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FINAL

TECHNICAL SAMPLING & ANALYSIS PLAN

WOODBRIDGE RESEARCH FACILITY, VIRGINIA

Prepared By:

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

19951115 093

Prepared For:

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

August 1995

Under Contract Number DAAA15-91-D-0009, Delivery Order 0001, Modification 2

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LIST OF ACRONYMS & ABBREVIATIONS

AB	Ambient Blanks
AREE	Areas Requiring Environmental Evaluation
ARL	Army Research Laboratory
BDAT	Best Demonstrated Available Technology
bgs	Below Ground Surface
C/SS	Calibration/Service Specification
CERFA	Community Environmental Response Facilitation Act
CONUS	Continental United States
DOI	Department of the Interior
ELISA	Enzyme Linked Immunosorbent Assay
EMI	Electromagnetic Indicator
ERADCOM	Electronics Research & Development Command
ESE	Environmental Science and Engineering, Inc.
FID	Flame Ionization Detector
gpd	Gallons per day
gpm	Gallons per minute
GPR	Ground Penetrating Radar
GWAP	Graphical Well Analysis Package
HDL	Harry Diamond Laboratory
HSA	Hollow-stem Auger
I.D.	Inside Diameter
IRDMIS	Installation Restoration Data Management Information System
LABCOM	Laboratory Command
LDR	Land Disposal Rule
MERDC	Mobility Equipment Research and Development Center
MHz	Mega Hertz
mL	Milliliter
mm	Millimeter
mph	Miles per hour
MSL	Mean Sea Level
NBS	National Bureau of Standards
NEPA	National Environmental Protection Agency
NPDES	National Pollutant Discharge Elimination System
NRMP	National Resource Management Plan
NTU	Nephelometric Turbidity Unit
O.D.	Outside Diameter
OSW	Office of Solid Waste
OVA	Organic Vapor Analyzer
OWSD	Occoquan-Woodbridge Sanitation District
PCB	Polychlorinated Biphenyl
PID	Photoionization Detector
POC	Point-of-Contact
POL	Petroleum, Oil, and Lubricant
ppm	Parts per million
PVC	Polyvinyl Chloride

List of Acronyms & Abbreviations

Continued

PWCSA	Prince William County Service Authority
QA/QC	Quality Assurance/Quality Control
QAP	Quality Assurance Plan
RB	Rinsate Blanks
RCRA	Resource Conservation and Recovery Act
RD	Radio Detection
RI	Remedial Investigation
SI/RI	Site Inspection/Remedial Investigation
SSI	Supplemental Site Investigation
TB	Trip Blanks
TCLP	Toxicity Characteristic Leaching Procedure
TSAP	Technical Sampling and Analysis Plan
μg/g	Micrograms per gram
μg/L	Micrograms per liter
μm	Micrometer
USAEC	U.S. Army Environmental Center
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
VADEQ	Virginia Department of Environmental Quality
VHWM	Virginia Hazardous Waste Management
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound
VR	Virginia Regulation
WRF	Woodbridge Research Facility

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SECTION 1.0
INTRODUCTION

This Technical Sampling and Analysis Plan (TSAP) includes detailed procedures for all proposed field activities for the Phase I Supplemental Site Investigation (SSI)/Virginia Department of Environmental Quality (VADEQ) Response Action, and the Phase II SSI. The facility background, environmental setting, field operating and sampling procedures, and field Quality Assurance/Quality Control (QA/QC) and recordkeeping are discussed in this TSAP. The subject of facility background described below consists of a description of the facility including a discussion of the location and history of the property. Also provided are brief summaries of previous investigations that have been performed at Woodbridge Research Facility (WRF).

1.1 FACILITY DESCRIPTION AND BACKGROUND

WRF occupies approximately 579 acres of land in the town of Woodbridge in the easternmost portion of Prince William County, Virginia. The facility is located 22 miles southwest of Washington, D.C., as shown in Figure 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 WRF. A facility location map is provided as Figure 1-2.

Historical records of the property which comprises the present-day WRF date back to the late 17th century when Martin Scarlet purchased approximately 700 acres (including the WRF site) from Captain Edward Streator. 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

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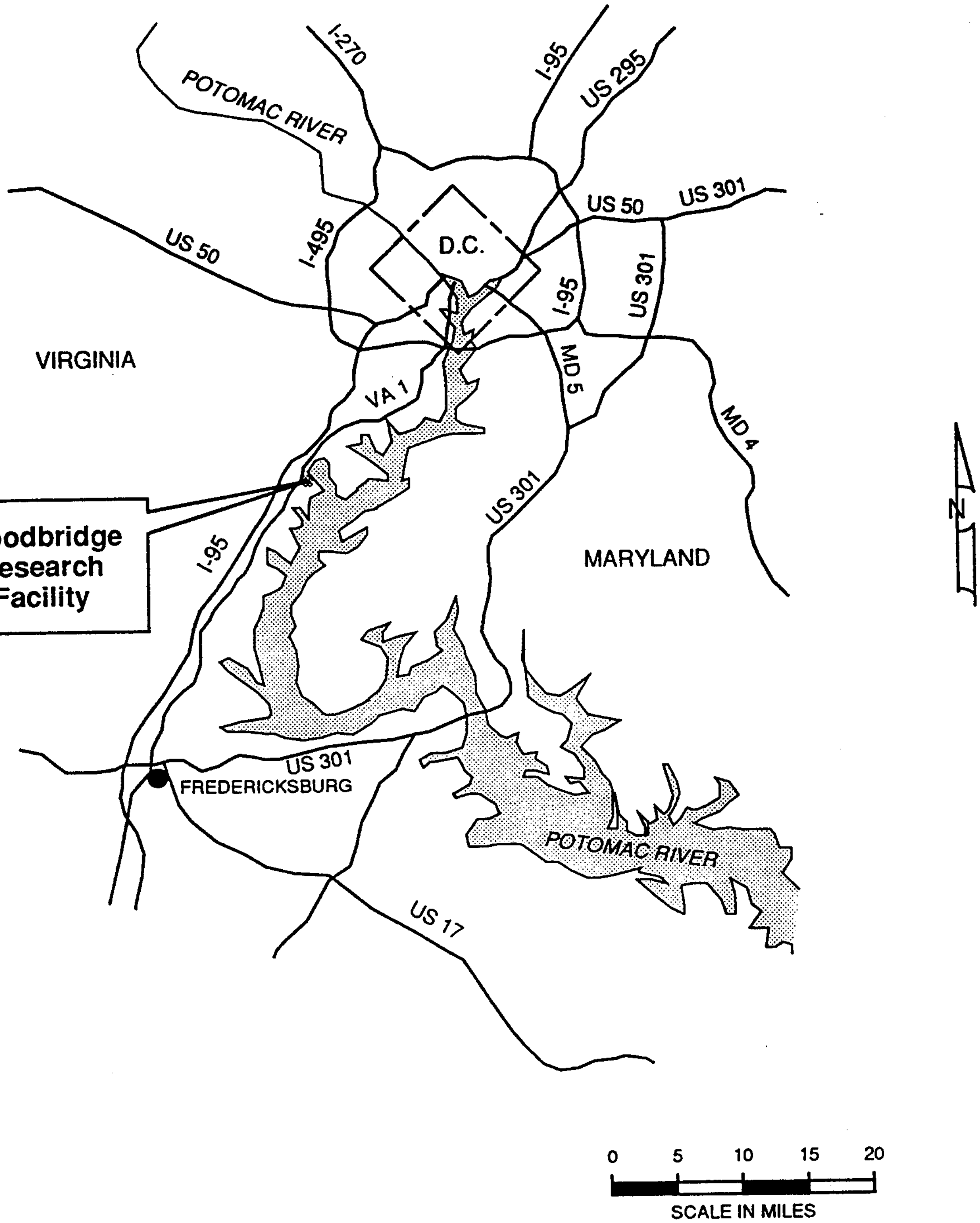

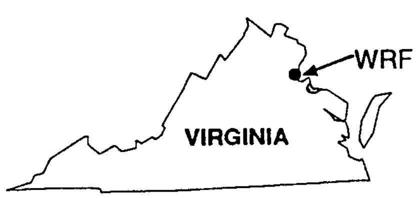

EARTH TECH

FIGURE 1-1

LOCATION MAP
WOODBRIDGE RESEARCH FACILITY
WOODBRIDGE, VIRGINIA

Fig 1-1 Wdbrdge Loc Map

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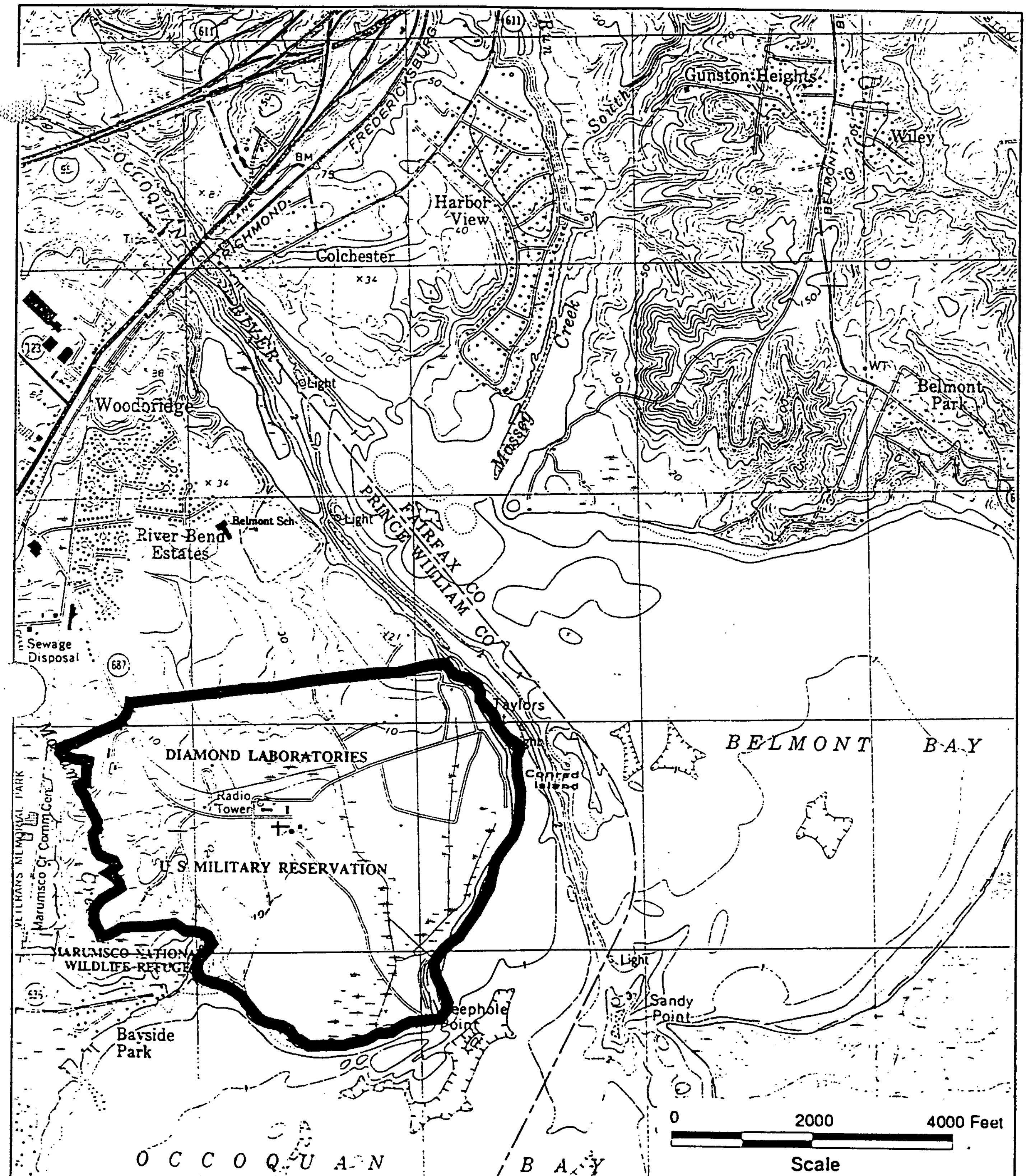
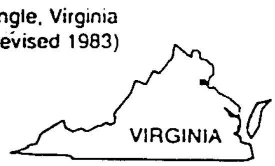


SOURCE: USGS Fort Belvoir 7.5' Quadrangle, Virginia (1965, photorevised 1983)

North



QUADRANGLE LOCATION

EARTH TECH

FIGURE 1-2

WOODBRIDGE RESEARCH FACILITY LOCATION MAP

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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 (HDLs) 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 (DOI) 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. In October 1992, HDL was absorbed into Army Research Laboratory (ARL), and most activities were relocated to the Adelphi Laboratory Center in Adelphi, Maryland. The current mission of the facility is to support ARL in Adelphi, Maryland in investigating nuclear weapons effects and Army systems survivability. Scientists, engineers, and technical and administrative personnel are 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 are simulated utilizing on-site electromagnetic pulsers. Activities have been relocated to White Sands, New Mexico, Aberdeen Proving Ground, Adelphi Laboratory Center, and Fort Belvoir. The WRF closed as an active Army facility 16 September 1994.

1.2 SUMMARY OF PREVIOUS INVESTIGATIONS

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

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

A summary of the waste management practices identified during the installation assessment is provided below. Waste oils generated by motor vehicle maintenance activities at the motor pool were stored in 55-gallon drums and transported to the Adelphi Laboratory Center at Adelphi, Maryland for disposal. During the previous 9 years approximately 100 gallons of waste oil had been generated. Effluent from the vehicle wash rack located behind Building 202 flowed through an oil separator and then into a stormwater drainage ditch. Oil removed from the wastewater was transported to the Adelphi Laboratory Center for disposal. No wastewater was treated at WRF. Sanitary sewage flowed by gravity from the main building complex to a sewage ejection station (Building 301) and then into the main sanitary sewer line (part of the Occoquan-Woodbridge Sanitation District (OWSD)) for off-site treatment. Sanitary wastes generated at Building 306 flowed to a holding tank. Wastes from the tank were hauled to the OWSD system when the capacity of the tank was reached. No National Pollutant Discharge Elimination System (NPDES) permits existed for the Building 202 wash rack or the Building 301 ejection station overflow line (which drains into Occoquan Bay). There were no records indicating the existence of holding ponds at WRF.

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

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

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

In 1984, a Plan for the Assessment of Contamination at Woodbridge Research Facility was completed by ESE to determine the extent of PCB contamination at a former waste disposal area (Landfill No. 2). A WRF employee had informed the installation in January 1984 that approximately 20 transformers and 70 capacitors containing PCBs were buried in a trench at Landfill No. 2. The source of these items was the antennae fields that were dismantled in the early 1970's. WRF excavated some test pits within the vicinity of the burial. PCB contamination was reported based on limited sampling and analysis of soil in the excavated area by Versar, Inc. In February 1984 ESE conducted further soil sampling at Landfill No. 2 in accordance with the 1982 U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) QA/QC Program. The analyses confirmed PCB contamination. Concentrations of 0.6 to 200 micrograms per gram (μg/g) PCBs were detected in the trench soils sampled to a depth of approximately 4 feet. It was not determined whether groundwater contamination by PCBs existed, whether PCBs were migrating off the installation in the groundwater, or whether the potential for contaminant migration off the installation existed. Water quality data from 1970-1980 revealed no migration of toxic/hazardous materials, including PCBs, from WRF into Occoquan or Belmont Bays. The records search which was conducted in 1981 indicated no presence of toxic/hazardous materials in the groundwater; however, no PCB analyses had been performed at that time. At a later date, two on-site supply wells located at least 2,000 feet from Landfill No. 2 were sampled and analyzed and reported PCB concentrations at non-detectable levels. A Remedial Action Plan for the Woodbridge Research Facility PCB Disposal Site was completed by ESE in 1984 for the excavation and disposal of PCB-containing items and PCB-contaminated soil at Landfill No. 2. In 1985 a technical plan, Woodbridge Research Facility Remediation of PCB Contamination, for remediation of PCB contamination at Landfill No. 2 was prepared by Roy F. Weston, Inc.

The Closure Plan for Transformer/Capacitor Burial Trench-Harry Diamond Laboratories, Woodbridge Research Facility, Woodbridge, Virginia (1985) addressed exhumation activities for the disposal trench at Landfill No. 2. The closure work was completed by Roy F. Weston, Inc. Six transformers and 85 capacitors were reportedly removed from Landfill No. 2. Approximately 660 cubic yards of PCB-contaminated material were removed from the site. Seventy-six composite soil samples, including duplicates, were submitted to the ESE laboratory. Sixty grab samples of the soil remaining in the trench were also collected and sent to the ESE laboratory for analysis. Analyses of total PCBs were performed in accordance with USATHAMA-certified analytical procedures. The composite soil samples indicated that the highest PCB concentrations were found at the burial of the transformers and capacitors. Excavated soil containing total PCB concentrations greater than or equal to 3 parts per million (ppm) (3 μg/g) was disposed at a Chemical Waste Management, Inc. hazardous waste landfill facility. Soil from the side wall and floor of the excavated trench was sampled, analyzed, and considered "clean". Closure of Landfill No. 2 involved backfilling the excavated area with uncontaminated soil (less than 3 ppm [3 μg/g] PCBs).

In 1985, the Remedial Investigation (Part I) and Feasibility Study (Part II) at Woodbridge Research Facility was finalized by ESE. The Remedial Investigation (RI) included installation of six monitoring wells (one upgradient and five downgradient) and the collection of sediment samples from the swampy area adjacent to Landfill No. 2. Two observation wells were also constructed upgradient of the landfill to better define the direction of groundwater flow. The results of composite soil core sampling during monitoring well drilling immediately downgradient of Landfill No. 2 indicated less than 0.6 μg/g PCBs (the analytical detection limit). The sediment samples in the swampy area to the southeast of Landfill No. 2 did not show any detectable concentrations of PCBs. Detectable levels of PCBs were not found in the groundwater samples from any of the monitoring wells. The analytical detection limits for groundwater samples were 3.0 μg/g and 0.9 μg/g for PCB 1016 and PCB 1260, respectively. Groundwater, sediment, surface water, and soil samples collected in areas adjacent to Landfill No. 2 did not contain PCBs, suggesting that PCB contamination was confined to the landfill area.

Landfill No. 1 had been a "debris" fill and reportedly was not used to bury transformers or capacitors. Three sediment samples and two surface water samples were collected at Landfill No. 1 during the RI. All of the sediment samples within the boundaries of Landfill No. 1 had low concentrations of PCBs (0.2 to 5 μg/g). The source of PCB contamination at Landfill No. 1 is unknown. At the surface water sampling locations outside the west boundary of Landfill No. 1, PCBs were not detected. Due to the number of samples collected at Landfill No. 2 which had no detectable amount of PCBs, the samples were reanalyzed using a method that allows for a PCB detection limit in soil/sediment of 0.02 μg/g. All samples taken outside both landfills contained less than 0.02 μg/g PCBs. Of the U.S. Environmental Protection Agency (USEPA) organic priority pollutants, low level concentrations of di-n-octyl phthalate (16 to 32 micrograms per liter (μg/L)) and bis(2-ethylhexyl)phthalate (20 to 25 μg/L) were detected in the groundwater and surface water samples of Landfills No. 2 and 1, respectively. No EPA human health standard has been established for di-n-octyl phthalate. Wire cable whose outer sheath is comprised of plastic and rubber has been buried in the landfills and could explain the presence of these compounds.

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

The <u>Final Report for the Remediation of PCB Contamination at Woodbridge Research Facility</u> was completed by Roy F. Weston, Inc. in 1986. The report details site preparation, removal and disposal operations for PCB contamination, and restoration at Landfill No. 2. The analytical results of composite soil sampling during remediation at Landfill No. 2 indicated that the highest PCB concentrations were found at the burial of the transformers and capacitors. Pursuant to the request of USATHAMA, all soil piles containing detectable PCB concentrations (greater than 0.6 μg/g) were removed from the site and disposed at the Chemical Waste Management hazardous waste landfill facility in Model City, New York. Groundwater sampling was performed at all monitoring well points adjacent to Landfill No. 1 and Landfill No. 2. The results of groundwater monitoring three months after closure of Landfill No. 2 indicated non-detectable levels (less than 0.6 μg/L) of PCBs. In 1986 Weston implemented a five year groundwater monitoring program for Landfill No. 2. PCB concentrations of up to 7 μg/L were found in groundwater samples from MW2 and MW3. Sampling of the monitoring well network at Landfill No. 1 over approximately four years did not result in the detection of PCBs in the groundwater.

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

An Environmental Assessment of the Woodbridge Research Facility Operations at Woodbridge, Virginia was completed by the U.S. Army Laboratory Command (LABCOM), Harry Diamond Laboratories at WRF, and LABCOM's Installation Support Activity in 1989. This assessment was required by the National Environmental Protection Agency (NEPA). Its purpose was to determine if the day-to-day operations at WRF have any significant impact on the surrounding environment. No samples were collected.

An Enhanced Preliminary Assessment, Woodbridge Research Facility, Virginia (1992) was prepared by Roy F. Weston, Inc. for USATHAMA. Twenty-nine Areas Requiring Environmental Evaluation (AREEs) were identified. The AREEs include landfills (including Landfill No. 1 and Landfill No. 2), a pistol range, oil-contaminated areas, waste handling areas, storage areas, test areas, underground storage tanks (former and existing), transformers, oil/water separators, asbestos, drainage ditches, and spill areas. The report presents a summary of findings for each AREE, environmental concerns due to the AREE hazardous materials, and recommendations for further action. The AREEs serve as the basis for the Site Inspection/Remedial Investigation (SI/RI) to be performed by EARTH TECH.

A Community Environmental Response Facilitation Act (CERFA) Report first published in October 1993 identified two additional AREEs (AREEs 29 and 30). The CERFA report, finalized in April 1994, was provided as a mechanism for installations for closure to identify "clean" areas for property transfer.

A preliminary phase of SI activities was conducted by the U.S. Army at WRF in September - October 1993. A final SI Report was completed in May 1995. The results of the Preliminary SI led to a SSI and a VADEQ Response Action. This TSAP addresses activities to be performed during this phase of the investigation at WRF.

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SECTION 2.0
ENVIRONMENTAL SETTING

This section begins with a brief description of the surrounding demography and land use. The section continues by describing physical features associated with the environmental setting at the WRF, including topography and surface water, soils, geology and hydrogeology, meteorology, and ecology.

2.1 SURROUNDING DEMOGRAPHY AND LAND USE

This section includes discussions of population and land use. Also provided is an outline of the cultural environment associated with the WRF.

2.1.1 Population

According to a 1991 estimate, the population in Prince William County is 219,033, and Woodbridge has a population of 30,860. 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.

2.1.2 Land Use

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 William County Zone 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 which are administered by the U.S. Army Engineer Center and Fort Belvoir, Fort Belvoir, Virginia.

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

2.1.3 Cultural Environment

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

2.2 TOPOGRAPHY AND SURFACE WATER FEATURES

The WRF lies entirely within the Coastal Plain physiographic province, less than 5 kilometers east of the Piedmont Province. The WRF is situated on a neck of land on the west side of the Potomac River. 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).

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 facility is also bisected by an unnamed creek originating from residential and partly industrialized areas to the north. This creek flows around the main compound and is fed by several smaller drainage lines before eventually feeding to Belmont Bay. Several additional drainage ditches are also found on the property. These waters are tidal tributaries of the Potomac River and are classified by the Commonwealth of Virginia as Class II waters. Figures 2-1 and 2-2 depict the surface water drainage patterns and flow directions found at WRF. The facility is located in the Occoquan River drainage basin of the Occoquan watershed.

2.3 SOILS

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

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

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

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

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

Continued

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

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

Continued

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

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

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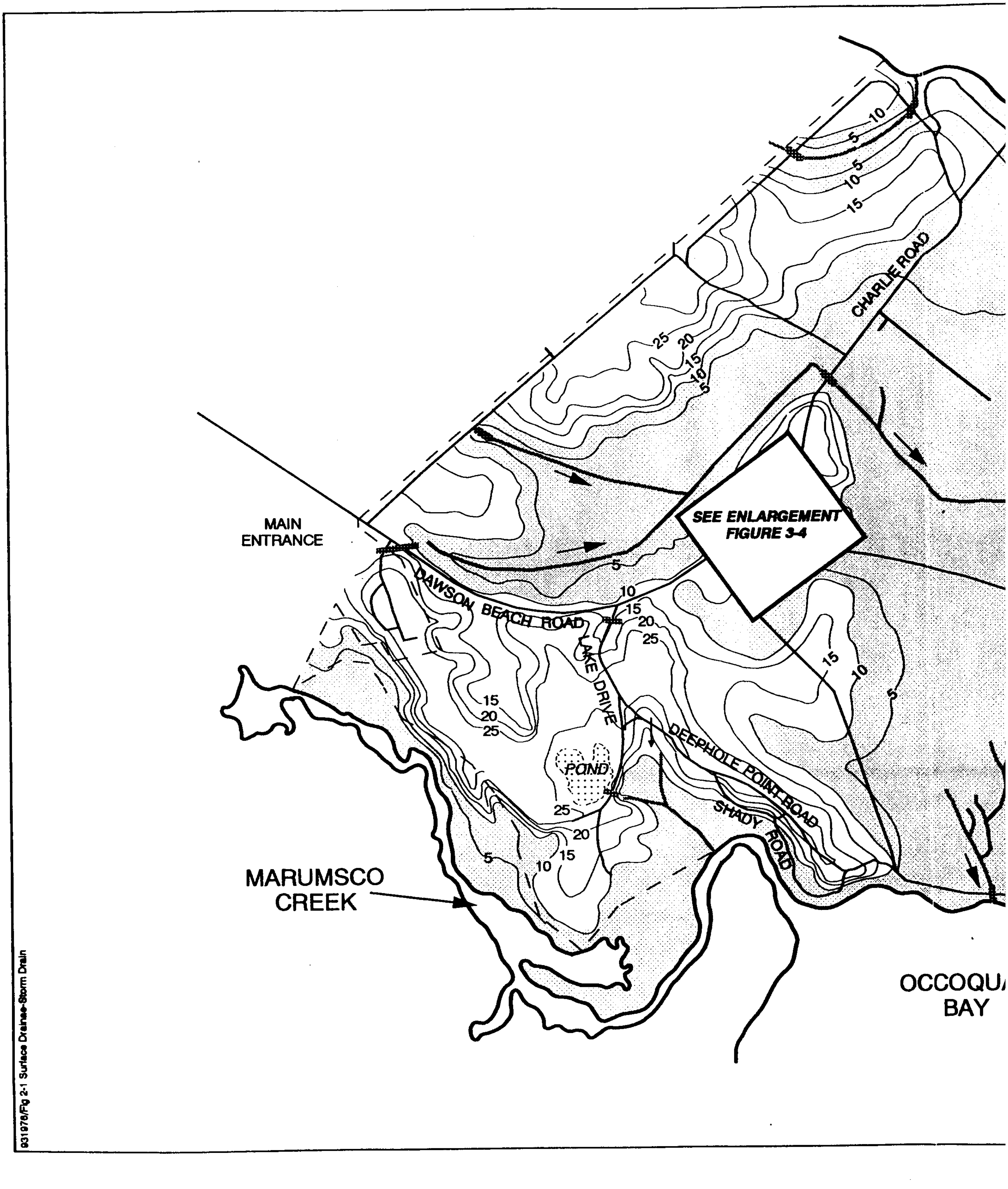

93197б/Fig 2-1 Surface Drainage-Storm Drain

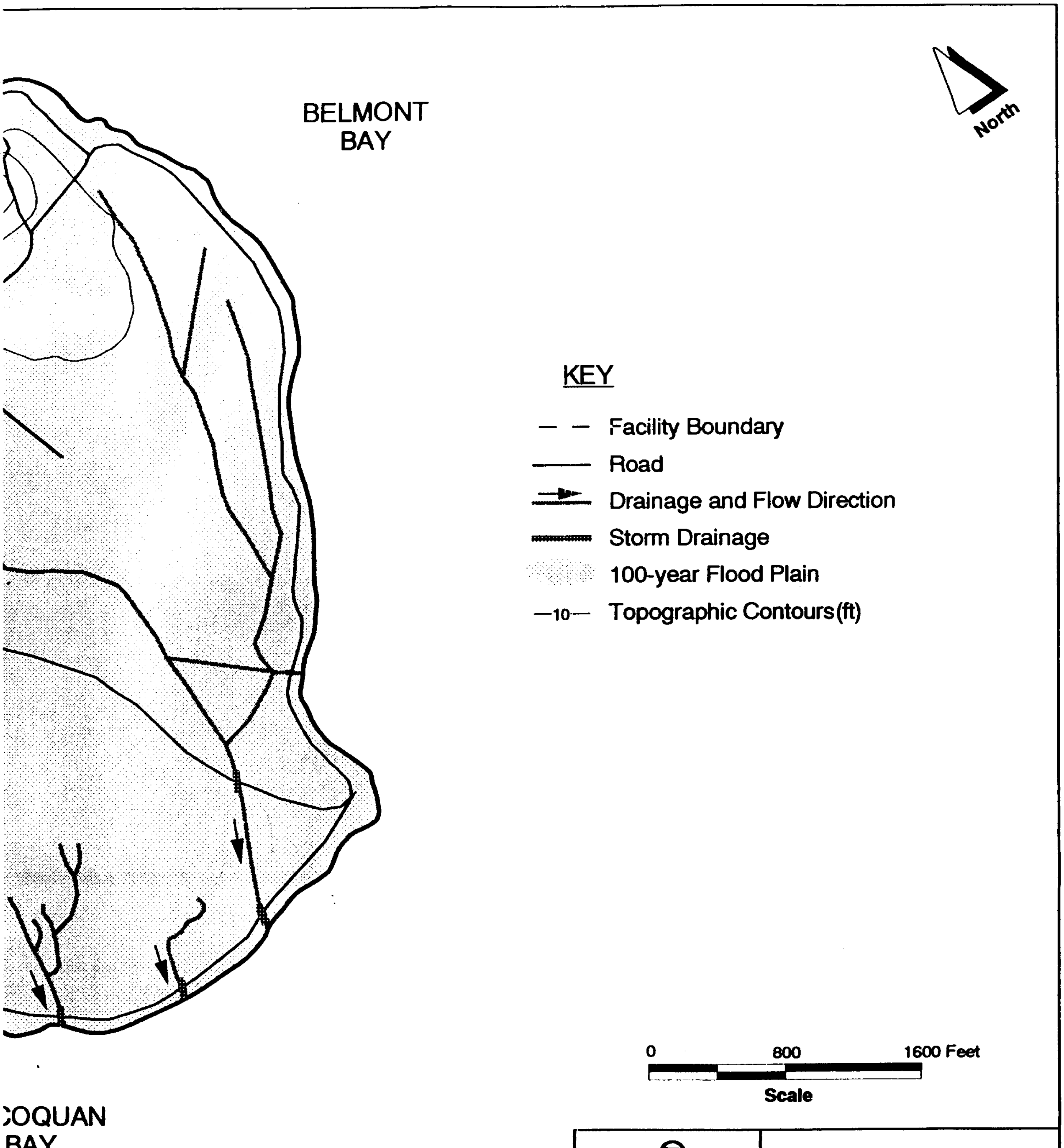

FIGURE 2-1

**Woodbridge Research Facility
Surface Drainage and Floou Plain
Boundaries**

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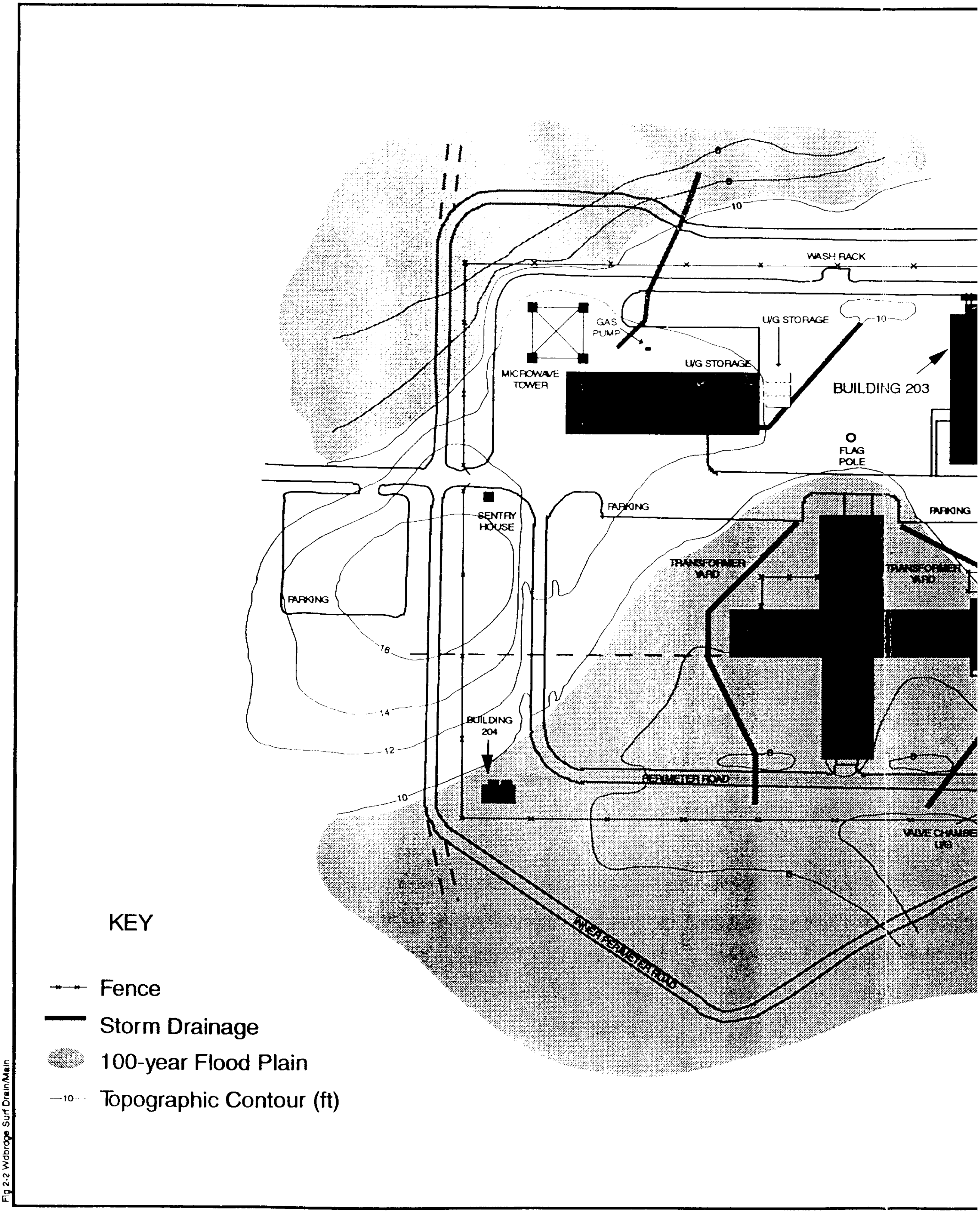
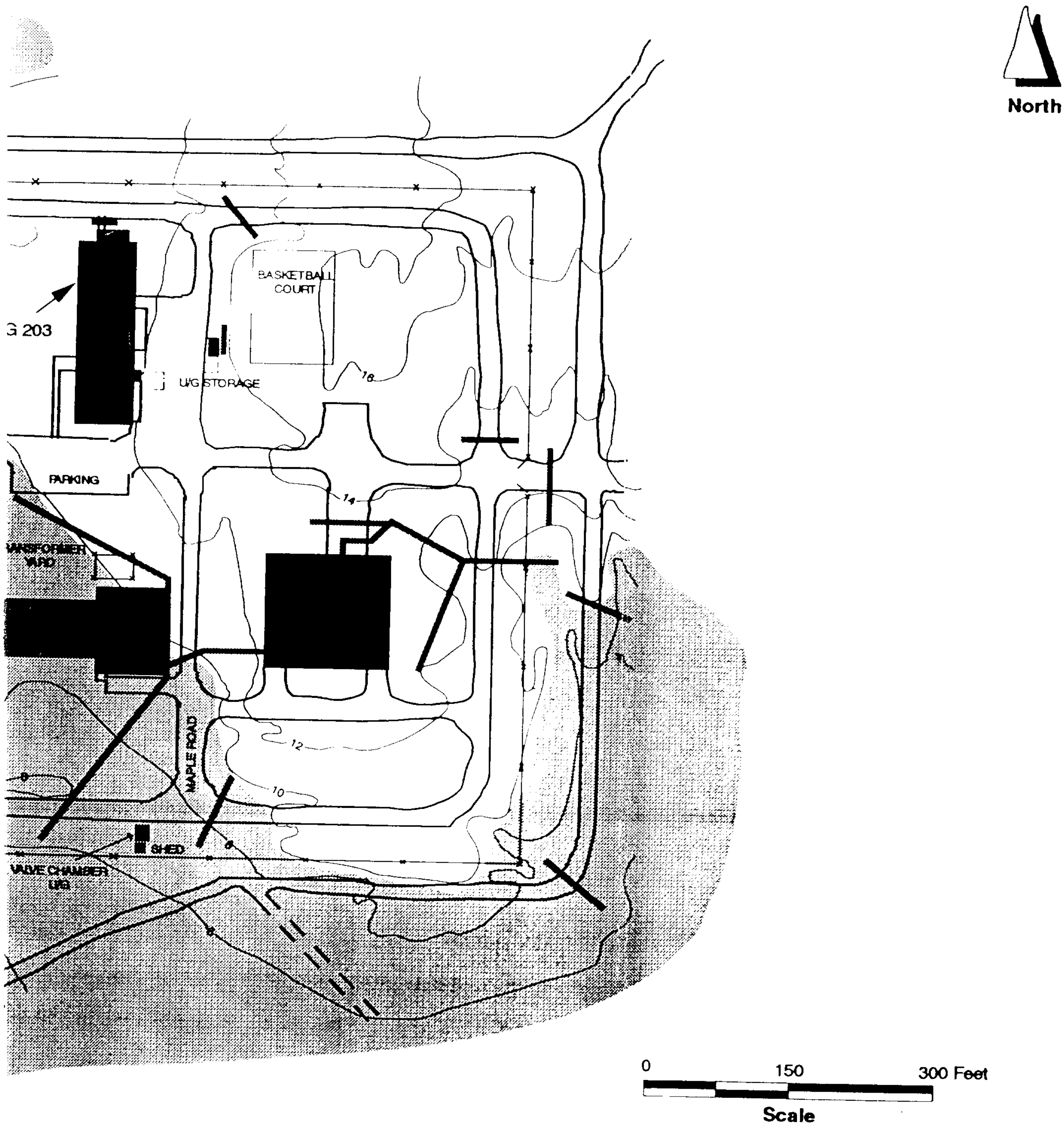


Fig 2-2 Wdbridge Surf Drain/Main



EARTH TECH

FIGURE 2-2

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

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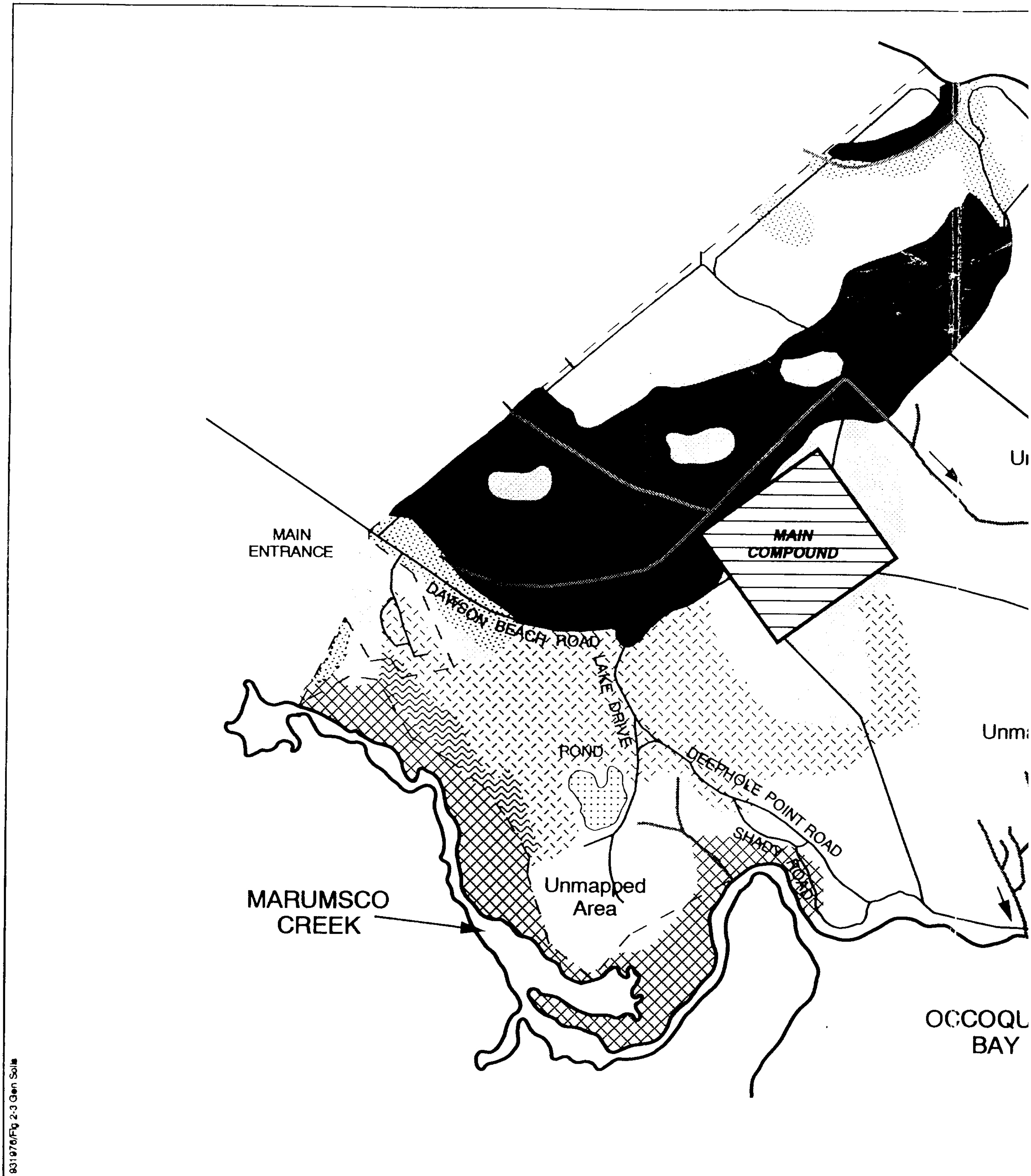

931976/Fig 2-3 Gen Soils

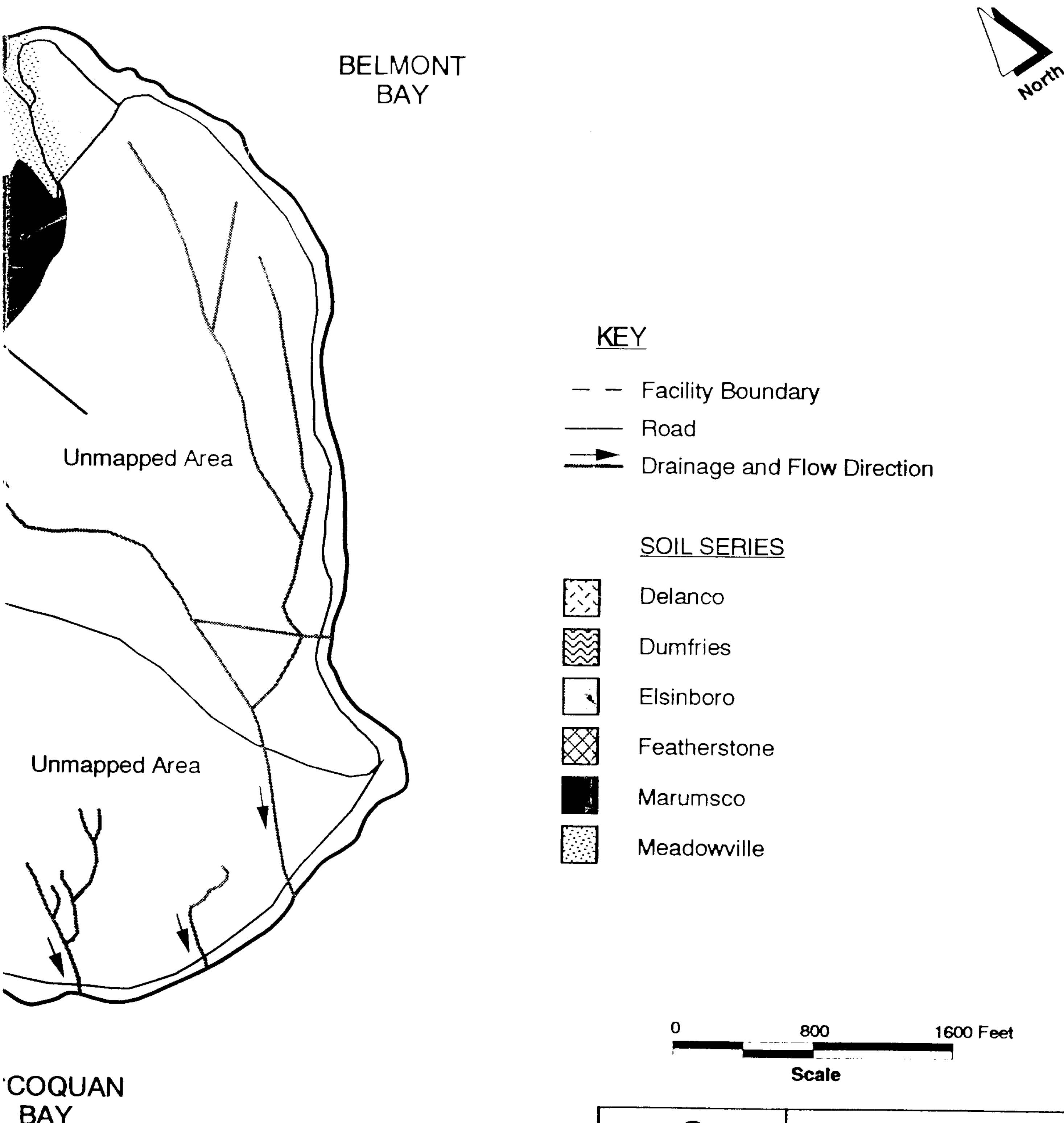

FIGURE 2-3

**Woodbridge Research Facility
General Soils Map**

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- ★ ***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.

- ★ ***Elsinboro 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.

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

2.4 GEOLOGY AND HYDROGEOLOGY

2.4.1 Geology

The WRF is comprised of Coastal Plain sediments that dip and thicken toward the east to form a wedge. Underlying the coastal plain sediments are undifferentiated Paleozoic meta-sedimentary and meta-igneous rocks. Well borings performed by the U.S. Geological Survey (USGS) indicate that bedrock depth ranges from approximately 94 to 105 feet below ground surface (bgs) less than one-fourth mile to the northwest of WRF. However, two wells drilled into the lower Potomac aquifer approximately one-half mile away in the central part of the WRF site indicated bedrock at a depth of approximately 150 feet bgs. The sediments overlying bedrock are principally gravels, sand, and clay of the Cretaceous-age Potomac Group. The upper surficial sediments include terrace and alluvial deposits of Pleistocene and Holocene (recent) ages. Descriptions of the types of units as described by the USGS are given below.

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

TYPE 1 Type 1 deposits consist of medium to coarse feldspathic quartz sand, very light gray to pinkish gray in outcrop; fresh material in test borings may be greenish gray; locally oxidized to yellow, orange, and brown. Matrix is clay-silt that may constitute 40 percent or more of the sediment. Crossbedded sand units are generally 0.5 to 4 feet thick; trough crossbedding predominates. Gravelly sands contain pebbles and cobbles of vein quartz and quartzite or, less commonly, other metamorphic rock types. Intraformational conglomerate clasts are pebbles of clay and silt; locally, boulders of clay-silt are as much as 2 or 3 feet in maximum dimension. Type 1 sediments probably represent channel-lag and channel-bar or point-bar deposits.

TYPE 2 Type 2 deposits consist of silty clay, clayey silt, and clayey fine sand; greenish gray; commonly mottled red or reddish brown; clay minerals are predominantly montmorillonite and illite. Commonly forms clay-silt plugs, 2 to 10 feet thick and 60 feet or more wide, within a dominantly medium to coarse sand sequence. Plugs are probably the result of filling of abandoned stream channels by fine sediments during flood stages. Coalified stems of plants, including trunk-size material 1 foot or more in diameter, are common in Types 1 and 2; silicified tree trunks are present but rare.

TYPE 3 Type 3 deposits consist of dark yellowish-brown to olive-gray lignitic sandy silt and clay; contains well-preserved leaf and stem impressions of ferns, cycads, and gymnosperms. Occurrences as thin to thick beds within Type 1 sediments 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 correlate with Potomac River deposits mapped in the Quantico quadrangle (Mixon *et al.*, 1972).

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

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

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

2.4.2 Hydrogeology

Groundwater availability in the Coastal Plain sediments is generally good, although the limited areal extent and relative thinness of the sediments in Prince William County restrict the amount that can be developed.

The surface of the water table is rarely flat, usually displaying undulations conforming to the topography. The water table is higher under hills than under valleys. However, the relief of the water table surface is more subdued than the topographic relief. Therefore, the depth to the water table is greater under a hill than under a valley. The rate of movement ranges from a few inches per year to a few feet per day.

Due to the presence of laterally extensive sand beds, Coastal Plain sediments are good aquifers. 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. Unfortunately, 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

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

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

Water service is provided by the Prince William County Service Authority (PWCSA). Prior to obtaining water from the PWCSA, the facility's water requirements were supplied by on-site wells. There are two deep wells located 1,400 feet southeast of the main compound. Reportedly, an abandoned in-place 4-inch water line connects Well No. 1 to Well No. 2, and an abandoned in-place 6-inch water line extends from Well No. 2 to the main compound. Well No. 1 is abandoned with no pump. Well No. 2 has an inoperative 30 gpm pump. From the main compound, an abandoned in-place 2-inch water line extends to the pond along Lake Drive. There is a potential for the wells to provide water only to the pond. The water is considered to be non-potable due to its recent history of disuse. There is no plan to upgrade the well system or to restore it as the facility's water source. Depths to the water table are variable, ranging from at or near land surface in low marshy areas, to within 3 feet of land surface in the topographically flat areas where the two existing wells at WRF are located, to an undetermined depth below land surface in the higher, better drained areas.

2.5 METEOROLOGY

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 (National Resource Management Plan (NRMP), 1991).

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

2.6 ECOLOGY

2.6.1 Wetlands

Approximately 150 acres of WRF is 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*)
- ★ Pickerelweek (*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 (*Nuphan variegatum*)

The WRF is bordered on the west by Marumsco National Wildlife Refuge, a large wetland system that, along with the WRF's wetlands, serves as a feeding areas for many species of resident and migratory waterfowl and shorebirds. Herons, Black Ducks, Mallards, Wood Ducks and Canada Geese nest here. From a joint program with the U.S. Fish and Wildlife Service (USFWS) and the Laboratory, 375 plant species, 200 bird species, and other wildlife have been documented in the Marumsco National Wildlife Refuge/WRF area.

2.6.2 Flora and Fauna

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

A fence around the installation controls immigration and emigration of large species (primarily white-tailed deer). The primary activities affecting populations at WRF are deer hunting, fishing, and pond stocking. Hunting was permitted on the WRF by authority of the HDL Memorandum 420-74, and authorized by the Cooperative Plan

Agreement for the Conservation and Development of Fish and Wildlife Resources. In the past, duck, dove, and white-tailed deer hunting were allowed on the WRF. The facility's white-tailed deer population averages 175 in September of each year. The staff at the WRF worked closely with the Virginia Department of Game and Inland Fisheries to set annual harvest limits. Hunting removed between one-third and one-half of the deer population annually. About half of the animals harvested were does. The last U.S. Army-sponsored deer harvest occurred in 1994. The U.S. Army will no longer conduct and manage deer harvests.

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

Habitat for a number of raptors, including the Bald Eagle, is present on the facility. Although no eagle nests have been documented, Bald Eagles use the site as a resting and feeding area, primarily along the shore from Marumsco Creek to the old picnic grounds. Ospreys, Red-Shouldered Hawks, Red-Tailed Hawks, and Great Horned Owls have been documented as nesters on the WRF.

SECTION 3.0
FIELD OPERATIONS

3.1 SITE RECONNAISSANCE, PREPARATION, AND RESTORATION

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

The ARL, in coordination with U.S. Army Environmental Center (USAEC), will provide the following:

1. Accumulation points on the base where any drill cuttings or well discharge fluid containers can be placed.

2. Existing engineering plans, drawings, diagrams, aerial photographs, etc., to facilitate evaluation of tank or underground utility locations.

3. Personnel identification badges, vehicle passes, and/or entry permits.

4. A secure staging area for storing equipment and supplies.

5. A paved decontamination area with an electrical supply and potable water supply.

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

A staging area will be designated or constructed for storing equipment and supplies, including a decontamination area and a storage area for solid and liquid wastes generated during the field tasks. Access to electrical and telephone utilities will also be provided for office trailers.

An area within the staging area will be designated as the Materials Storage Area. Well construction materials, empty drums, decontaminated equipment not currently in use, and the project field office trailer will all be kept in this area.

The area designated as the Equipment Decontamination Area will be large enough to accommodate a backhoe or a drilling rig. Decontamination waters, mud, etc., may be contained within the central sump. Water will be periodically pumped from the sump into EARTH TECH-provided holding tanks or Baker Tanks brought on-site for liquid storage. Solid wastes generated from equipment decontamination will be stored in bulk containers or 55-gallon drums.

Emergency equipment (e.g., fire extinguishers, personnel safety equipment, etc.) will be kept in plain view in an easily accessible area at each site where work is being conducted. If available, each work crew will be equipped with a mobile phone or two-way radio in communication with the field office in order to quickly alert the appropriate base emergency service should their assistance be required.

The objective of site restoration is to leave the area of investigation essentially as it was originally, except for the physical addition of monitoring wells and guard posts. Soil cuttings, unused well construction materials, and stakes and flagging will be removed from each site at the conclusion of work. Minimal disturbance of vegetation or increases in erosion potential are anticipated as a result of this effort. Site restoration also includes close coordination with WRF personnel to ensure that clean-up operations are in accordance with the overall management of their operations.

3.2 Geophysical Surveys

All geophysical activities will be supervised by an experienced geophysicist. Data collection, reduction, and interpretation will follow procedures described in Zohdy *et al.* (1974), Benson *et al.* (1984), and USEPA (1987). Equipment calibration procedures are described in Section 5.2. A detailed log of geophysical activities will be maintained by the site geophysicist.

Several surface geophysical techniques will be used to detect buried utilities or other objects at appropriate sites and soil borehole and monitoring well locations. Results will be used to position the drilling sites to avoid buried hazards. The survey activities will be coordinated with the ARL personnel and USAEC Point-of-Contact (POC).

The geophysical methods used for these surveys are electromagnetic indicator (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 will be used because underground utilities are made of many different materials (ferrous steel, aluminum, polyvinyl chloride (PVC), and ceramic). EMI profiling can detect changes in electrical properties. GPR responds to changes in dielectric properties. Magnetics can detect only ferrous objects. Using a combination of these techniques increases the confidence that buried hazards will either be detected and avoided, or if the desire is to investigate, detected and examined. Geophysical surveys will 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 will be collected with a Radio Detection RD-600/400 system. Effective penetration depth is 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 (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 will be collected with a Geophysical Survey System, Inc. Model 3 using the 120-Mega Hertz (MHz), 300-MHz, and/or 500-MHz antennae depending on the desired penetration and target resolution. Effective penetration depth is 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 will be collected with a Schonstedt GA-52BG radiometer. Effective penetration depth is about 10 feet.

3.3 EXCAVATION

Excavation is planned to locate the extent and depth of contamination at several sites as well as allowing visual observations of the subsurface. Trenches or test pits can be dug to collect samples representative of the area. Excavation will be done with backhoes and front loaders. Backhoes excavate from a stationary position, which is beneficial to prevent cross contamination at a site. Front loaders may be used for stiff materials and large areas.

The walls of the excavation should be as near vertical as safety permits. When excavating a trench, the width should not be greater than the bucket width. Test pits can cover a greater area. The operator will be informed where to deposit the excavated material. At the main compound, all exhumed soil will be placed on plastic directly beside the excavated trenches, in the event that the excavated soil is contaminated. At the sites outside the main compound, the heavy vegetation and/or variable terrain may inhibit the use of plastic. In these cases, the exhumed soil will be placed directly beside the excavated trenches. Samples will be collected as described in Section 4.1.1. All activities, including lithological descriptions, will be recorded on the Excavation Log Form. Air monitoring with an organic vapor analyzer (OVA) or HNu will be conducted continuously in the excavated area and in the breathing zone. Trenches or test pits will be backfilled with the exhumed soils upon completion.

3.4 DIRECT PUSH SAMPLING

The direct push method was used during the Preliminary SI to collect soil and groundwater samples for several sites.

If direct-push sampling is to be employed, soil samples will be collected by hydraulically driving a 1.25-inch diameter piston-type sampler to the top of the desired sample interval (conditions permitting). The piston within the sampler will then be released and the pipe will be advanced through the target interval. The soil core will enter the sampler, which contains a new non-reactive plastic or stainless steel liner. After the drive rod is removed from the soil, the liner containing the soil column can be removed. The soil will be removed from the liner while being monitored with an OVA. Visual observations and OVA readings will be recorded. With the exception of soil samples collected for volatile analyses, the soil will be homogenized and then transferred to the sample containers via stainless-steel scoop for a grab sample. Replicates can be put in separate sample containers from the homogenized soil. Soil collected for head space analysis will be agitated and aerated as little as possible prior to sealing the sample jar.

Prior to the collection of groundwater samples, all sampling equipment will be decontaminated by washing with a non-phosphate, non-volatile cleaner and distilled water. The hydraulic probe will be used to drive 1.25-inch diameter steel pipe to the prescribed depth (conditions permitting) at each location. The bottom of the pipe will be opened to allow water to enter from the soil. The actual depth to groundwater will be measured in the initial hole. Samples of groundwater will be collected with a Teflon™ sampling tube or a stainless steel mini-bailer lowered through the steel pipe. Water samples will be stored in the appropriate container as specified by the analysis to be performed. Containers will be rinsed three times with sample location water prior to filling.

3.5 DRILLING

This section describes the drilling methods and associated activities to be used for drilling the soil boreholes for collecting soil samples and for monitoring well installation. Drilling and sampling activities will be supervised by a registered geologist, certified engineering geologist, or professional engineer. A detailed log of the drilling activities and materials encountered will be maintained by the site geologist or hydrogeologist. Drilling and sampling methods will follow procedures described in the *USATHAMA Geotechnical Requirements for Drilling, Monitor Wells, Data*

Acquisition, and Reports (USATHAMA, 1987), the *RCRA Ground Water Monitoring Technical Enforcement Guidance Document* (USEPA, 1986b), and *A Compendium of Superfund Field Operations Methods* (USEPA, 1987). The method to be used during drilling of the soil boreholes and monitoring wells will be hollow-stem auger (HSA). No drilling fluids will be used. The method is described below.

BOREHOLE AND MONITOR WELL DRILLING

All soil boreholes will be drilled using HSA techniques. Six-, 8-, or 10-inch outside diameter (O.D.) continuous-flight HSAs in 5-foot sections will be forced into the ground while rotating. A special auger bit or cutter head is attached to the leading flight section and cuts 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.

3.5.1 Borehole Drilling

Boreholes will be sampled continuously to the water table following procedures described in Section 4.1.1. Using the HSA technique, a 6- or 8-inch O.D. hole will be drilled for collection of soil samples to the depth of first groundwater or the bedrock surface. Drilling will be performed to document hydrologic conditions, lithologically log the borehole, and allow collection of subsurface samples for chemical analysis.

Boreholes drilled for soil sample collection will be grouted after the borehole is logged and samples are collected. The grout slurry will consist of a mixture of Type II or Type V Portland-type cement and powdered sodium bentonite in a 20:1 mixture with a maximum of 8 gallons of potable water per 94 pound bag of cement. Grouting will be done either while the augers are being removed, or, if the borehole remains open, after the augers have been removed. The slurry will be tremied from the bottom of the borehole to the ground surface. All soil cuttings generated during drilling will be handled as described in Section 3.11. All downhole drilling equipment will be decontaminated before moving to each new drilling location following procedures described in Section 3.10. Each borehole location will be permanently marked, including the boring number, and the location will be recorded on a project map for each specific site or area.

Drilling records will be kept in the daily field logbook for the program and on logs for each borehole. The items to be included in the daily field logbook are described in Section 7.0, Recordkeeping. Information is also recorded on the field borehole log in compliance with the existing USATHAMA (now USAEC) guidance.

3.5.2 Monitoring Well Drilling

Monitoring wells will be installed in order to collect groundwater samples. Procedures given in the previous section will be followed for the drilling of monitoring wells.

Hydrologic and lithologic information will be obtained from the cuttings at 5-foot intervals. Any changes to the proposed wells will be documented in the daily field logbook. Well drilling records will be kept in the field daily logbook and on the borehole logs. Storage and disposal of drill cuttings will be handled as described in Section 3.11.

3.5.3 Air Monitoring During Drilling

Air will be monitored during all drilling and sampling activities from various locations. An OVA using a flame ionization detector (FID) or an HNu using a photoionization detector (PID) will be used to monitor concentrations of total volatile organic compounds (VOCs) at various locations of the exclusion zone, in the breathing space at worker chest level, and down the borehole immediately below the ground surface. Air monitoring concentrations will be recorded in the remarks column on the borehole logs. If air concentrations exceed those specified in the Site Health and Safety Plan, drilling will be stopped and appropriate action taken according to the guidelines established in the Site Health and Safety Plan.

3.6 WELL INSTALLATION

Well installation will include well construction, well head completion, and well development. These procedures follow methods described in the *USATHAMA Geotechnical Requirements* (March 1987), the *RCRA Ground Water Monitoring Technical Enforcement Guidance Document* (USEPA, 1986b), and the 1973 Virginia Groundwater Act.

3.6.1 Well Construction

Monitoring wells will be completed using Schedule 40, 4-inch inside diameter (I.D.) PVC riser pipe with USAEC approval. All well screens and submerged casing will be constructed of PVC. All well casings will be flush threaded. Samples of the water bearing formation will be collected during drilling for field sieve analysis. The results of the sieve analyses will be used to select the appropriate screen slot size and filter pack for each monitoring well. The particle size of the filter pack material will be four to six times the 70 percent sieve size of the formation material (USEPA, 1975). The screen slot size will be chosen to prevent 90 percent of the filter pack from passing through it into the well. In general, if the wells are screened in fine-grained materials, 0.01-inch slot well screens with Lonestar #2 sand will likely be used. If the wells are completed in coarser-grained materials, 0.02-inch slot well screens with Lonestar #3 sand may be used.

Screen and casing sections will be inspected, and if necessary, will be steam cleaned at the Equipment Decontamination Area, wrapped in plastic for transportation to the monitoring well location, and assembled at the ground surface. The casing will be kept covered and on a plastic ground cover to avoid contamination until the casing is lowered down the borehole.

Wells will be screened within the unconsolidated alluvial sediments beneath the site. For wells to be completed to monitor the upper part of the water-bearing formation, sufficient well screen will be placed so a minimum of 5 feet of screen extends above the water table to accommodate water level fluctuations. This will allow for detection of floating hydrocarbons on the water surface even in the event of water table fluctuations. Blank well casing (riser pipe) will be placed from the top of the well screen to the ground surface. The well casing will be sealed at the bottom with a threaded base plug and at the top with a locking, vented well cap. The well casing will be plumb and centered in the borehole.

Once the casing is installed, the filter pack, consisting of washed and graded silica sand sized according to the field sieve analyses, will be placed in the annulus between the well casing and the borehole wall. The sand will be furnished in sacks and will be clean and free of oil, acid, organics, or other deleterious material. The filter pack will be placed from the bottom of the borehole to approximately 5 feet above the top of the well screen. The filter pack material will be slowly introduced into the annular spacing between the drill casing and the well casing. Either the annular space will be used to conduct the sand, or a tremie pipe will be inserted into the annular space to conduct the sand.

The volume of filter pack material used will be recorded in the field log book during well construction. The filter pack depth will be periodically measured to monitor the depth and the volume of sand used will be compared to the volume of annulus filled each time a section of drill casing is pulled up and removed to locate any points of bridging between the well casing and the borehole wall. If a significant discrepancy arises between the sand volume used versus the filled volume measured, the source of this error will be identified and mitigated. Potable water down the annulus may be used to break bridges if they are encountered. The amount of water introduced into the well will be kept at a minimum, and the quantities will be recorded in the field log book.

After the filter pack has been placed, a 5-foot, pure sodium bentonite seal (either granular for unsaturated conditions or pellet form for saturated conditions) will be introduced down the annulus above the filter pack. The bentonite will be saturated with potable water and allowed to hydrate for 1 hour. After the bentonite seal has hydrated, the remaining annulus will be grouted using a Type II or Type V Portland cement/bentonite slurry. The slurry will consist of a 20:1 ratio by weight of cement to bentonite with a maximum of 8 gallons of potable water for each 94 pounds of dry grout mix. The bentonite will be free of additives that may affect water quality. The grout will be pumped into place using a tremie pipe. For shallow wells, the height of bentonite seal may be reduced with USAEC approval.

3.6.2 *Well Head Completion*

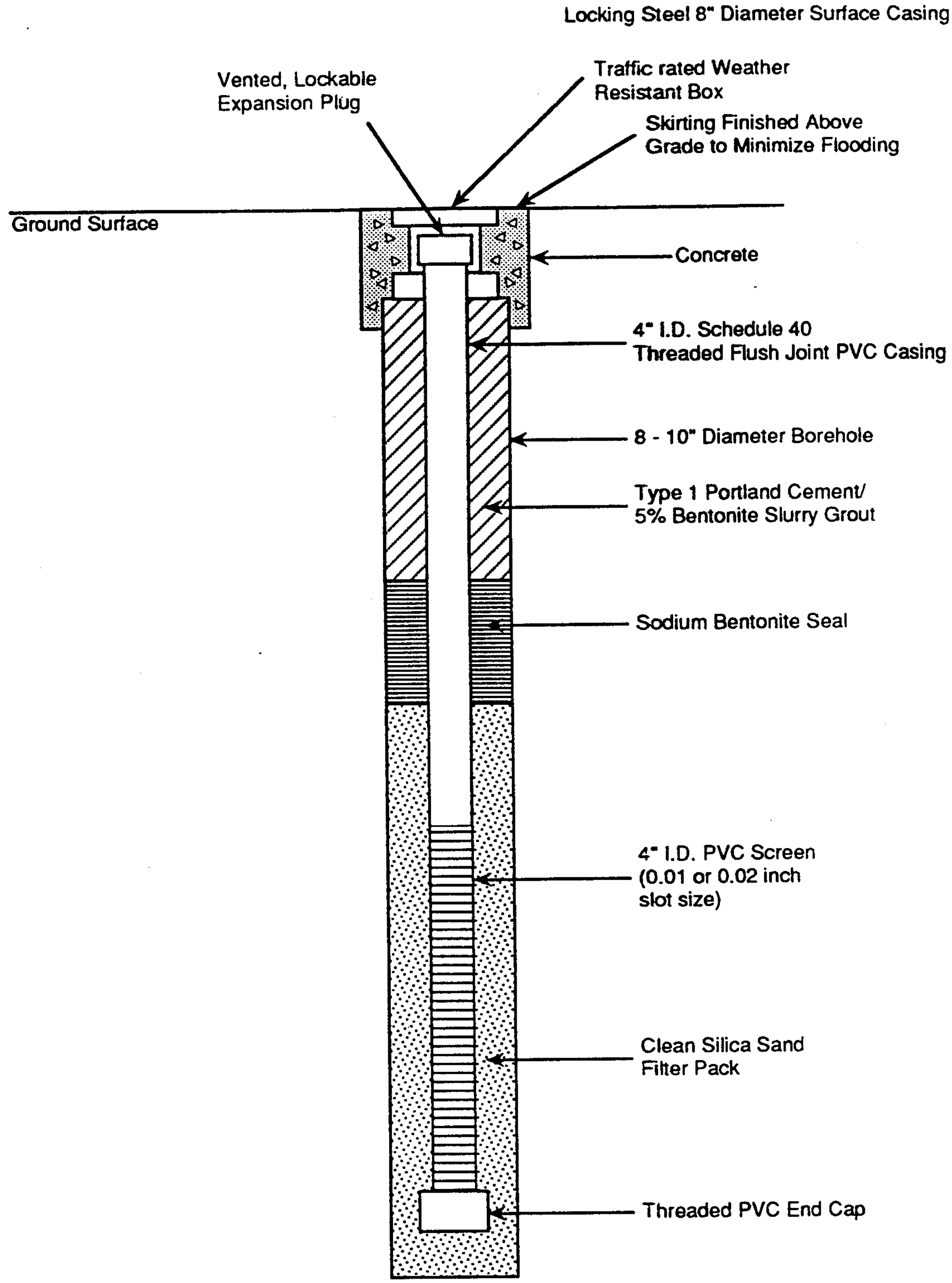
The monitoring wells will be completed either flush with the ground surface or sticking up above the ground surface, depending on site conditions. The USAEC POC will decide which method will be used to complete each well.

If wells are to be completed in high-traffic areas or other locations where wells will not be permitted to extend above the ground surface, they will be completed flush with the ground surface as follows: the casing will be cut 2 to 3 inches below the ground surface, and a cast-iron assembly with a protective lid will be centered over the well casing. The assembly will be centered in a 3-foot-diameter concrete pad which is sloped away from the assembly to avoid surface accumulation of water. Drain pipes and pea gravel may be placed in the assembly to allow for free drainage of surface water within the assembly. A minimum 4-inch clearance will be maintained between the well casing top and the bottom of the assembly. A locking well cap with an expandable seal will be used. The well number will be clearly marked on the assembly cover and inside the well casing using an impact method. The northern side of the top of the inside well casing will be notched for use as a water level datum point. Figure 3-1 shows a typical monitoring well design with a flush-grade completion.

If an aboveground surface completion is desired, the well casing will be extended 2 to 3 feet above the ground surface. An 8-inch-diameter steel guard pipe will be placed over the well casing and seated in a 2-foot by 2-foot by 4-inch concrete surface pad. The pad will be sloped away from the well casing. A lockable cap or lid will be installed on the guard pipe. A vented well cap will be placed on the inside well casing. The inside casing will be notched on the north side for use as a water level measurement datum point. Four 3-inch diameter concrete-filled steel guard posts will be installed. The guard posts will be 5 feet in length and will be installed radially 3 feet from the wellhead. The guard posts will be recessed 2 feet into the ground and set in concrete. The posts will not be set into the concrete pad placed at the well base. Each well will be clearly marked using paint and/or impact lettering. The USAEC POC will specify paint color.

Figure 3-2 shows a typical monitoring well design with an above-grade completion. All wells will be secured as soon as possible after drilling with corrosion-resistant locks. The locks will either have identical keys or be keyed for opening with one master key. The lock keys will be turned over to the USAEC POC following completion of the field program.

Well completion diagrams showing well construction details will be completed by the EARTH TECH geologist/hydrogeologist who supervises the well installation. Well construction activities will be summarized in the field logbook and any changes from the planned well construction will be noted. Lithologic symbols on the completion diagrams will correspond to the descriptions on the borehole logs. The construction



Not To Scale

EARTH TECH

FIGURE 3-1

TYPICAL MONITORING WELL WITH FLUSH-GRADE COMPLETION

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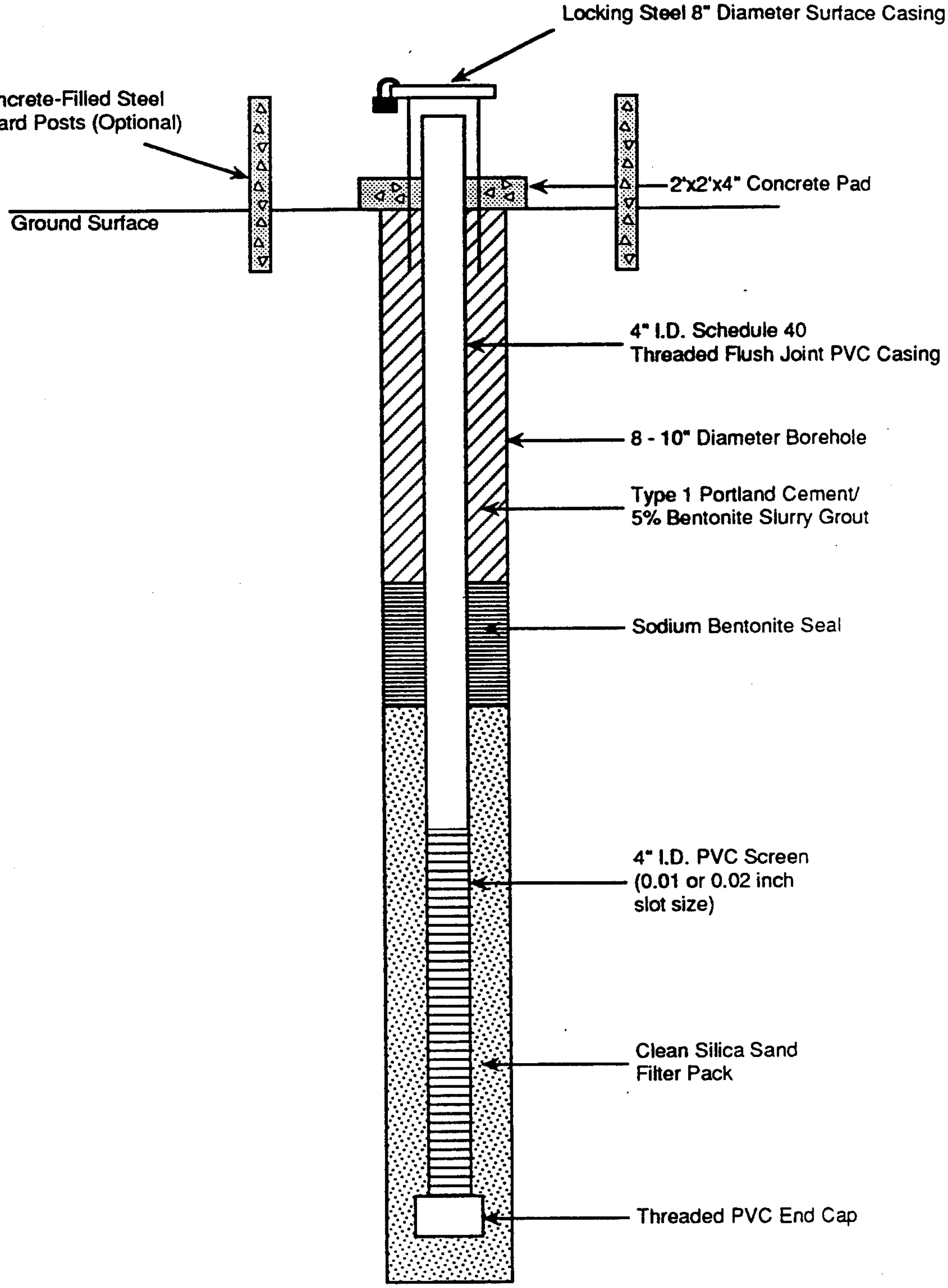

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EARTH TECH

FIGURE 3-2

TYPICAL MONITORING WELL WITH ABOVE-GRADE COMPLETION

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logs will be submitted in the final report as per USAEC requirements, and completion details will be forwarded to permitting agencies by the drilling subcontractors.

3.6.3 Well Development

Each newly installed monitoring well will be developed no sooner than 48 hours following well completion. The wells will be developed using a combination of bailing, surging, and pumping. The fine-grained materials accumulated in the well casing will be bailed from the well with a suction bailer until the bottom of the well casing can be probed. After bailing, the well will be surged using a surge block to flush any fine-grained materials from the filter pack. The well will then be bailed again to remove fine-grained materials until the bottom of the well casing can be probed. After two or more bailings, a submersible pump will be placed in the well and pumped. During pumping, groundwater parameters consisting of pH, temperature, and specific conductance will be monitored and recorded on the Well Development/Purge Log. Water level measurements and pumping rates will also be recorded on the form. Pumping rates will be measured using either the bucket/stopwatch method or an in-line flow meter. The bucket/stopwatch method will consist of pumping the well discharge into a known volume container (usually a calibrated 5-gallon bucket). A stopwatch is started when flow begins entering the container and is stopped when the container is full. This will give the time in minutes and seconds that it took to discharge the known volume of water from the well. This number will be converted to gallons per minute and recorded on the field data sheets. This procedure will be repeated several times to establish an average pumping rate. The gallons pumped during development will be calculated based on the average pumping rate and the total time the well is pumped. The water level drawdown achieved by the end of the purging divided by the total gallons pumped will be recorded as an estimation of specific capacity and recorded on the data sheet.

Wells will be developed until the well water is clear to the unaided eye, the sediment thickness is less than 1% of the screen length, and a minimum of five borehole volumes are removed. If the recharge is slow so the required volume cannot be removed in 48 consecutive hours, or the water remains discolored or excess sediments remain after the five borehole volume removal, the USAEC Project Officer will be contacted for guidance. Well development will be completed at least fourteen days prior to sampling. Wells will be purged prior to sampling (see Section 4.1.3).

Well development water will be handled as described in Section 3.11. Purge equipment will be decontaminated in the same manner as the water sampling equipment (described in Section 4.1.4).

3.6.4 Well Abandonment

Well abandonment may be necessary if wells are identified that require proper abandonment. Wells which require abandonment include wells which were installed improperly or wells which are no longer functional (i.e., representative groundwater samples can no longer be obtained). Before any well abandonment procedures are performed, a well decommissioning work plan will be submitted and approved by USAEC and the Commonwealth of Virginia. Wells will be abandoned in accordance with procedures outlined in the 1973 Virginia Groundwater Protection Act.

3.6.5 Measurement of Potentiometric Water Levels

Water levels will be measured in all new monitoring wells following completion of well installation, sampling, and aquifer testing. Measurements will be recorded as feet below the measuring point elevation (usually top of casing) to the nearest 0.01 foot and will be referenced to MSL. Measurements will be taken after wells have been developed and prior to any well purging activities. The measurements will be taken within as short a time period as practical so that water levels are representative of a given period. Groundwater contour maps of WRF will be developed based on water level elevations recorded.

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

1. Remove the locking and protective caps.

2. Sample the air in the well head for the presence of organic vapors using either an OVA or HNu.

3. Conduct a visual (mirror) survey of the well.

4. Assess the presence of light (floater) and/or dense (sinker) immiscible layer(s) using an interface probe. If immiscible layers are present, measure the depth of the water and the thickness of the immiscible layer(s).

5. If there are no immiscible layers, determine the static water level depth from the top of the inside well casing (surveyed measuring point) to the nearest 0.01 foot using an electric sounder.

6. Do not measure the depth to the bottom of the well at this time (in order to avoid disturbing any accumulated sediment). Obtain depth to bottom information from well installation log. Calculate standing water volume as: depth of water column times cross-sectional area of the well.

7. Calculate the corrected water level if free product is observed.

Monitoring the air above the well head will indicate toxic potential for workers. Action levels are listed in the Site Health and Safety Plan. The air monitoring may also indicate the presence of immiscible layers. The electric sounder will be used to measure the static water level depth if no immiscible layers are present. If there is an immiscible layer, the interface probe will be lowered down the well to measure both the static water level and light or heavy immiscible layers. The interface probe will first measure the air/floater interface and the floater/water interface to establish the thickness of the floater layer. The probe can then be lowered to the bottom of the well to register the presence of free-phase "sinker" organic compounds. If fuel or other floating hydrocarbons are detected, water levels will be corrected to account for the presence of the floating hydrocarbons using the following equation:

$$PE = MP - WL + SG\,(WL-FL)$$

Where:	PE	=	Piezometric elevation, in feet
	MP	=	measuring point elevation, in feet
	WL	=	depth to water, in feet below MP
	FL	=	depth to fuel, in feet below MP
	SG	=	specific gravity of the fuel (fuel density/water density)

True product thickness will be estimated from the boring logs by noting the first appearance of soil contamination and the depth to groundwater.

The calibrated water level probes, i.e., electric sounders and interface probes, will be decontaminated before use in each well. Decontamination procedures will follow those for the water sampling equipment as described in Section 4.1.4.

The groundwater at the WRF is most likely influenced by tidal effects. To minimize the effects of tidal influence on the groundwater levels measured the measurements for an individual AREE will be collected over as short a time period as possible. With this approach, a comparison of water levels measured from AREE to AREE may not be appropriate; however, comparable measurements for an individual AREE should be acceptable.

3.7 Aquifer Tests

Selected monitoring wells will be tested if additional information is needed to more completely characterize and assess the groundwater conditions beneath the specific area, especially the migration potential of groundwater contamination. The testing will provide data from which hydraulic properties, including hydraulic conductivity, transmissivity, flow velocity, and storage coefficient, can be calculated.

The recommendations for aquifer testing and which wells should be tested will be based on data obtained during-the previous tasks of the geotechnical investigation and the analytical laboratory results of the groundwater samples obtained from the on-site monitoring wells.

Single well tests (commonly referred to as slug tests) will be used to test the localized groundwater system in which the wells are installed. Slug tests can be conducted relatively quickly and easily, and can provide reliable data from which hydraulic conductivities can be calculated. In addition, pumping tests can provide information on the intercommunication of different groundwater systems.

A rising head method or falling head method of slug testing will be performed. Both methods measure changes in hydraulic head over time. The procedure for conducting a rising head slug test will involve instantaneously removing a predetermined volume of water from the well with a bailer and measuring the rise in hydraulic head in the well. The procedure for conducting a falling head slug test will be to instantaneously introduce a predetermined volume of water into the well with a bailer and measuring the fall in hydraulic head. Both types of slug tests are conducted until the hydraulic head has recovered to 90 percent of the static water level that was gauged just before the start of the test. A transducer type continuous data logger instrument will be used to record the water levels in the well being tested and in the nearby observation wells.

The aquifer testing equipment (bailer, hoses and tubing, pressure transducers, etc.) that may be used for aquifer testing will be decontaminated prior to testing wells to prevent the introduction of potential contamination. USAEC approved water will be used for the wash and rinse decontamination procedure.

Pumping tests may also be used in new or existing wells if slug tests do not provide adequate information. Each test will include one pumping well and from one to five observation wells. The tests will consist of a step-drawdown test and a long-term constant rate pumping test. Prior to the long-term pumping test, the optimum pumping rate will be established by conducting a step-drawdown test, consisting of pumping at several discharge rates and plotting drawdown curves. Analysis of these curves will assess which rate will cause enough drawdown to stress the aquifer and not evacuate the well during the long-term pumping test. After the step-drawdown test, the well will be allowed to recover to its static water level before the long-term pumping test begins. The long-term tests will consist of up to 72 hours of pumping and up to 72 hours of recovery. The duration of the pumping test will be kept as short as possible due to the requirement that all water produced be contained, characterized, and treated, if necessary, prior to discharge. A submersible pump will be placed in the pumping well and be pumped at a constant rate for up to 72 hours. When the pumping test begins, water levels will be measured in both the pumping well and nearby observation well(s) and recorded using a HERMIT data logger manufactured by In-Situ Inc. The data logger consists of a data acquisition system connected to one or several pressure transducer(s). The pressure transducer is lowered down the well to a level below the estimated elevation in the well influenced by the lowest tide. The data logger is programmed to record water levels measured by the transducer and converts the measurements from psi to depth-to-water in feet or meters. The data logger takes measurements according to a pre-set logarithmic schedule (Table 3-1) which allows for measurements in shorter time intervals and with greater accuracy than an electric sounder. Water level measurements will be taken periodically using a calibrated electric sounder to check the accuracy of the HERMIT measurements.

TABLE 3-1
HERMIT LOGARITHMIC SAMPLING SCHEDULE

Elapsed Time	Sample Interval	Number of Points
0-2 seconds	0.2 seconds	11
2-20 seconds	1 second	18
20-120 seconds	5 seconds	20
2-10 minutes	0.5 minutes	16
10-100 minutes	2 minutes	45
100-1,000 minutes	10 minutes	90
1,000-10,000 minutes	100 minutes	90
1 week	500 minutes	--

After the appropriate period of pumping, the pumping test will be terminated and the recovery test will begin. Recovery water levels will also be measured in both the pumping and observation wells using the HERMIT data logger. Recovery tests will continue until drawdown recovers at least 90 percent. An electric sounder may be used to take drawdown and recovery measurements in the observation wells if a HERMIT data logger is not available. These measurements will be recorded on an appropriate pump test data sheet.

The discharge from the pumping test will be pumped into a Baker Tank or other containment vessel. If large pumping rates are anticipated, an additional tank may be required for use while the first tank is being emptied. A vacuum truck will empty the tank(s) and properly dispose of the water.

Pumping wells will be selected after all new wells have been installed. Final design of the pump test, including duration, configuration of observation wells, and selection of proper analytical methods (to account for degree of confinement, partial water table penetration, boundary conditions and other factors) will occur once the pumping wells are selected and the hydrogeologic setting is more fully understood.

A hard copy of the drawdown and recovery data will be printed out in the field using the HERMIT field printer. The data will then be transferred from the HERMIT to a portable personal computer. The data will be converted to drawdown and recovery curves using HERMITDM software. The drawdown and recovery data for both the pumping well and observation well(s) will be used to estimate hydraulic conductivity, transmissivity, and storativity for the aquifer using the Graphical Well Analysis Package (GWAP) software. Equations used to analyze the data will depend on the hydrogeologic setting and results of drawdown and recovery curves. These data will be used to estimate contaminant migration potentials.

The equation used to estimate groundwater velocity is as follows (Driscoll, 1986):

$$V = \frac{K\frac{h_1 - h_2}{L}}{7.5\eta}$$

Where:	V	=	groundwater velocity (ft/day)
	K	=	hydraulic conductivity (gal/day/ft^2)
	$\frac{h_1 - h_2}{L}$	=	hydraulic gradient (ft/ft)
	η	=	aquifer porosity
	7.5	=	conversion factor from gal to ft^3

3.8 PCB SCREENING

The D TECH® PCB field test kit is based on an Enzyme Linked Immunosorbent Assay (ELISA). Immunoassay is a technology recognized by the USEPA as a valuable field screening tool. The EPA's Office of Solid Waste (OSW) has issued immunoassay methods for analyses performed under the Resource Conservation and Recovery Act (RCRA). The method for PCBs has been incorporated into SW-846 as Method 4020. The field test results correlate to EPA SW-846 Method 8080.

For the D TECH® PCB field test kit, antibodies specific to PCB are linked to latex particles. PCB molecules present in the sample are captured by these latex particles and collected on the membrane surface of the collection device. A color developing solution is then added, and the presence (or absence) of PCB can be measured with the hand-held DTECHTOR meter for semiquantitative results. The test kit provides results to the 0.5 ppm (μg/g) range. The test kit takes less that 25 minutes to complete the seven required steps.

3.9 SURVEYING

Each new monitoring well and soil borehole location will be referenced to standard horizontal and vertical control (third-order survey) by a licensed land surveyor. Geophysical subsurface utility clearance survey grids will not be surveyed. At least one location will be surveyed along each geophysical grid. For monitoring wells, elevations will be surveyed at the top of the inside well casing and at the ground surface adjacent to the well. The reference point will be clearly and permanently marked on the north side of the inside well casing for future water level measurements. Elevations of the casing will be surveyed to the nearest 0.01 foot and elevations of the ground surface will be measured to the nearest 0.01 foot, referenced to MSL. The horizontal location of each well and borehole will be surveyed to the nearest 1 foot. The new survey will be tied to the same benchmark as the previous surveys and will use the same coordinate system.

3.10 Drilling Equipment Decontamination

Decontamination of drilling equipment is required prior to drilling each soil borehole and monitoring well. Decontamination information will be recorded on a Decontamination Record form. Drilling will be performed from least to most contaminated sites when possible. All downhole drilling tools, bits, drill rods, augers, and drill equipment as well as the rig will be steam cleaned with approved water prior to arrival on site. Equipment will be washed with approved water prior to each borehole.

A decontamination area will be set up for all equipment decontamination. Decontamination materials (solids and fluids) will be drained to a collection sump and disposed in accordance with applicable regulations, following proper chemical characterization and evaluation of disposal options.

3.11 Waste Handling

Investigation-derived hazardous waste generated during the SSI will remain at WRF in a temporary storage area until they can be characterized and properly disposed by EARTH TECH. The appropriate EPA guidance documents, such as "Management of Investigation Derived Wastes During Site Inspection", will be used for handling investigation-derived waste.

Investigation-derived wastes include:

- ★ Materials identified as hazardous during the excavation program
- ★ Cuttings from monitoring well boreholes
- ★ Cuttings from soil boreholes
- ★ Groundwater from development of newly constructed wells
- ★ Groundwater from aquifer tests
- ★ Groundwater from purging of three to six well volumes of water prior to sampling groundwater monitoring wells
- ★ Decontamination fluids and disposable protective clothing and supplies.

These wastes are not always hazardous. Based on the sampling results and field instrument readings, cuttings and groundwater can be spread around their holes or poured into 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 (VR) 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 definitions in the Federal regulations which define 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, reactivity, corrosivity, 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 millimeter (mm) (0.25 inches) per year at a test temperature of 55°C (130°F).

★ ***Reactivity***. A material is reactive if a representative sample of the material has any of the following properties:

- It is normally unstable and readily undergoes violent change without detonating
- It forms potentially explosive mixtures with water
- It reacts violently with water

- When mixed with water, it generates toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment

- It is a cyanide- or sulfur-bearing material which, when exposed to pH conditions between 2 and 12.5, can generate toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment

- It is capable of detonation or explosive reaction if it is subjected to a strong initiating source, or is heated under confinement

- It is readily capable of detonation or explosive decomposition or reaction at standard temperature or pressure

- It is a forbidden explosive or Class A or Class B explosive, as defined in 49 CFR 173.51, 173.53, or 173.88.

★ ***Toxicity***. Wastes exhibit the toxicity characteristic under RCRA if an extract obtained using the Toxicity Characteristic Leaching Procedure (TCLP) from a representative sample of that waste exceeds the regulatory levels listed in Table 3-2. When the waste contains less than 0.5 percent filterable solids, the waste itself, after filtering as specified in the TCLP procedure, is considered to be the extract.

FEDERAL REGULATIONS

As mentioned previously, Federal regulations for the LDR apply in the Commonwealth of Virginia. The LDR 51 CFR 40572 (November 7, 1986) limits the concentrations of hazardous constituents in wastes that can be disposed of on land. These limits are based on Best Demonstrated Available Technology (BDAT) for waste treatment and are specific for different industrial waste streams. For example, F006 refers to wastewater treatment sludges, and F007 refers to spent cyanide plating bath solutions. Since it is impossible to tell what the source of the waste is, the LDR limits cannot be determined. Consequently, the TCLP limits will be used to determine whether disposal in a landfill is appropriate. Disposal limits will be assessed as necessary for those wastes not requiring disposal in a landfill.

MONITORING WELL/BOREHOLE SOIL CUTTINGS

Soil cuttings will be generated in the course of drilling boreholes and monitoring wells. Field screening will be conducted on soil cuttings to evaluate whether they are contaminated. Screening will consist of monitoring using either an OVA or HNu and visual inspection. Soils with elevated OVA or HNu readings (>50 ppm above background) or obvious staining or discoloration will be considered potentially contaminated. All potentially contaminated

TABLE 3-2
MAXIMUM CONCENTRATION OF CONTAMINANTS FOR THE TOXICITY CHARACTERISTICS

EPA HW No.[1]	Contaminant	Regulatory Level (mg/L)[4]
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.

4 1 mg/L = 1,000 µg/L

cuttings will be placed into contractor-supplied containers and temporarily stored at the drilling site. These containers will be periodically moved to the investigation-derived waste storage area where the waste (soil cuttings) will be transferred to bulk containers. All transfer containers shall be steam-cleaned between borings when suspected contaminated cuttings are transported. Transfer containers will be moved in batches to a designated storage area where the roll-offs will be held.

Each bulk container will be numbered, and sources of the cuttings deposited in each container will be recorded in the site geologist's log book and on a Bulk Container Log Form attached to the bulk container. Data to be recorded will include borehole or well number, depth interval and date. Lids will be fastened immediately after filling. Composite soil samples of the drill cuttings will be analyzed for the following parameters: volatile organics, PCBs, ignitability, and TCLP. For volatile organic analysis (VOA), the containers will be filled in a manner which minimizes aeration of the samples so that no headspace exists in the container. The analytical results will be compared with regulatory criteria and standards to assess if the cuttings must be classified as hazardous wastes. If comparison with criteria or standards indicate the cuttings are hazardous, this material will be stored in the waste accumulation area until it is properly disposed of following Federal and State regulatory guidelines. A map of the storage area will be prepared so individual roll-offs can be located when necessary.

Well Development/Purge/Pump Test Water

If water purged from groundwater monitoring wells during well development or prior to sample collection is likely to be hazardous based on site findings and field instrument readings, it will be placed in a temporary storage. The portable tank will be transported to a holding area where the contents will be transferred to a Baker tank(s) for storage, sampling, and laboratory analysis. A record will be kept of the contents of the tank. This record will be updated as additional wastewater from the mobile tanks is pumped into the Baker Tank(s). Water generated by aquifer tests, if likely to be hazardous, will require one or more tanker trucks for temporary storage and transfer to Baker tanks.

Two depth-discrete water samples will be collected from each Baker tank, one from the top and one from the bottom of the tank. The results of the laboratory analyses will be compared to regulatory criteria or standards to assess if the well development/purge water must be classified as hazardous waste. If the comparison with the criteria or standards indicate the water is nonhazardous, the water will be disposed of via the sanitary sewer to the wastewater treatment plant or poured into the ground next to the well to allow infiltration. If the comparison with the criteria or standards indicates the water is hazardous, the water will be containerized in a Baker tank(s) for disposal or treatment in accordance with State, Federal, and local regulations.

Disposable Protective Clothing and Supplies

A variety of wastes will be 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 will be presumed hazardous and will be placed in 55-gallon drums and stored until field work is completed. Drums will be labeled, sealed, and transported by truck to the previously mentioned temporary storage area. The label will describe its contents and the date of collection.

SECTION 4.0
ENVIRONMENTAL SAMPLING

4.1 FIELD SAMPLING PROCEDURES

Soil, sediment, surface water, and groundwater samples will be collected as part of the SSI at WRF. The methodologies to be used in collecting these samples, including descriptions of field QA/QC samples, are discussed in the following subsections. A summary of samples by analysis for the Phase I SSI, Phase II SSI, and VADEQ Response Plan are given in Tables 4-1, 4-2, and 4-3, respectively.

4.1.1 Soil and Sediment Sampling

During soil and sediment sampling, field personnel will fill all sample containers using the following precautions.

- ★ New gloves will be worn at each sample location.
- ★ The sampler will not lay the cap down or touch the inside of the cap.
- ★ The inside of the bottle will not come in contact with anything other than the sample (or preservative, if applicable).
- ★ After the sample volume is placed into the container, the cap will be replaced carefully.
- ★ Sample equipment will be decontaminated between sample locations.
- ★ For VOA, the containers will be filled in a manner to minimize aeration of the samples so that no headspace exists in the container.

Following the collection of samples, containers will be placed in a cooler (4°C), and the sample custody documentation and shipping procedures will be completed as discussed in Sections 4.2 and 4.3. Samples will be collected in containers that have been cleaned according to protocols in Appendix F of USATHAMA Quality Assurance Plan (QAP) (1990). The laboratory will provide the appropriate containers.

TABLE 4-1
SUMMARY OF SOIL AND LIQUID SAMPLE ANALYSES FOR PHASE I SSI ACTIVITIES

Soil Samples	PCB	Metals	VOC	BNA	TPH	Pesticide	Ethylene Glycol
AREE 6B	2	2	2	2	2	2	
AREE 7		36					
AREE 12	10	10	10	10	10	10	
AREE 13		3					
AREE 18		2	2	2			
AREE 21	8	8	8	8	8	8	
AREE 25	24	24				24	
AREE 26	6	6					6
Subtotal	50	91	22	22	20	44	6
QC	2	8	2	2	2	2	1
Total Soil	52	99	24	24	22	46	7

Liquid Samples	PCB	Metals	VOC	BNA	TPH	Pesticide	Ethylene Glycol
AREE 26	1	1	1	1	1	1	1
Total Liquid	1	1	1	1	1	1	1

Key:
AREE = Areas Requiring Environmental Evaluation
PCB = Polychlorinated Biphenyl
VOC = Volatile Organic Compound
BNA = Base/Neutral Acid
TPH = Total Petroleum Hydrocarbon
QC = Quality Control

TABLE 4-2
SUMMARY OF SOIL AND GROUNDWATER SAMPLE ANALYSES FOR PHASE II SSI

Soil Samples	PCB Screening	Metals	BNA	PCB/ Pesticide	Dioxin	VOC	TPH
Background		3	3	3	3	3	
AREE 14		2	2	2		2	2
AREE 15	5	1	1	1		1	1
AREE 17		3	3	3		3	3
AREE 18		2	2	2		2	2
AREE 20		4	4	4	4	4	4
AREE 21	10	1	1	1		1	1
AREE 22	28	0	0	0		0	0
AREE 29	4	3	3	3		3	3
AREE 30		4	4	4		4	4
AREE 33		4	4	4		4	4
AREE 34		4	4	4		4	4
AREE 35	125	12	12	12		12	12
AREE 38		5	5	5		5	5
AREE 39	3	5	5	5		5	5
AREE 40		1	1	1		1	1
Subtotal	175	54	54	54	7	54	51
QC	0	16	16	16	2	36	15
Total Soil	175	70	70	70	9	90	66

Groundwater Samples	Metals	BNA	PCB/ Pesticide	Dioxin	VOC	TPH
AREE 14	1	1	1		1	1
QC	1	1	1		3	1
Total Liquid	2	2	2	0	4	2

Key:
AREE = Areas Requiring Environmental Evaluation
PCB = Polychlorinated Biphenyl
VOC = Volatile Organic Compound
BNA = Base/Neutral Acid
TPH = Total Petroleum Hydrocarbon
QC = Quality Control

TABLE 4-3
SUMMARY OF SOIL AND GROUNDWATER SAMPLE ANALYSES FOR VADEQ RESPONSE PLAN FOR BUILDING 202 ACTIVITIES

Soil	Number of Samples	Number of Replicates/Duplicates	Number of Rinsate Blanks	Number of Trip Blanks	Number of Ambient Blanks	Total
Total Petroleum Hydrocarbons (E418.1)	37	4	4	NA	NA	45
Polychlorinated Biphenyls by Gas Chromatograph (SW8080)	37	4	4	NA	NA	45
Lead (SW6010)	37	4	4	NA	NA	45
Benzene, Toluene, Ethylbenzene, Xylenes (SW8020)	37	4	4	4	NA	49
Water						
Total Petroleum Hydrocarbons (E418.1)	19	2	2	NA	NA	23
Benzene, Toluene, Ethylbenzene, Xylenes (SW8020)	8	1	1	1	1	12
Filtered Lead (SW6010)	8	1	1	NA	NA	10
Unfiltered Lead (SW6010)	8	1	1	1	1	10
Volatile Organic Compound (SW8260)	11	1	5	5	5	27
Semivolatile Organic Compound (SW8270)	11	1	5	NA	NA	17
Polychlorinated Biphenyl/Pesticide (SW8080)	11	1	5	NA	NA	17
Filtered Metals (SW6010)	11	1	5	NA	NA	17

Key: NA = Not Applicable

Split-Spoon Sampling Technique

When the desired depth is reached, soil samples will be obtained through the hollow stem of the augers with a split-spoon sampler. The split-spoon method to be used to collect samples will be 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. The number of blows of the hammer needed to drive the sampler six inches in penetration will be recorded onto the boring logs by the supervising geologist. An OVA will be used to scan drill cuttings and split-spoon samples for soil vapors. The use of the OVA and visual observations will be used to make a field determination as to the presence of contamination in the subsurface. If contamination is apparent, continuous split-spoons will be obtained for the entire depth of the boring. If there is no apparent contamination, split-spoon samples will be obtained in five-foot intervals. All the soil samples obtained during the advancement of the borings will be labeled and stored in accordance with stated requirements. The soil will be homogenized, and then transferred to the sample containers via stainless-steel scoop for a grab sample. Replicates can be put in separate sample containers from the homogenized soil. Soil collected for head space analysis will be agitated and aerated as little as possible prior to sealing the sample jar.

The remaining soil will be used for lithologic description according to the Unified Soil Classification System. The description will include composition, color, stratification, condition, odors, and organic vapor measurements. Sample data will be recorded on the field borehole logs.

Soil Sampling from Excavated Areas

Two types of samples can be collected from excavations: disturbed or undisturbed samples. Disturbed samples are those that have been collected in a manner in which the in-situ physical structure of the soil has been disrupted. Undisturbed samples are collected by isolating by hand a large cube of soil at the base or side of the excavation. If composite samples are to be collected, disturbed samples are appropriate. Undisturbed samples are recommended for volatile analyses and to determine contamination in exact locations.

Disturbed sampling techniques typically include sampling from the walls or floors of the trench or test pit by means of scraping or digging with a trowel, rockpit, or shovel. Disturbed samples may also be collected directly from a backhoe or front end loader bucket during excavation. Care must be taken to assure that the sample is actually from the unit desired and does not include slough or scraped material from the sides of the trench or test pit. The following procedure will prevent sampling material being collected from the side.

After making a cut, have the operator set the full bucket in a safe location. Using a clean stainless steel spatula, scrape the first 3 inches of soil out of the bucket. The sample may now be collected from the center of the bucket. Avoid the soil 3 inches from either side or the bottom of the bucket. The sample container (glass jar or metal sleeve) should be pushed into the soil in order to collect the soil. Replicates can be taken from the same bucket. Disturbed samples will be collected from sampling locations with this technique.

Undisturbed soil samples can be obtained from trenches and test pits. A large cube of soil should be removed from the base or side of the excavation with knives or shovels. After the block of soil is removed it is placed in an airtight, padded container for shipment to the lab. The overexcavated sample is trimmed at the laboratory to the proper size for the analysis.

SOIL SAMPLING FROM DIRECT PUSH BORINGS

Direct push soil sampling techniques are similar to split-spoon sampling techniques. Stainless steel sleeves are advanced down the casing to collect samples at specified depths. The sleeves will be handled in the same manner as the split-spoon samples. This technique is detailed in Section 3.4.

SURFACE SOIL SAMPLING

The surface soil samples will be composite samples, except for the samples to be analyzed for volatile organics. The samples for VOA should be agitated and aerated as little as possible prior to sealing the sampling jar. Replicates can be made from the composite soil. Composite samples will be collected as follows.

1. The sampling location will be marked with a stake or flag.

2. Scoop soil at sample location into a stainless steel bucket with a stainless steel scoop using the surface scrape method. Surface samples should be taken from a depth of six inches to two feet.

3. The soil will be mixed to homogenize the sample.

4. Sample jars for the appropriate analyses will then be filled with the composited soil, labeled, placed in plastic bags, and stored in a cooler with ice.

5. A sample will be collected from the staked location for VOA.

6. The soil will be used for lithologic description according to the Unified Soil Classification System. Sample data obtained will be recorded on the Soil/Sediment Sampling Record.

SEDIMENT SAMPLING

The following procedures establish a uniform method for the collection of sediment samples, which are samples of the solid matter that exists below the liquid phase of a sample medium.

* ★ The farthest downstream sample location will be sampled first. Sediment samples collected in upstream and downstream locations will be obtained in areas of similar environment, and whenever possible, will be obtained from slow-moving pool areas. In addition, sediment samples will be collected at approximately the same location as the associated aqueous sample. Aqueous samples will be obtained first to avoid excess suspended particles from the sediment sampling operations. To avoid the disturbance of the sampling area, sample locations in streams and other waterbodies will always be approached from the downstream side.

* ★ Scoop sediment at the sample location into the sample jars via a stainless-steel scoop. Sediment sample jars will be tripled rinsed with the surface water from the appropriate location prior to collecting the sediment sample. If multiple aliquots are required, all aliquots (except VOA aliquot) will be placed in a stainless-steel bucket and mixed thoroughly before placement into sample containers. Sediment samples will be collected 2 to 6 inches below sediment-water interface. Sediment VOA samples will be packed as full as possible. Replicates will be collected at the same time of the sample from the same bucket of composite soil.

4.1.2 Decontamination of Soil Sampling Equipment

The soil sampling equipment will be decontaminated after every sample is collected to prevent cross-contamination. Equipment will be scrubbed and rinsed with distilled water or USAEC-approved water. Sampling equipment will be protected from ground surface contamination by being placed on plastic sheeting.

The bucket and arm of the backhoe will be steam cleaned between trenches. All measuring equipment (tapes, sounders, etc.) will also be thoroughly decontaminated prior to use and between sampling points. In general, equipment will be scrubbed and rinsed with distilled water. Equipment such as OVAs will be wiped clean with a moist towel a the end of each work day. Discarded materials, including paper towels and decontamination fluids, will be disposed in accordance with applicable regulations, following proper chemical characterization and evaluation of disposal options.

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.

4.1.3 Groundwater Sampling

Field personnel will fill all sample containers using the same precautions as with soil sampling. In addition, water sample containers will be rinsed three times with sample location water prior to filling the containers. Samples will be collected from the new wells no sooner than fourteen days following well development, because development methods proposed may agitate and aerate the water column, yielding samples that are non-representative. This fourteen day waiting period will allow the groundwater in the well to reach equilibrium conditions. Groundwater samples will be collected from the least likely contaminated well locations to the most likely contaminated well locations in order to lower the possibility of cross contamination. Groundwater sampling methods (discussed below) follow procedures described in the *RCRA Ground Water Monitoring Technical Enforcement Guidance Document* (USEPA, 1986b) and USATHAMA *Geotechnical Requirements for Drilling, Monitor Wells, Data Acquisition, and Reports* (USATHAMA, 1987).

WELL PURGING

The water standing in the well may not be representative of site groundwater. Therefore, it is necessary to purge the well prior to sampling in order to obtain a representative sample. Before purging the well, the static water level and any immiscible layer(s) will be measured using an electric sounder and an interface probe. If immiscible layers are detected, they will be sampled using a clear acrylic bailer. If no immiscible layers have been detected, an electric sounder will be used to measure the static water level. After the static water level and any immiscible layers have been measured, the depth to the bottom of the well will be sounded using a weighted, calibrated measuring tape.

After the static level(s) and well depth have been measured, a pump will be lowered down the well and set in the lower portion of the submerged well screen. The flow rate of the pump will be monitored using an in-line flow meter. The flow rates will be periodically checked and recorded on the sampling form. At least five borehole volumes will be purged from the well, unless the well is evacuated before five volumes have been purged. This method accounts for water in both the well casing and sand pack. If the well is incapable of yielding five borehole volumes, the well will be pumped until it has been evacuated and then will be allowed to recover. After the well has recovered sufficiently for a sample, the sample will be collected and tested for pH, specific conductance, and temperature. Color and odor of the discharge will also be noted. If the well is capable of yielding five borehole volumes, samples will be collected and tested for pH, specific conductance, and temperature. Samples will be measured quickly in order to minimize contact with the atmosphere. Values for each of these parameters will be recorded on the well development/purge log. Color and any odor will be recorded under the remarks column.

A stainless steel submersible pump may be used for purging the wells. Other purging devices such as a bailer, peristaltic pump, gas-lift pump, centrifugal pump, or venturi pump may be used. These pumps cause some volatilization of samples, but are acceptable for purging if the water is allowed to stabilize before sampling.

Sample Withdrawal

Table 4-4 lists the containers to be used to collect each type of sample. Containers will be rinsed three times with sample location water prior to filling. Samples will be collected using either a Teflon™ bailer or a low flow pump.

For those samples collected with a Teflon™ bailer, a stainless steel cable or Teflon™-coated wire will be used to lower sampling equipment into the well. Samples will be collected by placing the Teflon™ sampling nipple into the bottom of the bailer and allowing the sample to flow directly into the sampling container(s). Duplicates will be collected immediately after the sample by filling the bailer again.

For those samples collected with a low flow pump, the following procedure will be followed:

1. Lay out polyethylene sheeting and place all equipment on the sheeting. To avoid cross-contamination, do not let any downhole equipment touch the ground surface.

2. Measure the depth to water in the well again. If the measurement has changed more than 1/100th of a foot, check and record the measurement again.

3. Attach and secure the polyethylene tubing to the low flow pump. As the pump is slowly lowered into the well, secure the safety drop cable, tubing, and electrical lines to each other using nylon stay-ties placed approximately five feet apart.

4. The pump should be set at approximately the middle of the screen. Avoid placing the pump intake less than two feet above the bottom of the well, as this may cause mobilization of any sediment present in the bottom of the well. Start purging the well at 0.2 to 0.5 liters per minute. Avoid surging. Observe air bubbles displaced from discharge tube to assess progress of steady pumping until water arrives at the surface.

5. The water level in the well should be monitored during purging, and ideally, the purge rate should equal the well recharge rate so that there is little or no drawdown in the well. (The water level should stabilize for the specific purge rate.) There should be at least one foot of water over the pump intake so there is no risk of the pump suction being broken, or entrainment of air in the sample. Record adjustments in the purge rate and changes in depth to water in the logbook. Purge rates should, if

Table 4-4
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	
Hydrogen Ion (pH)	P,G	50	NA	None Required	NA	Analyze immediately
Total Petroleum Hydrocarbons	G	2×1,000	50	Cool 4°C HCl to pH <2	4°C	28 days
Gasoline	G, Teflon-™ lined septum	3×40	50	Cool 4°C HCl to pH <2	4°C	14 days
Diesel	G, Teflon-™ lined septum	1,000	50	Cool 4°C	4°C	14 days until extraction, 40 days after extraction
Metals	P, G	1,000	50	Cool 4°C HNO_3 to pH <2	4°C	6 months
Lead	P,G	100	10	Cool 4°C HNO_3 to pH <2	4°C	6 months
Temperature (field)	P, G	1,000	NA	None Required	NA	Analyze immediately
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	Cool 4°C	4°C	7 days until extraction, 40 days after extraction
Volatile Organics	G, Teflon-™ lined septum	3×40	2×50	Cool 4°C HCl to pH <2	4°C	14 days (7 days if not pH adjusted)
Semivolatile Organics	G, Teflon™ screw cap	4×1,000	50	Cool 4°C	4°C	7 days (water) and 7 days (soil) until extraction, 40 days after extraction
Dioxins	Glass amber Teflon-lined screw cap	2×1,000	100	Cool 4°C	4°C	7 days for extraction, analyzed within 40 days after extraction

NOTE: * Extraction holding times are from date of sample collection; analysis times are from date of extraction.

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.

needed, be decreased to the minimum capabilities of the pump (0.1 to 0.2 liters per minute) to avoid affecting well drawdown. The well should not be purged dry. If the recharge rate of the well is so low that the well is purged dry, then the contractor may wait until the well has recharged to a sufficient level and collect the appropriate volume of water for the sample with the pump.

6. During well purging, use the flow-through cell to monitor the field parameters frequently (every three to five minutes) until the parameters have stabilized to within 10 percent (plus or minus five percent) over a minimum of three readings. Repeatedly collect water and assess turbidity. Turbidity and DO are typically the last parameters to stabilize. If turbidity readings fall below 5 nephelometric turbidity units (NTUs), then the stabilization range can be amended to 20 percent (plus or minus 10 percent) over a minimum of three readings.

7. Once the field parameters have stabilized, collect the samples directly from the end of the discharge tube. VOCs and analytes that degrade by aeration should be collected first. All sample bottles should be filled by allowing the water from the discharge tube to flow gently down the inside of the bottle with minimal turbulence. Cap each bottle as it is filled.

8. The pump assembly should be carefully removed from the well. The tubing should be dedicated to each well, and should be placed in a large plastic garbage bag, sealed, and labeled with the appropriate well identification number.

9. Close and lock the well.

Samples for VOA will be collected in 40 milliliter (mL) glass bottles allowing no headspace. This will be accomplished by filling the bottle until a reverse meniscus is over the top, and then fitting the cap securely. Headspace will be checked by inverting the bottle and tapping the lid to see if any air bubbles are visible in the bottle.

Samples collected for inorganic analysis will be collected in the same manner as the organics but will be placed in plastic or glass containers filled to the top. Preservatives will be added following sample collection. The pH of the preserved samples will be measured and recorded in the field logbook. Filtered and unfiltered groundwater samples will be submitted for samples collected for metals analyses. Filtered samples will be filtered through a 0.45 micrometer (μm) membrane filter using an in-line positive pressure filtration within 15 minutes of sampling and prior to preservation. Bottles for filtered samples will be rinsed three times with filtered water.

The samples will be collected in order of decreasing volatilization as follows:

1. Volatile organics
2. Semivolatile organics
3. Other organics (namely PCB)
4. Inorganics.

GROUNDWATER SAMPLING FROM DIRECT PUSH PROBES

Groundwater samples will be collected from direct push locations in a manner similar to collecting samples from existing wells. A Teflon™ sampling tube will be placed down the pipe and groundwater will be collected from the bottom of the hole. Samples are placed in bottles for laboratory analysis. This method is detailed in Section 3.4.

SURFACE WATER SAMPLING

The following procedures describe how to obtain surface water samples from surface water bodies which receive runoff (i.e., streams, ponds, and lakes).

★ For stream sampling, the farthest downstream sample location will be sampled first. All sample containers will be triple rinsed with the surface water prior to sample collection. The rinsing equipment precludes adding preservative to bottles before they are shipped to the sampling site. Bottles for filtered samples will be rinsed with filtered sample water and bottles for unfiltered samples will be rinsed with unfiltered water. The mouth of the sample container will be oriented upstream, while the sampling personnel stand downstream so as not to disturb any sediment that could potentially contaminate the sample. Duplicates will be collected immediately after the sample by repeating the procedure.

★ For larger bodies of surface water (i.e., lakes), samples will be collected near the shore unless boats are feasible and permitted. Samples from shallow depths will be collected by submerging the sample container. Samples from nonshallow depths will be collected using a point-source bailer. Samples will be collected at ½ to ⅔ of the water depth. Depth of water will be measured prior sample collection.

★ All surface water samples will be collected before sediment samples to avoid excess suspended particles from the sediment sampling locations.

★ Preservatives will be added and caps secured. The sample containers will be placed in a temperature controlled (4°C) chest immediately after sampling. All sampling equipment will be rinsed in accordance with decon procedures given in Section 4.1.4.

4.1.4 Water Sampling Equipment Decontamination

All sampling equipment, including internal components, will be thoroughly decontaminated prior to use and between sample points to avoid cross contamination. All equipment used for water sampling will be decontaminated by scrubbing and rinsing with distilled or USAEC-approved water.

Ample time will be given for evaporation of solvents and for the equipment to dry prior to reuse. Equipment will be protected from ground contamination by placing it on plastic sheeting. Sampling equipment that is not readily decontaminated will be discarded after each use. Discarded materials, including decontamination solutions, will be accumulated and stored in appropriate receptacles for proper disposal.

Purge equipment, including bailers and pumps, will be decontaminated by flushing/pumping distilled water through the components. The exterior of the pump inlet hose will also be rinsed.

All measuring equipment and apparatus will be thoroughly decontaminated prior to use and between sampling points to avoid cross contamination. Groundwater meters, such as the conductivity meter, will be thoroughly rinsed with distilled water after each use. Discarded materials, including paper towels and decontamination fluids, will be disposed of in accordance with applicable regulations.

If a rig is used to handle equipment during purging or sampling, any grease that may contact equipment going into the well will be removed with distilled water. The rig will then be steam cleaned and rinsed with potable water.

4.2 SAMPLE HANDLING

The sample containers, methods of preservation, and holding times are given in Table 4-4. The procedures for sample labeling and packaging are discussed in the following sections.

4.2.1 Field Sample Identification

Unique field sample identification numbers will be designated by a four-part code. The first two digits represent the AREE number, the middle four 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 will be consecutive as they are collected at a location. An example of the sample identification is described below:

03MW0201

Where:	03	=	The AREE Number (AREE 3)
	MW	=	Type of Sample Location (Monitoring Well)

02	=	Sample Location Number (Monitoring Well 2)
01	=	Sample Number (First Sample from MW02).

The following are abbreviations for the sample location types:

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

The samples will also be labeled with a site type and identification required by Installation Restoration Data Management Information System (IRDMIS) to describe the sampling location. Each sampling location will be assigned a site type and ID before sampling takes place. Applicable site type codes are listed below. A complete list is given in Section 9.17 of the IRDMIS Data Dictionary (IRDMIS, 1993).

GROUNDWATER:

FBLK	Field Blank
OTFL	Outfall
TRIP	Trip Blank
UNKG	Unknown Grab Sample
WELL	Completed Well

SEDIMENT:

CREK	Creek
DTCH	Ditch or Drainage
FBLK	Field Blank
MT	Marshy Area
OTFL	Outfall
POND	Pond
SEA	Sea, ocean, or bay (salt water)
SUMP	Sump
TANK	Tank
TRIP	Trip Blank

SOIL:

AREA	Area of Land
BORE	Borehole
COMP	Composite Soil Sample taken within 100 m diameter
EXCV	Excavation Pit Sample
FBLK	Field Blank
GRAB	Grab Sample
LAFL	Landfill
TRIP	Trip Blank

SURFACE WATER:

CREK	Creek
DTCH	Ditch or Drainage
FBLK	Field Blank
MT	Marshy Area
OTFL	Outfall
POND	Pond
SEA	Sea, ocean, or bay (salt water)
SUMP	Sump
TANK	Tank
TRIP	Trip Blank

ANIMAL TISSUE:

BIOL	Biological Sample

If more than one container is collected from the same location on one day to provide the laboratory with enough sample to analyze or due to different analyses requirements, all containers should be labeled with the same identification number. The sample number, along with the date and time the sample was obtained, will be recorded in the field log and written on the sample label. After collection and identification, the samples will be maintained under chain-of-custody procedures (see Section 4.3).

Quality control samples will be labeled sequentially with the sample type preceding the sample number. The abbreviations for sample type are TB for Trip Blanks, RB for Rinsate Blanks, and AB for Ambient Blanks. An example of a field identification number is TB01. The rinsate blanks should include a note in the field log as to which sample it is associated.

4.2.2 Sample Packaging and Shipping

All samples will be packaged carefully to avoid breakage or contamination and will be shipped to the laboratory at the proper temperatures. The sample packaging requirements listed below will be followed.

★ Sample bottle lids will not be mixed. All sample lids will stay with the original containers. All lids will be secured with custody seals.

★ If the sample volume level is low because of limited sample availability, the level will be marked with a grease pencil. This procedure will help the laboratory determine if any leakage occurred during shipment.

★ Samples collected during the SSI are anticipated to be low concentration samples. All sample containers will be placed in plastic bags. All glass sample bottles will be wrapped in bubble pack and placed in plastic bags to minimize the potential for breakage and contamination during shipment. Plastic bottles will not be wrapped in bubble pack, but will be placed in plastic bags.

★ All samples will be cooled unless "no cooling" has been specified. The sample containers will be packed in coolers. Empty space around the samples will be filled with inert packing material. The coolers will then be filled with ice within Zip-lock™ bags or blue ice.

★ The chain-of-custody record will be placed in a plastic bag and taped to the inside of the cooler lid.

★ All shipping containers will be locked or custody sealed for shipment to the laboratory. Custody seals should be placed on all sides of the shipping container (except side with hinges). The custody seal will consist of a regular paper custody seal or filament tape wrapped around the shipping container at least twice, with the end of the tape signed before the samples are shipped.

4.3 SAMPLE CUSTODY IN THE FIELD

4.3.1 Sample Custody

In order to maintain and document sample custody, the following chain-of-custody procedures will be strictly followed. A sample is considered to be under custody if:

★ It is in actual possession of the responsible person

★ It is in view, following physical possession

★ It is in the possession of a responsible person and is locked or sealed to prevent tampering

★ It is in a secure area.

4.3.2 Chain-of-Custody Record

Sample custody is maintained by a "Chain-of-Custody Record". The custody record is completed by the individual collecting the sample. The information recorded on this record will include the following:

Date	-	Date chain of custody was filled out
Page	-	Page number and total number of pages
Laboratory	-	Name of laboratory where samples are to be shipped (Pace, Inc.)
Address	-	Address of laboratory doing the analysis (1710 Douglas Drive North, Minneapolis, MN 55422)
Client	-	EARTH TECH
Address	-	Address of contractor
Project Name	-	The project title
Project Number	-	The project number
Method of Shipment	-	E.g., FEDEX, courier

Airbill Number	-	Shippers identification number for that shipment
Shipment Number	-	Consecutive number from start of project
Project Manager	-	Project manager's name
Telephone No.	-	Project manager's telephone number
Fax No.	-	Project manager's fax number
Samplers	-	Signature of person(s) collecting the samples
Site Type and ID	-	Sampling location identification
Field Sample Number	-	Entire field sample number
Depth	-	Print the sample depth
Date, Time	-	Date and time sample was collected
Sample Type	-	Print the type of material, e.g., SO-soil; WG-groundwater
Sampling Technique	-	Identify how the sample was collected
Type/Size of Container	-	Print the type or size of sample container, e.g., S.S. liner or 40 mL VOA
Type of Preservation	-	Print the preservation temperature (e.g., 4°C) and the preservation chemical (e.g., HNO_3 to $pH < 2$)
Filtered	-	Put a check mark if sample has been filtered in the field
Number of Containers	-	Number of sample containers
Analysis Required	-	Print the type of analysis required (e.g., oil & grease), or method number (e.g., E413.1)
Relinquished by	-	Signature and printed name of the person giving up the sample
Company	-	Print the name of the organization giving up the sample

Reason	-	State reason for sample transfer, e.g., transport to laboratory
Date/Time	-	Date and time at which sample custody was relinquished
Received by	-	Signature and printed name of the receiving person
Company	-	Print the name of the receiving organization
Date/Time	-	Date and time at which sample was received (or shipped)
Comments	-	Special instructions, such as rush analysis, or other pertinent information regarding the samples.

4.3.3 Transfer of Custody

Samples will be sent to: **Pace, Inc.**
1710 Douglas Drive North
Minneapolis, MN 55422

Field personnel initially collecting the samples are responsible for the care and custody of the samples until they are properly transferred or delivered to laboratory personnel. All samples will be accompanied by a chain-of-custody record. When transferring the possession of samples, the individuals relinquishing and receiving the samples will sign, date, and note the time on the record. The company from which the sample is relinquished and to which it is delivered, and the reason for transfer will also be noted. This record documents the transfer of samples from the custody of the sampler to that of another person, or the permanent custody of the laboratory. All samples should be received by the laboratory within 48 hours of the sample collection period.

The relinquishing individual will record specific shipping data (airway bill number, office, time, and date) on the original and duplicate custody records. It is the Project Manager's responsibility to ensure that all shipping data are consistent and that they are made part of the permanent job file.

If sent by common carrier, a bill of lading will be used. Freight bills and bills of lading will be retained as part of the permanent documentation.

4.4 FIELD QUALITY CONTROL SAMPLES

The following subsections describe the preparation and collection of the field QC samples. The QC sample identification system is discussed in Section 4.2.1. All duplicate and replicate samples will be labeled in the same manner as field samples so they cannot be identified as duplicates or replicates by laboratory personnel.

4.4.1 Trip Blanks

A trip blank is a VOA sample bottle filled by the laboratory with Type II reagent grade water. The trip blank is transported to the sampling site, handled like a sample, and returned to the laboratory with samples submitted for VOCs. The trip blank will not be opened in the field. One trip blank will accompany every shipment that contains water samples sent for VOCs. The trip blank will be analyzed for the same VOCs as the samples. The trip blanks are only required for water samples.

4.4.2 Ambient Conditions Blanks

Ambient conditions blanks are prepared by pouring Type II reagent grade water into sample containers at a sampling site. These blanks are handled as samples and then sent to the laboratory for analysis. One ambient conditions blank will be collected for every VOC sampling event for water at a particular site or area. Ambient conditions blanks are analyzed for VOCs only.

4.4.3 Rinsate Blanks

After sampling equipment is deconned, rinsate blanks are prepared by pouring or pumping Type II reagent grade water through the sampling device into the sample bottle. The blank is then transported to the laboratory for analysis. One rinsate blank will be collected every day for every matrix per equipment type. The rinsate blanks will be analyzed for the same parameters as the sample(s) taken that day.

4.4.4 Duplicates

Field duplicates are defined as two samples collected independently at a single sampling location during a single act of sampling. Duplicate water samples will be collected at a rate of ten percent of the field samples. The sample and the duplicate will be analyzed for the same parameters. The duplicates will be collected by the same procedures as the sample immediately following its collection.

4.4.5 Replicates

A field replicate is defined as a single sample that is divided into two equal parts for the purpose of analysis. For split-spoon samples, the composite soil will be split into the sample and replicate. For surface soil samples, sediment, and direct push samples, composite samples will be blended and split in the field except for volatile organic samples, which will be collected from adjacent locations before they are composited. Field replicates, which will be collected at a rate of ten percent of the total sample number, will be collected for soil and sediment samples and analyzed for all parameters.

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SECTION 5.0
FIELD MEASUREMENTS

The following sections discuss in detail the field measurements to be performed during the field investigation of WRF. Equipment calibration and maintenance are also discussed.

5.1 FIELD PARAMETERS

Properties of water, soil, and air will be measured during the field activities. Geophysical techniques will be used to measure changes in subsurface electrical conductivity, magnetic, and dielectric. Soil sample headspace will be measured for total volatile organic concentrations. Specific conductance, pH, and temperature will be measured in the groundwater samples. In wells, the depth to water, thickness of any detected immiscible layers, volume of water discharged, and well drawdown and recovery will be measured. Field parameters and the equipment that will be used for the field measurements are presented in Table 5-1.

5.2 EQUIPMENT CALIBRATION

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

Field equipment will be calibrated prior to use in the field as appropriate. The calibration procedures will follow standard manufacturers' instructions to ensure that the equipment is functioning within established tolerances and as required by the project. Calibration procedures are described in Section 5.2.2, and the frequency of calibration is given in Table 5-2. Copies of the instrument manuals and calibration/service specifications (C/SSs) will be maintained in the field office. A record of field calibration of analytical instruments will be maintained in the instrument calibration/maintenance logbook by field personnel. Other equipment calibration records (e.g., thermometers, sounders) will be maintained at EARTH TECH offices. These records will be subject to QA audit. Any notes on unusual results, changing of standards, battery charging, and operation and maintenance of the field equipment will be included in the calibration/maintenance logbook or on an equipment calibration daily log form.

TABLE 5-1
FIELD PARAMETERS AND MEASURING EQUIPMENT

Parameter	Equipment
Soil Electrical Conductivity	Radio Detection RD-600 System
Magnetic Field Variations	Schonstedt GA-52B Gradiometer
Radar Frequency Waves	Geophysical Survey System, Inc. Mode 3 System
Soil Headspace Total Volatile Organic Concentration	OVA or HNu
Specific Conductance	Conductivity Meter
pH	pH Meter
Temperature	Thermometer (°C)
Hydraulic Head	Data Logger or Electric Tape (Sounder)
Thickness of Free Product and Depth to Water	Interface Probe
Volume of Discharged Groundwater	Calibrated 5-gallon bucket or flow meter
Grain Size	Sieves: Number 10, 20, 40, 60, and 100
PCB Concentration (Screening)	PCB Immunoassay Test Kit

Key: OVA = Organic Vapor Analyzer
PCB = Polychlorinated Biphenyl

TABLE 5-2
CALIBRATION FREQUENCY FOR FIELD TEST EQUIPMENT

Equipment	Calibration Frequency
Surface Geophysical Equipment	One-time factory calibration
OVA	Full calibration every 6 months. Field calibration check prior to use and at end of day.
HNu	Factory calibration. Field calibration check prior to use and at end of day.
pH/Conductivity Meter	Full calibration every 2 months. pH -- field check daily or prior to use and at end of day. Conductivity -- field check prior to use and at end of day.
Thermometer	Mercury and electronic thermometers are calibrated to National Bureau of Standards (NBS) standards by the manufacturer or upon receipt. Dial thermometers are calibrated every 12 months.
Data Loggers	Every 12 months.
Electric Tape (Sounder)	Every 12 months.
Interface Probe	Every 12 months.
Container for Measuring Water Volume	Lifetime, except visual inspection.
Sieves	Full calibration every 24 months and visual check every 12 months.
PCB Immunoassay Test Kit	Prior to each sample.

Key: OVA = Organic Vapor Analyzer
PCB = Polychlorinated Biphenyl

All instruments are to be stored, transported, and handled with care to preserve equipment accuracy. Damaged instruments will be taken out of service immediately and not used again until a qualified technician repairs and recalibrates the instruments.

5.2.1 Calibration Frequencies

Table 5-2 presents a list of field measurement equipment to be used during the field work, along with the frequency of calibration.

5.2.2 Calibration Procedures

Calibration is performed in accordance with the manufacturers' instructions or EARTH TECH's C/SSs which are based on manufacturer instructions or ASTM procedures.

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

★ ***Surface Geophysical Survey Equipment***. The EMI, GPR, and magnetics instruments are calibrated once by the factory and maintained according to manufacturers' specifications. Each instrument has built-in functional tests which will be performed daily and the results will be documented. If the instruments are not functioning properly, they will be sent to the manufacturer for repair and recalibration. Any data recorded with a possibly malfunctioning instrument will be remeasured.

  Daily verification of the EMI, GPR, and magnetic instruments will be performed at an established test site. Since these techniques are used to find buried objects, the tests will consist of locating a known buried object along a monumented profile. Test procedures and results will be documented. Data from different days should be similar since the same profile will be measured over the immobile object.

★ ***pH/Conductivity Meter***. Calibration for pH is performed every 2 months using standard buffer solutions having pH values of 4, 7, and 10. Calibration knobs are used to set the meter to read the value of the standards. The meter is calibrated at the start and end of each sampling day with pH buffers 4 and 7 or 7 and 10, depending on the expected ranges of pH in the samples for that day. The meter is also periodically checked during the sampling period using pH buffer 7. If the reading varies more than one-tenth of a unit between calibration checks, the meter will be recalibrated. Conductivity calibration is performed at the start of each sampling day by using KCl standard solutions supplied by the instrument manufacturer. The meter must read within 1 percent of full scale to be considered calibrated. Readings from conductivity meters are normally stable; thus, calibration checks are usually limited to the beginning and end of the sampling day. If the calibration check at the end of the day indicates the meter is not within tolerance, the data will be flagged to note the percent difference between the meter and standard.

★ ***Thermometer***. Mercury thermometers and electronic thermometers are calibrated to National Bureau of Standards (NBS) standards prior to initial use and are visually inspected at least once a year. Dial thermometers are calibrated at three points against a NBS-calibrated thermometer once a year.

★ ***Organic Vapor Analyzer***. All calibrations are performed using a commercially prepared, fixed concentration of methane gas balanced as air (zero hydrocarbon contaminant), unless otherwise requested. Field calibration is performed at the start of each day using calibration gas. The OVA will be recalibrated with the same calibration gas at the completion of each day of field readings. Recalibration will also be performed in the field if the unit experiences abnormal perturbations or if readings become erratic, and after the unit is refilled with ultrapure hydrogen. All three ranges of the unit are calibrated every 6 months using appropriate concentrations of methane gas.

★ ***HNu***. The HNu Model 101 is initially calibrated at the factory. Additional calibrations will be made at the beginning and end of each day of field work using calibration gas. The HNu will be equipped with a 10.2eV lamp, and will be calibrated using 100 ppm isobutylene in air.

★ ***Electric Tape (Water Level Sounder)***. The alarm function is checked by immersion in water. The length of tape is manually checked against a surveyor's steel tape annually.

★ ***Interface Probe***. The alarm functions are checked by immersion in water and oil, respectively. The capability of measuring the thickness of the oil layer is checked against a known oil thickness. The length of tape is manually checked against a surveyor's steel tape annually.

★ ***Pressure Transducer***. The depth indication is checked against a surveyor's steel tape or calibrated water level sounder annually.

★ ***Container***. Containers used to measure waste volume, e.g., bailers, or containers used to calculate water flow, are calibrated upon acquisition by measuring the water volume with another calibrated container.

★ ***Flow Meter***. Flow meters are checked once a year by timing the delivery of water into a container of known volume.

- ★ ***Sieves***. Sieves #10, 20, 40, 60, and 100, plus a pan, are used and calibrated as a set. The calibration is performed with NBS certified glass beads using hand shaking. This calibration is performed initially and every 24 months thereafter. Sieves shall receive a recorded visual inspection every 12 months.

- ★ ***PCB Immunoassay Test Kit***. The hand-held DTECHTOR meter used in the PCB immunoassay test must be calibrated prior to each sample test.

5.3 EQUIPMENT MAINTENANCE

Maintenance responsibilities for field equipment are coordinated through an instrument technician whose primary duty is ensuring that available equipment and instrumentation are ready for use, and that returned equipment is checked out, serviced, and returned to available inventory in a timely manner. Maintenance during use is the responsibility of the project team using the equipment. Calibration/maintenance logbooks contain information on instrument maintenance, calibration, and repair. A separate logbook is maintained for each instrument. Field notebooks contain this information for various other equipment. Backup equipment, spare parts, and other supplies will be brought to the field to every extent possible. In addition to spare parts and supply inventories, EARTH TECH nonassigned equipment represents an extensive in-house source of backup equipment and instrumentation.

SECTION 6.0
FIELD QA/QC PROGRAM

Field parameters to be measured for groundwater include temperature, pH, and specific conductance. Field duplicates, replicates, and field blanks described in Section 4.4 will be collected to provide quality control of the field program.

6.1 CONTROL PARAMETERS

Before groundwater samples are taken, temperature, pH, and specific conductance are monitored to establish whether they have stabilized or not. Stability is achieved when the last two readings agree within 10 percent. Temperature, pH, and specific conductance measurements will be taken when groundwater samples are collected for laboratory analysis. Groundwater duplicates and soil replicates will be collected as 10 percent of the samples to provide field QC.

6.2 CONTROL LIMITS AND CORRECTIVE ACTION

Table 6-1 gives details on the control limits and the required corrective actions necessary if the measurements are not within the limits.

TABLE 6-1
SUMMARY OF FIELD QUALITY CONTROL PROCEDURES

Method	Parameter	QC Performed	Frequency	Acceptance Criteria	Corrective Action
E120.1	Specific Conductance (aqueous)	Duplicate Analysis	10%	RPD < 5%	1) Obtain third value 2) Recalibrate
E150.1	pH (aqueous)	Duplicate Analysis	10%	± 0.1 pH	1) Obtain third value 2) Recalibrate
E170.1	Temperature (aqueous)	Duplicate Analysis	10%	± 1.0°C	1) Obtain third value 2) Use different thermometer
ASTM D422	Grain Size (soil)	Duplicate Analysis	10%	TPD <10%	1) Obtain third value

SECTION 7.0
RECORDKEEPING

7.1 DAILY LOGS

All information pertinent to a field survey and/or sampling will be recorded on appropriate data sheets and/or in a project field logbook which will be a waterproof, bound book with consecutively numbered pages. The bottom of each page in the logbook will be signed or initialed by the person making the entries. Entries in the logbook will be made in waterproof ink and will include the following:

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

For each sample the following will be provided:

- ★ Observations of sample or collection environment, if needed
- ★ Identification of sampling device
- ★ Any field measurements made (e.g., air monitoring, etc.)
- ★ Sequence of collection
- ★ Type of sample matrix (e.g., soil, groundwater, etc.)
- ★ Estimated volume of liquid samples
- ★ Date and time of collection
- ★ Field sample identification number
- ★ Sampler's name
- ★ Sample type (composite, split, etc.)
- ★ Preservatives used.

In addition to the information entered into the logbook, the following data sheets presented in Appendix A will be filled out: Borehole Log, Well Construction Log, Well Development, Groundwater Purging and Sampling Sheet, Pump Test Data Sheet, Excavation Log, and Soil/Sediment Sampling Record. These forms will be submitted to USAEC within three days of completion.

7.2 CORRECTIONS TO DOCUMENTATION

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

7.3 PHOTOGRAPHS

Photographs, if taken, will be recorded in the appropriate logbook section or in additional sections as needed. Information to be recorded includes:

- ★ Roll and frame number
- ★ Time
- ★ Photographer
- ★ Location (e.g., east side of Building 3)
- ★ Subject (e.g., installation of Borehole XX)
- ★ Significant features
- ★ Names of any personnel included in the photograph.

APPENDIX A

FORMS

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pace INCORPORATED®
THE ASSURANCE OF QUALITY

U- 01040

USATHAMA
CHAIN-OF-CUSTODY RECORD (COC)
Analytical Request

Installation ____________________ Report To: ____________________ Pace Client No. ____________________

Prime Contractor ____________________ Bill To: ____________________ Pace Project Manager ____________________

Sample Program ____________________ P.O. # / Billing Reference ____________________ Pace Project No. ____________________

Sampled By (PRINT):

Sampler Signature Date Sampled

FILE NAME	SITE TYPE	SITE ID	FIELD SAMPLE NO.	MTRX	SAMPLE DEPTH	SMPL TECH	PACE NO.	NO. OF CONTAINERS	PRESERVATIVES: UNPRESERVED	H_2SO_4	HNO_3	HCl	NaOH	UM05 VOA GC/MS	UG03 VOA GC/HALL	UP01 · VOA GC/PID	UM06 BNA GC/MS	UH21 OCP GC/ECD	UH22 HERB GC/ECD	SS15 METALS ICP	SB07 MERCURY CVAA	SD08 METALS GFAA	TY03 CYANIDE	TPH 418.1	TT12 ANIONS-IC	TY11 TOTAL PO_4	TF15 ORTHO PO_4	LM05 VOA GC/MS	LG03 VOA GC/HALL	LP01 VOA GC/PID	LM06 BNA GC/MS	LH19 OCP GC/ECD	LH20 HERB GC/ECD	JS14 METALS ICP	JB06 MERCURY CVAA	JC02 METALS FIAA	KY04 CYANIDE	TCLP SW1311	EXPLOSIVES H_2O	EXPLOSIVES SOIL				LABORATORY REMARKS

SHIPPING AIRBILL NO.	NO. OF COOLERS	NO. OF COC IN SHIPMENT	TOTAL CONT.

RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME

Field Sampling Remarks:

The Earth Technology Corporation

Soil / Sediment Sampling Record

Project Name ______________________ Project Number ______________
Location ______________________ Sample Number ______________
Recorded By ______________________ Duplicate Number ______________
Date ______________________ Checked by ______________
Site ______________________ Date ______________

Sampling Equipment ______________________

Sample Type: ☐ Soil ☐ Sediment ☐ Rock

Sample Type Description

USCS Soil Type ______________________
Color ______________________
Odor ______________________
Depth ______________________
Number of Samples ______________________
Comments ______________________

Sampling Point (sketch):

Decontamination

Equipment: ☐ Hand auger
Type ________
Trowel
☐ Other
☐ ________

Decontamination Fluids: ______________

☐ Steam/Hot Water
☐ Detergent/ Water
☐ Potable Water
☐ Deionized Water
☐

☐ Methanol
☐ Hexane
☐ HNO_3; dilution
☐ Other
☐ ______________

Form F-1026
8/92

The Earth Technology Corporation

Decontamination Record

Project Name ______________________________ Project Number ______________

Recorded By ______________________________ Site ______________

Date ______________ Time ______________ Checked By ______________

Date ______________

Decontamination after borehole/well/sampling point ______________________________

Equipment	Use	Steam/Hot Water	Detergent/Water	Potable Water	Deionized Water	Type II Water	Other Water	Methanol	Hexane	HNO_3 (Dilution)			Equip. Blank No.
Drill rig													
Drill Rods													
Augers													
Soil sampler													
Pump													
(Type)													
Bailer													
Trowel													
Hand auger													

Use key : GS - Groundwater Sampling, SS - Soil Sampling, WP - Well Purging

Comments (e.g. initial decon, between which locations, or if last decon for the day)

____

____

____

____

____

____

____

____

Form F-1022
9/1/91

Ground Water Purging and Sampling Record

Date:	Well ID:	Sample Number:	Recorded By:
Project Name:	Well Location:	Duplicate Number:	Checked By:
Project Number:			

Equipment

pH/Conductivity/Temperature Meter #:	Purging Equipment:
PID #:	Sampling Equipment:
Electric Sounder #:	

Well Data

Elevation:	Water Column in Well:	Total Vol. Extr.:
Well Diameter:	Borehole Diameter:	Ambient PID:
Well Depth:	Water Column in Borehole:	Well Mouth PID:
Depth to Well Water:	Standing Water Vol.:	

Ground Condition of Well:
Remarks:

	Purging				Sampling	
	1	2	3	4	1	2
Time						
Rate						
Temperature						
pH						
Conductivity						
Vol. Purged						
Remarks						

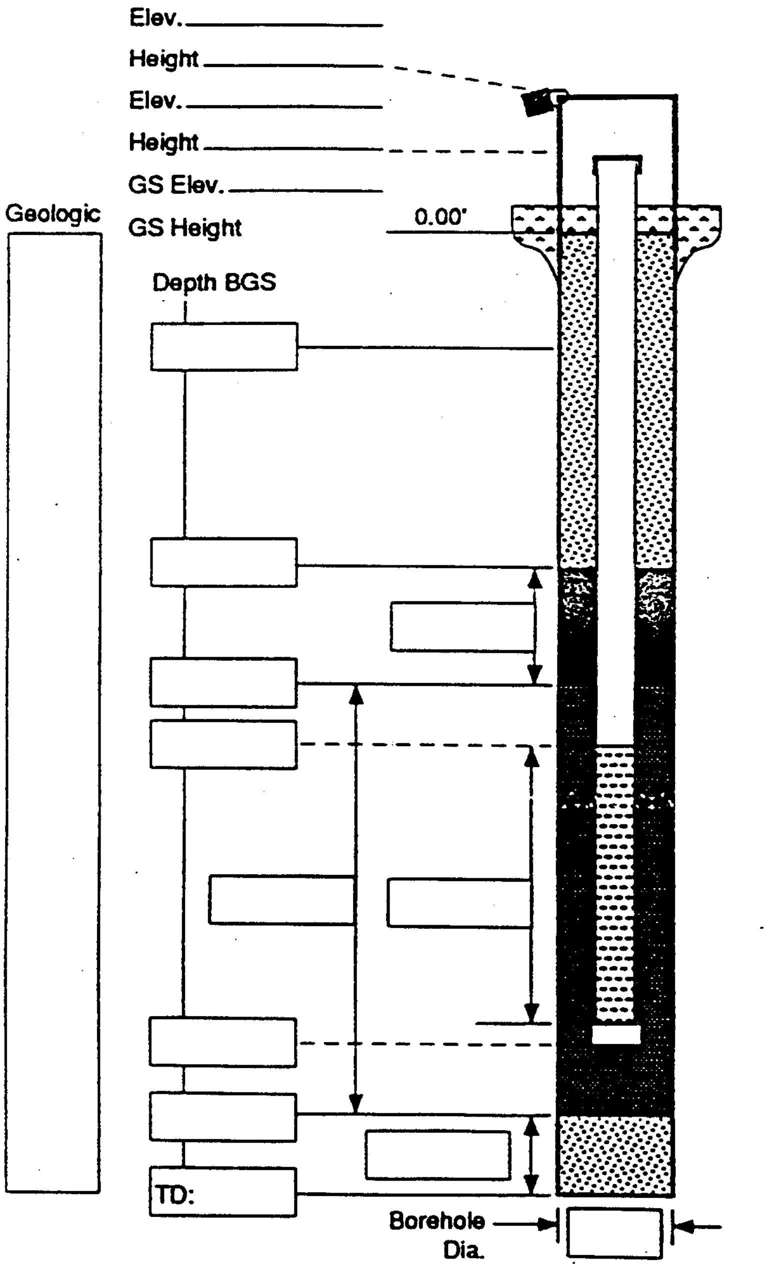
Collected Samples

	1	2	3	4	5	6
Sample Type						
Analytical Param						
Volume Required						
Preservation						
Field Filtered						
Time						

The Earth Technology Corporation

Monitoring Well Construction Log - Above Ground

Project Name:	Project Number:	Date:
Well	Well ID:	Sheet ___ of ___
Driller:	Borehole Diameter (in):	Total Depth (ft):
Drilling Agency:	Date Started:	Depth to Water (ft):
Drilling Equipment:	Date Finished:	Elevation and Datum:
Drilling Method:	Logged by:	Checked by:
Drilling Fluid:	Number of Samples:	Date:



PROTECTIVE CSG

Material / Type:

Diameter: ___

Depth BGS: ___ Weep Hole (Y / N)

GUARD POSTS (Y / N)

No.: ___ Type: ___

SURFACE PAD

Composition and Size: ___

RISER PIPE

Type: ___

Diameter: ___

Total Length (TOC to TOS): ___

Ventilated Cap (Y / N)

GROUT

Composition and Proportions: ___

___

Tremied (Y / N)

Interval BGS: ___

CENTRALIZERS

Depth(s) ___

SEAL

Type: ___

Source: ___

Setup / Hydration Time: ___ Vol. Fluid Added ___

Tremied (Y / N)

FILTER PACK

Type: ___

Amt. Used: ___

Tremied (Y / N) ___

Source: ___

Gr. Size Dist.:

SCREEN

Type: ___

Diameter: ___

Slot Size and Type: ___

Interval BGS: ___

WELL FOOT (Y / N)

Interval BGS: ___ Length ___

Bottom Cap (Y / N)

BACKFILL PLUG

Material: ___

Setup / Hydration Time: ___

Tremied (Y / N)

Form F-1024
9/1/91

The Earth Technology Corporation

Pump Test Data Sheet

Project Name ______________________ Project No. ______________________

Location ______________________ Date ______________________

Pumping/Observation Well No. ______________________ Recorded by ______________________

Distance from Pumped Well ______________________

Static Water Level ______________________ Datum Point ______________________

Screen Interval ______________________ Elevation of Datum Point ______________________

Duration of Test: ______________________ Depth to Bottom Well (ft.) ______________________

Pumping ____________ Recovery ____________ Saturated Thickness (ft.) ______________________

Water Level Measuring Equipment ______________________

Flow (Q) Measuring Equipment ______________________ Checked by ____________ Date ____________

Time			Time Since Pumping Started	Time Since Pumping Stopped	Ratio	Water Level (ft. below datum)	Water Level Change s or s'	Flow Rate (Q) gal/min.	Remarks
Date	Hr.	Min.	t (min.)	t' (min.)	t/t'				

(Attach Hermit data log to data sheet)

The Earth Technology Corporation

Slug Test Data Sheet

Project Name ______________________ Project No. ______________________

Location ______________________ Date ______________________

Well No. ______________________ Recorded by ______________________

Volume Displaced/Added/Removed ______________________

Static Water Level (H_0) ______________________ Datum Point ______________________

Screen Interval ______________________ Elevation of Datum Point ______________________

Duration of Test: ______________________ Depth to Bottom Well (ft.) ______________________

Radius of Well Casing (ID) __________ in(÷12= ______ ft) Saturated Thickness (ft.) ______________________

Water Level Measuring Equipment ______________________

Radius of Well Borehole: __________ in(÷12= ______ ft) Checked by ______________ Date ______________

Time			Time Since Slug Introduced /Removed	Water Level (ft. below datum)	Water Level Change	Remarks
Date	Hr.	Min.	t (min.)	H	$H - H_0$	

Form F-1002
9/1/91

WELL DEVELOPMENT LOG

Date:	Well ID:	Sample Number:	Recorded By:
Project Name:	Well Location:	Duplicate Number:	Checked By:
Project Number:	Date Well Installed:		

EQUIPMENT

pH/Conductivity/Temperature Meter #:

Purging Equipment:

PID #:

Electric Sounder #:

WELL DATA

Elevation:	Water Column in Well:	Total Vol. Extr.:
Well Diameter:	Borehole Diameter:	Ambient PID:
Well Depth:	Water Column in Borehole:	Well Mouth PID:
Static Water Level:	Standing Water Vol.:	Static Water Level 24 Hrs. After Development:
Screen Length:		

Ground Condition of Well:

Remarks:

PURGING

	1	2	3	4
Time				
Rate				
Temperature				
pH				
Conductivity				
Vol. Purged				
Remarks				

The Earth Technology Corporation

Borehole Log

Project Name:		Project Number:
Borehole Location:	Borehole No.	Sheet 1 of
Drilling Agency:	Driller:	
Drilling Equipment:	Date Started:	Total Depth (feet):
Drilling Method:	Date Finished:	Depth to Bedrock (feet):
Drilling Fluid	Number of Samples:	Depth to Water (feet):
Completion Information:	Borehole Diameter (in):	Elevation and Datum:
	Logged by:	Checked by:

Depth (feet)	Sample					Analysis	LOG	Lithologic Description	Remarks
	Number	Interval	Blow Count	Recovery	Time	PID or FID (ppm) S/B*	USCS or Rock Type		
5									
10									
15									

KEY: * S/B = Sample Reading / Background Reading; NA = Not Analyzed; BZ = Breathing Zone; BG = Background; BH = Borehole Headspace

The Earth Technology Corporation

Borehole Log

(Continuation Sheet)

Project Name:	Project Number:	Sheet 2 of
		Logged by:
Borehole Location:	Borehole Number:	Date:

Depth	Sample: Number	Sample: Interval	Sample: Blow Count	Sample: Recovery	Sample: Time	Analysis: PID or FID (ppm) S/B*	LOG: USCS or Rock Type	Lithologic Description	Remarks
20									
25									
30									
35									

KEY: * S/B = Sample Reading / Background Reading; NA = Not Analyzed; BZ = Breathing Zone; BG = Background; BH = Borehole Headspace

The Earth Technology Corporation

Excavation Log

Project Name ______________________ Project No. ______________ Date __________

Surface Elevation ______________________ Location ______________________

Completion Depth ____________ Depth to Water ______________ Coordinates ______________

Recorded by ______________________ Checked by ______________ Date __________

Depth (Ft)	Symbol	Samples	Feet / Plan View	
0				Monitor Equipment
				PI Meter ID# ________
				Explosive Gas ID# ________
				Avail. Oxygen ID# ________
5				OVA ID# ________
				Other ID# ________
				________
				Photographs, Roll ________
10				________
				Exposure ________
15				
20			Cross Section	

Soil Description, Site Observations

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Samples Obtained

Sample No.	Depth Below Grade (Ft)	Depth Below Tank Bottom (Ft)	Field Analysis	Headspace Reading (ppm)

Reference: Field Book, Pg. ______________________

Attachments ______________________

Form F-1029
2/15/91

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pace INCORPORATED
THE ASSURANCE OF QUALITY

U- 01040

USATHAMA CHAIN-OF-CUSTODY RECORD (COC)
Analytical Request

Installation ____________________ Report To: ____________________ Pace Client No. ____________________

Prime Contractor ____________________ Bill To: ____________________ Pace Project Manager ____________________

Sample Program ____________________ P.O. # / Billing Reference ____________________ Pace Project No. ____________________

Sampled By (PRINT):

Sampler Signature Date Sampled

FILE NAME	SITE TYPE	SITE ID	FIELD SAMPLE NO.	MTRX	SAMPLE DEPTH	SMPL TECH	PACE NO.	NO. OF CONTAINERS

PRESERVATIVES: UNPRESERVED	H_2SO_4	HNO_3	HCl	NaOH	

UM05 VOA GC/MS	UG03 VOA GC/HALL	UP01 VOA GC/PID	UM06 BNA GC/MS	UH21 OCP GC/ECD	UH22 HERB GC/ECD	SS15 METALS ICP	SB07 MERCURY CVAA	SD08 METALS GFAA	TY03 CYANIDE	TPH 418.1	TT12 ANIONS-IC	TY11 TOTAL PO_4	TF15 ORTHO PO_4

LM05 VOA GC/MS	LG03 VOA GC/HALL	LP01 VOA GC/PID	LM06 BNA GC/MS	LH19 OCP GC/ECD	LH20 HERB GC/ECD	JS14 METALS ICP	JB06 MERCURY CVAA	JC02 METALS FIAA	KY04 CYANIDE	TCLP SW1311	EXPLOSIVES H_2O	EXPLOSIVES SOIL				LABORATORY REMARKS

SHIPPING AIRBILL NO.	NO. OF COOLERS	NO. OF COC IN SHIPMENT	TOTAL CONT.

RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME

Field Sampling Remarks:

The Earth Technology Corporation

Decontamination Record

Project Name ______________________ Project Number ______________

Recorded By ______________________ Site ______________

Date ____________ Time ____________ Checked By ______________

Date ______________

Decontamination after borehole/well/sampling point ______________________

Equipment	Use	Steam/Hot Water	Detergent/Water	Potable Water	Deionized Water	Type II Water	Other Water	Methanol	Hexane	HNO_3 (Dilution)			Equip. Blank No.
Drill rig													
Drill Rods													
Augers													
Soil sampler													
Pump													
(Type)													
Bailer													
Trowel													
Hand auger													

Use key : GS - Groundwater Sampling, SS - Soil Sampling, WP - Well Purging

Comments (e.g. initial decon, between which locations, or if last decon for the day)

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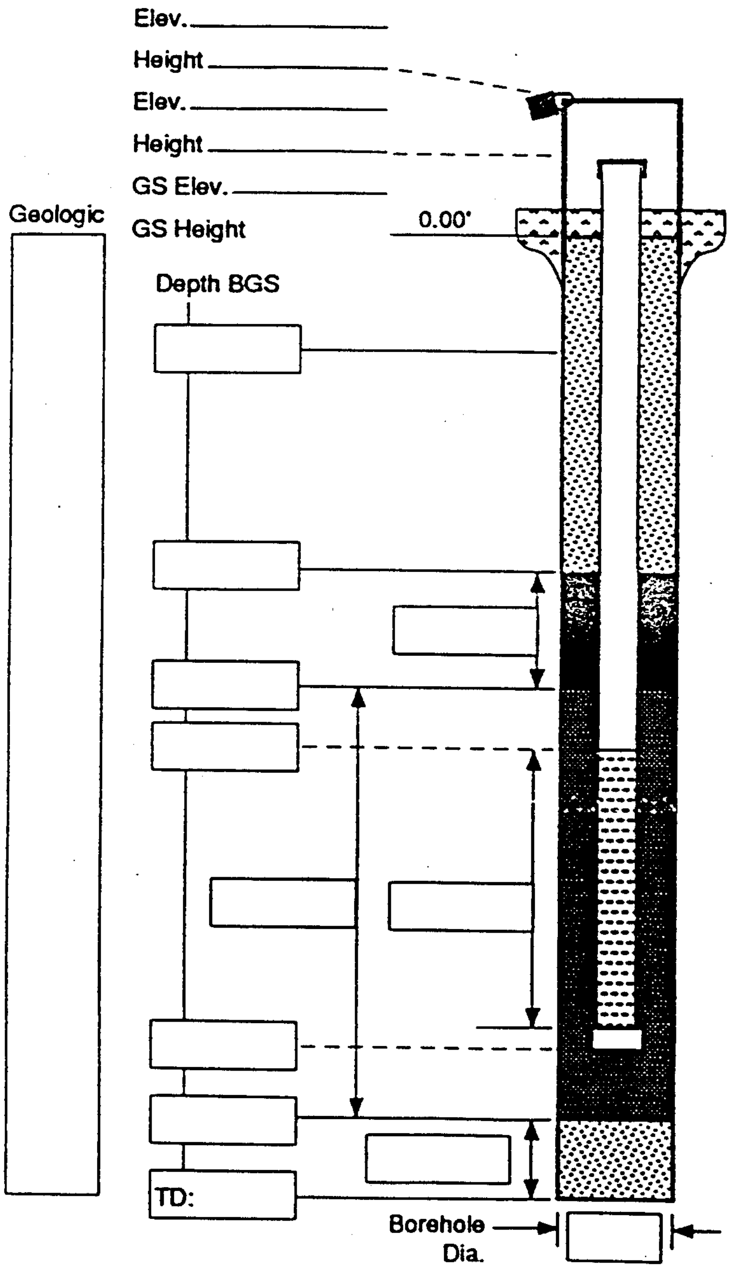
Form F-1022
9/1/91

The Earth Technology Corporation

Monitoring Well Construction Log - Above Ground

Project Name:	Project Number:	Date:
Well	Well ID:	Sheet ____ of ____
Driller:	Borehole Diameter (In):	Total Depth (ft):
Drilling Agency:	Date Started:	Depth to Water (ft):
Drilling Equipment:	Date Finished:	Elevation and Datum:
Drilling Method:	Logged by:	Checked by:
Drilling Fluid:	Number of Samples:	Date:



PROTECTIVE CSG

Material / Type:

Diameter: ____

Depth BGS: ____ Weep Hole (Y / N)

GUARD POSTS (Y / N)

No.: ____ Type: ____

SURFACE PAD

Composition and Size: ____

RISER PIPE

Type: ____

Diameter: ____

Total Length (TOC to TOS): ____

Ventilated Cap (Y / N)

GROUT

Composition and Proportions: ____

____

Tremied (Y / N)

Interval BGS: ____

CENTRALIZERS

Depth(s) ____

SEAL

Type: ____

Source: ____

Setup / Hydration Time: ____ Vol. Fluid Added ____

Tremied (Y / N)

FILTER PACK

Type: ____

Amt. Used: ____

Tremied (Y / N) ____

Source: ____

Gr. Size Dist.:

SCREEN

Type: ____

Diameter: ____

Slot Size and Type: ____

Interval BGS: ____

WELL FOOT (Y / N)

Interval BGS: ____ Length ____

Bottom Cap (Y / N)

BACKFILL PLUG

Material: ____

Setup / Hydration Time: ____

Tremied (Y / N)

The Earth Technology Corporation

Slug Test Data Sheet

Project Name ______________________ Project No. ______________________

Location ______________________ Date ______________________

Well No. ______________________ Recorded by ______________________

Volume Displaced/Added/Removed ______________________ Datum Point ______________________

Static Water Level (H_0) ______________________ Elevation of Datum Point ______________________

Screen Interval ______________________ Depth to Bottom Well (ft.) ______________________

Duration of Test: ______________________ Saturated Thickness (ft.) ______________________

Radius of Well Casing (ID) ________ in(÷12= ______ ft)

Water Level Measuring Equipment ______________________

Radius of Well Borehole: ________ in(÷12= ______ ft) Checked by ______________ Date ______________

Time			Time Since Slug Introduced /Removed	Water Level (ft. below datum)	Water Level Change	Remarks
Date	Hr.	Min.	t (min.)	H	$H - H_0$	

The Earth Technology Corporation*

Borehole Log

Project Name:		Project Number:
Borehole Location:	Borehole No.	Sheet 1 of
Drilling Agency:	Driller:	
Drilling Equipment:	Date Started:	Total Depth (feet):
Drilling Method:	Date Finished:	Depth to Bedrock (feet):
Drilling Fluid	Number of Samples:	Depth to Water (feet):
Completion Information:	Borehole Diameter (in):	Elevation and Datum:
	Logged by:	Checked by:

Depth (feet)	Sample					Analysis	LOG	Lithologic Description	Remarks
	Number	Interval	Blow Count	Recovery	Time	PID or FID (ppm) S/B*	USCS or Rock Type		
5									
10									
15									

KEY: * S/B = Sample Reading / Background Reading; NA = Not Analyzed; BZ = Breathing Zone;
BG = Background; BH = Borehole Headspace

The Earth Technology Corporation

Excavation Log

Project Name ______ Project No. ______ Date ______

Surface Elevation ______ Location ______

Completion Depth ______ Depth to Water ______ Coordinates ______

Recorded by ______ Checked by ______ Date ______

Depth (Ft)	Symbol	Samples	Feet / Plan View
0			
5			
10			
15			
20			Cross Section

Monitor Equipment

PI Meter ID# ______

Explosive Gas ID# ______

Avail. Oxygen ID# ______

OVA ID# ______

Other ID# ______

______

Photographs, Roll ______

______

Exposure ______

Soil Description, Site Observations

Samples Obtained

Sample No.	Depth Below Grade (Ft)	Depth Below Tank Bottom (Ft)	Field Analysis	Headspace Reading (ppm)

Reference: Field Book, Pg. ______

Attachments ______

Form F-1029
2/15/91