from 2,166 ppm at 6 to 8 feet bgs to 149 ppm at 10 to 12 feet bgs. Other subsurface soil results from the UST(s) trench area indicated 143 ppm TPHs at borehole A08-9 and 209 ppm to 302 ppm TPHs at 7.5 feet bgs in excavations into the former UST(s) trench. Surface soil sample results at the former UST(s) area indicated TPHs concentrations below regulatory guidance, ranging from 14 ppm to 42 ppm. Subsurface soil concentrations are depicted on Figure 4-1.

Soil sample results at the former UST/existing UST north of Building 202 indicated TPHs concentrations at A23-1 (353 ppm) and A23-2 (75 ppm) at 4 to 6 feet bgs. No TPHs was detected at 8-10 feet bgs in either boring. TPHs concentrations were also detected at BH-37 (159 ppm) and BH-38 (82 ppm) at 6 to 10 feet bgs. Results of soil analysis taken at Borehole BH-37 also indicated organic concentrations of phenanthrene (.42 ppm), naphthalene/tarcamphor (.48 ppm), 2-methylnaphthalene (.36 ppm) and acetone (.026 ppm). No organics were detected in soil samples obtained at BH-38, however, inorganic analysis indicated an elevated concentration of cadmium (470 ppm). No other elevated concentrations of inorganics were detected in these samples.

Monitoring wells MW-31 through MW-34, located downgradient of former UST(s)/existing UST east of Building 202, were sampled for groundwater analysis in May 1994 and resampled in April 1995. Newly installed monitoring wells MW-35 and MW-36 installed during the SCR to further characterize the site were also sampled. Groundwater samples obtained in May 1994 during the Draft SCR were analyzed for TPHs, BTEX, and Lead. Groundwater samples obtained in April 1995 for



the SCR were analyzed for VOCs, SVOCs, TPHs, PCB/pesticides, and metals.

Groundwater results of the May 1994 sampling event indicated 0.653 ppb ethylbenzene at MW-32S. Monitoring well MW-32S is located within the former UST(s) trench area. Downgradient monitoring wells did not detect TPHs or any other significant contamination. Groundwater results of the April 1995 sampling event did not detect VOCs, SVOCs, TPHs, PCB/Pesticides, or elevated metals.

Based on the analytical result of the above groundwater analyses, the groundwater investigation did not indicate TPHs leaching to the groundwater from soils adjacent to the former/existing UST north of Building 202. Groundwater samples collected from wells MW-13 and MW-14, located adjacent to the existing UST did not detect TPHs or BTEX compounds. Lead was detected in the two unfiltered samples from these wells at concentrations of 3.6 ppb and 7.2 ppb; however, lead was not detected in either of the filtered samples. Groundwater analysis at MW-37 and MW-38 installed directly downgradient of the UST, and background well MW-40 did not detect VOCs, SVOCs, PCB/pesticide, TPHs, or elevated metals concentrations.

Important observations for this qualitative risk evaluation are as follows:

- Analytical results for the soil samples did not indicate BTEX contamination.
- The TPHs concentrations which were detected in subsurface soils adjacent to the former UST(s) trench east of Building 202 were not reported for downgradient soils. TPHs concentrations identified in subsurface soils adjacent to the UST north at Building 202 decreased with vertical and horizontal distance.
- The analytical results for the surface soil samples collected during the SCR do not indicate BTEX contamination, nor are these samples reported to contain TPH in concentrations which exceed the regulatory guidance suggesting risk evaluation.
- At the two former UST trench locations the groundwater investigations in May 1994 and April 1995 did not detect TPH leaching, from the identified TPH-contaminated soils into the shallow water table aquifer.

4.4 ENVIRONMENTAL FATE AND TRANSPORT

One group of compounds, represented by TPHs, have been detected in soils underlying portions of the site. The presence of these compounds presumably occurred as a result of gasoline leaks and/or spills at the site. Gasoline is composed of a mixture of a large number of organic compounds. According to characterization data provided by the American Petroleum Institute (API, 1985), gasoline typically consists of three major groups: (1) small-chain paraffins, (2) small cycloparaffins, and

(3) small aromatic groups. Paraffins, cycloparaffins, and aromatics are estimated to comprise 55, 15, and 30 percent (by weight), respectively, of TPHs.

Typically, spills and leaks at UST(s) usually impact area soils before reaching the groundwater, and most of the hydrocarbon compounds remain in the unsaturated zone. The most soluble group of organics in gasoline, the aromatics, is expected to most freely leach from the soil into the groundwater. Nevertheless, leaching is not considered a major route of transport because most spilled and/or leaked benzene remains in the soil, where it volatilizes and biodegrades (Tucker, *et al.*, 1986).

The paraffin group is composed of normal and branched open-chain hydrocarbons containing approximately 6 to 12 carbon atoms. Paraffins are expected to volatilize and biodegrade significantly from soils and are not expected to exist in significant levels in groundwater due to their low solubility. The small amounts that exist in groundwater are expected to be eliminated mostly by biodegradation.

The cycloparaffin group is composed of substituted closed-chain hydrocarbons (rings) containing approximately 6 to 12 carbon atoms. Cycloparaffins are similar to the open-chain paraffins and are expected to volatilize and biodegrade significantly from soils. They are not expected to exist in significant levels in groundwater due to their low solubility. The small amounts that exist in groundwater are expected to be eliminated mostly by biodegradation.

The aromatics group is composed largely of benzene, ethylbenzene, toluene, and mixed xylenes. The common benzene ring and the small degree of substitution in these compounds account for their similar physical-chemical properties. Table 4-2 presents physical-chemical properties of interest for these chemicals. The aromatics have moderate octanol-water partition coefficients (K_{ow}), organic carbon adsorption coefficients (K_{oc}), aqueous solubilities, and vapor pressures. Benzene shows approximately an order of magnitude higher solubility and vapor pressure as well as lower K_{ow} and K_{oc} values than toluene, ethylbenzene, and the xylenes. These compounds are expected to be mobile in the environment. In soil, they are expected to be eliminated by biodegradation and volatilization. In groundwater, they are expected to undergo mostly aerobic biodegradation. The absence of BTEX in soil samples from UST(s) areas at Building 202 is most likely due to volatilization and biodegradation from the soil.

The aromatics are expected to exhibit the same degree of volatility in the environment. They have dimensionless Henry's law constant (H) values ranging from 0.1 to 0.3 at 25 degrees Celsius. The order of volatility based exclusively on H values (in descending order with the more volatile first) is as follows:

ethylbenzene > toluene > benzene > xylenes

TABLE 4-2
PHYSICAL-CHEMICAL PROPERTIES OF BTEX

COPEC ⁽¹⁾ Class	COPEC	Toxicity Properties			
		USEPA Toxicity Values ⁽²⁾		K_{oc} ⁽³⁾	K_{ow}
		Slope Factor	Oral Reference Dose		
Volatile Organic Compounds	Benzene	1E-1	ND	5.0E + 1	1.3E + 2 ⁽⁴⁾
	Ethylbenzene	NC	1E-1	2.4E + 2	1.4E + 3 ⁽⁵⁾
	Tetrachloroethylene	5.1E-2	1E-2	3.3E + 2	2.5E + 3 ⁽⁶⁾
	Xylenes, Total	NC	2.0E + 0	1.6E + 2	1.4E + 3 ⁽⁵⁾

⁽¹⁾ Abbreviations: COPEC, chemical of potential ecological concern; K_{oc} , organic carbon sorption coefficient; K_{ow} , octanol-water partition coefficient; NC, noncarcinogenic; ND, no data available in IRIS database; NA, not applicable.

⁽²⁾ IRIS, 1994. Information from this human health database used only in preliminary toxicity screening.

⁽³⁾ Sources: Methyl ethyl ketone and methyl isobutyl ketone, Howard (1990); all other chemicals, ATSDR Toxicity Profiles for each respective COPEC. If a range was given, the mean was calculated.

⁽⁴⁾ USEPA, 1984a.

⁽⁵⁾ Howard, 1990.

⁽⁶⁾ USEPA, 1984d.

Volatilization of these aromatics from groundwater through soil is expected to be a minor elimination route. Upon groundwater discharge to surface water, volatilization of these compounds is rapid. Once benzene, toluene, and the xylenes are released into the atmosphere, they are expected to hydroxylase quickly (Agency for Toxic Substances and Disease Registry [ATSDR], 1988, 1989a, 1989b). Ethylbenzene is known to undergo extensive reactions with hydroxides, nitrate (NO_3) radicals, and atomic oxygen in the atmosphere (ATSDR, 1989c).

Adsorption to aquifer sediment, particularly the organic fraction, is also expected to have a minor effect on transport of these compounds. K_{oc} values are a good measure of the extent of adsorption to organic soil fractions. The aromatics show a K_{oc} range of about 50 to 1,700 liters per kilogram (L/kg) (USEPA, 1986d). The order of this range is parallel to the log K_{ow} , another indicator of adsorption to organic soil. Based on these parameters, the order of adsorption to soil appears to be as follows:

benzene < toluene < xylenes < ethylbenzene

Another parameter useful in evaluating the mobility of compounds in the soil/water complex of a groundwater system is aqueous solubility. Solubility of the aromatics ranges from about 100 to 1,600 mg/L. The order of solubility values parallels the log K_{ow} and K_{oc} order in reverse, as follows:

benzene > toluene > xylenes > ethylbenzene

Based on these parameters, benzene, with the smallest K_{oc} and highest water solubility, is expected to be the most mobile in the groundwater system, while ethylbenzene is found to be the least mobile. Disregarding adsorption characteristics of these compounds to nonorganic soil particles, the predicted order of mobility is expected to be as follows:

benzene > toluene > xylenes > ethylbenzene

To summarize, the aromatics are expected to show a moderate degree of mobility in the soil/water groundwater system, except in the case of benzene, where a greater mobility level is expected. Mobility will decrease as the soil organic content increases.

Both chemical and biological degradative pathways may affect the persistence of aromatics. The chemical pathways of interest are hydrolysis and other chemical reactions that can occur in the groundwater system. The biological pathways of concern are mediated by the microbial populations (either aerobic or anaerobic) of the groundwater system.

Chemical reactions of aromatics such as hydrolysis and oxidation have been reported to be insignificant. Available data indicate that chemical degradation of benzene in water is also insignificant (ATSDR, 1989a). Similar results are reported for toluene, ethylbenzene, and xylenes (U.S. Air Force, 1989; ATSDR, 1988, 1989b, 1989c).

Biodegradation of the aromatics is of greater significance in the environment than chemical degradation. Biodegradation rate depends on acclimation of relevant strains of microbial populations under the proper environment (temperature, nutrient level, etc.). In general, laboratory experiments with isolated strains of microbes have shown that aromatics are biodegraded. The extrapolation of these results to field conditions is rarely straightforward. For the soil/water media of the site, important considerations include the levels of relevant degrading microbial strains that have adapted to the media and the amount of oxygen available. The shallow groundwater system at the site would be expected to be aerobic. The presence of compounds that undergo oxygen-demanding biodegradation processes would reduce the oxygen content.

Aerobic and anaerobic benzene biodegradation have been documented both in laboratory and *in-situ* conditions. Aerobic biodegradation seems to occur more rapidly than does anaerobic biodegradation. Reported anaerobic transformation end products are catechols, which can undergo ring fission (ATSDR, 1989a). Many biodegradation studies have been conducted with benzene. One set of laboratory results found 99-percent anaerobic degradation in 120 weeks; in an *in-situ* anoxic biological study of a hydrocarbon-contaminated aquifer, complete benzene removal was reported to occur in 6 months (ATSDR, 1989a).

Toluene has been reported to undergo aerobic degradation by many species of microorganisms. In one study, rapid toluene biodegradation (90 percent lost in 7 days) was reported in a shallow aquifer (ATSDR, 1988). No data on anaerobic degradation have been reported.

Xylenes are known to biodegrade under laboratory and field conditions; however, quantitative data are limited. This is especially true in groundwater systems. Based on the structural similarity of xylenes to toluene and ethylbenzene, inferences can be made regarding their biodegradability (U.S. Air Force, 1989). Some reports indicate that, in general, xylene biodegradation in most aquatic systems will be poor to moderate (ATSDR, 1989b).

Ethylbenzene is known to biodegrade both aerobically and anaerobically (U.S. Air Force, 1989; ATSDR, 1989c). Aerobic degradation is more rapid than anoxic degradation based on various field and laboratory observations (ATSDR, 1989c). At greater depths from the surface, decreasing levels of degrading microbial colonies and increased anoxic conditions are expected to retard biodegradation (ATSDR, 1989c).

In summary, petroleum is typically retained in the unsaturated zone as residual hydrocarbon, such that most of the petroleum at UST-contaminated sites is in the unsaturated zone. Volatilization is expected to be the dominant fate process resulting in losses of hydrocarbons from the unsaturated soils. Nearly all components of gasoline and diesel fuel, including the aromatics, are subject to biodegradation under aerobic conditions. Groundwater analyses at Building 202 indicates that residual hydrocarbons are degraded below significant levels prior to reaching the groundwater table. No contaminants (with the exception of ethylbenzene at .65 ppb) were

detected in the shallow groundwater from residual hydrocarbons in subsurface soils at former UST(s). The point closest to Building 202 at which groundwater is at the elevation of surface water is located approximately 400 feet downgradient of the UST(s) at an unnamed drainage channel. In the event that residual hydrocarbons leached to the shallow groundwater, transport of the residual contaminants would require 17 years to reach the unnamed drainage channel discharge, based on the hydraulic gradient and permeability defined in Section 3.0. The transport rate of 17 years is based on that most permeable aquifer hydraulic conductivity result obtained at MW-39. All other aquifer hydraulic conductivity results indicated groundwater velocities of a few feet per year. Volatilization from groundwater is slow; migration with flowing groundwater, dispersion, and biodegradation are the dominant fate processes in groundwater.

4.5 EXPOSURE ASSESSMENT

The exposure assessment uses information obtained from the site characterization and the environmental fate and transport analysis to identify significant complete exposure pathways and to estimate actual or potential concentrations of contaminants of potential concern for each exposure pathway. Behavioral or physiological factors influencing exposure frequency and exposure levels are then presented in a series of exposure scenarios as a basis for quantifying chemical intake levels by receptor populations for each significant completed exposure pathway. The results of the exposure assessment are used to determine the potential human health and environmental risks associated with the study area. TPHs compounds represent a large conglomerate of compounds not necessarily consistent from site to site; thus, no toxicity criteria are available. Generally, BTEX would be an appropriate subset of chemicals to represent potential risk; however, no BTEX was identified in soil and groundwater analyses. The risk assessment, therefore, will focus on the qualitative health and ecological impacts of TPHs.

4.5.1 Local Land Use/Potentially Exposed Populations

The USFWS, an organization within the DOI, will designate the property as a component of the National Wildlife Refuge system. Representatives of the USFWS have announced that the main compound area including Building 202 will be utilized for administrative and educational purposes. The remainder of the installation is to be maintained as habitat for the wildlife and flora at the WRF.

All area residential, business, and commercial properties are supplied water by the PWCSA, which uses water from the Occoquan River reservoir at Occoquan, Virginia. Local residents are currently served by a public sewage system. The shallow groundwater is not used as a drinking water supply.

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 bisected by an unnamed drainage channel originating from residential and partly industrialized areas to the north. The channel flows west to east across the facility, passing approximately 200 feet to the north of the site. Surface water at Building 202 flows in a northerly direction toward the drainage channel with the ground surface grade. This channel flows easterly beyond the main compound and is fed by several smaller drainage lines before turning south and eventually feeding to Belmont Bay southeast of the main compound. 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. Figure 1-8 in Section 1.0 depicts the surface water drainage patterns and flow directions found at Building 202 and the WRF.

At the site 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 1-8. The groundwater gradient varies 0.59 feet from 5.15 feet MSL at upgradient well MW-40 to 4.56 feet MSL at downgradient well MW-39. The gradient of the water table indicates that the water table likely discharges to the drainage channel and adjacent low marshy areas approximately 400 feet downgradient of Building 202. The direction of groundwater flow at Building 202 is depicted on Figure 1-9, Section 1.0.

4.5.1.1 Human Receptors

Onsite human receptors include future administrative workers and visitors who might utilize Building 202 or be outdoors of Building 202 at the former UST(s) locations. No contaminants were identified beneath Building 202; therefore, volatilization into the building to human receptors is not anticipated. Surface soils do not indicate TPH concentrations exceeding guidance suggesting potential risk. The residual TPH in subsurface soils is not anticipated to be disturbed in the future use of the proposed wildlife refuge.

4.5.1.2 Environmental Receptors

No leaching of TPHs from the soils which make up the backfill for the UST(s) trenches to the shallow groundwater has been identified in two groundwater monitoring events approximately 1 year apart; therefore, transport of TPHs via onsite groundwater to surface water discharge and environmental receptors is not considered. Surface soil at the former and existing UST(s) locations are below concentrations suggesting risk potential.

4.5.2 Exposure Pathways

An exposure pathway is the route that a chemical or physical agent takes from a source to an exposed population or individual (receptor) and describes a unique mechanism by which the receptor may be potentially exposed to chemicals or physical

agents at or originating from the site. For an exposure pathway to be complete, the following four elements must be present:

1. A source or release from a source (e.g., vapor emissions released from groundwater to air)
2. A likely environmental migration route (e.g., groundwater to surface water discharge)
3. An exposure point where receptors may come in contact with site-related chemical or physical agents (e.g., Main Drainage Channel)
4. A route by which potential receptors may be exposed to a site-related chemical or physical agent (e.g., inhalation of vapors).

If any one of these components is not present, the exposure pathway is considered incomplete and is not expected to contribute to the total exposure from the site. A screening of potential exposure pathways was conducted such that the risk characterization focuses only on the completed exposure pathways and eliminates from further consideration of those pathways that are incomplete.

4.5.2.1 Water Consumption Pathway

Domestic consumption of groundwater is a pathway of concern when humans use private wells that tap into the underlying groundwater close to the site. Exposure will occur as a result of ingestion, inhalation, and direct dermal contact with TPHs chemicals during domestic activities. This concern is not considered valid at Building 202 based on available information that leaching of TPHs from the soil matrix at the UST(s) to the shallow groundwater has not been detected and that all area residential and commercial properties are supplied water by the PWCSA. Thus, the pathway is considered incomplete.

4.5.2.2 Direct Contact Pathway

No direct contact with TPHs in subsurface soil media is expected by onsite or offsite human receptors. Surficial soil TPHs concentrations were below VADEQ regulatory guidelines suggesting risk assessment of soils exceeding 100 ppm. The residual TPHs localized in subsurface soils at the former UST(s) are located under paved and landscaped areas not expected to be disturbed in the future use scenario at the facility. No migration of residual TPHs in soils at the UST(s) trenches has been identified for transport in the shallow groundwater table to direct contact with receptors.

4.5.2.3 Soil Ingestion Pathway

The soil ingestion pathway is based on direct ingestion of contaminated surficial soils. Surficial soil TPHs concentrations were below VADEQ regulatory guidelines suggesting risk assessment of soils exceeding 100 ppm. The residual TPHs localized in subsurface soils at the former UST(s) are located under paved and landscaped areas not expected to be disturbed in the future use scenario at the facility.

4.5.2.4 Inhalation Pathway

Inhalation of contaminants can occur from exposure to fugitive dusts from surficial soils and from exposure to contaminated air due to volatilization of the contaminants of potential concern. The residual TPHs localized in soils at the former UST(s) are located under paved and landscaped areas not expected to be disturbed in the future use scenario at the facility. Surficial soil TPHs concentrations were below VADEQ regulatory guidelines suggesting risk assessment of soils exceeding 100 ppm.

No soil contamination was reported above detection limits under Building 202; thus, no TPHs chemicals are expected to migrate directly from soil and accumulate in Building 202.

4.5.2.5 Environmental Receptor Pathway

No contamination of the shallow groundwater from UST(s) trenches at Building 202 has been identified in chemical analysis of groundwater samples. Therefore the transportation of TPHs to surface water bodies and environmental receptors by onsite groundwater to surface water discharge is not a likely pathway.

4.5.2.6 Summary of Potential Exposure Pathways

Based on the chemical analysis in the site characterization and current/future use of the facility, the pathways considered in this section are considered to be incomplete.

4.5.2.7 Summary and Recommendations

In order to monitor any migration that may occur, quarterly sampling for BTEX and TPH is recommended for MW-32D, MW-32S, and the sump before the site is closed by VADEQ. Quarterly sampling should be conducted for one year. In short, no human or environmental health threats are estimated from the present level of contamination identified onsite. No health threats were expected from residual TPHs identified at former UST(s) subsurface soil media for human and environmental receptors. If sampling results are clean, the site will be considered a good candidate for a request to the VADEQ for UST closure under the no further action option.