TASK ORDER NO. 4
FINAL DRAFT VERIFICATION INVESTIGATION
RADFORD ARMY AMMUNITION PLANT, VIRGINIA
VOLUME I OF III
Contract No. DAAA15-90-D-0015

Prepared for:

Commander, U.S. Army Toxic and Hazardous Materials Agency
Aberdeen Proving Ground, Maryland 21010-5401

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VERIFICATION INVESTIGATION
VOLUME I
Section 1.0 through Section 32.0

(Final Draft)

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EXECUTIVE SUMMARY

This draft report for Task Order 4, Verification Investigation (VI) at Radford Army Ammunition Plant (RAAP), Radford, Virginia, has been prepared for the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) and is being submitted under the requirements of Contract No. DAAA15-90-D-0015. RAAP is a Government-owned, contractor-operated (GOCO) military industrial installation supplying solvent and solventless propellant grains and TNT explosives. The present contractor-operator is Hercules Incorporated (formerly Hercules Powder Company).

RAAP was issued a draft Permit for Corrective Action and Incinerator Operation (Permit) by the U.S. Environmental Protection Agency (EPA), on December 13, 1989. The Permit, which became effective February 1992, requires RAAP to conduct a VI and, if necessary, a RCRA Facility Investigation (RFI) for suspected releases from select solid waste management units (SWMUs). A VI Work Plan was prepared based on the requirements of the Permit, other EPA guidance documents, and requirements of USATHAMA.

RAAP is located in the mountains of southwest Virginia in Pulaski and Montgomery Counties. The installation consists of two noncontiguous areas--the Radford Unit (or Main Section) and the New River Ammunition Storage Area Unit located about 6 miles west of the Main Section. The New River divides the Main Section of RAAP into two areas. Within the New River meander is the "Horseshoe Area" and south of the New River is the "Main Manufacturing Area". The Main Section of RAAP is the focus of this report.

The object of the VI is to evaluate whether toxic or hazardous contaminants are present and are, or have the potential of, migrating beyond the boundaries of the identified SWMUs, by investigating the nature and extent of hazardous constituents in surface water, groundwater, soil, and sediment. The need for further VI efforts, for recommending a RFI, or for interim corrective action measures was also determined.

The SWMUs were evaluated by drilling exploratory boreholes, installing groundwater monitoring wells, performing geophysics and soil gas surveys, collecting environmental media samples and submitting the samples for chemical analysis, collecting soil samples for physical testing, comparing contaminant levels in the samples to practical quantitation limits and health-based limits, collecting aquifer characterization data to assess site-specific hydrogeology, and collecting quality control samples for data evaluation.

The Permit identified 36 SWMUs for VI efforts that are included in this report. One SWMU in the Permit was omitted from the VI when it was determined not to exist. Another SWMU not in the Permit was added to the VI during the field effort. One of three general methods of investigating or managing the SWMUs provided in the Permit was applied during the VI: waste characterization, environmental sampling, and evaluation of standard operating procedures (SOPs). The waste from nine SWMUs was characterized to determine if the waste was hazardous or non-hazardous. Environmental media at 26 SWMUs were sampled for the presence of hazardous contaminants. Standard operating procedures for three waste oil SWMUs were documented. The Permit also provided for the grouping of SWMUs into one investigation area if this would result in a more thorough presentation of data and understanding of the area. This grouping method was used for SWMUs 8, 9, 36, 37, 38, 50, and Q, SWMUs 10 and 35, and SWMUs 27, 29, and 53.

Investigation of the VI SWMUs consisted of drilling 35 boreholes, installing 21 wells and piezometers, and performing four geophysical surveys and one soil gas survey. Sixty-eight soil, 32 groundwater, seven surface water, eight sediment and 18 waste samples were collected, as were 10 duplicates from various media. Quality control sample types included trip blanks, rinse water samples, equipment blanks, matrix spikes, and method blanks.

Eight proposed action options have been developed based on the level of contamination detected and the completeness of the VI program in evaluating the SWMUs:

- <u>No Further Action</u>--A contamination problem does not exist or is considered insignificant.
- <u>Monitor Site</u>--An approved closure or monitoring plan is in place at the site, and environmental conditions do not warrant further action.
- <u>Collect Additional VI Data</u>--Contaminants have been detected but the available data are not sufficient to confirm the need for a RFI.

- Conduct VI--Waste characterization at the site has indicated the waste to be hazardous.
- Conduct RFI--Contaminants have been detected in site media and contaminant migration has been confirmed or is strongly suggested.
- Interim Measures--Remedial measures are considered appropriate to improve site conditions.
- Conduct Corrective Measures Study (CMS)--Contaminants have been detected in site media, and the data are sufficient to initiate CMS activities without performing a RFI.
- Perform Dye Tracer Study--Better definition of groundwater flow patterns is necessary to evaluate the need for a RFI, CMS or corrective action.

Table ES-1 lists pertinent characteristics of each site with respect to which VI program method was used at the SWMU, whether source contaminants have been detected, whether contaminants have been detected away from the source, whether there is a likely potential for off-site contamination migration, and the proposed action recommended for each SWMU.

Standard operating procedures were prepared by RAAP for all waste oil handling and apply to SWMUs 61, 75, and 76. The following recommendations are made for the 25 SWMU areas investigated for the VI:

- No Further Action at 10 SWMUs
- Monitoring at 2 SWMUs
- Additional VI data collection at 6 SWMUs
- Conduct VI at 2 SWMUs
- Conduct RFI at 2 SWMUs
- Perform Interim Measures at 5 SWMUs

Table ES-1
Summary of VI Conclusions
Radford Army Ammunition Plant, Virginia

SMWU Nos.	SWMU Name	VI Program	Contaminant Source Present	Contamination Detected Away from Source	Potential Media for Contaminant for Migration	Proposed Action
6	Acidic Wastewater Lagoon	Media Sampling	Yes – BHBN	No	--	No further action.
8, 9, 36, 37, 38, 50 and Q	Calcium Sulfate Lagoons, Drying Beds and Disposal Areas	Waste Characterization	Yes – BHBN	--	--	No further action.
10, 35	Bio–Plant Equalization Basin and Calcium Sulfate Drying Bed	Media Sampling	Yes – AHBN	Yes – AHBN	Yes – GW	Collect additional VI data.
26	Fly Ash Landfill No. 1	Media Sampling	Yes – NS	Yes – ABG	Yes – GW	Monitor site.
27, 29, 53	Calcium Sulfate Landfill, Fly Ash Landfill No. 2, Activated Carbon Disposal Area	Media Sampling	Yes – NS	Yes – ABG	Yes – GW, SW, SE	Collect additional VI data.
31	Coal Ash Settling Lagoons	Waste Characterization	Yes – AHBN	--	Yes – GW	Conduct VI.
32	Inert Waste Landfill No. 1	Media Sampling	No – NS	No	--	No further action.
39	Incinerator Wastewater Ponds	Waste Characterization	Yes – AHBN	--	Yes – GW	Interim measures. Conduct VI.
40	Sanitary Landfill (NG Area)	Media Sampling	Unknown	Unknown	Yes – GW	Perform dye tracer study.
41	Redwater Ash Landfill Redwater Ash Landfill Lagoon	Media Sampling	Yes – NS Yes – BHBN	Yes – AHBN No	-- --	No further action.
43	Sanitary Landfill (Adjacent to New River)	Media Sampling	Yes – NS	Yes – ABG	--	Interim measures.
45	Sanitary Landfill (West of Main Bridge)	Media Sampling	Yes – NS	Yes AHBN	Yes – GW	Collect additional VI data.
46	Waste Propellant Disposal Area	Media Sampling	No	Unknown	--	No further action.
48	Oily Wastewater Disposal Area	Media Sampling	Yes – BHBN	Unknown	Yes – GW	Conduct RFI.
54	Propellant Ash Disposal Area	Media Sampling	Yes – NS	Yes – ABG	Yes – GW, SW, SE, SO	Interim measures. Conduct CMS Program. Monitor site.

Table ES-1 (Cont'd)

SMWU Nos.	SWMU Name	VI Program	Contaminant Source Present	Contamination Detected Away from Source	Potential for Migration	Proposed Action
57	Pond by Buildings No. 4931 and 4932	Media Sampling	Yes – BHBN	Unknown	--	No further action.
58	Rubble Pile	Media Sampling	Unknown	No	--	No further action.
59	Bottom Ash Pile	Media Sampling	Yes – NS	Yes – ABG	--	No further action.
61	Mobil Waste Oil Tanks	Standard Operating Procedures	--	--	--	--
68	Chromic Acid Treatment Tanks	Media Sampling	Yes – AHBN	Unknown	Yes – SO	Conduct RFI.
69	Pond by Chromic Acid Treatment Tanks	Media Sampling	Yes – AHBN	Yes – AHBN	Yes – SW, SE, SO	Interim measures.
71	Flash Burn Parts Area	Media Sampling	No	Yes – ABG	Yes – SO	Collect additional VI data.
74	Inert Landfill No. 3	Media Sampling	No – NS	No	--	No further action.
75	Waste Oil UST	Standard Operating Procedures	--	--	--	--
76	Waste Oil USTs	Standard Operating Procedures	--	--	--	--
F	Drum Storage Area	Media Sampling	Yes – BHBN	Unknown	--	No further action.
P	Battery Storage Area	Media Sampling	Yes – BHBN	Unknown	--	No further action.
	Former Lead Furnace Area	Media Sampling	Yes – BHBN	Yes – AHBN	Yes – GW	Collect additional VI data. Interim measures. Perform dye tracer study.

Footnotes:

ABG = Above background concentration
BHBN = Below health based number
AHBN = Above health based number
NS = Not sampled
GW = Groundwater
SW = Surface Water
SE = Sediment
SO = Soil

- Conduct CMS at 1 SWMU
- Perform Dye Tracer Study at 2 SWMUs.

No SWMU was found to pose an imminent or significant risk to human health or the environment. However, SWMU 54 is outside the RAAP perimeter fence, and persons using the New River for recreation can potentially contact the waste, which is a suspected mutagen. Health based numbers have been exceeded by various parameters at several SWMUs, but only at SWMU 69 and the Former Lead Furnace Area are interim corrective measures recommended to remove or reduce the contaminant source.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACO	Administrative Contracting Officer
ASTM	American Society for Testing and Materials
AWQC	Ambient Water Quality Criteria
bgl	Below ground level
BNA	Base Neutral/Acid Extractable Organic Compound
CAMBL	Continuous Automated Multi-Base Line
CASBL	Continuous Automated Single-Base Line
CEC	Cation Exchange Capacity
CFR	Code of Federal Regulations
CL	Silty clay
cm/sec	Centimeters per second
CMS	Corrective Measures Study
CTM	Chas. T. Main of Virginia, Inc.
EM	Electromagnetic
EP	Extraction Procedure
EPA	U.S. Environmental Protection Agency
ESE	Environmental Science and Engineering, Inc.
F	Fahrenheit
FAL	Fly Ash Landfill
GC/MS	Gas Chromatography/ Mass Spectroscopy
gm	Gram
GM	Silty Gravel
GOCO	Government-owned, Contractor-operated
GT	Greater Than
HAZ MAT	Hazardous Material
HBN	Health Based Number
HMX	High Melting Point Explosive
I.D.	Inside Diameter
IRDMIS	Installation Restoration Data Management Information System

LOEL	Lowest Observed Effect Level
MCA	Military Construction, Army
MCL	Maximum Contaminant Level
meq	Milliequivalent
mg/l	Milligrams per liter
mgd	Million gallons per day
ML	Clayey silt
mph	Miles per hour
MSDS	Material Safety Data Sheet
msl	Mean sea level
MW	Monitoring Well
NC	Nitrocellulose
NG	Nitroglycerin
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NROW	New River Ordnance Works
NX	Diameter size (approximately 2 1/2" I.D.)
ODCP	Oil Discharge Contingency Plan
PAH	Polynuclear Aromatic Hydrocarbon
pH	Hydrogen-ion activity in gram equivalents per liter
PQL	Practical Quantitation Limit
psi	Pounds per square inch
psig	Pounds per square inch gauge
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control
RAAP	Radford Army Ammunition Plant
RAGS	Risk Assessment Guideline for Superfund
RBC	Rotating Biological Contactor
RCRA	Resource Conservation and Recovery Act
RD	Reference Dose

RFI	RCRA Facility Investigation
ROW	Radford Ordnance Works
RPD	Relative Percent Difference
SAR	Sulfur Acid Regeneration
SCS	Soil Conservation Service
SM	Silty Sand
SW	Well-graded sand
SOP	Standard Operating Procedure
SPT	Standard Penetration Test
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TIC	Tentatively Identified Compound
TNT	Trinitrotoluene
TOC	Total Organic Carbon
TOX	Total Organic Halogen
UBK	Uptake Biokinetic
ug/dl	Micrograms per deciliter
ug/g	Micrograms per gram
umhos/cm	Micromhos per centimeter
UNK	Unknown
USACE	U.S. Army Corps of Engineers
USAEHA	U.S. Army Environmental Hygiene Agency
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USCS	Unified Soil Classification System
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UST	Underground Storage Tank
VaDOH	Virginia Department of Health

VHMR	Virginia Hazardous Waste Management Regulations
VI	Verification Investigation
VOC	Volatile Organic Compound
VPI&SU	Virginia Polytechnic Institute and State University
VDWM	Virginia Department of Waste Management

1.0 INTRODUCTION

This document is the draft report for Task Order 4, Verification Investigation (VI) at Radford Army Ammunition Plant (RAAP), Radford, Virginia. This report has been prepared for the U. S. Army Toxic and Hazardous Materials Agency (USATHAMA) and is being submitted under the requirements of Contract No. DAAA15-90-D-0015.

RAAP was issued a draft Permit for Corrective Action and Incinerator Operation (Permit) by the U.S. Environmental Protection Agency (EPA), on December 13, 1989. The permit (No. VA-21-002-0730), which became effective February 1992, under the criteria of Section 3004(u) of the Resource Conservation and Recovery Act (RCRA), requires RAAP to conduct a VI and, if necessary, a RCRA Facility Investigation (RFI) for suspected releases from select solid waste management units (SWMUs). Activities performed to collect and analyze data presented in this report were conducted in accordance with the VI Work Plan (Dames & Moore, 1990a). The VI Work Plan was prepared based on the requirements of the Permit, other EPA guidance documents and requirements of USATHAMA.

1.1 PURPOSE OF STUDY

The objective of the VI is to evaluate whether toxic or hazardous contaminants are present and are, or have the potential of, migrating beyond the boundaries of the identified SWMUs. The objectives of Dames & Moore's field investigation for the VI at RAAP were to obtain data to be used in conjunction with existing data to evaluate the nature and extent of hazardous constituents in surface water, groundwater, soil, and sediment and to determine the need for further VI efforts, for recommending an RFI or for interim corrective action measures.

Site-specific hydrogeology was further defined through implementation of a field program that included boring/monitoring well installation. Geotechnical and chemical results on data collected during the field program will be used in conjunction with existing data to identify the presence, approximate extent, and migration potential of contaminants from the SWMUs.

Specifically, the objectives of the VI at RAAP were to:

- Characterize and quantify contamination in groundwater, soil, surface water, and sediment at identified SWMUs.
- Better define the geology and hydrology in the vicinity of the SWMUs, with emphasis on contaminant transport.
- Assess the risks that contaminants attributable to each site may pose to human health or the environment, if detected concentrations indicate the possibility of adverse impacts.
- Assess the need to conduct an RFI for each of the SWMUs investigated.

The Permit provided for three general methods of investigating or managing the SWMUs: 1) characterize the waste present in the SWMU to determine if the waste is hazardous or non-hazardous; 2) sample environmental media immediately adjacent to the SWMU for the presence of hazardous contaminants; and 3) prepare standard operating procedures for waste oil SWMUs to manage the waste and respond to potential releases. Each of these three methods have been employed for the VI. Section 5.0 presents waste characterization findings, Section 6.0 through 28.0 present SWMU-specific environmental and media sampling results and Section 29.0 presents waste oil management procedures.

The Permit provided for the grouping of SWMUs into one investigation area if geographic, historic and chemical data indicate that grouping SWMUs would result in a more thorough presentation of data and understanding of the area. This grouping method was used for the characterization of waste from seven similar SWMUs (8, 9, 36, 37, 38, 50, and Q) and for the environmental media sampling analyses for two SWMUs (10 and 35).

1.2 SCOPE OF WORK

The VI program for RAAP which was performed to fulfill the objectives and requirements of the permit included the following:

- Investigated a total of 37 SWMUs.
- Drilled exploratory boreholes and installed groundwater monitoring wells.
- Performed geophysics and soil gas survey to aid in delineating SWMUs boundaries and extent of contamination.
- Collected groundwater, soil, surface water, sediment, and waste samples from specified SWMUs and submitting the samples for chemical analysis.
- Collected soil samples during drilling for physical testing.
- Compared contaminant levels in the samples to practical quantitation limits and health-based limits specified in the permit.
- Collected groundwater elevation data from existing and newly installed wells, reviewed existing aquifer test results, and performed additional slug tests to assess site-specific hydrogeology.
- Collected background soil samples for comparison and evaluation of SWMU-specific chemical data.
- Collected and analyzed quality control (QC) samples for data evaluation.

Data derived from the above effort was used to screen from further investigation those SWMUs that do not pose a threat to human health or the environment, and to identify suspected releases of hazardous waste or hazardous constituents from SWMUs that require further investigation and/or implementation of interim corrective measures.

1.3 REPORT ORGANIZATION

This report consists of 32 sections and nine supporting appendices. Section 2.0 presents the history, SWMUs under investigation and environmental setting at RAAP. Section 3.0 summarizes the VI field investigation program, Section 4.0 provides the quality assurance/quality control (QA/QC) program, and Section 5.0 presents the characterization of waste produced at various treatment units. Sections 6.0 through 28.0 present the results of the Vis for the various SWMUs. Sections 29.0 and 30.0 present waste oil handling procedures and industrial sewers information, respectively. A summary of the conclusions and recommendations for the entire VI program is presented in Section 31.0. References are provided in Section 32.0.

Appendices A through H present physical and chemical data, field procedures, risk assessment methods and supporting reports on VI related activities.

2.0 INSTALLATION DESCRIPTION

RAAP is a Government-owned, contractor-operated (GOCO) military industrial installation supplying solvent and solventless propellant grains and TNT explosives. The present contractor-operator is Hercules Incorporated (formerly Hercules Powder Company).

2.1 LOCATION

RAAP is located in the mountains of southwest Virginia (Figure 2-1) in Pulaski and Montgomery Counties. The installation consists of two noncontiguous areas--the Radford Unit (or Main Section) and the New River Ammunition Storage Area Unit. The Main Section is located approximately 5 miles northeast of the city of Radford, Virginia, approximately 10 miles west of Blacksburg and 47 miles southwest of Roanoke. The New River Unit is located about 6 miles west of the Main Section, near the town of Dublin (Figure 2-2). The Main Section of RAAP (Figure 2-3) is the focus of this report; all uses of the terms "RAAP" or "the installation" in this report refer to the Main Section only.

RAAP lies in one of a series of narrow valleys typical of the eastern range of the Appalachian Mountains. Oriented in a northeast-southwest direction, the valley is approximately 25 miles long, with a width of 8 miles at the southwest end, narrowing to 2 miles at its northeast end. The plant lies along the New River in the relatively narrow northeast corner of the valley.

The New River divides the Main Section of RAAP into two areas. Within the New River meander is the "Horseshoe Area." Located in the Horseshoe Area are the Nitroglycerin (NG) No. 2 Area, the Cast Propellant Area, and the Continuous Solvent Propellant Area. Many of the former landfills at RAAP are located in this area, as are the Hazardous Waste Landfill, the currently active Sanitary Landfill, and the Waste Propellant Burning Ground. South of the New River is the "Main Manufacturing Area," which includes the Finishing Area; the TNT Area; the NG, Nitrocellulose (NC), and Acid Areas; the Automated Propellant Area; and the Administration Area.

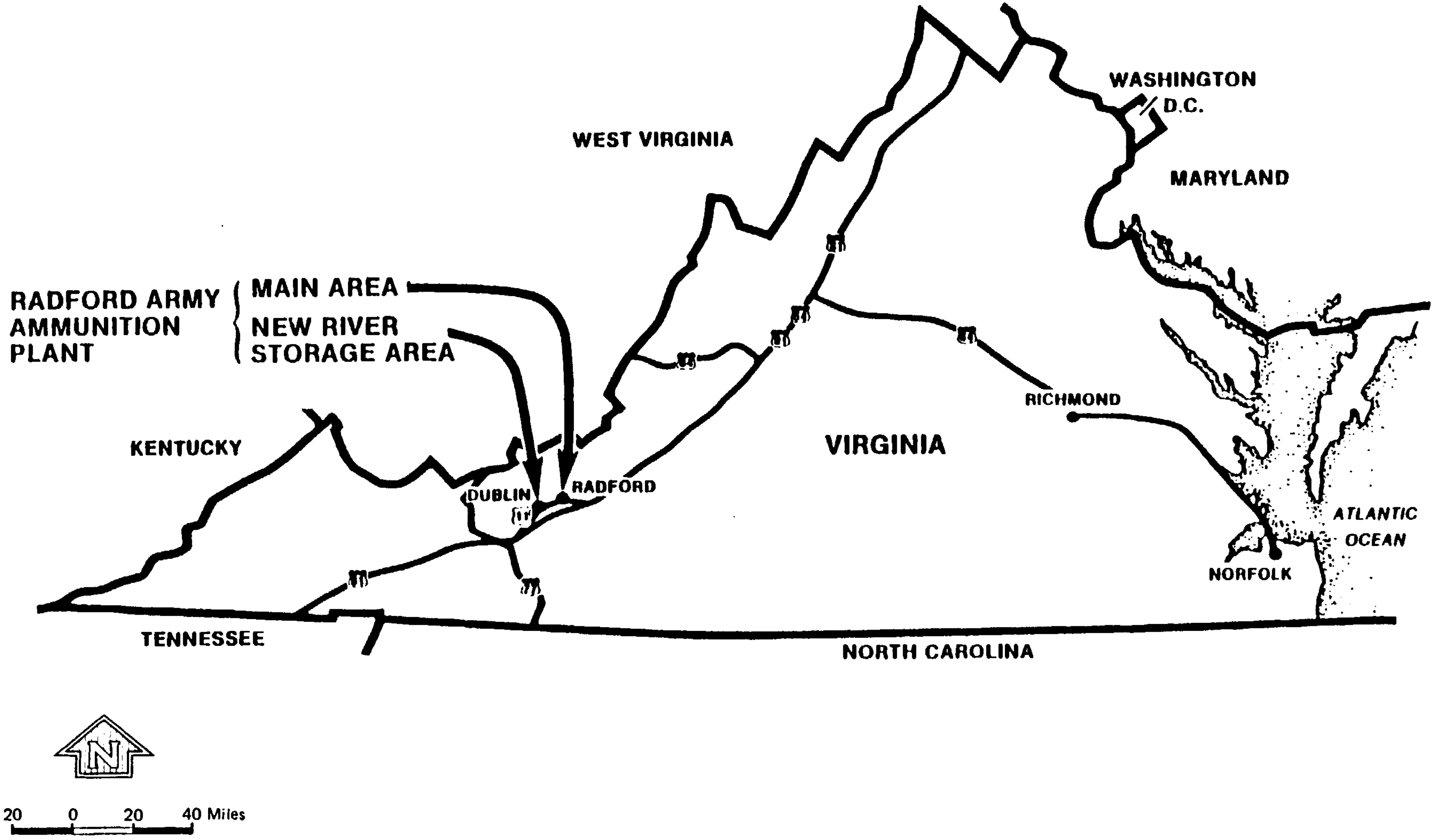

FIGURE 2-1
LOCATION MAP,
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

SOURCE: USAEHA,1980b.

Dames & Moore

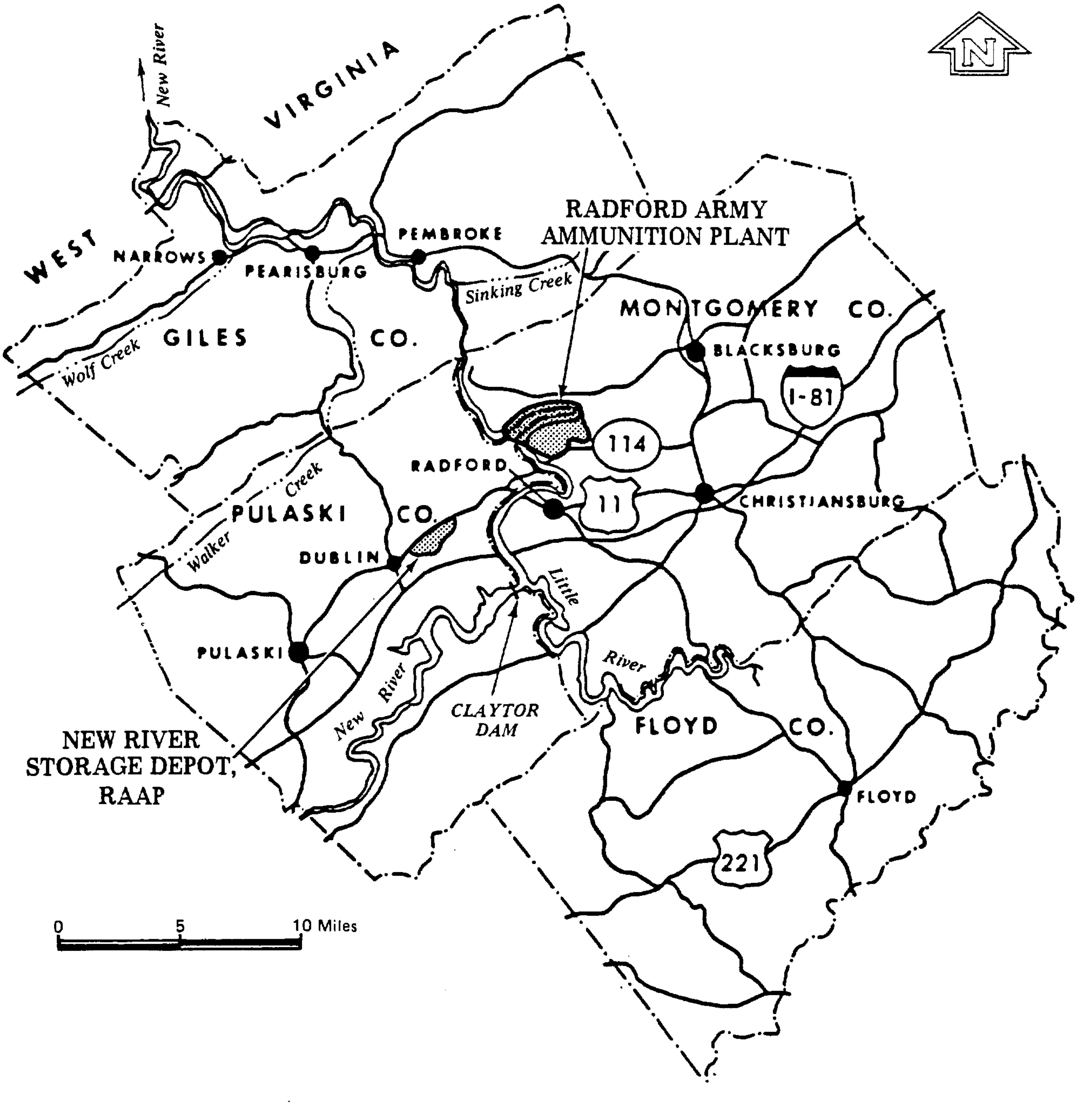

FIGURE 2-2
RAAP AND VICINITY MAP
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

SOURCE: USAEHA, 1980b.

Dames & Moore

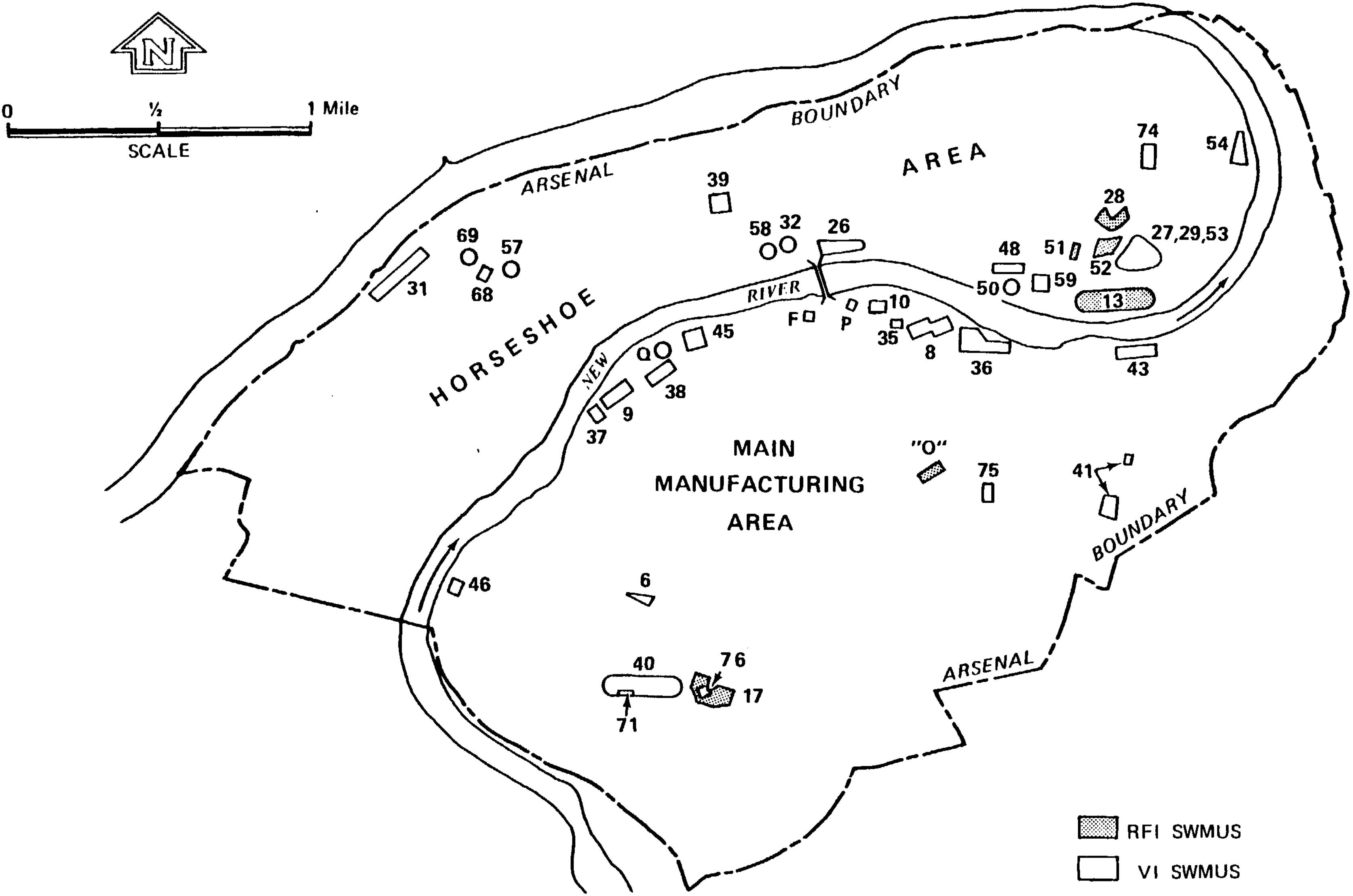

FIGURE 2-3
LAYOUT AND SWMU LOCATION MAP
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

BASE MAP SOURCE: USATHAMA, 1976

Dames & Moore

2.2 HISTORY

2.2.1 Facility Responsibilities

RAAP is assigned the following general responsibilities (USATHAMA, 1976):

- Manufacture of explosives and propellants.
- Handling and storage of strategic and critical materials as directed for other government agencies.
- Operation and maintenance, as directed, of active facilities in support of current operations. Maintenance and/or lay-away, in accordance with Ammunition Procurement and Supply Agency instructions, of standby facilities, including any machinery and packaged lines received from industry, in such conditions as will permit rehabilitation and resumption of production within the time limitations prescribed.
- Receipt, surveillance, maintenance, renovation, demilitarization, salvage, storage, and issue of assigned Field Service Stock and industrial stock as required or directed.
- Procurement, receipt, storage, and issue of necessary supplies, equipment, components, and essential materials.
- Mobilization planning, including review and revision of plant as required.
- Custodial maintenance and administrative functions of subinstallations.
- Support services for tenants.

This mission is accomplished through the efforts of the operating contractor, Hercules Inc. The Administrative Contracting Officer (ACO) and his staff provide technical assistance and administer the contracts with the civilian operating contractors. RAAP provides logistics support for tenant activities such as the U.S.

Army Research, Development and Acquisition Information Systems Agency, which is charged with performing data processing activities during peacetime and mobilization.

2.2.2 Facility History

Construction of the current RAAP production facility began in 1940 with the impending participation of the United States in World War II, and the determination by Congress of a need for increased ammunition production facilities. Initially, RAAP consisted of two distinct areas--a smokeless-powder plant [Radford Ordnance Works (ROW)] and a bag-manufacturing-and-loading plant for artillery, cannon, and mortar projectiles [New River Ordnance Works (NROW)]. These two production facilities continued to be operated separately from 1940 to 1945. Late in 1945, ROW was designated Radford Arsenal, and NROW was a subpost. By January 1950, NROW was made an integral part of Radford Arsenal and no longer considered a subpost. The arsenal was renamed Radford Ordnance Plant in 1961 and was finally redesignated RAAP in August 1963 (USATHAMA, 1984).

Since its inception as a GOCO facility in 1940, RAAP has been operated by Hercules. Expansion of both ROW and NROW continued throughout World War II. Late in 1945, the Radford Unit was placed on standby status. The following year, the nitric acid area of the plant was reactivated to produce ammonium nitrate fertilizer, an activity that continued until 1949 under contract with Hercules Powder Company (now Hercules Inc.). In September 1945, the New River Unit was declared surplus; but in April 1946, the magazine areas were changed from surplus status to standby. Between December 1946 and January 1948, large parcels of the New River plant manufacturing area were sold (USATHAMA, 1984).

Between 1952 and 1958, Goodyear Aircraft Corp., of Akron, Ohio, contracted to manufacture component parts used in missile production at RAAP. The close coordination required between Goodyear and Hercules led to Goodyear moving its assembly and coating operations to RAAP. In 1958, Hercules took over the Goodyear operations at this plant (USATHAMA, 1984).

The continuous TNT plant was put into production in mid-1968 and remained in operation until destroyed by an explosion in May 1974. This plant had five main operational areas--the nitration lines, the finishing buildings, the red water concentration facility, the acid neutralization facility, and the spent acid recovery plant. C-line in the TNT area ran from 1983 to 1986, when the TNT plant was placed on standby. Later, in December 1988, a facility cleanup was conducted and the plant was prepared for long-term standby status.

A chronological listing of major RAAP facilities and activities is presented in Table 2-1.

2.2.3 Industrial Operations

The principal end products produced at RAAP since 1941 are TNT, single-base and multibase propellant, and cast and solventless propellant. Intermediate products produced are oleum (concentrated sulfuric acid), nitric acid, NG, and NC.

The production mission of RAAP is accomplished at the primary and secondary manufacturing areas. The primary manufacturing processes are the production of single-base and multibase solvent propellants, cast and solventless propellants, and TNT. Separate process areas are provided for the production of solvent-type propellant, referred to as rolled powder. The process steps are essentially the same in the production of solvent-type single-, double-, and triple-base propellants. Major differences are in the specific chemicals and explosives ingredients added. Single-base and double-base propellants may include one or more of the following chemicals--barium nitrate, potassium nitrate, ethyl centralite, graphite, carbon black, potassium sulfate, lead carbonate, dibutylphthalate, diphenylamine. Triple-base propellants consist of ethyl centralite and potassium sulfate cryolite, while special high energy propellants contain HMX. The secondary manufacturing operations at RAAP are the production of oleum, sulfuric and nitric acids, NG, and NC.

TABLE 2-1

Chronological List of Major Activities at RAAP

Date	Activity
August 1940	Contract signed with Hercules Powder Company for construction and operation of smokeless powder plant
September 1940	Construction of Radford Plant
April 1941	Production started at Radford Plant
1941	Separate New River bag loading plant constructed
1941/45	Construction of various facilities continued
1945	Consolidation of Radford and New River plants
1945	Production stopped--plant in standby
1946/49	Ammonium nitrate produced in Acid Area
1949	Limited resumption of powder production
1950	Plant reactivated for Korean Conflict
1950/51	Large areas of plant rehabilitated
1951	Multibase propellant and cast rocket grain facilities constructed
1967/68	Continuous TNT lines constructed
1970/72	New acid plants constructed
1971/	Preproduction project work on Continuous Automated Multibase Line (CAMBL) started
1972/	Continuous Automated Single-Base Line (CASBL) construction started
1972/	Continuous nitrocellulose nitration construction started
1973/	Military Construction, Army (MCA) pollution abatement facilities construction started
May 1974	TNT plant explosion
1976/	Continuous Automated Single-Base Line M6/M1 conversion started
1978	Construction started on biological wastewater treatment plant
1980	C-line Nitrocellulose Manufacturing Area closed
1983	TNT plant reopened
1986	TNT plant placed on standby
1987	C-line Nitrocellulose Manufacturing Area reopened
December 1988	TNT plant cleanup, preparation for long-term standby

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SOURCE: Modified from USATHAMA, 1976.

2.3 SWMUs FOR VERIFICATION INVESTIGATION

The RCRA permit for RAAP has identified the following 36 SWMUs for VI efforts:

- SWMU 6: Acidic Wastewater Lagoon
- SWMU 8: Calcium Sulfate Settling Lagoons (A-B Line)
- SWMU 9: Calcium Sulfate Settling Lagoons (C-Line)
- SWMU 10: Biological Treatment Plant Equalization Basin
- SWMU 26: Fly Ash Landfill No. 1
- SWMU 27: Calcium Sulfate Landfill
- SWMU 29: Fly Ash Landfill No. 2
- SWMU 31: Coal Ash Settling Lagoons
- SWMU 32: Inert Waste Landfill No. 1
- SWMU 35: Calcium Sulfate Drying Bed (NE Section)
- SWMU 36: Calcium Sulfate Drying Bed (NE Section)
- SWMU 37: Calcium Sulfate Drying Bed (NW Section)
- SWMU 38: Calcium Sulfate Drying Bed (NW Section)
- SWMU 39: Incinerator Wastewater Ponds
- SWMU 40: Sanitary Landfill (NG Area)
- SWMU 41: Red Water Ash Landfill
- SWMU 43: Sanitary Landfill (Adjacent to New River)
- SWMU 45: Sanitary Landfill (West of Main Bridge)
- SWMU 46: Waste Propellant Disposal Area
- SWMU 48: Oily Wastewater Disposal Area
- SWMU 50: Calcium Sulfate Disposal Area
- SWMU 53: Activated Carbon Disposal Area
- SWMU 54: Disposal Area for Ash from Burning of Propellants
- SWMU 57: Pond by Buildings No. 4931 and 4928
- SWMU 58: Rubble Pile
- SWMU 59: Bottom Ash Pile
- SWMU 61: Mobil Waste Oil Tanks
- SWMU 68: Chromic Acid Treatment Tanks

- SWMU 69: Pond by Chromic Acid Treatment Tanks
- SWMU 71: Flash Burn Parts Area
- SWMU 74: Inert Landfill No. 3
- SWMU 75: Waste Oil Underground Storage Tank (UST)
- SWMU 76: Waste Oil USTs (South of Oleum Plant)
- SWMU F: Drum Storage Area (Near Building No. 9387-2)
- SWMU P: Spent Battery Storage Area (Scrap Metal Salvage Yard)
- SWMU Q: Calcium Sulfate Drying Bed

One SWMU, the Former Lead Furnace Area, was added to the VI by USATHAMA during the conduct of the field program. In addition, SWMU 49 was identified in the permit for investigation. However, as a result of the data collection and evaluation efforts for the VI Work Plan, it was concluded that SWMU 49 did not exist.

An additional six SWMUs were identified for RFI efforts; they are addressed in a separate RCRA Facility Investigation report prepared under the permit requirements.

2.4 ENVIRONMENTAL SETTING

2.4.1 Climate

The climate of the area encompassing Montgomery and Pulaski Counties is classified as "moderate continental" and is characterized by moderately mild winters and warm summers. The climate is determined, for the most part, by the prevailing westerly wind, with a southerly component in the warm season and a northerly component during the cold season. The year-round average surface-air velocity is 8 miles per hour (mph).

The mean annual precipitation in the two-county area is about 39 inches. Tables 2-2 and 2-3 list the average monthly precipitation and temperature for several stations in and around each county. Snowfall in the same area averages 17 inches annually.

TABLE 2-2

Average Monthly Precipitation for Locations Near RAAP

Station	Annual Precipitation (inches)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Years of Record
Allisonia	36.14	2.50	3.04	4.03	3.74	3.21	2.86	3.96	3.44	2.96	2.13	1.60	2.58	9
Blacksburg	40.73	3.18	3.08	3.61	3.17	3.73	4.21	4.70	3.90	3.03	2.77	2.35	3.03	70
Floyd	44.73	3.40	3.36	3.64	3.59	3.97	4.25	4.86	4.31	4.56	2.96	2.66	3.17	28
Glen Lyn	37.38	3.10	2.97	3.38	2.90	3.23	3.50	4.17	3.92	2.54	2.61	2.27	2.79	47
Pulaski	38.23	2.86	2.84	3.72	2.98	3.44	3.72	4.40	4.42	2.70	2.02	2.39	2.79	18
Claytor Dam	36.53	2.96	2.67	3.26	2.81	3.31	3.49	4.25	3.34	2.78	2.74	2.13	2.79	55

SOURCE: NOAA, 1973.

TABLE 2-3

Average Monthly Temperatures (°F), 1931-1960, for Locations Near RAAP

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Period of Record	
													High	Low
Blacksburg	35.3	36.5	42.5	53.0	62.0	69.4	72.5	71.4	65.4	55.0	43.6	35.6	100	-27
Floyd	35.3	37.8	42.7	53.2	61.9	69.2	72.0	71.1	64.8	55.1	43.9	36.9	103	-8
Glen Lyn	36.6	38.0	44.3	55.2	64.5	71.7	74.6	73.6	67.5	56.9	45.0	36.5	102	-9

SOURCE: NOAA, 1973.

Both counties lie in one of the areas of highest occurrence of dense fog in the United States. Dense fog can be expected to occur between 20 and 45 days per year.

2.4.2 General Topography

RAAP lies within the Valley and Ridge Province of the Appalachian Physiographic Division. The Valley and Ridge Province is characterized by a series of long, narrow, flat-topped mountain ridges separated by valleys of varying widths. Either of these landforms may predominate; the mountains may be widely spaced and isolated or so closely spaced that the lowlands are disconnected or absent. A distinctive feature of the installation area is the absence of mountain ridges.

The topography within the installation (Insert 1) varies from a relatively flat flood plain to elevated uplands in the extreme southeast section. The New River forms the RAAP boundary on the north, with the elevation approximately 1,675 feet above mean sea level (msl). The eastern boundary represents a transition from flood plain elevation (1,680 feet msl) to an elevation of 1,900 feet msl in the upland. The southern boundary traverses terrain consisting of creek bottoms and sharply rising summits. The western boundary follows the bluff line overlooking the New River to the point where the Norfolk and Western Railroad crosses the lower arm of the Horseshoe Area. In the Horseshoe Area to the north and east, the New River has a narrow flood plain. Just west of the Waste Propellant Burning Ground, the flood plain is terminated by steep bluffs that extend westward to the plant boundary.

The Horseshoe Area exhibits rolling karst terrain, with three prominent terraces and escarpments that are remnants of ancient New River flood plains.

2.4.3 General Geology and Soils

2.4.3.1 Soils. The near-surface soil at RAAP is divided into three general soil associations identified as "Map Units" by the Soil Conservation Service (SCS, 1985a; SCS, 1985b). One unit covers the higher elevation areas below the south and southeast sections of RAAP, with two very similar associations found beneath the relatively flat-lying portions of the Manufacturing Area and the Horseshoe Area. The following paragraphs describe the characteristics of these three soil map units.

The Groseclose-Poplimento-Duffield association consists of deep, well-drained, gently sloping-to-steep soils that have a clayey subsoil and have formed in limestone, shale, and sandstone residuum and colluvium on broad, moderately dissected uplands. Sinkholes are common in some areas. Slopes are dominantly 0 to 25 percent, but steeper slopes are apparent near the New River and other streams.

This map unit covers the uplands on the southern and southeastern areas of RAAP. Usually this association is about 21 percent Groseclose soils, 15 percent Poplimento soils, and 9 percent Duffield soils. The remaining 55 percent is minor soils.

The Groseclose, Poplimento, and Duffield soils are found on broad ridgetops and side slopes. They have a loam or silt loam surface layer and a clay subsoil. In some areas, the surface layer is cherty.

The minor soils in this map unit are in the Berks, Caneyville, Lowell, Opequon, Rayne, Vertrees, Ernest, McGary, Ross, and Weaver series. The well-drained Berks, Caneyville, Lowell, Opequon, Rayne, and Vertrees soils and the moderately well-drained Ernest soils are on ridgetops and side slopes; and the somewhat poorly drained McGary, the well-drained Ross, and the moderately well-drained Weaver soils are on flood plains.

The soils on the broad, gently sloping ridges are suited to cultivated crops--such as corn, small grains, and alfalfa--while the steeper soils are suited to pasture. The major limitations for farming are the low natural fertility and acidity of the soils. The erosion hazard is severe in steep areas. Scattered areas of stony and rocky soils are poorly suited to cultivation.

The clayey subsoil, slow permeability, low strength, high shrink-swell potential, and slope limit the nonfarm uses of the soils. The high slope limits urban development.

The Unison-Braddock association consists of deep, well-drained, gently sloping-to-moderately steep soils that have a clayey subsoil. These soils have formed in old alluvium and on stream terraces and alluvium fans. This map unit is found on the level ground of the RAAP Manufacturing Area between the uplands and the New River.

These soils are found on remnants of old stream terraces and on alluvial fans. Most surfaces are broad and gently sloping and sinkholes are common where the old alluvium is underlain by limestone. Small areas of residual soils are on the steep side slopes created by stream downcutting. A few areas of moderately steep terrace soils occur where material from the original surface layer has been beveled or reworked. Slopes are dominantly 0 to 25 percent, but areas of steeper slopes are included.

This map unit is made up of about 34 percent Unison soils, 15 percent Braddock soils, and 51 percent minor soils. The surface layer of the Unison and Braddock soils is fine, sandy loam or loam, and the subsoil is clay. Rounded pebbles and cobblestones are on the surface and throughout the soil in some areas.

The minor soils in this map unit are in the Berks, Caneyville, Groseclose, Opequon, Weikert, Duffield, Hayter, Guernsey, McGary, Ross, and Weaver series. The well-drained Berks, Caneyville, Groseclose, Opequon, and Weikert soils are on side slopes and ridgetops; the well-drained Duffield soils are on foot slopes, in upland depressions, and along drainageways; the well-drained Hayter soils and moderately well-drained Guernsey soils are on terraces; and the somewhat poorly drained McGary soils, well-drained Ross soils, and moderately well-drained Weaver soils are on flood plains.

The soils in the broad, gently sloping areas are suited to corn, small grains, and alfalfa, while the steeper areas are suited to pasture. The major limitations for farming are the acidity of the soil, the low natural fertility, and--in some areas--the high content of coarse fragments. The erosion hazard is severe on side slopes. The clayey subsoil, moderate permeability, low strength, and slope limit nonfarm uses of these soils.

The Braddock-Wheeling association consists of deep, nearly level-to-hilly soils that have a clayey or loamy subsoil formed in alluvium. These soils are found throughout the horseshoe area of RAAP and are very similar to the Unison-

Braddock unit. The unit consists of high and low terraces. Slopes range from 0 to 30 percent. This unit is made up of about 40 percent Braddock soils, 12 percent Wheeling soils, and 48 percent other soils.

The Braddock soils are on undulating-to-hilly, high terraces. The soils have a surface layer of dark yellowish brown loam and a subsoil of yellowish red and red clay.

The Wheeling soils are on nearly level, low terraces near streams. The soils have a surface layer of dark brown, sandy loam and a subsoil of dark brown, sandy clay loam.

The dominant minor soils are Carbo soils on convex side slopes and along small streams, Cotaco soils on low terraces, and Fluvaquents soils on long, narrow flood plains adjacent to streams.

Most of the acreage of this unit is used for cultivated crops, pasture, hay, and a few types of community development. Some of the steeper areas are wooded. The soils are suited to all of the crops grown in the county and support many dairy and beef cattle operations. The hazard of erosion is a major farming concern. The major trees are upland oaks, eastern white pine, Virginia pine, hickory, and black locust. The potential productivity for trees is high.

Permeability, a clayey subsoil, and slope are the main limitations of the unit, especially the Braddock soils, for community development.

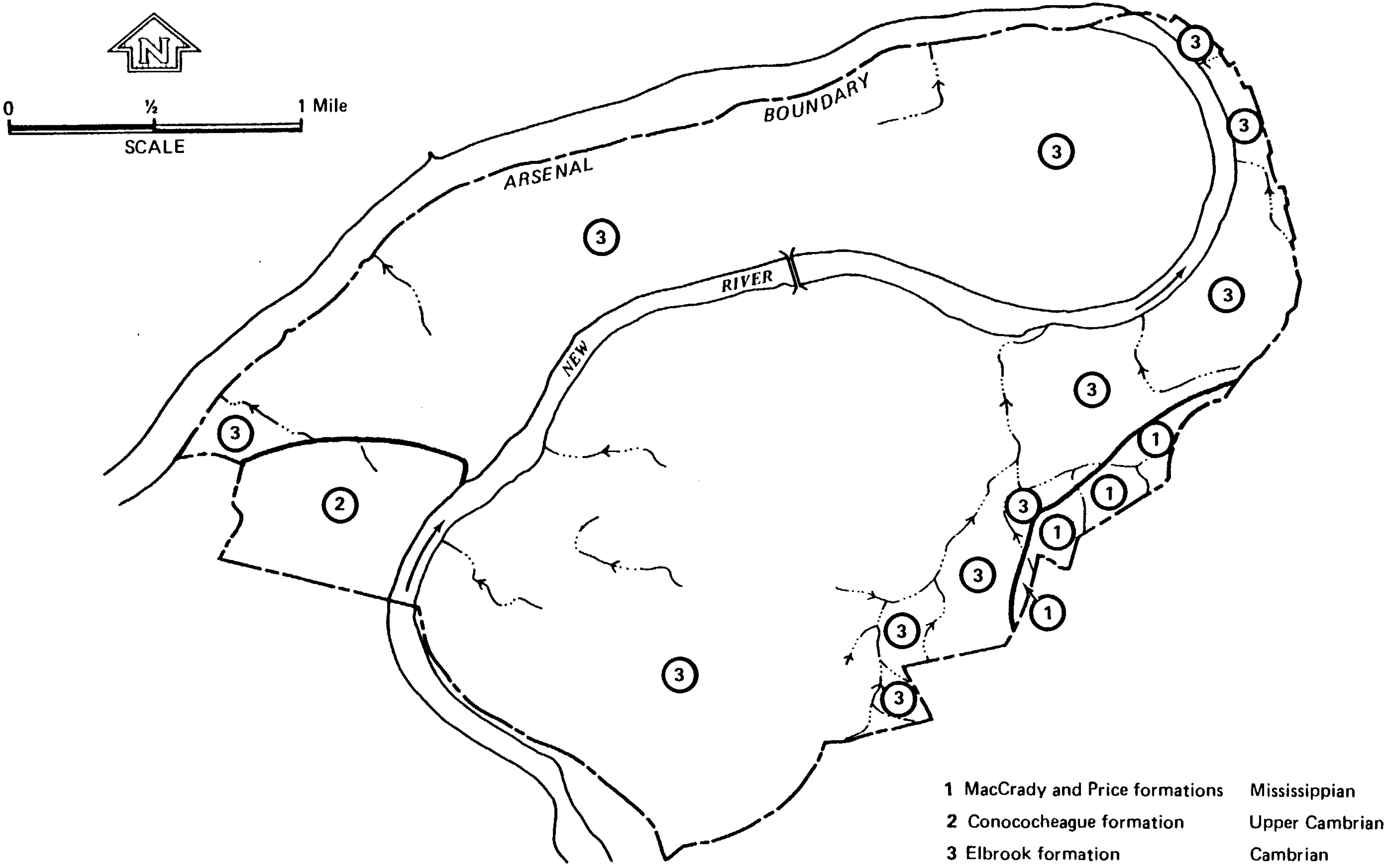
2.4.3.2 Structural Geology. The Valley and Ridge Province is characterized by folded and thrust-faulted strata of mostly sedimentary rocks formed between 600 and 300 million years ago. The thrust faults and folds indicate that the rocks were much compressed in the horizontal direction. Strike of bedding planes is north to south and dips to the southeast. RAAP occupies the Blacksburg-Pulaski Synclinorium and rests on the Pulaski Fault thrust sheet. The rocks have been thrust approximately 8 miles west-southwest. The thrust plate has been breached by erosion, exposing Mississippian sandstones and shales of the McCrady/Price Formation in a fenster (window) east of the main plant area along Stroubles Creek. The fault trace is exposed above the computer complex bunker where the Mississippian McCrady/Price Formation can be seen underlying the Cambrian Elbrook Formation. There is no evidence of recent faulting. However, the Radford area has experienced seven earth tremors in the last 200 years that recorded an intensity of VI or higher on the Modified Mercalli Scale (USAEHA, 1980a).

2.4.3.3 Stratigraphy. RAAP is underlain by four major rock units and one unconsolidated sedimentary unit that range in geologic age from Cambrian to Quaternary. The rock units are as follows--Cambrian Formations (Rome, Elbrook, and Conococheaque) and Mississippian Formations (McCrady/Price). Dip of the rock units varies over RAAP from nearly horizontal to 50 degrees. The unconsolidated sediments are Quaternary in age and include alluvial, residual, and colluvial deposits. Figure 2-4 is a general geologic map of the major consolidated rock formations at RAAP. The following paragraphs describe the consolidated and unconsolidated formations at RAAP (USAEHA, 1980a).

The Elbrook Formation is the major rock unit cropping out at RAAP. This formation is composed of thickly bedded, blue-gray dolomite interspersed with blue-gray to white limestones; brown, green, and red shales; argillaceous limestones; and brecciated limestones (colors of which range from mottled light to dark gray and yellow brown). Sinkholes, solution channels, pinnacled surfaces, and vugs are common to the Elbrook. This formation ranges from 1,400 to 2,000 feet in thickness.

The Rome Formation underlies the Elbrook Formation, but it is not known if the Rome crops out at RAAP due to the complex tilted and fractured structure of the overlying Elbrook. The Rome is composed of red and green shales, sandstone, dolomite, and limestone. The red shales commonly mark the basal unit. Thickness ranges from 1,000 to 2,000 feet.

Mississippian rocks of the McCrady/Price Formation outcrop in a fenster east of the main plant area along and south of Stroubles Creek. This formation consists of mottled red and green shale and mudstone interspersed with brownish-green siltstone and sandstone. The formation ranges upwards to 1,500 feet in thickness.



1	MacCrady and Price formations	Mississippian
2	Conococheague formation	Upper Cambrian
3	Elbrook formation	Cambrian

FIGURE 2-4
GENERAL GEOLOGIC MAP
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

SOURCE: USATHAMA, 1976

Dames & Moore

Unconsolidated sediments (overburden) mantle the major portion of RAAP. These sediments include alluvial plain sediments deposited by the New River prior to entrenchment; residual deposits from in-place weathering of parent bedrock; and colluvial deposits developed by residual slope wash. Alluvial plain deposits commonly line the New River and Stroubles Creek as recent flood-plain material or as geologically older terraces. On the horseshoe loop, three terraces are in evidence. In general, there is a textural fining upwards, with gravels and silty, clayey sands forming the basal unit followed by finer micaceous silts and clays. Sporadic cobbles and boulders (known as river jack) occur as lenses throughout the alluvial strata. Thickness of the alluvial deposits varies from a few feet to 50 feet, with an average of 20 feet.

Residual deposits (clays and silts) are a result of the mechanical, physical, and chemical weathering of the parent bedrock (primarily Elbrook Dolomite at RAAP). Most of RAAP is covered by residual deposits. In most cases along the New River and in the Horseshoe Area, these residual deposits underlie the alluvium, except where the residuum has been eroded to bedrock and replaced by alluvium. The depth of the residuum varies from a few feet to 40 feet.

Colluvial deposits are generally formed from mass-wasting of slopes and escarpments. In general these deposits are a heterogeneous mixture of alluvium, residuum, and rock debris that has migrated from the original position. These deposits are generally interbedded between the strata of alluvium and residuum; thickness is variable.

2.4.4 Groundwater Conditions

The conditions at RAAP are complex in terms of defining the water table and the available supply of groundwater. Several borings within the Horseshoe Area of RAAP indicate that the water table within the flood plain is approximately at the same elevation as the surface water of the river. These conditions also exist in the flood plain across the river in the Main Manufacturing Area of RAAP.

In areas of high elevations within the Horseshoe Area and south of the river within the Manufacturing Area, the water table is extremely variable. Because of impervious layers, solution cavities, and the thickness of overburden, extreme caution must be exercised in projecting water table data from existing borings into a new area.

Groundwater beneath RAAP is mainly derived from the infiltration of surface water through the unsaturated soil mantle into the saturated zone of the soil or bedrock. Groundwater fills the interconnected primary and secondary pore spaces in the bedrock, with the vast majority of available water occurring within the secondary pore spaces. The secondary pore spaces include fractures, open bedding planes, open foliation surfaces, and solution cavities. The limestone and dolomite underlying RAAP is severely fractured, foliated, and faulted as a result of movement along the Pulaski Fault System. The topographic maps clearly show evidence of solution cavities and collapse structures within the less competent limestone units.

Groundwater levels in the bedrock or soil aquifers generally respond immediately to heavy precipitation and may rise several feet in a short time. This illustrates the direct connection between the groundwater and surface water that could compromise the quality of groundwater for domestic use. This condition exists throughout RAAP and especially in areas where surface water has been intentionally routed into the sinkholes. Stormwater flows to the bottom of the sinkholes and percolates downward into the unconfined aquifer. The New River is the discharge for groundwater at RAAP as it is for regional groundwater flow. The saturated zone at RAAP can be generally in either the soil or bedrock. Open fractures and karst structures beneath the soil mantle, coupled with the relatively low elevation of the New River (1,680 feet msl), provide accessible conduits for groundwater flow, thereby rapidly draining the overlying, less permeable soils (CTM, 1988).

Water levels from wells scattered throughout RAAP were measured and elevations determined in order to create a general groundwater elevation map for the facility. Table 2-4 summarizes the data gathered and Insert 2 presents these data in the form of an approximate groundwater elevation map. Several wells had water levels unusually shallow or deep in relationship to other nearby wells. These wells probably intercepted perched groundwater zones or were influenced by karstic

Table 2-4
Groundwater Elevation Information
Radford Army Ammunition Plant, Virginia

Well	TOC Elevation	Measure Date	Gr.Sur. Elevation	Depth of Water FTOC	Stickup	Water Elevation	Survey Source
MW13	1803.54	3/12/92	1801.14	43.57	2.40	1759.97	BCM, 1984; USACE, 1981
7WCA	1715.81	3/12/92	1713.23	24.80	2.58	1691.01	USACE, 1988
S7W9	1712.59	3/12/92	1710.48	23.00	2.11	1689.59	USACE, 1988
W10	1706.86	3/12/92	1704.98	17.20	1.88	1689.66	USACE, 1988
H-1	1715.53	3/12/92	1712.48	29.47	3.05	1686.06	USACE, 1981
H-2	1712.70	3/12/92	1709.90	25.00	2.80	1687.70	USACE, 1981
H-3	1712.98	3/12/92	1709.66	25.80	3.32	1687.18	USACE, 1981
H-4	1713.90	3/12/92	1710.90	26.10	3.00	1687.80	USACE, 1981
HDH2	1716.81	3/12/92	1713.81	30.90	3.00	1685.91	BCM, 1984
10MW1	1703.62	3/12/92	1701.28	16.67	2.34	1686.95	VI
D-3	1702.95	3/12/92	1700.51	16.00	2.44	1686.95	VI
D3D	1702.64	3/12/92	1700.70	16.05	1.94	1686.59	VI
D-4	1714.38	3/12/92	1713.42	22.00	0.96	1692.38	VI
D5	1699.01	3/12/92	1696.12	6.30	2.89	1692.71	BCM, 1984; USACE, 1981
D6	1702.13	3/12/92	1699.64	11.02	2.49	1691.11	BCM, 1984; USACE, 1981
DDH2	1702.53	3/12/92	1700.78	15.87	1.75	1686.66	VI
DDH4	1715.85	3/12/92	1713.16	24.95	2.69	1690.90	VI
DG-1	1712.08	3/12/92	1709.96	22.30	2.12	1689.78	VI
D-2	1715.94	3/12/92	1713.12	20.85	2.82	1695.09	BCM, 1984; USACE, 1981
DDH3	1718.70	3/12/92	1715.70	24.95	3.00	1693.75	BCM, 1984; USACE, 1981
D8	1714.40	3/12/92	1711.75	22.68	2.65	1691.72	BCM, 1984; USACE, 1981
DDH1	1702.00	3/12/92	1699.00	15.58	3.00	1686.42	BCM, 1984; USACE, 1981
D7	1703.61	3/12/92	1701.04	18.00	2.57	1685.61	BCM, 1984; USACE, 1981
17PZ1	1907.02	3/12/92	1904.70	93.00	2.32	1814.02	RFI
41MW1	1805.15	3/12/92	1802.87	20.03	2.28	1785.12	VI
41MW2	1797.45	3/12/92	1795.44	52.05	2.01	1745.40	VI
41MW3	1759.35	3/12/92	1757.26	27.74	2.09	1731.61	VI
43MW1	1705.87	3/12/92	1703.90	17.99	1.97	1687.88	VI
43MW2	1707.62	3/12/92	1704.95	24.00	2.67	1683.62	VI
43MW3	1703.35	3/12/92	1701.15	20.89	2.20	1682.46	VI
43MW4	1702.78	3/12/92	1700.90	19.80	1.88	1682.98	VI
43MW5	1702.94	3/12/92	1700.40	17.77	2.54	1685.17	VI
43MW6	1703.88	3/12/92	1701.24	19.07	2.64	1684.81	VI
45MW1	1709.70	3/12/92	1707.53	25.00	2.17	1684.70	VI
45MW2	1706.17	3/12/92	1703.74	21.21	2.43	1684.96	VI
45MW3	1706.52	3/12/92	1704.14	21.42	2.38	1685.10	VI
8B	1740.14	3/12/92	1738.20	11.00	1.94	1729.14	RFI
9B	1736.78	3/12/92	1734.30	17.22	2.48	1719.56	USACE, 1988
OMW1	1780.04	3/12/92	1777.60	17.40	2.44	1762.64	RFI
P-1	1779.69	3/12/92	1777.10	12.32	2.59	1767.37	RFI
P-2	1758.64	3/12/92	1756.80	3.12	1.84	1755.52	RFI
P-3	1754.59	3/12/92	1753.20	4.60	1.39	1749.99	RFI
P-4	1773.17	3/12/92	1771.20	22.90	1.97	1750.27	RFI

Table 2–4 (cont'd)

Well	TOC Elevation	Measure Date	Gr.Sur. Elevation	Depth of Water FTOC	Stickup	Water Elevation	Survey Source
S4W1	1753.27	3/12/92	1750.70	8.90	2.57	1744.37	RFI
S4W2	1736.63	3/12/92	1734.63	14.00	2.00	1722.63	USACE, 1988
S4W3	1721.26	3/12/92	1719.56	16.37	1.70	1704.89	USACE, 1988
S4W4	1735.70	3/12/92	1733.72	12.33	1.98	1723.37	USACE, 1988
WC1–2	1786.58	3/12/92	1784.80	39.48	1.78	1747.10	RFI
WC2–2	1739.98	3/12/92	1738.14	18.17	1.84	1721.81	USACE, 1988
WC3–2	1725.80	3/12/92	1723.43	17.70	2.37	1708.10	USACE, 1988
5WCA	1779.96	3/12/92	1777.37	12.00	2.59	1767.96	USACE, 1988
5WC1–1	1789.99	3/12/92	1787.55	17.00	2.44	1772.99	USACE, 1988
S5W5	1775.25	3/12/92	1773.32	2.50	1.93	1772.75	USACE, 1988
S5W6	1771.43	3/12/92	1769.42	5.70	2.01	1765.73	USACE, 1988
S5W7	1778.59	3/12/92	1776.59	11.50	2.00	1767.09	USACE, 1988
13MW1	1701.44	3/12/92	1698.66	19.32	2.78	1682.12	RFI
13MW2	1702.62	3/12/92	1701.21	20.42	1.41	1682.20	RFI
13MW3	1694.47	3/12/92	1693.81	12.70	0.66	1681.77	RFI
13MW4	1696.40	3/12/92	1695.18	16.00	1.22	1680.40	RFI
13MW5	1696.40	3/12/92	1695.26	16.03	1.14	1680.37	RFI
13MW6	1696.04	3/12/92	1693.85	15.77	2.19	1680.27	RFI
13MW7	1695.21	3/12/92	1693.77	14.72	1.44	1680.49	RFI
B2	1772.65	3/12/92	1769.47	80.37	3.18	1692.28	USACE, 1981
B3	1767.89	3/12/92	1765.09	74.91	2.80	1692.98	USACE, 1981
B4	1767.50	3/12/92	1764.64	71.90	2.86	1695.60	USACE, 1981
BDH2	1785.24	3/12/92	1783.77	89.73	1.47	1695.51	VI est.
BDH3	1830.73	3/12/92	1829.55	86.30	1.18	1744.43	VI est.
7	1774.60	3/12/92	1772.10	26.40	2.50	1748.20	USAEHA, 1980b
FAL2	1757.93	3/12/92	1756.13	35.92	1.80	1722.01	USEPA, 1989
FAL3	1758.43	3/12/92	1757.43	66.50	1.00	1691.93	USEPA, 1989
16–1	1815.82	3/12/92	1814.54	50.40	1.28	1765.42	RFI
16–2	1810.99	3/12/92	1809.24	55.78	1.75	1755.21	RFI
16–3	1824.77	3/12/92	1823.37	59.03	1.40	1765.74	RFI
16–4	1836.76	3/12/92	1835.84	53.72	0.92	1783.04	RFI
28MW1	1827.18	3/12/92	1825.71	31.73	1.47	1795.45	RFI
28MW2	1821.56	3/12/92	1819.91	62.84	1.65	1758.72	RFI
51MW1	1823.13	3/12/92	1821.24	7.74	1.89	1815.39	RFI
51MW2	1834.77	3/12/92	1833.29	49.54	1.48	1785.23	RFI
C–1	1840.14	3/12/92	1836.94	52.12	3.20	1788.02	RFI
C–4	1826.84	3/12/92	1824.74	54.71	2.10	1772.13	RFI
CDH–2	1826.28	3/12/92	1823.79	56.92	2.49	1769.36	RFI
MW–9	1808.88	3/12/92	1806.54	65.15	2.34	1743.73	RFI
WC–1A	1812.61	3/12/92	1810.54	68.93	2.07	1743.68	RFI
WC–2A	1818.05	3/12/92	1816.07	64.62	1.98	1753.43	RFI
32MW1	1738.31	3/12/92	1736.40	56.90	1.91	1681.41	VI
54MW1	1707.78	3/12/92	1705.68	18.52	2.10	1689.26	VI
54MW2	1701.41	3/12/92	1698.86	21.61	2.55	1679.80	VI
54MW3	1702.15	3/12/92	1700.56	22.64	1.59	1679.51	VI
74MW1	1734.85	3/12/92	1732.59	24.28	2.26	1710.57	VI

Note:
FTOC = From top of casing.

features, such as sinkholes or conduits, which exerted a strong local influence which was not reflective of the overall unconfined water table. The overall water table resulting from these measurements was what would be expected in an area dominated by a major river--flow was generally towards the New River and away from areas of higher elevation. The southernmost area of RAAP consists of folded rocks which have numerous sinkholes and a deep water table. The karst nature of the geologic units probably determines flow through the bedrock in this area and true flow is most certainly much more complicated than the simple flow lines presented on Insert 2. Bedrock groundwater in this southern area probably flows towards and discharges into either the New River to the west or the unnamed tributary of Stroubles Creek to the east.

Groundwater supplies in the Valley and Ridge Province are presently of good or superior quality compared to surface water supplies. However, due to extended contact with minerals, many groundwater supplies contain higher levels of dissolved solids than the streams into which they discharge. Because of the sinkholes and underground caverns in the karst aquifers, there is a threat to the groundwater due to direct infiltration of contaminated surface water, where present.

2.4.5 Surface Water Drainage

The New River is the major drainage within RAAP. The river varies from 200 to 1,000 feet in width, but averages about 410 feet. Generally, the depth is about 4 to 6 feet; however, pools may be 10 feet deep between rock outcrops in the river bed. The flow through RAAP is regulated by a control structure located approximately 7 miles south of the installation. There are 13 miles of river shoreline within the RAAP boundaries.

Stroubles Creek is the largest tributary of the New River and originates in the southeast sector of RAAP. This creek is fed by several branches that originate on and off post. The larger surface drainageways within the installation and their direction of flow are shown in Figure 2-5. Manmade surface drainageways at RAAP also influence local drainage. Regardless of location, the direction of surface drainage flow is ultimately to the New River.

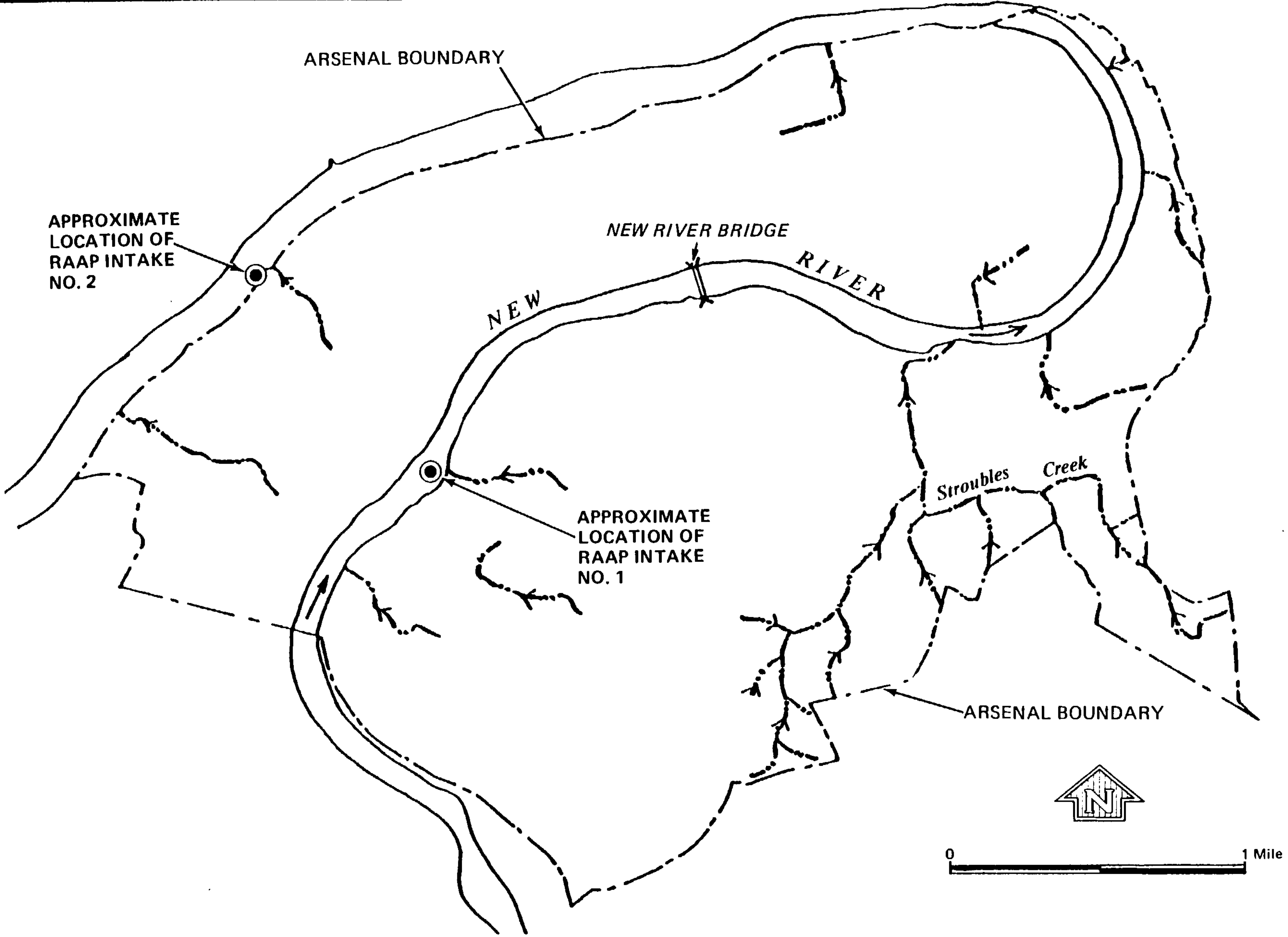


FIGURE 2-5
SURFACE WATER DRAINAGE,
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

SOURCE: USAEHA, 1980b.

Dames & Moore

Subsurface drainage is present in RAAP through the sinks or solution cavities formed by percolating waters within the underlying limestone. These cavities vary in size and shape and may be interconnected, forming underground drainageways. Groundwater flow at RAAP is discussed in Section 2.4.4.

Stroubles Creek consists primarily of stormwater runoff and effluent from the Blacksburg, Virginia, Municipal Wastewater Treatment Plant. The creek empties into the New River on the RAAP installation and contributes significant loadings of domestic and industrial wastewater (USATHAMA, 1976). As mentioned in Section 2.4.4, groundwater discharging from the karst bedrock in the southern areas may all supply significant stream flow.

Both industrial and domestic wastewaters are being discharged into the New River from the city of Radford, upstream from RAAP. Previously, Radford provided only primary sewage treatment before discharging 2.5 million gallons per day (mgd) into the New River (USATHAMA, 1976), secondary treatment is now provided at the Peppers Ferry Regional Wastewater Treatment Plant.

The Commonwealth of Virginia has classified Stroubles Creek and the stretch of New River passing through the confines of RAAP as water generally satisfactory for beneficial uses, which include public or municipal water supply, secondary contact recreation, and propagation of fish and aquatic life (USATHAMA, 1976).

All water used at RAAP is taken from the New River. The river flow varies due to water management at Claytor Dam, approximately 9 miles upgradient from RAAP (Figure 2-2). Typical flows are about 3,800 mgd. Separate water systems are provided for the main plant and the Horseshoe Area. Intake No. 1 is located approximately 2 miles upstream of the mouth of Stroubles Creek. Intake No. 2 is located approximately 6 miles downstream of the mouth of Stroubles Creek (Figure 2-5). Upstream of RAAP, the New River serves as a source of drinking water for the towns of Blacksburg and Christiansburg.

In 1976, water quality analyses of the New River were conducted both where the river enters the RAAP installation and where it exits the installation. The analyses indicated that the quality of the water when it leaves the installation was essentially the same as when it enters. Table 2-5 provides a summary of the general water quality of the New River, determined in 1976.

2.5 LAND USE

Land in the vicinity of RAAP is mostly rural. Development has been kept to a minimum in much of the area due to the steep terrain. Much of the area surrounding RAAP that is less rugged is agricultural. Although there are private residences immediately adjacent to the installation, the nearest substantial residential area is Fairlawn, located approximately 3 miles to the southwest. Property owners immediately adjacent to the installation boundary are identified in Figure 2-6 and Table 2-6. Located approximately 5 miles to the southwest is Radford (estimated 1988 population of 12,000). To the north of RAAP is the Jefferson National Forest. The population densities of Montgomery and Pulaski Counties are 173.1 and 106.9 persons per square mile, respectively. Additional information on local demographics and ecological populations is provided in the identification of potential receptors in Appendix A.

Montgomery County, with an area of 394 square miles and an estimated 1988 population of 67,000, is bordered by mountains to the east, north, and south and by the New River on the west. The primary roads in the county are US Route 11, Interstate 81, and US Route 460. The county seat is Christiansburg.

Pulaski County, to the west of Montgomery County, is 328 square miles in size and had an estimated 1988 population of 34,000. The county is bounded by mountains to the north, west, and south and by the New River on the east. The primary roads are US Route 11 and Interstate 81, which run east-west through the center of the county. Pulaski County is generally mountainous except in the central portion, where the hills are gently rolling. The town of Pulaski is the county seat.

Since 1960, Montgomery and Pulaski Counties have experienced strong population growth. Montgomery County consistently exhibits the strongest population growth in the New River Valley Region (comprised of Giles, Floyd, Pulaski, and Montgomery Counties and the city of Radford), posting increases far in excess of regional trends.

TABLE 2-5

Analyses of the New River Entering and Leaving Radford Army Ammunition Plant, Virginia

PARAMETER	CONCENTRATION[a]	
	ENTERING	LEAVING
Alkalinity (as $CaCO_3$)	45	45
BOD	2	2
COD	10	10
Total Solids	66	66
Total Dissolved Solids	61	61
Total Suspended Solids	5	5
Total Volatile Solids	29	29
Ammonia	0	0
Kjeldahl Nitrogen	0.4	0.4
Nitrate (as Nitrogen)	0.4	0.7
Phosphorus Total	< 0.3	< 0.3
Color (Color Units)	16	15
Nitrite	< 0.01	< 0.01
Sulfate	4	10
Sulfide	< 0.1	< 0.1
Bromide	0.59	0.59
Aluminum	< 0.10	< 0.10
Cadmium	< 0.005	< 0.005
Chloride	5.2	5.7
Copper	< 0.010	< 0.010
Iron	0.35	0.33
Lead	< 0.010	< 0.010
Magnesium	5	4
Mercury	< 0.002	< 0.002
Beryllium	0	0
Boron	0	0

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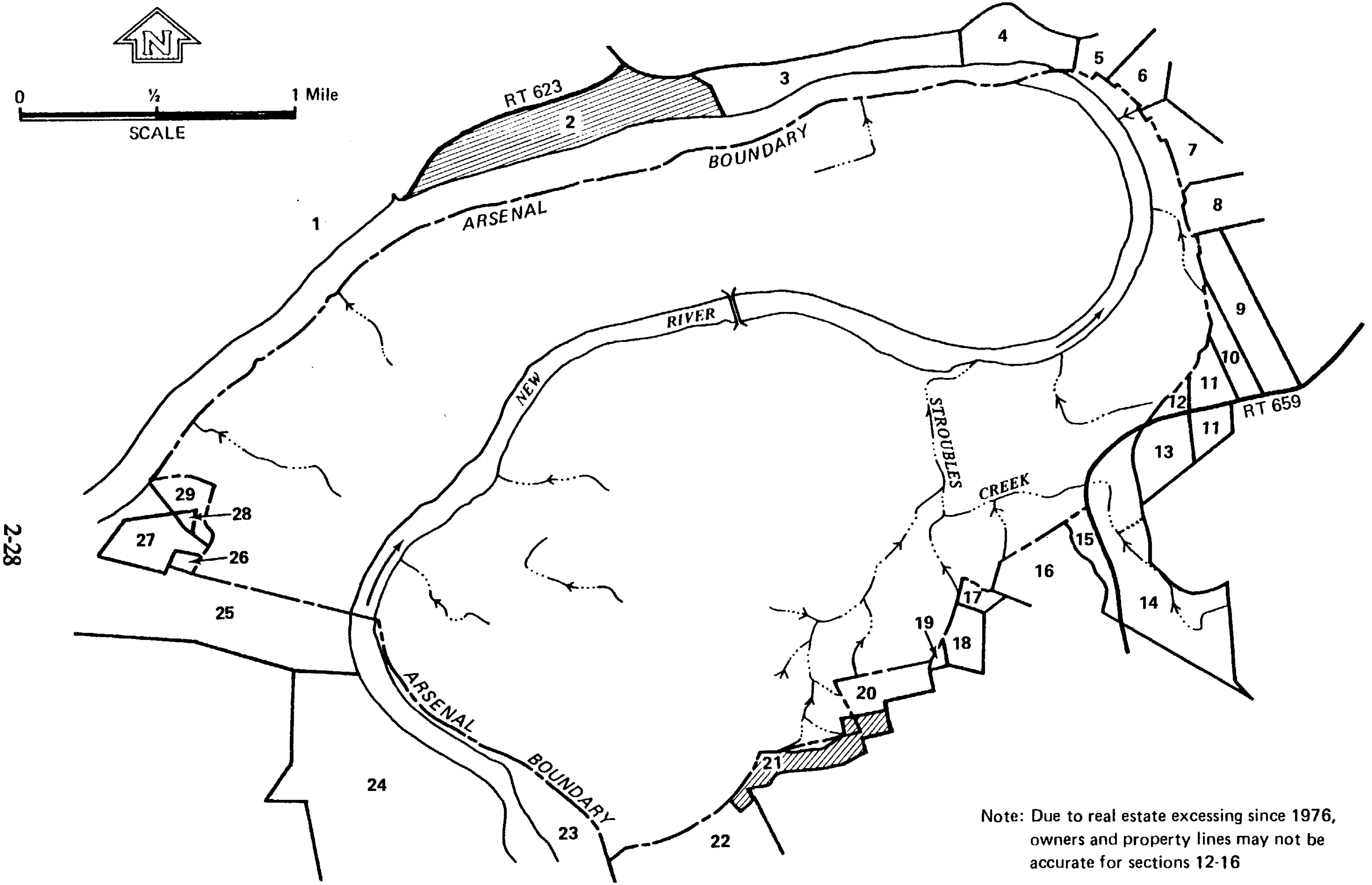
[a] All results are in milligrams per liter (mg/l), except as noted.

SOURCE: USATHAMA, 1976.



Note: Due to real estate excessing since 1976, owners and property lines may not be accurate for sections 12-16

▨ Numerous owners of small parcels

FIGURE 2-6
ADJACENT PROPERTY OWNERS
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

BASE MAP SOURCE: USATHAMA, 1976

Dames & Moore

TABLE 2-6

Property Owners Adjacent to RAAP
(May 1990)

1. Virginia Polytechnic Institute
2. H. M. Albert Estate (26 individual lots)
3. Albert, M. L. _et al_. and Albert, Genoa T. Graves
4. Price, H. L.
5. Shaver, J. L.
6. Trower, W. P.
7. Humphrey, L. P.
8. Gallimore, E. A.
9. Nuckols, R. D.
10. Gallimore, C. R.
11. Cadle, R. Y.
12. Johnson, D., Mr. and Mrs.
13. Akers, James, Mr. and Mrs.
14. Blacksburg, Christiansburg, VPI Water Authority
15. Belvins, C. E.
16. Blacksburg, Christiansburg, VPI Water Authority
17. Howard, R. N.
18. Blacksburg, Christiansburg, VPI Water Authority
19. U.S.A.
20. Blacksburg, Christiansburg, VPI Water Authority
21. R.D. Stafford Lots (142 individual lots)
22. Hampton, Dr. C. L.
23. Oak Manor Farms
24. Ratcliffe, V. D. & Mason, L. D.
25. Stanley, R., Jr. and Nadine S.
26. McGraw, W. T., Mr. and Mrs.
27. Robertson, J. M.
28. Smith, S. J., Smith, V. & White, A. S.
29. Smart, J. H.

Manufacturing is the largest individual employment sector in the area, with 17,282 employees in the second quarter of 1988 accounting for 33.8 percent of the area's total employment. Hercules Incorporated employees involved in the manufacture of explosives and propellants are included in these figures.

RAAP is the only facility in the country with the capability to produce TNT and as such is not considered a likely candidate for surplus excessing by the U.S. Army. Future land use of RAAP should be considered the same as present land use when long term planning and projections are performed.

2.6 FLORA AND FAUNA

Lists of the mammals, birds, reptiles, amphibians, aquatic invertebrates, trees, and plants found on the installation and of the fish inhabiting the New River where it flows through the installation are presented in earlier environmental assessments of RAAP and are not included herein. These lists were compiled by combining data from the RAAP Woodland Management Plan, the RAAP Fish and Wildlife Management Plan, the 1973 RAAP declaration of timber available for harvest, the RAAP Land Management Plan, and verbal information from the forester at RAAP (USATHAMA, 1976).

Several studies of fish and aquatic invertebrates, deer populations, and growth rates of tree rings at RAAP were conducted by several departments of the Virginia Polytechnic Institute and State University (VPI&SU) in Blacksburg, Virginia. For most of the installation's life forms, there is little information available about the occurrence, abundance, breeding areas, and distributions.

It is probable that all of the reptiles, all of the mammals (except the bobcat), and most of the birds (except migratory waterfowl) listed in the 1976 Installation Assessment (USATHAMA, 1976) breed on the installation. Foxes periodically build up large populations, and the Virginia Commission of Game and Inland Fisheries cooperates in trapping them to prevent rabies outbreaks. The last trapping program for foxes was conducted in 1966. Deer also become overabundant and are sometimes significant road hazards. A deer capture program was conducted annually by the State Game Commission to maintain a constant population until 1990. Controlled hunting is now used to regulate the deer population.

Because the installation is on the Atlantic Flyway, the New River is a haven for many species of migratory waterfowl throughout the spring and winter.

No threatened or endangered species are suspected of dwelling at RAAP, nor are there any known species with unusual aesthetic value. There are no species known to occur exclusively at RAAP or to be absent from the rest of the counties or State; there are no species known for which the installation lies at the limit of their ranges. Indications are that some species, including ruffed grouse and upland plovers, have decreased in number or have disappeared from RAAP (USATHAMA, 1976).

Limited deer hunting with bow and arrow is permitted within RAAP. Deer are also trapped by the Virginia Department of Conservation for restocking in neighboring counties. Public fishing is permitted from boats in the New River.

A survey made of the fish population in the New River by VPI&SU determined that there was an adequate stock of native species for sportfishing. Salt blocks, grain fields, and grain-stocked shelters have been provided on RAAP for game species. There is no other active management of the wildlife.

According to the most recent Woodland Management Plan, the forest area of RAAP is essentially the same as when originally acquired. All hardwood of merchandisable size inside the security fence along the New River was removed because of damage by 2,4-dichlorophenoxyacetic acid (24D), which was sprayed to eliminate musk thistle in 1971. Musk thistle was declared a noxious weed by the Virginia General Assembly, and its control is required by law. In the 1950s approximately 3,000 acres were reforested.

There are 2,537 acres of managed woodlands. The rolling areas and one flat bottom have been reforested. No reforestation has occurred in the Main Manufacturing Area. In 1964, 922 acres of the Horseshoe Area were reforested. The cutting cycle on existing forest lands is 7 years; the first cutting took place in

1966. Reforestation and forest improvement were in effect from 1955 to 1973 at suitable sites. Black walnut and white oak will be retained on the stump, if they are in good condition, to provide a mobile reserve. Unsuitable or diseased trees are removed. As recommended by the Virginia Forestry Department, timber stands have been improved in all areas through selective cutting of mature trees with mechanized equipment when possible. Weed trees have been sprayed with ammonium sulfamate. Controlled burning is not practiced because of the fire hazard.

3.0 SUMMARY OF VI FIELD PROGRAM

3.1 OVERVIEW

The VI field program at RAAP included geotechnical, sampling, and analytical investigations, that provided data on the physical and chemical characteristics of media of interest at SWMUs being studied. Data gained through this program supplemented existing data, therefore enabling better characterization of surface, subsurface, and hydrogeologic conditions at RAAP in order to identify releases or suspected releases of hazardous waste or hazardous constituents into soil, sediment, surface water, and groundwater. Table 3-1 summarizes the major activities during the VI at each SWMU.

Geotechnical activities, included the drilling of nine exploratory soil borings, the installation of 20 groundwater monitoring wells and one piezometer, a soil gas survey, the collection of water level measurements, and the inspection of existing on-post wells. Geophysical investigation methods were also used at four SWMUs to better define subsurfaces characteristics at each site. The analysis of information gathered from these field investigations helped better define local surface drainage features, subsurface lithology, aquifer characteristics, the location and/or areal extent of subsurface contaminant sources, and possible pathways for contaminant migration. This information is useful to evaluate the need for any follow up investigations, RFI activities, corrective measures, or monitoring.

The sampling and analytical program included the chemical analyses of representative samples of groundwater, surface water, soils, sediment, and waste for use in identifying contaminants at RAAP. Physical testing of representative soil samples from each boring were performed in order to characterize soil formations and their hydrogeological properties.

3.2 GEOPHYSICAL SURVEYS

To better identify SWMU boundaries, locate probable areas of disposal (trenches, pits, etc.) and to assist in well placement, geophysical surveys were conducted at the following SWMUs:

Table 3–1
Summary of 1991/1992 VI Field Program
Radford Army Ammunition Plant, Virginia

SMWU Nos.	SWMU Name	Bores	Wells/ Piez.	Geophysical Survey	Environmental Samples					
					Soil	Ground Water	Surface Water	Sediment	Waste	Duplicates
6	Acidic Wastewater Lagoon	2	--	--	4	1	--	--	--	1
8, 9, 36, 37, 38, 50 and Q	Calcium Sulfate Lagoons, Drying Beds and Disposal Areas	--	--	1	--	--	--	--	12	1
10, 35	Bio–Plant Equalization Basin and Calcium Sulfate Drying Bed	1	1	--	6	10	1	3	--	--
26	Fly Ash Landfill No. 1	--	--	--	--	4	--	--	--	--
27, 29, 53	Calcium Sulfate Landfill, Fly Ash Landfill No. 2, Activated Carbon Disposal Area	--	--	--	--	a	1	3	--	2
31	Coal Ash Settling Lagoons	--	--	--	--	--	--	--	3	1
32	Inert Waste Landfill No. 1	2	1	--	--	1	--	--	--	--
39	Incinerator Wastewater Ponds	--	--	--	3	--	--	--	3	1
40	Sanitary Landfill (NG Area)	4	2	--	--	--	--	--	--	--
41	Redwater Ash Landfill	6	3	--	2	3	1	--	--	1
43	Sanitary Landfill (Adjacent to New River)	6	6	--	--	6	2	--	--	1
45	Sanitary Landfill (West of Main Bridge)	3	3	1	--	3	--	--	--	--
46	Waste Propellant Disposal Area	--	--	1	2	--	--	--	--	--
48	Oily Wastewater Disposal Area	3	--	--	5	--	--	--	--	--

Table 3–1 (cont'd)

					Environmental Samples					
SMWU Nos.	SWMU Name	Bores	Wells/ Piez.	Geophysical Survey	Soil	Ground Water	Surface Water	Sediment	Waste	Duplicates
54	Propellant Ash Disposal Area	4	4	1	--	3	--	--	--	--
57	Pond by Buildings No. 4931 and 4932	--	--	--	--	--	1	1	--	--
58	Rubble Pile	--	--	--	3	--	--	--	--	--
59	Bottom Ash Pile	--	--	--	2	--	--	--	--	1
68	Chromic Acid Treatment Tanks	--	--	--	2	--	--	--	--	--
69	Pond by Chromic Acid Treatment Tanks	--	--	--	2	--	1	1	--	--
71	Flash Burn Parts Area	--	--	--	3	--	--	--	--	--
74	Inert Landfill No. 3	1	1	--	--	1	--	--	--	--
F	Drum Storage Area	--	--	--	8	--	--	--	--	--
P	Battery Storage Area	--	--	--	10	--	--	--	--	1
	Former Lead Furnace Area	3	--	--	6	--	--	--	--	--
	Background	--	--	--	10	--	--	--	--	--
	TOTALS	35	21	4	68	32	7	8	18	10

Footnotes

[a] Nine sample results from three quarterly monitoring wells evaluated.

- Trenches near SWMU 38
- SWMU 45--Sanitary Landfill (West of Main Bridge)
- SWMU 46--Waste Propellant Disposal Area
- SWMU 54--Propellant Ash Disposal Area.

The areas of coverage, survey grid-spacings, and SWMU-specific details including results of the surveys are provided in Appendix H of this report. A summary of the findings at each SWMU is included in the sections detailing characterization of these SWMUs.

Two different types of geophysical instruments were used for conducting the magnetic survey and the electromagnetic conductivity survey. Magnetometers were used to locate subsurface ferrous materials, and an electromagnetic induction meter was used to map conductive materials in the ground and also to detect metals.

The magnetometer survey to identify ferrous materials (iron and steel) was conducted using a pair of GeoMetrics G-856 proton magnetometers. These instruments measure the total density of the magnetic field. One of the magnetometers was located at a base station to monitor the change in the earth's magnetic field with respect to time, or temporal shift. Measurements were automatically recorded at 2 minute intervals. The second magnetometer provided spatial measurements of the magnetic field. The sensor was located at an elevation of 8 feet to minimize the effect of small, shallow iron objects which may cause "noise" or interference patterns in the data. The spatial measurements of the magnetic field were corrected for the temporal shift by subtracting the measurements made at the base station. Data from the base magnetometer showed that the base magnetic field was not large. A linear interpolation from the base station was generated and plotted. In the magnetic data, a higher than normal total magnetic field intensity is generally found over ferrous material. Associated with the high intensity, a low is generally found north of the high.

An audio-indicating fluxgate magnetometer was used to potentially locate the stub of a metal signpost at SWMU 46. The magnetometer used was a Schonstedt MAC-SIB magnetic locator.

The electromagnetic (EM) survey was conducted using a Geonics EM-31 electromagnetic induction meter. The EM-31 measures the apparent conductivity of the subsurface through principles of electromagnetic induction.

The EM-31 consists of two horizontal coplanar loops separated by a rigid boom. One loop acts as a transmitter while the second loop acts as a receiver. The transmitter induces eddy currents in the earth that is a primary field, which, in turn, produces a secondary field. The receiver intercepts the secondary field. The EM-31 measures the terrain conductivity by comparing the strength of the secondary field to that of the primary field.

The depth of investigation by EM is a function of the intercoil spacing and the orientation of the antenna dipoles. The EM-31 has intercoil spacing of 12 feet, and when used in the horizontal mode, has an effective depth of analysis of approximately 20 feet.

The electromagnetic data generally can indicate large-area and nearby metal objects with negative values. The EM-31 can indicate distant moderate-sized metal objects as high conductivity; therefore, both high and very low readings of apparent conductivity can indicate the location of metal. However, high conductivity can also be caused by some chemical constituents in the soil and by conductive soils such as clay. Low conductivity materials such as wood and oil are generally not detectable by the EM-31. Disturbances of the natural soils will sometimes be indicated by changes in conductivity.

3.3 SOIL GAS SURVEY

A soil gas survey was performed by Target Environmental Services, Inc. in the area of SWMU 48 to determine the extent of apparent fuel contamination encountered in the area of soil boring 48SB3. Eight soil gas samples were collected in a 50 foot grid centered on soil boring 48SB3, covering an area of 100 feet by 100 feet (Section 17.3.2). The report from Target Environmental Services, including the results of the eight soil gas samples collected from SWMU 48, is included as Appendix G of this report.

To collect the samples, a 1/2-inch hole was produced to a depth of approximately 4 feet by using a drive rod. The entire sampling system was purged with ambient air drawn through an organic vapor filter cartridge, and a stainless steel probe was inserted to the full depth of the hole and sealed off from the atmosphere. A sample of in-situ soil gas was then withdrawn through the probe and used to purge atmospheric air from the sampling system. A second sample of soil gas was withdrawn through the probe and encapsulated in a pre-evacuated glass vial at two atmospheres of pressure (15 psig). The self-sealing vial was detached from the sampling system, packaged, labeled, and taken to Target's mobile laboratory for analysis.

Targets standard decontamination procedures were used during this program. Prior to the day's field activities, all sampling equipment, slide hammer rods, and probes were decontaminated by washing with soapy water and rinsing thoroughly. Internal surfaces were flushed dry using pre-purified nitrogen or filtered ambient air, and external surfaces were wiped clean using clean paper towels. Between samples, the exterior of the probe and rods were cleaned by towels. The interior of the probe was purged from five to eight times with ambient air before each sample. Field control samples were collected at the beginning and end of each day's field activities. These QA/QC samples were obtained by filtering ambient air through a dust and organic vapor filter cartridge and collecting in the same manner as described above.

3.4 BORING AND SAMPLING PROGRAM

All geotechnical boring, well installation, and soil sampling methods were performed in accordance with the Verification Investigation Plan (Dames & Moore, 1990a) or using methods approved by USATHAMA when unusual conditions were encountered. Appendix B presents the procedures used during the field drilling and sampling program. The following sections discuss the borehole drilling and sampling program associated with this VI report. As shown in Table 3-1, the field program for the VI study areas included the following:

- Twenty-one borings for well and piezometer installations at eight SWMUs.

- Nine exploratory soil borings performed at four SWMUs.
- Physical soil tests performed on 24 soil boring samples.

3.4.1 Exploratory Soil Boring Methodology

A total of nine exploratory soil borings were performed at the following SWMUs:

- SWMU 6--Acidic Wastewater Lagoon - two borings
- SWMU 41--Red Water Ash Landfill - one borings
- SWMU 48--Oily Wastewater Disposal Area - three borings
- Former Lead Furnace Area - three borings

The exploratory borings were relatively shallow, ranging in depth from 7 to 22 feet. The soil zone was penetrated using 4.25-inch inside diameter (I.D.) hollow stem augers. Soil sampling was accomplished with an internally mounted 5-foot soil corer, except for one soil boring in SWMU 48 which was continuously sampled with a 24-inch split spoon sampler driven using methods specified in the Standard Penetration Test (SPT) (ASTM D-1586). Detailed soil boring logs, provided in Appendix E, were developed from information gathered by field observation of soil cores. Boring completion details are presented in Table 3-2.

Soil sampling and boring locations for each SWMU investigation are shown on each SWMU location maps provided in Sections 5.0 through 28.0. Table 3-2 provides a summary of the sampling points. Additional sampling and boring information is included in the investigation program section for each SWMU. All soil samples are from discrete locations. Detailed soil sampling procedures are included in Appendix B.

3.4.2 Well Drilling Methodology

From August through October 1991, a total of 36 borings were drilled for data collection and the installation of one piezometer and 20 wells.

Table 3–2
Summary of VI Boring Program
Radford Army Ammunition Plant, Radford, Virginia

Boring	Date	Total Depth (feet)*	Boring Method	Sample Method	Depth of Chemically Analyzed Samples (feet)*	SWMU
6SB1	11/05/91	21.0	4" HSA	Moss	18.0, 20.5	6
6SB2	11/04/91	22.0	4" HSA	Moss	14.0, 22.0	6
10MW1	08/16/91	31.0	6" HSA	SPT		10
17SB1	11/05/91	9.0	4" HSA	Moss	8.0, 9.0	FLFA
17SB2	11/05/91	10.0	4" HSA	Moss	5.0, 10.0	FLFA
17SB3	11/05/91	7.0	4" HSA	Moss	2.5, 5.5–7.0	FLFA
32MW1	09/27/91	88.0	6" HSA/6" Ream	SPT–NX		32
32MW2A	09/25/91	3.0	6" HSA	SPT		32
32MW2B	09/30/91	57.0	6" HSA/6" Ream	SPT–NX		32
40MW1A	10/23/91	162.0	6" Roller/10" Roller/8" AH	SPT–NX		40
40MW2	10/30/91	60.0	6" Roller/10" Roller/8" AH	SPT–NX		40
40MW3A	10/21/91	49.0	6" Roller/10" Roller/8" AH	SPT–NX		40
40MW4	10/29/91	90.0	6" Roller/10" Roller/8" AH	SPT–NX		40
41MW1	10/10/91	81.0	6" Roller/10" Roller/8" AH	SPT–NX		41
41MW2	09/06/91	124.6	6" Roller/10" Roller/8" AH	SPT–NX		41
41MW3	10/17/91	62.0	6" Roller/10" Roller/8" AH	SPT–NX		41
41MW3A	10/15/91	27.0	6" Roller	SPT		41
41MW3B	10/16/91	55.0	6" Roller/10" Roller/8" AH	SPT–NX		41
41SB1	10/25/91	15.0	4" HSA	Moss	10.0, 15.0	41
43MW1	08/13/91	28.0	6" HSA/6" Roller	SPT		43
43MW2	08/14/91	35.0	6" HSA/6" Roller	SPT		43
43MW3	08/19/91	38.0	6" HSA/6" Roller	SPT–NX		43
43MW4	08/19/91	31.0	6" HSA/6" Roller	SPT–NX		43
43MW5	08/15/91	42.8	6" HSA/6" Roller	SPT–NX		43
43MW6	08/14/91	38.5	6" HSA/6" Roller	SPT–NX		43
45MW1	09/28/91	29.0	6" HSA	SPT		45
45MW2	09/30/91	26.0	6" HSA	SPT		45
43MW3	09/30/91	32.0	6" HSA	SPT		45
48SB1	08/19/91	15.0	4" HSA	Moss	9.5, 14.0	48
48SB1A	08/16/91	20.0	6" HSA	SPT		48
48SB2	08/16/91	22.0	4" HSA	Moss	10.0, 20.0	48
48SB3	08/19/91	20.0	4" HSA	Moss	20.0	48
54MW1	11/06/91	60.0	6" Roller/10" Roller/8" AH	SPT		54
54MW1A	09/17/91	52.0	6" HSA/6" Roller	SPT–NX		54
54MW2	09/17/91	30.0	6" HSA/6" Roller	SPT–NX		54

Table 3–2 (Cont'd)

Boring	Date	Total Depth (feet)*	Boring Method	Sample Method	Depth of Chemically Analyzed Samples (feet)*	SWMU
54MW3	09/18/91	32.0	6" HSA/6" Roller	SPT–NX		54
74MW1	10/07/91	50.8	6" Roller	SPT–NX		74

Footnotes

* = Depth provided are in feet below ground surface.
Moss = continuous core soil sampling
SPT = Standard Penetration Test Soil Sampling
NX = NX–size rock core sampling
Roller = Tri cone rotary bit
AH = Air Hammer
FLFA = Former Lead Furnace Area

Methods of drilling in unconsolidated overburden included hollow-stem auger and air rotary. Where possible, boreholes into bedrock were cored using an NX-sized diamond or carbide-studded bit. This method provided an intact sample of bedrock to evaluate lithology, structure, and physical condition. NX rock coring was discontinued when excessive amounts of drilling water were lost to the formation.

The following procedures were followed when performing well borings. Where possible, a 6.25-inch I.D. dry hollow stem was used to penetrate the unconsolidated soils. Split spoon sampling was conducted at 5-foot intervals during drilling to allow a detailed log to be developed for each boring. The method used to collect the split spoon samples was the SPT (ASTM D-1586).

Where river jack sediments (cobbles and boulders) prevented further penetration of the overburden using the hollow stem auger method, an air rotary drilling method was used in which a 6-inch tri-cone roller bit was advanced into the soil. Split spoon soil samples were collected every five feet to develop a detailed boring log, as described above.

When bedrock was encountered, the overburden was cased off using 10-inch temporary polyvinyl chloride casing (PVC), and NX rock coring was performed to obtain intact samples of bedrock for subsurface logging. After completion of the rock coring, the borehole was reamed out using an 8-inch roller bit or 8-inch air hammer to the appropriate well depth and well installation procedures initiated.

Every effort was made during all drilling and sampling efforts to avoid methods that could introduce potential cross-contamination. The drill rig and all sampling equipment was decontaminated prior to arrival at RAAP, prior to drilling the first borehole, and after the drilling of each borehole by a portable steam-cleaner at a steam temperature of 220° F and a pressure of 1,000 psi.

3.5 WELL INSTALLATION AND DEVELOPMENT

3.5.1 Monitoring Well Installation

Twenty monitoring wells and one piezometer were installed at the following SWMUs:

- SWMU 10--Biological Treatment Plant Equalization Basin - one well
- SWMU 32--Inert Waste Landfill No. 1 - one well
- SWMU 40--Sanitary Landfill (Nitroglycerine Area) - two wells
- SWMU 41--Red Water Ash Landfill - three wells
- SWMU 43--Sanitary Landfill (adjacent to New River) - six wells
- SWMU 45--Sanitary Landfill (west of Main Bridge) - three wells
- SWMU 54--Disposal Area for Ash from Burning Propellants - three wells and one piezometer
- SWMU 74--Inert Landfill No. 3 - one well

Clean, pre-decontaminated and plastic-wrapped monitoring wells were installed in newly drilled and reamed boreholes, either through the hollow stem augers or, when the drilling method was air rotary, through the temporary 10-inch PVC casing. Both of these methods prevented cave-in of the overburden during well installation. Sand filter pack, bentonite pellets, and cement bentonite grout were installed according to specifications included in the VI work plan.

Monitoring well construction diagrams are included in Appendix E and are summarized in Table 3-3. Detailed well installation procedures are included in Appendix B.

3.5.2 Well Development

Proper well development serves to remove water and other fluids or materials introduced in the aquifer as a result of borehole drilling operations. It also functions to reduce the amount of fine-grained sediment around the sand-packed portions of the annulus,

Table 3-3
Monitoring Well/Piezometer Construction Details
Radford Army Ammunition Plant, Virginia

Monitoring Well	Date	Total Depth (feet)[1]	Screen Material	Screen Depth	Hydrologic Unit
10MW1	8/16/91	28.5	4" PVC	13.5-28.5	UA
32MW1	9/27/91	87.0	2" PVC	72.0-87.0	BR
40MW2	10/30/91	55.0	4" PVC	35.0-55.0	BR
40MW4	10/29/91	62.8	4" PVC	42.8-62.8	BR
41MW1	10/10/91	80.0	4" PVC	60.0-80.0	BR
41MW2	9/06/91	120.0	4" PVC	105.5-120.5	BR
41MW3	10/17/91	60.0	4" PVC	45.0-60.0	BR
43MW1	8/13/91	28.0	4" PVC	13.0-28.0	UA/BR
43MW2	8/14/91	34.5	4" PVC	19.5-34.5	UA/BR
43MW3	8/19/91	37.5	4" PVC	22.5-37.5	BR
43MW4	8/19/91	28.5	4" PVC	13.5-28.5	UA/BR
43MW5	8/15/91	42.3	4" PVC	32.3-42.3	BR
43MW6	8/14/91	38.0	4" PVC	28.0-38.0	BR
45MW1	9/28/91	27.5	4" PVC	17.3-27.3	UA
45MW2	9/30/91	24.8	4" PVC	14.8-24.8	UA
45MW3	9/30/91	30.0	4" PVC	20.0-30.0	UA
54MW1	11/06/91	54.8	4" PVC	34.8-54.8	BR
54MW1A[2]	9/17/91	51.0	4" PVC	36.0-51.0	BR
54MW2	9/17/91	28.0	4" PVC	18.0-28.0	UA/BR
54MW3	9/18/91	30.0	4" PVC	20.0-30.0	UA/BR
74MW1	10/07/91	50.4	4" PVC	35.4-50.4	BR

Notes:

[1] = Depths are reported in feet below ground surface.
[2] = 4" Piezometer
UA = Unconsolidated alluvium
BR = Bedrock

which might otherwise clog the well screen, and to enhance porosity for free flow in the screened zone. Well development equipment was decontaminated prior to use and between wells. Prior to development, the static water level was measured and recorded. Field conductivity, temperature, and pH measurements were recorded before, at least twice during, and at completion of development to ensure that the development process is complete.

Dames & Moore developed each monitoring well as soon as was practical, but no sooner than 48 hours after the placement of the internal mortar collar around the well. Methods and equipment used for well development at RAAP included bailing, the use of a 4-inch submersible pump and a surface pump, and air development in only well 32MW1 using an air compressor. Well 32MW1 was constructed of 2-inch PVC when irregular rock shifts after borehole enlargement (reaming) prevented the installation of 4-inch PVC. Air development with bailing was the only available method that could remove the volume of water needed to conform to development specifications. Specific well development procedures are described in Appendix B.

3.6 PHYSICAL TESTING

Soil samples were collected from each boring and placed in sample jars and labeled. Of these soil samples collected, 24 representative soil samples were shipped to Dames & Moore's soil testing laboratory for physical testing. Atterberg limits (ASTM D-4318), grain size analysis (ASTM D-422), and classification by the Unified Soil Classification System (USCS) were performed on these samples. Table 3-4 summarizes the results of the physical analyses.

3.7 SAMPLING AND ANALYTICAL PROGRAM

The purpose of the VI sampling program was to collect representative samples of groundwater, surface water, soils, sediment, and waste for use in identifying contaminants at the SWMUs identified in the RCRA Permit. The locations and number of samples were selected to determine if contaminants have migrated from the SWMUs and into the surrounding environment at concentrations of concern. The collection procedures took into

TABLE 3-4
Summary of Grain Size Analyses of Soil Samples
Verification Investigation
Radford Army Ammunition Plant, Virginia

Sample No.	Sample Depth(feet)[a]	Percent Gravel/Sand/Fines[b]	Soil Symbol USCS/AL[c]
10MW1	5-7	0.0/44.2/33.2/22.6[d]	ML/ML
17SB1	8	2.5/25.2/72.3	CL/CL
17SB2	10	7.8/28.6/63.6	CL/CL
17SB3	3	2.3/19.6/78.1	CL/CL
32MW1	10-12	42.5/48/9.5	SC-SM/CL-ML
32MW2B	6.5-7	0.4/45.3/54.3	ML/ML-OL
40MW1	0-2	15.7/54.9/29.4	CH/CH
40MW2	10-12	9.8/17.3/72.9	MH/MH-OH
40MW3	0-2	0.6/13.6/85.8	CL/CL
40MW3	38-49	5.1/22.7/72.2	CL/CL
40MW4	5-7	0.2/19.0/80.8	MH/MH-OH
41MW1	0-2	0.0/67.4/32.6	CH/CH
41MW2	20-22	0.0/15.4/84.6	CH/CH
41MW3	15-17	49.0/21.7/29.3	SC/CH
43MW1	11-11.5	0.0/51.7/48.3	SC/CL
43MW2	5-7	2.7/62.3/35.0	SC-SM/CL-ML
43MW3	10-12	0.0/70.5/29.5	SM/NP
43MW4	5-7	0.0/43.0/57.0	CL/CL
43MW4	15-17	0.0/80.7/19.3	SM/SM
43MW6	0-2	0.0/52.6/47.4	SC/CL
45MW1	10-12	6.2/69.4/24.4	SM/SM
45MW2	5.5-6	0.0/89.7/10.3	SP-SM/SP-SM
45MW3	26-27	26.7/28.4/44.9	SC/CL
54MW1	5-7	0.8/54.3/44.9	SC-SM/CL/ML
54MW2	5-7	0.0/71.8/28.2	SM/CL-ML
54MW3	15-17	0.0/66.0/34.0	SM/SM
74MW1	16.5-17	0.0/94.3/5.7	SP-SM/SP-SM

Notes:

[a] = Depths are reported in feet below ground surface.

[b] = Gravel-retained on #4 sieve
Sand - passed #4 sieve but remained on #200 sieve
Fines -passed #200 sieve

[c] = USCS - Unified Soil Classification System
AL - Atterberg Limits soil classification
NP - Not plastic

[d] = 'Fines' are represented as percent silt and percent clay, respectively, for SWMU 10

account characteristics of known contaminants, as well as the need to identify suspected contaminants and measure a range of standard parameters (e.g., analysis for drinking water standards and parameters that monitor changes in the sample, such as pH and conductivity). All sampling procedures were accomplished in accordance with the approved work plan, and are discussed in Appendix B of this report. A summary of the samples collected and the analyses performed for each sample is provided in Table 3-5.

The analytical parameters discussed in this section refer to the constituents that were specifically identified in Attachment A of the RCRA permit. The USATHAMA and laboratory analytical methods and reference codes are summarized in Table 3-6. The Certified Reporting Limit (CRL) and specific test name and certified method using (USEPA method number if possible) for each analyte of interest are listed in Table 3-6. In addition, the permit Practical Quantitation Limits (PQLs) and Health Based Numbers (HBNs) are also provided. Dames & Moore derived HBNs for those constituents for which a HBN was not specified in the RCRA permit; these HBNs and the methodology used to develop the numbers are presented in Appendix D. PQLs and HBNs also are included on the chemical summary tables developed for each SWMU characterization.

The analytical program, summarized in Tables 3-5 and 3-6, included soil, groundwater, sediment, surface water and waste analyses for Target Analyte List (TAL) metals, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), explosives, total petroleum hydrocarbons (TPH), nitrate, sulfate, chloride, total organic halogens (TOX), total organic carbon (TOC), and toxicity characteristic leaching (TCLP) procedure metals and organics. (Note: The term SVOCs is used throughout this report rather than the term base-neutral/acid extractables or BNAs. These two terms are considered equivalent.) The VOC and SVOC analyses included those constituents that are identified in "List 1" or "List 2" of Attachment A of the RCRA permit and are specified in Table 3-6. It was determined by the laboratory that the VOC and SVOC analytical methods would include all compounds specified on both "List 1" and "List 2"; therefore, only one analytical run was performed for each method. The VOC and SVOC analyses also included a library scan to attempt identification of unknown responses in the gas chromatograph

Table 3–5
Summary of VI Analytical Program
Sorted by SWMU and Sample ID
Radford Army Ammunition Plant, Virginia

						Analytical Parameters																
						TAL METALS															TCLP	
SWMU	Sample ID	Samp Matrix	Site Type	Sample Date	Sample Depth	T	U	F	Expl.	VOCs	SVOCs	TOC	TOX	NO_2+NO_3	TKN	PHNLs	Cl	SO_4	PO_4	TPH	Organics	Metals
27,29,53	29SE1	SE	BASN	03/03/92	1	X			X	X	X											
27,29,53	29SE2	SE	BASN	03/03/92	1	X			X	X	X											
27,29,53	29SE2D	SE	BASN	03/03/92	1	X			X	X	X											
27,29,53	29SE3	SE	DTCH	03/03/92	1	X			X	X	X											
27,29,53	29SW1	SW	BASN	03/03/92	--	X			X	X	X	X	X									
27,29,53	29SW1D	SW	BASN	03/03/92	--	X			X	X	X	X	X									
27,29,53	WELL 7	GW	WELL	08/13/91	--	RAAP quarterly monitoring parameters																
27,29,53	WELL 7	GW	WELL	12/06/91	--	RAAP quarterly monitoring parameters																
27,29,53	WELL 7	GW	WELL	2/17/92	--	RAAP quarterly monitoring parameters																
27,29,53	FAL-2	GW	WELL	08/13/91	--	RAAP quarterly monitoring parameters																
27,29,53	FAL-2	GW	WELL	12/06/91	--	RAAP quarterly monitoring parameters																
27,29,53	FAL-2	GW	WELL	2/17/92	--	RAAP quarterly monitoring parameters																
27,29,53	FAL-3	GW	WELL	08/13/91	--	RAAP quarterly monitoring parameters																
27,29,53	FAL-3	GW	WELL	12/06/91	--	RAAP quarterly monitoring parameters																
27,29,53	FAL-3	GW	WELL	2/17/92	--	RAAP quarterly monitoring parameters																
10	10MW1	GW	WELL	09/13/91	21		X	X	X	X	X	X	X	X	X	X	X	X	X			
10	10SE1	SE	BASN	08/21/90	0.5			X	X	X	X											X
10	10SS1	SO	PLUG	08/21/90	0.5			X	X	X	X											X
10	10SS2	SO	PLUG	08/21/90	0.5			X	X	X	X											X
10	10SS3	SO	PLUG	08/21/90	0.5			X	X	X	X											X
10	10SS4	SO	PLUG	08/21/90	0.5			X	X	X	X											X
10	10SS5	SO	PLUG	08/21/90	0.5			X	X	X	X											X
10	10SW1	SW	BASN	08/22/90	0			X	X	X	X											X
10	D-3	GW	WELL	08/22/90	28			X	X	X	X											
10	D-3	GW	WELL	09/17/91	28		X	X	X	X	X	X	X	X	X	X	X	X	X			
10	D-3D	GW	WELL	09/17/91	58		X	X	X	X	X	X	X	X	X	X	X	X	X			
10	D-4	GW	WELL	09/20/91	26		X	X	X	X	X	X	X	X	X	X	X	X	X			
10	DDH2	GW	WELL	09/19/91	24		X	X	X	X	X	X	X	X	X	X	X	X	X			
10	DDH2	GW	WELL	08/22/90	24			X	X	X	X											
10	DDH4	GW	WELL	08/22/90	27			X	X	X	X											
10	DDH4	GW	WELL	09/19/91	27		X	X	X	X	X	X	X	X	X	X	X	X	X			
10	DG-1	GW	WELL	09/19/91	28		X	X	X	X	X	X	X	X	X	X	X	X	X			
26	B2	GW	WELL	02/12/92	87		X	X		X	X	X	X									
26	B4	GW	WELL	02/18/92	87		X	X		X	X	X	X									
26	BDH2	GW	WELL	02/19/92	88.3		X	X		X	X	X	X									
26	BDH3	GW	WELL	02/11/92	100		X	X		X	X	X	X									
31	31SL1	SL	CHMP	02/25/92	1	X					X											
31	31SL2	SL	CHMP	02/25/92	1	X					X											
31	31SL3	SL	CHMP	03/10/92	1	X					X											
31	31SL3D	SL	CHMP	03/10/92	1	X					X											
32	32MW1	GW	WELL	02/18/92	60		X	X		X	X	X	X									
35	35SE1	SE	BASN	08/21/90	4	X			X	X	X											X
35	35SE2	SE	BASN	08/21/90	4	X			X	X	X											X
35	35SL1	SE	BASN	01/15/92	5					X	X											X
35	35SS2	SO	BASN	08/21/90	6				X	X	X											X
36	36SL1	SE	BASN	01/15/92	5					X	X											X
36	36SL2	SE	BASN	01/15/92	5					X	X											X
36	36SL3	SE	BASN	01/15/92	5					X	X											X
37	37SL1	SE	BASN	01/15/92	5					X	X											X
38	38SL1	SE	BASN	01/15/92	5					X	X											X
39	39SL1	SE	CHMP	02/25/92	1	X			X		X											
39	39SL2	SE	CHMP	02/25/92	1	X			X		X											
39	39SL3	SE	CHMP	02/25/92	1	X			X		X											
39	39SS1	SO	PLUG	02/25/92	0.5	X			X		X											

Table 3–5 (cont'd)

						Analytical Parameters																
						TAL METALS															TCLP	
SWMU	Sample ID	Samp Matrix	Site Type	Sample Date	Sample Depth	T	U	F	Expl.	VOCs	SVOCs	TOC	TOX	NO_2+NO_3	TKN	PHNLs	Cl	SO_4	PO_4	TPH	Organics	Metals
39	39SS2	SO	PLUG	02/25/92	0.5	X			X		X											
39	39SS3	SO	PLUG	02/25/92	0.5	X			X		X											
40	40MW2	NS	NS	--	--																	
40	40MW4	NS	NS	--	--																	
41	41MW1	GW	WELL	03/03/92	70		X	X	X		X	X	X									
41	41MW2	GW	WELL	03/03/92	113		X	X	X		X	X	X									
41	41MW3	GW	WELL	03/04/92	53		X	X	X		X	X	X									
41	41MW3D	GW	WELL	03/04/92	53		X	X	X		X	X	X									
41	41SB1	SO	BORE	10/25/91	8	X			X		X											
41	41SB1	SO	BORE	10/25/91	14	X			X		X											
41	41SW1	SW	SPRG	03/10/92	0		X		X		X	X	X									
43	43MW1	GW	WELL	10/29/91	21		X	X		X	X	X	X	N								
43	43MW1D	GW	WELL	10/29/91	21		X	X		X	X	X	X	N								
43	43MW2	GW	WELL	10/29/91	27		X	X		X	X	X	X	N								
43	43MW3	GW	WELL	10/30/91	30		X	X		X	X	X	X	N								
43	43MW4	GW	WELL	10/30/91	21		X	X		X	X	X	X	N								
43	43MW5	GW	WELL	10/31/91	37		X	X		X	X	X	X	N								
43	43MW6	GW	WELL	11/01/91	33		X	X		X	X	X	X	N								
43	43SP1	SW	SPRG	10/31/91	0		X	X		X	X	X	X	N								
43	43SP2	SW	SPRG	10/31/91	0		X	X		X	X	X	X	N								
45	45MW1	GW	WELL	11/08/91	22		X	X		X	X	X	X									
45	45MW2	GW	WELL	11/08/91	20		X	X		X	X	X	X									
45	45MW3	GW	WELL	11/07/91	25		X	X		X	X	X	X									
46	46SS1	SO	PIT	10/29/91	1	X			X													
46	46SS2	SO	PIT	10/29/91	1	X			X													
48	48SB1	SO	BORE	08/19/91	9.5	X				X	X											X
48	48SB1	SO	BORE	08/19/91	14	X				X	X											X
48	48SB2	SO	BORE	08/16/91	12	X				X	X											X
48	48SB2	SO	BORE	08/16/91	22	X				X	X											X
48	48SB3	SO	BORE	08/19/91	20	X				X	X											X
50	50SL1	SL	PLUG	08/17/91	5					X	X											X
50	50SL2	SL	PLUG	08/17/91	5					X	X											X
54	54MW1	GW	WELL	02/06/92	45			X	X	X	X	X	X									
54	54MW2	GW	WELL	02/06/92	23			X	X	X	X	X	X									
54	54MW3	GW	WELL	02/07/92	25			X	X	X	X	X	X									
57	57SE1	SE	BASN	02/16/92	0.5	X				X	X											
57	57SW1	SW	BASN	02/10/92	0		X			X	X	X	X	N								
58	58SS1	SO	PLUG	02/10/92	0.5	X																
58	58SS2	SO	PLUG	02/10/92	0.5	X				X	X											
58	58SS3	SO	PLUG	02/10/92	0.5	X				X	X											
59	59SS1	SO	PLUG	03/05/92	0.5	X					X											
59	59SS1D	SO	PLUG	03/05/92	0.5	X					X											
59	59SS2	SO	PLUG	03/05/92	0.5	X					X											
6	6SB1	SO	BORE	11/05/91	20.5	X																
6	6SB1	SO	BORE	11/05/91	18	X																
6	6SB1D	SO	BORE	11/05/91	18	X																
6	6SB2	SO	BORE	11/04/91	14	X																
6	6SB2	SO	BORE	11/04/91	22	X																
6	MW13	GW	WELL	02/19/92	38			X				X	X									
6	MW14	NS	NS	--	--																	
6	MW15	NS	NS	--	--																	
6	MW16	NS	NS	--	--																	
68	68SS1	SO	PLUG	02/04/92	0.5	X																
68	68SS2	SO	PLUG	02/04/92	0.5	X																
68	68SS1	SO	PLUG	02/04/92	0.5	X																
68	68SS2	SO	PLUG	02/04/92	0.5	X																

Table 3–5 (cont'd)

						Analytical Parameters																
	Sample	Samp	Site	Sample	Sample	TAL METALS															TCLP	
SWMU	ID	Matrix	Type	Date	Depth	T	U	F	Expl.	VOCs	SVOCs	TOC	TOX	NO_2+NO_3	TKN	PHNLs	Cl	SO_4	PO_4	TPH	Organics	Metals
69	69SE1	SE	BASN	02/10/92	0.5	X																
69	69SS1	SO	PLUG	02/10/92	0.5	X																
69	69SS2	SO	PLUG	02/10/92	0.5	X																
69	69SW1	SW	BASN	02/10/92	0		X					X	X									
71	71SS1	SO	PLUG	02/05/92	0.5	X			X											X		
71	71SS2	SO	PLUG	02/05/92	0.5	X			X											X		
71	71SS3	SO	PLUG	02/05/92	0.5	X			X											X		
74	74MW1	GW	WELL	11/01/91	43			X		X	X	X	X	N								
8	8SL1	SL	BASN	01/15/92	1					X	X											X
8	8SL1	SL	BASN	01/21/92	1																	
8	8SL2	SL	BASN	01/15/92	1					X	X											X
9	9SL1	SL	BASN	01/15/92	1					X	X											X
9	9SL2	SL	BASN	01/15/92	1					X	X											X
F	FSS1	SO	PLUG	02/05/92	0.5					X	X											
F	FSS2	SO	PLUG	02/05/92	0.5					X	X											
F	FSS3	SO	PLUG	02/05/92	0.5					X	X											
F	FSS4	SO	PLUG	02/05/92	0.5					X	X											
F	FSS5	SO	PLUG	02/18/92	0.5					X	X											
F	FSS6	SO	PLUG	02/18/92	0.5					X	X											
F	FSS7	SO	PLUG	02/18/92	0.5					X	X											
F	FSS8	SO	PLUG	02/18/92	0.5					X	X											
P	PSB1	SO	PLUG	03/05/92	0.5	X	X	X														
P	PSB1	SO	PLUG	03/05/92	4.2	X	X	X														
P	PSB2	SO	PLUG	03/05/92	0.5	X	X	X														
P	PSB2	SO	PLUG	03/05/92	4.3	X	X	X														
P	PSB2D	SO	PLUG	03/05/92	4.3	X	X	X														
P	PSB3	SO	PLUG	03/05/92	0.5	X	X	X														
P	PSB3	SO	PLUG	03/05/92	4.3	X	X	X														
P	PSB4	SO	PLUG	03/05/92	0.5	X	X	X														
P	PSB4	SO	PLUG	03/05/92	4.7	X	X	X														
P	PSB5	SO	PLUG	03/05/92	0.5	X	X	X														
P	PSB5	SO	PLUG	03/05/92	4.3	X	X	X														
Q	QSL1	SL	BASN	01/15/92	5					X	X											X
FLFA	17SB1	SO	BORE	11/05/92	8	X																X
FLFA	17SB1	SO	BORE	11/05/92	9	X																X
FLFA	17SB2	SO	BORE	11/05/92	5	X																X
FLFA	17SB2	SO	BORE	11/05/92	10	X																X
FLFA	17SB3	SO	BORE	11/05/92	5	X																X
FLFA	17SB3	SO	BORE	11/05/92	7	X																X

Footnotes:

BORE = Soil Boring
BASN = Basin
CHMP = Composite Sample
CL = Chloride
DTCH = Ditch
Expl = Explosives
F = Filtered metals
FLFA = Former Lead Furnace Area
GW = Groundwater
NO_2 & NO_3 = Nitrite and Nitrate
NS = Not Sampled; well dry.
PHNLs = Total Phenol
PO_4 = Phosphate

SL = Sludge
SO = Soil
SO_4 = Sulfate
SPRG = Spring
SVOCs = Semivolatile Organic Compounds
T = Total Metals
TAL Metals = Target Analyte List Metals
TCLP = Toxicity Characteristic Leaching Procedure
TOC = Total Organic CorrCompound
TPH = Total Petroleum Hydrocarbons
U = Unfiltered metals
VOCs = Volatile Organic Compounds

TABLE 3–6

SUMMARY OF ANALYTICAL METHODS, PQLS AND HBNs FOR VI

VI ANALYTICAL EFFORT FOR WATER

METHOD UM20 (624): VOLATILE ORGANICS IN WATER BY GC/MS FOR BOTH PRIORITY POLLUTANTS AND HAZARDOUS SUBSTANCE LIST COMPOUNDS (a)

SHORT NAME	STORET	LONG NAME	PRIORITY POLL.	HAZARDOUS SUBST. LIST	CRL	USATHAMA UCL	CLP CRDL	PQL	HBN
111TCE	34506	1,1,1-TRICHLOROETHANE	Y	Y	0.5	200	5	5	200
112TCE	34511	1,1,2-TRICHLOROETHANE	Y	Y	1.2	200	5	5	6
11DCE	34501	1,1-DICHLOROETHENE	Y	Y	0.5	200	5	5	7
11DCLE	34496	1,1-DICHLOROETHANE	Y	Y	0.68	200	5	5	0.4
12DCLE	34531	1,2-DICHLOROETHANE	Y	Y	0.5	50	5	5	5
12DCLP	34541	1,2-DICHLOROPROPANE	Y	Y	0.5	200	5	5	6
2CLEVE	34576	2-CHLOROETHYLVINYL ETHER	Y	N	0.71	200			
BRDCL	32101	BROMODICHLOROMETHANE	Y	Y	0.59	200	5	5	700
C13DCP	34704	CIS-1,3-DICHLOROPROPENE	Y	Y	0.58	230	5	10	0.2
C2H3CL	39175	VINYL CHLORIDE	Y	Y	2.6	200	10	10	2
C2H5CL	34311	CHLOROETHANE	Y	Y	1.9	200	10	10	—
C6H6	34030	BENZENE	Y	Y	0.5	200	5	5	5
CCL3F	34488	TRICHLOROFLUOROMETHANE	Y	N	1.4	50		5	1E+4
CCL4	32102	CARBON TETRACHLORIDE	Y	Y	0.58	200	5	5	5
CH2CL2	34423	METHYLENE CHLORIDE	Y	Y	2.3	100	5	5	5
CH3BR	34413	BROMOMETHANE	Y	Y	5.8	100	10	10	50
CH3CL	34418	CHLOROMETHANE	Y	Y	3.2	200	10	10	30
CHBR3	32104	BROMOFORM	Y	Y	2.6	200	5	5	700
CHCL3	32106	CHLOROFORM	Y	Y	0.5	200	5	5	600
CLC6H5	34301	CHLOROBENZENE	Y	Y	0.5	200	5	5	1000
		DICHLORODIFLUOROMETHANE (c)						5	7000
DBRCL	32105	DIBROMOCHLOROMETHANE	N	Y	0.67	100	5		
ETC6H5	34371	ETHYLBENZENE	Y	Y	0.5	200	5	5	4000
MEC6H5	34010	TOLUENE	Y	Y	0.5	200	5	5	1E+4
		TRANS-1,2-DICHLOROETHYLENE (b)						5	700
T13DCP	34699	TRANS-1,3-DICHLOROPROPENE	N	Y	0.7	280	5	10	0.2
		1,1,1,2-TETRACHLOROETHANE (d)						5	10
TCLEA	34516	1,1,2,2-TETRACHLOROETHANE	Y	Y	0.51	200	5	5	2
TCLEE	34475	TETRACHLOROETHENE	Y	Y	1.6	200	5	5	7
TRCLE	39180	TRICHLOROETHENE	Y	Y	0.5	200	5	5	5
XYLEN	99649	XYLENE	N	Y	0.84	200	5	5	7E+4
ACET	81552	ACETONE	N	Y	13	200	10	100	4000
CS2	77041	CARBON DISULFIDE	N	Y	0.5	200	5	5	4000
12DCE	99642	1,2-DICHLOROETHENE (TOTAL)			0.5	200	5		
MEK	81595	METHYL ETHYL KETONE	N	Y	6.4	200		100	2000
C2AVE	77057	VINYL ACETATE	N	Y	8.3	50	10		
MIBK	81596	METHYL ISOBUTYL KETONE	N	Y	3	200	10	100	2000
MNBK	77103	METHYL-N-BUTYL KETONE	N	Y	3.6	200	10		
STYR	77128	STYRENE	N	Y	0.5	200	5		
		NONCERTIFIED ANALYTES							
CL2BC	81524	DICHLOROBENZENE (TOTAL)							
ACROL	34210	ACROLEIN						5	50
ACRYLO	34215	ACRYLONITRILE						5	0.06

Note: All Units are in microgram/liter (ug/l).

TABLE 3-6 (cont'd)

METHOD UM18 (625); EXTRACTABLE ORGANICS (BNAs) IN WATER BY GC/MS FOR BOTH PRIORITY POLLUTANTS AND HAZARDOUS SUBSTANCE LIST COMPOUNDS (a)

SHORT NAME	STORET	LONG NAME	PRIORITY POLL.	HAZARDOUS SUBST. LIST	CRL	USATHAMA UCL	CLP CRDL	PQL	HBN
124TCB	34551	1,2,4-TRICHLOROBENZENE	Y	Y	1.8	50	10	10	700
12DCLB	34536	1,2-DICHLOROBENZENE	Y	Y	1.7	50	10	10	3000
13DCLB	34566	1,3-DICHLOROBENZENE	Y	Y	1.7	200	10	5	3000
14DCLB	34571	1,4-DICHLOROBENZENE	Y	Y	1.7	200	10	5	75
245TCP	77687	2,4,5-TRICHLOROPHENOL	N	Y	5.2	200	50	50	4000
24DCLP	34601	2,4-DICHLOROPHENOL	Y	Y	2.9	200	10	10	100
24DMPN	34606	2,4-DIMETHYLPHENOL	Y	Y	5.8	100	10	10	20
24DNP	34616	2,4-DINITROPHENOL	Y	Y	21	100	50	50	70
24DNT	34611	2,4-DINITROTOLUENE	Y	Y	4.5	200	10	10	0.05
2CLP	34586	2-CHLOROPHENOL	Y	Y	0.99	200	10	10	200
2CNAP	34581	2-CHLORONAPHTHALENE	Y	Y	0.5	200	10	10	—
2MNAP	77416	2-METHYLNAPHTHLENE	N	Y	1.7	50	10		
2MP	99073	2-METHYLPHENOL	N	Y	3.9	200	10	10	2000
2NANIL	99077	2-NITROANILINE	N	Y	4.3	100	50		
2NP	34591	2-NITROPHENOL	Y	Y	3.7	100	10		
33DCBD	34631	3,3-DICHLOROBENZIDINE	Y	Y	12	100	20	20	0.08
		3-METHYLPHENOL (e)							
3NANIL	99078	3-NITROANILINE	N	Y	4.9	100	50		
46DN2C	34657	2-METHYL-4,6-DINITROPHENOL	Y	Y	17	100	50	50	40
4BRPPE	34636	4-BROMOPHENYLPHENYL ETHER	Y	Y	4.2	100	10	10	—
4CL3C	34452	3-METHYL-4-CHLOROPHENOL	Y	Y	4	200	10	10	200
4CLPPE	34641	4-CHLOROPHENYLPHENYL ETHER	Y	Y	5.1	100	10		
4MP	99074	4-METHYLPHENOL	N	Y	0.52	200	10	10	2000
4NANIL	99079	4-NITROANALINE	N	Y	5.2	100	50	20	—
4NP	34646	4-NITROPHENOL	Y	Y	12	100	50	50	—
ANAPNE	34205	ACENAPHTHENE	Y	Y	1.7	50	10		
ANAPYL	34200	ACENAPHTHYLENE	Y	Y	0.5	50	10		
ANTRC	34220	ANTHRACENE	Y	Y	0.5	100	10	2	2
B2CEXM	34278	BIS(2-CHLOROETHOXY) METHANE	Y	Y	1.5	50	10	10	—
B2CIPE	34283	BIS(2-CHLOROISOPROPYL) ETHER	Y	Y	5.3	200	10	10	40
B2CLEE	34273	BIS(2-CHLOROETHYL) ETHER	Y	Y	1.9	50	10	10	0.03
B2EHP	39100	BIS(2-EHTYLHEXYL) PHTHALATE	Y	Y	4.8	100	10	10	3
BAANTR	34526	BENZO [A] ANTHRACENE	Y	Y	1.6	100	10	0.1	0.01
BAPYR	34247	BENZO [A] PYRENE	Y	Y	4.7	100	10	0.2	0.003
BBFANT	34230	BENZO [B] FLUORANTHENE	Y	Y	5.4	50	10	0.2	0.02
BBZP	34292	BUTYLBENZYL PHTHALATE	Y	Y	3.4	100	50	10	9000
BENZOA	77247	BENZOIC ACID	N	Y	13	100	10		
BGHIPY	34521	BENZO [G,H,I] PERYLENE	Y	Y	6.1	50	10		
BKFANT	34242	BENZO [K] FLUORANTHENE	Y	Y	0.87	100	10	0.4	4
BZALC	77147	BENZYL ALCOHOL	N	Y	0.72	100	10		
CHRY	34320	CHRYSENE	Y	Y	2.4	100	10	2	0.2
CL6BZ	39700	HEXACHLOROBENZENE	Y	Y	1.6	100	10	0.5	0.02
CL6CP	34386	HEXACHLOROCYCLOPENTADIENE	Y	Y	8.6	100	10	10	200
CL6ET	34396	HEXACHLOROETHANE	Y	Y	1.5	50	10	10	300
DBAHA	34556	DIBENZ [A,H] ANTHRACENE	Y	Y	6.5	50	10	0.3	0.0007
DBZFUR	81302	DIBENZOFURAN	N	Y	1.7	50	10		
DEP	34336	DIETHYL PHTHALATE	Y	Y	2	200	10	10	30000
DMP	34341	DIMETHYL PHTHALATE	Y	Y	1.5	100	10	10	400000
DNBP	39110	DI-N-BUTYL PHTHALATE	Y	Y	3.7	200	10	10	4000
FANT	34376	FLUORANTHENE	Y	Y	3.3	100	10	10	200
FLRENE	34381	FLUORENE	Y	Y	3.7	50	10		
HCBD	34391	HEXACHLOROBUTADIENE	Y	Y	3.4	100	10	5	5
ICDPYR	34403	INDENO [1,2,3-CD] PYRENE	Y	Y	8.8	100	10	0.4	2

Note: All units are in ug/l.

TABLE 3-6 (cont'd)

SHORT NAME	STORET	LONG NAME	PRIORITY POLL.	HAZARDOUS SUBST. LIST	CRL	USATHAMA UCL	CLP CRDL	PQL	HBN
ISOPHR	34408	ISOPHORONE	Y	Y	4.8	50	10		
NAP	34696	NAPHTHALENE	Y	Y	0.5	20	10	5	10000
NB	34447	NITROBENZENE	Y	Y	0.5	50	10	10	20
NNDNP	34428	N-NITROSO, DI-N-PROPYLAMINE	Y	Y	4.4	50	10	10	0.005
NNDPA	34433	N-NITROSODIPHENYLAMINE	Y	Y	3	200	10	10	7
PCP	39032	PENTACHLOROPHENOL	Y	Y	18	100	50	50	1000
PHANTR	34461	PHENANTHRENE	Y	Y	0.5	100	10	7	2
PHENO	34694	PHENOL	Y	Y	9.2	200	10	10	20000
PYR	34469	PYRENE	Y	Y	2.8	100	10	10	4000
246TCP	34621	2,4,6-TRICHLOROPHENOL	Y	Y	4.2	100	10	10	2
26DNT	34626	2,6-DINITROTOLUENE	Y	Y	0.79	200	10	10	—
4CANIL	99075	4-CHLOROANALINE	N	Y	7.3	100	10	10	100
DNOP	34596	DI-N-OCTYL PHTHALATE	Y	Y	15	100	10	10	—
NONCERTIFIED ANALYTES									
MEXCL	39480	METHOXYCHLOR	N	Y	5.1		0.5		
CLDANA	39348	CHLORDANE, ALPHA	Y	Y	5.1		0.5		
CLDAN	39810	CHLORDANE, GAMMA	Y	Y	5.1		0.5		
ALDRN	39330	ALDRIN	Y	Y	4.7		0.05		
ABHC	39337	BHC, A	Y	Y	4		0.05		
BBHC	39338	BHC, B	Y	Y	4		0.05		
DBHC	34259	BHC, D	Y	Y	4		0.05		
PPDDD	39310	DDD, PP	Y	Y	4		0.1		
PPDDE	39320	DDE, PP	Y	Y	4.7		0.1		
PPDDT	39300	DDT, PP	Y	Y	9.2		0.1		
DLDRN	39380	DDIELDRIN	Y	Y	4.7		0.1		
AENSLF	34361	ENDOSULFAN A	Y	Y	9.2		0.05		
BENSLF	34356	ENDOSULFAN B	Y	Y	9.2		0.1		
ESFSO4	34351	ENDOSULFAN SULFATE	Y	Y	9.2		0.1		
ENDRIN	39390	ENDRIN	Y	Y	7.6		0.1		
HPCL	39410	HEPTACHLOR	Y	Y	2		0.05		
HPCLE	39420	HEPTACHLOR EPOXIDE	Y	Y	5		0.05		
GBHC	34340	BHC, G (LINDANE)	Y	Y	4		0.05		
PCB016	34671	PCB-1016	Y	Y	21		0.5		
PCB221	39488	PCB-1221	Y	Y	21		0.5		
PCB232	39492	PCB-1232	Y	Y	21		0.5		
PCB242	39496	PCB-1242	Y	Y	30		0.5		
PCB248	39500	PCB-1248	Y	Y	30		0.5		
PCB254	39504	PCB-1254	Y	Y	36		1		
PCB260	39508	PCB-1260	Y	Y	36		1		
TXPHEN	39400	TOXAPHENE	Y	Y	36		1		
BENZID	39120	BENZIDINE	Y	N	10				
ENDRN	34366	ENDRIN ALDEHYDE	Y	N	8				
NNDME	34438	N-NITROSODIMETHYLAMINE	Y	N	2				
KEND	78008	ENDRIN KETONE	N	Y	8		0.1		
12DPH	34346	1,2-DIPHENYL HYDRAZINE	Y	N	2				

Note: All units are in ug/l.

TABLE 3–6 (cont'd)

SHORT NAME	STORET	LONG NAME	PRIORITY POLL.	HAZARDOUS SUBST. LIST	CRL	USATHAMA UCL	CLP CRDL	PQL	HBN
SB	(200.7)	ANTIMONY	Y	Y	38	6000	60	30	10
BA		BARIUM	N	Y	5	10000	200	20	1000
BE		BERYLLIUM	Y	Y	5	1000	5	3	0.007
CD		CADMIUM	Y	Y	4	5000	5	1	10
CR		CHROMIUM	Y	Y	6	50000	10	10	50
NI		NICKEL	Y	Y	34.3	12500	40	50	700
PB	SD20 (239.2)	LEAD	Y	Y	1.25	100	5	10	50
AG	SD23 (272.2)	SILVER	Y	Y	0.25	10	10	2	50
AS	SD22 (206.2)	ARSENIC	Y	Y	2.54	100	10	10	500
SE	SD21 (270.2)	SELENIUM	Y	Y	3.02	100	5	20	10
HG	SB01 (245.1)	MERCURY	N	Y	0.234	10	0.2	2	2
METHOD UW14 (609): NITROAROMATICS (EXPLOSIVES) IN WATER BY HPLC									
HMX		CYCLOTETRAMETHYLENETETRANITRAMINE			1.65	28.9			
RDX		CYCLONITE			2.11	43.9			
TETRYL		NITRAMINE			0.558	44.5			
246TNT		2,4,6–TRINITROTOLUENE			0.588	40.2			
26DNT		2,6–DINITROTOLUENE			1.15	52.4			
24DNT		2,4–DINITROTOLUENE			0.612	40.2			
CLASSICAL CHEMISTRY									
TOC	(415.2)	TOTAL ORGANIC CARBON	N	N	1 mg/L				
TOX	(9020)	TOTAL ORGANIC HALOGENS	N	N	5 ug/L				
TSS	(160.2)	TOTAL SUSPENDED SOLIDS	N	N	2 mg/L				
TDS	(160.1)	TOTAL DISSOLVED SOLIDS	N	N	5 mg/L				
COD	(410.4)	CHEMICAL OXYGEN DEMAND	N	N	20 mg/L				

CRL: CERTIFIED REPORTING LIMIT
UCL: UPPER CERTIFIED LIMIT
CRDL: CLP CONTACT REQUIRED DETECTION LIMIT
PQL: PRACTICAL QUANTITATION LIMIT
HBN: HEALTH BASE NUMBER
CLP: CONTACT LABORATORY PROGRAM

SYNONYMS

p–CHLOROANALINE = 4–CHLOROANALINE
p–CHLORO–m–CRESOL = 3–METHYL–4–CHLOROPHENOL
m–CRESOL = 3–METHYLPHENOL
o–CRESOL = 2–METHYLPHENOL
p–CRESOL = 4–METHYLPHENOL
o–DICHLORBENZENE = 1,2–DICHLOROBENZENE
m–DICHLORBENZENE = 1,3–DICHLOROBENZENE
p–DICHLORBENZENE = 1,4–DICHLOROBENZENE
4,6–DINITRO–o–CRESOL = 2–METHYL–4,6–DINITROPHENOL
2–NITROANALINE AVAILABLE USING CLP METHOD
p–NITROANALINE = 4–NITROANALINE
p–NITROPHENOL = 4–NITROPHENOL

Note: All units are in ug/l.

TABLE 3–6 (cont'd)

VI ANALYTICAL EFFORT FOR SOIL

METHOD LM19 (8240); VOLATILE ORGANICS IN SOIL BY GC/MS FOR BOTH PRIORITY POLLUTANTS AND HAZARDOUS SUBSTANCE LIST COMPOUNDS (a)

SHORT NAME	STORET	LONG NAME	PRIORITY POLL.	HAZARDOUS SUBST. LIST	USATHAMA		CLP CRDL	PQL	HBN
					CRL	UCL			
					UNITS ARE IN UG/KG				
111TCE	98692	1,1,1–TRICHLOROETHANE	Y	Y	4.4	200	5	5	1E+6
112TCE	98693	1,1,2–TRICHLOROETHANE	Y	Y	5.4	200	5	5	1E+5
11DCE	98789	1,1–DICHLOROETHENE	Y	Y	3.9	100	5	5	1E+4
11DCLE	98683	1,1–DICHLOROETHANE	Y	Y	2.3	200	5	5	8000
12DCE	97721	1,2–DICHLOROETHENE			3	100	5		
12DCLE	98684	1,2–DICHLOROETHANE	Y	Y	1.7	200	5	5	8000
12DCLP	98790	1,2–DICHLOROPROPANE	Y	Y	2.9	200	5		
ACET	97020	ACETONE	N	Y	17	100	10	100	1E+6
BRDCL	98783	BROMODICHLOROMETHANE	Y	Y	2.9	200	5	5	1E+6
C13DCP	98791	CIS–1,3–DICHLOROPROPENE	Y	Y	3.2	248	5	10	4000
C2AVE	97723	VINYL ACETATE	N	Y	3.2	100	10		
C2H3CL	98795	VINYL CHLORIDE	Y	Y	6.2	200	10	10	300
C2H5CL	98786	CHLOROETHANE	Y	Y	12	200	10	10	—
C6H6	98699	BENZENE	Y	Y	1.5	200	5	5	2E+4
CCL3F	98794	TRICHLOROFLUOROMETHANE	Y	N	5.9	100		5	1E+6
CCL4	98680	CARBON TETRACHLORIDE	Y	Y	7	200	5	5	5E+4
CH2CL2	98689	METHYLENE CHLORIDE	Y	Y	12	200	5	5	9E+4
CH3BR	98785	BROMOMETHANE	Y	Y	5.7	200	10	10	1E+5
CH3CL	98787	CHLOROMETHANE	Y	Y	8.8	100	10	10	5E+5
CHBR3	98784	BROMOFORM	Y	Y	6.9	200	5	5	1E+6
CHCL3	98682	CHLOROFORM	Y	Y	0.87	200	5	5	1E+5
CLC6H5	98681	CHLOROBENZENE	Y	Y	0.86	200	5	5	3E+4
CS2	97472	CARBON DISULFIDE	N	Y	4.4	100	5	5	1E+6
		DICHLORODIFLUOROMETHANE (c)						5	1E+6
DBRCL	98788	DIBROMOCHLOROMETHANE	N	Y	3.1	200	5		
ETC6H5	98688	ETHYLBENZENE	Y	Y	1.7	200	5	5	1E+6
MEC6H5	98691	TOLUENE	Y	Y	0.78	200	5	5	1E+6
MEK	98801	METHYL ETHYL KETONE	N	Y	70	200	10	100	1E+6
MIBK	98696	METHYL ISOBUTYL KETONE	N	Y	27	100	10	100	1E+6
MNBK	97722	METHYL–N–BUTYL KETONE	N	Y	32	100	10		
STYR	97734	STYRENE	N	Y	2.6	200	5		
		TRANS–1,2–DICHLOROETHYLENE (b)						5	1E+6
T13DCP	98792	TRANS–1,3–DICHLOROPROPENE	N	Y	2.8	152	5	10	4000
		1,1,1,2–TETRACHLOROETHANE (d)						0.1	3E+5
TCLEA	98793	1,1,2,2–TETRACHLOROETHANE	Y	Y	2.4	200	5	5	4E+4
TCLEE	98690	TETRACHLOROETHENE	Y	Y	0.81	200	5	5	1E+5
TRCLE	98694	TRICHLOROETHENE	Y	Y	2.8	200	5	5	6E+4
XYLEN	97724	XYLENE	N	Y	1.5	200	5	5	1E+6

NONCERTIFIED ANALYTES

SHORT NAME	STORET	LONG NAME	PRIORITY POLL.	HAZARDOUS SUBST. LIST	CRL	UCL	CLP CRDL	PQL	HBN
CL2BC	98803	DICHLOROBENZENE (TOTAL)							
ACROL	97028	ACROLEIN						5	1E+6
ACRYLO	97029	ACRYLONITRILE						5	1000
2CLEVE	98796	2–CHLOROETHYLVINYL ETHER							

Note: All units are in microgram/kilogram (ug/kg).

TABLE 3-6 (cont'd)

METHOD LM18 (8270); EXTRACTABLE ORGANICS (BNAs) IN SOIL BY GC/MS FOR BOTH PRIORITY POLLUTANTS AND HAZARDOUS SUBSTANCE LIST COMPOUNDS

SHORT			PRIORITY	HAZARDOUS	USATHAMA		CLP		
NAME	STORET	LONG NAME	POLL.	SUBST. LIST	CRL	UCL	CRDL	PQL	HBN
					UNITS ARE IN UG/G				
124TCB	99492	1,2,4-TRICHLOROBENZENE	Y	Y	0.04	13	0.3	0.01	1000
12DCLB	99470	1,2-DICHLOROBENZENE	Y	Y	0.11	13	0.3	0.01	1000
13DCLB	99472	1,3-DICHLOROBENZENE	Y	Y	0.13	13	0.3	0.005	1000
14DCLB	99469	1,4-DICHLOROBENZENE	Y	Y	0.098	13	0.3	0.005	400
245TCP	97732	2,4,5-TRICHLOROPHENOL	N	Y	0.10	13	2	2	1000
24DCLP	99498	2,4-DICHLOROPHENOL	Y	Y	0.18	13	0.3	0.3	200
24DMPN	99499	2,4-DIMETHYLPHENOL	Y	Y	0.69	1.3	0.3	0.3	400
24DNP	99495	2,4-DINITROPHENOL	Y	Y	2.1	6.7	2	2	200
24DNT	99474	2,4-DINITROTOLUENE	Y	Y	0.14	13	0.3	0.3	1
2CLP	99497	2-CHLOROPHENOL	Y	Y	0.06	13	0.3	0.3	400
2CNAP	99464	2-CHLORONAPHTHALENE	Y	Y	0.036	13	0.3	0.3	—
2MNAP	97733	2-METHYLNAPHTHLENE	N	Y	0.049	6.7	0.3		
2MP	97461	2-METHYLPHENOL	N	Y	0.029	1.3	0.3	0.3	1000
2NANIL	97728	2-NITROANILINE	N	Y	0.062	13	2		
2NP	99495	2-NITROPHENOL	Y	Y	0.14	13	0.3		
33DCBD	99471	3,3-DICHLOROBENZIDINE	Y	Y	6.3	13	0.7	1	2
		3-METHYLPHENOL (e)						0.3	1000
3NANIL	9772	3-NITROANILINE	N	Y	0.45	13	2		
46DN2C	99686	2-METHYL-4,6-DINITROPHENOL	Y	Y	0.55	13	2	5	80
4BRPPE	99462	4-BROMOPHENYLPHENYL ETHER	Y	Y	0.033	6.7	0.3	0.3	—
4CL3C	99683	3-METHYL-4-CHLOROPHENOL	Y	Y	0.095	13	0.3	0.3	1000
4CLPPE	99465	4-CHLOROPHENYLPHENYL ETHER	Y	Y	0.033	13	0.3		
4MP	97460	4-METHYLPHENOL	N	Y	0.24	1.3	0.3	0.3	1000
4NANIL	97730	4-NITROANALINE	N	Y	0.41	13	2	1	—
4NP	99496	4-NITROPHENOL	Y	Y	1.4	33	2	3	—
ANAPNE	99450	ACENAPHTHENE	Y	Y	0.036	13	0.3		
ANAPYL	99451	ACENAPHTHYLENE	Y	Y	0.033	6.7	0.3		
ANTRC	99452	ANTHRACENE	Y	Y	0.033	13	0.3	0.1	40
B2CEXM	99459	BIS(2-CHLOROETHOXY) METHANE	Y	Y	0.059	13	0.3	0.3	—
B2CIPE	99461	BIS(2-CHLOROISOPROPYL) ETHER	Y	Y	0.2	13	0.3	0.3	90
B2CLEE	99458	BIS(2-CHLOROETHYL) ETHER	Y	Y	0.033	6.7	0.3	0.3	0.06
B2EHP	99460	BIS(2-EHTYLHEXYL) PHTHALATE	Y	Y	0.62	13	0.3	0.3	50
BAANTR	99453	BENZO [A] ANTHRACENE	Y	Y	0.17	13	0.3	0.009	0.2
BAPYR	99456	BENZO [A] PYRENE	Y	Y	0.25	13	0.3	0.02	0.06
BBFANT	99454	BENZO [B] FLUORANTHENE	Y	Y	0.21	3.3	0.3	0.02	0.4
BBZP	99463	BUTYLBENZYL PHTHALATE	Y	Y	0.17	6.7	0.3	0.3	3000
BENZOA		BENZOIC ACID	N	Y			2		
BGHIPY	99691	BENZO [G,H,I] PERYLENE	Y	Y	0.25	3.3	0.3		
BKFANT	99454	BENZO [K] FLUORANTHENE	Y	Y	0.066	0.67	0.3	0.02	80
BZALC	97731	BENZYL ALCOHOL	N	Y	0.19	1	0.3		
CHRY	99690	CHRYSENE	Y	Y	0.12	36.7	0.3	0.02	4
CL6BZ	99478	HEXACHLOROBENZENE	Y	Y	0.033	6.7	0.3	0.03	0.4
CL6CP	98647	HEXACHLOROCYCLOPENTADIENE	Y	Y	6.2	13	0.3	0.3	600
CL6ET	99480	HEXACHLOROETHANE	Y	Y	0.15	13	0.3	0.3	80
DBAHA	99466	DIBENZ [A,H] ANTHRACENE	Y	Y	0.21	13	0.3	0.02	0.01
DBZFUR	97727	DIBENZOFURAN	N	Y	0.035	6.7	0.3		
DEP	99472	DIETHYL PHTHALATE	Y	Y	0.24	6.7	0.3	0.3	1000
DMP	99473	DIMETHYL PHTHALATE	Y	Y	0.17	13	0.3	0.3	1000
DNBP	99467	DI-N-BUTYL PHTHALATE	Y	Y	0.061	3.3	0.3	0.3	3000
FANT	99689	FLUORANTHENE	Y	Y	0.068	13	0.3	0.3	500
FLRENE	99692	FLUORENE	Y	Y	0.033	13	0.3		
HCBD	99479	HEXACHLOROBUTADIENE	Y	Y	0.23	13	0.3	0.005	90
ICDPYR	99482	INDENO [1,2,3-CD] PYRENE	Y	Y	0.29	13	0.3	0.03	40

Note: All units are in microgram/gram (ug/g).

TABLE 3–6 (cont'd)

SHORT NAME	STORET	LONG NAME	PRIORITY POLL.	HAZARDOUS SUBST. LIST	CRL	USATHAMA UCL	CLP CRDL	PQL	HBN
ISOPHR	99483	ISOPHORONE	Y	Y	0.033	13	0.3		
NAP	99696	NAPHTHALENE	Y	Y	0.037	3.3	0.3	0.005	1000
NB	99485	NITROBENZENE	Y	Y	0.045	13	0.3	0.3	40
NNDNP	99487	N–NITROSO, DI–N–PROPYLAMINE	Y	Y	0.2	13	0.3	0.3	0.1
NNDPA	99488	N–NITROSODIPHENYLAMINE	Y	Y	0.19	13	0.3	0.3	100
PCP	99682	PENTACHLOROPHENOL	Y	Y	1.3	6.7	2	2	1000
PHANTR	99489	PHENANTHRENE	Y	Y	0.033	13	0.3	0.5	40
PHENO	99685	PHENOL	Y	Y	0.11	3.3	0.3	0.3	1000
PYR	99490	PYRENE	Y	Y	0.033	3.3	0.3	0.3	1000
246TCP	99684	2,4,6–TRICHLOROPHENOL	Y	Y	0.17	13	0.3	0.6	40
26DNT	9947	2,6–DINITROTOLUENE	Y	Y	0.085	13	0.3	0.3	—
4CANIL	99726	4–CHLOROANALINE	N	Y	0.81	3.3	0.3	0.3	300
DNOP	99476	DI–N–OCTYL PHTHALATE	Y	Y	0.19	6.7	0.3	0.3	—
NONCERTIFIED ANALYTES									
MEXCL	97569	METHOXYCHLOR	N	Y	0.33		5		
CLDANA	97767	CHLORDANE, ALPHA	Y	Y	0.33		5		
CLDAN	97768	CHLORDANE, GAMMA	Y	Y	0.33		5		
ALDRN	98356	ALDRIN	Y	Y	0.33		0.5		
ABHC	98357	BHC, A	Y	Y	0.27		0.5		
BBHC	98358	BHC, B	Y	Y	0.27		0.5		
DBHC	98359	BHC, D	Y	Y	0.27		0.5		
PPDDD	98362	DDD, PP	Y	Y	0.3		1		
PPDDE	98363	DDE, PP	Y	Y	0.31		1		
PPDDT	98364	DDT, PP	Y	Y	0.31		1		
DLDRN	98365	DDIELDRIN	Y	Y	0.31		1		
AENSLF	98366	ENDOSULFAN A	Y	Y	0.62		0.5		
BENSLF	98367	ENDOSULFAN B	Y	Y	0.62		1		
ESFSO4	98368	ENDOSULFAN SULFATE	Y	Y	0.62		1		
ENDRIN	98369	ENDRIN	Y	Y	0.45		1		
HPCL	98371	HEPTACHLOR	Y	Y	0.13		0.5		
HPCLE	98372	HEPTACHLOR EPOXIDE	Y	Y	0.33		0.5		
GBHC	98360	BHC, G (LINDANE)	Y	Y	0.27		0.5		
PCB016	98140	PCB–1016	Y	Y	1.4		5		
PCB221	98351	PCB–1221	Y	Y	1.4		5		
PCB232	98352	PCB–1232	Y	Y	1.4		5		
PCB242	98353	PCB–1242	Y	Y	1.4		5		
PCB248	98436	PCB–1248	Y	Y	2.0		5		
PCB254	98354	PCB–1254	Y	Y	2.3		10		
PCB260	98139	PCB–1260	Y	Y	2.6		10		
TXPHEN	98373	TOXAPHENE	Y	Y	2.6		10		
BENZID	99457	BENZIDINE	Y	N	0.85				
ENDRN	98370	ENDRIN ALDEHYDE	Y	N	0.53				
NNDME	99486	N–NITROSODIMETHYLAMINE	Y	N	0.14				
KEND	97720	ENDRIN KETONE	N	Y	0.53		1		
12DPH	99477	1,2–DIPHENYL HYDRAZINE	Y	N	0.14				

Note: All units are in ug/g.

TABLE 3–6 (cont'd)

METALS IN SOIL

SHORT NAME	METHOD	LONG NAME	PRIORITY POLL.	HAZARDOUS SUBST. LIST	USATHAMA CRL	USATHAMA UCL	CLP CRDL	PQL	HBN
					UNITS ARE IN UG/G				
SB	JS11	ANTIMONY	Y	Y	3.8	5000	12	20	30
BA	(6010)	BARIUM	N	Y	29.6	200	40	1	1000
BE		BERYLLIUM	Y	Y	1.86	20	1	0.2	0.1
CD		CADMIUM	Y	Y	3.05	20	1	2	40
CR		CHROMIUM	Y	Y	12.7	5000	2	4	400
NI		NICKEL	Y	Y	12.6	5000	8	3	1000
TL		THALLIUM	Y	Y	31.3	5000	2	20	6
PB	JD17 (7421)	LEAD	Y	Y	0.177	10	1	2	—
AG	JD18 (7761)	SILVER	Y	Y	0.025	1	2	4	200
AS	JD19 (7060)	ARSENIC	Y	Y	0.25	10	2	30	0.5
SE	JD15 (7740)	SELENIUM	Y	Y	0.25	10	1	40	200
HG	JB01 (7471)	MERCURY	N	Y	0.05	1	0.04	0.1	20

TCLP METALS

SHORT NAME	METHOD	LONG NAME	PRIORITY POLL.	HAZARDOUS SUBST. LIST	USATHAMA CRL	USATHAMA UCL	CLP CRDL	PQL	HBN
BA	SS10	BARIUM	N	Y	5	10000	200	20	1000
CD	(200.7)	CADMIUM	Y	Y	4	5000	5	1	10
CR		CHROMIUM	Y	Y	6	50000	10	10	50
PB	SD20 (239.2)	LEAD	Y	Y	1.26	100	5	10	50
AG	SD23 (272.2)	SILVER	Y	Y	0.25	10	10	2	50
AS	SD22 (206.2)	ARSENIC	Y	Y	2.54	100	10	10	500
SE	SD21 (270.2)	SELENIUM	Y	Y	3.02	100	5	20	10
HG	SB01 (245.1)	MERCURY	N	Y	0.234	10	0.2	2	2

Note: Units for metals are in ug/g and for TCLP metals leachate test are in ug/l.

TABLE 3-6 (cont'd)

METHOD LW12 (8090): NITROAROMATICS (EXPLOSIVES) IN SOIL BY HPLC

SHORT NAME	LONG NAME	PRIORITY POLL.	HAZARDOUS SUBST. LIST	USATHAMA CRL	USATHAMA UCL	CLP CRDL	PQL	HBN
				UNITS ARE IN UG/G				
24DNT	2,4-DINITROTOLUENE			0.424	21.2	0.938		
26DNT	2,6-DINITROTOLUENE			0.524	26.2	0.977		
HMX	CYCLOTETRAMETHYLENETETRANITRAMINE			0.666	33.3	1.000		
RDX	CYCLONITE			0.587	21.9	0.929		
TETRYL	NITRAMINE			0.731	20.2	1.130		
246TNT	2,4,6-TRINITROTOLUENE			0.456	22.8	1.010		

CLASSICAL CHEMISTRY

TRPH	(9771)	TOTAL PETROLEUM HYDROCARBONS
CEC	(f)	CATION EXCHANGE CAPACITY

CRL: CERTIFIED REPORTING LIMIT
UCL: UPPER CERTIFIED LIMIT
CRDL: CLP CERTITFIED REPORTING DETECTION LIMIT
PQL: PRACTICAL QUANTITATION LIMIT
HBN: HEALTH BASE NUMBER

SYNONYMS

p-CHLOROANALINE = 4-CHLOROANALINE
p-CHLORO-m-CRESOL = 3-METHYL-4-CHLOROPHENOL
m-CRESOL = 3-METHYLPHENOL
o-CRESOL = 2-METHYLPHENOL
p-CRESOL = 4-METHYLPHENOL
o-DICHLORBENZENE = 1,2-DICHLOROBENZENE
m-DICHLORBENZENE = 1,3-DICHLOROBENZENE
p-DICHLORBENZENE = 1,4-DICHLOROBENZENE
4,6-DINITRO-o-CRESOL = 2-METHYL-4,6-DINITROPHENOL
2-NITROANALINE AVAILABLE USING CLP METHOD
p-NITROANALINE = 4-NITROANALINE
p-NITROPHENOL = 4-NITROPHENOL

(a) Non-target compounds are searched
(b) TRANS-1,2-DICHLOROETHYLENE difficult to separate from 1,2-DICHLOROETHENE; method capabilities under review
(c) Method capabilities under review; complete information to be provided
(d) 1,1,1,2 TETRACHLOROETHANE difficult to separate from 1,1,2,2 TETRACHLOROETHANE; method capabilities under review
(e) 3-METHYLPHENOL difficult to separate from 4-METHYLPHENOL; method capabilities under review
(f) Specific method to be determined.

Note: All units are in ug/g.

(GC) that accounted for greater than 10 percent of the total ion current or had an estimated concentration greater than 10 ug/L. These compounds are reported as tentatively identified compounds (TICs). When an identification of a compound is not possible, it is reported as an unknown with a sequential number (e. g. UNK001).

Complete analytical results for the VI environmental samples are presented in Appendix E. Chemical summary tables have been completed for each of the SWMU characterizations that present only those analytes that were detected in at least one of the samples analyzed. If no analytes were present for a particular analytical class (i.e., VOCs), then the class and a corresponding "None Detected" is reported. The summary tables also include the PQLs and HBNs. Chemical concentrations that exceed the HBN are flagged with brackets, "[ ]".

The analytical data collected for the VI are evaluated for the presence of those analytes detected at concentrations exceeding the PQLs, indicating a potential release of hazardous constituents to the environment. For those analytes with detections exceeding the PQLs, the data are compared to background data, when available, to determine if the data are indicative of naturally occurring levels or represent possible site contamination. Chemical concentrations in excess of background levels are compared to the HBNs specified in the RCRA permit. Those compounds detected at levels exceeding the HBNs are identified as potential contaminants of concern and are further evaluated in the baseline risk assessment.

3.7.1 Groundwater Sampling

A total of 27 groundwater samples were collected between October 1991 and March 1992 from 10 existing wells and 20 wells installed under this VI. Replicate samples from two wells were also taken for quality control (QC). These wells, as identified in Table 3-5 were sampled as part of the groundwater investigation at the following SWMUs:

- SWMU 6--Acidic Wastewater Lagoon
- SWMU 10--Biological Treatment Plant Equalization Basin

- SWMU 26--FAL No. 1
- SWMUs 27, 29, and 53--Calcium Sulfate Landfill, FAL No. 2, and Activated Carbon Disposal Area
- SWMU 32--Inert Waste Landfill No. 1
- SWMU 41--Red Water Ash Landfill
- SWMU 43--Sanitary Landfill (adjacent to New River)
- SWMU 45--Sanitary Landfill (West of Main Bridge)
- SWMU 54--Propellant Ash Disposal Area
- SWMU 74--Inert Landfill No. 3.

Groundwater sampling procedures were accomplished in accordance with the approved work plan, and are discussed in Appendix B of this report.

3.7.2 Surface Water Sampling

A total of five surface water samples (four environmental and one replicate QC) were collected between February and March of 1992 from the following SWMUs for the VI program:

- SWMU 29--FAL No. 2
- SWMU 41--Red Water Ash Landfill
- SWMU 57--Pond by Buildings 4931 and 4928
- SWMU 69--Pond by SWMU 68.

Surface water sampling procedures were accomplished in accordance with the approved work plan, and are discussed in Appendix B of this report.

3.7.3 Sediment Sampling

A total of six sediment samples (five environmental and one replicate QC) were collected from February to March 1992 from the following SWMUs during the VI program:

- SWMUs 27, 29, and 53--Calcium Sulfate Landfill, FAL No. 2, and Activated Carbon Disposal Area
- SWMU 57--Pond by Buildings 4931 and 4928
- SWMU 69--Pond by SWMU 68.

Sediment sampling procedures were accomplished in accordance with the approved work plan, and are discussed in Appendix B of this report.

3.7.4 Soil Sampling

A soil sampling program which consisted of the collection of both near-surface soil samples and soil boring samples was performed for the VI at RAAP. A total of 35 near-surface soil samples and one QC sample were collected between October 1991 and March of 1992. Additionally, 11 soil boring samples and one QC sample were collected between August and November 1991 for the VI. The approximate soil sampling locations are shown on the individual SWMU location maps provided in Sections 5.0 through 28.0. Table 3-5 provides a summary of the sampling data collected during the VI.

Near-surface and soil boring sampling procedures were accomplished in accordance with the approved work plan, and are discussed in Appendix B of this report. Soil samples were collected at the following SWMUs:

- SWMU 6--Acidic Wastewater Lagoon
- SWMU 39--Incinerator Wastewater Ponds
- SWMU 41--Red Water Ash Landfill
- SWMU 46--Waste Propellant Disposal Area
- SWMU 48--Oily Wastewater Disposal Area
- SWMU 58--Rubble Pile
- SWMU 59--Bottom Ash Pile
- SWMU 68--Chromic Acid Treatment Tanks

- SWMU 69--Pond by SWMU 68
- SWMU 71--Flash Burn Parts Area
- SWMU F--Drum Storage Area
- SWMU P--Spent Battery Storage Area.

3.7.5 Waste Sampling

Wastes disposed of at the following Calcium Sulfate Areas were generated as a result of identical or similar manufacturing processes and, therefore, should be homogenous in character: SWMUs 8, 9, 35, 36, 37, 38, Q, 50, and the Sludge Disposal Area Near SWMU 38. Although some of the SWMUs contain dried (dewatered) sludges, and the water content varied at each SWMU, the hazardous (or nonhazardous) characteristics of the wastes from these units should be similar. A total of nine waste analyses were conducted on sludges collected from each of these SWMUs to determine whether the wastes contain constituents at concentrations exceeding maximum allowable permit limits. Waste samples were collected between August 1991 and February 1992.

Wastewater carrying fly ash, disposed of at SWMU 31, is considered to be homogenous. Waste analysis was conducted at this SWMU to determine whether the waste contains any hazardous constituents.

SWMUs 8, 9, and 31 consist of liquid-filled settling lagoons. Sludge from these units was sampled with a hand auger equipped with a sludge sampler. Samples were collected from the edges of the lagoons.

SWMUs 35, 36, 37, 38, Q, and the Sludge Disposal Area Near SWMU 38 consist of sludge drying beds or sludge disposal areas. In the disposal areas and in drying beds that contain only dried, solidified sludge, the sludge was sampled with hand augers. SWMU 50, which also consisted of dried, solidified sludge, was sampled using a 5-foot sample corer advanced through a 4.25-inch I.D. continuous flight hollow stem auger that was advanced by a drill rig. In the drying beds that contain liquified or very wet sludge, samples were collected with a hand auger equipped with a sludge sampler. Waste sampling procedures were accomplished in accordance with the approved work plan, and are discussed in Appendix B of this report.

3.7.6 Background Soil Sampling

A total of 10 background soil samples were collected for the RFI from off-post locations in the immediate vicinity of RAAP to provide data for comparison to SWMU-specific samples collected. These data are available from the RFI to use in this VI. Sampling locations (See Figure 4-1) are areas considered to be representative of background conditions and soil types of the SWMUs under investigation; the locations are not thought to be influenced by any activities that would be known to impact the "natural" concentrations of metals. The 10 samples were tested only for metals, because these are the major constituents of concern known to be naturally occurring.

4.0 QUALITY CONTROL/QUALITY ASSURANCE PROGRAM

4.1 QA/QC SAMPLES, METHODS, AND PROCEDURES

During the VI, a Quality Assurance/Quality Control (QA/QC) program was implemented, which included field quality control activities, a laboratory quality assurance program, and a quality assurance review of the laboratory reporting deliverables. The field quality control activities included: collecting samples following procedures that maintain the integrity of the samples, using appropriate sample containers, preserving the samples, maintaining chain-of-custody procedures, and meeting holding time requirements.

The laboratory QA/QC procedures for the evaluation and documentation of analytical methodologies and the reduction and reporting of the data were performed according to the procedures, guidelines, and requirements specified in the USATHAMA QA Program (USATHAMA, 1990). All chemical analyses during this investigation were performed in accordance with USATHAMA QA/QC requirements using USATHAMA certified methods. For those analyses for which there are no USATHAMA-certified methods, EPA or equivalent methods were used when available.

QA/QC measures completed by Dames & Moore included following appropriate sample collection procedures; sample tracking and management; checking of chain-of-custody forms; and evaluation of matrix spikes and duplicates, method, trip, equipment, and field blanks. In addition, comprehensive data validation was performed by the chemical laboratory and USATHAMA prior to submission and during the processing of the chemical data through the Installation Restoration Data Management Information System (IRDMIS), as specified in the QA manual (USATHAMA, 1985a). The procedures included, but were not limited to: the verification of sample holding times; checking and approval of laboratory control charts; examination of calibration and tuning results; checking calculations; evaluation of GC/MS library searches; and comparison of transfer file, record and group check results with analysis results.

The available QC data for the investigation conducted at RAAP were obtained from the QC file from the IRDMIS. A summary of the positive detections of analytes in the drilling water source samples and in method trip and equipment blanks is provided in this section. Duplicate samples collected during the field program also are evaluated and background levels for inorganic constituents are developed. A complete listing of the QC analytical data is presented in Appendix F.

4.2 DRILLING AND RINSE WATER SOURCE

Four samples of the water source used during drilling activities and to decontaminate the sampling equipment were collected prior to initiation of the field efforts and analyzed for the parameters specified above. Results from this analysis were compared to the results of the environmental samples analyses so that an evaluation could be made on the potential for inadvertent contamination of the environmental samples by the source. The water used for decontamination procedures was collected at the RAAP potable water treatment plant at a New River intake point prior to treatment. Samples were collected on two separate occasions, in August 1990, prior to the SWMU 10 sampling efforts, and in June 1991, prior to the initiation of the VI field program. As shown in Table 4-1, several inorganics were detected, but the concentrations were within the expected range for the source water. No VOC or SVOC compounds were detected. It is concluded from the analytical results that the rinse water used during drilling activities and to decontaminate sample equipment did not introduce contaminants to the collected samples.

4.3 METHOD BLANKS

The method blank samples were analyzed to determine potential laboratory contamination. For method blanks, the entire sample preparation and analysis method is carried out on a standard water matrix sample without the addition of target analytes to verify the absence (or presence) of sample contamination in the laboratory. Positive results may indicate either contamination of the chemical reagents, or contamination of the glassware and implements used to store or prepare the sample and resulting solutions (USEPA, 1989b). Where contamination is found in the blanks, it can be assumed that detection of similar contamination in environmental samples may be the result of laboratory-induced contamination.

Table 4-1
Summary of Positive Analytical Detections in Drilling Water Source Samples
Radford Army Ammunition Plant, Virginia

Field ID	Sample Date	Compound [a]	Units [b]	Concentration	Lot [c]
RADW*1	21-aug-1990	BA	UGL	27.5	TGI
RADW*1	21-aug-1990	PB	UGL	1.84	TUA
RADW*2	21-aug-1990		UGL	None Detected	
RDDW*1	21-jun-1991	NIT	UGL	650	UQV
RDDW*1	21-jun-1991	BA	UGL	22.2	VKN
RDDW*1	21-jun-1991	CA	UGL	10100	VKN
RDDW*1	21-jun-1991	FE	UGL	183	VKN
RDDW*1	21-jun-1991	K	UGL	1310	VKN
RDDW*1	21-jun-1991	MG	UGL	4430	VKN
RDDW*1	21-jun-1991	MN	UGL	29.8	VKN
RDDW*1	21-jun-1991	NA	UGL	3390	VKN
RDDW*1	21-jun-1991	TOX	UGL	217	VZA
RDDW*1	21-jun-1991	PH		5.31	VZF
RDDW*1	21-jun-1991	TOC	UGL	3210	VZK
RDDW*2	21-jun-1991	NIT	UGL	700	UQW
RDDW*2	21-jun-1991	UNK644	UGL	10	VIT
RDDW*2	21-jun-1991	UNK645	UGL	7	VIT
RDDW*2	21-jun-1991	BA	UGL	20.6	VKO
RDDW*2	21-jun-1991	CA	UGL	10100	VKO
RDDW*2	21-jun-1991	FE	UGL	143	VKO
RDDW*2	21-jun-1991	K	UGL	684	VKO
RDDW*2	21-jun-1991	MG	UGL	4410	VKO
RDDW*2	21-jun-1991	MN	UGL	30.3	VKO
RDDW*2	21-jun-1991	NA	UGL	3340	VKO
RDDW*2	21-jun-1991	TOX	UGL	145	VZB
RDDW*2	21-jun-1991	PH		5.49	VZG
RDDW*2	21-jun-1991	TOC	UGL	2520	VZL

Footnotes:

[a] Chemical abbreviations are provided in Appendix C.

[b] UGL = Micrograms per liter.

[c] Refers to the three-letter designation assigned by the laboratory to each lot (set) of samples.

The results of the method blank analyses are presented in Appendix F. A summary of analytes detected in the above analyses are shown in Tables 4-2 and 4-3.

Comparison of concentrations of constituents detected in blanks with concentrations detected in samples was performed using the guidelines published in the Risk Assessment Guideline for Superfund (RAGS) (USEPA, 1989b), and Functional Guidelines for Evaluating Organic Analyses (USEPA, 1988b). According to EPA Guidance, detections of common laboratory contaminants (e.g., methylene chloride, acetone, toluene, 2-butanone, and common phthalate esters) are considered positive detections only if they exceed ten times the maximum concentration detected in any blank (USEPA, 1989b). In addition, detections of chemicals that are not common laboratory contaminants are considered positive only if they exceed five times the maximum concentration detected in any blank. If the detected concentration of a suspected laboratory contaminant is less than five or ten times the concentration detected in the method blanks, then the samples containing that chemical are treated as non-detects, and the detection level is equal to the blank-related chemical concentration.

As indicated in Tables 4-2 and 4-3, several inorganic and organic constituents were detected in the soil and water method blanks. The number of inorganic and organic analyses performed on the soil method blanks was approximately 10 and 20, respectively. For the water method blanks, the approximate total analyses were 15 and 31, respectively. The variation in the number of times a particular constituent was analyzed is due to the use of multiple methods, i.e., some metals were analyzed by both graphite furnace atomic absorption (GFAA) and inductively coupled plasma (ICP). In addition, some of the organic constituents, generally those detected in 100 percent of samples analyzed and unknown compounds, were detected in the GC/MS library scans as TICs. The positive detections in the method blanks were used to evaluate the environmental data for each SWMU characterization to determine if the detected concentrations were the result of laboratory artifacts. This QC discussion is presented in the appropriate SWMU data evaluation subsections of Section 5.0 through 28.0.

Table 4–2
Summary of Method Blank Data for Soil and Sediment Samples
Radford Army Ammunition Plant, Virginia

Abbreviation	Compound Name	Units	Number of Blank Analyses	Number of Positive Detections	Maximum Concentration
111TCE	1,1,1–TRICHLOROETHANE	UGG	19	2	0.01
12DCLB	1,2–DICHLOROBENZENE	UGG	20	1	0.15
2CHE1L	2–CYCLOHEXEN–1–OL	UGG	1	1	0.2
2CHE1O	2–CYCLOHEXEN–ONE	UGG	1	1	0.2
ACET	ACETONE	UGG	19	3	0.05
AL	ALUMINIUM	UGG	10	10	2190
AS	ARSENIC	UGG	10	5	0.75
BA	BARIUM	UGG	10	3	8.3
B2EHP	BIS(2–ETHYLHEXYL) PHTHALATE	UGG	20	1	2.6
CA	CALCIUM	UGG	10	8	11500
CR	CHROMIUM	UGG	10	2	6.94
CU	COPPER	UGG	10	4	1.86
12EPCH	CYCLOHEXENE OXIDE	UGG	5	5	0.7
C16ABE	HEXADECANOIC ACID, BUTYL ESTER	UGG	1	1	1
HXADOE	HEXANEDIOIC ACID, DIOCTYL ESTER	UGG	2	2	0.4
FE	IRON	UGG	10	10	2590
MG	MAGNESIUM	UGG	10	10	1680
MN	MANGANESE	UGG	10	5	57.1
NI	NICKEL	UGG	10	1	1.9
C18ABE	OCTADECANOIC ACID, BUTYL ESTER	UGG	1	1	0.7
K	POTASSIUM	UGG	10	5	399
SE	SELENIUM	UGG	10	1	0.29
NA	SODIUM	UGG	10	10	3050
MEC6H5	TOLUENE	UGG	20	2	0.2
TPHC	TOTAL PETROLEUM HYDROCARBONS	UGG	1	1	2.59
CCL3F	TRICHLOROFLUOROMETHANE	UGG	19	6	0.03
TCLTFE	TRICHLOROTRIFLUOROETHANE	UGG	2	2	0.01
UNK073	Unknown Compound # 073	UGG	3	3	0.03
UNK112	Unknown Compound # 112	UGG	2	2	0.004
UNK527	Unknown Compound # 527	UGG	1	1	0.2
UNK586	Unknown Compound # 586	UGG	1	1	0.3
UNK643	Unknown Compound # 643	UGG	1	1	0.3
UNK649	Unknown Compound # 649	UGG	2	2	0.5
UNK650	Unknown Compound # 650	UGG	3	3	0.8
UNK651	Unknown Compound # 651	UGG	4	4	2
UNK652	Unknown Compound # 652	UGG	7	7	1
UNK653	Unknown Compound # 653	UGG	2	2	0.5
UNK660	Unknown Compound # 660	UGG	5	5	0.9
UNK661	Unknown Compound # 661	UGG	1	1	0.5
UNK670	Unknown Compound # 670	UGG	1	1	0.3
UNK672	Unknown Compound # 672	UGG	1	1	0.3
V	VANADIUM	UGG	9	2	6.23
ZN	ZINC	UGG	10	2	9.88

Table 4–3
Summary of Method Blank Data for Groundwater and Surface Water Samples
Radford Army Ammunition Plant, Virginia

Abbreviation	Compound Name	Units	Number of Blank Analyses	Number of Positive Detections	Maximum Concentration
34DNT	3,4–DINITROTOLUENE	UGL	8	8	5.52
111TCE	1,1,1–TRICHLOROETHANE	UGL	31	2	8.3
TCLEA	1,1,2,2–TETRACHLOROETHANE	UGL	31	3	2.1
2BUXEL	2–BUTOXYETHANOL	UGL	1	1	1
5M2HXO	5–METHYL–2–HEXAONE	UGL	1	1	300
ACET	ACETONE	UGL	31	3	41
B2EHP	BIS(2–ETHYLHEXYL) PHTHALATE	UGL	31	3	110
CHCL3	CHLOROFORM	UGL	31	5	1.8
12EPCH	CYCLOHEXENE OXIDE	UGL	17	17	8
DIACAL	DIACETONE ALCOHOL	UGL	3	3	40
HXADOE	HEXANEDIOIC ACID, DIOCTYL ESTER	UGL	1	1	8
FE	IRON	UGL	15	1	79.6
PB	LEAD	UGL	24	2	4.5
MESTOX	MESITYL OXIDE	UGL	1	1	2
PHANTR	PHENANTHRENE	UGL	31	1	1
K	POTASSIUM	UGL	15	1	1080
AG	SILVER	UGL	26	1	5.77
MEC6H5	TOLUENE	UGL	35	4	5
TOC	TOTAL ORGANIC CARBON	UGL	9	1	120
TOX	TOTAL ORGANIC HALOGENS	UGL	17	2	0.06
UNK208	Unknown Compound # 208	UGL	2	2	10
UNK517	Unknown Compound # 517	UGL	1	1	20
UNK519	Unknown Compound # 519	UGL	1	1	40
UNK525	Unknown Compound # 525	UGL	1	1	5
UNK527	Unknown Compound # 527	UGL	2	2	6
UNK531	Unknown Compound # 531	UGL	1	1	80
UNK532	Unknown Compound # 532	UGL	2	2	10
UNK542	Unknown Compound # 542	UGL	2	2	5
UNK560	Unknown Compound # 560	UGL	1	1	6
UNK632	Unknown Compound # 632	UGL	1	1	5
UNK633	Unknown Compound # 633	UGL	1	1	10
UNK635	Unknown Compound # 635	UGL	1	1	20
UNK636	Unknown Compound # 636	UGL	1	1	20
UNK641	Unknown Compound # 641	UGL	1	1	4
UNK644	Unknown Compound # 644	UGL	1	1	2
UNK646	Unknown Compound # 646	UGL	1	1	20
UNK648	Unknown Compound # 648	UGL	2	2	8
UNK649	Unknown Compound # 649	UGL	1	1	9
UNK675	Unknown Compound # 675	UGL	1	1	7

Of particular interest is the compound 34DNT, which was detected in all eight water method blanks associated with explosives analyses. However, this compound was not detected in any of the environmental samples collected at RAAP. The presence of 34DNT in the method blanks may be related to the use of this compound in the natural and standard-matrix QC samples. One or more QC samples containing 34DNT as a spiked compound was analyzed in each lot in which there was a corresponding positive detection of 34DNT in the method blank. The occurrence of 34DNT in the method blank may be the result of potential cross-contamination during preparation and/or analyses of the spike and method blank samples or may be the result of a residual response from the laboratory instrumentation. The concentrations (approximately 5 ug/l) detected in the method blanks were similar to the spiked levels (4.94 ug/l). The presence of 34DNT does not require additional evaluation because it was not detected in any of the environmental samples.

Some metals also were detected in the method blanks. The occurrences of these inorganics in the analytical data set are most likely the result of their presence in the soil sample used by the laboratory for the extraction and preparation of the method blank. This soil sample is typically heated to remove any organic compounds but the heating process does not eliminate the presence of inorganic constituents, which are often inherent in a soil sample. The occurrence of metals in the water method blanks suggest that the reagent water was not completely deionized. The low levels of metals detected do not indicate a gross contamination problem in the laboratory as the deionizer unit is routinely monitored by the laboratory. The presence of the inorganic constituents in the method blanks is not considered to be an indication of laboratory contamination, and, therefore, the site samples should not be affected by these results.

4.4 TRIP BLANKS

Trip blanks are used to indicate potential contamination due to migration of VOCs from the air on the site, or in sample shipping containers, into the sample (USEPA, 1989b). Trip blank vials are filled in the laboratory and sent to the field with the sample bottles, then returned unopened to the laboratory along with other samples for volatile analyses.

Volatiles introduced to samples by vehicle exhaust or other sources could be identified through trip blank analysis and thus discounted as detections of actual site contaminants. As with other samples, trip blank results could also reflect laboratory-introduced contaminants as detected in method blanks.

Table 4-4 presents a summary of the positive detections in the trip blank samples analyzed during the VI analytical program. Trichlorofluoromethane was detected in trip blanks on six different days at concentrations ranging from 1.7 to 3.01 ug/l. Methylene chloride was detected in three different trip blanks at concentrations ranging from 3.3 to 4.72 ug/l. Chloromethane (7.67 ug/l) and 1,1,1-trichloroethane (1,1,1-TCE)(0.574 ug/l) were detected in one trip blank each on different days. One unknown semi-volatile was detected in a trip blank on February 19, 1992. Table 4-5 lists the samples that were shipped in the same coolers as the associated trip blanks. It is assumed that contaminants detected in a trip blank could also be an indication of contaminants introduced in the samples shipped the same day. These samples were evaluated for possible trip blank contamination and are discussed in the appropriate SWMU characterization section.

4.5 EQUIPMENT BLANKS

Equipment blanks were prepared in the field by pouring the source water over decontaminated sampling equipment and submitting this water sample for analysis. These blanks were used to evaluate the effectiveness of field equipment decontamination procedures. Although contaminants found in the equipment blanks could be indicative of improper or inadequate equipment cleaning procedures, they could also be indicative of laboratory-introduced contamination and were thus compared with method blank analysis results. Contaminants attributable to inadequate equipment cleaning would be taken into account in evaluating samples analysis results; the presence of such contaminants could indicate cross-contamination among sample locations. Considerations similar to evaluation of method blanks were employed.

A summary of the positive detections for equipment blanks is presented in Table 4-6. The environmental samples associated with the equipment blanks are presented in Table 4-7. The majority of the constituents detected in the equipment blanks were inorganics.

Table 4–4
Summary of Positive Detections in Trip Blanks
Radford Army Ammunition Plant, Virginia

Compound [a]	Sample Date	Units [b]	Concentration
111TCE	18–feb–1992	UGL	0.574
CCL3F	30–jan–1992	UGL	2.91
	04–feb–1992	UGL	1.7
	04–feb–1992	UGL	3.01
	06–feb–1992	UGL	2.71
	10–feb–1992	UGL	2
	28–feb–1992	UGL	2.81
CH2CL2	21–jun–1991	UGL	3.58
	21–jun–1991	UGL	3.3
	26–sep–1991	UGL	4.72
CH3CL	10–feb–1992	UGL	7.67
UNK167	19–feb–1992	UGL	6

FOOTNOTES:

[a] Chemical abbreviations are provided in Appendix C.
[b] UGL = Micrograms per liter.

Table 4-5
Summary of Trip Blank Samples and Associated Environmental Samples
Radford Army Ammunition Plant, Virginia

QC	Sample	ESE Fld.	Site	Sample	Associated Environmental Samples								
Type	ID	Grp. No.	Type	Date	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9
Trip Blank	TRIP	RDDW 4	TRIP	06/21/91	RAAP-1 (RDDW*1)								
	TRIP	RDDW 5	TRIP	06/21/91	RAAP-1 (RDDW*2)								
	TRIP1	RDFQC 1	TRIP	08/20/91									
	TRIP1	RDWA 25	TRIP	09/17/91	D-3D	D-3							
	TRIP2	RDFQC 2	TRIP	08/22/91	13SB5A	13SB5B	13SB5C	13SC4A	13SC4B	13SC4C			
	TRIP2	RDWA 26	TRIP	09/19/91	DG-1	DDH2							
	TRIP3	RDFQC 3	TRIP	08/27/91	13SC6A	13SC6B	13SC6C	13SS3	13SS4	EQBK9			
	TRIP3	RDWA 27	TRIP	09/20/91	D-4	DDH4							
	TRIP4	RDFQC 4	TRIP	08/27/91	13SC6A	13SC6B	13SC6C	13SS3	13SS4	EQBK9			
	TRIP5	RDFQC 5	TRIP	08/28/91	13SC7A	13SC7B	13SC7C	13SB4A	13SB4B	13SB4C			
	TRIP5	RDWA 29	TRIP	09/13/91	10MW1	RAAP-1 (RDDW*23)							
	TRIP6	RDFQC 6	TRIP	10/08/91	12WW1	13MW7	13MW1						
	TRIP6	RDWA 30	TRIP	01/28/92	51MW2	51MW1							
	TRIP7	RDFQC 7	TRIP	09/26/91	OSE1	OSE2	OSP1						
	TRIP 8	RDFQC 8	TRIP	10/10/91	13MW3	13MW2	13MW4						
	TRIP9	RDFQC 9	TRIP	10/09/91	13MW5	13MW6	13SS1	13SS1MS	13SS2	13SE1	13SE2		
	TRIP10	RDFQC 10	TRIP	10/23/91	EQBK4	OSB2A	OSB3A						
	TRIP11	RDFQC 11	TRIP	10/24/91	OSB/OA	EQBK5	OSB1A	OSB1B	OSB10				
	TRIP12	RDFQC 12	TRIP	10/25/91	EQBK6	OSB5A	OSB5AD	OSB8	41SB1A	41SB1B			
	TRIP	RDFQC 26	TRIP	11/07/91	45MW3								
	TRIP	RDFQC 30	TRIP	11/08/91	45MW1	45MW2							
	TRIP13	RDFQC 13	TRIP	10/29/91	46SS1	46SS2							
	TRIP	RDWB 11	TRIP	10/29/91	43MW1	43WW1							
	TRIP	RDWB 12	TRIP	10/30/91	43MW3	43MW4							
	TRIP	RDWB 13	TRIP	10/31/91	43SP1	43SP2							
	TRIPCC	RDWB 14	TRIP	11/01/91	43MW2	43MW6	43MW5						
	TRIP14	RDFQC 14	TRIP	11/02/91									
	TRIP15	RDFQC 15	TRIP	11/04/91									
	TRPBLK	RDWC 83	TRIP	01/29/92	WC2-A	28WW1	MW9						
	TRIP	RDFQC 28	TRIP	01/24/92	WC1-A								
	TRIPAAA	RDFQC 27	TRIP	01/15/92									
	030392	RDFQC 29	TRIP	03/03/92	29SE2D	29SE2	29SE1	29SE3	29SW1	29SW1D			
	TRPBLK	RDWC 26	TRIP	02/04/92	16-1	C4							
	TRPBLK	RDWC 27	TRIP	01/30/92	28MW1	C-1							
	TRIP	RDWC 28	TRIP	02/04/92	28MW2								
	TRIP--	RDWC 29	TRIP	02/28/92	WC1-2	S4W4							
	TRIP--	RDWC 30	TRIP	02/06/92	FSS3	FSS4	68SS1	68SS2	71SS1	71SS2	71SS3	FSS1	FSS2
	TRPBLK	RDWC 79	TRIP	02/18/92	FSS5	FSS6	FSS7	FSS8					
	022092	RDWC 80	TRIP	02/20/92	P-2	P-3	P-4						
	TRPBLK	RDWC 82	TRIP	02/18/92	32MW1	B-4							
	TRPBLK	RDWC 84	TRIP	02/25/92	31SL1	31SL2	31SL3	EQBK9	8B				
	TRPBLK	RDWC 85	TRIP	02/11/92	BDH3	B-2							
	TRPBLK	RDWC 86	TRIP	02/24/92	OMW1	P-1	S4W1						
	021992A	RDWC 87	TRIP	02/19/92	EQB021992	13							
	021992B	RDWC 88	TRIP	02/19/92	BDH2								
	TRIP	RDWD 5	TRIP	02/10/92	57SW1	69SW1	57SE1	58SS3	69SE1	69SS1	69SS2	58SS1	58SS2
	TRIP		TRIP	04/16/92	NRSW1	NRSW3	NRSW4	NRSWDUP	NRSE1	NRSE2	NRSE3	NRSE4	NRSEDUP

Table 4-6
Summary of Positive Detections in Equipment Blanks
Radford Army Ammunition Plant, Virginia

Field ID	Sample Date	Compound[a]	Units[b]	Concentration	Lot[c]
RDFQC*16	20-aug-1991	BA	UGL	17.8	VKW
RDFQC*16	20-aug-1991	CA	UGL	10900	VKW
RDFQC*16	20-aug-1991	FE	UGL	252	VKW
RDFQC*16	20-aug-1991	K	UGL	1690	VKW
RDFQC*16	20-aug-1991	MG	UGL	4780	VKW
RDFQC*16	20-aug-1991	MN	UGL	25	VKW
RDFQC*16	20-aug-1991	NA	UGL	4410	VKW
RDFQC*16	20-aug-1991	CS2	UGL	1.47	WAV
RDFQC*16	20-aug-1991	PB	UGL	2.06	WEI
RDFQC*16	20-aug-1991	UNK620	UGL	100	WIJ
RDFQC*17	22-aug-1991	BA	UGL	17	VKW
RDFQC*17	22-aug-1991	CA	UGL	11600	VKW
RDFQC*17	22-aug-1991	FE	UGL	988	VKW
RDFQC*17	22-aug-1991	K	UGL	2400	VKW
RDFQC*17	22-aug-1991	MG	UGL	4950	VKW
RDFQC*17	22-aug-1991	MN	UGL	38.5	VKW
RDFQC*17	22-aug-1991	NA	UGL	4540	VKW
RDFQC*17	22-aug-1991	111TCE	UGL	1.78	WAW
RDFQC*17	22-aug-1991	2E1HXL	UGL	8	WAW
RDFQC*17	22-aug-1991	PB	UGL	5.97	WEI
RDFQC*17	22-aug-1991	UNK621	UGL	200	WIK
RDFQC*18	27-aug-1991	AL	UGL	169	VKW
RDFQC*18	27-aug-1991	BA	UGL	22.2	VKW
RDFQC*18	27-aug-1991	CA	UGL	11400	VKW
RDFQC*18	27-aug-1991	FE	UGL	4290	VKW
RDFQC*18	27-aug-1991	K	UGL	2790	VKW
RDFQC*18	27-aug-1991	MG	UGL	5000	VKW
RDFQC*18	27-aug-1991	MN	UGL	36.1	VKW
RDFQC*18	27-aug-1991	NA	UGL	4590	VKW
RDFQC*18	27-aug-1991	ZN	UGL	24.1	VKW
RDFQC*18	27-aug-1991	PB	UGL	1.41	WEI
RDFQC*18	27-aug-1991	UNK619	UGL	300	WIL
RDFQC*18	27-aug-1991	UNK628	UGL	10	WIL
RDFQC*19	23-oct-1991	UNK620	UGL	40	XDE
RDFQC*20	24-oct-1991	CHCL3	UGL	1.54	WTT
RDFQC*20	24-oct-1991	UNK620	UGL	80	XDE
RDFQC*21	25-oct-1991	HXADOE	UGL	7	XDG
RDFQC*21	25-oct-1991	UNK620	UGL	200	XDG
RDFQC*21	25-oct-1991	UNK629	UGL	10	XDG
RDFQC*21	25-oct-1991	UNK675	UGL	90	XDG
RDFQC*21	25-oct-1991	UNK691	UGL	30	XDG
RDFQC*22	02-nov-1991	UNK617	UGL	70	XDJ
RDFQC*23	05-nov-1991	AL	UGL	159	WZJ
RDFQC*23	05-nov-1991	BA	UGL	13.4	WZJ
RDFQC*23	05-nov-1991	CA	UGL	12000	WZJ
RDFQC*23	05-nov-1991	FE	UGL	367	WZJ
RDFQC*23	05-nov-1991	K	UGL	1570	WZJ
RDFQC*23	05-nov-1991	MG	UGL	5440	WZJ
RDFQC*23	05-nov-1991	MN	UGL	11.9	WZJ
RDFQC*23	05-nov-1991	NA	UGL	5260	WZJ
RDFQC*23	05-nov-1991	ZN	UGL	25	WZJ
RDFQC*23	05-nov-1991	PB	UGL	4.34	WEU
RDFQC*24	25-feb-1992	BA	UGL	18.5	WZV
RDFQC*24	25-feb-1992	CA	UGL	14100	WZV
RDFQC*24	25-feb-1992	CU	UGL	19	WZV
RDFQC*24	25-feb-1992	FE	UGL	324	WZV
RDFQC*24	25-feb-1992	K	UGL	1670	WZV
RDFQC*24	25-feb-1992	MG	UGL	4540	WZV
RDFQC*24	25-feb-1992	MN	UGL	18.1	WZV
RDFQC*24	25-feb-1992	NA	UGL	4480	WZV
RDFQC*24	25-feb-1992	ZN	UGL	112	WZV
RDFQC*24	25-feb-1992	PB	UGL	4.23	XWG
RDWA*10	19-sep-1991	PO4	UGL	53.5	RDQ
RDWA*10	19-sep-1991	N2KJEL	UGL	219	SKK
RDWA*10	19-sep-1991	CL	UGL	3560	UFW
RDWA*10	19-sep-1991	NIT	UGL	1800	WNE
RDWA*10	19-sep-1991	CS2	UGL	2.04	WTE
RDWA*10	19-sep-1991	TOC	UGL	2560	WVG

Table 4-6 (cont'd)

Field ID	Sample Date	Compound[a]	Units[b]	Concentration	Lot[c]
RDWA*10	19-sep-1991	TOX	UGL	123	WVH
RDWA*10	19-sep-1991	PH		7.5	WVQ
RDWA*10	19-sep-1991	BA	UGL	18	WZA
RDWA*10	19-sep-1991	CA	UGL	9960	WZA
RDWA*10	19-sep-1991	K	UGL	1270	WZA
RDWA*10	19-sep-1991	MG	UGL	4450	WZA
RDWA*10	19-sep-1991	MN	UGL	6.76	WZA
RDWA*10	19-sep-1991	NA	UGL	4510	WZA
RDWA*23	13-sep-1991	N2KJEL	UGL	886	SKK
RDWA*23	13-sep-1991	CL	UGL	3560	UFW
RDWA*23	13-sep-1991	NIT	UGL	5500	WNE
RDWAU*10	19-sep-1991	AL	UGL	246	WZA
RDWAU*10	19-sep-1991	BA	UGL	88.1	WZA
RDWAU*10	19-sep-1991	CA	UGL	9860	WZA
RDWAU*10	19-sep-1991	FE	UGL	385	WZA
RDWAU*10	19-sep-1991	K	UGL	2040	WZA
RDWAU*10	19-sep-1991	MG	UGL	4470	WZA
RDWAU*10	19-sep-1991	MN	UGL	136	WZA
RDWAU*10	19-sep-1991	NA	UGL	4310	WZA
RDWC*17	10-mar-1992	PB	UGL	1.95	XWL
RDWC*17	10-mar-1992	BA	UGL	19.8	YOC
RDWC*17	10-mar-1992	CA	UGL	13000	YOC
RDWC*17	10-mar-1992	CU	UGL	26.5	YOC
RDWC*17	10-mar-1992	FE	UGL	205	YOC
RDWC*17	10-mar-1992	K	UGL	930	YOC
RDWC*17	10-mar-1992	MG	UGL	4200	YOC
RDWC*17	10-mar-1992	MN	UGL	15.1	YOC
RDWC*17	10-mar-1992	NA	UGL	4080	YOC
RDWC*17	10-mar-1992	ZN	UGL	113	YOC
RDWC*42	06-feb-1992	AL	UGL	151	WZS
RDWC*42	06-feb-1992	BA	UGL	20	WZS
RDWC*42	06-feb-1992	CA	UGL	11600	WZS
RDWC*42	06-feb-1992	CU	UGL	11.8	WZS
RDWC*42	06-feb-1992	FE	UGL	209	WZS
RDWC*42	06-feb-1992	K	UGL	1960	WZS
RDWC*42	06-feb-1992	MG	UGL	4320	WZS
RDWC*42	06-feb-1992	MN	UGL	16.9	WZS
RDWC*42	06-feb-1992	NA	UGL	4120	WZS
RDWC*42	06-feb-1992	ZN	UGL	25.5	WZS
RDWC*42	06-feb-1992	UNK649	UGL	10	XDW
RDWC*42	06-feb-1992	UNK686	UGL	6	XDW
RDWC*42	06-feb-1992	TOC	UGL	2.27	XVM
RDWC*42	06-feb-1992	PH		6.91	XVS
RDWC*42	06-feb-1992	TOX	UGL	124	XVZ
RDWC*53	19-feb-1992	AL	UGL	168	WZV
RDWC*53	19-feb-1992	BA	UGL	19.7	WZV
RDWC*53	19-feb-1992	CA	UGL	10700	WZV
RDWC*53	19-feb-1992	FE	UGL	309	WZV
RDWC*53	19-feb-1992	K	UGL	1040	WZV
RDWC*53	19-feb-1992	MG	UGL	4080	WZV
RDWC*53	19-feb-1992	MN	UGL	28.2	WZV
RDWC*53	19-feb-1992	NA	UGL	4030	WZV
RDWC*53	19-feb-1992	PH		7.41	YEG
RDWC*53	19-feb-1992	TOC	UGL	1340	YEK
RDWC*53	19-feb-1992	TOX	UGL	23.1	YEN
RDWC*73	10-mar-1992	BA	UGL	17.2	YOC
RDWC*73	10-mar-1992	CA	UGL	13300	YOC
RDWC*73	10-mar-1992	CU	UGL	25.3	YOC
RDWC*73	10-mar-1992	FE	UGL	258	YOC
RDWC*73	10-mar-1992	K	UGL	1400	YOC
RDWC*73	10-mar-1992	MG	UGL	4100	YOC
RDWC*73	10-mar-1992	MN	UGL	9.9	YOC
RDWC*73	10-mar-1992	NA	UGL	3890	YOC
RDWC*73	10-mar-1992	ZN	UGL	78.8	YOC

Footnotes:

[a] Chemical abbreviations are provided in Appendix C.

[b] UGL = Micrograms per liter.

[c] Refers to the three-letter designation assigned by the laboratory to each lot (set) of samples.

Table 4–7
Summary of Equipment Blank Samples and Associated Environmental Samples
Radford Army Ammunition Plant, Virginia

Sample ID	Field ID	Site Type	Sample Date	Sample Before	Sample After
EQBK1	RDFQC*16	RNSW	08/20/91	48SB3B	13SB1A
EQBK2	RDFQC*17	RNSW	08/22/91	13SB5C	13SC5A
EQBK3	RDFQC*18	RNSW	08/27/91	13SC6C	13SC7A
EQBK4	RDFQC*19	RNSW	10/23/91	OSB3A	OSB2A
EQBK5	RDFQC*20	RNSW	10/24/91	OSB10	OSB5A
EQBK6	RDFQC*21	RNSW	10/25/91	OSB5D	OSB8
EQBK7	RDFQC*22	RNSW	11/02/91	OSB4	OSB6
EQBK8	RDFQC*23	RNSW	11/05/91	6SB1B	175B1A
RB BLANK	RDWA*10	RNSW	09/19/91	DG–1	DDH4
EBK– –	RDWC*42	RNSW	02/06/92	54MW3	54MW2
EQBK9	RDFQC*24	RNSW	02/25/92	31SL1	17ASS1A
EQB– –	RDWC*53	RNSW	02/19/92	13	BDH2
EQBK– –	RDWC*17	RNSW	03/10/92	BKGDSO–1	BKGDSD–1
EQBK– –A	RDWC*73	RNSW	03/10/92	OSB4B	OSB6

RNSW = Rinse Water.

The concentrations are similar to those detected in the drilling water sample, indicating that the equipment had been appropriately cleaned. Five organic compounds were detected, but the concentrations are relatively low and many of the constituents were also detected in the method and/or trip blanks.

4.6 MATRIX SPIKES AND MATRIX SPIKE DUPLICATES

Matrix spike and matrix spike duplicate samples were collected and analyzed at a rate of one every 20 samples of each matrix. The matrix spike and matrix spike duplicate consist of a field sample spiked in the laboratory with a range of compounds selected according to the method to be employed. The purpose of these sample analyses is to evaluate the potential effect, if any, of the sample matrix on the analytical results. Matrix effects can include method interferences and may result in a low or high bias of the sample results. Matrix spike sample results are evaluated by determining the percent recovery of the known spiked concentration. Percent recoveries are calculated by dividing the measured analytical value by the spiked (surrogate) concentration. Typical recoveries generally range from 80 to 120 percent, but may be lower or higher based on historical observations for a given analytical method and parameter.

A complete listing of all matrix spike and matrix spike duplicate data for RAAP samples is provided in Appendix F. A summary of the data are presented in Table 4-8, which presents a range of the percent recoveries for each respective analyte and method and a distribution of the number of recoveries in a defined range. As indicated in Table 4-8, the recoveries for the majority of samples are within the expected 80 to 120 percent range. However, a few, particularly the soil and water SVOC analyses, show lower recoveries.

The GC/MS SVOC surrogates vary in percent recoveries. (Note: It was determined prior to inplementation of the Work Plan that GC/MS surrogate data would be used to evaluate matrix effects.) The Contract Laboratory Program (CLP) ranges for these recoveries are identified as follows:

Table 4-8
Matrix Spike Recoveries
RAAP, VA

Meth	Name	No. Of Analyses	Range Of Percent Recovery Low	High	Number of Analyses ---Within Percent Recovery Range-- <60	60-79	80-120	121-140	>140
WATER SAMPLES --									
00	TOTAL ORGANIC CARBON	20	85.0	120.0	0	0	20	0	0
00	TOTAL ORGANIC HALOGENS	27	79.3	139.0	0	1	23	3	0
H2	PHENOLICS (NON-SPECIFIC)	2	92.0	93.4	0	0	2	0	0
SB01	MERCURY	20	47.4	103.6	2	1	17	0	0
SD09	THALLIUM	16	47.4	138.0	0	0	13	3	0
SD20	LEAD	16	79.5	116.0	0	1	15	0	0
SD21	SELENIUM	26	65.9	112.3	0	13	13	0	0
SD22	ARSENIC	26	72.8	142.9	0	0	14	8	4
SD23	SILVER	12	78.3	101.3	0	1	11	0	0
SS10	ALUMINIUM	14	94.0	125.0	0	0	12	2	0
SS10	ANTIMONY	14	97.5	138.2	0	0	12	2	0
SS10	BARIUM	26	77.5	120.0	0	2	24	0	0
SS10	BERYLLIUM	14	85.5	137.0	0	0	12	2	0
SS10	CADMIUM	26	80.0	106.0	0	0	26	0	0
SS10	CALCIUM	14	34.4	222.0	2	0	9	1	2
SS10	CHROMIUM	26	86.5	118.5	0	0	26	0	0
SS10	COBALT	14	88.0	131.8	0	0	12	2	0
SS10	COPPER	14	92.8	116.8	0	0	14	0	0
SS10	IRON	14	49.4	128.0	2	0	10	2	0
SS10	MAGNESIUM	14	71.5	158.0	0	2	10	0	2
SS10	MANGANESE	14	90.8	122.2	0	0	13	1	0
SS10	NICKEL	14	93.6	136.6	0	0	12	2	0
SS10	POTASSIUM	12	103.8	150.0	0	0	10	0	2
SS10	SILVER	16	86.4	112.4	0	0	16	0	0
SS10	SODIUM	14	92.6	133.0	0	0	10	4	0
SS10	THALLIUM	4	100.0	116.5	0	0	4	0	0
SS10	VANADIUM	14	97.0	123.8	0	0	12	2	0
SS10	ZINC	14	94.8	118.6	0	0	14	0	0
TF22	NITRITE,NITRATE	8	93.3	124.0	0	0	7	1	0
TT10	CHLORIDE	1	116.0	116.0	0	0	1	0	0
TT10	SULFATE	1	104.0	104.0	0	0	1	0	0
UH13	DECACHLOROBIPHENYL	6	13.6	33.6	6	0	0	0	0
UH13	ENDRIN	1	63.4	63.4	0	1	0	0	0
UH13	HEPTACHLOR	1	103.4	103.4	0	0	1	0	0
UH13	LINDANE	1	45.0	45.0	1	0	0	0	0
UH13	METHOXYCHLOR	1	56.3	56.3	1	0	0	0	0
UH13	TETRACHLOROMETAXYLENE	6	46.7	88.0	1	3	2	0	0
UM18	1,4-DICHLOROBENZENE	1	101.8	101.8	0	0	1	0	0
UM18	2,4,6-TRIBROMOPHENOL	94	13.0	103.0	36	55	3	0	0
UM18	2-FLUOROBIPHENYL	94	36.0	139.2	3	16	74	1	0
UM18	2-FLUOROPHENOL	94	17.0	152.0	15	4	73	1	1
UM18	24DNT	1	86.0	86.0	0	0	1	0	0
UM18	NITROBENZENE-D5	94	33.2	146.8	3	17	72	1	1
UM18	PENTACHLOROPHENOL	1	79.4	79.4	0	1	0	0	0
UM18	PHENOD6	94	36.0	174.0	15	8	69	0	2
UM18	TERPHENYL - D14	94	36.4	161.8	4	5	75	8	2
UM20	1,2-DICHLOROETHANE-D4	133	82.0	129.4	0	0	120	13	0
UM20	4-BROMOFLUOROBENZENE	133	81.0	101.0	0	0	133	0	0
UM20	TOLUENE-D8	133	81.2	100.0	0	0	133	0	0
UW32	34DNT	50	77.9	121.9	0	1	48	1	0

Table 4-8 (Cont'd)

			Range Of Percent Recovery		Number of Analyses ---Within Percent Recovery Range--				
Meth	Name	No. Of Analyses	Low	High	<60	60-79	80-120	121-140	>140
SOIL SAMPLES --									
JB01	MERCURY	24	67.7	114.4	0	2	22	0	0
JD15	SELENIUM	26	22.3	64.9	23	3	0	0	0
JD19	ARSENIC	26	4.0	4772.7	6	8	10	0	2
JS16	BERYLLIUM	15	64.9	111.8	0	0	15	0	0
JS16	CADMIUM	15	84.7	110.2	0	0	15	0	0
JS16	CHROMIUM	15	107.2	115.0	0	0	15	0	0
JS16	COPPER	15	100.5	106.2	0	0	15	0	0
JS16	NICKEL	15	104.5	115.8	0	0	15	0	0
JS16	SILVER	15	91.5	100.6	0	0	15	0	0
JS16	THALLIUM	15	96.8	117.9	0	0	15	0	0
JS16	ZINC	15	84.1	112.0	0	0	15	0	0
LM18	2,4,6-TRIBROMOPHENOL	125	23.0	164.2	14	19	79	12	1
LM18	2-FLUOROBIPHENYL	125	60.3	147.6	0	7	117	0	1
LM18	2-FLUOROPHENOL	125	46.1	140.4	4	12	94	14	1
LM18	NITROBENZENE-D5	125	38.8	123.6	11	20	92	2	0
LM18	PHENOD6	125	45.2	124.9	3	14	105	3	0
LM18	TERPHENYL - D14	125	50.9	121.8	9	52	63	1	0
LM19	1,2-DICHLOROETHANE-D4	110	67.9	114.0	0	2	108	0	0
LM19	4-BROMOFLUOROBENZENE	110	52.0	176.0	2	1	104	2	1
LM19	TOLUENE-D8	110	70.0	200.0	0	0	107	0	3
LW12	135TNB	4	92.9	149.5	0	0	3	0	1
LW12	246TNT	4	86.6	101.4	0	0	4	0	0
LW12	24DNT	4	86.2	122.8	0	0	3	1	0
LW12	NITROBENZENE	4	86.2	139.6	0	0	2	2	0
LW12	RDX	4	92.8	122.0	0	0	3	1	0

Surrogate	CLP Lower Limit (%)	CLP Upper Limit (%)
2-Fluorophenol	25	121
Phenol-D6	24	113
2,4,6-Tribromophenol	19	122
Nitrobenzene-D5	23	120
2-Fluorobiphenyl	30	115
Terphenyl-D14	18	137

These are advisory limits for surrogate recoveries. Samples that exceed these values may need to be evaluated on a case by case basis. Based on information from the laboratory, ESE has seen matrix effects occur with the "acid surrogates" (i.e., phenolic compounds) due high oxidation potential, especially in waters with high salt content. This could explain the number of analyses in Table 4-8 with recoveries <60% for the acid surrogates. Therefore, the data for these samples can be considered acceptable.

The selenium (Se) recoveries identified in Table 4-8 have been reviewed by the laboratory. Acceptance criteria for CLP for Se is 75-125 percent however, recoveries outside this range are not uncommon, particularly for naturally occurring elements such as selenium. Background concentration of elements in samples tend to cause recoveries to be skewed. In addition, soil and water environmental samples are susceptible to matrix effects for trace metals analysis since the analysis involves spectrophotometric instrumentation. Several graphite furnace methods require addition of matrix modifiers to remove most spectral interferences. The data should be acceptable since the control charts have been reviewed and accepted by USATHAMA by chemistry personnel in accordance with procedures specified in USATHAMA QA manual (USATHAMA, 1990).

4.7 REPLICATES

Field replicate (duplicate) analysis results may serve as an indication of overall field and laboratory precision; therefore, the results may have more variability than laboratory duplicates (which measure only laboratory performance). It is also acknowledged that soil duplicate results will show a greater variance than water matrix samples due to the nonhomogeneous nature of soils. For organics and inorganics, it is recommended that the results reported for each sample be compared and that a Relative Percent Difference (RPD) be calculated using the following equation:

$$\text{RPD} = \frac{(S - D)}{(S + D)/2} \times 100$$

Where: S = First sample value (original)

D = Second sample value (duplicate).

The results of the chemical analyses of the unfiltered groundwater duplicate samples are presented in Table 4-9. Except for TOX, TOC, and potassium (in one sample), the RPD values for the groundwater data ranged from 0 to 19 percent, which indicates an acceptable range of analytical precision. The RPD of potassium in the duplicate sample from well 43MW1 was 55 percent. The laboratory's ability to replicate TOX and TOC values was not as precise. The RPDs for TOX were 90 to 131 percent and the TOC RPD values were 5 and 118 percent.

The sample analyses of the duplicate soil samples are presented in Table 4-10. The results of soil duplicate analyses differed by as much as 120 percent. The RPD value for the semivolatile detected (phenanthrene) in one set of duplicate samples was 41 percent. The differences in the soil duplicate samples can be expected due to the variability associated with the heterogeneous nature of the soil matrix, potential matrix effects, and increased analytical variability associated with the quantification of analytical values near the detection limit.

The RPD values for the two sets of sediment duplicate samples (Table 4-11) ranged from 0 to 21 percent except for one selenium RPD value (56 percent) and one arsenic RPD value (63 percent). These RPD values indicate an acceptable range of analytical precision.

As indicated in Table 4-12, the RPD values of the surface water duplicate samples (29SW1) were as great as 137 percent for inorganic chemicals. Higher RPD values for surface water can be expected due to variability associated with high particulate matter and

Table 4-9
Summary of Duplicate Data For Groundwater Samples Collected During the VI
(Only Those Analytes Detected In At Least One Sample Are Presented)
Radford Army Ammunition Plant, Virginia

SITE ID	41MW3			43MW1		
S. DATE	04-mar-92			29-oct-91		
DEPTH (ft)	53			21		
MATRIX	CGW			CGW		
UNITS	UGL			UGL		
FIELD ID	RDWC*68	RDWC*71		RDWB*1	RDWB*8	
	Original	Duplicate	RPD	Original	Duplicate	RPD
TAL Inorganics						
BARIUM	16.5	15.7	5	55.6	54.7	2
CALCIUM	121000	122000	1	55900	56900	2
POTASSIUM	2570	2940	13	779	1370	55
MAGNESIUM	64000	65000	2	23800	24100	1
MANGANESE	10.1	10.2	1	4.81	5.84	19
SODIUM	221000	224000	1	10500	10500	0
LEAD	LT 1.26	3.58	ND	LT 1.26 B	LT 1.26 B	0
VANADIUM	14.6	15.3	5	LT 11	LT 11	0
Volatiles						
1,1,1-TRICHLOROETHANE	NT	NT	NA	LT 0.5	LT 0.5	0
1,1-DICHLOROETHANE	NT	NT	NA	LT 0.68	LT 0.68	0
1,2-DICHLOROETHENE	NT	NT	NA	LT 0.5	LT 0.5	0
TRICHLOROFLUOROMETHANE	NT	NT	NA	LT 1.4	LT 1.4	0
METHYLENE CHLORIDE	NT	NT	NA	LT 2.3	LT 2.3	0
TRICHLOROETHYLENE	NT	NT	NA	LT 0.5	LT 0.5	0
Other						
pH	7.07	7.13	1	6.73	6.63	1
TOTAL ORGANIC CARBON	24400	23300	5	2820	11000	118
TOTAL ORGANIC HALOGENS	36.1	95	90	141	29.3	131

Footnotes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.
CGW = Chemical groundwater.
LT = Concentration is reported as less than the certified reporting limit.
NA = Not applicable.
ND = Analyte was not detected in either the original or duplicate sample.
NT = Not tested; parameters were not tested (included) in the sample analyses.
RPD = Relative percent difference.
TAL = Target Analyte List.
UGL = Micrograms per liter.

Table 4-10
Summary of Duplicate Data For Soil Samples Collected During the VI
(Only Those Analytes Detected In At Least One Sample Are Presented)
Radford Army Ammunition Plant, Virginia

SITE ID	59SS2			6SB1			PSB2		
S. DATE	05-mar-92			05-nov-91			05-mar-92		
DEPTH (ft)	0.5			18			4.3		
MATRIX	CSO			CSO			CSO		
UNITS (#)	UGG			UGG			UGG		
SITE ID	59SS2			6SB1			PSB2		
FIELD ID	RVFS*108 Original	RVFS*109 Duplicate	RPD	RVFS*12 Original	RVFS*16 Duplicate	RPD	RVFS*105 Original	RVFS*79 Duplicate	RPD
TAL Inorganics									
SILVER	0.701	LT 0.589	ND	LT 0.589	1.11	ND	0.81	0.753	7
ALUMINIUM	6270	8110	26	9830	31300	104	15300	15800	3
ARSENIC	34	40	16	3.14	2.57	20	1.5	1.17	25
BARIUM	181	174	4	99.4	85	16	104	126	19
BERYLLIUM	0.736	LT 0.5	ND	LT 0.5	LT 0.5	0	0.745	0.732	2
CALCIUM	785	1390	56	355	353	1	1540	2740	56
COBALT	3.03	2.84	6	8.83	18.5	71	12.2	11.6	5
CHROMIUM	14.4	22.2	43	25.5	30.7	19	27.1	25.6	6
COPPER	17	11.4	39	6.21	17.4	95	65.3	125	63
IRON	20600	22200	7	20600	40000	64	25700	24400	5
MERCURY	0.575	0.546	5	LT 0.05	LT 0.05	0	LT 0.05	LT 0.05	ND
POTASSIUM	530	402	27	551	2200	120	1810	1880	4
MAGNESIUM	528	464	13	621	2470	120	4110	4720	14
MANGANESE	38.9	97	86	827	300	94	457	447	2
SODIUM	231	208	10	173	184	6	163	200	20
NICKEL	6.31	6.43	2	6.28	16.6	90	17.9	16.9	6
LEAD	30.6	22.7	30	19.4	29.6	42	23.5	21.9	7
ANTIMONY	LT 7.14	LT 7.14	0	LT 7.14	12.3	ND	LT 7.14	LT 7.14	0
SELENIUM	0.646	0.751	15	LT 0.25 B	LT 0.25 B	0	LT 0.25	LT 0.25	0
THALLIUM	LT 6.62	LT 6.62	0	LT 6.62	14.9	ND	LT 6.62	LT 6.62	0
VANADIUM	25.3	33.3	27	42.2	88	70	49.6	46.4	7
ZINC	41.6	35.7	15	36.1	61.9	53	81.4	89.1	9
Semivolatiles									
PHENANTHRENE	0.371	0.245	41	NT	NT	NA	NT	NT	NA

Footnotes:

CSO = Chemical soil.
LT = Concentration is reported as less than the certified reporting limit.
NA = Not Applicable.
ND = Analyte was not detected in either the original or duplicate sample.
NT = Not tested; parameters were not tested (included) in the sample analyses.
RPD = Relative percent difference.
TAL = Target Analyte List.
UGG = Micrograms per gram.

Table 4-11
Summary of Duplicate Data For Sediment Samples Collected During the VI
(Only Those Analytes Detected In At Least One Sample Are Presented)
Radford Army Ammunition Plant, Virginia

SITE ID	29SE2			31SL3		
S. DATE	03-mar-92			10-mar-92		
DEPTH (ft)	1			1		
MATRIX	CSE			CSE		
UNITS	UGG			UGG		
FIELD ID	RVFS*24	RVFS*43		RVFS*114	RVFS*115	
	Original	Duplicate	RPD	Original	Duplicate	RPD
TAL Inorganics						
SILVER	1	LT 0.589	ND	LT 0.589	LT 0.589	
ALUMINIUM	17700	21600	20	15900	14500	9
ARSENIC	34	17.7	63	6.54	6.98	7
BARIUM	250	217	14	118	113	4
BERYLLIUM	3.09	2.56	19	2.33	2.3	1
CALCIUM	2670	2680	0	2130	2050	4
COBALT	14.5	16.7	14	11	9.96	10
CHROMIUM	28.6	34.2	18	16.2	15.4	5
COPPER	30.1	36.7	20	32.9	30.8	7
IRON	24800	29500	17	10000	8650	14
MERCURY	0.174	0.147	17	LT 0.05	LT 0.05	0
POTASSIUM	2170	2320	7	1030	837	21
MAGNESIUM	2510	2700	7	1440	1220	17
MANGANESE	289	341	17	347	288	19
SODIUM	388	395	2	541	527	3
NICKEL	18.9	21.3	12	21.5	20.2	6
LEAD	23.3	24.2	4	LT 10.5	LT 10.5	0
SELENIUM	2.32	1.31	56	0.882	LT 0.25	ND
VANADIUM	67.3	78.1	15	33.6	30.8	9
ZINC	56.7	59.2	4	68	61.3	10
Volatiles						
TOLUENE	0.006	LT 0.001	ND	NT	NT	NA
TRICHLOROTRIFLUOROETHANE	0.034	0.034	0	NT	NT	NA
TRICHLOROETHYLENE	0.035	LT 0.003	ND	NT	NT	NA
Semivolatiles						
1,2-DICHLOROBENZENE	LT 0.11	LT 0.11	0	3.46	3.32	4
2-METHYLNAPHTHALENE	0.144	0.15	4	1.53	1.47	4
NAPHTHALENE	0.099	0.095	4	1.33	1.42	7
PHENANTHRENE	0.086	0.081	6	1.18	1.26	7

Footnotes:

CSE = Chemical sediment.
LT = Concentration is reported as less than the certified reporting limit.
NA = Not applicable.
ND = Analyte was not detected in either the original or duplicate sample.
NT = Not tested; parameters were not tested (included) in the sample analyses.
RPD = Relative percent difference.
TAL = Target Analyte List.
UGG = Micrograms per gram.

Table 4–12
Summary of Duplicate Data For Surface Water Samples Collected During the VI
(Only Those Analytes Detected In At Least One Sample Are Presented)
Radford Army Ammunition Plant, Virginia

SITE ID	29SW1		
S. DATE	03–mar–92		
DEPTH (ft)	0		
MATRIX	CSW		
UNITS	UGL		
FIELD ID	RDWC*66	RDWC*72	
	Original	Duplicate	RPD
TAL Inorganics			
SILVER	LT 0.25	LT 0.25	0
ALUMINIUM	3110	845	115
ARSENIC	3.41	LT 2.54	ND
BARIUM	115	41.9	93
CALCIUM	56800	55600	2
COPPER	8.56	LT 8.09	ND
IRON	3620	671	137
POTASSIUM	3870	4360	12
MAGNESIUM	8670	8400	3
MANGANESE	54.2	30.8	55
SODIUM	4720	4620	2
SELENIUM	3.62	LT 3.02	ND
Other			
pH	6.85	7.42	8
TOTAL ORGANIC CARBON	3650	6250	53
TOTAL ORGANIC HALOGENS	15.1	78.4	135

Footnotes :

CSW = Chemical surface water.
LT = Concentration is reported as less than the certified reporting limit.
ND = Analyte was not detected in either the original or duplicate sample.
RPD = Relative percent difference.
TAL = Target Analyte List.
UGL = Micrograms per liter.

suspended solids associated with the New River. Inorganic constituents tend to adsorb tothe particulate matter and suspended solids, causing the variability in the analytical data.

4.8 BACKGROUND SOILS

Background soil samples were collected from nine off-post locations and one location on-post near the housing area at RAAP, as shown on Figure 4-1. These locations wereconsidered to be unaffected by areas of known or suspected contamination. Five locations were chosen to be representative of upland type soils found on RAAP and five locations were selected as representative of alluvial type soils. Data from the analyses of the upland background soil samples (BKSS1, BKSS3, BKSS7, BKSS8, and BKSS9) would be compared to soil sample results from similar on-post SWMUs. The alluvial background soil locations (BKSS2, BKSS4, BKSS5, BKSS6, and BKSS10) would be similarly used to compare soil data at appropriate on-post SWMUs. Comparison concentrations also have been developed for the entire set of background samples whenever individual SWMUs cannot be adequately placed into either an alluvial or uplands environment.

Each surficial soil sample was collected from a visually undisturbed area at a depth of 0 to 0.5 feet below any surface vegetation or debris. To develop the background comparison levels, the mean and standard deviations of the background soil samples were calculated. The soil comparison levels were selected from the upper 95 percent confidence interval of the background data set, which is equal to the mean plus two standard deviations. The detection limits were used in the calculations of background criteria for those analytes that were not detected in a particular sample. The use of inorganics (metals and anions) concentrations for the development of comparison criteria is appropriate because these constituents occur naturally in soil. Background data for organic compounds in soil are generally not available because most of these compounds are not naturally occurring and, therefore, are not typically present in soil.

The background comparison levels for the entire data set of upland and alluvial soils, and separate comparison levels for upland soils and alluvial soils are presented in Tables 4-13, 4-14, and 4-15, respectively.

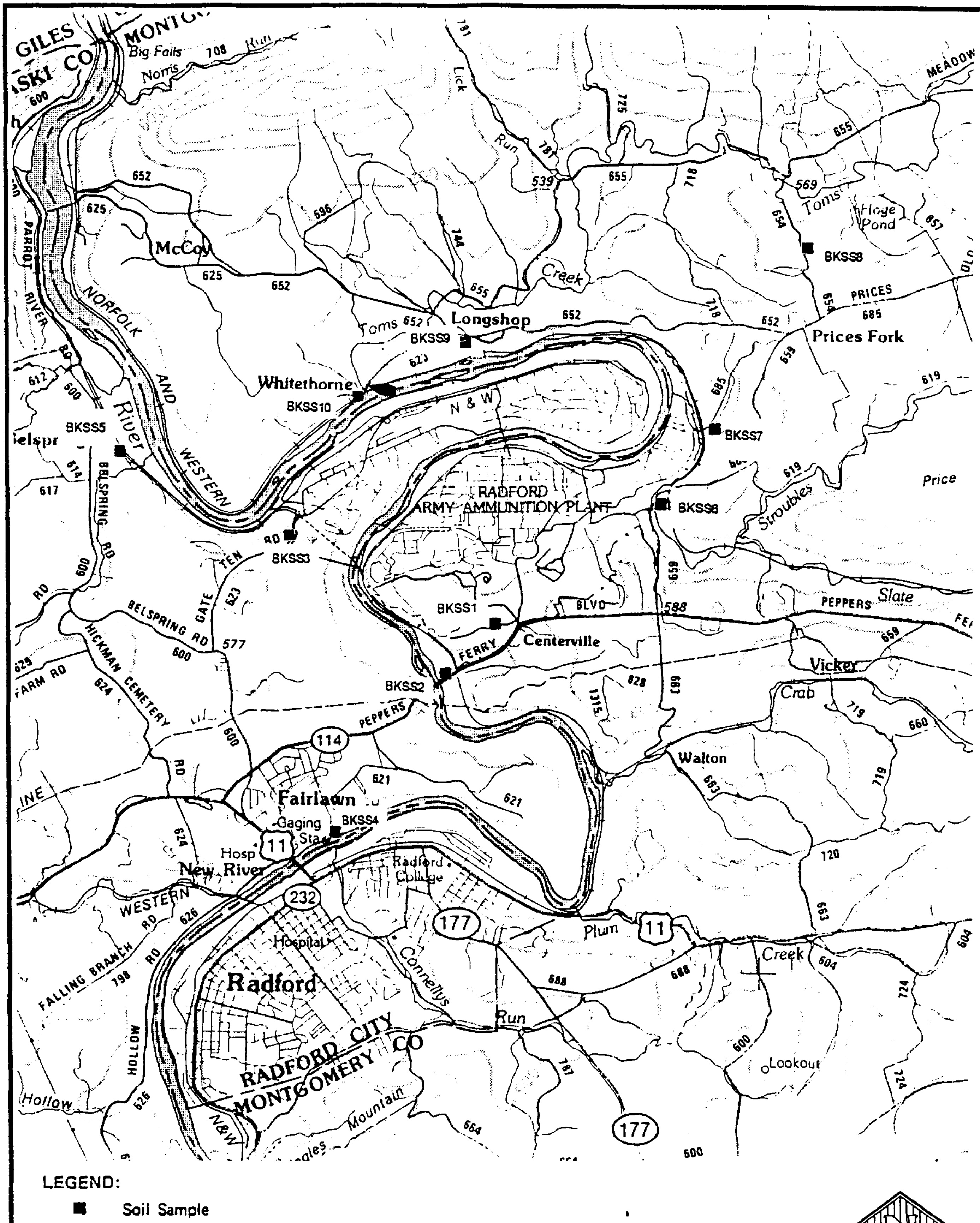


FIGURE 4–1
BACKGROUND SOIL SAMPLING LOCATIONS
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Scale 1:75,000

Table 4-13
Calculation of Background Comparison Levels
Radford Army Ammunition Plant, Virginia

Site ID	BKSS1	BKSS2	BKSS3	BKSS4	BKSS5	BKSS6	BKSS7	BKSS8	BKSS9	BKSS10	Statistical Values		Background Comparison Level
Site Type	PLUG	PLUG	PLUG	PLUG	PLUG	PLUG	PLUG	PLUG	PLUG	PLUG			
Field ID	RVFS*88	RVFS*52	RVFS*49	RVFS*51	RVFS*64	RVFS*89	RVFS*90	RVFS*65	RVFS*113	RVFS*66			
Date	03/10/92	03/10/92	03/10/92	03/10/92	03/10/92	03/10/92	03/10/92	03/10/92	03/10/92	03/10/92			
Depth	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	Mean	Std. Dev.	Mean + 2*(Std. Dev)
Analyte													
Aluminum	19100	12200	9710	16800	7620	9730	6830	16600	8380	10500	11747	4290	20328
Antimony	7.14 LT	7.14 LT	7.14 LT	9.78	7.14 LT	7.14 LT	7.14 LT	7.14 LT	7.14 LT	7.14 LT	7.40	0.83	9.07
Arsenic	5.380	5.980	6.420	3.450	3.490	8.070	3.520	7.320	3.790	4.000	5.14	1.73	8.61
Barium	56.5	152.0	74.2	180.0	88.5	143.0	70.5	103.0	66.1	147.0	108.08	43.75	195.58
Beryllium	0.922	0.500 LT	0.799	0.720	0.500 LT	0.500 LT	0.500 LT	0.811	0.500 LT	0.802	0.66	0.17	1.00
Cadmium	0.700 LT	1.070	0.700 LT	0.700 LT	0.700 LT	0.700 LT	0.700 LT	0.700 LT	0.700 LT	0.700 LT	0.74	0.12	0.97
Calcium	6270	27100	19600	78000	41300	12300	100000	23200	3560	7430	31876	32565	97006
Chromium	32.00	20.70	39.80	20.20	12.50	16.70	13.00	28.50	25.90	21.30	23.06	8.61	40.29
Cobalt	22.10	11.50	19.70	9.19	4.00	13.30	5.04	12.90	12.50	13.60	12.38	5.63	23.65
Copper	22.60	15.40	23.40	13.30	12.80	42.60	14.00	16.30	7.86	18.80	18.71	9.60	37.90
Iron	28600	40800	31300	22900	11200	29500	10500	25100	16900	25900	24270	9362	42993
Lead	255.00	264.00	80.80	75.60	27.00	10.50 LT	62.30	10.50 LT	27.40	68.10	88.12	94.01	276.13
Magnesium	16200	9780	11200	31800	22800	4650	41200	12800	2370	5760	15856	12571	40997
Manganese	400	1950	436	1000	221	914	199	298	892	927	724	536	1795
Mercury (Lev2)	0.05 LT	0.05 LT	0.05 LT	0.05 LT	0.05 LT	0.05 LT	0.05 LT	0.05 LT	0.05 LT	0.05 LT	0.05	0.00	0.05
Nickel	27.40	18.40	24.50	15.60	6.20	24.10	11.30	27.40	11.00	18.50	18.44	7.41	33.25
Potassium	3160	1430	1520	4180	795	1320	1460	2590	656	1690	1880	1104	4088
Selenium	0.250 LT	0.250 LT	0.250 LT	0.250 LT	0.250 LT	0.541	0.250 LT	0.250 LT	0.250 LT	0.250 LT	0.28	0.09	0.46
Silver	1.050	1.540	1.030	1.670	1.060	1.200	1.570	1.050	0.589 LT	1.020	1.18	0.33	1.83
Sodium	211	382	246	278	258	235	299	226	205	239	258	52	362
Thallium	6.62 LT	6.62 LT	6.62 LT	6.62 LT	6.62 LT	6.62 LT	6.62 LT	6.62 LT	6.62 LT	6.62 LT	6.62	0.00	6.62
Vanadum	55.70	32.30	60.40	36.60	28.10	19.90	23.40	36.50	27.70	28.90	34.95	13.28	61.50
Zinc	345.00	840.00	58.30	284.00	69.70	60.40	73.20	63.90	36.10	283.00	211	250	711

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1) All data values are IRDMIS Level 3, except for mercury.
2) Units are in micrograms per gram (UGG).
3) LT = Less than the detection limit.

Table 4-14
Calculation of Background Comparison Levels for Upland Soils
Radford Army Ammunition Plant, Virginia

Site ID	BKSS1	BKSS3	BKSS7	BKSS8	BKSS9	Statistical Values		Background Comparison Level
Site Type	PLUG	PLUG	PLUG	PLUG	PLUG			
Field ID	RVFS*88	RVFS*49	RVFS*90	RVFS*65	RVFS*113			
Date	03/10/92	03/10/92	03/10/92	03/10/92	03/10/92			
Depth	0.500	0.500	0.500	0.500	0.500	Mean	Std. Dev.	Mean + 2*(Std. Dev)
Analyte								
Aluminum	19100	9710	6830	16600	8380	12124	5398.4	22921
Antimony	7.14 LT	7.14 LT	7.14 LT	7.14 LT	7.14 LT	7.14	0	7.14
Arsenic	5.380	6.420	3.520	7.320	3.790	5.286	1.6423	9
Barium	56.5	74.2	70.5	103.0	66.1	74.06	17.478	109
Beryllium	0.922	0.799	0.500 LT	0.811	0.500 LT	0.7064	0.1944	1.10
Cadmium	0.700 LT	0.700 LT	0.700 LT	0.700 LT	0.700 LT	0.7	0	0.70
Calcium	6270	19600	100000	23200	3560	30526	39734	109994
Chromium	32.00	39.80	13.00	28.50	25.90	27.84	9.8078	47.46
Cobalt	22.10	19.70	5.04	12.90	12.50	14.448	6.7238	27.90
Copper	22.60	23.40	14.00	16.30	7.86	16.832	6.4267	29.69
Iron	28600	31300	10500	25100	16900	22480	8613.5	39707
Lead	255.00	80.80	62.30	10.50 LT	27.40	87.2	97.822	282.84
Magnesium	16200	11200	41200	12800	2370	16754	14588	45931
Manganese	400	436	199	298	892	445	266.48	978
Mercury (Lev2)	0.05 LT	0.05 LT	0.05 LT	0.05 LT	0.05 LT	0.05	0	0.05
Nickel	27.40	24.50	11.30	27.40	11.00	20.32	8.455	37.23
Potassium	3160	1520	1460	2590	656	1877.2	993.31	3864
Selenium	0.250 LT	0.250 LT	0.250 LT	0.250 LT	0.250 LT	0.25	0	0.25
Silver	1.050	1.030	1.570	1.050	0.589 LT	1.0578	0.3475	1.75
Sodium	211	246	299	226	205	237.4	37.899	313.20
Thallium	6.62 LT	6.62 LT	6.62 LT	6.62 LT	6.62 LT	6.62	0	6.62
Vanadium	55.70	60.40	23.40	36.50	27.70	40.74	16.576	73.89
Zinc	345.00	58.30	73.20	63.90	36.10	115.3	129.13	373.56

1) All data values are IRDMIS Level 3, except for mercury.
2) Units are in micrograms per gram (UGG).
3) LT = Less than the detection limit.

Table 4–15
Calculation of Background Comparison Levels For Alluvial Soils
Radford Army Ammunition Plant, Virginia

Site ID	BKSS2	BKSS4	BKSS5	BKSS6	BKSS10	Statistical Values		Background Comparison Level
Site Type	PLUG	PLUG	PLUG	PLUG	PLUG			
Field ID	RVFS*52	RVFS*51	RVFS*64	RVFS*89	RVFS*66			
Date	03/10/92	03/10/92	03/10/92	03/10/92	03/10/92			
Depth	0.500	0.500	0.500	0.500	0.500	Mean	Std. Dev.	Mean + 2*(Std. Dev)
Analyte								
Aluminum	12200	16800	7620	9730	10500	11370	3452.6	18275
Antimony	7.14 LT	9.78	7.14 LT	7.14 LT	7.14 LT	7.668	1.1806	10.03
Arsenic	5.980	3.450	3.490	8.070	4.000	4.998	2.0042	9.01
Barium	152.0	180.0	88.5	143.0	147.0	142.1	33.287	209
Beryllium	0.500 LT	0.720	0.500 LT	0.500 LT	0.802	0.6044	0.1459	0.90
Cadmium	1.070	0.700 LT	0.700 LT	0.700 LT	0.700 LT	0.774	0.1655	1.10
Calcium	27100	78000	41300	12300	7430	33226	28332	89890
Chromium	20.70	20.20	12.50	16.70	21.30	18.28	3.6935	25.67
Cobalt	11.50	9.19	4.00	13.30	13.60	10.318	3.9449	18.21
Copper	15.40	13.30	12.80	42.60	18.80	20.58	12.534	45.65
Iron	40800	22900	11200	29500	25900	26060	10723	47506
Lead	264.00	75.60	27.00	10.50 LT	68.10	89.04	101.55	292.14
Magnesium	9780	31800	22800	4650	5760	14958	11862	38682
Manganese	1950	1000	221	914	927	1002.4	616.85	2236
Mercury (Lev2)	0.05 LT	0.05 LT	0.05 LT	0.05 LT	0.05 LT	0.05	0	0.05
Nickel	18.40	15.60	6.20	24.10	18.50	16.56	6.5622	29.68
Potassium	1430	4180	795	1320	1690	1883	1324.7	4532
Selenium	0.250 LT	0.250 LT	0.250 LT	0.541	0.250 LT	0.3082	0.1301	0.57
Silver	1.540	1.670	1.060	1.200	1.020	1.298	0.2918	1.88
Sodium	382	278	258	235	239	278.4	60.385	399
Thallium	6.62 LT	6.62 LT	6.62 LT	6.62 LT	6.62 LT	6.62	0	6.62
Vanadium	32.30	36.60	28.10	19.90	28.90	29.16	6.1675	41.49
Zinc	840.00	284.00	69.70	60.40	283.00	307.42	317.14	942

1) All data values are IRDMIS Level 3, except for mercury.
2) Units are in micrograms per gram (UGG).
3) LT = Less than the detection limit.

4.9 ADDITIONAL DATA REVIEW

During the QC review of the chemical data, it was observed that there were several values that were reported with a "GT" as a data qualifier. This "GT" data qualifier is reported by the laboratory when the analyte concentration in the sample is greater than the maximum approved concentration of the analytical method being used. Typically, the sample is reanalyzed using a higher dilution factor (or for soil samples a smaller sample size is used) so that the concentration obtained is within the calibration range of the method. However, in some cases due to time constraints, workload, or sample size, a sample cannot be reanalyzed within the holding time (this is especially true for volatiles) and the last value obtained is reported with a "GT" as a data qualifier. For soil samples, there is a minimum sample size specified by the analytical method. When this minimum size is reached, additional analyses are not performed and the value obtained is reported with a "GT" data qualifier. These data are considered to be acceptable for both qualitative and quantitative use in the contamination and risk assessments, but the presence of the qualifier indicates that the concentration is higher than the reported value. It should be noted, that to the extent possible, all efforts were made to reanalyze these samples within the specified holding times to obtain a value within the method calibration range.

4.10 SUMMARY AND CONCLUSIONS

The results of the QA review of the analytical data indicate that some compounds were detected in the method and trip blanks, suggesting possible laboratory and/or shipping contamination. The QA results will be used to qualify positive detections of environmental data that are suspect laboratory, sampling, and/or shipping artifacts. The evaluation of the equipment blanks indicate that sample cleaning and decontamination activities were appropriately performed. The results of the duplicate analyses indicate that some of the values are outside of the suggested range for acceptable precision; however, these results are primarily due to heterogeneity of sample matrix or variability in suspended solids in surface water samples. The duplicate results are acceptable and are not considered to compromise the analytical quality and intended use of the data.

5.0 WASTE CHARACTERIZATION INVESTIGATIONS

5.1 CALCIUM SULFATE AT SWMU 8, SWMU 9, SWMU 36, SWMU 37, SWMU 38, SWMU 50, AND SWMU Q

5.1.1 Background and Environmental Setting

5.1.1.1 SWMU Histories. The Calcium Sulfate Areas include SWMUs 8, 9, 35, 36, 37, 38, Q, 50, and the disposal area near SWMU 38. SWMU 35 has been combined with SWMU 10 for the VI and is discussed in Section 7.0.

SWMU 8, Calcium Sulfate Settling Lagoons (A-B Line Acidic Wastewater), consists of two unlined, below-grade earthen lagoons located in the northeast section of the Main Manufacturing Area along the south bank of the New River (Figure 5-1). Each rectangular lagoon is approximately 200 feet long, 150 feet wide, and 10 feet deep. It is estimated that these currently active lagoons began operation in the early 1950s during the Korean War (USACE, 1981). The lagoons are operated on an alternating basis to accommodate maintenance and dredging. The adjacent sludge drying beds are at SWMU 36.

SWMU 8 manages neutralized, formerly acidic wastewater from the A-B Line Acidic Wastewater Treatment Plant (SWMU 19). The neutralization process that takes place at the treatment plant is as follows:

$$\underset{\text{(Hydrated lime)}}{Ca(OH)_2} + \underset{\text{(Sulfuric acid)}}{H_2SO_4} ==> \underset{\text{(Calcium sulfate)}}{CaSO_4} + \underset{\text{(Water)}}{2H_2O}$$

The wastewater containing the calcium sulfate flows through a series of weir gates in the lagoons, causing the calcium sulfate to precipitate out and settle to the bottom of the lagoons as a sludge. The supernatant is discharged to the New River via National Pollutant Discharge Elimination System (NPDES) Outfall 007 (Permit No. VA 0000248), adjacent to the unit (USATHAMA, 1976). The calcium sulfate sludge is dredged from the lagoons on a periodic basis (approximately once every 5 to 7 months) and placed in adjacent drying beds (SWMU 36). After drying, the sludge is removed from the beds; since 1982, it has

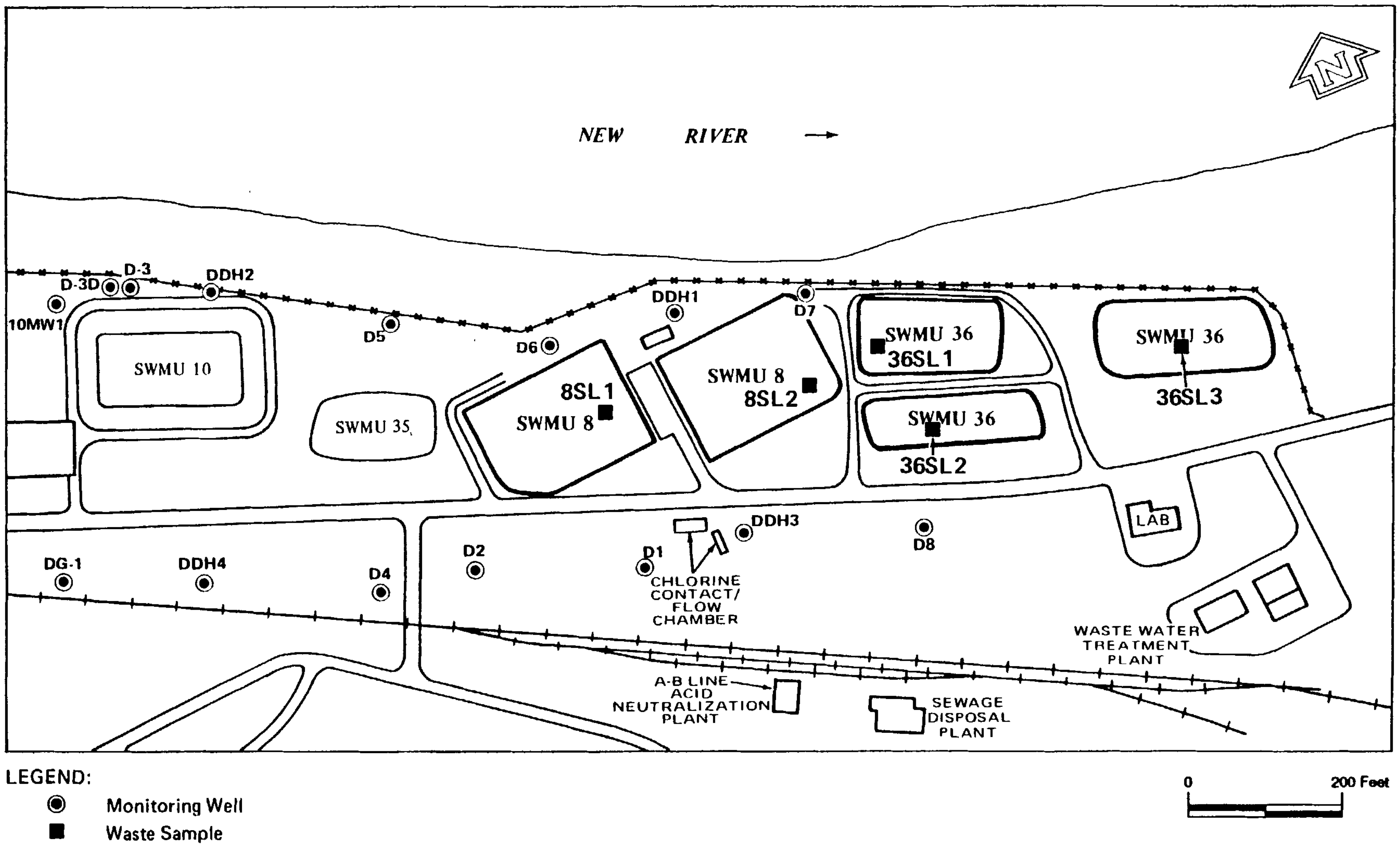

FIGURE 5-1
WASTE CHARACTERIZATION SAMPLE LOCATIONS
SWMU 8 – CALCIUM SULFATE SETTLING LAGOONS
SWMU 36 – CALCIUM SULFATE DRYING BEDS
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

been disposed of in Fly Ash Landfill No. 2 (SWMU 29). Prior to 1982, the sludge from each calcium sulfate SWMU was disposed of in Fly Ash Landfill No. 1 (SWMU 26), the Calcium Sulfate Landfill (SWMU 27), SWMU 50 and an area near SWMU 38.

SWMU 9, Calcium Sulfate Settling Lagoons (C-Line Nitrocellulose Wastewater), consists of two below-grade, unlined earthen lagoons located in the northwest area of the manufacturing facility (Figure 5-2). Each rectangular lagoon is approximately 150 feet long by 75 feet wide, and 8 to 10 feet deep. Operation of these currently active lagoons began in 1950-1953 during the Korean War (USACE, 1981). The lagoons are operated on an alternating basis to accommodate maintenance and dredging activities. The sludge drying beds adjacent to SWMU 9 are SWMU 37, SWMU 38, and SWMU Q.

SWMU 9 receives neutralized, formerly acidic wastewater from the C-Line Acidic Wastewater Treatment Plant (SWMU 20). The neutralization process that takes place at the treatment plant is similar to the process occurring for A-B Line Wastewater prior to entering SWMU 8.

The wastewater containing the calcium sulfate is gravity-fed into SWMU 9 via an underground process sewer pipe. The wastewater then flows through a series of weir gates in the lagoons, causing the calcium sulfate to precipitate out and settle to the bottom of the lagoons as a sludge. The water is discharged to the New River via NPDES Outfall 005 (Permit No. VA 0000248), adjacent to the unit. Similar to SWMU 8, the calcium sulfate sludge is dredged from the lagoons on a periodic basis (approximately once every 5 to 7 months) and placed in adjacent drying beds (SWMUs 37, 38, and Q). After drying, the sludge is removed from the beds.

SWMU 36, Calcium Sulfate Drying Bed (Northeast Section), is located along the New River in the northeast section of the Main Manufacturing Area. SWMU 36 is located immediately east of and adjacent to SWMU 8 (Figure 5-1). The drying beds were excavated into the natural grade and are unlined. Approximately once every 5 to 7 months, calcium sulfate sludge is dredged from SWMU 8 and pumped into one of the drying beds in SWMU 36 to dehydrate. After drying, the sludge is removed for disposal.

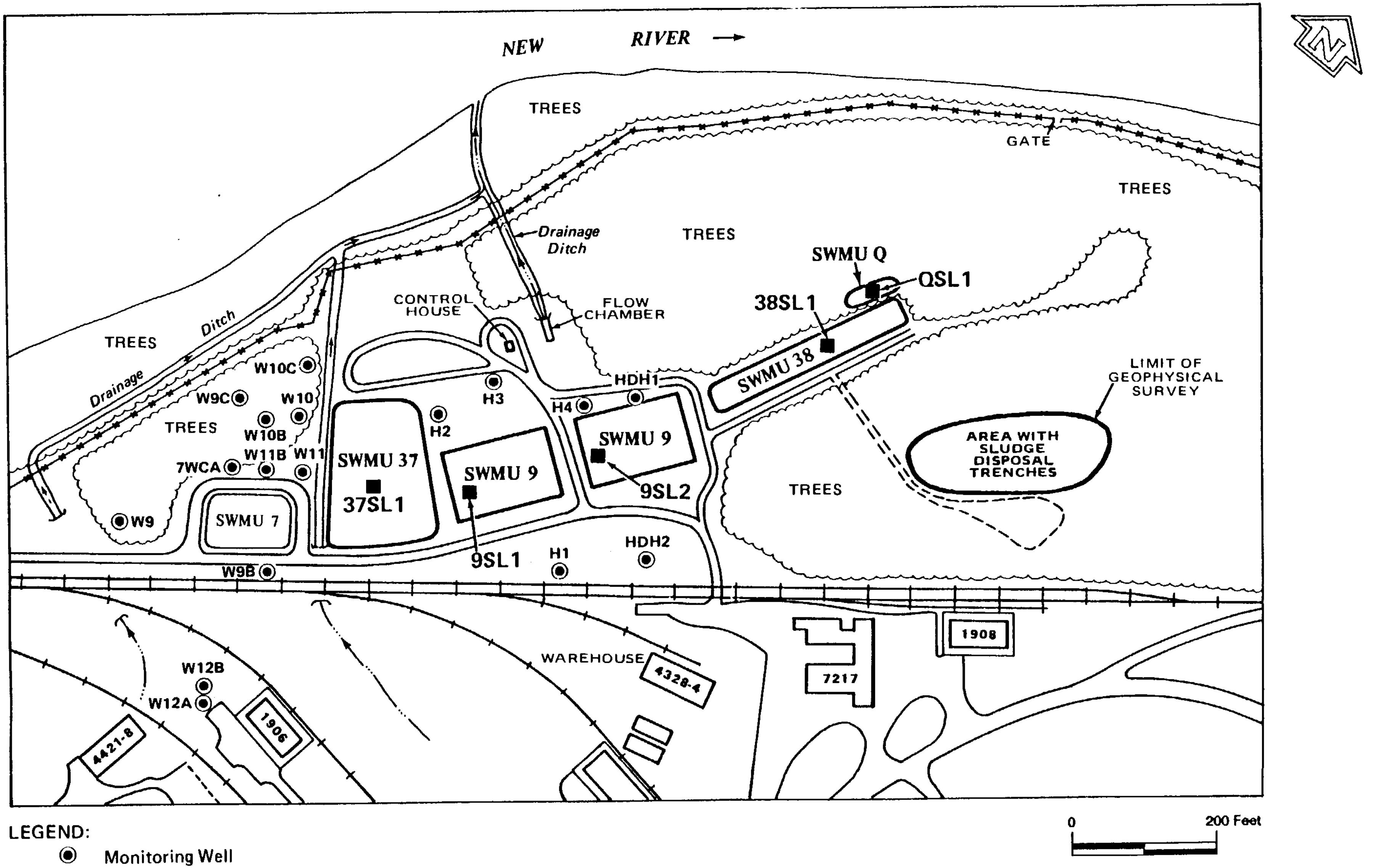

FIGURE 5-2
WASTE CHARACTERIZATION SAMPLE LOCATIONS
SWMU 9 – CALCIUM SULFATE SETTLING LAGOONS
SWMUs 37 AND 38 – CALCIUM SULFATE DRYING BEDS
SWMU Q – CALCIUM SULFATE DRYING BED
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

SWMU 36 consists of three separate drying beds, apparently of different ages. Based on a review of historical aerial photography, the northernmost bed (closest to the New River) appears to be the original drying bed. To the south of this bed is apparently the second oldest bed. These two beds are approximately 40 to 50 feet wide, 200 feet long, and 10 to 15 feet deep. The eastern-most bed was constructed last and is about 60 feet wide by 200 feet long.

SWMUs 37 and 38, Calcium Sulfate Drying Beds (Northwest Section), are located along the New River in the northwest section of the RAAP Main Manufacturing Area. SWMU 37, about 80 feet wide by 100 feet long, is located immediately southwest of and adjacent to SWMU 9 (Figure 5-2). SWMU 38, about 40 feet wide by 225 feet long, is located immediately northeast of and adjacent to SWMU 9. The units are excavated into the natural grade and are unlined. The depth of each unit was assumed to be 6 to 8 feet (USACE, 1981). Immediately northwest of and adjacent to SWMU 38 is SWMU Q (Figure 5-2). This abandoned lagoon was reported to be a sludge drying bed that was used when SWMU 38 was full. Sludge was pumped from SWMU 38 to SWMU Q via pipes that ran through a depression in the berm surrounding the drying bed.

As discussed previously, calcium sulfate sludge has been disposed of in various locations throughout RAAP, including Fly Ash Landfills Nos. 1 and 2 (SWMUs 32 and 29) and the Calcium Sulfate Landfill (SWMU 27). Another disposal area, SWMU 50 (Calcium Sulfate Disposal Area), was reported by EPA to be located in the Horseshoe Area approximately 3,400 feet east of the main New River bridge. The unit was reported to be contiguous to SWMU 48 (Oily Wastewater Disposal Area) and SWMU 49 (Red Water Ash Disposal Area), with no distinction possible by visual observation (USEPA, 1987). However, based on a review of historical aerial photographs and an interview with plant personnel, it has been determined that sludge disposal occurred in an open area south of SWMU 48 (Figure 5-3). The unit is approximately 300 feet by 300 feet in size. Until 1982, this was the major disposal area at RAAP for calcium sulfate sludge removed from the calcium sulfate drying beds (SWMUs 35, 36, 37, 38, and Q).

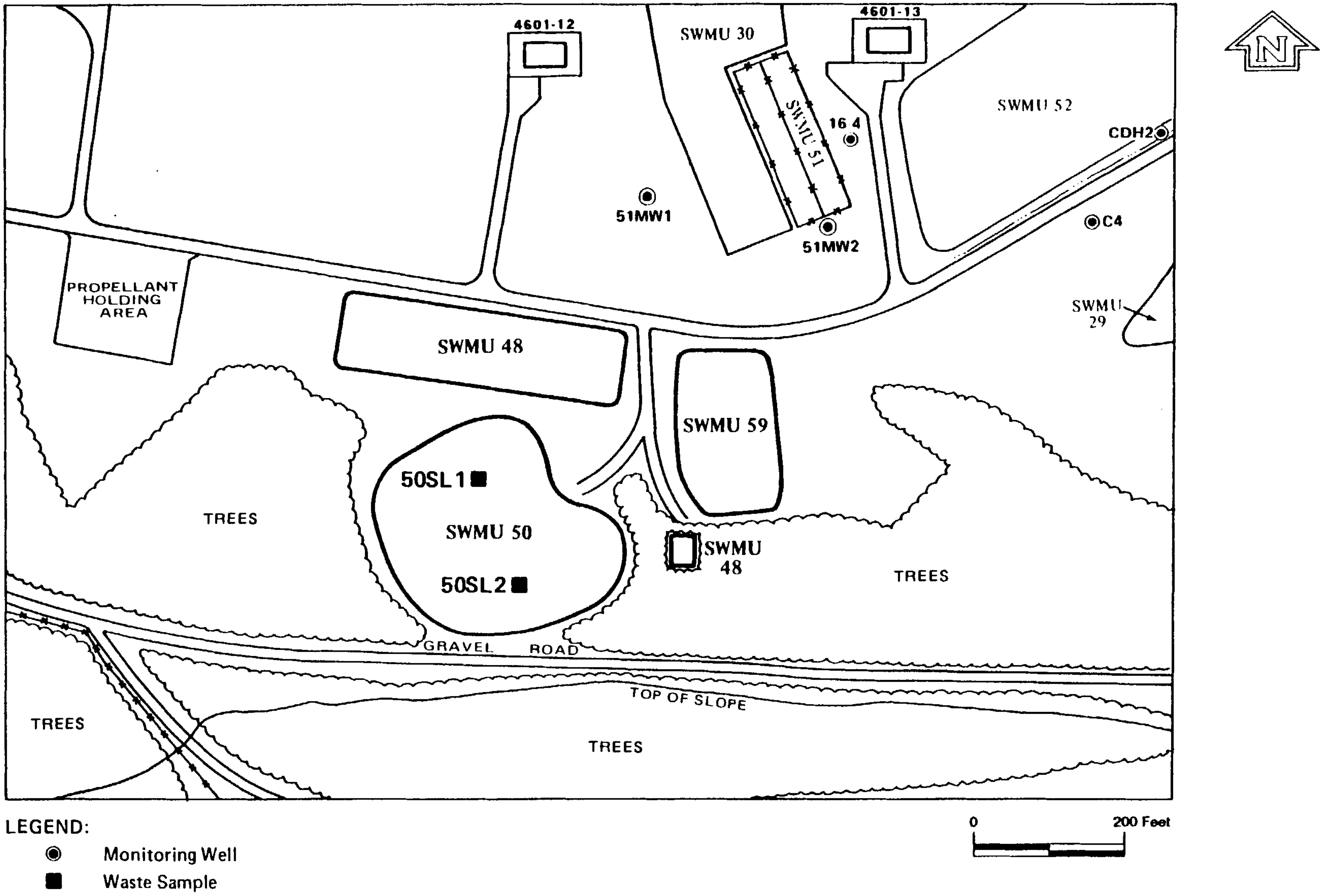

FIGURE 5-3
WASTE CHARACTERIZATION SAMPLE LOCATIONS
SWMU 50 – CALCIUM SULFATE DISPOSAL AREA
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Dames & Moore

In addition to SWMU 50, another sludge disposal area was identified during the March 1990 facility visit. In a wooded area located west east of and adjacent to SWMU 38 (Figure 5-2), trenches were used for the disposal of an unknown quantity of sludge.

Analyses performed on sludge samples collected from SWMU 8 indicate that the sludge does not exhibit any of the four hazardous waste characteristics as outlined in 40 CFR 261.34. However, there is concern that the sludge contains some organic compounds used in manufacturing activities at RAAP (USEPA, 1987; USACE, 1981). The sludge present in SWMUs 9, 36, 37, 38, Q, and 50 is assumed to have the same characteristics as that in SWMU 8.

5.1.1.2 Environmental Setting. Soil and rock borings completed in the vicinity of the SWMU 8 area as part of a hydrogeologic investigation (USACE, 1981) indicated the presence of two major lithologic units--unconsolidated sand with some gravel and clay lenses overlying limestone/dolostone bedrock.

The consolidated deposits, which thicken away from the river, consist primarily of fine- to coarse-grained, yellowish-brown sand varying in thickness between 14 and 30 feet. Zones of large cobbles (river jack) are present, but are not as common as found at other sites at RAAP. Silty brown clay lenses found at the land surface may represent recent deposition during flood events.

Underlying the sand unit is the gray limestone/dolostone of the Elbrook Formation. At SWMU 8, the gray limestone/dolostone is highly argillaceous. The limestone/dolostone itself is highly fractured and fragmented. A total of 29 field and laboratory permeability tests were performed during the investigation. The reported permeability for the unconsolidated material ranges from less than 3.28×10^{-6} centimeters per second (cm/sec) to 1.37×10^{-2} cm/sec. The lowest permeabilities are found in clay and silt lenses of the unit, and the highest permeabilities are found in the gravel. Seven in situ permeability tests were conducted on material of the Elbrook Formation. The average permeability of the limestone/dolostone is 8.42×10^{-3} cm/sec with a range from 1.73×10^{-4} to 2.08×10^{-2} cm/sec.

These data support the observation that the formation is highly fractured, and it is likely that groundwater flows through these channels with virtually no restriction.

The water table at this unit is found at a depth ranging from 10 to 23 feet below ground surface. Groundwater flow is essentially toward the New River. The available data indicate that the water table may also slope toward Stroubles Creek on the east side of SWMU 36 (USACE, 1981). Eight monitoring wells were installed in the vicinity of SWMU 8 as part of the 1980 hydrogeologic evaluation (USACE, 1981). Well locations are shown in Figure 5-1.

Soil and rock borings completed at the SWMU 9 Area during a hydrogeologic investigation conducted in 1980 (USACE, 1981) indicated the presence of two major lithologic units--unconsolidated sand and gravel with clay lenses overlying limestone/dolostone bedrock.

The unconsolidated deposits consist primarily of fine- to coarse-grained, yellowish-brown sand that is approximately 30 feet thick. With depth, large cobbles (river jack) become more dominant in the unit, and lenses of brown, silty clay are more dominant in the upper part of the unit.

Underlying the sand and gravel unit is the gray limestone/dolostone of the Elbrook Formation. The bedrock is highly argillaceous, and a large mudstone unit--which generally trends between borings H-1 and H-3--is present. The limestone/dolostone is moderately weathered and fractured. Up to 17 feet of bedrock was penetrated during the boring program.

A total of 16 field and laboratory permeability tests were performed by the USACE to determine the ability of the earth material at SWMU 9 to transmit fluids. The unconsolidated material exhibited a permeability ranging from 1.5×10^{-5} to 7.8×10^{-3} cm/sec, with an average of 6.45×10^{-4} cm/sec. Although the permeability appears to be low considering the prevalence of sand and gravel beneath the SWMU 9 Area, the unit is poorly sorted, which may result in filling of the large pore spaces by fine-grained silt and clay, thus decreasing permeability.

Three permeability tests were performed for limestone/dolostone material. Permeabilities range from 1.85×10^{-3} to 8.05×10^{-3} cm/sec, with an average value of 5.90×10^{-3} cm/sec. Two cation-exchange capacity (CEC) tests were performed by the USACE on unconsolidated sediments at the SWMU 9 Area. The samples tested were silty sand and clayey silt, with CEC values of 8.3 milliequivalents (meq)/100 grams (gm) and 9.0 meq/100 gm of soil, respectively.

The water table at the SWMU 9 Area is found generally along the bedrock surface, at a depth of 26 to 29 feet below ground surface. The water table, as indicated by the limited data available, appears to be virtually flat. Although it appears that the water table may be about 0.5 foot higher immediately beneath the impoundments in comparison with other monitor wells, the presence of a water table mound cannot be confirmed. The water table elevation is highest at H-4, which is immediately adjacent to the discharge line from the impoundments (which could be leaking).

Available water level data indicate that when water levels in the New River are altered by releases from the dam upstream of RAAP, the water table fluctuates accordingly. The groundwater flow in the vicinity of the SWMU 9 Area would be toward the New River, because there is no major point of groundwater discharge inland from the river that would reverse hydraulic gradients (USACE, 1981). In 1980, six monitoring wells were installed at the SWMU 9 Area as part of the hydrogeologic evaluation. Well locations are shown in Figure 5-2.

5.1.1.3 Geophysical Survey. Sludge excavated from SWMU 37 and SWMU 38 was reportedly placed in trenches excavated in the wooded area east of SWMU 38. A geophysical survey was performed at RAAP during the VI; this area was one of the areas explored (Appendix H). As shown in Figure 5-4, two areas with abnormally high conductivity readings were found. Each area centered on generally treeless but weed covered areas 200 feet east and southeast of SWMU 38. Several sludge filled trenches are probably located at these two locations.

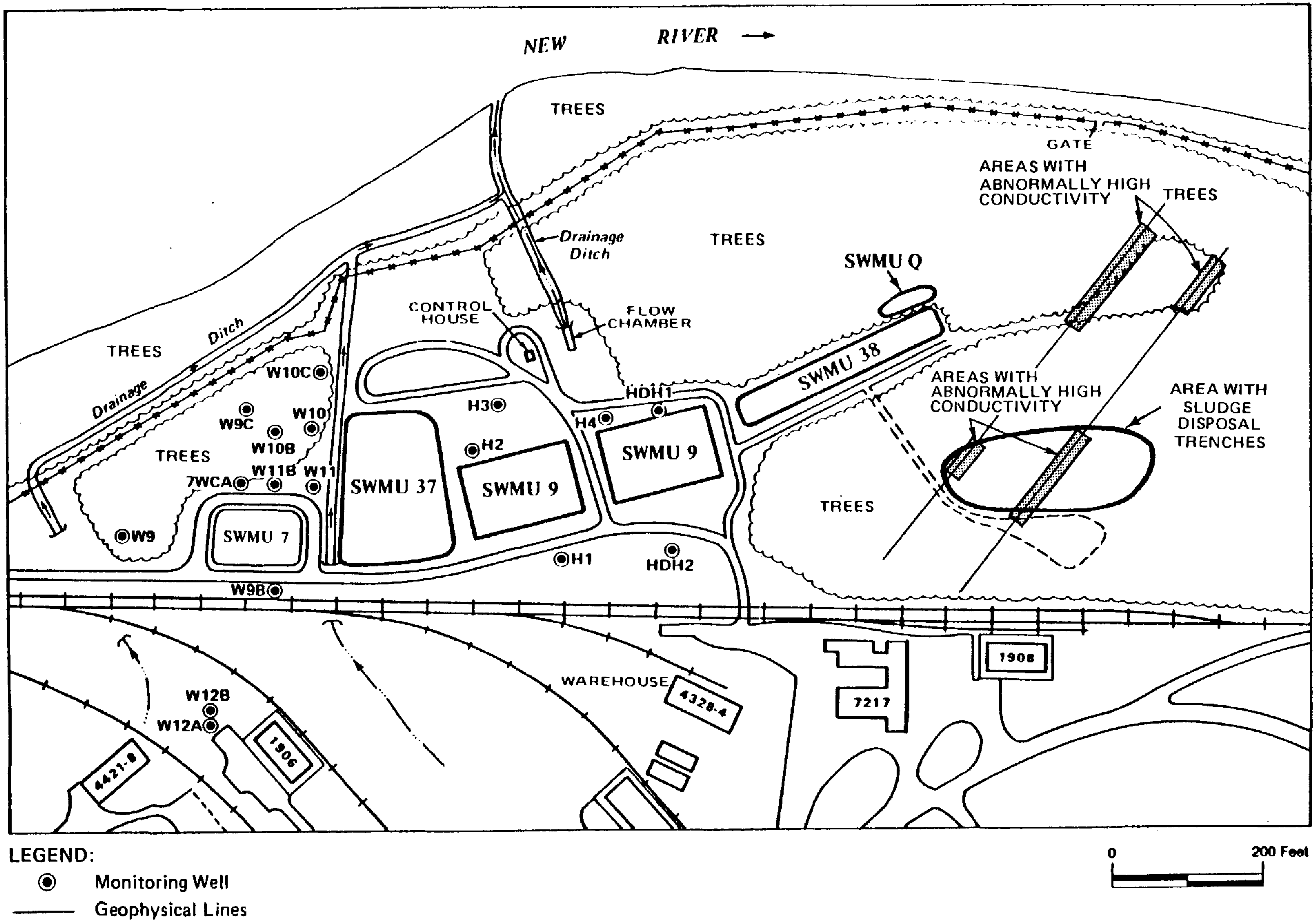

FIGURE 5-4
GEOPHYSICAL SURVEY RESULTS
CALCIUM SULFATE SLUDGE DISPOSAL TRENCHES
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

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5.1.2 Sample and Analyses Program

Wastes at these units were generated from similar processes and are considered to be relatively homogenous in character. As provided for in the permit, wastes from these units were sampled and analyzed to evaluate whether any hazardous constituent concentrations exceed the health based numbers (HBNs) in the permit (see Appendix D).

The calcium sulfate settling lagoons at SWMUs 8 and 9 consist of liquid-filled sludge settling lagoons. One sample was collected from each of the two lagoons at SWMU 8, (8SL1 and 8SL2), and one sample was collected from each of the two lagoons at SWMU 9 (9SL1 and 9SL2). Sample locations were along the edges of the lagoons. The top one foot of sludge was sampled. The four sludge samples were analyzed for VOCs, SVOCs, and TCLP metals.

There are a total of six calcium sulfate drying beds at SWMUs 36, 37, 38, and Q. In the two drying beds that contained liquids, SWMU 36 (north bed) and SWMU 38, one sample was collected from the top one foot of sludge present in each bed. Sample locations were along the edges of the bed where sampling from the edge was possible. In the four drying beds that contain only dried, solidified sludge, SWMU 36 (east and south beds), SWMU 37, and SWMU Q, a 5-foot hand auger boring was drilled in the central part of the beds. One sample was composited from each 5-foot hole to ensure a representative sample of numerous sludge drying episodes. All samples collected from the drying beds were analyzed for VOCs, SVOCs, and TCLP metals. Samples 36SL1, 36SL2, 36SL3, 37SL1, 38SL1, and QSL1 were collected, as shown in Figures 5-1 and 5-2.

At the Calcium Sulfate Disposal Area, SWMU 50, two soil borings were drilled (Figure 5-3) to collect two sludge samples (50SL1, 50SL2) for waste characterization. Five-foot borings were drilled into the central unit, and a 5-foot core was collected for chemical analysis. The samples were analyzed for VOCs, SVOCs, and TCLP metals. In the Sludge Disposal Area Near SWMU 38, a geophysical survey was performed to delineate specific sludge disposal boundaries and trench locations. Details of the geophysical techniques that were used are discussed in Section 5.2. Two lines spaced approximately 100 feet apart were traversed, with magnetic and electromagnetic readings taken at 15-foot intervals. The geophysical survey covered an area of less than one acre, as shown in Figure 5-4.

No sampling activities were proposed at the Sludge Disposal Area Near SWMU 38. Because sludge disposed of in this area was generated in the nearby settling lagoons and drying beds, described above, the analytical results from the samples collected from those units will indicate whether the sludge disposal area contains hazardous constituents at concentrations potentially above maximum allowable permit limits.

5.1.3 Comparison to Health Based Numbers and TCLP Criteria

The waste characterization investigation at the Calcium Sulfate Settling Lagoons and Drying Beds included the collection of four sludge samples from four settling lagoons at SWMUs 8 and 9 and six sludge samples from drying beds at SWMUs 36, 37, 38 and Q. Additionally, two composite sludge samples were collected at SWMU 50, the Calcium Sulfate Disposal Area. The results of the chemical analyses indicated that VOCs, SVOCs and TCLP metals were detected in several of the sludge samples. However, no reported concentrations exceeded the HBNs or TCLP waste characterization criteria and are a concern. Chemical analyses results for the sludge samples are presented in Table 5-1 for SWMUs 8 and 36 and Table 5-2 for SWMUs 9, 37, 38, Q, and 50.

Chemical analyses of 8SL1 and 8SL2 indicate detectable concentrations of two VOCs and three metals in sludges and sludge leachates from samples collected in the two settling lagoons at SWMU 8. A chloroform concentration of 0.016 ug/g for 8SL1 and a 111TCE concentration of 0.025 ug/g for 8SL2 were reported at levels slightly greater than the analytical PQLs. However, these VOC concentrations were several orders of magnitude less than the 100 ug/g and 1000 ug/g HBNs for these constituents in soil. Barium, chromium and silver from TCLP analyses also were reported at detectable concentrations for these sludge samples. Similar leachate concentrations of barium, chromium and silver were reported for samples 8SL1 and 8SL2, indicating a relatively homogenous mixture of sludge within the two neutralization lagoons. The results of the TCLP metal analyses indicated that leachable levels of barium, chromium, silver and other metals in the lagoon sludges are

Table 5-1
Summary of Analytical Data For Sediment Samples Collected At SWMUs 8 and 36
Radford Army Ammunition Plant, Virginia

SITE ID		36SL1	36SL2	36SL3	8SL1	8SL2	
FIELD ID		RVFS*31	RVFS*32	RVFS*33	RVFS*17	RVFS*18	
S. DATE		15-jan-92	15-jan-92	15-jan-92	15-jan-92	15-jan-92	
DEPTH (ft)		5.0	5.0	5.0	1.0	1.0	
MATRIX	PQLs	CSE	CSE	CSE	CSE	CSE	HBN
UNITS (#)	UGG	UGG	UGG	UGG	UGG	UGG	UGG
Volatiles							
1,1,1-TRICHLOROETHANE	0.005	LT 0.004	0.011	LT 0.004	LT 0.004	0.025	1000
ACETONE	0.1	0.229	LT 0.017	LT 0.017	LT 0.017	LT 0.017	1000
CHLOROFORM	0.005	LT 0.001	LT 0.001	LT 0.001	0.016	LT 0.001	100
Semivolatiles							
DI-N-BUTYL PHTHALATE	0.3	4.4	1.11	LT 0.305	LT 0.305	LT 0.305	1000
FLUORANTHENE	0.3	4.77	LT 0.34	LT 0.34	LT 0.34	LT 0.34	500
N-NITROSODIPHENYLAMINE	0.3	24.3	12.3	12.2	LT 0.95	LT 0.95	100
PHENANTHRENE	0.5	2.12	0.43	LT 0.165	LT 0.165	LT 0.165	40
TOTAL UNKNOWN TICs	NA	(6)45.2	(1)4.17	(1)4.13	ND	ND	NSA
TCLP Metals (UGL)							
BARIUM	20	284	209	371	341	231	100000
CHROMIUM	10	36.2	30.4	LT 6.02	15.4	40.6	5000
SILVER	2	7.84	6.21	12.5	5.49	5.29	5000

Footnotes:

CSE = Chemical sediment.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

ND = Analyte was not detected.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TCLP = Toxicity Characteristic Leaching Procedure.

TICs = Tentatively identified compounds that were detected in the GC/MS library scans. TCLP criteria presented as the HBN for these analyses.

UGG = Micrograms per gram.

UGL = Micrograms per liter.

Units(#) = Units are in UGG except for TCLP constituents, which are expressed in UGL.

( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

[ ] = Brackets indicate that the detected concentration exceeds the HBN (No exceedances on this table).

Table 5–2
Summary of Analytical Data For Sediment Samples Collected At SWMUs 9, 37, 38, 50, and Q
Radford Army Ammunition Plant, Virginia

SITE ID		37SL1	38SL1	50SL1	50SL2	9SL1	9SL2	QSL1	
FIELD ID		RVFS*34	RVFS*35	RVFS*9	RVFS*10	RVFS*20	RVFS*21	RVFS*87	
S. DATE		15–jan–92	15–jan–92	17–aug–91	17–aug–91	15–jan–92	15–jan–92	15–jan–92	
DEPTH (ft)		5.0	5.0	5.0	5.0	1.0	1.0	5.0	
MATRIX	PQLs	CSE	CSE	CSE	CSE	CSE	CSE	CSE	HBN
UNITS (#)	UGG	UGG	UGG	UGG	UGG	UGG	UGG	UGG	UGG
Volatiles									
1,1,1–TRICHLOROETHANE	0.005	LT 0.004	LT 0.004	5.15	LT 2.2	LT 0.004	LT 0.004	LT 0.004	1000
ACETONE	0.1	LT 0.017	LT 0.017	LT 8.5	LT 8.5	LT 0.017	0.091	LT 0.017	1000
CHLOROFORM	0.005	LT 0.001	LT 0.001	1.72	LT 0.435	0.015	LT 0.001	LT 0.001	100
Semivolatiles									
2–METHYLNAPHTHALENE	0.3	LT 0.245	LT 0.049	0.469	LT 0.049	LT 0.245	LT 0.245	LT 0.049	NSA
DI–N–BUTYL PHTHALATE	0.3	41.5	1.48	LT 0.061	LT 0.061	LT 0.305	29.4	3.01	1000
N–NITROSODIPHENYLAMINE	0.3	5.71	0.702	LT 0.19	LT 0.19	LT 0.95	LT 0.95	LT 0.19	100
NAPHTHALENE	0.3	LT 0.185	LT 0.037	0.432	LT 0.037	LT 0.185	LT 0.185	LT 0.037	1000
PHENANTHRENE	0.5	LT 0.165	LT 0.033	0.15	LT 0.033	LT 0.165	LT 0.165	LT 0.033	40
Semivolatile TICs									
CYCLOHEXENE OXIDE	NA	ND	0.425 S	ND	ND	ND	ND	ND	NSA
HEXADECANOIC ACID, BUTYL ESTER	NA	ND	ND	ND	1.66 S	ND	ND	ND	NSA
TOTAL UNKNOWN TICs	NA	(1)3.88	ND	(1)0.53	(4)2.76	ND	(4)49.5	(1)0.639	NSA
TCLP Metals (UGL)									
ARSENIC	10	LT 2.54	LT 2.54	3.52	LT 2.54	LT 2.54	LT 2.54	LT 2.54	5000
BARIUM	20	180	756	140	133	628	801	196	100000
CADMIUM	1	LT 4.01	LT 4.01	LT 4.01	LT 4.01	LT 4.01	8.75	LT 4.01	1000
CHROMIUM	10	15.5	9.69	40.8	22.5	37	20.1	LT 6.02	5000
LEAD	10	LT 18.6	LT 18.6	67	48	37.5	27.7	LT 18.6	5000
SILVER	2	4.95	LT 4.6	LT 4.6 B	LT 4.6 B	LT 4.6	4.67	8.17	5000

Footnotes :

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CSE = Chemical sediment.

ND = Analyte was not detected.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

S = Results are based on an internal standard; flag is used for TICs detected in library scans.

TCLP = Toxicity Characteristic Leaching Procedure. TCLP criteria presented as the HBN for these analyses.

TICs = Tentatively identified compounds that were detected in the GC/MS library scans.

UGG = Micrograms per gram.

UGL = Micrograms per liter.

Units(#) = Units are in UGG except for TCLP constituents, which are expressed in UGL.

( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

[ ] = Brackets indicate that the detected concentration exceeds the HBN (No exceedances on this table).

two to three orders of magnitude less than the regulatory levels (40 CFR 261.24) for characterizing a waste as hazardous. SVOCs were not detected in the two sludge samples.

A total of two VOCs, four SVOCs and three TCLP metals were detected in sludge samples collected from the three calcium sulfate drying beds at SWMU 36. These drying beds periodically receive accumulated sludge from SWMU 8 and were expected to contain constituents similar to that of SWMU 8. The chemical results show that 111TCE was the only VOC detected in both the lagoon (SWMU 8) and in any associated drying bed sludge sample, at 0.011 ug/g in drying bed sample 36SL2. Acetone was the only other VOC detected in the drying bed sludge and was reported at a concentration of 0.229 ug/g in 36SL1 only. However, the concentrations of these VOCs do not exceed the permit VOC HBNs for soil. Low to moderate concentrations of one to four SVOCs and one to six VOC TICs were reported for the three sludge samples. However, concentrations of the known VOCs are less than the permit HBNs by factors ranging from 4 to nearly 1,000. Sludge leachate concentrations of barium, chromium and silver for 36SL1 and 36SL2, and barium and silver for 36SL3 were less than the TCLP regulatory criteria.

As presented in Table 5-2, the results of the chemical analyses of 9SL1 and 9SL2 indicated detectable concentrations of two VOCs, one identified and four unknown SVOCs, and five TCLP metals in sludges and sludge leachates from samples collected in the two settling lagoons at SWMU 9. Chloroform and acetone, two VOCs reported at concentrations of 0.015 ug/g and 0.091 ug/g, were detected in sludge samples 9SL1 and 9SL2, respectively. However, these VOC concentrations were several orders of magnitude less than the 100 ug/g and 1000 ug/g HBNs for these constituents in soil and are not a concern. One identified SVOC, Di-N-butyl phthalate (DNBP), and four unknown SVOC TICs (49.5 ug/g total concentration) were reported for sample 9SL2 only. The concentration of DNBP reported for 9SL2 (i.e., 29.4 ug/g), however, was less than the HBN of 1000 ug/g for soil. SVOCs were not detected in sludge sample 9SL1. The results of the TCLP leachate analyses indicated detectable concentrations of barium, chromium and lead for sludge sample 9SL1. Similar levels of barium, chromium and lead were reported for sample 9SL2 leachate, with additional low levels of cadmium and silver as well. However, metal concentrations for the TCLP leachate analyses of samples 9SL1 and 9SL2 were two to three orders of magnitude less than the regulatory criteria.

Chemical results for SWMUs 37, 38 and Q indicate the presence of three SVOCs and three TCLP metals in sludge samples collected from the calcium sulfate drying beds associated with SWMU 9. VOCs, though, were not detected in any of these sludge samples. The three drying beds periodically receive accumulated sludge from SWMU 9 and were expected to contain constituents similar to that of SWMU 9. The chemical results show that DNBP was the only SVOC detected in any lagoon sample (9SL2) and in all sludge samples from the associated drying beds, with drying bed concentrations ranging from 1.48 ug/g to 41.5 ug/g in 38SL1 and 37SL1, respectively. N-Nitrosodiphenylamine, a SVOC not found in either of the SWMU 9 settling lagoon sludge samples, was also detected in sludge samples collected from SWMUs 37 and 38. However, the concentrations of these SVOCs were one to nearly two orders of magnitude less than the permit HBN criteria. Additionally, metal concentrations for the TCLP leachate analyses were two to three orders of magnitude less than the regulatory criteria.

The results of the chemical analyses of samples collected from SWMU 50 indicate the presence of two VOCs, three known SVOCs and arsenic in one sample/sample leachate only. Both VOCs, 111TCE and chloroform, and arsenic were limited to sample 50SL1, which was collected at the northern portion of the calcium sulfate disposal site. Similarly, three known SVOCs, the polynuclear aromatic hydrocarbons (PAHs) 2-methylnaphthalene, naphthalene and phenanthrene, were detected in 50SL1 only. Constituents detected in sample 50SL2, collected in the southern portion of the site, included estimated concentrations of one known and four unknown SVOC TICs. Detected or estimated analyte concentrations in both SWMU 50 samples were less than permit HBN comparison criteria. Additionally, metal concentrations reported for the TCLP leachate analyses were less than regulatory criteria.

5.1.4 Summary and Recommendations

The results of the chemical analyses of 12 representative sludge samples collected from SWMUs 8, 9, 36, 37, 38, Q and 50 indicated that a limited number of VOCs, SVOCs and TCLP metals were detected at low concentrations at 11 calcium sulfate settling lagoons, drying beds and disposal areas. Similar concentrations of several organic and inorganic analytes demonstrated that the sludge material distributed to lagoons and drying beds is homogenous within a site (i.e., SWMUs 8 and 36) as well as between sites (i.e., SWMUs 8 and 9). Although wastes at SWMUs 8 and 36 may have contributed to concentrations of 111TCE, chloroform and DNBP detected in shallow groundwater (USACE, 1981), the relatively low concentrations of these constituents detected in these recent samples indicated that SWMUs 8 and 36 are not likely to be major source areas. Greater contaminant concentrations reported at SWMUs 9 and 37 indicated that these units may be more significant sources of DNBP in groundwater downgradient of the sites. Subsurface samples of material at SWMU 50 indicate limited concentrations of two VOCs and three SVOCs. However, the concentrations of these and other constituents in the sludge samples were reported at levels significantly below permit HBNs or TCLP hazardous waste characterization criteria. The calcium sulfate lagoon, drying bed and disposal area sludges presently do not constitute a significant threat to human health and the environment because levels of contaminants are not considered to be hazardous as defined by present regulatory standards and HBN criteria. Additionally, present operations at the site, such as periodic removal and landfilling of the waste sludges, likely limit any potential downward migration of these constituents to groundwater. Based on the results of this investigation and present waste handling operations, no further action is recommended for these SWMUs.

5.2 COAL ASH AT SWMU 31

5.2.1 Background and Environmental Setting

5.2.1.1 SWMU 31 History. The Coal Ash Settling Lagoons (SWMU 31) are located in the northwest section of the Horseshoe Area (Figure 5-5). The unit has previously been referred to as both the "fly ash settling lagoon" and the "bottom ash settling lagoon." As

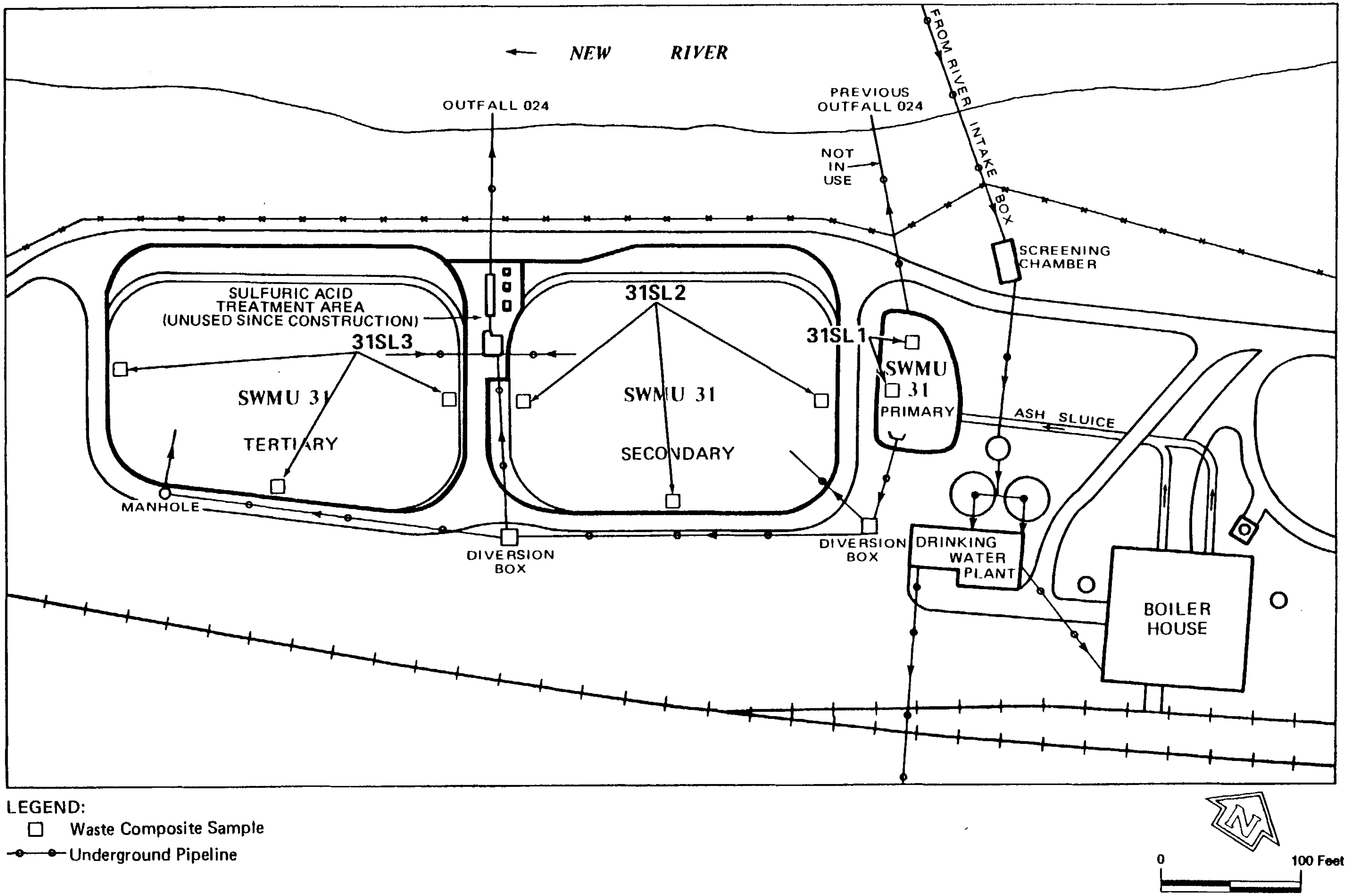


FIGURE 5-5
WASTE CHARACTERIZATION SAMPLE LOCATIONS
SWMU 31 – COAL ASH SETTLING LAGOONS
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Dames & Moore

referenced in the permit (USEPA, 1989), this unit will be referred to as the Coal Ash Settling Lagoons throughout this report, reflecting the probability that both fly ash and bottom ash have been discharged into it. In addition, the flocculating basin underdrainage and filter backwash water from Water Plant 4330 reportedly flowed to this unit (USATHAMA, 1976).

SWMU 31 is associated with Power House No. 2, which burns low sulfur coal to supply steam at 150 pounds per square inch (psi) to the buildings in the Horseshoe Area. No electrical power is generated at this power plant, which is scheduled to be closed according to RAAP representatives. Prior to 1971, when electrostatic precipitators were installed at the power house, fly ash-contaminated wastewater was discharged directly to the New River (USATHAMA, 1984).

SWMU 31 consists of three unlined settling lagoons. Water carrying fly ash from the power house flows down a below-grade, concrete-lined sluice waterway to the primary settling lagoon, which was constructed in about 1962. At one time, the supernatant from the primary settling lagoon was emptied directly into the New River via Outfall 024 (Permit No. VA 0000248). In 1978 or 1979, additional components were added to the unit; wastewater now flows from the primary settling lagoon through a below-ground pipe to a concrete sump. The sump is 18 to 20 feet deep, 2 feet of which is abovegrade. From the concrete sump, water is discharged to the secondary settling lagoon, which is approximately 150 feet wide by 200 feet long and of an unknown depth. From the secondary settling lagoon, water is discharged to the tertiary settling lagoon.

The effluent from the tertiary settling basin is designed to discharge to the New River via Outfall 024 following pH adjustment with sulfuric acid. Facility representatives indicate that prior to 1992, there has never been a discharge. All water discharged to the basin before 1992 apparently percolated through the basin into the surrounding soils or evaporated.

Coal ash that has settled out in the three lagoons is periodically dredged and disposed of in FAL No. 2 (SWMU 29). Previously, it was disposed of in FAL No. 1 (SWMU 26).

5.2.1.2 Environmental Setting.

SWMU 31 is located in the northwest section of the Horseshoe Area on a nearly level terrace adjacent to the New River at an approximate elevation of 1,700 feet above msl. No site-specific subsurface investigations have been conducted at SWMU 31. However, subsurface conditions below SWMU 31 would likely be similar to other SWMUs along the flood plain bordering the New River. Approximately 20 to 30 feet of unconsolidated alluvial sediments--mostly sand, clay, and silt--can be expected. Occasional seams of gravels or cobbles (river jack) would also be expected. Bedrock would likely consist of fractured limestone/dolostone of the Elbrook Formation. The water table should be encountered at an elevation similar to the nearby New River. If the water table is within the bedrock, the aquifer would be karstic with high velocity through solution features and fractures. Groundwater flow direction would be north toward the New River.

5.2.2 Sample and Analyses Program

The coal ash that is discharged to this unit is considered to be relatively homogenous in character. Three composite sludge samples were collected, one from each of the three lagoons at SWMU 31 (Figure 5-5). Sample locations were selected along the edges of the lagoons. The top one foot of sludge beneath the water/sludge interface was sampled. Three samples from each of two lagoons and two samples from a third lagoon were composited, resulting in a total of three samples (31SL1, 31SL2, 31SL3) submitted for chemical analysis. These samples were analyzed for metals and SVOCs. A duplicate sample of 31SL3 was also collected and analyzed.

5.2.3 Comparison to Health Based Numbers

The waste characterization investigation included the collection of three composite sludge samples, one each from three settling lagoons at SWMU 31. As presented in Table 5-3, the results of the chemical analyses indicated that concentrations of arsenic, beryllium and cobalt in all samples exceeded the HBN criteria. Thallium was also detected in sample 31SL2 (i.e., from the secondary treatment basin) at a concentration greater than the HBN

Table 5-3
Summary of Analytical Data For Sediment Samples Collected At SWMU 31
Radford Army Ammunition Plant, Virginia

SITE ID		31SL1	31SL2	31SL3	31SL3	
FIELD ID		RVFS*27	RVFS*28	RVFS*114	RVFS*115	
S. DATE		25-feb-92	25-feb-92	10-mar-92	10-mar-92	
DEPTH (ft)		1.0	1.0	1.0	1.0	
MATRIX	PQLs	CSE	CSE	CSE	CSE	HBN
UNITS	UGG	UGG	UGG	UGG	UGG	UGG
TAL Inorganics						
ALUMINIUM	14.1	8770	18900	15900	14500	230000
ARSENIC	30	[9.78]	[4.59]	[6.54]	[6.98]	0.5
BARIUM	1	80.8	149	118	113	1000
BERYLLIUM	0.2	[2.3]	[1.41]	[2.33]	[2.3]	0.1
CALCIUM	100	1790 B	3980 B	2130 B	2050 B	NSA
CHROMIUM	4	11.1	34.2	16.2	15.4	400
COBALT	3	[8.16]	[16.1]	[11]	[9.96]	0.8
COPPER	7	26.4	27.4	32.9	30.8	2900
IRON	1000	7380	33300	10000	8650	NSA
LEAD	2	LT 10.5	19.7	LT 10.5	LT 10.5	200
MAGNESIUM	50	951	6620	1440	1220	NSA
MANGANESE	0.275	134	664	347	288	8000
MERCURY	0.1	0.142	LT 0.05	LT 0.05	LT 0.05	20
NICKEL	3	18.7	22.5	21.5	20.2	1000
POTASSIUM	37.5	576	2650	1030	837	NSA
SELENIUM	40	LT 0.25	LT 0.25	0.882	LT 0.25	200
SILVER	4	LT 0.589	1.23	LT 0.589	LT 0.589	200
SODIUM	150	370 B	328 B	541 B	527 B	NSA
THALLIUM	20	LT 6.62	[14.5]	LT 6.62	LT 6.62	6
VANADIUM	0.775	21.2	64.5	33.6	30.8	560
ZINC	30.2	38.6	95.8	68	61.3	16000
Semivolatiles						
1,2-DICHLOROBENZENE	0.01	LT 0.11	LT 0.11	3.46	3.32	1000
2-METHYLNAPHTHALENE	0.3	1.15	0.134	1.53	1.47	NSA
DIBENZOFURAN	0.3	0.285	LT 0.035	LT 0.175	LT 0.175	NSA
FLUORANTHENE	0.3	0.157	LT 0.068	LT 0.34	LT 0.34	500
FLUORENE	0.3	0.09	LT 0.033	LT 0.165	LT 0.165	3200
NAPHTHALENE	0.3	0.556	0.092	1.33	1.42	1000
PHENANTHRENE	0.5	0.738	0.078	1.18	1.26	40
Semivolatile TICs						
1-METHYLNAPHTHALENE	NA	0.917 S	ND	ND	ND	NSA
2,6,10,14-TETRAMETHYLPENTADECANE	NA	1.65 S	ND	ND	4.88 S	NSA
CYCLOHEXENE OXIDE	NA	ND	0.296 SB	ND	ND	NSA
DECANE	NA	0.55 S	ND	ND	ND	NSA
HENEICOSANE	NA	0.55 S	ND	ND	ND	NSA
HEPTADECANE	NA	0.917 S	ND	ND	ND	NSA

Table 5–3 (Cont'd)

SITE ID		31SL1	31SL2	31SL3	31SL3	
FIELD ID		RVFS*27	RVFS*28	RVFS*114	RVFS*115	
S. DATE		25–feb–92	25–feb–92	10–mar–92	10–mar–92	
DEPTH (ft)		1.0	1.0	1.0	1.0	
MATRIX	PQLs	CSE	CSE	CSE	CSE	HBN
UNITS	UGG	UGG	UGG	UGG	UGG	UGG
Semivolatile TICs						
HEXADECANOIC ACID, BUTYL ESTER	NA	ND	ND	7.61 S	2.44 S	NSA
OCTADECANOIC ACID, BUTYL ESTER	NA	ND	ND	5.08 S	ND	NSA
PENTACOSANE	NA	ND	ND	ND	2.44 S	NSA
TRIDECANE	NA	ND	ND	ND	ND	NSA
TOTAL UNKNOWN TICs	NA	(13)10.8	(1)1.19	ND	(5)383	NSA

Footnotes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CSE = Chemical sediment.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

ND = Analyte was not detected.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

S = Results are based on an internal standard; flag is used for TICs detected in library scans.

TAL = Target Analyte List.

TICs = Tentatively identified compounds that were detected in the GC/MS library scans.

UGG = Micrograms per gram.

( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

criterion. However, arsenic and cobalt are not considered a concern because the levels were less than or slightly greater than the soil background criteria (Tables 4-12, 4-13, and 4-14) and represent concentrations expected to be in native soil. Beryllium was detected at levels nearly three times the background criterion. However, beryllium has a low solubility and is expected to be adsorbed onto clay mineral surfaces at a low pH and to be complexed into insoluble compounds at high pH. In most natural environments, beryllium is likely to be sorbed or precipitated, rather than dissolved and is not expected to impact surface water, groundwater or underlying soil. Thallium is not expected to be a concern because of its limited occurrence at the site. Additionally, thallium is relatively immobile in the environment and is not expected to impact surface water, groundwater or underlying soil. Several other metals such as aluminum, chromium, mercury, selenium and vanadium were detected at concentrations greater than the soil background criteria and likely represent concentrated metals resulting from disposal operations. However, these metals are not considered a concern because the levels were below HBN criteria.

Several SVOCs and SVOC TICs were detected in the three sludge samples. Most of the detected SVOCs are PAHs and other saturated hydrocarbons associated with petroleum products such as commercial coal tar, gasoline, solvents, power plant emissions and coal ash and cinders. Although several known and unknown SVOCs were detected, these organic compounds are not considered a concern because the concentrations generally are several orders of magnitude less than applicable HBNs. Many of these organic constituents readily adsorb onto particulate matter, especially in the presence of soil organic material and are not expected to impact deeper soil or groundwater at the site. However, these constituents may be available for transport if brought into solution by the chemical action of solvents.

5.2.4 Summary and Recommendations

Four metals--arsenic, beryllium, cobalt, and thallium-- were detected above HBNs in at least one sample collected of SWMU 31 waste. Arsenic and cobalt concentrations were similar to background soil concentrations and should not be considered as indicative of site contamination. Chemical characteristics of beryllium and thallium suggest that these metals are not mobile in the environment and migration out of the ponds may not be occurring. Other metals were detected at concentrations above background but below HBNs. No SVOCs were detected above their respective HBNs.

A VI is recommended for SWMU 31 to determine if metals are migrating from the ponds at significant concentrations. Since at least one HBN exceedance occurred in waste from each pond, a groundwater sample should be collected downgradient from each pond and analyzed for TAL metals. Two upgradient wells should also be installed and groundwater samples collected for comparison purposes.

5.3 INCINERATOR SCRUBBER WASTEWATER SLUDGE AT SWMU 39

5.3.1 Background and Environmental Setting

5.3.1.1 SWMU 39 History. This unit is located in the north-central section of the Horseshoe Area. It is located adjacent to and associated with the Hazardous Waste Incinerator (SWMU 14).

SWMU 39 (Figure 5-6) consists of a concrete-lined aeration pond and two unlined earthen ponds. The aeration pond serves as a cooling pond for incinerator scrubber and cooling water, which has been described as either contact or noncontact cooling water. The gas cooler uses water to cool the exhaust gas from the afterburner to 160° F. The scrubber system is designed to cool the exhaust gases to 140° F. The wastewater from the cooler and scrubber is pumped to the spray pond, with the supernatant recycled and reused in the cooler and scrubber. According to a facility representative, caustic is periodically added to the water to neutralize it, and the water is pumped to the Biological Treatment Plant (SWMU 10). Sludges have reportedly never been removed from the pond for disposal. During spray aeration, water is usually windblown from the pond to settle onto the surrounding ground surface. Therefore, there is the potential for contamination of surface soils by the wastewaters.

The settling ponds are excavated an estimated 6 to 8 feet into the natural grade. These ponds receive overflow from the aeration pond, though overflow is reportedly rare. Both are evaporation ponds, with no outlet from either pond.

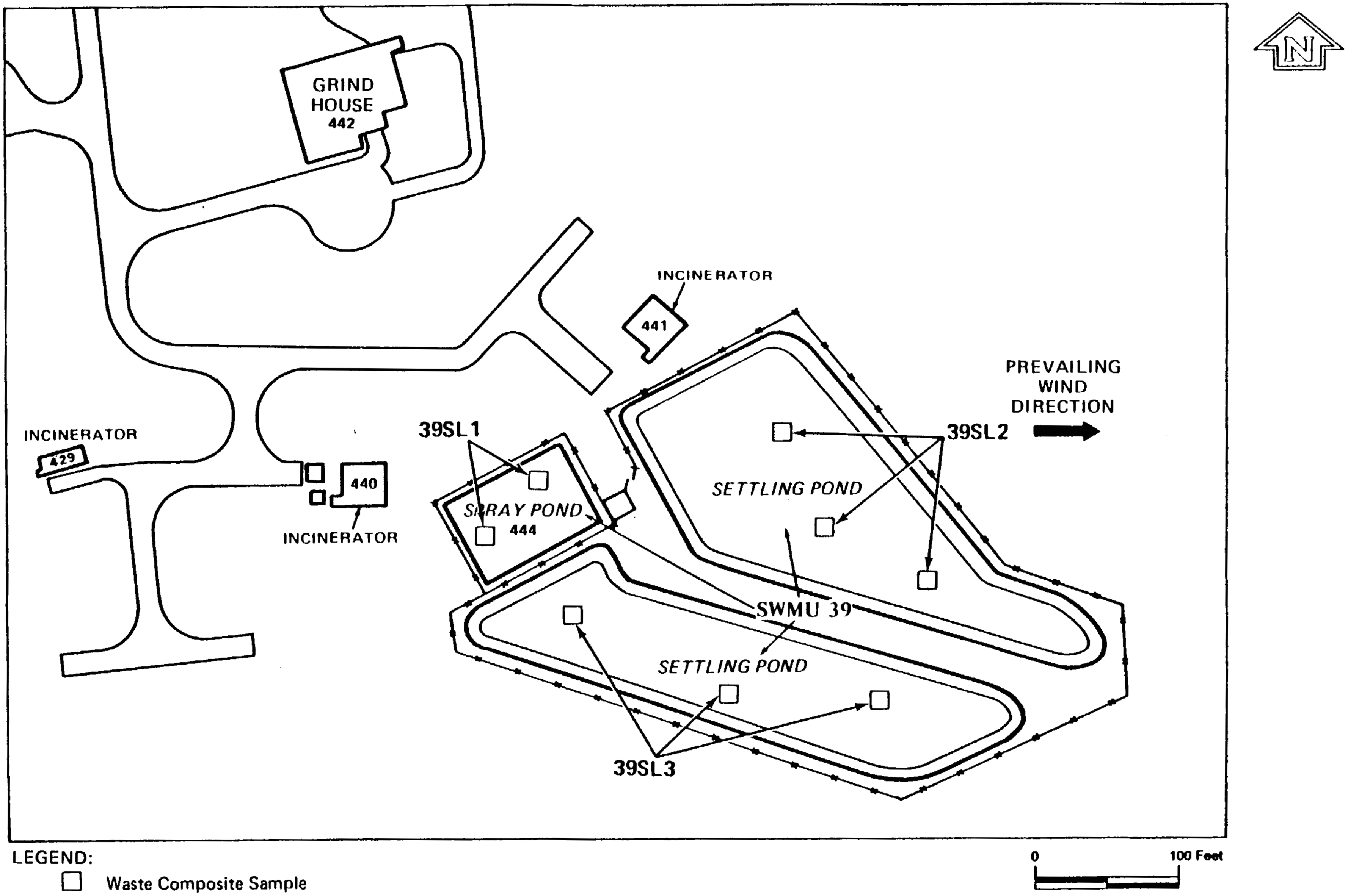


FIGURE 5-6
WASTE CHARACTERIZATION SAMPLE LOCATIONS
SWMU 39 – INCINERATOR WASTEWATER PONDS
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

5.3.1.2 Background and Environmental Setting. SWMU 39 is located on the edge of a nearly level terrace adjacent to the New River at an approximate elevation of 1,700 feet above msl. No site-specific subsurface investigations have been performed at SWMU 39, but the subsurface conditions can be inferred from similar areas along the New River. Approximately 20 to 30 feet of unconsolidated alluvial sediment--mostly sand, clay, and silt--can be expected. Occasional seams of gravel or cobbles (river jack) would also be expected. Bedrock would likely consist of fractured limestone/dolostone of the Elbrook Formation. The water table should be encountered at an elevation similar to the nearby New River. If the water table is within the bedrock, the aquifer would be karstic with high velocity though solution features and fractures. Groundwater flow direction below SWMU 39 would be north toward the New River.

5.3.2 Sample and Analyses Program

To address the potential for groundwater contamination in the vicinity of the ponds, waste characterization was performed on sludge samples collected from the ponds. Two sludge samples were collected from the aeration pond, and three samples were collected from each of the settling ponds. Sample depths were 0 to 1 foot below the water/sludge interface. The two or three samples from each pond were composited, resulting in a total of three sludge samples (39SL1, 39SL2, and 39SL3) submitted for analysis. These samples were analyzed for metals, explosives, and SVOCs as indicated in Table 5-4.

5.3.3 Comparison to Health Based Numbers

The waste characterization investigation included the collection of three composite sediment samples, one each from the spray pond and two settling ponds at SWMU 39. As presented in Table 5-4 the results of the chemical analyses indicated that concentrations of antimony, arsenic, barium, beryllium, cobalt, copper, lead and thallium in one or more sediment samples exceeded the HBN criteria. Concentrations of antimony, arsenic and thallium were greatest in the concrete spray field sample (i.e., 39SL1) and the levels exceeded the background criteria by factors ranging from four for arsenic to greater than 10 for antimony and thallium. These elements are not highly mobile in the environment

Table 5-4
Summary of Analytical Data For Sediment Samples Collected At SWMU 39
Radford Army Ammunition Plant, Virginia

SITE ID		39SL1	39SL2	39SL3	
FIELD ID		RVFS*37	RVFS*38	RVFS*39	
S. DATE		25-feb-92	25-feb-92	25-feb-92	
DEPTH (ft)		1.0	1.0	1.0	
MATRIX	PQLs	CSE	CSE	CSE	HBN
UNITS	UGG	UGG	UGG	UGG	UGG
TAL Inorganics					
ALUMINIUM	14.1	19400	17500	22800	230000
ANTIMONY	20	[105]	LT 7.14	LT 7.14	30
ARSENIC	30	[36]	[2.95]	[2.4]	0.5
BARIUM	1	[1200]	429	131	1000
BERYLLIUM	0.2	LT 0.5	[1]	[1.16]	0.1
CALCIUM	100	3900 B	687 B	24300	NSA
CHROMIUM	4	248	206	38.8	400
COBALT	3	[8.45]	[8.22]	[14.8]	0.8
COPPER	7	[57000]	403	21.1	2900
IRON	1000	29300	26600	33600	NSA
LEAD	2	[97000]	[21000]	33.5	200
MAGNESIUM	50	2990	2690	13700	NSA
MANGANESE	0.275	339	147	617	8000
NICKEL	3	66.6	57.2	20.5	1000
POTASSIUM	37.5	2890	1420	2650	NSA
SILVER	4	7.51	0.934	1.27	200
SODIUM	150	877 B	203 B	245 B	NSA
THALLIUM	20	[85.6]	[28]	[32.3]	6
VANADIUM	0.775	28.1	54	68	560
ZINC	30.2	356	145	74.7	16000
Explosives	NA	None Detected	None Detected	None Detected	NSA
Semivolatiles					
BIS(2-ETHYLHEXYL) PHTHALATE	0.3	29.8	LT 0.62	LT 0.62	50
BUTYLBENZYL PHTHALATE	0.3	18.1	LT 0.17	LT 0.17	1000
DI-N-BUTYL PHTHALATE	0.3	9.3	1.62	LT 0.061	1000
FLUORANTHENE	0.3	LT 0.68	0.142	LT 0.068	500
PHENANTHRENE	0.5	5.98	0.143	LT 0.033	40
PYRENE	0.3	10.3	0.254	LT 0.033	1000
Semivolatile TICs					
2,6,10,14-TETRAMETHYLPENTADECANE	NA	58 S	1.14 S	0.517 S	NSA
CYCLOHEXENE OXIDE	NA	ND	0.253 SB	ND	NSA
HENEICOSANE	NA	58 S	ND	ND	NSA
HEPTADECANE	NA	87 S	ND	ND	NSA
HEXADECANE	NA	58 S	ND	ND	NSA

Table 5-4 (Cont'd)

SITE ID		39SL1	39SL2	39SL3	
FIELD ID		RVFS*37	RVFS*38	RVFS*39	
S. DATE		25-feb-92	25-feb-92	25-feb-92	
DEPTH (ft)		1.0	1.0	1.0	
MATRIX	PQLs	CSE	CSE	CSE	HBN
UNITS	UGG	UGG	UGG	UGG	UGG
Semivolatile TICs					
TETRADECANE	NA	17.4 S	ND	ND	NSA
TOTAL UNKNOWN TICs	NA	(17)1723	(4)380	(2)52.2	NSA

Footnotes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CSE = Chemical sediment.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

ND = Analyte was not detected.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TAL = Target Analyte List.

TICs = Tentatively identified compounds that were detected in the GC/MS library scans.

UGG = Micrograms per gram.

( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

and are not expected to impact surface water, groundwater or the underlying soil at the present concentrations. Copper and lead in the spray field sample and lead in the southern settling pond sample (39SL2) may be a concern. Copper, which was detected in the spray field sample at nearly 20 times the HBN criterion (5.7 percent of sample by weight), is among the more mobile metals in the environment and can be brought into solution through reactions with organic acids or complexing organic compounds. Although lead has a strong affinity to adsorb to inorganic solids and organic materials, the relatively high concentrations reported in the spray field (9.7 percent by weight) and northern settling pond (2.1 percent by weight) samples may be a concern to groundwater, particularly in the presence of infiltrating acidic wastewater or precipitation. Several other metals such as aluminum, chromium, nickel, silver, sodium and vanadium were detected at concentrations greater than the soil background criteria and likely represent concentrated metals resulting from disposal operations; however, the concentrations of these metals were below HBN criteria.

No explosives were detected in any sediment sample. Several SVOCs and SVOC TICs were detected but were limited mainly to samples obtained from the spray field and northern settling ponds. Most of the detected SVOCs are PAHs and other saturated hydrocarbons which are associated with petroleum products such as commercial coal tar, gasoline, solvents, power plant emissions and coal ash and cinders. Although several known and unknown SVOCs were detected, the concentrations of these organic compounds generally are several orders of magnitude less than applicable HBNs. Many of these organic constituents readily adsorb onto particulate matter, especially in the presence of soil organics, and are not expected to impact deeper soil or groundwater at the site. However, these constituents may be available for transport if brought into solution by the chemical action of solvents.

5.3.4 Summary and Recommendations

Eight metals--antimony, arsenic, barium, beryllium, cobalt, copper, lead, and thallium--were detected above HBNs in at least one sample collected of SWMU 39 waste. The most impacted sample was from the spray pond, but each pond sample had at least four metals which had concentrations in excess of HBNs. Lead and copper are present at such high concentrations in the spray pond (9.7 percent lead, 5.7 percent copper) and the northern settling pond (2.1 percent lead) that the absorption properties which can normally be expected to keep them immobile may be ineffective. No explosives were detected. Six SVOCs and several SVOC TICs were detected, but at concentrations below HBNs.

A VI is recommended for SWMU 39 to determine if metals are migrating from the ponds at significant concentrations. Since at least four metals exceeded HBNs in each pond, a groundwater monitoring network encompassing the area is recommended. Interim measures to remove the soil from the unlined ponds is also recommended since the high concentrations of some detected metals are likely to cause the sediment to fail TCLP criteria. Confirmatory TCLP analyses on the pond sediments are also recommended. Section 11.0 presents a VI analysis of soil samples collected in an area next to the spray pond which is impacted by wind blown spray water.

5.4 SUMMARY OF RECOMMENDED ACTIONS

Three waste types were characterized at RAAP and an evaluation was made on the potential of each waste type to be hazardous based on a comparison of the concentrations of various analytes in the waste to HBNs and background concentrations. The following recommendations present a summary of the evaluation for each waste type.

5.4.1 Calcium Sulfate

No analyte was detected at a concentration exceeding HBNs as presented in the RCRA Permit. Based on this finding, calcium sulfate should not be considered a potential hazardous material and no further action is necessary at the various calcium sulfate disposal areas.

5.4.2 Coal Ash

This waste, being deposited at SWMU 31, has concentrations of four metals above HBNs. Because this waste is deposited in unlined ponds with extensive infiltration of contact water, a VI is recommended for the purpose of evaluating the potential impact this waste may have on groundwater.

5.4.3 Incinerator Scrubber Wastewater Sludge

This waste, being deposited at SWMU 39, has concentrations of eight metals above HBNs. Two of the three ponds are unlined and infiltration of impacted water will occur. Interim measures to remove the sediment is recommended with TCLP analyses for metals performed in order to confirm the probably characteristic toxicity. A VI is recommended for the purpose of evaluating the potential impact to the groundwater.

6.0 VERIFICATION INVESTIGATION OF SWMU 6, ACIDIC WASTEWATER LAGOON

6.1 SWMU 6 BACKGROUND AND INVESTIGATION PROGRAM

6.1.1 SWMU History

The Acidic Wastewater Lagoon (SWMU 6) was an unlined surface impoundment located approximately 2,000 feet northwest of the Administration Area (Figure 6-1). The lagoon, described in previous investigation reports as "tear-dropped" or "triangular" in shape, was approximately 80 feet long by 30 feet wide at its widest point. From 1974 to 1980, the lagoon received overflows and rinse waters from an acid storage tank area in the C-Line NC manufacturing area. During its active life, SWMU 6 received wastewaters that typically exhibited the characteristic of a corrosive liquid (D002). There were no overflow controls at the lagoon.

Between 1980 and 1987, the C-Line NC manufacturing area was shut down and no wastewaters were introduced to the lagoon during this period. In 1987, the lagoon was filled with soil and replaced by a holding tank, from which water flows to the C-Line Waste Acid Treatment Plant, building 420-2. No RCRA closure activities have occurred at SWMU 6 (USEPA, 1987).

6.1.2 Previous Investigations

In 1981, four monitoring wells (MW13, MW14, MW15, and MW16) were installed at the unit as part of an Army Pollution Abatement Study at SWMUs 4, 5, 6, and 7 (USAEHA, 1981). Well locations are shown in Figure 6-1. Three of these wells (MW14, MW15, and MW16) could not be sampled after installation, because no groundwater was present after well development. Sampling of MW13 indicated detectable groundwater concentrations of sulfate, sodium, manganese, zinc, nitrate (as N), and total dissolved solids (TDS). The high conductivity of the sample from MW13 indicated potential groundwater contamination. Later sampling of MW14 and MW15 indicated the presence of acetone at concentrations of 7 and 27 ug/L respectively (BCM, 1984). However, acetone is a typical laboratory cleaning agent. The groundwater table apparently rose to intersect the well

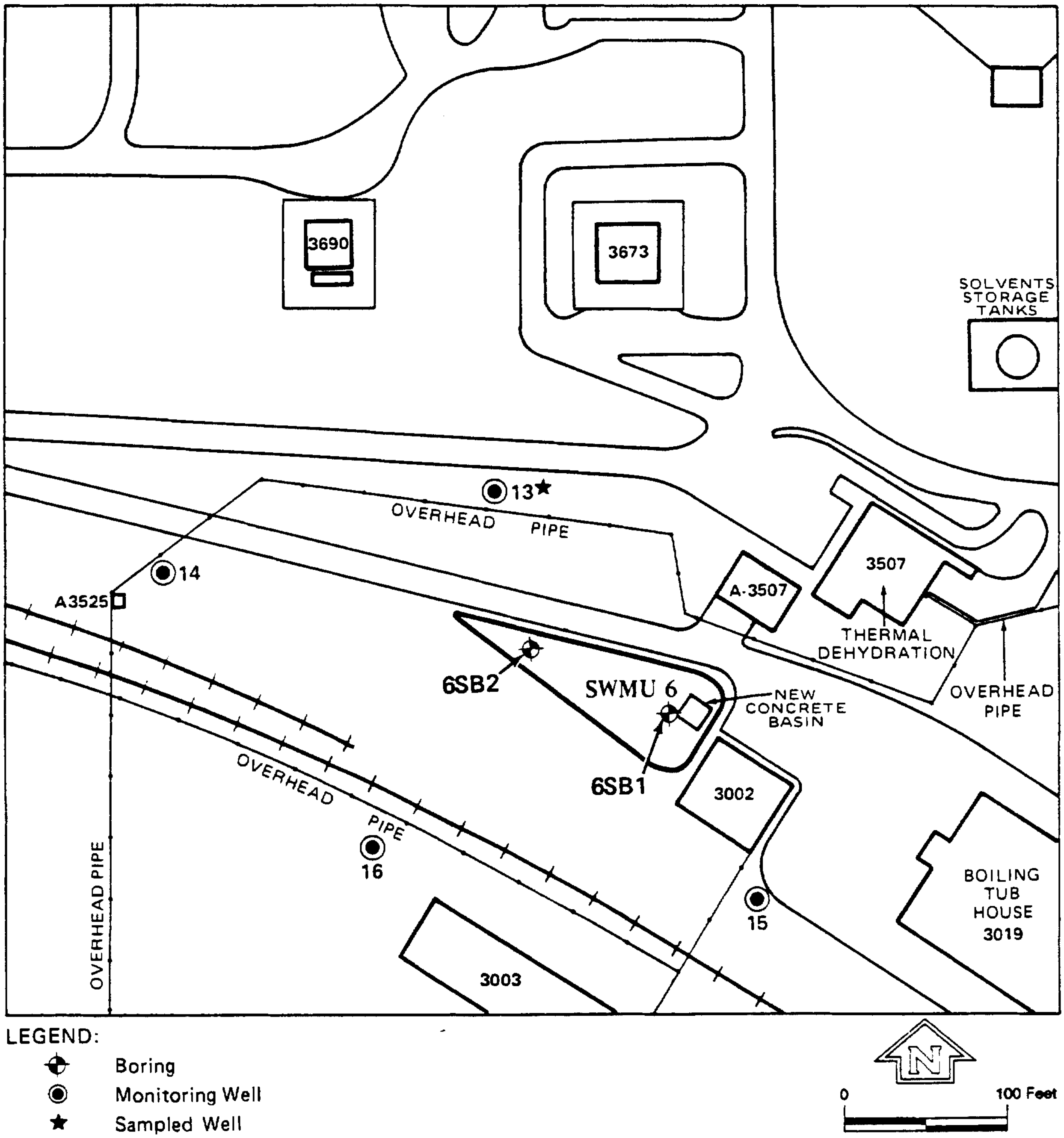


FIGURE 6-1
LOCATION MAP
SWMU 6 – ACIDIC WASTEWATER LAGOON
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

screens of MW14 and MW15. Well MW16 was terminated at a very shallow depth and may have been installed permanently above the unconfined water table.

Soil samples collected at the lagoon showed trace concentrations of nitrocellulose in three of six samples (USEPA, 1987), indicating that surface water runoff in the area may have contained NC.

6.1.3 VI Program

Sampling was conducted at SWMU 6 to determine whether soil contamination exists from acidic wastewater that was formerly discharged to the lagoon. Two boreholes (6SB1 and 6SB2) were drilled at this SWMU (Figure 6-1). Boring 6SB1 was drilled to a depth of 21.0 feet in what was thought to likely be the deepest part of the lagoon, which would have contained wastewater over the longest period. No apparent zone of contamination was observed. Two samples were collected from this boring for chemical analysis at depths of 18.0 feet and 20.5 feet and were analyzed for metals and pH.

Boring 6SB2 was drilled to a depth of 22.9 feet in what was thought to be the shallower section of the lagoon. Boring 6SB2 was, however, one foot deeper than boring 6SB1, and showed indications of sludge material from 14.0 feet to 20.0 feet. Two samples were collected from this boring for chemical analysis, 6SB2A and 6SB2B, at depths of 14.0 and 22.0 feet, respectively, and were analyzed for metals and pH.

There are currently four existing wells at SWMU 6 that were scheduled to be sampled. Well 13 was the only well that contained water. A groundwater sample was collected from this well and analyzed for metals, pH, TOC, and TOX. Wells 14, 15, and 16 were dry and could not be sampled.

No new monitoring wells were installed at SWMU 6 due to the karst terrain and the uncertainty that wells would actually intercept groundwater flowing beneath the former lagoon area. The suspected sinkhole occupied by the lagoon makes the investigation of groundwater extremely difficult. Installation of additional wells at this location was not considered to be appropriate.

6.2 ENVIRONMENTAL SETTING

6.2.1 Topography

SWMU 6 is a flat level area, approximately 1,800 feet msl, located between two upland ridges. To the north the ridge rises approximately six feet; there are asphalt roads and buildings located on this ridge. The ridge to the south rises approximately 10 feet, where railroad tracks and an asphalt road are present. SWMU 6 is located in the middle of the industrial area where buildings, overhead pipes, railroad tracks, and asphalt roads are numerous. The lagoon was completely filled, and the area is now level with adjacent areas and covered with grass.

6.2.2 Geology and Soils

SWMU 6 is suspected to occupy a collapsed sinkhole. Previous investigations in SWMU 6 conducted in 1981 encountered subsurface cavities during the drilling and installation of four monitoring wells. Also, 300 pounds of filter sand was reportedly lost into a subsurface cavity during the grouting of one well (USAEHA, 1981).

A geophysical survey investigation conducted at SWMU 6 in 1984 indicated the presence of a soil horizon at 17.6 feet below the ground surface. This horizon was interpreted as a lithologic change in the overburden. A break in the profile was interpreted as a possible collapsed sinkhole (USACE, 1984).

The suspected sinkhole is also supported by a reported history of collapses and subsidences of roads and foundations near the former lagoon.

Generally, the subsurface conditions encountered in the vicinity of SWMU 6 consist of a reddish-brown silty clay extending in each boring to bedrock or borehole termination. Depth to Elbrook Formation bedrock ranged from 21 feet to greater than 45 feet. Two additional borings (6SB1 and 6SB2) were performed in the depression within SWMU 6 for the VI program. These borings were extended to approximately 21 feet below the ground surface, encountering a reddish-brown silty clay to the depths explored.

6.2.3 Groundwater Conditions

In 1981, four monitoring wells (MW13, MW14, MW15, and MW16) were installed at the unit as part of an Army Pollution Abatement Study at SWMUs 4, 5, 6, and 7 (USAEHA, 1981). Well locations are shown in Figure 6-1. Three of these wells (MW14, MW15, and MW16) could not be sampled after installation, because no groundwater was present after well development.

During development of these wells, all fluid was lost due to subsurface cavities. Periodic groundwater level measurements taken during the VI field program indicate that monitoring wells MW14, MW15, and MW16 continue to be dry. Monitoring well MW13 generally had 3 to 4 feet of water (approximate elevation of 1,760 feet msl) in the well screen during the VI.

Groundwater has occasionally been present in monitoring wells MW14 and MW15 and may be the result of perched water within the overburden clay layer rather than unconfined water table conditions. Groundwater seepage in the assumed sinkhole would probably result in rapid groundwater flow through fractures and cavities away from SWMU 6 toward the New River but the actual path and direction of the flow cannot be easily determined due to the karst nature of the bedrock.

6.2.4 Surface Water Drainage

SWMU 6 is a flat level area located between two upland ridges. Based on topography, surface water runoff from these upland ridges on the northern and southern sides of the SWMU is expected to flow into the SWMU area. The surface runoff within SWMU 6 likely flows into storm sewer catch basins that are located on the northeast and southeast ends of the SWMU.

6.3 CONTAMINATION ASSESSMENT

The VI field program at SWMU 6 included the collection of four soil samples from two soil borings in the Acid Wastewater Lagoon and one groundwater sample near the former lagoon at MW13. One sample from each boring was collected at a depth ranging from 14 to 18 feet in soil suspected to be contaminated by past waste disposal activities. A second sample was collected from presumably clean soil below the suspected contaminated zone at a depth of 20 to 22 feet.

6.3.1 Soil

In total, 19 metals were detected in the four soil samples collected from the former wastewater lagoon. These samples were collected from within the SWMU and can be compared to HBNs as well as PQLs for site evaluation. As shown in Table 6-1, soil sample concentrations of arsenic and cobalt exceeded the HBN criteria. However, these elements are not a concern because the levels were less than the soil background criteria and represent concentrations expected to be in native alluvial soil. Arsenic was also detected at less than the PQL. Concentrations of other metals, such as chromium and vanadium in all samples, were greater than the alluvial soil background criteria presented in Section 4.0, but the detected concentrations are below applicable HBNs. Thallium in one sample exceeded the soil HBN criterion in the duplicate analysis of 6SB1, but the concentration was less than the PQL. However, thallium is not considered to be a concern because it was detected in only one sample. Thallium also is a relatively immobile constituent in the soil and is not expected to impact soil or groundwater below the site. No other metal concentration exceeded HBN criteria.

6.3.2 Groundwater

Six metals were detected in one groundwater sample collected from MW13. As shown in Table 6-2, metal concentrations were less than HBN criteria and are not considered a concern at the site. However, chromium was detected in the groundwater sample collected from MW13 but at a concentration below the PQL as well as below the HBN. The presence of chromium in the MW13 sample suggests that groundwater near the site may have been impacted by chromium released into the environment in the SWMU 6 area. TOC and TOX concentrations for MW13 were 1,400 ug/l and 53.7 ug/l respectively.

Table 6-1
Summary of Analytical Data For Soil Samples Collected At SWMU 6
Radford Army Ammunition Plant, Virginia

SITE ID		6SB1	6SB1	6SB1	6SB2	6SB2	
FIELD ID		RVFS*12	RVFS*16	RVFS*13	RVFS*14	RVFS*15	
S. DATE		05-nov-91	05-nov-91	05-nov-91	04-nov-91	04-nov-91	
DEPTH (ft)		18.0	18.0	20.5	14.0	22.0	
MATRIX	PQLs	CSO	CSO	CSO	CSO	CSO	HBN
UNITS	UGG	UGG	UGG	UGG	UGG	UGG	UGG
TAL Inorganics							
ALUMINIUM	14.1	9830	31300	12800	29400	10800	230000
ANTIMONY	20	LT 7.14	12.3	LT 7.14	LT 7.14	LT 7.14	30
ARSENIC	30	[3.14 B]	[2.57 B]	[4.14]	[3.02 B]	[2.78 B]	0.5
BARIUM	1	99.4	85	104	66.7	97.6	1000
CALCIUM	100	355 B	353 B	959 B	5170 B	824 B	NSA
CHROMIUM	4	25.5 B	30.7	43.3	33.1	42.4	400
COBALT	3	[8.83]	[18.5]	[15.8]	[11.3]	[14.3]	0.8
COPPER	7	6.21 B	17.4	11.4	14.5	9.16	2900
IRON	1000	20600	40000	26300	33300	29100	NSA
LEAD	2	19.4	29.6	23.8	18.6	23.8	200
MAGNESIUM	50	621 B	2470 B	2160 B	4900 B	1010 B	NSA
MANGANESE	0.275	827	300	1340	303	1020	8000
NICKEL	3	6.28	16.6	11.7	12.6	7.34	1000
POTASSIUM	37.5	551 B	2200	699 B	1500 B	538 B	NSA
SILVER	4	LT 0.589	1.11	LT 0.589	LT 0.589	LT 0.589	200
SODIUM	150	173 B	184 B	243 B	189 B	166 B	NSA
THALLIUM	20	LT 6.62	[14.9]	LT 6.62	LT 6.62	LT 6.62	6
VANADIUM	0.775	42.2	88	55.8	71.4	46.9	560
ZINC	30.2	36.1 B	61.9	36 B	49	40.2 B	16000
Other							
pH	NA	6.72	6.56	6.39	7.25	6.64	NSA

Footnotes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CSO = Chemical soil.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TAL = Target Analyte List.

UGG = Micrograms per gram.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

Table 6–2
Summary of Analytical Data For Groundwater Samples Collected At SWMU 6
Radford Army Ammunition Plant, Virginia

SITE ID		MW13	
FIELD ID		RDWC*54	
S. DATE		19–feb–92	
DEPTH (ft)		38.0	
MATRIX	PQLs	CGW	HBN
UNITS	UGL	UGL	UGL
TAL Inorganics			
BARIUM	20	35.6	1000
CALCIUM	500	39500	NSA
CHROMIUM	10	9.31	50
MAGNESIUM	500	17900	NSA
POTASSIUM	375	3460	NSA
SODIUM	500	3290	NSA
Other			
TOTAL ORGANIC CARBON	1000	1400	NSA
TOTAL ORGANIC HALOGENS	1	53.7	NSA
pH	NA	6.87	NSA

Footnotes:

CGW = Chemical groundwater.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TAL = Target Analyte List.

UGL = Micrograms per liter.

6.4 CONCLUSIONS

The VI conducted at the Acidic Wastewater Lagoon (SWMU 6) consisted of the collection and chemical analysis of four soil samples (from two soil borings) and one groundwater sample. Although arsenic and cobalt were detected above HBN criteria, the concentrations are representative of levels expected to be in native alluvial soil. Thallium exceeded the soil HBN criterion in the duplicate analysis of 6SB1; however, thallium is not considered a concern because the concentration is only slightly greater than the HBN criterion and is limited to only one sample. Chromium concentrations detected in the soil samples and the groundwater sample were below the HBN criterion, but greater than the background samples, suggesting the chromium concentrations could be the result of past waste disposal practices. The waste from the lagoon has been removed, and the lagoon filled with soil and seeded, thus preventing further contamination. Since the chromium concentrations detected in the groundwater were below the PQL and no further contamination is expected to be released, the presence of chromium is not considered to be of concern at SWMU 6.

6.5 RECOMMENDED ACTION

Each of the soil samples were collected from what is considered the source area for any contamination which may have escaped into the environment. Because the source soil metals concentrations are not significantly different from background soil concentrations, or are below HBNs, there is little potential for this SWMU to be a threat to the environment in the future. Therefore, no further action is recommended for SWMU 6.

Note: This section was revised September 8, 1994 under separate cover

7.0 VERIFICATION INVESTIGATION OF SWMU 10, BIOLOGICAL TREATMENT EQUALIZATION BASIN AND SWMU 35, CALCIUM SULFATE DRYING BED

7.1 SWMU 10 AND SWMU 35 BACKGROUND AND INVESTIGATION PROGRAM

The U.S. Environmental Protection Agency (EPA) issued the Permit for Corrective Action and Incinerator Operation to RAAP in late 1989 and included SWMU 10 and SWMU 35 as sites requiring a VI. Since 1989, four environmental investigations have been performed at SWMU 10 and SWMU 35 that confirmed the presence and probable release of site related contaminants (Dames & Moore, 1991a, 1991b and 1992; Geophex, 1990). The most recent investigation (Dames & Moore, 1992) was a groundwater quality assessment for SWMU 10 performed in order to comply with Virginia Department of Waste Management interim status regulations.

An interagency agreement between EPA and the U.S. Army in March 1992 resulted in the acceptance of the permit as written in 1989. Because of the extent of investigations, the original recommendation to perform a VI included in the permit is no longer appropriate at these SWMUs. In order to adequately evaluate the potential impacts known site contamination may pose to human health or the environment, the VI has been expanded in content to be equivalent to a RCRA Facility Investigation. Section 7.2, Environmental Setting, presents a detailed description of the hydrogeology of the study area. Section 7.3, Contamination Assessment, presents a comparison of chemical data to health based numbers, and Section 7.5 presents the results of a baseline risk assessment.

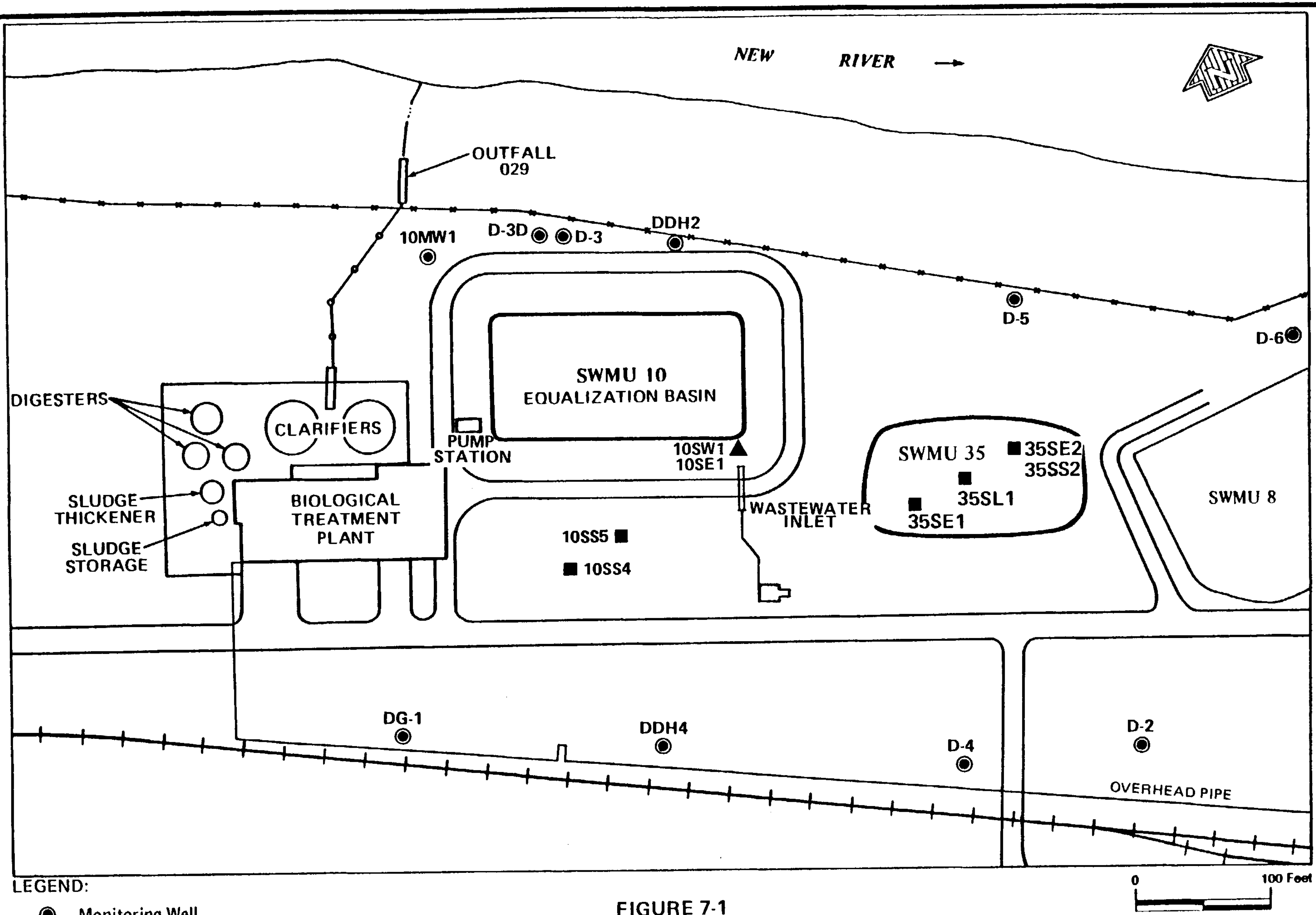
7.1.1 SWMU Histories

7.1.1.1 SWMU 10--Biological Treatment Plant Equalization Basin. This unit, located along the New River in the north-central part of the Main Manufacturing Area is the first of nine components that make up a biological wastewater treatment system at RAAP. This system treats wastewaters of widely varying characteristics, including nonacidic wastewaters from propellant manufacturing (on both a batch and continuous basis), pretreated wastewaters from nitroglycerine (NG) manufacturing and alcohol rectification, and wastes from recovery of ethyl ether (USEPA, 1987). The biological treatment system was built in 1978/1979 and became operational in 1980. Prior to 1980, these wastewaters were discharged directly to the New River.

This basin was reportedly constructed on top of a nitrocellulose (NC) fines settling lagoon (USACE, 1981). The lagoon was approximately 200 feet by 100 feet in size and surrounded by a 7-foot-high dike. The lagoon was filled with very soft, wet NC fines. According to construction plans for the equalization basin, the fines were removed prior to construction of the basin.

The Equalization Basin is approximately 160 feet wide by 255 feet long, located adjacent to the total and west of SWMU 35 (Figure 7-1). The total depth of the basin is 10.5 feet. The basin is filled with 7.5 feet of water to realize the design capacity of 1,350,000 gallons. The containment walls are constructed of concrete, and the basin is lined with a soil/cement/clay liner. The unit was expanded to its current dimensions since original construction. The basin's northern and eastern outside embankments are reinforced with rip-rap. Suspended polymeric dividers accommodate aeration/equalization and divide the basin into three compartments. According to the plant operator interviewed during the March 1990 facility visit, the basin has never overflowed. Operating procedures are such that influent flows are cut off if the basin capacity is reached.

The eastern and central compartments of the basin are each equipped with two surface aerators. The western compartment is equipped with a subsurface jet injection-type aerator. From the equalization basin, the wastewater is pumped at a constant rate to the biological treatment system. As originally designed, the biological treatment system consisted of two parallel trains of six rotating biological contactors (RBCs). The first two RBCs in each train were designed to operate anaerobically; the remaining four units were to operate aerobically. Following startup, it was discovered that the anaerobic RBCs were hindering plant performance, and they were subsequently converted to aerobic RBCs. At present, the plant is operating with 12 aerobic RBCs on-line. These units have a total surface area of 611,200 square feet. The RBCs are run as three-stage systems, with the first two RBCs in each train operated as a single stage (USEPA, 1987).



LEGEND:

- ● Monitoring Well
- -o-o- Underground Pipeline
- ■ Soil/Waste Sample
- ▲ Wastewater/Sediment Sample

FIGURE 7-1
MONITORING WELLS, BORINGS AND SAMPLING LOCATIONS
SWMU 10, EQUALIZATION BASIN AND SWMU 35, CALCIUM SULFATE DRYING BED
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Dames & Moore

From the RBC trains the wastewater flows to two circular, center-feed, peripheral weir clarifiers. Clarified effluent is discharged to the New River at NPDES Outfall No. 029.

Sludge handling consists of aerobic digestion, chemical conditioning, and belt press dewatering. The three digesters (83,000 gallons each) are maintained at about 75 percent of capacity to prevent overflows. The sludge from the digesters is a listed hazardous waste (K044, sludge from the treatment of wastewater from explosives manufacturing (USAEHA, 1980a)). Prior to February 1990, the sludge was landfilled in Fly Ash Landfill No. 2 (SWMU 29); at present, it is containerized and shipped to an off-post hazardous waste landfill.

Evidence of ground scarring and possible disposal trenches was visible on aerial photographs for the study area taken in 1971. The NC settling pond was present at the same location as the SWMU 10 Equalization Basin, and was approximately the same size. SWMU 35, as well as SWMUs 8 and 36, were also present, and in the same size and configuration as today. Ground scarring (and possible trenches) was seen in the area between the road and the railroad tracks south of SWMU 10 and SWMU 35. Two general scarred areas were visible. One area extended from the western side of the NC settling pond to the eastern side of the western SWMU 8 lagoon. The other scarred area extended from the central part of the eastern SWMU 8 lagoon to the western side of the southern SWMU 36 drying bed. RAAP personnel indicated that the area between the road and the railroad tracks was once used for trench burial of sediments removed from the ponds at SWMU 10, SWMU 35, SWMU 8, and SWMU 36. The outlines of these trenches are still visible when the area is examined. Because the trenches were in use prior to the construction of the Bio-Plant, the SWMU 10 basin sediments referred to by RAAP personnel were probably the NC settling pond sediments.

7.1.1.2 SWMU 35--Calcium Sulfate Drying Bed. SWMU 35, a Calcium Sulfate Drying Bed (northeast section), is located along the New River in the northeast section of the Main Manufacturing Area (Figure 7-1). SWMU 35 is located immediately east of SWMU 10 and west of and adjacent to SWMU 8 (Calcium Sulfate Settling Lagoons). This drying bed has been previously described as "an abandoned lagoon (mud)" (USACE, 1981). The drying bed was excavated into the natural grade and is unlined. Until approximately 1980, calcium sulfate sludge was dredged from SWMU 8 and pumped into SWMU 35 to dehydrate every 5 to 7 months. After drying, the sludge was removed for disposal. The sludge was disposed of in various locations at RAAP, as described in Section 5.1.1.

SWMU 35 is approximately 160 feet by 80 feet with approximately 8 feet of sediment remaining in the basin. RAAP reported that sediment from SWMU 10 was probably deposited in SWMU 35, most likely during the early 1980s. Because of this probable interrelation between SWMU 10 and SWMU 35, the VI for these SWMUs was combined.

7.1.2 Previous Investigations

Wells in the SWMU 10 and SWMU 35 area were sampled after installation in 1980 (USACE, 1981) and in 1984 (USATHAMA, 1984). Historically, the Virginia groundwater standard of 0.005 mg/l for zinc has been exceeded in wells D-2 and D-3. Nitrate-N in downgradient wells DDH2 and D-3 exceeded the Maximum Contaminant Level (MCL) of 10.0 mg/l at concentrations of 11.0 and 21 mg/l, respectively. Nitrate also was detected in upgradient well D-5 at 21 mg/l exceeding the MCL. Fluoride was the only other constituent that exceeded a regulatory standard. It was detected in all four wells (D-2 through D-5) in 1981, but was detected in the highest concentration in upgradient well D-2 at 4.8 mg/l, which was the only exceedance of the MCL of 4.0 mg/l. Concentrations of calcium, nitrate-N, total dissolved solids (TDS), sulfate, and zinc were apparently higher in downgradient wells. A detailed analyses of historical data was performed in the SWMU 10 Characterization Report (Dames & Moore, 1992).

In August 1990, Geophex, Ltd. performed a hydrogeological and environmental investigation of the Bio-Plant Equalization Basin (Geophex, 1990). The field program consisted of the installation of two monitoring wells, DG-1 and D-3D (see Figure 7-1). Monitoring well DG-1 was installed upgradient of the southwestern corner of the equalization basin. Well D-3D was installed into the bedrock at a depth of approximately 65 feet. The purpose of this well was to investigate the groundwater quality of the deeper bedrock section of the unconfined aquifer. Pump tests also were performed to calculate the horizontal and vertical groundwater flow velocities.

Six groundwater samples were collected from monitoring wells -- DG-1, D-3, D-3D, D-4, DDH2, and DDH4 -- and analyzed for TCLP metals, VOCs (SW846 Method 8240), SVOCs (SW846 Method 8270) and various reactivity parameters.

The only constituent that was detected in any of the groundwater samples was DNBP at a concentration of 28 ug/l in downgradient well D-3. Note that this constituent was not detected in the nearby deeper aquifer well D-3D. The detected concentration of DNBP was less than the HBN of 4,000 ug/l.

7.1.3 VI Program

Dames & Moore performed an environmental site investigation at the Bio-Plant in August 1990 to collect data in support of a construction project proposed to replace the existing equalization basin with two new tanks (Dames & Moore, 1991a). The environmental samples were collected to evaluate whether the Bio-Plant area soils contained hazardous constituents that may be subject to remedial actions if disturbed during construction activities. The sample results also were used to evaluate potential human health and environmental impacts to onsite workers during construction activities.

As shown in Figure 7-1, one surface water (10SW1) and one sediment/sludge sample (10SE1) were collected from inside the SWMU 10 Bio-Plant Equalization Basin as part of the site characterization program. Additionally, two near-surface soil samples (10SS4 and 10SS5) were collected from the new RBC area, approximately 100 feet south of the SWMU 10 Equalization Basin. These samples were collected because constituents in the surrounding soils may potentially impact groundwater downgradient of the basin. Likewise, soil and sediment samples from adjacent SWMU 35, the Calcium Sulfate Drying Bed, were collected because SWMU 35 is located upgradient of monitoring well locations where contamination was previously detected and may have impacted groundwater downgradient of SWMU 10.

At two locations within the drying bed, sediment samples 35SE1 and 35SE2 were collected and homogenized from the upper 4 feet. A sample of underlying soil also was collected from one location (i.e., 35SS2). A second soil sample underlying the sediment was to be collected and analyzed from SWMU 35. Because of the large amount of water perched in the bed sediment, it was not possible to collect a discrete and undisturbed (i.e., a sample unaffected by and free of overlying sludge and liquid) soil sample at this location.

As part of the Bio-Plant investigation, three groundwater samples were collected from wells D-3, DDH2, and DDH4 associated with the Bio-Plant Equalization Basin. All soil, sediment, groundwater and surface water samples were analyzed for VOCs, SVOCs, metals, and explosives. In addition, soil and sediment samples were analyzed for TCLP metals.

Additional groundwater samples were collected from seven monitoring wells at the Bio-Plant Equalization Basin during the VI field program conducted in September 1991. Three upgradient monitoring wells (i.e., DG-1, DDH4, and D-4) and four downgradient wells (i.e., 10MW1, D-3D, D-3, and DDH2) were sampled during the field program (see Figure 7-1). Monitoring well 10MW1 was the only well installed by Dames & Moore during the VI. All monitoring wells, except D-3D, were completed through the unconsolidated silt/sand and gravel deposits and into the shallow unconfined aquifer at the bedrock interface. Monitoring well D-3D was installed to evaluate potential migration in the deeper limestone bedrock section of the same aquifer.

All groundwater samples collected in 1991 were analyzed by Environmental Science and Engineering (ESE) for metals (filtered and unfiltered), VOCs, SVOCs, explosives and general water quality parameters including nitrogen, chloride, sulfate, total phosphorus, and total phenols. In addition, indicator parameters such as total organic carbon, total organic halogens, pH, and specific conductance were analyzed for all samples. These indicator compounds were analyzed in quadruplicate for upgradient well DDH2 and downgradient well DDH4. These data will be used to determine statistically significant increases in constituents measured in the downgradient groundwater as compared to those detected upgradient (background).

Quality control samples were collected during the field program to evaluate sampling and decontamination activities. Two field blank samples (RAAP-1) of the water used to decontaminate the sampling equipment were collected at the time of the field efforts and analyzed for the parameters specified above. Results from these samples were compared to the results of the environmental samples to evaluate potential inadvertent contamination of samples by potable water used to rinse sampling equipment. The decontamination water was collected from the settling basin of the RAAP potable water treatment plant.

A second quality control sample consisted of a laboratory prepared trip blank of distilled water which was sent from the laboratory, handled in the field, and resubmitted to the laboratory with environmental VOC samples. This sample was analyzed for VOCs so that an evaluation could be made of the potential for inadvertent contamination of environmental samples due to shipping and handling.

An equipment blank (RBLANK) was collected to evaluate the sample equipment cleaning and decontamination activities. This sample was collected by pouring the decontamination source water from the potable water treatment plant over the sampling equipment (e.g., hand auger) after the completion of decontamination and cleaning.

7.2 ENVIRONMENTAL SETTING

7.2.1 Topography

The SWMU 10 and SWMU 35 area is relatively flat with a slight slope northward toward the New River. Surface elevations range from 1,708 feet msl near the road to 1,698 feet msl on the northern side of both basins. The walls of the Equalization Basin were constructed above natural grade with the interior extending to below the natural grade. The whole structure consists of concrete or a soil/concrete mixture. SWMU 35 is a surface depression with the level of sediment within it approximately 4 feet below natural grade. The northern rim at the basin is a little lower (1,703 feet msl) than the southern rim (1,704 feet msl). No drainage into SWMU 35 should be able to escape via surface runoff. Surface ditches are present northwest of SWMU 10 and northeast of SWMU 35, which have a decrease in elevation to less than 1,695 feet msl before leaving the site underneath the fence.

7.2.2 Geology and Soils

The geology of the SWMU 10 and SWMU 35 area has been explored for this VI through the drilling of one soil and rock boring (10MW1), and data from nine other soil and rock borings drilled in the SWMU 10 and SWMU 35 area during previous investigations (USACE, 1981; Geophex, 1990). These borings ranged from 31 feet to 64 feet in depth.

Data from these bores were used to construct four cross-sections and two groundwater elevation maps presented later in this section. As shown in Figure 7-2, four cross-sections (A-A', B-B', C-C', and D-D') were prepared to illustrate the subsurface conditions in the vicinity of the study area.

The following subsections describe the unconsolidated soil and bedrock geology of the SWMU 10 and SWMU 35 site area as revealed through the various borings performed since 1980.

7.2.2.1 Unconsolidated Soil. Investigations conducted at the study area site in 1991 confirm the general soil conditions described previously (USACE, 1981; Geophex, 1990), and allow for a more detailed understanding of subsurface conditions. Unconsolidated soil deposits, which thicken away from the river, consist of a brown clayey silt overlying a fine-to-coarse grained, micaceous, yellowish brown sand. Several feet of yellowish brown sand and gravel overlie bedrock. These alluvial-floodplain deposits vary in thickness between 14 and 30 feet. Zones of large cobbles (river jack) are present south of SWMU 10 and SWMU 35, but are not as common as found at other sites at RAAP. Silty brown clay lenses found at the land surface may represent recent deposition during flood events.

Four cross-sections were prepared to illustrate the geologic conditions in the area. Cross-section A-A' (Figure 7-3) trends generally west to east nearly parallel to the railroad tracks south of the SWMU 10 area. Cross-section B-B' (Figure 7-4) trends generally west to east nearly parallel to the fence immediately north of the SWMU 10 area. Cross-section C-C' (Figure 7-5) trends north to south across SWMU 10 and Cross-section D-D' (Figure

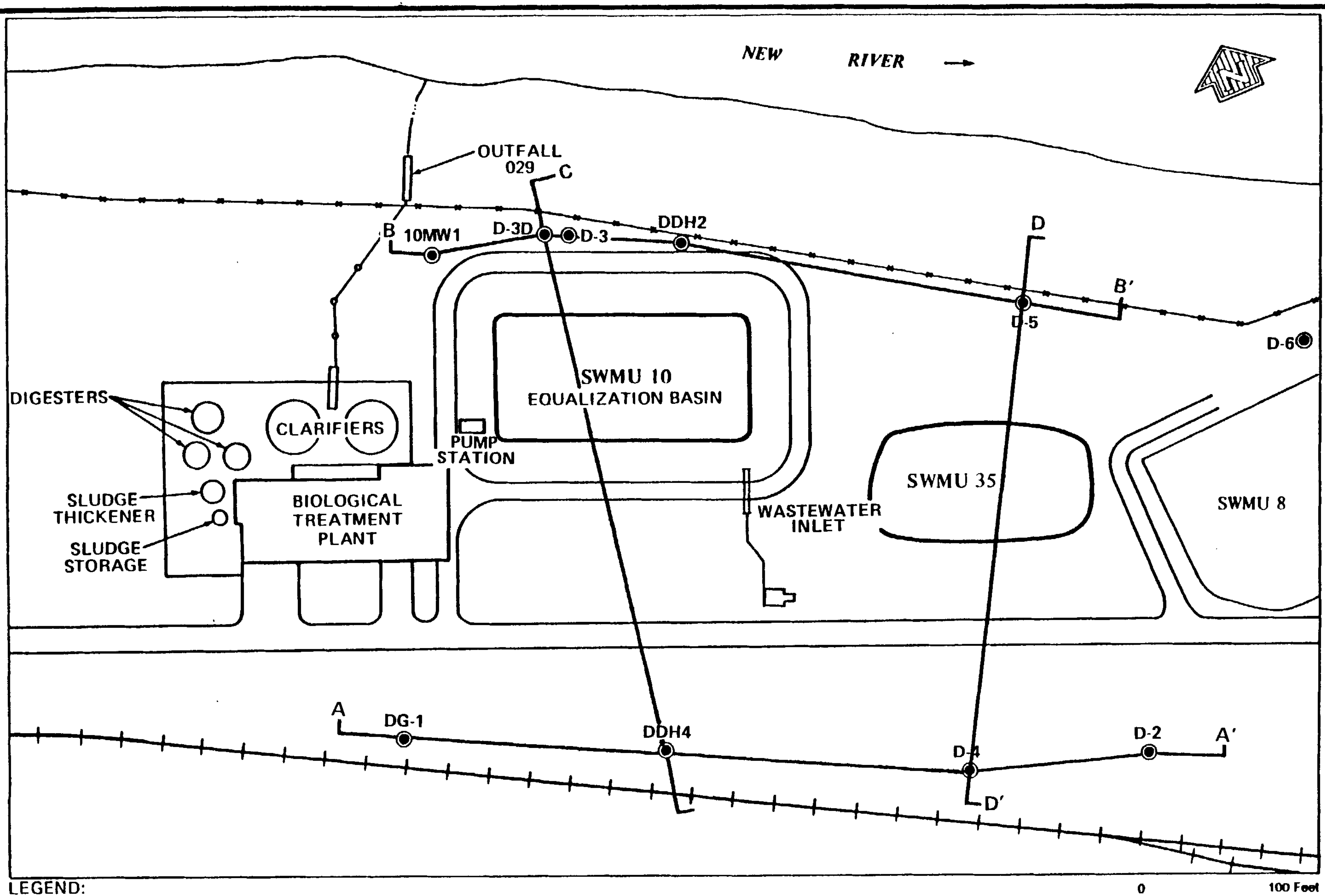


FIGURE 7-2
LOCATIONS OF HYDROGEOLOGIC CROSS-SECTIONS
SWMU 10 AND SWMU 35
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Dames & Moore

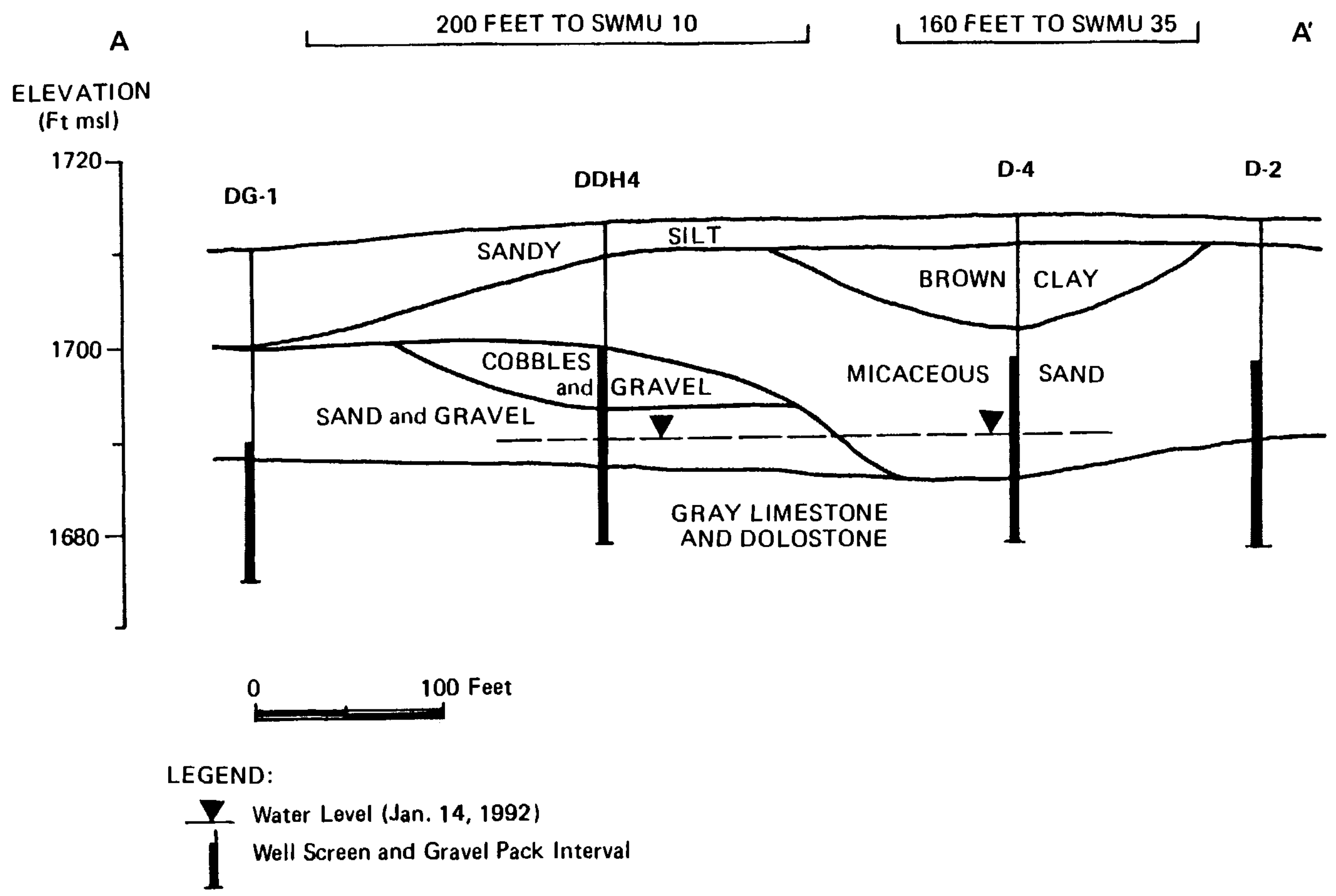


FIGURE 7-3
HYDROGEOLOGIC CROSS-SECTION A-A'
SWMU 10 AND SWMU 35
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

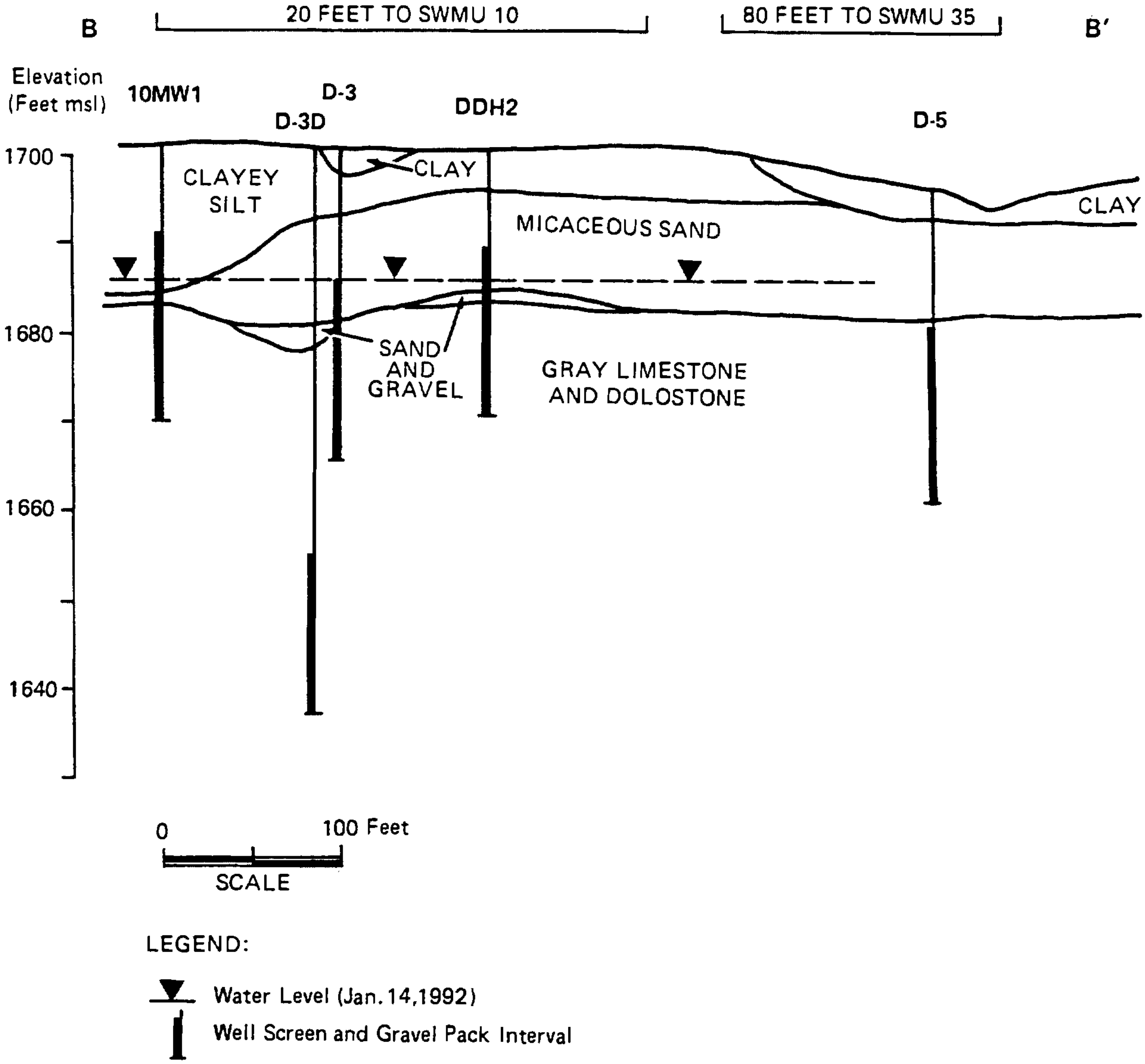


FIGURE 7-4
HYDROGEOLOGIC CROSS-SECTION B-B'
SWMU 10 AND SWMU 35
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Dames & Moore

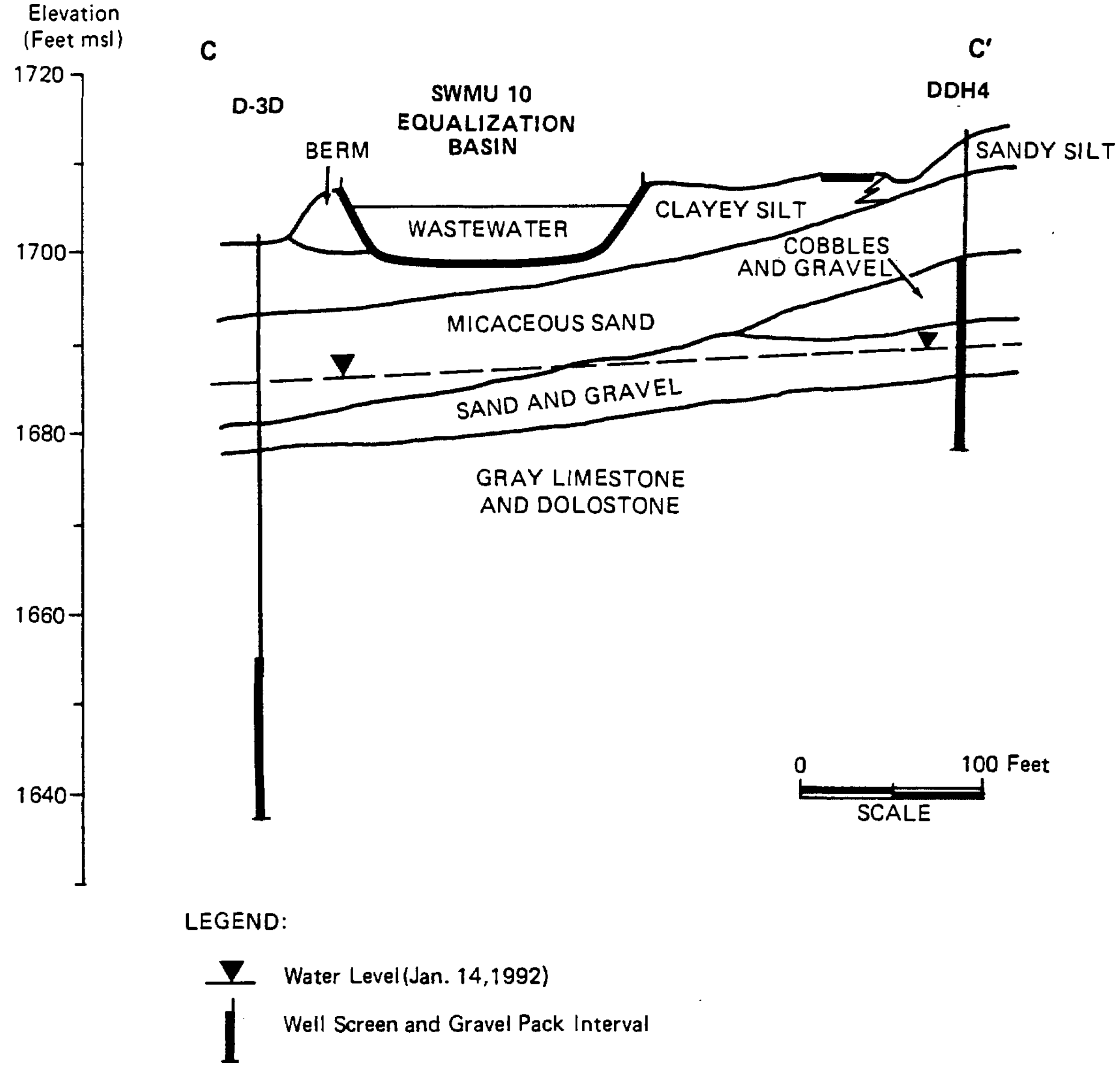


FIGURE 7-5
HYDROGEOLOGIC CROSS-SECTION C-C'
SWMU 10 AND SWMU 35
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

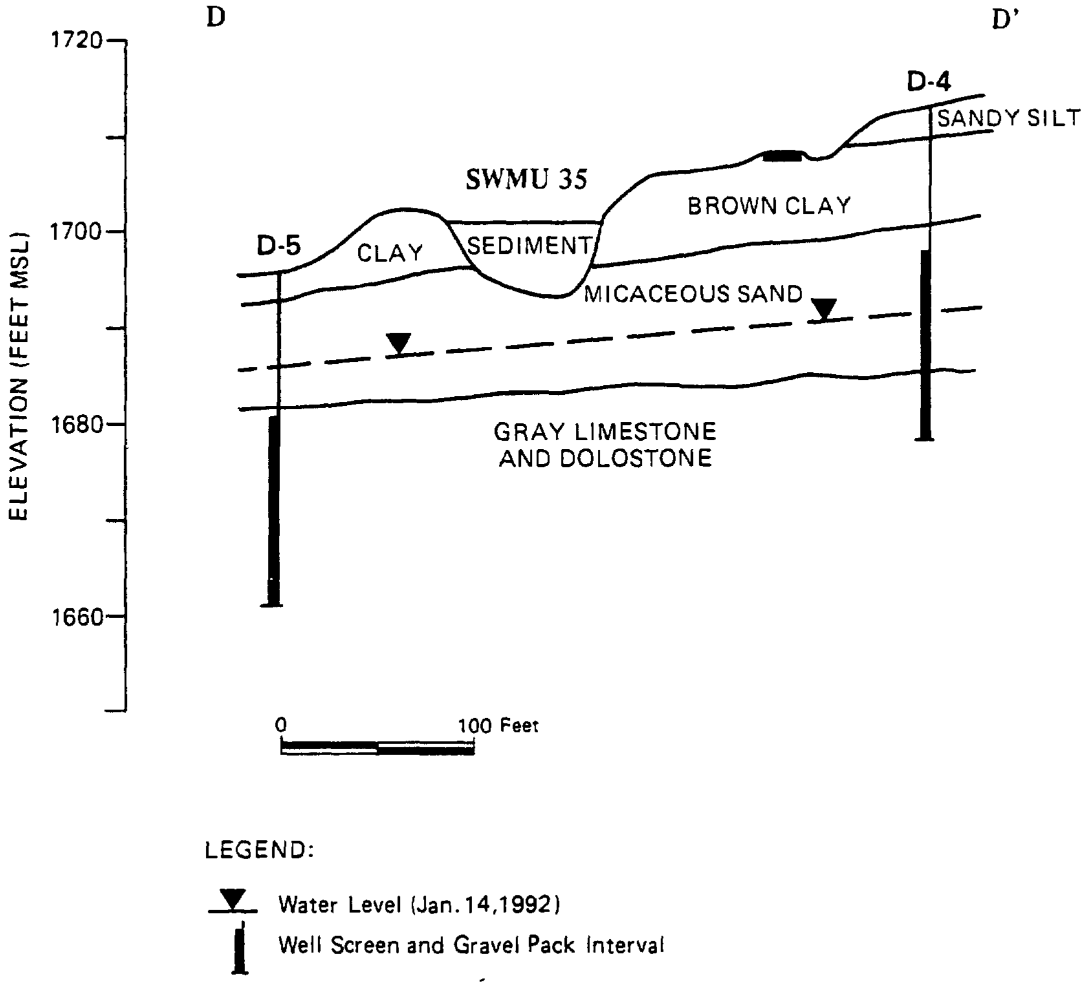


FIGURE 7-6
HYDROGEOLOGIC CROSS-SECTION D-D'
SWMU 10 AND SWMU 35
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

7-6) trends north to south across SWMU 35. These cross-sections illustrate both the lateral and vertical variability of the three distinctive layers of alluvial-plain deposits described previously.

Two soil samples were subject to physical testing of grain size (sieve) analyses, hydrometer testing, and Atterberg Limits testing. These samples were collected from the two different soil zones encountered in boring 10MW1. A sample from the clayey silt encountered was taken from a depth of 5 to 7 feet. The underlying silty (micaceous) sand was sampled from a depth of 15 to 17 feet. The laboratory data sheets are presented in Appendix E.

The soil sample collected from 5 to 7 feet was classified in the Unified Soil Classification System (USCS) as a clayey silt (ML), and the soil sample collected from 15 to 17 feet was classified in the USCS as a non-plastic silty sand (SM). The moisture content of the above samples was 21.0 and 31.5 percent, respectively. These classifications and values were consistent with the soil characteristics observed while logging the soil borings during field activities.

7.2.2.2 <u>Bedrock</u>. Underlying the unconsolidated soils in the SWMU 10 and SWMU 35 area is the gray limestone/dolostone of the Elbrook Formation. The gray limestone/dolostone is highly argillaceous. The limestone/dolostone itself is highly fractured and fragmented with calcite healed fractures and zones of filled and unfilled vugs. Up to 41 feet of the Elbrook Formation was penetrated during the 1990 boring program (Geophex, 1990).

The bedrock surface in the vicinity of SWMU 10, as revealed by the borings, slopes north to the New River at a grade of approximately 1.6 percent (Figure 7-5) from an elevation of approximately 1,688 feet msl along Cross-section A-A'. Some bedrock irregularities were noted between borings 10MW1, D-3D, and D-3 (Figure 7-4).

7.2.3 Groundwater Conditions

The hydrogeologic conditions within the unconsolidated soil were investigated through field examination of soil samples, 22 field and laboratory permeability/conductivity tests (USACE, 1981; Geophex, 1990), grain-size hydrometer analysis and Atterberg Limits tests on two soil samples, and a field rising-head (slug) test on monitoring well 10MW1. The hydrogeologic conditions of the bedrock were investigated by field examination of rock cores from a monitoring well boring (10MW1) and data of six field hydraulic conductivity tests from a previous study (Geophex, 1990). Groundwater elevations were measured from the wells in the SWMU 10 area during the field program and are presented in Table 7-1.

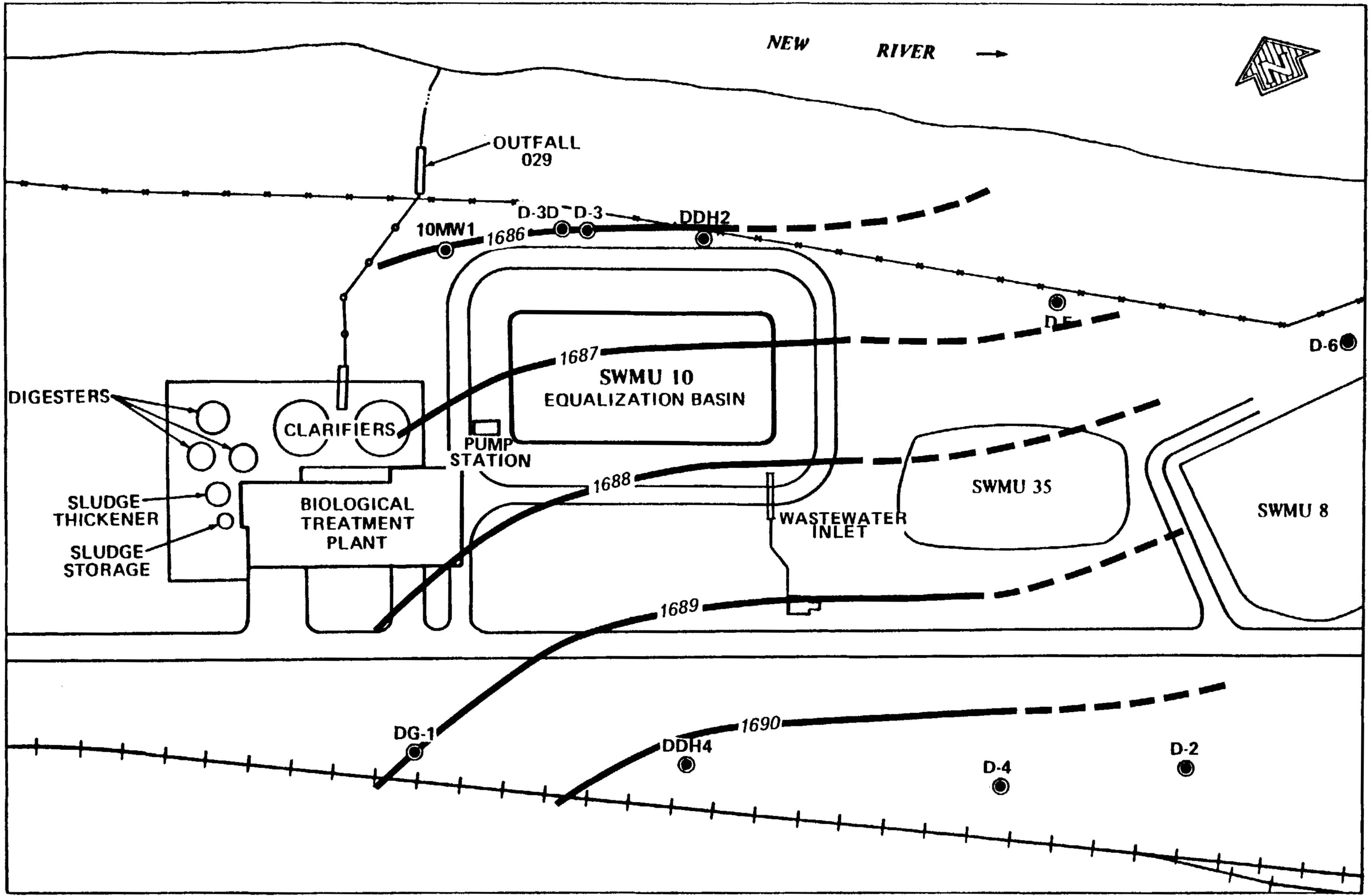
A relatively shallow groundwater table was encountered from 14 feet to 23 feet below ground surface in the study area. The unconfined water table is generally present several feet above the bedrock surface within either the micaceous sand or sand and gravel layer. Based on groundwater measurements obtained in January and March 1992, the unconfined water table gradient slopes north toward the New River at approximately 1.1 percent, generally following the slope of the bedrock surface. Groundwater level contours for the area are shown in Figures 7-7 and 7-8. No mounding or other irregular groundwater pattern has been observed at SWMU 10 except for a slight change in the groundwater flow direction toward the outfall 029 area which has a deep ravine leading to the New River. A significant mounding effect (Figure 7-8) appears to be associated with SWMU 35 due to the unlined nature of this basin. Surface water can drain into this basin and directly recharge the unconfined aquifer. SWMU 8 also appears to cause a mounding effect which alters the groundwater flow in this area.

Groundwater flow below the area primarily occurs through three geologic units; the unconsolidated micaceous sand, the unconsolidated sand and gravel, and the consolidated bedrock. The hydrogeological characteristics of each unit are different resulting in different groundwater flow velocities. Previous studies (USACE, 1981; Geophex, 1990) have presented permeability and hydraulic conductivity data for these three geologic layers from six of the seven well borings at SWMU 10. The hydraulic conductivity of the seventh well (10MW1) was calculated from rising-head (slug) tests conducted in 1991. A summary of permeability and hydraulic conductivity data are shown in Table 7-2.

The lowest permeabilities and hydraulic conductivities for the water bearing units are found in the unconsolidated micaceous sand unit, and the highest permeabilities and

TABLE 7–1
GROUNDWATER ELEVATIONS
SWMU 10 EQUALIZATION BASIN
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Well	Date	Elevation (feet msl)
10MW1	1–14–92	1685.96
	3–12–92	1686.95
D–3D	1–14–92	1685.79
	3–12–92	1686.59
D–3	1–14–92	1686.02
		1686.95
DDH2	1–14–92	1686.09
		1686.66
D–5	3–12–92	1692.22
DG–1	1–16–92	1688.93
	3–12–92	1689.78
DDH4	1–14–92	1690.21
	3–12–92	1690.90
D–4	1–14–92	1690.55
	3–12–92	1692.38
D–2	3–12–92	1694.77



LEGEND:

● Monitoring Well

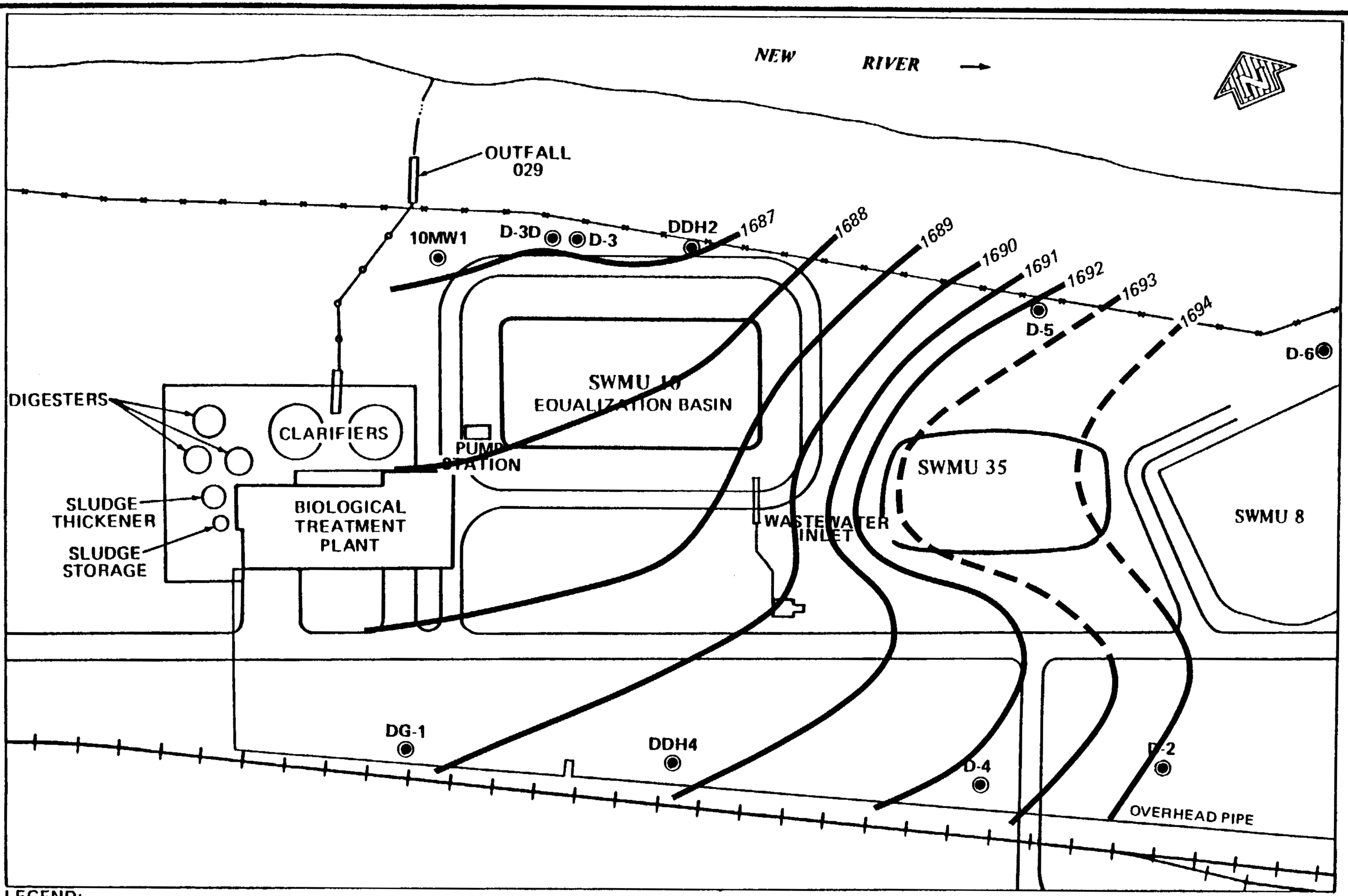
-o-o- Underground Pipeline

▬1687▬ Groundwater Elevation Contour (feet msl) Jan. 14/16, 1992

FIGURE 7-7
GROUNDWATER ELEVATION MAP
SWMU 10 AND SWMU 35
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

0 100 Feet

Dames & Moore



LEGEND:

● Monitoring Well

-o-o- Underground Pipeline

▬1687▬ Groundwater Elevation Contour (feet msl)
March 12, 1992

0 100 Feet

FIGURE 7-8
GROUNDWATER ELEVATION MAP
SWMU 10 AND SWMU 35
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Dames & Moore

TABLE 7-2
SUMMARY OF HYDRAULIC CONDUCTIVITY/PERMEABILITY DATA
SWMU 10 AND SWMU 35
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Well/Boring	Dominent Lithologic Unit	Permeability/ Hydraulic Conductivity (cm/sec)	Type of Test	Reference
DG-1	Sand and Gravel	8.6×10^{-4}	HC	Geophex, 1990
DDH4	Sand and Gravel	9.9×10^{-4}	HC	Geophex, 1990
DDH4	Sand and Gravel	2.17×10^{-3}	P	USACE, 1981
DDH4	Sand and Gravel	8.33×10^{-3}	P	USACE, 1981
DDH4	Micaceous Sand	3.07×10^{-4}	P	USACE, 1981
DDH4	Micaceous Sand	8.65×10^{-4}	P	USACE, 1981
D-4	Micaceous Sand	2.8×10^{-3}	HC	Geophex, 1990
10MW1	Micaceous Sand	$4.5\ 10^{-4}$	HC	Appendix E
D-3D	Bedrock	2.6×10^{-4}	HC	Geophex, 1990
D-3	Micaceous Sand	8.8×10^{-4}	HC	Geophex, 1990
DDH2	Sand and Gravel	1.3×10^{-3}	HC	Geophex, 1990
DDH2	Micaceous Sand	1.73×10^{-4}	P	USACE, 1981
DDH2	Micaceous Sand	2.86×10^{-4}	P	USACE, 1981

P = Permeability
HC = Hydraulic Conductivity

hydraulic conductivities are found in the sand and gravel. The average permeability/ hydraulic conductivities for the micaceous sand unit are 5.0 x 10^{-4} cm/sec and an average of 2.73 x 10^{-3} cm/sec for the sand and gravel unit. The hydraulic conductivity measured for bedrock at D-3D was 2.6 x 10^{-4} cm/sec but the bedrock has irregular water bearing fractures and measured values should always be considered only a rough estimate.

Groundwater in the unconsolidated water table aquifer will flow predominantly through the sand and gravel layer northward but this unit almost pinches out at the basin areas. As the sand and gravel layer pinches out, groundwater would then continue to flow northward to the New River predominantly through the micaceous sand unit. Because the micaceous sand unit is the most likely layer through which potential contaminants may flow if they leak from the basin, knowing the flow velocity for this layer is important for evaluating the study area.

Assuming the representative water bearing unit to be the micaceous sand layer, the groundwater flow velocity may be calculated by knowing the estimated average hydraulic conductivity (5.0 x 10^{-4} cm/sec), the hydraulic gradient (1.1 percent) as measured from Figure 7-8, and the estimated formation porosity (30 percent). By using the Darcy equation and standard equation of hydraulics, the estimated average linear horizontal groundwater flow velocity is 1.8 x 10^{-5} cm/sec (19 ft/yr).

The horizontal groundwater velocity for the sand and gravel unit can also be estimated using the average hydraulic conductivity/permeability (2.73 x 10^{-3} cm/sec), the measured gradient (1.1 percent) and an estimate of porosity for sand and gravel (25 percent). Using these values and the Darcy equation gives an average linear velocity of 1.2 x 10^{-4} cm/sec (124 ft/yr).

The estimated porosity of 30 percent used for the micaceous sand layer is based on a range of porosities common for unconsolidated non-plastic silty sand (25-40 percent), and the estimated porosity of 25 percent used for the sand and gravel layer is based on a range of porosities common for unconsolidated sand and gravel mixtures (10-25 percent; Johnson Filtration Systems, Inc., 1986).

A dilution factor was calculated for groundwater migrating from the study area and discharging into the New River in order to assess the potential impact site contamination may have on the quality of the New River water. Dilution of incipient groundwater by the New River would be important in decreasing the concentrations of potential contaminants released to the river. As shown on Table 7-3, the dilution factor for each month was estimated using stream-flow data provided by the U.S. Geological Survey for the New River and the estimated groundwater velocities presented above. The average linear groundwater velocity was multiplied by the approximate cross-sectional area (500 feet x 5 feet) of the unconsolidated water table aquifer along the northern edge of the Equalization Basin and the effective aquifer porosity to estimate the total aquifer discharge to the New River. This estimated aquifer discharge was then divided into the mean flow rate of the New River to estimate a river dilution factor. The mean monthly surface water/groundwater dilution factors ranged from a minimum of 1,000,000 (September using the maximum groundwater velocity) to a maximum of 10,000,000 (March using the minimum groundwater velocity). The actual month in which groundwater samples were collected (September, 1991) had a flow rate only two-thirds of the mean flow rate for the last 52 years for September and the estimated dilution minimum and maximum factors were correspondingly less--700,000 to 4,000,000 times, respectively.

7.2.4 Surface Water Drainage

The SWMU 10 Equalization Basin is fully encircled by a concrete wall which prevents surface water runoff outside of the basin from mixing with waste in the basin. Runoff in the vicinity of the Bio-Plant would flow northward to the New River following the general drainage pattern downslope to the river. However, runoff south and east of SWMU 10 flows toward the SWMU 35 settling basin, which is an unlined depression. No runoff from SWMU 35 migrates out of the confines of the basin. Because of the aboveground and fully enclosed construction of the Equalization Basin, no significant interaction with surface water leaving the area is likely for SWMU 10.

TABLE 7–3
ESTIMATED DILUTION FACTORS FOR GROUNDWATER DISCHARGING INTO THE NEW RIVER
SWMU 10 AND SWMU 35, RAAP, VIRGINIA

Month	New River Mean Flow[a] (ft^3/sec)	Dilution Factor Min. Vel. 19 ft/year[b]	Dilution Factor Max. Vel. 124 ft/year[c]
January	4153	9E+06	2E+06
February	5310	1E+07	2E+06
March	5927	1E+07	2E+06
April	5520	1E+07	2E+06
May	4479	1E+07	2E+06
June	3451	8E+06	1E+06
July	2793	6E+06	1E+06
August	2647	6E+06	1E+06
September	2531	6E+06	1E+06
October	2772	6E+06	1E+06
November	3059	7E+06	1E+06
December	3655	8E+06	1E+06
Annual Mean	3850	9E+06	2E+06
September 1991[d]	1703	4E+06	7E+05

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[a] Monthly mean at Radford, VA since 1940 (USGS, 1992).

[b] Mean flow /(500 ft * 5 ft * 19 ft/year * 30% porosity * 1 year/365 days * 1 day/24 hrs * 1 hr/3600 sec)

[c] Mean flow /(500 ft * 5 ft * 124 ft/year * 25% porosity * 1 year/365 days * 1 day/24 hrs * 1 hr/3600 sec)

[d] Month of Groundwater samples.

7.3 CONTAMINATION ASSESSMENT

The RCRA permit required groundwater samples to be collected from SWMU 10 and either waste characterization samples or soil and groundwater samples from SWMU 35. The VI Work Plan outlined a program consisting of three well samples for SWMU 10 and one waste characterization sample from SWMU 35. The four investigations for the SWMU 10 and SWMU 35 area performed subsequent to the issuance of the RCRA permit resulted in the collection of a sufficient number of environmental samples to perform an analysis equivalent to an RFI instead of a VI. One surface water and one sediment sample have been collected of the waste present in SWMU 10 and three samples were collected from the sediment in SWMU 35. Analytical data for these samples should be considered representative of the maximum contaminant concentrations present at both SWMUs. Two soil samples were collected from the surficial soil adjacent to, but outside of, the SWMU basins and should represent ambient area concentrations which may not be necessarily affected by the waste. One soil sample was also collected from below the SWMU 35 sediment, but above the water table; results should provide an indication of the likelihood of vertical migration of contaminants in this SWMU. Groundwater samples were collected from seven wells outside of the boundaries of the SWMUs at four downgradient and three upgradient locations. These well locations are more appropriate for an evaluation of SWMU 10 rather than SWMU 35, but reasonable interpolation of data is appropriate. The following sections present the evaluation of the environmental samples collected.

7.3.1 Soil

Samples 10SS4 and 10SS5 were collected at a depth of 0.5 foot in a grassy area south of SWMU 10 (Dames & Moore, 1991a). Samples 10SS1, 10SS2 and 10SS3 were collected west of the Bio-Plant building and are not applicable to the basins area, but are included for comparison purposes. Results of the chemical analyses are presented in Table 7-4.

The results of the chemical analyses indicated that concentrations of arsenic and lead in these soil samples exceeded the HBN criteria. Arsenic is not a concern because the levels were less than the soil background criteria (Table 4-14) and reflect concentrations

Table 7–4
Summary of Analytical Data For Soil Samples Collected At SWMU 10 amd SWMU 35
Radford Army Ammunition Plant, Virginia

SITE ID		10SS1	10SS2	10SS3	10SS4	10SS5	35SS2	
FIELD ID		RADS*9	RADS*8	RADS*7	RADS*1	RADS*2	RADS*6	
S. DATE		21–aug–90	21–aug–90	21–aug–90	21–aug–90	21–aug–90	21–aug–90	
DEPTH (ft)		0.5	0.5	0.5	0.5	0.5	6.0	
MATRIX	PQLs	CSO	CSO	CSO	CSO	CSO	CSO	HBN
UNITS (#)	UGG	UGG	UGG	UGG	UGG	UGG	UGG	UGG
TAL Inorganics								
ARSENIC	30	[5.61]	[0.831 B]	[1.86 B]	[3.69]	[2.19 B]	[1.23 B]	0.5
BARIUM	1	309	360	199	125	254	184	1000
CHROMIUM	4	LT 12.7	23.9	26.2	44.4	LT 12.7	28.5	400
LEAD	2	GT 5000	9.07	9.02	GT 5000	GT 5000	11.4	200
MERCURY	0.1	0.058	LT 0.05	LT 0.05	LT 0.05	LT 0.05	LT 0.05	20
SILVER	4	0.048	LT 0.025	LT 0.025	LT 0.025	0.033	0.04	200
Explosives								
24DNT	0.424	LT 0.424	LT 0.424	LT 0.424	LT 0.424	0.985	LT 0.424	1
Volatiles								
TOLUENE	0.005	LT 0.001	LT 0.001	LT 0.001	LT 0.001	LT 0.001	0.001	1000
TOTAL UNKNOWN TICs	NA	ND	ND	ND	ND	ND	(1)0.036	NSA
Semivolatiles								
2–METHYLNAPHTHALENE	0.3	1.65	LT 0.049	LT 0.049	LT 0.049	LT 0.049	LT 0.049	NSA
24DNT	0.3	LT 0.14	LT 0.14	LT 0.14	LT 0.14	0.342	LT 0.14	1
ACENAPHTHYLENE	0.3	LT 0.033	LT 0.033	LT 0.033	0.168	LT 0.033	LT 0.033	NSA
ANTHRACENE	0.1	LT 0.033	LT 0.033	LT 0.033	0.052	LT 0.033	LT 0.033	40
BENZO [K] FLUORANTHENE	0.02	LT 0.066	LT 0.066	LT 0.066	0.083	LT 0.066	LT 0.066	80
CHRYSENE	0.02	0.781	LT 0.12	LT 0.12	LT 0.12	0.21	LT 0.12	4
DI–N–BUTYL PHTHALATE	0.3	LT 0.061	LT 0.061	LT 0.061	0.098	1.34	LT 0.061	1000
DIBENZOFURAN	0.3	0.48	LT 0.035	LT 0.035	LT 0.035	LT 0.035	LT 0.035	NSA
FLUORANTHENE	0.3	0.211	LT 0.068	LT 0.068	0.158	0.225	LT 0.068	500
FLUORENE	0.3	0.093	LT 0.033	LT 0.033	LT 0.033	LT 0.033	LT 0.033	3200
NAPHTHALENE	0.3	0.888	LT 0.037	LT 0.037	LT 0.037	LT 0.037	LT 0.037	1000
PHENANTHRENE	0.5	0.951	LT 0.033	LT 0.033	0.047	0.094	LT 0.033	40
PYRENE	0.3	0.215	LT 0.033	LT 0.033	LT 0.033	0.162	LT 0.033	1000
Semivolatile TICs								
1–METHYLNAPHTHALENE	NA	1.14 S	ND	ND	ND	ND	ND	NSA
2,6,10,14–TETRAMETHYLPENTADECANE	NA	2.28 S	ND	ND	ND	ND	ND	NSA
2,6–DIMETHYLUNDECANE	NA	1.14 S	ND	ND	ND	ND	ND	NSA
DIMETHYLNAPHTHALENES	NA	1.14 S	ND	ND	ND	ND	ND	NSA
DODECANE	NA	0.91 S	ND	ND	ND	ND	ND	NSA

Table 7-4 (Cont'd)

SITE ID		10SS1	10SS2	10SS3	10SS4	10SS5	35SS2	
FIELD ID		RADS*9	RADS*8	RADS*7	RADS*1	RADS*2	RADS*6	
S. DATE		21-aug-90	21-aug-90	21-aug-90	21-aug-90	21-aug-90	21-aug-90	
DEPTH (ft)		0.5	0.5	0.5	0.5	0.5	6.0	
MATRIX	PQLs	CSO	CSO	CSO	CSO	CSO	CSO	HBN
UNITS (#)	UGG	UGG	UGG	UGG	UGG	UGG	UGG	UGG
Semivolatile TICs								
EICOSANE	NA	1.14 S	ND	ND	ND	ND	ND	NSA
HEPTADECANE	NA	2.28 S	ND	ND	ND	ND	ND	NSA
PENTADECANE	NA	1.14 S	ND	ND	ND	ND	ND	NSA
TETRACOSANE	NA	2.28 S	ND	ND	ND	ND	ND	NSA
TETRADECANE	NA	1.14 S	ND	ND	ND	ND	ND	NSA
TOLUENE	NA	ND	ND	ND	ND	0.114 S	ND	NSA
TOTAL UNKNOWN TICs	NA	(9)10.7	ND	ND	ND	(6)2.06	ND	NSA
TCLP Metals (UGL)								
BARIUM	20	878	1220	337	532	981	238	100000
LEAD	10	5.31 B	5.1 B	3.8 B	13.2 B	6.29 B	6.94 B	5000

Footnotes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CSO = Chemical soil.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

ND = Analyte was not detected.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

S = Results are based on an internal standard; flag is used for TICs detected in library scans.

TAL = Target Analyte List.

TCLP = Toxicity Characteristic Leaching Procedure.

TICs = Tentatively identified compounds that were detected in the GC/MS library scans.

UGG = Micrograms per gram.

Units(#) = Units are in UGG except for TCLP constituents, which are expressed in UGL.

( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

GT = Concentration is reported as greater than the maximum certified concentration.

expected to be in natural alluvial soils. Concentrations of barium and chromium exceeded the soil background criteria but are not considered to be a concern because they were less than HBN and TCLP criteria. These metals are not expected to impact surface water, groundwater or underlying soil. However, lead concentrations for both samples were at least 25 times greater than the soil HBN and background criterion, and may be a concern at the site. Sample 10SS1, collected west of the Bio-Plant building, has similar lead concentrations indicating general plant-wide causes may be responsible rather than SWMU-specific contamination. Although lead has a strong affinity to adsorb to inorganic solids and organic materials, the relatively high concentrations reported in the samples may be a concern to groundwater and nearby surface water, particularly in the presence of a shallow water table, highly permeable soil and low pH or acidic infiltrating precipitation. However, TCLP leachate results for lead were below the regulatory level and indicated that these samples would not be regulated wastes.

The explosive 24DNT, at a concentration of 0.985 ug/g, was the only explosive detected and was limited to one sample only (10SS5). However, the concentration reported was below the permit HBN of 1 ug/g. No VOCs were detected in either sample.

Several SVOCs were detected in both on-site soil samples as well as sample 10SS1. Most of the detected SVOCs are PAHs and other saturated hydrocarbons which are associated with petroleum products such as commercial coal tar, gasoline, solvents, power plant emissions and coal ash and cinders. These SVOCs probably indicate that fill material used to grade the area is the source of the SVOCs rather than the SWMUs. Although several known and unknown SVOCs were detected, these organic compounds are not considered to be a concern because the concentrations are several orders of magnitude less than applicable HBNs. Many of these organic constituents readily adsorb onto particulate matter, especially in the presence of soil organics, and are not expected to impact soil, groundwater or nearby surface water at the site.

Five metals were detected in the soil sample (13SS2) collected from below the SWMU 35 sediment. The arsenic concentration exceeded the HBN, but this concentration was within the range of background concentrations. The other metals (barium, chromium, lead, and silver) were detected at concentrations below the HBNs and at levels consistent with the background concentrations. The chromium concentration was slightly above the background criterion, but similar to nearby off-site samples 10SS2 and 10SS3. TCLP barium and lead were detected, but the lead concentration was below the PQL, and the barium concentration was lower than the other five soil samples collected, and far less than the TCLP criteria.

Toluene was the only VOC detected, but at a concentration below both the PQL and HBN. One VOC TIC was detected at a low concentration (0.036 ug/g) and should not be considered a concern. No SVOC was detected.

7.3.2 Sediment

One sediment sample was collected from within the Equalization Basin (SWMU 10). Three sediment and one underlying soil samples were collected from the SWMU 35, Calcium Sulfate Drying Bed. Two samples collected in 1990 were analyzed for metals, TCLP metals, explosives, VOCs and SVOCs. The sample collected in 1992 (35SL1) was analyzed for VOCs and TCLP metals only. The results of the chemical analyses for these samples are presented in Table 7-5.

In total, eight metals were detected in the basin and drying bed sediment samples. Of these eight, only arsenic and lead exceeded HBNs. Arsenic is not considered a concern because the levels were less than the soil background criteria and reflect concentrations expected to be in natural alluvial soils. However, lead concentrations in all sediment samples ranged from 25 to 250 times greater than the soil HBN and background criterion and may be a concern at the site. The lead concentration from sample 35SS2 (i.e., 11.4 ug/g) was below the HBN and soil background criterion and indicated that lead contamination in SWMU 35 is likely limited to sediment and sludges above a depth of 6 feet. Only sample 10SE1 would be considered a TCLP hazardous waste due only to the amount of leachable lead. Other TCLP criteria were not exceeded.

Four explosives -- 246TNT, 24DNT, HMX and RDX -- were detected in the Equalization Basin sediment sample 10SE1 at concentrations of 2.36, 94, 1.81 and 2.45 ug/g,

Table 7-5
Summary of Analytical Data For Sediment Samples Collected At SWMU 10 and SWMU 35
Radford Army Ammunition Plant, Virginia

SITE ID		10SE1	35SE1	35SE2	35SL1	
FIELD ID		RADS*10	RADS*3	RADS*5	RVFS*36	
S. DATE		22-aug-90	21-aug-90	21-aug-90	15-jan-92	
DEPTH (ft)		0.5	4.0	4.0	5.0	
MATRIX	PQLs	CSE	CSE	CSE	CSE	HBN
UNITS (#)	UGG	UGG	UGG	UGG	UGG	UGG
TAL Inorganics						
ARSENIC	30	[3.48]	[3.62]	[5.76]	NT	0.5
BARIUM	1	175	174	304	NT	1000
CHROMIUM	4	85.7	124	122	NT	400
LEAD	2	[GT 50000]	[GT 50000]	[GT 50000]	NT	200
MERCURY	0.1	0.685	0.347	0.472	NT	20
NICKEL	NA	LT 12.6	52.2	80.4	NT	1000
SILVER (GFAA)	0.589	44	29	1.57	NT	200
SILVER(ICP)	2.5	34.6	45	LT 2.5	NT	200
Explosives						
246TNT	0.456	2.36	LT 4.6	LT 5.9	NT	40
24DNT	0.424	[94]	[11]	LT 5.5	NT	1
HMX	0.666	1.81	LT 6.7	LT 8.7	NT	4000
RDX	0.587	2.45	LT 5.9	LT 7.6	NT	63.6
Volatiles						
ACETONE	0.1	0.789	GT 0.1	LT 0.017	LT 0.017	1000
TOLUENE	0.005	GT 1	0.004	0.014	LT 0.001 B	1000
Volatile TICs						
DIMETHYL DISULFIDE	NA	0.383 S	ND	ND	ND	NSA
TOTAL UNKNOWN TICs	NA	(1)0.51	ND	ND	ND	NSA
Semivolatiles						
24DNT	0.3	[327]	LT 2.8	LT 0.14	LT 0.7	1
DI-N-BUTYL PHTHALATE	0.3	491	18.1	0.47	1.37	1000
DIETHYL PHTHALATE	0.3	55	LT 4.8	LT 0.24	LT 1.2	1000
FLUORANTHENE	0.3	4.14	LT 1.36	LT 0.068	LT 0.34	500
N-NITROSODIPHENYLAMINE	0.3	[602]	40	1.23	4.55	100
PHENANTHRENE	0.5	2.63	LT 0.66	0.13	0.531	40
Semivolatile TICs						
HEPTADECANE	NA	ND	ND	0.418 S	ND	NSA
HEXADECANE	NA	5.1 S	ND	ND	ND	NSA

Table 7-5 (Cont'd)

SITE ID		10SE1	35SE1	35SE2	35SL1	
FIELD ID		RADS*10	RADS*3	RADS*5	RVFS*36	
S. DATE		22-aug-90	21-aug-90	21-aug-90	15-jan-92	
DEPTH (ft)		0.5	4.0	4.0	5.0	
MATRIX	PQLs	CSE	CSE	CSE	CSE	HBN
UNITS (#)	UGG	UGG	UGG	UGG	UGG	UGG
Semivolatile TICs						
TOLUENE	NA	25.5 S	ND	0.209 S	ND	NSA
TOTAL UNKNOWN TICs	NA	(17)296	(1)21.2	(5)2.3	(2)776	NSA
TCLP Metals (UGL)						
ARSENIC	10	4.05	LT 2.54	LT 2.54	LT 2.54	5000
BARIUM	20	494	586	255	266	100000
CADMIUM	1	LT 4.01	7.91	LT 4.01	4.12	1000
CHROMIUM	10	LT 6.02	27.9	LT 6.02	LT 6.02	5000
LEAD	10	[8400]	1800	99.8	42.8	5000
NICKEL	NA	160	121	56.6	NT	NSA
SILVER	2	LT 4.6	LT 4.6	LT 4.6	12.9	5000

Footnotes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CSE = Chemical sediment.

GFAA = Grafite Furnace Atomic Absorption

GT = Greater than; detected value is greater than the maximum certified concentration.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

ICP = Inductively Coupled Plasma

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

ND = Analyte was not detected.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

NT = Not tested; parameters were not tested (included) in the sample analyses.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

S = Results are based on an internal standard; flag is used for TICs detected in library scans.

T = Analyte was detected in corresponding trip blank; values are flagged if the sample concentration is less than 10 times the trip blank concentration for common laboratory constituents and 5 times for all other constituents.

TAL = Target Analyte List.

TCLP = Toxicity Characteristic Leaching Procedure. TCLP criteria included in HBN column for these analyses.

TICs = Tentatively identified compounds that were detected in the GC/MS library scans.

UGG = Micrograms per gram.

Units(#) = Units are in UGG except for TCLP constituents, which are expressed in UGL.

( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

respectively. A concentration of 11 ug/g for 24DNT was also detected in one drying bed sample (i.e., 35SE1) only. Only concentrations of 24DNT exceeded HBN criteria for explosives and may be a concern. Note that 24DNT also was detected in the SVOC analyses for 10SE1 at a much higher concentration of 327 ug/g. The analytical result from the explosives analysis is considered to be more definitive as this method has been specifically developed to test for explosives and has a lower PQL.

In total, two VOCs and five SVOCs were detected in the sediment samples, but only one SVOC -- N-nitrosodiphenylamine (NNDPA) in sample 10SE1 -- exceeded applicable HBN criteria. The concentration of NNDPA exceeded the HBN by slightly greater than a factor of six and may be a concern. Other reported SVOCs, consisting of phthalate compounds and PAHs, were below HBN criteria and are not a concern. Acetone and toluene were the only VOCs detected in these samples and were below their respective HBNs.

As demonstrated by the sample results, many contaminants detected in the SWMU 35 sediment were similar to those detected in samples from the Bio-Plant Equalization Basin. The magnitudes of the concentrations also were similar but were generally lower than those from SWMU 10. The only constituent detected in SWMU 35 sediments that was not detected in SWMU 10 was nickel, the concentration of which did not exceed the HBN. These data indicated that potential migration of constituents from the two SWMUs would have a similar impact on groundwater quality.

7.3.3 Groundwater

A summary of the analytical data for the groundwater samples collected in 1990 and 1991 is presented in Tables 7-6. Chemical results for both filtered and unfiltered metals samples are included in these data.

As indicated in Table 7-6, 18 metals were detected in one or more of the samples analyzed. The majority of the metals detected and the highest concentrations were present in unfiltered samples from the upgradient wells DG-1 and DDH4. The unfiltered sample from well DG-1 exhibited the greatest number of constituents at generally the maximum

Table 7-6
Summary of Analytical Data for Groundwater Samples Collected At SWMU 10 and SWMU 35
Radford Army Ammunition Plant, Virginia

SITE ID		10MW1	D-3	D-3(+)	D-3	D-3D	D-3D(+)	D-4	
FIELD ID		RDWA*7	RDWA*3	RDWAU*3	RADW*4	RDWA*2	RDWAU*2	RDWA*4	
S. DATE		13-sep-91	17-sep-91	17-sep-91	22-aug-90	17-sep-91	17-sep-91	20-sep-91	
DEPTH (ft)		21.0	28.0	28.0	28.0	58.0	58.0	28.0	
MATRIX	PQLs	CGW	CGW	CGW	CGW	CGW	CGW	CGW	HBN
UNITS	UGL	UGL	UGL	UGL	UGL	UGL	UGL	UGL	UGL
TAL Inorganics									
ALUMINIUM	141	LT 141	278	7270	NT	LT 141	558	LT 141	101500
ANTIMONY	30	LT 38	LT 38	LT 38	LT 38	LT 38	LT 38	LT 38	10
ARSENIC	10	LT 2.54	LT 2.54	LT 2.54	LT 2.54	LT 2.54	LT 2.54	LT 2.54	50
BARIUM	20	97.2	29.3	76.8	31.6	35	41.8	99.1	1000
CALCIUM	500	70900	169000	177000	NT	158000	156000	37900	NSA
CHROMIUM	10	LT 6.02	LT 6.02	12.9	LT 6.02	LT 6.02	LT 6.02	LT 6.02	50
COBALT	70	LT 25	LT 25	LT 25	NT	LT 25	LT 25	LT 25	0.35
COPPER	60	LT 8.09	17.1	31.6	NT	LT 8.09	12.3	LT 8.09	1295
IRON	38.1	LT 38.8	270	13800	NT	LT 38.8	645	LT 38.8	NSA
LEAD	10	LT 1.26	3.36	17.7	2.49 B	LT 1.26	6.83	LT 1.26	50
MAGNESIUM	500	24200	44800	53500	NT	41200	41100	19600	NSA
MANGANESE	2.75	2.87	108	351	NT	LT 2.75	26.9	13.6	3500
NICKEL	50	LT 34.3	LT 34.3	LT 34.3	LT 34.3	LT 34.3	LT 34.3	LT 34.3	700
POTASSIUM	375	1930	1650	3810	NT	1170	1910	1180	NSA
SILVER	2	LT 0.25	LT 0.25	LT 0.25	NT	LT 0.25	LT 0.25	LT 0.25	50
SODIUM	500	13500	14400	14400	NT	16600	16600	8240	NSA
VANADIUM	40	LT 11	LT 11	25.6	NT	LT 11	LT 11	LT 11	245
ZINC	50	LT 21.1	28.3	122	NT	LT 21.1	47.1	LT 21.1	7000
Explosives									
24DNT	0.064	[0.072 C]	LT 0.064	NT	NT	[0.183 C]	NT	LT 0.064	0.05
26DNT	0.074	LT 0.074	LT 0.074	NT	NT	LT 0.074	NT	LT 0.074	0.051
HMX	1.21	2.57 C	3.4 C	NT	8.37 C	2.82 C	NT	4.24 C	1750
TETRYL	NA	NT	NT	NT	1.19	NT	NT	NT	NSA
Volatiles									
1,2-DICHLOROETHANE	5	LT 0.5	LT 0.5	NT	LT 0.5	0.583	NT	LT 0.5	5
CARBON DISULFIDE	5	1.13	0.737	NT	LT 0.5	2.61	NT	LT 0.5	4000
CHLOROFORM	5	1.74 B	1.54 B	NT	LT 0.5	2.05 B	NT	8.51	600
CHLOROMETHANE	10	LT 3.2	LT 3.2	NT	LT 3.2	LT 3.2	NT	5.67	30
TOLUENE	5	LT 0.5	LT 0.5	NT	LT 0.5	LT 0.5	NT	LT 0.5	10000
Semivolatiles									
BIS(2-ETHYLHEXYL) PHTHALATE	10	LT 4.8	LT 4.8	NT	LT 4.8	[4.73]	NT	LT 4.8	3
Semivolatile TICs									
CAPROLACTAM	NA	ND	ND	ND	ND	30 S	ND	ND	NSA

Table 7–6 (Cont'd)

SITE ID		10MW1	D–3	D–3(+)	D–3	D–3D	D–3D(+)	D–4	
FIELD ID		RDWA*7	RDWA*3	RDWAU*3	RADW*4	RDWA*2	RDWAU*2	RDWA*4	
S. DATE		13–sep–91	17–sep–91	17–sep–91	22–aug–90	17–sep–91	17–sep–91	20–sep–91	
DEPTH (ft)		21.0	28.0	28.0	28.0	58.0	58.0	28.0	
MATRIX	PQLs	CGW	CGW	CGW	CGW	CGW	CGW	CGW	HBN
UNITS	UGL	UGL	UGL	UGL	UGL	UGL	UGL	UGL	UGL
Semivolatile TICs									
TOTAL UNKNOWN TICs	NA	(3)19	(1)4	ND	ND	(4)47	ND	(1)5	NSA
Other									
CHLORIDE	1000	18900	21100	NT	NT	21300	NT	17800	NSA
NITRITE,NITRATE	100	520	[26000]	NT	NT	[30000]	NT	110	10000
NITROGEN BY KJELDAHL METHOD	NA	257	686	NT	NT	914	NT	667	NSA
PHENOLICS (NON–SPECIFIC)	NA	LT 7.12	LT 7.12	NT	NT	40.8	NT	LT 7.12	NSA
PHOSPHATE	NA	139	297	NT	NT	64.4	NT	1500	NSA
SULFATE	NA	28000	180000	NT	NT	235000	NT	13900	NSA
TOTAL ORGANIC CARBON	1000	6920	22300	NT	NT	9630	NT	6280	NSA
TOTAL ORGANIC HALOGENS	1	97.8	99.3	NT	NT	156	NT	68.4	NSA
pH	NA	8.13 K	8.23	NT	NT	7.87	NT	6.99 K	NSA

Table 7-6 (Cont'd)

SITE ID		D-4 (+)	DDH2	DDH2	DDH2	DDH2	DDH2 (+)	DDH2	
FIELD ID		RDWAU*4	RDWA*31	RDWA*32	RDWA*33	RDWA*5	RDWAU*5	RADW*3	
S. DATE		20-sep-91	19-sep-91	19-sep-91	19-sep-91	19-sep-91	19-sep-91	22-aug-90	
DEPTH (ft)		28.0	24.0	24.0	24.0	24.0	24.0	24.0	
MATRIX	PQLs	CGW	CGW	CGW	CGW	CGW	CGW	CGW	HBN
UNITS	UGL	UGL	UGL	UGL	UGL	UGL	UGL	UGL	UGL
TAL Inorganics									
ALUMINIUM	141	23800	NT	NT	NT	LT 141	697	NT	101500
ANTIMONY	30	LT 38	NT	NT	NT	LT 38	LT 38	LT 38	10
ARSENIC	10	4.16	NT	NT	NT	LT 2.54	LT 2.54	LT 2.54	50
BARIUM	20	285	NT	NT	NT	16.8	28.1	27.3	1000
CALCIUM	500	88700	NT	NT	NT	210000	209000	NT	NSA
CHROMIUM	10	[92.1]	NT	NT	NT	LT 6.02	6.19	LT 6.02	50
COBALT	70	LT 25	NT	NT	NT	LT 25	LT 25	NT	0.35
COPPER	60	47.9	NT	NT	NT	9.04	8.89	NT	1295
IRON	38.1	66100	NT	NT	NT	LT 38.8	2450	NT	NSA
LEAD	10	[100]	NT	NT	NT	LT 1.26	4.23	2.82 B	50
MAGNESIUM	500	61800	NT	NT	NT	36500	38300	NT	NSA
MANGANESE	2.75	528	NT	NT	NT	3.79	81.5	NT	3500
NICKEL	50	LT 34.3	NT	NT	NT	LT 34.3	LT 34.3	LT 34.3	700
POTASSIUM	375	6320	NT	NT	NT	546	827	NT	NSA
SILVER	2	LT 0.25	NT	NT	NT	LT 0.25	LT 0.25	NT	50
SODIUM	500	8160	NT	NT	NT	20400	19800	NT	NSA
VANADIUM	40	83.6	NT	NT	NT	LT 11	LT 11	NT	245
ZINC	50	115	NT	NT	NT	LT 21.1	26	NT	7000
Explosives									
24DNT	0.064	NT	NT	NT	NT	LT 0.064	NT	NT	0.05
26DNT	0.074	NT	NT	NT	NT	[0.082 C]	NT	NT	0.051
HMX	1.21	NT	NT	NT	NT	5.33 C	NT	2.27 C	1750
TETRYL	NA	NT	NT	NT	NT	NT	NT	LT 0.556	NSA
Volatiles									
1,2-DICHLOROETHANE	5	NT	NT	NT	NT	1.51	NT	LT 0.5	5
CARBON DISULFIDE	5	NT	NT	NT	NT	2.49	NT	LT 0.5	4000
CHLOROFORM	5	NT	NT	NT	NT	1.54	NT	LT 0.5	600
CHLOROMETHANE	10	NT	NT	NT	NT	13.7	NT	LT 3.2	30
TOLUENE	5	NT	NT	NT	NT	LT 0.5	NT	LT 0.5	10000
Semivolatiles									
BIS(2-ETHYLHEXYL) PHTHALATE	10	NT	NT	NT	NT	LT 4.8	NT	LT 4.8	3
Semivolatile TICs									
CAPROLACTAM	NA	ND	ND	ND	ND	ND	ND	ND	NSA

Table 7–6 (Cont'd)

SITE ID		D–4 (+)	DDH2	DDH2	DDH2	DDH2	DDH2 (+)	DDH2	
FIELD ID		RDWAU*4	RDWA*31	RDWA*32	RDWA*33	RDWA*5	RDWAU*5	RADW*3	
S. DATE		20–sep–91	19–sep–91	19–sep–91	19–sep–91	19–sep–91	19–sep–91	22–aug–90	
DEPTH (ft)		28.0	24.0	24.0	24.0	24.0	24.0	24.0	
MATRIX	PQLs	CGW	CGW	CGW	CGW	CGW	CGW	CGW	HBN
UNITS	UGL	UGL	UGL	UGL	UGL	UGL	UGL	UGL	UGL
Semivolatile TICs									
TOTAL UNKNOWN TICs	NA	ND	ND	ND	ND	(5)135	ND	ND	NSA
Other									
CHLORIDE	1000	NT	NT	NT	NT	21400	NT	NT	NSA
NITRITE,NITRATE	100	NT	NT	NT	NT	[38000]	NT	NT	10000
NITROGEN BY KJELDAHL METHOD	NA	NT	NT	NT	NT	533	NT	NT	NSA
PHENOLICS (NON–SPECIFIC)	NA	NT	NT	NT	NT	LT 7.12	NT	NT	NSA
PHOSPHATE	NA	NT	NT	NT	NT	158	NT	NT	NSA
SULFATE	NA	NT	NT	NT	NT	380000	NT	NT	NSA
TOTAL ORGANIC CARBON	1000	NT	6420	6550	6190	5080	NT	NT	NSA
TOTAL ORGANIC HALOGENS	1	NT	115	148	93.5	79.1	NT	NT	NSA
pH	NA	NT	NT	NT	NT	6.97	NT	NT	NSA

Table 7–6 (Cont'd)

SITE ID		DDH4	DDH4	DDH4	DDH4	DDH4 (+)	DDH4	DG–1	
FIELD ID		RDWA*34	RDWA*35	RDWA*36	RDWA*6	RDWAU*6	RADW*2	RDWA*1	
S. DATE		19–sep–91	19–sep–91	19–sep–91	19–sep–91	19–sep–91	22–aug–90	19–sep–91	
DEPTH (ft)		27.0	27.0	27.0	27.0	27.0	27.0	28.0	
MATRIX	PQLs	CGW	CGW	CGW	CGW	CGW	CGW	CGW	HBN
UNITS	UGL	UGL	UGL	UGL	UGL	UGL	UGL	UGL	UGL
TAL Inorganics									
ALUMINIUM	141	NT	NT	NT	LT 141	22400	NT	LT 141	101500
ANTIMONY	30	NT	NT	NT	LT 38	LT 38	LT 38	LT 38	10
ARSENIC	10	NT	NT	NT	LT 2.54	LT 2.54	LT 2.54	LT 2.54	50
BARIUM	20	NT	NT	NT	58.3	280	63.9	87.5	1000
CALCIUM	500	NT	NT	NT	43500	54300	NT	48900	NSA
CHROMIUM	10	NT	NT	NT	LT 6.02	45.4	LT 6.02	LT 6.02	50
COBALT	70	NT	NT	NT	LT 25	LT 25	NT	LT 25	0.35
COPPER	60	NT	NT	NT	LT 8.09	183	NT	LT 8.09	1295
IRON	38.1	NT	NT	NT	LT 38.8	83600	NT	LT 38.8	NSA
LEAD	10	NT	NT	NT	1.63	39.6	4.88 B	LT 1.26	50
MAGNESIUM	500	NT	NT	NT	23100	51800	NT	24400	NSA
MANGANESE	2.75	NT	NT	NT	LT 2.75	2640	NT	3.36	3500
NICKEL	50	NT	NT	NT	LT 34.3	52.6	LT 34.3	LT 34.3	700
POTASSIUM	375	NT	NT	NT	888	7720	NT	1150	NSA
SILVER	2	NT	NT	NT	LT 0.25	0.443	NT	LT 0.25	50
SODIUM	500	NT	NT	NT	8230	7820	NT	8190	NSA
VANADIUM	40	NT	NT	NT	LT 11	83	NT	LT 11	245
ZINC	50	NT	NT	NT	LT 21.1	231	NT	LT 21.1	7000
Explosives									
24DNT	0.064	NT	NT	NT	LT 0.064	NT	NT	LT 0.064	0.05
26DNT	0.074	NT	NT	NT	LT 0.074	NT	NT	LT 0.074	0.051
HMX	1.21	NT	NT	NT	7.01 C	NT	10.1 C	5.59 C	1750
TETRYL	NA	NT	NT	NT	NT	NT	LT 0.556	NT	NSA
Volatiles									
1,2–DICHLOROETHANE	5	NT	NT	NT	LT 0.5	NT	LT 0.5	LT 0.5	5
CARBON DISULFIDE	5	NT	NT	NT	LT 0.5	NT	LT 0.5	LT 0.5	4000
CHLOROFORM	5	NT	NT	NT	7.79	NT	1.74	6.67	600
CHLOROMETHANE	10	NT	NT	NT	LT 3.2	NT	LT 3.2	LT 3.2	30
TOLUENE	5	NT	NT	NT	0.873	NT	LT 0.5	0.667	10000
Semivolatiles									
BIS(2–ETHYLHEXYL) PHTHALATE	10	NT	NT	NT	LT 4.8	NT	LT 4.8	LT 4.8	3
Semivolatile TICs									
CAPROLACTAM	NA	ND	ND	ND	ND	ND	ND	ND	NSA

Table 7-6 (Cont'd)

SITE ID		DDH4	DDH4	DDH4	DDH4	DDH4 (+)	DDH4	DG-1	
FIELD ID		RDWA*34	RDWA*35	RDWA*36	RDWA*6	RDWAU*6	RADW*2	RDWA*1	
S. DATE		19-sep-91	19-sep-91	19-sep-91	19-sep-91	19-sep-91	22-aug-90	19-sep-91	
DEPTH (ft)		27.0	27.0	27.0	27.0	27.0	27.0	28.0	
MATRIX	PQLs	CGW	CGW	CGW	CGW	CGW	CGW	CGW	HBN
UNITS	UGL	UGL	UGL	UGL	UGL	UGL	UGL	UGL	UGL
Semivolatile TICs									
TOTAL UNKNOWN TICs	NA	ND	ND	ND	(3)308	ND	ND	(1)6	NSA
Other									
CHLORIDE	1000	NT	NT	NT	17200	NT	NT	19100	NSA
NITRITE,NITRATE	100	NT	NT	NT	15.1	NT	NT	3000	10000
NITROGEN BY KJELDAHL METHOD	NA	NT	NT	NT	314	NT	NT	1050	NSA
PHENOLICS (NON-SPECIFIC)	NA	NT	NT	NT	LT 7.12	NT	NT	LT 7.12	NSA
PHOSPHATE	NA	NT	NT	NT	990	NT	NT	2000	NSA
SULFATE	NA	NT	NT	NT	11900	NT	NT	13900	NSA
TOTAL ORGANIC CARBON	1000	3710	3310	3620	3420	NT	NT	8720	NSA
TOTAL ORGANIC HALOGENS	1	250	199	198	208	NT	NT	142	NSA
pH	NA	NT	NT	NT	6.83	NT	NT	7.37	NSA

Table 7-6 (Cont'd)

SITE ID		DG-1(+)	
FIELD ID		RDWAU*1	
S. DATE		19-sep-91	
DEPTH (ft)		28.0	
MATRIX	PQLs	CGW	HBN
UNITS	UGL	UGL	UGL
TAL Inorganics			
ALUMINIUM	141	89000	101500
ANTIMONY	30	[62.7]	10
ARSENIC	10	LT 2.54	50
BARIUM	20	972	1000
CALCIUM	500	120000	NSA
CHROMIUM	10	[107]	50
COBALT	70	[48.9]	0.35
COPPER	60	73.2	1295
IRON	38.1	124000	NSA
LEAD	10	[60.3]	50
MAGNESIUM	500	118000	NSA
MANGANESE	2.75	[6180]	3500
NICKEL	50	89.9	700
POTASSIUM	375	21100	NSA
SILVER	2	LT 0.25	50
SODIUM	500	8380	NSA
VANADIUM	40	201	245
ZINC	50	587	7000
Explosives			
24DNT	0.064	NT	0.05
26DNT	0.074	NT	0.051
HMX	1.21	NT	1750
TETRYL	NA	NT	NSA
Volatiles			
1,2-DICHLOROETHANE	5	NT	5
CARBON DISULFIDE	5	NT	4000
CHLOROFORM	5	NT	600
CHLOROMETHANE	10	NT	30
TOLUENE	5	NT	10000
Semivolatiles			
BIS(2-ETHYLHEXYL) PHTHALATE	10	NT	3
Semivolatile TICs			
CAPROLACTAM	NA	ND	NSA

Table 7–6 (Cont'd)

SITE ID		DG–1 (+)	
FIELD ID		RDWAU*1	
S. DATE		19–sep–91	
DEPTH (ft)		28.0	
MATRIX	PQLs	CGW	HBN
UNITS	UGL	UGL	UGL
Semivolatile TICs			
TOTAL UNKNOWN TICs	NA	ND	NSA
Other			
CHLORIDE	1000	NT	NSA
NITRITE,NITRATE	100	NT	10000
NITROGEN BY KJELDAHL METHOD	NA	NT	NSA
PHENOLICS (NON–SPECIFIC)	NA	NT	NSA
PHOSPHATE	NA	NT	NSA
SULFATE	NA	NT	NSA
TOTAL ORGANIC CARBON	1000	NT	NSA
TOTAL ORGANIC HALOGENS	1	NT	NSA
pH	NA	NT	NSA

Footnotes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.
C = Indicates that analysis was confirmed using a second column.
CGW = Chemical groundwater.
HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).
K = Indicates holding time for extraction and preparation was not met, but data quality is not believed to be affected.
LT = Concentration is reported as less than the certified reporting limit.
NA = Not available; PQLs are not available for TICs detected in the library scans.
ND = Analyte was not detected.
NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.
NT = Not tested; parameters were not tested (included) in the sample analyses.
PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.
S = Results are based on an internal standard; flag is used for TICs detected in library scans.
TAL = Target Analyte List.
TCLP = Toxicity Characteristic Leaching Procedure.
TICs = Tentatively identified compounds that were detected in the GC/MS library scans.
UGL = Micrograms per liter.
( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.
+ = Indicates that sample was analyzed for unfiltered TAL metals only.
[ ] = Brackets indicate that the detected concentration exceeds the HBN.

concentrations. As expected, the unfiltered samples contained higher concentrations of constituents than the corresponding filtered samples from the same well.

Several of the constituents detected, such as aluminum, calcium, iron, potassium, magnesium and sodium, can be characterized as naturally occurring inorganics. The concentrations of these metals are within the range that would be expected for groundwater in a karst environment containing carbonate and dolomite rocks.

Metals that were detected above HBN criteria were antimony, chromium, cobalt, lead and manganese but were limited to two unfiltered samples from upgradient wells D-4 and DG-1. All five metals were detected in the sample from well DG-1 while only chromium and lead were detected in the sample from well D-4. Generally, most of the elevated concentrations were approximately twice the HBN, but antimony and cobalt in the sample from DG-1 were nearly one to more than two orders of magnitude greater than the criteria. These metals are not related to SWMU 10 or SWMU 35 concentrations because the concentrations were detected in upgradient samples and represent source areas other than these SWMUs. These levels likely represent elements extracted from the aquifer soil and rock and may not reflect constituents transported in solution by groundwater.

With a few exceptions, concentrations of dissolved metals reported for filtered samples indicated similar groundwater quality upgradient and downgradient of SWMU 10. However, the results of samples D4, DG-1 and DDH4 indicated that upgradient groundwater may be slightly enriched in barium. Additionally, aluminum, copper, iron and zinc were absent in filtered upgradient samples but were detected in one or more downgradient groundwater samples. Lead, although detected in one upgradient sample (but at a level slightly greater than the detection limit), was detected at slightly elevated concentrations in two downgradient samples (i.e., D-3 and D-3D) as well. However, all metal concentrations for filtered samples are below HBN criteria and are not considered a concern.

HMX, 24DNT and 26DNT were the only explosives detected in the 1991 samples. HMX was present in all seven wells with the highest concentration reported in upgradient well DDH4; however, all values were at least two orders of magnitude below the HBN of 1,750 ug/l. The upgradient concentrations of HMX were greater than the downgradient concentrations except for well DDH2 which was greater than one of the upgradient samples (D-4). 26DNT was present in one sample collected from downgradient well DDH2. The detected concentration of 0.082 ug/l was close to the detection limit of 0.074 ug/l. Due to its suspected carcinogenicity, the HBN is very low, 8.051 ug/l, and any detections generally exceed the HBN. 24DNT was detected in two downgradient wells (10MW1 and D-3D), at concentrations (0.072 ug/l and 0.183 ug/l, respectively) which exceeded the HBN (0.05 ug/l).

In the 1990 samples, HMX was detected in each of the three wells sampled with the upgradient concentration also greater (10.1 ug/l) than the two downgradient samples (8.37 and 2.27 ug/l). Tetryl was detected only once in any sample collected in the study area, and this was in the 1990 groundwater sample from D-3 at 1.19 ug/l.

Five VOCs -- carbon disulfide, chloroform, chloromethane, 1,2-dichloroethane (12DCLE), and toluene -- were detected in the groundwater samples. No VOC concentration exceeded a HBN criterion. Carbon disulfide was present in each of the four downgradient samples but in none of the upgradient samples collected in 1991. However, all concentrations were three orders of magnitude less than the HBN criterion and are not considered a concern. Similarly, 12DCLE was only detected downgradient in samples from wells D-3D and DDH2. The concentrations, however, were below the HBN criterion. Chloroform was detected in all wells sampled. However, chloroform was detected in several laboratory method blanks, indicating that it is an artifact of the laboratory analyses. Chloromethane and toluene were detected in one downgradient sample (DDH2) and several upgradient well samples at low concentrations that did not exceed the HBN criteria for these VOCs.

One SVOC and one SVOC TIC were detected in downgradient sample D-3D. Although detected at a concentration greater than the HBN, the SVOC B2EHP is not considered a concern because it slightly exceeded the HBN criteria at a level below the PQL and was detected in one sample only. Caprolactum, a SVOC TIC, was tentatively identified and the concentration is an estimate based on an internal standard. The total concentration of unidentified TICs for each sample was reported. The highest concentration of TICs occurred in upgradient sample DDH4.

Several other water quality parameters were reported for the groundwater samples. Nitrogen, chloride, sulfate, total phosphorus, and total phenols were analyzed to establish the general groundwater quality in the study area. Except for phenol, these constituents were detected in both upgradient and downgradient wells. Nitrogen, chloride, and sulfate were generally detected at higher concentrations in the downgradient samples. Nitrite/nitrate concentrations of samples D-3, D-3D and DDH2, which are located directly downgradient of the Equalization Basin, exceeded the HBN criterion by factors of approximately two to four and may be a concern. Although no HBN criterion is available for sulfate, downgradient concentrations of sulfate were elevated above the background levels. The occurrence of nitrogen may be the result of the construction of SWMU 10 on an old nitrocellulose settling lagoon. The sulfate may be attributable to the migration of constituents from the calcium sulfate drying beds. Elevated total phosphorus samples, in comparison to downgradient concentration, indicated potential contaminant sources upgradient of SWMUs 10 and 35.

As discussed previously, the SWMU 10 area was the subject of a Virginia Department of Waste Management directed investigation (Dames & Moore, 1992). As part of this study, upgradient verses downgradient statistical comparisons of indicator parameters from groundwater samples was required. TOX, TOC, pH, and specific conductance were analyzed as indicators of groundwater contamination. Four replicate downgradient measurements from DDH2 were compared with four replicate upgradient measurements from DDH4 to determine if there has been a statistically significant increase in downgradient constituent levels. These data were used to assess the impact of activities at SWMU 10 on groundwater quality.

The statistical comparison was performed using the Student's T-Test at the 0.01 level of significance. A one-tailed test was used for all parameters except pH, since the concern was for significant increases over background. A two-tailed test was used for pH since both significant increases and decreases were of concern.

Cochran's Approximation to the Behrens-Fisher Student's T-Test, as described in Appendix 10.4 of the Virginia Hazardous Waste Management Regulations (VHMR), was used for the statistical calculations (VDWM, 1988). This method involved the calculation of the background (upgradient) and downgradient sample means and variances for each variable measured. The resulting statistics are used to estimate a sample population t-statistic (t^*) and compare it to a tabulated t-statistic (t_c) based on the standard normal deviate. If t^* is equal to or larger than t_c, the data would indicate that the downgradient water-quality parameter is not equal to that of the upgradient samples at an acceptable level of significance or risk (i.e., level of probability). The opposite conclusion would be reached if t^* is less than t_c. If the t^* value is negative (except for pH) then there is most likely no significant difference in the monitoring data and the background data. This comparison of t^* and t_c was performed for each indicator parameter.

For subsequent analysis of monitoring wells, such as in quarterly sampling, the statistical analysis should be performed not only on the background and the downgradient monitoring wells, but each set of quarterly data should be compared with earlier measurements (i.e., baseline data) from the same well to determine if there have been statistically significant changes in groundwater quality at each monitoring point.

As indicated in Table 7-7, TOX was determined to be statistically lower in the downgradient well; pH was calculated to be within the same range as the upgradient well. Both TOC and specific conductance were determined to show a statistically significant increase greater than background. This indicates that the downgradient well DDH2 contains more organic carbon and dissolved ionic constituents, which suggests a possible impact on the groundwater quality from activities at SWMU 10.

7.3.4 Surface Water

As presented in Table 7-8, surface water sample 10SW1 was collected from the Equalization Basin and as such, is expected to exhibit a high degree of contamination. This

TABLE 7-7
CALCULATION OF STUDENT'S T-TEST FOR GROUNDWATER SAMPLES IN THE VICINITY OF SWMU 10
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

		Upgradient Groundwater Measurements From Well DDH4						
Compound[1]	Units	Replicate 1	Replicate 2	Replicate 3	Replicate 4	n(b)	x(b)	s2(b)
TOC	ug/L	3420	3710	3310	3620	4	3515.00	33366.67
TOX	ug/L	208	250	199	198	4	213.75	604.25
Specific Conductance	umhos/cm	400	400	400	400	4	400.00	0.00
pH	--	6.84	7.02	6.97	7.17	4	7.00	0.02

		Downgradient Groundwater Measurements From Well DDH2						
Compound[2]	Units	Replicate 1	Replicate 2	Replicate 3	Replicate 4	n(s)	x(s)	s2(s)
TOC	ug/L	5080	6420	6550	6190	4	6060.00	449000.00
TOX	ug/L	79.1	115	148	93.5	4	108.90	897.07
Specific Conductance	umhos/cm	1180	1180	1160	1120	4	1160.00	800.00
pH	--	6.38	6.61	6.71	6.68	4	6.60	0.02

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[1] TOC = Total Organic Carbon
TOX = Total Organic Halogens

TABLE 7-7 (CONT'D)

CALCULATED t VALUES :

Analyte	t*	t(c)	Is t* > t(c) ?
TOC	7.33	((V19/R19*4.541)+(\	YES
TOX	−5.41	((V20/R20*4.541)+(\	No
Specific Conductance	53.74	((V22/R22*4.541)+(\	YES
pH	4.01	((V23/R23*5.841)+(\	No

EQUATIONS :

$$t^* = \frac{x(s) - x(b)}{(s2(s)/n(s) + s2(b)/n(b))^{0.5}}$$

Where :

t* = the calculated value of the t-statistic to be compared to t(c), the comparison t-statistic.
n(b) = number of background measurements
x(b) = background mean
s2(b) = background variance
n(s) = number of monitoring well area measurements
x(s) = monitoring sample mean
s2(s) = monitoring sample variance

$$t(c) = \frac{W(b)*t(b) + W(s)*t(s)}{W(b) + W(s)}$$

Where :

t(b) = t-value from standard t-table with [n(b)−1] degrees of freedom at the 0.01 level of significance.
t(b) = 4.541 for TOC, TOX, and specific conductance
t(b) = 5.841 for pH
t(s) = t-value from standard t-table with [n(s)−1] degrees of freedom at the 0.01 level of significance.
t(s) = 4.541 for TOC, TOX, and specific conductance
t(s) = 5.841 for pH
W(b) = s2(b)/n(b)
W(s) = s2(s)/n(s)

Table 7-8
Summary of Analytical Data For Surface Water Samples Collected At SWMU 10
Radford Army Ammunition Plant, Virginia

SITE ID		10SW1	
FIELD ID		RADW*5	
S. DATE		22-aug-90	
DEPTH (ft)		0.0	
MATRIX	PQLs	CSW	HBN
UNITS	UGL	UGL	UGL
TAL Inorganics			
BARIUM	20	210	1000
CHROMIUM	10	6.22	50
LEAD	10	[250]	50
SILVER	NA	4.97	NSA
Explosives			
24DNT	0.064	[1700]	0.05
HMX	1.21	2.98 C	1750
Volatiles			
CHLOROFORM	5	6.36	600
TOTAL UNKNOWN TICs	NA	(1)4000	NSA
Semivolatiles			
2-NITROANILINE	50	7.1	NSA
N-NITROSODIPHENYLAMINE	10	[51.3]	7
TOTAL UNKNOWN TICs	NA	(10)652	NSA

Footnotes:

C = Indicates that analysis was confirmed using a second column.

CSW = Chemical surface water.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TAL = Target Analyte List.

TICs = Tentatively identified compounds that were detected in the GC/MS library scans.

UGL = Micrograms per liter.

( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

sample contained four metals, two explosives, one VOC and two SVOCs. Of these, one metal, one explosive and one SVOC exceeded HBN criteria. Of the four metals detected (i.e., barium, chromium, lead and silver) only the concentration of lead exceeded the HBN criteria. The concentration of lead exceeded the HBN by a factor of five and may be a concern. Two explosives -- 24DNT and HMX -- were detected in this sample. The concentration of 24DNT was more than 30,000 times the HBN and may be a concern. NNDPA also exceeded the HBN by a factor of seven and may be a concern.

7.4 POTENTIAL MIGRATION OF CONTAMINANTS

The analytical data indicates that hazardous constituents have been detected in the SWMU 10 and SWMU 35 sediments, surface water, and groundwater. Extremely high concentrations of lead and 24DNT were detected in the Equalization Basin sediment and surface water. However, relatively low concentrations of basin constutuents were detected in the downgradient well samples. This incongruity between basin and groundwater contaminants suggests that contaminants may have been introduced at some other place in the treatment system or are due to some preexisting condition. It is also possible that concentrations of lead, 24DNT and 26DNT could be due to migration from SWMU 35, if a high groundwater mound forms in SWMU 35 or SWMU 8 which causes groundwater to flow beneath SWMU 10 (see Section 7.2.3).

Nitrogen (as nitrate and nitrite) exceeded the HBN in the downgradient wells. The occurrence of nitrogen in higher concentrations in the downgradient wells is thought to be related to the previous use of the area, prior to the construction of SWMU 10. The Equalization Basin was constructed on top of an old settling lagoon which contained nitrocellulose fines. The NC fines were reportedly removed prior to construction but residual nitrogen may have remained or already migrated from the lagoon to surrounding soils. The former presence of NC fines are likely the reason for the higher nitrate and nitrate levels and TOC readings in downgradient monitoring wells. Nitrocelluous is a nitrated natural organic which can release nitrogen and organic carbons to the groundwater.

Similarly, sulfate is expected to contribute to the higher specific conductance measurements recorded for downgradient samples. The occurrence of sulfate is probably from the migration of sulfate from SWMU 35, Calcium Sulfate Drying Bed.

A comparison of the data for surface water and sediment samples from the Equalization Basin indicated that contaminants in the surface water influent are concentrating in the sediments of the basin. The data from sediment samples from the Calcium Sulfate Drying Bed are similar to the types of constituents detected in the SWMU 10 sediment sample. This is to be expected since sludge removed from SWMU 10 was reportedly placed in the drying bed.

Previous EP Toxicity and TCLP data for basin sludge samples indicates that hazardous levels of contaminants are not expected to migrate from the sludge since none of the regulatory criteria were exceeded. Based on the previous TCLP data, the sludge would not be considered hazardous waste, but because the sludge contains a K001 listed waste, it would be regulated as hazardous. However, additional TCLP data collected by Dames & Moore indicated that leachable lead in the basin sludge exceeded the criteria, resulting in classification as a hazardous waste. Groundwater data from downgradient wells indicate that the lead is not migrating from the basin at levels exceeding the HBN criterion.

Constituents detected in the groundwater are expected to migrate both horizontally and vertically within the soil and bedrock sections of the unconfined aquifer. Horizontal migration of constituents will most likely result in the discharge of constituents to the New River located north of the site. The analytical data also indicated that vertical migration of constituents has occurred based on constituents detected in a sample from the well installed deeper into the aquifer (D-3D). Except for nitrogen, the majority of constituents are less than HBNs and continual migration is expected to result in further dilution.

Due to the nature of the limestone aquifer and the possibility of solution cavities, there may be rapid transport pathways, which could result in an erratic movement of contaminants. However, none of these cavities were encountered during drilling operations, and contaminants within the deeper bedrock section of the unconfined aquifer are expected to discharge to the New River.

7.5 BASELINE RISK ASSESSMENT

Based on the contamination assessment presented in Section 7.3, only one potential contaminant of concern--lead--has been identified for soil samples collected from the surface layer south of SWMU 10. Potential contaminants of concern for sediment of the Bio-Plant Equalization Basin are lead, 24DNT, and NNDPA. Potential contaminants of concern for sediment of the Calcium Sulfate Drying Bed are lead and 24DNT. Contaminants of concern for groundwater downgradient of SWMUs 10 and 35 include 24DNT, 26DNT, nitrate/nitrite, and sulfate. Although antimony, chromium, cobalt, lead, and manganese were detected at elevated levels in unfiltered groundwater samples, these samples were collected upgradient of SWMUs 10 and 35, and therefore are not considered potential contaminants of concern for SWMUs 10 and 35. Contaminants of concern for the surface water sample collected from near the wastewater inlet in the Equalization Basin include lead, 24DNT, and NNDPA. The potential impact of these contaminants to human health and the environment is discussed below in Sections 7.5.1 and 7.5.2, respectively.

7.5.1 Human Health Evaluation

No groundwater wells other than for monitoring purposes are located downgradient of SWMUs 10 and 35. Groundwater in the vicinity of SWMUs 10 and 35 generally flows northward toward the New River and most likely discharges to the river. Therefore, shallow groundwater would not likely migrate toward any groundwater users in the vicinity of RAAP. As discussed in Section 2.5, future land use is considered to be similar to the current land use scenario--i.e., RAAP will continue to remain an active army installation and there are no plans for future residential development of RAAP. Therefore, it is highly unlikely that groundwater wells would be installed in the future between SWMUs 10 and 35 and the New River. Based on this evaluation, potential groundwater exposure pathways are not considered operable under the current or future land use scenario.

As discussed above, there is the potential for discharge of groundwater contamination to the New River. Persons boating, fishing, or swimming in the river could potentially be exposed to contaminants migrating from SWMUs 10 and 35 via shallow groundwater. In addition, a drinking water intake is located 6 miles downstream of RAAP. However, due to the fact that potential contaminants of concern were detected at a maximum of only four times their respective HBNs, along with the significant dilution capacity of the river (1,000,000 times), potential exposure from SWMUs 10 and 35 is considered negligible. Therefore, these potential exposure pathways are not considered significant.

The two soil samples collected just south of SWMU 10 contained elevated levels of lead (>5,000 ug/g). Potential soil exposure routes typically include incidental ingestion, inhalation, and dermal absorption of soil contamination. Because access to RAAP is strictly controlled, and recreational activities do not occur in the vicinity of SWMU 10, direct contact with the soil and subsequent ingestion and dermal absorption of soil contaminants is not expected to occur on a regular basis. Although workers may presumably contact this soil, worker activity in this area is expected to be infrequent. Therefore, the incidental ingestion and dermal absorption of soil contaminants pathways are not considered significant.

Because lead was detected at an elevated level in surface soil, there is the possibility of contaminated dust to become airborne and for workers in the vicinity of SWMU 10 and SWMU 35 to be exposed via inhalation of contaminated dust. The areal extent of lead contamination in this area is unknown. However, lead was detected at elevated levels in both surface soil samples, as well as in a sample collected west of the Bio-Plant building, indicating that there may be widespread lead contamination. SWMU 10 is currently active and maintenance men regularly visit the Bio-Plant; however, only a limited amount of time is spent outdoors. Although the area is partly grassy, contaminated dust may become airborne via wind erosion or due to truck traffic in the area. Although workers' exposure may be daily, the exposure period would likely be only a small fraction of the workday, resulting in a low to moderate exposure.

An evaluation of the potential for toxic effects upon inhalation exposure to lead indicates that inhalation exposure to lead is associated with neurological and hematological effects. Adverse hematological effects in children occur at blood levels of 10 to 15 micrograms per deciliter (ug/dl), and possibly lower (USEPA, 1991d). Irreversible chronic neuropathy, characterized by decreased glomerular filtration rates, interstitial fibrosis, mitochondrial changes, and azotemia, is sometimes found in chronically exposed workers with blood lead levels of 40 to 60 ug/dl (USEPA, 1991d). Because lead has no known toxicity threshold, EPA has not calculated reference doses (RfDs) for lead exposure (USEPA, 1992a); instead EPA has developed an uptake biokinetic (UBK) model for assessing exposure to lead (see Appendix D). Although lead is classified as a B2 carcinogen, inhalation carcinogenicity studies present conflicting data (USEPA, 1992a).

The UBK model is used to estimate total lead uptake (ug/Pb day) in children (0 to 6 years old) and to predict a corresponding blood lead level (ug Pb/dl). This model only calculates lead uptake for children and is thus only applicable to a residential land use scenario, whereas at RAAP we are concerned with a worker exposure scenario. Furthermore, the UBK model estimates total lead exposure based on inhalation, ingestion of soil, ingestion of groundwater, and dietary uptake. The primary operable exposure pathway for workers at SWMU 10 is via inhalation of dust. Therefore, only a qualitative assessment of the potential hazard resulting from lead exposure to workers can be conducted.

To conduct a qualitative evaluation of the potential hazard resulting from lead exposure to workers, preliminary cleanup criteria are calculated for lead using the UBK model (residential land use scenario). These preliminary cleanup criteria are then compared to the concentrations detected in site soil, taking into consideration the decreased exposure period and pathways for workers. EPA (1991d) has identified blood lead concentrations of 10 to 15 ug/dl as levels of concern for adverse effects in children. Based on application of the UBK model, a cleanup range of 200 to 500 mg/kg is identified for potential residential exposure to lead. At a soil concentration of 200 mg/kg Pb, >99.8 percent of an exposed sensitive population (young children) would be expected to have blood lead levels of less than or equal to 10 ug/dl. At a soil concentration of 500 mg/kg Pb, >92 percent of young children would be expected to have blood lead levels of less than or equal to 10 ug/dl and >99.4 percent of the children would have blood lead levels of less than or equal to 15 ug/dl. Although lead was detected in surface soil samples at concentrations of >5,000 mg/kg, which are more than an order of magnitude above the residential criteria, the exposure period for workers is much less than residential exposure an the primary operable exposure pathway is inhalation (the UBK model estimates total lead exposure based on inhalation, ingestion of soil, ingestion of groundwater, and dietary uptake). The reduced exposure period and the presence of only one exposure pathway for a less sensitive population (onsite workers) is expected to result in blood lead concentrations less than levels of concern for adverse effects. Therefore, the potential hazard to workers resulting from inhalation exposure to lead contaminated soil is estimated to be low.

The sediment/surface water samples were collected from within the Equalization Basin and the Calcium Sulfate Drying Bed. There are no potential human receptors to the sediment/surface water within these basins, except for workers who may occasionally contact the sediment/surface water during cleaning operations. Workers would presumably wear protective equipment (i.e., gloves) and exposure is expected to be infrequent. Because the Equalization Basin contains surface water, the potential for contaminated sediment to become airborne and subsequently inhaled is not considered a viable migration pathway. The Calcium Sulfate Drying Bed may contain surface water during periods of heavy rain and surface runoff; otherwise it is usually dry. However, because the surface is compacted and cracked and very little loose soil is present, the potential for contaminated sediment to become airborne and subsequently inhaled is negligible. Therefore, exposure to contaminants in the sediment/surface water is expected to be insignificant.

As discussed in Section 2.5, future land use is considered to be similar to the current land use scenario--i.e., RAAP will continue to remain an active army installation and there are no plans for future residential development of RAAP. Thus, potential future exposure is assumed to be similar to potential current exposure.

7.5.2 Environmental Evaluation

Aquatic life is not present in the Equalization Basin; therefore, potential impacts to aquatic life are not considered for the surface water/sediment sample collected from this area. Although, the Equalization Basin and Calcium Sulfate Drying Beds are not fenced in and wildlife may have access to the area and the surrounding soil, there is a fence between the SWMU 10 and SWMU 35 area and the river bank, thereby precluding wildlife access via the river bank. The nearby road is used often and it is unlikely that wildlife would frequent the area. Therefore, potential exposure of environmental receptors to the surface water/sediment contamination in the Equalization Basin and Calcium Sulfate Drying Beds, and soil contamination in the surface soil appears to be minimal.

As discussed above, there is the potential for discharge of groundwater contamination to the New River, which could potentially impact aquatic life. Although data are insufficient for establishing aquatic life criteria for 24DNT and 26DNT, the lowest observed effect level (LOEL) for chronic effects to freshwater aquatic life is reported as 230 ug/l (USEPA, 1986). Because the maximum detected concentration in site groundwater is 0.082 ug/l of 26DNT, and significant dilution is expected to occur upon discharge to the New River, the low detections of 24DNT and 26DNT in site groundwater do not appear to be of environmental concern.

Ambient Water Quality Criteria (AWQC) are not available for nitrate/nitrite or sulfate. However, because of the significant dilution that is expected to occur upon discharge to the New River, the impact to aquatic life due to the detection of nitrate/nitrite and sulfate in site groundwater and subsequent discharge to the New River is expected to be low.

7.5.3 Conclusions of the Human Health and Environmental Evaluation

Although 24DNT, 26DNT, nitrate/nitrite, and sulfate were detected at elevated levels in SWMU 10 and 35 groundwater, the detection of these constituents in groundwater does not appear to present a current or potential future human health risk or environmental threat. The lack of groundwater receptors and the fact that significant dilution would occur upon discharge of groundwater to the New River, would result in negligible exposure.

Exposure to workers via inhalation of lead contaminated dust generated from the new RBC area is a complete exposure pathway. The potential exposure and hazard are estimated to be low to moderate.

Although elevated concentrations of lead, 24DNT, and NNDPA were detected in surface water and sediment of the Equalization Basin and Calcium Sulfate Drying Bed, it is unlikely that human and environmental receptors would directly contact the surface water and sediment, except possibly on an infrequent basis. It is also not likely that contaminated sediment in these areas would become airborne. Therefore, these exposure pathways are not considered significant.

7.6 CONCLUSIONS

The SWMU 10 and SWMU 35 investigation has provided chemical data useful for defining the extent and magnitude of sediment, surface water, and groundwater contamination from the Bio-Plant Equalization Basin. Additionally, the results of the monitoring well program have been used to define the hydrogeologic properties of the subsurface. These investigations have led to the following conclusions:

- Approximately 20 feet of unconsolidated sediments underlie the study area and overlay the limestone/dolostone Elbrook Formation.
- Groundwater is present approximately 15 feet below the basins within sandy sediments and flows northward towards the New River at a velocity of 19 to 127 feet per year.
- The groundwater table does not appear to be physically affected (mounding, change in flow direction) by the SWMU 10 basin.
- The unconfined aquifer below the SWMU 35 basin is affected by infiltration of surface run-on, causing a groundwater mound. This mounding, along with a likely mounding effect due to SWMU 8 east of SWMU 35, alters the usual

groundwater flow direction from generally northward (to the New River) to the northwest and possibly under SWMU 10. Contaminants present in the sediments of SWMU 35 are not restricted from entering the unconfined aquifer and migrating with the groundwater.

- Three contaminants were detected in the SWMU 10 basin sediment at concentrations greater than permit-specific HBNs and background concentrations--lead, NNDPA, and 24DNT.
- Similar constituents were detected in the SWMU 10 basin water but only lead, 24DNT, and NNDPA exceeded HBNs.
- Two contaminants were detected in SWMU 35 sediment-- lead, and 24DNT-- at concentrations which exceeded HBNs and background concentrations.
- TCLP data from the Bio-Plant Equalization Basin sludge indicate that leachable lead exceeds the regulatory limit. Because the sludge is a TCLP characteristic waste and contains K044 regulated waste, the sludge, if removed, would be treated as a hazardous waste and would require subsequent disposal or treatment, as such.
- Five metals--antimony, chromium, cobalt, lead, and manganese--were detected in groundwater samples at concentrations above HBNs, but only in unfiltered upgradient samples. Two explosives--24DNT and 26DNT--exceeded HBNs in three downgradient well samples, but only one exceedance occurred in each sample.
- The groundwater data collected from the study area indicate that contaminants may not be migrating from the basin but rather may be leaching out of SWMU 35 sediment and migrating to the SWMU 10 wells. A comparison of upgradient and downgradient groundwater data suggests that several contaminants were detected at higher concentrations in upgradient wells. The sludge burial trenches between the road and the railroad tracks

south of SWMU 10 are the likely off-site source for the detected upgradient contamination.

- Nitrogen (as nitrate and nitrite) exceeded the HBN of 10,000 ug/l in downgradient wells. The occurrence of nitrogen is suspected to be related to the former use of the area as a NC settling pond prior to construction of the Equalization Basin. The NC fines were reportedly removed prior to construction but residual nitrogen may have remained or migrated to the surrounding soil.
- The former presence of NC fines are thought to be the reason for the higher nitrogen (as nitrate and nitrite) concentrations and TOC readings in the downgradient wells. Similarly, the elevated sulfate levels in downgradient wells are suspected to result in the higher downgradient conductivity reading. The sulfate in the downgradient wells may be attributable to SWMU 35, the Calcium Sulfate Drying Bed. Calcium concentrations also were noted to be higher in the eastern downgradient well (DDH2) located nearer to SWMU 35. The TOC and specific conductance were determined to be statistically elevated in a t-test comparison of background (upgradient) and downgradient monitoring well data. TOX and pH were determined not to be statically different from background data.
- An evaluation of the chemical data and the statistical assessment of the indicator parameters suggests that degradation of groundwater downgradient of SWMU 10 has occurred. However, the Equalization Basin is not considered to be the source of the contamination because the groundwater chemistry does not coincide with the contaminants detected in the basin sludge and surface water.
- The groundwater degradation is most likely the result of: an upgradient offsite source; the former use of the SWMU 10 basin area as a NC settling lagoon; and the sediments in SWMU 35, Calcium Sulfate Drying Bed.

- If groundwater in the immediate vicinity of the site were ingested, then a potential unacceptable risk would be present. However, there are no current downgradient groundwater uses, and, given the industrial use of the facility, there are not expected to be any future users. Therefore, this pathway is not considered to be operable. Shallow groundwater in the vicinity of SWMU 10 and SWMU 35 flows toward the New River and would not likely migrate toward any groundwater users in the vicinity of RAAP.
- Persons boating, fishing, or swimming in the river could potentially be exposed to contaminants migrating from the study area via shallow groundwater. However, due to the significant dilution capacity of the river, potential exposure is considered minimal.

7.7 RECOMMENDED ACTION

The available information indicates that leakage from the SWMU 10 Equalization Basin may not be the source of downgradient groundwater contamination. Nitrate contamination from a NC settling lagoon present in the soil prior to construction of the Equalization Basin appears to have adversely impacted the groundwater. The data also indicate that an adverse impact to the groundwater from two explosives and sulfate downgradient of SWMU 10 may be due to migration of contaminants from SWMU 35 immediately east of SWMU 10. Groundwater upgradient of SWMU 10 has been adversely impacted (metals and HMX) from an off-site source, possibly the sludge burial area located in the vicinity of the upgradient wells.

The baseline risk assessment of human health and environmental concerns indicates that since there are no current nor anticipated future groundwater uses in the vicinity at SWMU 10 and SWMU 35, exposure to contaminated groundwater should not be of concern.

The groundwater upgradient and downgradient of SWMU 35 was not specifically sampled as part of the VI program, and the lack of these data prevent a complete evaluation of the study area. It is recommended that the upgradient (D-2) and downgradient (D-5) wells for SWMU 35 be added to the Virginia Department of Waste

Management (VDWM) quarterly monitoring program for SWMU 10. Parameters recommended for the quarterly monitoring would be those found to be of concern--chromium, lead, explosives, nitrogen, TOC, TOX, and sulfate. Even though filtered metals samples had no exceedances of HBNs, it is recommended that filtered and unfiltered samples be analyzed for lead and chromium. The results of this sampling should be evaluated to better define the magnitude of contamination in the groundwater.

Since there are no imminent threats to human health or the environment, no emergency corrective measures are recommended. However, the sediment in SWMU 35 appears to be a source of groundwater contamination and should be removed or immobilized to prevent further releases.

An investigation should be performed in the area upgradient of SWMU 10 and SWMU 35 to determine if the source of groundwater contaminants detected in upgradient wells is due to the sludge burial trenches and to evaluate the potential extent and magnitude of possible soil contamination.

The seven wells associated with SWMU 10 were surveyed as part of the VI, but the other wells associated with SWMU 35 and SWMUs 8 and 36 were not included in that survey. The historical survey data for these wells should be confirmed and made compatible with the new SWMU 10 well surveying data.

8.0 VERIFICATION INVESTIGATION OF SWMU 26, FLY ASH LANDFILL NO. 1

8.1 SWMU 26 BACKGROUND AND INVESTIGATION PROGRAM

8.1.1 SWMU History

SWMU 26 is a closed, unlined landfill originally called Fly Ash Landfill (FAL) No. 1, located in the south-central section of the Horseshoe Area, about 600 feet northeast of the main bridge over the New River (Figure 8-1). It is situated on the north slope of an east-west trending ridge that rises more than 170 feet above the river. The highest point on the landfill has an elevation of more than 1,850 feet msl. The landfill was formed by excavating a deep, flat-bottomed pit, primarily into the north sloping portion of the ridge (USACE, 1981). The unit is approximately 1,100 feet long and 200 to 250 feet wide.

Fly ash disposal at SWMU 26 began in 1971 (USATHAMA, 1984). Prior to 1971, fly ash was discharged directly to the New River. The Virginia Department of Health granted a solid waste management (groundwater) permit (Permit No. 399) to operate the landfill in April 1983. As per the permit, the landfill is currently monitored quarterly as a solid waste disposal unit. The permit specified that the landfill could receive "fly ash and bottom ash wastes from powerhouses 1 and 2 on the plant premises." This permit did not allow the disposal of asbestos or hazardous waste at the landfill. However, in addition to fly ash, unknown quantities of calcium sulfate sludge (from SWMUs 36, 37, and 38) and asbestos were reportedly disposed of in the landfill (USEPA, 1987). During the active life of the unit, 60 to 100 tons/day of fly ash were reportedly disposed of in the landfill (USATHAMA, 1984). The landfill reached capacity and was closed in mid-1985.

8.1.2 Previous Investigations

In 1980, seven monitoring wells and one boring were completed around SWMU 26 as part of a hydrogeologic evaluation of four SWMUs at RAAP (USACE, 1981). In 1988, one well (CTM-1) and one boring (CTM-12) were completed near SWMU 26 as part of a landfill siting investigation (CTM, 1988). Well and boring locations are presented on Figure 8-1.

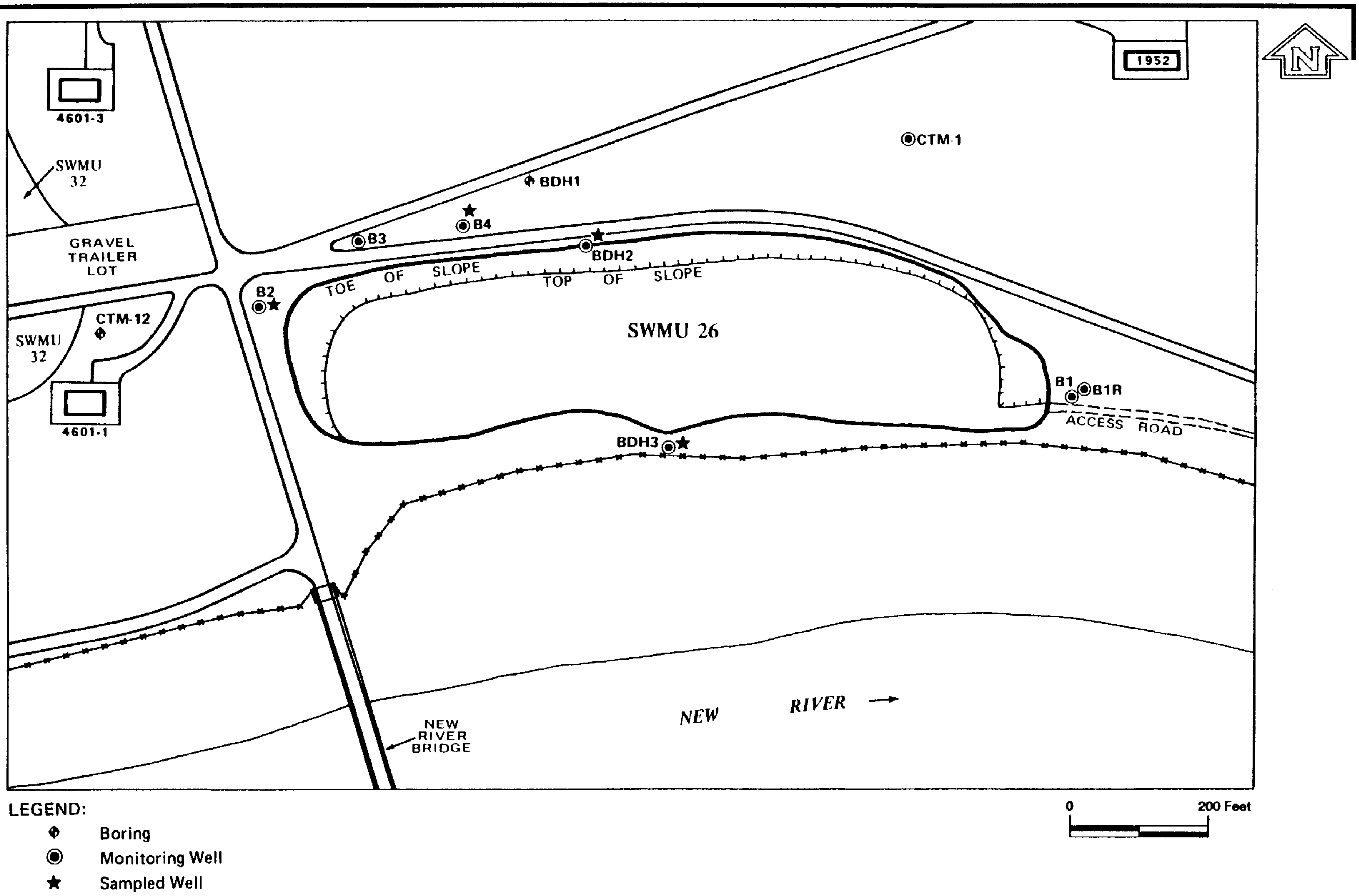

FIGURE 8-1
LOCATION MAP
SWMU 26 – FLY ASH LANDFILL No. 1
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Dames & Moore

Analyses on samples collected from four of the monitoring wells indicated that groundwater quality at the landfill, as indicated by TDS, was below the Secondary Drinking Water Standard of 500 mg/l. TDS ranged from 265 to 480 mg/l in the four samples collected from wells at the SWMU.

Review of the analyses performed for characterizing inorganic constituent concentrations suggested that water quality impacts from the landfill were minimal. Samples from one downgradient well (B-4) exhibited fluoride levels above the recommended drinking water standards. However, samples from the upgradient well (B1R) showed both fluoride and iron concentrations to be above these same standards.

The organics detected during the 1981 sampling include 4-nitrophenol; chlorinated solvents such as chloroform and methylene chloride; plasticizers such as bis (2-ethylhexyl) phthalate, di-n-butyl phthalate, and butyl benzyl phthalate; and volatile organics including benzene and toluene. All organics, except methylene chloride (a typical laboratory artifact), were found at levels near or below the available accepted drinking water and ambient water quality standards. The data were determined to be inadequate to determine whether a direct relationship existed between the source of these organic contaminants and the landfill.

8.1.3 VI Program

There are currently eight monitoring wells in the vicinity of SWMU 26 (Figure 8-1). These wells were installed during the 1980 and 1988 investigations of the unit. Available well construction details for existing wells are provided in Appendix E. It was proposed in the VI Work Plan that four of these wells--B2, CTM-1, and BDH1 (downgradient) and BDH3 (upgradient)--be inspected to determine whether they are suitable for sampling. If a well was not suitable for any reason, another appropriate well was substituted with USATHAMA approval. Because BDH1 was identified as an existing boring in the field and CTM-1 was found to be dry, wells B-4 and BDH2 were substituted with USATHAMA approval. The four selected wells were sampled and analyzed for metals, VOCs, SVOCs, TOC, TOX, and pH.

8.2 ENVIRONMENTAL SETTING

8.2.1 Topography

SWMU 26 is a sloping plateau with a steeply sloping north side located in the south central section of the Horseshoe Area, about 600 feet northeast of the main bridge over the New River. It is situated on the north slope of an east-west trending ridge that rises about 170 feet above the river. The ground surface of the SWMU slopes from a maximum elevation of 1,850 feet msl at the southeastern end of the SWMU to 1,770 feet msl at the northwestern end. The SWMU itself is a large grassy field with an unimproved road on the southern boundary which leads to three monitoring wells. SWMU 26 is bordered on the south by a tree covered ridgeline which then slopes southward to the New River. At the bottom of the slope to the north are several asphalt roads trending east to west. Between these roads is a small grassy area which turns into a tree covered area approximately 300 feet east of their intersection. Located approximately 100 feet to the west is a gravel trailer lot with SWMU 32 located west of this lot. Explosives storage buildings are located a few hundred feet west, north and east of SWMU 26.

8.2.2 Geology and Soils

Soil and rock borings completed at and near SWMU 26 indicated the presence of two major lithologic units--unconsolidated sand and gravel with some clay lenses overlying limestone/dolostone bedrock.

The unconsolidated deposits consist primarily of fine- to coarse-grained, yellowish-brown sand that varies between 30 to 86 feet in thickness at borings B-4 and B1R, respectively. Several major lenses of large cobbles (river jack) are found throughout the unit. An areally extensive clay unit was encountered above the sand in borings completed to the north of the landfill. The material is characterized as a silty-to-gravelly, red-brown, plastic clay that may represent a talus-type deposit from the highland area to the south. The clay unit appears to have been removed from the landfill during construction.

Underlying the sand and gravel unit is the gray limestone/dolostone of the Elbrook Formation. The unit is highly fractured and fragmented with breccia, vugs, and solution channels, but may be massive for short intervals. Many of the fractures have been totally or partially filled with calcite, and many others have been filled with clay and fine sand. Borings were completed as much as 62 feet into the limestone/dolostone bedrock.

Thirty-four field and laboratory permeability tests were conducted by USACE to determine the ability of the earth material at FAL No. 1 to transmit fluids. The unconsolidated material exhibits an average permeability of 4.06×10^{-3} cm/sec, with a range between 2.8×10^{-6} and 1.09×10^{-2} cm/sec. The lower permeabilities (2.8×10^{-6} cm/sec and 1.3×10^{-5} cm/sec) were found in the clay lenses of the unit. Average permeability of the sand and gravel sections of the unit is 6.62×10^{-3} cm/sec, with a range between 3.00×10^{-4} and 1.09×10^{-2} cm/sec. The results of in situ permeability tests performed on the limestone/dolostone indicated an average permeability of 2.85×10^{-5} cm/sec.

Considering the high level of fracturing encountered in the limestone beneath SWMU 26, it can likely be assumed that there are open channels in the rock through which fluids flow with virtually no restrictions. In these flow channels, permeability could be considered to be almost limitless.

Three CEC tests were performed by USACE on selected samples of the unconsolidated material at FAL No. 1. All samples tested were silty-to-sandy in nature and exhibited a CEC between 6.1 and 10.7 meq/100 gm of soil.

8.2.3 Groundwater Conditions

The water table at the SWMU 26 Area is found within the limestone/dolostone bedrock from 73 to 81 feet below land surface (except at well B1R, where the depth to water is 132 feet). As shown on Insert 2, the water table should slope both north and south away from the east-west ridge immediately south of SWMU 26. Groundwater beneath SWMU 26 appears to be mounded under the ridgeline and the southernmost section of the landfill. Because of this, well BDH3 may not be a true upgradient well. If BDH3 is not an upgradient well, then no upgradient well location is possible for this site. The groundwater table elevations decrease rapidly to the north with the water level in well B-4 at only a slightly greater elevation than the elevation of the New River. This suggests that the karst development of the bedrock is very mature in this part of the Horseshoe Area.

8.2.4 Surface Water Drainage

Based on topography, surface water runoff is expected to flow northwest following the topography and then into drainage ditches along the central north-south road for approximately 2,400 feet before discharging into the New River north of the Horseshoe Area. According to RAAP utility maps, there are no manholes, catch basins, or storm drains located in the immediate vicinity of SWMU 26.

8.3 CONTAMINATION ASSESSMENT

The field investigation at FAL No. 1 included the chemical analyses of four groundwater samples collected from one well south (BDH3) and three wells north (B2, B4 and BDH2) of the landfill. The four wells that were installed as part of a previous investigation were constructed to intercept groundwater in the first water-bearing formation below the site. The results of the chemical analyses indicated that low concentrations of metals, VOCs and SVOC TICs were present in the groundwater sample collected from well BDH3, indicating the migration of contaminants southward. Several metals, one VOC TIC, one SVOC and several unknown SVOC TICS were detected in samples collected from wells north of the landfill. However, a concentration of only one SVOC in these samples exceeded the HBN criteria. The results of the chemical analyses are presented in Table 8-1.

In total, nine metals were detected in the four groundwater samples collected at SWMU 26. Of these nine metals, mercury was detected only in sample BDH3; however, it was reported at a level slightly greater than the analytical detection limits but below the PQL and HBN. Barium, calcium, magnesium, potassium, and sodium were detected above their PQLs in all four well samples. Copper and lead were detected in various wells but below their PQLs. Manganese was detected in two northern wells above the PQL. Concentrations of all metals were less than applicable HBN criteria and are not considered a concern.

Table 8-1
Summary of Analytical Data For Groundwater Samples Collected At SWMU 26
Radford Army Ammunition Plant, Virginia

SITE ID		B2	B4	BDH2	BDH3	
FIELD ID		RDWC*62	RDWC*63	RDWC*60	RDWC*61	
S. DATE		12-feb-92	18-feb-92	19-feb-92	11-feb-92	
DEPTH (ft)		87.0	87.0	88.3	100.0	
MATRIX	PQLs	CGW	CGW	CGW	CGW	HBN
UNITS (#)	UGL	UGL	UGL	UGL	UGL	UGL
TAL Inorganics						
BARIUM	20	21.9	47.7	31.3	29.4	1000
CALCIUM	500	69800	100000	61400	111000	NSA
COPPER	60	LT 8.09	LT 8.09	9.66	LT 8.09	1295
LEAD	10	2.82	LT 1.26	1.52	1.84	50
MAGNESIUM	500	34400	47000	30400	57500	NSA
MANGANESE	2.75	LT 2.75	2.93	7.39	LT 2.75	3500
MERCURY	2	LT 0.243	LT 0.243	LT 0.243	0.434	2
POTASSIUM	375	2070	2640	2040	2470	NSA
SODIUM	500	1950	16400	3120	13600	NSA
Volatiles						
1,1-DICHLOROETHYLENE	5	LT 0.5	LT 0.5	LT 0.5	2.83	7
CARBON DISULFIDE	5	LT 0.5	LT 0.5	0.782	2.49	4000
TOLUENE	5	0.794	LT 0.5	LT 0.5	1.86	10000
TRICHLOROFLUOROMETHANE	5	LT 1.4	LT 1.4	LT 1.4	17	10000
Volatile TICs						
FREON	NA	ND	ND	ND	20 S	NSA
Semivolatiles						
BIS(2-ETHYLHEXYL) PHTHALATE	10	[20.9]	LT 4.8	LT 4.8	LT 4.8	3
Semivolatile TICs						
2-BUTOXYETHANOL	NA	7 S	ND	ND	ND	NSA
CYCLOPENTANONE	NA	6 S	ND	ND	ND	NSA
TOTAL UNKNOWN TICs	NA	(18)1020	(7)93	ND	(7)65	NSA

Table 8-1 (Cont'd)

SITE ID		B2	B4	BDH2	BDH3	
FIELD ID		RDWC*62	RDWC*63	RDWC*60	RDWC*61	
S. DATE		12-feb-92	18-feb-92	19-feb-92	11-feb-92	
DEPTH (ft)		87.0	87.0	88.3	100.0	
MATRIX	PQLs	CGW	CGW	CGW	CGW	HBN
UNITS (#)	UGL	UGL	UGL	UGL	UGL	UGL
Other						
TOTAL ORGANIC CARBON	1000	21300	3310	2280	1470	NSA
TOTAL ORGANIC HALOGENS	1	96.4	35.1	56.9	43.3	NSA
pH	NA	7.45	7.24	6.96	7.17	NSA

Footnotes:

CGW = Chemical groundwater.
HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).
LT = Concentration is reported as less than the certified reporting limit.
NA = Not available; PQLs are not available for TICs detected in the library scans.
ND = Analyte was not detected.
NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.
PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.
S = Results are based on an internal standard; flag is used for TICs detected in library scans.
TAL = Target Analyte List.
TICs = Tentatively identified compounds that were detected in the GC/MS library scans.
UGL = Micrograms per liter.
( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.
[ ] = Brackets indicate that the detected concentration exceeds the HBN.

Low concentrations of four VOCs and one VOC TIC were reported for the sample collected from BDH3, indicating that contamination has impacted groundwater south of the landfill. Only one detected VOC exceeded the PQL, trichlorofluoromethane in BDH3. Two of the same VOCs, carbons disulfide and toluene, were detected in northern well samples BDH2 and B2 but at trace concentrations slightly greater than the analytical detection limits and less than in sample BDH3. VOC concentrations for all samples, however, were less than the HBN criteria and are not considered a concern. Bis(2-ethylhexyl) phthalate (B2EHP), a SVOC plasticizer used at RAAP, was detected in the well B2 sample at a concentration nearly seven times the HBN criterion, but only twice the PQL; however, B2EHP was determined to be a laboratory artifact related to sampling and analysis. The maximum concentration of B2EHP in the method blanks analyzed was approximately five times the concentration detected in the well B2 sample. Toluene and B2EHP were the only organic constituents identified in this and previous analyses of groundwater samples for SWMU 26. For this round of sampling, estimated concentrations of SVOC TICs were reported for only one sample (B2). Unknown SVOC TICs were reported in groundwater samples collected north and south of the landfill. The sample from well B2 provided the greatest number and concentrations of SVOC TICs--18 unknown constituents with a combined concentration of 1,020 ug/l. The elevated TOC and TOX levels for the well B2 sample may reflect the detected concentrations of SVOC TICs. Although increased slightly in the northern direction, TOC and TOX concentrations for the three wells were comparable.

8.4 CONCLUSIONS

The VI at SWMU 26 involved the chemical analysis of four groundwater samples. Low concentrations of metals, VOCs, and SVOC TICs were detected in the groundwater. The concentrations of the detected constituents were usually below the PQL and always below the HBN criteria, except for the HBN exceedance for B2EHP in one sample (B2). B2EHP was determined to be a laboratory artifact related to sampling and/or analysis procedures because B2EHP in the method blank was detected at levels five times the level found in sample B2. The results of the investigation indicate that present concentrations of the metals, VOCs, and SVOC TICs are not likely to be a concern to human health and the environment as based on available HBNs. The locations of the sampled wells were adequate to detect the maximum concentrations of contaminants which may be migrating from the landfill.

8.5 RECOMMENDED ACTION

Based on the field investigation results, the groundwater quality does not appear to be of concern and future concentrations are not expected to be greater than when sampled. No corrective measures are needed and an RFI is not recommended.

Note: This section was revised August 19, 1994 under separate cover

9.0 VERIFICATION INVESTIGATION OF SWMU 27, CALCIUM SULFATE LANDFILL, SWMU 29, FLY ASH LANDFILL NO. 2 AND SWMU 53, ACTIVATED CARBON DISPOSAL AREA

9.1 SWMU 27, SWMU 29, AND SWMU 53 BACKGROUND AND INVESTIGATION PROGRAM

SWMUs 27, 29, and 53, as identified for a VI in the RCRA Permit, occupy the same location. SWMU 27 and SWMU 53 were small disposal areas that were covered with SWMU 29 when operations began at this SWMU after the closure of Fly Ash Landfill No. 1 (SWMU 26). In accordance with provisions in the permit that allow the grouping of SWMUs for investigation, these three SWMUs have been considered as one area for investigation (Figure 9-1).

9.1.1 SWMU Histories

The Calcium Sulfate Landfill (SWMU 27) is a closed, unlined earthen landfill located in the southeastern section of the Horseshoe Area. It is located within the boundary of Fly Ash Landfill No. 2 (SWMU 29). The landfill was used for disposal of calcium sulfate sludge during 1981 and 1982. The landfill has been described as triangular-shaped and is approximately 150 feet long. Since disposal operations ceased, this unit has been completely covered by Fly Ash Landfill No. 2. The sludge disposed of in SWMU 27 was generated from the neutralization of sulfuric acid at the A-B Line and C-Line acidic wastewater treatment plants (Section 5.1.1).

Fly Ash Landfill (FAL) No. 2 (SWMU 29) is an active, unlined earthen landfill located in the southeast section of the Horseshoe Area. It is approximately 200 feet east of the Closed Sanitary Landfill (SWMU 52). The FAL No. 2 was constructed in October and November 1981. The 10-acre unit was permitted by the Virginia Department of Health in May 1982 (Permit No. 353) as an industrial waste landfill that could receive "fly ash, calcium sulfate sludge, and sludge from water treatment plants" (Va DOH, 1982).

The permit application presented the operation of the landfill as taking place in two stages of both trench fill and area fill methods. Stage 1 was to consist of the excavation and

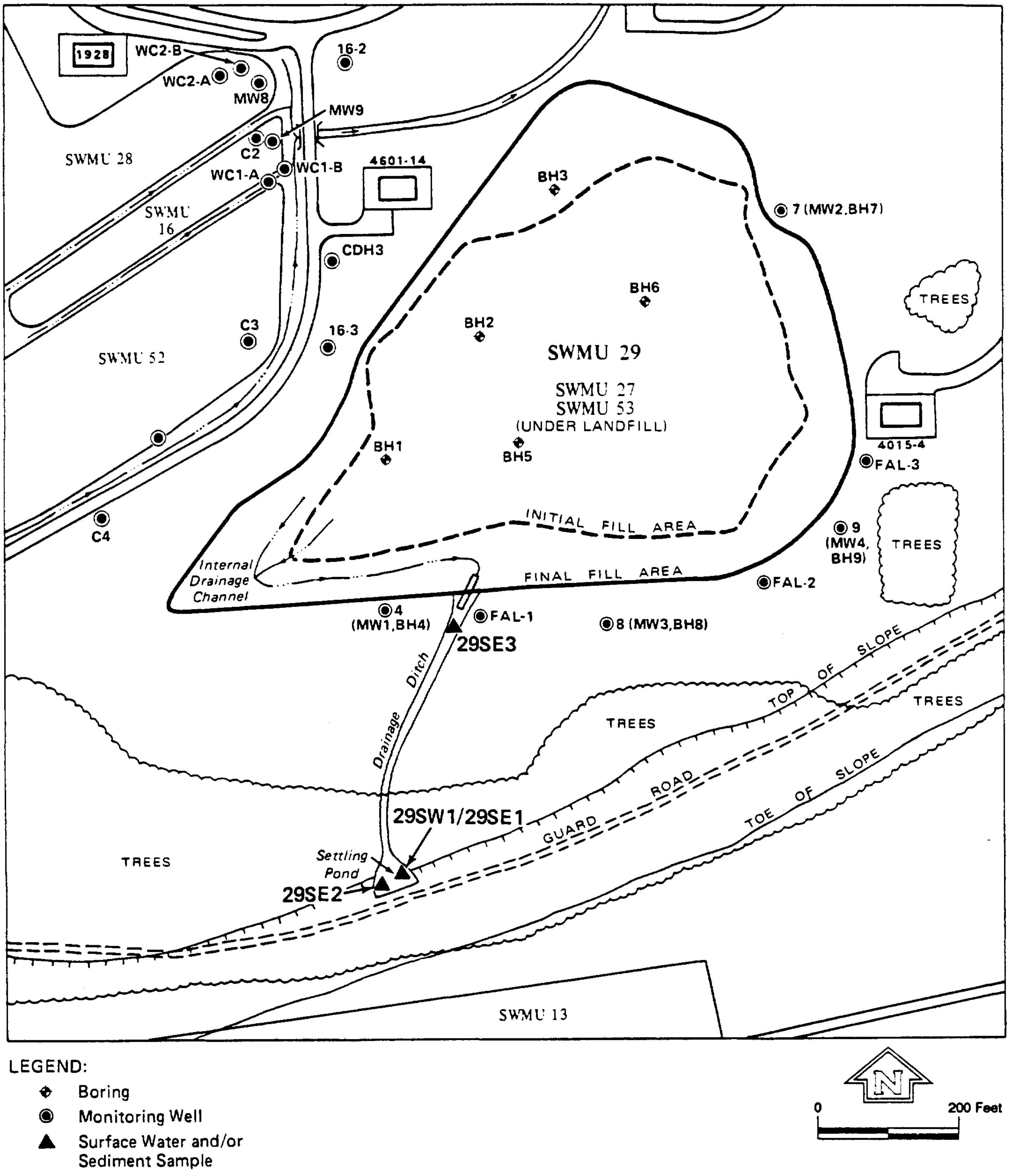

FIGURE 9-1
LOCATION MAP
SWMU 29 – FLY ASH LANDFILL No. 2
SWMU 27 – CALCIUM SULFATE LANDFILL
SWMU 53 – ACTIVATED CARBON DISPOSAL AREA
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

filling of seven trenches, about 50 feet long and averaging 25 feet deep, and ranging in length from 280 to 720 feet. The direction of fill was to be from east to west. The unit is currently operating in Stage 2, which consists of area filling, in five lifts, of 10-foot layers on top of the previously filled trenches. The direction of fill for Stage 2 is from east to west. During area filling, berms are constructed to control blowing ash. A site for a third fly ash landfill is currently being investigated by RAAP to replace this unit, which is nearing capacity.

Daily cover is not required at FAL No. 2 because of the inert characteristics of the wastes being landfilled. The permit requires 2 feet of cover to be placed on each trench or fill area as it is filled. Final cover will consist of at least 2 feet of compacted natural soil, graded to slopes of 3:1 and seeded with grass to retard erosion and minimize rainwater percolation. Runoff will be directed south to a central drainage ditch that coincides with and is effluent to the natural topographic ravine (USAEHA, 1980b). Surface water from the landfill drains to a ditch that leads to a retention pond located approximately 300 feet south of the landfill and north of SWMU 13.

The Activated Carbon Disposal Area (SWMU 53) is located within FAL No. 2 (SWMU 29). When observed in 1986, the disposal area was described as a 500-foot-long by 50-foot-wide plateau of an unknown height (USEPA, 1987). The date of disposal is unknown; however, based on the operating procedures and age of FAL No. 2, it can be assumed that disposal occurred before October 1981 when SWMU 29 was constructed. Since 1986, the disposal area has been completely covered by subsequent fly ash landfilling operations.

Activated carbon is used in two manufacturing operations at RAAP. In propellant manufacturing operations, activated carbon is used to recover solvents, ethyl alcohol, and ethyl ether. It was reported, but not confirmed, that the activated carbon disposed of at SWMU 53 was from these alcohol recovery units (USEPA, 1987).

9.1.2 Previous Investigations

The 1987 RCRA Facility Assessment (USEPA, 1987) states that results of groundwater samples from the monitoring wells installed in the vicinity of the Calcium Sulfate Landfill (SWMU 27) were indicative of groundwater contamination. The locations and specific analytes and concentrations of samples from these wells were not detailed in this report. Due to the contiguous location of the Calcium Sulfate Landfill (SWMU 27) and both the Activated Carbon Disposal Area (SWMU 53) and the Closed Sanitary Landfill (SWMU 52), this reported groundwater contamination cannot be directly attributed to SWMU 27.

A land disposal study was conducted in 1980 to determine the suitability of the site for the fly ash landfill (USAEHA, 1980b). Nine boreholes were drilled and four monitoring wells were installed; these locations are shown on Figure 9-1. A hydrogeologic interpretation of subsurface data, taken from published sources, on-site drilling and soil sampling, and subsequent laboratory analysis of soil samples, indicated that the site was geologically suitable for ash landfill operations.

The monitoring wells installed in 1980 were not properly developed or were completed above the water table, resulting in two wells (MW1 and MW4) being dry after installation. Samples were collected from MW2 and MW3 for laboratory analysis. The specific conductance measured in MW2 was 847 umhos/cm, slightly above the EPA-recommended concentration limit of 800 umhos/cm for drinking water. TDS for MW2 was 522 mg/l, slightly above the EPA-recommended concentration of 500 mg/l. The pH of samples from both wells was 8.45, attributed to the carbonate bedrock. Both samples showed cadmium concentrations (0.022 mg/l and 0.005 mg/l) that exceeded prevailing Virginia standards of 0.0004 mg/l for groundwater. Other metals detected were zinc, copper, lead, sodium, magnesium, calcium, and potassium, all of which were below Virginia and EPA standards (USAEHA, 1980b).

The quantity and source of refuse disposed of at the landfill (on a daily basis at full plant operation) was estimated as follows in the permit application (Webb, 1982):

Source	Quantity (lb/day)	Quantity (yd^3/day)
Bottom ash and fly ash from Powerhouse No. 1	200,000	185
Calcium sulfate from the sulfuric acid regeneration (SAR) treatment plant	150,000	68
Sludge from water treatment plant, Building 409 (SWMU 16)	8,825	4
Sludge from water treatment plant, Building 407 (SWMU 19)	4,928	2.2
Fly ash from Powerhouse No. 2	7,000	6.5

The volumes listed above were based on the bottom ash and fly ash having a density of 40 pounds per cubic foot (lb/ft^3); calcium sulfate having a density of 82 lb/ft^3 at 20 percent solids; and the water treatment plant sludge having a density of 82 lb/ft^3 at 35 percent solids. The quantity of ash may vary depending on the ash content of coal. Theoretically, 6,239 pounds of the ash are used daily at the water treatment plants for precoating the pressure filters and conditioning the sludge. The remainder is landfilled. Lime can also be used as a precoating and conditioning material at the water treatment plants. When lime is used, the entire amount of ash from Powerhouse No. 2 is landfilled.

The bottom ash from Boiler House No. 2 is not landfilled, but is used as an aggregate on plant roads during icy or snowy weather and for the stabilization of a temporary road at the landfill. The sludge from the water filter plants contains alum and solids that are filtered out of the raw water from the river, and either the lime or ash that is used for precoating and conditioning. All of the above materials are inert and compatible. Sample analyses of materials landfilled at FAL No. 2 are outlined in Table 9-1 (Olver, 1980).

TABLE 9-1

Analyses of Samples Landfilled at SWMU 29, Fly Ash Landfill No. 2[a]
Radford Army Ammunition Plant, Virginia

Analyte	SAR Treatment Plant Sludge	Water Treatment Plant Sludge	Power House No. 1 Fly Ash	Power House No. 2 Fly Ash
pH	6.5	10.1	5.0	2.6
Total solids	99.7%	60.1%	82.9%	96.7%
Organic matter	16.2%	17.1%	5.8%	2.7%
Chloride	179	1,430	1,400	1,970
Alkalinity as $CaCO_3$	1,900	134,000	3	<1
TKN-N	397	4,450	117	64
NH_3-N	231	383	48	23
Cadmium	6.0	10.0	2.4	8.2
Calcium	140,000	216,000	3,510	9,680
Chromium	10	50	37	66
Copper	4.0	1,280	72.6	185
Lead	16	47	19	119
Magnesium	4,500	4,980	2,420	1,850
Manganese	22	598	54	36
Mercury	0.4	<0.1	1.0	0.8
Nickel	10.0	30.0	60.5	144
Potassium	50	747	3,030	1,030
Zinc	6.8	136	34	309

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[a] With the exception of pH (which has no units), concentrations are in milligrams per kilogram unless otherwise noted.

Source: (Olver, 1980).

9.1.3 VI Program

Because SWMUs 27 and 53 have been covered by fly ash landfilling operations at SWMU 29, the three units have been combined into one study area. A groundwater monitoring program that includes collection of water levels and samples from five existing wells was proposed to identify potential contaminant migration from any of the three units in the study area.

There are four existing monitoring wells located downgradient of the study area--FAL-1, FAL-2, FAL-3, and Well 7 (Figure 9-1). These wells were not sampled because RAAP is currently performing quarterly monitoring on these wells and these data were available for evaluation.

To evaluate whether contaminants are migrating via surface water/sediment runoff, one sediment sample (29SE3) was collected from the drainage ditch that flows south from the study area. Two sediment samples (and one duplicate) were also collected from the settling pond. These samples were collected from 0 to 6 inches below the water/sediment interface and analyzed for metals, explosives, VOCs, and SVOCs. A surface water sample and duplicate(29SW1) were also collected from the settling pond and analyzed for the same constituents as the sediment samples, as well as for TOC, TOX, and pH.

9.2 ENVIRONMENTAL SETTING

9.2.1 Topography

The Calcium Sulfate Landfill (SWMU 27), the active FAL No. 2 (SWMU 29), and the Activated Carbon Disposal Area (SWMU 53) are located in the southeastern section of the Horseshoe Area. These SWMUs are approximately 200 feet east of SWMU 52. SWMUs 27, 29, and 53 are also approximately 300 feet east of SWMUs 28 and 16, and 600 feet north of SWMU 13. The topography of the Horseshoe Area is characterized by three prominent terraces and escarpments that are remnants of ancient New River flood plains. SWMU 29 occupies the eastern middle terrace flat and the escarpment face of the upper terrace in the horseshoe meander loop. The original topography of the eastern half of SWMU 29 was generally level, approximately 1,760 to 1,770 feet msl. The original topography of the western half of SWMU 29 was moderately steeply sloping towards the east. The maximum elevation is approximately 1,820 feet msl at the western edge.

There are buildings and paved roads, including a security road, in the vicinity of SWMUs 27, 29, and 53.

9.2.2 Geology and Soils

The geology of SWMU 29 is represented primarily by an overburden of New River alluvium composed of reddish-brown, micaceous clays and silts, with lenses of sandy silts interspersed about the perimeter of the unit. Also evident are some thin lenses of river jack (sporadic cobbles and boulders) (USAEHA, 1980b). Boring logs indicate that the depth of overburden ranges from 17 to 49 feet. The Elbrook Formation underlies the unconsolidated sediments. An irregular weathered zone is present at the top of bedrock.

9.2.3 Groundwater Conditions

Drilling revealed that a low-yield groundwater table is present beneath the landfill near the interface of the overburden and the weathered Elbrook Formation. The groundwater table is recharged by local precipitation percolating through the unconsolidated overburden. Groundwater flows radially (south and east) from the base of the landfill towards the New River. Groundwater elevations usually range from 1,740 feet msl to 1,750 feet msl (Insert 2).

9.2.4 Surface Water Drainage

Surface drainage of FAL No. 2 (SWMU 29) is to the south via a central drainage ditch that flows toward the Waste Propellant Burning Ground (SWMU 13). A settling pond was constructed upgradient of SWMU 13 so that runoff should not enter the unit. The settling pond is located approximately 300 feet south of SWMUs 27, 29, and 53, and approximately 150 feet north of SWMU 13. According to RAAP utility maps, there were no manholes, catch basins, or storm drains in the vicinity of SWMUs 29, 27, and 53.

9.3 CONTAMINATION ASSESSMENT

The VI field investigation included the collection of one surface water and three sediment samples in the drainage ditch and settling pond downslope of the landfill. Although not part of the VI, groundwater samples are collected by RAAP personnel as part of a quarterly monitoring program. The results of recent sampling efforts are presented to evaluate the impact of the landfill on groundwater quality.

The results of the chemical analyses indicated that sediment samples contained several metals at concentrations slightly greater than HBNs but similar to the background soil chemistry criteria; these metals, therefore, are not considered a concern. Low concentrations of several VOCs and SVOCs were also reported for the sediment samples but were less than HBN criteria. However, VOCs, SVOCs, explosives and elevated metals were not detected in the surface water sample. Groundwater samples collected downgradient of the landfill contained no SVOCs. Metal concentrations in groundwater were less than the HBN criteria and are not considered a concern.

9.3.1 Sediment

Twenty metals were detected in sediments collected from the settling pond (Table 9-2). Arsenic, barium, beryllium, mercury, and selenium concentrations in the pond sediment samples exceeded the background comparison criteria for uplands soil. However, arsenic and selenium concentrations were below their PQLs, but above their HBNs. Beryllium was the only metal of the three remaining metals that exceeded background concentration, which also exceeded the HBN. Cobalt concentrations exceeded the HBN, but were also within the range of background concentrations. Therefore, barium, beryllium, and mercury were detected at elevated concentrations above PQLs, but only beryllium is considered a contaminant of concern because it exceeded the HBN.

Contaminants in the ditch sediment sample are similar to those in the pond sediment, but the concentrations are generally lower. Beryllium in the ditch sediment is also considered a contaminant of concern for reasons similar to the pond sediment.

Table 9-2

Summary of Analytical Data For Sediment Samples Collected At SWMUs 27, 29, and 53

Radford Army Ammunition Plant, Virginia

SITE ID		29SE1	29SE2	29SE2	29SE3	
FIELD ID		RVFS*23	RVFS*24	RVFS*43	RVFS*25	
S. DATE		03-mar-92	03-mar-92	03-mar-92	03-mar-92	
DEPTH (ft)		1.0	1.0	1.0	1.0	
MATRIX	PQLs	CSE	CSE	CSE	CSE	HBN
UNITS	UGG	UGG	UGG	UGG	UGG	UGG
TAL Inorganics						
ALUMINIUM	14.1	19200	17700	21600	12400	230000
ARSENIC	30	[24]	[34]	[17.7]	[4.53]	0.5
BARIUM	1	256	250	217	91.5	1000
BERYLLIUM	0.2	[2.74]	[3.09]	[2.56]	[1.17]	0.1
CALCIUM	100	2560 B	2670 B	2680 B	6220	NSA
CHROMIUM	4	33.6	28.6	34.2	25.9	400
COBALT	3	[13.9]	[14.5]	[16.7]	[13.5]	0.8
COPPER	7	27	30.1	36.7	9.94	2900
IRON	1000	31800	24800	29500	21500	NSA
LEAD	2	22.2	23.3	24.2	19	200
MAGNESIUM	50	2440	2510	2700	3120	NSA
MANGANESE	0.275	426	289	341	1180	8000
MERCURY	0.1	0.132	0.174	0.147	LT 0.05	20
NICKEL	3	18.2	18.9	21.3	10.6	1000
POTASSIUM	37.5	1990	2170	2320	812	NSA
SELENIUM	40	1.27	2.32	1.31	LT 0.25	200
SILVER	4	0.957	1	LT 0.589	0.898	200
SODIUM	150	389 B	388 B	395 B	186 B	NSA
VANADIUM	0.775	75.6	67.3	78.1	44.5	560
ZINC	30.2	59.1	56.7	59.2	27.2	16000
Explosives	NA	None Detected	None Detected	None Detected	None Detected	NSA
Volatiles						
TOLUENE	0.005	0.006	0.006	LT 0.001	LT 0.001	1000
TRICHLOROETHYLENE	0.005	LT 0.003	0.035	LT 0.003	0.011	60
Volatile TICs						
TRICHLOROTRIFLUOROETHANE	NA	0.049 S	0.034 S	0.034 S	0.024 S	NSA
TOTAL UNKNOWN TICs	NA	(2)0.022	(3)0.031	ND	ND	NSA
Semivolatiles						
2-METHYLNAPHTHALENE	0.3	0.39	0.144	0.15	0.116	NSA
DIBENZOFURAN	0.3	0.086	LT 0.035	LT 0.035	LT 0.035	NSA
NAPHTHALENE	0.3	0.226	0.099	0.095	0.066	1000

Table 9-2 (Cont'd)

SITE ID		29SE1	29SE2	29SE2	29SE3	
FIELD ID		RVFS*23	RVFS*24	RVFS*43	RVFS*25	
S. DATE		03-mar-92	03-mar-92	03-mar-92	03-mar-92	
DEPTH (ft)		1.0	1.0	1.0	1.0	
MATRIX	PQLs	CSE	CSE	CSE	CSE	HBN
UNITS	UGG	UGG	UGG	UGG	UGG	UGG
Semivolatiles						
PHENANTHRENE	0.5	0.25	0.086	0.081	0.07	40
Semivolatile TICs						
2,6,10,14-TETRAMETHYLPENTADECANE	NA	0.646 S	ND	ND	ND	NSA
TOTAL UNKNOWN TICs	NA	(3)2.1	(6)5.29	(13)36.2	ND	NSA

Footnotes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CSE = Chemical sediment.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

ND = Analyte was not detected.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

S = Results are based on an internal standard; flag is used for TICs detected in library scans.

TAL = Target Analyte List.

TICs = Tentatively identified compounds that were detected in the GC/MS library scans.

UGG = Micrograms per gram.

( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

Trace concentrations of two VOCs and one VOC TIC were detected in the sediment samples. Low concentrations of several SVOCs were detected as well. Most of the detected SVOCs are PAHs and other saturated hydrocarbons associated with petroleum products, such as commercial coal tar, gasoline, solvents, power plant emissions, and coal ash and cinders. Many of these organic constituents readily adsorb onto particulate matter, especially in the presence of soil organic material, and are not expected to impact deeper soil or groundwater at the site. Although several known and unknown VOCs and SVOCs were detected, these organic compounds are not considered a concern because the concentrations generally are several orders of magnitude less than applicable HBNs.

9.3.2 Groundwater

As presented in Table 9-3, a total of six metals were detected in the groundwater samples collected at three locations downgradient of the landfill. Although not normally detected in groundwater at RAAP, chromium was reported in samples collected from FAL-3 and Well 7. Also, lead was reported at a moderate concentration in the February 1992 sample collected from FAL-2. The lead and other metals concentrations for the FAL-2 sample appeared to be high when compared to the results of the two previous sample analyses. However, the concentrations of these and all other metals in the samples were less than applicable HBN criteria. Although analyzed for during only one sample round, SVOCs were not detected in groundwater samples from the three well sites.

9.3.3 Surface Water

Surface water sample 29SW1, collected from the settling pond that receives runoff from the landfill, contained 11 metals at detectable concentrations, but only eight metals concentrations exceeded PQLs. All of metal concentrations were below HBN criteria (Table 9-4). Explosives, VOCs and SVOCs were not detected in the sample and are not expected to be a concern at the site.

9.4 CONCLUSIONS

The VI conducted at SWMU 27, Calcium Sulfate Landfill, SWMU 29, Fly Ash Landfill No. 2 and SWMU 53, Activated Carbon Disposal Area, consisted of the

Table 9–3
Summary of Analytical Data For Groundwater Samples Collected At SWMUs 27, 29, and 53
Radford Army Ammunition Plant, Virginia

SITE ID		FAL2	FAL2	FAL2	FAL3	FAL3	FAL3	WELL7	
FIELD ID		QG914003	QG913003	QG921003	QG914002	QG913002	QG921002	QG914001	
S. DATE		06–dec–91	13–aug–91	17–feb–92	06–dec–91	13–aug–91	17–feb–92	06–dec–91	
DEPTH (ft)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	
MATRIX	PQLs	CGW	CGW	CGW	CGW	CGW	CGW	CGW	HBN
UNITS (#)	UGL	UGL	UGL	UGL	UGL	UGL	UGL	UGL	UGL
Metals									
CHROMIUM	10	ND 1	NT	NT	30	NT	NT	12	50
IRON	38.1	16000	16000	67000	17000	3000	6600	2100	NSA
LEAD	5	ND 5	6	20	6	ND 5	ND 5	ND 5	50
MANGANESE	2.75	480	170	1100	160	70	230	ND 30	3500
MERCURY	2	0.3	NT	NT	0.4	NT	NT	ND 0.2	2
SODIUM	500	18000	1200	2300	2400	14000	15000	3400	NSA
Semivolatiles									
	NA	None Detected	NT	NT	None Detected	NT	NT	None Detected	NSA
Other									
ACIDITY	NA	20000	NT	NT	32000	NT	NT	14000	NSA
ALKALINITY	NA	370000	272000	370000	540000	330000	340000	130000	NSA
CHEMICAL OXYGEN DEMAND	NA	90000	27000	130000	72000	ND 15000	ND 15000	ND 15000	NSA
CHLORIDE	1000	4000	2000	4000	4000	5000	7000	4000	NSA
NITRITE,NITRATE	100	4300	1300	1400	530	2400	690	780	10000
NITROGEN BY KJELDAHL METHOD	NA	400	NT	NT	100	NT	NT	200	NSA
PHOSPHATE	NA	360	390	ND 60	430	ND 60	ND 60	ND 60	NSA
SPECIFIC CONDUCTIVITY	NA	765	493	480	608	689000	630	277	NSA
SULFATE	NA	46000	4000	7000	10000	38000	48000	ND 2000	NSA
TOTAL DISSOLVED SOLIDS	NA	425000	289000	417000	336000	424000	455000	121000	NSA
TOTAL HARDNESS	NA	460000	280000	370000	300000	336	464000	200000	NSA
TOTAL ORGANIC CARBON	1000	366	571	931	354	437	424	347	NSA
TOTAL SUSPENDED SOLIDS	NA	426000	NT	NT	2540000	NT	NT	43000	NSA
pH	NA	6.81	6.81	6.68	6.82	6.78	6.5	6.35	NSA
pH AS TESTED IN THE FIELD	NA	7.1	7.2	6.8	7.1	7	7.1	7	NSA

Table 9–3 (Cont'd)

SITE ID		WELL7	WELL7	
FIELD ID		QG913001	QG921001	
S. DATE		13–aug–91	17–feb–92	
DEPTH (ft)		0.0	0.0	
MATRIX	PQLs	CGW	CGW	HBN
UNITS (#)	UGL	UGL	UGL	UGL
Metals				
CHROMIUM	10	NT	NT	50
IRON	38.1	3000	400	NSA
LEAD	5	ND 5	6	50
MANGANESE	2.75	30	ND 30	3500
MERCURY	2	NT	NT	2
SODIUM	500	2400	1800	NSA
Semivolatiles				
	NA	NT	NT	NSA
Other				
ACIDITY	NA	NT	NT	NSA
ALKALINITY	NA	116000	110000	NSA
CHEMICAL OXYGEN DEMAND	NA	ND 15000	ND 15000	NSA
CHLORIDE	1000	2000	4000	NSA
NITRITE,NITRATE	100	850	750	10000
NITROGEN BY KJELDAHL METHOD	NA	NT	NT	NSA
PHOSPHATE	NA	ND 60	ND 60	NSA
SPECIFIC CONDUCTIVITY	NA	236	200	NSA
SULFATE	NA	ND 2000	2000	NSA
TOTAL DISSOLVED SOLIDS	NA	150000	148000	NSA
TOTAL HARDNESS	NA	170000	112000	NSA
TOTAL ORGANIC CARBON	1000	205	432	NSA
TOTAL SUSPENDED SOLIDS	NA	NT	NT	NSA
pH	NA	6.05	6.07	NSA
pH AS TESTED IN THE FIELD	NA	6.5	6.6	NSA

Footnotes:

CGW = Chemical groundwater.
HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).
NA = Not available; PQLs are not available for these analytes.
ND = Analyte was not detected.
NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.
NT = Not tested; parameters were not tested (included) in the sample analyses.
PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.
UGL = Micrograms per liter.
Units(#) = Units are in UGL except for specific conductivity, which are expressed in UMHO.

Table 9-4
Summary of Analytical Data For Surface Water Samples Collected At SWMUs 27, 29, and 53
Radford Army Ammunition Plant, Virginia

SITE ID		29SW1	29SW1	
FIELD ID		RDWC*66	RDWC*72	
S. DATE		03-mar-92	03-mar-92	
DEPTH (ft)		0.0	0.0	
MATRIX	PQLs	CSW	CSW	HBN
UNITS	UGL	UGL	UGL	UGL
TAL Inorganics				
ALUMINIUM	141	3110	845	101500
ARSENIC	10	3.41	LT 2.54	50
BARIUM	20	115	41.9	1000
CALCIUM	500	56800	55600	NSA
COPPER	60	8.56	LT 8.09	1295
IRON	38.1	3620	671	NSA
MAGNESIUM	500	8670	8400	NSA
MANGANESE	2.75	54.2	30.8	3500
POTASSIUM	375	3870	4360	NSA
SELENIUM	20	3.62	LT 3.02	10
SODIUM	500	4720	4620	NSA
Explosives	NA	None Detected	None Detected	NSA
Volatiles	NA	None Detected	None Detected	NSA
Semivolatiles	NA	None Detected	None Detected	NSA
TOTAL UNKNOWN TICs	NA	ND	(1)9	NSA
Other				
TOTAL ORGANIC CARBON	1000	3650	6250	NSA
TOTAL ORGANIC HALOGENS	1	15.1	78.4	NSA
pH	NA	6.85	7.42	NSA

Footnotes:

CSW = Chemical surface water.
HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).
LT = Concentration is reported as less than the certified reporting limit.
NA = Not available; PQLs are not available for TICs detected in the library scans.
ND = Analyte was not detected.
NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.
PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.
TAL = Target Analyte List.
TICs = Tentatively identified compounds that were detected in the GC/MS library scans.
UGL = Micrograms per liter.
( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

evaluation of groundwater samples from three wells, three sediment samples, and one surface water sample. Groundwater samples collected downgradient of the landfill (SWMU 27, 29, 53) contained no SVOCs and metals concentrations were less than the HBN criteria.

Sediment samples collected from the drainage ditch and sediment pond that collect surface water/sediment runoff from the study area contained concentrations of metals above PQLs and background criteria. Barium, beryllium, and mercury concentrations were elevated, with beryllium exceeding the HBN. Trace concentrations of two VOCs, one VOC TIC, and low concentrations of several SVOCs were detected in the sediment samples. These organic compounds are not considered a concern because the concentrations are several orders of magnitude less than applicable HBNs. Although several unknown VOCs and SVOCs were also detected in sediment samples, these organic compounds are several orders of magnitude less than applicable HBNs.

The surface water sample collected from the settling pond contained 11 metals at detectable concentrations. However, all metals concentrations were below HBN criteria and are not considered a concern at the site. Explosives, VOCs, and SVOCs were not detected in the sample.

9.5 RECOMMENDED ACTION

Each of the groundwater, surface water, and sediment samples was collected from areas downgradient of the study area where any contaminant migration via groundwater or surface water/sediment runoff would occur. The groundwater data evaluated were inconclusive for the purpose of evaluating the quality of groundwater migrating from the site. It is recommended that the VI program presented in the VI Work Plan for this area should be performed and the site re-evaluated. The sediment in the settling pond has the potential to degrade the surrounding environment if contaminants migrate. However, present concentrations do not appear to be sufficiently high for significant migration to occur. The pond should be kept in good repair with sediment removed, when necessary, to prevent accidental discharge.

10.0 VERIFICATION INVESTIGATION OF SWMU 32, INERT WASTE LANDFILL NO. 1

10.1 SWMU 32 BACKGROUND AND INVESTIGATION PROGRAM

10.1.1 SWMU History

The Inert Waste Landfill No. 1 (SWMU 32) is a closed, unlined landfill located in the Horseshoe Area of RAAP, approximately 600 feet north of the main bridge over the New River and 100 feet east of the Rubble Pile (SWMU 58) (Figure 10-1). Although the 8-acre landfill was permitted by the Virginia Department of Health (Permit No. 400) in April 1983, the unit reportedly began receiving wastes in 1978. The permit allowed SWMU 32 to receive construction waste, demolition waste, plastics, excavated soil, and inert wastes. Approximately 50 to 100 tons/day of debris wastes were to be disposed of in the landfill, according to the permit.

The unit reached capacity and was closed sometime between July 1986 and April 1987 (USEPA, 1987). The closed landfill is approximately 600 feet by 600 feet in area, and 30 feet high. Indications are that wastes were deposited on the original ground surface, without excavation, and periodically covered with soil. It has been reported that in addition to inert materials such as soil, concrete, and fiberglass, the following materials were disposed of in the landfill--asphalt, cardboard boxes, fluorescent lamp tubes, bottom ash, wet coal, and empty laboratory containers (including some labeled sulfuric acid, sec-butyl alcohol, and lead salicylate (USEPA, 1987; USATHAMA, 1984).

The unit was closed with a 2-foot clay cap and topsoil, and then seeded. One area is covered with gravel and used for trailer parking. Erosional gullies have been repaired with rip rap.

10.1.2 Previous Investigations

This SWMU was identified in the RCRA Facility Assessment (USEPA, 1989) as having a potential for releasing contaminants into the environment. The landfill was included in the RCRA Permit for Corrective Action and Incinerator Operation

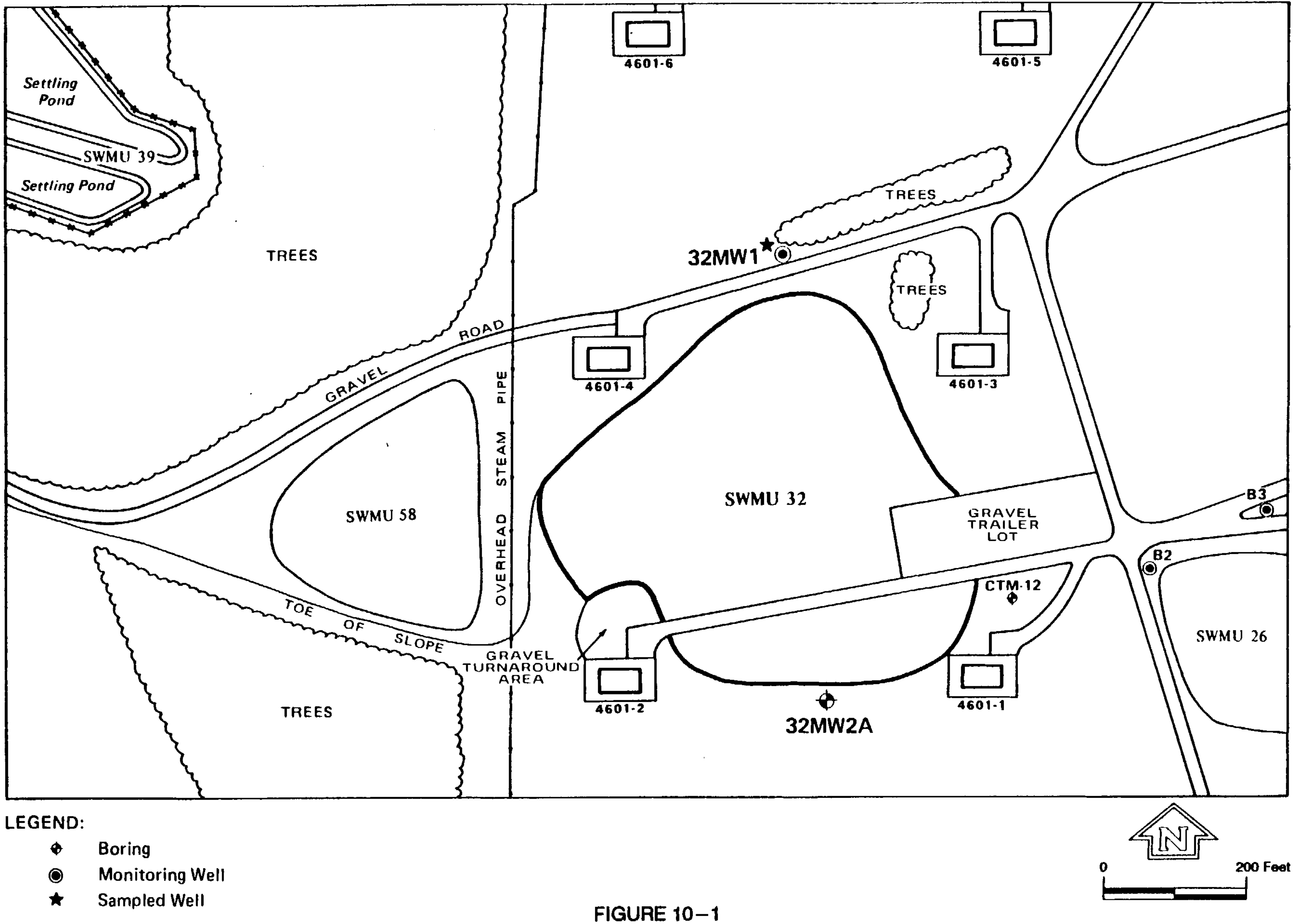

FIGURE 10–1
LOCATION MAP
SWMU 32 – INERT WASTE LANDFILL No. 1
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

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(USEPA, 1989) as warranting investigation. No site specific environmental investigations were conducted at the landfill prior to this VI.

10.1.3 VI Program

Because SWMU 32 was operated as an inert landfill under a Virginia Solid Waste Permit according to permit requirements (Section 10.1.1), it appears unlikely that hazardous constituents are associated with it. However, to evaluate whether groundwater quality has been impacted by wastes disposed of in this landfill, it was proposed that one well be installed upgradient (32MW1) and one well be installed downgradient (32MW2) of the landfill.

While drilling the upgradient boring, a large void was encountered from 45 to 57 feet. It was not possible to install a well at this location, so this borehole was abandoned as 32MW2A. There was no replacement well installed for this upgradient well at SWMU 32.

A groundwater monitoring well (32MW1) was installed downgradient of SWMU 32 to a depth of 88 feet. Following well installation and development, a sample was collected from this well and analyzed for metals, VOCs, SVOCs, TOC, TOX, and pH.

10.2 ENVIRONMENTAL SETTING

10.2.1 Topography

SWMU 32 is located in an area of broad and gently sloping ridges within the Horseshoe Area. The ground surface of the SWMU slopes from a maximum elevation of 1,770 feet msl at the southern end of the SWMU to a minimum elevation of 1,720 feet msl at the northern end of the SWMU. SWMU 32 is in the middle of a storage area where buildings, asphalt roads, and a nearby overhead steam pipe are located; there are four storage buildings around the SWMU, one at each corner. A gravel trailer lot is located in the southeastern section of the SWMU.

10.2.2 Geology and Soils

The subsurface conditions for SWMU 32 were investigated through the drilling of two soil and rock borings to a depth of 57 to 88 feet. In boring 32MW2A upgradient of SWMU

32 (Figure 10-1), unconsolidated silty clay (CL) and clayey silt (ML) was encountered to a depth of 24 feet overlying limestone or dolostone of the Elbrook Formation. In boring 32MW1 (Figure 10-1), downgradient of SWMU 32, unconsolidated soils encountered consisted of silty sands (SM) and gravels (GM) to a depth of 21 feet overlying limestone or dolostone of the Elbrook Formation.

Bedrock encountered in the vicinity of SWMU 32 consisted of fractured limestone and dolostone of the Elbrook Formation. Karst solution features were encountered in boring 32MW2A just upgradient (south) of SWMU 32--a large void was encountered between 45 and 55 feet and another void between 56 and 57 feet. No obvious solution features were encountered in boring 32MW1, downgradient of SWMU 32.

10.2.3 Groundwater Conditions

Groundwater was not encountered in boring 32MW2A, upgradient of SWMU 32. Groundwater was encountered at approximately 77 feet below ground surface in boring 32MW1 within limestone or dolostone bedrock. Based on the local topography and hydrogeologic conditions, the inferred direction of groundwater flow is northward toward the New River. Groundwater flow through the solution features encountered in the vicinity of SWMU 32 would likely be rapid.

10.2.4 Surface Water Drainage

Based on topography, surface water runoff from within SWMU 32 generally flows from the southern boundary to the northern boundary. Surface water runoff appears to flow north from the SWMU approximately 1,600 feet to the New River.

10.3 CONTAMINATION ASSESSMENT

One groundwater sample (32MW1) was collected downgradient of SWMU 32 to evaluate the impact of the landfill on groundwater quality. The results of the chemical analyses are presented in Table 10-1. The chemical analyses indicated that the groundwater quality has not been impacted by the landfill and is presently not considered a concern. The seven metals detected above PQLs in the sample are common constituents of groundwater

Table 10-1
Summary of Analytical Data For Groundwater Samples Collected At SWMU 32
Radford Army Ammunition Plant, Virginia

SITE ID		32MW1	
FIELD ID		RDWC*36	
S. DATE		18-feb-92	
DEPTH (ft)		80.0	
MATRIX	PQLs	CGW	HBN
UNITS	UGL	UGL	UGL
TAL Inorganics			
BARIUM	20	61.9	1000
CALCIUM	500	57200	NSA
IRON	38.1	57.5	NSA
MAGNESIUM	500	33200	NSA
MANGANESE	2.75	4.78	3500
POTASSIUM	375	753	NSA
SODIUM	500	3210	NSA
Volatiles	NA	None Detected	NSA
Semivolatiles	NA	None Detected	NSA
Other			
TOTAL ORGANIC CARBON	1000	1990	NSA
TOTAL ORGANIC HALOGENS	1	57.8	NSA
pH	NA	8.02	NSA

Footnotes:

CGW = Chemical groundwater.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TAL = Target Analyte List.

UGL = Micrograms per liter.

and the levels are consistent with those expected in groundwater within a limestone formation. The metals concentrations are one or more orders of magnitude less than applicable HBNs and are similar to those reported in upgradient groundwater samples obtained from other areas of RAAP. VOCs and SVOCs were not detected in the 32MW1 sample. Although the levels for TOC and TOX indicated that organic constituents were present in this sample, the full-screen VOC and SVOC analyses did not identify the presence of any constituents above the PQLs. The lack of detectable organic compounds indicates the air development of this well did not result in the introduction of contaminants.

10.4 CONCLUSIONS

The field investigation for the Inert Waste Landfill No. 1 (SWMU 32) consisted of the collection of one groundwater sample immediately north of the site. Based on local topography and hydrogeologic conditions, groundwater in the vicinity of SWMU 32 appears to flow northward. The results of the chemical analysis of the groundwater sample indicate that the groundwater quality has not been impacted by the landfill. Metals concentrations were detected below the applicable HBNs (when available) and were similar to the levels reported in upgradient groundwater samples collected from other SWMUs.

10.5 RECOMMENDED ACTION

Based on the results of the field investigation, the groundwater quality does not appear to have been impacted by the Inert Waste Landfill No. 1; therefore, no further action is recommended for SWMU 32.

Note: This section was revised August 31, 1994 under separate cover.

11.0 VERIFICATION INVESTIGATION OF SWMU 39, INCINERATOR WASTEWATER PONDS

11.1 SWMU 39 BACKGROUND AND INVESTIGATION PROGRAM

The RCRA Permit provided for the characterization of SWMU 39 waste prior to conduct of a VI for the purpose of determining whether the waste is potentially hazardous. The investigation of SWMU 39 included both a waste characterization and a VI of soils which may be potentially adversely impacted by contaminated spray water. Section 5.3 presents the waste characterization of the incinerator wastewater sludge. This section presents the VI on the surface soil adjacent to the spray pond and summarizes the waste characterization results.

11.1.1 SWMU History

This unit is located in the north-central section of the Horseshoe Area, adjacent to and associated with the Hazardous Waste Incinerator (SWMU 14).

SWMU 39 consists of a concrete-lined aeration pond and two unlined earthen ponds (Figure 11-1). The aeration pond serves as a cooling pond for incinerator scrubber and cooling water, which has been described as either contact or noncontact cooling water. The gas cooler uses water to cool the exhaust gas from the afterburner to 160° F. The scrubber system is designed to cool the exhaust gases to 140° F. The wastewater from the cooler and scrubber is pumped to the spray pond, with the supernatant recycled and reused in the cooler and scrubber. According to a facility representative, caustic is periodically added to the water to neutralize it, and the water is pumped to the Biological Treatment Plant (SWMU 10). Sludges have reportedly never been removed from the pond for disposal. During spray aeration, water is usually windblown from the pond to settle onto the surrounding ground surface. Therefore, there is the potential for contamination of surface soils by the wastewaters.

The settling ponds are excavated an estimated 6 to 8 feet into the natural grade. These ponds receive overflow from the aeration pond, though overflow is reportedly rare. Both are evaporation ponds, with no outlet from either pond.

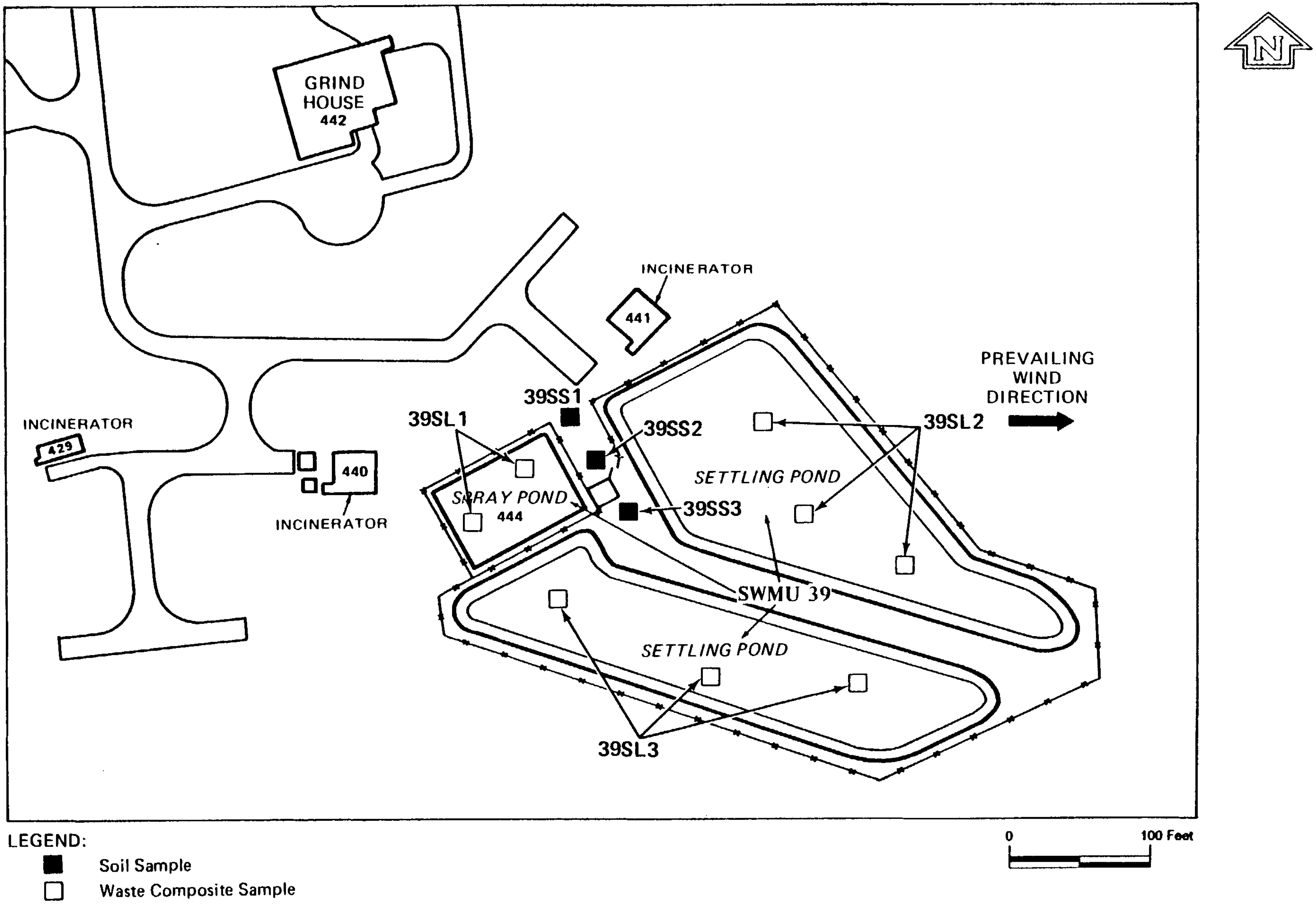

FIGURE 11-1
LOCATION MAP
SWMU 39 – INCINERATOR WASTEWATER PONDS
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

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11.1.2 Previous Investigations

Analysis of a sludge sample collected from the spray pond in 1983 (Olver, 1983) indicated that the sludge did not exhibit any of the four hazardous waste characteristics as outlined in 40 CFR 261.34. Analytical results were as follows:

- EP Toxicity (mg/l):

Silver	<0.1
Arsenic	0.010
Barium	1.1
Cadmium	<0.1
Chromium	0.3
Mercury	0.0010
Lead	0.2
Selenium	0.012

- Ignitability: Not ignitable at 60° C
- Corrosivity: Not corrosive
- Reactivity: Not reactive.

11.1.3 VI Program

There are two identified concerns at this unit--potential contamination of surface soils adjacent to the aeration pond from windblown spray and potential groundwater contamination from hazardous constituent releases from the aeration pond and the two unlined settling basins. To address the potential soil contamination, three surface soil samples (39SS1, 39SS2, and 39SS3) were collected east of the aeration pond in the area most likely to receive windblown spray (Figure 11-1). Samples were collected from a depth of 0 to 6 inches below any surface gravel or organic root zone and analyzed for metals, SVOCs, and explosives.

To address the potential for groundwater contamination in the vicinity of the ponds, a waste characterization was performed on sludge samples collected from the ponds. Soil collected from multiple sample locations from each lagoon was composited, resulting in a total of three sludge samples (39SL1, 39SL2, and 39SL3) submitted for analysis. These samples were analyzed for metals, explosives, and SVOCs. The results of the waste characterization are presented in Section 5.3.

11.2 ENVIRONMENTAL SETTING

11.2.1 Topography

SWMU 39 is generally a flat level area, at approximately 1,700 feet msl. A small section of the southern boundary rises to a maximum elevation of approximately 1,720 feet msl. SWMU 39 consists of a concrete-lined aeration pond and two unlined earthen ponds which were excavated an estimated 6 to 8 feet into the natural grade. There are very few buildings in the area with only dirt roads leading to SWMU 39.

11.2.2 Geology and Soils

No site-specific hydrogeologic studies have been performed at SWMU 39, but the subsurface conditions can be inferred from similar areas. Approximately 20 to 30 feet of unconsolidated sand, clay, and silt, with seams of gravels or cobbles, should overlie fractured limestone or dolostone of the Elbrook Formation in this area.

11.2.3 Groundwater Conditions

Groundwater probably flows northward toward the New River, approximately 1,200 feet away. Flow velocity through the bedrock may be very high due to the karstic nature of the bedrock. The groundwater elevation has been interpreted as being between 1,680 and 1,690 feet msl (Insert 2), or approximately 20 feet below the ground surface elevation.

11.2.4 Surface Water Drainage

Surface water runoff probably flows north towards the New River, approximately 1,200 feet away. There are two unlined settling ponds which receive overflow from the aeration pond. Both of these settling ponds are evaporation ponds and do not have any drainage outlets. According to RAAP utility maps, there are no storm drains, manholes, or catch basins located in the vicinity of SWMU 39.

11.3 CONTAMINATION ASSESSMENT

The VI field program included the collection of three soil samples east of the spray pond and the waste characterization consisted of sediment samples from the spray pond and two settling ponds at SWMU 39. Results of the chemical analyses of the soil and sediment samples are presented in Tables 11-1 and 5-4, respectively. The results of the VI for soil are presented below; the waste characterization is presented in Section 5.3.

11.3.1 Soil

Four metals--beryllium, chromium, thallium and vanadium--were detected at concentrations above the background alluvial soils comparison criteria (Table 4-14) in at least one soil sample. Each of these metals was also greater than their respective PQL. Of these four metals, only beryllium and thallium exceeded their HBNs. Arsenic and cobalt also exceeded their HBN, but their concentrations were below the background alluvial soil comparison criteria. Beryllium and thallium, therefore, are the only two metals found at concentrations which may be a concern in the surface soil at SWMU 39. Beryllium has a low solubility and is expected to be adsorbed onto clay mineral surfaces at a low pH and to be complexed into insoluble compounds at high pH. In most natural environments, beryllium is likely to be sorbed or precipitated, rather than dissolved and is not expected to impact surface water, groundwater or the underlying soil. Thallium is not anticipated to be a concern because it is relatively immobile in the environment and is not expected to impact surface water, groundwater or the underlying soil.

Explosives and SVOCs were not detected in any of the soil samples. Although a TIC was detected, it is not a concern because the compound was detected in the laboratory method blank and, therefore, can be considered an artifact of the laboratory analysis and not present in the soil samples.

11.3.2 Sediment

The waste characterization in Section 5.3 identified eight metals--antimony, arsenic, barium, beryllium, cobalt, copper, lead, and thallium--above HBNs in at least one sample

Table 11–1
Summary of Analytical Data For Soil Samples Collected At SWMU 39
Radford Army Ammunition Plant, Virginia

SITE ID		39SS1	39SS2	39SS3	
FIELD ID		RVFS*40	RVFS*41	RVFS*42	
S. DATE		25–feb–92	25–feb–92	25–feb–92	
DEPTH (ft)		0.5	0.5	0.5	
MATRIX	PQLs	CSO	CSO	CSO	HBN
UNITS	UGG	UGG	UGG	UGG	UGG
TAL Inorganics					
ALUMINIUM	14.1	14400	14900	17500	230000
ARSENIC	30	[2.52]	[2.71]	[2.74]	0.5
BARIUM	1	98.4	113	94.8	1000
BERYLLIUM	0.2	[0.628]	[1.21]	LT 0.5	0.1
CALCIUM	100	38500	1250 B	3300 B	NSA
CHROMIUM	4	26	27.5	30.2	400
COBALT	3	[11.2]	[13.4]	[13.5]	0.8
COPPER	7	15.1	19.8	22.1	2900
IRON	1000	25100	26700	29100	NSA
LEAD	2	21.8	LT 10.5	19.5	200
MAGNESIUM	50	19000	4250	5060	NSA
MANGANESE	0.275	517	562	506	8000
NICKEL	3	14.3	16.8	17.3	1000
POTASSIUM	37.5	1780	2080	1850	NSA
SILVER	4	1.35	0.972	LT 0.589	200
SODIUM	150	210 B	226 B	239 B	NSA
THALLIUM	20	[22.7]	[17.9]	LT 6.62	6
VANADIUM	0.775	50	52.2	54.4	560
ZINC	30.2	52.4	72.1	61.3	16000
Explosives	NA	None Detected	None Detected	None Detected	NSA
Semivolatiles	NA	None Detected	None Detected	None Detected	NSA
Semivolatile TICs					
CYCLOHEXENE OXIDE	NA	0.225 SB	0.225 SB	0.233 SB	NSA

Footnotes :

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

R = Analyte required for reporting purposes but not currently certified by USATHAMA.

S = Results are based on an internal standard; flag is used for TICs detected in library scans.

TICs = Tentatively identified compounds that were detected in the GC/MS library scans.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

CSO = Chemical soil.

TAL = Target Analyte List.

UGG = Micrograms per gram.

collected of SWMU 39 waste. The most impacted sample was from the spray pond, but each pond sample had at least four metals which had concentrations in excess of HBNs. Lead and copper are present at such high concentrations in the spray pond (9.7 percent lead, 5.7 percent copper) and the northern settling pond (2.1 percent lead) that the absorption properties which can normally be expected to keep them immobile may be ineffective. No explosives were detected. Six SVOCs and several SVOC TICs were detected, but at concentrations below HBNs.

11.4 BASELINE RISK ASSESSMENT

Based on the contamination assessment presented in Section 11.3 and the waste characterization in Section 5.3, eight metals--antimony, arsenic, barium, beryllium, cobalt, copper, lead, and thallium--have been identified as contaminants of concern for SWMU 39 sediment. No contaminants of concern were identified for surface soil, indicating that windblown spray has not caused significant downwind contamination. Samples were not collected from other environmental media. The potential impact of these metals to human health and the environment is discussed below in Sections 11.4.1 and 11.4.2, respectively.

11.4.1 Human Health Evaluation

The sediment samples were collected from within the settling and spray ponds, which are surrounded by a fence. There are no potential human receptors to the sediment/sludge within these ponds, except for workers who may occasionally contact the sludge during cleaning operations. Workers would presumably wear protective equipment (i.e., gloves) and exposure is expected to be infrequent. Therefore, exposure to contaminants in the sediment/sludge is expected to be insignificant. Although surface water samples were not collected from the ponds, worker exposure to surface water would also be infrequent and is considered insignificant.

Based on the analytical results, there is the potential for groundwater contamination beneath SWMU 39. However, no groundwater wells have been installed in this area and no groundwater data are available. Actual groundwater flow direction is also uncertain due to the karst geology, but flow is generally northward with discharge into the New River.

Therefore, the potential for groundwater exposure cannot be evaluated. It should be noted that a water supply well for RAAP is located approximately 1,200 feet west-northwest of SWMU 39. However, this well has been put out of service and all connecting distribution piping has been removed. If groundwater contamination is detected, then there is little potential for migration of contamination to a water supply well that is in service since no supply well exists within the Horseshoe Area.

11.4.2 Environmental Evaluation

As discussed above, the settling and spray ponds are enclosed by a fence, thereby precluding access by most wildlife. Although birds and possibly small rodents may presumably have access to these settling ponds, considering the surrounding environment, it is not likely that they would forage in this area or use the pond surface water as a primary drinking water source. Therefore, potential exposure to environmental receptors is expected to be insignificant.

11.4.3 Conclusions to Human Health and Environmental Evaluation

Exposure to contaminants in the sediment/sludge and surface water of the ponds is expected to be insignificant for both human and environmental receptors. Although, there is the potential for groundwater contamination beneath SWMU 39, no groundwater wells have been installed in this area and no groundwater data are available. Therefore, the potential for groundwater exposure cannot be evaluated.

11.5 CONCLUSIONS

The VI field program included the collection of three soil samples east of the spray pond and sediment samples from the spray pond and two settling ponds at SWMU 39. Soil samples collected downwind of the spray pond showed concentrations of several metals at slightly greater than HBNs but less than or only slightly greater than background criteria; therefore, these metal levels are not considered a concern. These soil sample results indicated that windblown spray has not caused significant downwind soil contamination. However, high concentrations of copper and lead were detected in sediment samples collected from the spray pond and northern settling pond. Antimony, arsenic, barium, beryllium, cobalt, and thallium were also reported above HBNs in the spray pond sample, indicating an accumulation of these metals in the spray pond sediment. Because the ponds are enclosed by a fence, and workers infrequently maintain the ponds, potential human or wildlife surface exposure is considered insignificant.

However, relatively high levels of leachable metals, primarily copper and lead, may have potentially impacted groundwater below the site if significant seepage from both the northern settling pond and spray pond has occurred. Copper is a relatively mobile constituent in the environment and may be readily mobilized in the presence of acidic infiltrating rainfall or wastewater. Copper would only be a concern if contaminants have seeped from the spray pond. Because the spray pond is lined with concrete, the potential to transport contaminants to the underlying soil and groundwater is less than that of the unlined settling ponds. Because SWMU 39 is located on limestone/dolostone residuum and limestone/dolostone with solution-cavity and fracture features, contaminants may be rapidly transported to the subsurface via infiltration of water through the soil column.

11.6 RECOMMENDED ACTION

Surficial soil has not been significantly impacted by wind-blown water from the spray pond and no further action is recommended for this environmental medium. As presented in Section 5.3, the sediment being deposited at SWMU 39 has shown concentrations of eight metals above HBNs. Two of the three ponds are unlined and infiltration of impacted water will occur. Interim measures to remove the sediment along with TCLP metals testing to confirm suspected characteristic toxicity are recommended. A VI is recommended for the purpose of evaluating the potential impact to the groundwater at this SWMU due to the sludge present in the ponds.

12.0 VERIFICATION INVESTIGATION OF SWMU 40, SANITARY LANDFILL (NG AREA)

12.1 SWMU 40 BACKGROUND AND INVESTIGATION PROGRAM

12.1.1 SWMU History

The Sanitary Landfill (Nitroglycerin Area) (SWMU 40) is located approximately 1,000 feet southeast of NG Area No. 1, in the south-central section of the RAAP Main Manufacturing Area. It is situated about 400 feet west-northwest of the Contaminated Waste Stage and Burn Area (SWMU 17) (Figure 12-1). This landfill was never permitted, and was reportedly used in the 1970s and early 1980s (following closure of SWMU 43) for the disposal of uncontaminated paper, municipal refuse, cement, and rubber tires (USEPA, 1987; USATHAMA, 1976). It is not known whether hazardous wastes or wastes containing hazardous constituents were ever disposed of in the landfill.

The landfill is approximately 430 feet by 100 feet in size (about 1 acre). The unit was an area fill; no trenches were excavated. The unit was closed with a soil cap and moderate grass cover. Since closure, excavated "clean" soils have been stockpiled on top of the unit by the USACE as a result of current construction activities at RAAP. In 1991 and 1992, a fenced enclosure for asbestos storage and other hazardous materials was constructed over the northeast corner of this SWMU.

12.1.2 Previous Investigations

This SWMU was identified in the RCRA Facility Assessment (USEPA, 1989) as having a potential for releasing contaminants into the environment and was included in the RCRA Permit for Corrective Action and Incinerator Operation (USEPA, 1989) as warranting investigation. No site-specific environmental investigations have been conducted at this location prior to this VI.

12.1.3 VI Program

Prior to this investigation, there were no monitoring wells located in the vicinity of this unit. To evaluate whether groundwater quality has been impacted by wastes disposed

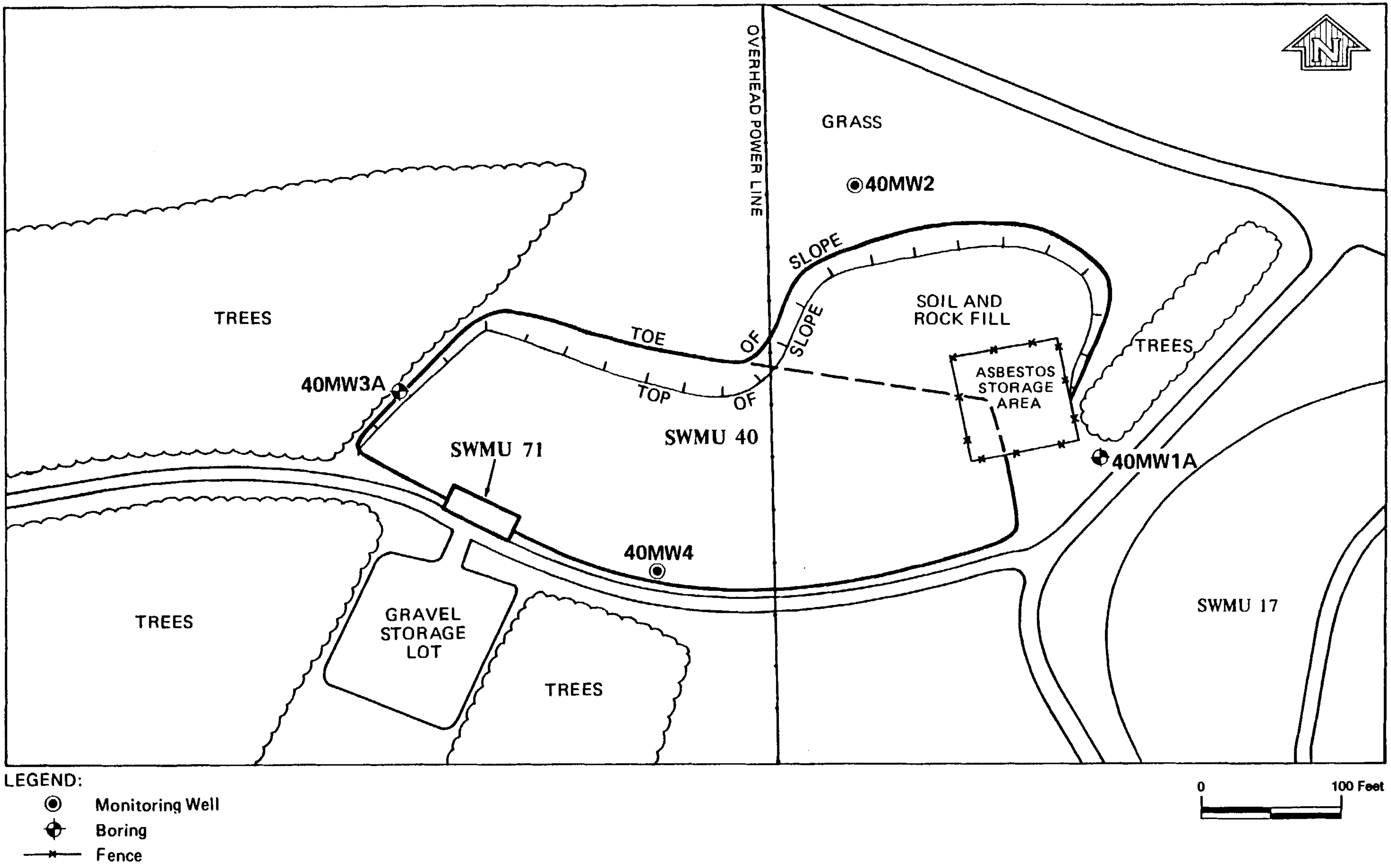

FIGURE 12-1
LOCATION MAP
SWMU 40 – SANITARY LANDFILL (NITROGLYCERIN AREA)
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

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of in this landfill, it was proposed in the VI Work Plan that four wells be installed at this unit--two along bedrock strike (40MW2 and 40MW4) and two along bedrock dip (locations of borings 40MW1A and 40MW3A) (Figure 12-1). The highly weathered and poor rock quality (voids, mudseams) at SWMU 40 prevented the installation of wells in water bearing strata.

The first borehole installed at SWMU 40 was 40MW3A, west of SWMU 40. From 38 to 40 feet a mud-filled cavity was encountered, preventing further drilling, and the borehole was abandoned. Boring 40MW1A, east of SWMU 40, was installed to a depth of 162 feet. This borehole was abandoned because no water was encountered during drilling. Borehole 40MW2 was advanced to a depth of 59 feet. No water was encountered at this depth, but well 40MW2 was installed to intercept any possible high water table at a future date. Borehole 40MW4 was advanced to a total depth of 90 feet. No water was encountered in this boring, but well 40MW4 was installed to a final depth of 62.8 feet (due to collapse) to intercept any possible high water table at a future date. Subsequent measurements taken at wells 40MW2 and 40MW4 (3-12-92) did not indicate any influx of water.

12.2 ENVIRONMENTAL SETTING

12.2.1 Topography

SWMU 40 is a area of gently to steep sloping ridges located in the south-central section of the Main Manufacturing Area. The landfill is approximately one acre in size. This landfill was apparently constructed on a natural depression that runs generally east to west in this part of RAAP. The ground surface of the SWMU slopes from a maximum elevation of 1,906 msl at the southern boundary to 1,890 msl at the northern boundary of the SWMU. The SWMU is bordered by trees on the west and a grassy slope on the north that ends at the biological treatment plant. The burning grounds (SWMU 17) are located approximately 100 feet to the east. There are many asphalt roads and buildings surrounding this SWMU.

12.2.2 Geology and Soils

The subsurface conditions for SWMU 40 were investigated through the drilling of four soil and rock borings to depths ranging from 50 to 162 feet. Borings completed east and west of SWMU 40 (Figure 12-1) encountered a thin layer of silty clay (CL) over limestone and dolostone bedrock. Borings completed both north and south of SWMU 40 encountered a thicker overburden sequence (14 to 17 feet) of silty clay (CL) overlying limestone or dolostone bedrock. Up to 160 feet of Elbrook Formation bedrock was penetrated during drilling. Bedrock in the vicinity of SWMU 40 generally consists of argillaceous limestone and dolostone with abundant clayey zones. The consistency of bedrock ranged from soft to hard with numerous zones of intense weathering and fracturing. Voids were encountered between 21.5 and 23 feet in boring 40MW1A, and a significant void (i.e., cave) was encountered from 38 to 44 feet in boring 40MW3A. The bedrock in the vicinity exhibits typical karst characteristics with evidence of subsurface solution features.

12.2.3 Groundwater Conditions

Groundwater conditions in the SWMU 40 area are controlled by the karstic nature of the Elbrook Formation. Two monitoring wells installed at SWMU 40 to a depth of 60 feet have been dry since installation. A piezometer installed in nearby SWMU 17 at a similar elevation has shown water levels during the VI program to be between 78 and 90 feet below ground surface (elevation 1,814 to 1,836 msl). Based on the observed subsurface conditions, groundwater movement below SWMU 40 would likely be rapid through fractures, voids, and solution cavities, with eventual discharge generally westward to northward into the New River.

12.2.4 Surface Water Drainage

SWMU 40 is located in the south-central section of the Main Manufacturing Area in an area of gently to steep sloping ridges. Based on topography, surface water runoff from within SWMU 40 generally flows northwest approximately 3,600 feet to the New River.

12.3 CONTAMINATION ASSESSMENT

The proposed groundwater sampling for the VI was unable to be completed due to wells 40MW2 and 40MW4 being dry, and as discussed in previous sections, the abandonment of two well borings. Since no groundwater samples were taken at SWMU 40, it is not known if potential contaminants from the landfill at SWMU 40 have impacted the groundwater quality below SWMU 40. Based on the subsurface conditions encountered in the vicinity of SWMU 40, it is likely that any contaminants from the landfill would migrate rapidly through karst solution features in the limestone bedrock and discharge to groundwater flowing toward the New River.

12.4 CONCLUSIONS

Since no groundwater samples were able to be collected at SWMU 40, it is unknown if potential contaminants from the landfill at SWMU 40 have impacted the groundwater quality below SWMU 40.

12.5 RECOMMENDED ACTION

Since subsurface conditions in SWMU 40 have prevented sampling of the two wells installed for the VI to date, it is recommended that the wells be periodically checked for groundwater and sampled if sufficient quantities of water are present for adequate well development and sampling.

An area-wide groundwater dye tracer study proposed for RAAP will help to better identify groundwater flow patterns at this SWMU.

13.0 VERIFICATION INVESTIGATION OF SWMU 41, RED WATER ASH LANDFILL

13.1 SWMU 41 BACKGROUND AND INVESTIGATION PROGRAM

13.1.1 SWMU History

The Red Water Ash Landfill (SWMU 41) is located in the southeast section of the Main Manufacturing Area at RAAP, east of the barracks area and adjacent to the out-of-service TNT wastewater treatment unit. SWMU 41 consists of two noncontiguous disposal areas (Figure 13-1).

Red water is a waste product generated during the production of TNT. Its name is derived from its characteristically intense red color. Red water contains numerous TNT byproducts, including alpha, beta, and gamma TNT isomers and TNT sodium disulfates. It characteristically has a pH of approximately 8, and consists of approximately 30 percent solids. Red water is a listed hazardous waste (K047).

From 1968 to 1972, prior to construction of the red water treatment plant, red water was concentrated by evaporation and burned in four rotary kilns located in the TNT manufacturing area (USATHAMA, 1976). The ash produced from these kilns was disposed of in SWMU 41 and SWMU 51 (TNT Neutralization Sludge Disposal Area). From 1972 to 1974, the red water was sold to the paper industry.

Red water ash has been described as yellowish-tan in color when dry. When wet, it turns a dark red and generates a dark red leachate. It is corrosive and fine-grained, though it may contain large clinkers.

The larger of the two disposal areas at SWMU 41 was a landfill that was never permitted and did not undergo formal closure. The unit was used for red water ash disposal from approximately 1967 to 1971. The approximate size of the unit is 100 feet by 150 feet, and it is located within a larger, relatively flat fill area. RAAP personnel have described the landfill as an excavated bowl that was lined with clay soils prior to ash disposal. The ash may be approximately 20 feet deep in places. Following disposal, the USACE used this

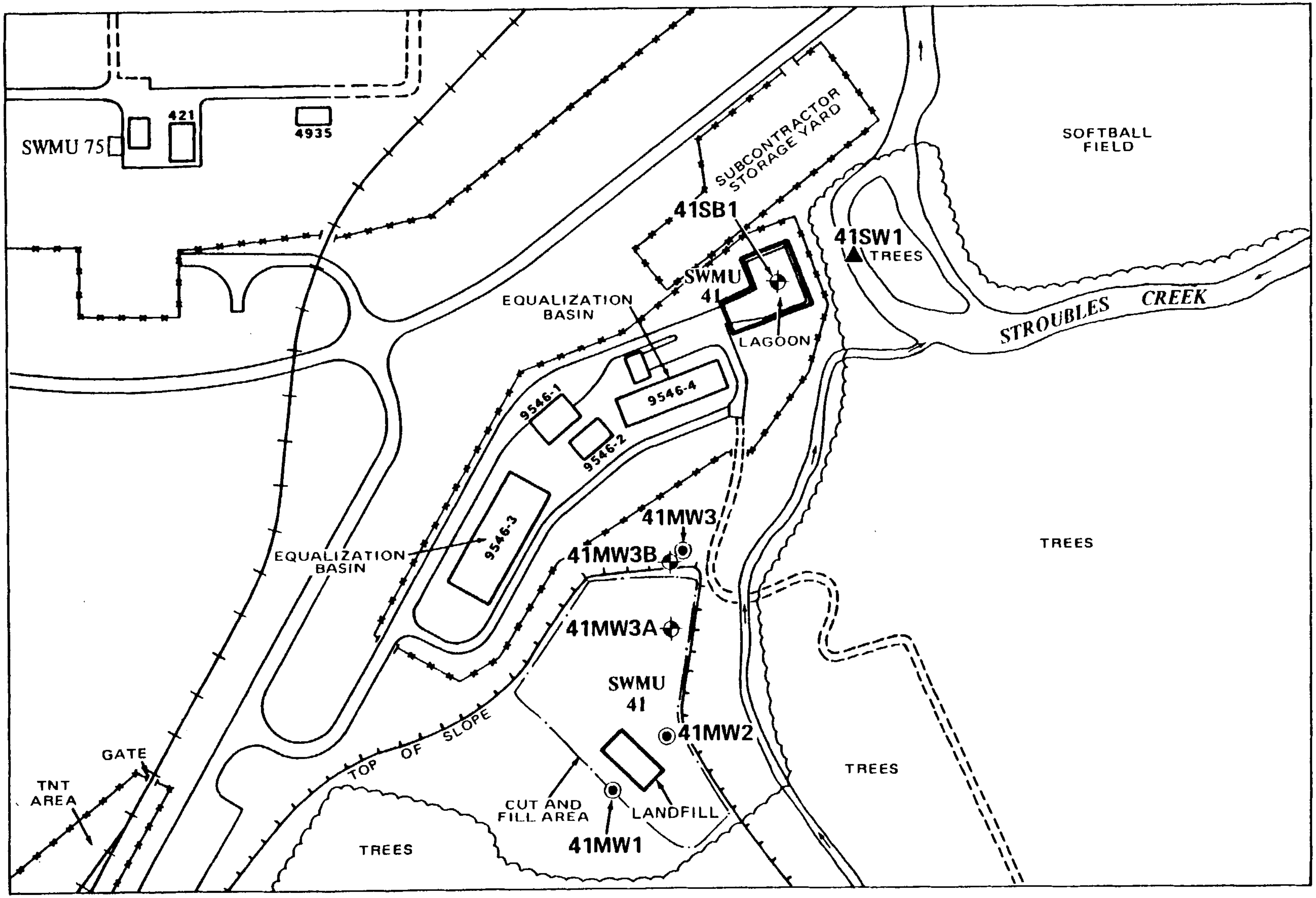

FIGURE 13-1
LOCATION MAP
SWMU 41 – RED WATER ASH LANDFILL
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

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area as the disposal area for "clean" soil excavated at nearby building construction sites. Up to 30 feet of this soil may be present over the ash.

A second ash disposal area is located approximately 600 feet to the northeast. This area consisted of an unlined lagoon that received runoff from the washing of trucks used to haul red water ash. Ash was also disposed of in the lagoon, which was eventually covered with 4 to 6 feet of soil. Potential leachate from the lagoon has reportedly been observed downslope from the disposal area, in the vicinity of Stroubles Creek. The lagoon was approximately 50 feet by 70 feet in area.

13.1.2 Previous Investigations

This SWMU was identified in the RCRA Facility Assessment (USEPA, 1987) as having a potential for releasing contaminants into the environment and was included in the RCRA permit for Corrective Action and Incinerator Operation (USEPA, 1989) as warranting investigation. No site-specific investigations have been conducted at this location prior to this VI.

13.1.3 VI Program

The two noncontiguous disposal areas that make up this unit--the landfill and a lagoon area--required separate sampling strategies. Three monitoring wells were installed to evaluate the potential impact of buried red water ash on the groundwater quality in the vicinity of the landfill. Based on the local topography, the inferred direction of groundwater flow is eastward from the landfill to the tributary of Stroubles Creek (Figure 13-1). One well was installed upgradient of the landfill (41MW1), and two wells (41MW2 and 41MW3) were installed downgradient of the disposal area. It was proposed that the downgradient wells be installed within the cut and fill area of the Red Water Ash Landfill. However, during drilling of boring 41MW3A, unusual soil conditions were encountered, suggesting that the Red Water Ash Landfill may have been penetrated. This borehole was abandoned and well 41MW3 was installed north of the cut and fill area. RAAP personnel subsequently collected a sample of the unusual soil encountered in 41MW3A and determined that it was not red water ash. Monitoring wells 41MW1 and 41MW2 were installed in their proposed locations. The depth of the upgradient and downgradient wells ranged from 62 to 127 feet. Groundwater samples were collected and analyzed for metals, explosives, SVOCs, TOC, TOX, and pH.

One surface water sample (41SW1) was scheduled to be collected from a seep at the bank of the small filled ash lagoon prior to the seep entering the tributary to Stroubles Creek. The bank was visited at various times throughout the VI field program, but the seep was not active during these visits. A surface water sample of the tributary of Stroubles Creek, at a point where a seep may have entered the creek, was collected as a substitute. This sample was analyzed for metals, explosives, SVOCs, TOC, TOX, and pH.

At the lagoon area located north of the landfill (Figure 13-1), the relatively thin cover material (in comparison to more than 30 feet at the landfill) allowed for sampling of the red water ash. One boring (41SB1) was drilled in the center of the lagoon, to a depth of 15 feet. Two soil samples were collected from the boring for chemical analysis. One sample was collected from an ash layer encountered from 6 to 13 feet. To evaluate whether hazardous constituents are leaching from the ash, one sample was collected from the soil underlying the ash. These two samples were analyzed for metals, explosives, and SVOCs.

13.2 ENVIRONMENTAL SETTING

13.2.1 Topography

SWMU 41 consists of two non-contiguous disposal areas, an unlined lagoon and a landfill. The lagoon is located approximately 100 feet west of Stroubles Creek. The topography in the immediate area of the lagoon is moderately sloping northeast towards Stroubles Creek. The elevation of the lagoon is approximately 1,770 to 1,780 feet msl. The landfill is approximately 600 feet southwest of the lagoon and approximately 150 feet west of a tributary of Stroubles Creek. The topography in the area of the landfill slopes lightly over the plateau area and then slopes steeply towards the creek on the northeast. The elevation of the landfill ranges from 1,803 feet msl on the southwestern side to 1,795 feet msl on the northeastern side. There are paved roads, out-of-service equalization basins, a subcontractor storage yard, and the inactive TNT area in the vicinity of SWMU 41. There is also a softball field across Stroubles Creek several hundred feet northeast of the lagoon.

13.2.2 Geology and Soils

The geology of the SWMU 41 area has been explored for this VI through the drilling of five soil borings (41MW1, 41MW2, 41MW3, 41MW3A, and 41MW3B) in the vicinity of SWMU 41 Red Water Ash Landfill and one soil boring (41SB1) in the center of the Red Water Ash Lagoon as shown in Figure 13-1. Three soil borings (41MW1, 41MW2, and 41MW3A) were performed in the upper plateau area where the Red Water Ash Landfill is located. These borings indicated the presence of fill extending from the ground surface to weathered bedrock at an approximate depth of 30 feet. Soils encountered were generally described as a silty clay (CL). Soil borings 41MW3 and 41MW3B performed north of the plateau (downgradient of the landfill area) also encountered apparently in-place fill from the ground surface to the weathered bedrock surface (approximately 30 feet). Soils encountered in boring 41MW3 were also described as a silty clay (CL). Finally, one boring was performed in the approximate center of the Red Water Ash Lagoon to a depth of 15 feet below ground surface (Figure 13-1). Fill and Red Water Waste was encountered to a depth of approximately 13 feet below ground surface. Soils encountered below the waste appeared to be natural soils generally described as a silty clay (CL). Groundwater was not encountered in this boring.

Weathered bedrock was generally encountered in SWMU 41 at approximately 30 feet below ground surface. In the upper plateau area, the bedrock surface slopes northward at approximately 15 to 25 percent. Up to 95 feet of bedrock was penetrated below SWMU 41 during the VI program. Rock coring was completed in two of the borings (41MW1 and 41MW3) through a maximum bedrock thickness of approximately 70 feet. The bedrock penetrated at SWMU 41 was generally described as a highly interbedded argillaceous gray limestone and dolomite with occasional thick beds of green shale. The limestone and dolomite encountered typically included brecciated and conglomeratic zones and vuggy and pitted surfaces. Evidence of faulting and deformation of the limestone/dolomite bedrock is evident in rock core samples from 41MW1 and is likely the result of intense deformation associated with the geologic thrust sheet fenster in this area of RAAP.

13.2.3 Groundwater Conditions

An unconfined groundwater table was encountered within bedrock at depths ranging from 55 to 100 feet below ground surface. Subsequent stabilized groundwater levels occurred within bedrock at depths generally ranging from 20 to 50 feet below ground surface. Based on measured groundwater levels, the groundwater flow direction below SWMU 41 is to the northeast toward Stroubles Creek (Insert 2). The measured hydraulic gradient between wells 41MW1 and 41MW2 was 40 percent and is approximately 8 percent between wells 41MW2 and 41MW3. The observed groundwater gradient is significantly greater than the apparent bedrock surface gradient and surrounding ground surface topography.

13.2.4 Surface Water Drainage

Based on topography, the surface water from the landfill (SWMU 41) appears to flow northeastward towards a tributary of Stroubles Creek. The tributary flows north and discharges into Stroubles Creek, just south of the SWMU 41 lagoon. Based on topography, surface water from the lagoon appears to flow east/northeast and discharges into Stroubles Creek. Stroubles Creek at this point flows north and discharges to the New River, approximately 2,800 feet north of SWMU 41.

According to the RAAP utility maps, there appear to be no manholes, catch basins, or storm drains in the immediate vicinity of SWMU 41.

13.3 CONTAMINATION ASSESSMENT

The field investigation at SWMU 41 included the collection of three groundwater samples (and one duplicate) in the vicinity of the landfill. Additionally, ash and soil samples from the lagoon north of the landfill and a surface water sample from Stroubles Creek were obtained.

13.3.1 Soil

The same 16 metals were detected in both the ash and underlying soil samples collected from the former wastewater lagoon. Each metal except for arsenic exceeded PQLs. Aluminum, barium, calcium, lead, magnesium, manganese, potassium, sodium, and zinc concentrations were higher in the ash sample than in the underlying soil sample. As shown in Table 13-1, concentrations of arsenic and cobalt exceeded the HBN criteria; however the levels of arsenic and cobalt in the ash were less than in the underlying soil sample, and also were less than the soil background criteria. These levels probably represent concentrations naturally occurring in native upland soil at RAAP. Concentrations of other metals, such as aluminum, barium, manganese and sodium in the ash sample, and chromium, iron and sodium in the underlying soil sample, exceeded the soil background criteria. However, these metals are not considered a concern because the levels were slightly elevated and did not exceed applicable HBN criteria.

No explosives and no SVOCs were detected in either the ash or soil sample. Five SVOC TICs were detected in the ash sample and none in the soil sample. These data indicate that there is no contamination concern from explosives or SVOCs at the lagoon area.

13.3.2 Groundwater

In total, 11 metals were detected in groundwater samples collected from three wells installed near the landfill. Antimony, barium, calcium, magnesium, manganese, potassium, and sodium were detected at concentrations above PQLs (Table 13-2). Of these metals, antimony, barium, calcium, magnesium, potassium, and sodium were greater in the downgradient well samples. Antimony was the only metal to exceed an HBN in the sample from well 41MW2, but the concentrations were below the detection level in the other three samples. The major ions (i.e., calcium, manganese, potassium and sodium) do not have HBNs and are not considered contaminants of concern. Sample 41MW2, collected downgradient and nearest the landfill, exhibited the highest concentrations of many of the inorganic constituents. One SVOC, B2EHP, was identified in one sample (41MW2) at a

Table 13-1

Summary of Analytical Data For Soil Samples Collected At SWMU 41
Radford Army Ammunition Plant, Virginia

SITE ID		41SB1	41SB1	
FIELD ID		RVFS*44	RVFS*45	
S. DATE		25-oct-91	25-oct-91	
DEPTH (ft)		8.0	14.0	
MATRIX	PQLs	CSO	CSO	HBN
UNITS	UGG	UGG	UGG	UGG
TAL Inorganics				
ALUMINIUM	14.1	25400	20600	230000
ARSENIC	30	[8.1]	[11.5]	0.5
BARIUM	1	140	84.5	1000
CALCIUM	100	62800	821 B	NSA
CHROMIUM	4	32.7 B	60.1	400
COBALT	3	[12.8]	[15.9]	0.8
COPPER	7	19.7	21.8	2900
IRON	1000	24400	40000	NSA
LEAD	2	74.7	37.3	200
MAGNESIUM	50	40800	4950 B	NSA
MANGANESE	0.275	1560	885	8000
NICKEL	3	20.8	25.2	1000
POTASSIUM	37.5	2080	1440 B	NSA
SODIUM	150	2040 B	887 B	NSA
VANADIUM	0.775	48.7	54.3	560
ZINC	30.2	241	87.7	16000
Explosives	NA	None Detected	None Detected	NSA
Semivolatiles	NA	None Detected	None Detected	NSA
Semivolatile TICs				
HEPTADECANE	NA	0.38 S	ND	NSA
NONADECANE	NA	0.38 S	ND	NSA
TOTAL UNKNOWN TICs	NA	(3)304	ND	NSA

Footnotes :

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TICs = Tentatively identified compounds that were detected in the GC/MS library scans.

( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

CSO = Chemical soil.
ND = Analyte was not detected.
TAL = Target Analyte List.
UGG = Micrograms per gram.

Table 13–2
Summary of Analytical Data For Groundwater Samples Collected At SWMU 41
Radford Army Ammunition Plant, Virginia

SITE ID		41MW1	41MW2	41MW3	41MW3	
FIELD ID		RDWC*69	RDWC*70	RDWC*68	RDWC*71	
S. DATE		03–mar–92	03–mar–92	04–mar–92	04–mar–92	
DEPTH (ft)		70.0	113.0	53.0	53.0	
MATRIX	PQLs	CGW	CGW	CGW	CGW	HBN
UNITS (#)	UGL	UGL	UGL	UGL	UGL	UGL
TAL Inorganics						
ANTIMONY	30	LT 38	[68]	LT 38	LT 38	10
BARIUM	20	19.9	81.9	16.5	15.7	1000
CALCIUM	500	24000	232000	121000	122000	NSA
LEAD	10	LT 1.26	1.41	LT 1.26	3.58	50
MAGNESIUM	500	31400	215000	64000	65000	NSA
MANGANESE	2.75	45.4	39	10.1	10.2	3500
POTASSIUM	375	938	1710	2570	2940	NSA
SILVER	2	0.321	0.962	LT 0.25	LT 0.25	50
SODIUM	500	960000	6500000	221000	224000	NSA
VANADIUM	40	LT 11	34.1	14.6	15.3	245
ZINC	50	LT 21.1	31.8	LT 21.1	LT 21.1	7000
Explosives	NA	None Detected	None Detected	None Detected	None Detected	NSA
Semivolatiles						
BIS(2–ETHYLHEXYL) PHTHALATE	10	LT 4.8	[5.64]	LT 4.8	LT 4.8	3
TOTAL UNKNOWN TICs	NA	ND	(7)84	ND	(3)47	NSA
Other						
TOTAL ORGANIC CARBON	1000	38000	82100	24400	23300	NSA
TOTAL ORGANIC HALOGENS	1	77.8	89.2	36.1	95	NSA
pH	NA	7.87	7.08	7.07	7.13	NSA

Footnotes :

CGW = Chemical groundwater.
HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).
LT = Concentration is reported as less than the certified reporting limit.
NA = Not available; PQLs are not available for TICs detected in the library scans.
ND = Analyte was not detected.
NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.
PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical metho
TAL = Target Analyte List.
TICs = Tentatively identified compounds that were detected in the GC/MS library scans.
UGL = Micrograms per liter.
( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. Th number beside the parenthesis is the total concentration of all TICs detected in each respective scan.
[ ] = Brackets indicate that the detected concentration exceeds the HBN.

concentration of 5.64 ug/l. This concentration slightly exceeded the HBN criterion of 3 ug/l for B2EHP; however, B2EHP was determined to be a laboratory artifact related to sampling and analysis. The maximum concentration of B2EHP in the method blanks analyzed was 110 ug/l, almost 20 times the level detected in well 41MW2. Several unknown SVOC TICs were reported for 41MW2 and the duplicate analysis of 41MW3. TOC was greatest in the nearby downgradient well sample 41MW2, but was less than the upgradient level further from the landfill in 41MW3.

13.3.3 Surface Water

In total, seven metals were detected above the PQLs in the surface water sample collected in Stroubles Creek (Table 13-3). The metals are common earth elements that are expected to be dissolved in surface water and were reported at concentrations less than the HBN criteria. One explosive (i.e., 246TNT) was detected in the sample but was reported at a level less than the HBN criterion. TOC and TOX were reported at 6,010 ug/l and 82.4 ug/l. No SVOCs were detected in the creek sample.

The source for the 246TNT in the surface water sample cannot be identified as SWMU 41 since no explosives were detected in any of the on-site samples. Two non-site scenarios are possible for the 246TNT in the Stroubles Creek sample based on the known RAAP history. One scenario is that material in Stroubles Creek or a tributary was adversely impacted when the TNT area was destroyed by the explosion in 1974. A second scenario is that the karst geology is resulting in an upgradient discharge of contaminated groundwater from an off-site source area, such as the Contaminated Waste Burning Areas (SWMU 17). Whether or not these possible scenarios are the source of the detected 246TNT, the concentration was below the HBN and is not considered a significant concern with respect to this SWMU.

13.4 BASELINE RISK ASSESSMENT

Based on the contamination assessment presented in Section 13.3, one contaminant of concern, antimony, has been identified for groundwater downgradient of SWMU 41. Contaminants of concern were not identified for site soil or surface water in Stroubles

Table 13-3
Summary of Analytical Data For Surface Water Samples Collected At SWMU 41
Radford Army Ammunition Plant, Virginia

SITE ID		41SW1	
FIELD ID		RDWC*76	
S. DATE		10-mar-92	
DEPTH (ft)		0.0	
MATRIX	PQLs	CSW	HBN
UNITS	UGL	UGL	UGL
TAL Inorganics			
BARIUM	20	55.9	1000
CALCIUM	500	58500	NSA
IRON	38.1	199	NSA
MAGNESIUM	500	29300	NSA
MANGANESE	2.75	27.8	3500
POTASSIUM	375	1850	NSA
SODIUM	500	14900	NSA
Explosives			
246TNT	0.635	1.38	11.7
Semivolatiles	NA	None Detected	NSA
Other			
TOTAL ORGANIC CARBON	1000	6010	NSA
TOTAL ORGANIC HALOGENS	1	82.4	NSA
pH	NA	7.99	NSA

Footnotes:

CSW = Chemical surface water.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TAL = Target Analyte List.

UGL = Micrograms per liter.

Creek. The potential impact of antimony in site groundwater to human health and the environment is discussed below in Sections 13.4.1 and 13.4.2, respectively.

13.4.1 Human Health Evaluation

No shallow groundwater wells other than for monitoring purposes are located downgradient of SWMU 41. Although a RAAP supply well is located approximately 2,000 feet northeast of SWMU 41, it is located on the opposite side of Stroubles Creek. Because SWMU 41 is located near a tributary of Stroubles Creek, and based on the local topography, the inferred direction of groundwater flow is eastward from the landfill to the tributary of Stroubles Creek, shallow groundwater most likely discharges to this tributary. Therefore, shallow groundwater would not likely migrate toward any groundwater users in the vicinity of RAAP. As discussed in Section 2.5, future land use is considered to be similar to the current land use scenario--i.e., RAAP will continue to remain an active army installation and there are no plans for future residential development of RAAP. Therefore, it is highly unlikely that groundwater wells would be installed in the future between SWMU 41 and the tributary of Stroubles Creek. Based on this evaluation, potential groundwater exposure pathways are not considered operable under the current or future land use scenario.

As discussed above, there is the potential for discharge of shallow groundwater contamination to the tributary of Stroubles Creek. However, there are no known domestic or recreational uses of this stream and a large portion of the flow in Stroubles Creek is attributable to effluent from the Blacksburg municipal sewage treatment plant. Although there is the potential for workers, employees, or trespassers to contact the surface water of the Stroubles Creek tributary, these events would presumably be isolated and infrequent. In addition, antimony was only detected in one of the four groundwater samples at a concentration of 68 ug/l, which is less than an order of magnitude above its HBN; the concentration would presumably be diluted upon discharge to the tributary of Stroubles Creek. Therefore, potential surface water exposure pathways are not considered significant.

13.4.2 Environmental Evaluation

As discussed above, there is the potential for discharge of groundwater contamination to the tributary of Stroubles Creek, which could potentially impact aquatic life. Although data are insufficient for establishing aquatic life criteria for antimony, the lowest observed effect level (LOEL) for chronic effects to freshwater aquatic life is reported as 1,600 ug/l (USEPA, 1986). Because antimony was detected at a concentration of 68 ug/l in shallow groundwater and dilution is expected to occur upon discharge to the tributary of Stroubles Creek, this one low detection of antimony in SWMU 41 groundwater does not appear to be of concern.

13.4.3 Conclusions of Human Health and Environmental Evaluations

Although antimony was detected above its HBN, due to the lack of groundwater and surface water receptors and the fact that dilution would occur upon discharge of groundwater to the tributary of Stroubles Creek, resulting in insignificant exposure, the detection of antimony does not appear to present a current or potential future human health risk or environmental threat.

13.5 CONCLUSIONS

The field investigation at the Red Water Ash Landfill (SWMU 41) consisted of collection of three groundwater samples, ash and soil samples from the lagoon (north of the landfill), and one surface water sample from Stroubles Creek. A total of 16 metals were detected in the ash and underlying soil samples. The concentrations of aluminum, barium, manganese, and sodium in the ash sample, and chromium, iron, sodium, and arsenic in the underlying soil sample exceeded the soil background criteria. Arsenic was above the HBN but because it only slightly exceeded the background criteria and the ash concentration was less than the underlying soil, it is not likely a result of the waste from site operations or considered a concern.

Several metals (antimony and barium) and the major ions (calcium, magnesium, potassium, and sodium) exceeded PQLs and appeared to be elevated in the downgradient groundwater samples. Antimony in a downgradient well was the only metal constituent that exceeded the HBN criterion, and may be a concern. Based on the results of the risk assessment, the level of antimony does not appear to present a current or potential future human risk or environmental threat. B2EHP exceeded the HBN, but is considered a laboratory artifact because of the levels found in the method blanks.

The seven metals detected in the surface water sample from Stroubles Creek are common earth elements with concentrations below the HBN criteria. One explosive, 246TNT, was detected in the surface water sample, but no explosives were detected in the on-site samples. The results of the investigation indicate that the waste from the Red Water Ash Landfill has not impacted the surface water.

13.6 RECOMMENDED ACTION

The level of antimony in a well downgradient from the Red Water Ash Landfill (SWMU 41) was the only concern identified by the analytical results. The concentration of antimony, however, does not appear to present a current or potential future human health risk or environmental threat; hence, further investigation is not recommended.

An investigation of the source for the 246TNT found in the Stroubles Creek sample may be warranted, but this issue appears unrelated to the SWMU 41 VI.

14.0 VERIFICATION INVESTIGATION OF SWMU 43, SANITARY LANDFILL (ADJACENT TO NEW RIVER)

14.1 SWMU 43 BACKGROUND AND INVESTIGATION PROGRAM

14.1.1 SWMU History

SWMU 43 is a closed, unlined sanitary landfill located immediately adjacent to the New River in the northeast section of the RAAP Main Manufacturing Area (Figure 14-1). The unit never operated as a permitted landfill. Because no plan or site documents are available, the exact boundaries of the unit have not been determined. Based on aerial photography, the landfill apparently extends east-west approximately 600 feet on either side of a drainage ditch that divides the area. The north-south boundaries are the riverbank and paved roadway, respectively. The landfill was a trench-fill operation. Subsidence of the soil cover has been noted during facility inspections. The landfill reportedly received 300 tons of paper and refuse over its active life; however, based on the estimated size of the landfill the quantities were probably larger.

It was reported by RAAP personnel that this landfill was operated from about 1967 through the early 1970s. A previous report (USATHAMA, 1984) described a sanitary landfill in the same location as having operated from 1958 to 1969. Aerial photographs indicate possible landfill operations at the unit prior to 1962. It seems likely, but is not certain, that landfilling occurred at SWMU 43 from the late 1950s to the early 1970s.

14.1.2 Previous Investigations

This SWMU was identified in the RCRA Facility Assessment (USEPA, 1989) as having a potential for releasing contaminants into the environment and was included in the RCRA Permit for Corrective Action and Incineration Operation (USEPA, 1989) as warranting investigation. No site-specific investigations have been conducted at this location prior to this VI.

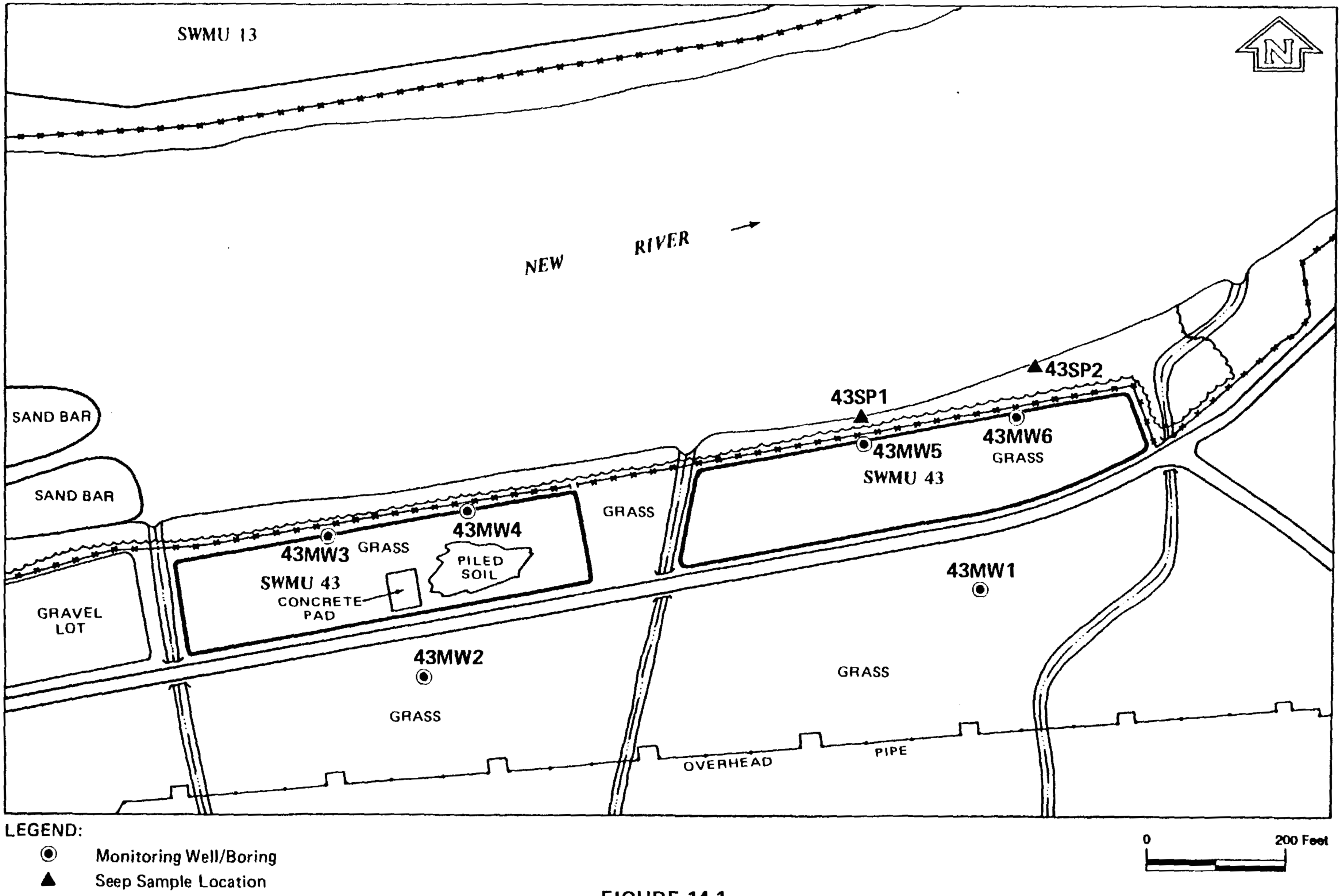


FIGURE 14-1
LOCATION MAP
SWMU 43 – SANITARY LANDFILL
(ADJACENT TO NEW RIVER)
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Dames & Moore

14.1.3 VI Program

Prior to this investigation, there were no existing wells in the vicinity of this landfill. To evaluate whether groundwater quality in the vicinity of this unit has been impacted by landfilled wastes, six monitoring wells were installed. One well was installed upgradient of each section of the landfill (43MW1 and 42MW2), and two wells were installed downgradient of each section (42MW3, 42MW4, 42MW5, and 42MW6) (Figure 14-1). The maximum depth of these six wells is 42 feet. Groundwater samples were collected from the six wells and analyzed for metals, VOCs, SVOCs, TOC, TOX, and pH. Two seep samples were also collected from the river bank north of the eastern half of the landfill and analyzed for metals, VOCs, SVOCs and TOC.

14.2 ENVIRONMENTAL SETTING

14.2.1 Topography

SWMU 43 is a flat level area at an approximate elevation of 1,700 msl. A drainage ditch located in the center of the SWMU divides the area into east and west sections . The western section is mostly grassy but has a small concrete pad, gravel parking area, and a pile of soil located adjacent to the roadway. The eastern section is entirely covered with grass. There are very few buildings in this section of the plant. Elongated depressions, which would correspond to the disposal trenches, are visible. The east half appears to have had more subsidence since the landfill was covered.

14.2.2 Geology and Soils

The geology of the SWMU 43 area has been explored for this VI through the drilling of two soil and rock borings south of SWMU 43 (43MW1 and 43MW2) and four soil and rock borings north of SWMU 43 (43MW3, 43MW4, 43MW5, and 43MW6), as shown in Figure 14-1. Generally, the subsurface conditions revealed by the boring program consisted of fine to coarse grained alluvial deposits, which progressively thicken away from the New River. Alluvial deposits encountered in the vicinity of SWMU 43 consist mainly of fine grained, micaceous, brown, sandy silts (ML) and silty sands (SM) with some interbedded silty clays (CL). Two of the downgradient borings (43MW5 and 43MW6) drilled along the fence bordering SWMU 43 encountered approximately 18 feet of sanitary landfill material. Landfill material encountered was composed mainly of paper, rubber, and plastic debris. Underlying this landfill material was a relatively thin layer of apparently undisturbed fine grained silt to silty sand over weathered limestone rock. Where sediments are thicker in the upgradient borings, a basal layer of river jack (silty gravel) (at 43MW2) or silty clay (at 43MW1) is present above weathered limestone bedrock. Bedrock encountered in the SWMU 43 area generally consists of highly argillaceous gray limestone and gray conglomeratic and brecciated limestone. Typically, the limestone encountered was weathered to highly weathered, and fractured with vuggy and pitted zones and occasional clay seams. During rock coring large quantities of water were lost in fractured and weathered zones within the bedrock. The observed depth to limestone rock ranged from 23 to 30 feet in the southern well bores and 17 to 21 feet in the northern well bores. Up to 23 feet of limestone were penetrated in the northern well bores in SWMU 43.

14.2.3 Groundwater Conditions

An unconfined ground water table was encountered from 18 to 23 feet within the overburden soils in the upgradient well, at the overburden and bedrock interface for wells installed through the landfill (43MW5 and 43MW6), or within the limestone bedrock in the remaining downgradient wells. As shown on Insert 2, groundwater at SWMU 43 flows northward towards the New River. Subsequent stabilized groundwater levels indicate the general direction of groundwater flow is north toward the New River at a hydraulic gradient of approximately 0.5 to 1 percent. The visible trench depressions were often very soft with standing water within them on the eastern half. This indicates that the landfill is recharged through surface water infiltration. Several groundwater seeps were observed discharging from the base of the embankment north of SWMU 43 along the New River. These seeps were detected north of the landfill area in the vicinity of monitoring wells 43MW5 and 43MW6 at an elevation of approximately 1,681 feet msl.

14.2.4 Surface Water Drainage

SWMU 43 is a flat level area located adjacent to the New River. Based on topography, surface water runoff from the SWMU is expected to flow towards a drainage ditch that is located in the center of SWMU 43 and would probably flow northward to the New River. The trench depressions also collect surface water which either infiltrates into the landfill or evaporates.

14.3 CONTAMINATION ASSESSMENT

Six groundwater samples and two seep (surface water) samples were collected to evaluate SWMU 43 conditions. Although several metals and low levels of VOCs were reported for the groundwater and surface water samples, all concentrations were less than the HBN criteria and are not expected to be a concern at the site. Concentrations of arsenic, calcium, magnesium, manganese, and possibly barium were higher in downgradient wells. Arsenic only exceeded the PQL once; this concentration in well 43MW6 (14 ug/L) was less than the HBN.

14.3.1 Groundwater

The results of the chemical analyses indicate the presence of metals, VOCs, and SVOCs in groundwater at SWMU 43 (Table 14-1). However, no constituents exceeded HBN criteria. The metals detected in higher concentrations in downgradient wells are common constituents of groundwater, and detected concentrations were at levels expected to be present in groundwater of a limestone formation. Downgradient samples from wells 43MW3 and 43MW6 exhibited the greatest concentrations of several ions; however, the concentrations are below any HBNs and may reflect normal ion variability. A total of three VOCs were detected in the two downgradient wells 43MW3 and 43MW6. However, two VOCs were detected below the PQL and the other VOC was carbon disulfide, a naturally occurring compound detected at a concentration two orders of magnitude less than the HBN. VOC TICs were also detected in samples from the same two wells. One SVOC TIC was reported in one sample but was detected in the laboratory method blank and is an artifact of the laboratory analyses. Unknown SVOC TICs were reported for both upgradient

Table 14-1
Summary of Analytical Data For Groundwater Samples Collected At SWMU 43
Radford Army Ammunition Plant, Virginia

SITE ID		43MW1	43MW1	43MW2	43MW3	43MW4	43MW5	43MW6	
FIELD ID		RDWB*1	RDWB*8	RDWB*2	RDWB*3	RDWB*4	RDWB*5	RDWB*6	
S. DATE		29-oct-91	29-oct-91	29-oct-91	30-oct-91	30-oct-91	31-oct-91	01-nov-91	
DEPTH (ft)		21.0	21.0	27.0	30.0	21.0	37.0	33.0	
MATRIX	PQLs	CGW	CGW	CGW	CGW	CGW	CGW	CGW	HBN
UNITS	UGL	UGL	UGL	UGL	UGL	UGL	UGL	UGL	UGL
TAL Inorganics									
ARSENIC	10	LT 2.54	LT 2.54	LT 2.54	5.54	4.16	3.09	14	50
BARIUM	20	55.6	54.7	86.9	45.7	152	44.3	165	1000
CALCIUM	500	55900	56900	47200	139000	85900	113000	111000	NSA
IRON	38.1	LT 38.8	67.8	LT 38.8	659	6630	84.5	14500	NSA
MAGNESIUM	500	23800	24100	20500	58400	30900	42300	47900	NSA
MANGANESE	2.75	4.81	5.84	LT 2.75	41.7	974	41	208	3500
POTASSIUM	375	779	1370	1020	1310	827	1060	1410	NSA
SODIUM	500	10500	10500	5990	23000	10200	11100	27900	NSA
Volatiles									
1,2-DICHLOROETHENE	5	LT 0.5	LT 0.5	LT 0.5	0.583	LT 0.5	LT 0.5	1.36	NSA
BENZENE	5	LT 0.5	LT 0.5	LT 0.5	0.505	LT 0.5	LT 0.5	LT 0.5	5
CARBON DISULFIDE	5	LT 0.5	LT 0.5	LT 0.5	6.01	LT 0.5	LT 0.5	2.27	4000
TOTAL UNKNOWN TICs	NA	ND	ND	ND	(1)10	ND	ND	(1)6	NSA
Semivolatiles	NA	None Detected	None Detected	None Detected	None Detected	None Detected	None Detected	None Detected	NSA
Semivolatile TICs									
CYCLOHEXENE OXIDE	NA	ND	ND	ND	ND	2 SB	ND	ND	NSA
TOTAL UNKNOWN TICs	NA	ND	ND	(1)10	(8)112	(5)180	ND	(3)18	NSA
Other									
TOTAL ORGANIC CARBON	1000	2820	11000	5330	4620	14300	7620	6690	NSA
TOTAL ORGANIC HALOGENS	1	141	29.3	14.8	65.7	52.5	66.5	59.8	NSA
pH	NA	6.73	6.63	6.59	6.57	6.53	7.1	6.69	NSA

Footnotes :

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CGW = Chemical groundwater.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TICs = Tentatively identified compounds that were detected in the GC/MS library scans.

( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

ND = Analyte was not detected.

TAL = Target Analyte List.

UGL = Micrograms per liter.

and downgradient samples. TOC, TOX, and pH were generally similar in upgradient and downgradient samples.

14.3.2 Surface Water

The results of the chemical analyses indicated the presence of 10 metals and one VOC in water samples collected from groundwater seepage points downgradient of wells 43MW5 and 43MW6 (Table 14-2). Nine metals were detected above PQLs, but no constituents exceeded HBN criteria. Concentrations of several metals were greatest in 43SP1, which is located downgradient of well 43MW5. Aluminum and vanadium (at less than the PQL) were detected in sample 43SP1 but were not detected in sample 43SP2 or the groundwater samples. Carbon disulfide, a VOC detected in two groundwater samples at the site, was detected in sample 43SP1 but was detected at a concentration of two orders of magnitude less than the HBN criterion. One SVOC TIC was reported but was detected in the laboratory method blank and is considered to be an artifact of the laboratory analyses. Low to moderate concentrations of unknown SVOC TICs were reported for both seepage samples. No other VOCs or SVOCs were detected in these samples.

14.4 CONCLUSIONS

The VI conducted at SWMU 43 consisted of the collection of six groundwater samples and two seep samples.

Groundwater samples were collected both upgradient and downgradient of SWMU 43. The results of the chemical analysis indicate the presence of metals, low levels of VOCs, and unknown VOCs and SVOC TICs in both upgradient and downgradient samples. However, the concentration of metals, VOCs, and SVOCs in groundwater were less than HBN criteria and, therefore, are not expected to be a concern at the site.

Surface water samples collected at groundwater seepage points indicated the presence of metals, one VOC, and unknown SVOC TICs at low levels. All constituents were less than HBN criteria and are not expected to be a concern at the site.

Table 14-2

Summary of Analytical Data For Surface Water Samples Collected At SWMU 43

Radford Army Ammunition Plant, Virginia

SITE ID		43SP1	43SP2	
FIELD ID		RDWB*7	RDWB*10	
S. DATE		31-oct-91	31-oct-91	
DEPTH (ft)		0.0	0.0	
MATRIX	PQLs	CSW	CSW	HBN
UNITS	UGL	UGL	UGL	UGL
TAL Inorganics				
ALUMINIUM	141	403	LT 141	101500
ARSENIC	10	15.2	3.94	50
BARIUM	20	194	84	1000
CALCIUM	500	92000	72300	NSA
IRON	38.1	32300	1730	NSA
MAGNESIUM	500	41100	28300	NSA
MANGANESE	2.75	1300	98.1	3500
POTASSIUM	375	856	1510	NSA
SODIUM	500	20800	9170	NSA
VANADIUM	40	13.2	LT 11	245
Volatiles				
CARBON DISULFIDE	5	3.29	LT 0.5	4000
Semivolatiles	NA	None Detected	None Detected	NSA
Semivolatile TICs				
CYCLOHEXENE OXIDE	NA	4 SB	4 SB	NSA
TOTAL UNKNOWN TICs	NA	(4)62	(1)6	NSA
Other				
TOTAL ORGANIC CARBON	1000	12200	6140	NSA

Footnotes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CSW = Chemical surface water.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TAL = Target Analyte List.

TICs = Tentatively identified compounds that were detected in the GC/MS library scans.

UGL = Micrograms per liter.

( ) = Parenthesis are used to indicate the numb S library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

S = Results are based on an internal standard; flag is used for TICs detected in library scan.

Based on groundwater and surface water sample results, groundwater quality has not been significantly impacted by landfilled wastes at SWMU 43.

14.5 RECOMMENDED ACTION

Because metals, VOCs and unknown SVOC TICs detected in groundwater and surface water samples collected at SWMU 43 are either not significantly different from background concentrations or are below HBNs, groundwater quality in the vicinity of SWMU 43 has not been significantly impacted by landfill wastes. Therefore, an RFI for SWMU 43 is not recommended. Filling the trench depressions and grading the site to prevent surface water infiltration would likely stop the seepages along the bank of the New River. This effort is recommended.

15.0 VERIFICATION INVESTIGATION OF SWMU 45, SANITARY LANDFILL (WEST OF MAIN BRIDGE)

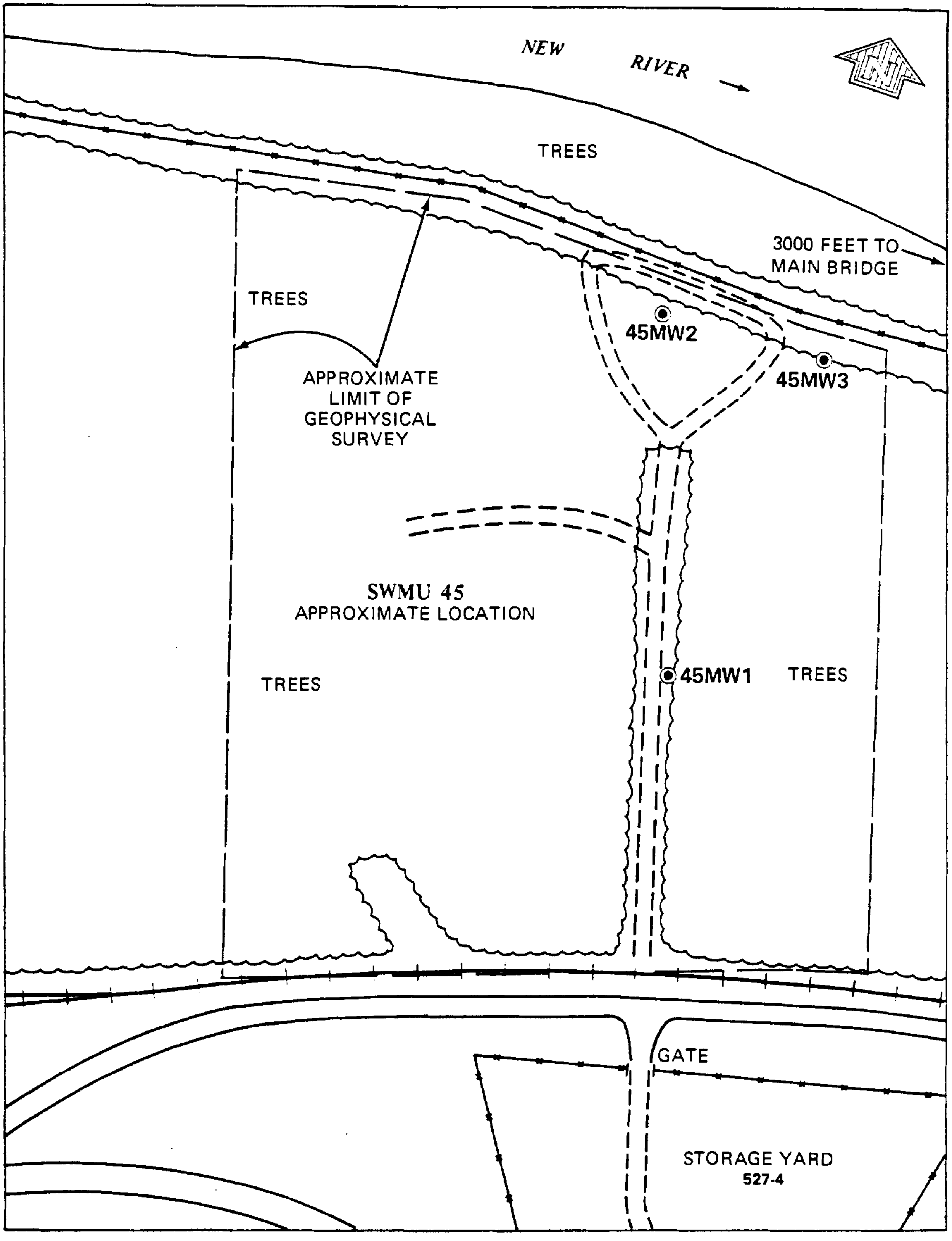
15.1 SWMU 45 BACKGROUND AND INVESTIGATION PROGRAM

15.1.1 SWMU History

SWMU 45, an inactive sanitary landfill, is located approximately 3,000 feet west of the main bridge over the New River, in the north-central section of the Main Manufacturing Area (Figures 15-1). The unit was never operated as a permitted landfill. The exact boundaries of the unit have not been determined, since no operational plans or diagrams are available. The area is overgrown with pine trees that were planted after the landfill operations ceased.

The RCRA Facility Assessment (USEPA, 1987) described this landfill as having operated during the 1970s. Another report (USATHAMA, 1984) describes this landfill as the first known landfill at RAAP, which operated between 1957 and 1961. Aerial photography from 1949 shows a cleared area with white ground scarring in the area between but just south of wells 45MW2 and 45MW3. Figure 15-1 also shows the well locations and presents the road pattern as seen in the 1949 photograph, but the tree pattern reflects current conditions. In 1962, there still were no trees evident, but the scarring was not visible in the aerial photography. However, a darker, possibly disturbed, area was visible in the area south of well 45MW2. In 1971, aerial photography showed none of the 1949 or 1962 scarring patterns, but a different white-scarred area along the former access road approximately 100 feet north of well 45MW1. The latter dates of landfill operation appear to be more reliable based on recollections of plant personnel, the aerial photography, and the apparent ages of the pine trees.

Paper and municipal refuse were the only materials reportedly disposed of in SWMU 45. It was also reported that wastes were placed in trenches and burned prior to burial. Evidence of burning has been observed in the area. If hazardous constituents were disposed of in this landfill, the potential exists for groundwater contamination.



LEGEND:

◉ Monitoring Well

0 100 Feet

FIGURE 15-1
LOCATION MAP
SWMU 45 – SANITARY LANDFILL
(WEST OF MAIN BRIDGE)
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Dames & Moore

15.1.2 Previous Investigations

This SWMU was identified in the RCRA Facility Assessment (USEPA, 1987) as having a potential for releasing contaminants into the environment and was included in the RCRA Permit for Corrective Action and Incinerator Operation (USEPA, 1989) as warranting investigation. No site-specific investigations have been conducted at this location prior to this VI.

15.1.3 VI Program

The boundaries and specific disposal area locations at this unit could not be determined from available information; therefore, to better delineate the landfill boundaries and trench locations, a geophysical survey was conducted over the approximate five-acre area identified in Figure 15-1.

Results of the geophysical survey enabled the appropriate placement of three monitoring wells--one upgradient (45MW1) and two downgradient (45MW2 and 45MW3) of the landfill area. In addition to the measurement of groundwater levels for each well, groundwater samples were collected and analyzed for metals, VOCs, SVOCs, explosives, TOC, TOX, and pH.

15.1.4 Geophysical Survey

. SWMU 45 was one of four areas at which geophysical instruments were used to acquire additional information on the physical configuration of a poorly delineated area. The following discussion summarizes the findings of this geophysical investigation, which has been included as Appendix H.

At SWMU 45, EM and magnetometer surveys were performed to identify the potential boundaries of the landfill. For the initial survey, measurements were taken at intervals of 10 feet along seven parallel north-south lines that were placed 100 feet apart. The survey covered an area 265 feet by 600 feet. Additional data were collected at intervals of 10 feet from line 2+00 East to 4+00 East and at intervals of five feet from 5+80 East to 6+20 East, since data from lines 3+00 East and 6+00 East showed anomalous features that warranted further investigation. Figure 15-2 presents the summary interpretation of the geophysical data.

The large, lined oval could identity an area where sludge or other conductive materials are present. The middle of this anomaly coincides with the visible outline of a former trench. It is possible that the width of the buried material is about the same as the width of the oval. It is also possible that conductive material has migrated from the smaller trench, increasing the size of the detected anomaly. There is a weak magnetic high of approximately 50 gammas at this conductivity anomaly. This can be interpreted to mean one of the following:

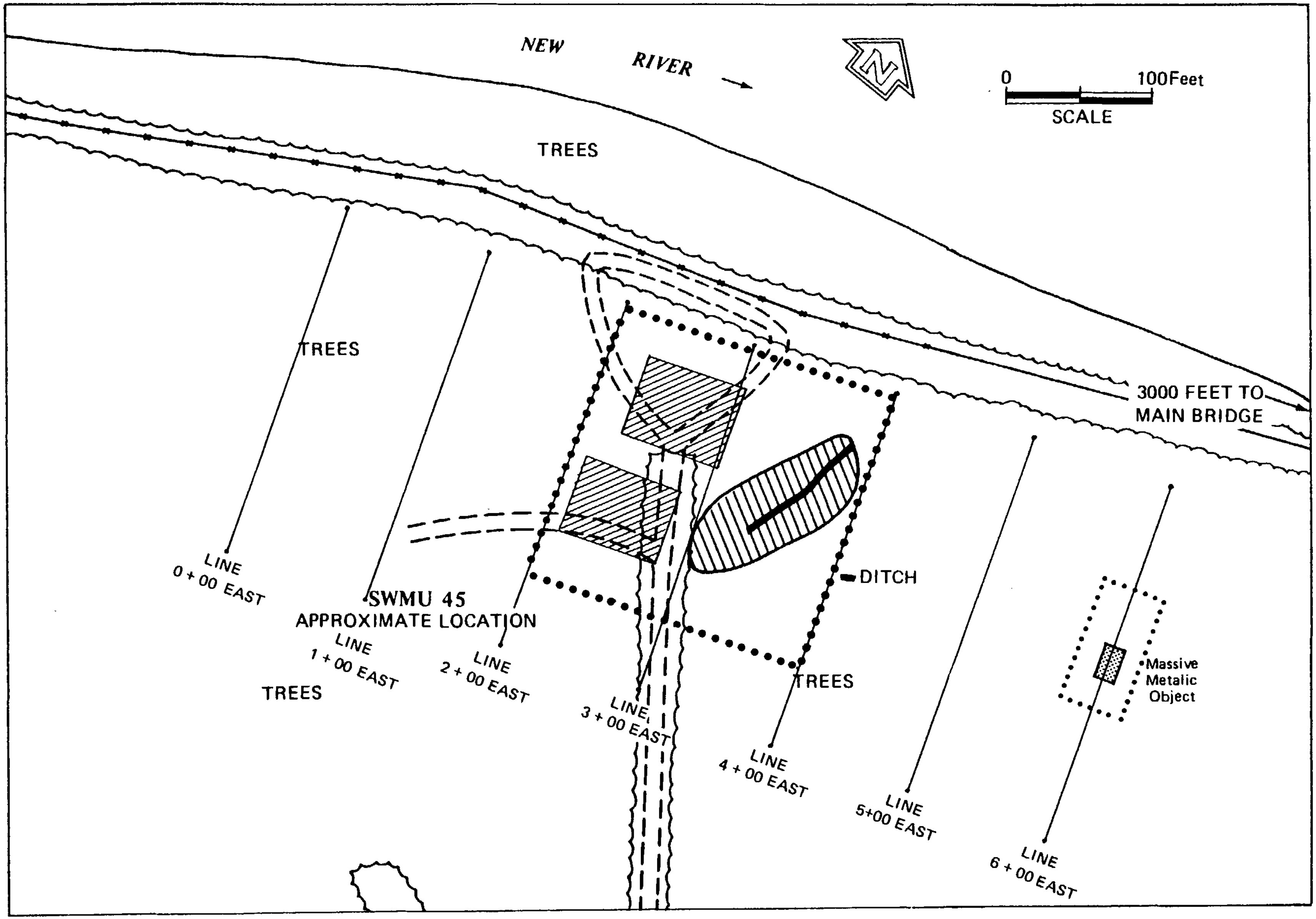
- A different, more magnetic earthen cover material was placed here;
- The buried materials are themselves somewhat magnetic;
- A fire has burned the earth here, leaving it magnetized.

The third interpretation could indicate that wastes were placed in landfill trenches and burned during landfill operation. The intense geophysical anomaly at line 6+00 East appears to be a large buried metal object centered at approximately 6+00 East, 1+50 North. Line 6+00 East was modeled to find the approximate depth and size of the buried metal object. A 2-1/2 dimensional model was generated by computer using Geosoft's "MAGMOD" which found the best fit for the metal object at a depth of approximately 2 feet, width of approximately 18 feet, and thickness of approximately 8 feet.

15.2 ENVIRONMENTAL SETTING

15.2.1 Topography

SWMU 45 is located in a generally flat area. The ground surface of the SWMU slightly slopes from a maximum elevation of 1,707 feet msl at the southern end of the SWMU to a minimum elevation of 1,703 feet msl at the northern end of the SWMU. The area is overgrown with pine trees and soil mounds and excavations are visible. The main asphalt road is located approximately 200 feet to the south, and the SWMU 9 area is



LEGEND:

▧ NON-METALLIC BURIAL – AREA B

▨ METAL BURIAL – AREA A

━ DITCH

FIGURE 15-2
GEOPHYSICAL SURVEY RESULTS
SWMU 45 – SANITARY LANDFILL
(WEST OF MAIN BRIDGE)
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

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located approximately 1,500 feet to the southwest. At the southern border of SWMU 45, adjacent to the main asphalt road is a set of railroad tracks that run generally east to west.

15.2.2 Geology and Soils

The geology of the SWMU 45 area has been explored for this VI through the drilling of three soil borings and the installation of three groundwater monitoring wells (45MW1, 45MW2, 45MW3) in the vicinity of SWMU 45 as shown in Figure 15-1. The subsurface conditions encountered during drilling consisted of fine-grained alluvial deposits composed of micaceous sandy silts (ML) and silty sands (SM) underlain by a thin layer (2 to 5 feet) of river jack (silty gravel). Beneath the river jack layer fine-grained silts and clayey sands were encountered. Boring 45MW3 was terminated at 26 feet on top of weathered limestone bedrock. Bedrock was not encountered in the other borings in SWMU 45; however, based on the observed subsurface conditions, bedrock would likely be encountered just below the depths penetrated in borings 45MW1 and 45MW2.

15.2.3 Groundwater Conditions

A shallow unconfined groundwater table was encountered during drilling within the fine-grained silts and silty sands or the silty gravel layer. Subsequent stabilized groundwater levels were measured at approximately 21 to 25 feet. Groundwater levels in SWMU 45 have fluctuated several feet during the VI program. Fluctuations in the groundwater table are probably the result of seasonal variations in precipitation and observed water levels in the New River. As seen in Insert 2, groundwater would flow northward and discharge into the New River.

15.2.4 Surface Water Drainage

SWMU 45 is generally a flat area that slopes slightly towards the northwest. Based on topography, surface water runoff is expected to flow northward towards the New River. According to RAAP utility maps, there are no manholes, catch basins, or storm drains located in the immediate vicinity of SWMU 45.

15.3 CONTAMINATION ASSESSMENT

The results of the chemical analyses indicate the presence of eight metals, two VOCs and one SVOC in groundwater at SWMU 45 (Table 15-1). However, only a single downgradient SVOC concentration exceeded HBN criteria. SVOC TICs were also detected, but these appeared to be more prevalent in the upgradient sample.

Five of the seven metals detected in downgradient samples are common constituents of groundwater and were at levels expected to be present in groundwater flowing through limestone. The other two metals, barium and lead, appear to be slightly elevated in one or more downgradient well samples, but lead was detected at a concentration below the PQL. However, the concentrations of all metals are below HBNs and may reflect normal ion variability in the groundwater.

Two VOCs were detected in the upgradient well and one downgradient well. However, the VOCs were detected at levels only slightly greater than the analytical detection limits but below the PQLs and were several orders of magnitude less than any HBN. One SVOC, bis(2-chloroethyl) ether (B2CLEE), was detected in 45MW3 at a concentration greater than the HBN criterion but less than the PQL. B2CLEE can be formed from the chlorination of water when ethyl ether is present. Its presence may indicate the past disposal of solvents or solvent based propellants.

15.4 BASELINE RISK ASSESSMENT

Based on the contamination assessment presented in Section 15.3, only one contaminant of concern--B2CLEE--has been identified for groundwater downgradient of SWMU 45. Samples were not collected from other environmental media. The potential impact B2CLEE in site groundwater to human health and the environment is discussed below in Sections 15.4.1 and 15.4.2, respectively.

15.4.1 Human Health Evaluation

No groundwater wells other than for monitoring purposes are located downgradient of SWMU 45. Groundwater in the vicinity of SWMU 45 generally flows northward toward the New River and most likely discharges to the river. Therefore, shallow groundwater would not migrate toward any groundwater users in the vicinity of RAAP. As discussed in Section 2.5, future land use is considered to be similar to the current land use scenario--i.e., RAAP will continue to remain an active army installation and there are no plans for future residential development of RAAP. Therefore, it is highly unlikely that groundwater wells would be installed in the future between SWMU 45 and the New River. Based on this evaluation, potential groundwater exposure pathways are not considered operable under the current or future land use scenario.

As discussed above, there is the potential for discharge of groundwater contamination to the New River. Persons boating, fishing, or swimming in the river could potentially be exposed to contaminants migrating from SWMU 45 via shallow groundwater. In addition, a drinking water intake is located 6 miles downstream of RAAP. However, due to the capacity of the river, which would result in significant dilution, and the low level of B2CLEE (3.39 ug/l) detected in one groundwater sample collected downgradient of SWMU 45, potential exposure from SWMU 45 is considered negligible. Therefore, these potential exposure pathways are not considered significant.

15.4.2 Environmental Evaluation

As discussed above, there is the potential for discharge of groundwater contamination to the New River, which could potentially impact aquatic life. Although data are insufficient for establishing aquatic life criteria for B2CLEE, acute toxicity of chloroalkyl ethers, in general, to freshwater aquatic life is reported to occur at concentrations as low as 238,000 ug/l (Clement, 1985). Because B2CLEE was detected at a concentration of 3.39 ug/l in shallow groundwater and significant dilution is expected to occur upon discharge to the New River, this one low detection of B2CLEE in SWMU 45 groundwater does not appear to be of environmental concern. Mixing with the river would also result in volatilization of the VOC, further reducing the concentration.

15.4.3 Conclusions of Human Health and Environmental Evaluation

Bis(2-chloroethyl) ether was detected above its HBN. However, the lack of groundwater receptors and the significant dilution and volatilization that would occur upon discharge of groundwater to the New River, would result in insignificant exposure. Therefore, the one low detection of B2CLEE does not appear to present a current or potential future human health risk or environmental threat.

15.5 CONCLUSIONS

The field investigation conducted at SWMU 45 consisted of the collection of three groundwater samples. The seven metals detected in the downgradient groundwater samples may reflect normal ion variability in groundwater flowing through limestone; therefore, the metal concentrations are not considered a concern. The two VOCs detected were at levels several orders of magnitude less than any HBN, and are not considered a concern. B2CLEE (a SVOC) was detected at a level 100 times the HBN criterion in a downgradient well, which may indicate the past disposal of solvents or solvent based propellants. Based on the risk assessment, the concentration of B2CLEE identified at SWMU 45 does not appear to present a current or potential future human health risk or environmental threat.

15.6 RECOMMENDED ACTION

The elevated concentration of B2CLEE detected in well 45MW3 may suggest that groundwater was contaminated from the past disposal of solvents or solvent based propellants. The B2CLEE concentration in groundwater was not identified as a current or potential future human health risk or an environmental threat. These data do not appear to be sufficient to recommend an RFI at this time. Confirmatory groundwater monitoring of VOC concentrations in the two downgradient wells is recommended. In the event that B2CLEE is detected in either of these wells, a monitoring program for this SWMU should be established.

16.0 VERIFICATION INVESTIGATION OF SWMU 46, WASTE PROPELLANT DISPOSAL AREA

16.1 SWMU 46 BACKGROUND AND INVESTIGATION PROGRAM

16.1.1 SWMU History

The Waste Propellant Disposal Area (SWMU 46) lies 200 feet from the New River, in the northwest section of the Main Manufacturing Area (Figure 2-3). Approximately 1 ton of propellants and propellant-contaminated soil were reportedly disposed at this location as a one-time occurrence because of a railroad derailment in the 1950s (USATHAMA, 1976). EPA identified the location of this unit as a 0.5-acre hummocky area 50 to 100 feet southeast of the bank of the New River. However, during the March 1990 facility visit, a broken-off sign identifying "BURIED EXPLOSIVE WASTE" was found in a low area between the railroad tracks and the driveway leading to Building 456, RAAP personnel verified that the sign was originally placed in the area where it was found. RAAP personnel also identified the hummocky area identified by EPA as the location of sanitary septic tank sludge burial in the 1970s.

The actual size of the Waste Propellant Disposal Area is not known. However, based on the waste quantity reportedly disposed, it is probably quite small. There is the potential for soil contamination by metals and explosives at SWMU 46.

16.1.2 Previous Investigations

This SWMU was identified in the RCRA Facility Assessment (USEPA, 1989) as having a potential for releasing contaminants into the environment and was included in the RCRA Permit for Corrective Action and Incinerator Operation (USEPA, 1989) as warranting investigation. No site-specific environmental investigations have been conducted at this location prior to this VI.

16.1.3 VI Program

Soil sampling was conducted at SWMU 46 to evaluate whether soil contamination exists from the one-time disposal of waste propellants. Before sampling began, a metal detection sweep was conducted to locate the base of the "BURIED EXPLOSIVE WASTE" sign. The buried sign stub was not located with the geophysical equipment. Therefore, during the March 1990 facility visit, test pits were made with a Gradall excavator in the area identified as the disposal location (Figure 16-1). Due to the unknown explosion hazard associated with disturbance by hand auguring or digging into this material, a Gradall excavator was used for remote excavation. Appropriate safety precautions approved by USATHAMA and RAAP were implemented prior to any surface disturbance activities in this area. Four 3'x3'x5' test pits were excavated in the area identified as the buried explosive waste area. There was no visual evidence of contamination or disturbed soils. Two soil samples were collected from separate pits and analyzed for metals and explosives.

16.1.4 Geophysical Survey

The location of SWMU 46 was ambiguous since this SWMU was first described in the RCRA Facility Assessment. The only physical evidence of this SWMU was a warning sign found at the location presented in Figure 16-1. Geophysical methods were used at this location to try to locate a metal base for the sign which apparently was broken off at ground level.

The metal locator was used to search for the "Buried Propellant Waste" signpost stub at SWMU 46. Two areas of anomalous features, where the sign stub may exist, were identified at 20 feet north and 45 feet west of the gate, and at 21 feet north and 35 feet west of the gate. The EM-31 was used to located the boundaries of the disposal area, but the existing fence and a north-south trending underground pipe located 32 feet west of the gate provided interference and "overpowered" the boundary data. A formal, recorded survey was not performed at SWMU 46. The metal sign stub was searched for in an attempt to confirm the original location of the sign as placed at the site during burial of the waste propellant, but none was found.

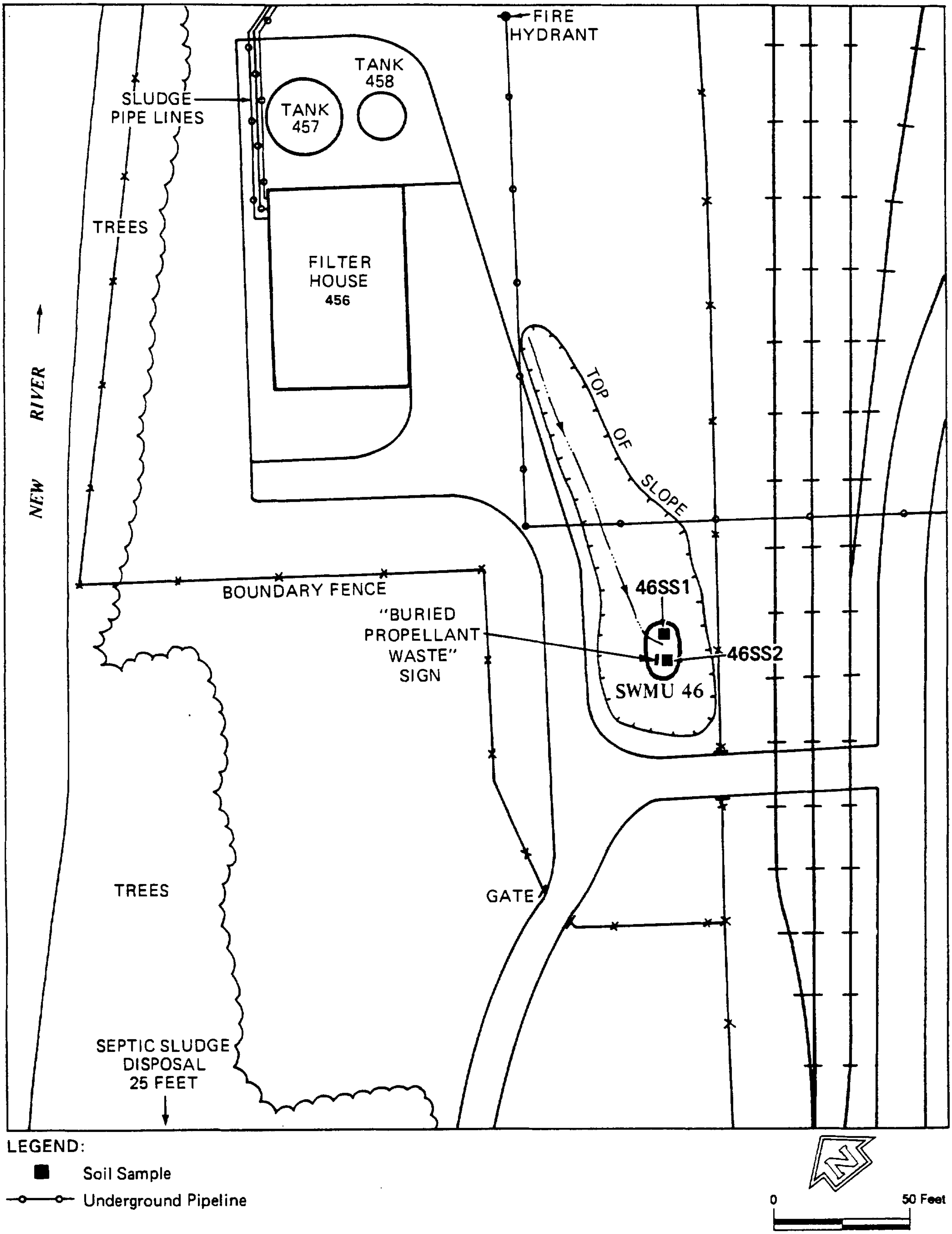

FIGURE 16-1
LOCATION MAP
SWMU 46 – WASTE PROPELLANT DISPOSAL AREA
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

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16.2 ENVIRONMENTAL SETTING

16.2.1 Topography

The Waste Propellant Disposal Area (SWMU 46) lies approximately 300 feet southeast/east of the New River in the northwest section of the Main Manufacturing Area. The actual size of SWMU 46 is not known. The reported location of SWMU 46 is a small depression with no drainage outward. The elevation of the area is approximately 1,710 to 1,720 feet msl. The filter house is northwest of SWMU 46. There are railroad tracks and paved roads in the area. The septic tank sludge disposal area is approximately 150 feet southwest of SWMU 46.

16.2.2 Geology and Soils

A limited subsurface investigation was conducted during the VI in the area of the "BURIED EXPLOSIVE WASTE" sign. Four large test pits excavated with a Gradall excavator in this area revealed apparently undisturbed natural soils to a depth of three feet below ground surface. Soils encountered consisted of fine grained sandy silts. Based on the location of SWMU 46 along the New River, subsurface conditions would be similar to other SWMUs along the New River flood plain. Subsurface conditions would likely consist of 20 to 30 feet of sandy silt, clay and gravel overlying Elbrook bedrock.

16.2.3 Groundwater Conditions

No site-specific hydrogeologic studies have been performed at SWMU 46, but groundwater conditions can be inferred from similar areas bordering the New River. Groundwater should overlie weathered Elbrook Formation bedrock and flow north discharging at the New River.

16.2.4 Surface Water Drainage

The reported location of SWMU 46 is a small depression with no drainage outward. This shape suggest that run-on would percolate into the subsurface and enter the water table. The New River, located only 300 feet to the northwest, is probably the discharge zone for the groundwater. According to the RAAP utility map, there are no manholes, catch basins, or storm drains in the vicinity of SWMU 46.

16.3 CONTAMINATION ASSESSMENT

The VI field program at the Waste Propellant Disposal Area included the analyses of two soil samples collected from a depth of approximately 1 foot. The samples were collected from two locations and at depths where explosives were suspected to be buried. The results of the chemical analyses indicated that concentrations of four metals exceeded the HBN criteria but are not considered a concern because the levels were less than the background criteria for alluvial soil. Explosives were not detected in either sample. A summary of the chemical analyses is presented in Table 16-1.

Chemical analyses of 46SS1 and 46SS2 indicated detectable concentrations of 18 metals in samples collected in the northeastern and southwestern portions of the propellant disposal area. Concentrations of aluminum, thallium and vanadium in one sample were above background comparison criteria (Table 4-12), but aluminum and vanadium exceeded by less than 10 percent. The thallium concentration was less than the PQL. Concentrations of arsenic, beryllium and cobalt in both samples and thallium in one sample (46SS2) exceeded HBN criteria. However, arsenic, beryllium and cobalt are not considered a concern because the levels are less than the soil background criteria and appear to represent natural concentrations of these constituents in native alluvial soil. Thallium is not considered a concern because the level reported for sample 46SS2 only slightly exceeded the HBN criterion and does not appear to be widespread throughout the site. Additionally, thallium is relatively immobile in the environment and is not expected to impact surface water, groundwater or underlying soil.

16.4 CONCLUSIONS

The VI conducted at the Waste Propellant Disposal Area (SWMU 46) consisted of collecting and chemically analyzing two shallow soil samples from representative portions

Table 16–1
Summary of Analytical Data For Soil Samples Collected At SWMU 46
Radford Army Ammunition Plant, Virginia

SITE ID		46SS1	46SS2	
FIELD ID		RVFS*47	RVFS*48	
S. DATE		29–oct–91	29–oct–91	
DEPTH (ft)		1.0	1.0	
MATRIX	PQLs	CSO	CSO	HBN
UNITS	UGG	UGG	UGG	UGG
TAL Inorganics				
ALUMINIUM	14.1	17100	21100	230000
ARSENIC	30	[2.13 B]	[3.57]	0.5
BARIUM	1	108	119	1000
BERYLLIUM	0.2	[0.842]	[0.832]	0.1
CALCIUM	100	2700 B	1170 B	NSA
CHROMIUM	4	31.7 B	38.3	400
COBALT	3	[15.6]	[19]	0.8
COPPER	7	12.6	16.5	2900
IRON	1000	28400	34000	NSA
MAGNESIUM	50	6360 B	5180 B	NSA
MANGANESE	0.275	653	671	8000
NICKEL	3	16	20.7	1000
POTASSIUM	37.5	1520 B	2170	NSA
SILVER	4	LT 0.589	0.788	200
SODIUM	150	215 B	233 B	NSA
THALLIUM	20	LT 6.62	[12.6]	6
VANADIUM	0.775	57.4	70.5	560
ZINC	30.2	67.3	82.8	16000
Explosives	NA	None Detected	None Detected	NSA

Footnotes :

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CSO = Chemical soil.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

NT = Not tested; parameters were not tested (included) in the sample analyses.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TAL = Target Analyte List.

UGG = Micrograms per gram.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

of the site. The results of the investigation indicated that present levels of metals constituents in soil at the disposal area are not significantly different from background levels. No detection of explosives in both samples indicate that explosives are not likely to be present at the site. Evidence indicates that this area may not have been the location of the buried propellant.

16.5 RECOMMENDED ACTION

Based on the analytical results of the soil investigation, no further action at this site is recommended.

17.0 VERIFICATION INVESTIGATION OF SWMU 48, OILY WASTEWATER DISPOSAL AREA

17.1 SWMU 48 BACKGROUND AND INVESTIGATION PROGRAM

17.1.1 SWMU History

The Oily Wastewater Disposal Area (SWMU 48) is located in the RAAP Horseshoe Area, approximately 3,400 feet east of the main bridge over the New River (Figure 17-1). EPA reported this unit as contiguous to SWMU 49 (Red Water Ash Disposal Area) and SWMU 50 (Calcium Sulfate Disposal Area), with no distinction possible by visual observation (USEPA, 1987). However, based on a review of historical aerial photographs and discussions with plant personnel, it has been determined that the unit consists of two separate disposal areas.

Prior to the start of off-post waste oil reclamation, oily wastewaters removed from oil/water separators throughout RAAP were disposed of at SWMU 48. It is estimated that 200,000 gallons or more of oil-contaminated wastewater were disposed of in unlined trenches at this unit.

17.1.2 Previous Investigations

This SWMU was identified in the RCRA Facility Assessment (USEPA, 1989) as having a potential for releasing contaminants into the environment and was included in the RCRA Permit for Corrective Action and Incinerator Operation (USEPA, 1989) as warranting investigation. No site-specific investigations have been conducted at this location prior to this VI.

17.1.3 VI Program

Three soil borings (48SB1, 48SB2, and 48SB3) were installed in the two disposal areas, as shown in Figure 17-1. Two soil samples were collected from each boring (except from 48SB3 where only one sample was collected) for chemical analysis. One sample from each of two borings (48SB1 and 48SB2) was collected from near-surface, visually oil-stained soil, with a second sample collected from visually "clean" soil beneath the upper layer. At 48SB3, only one sample was collected from soil at a depth of 20 feet. The maximum

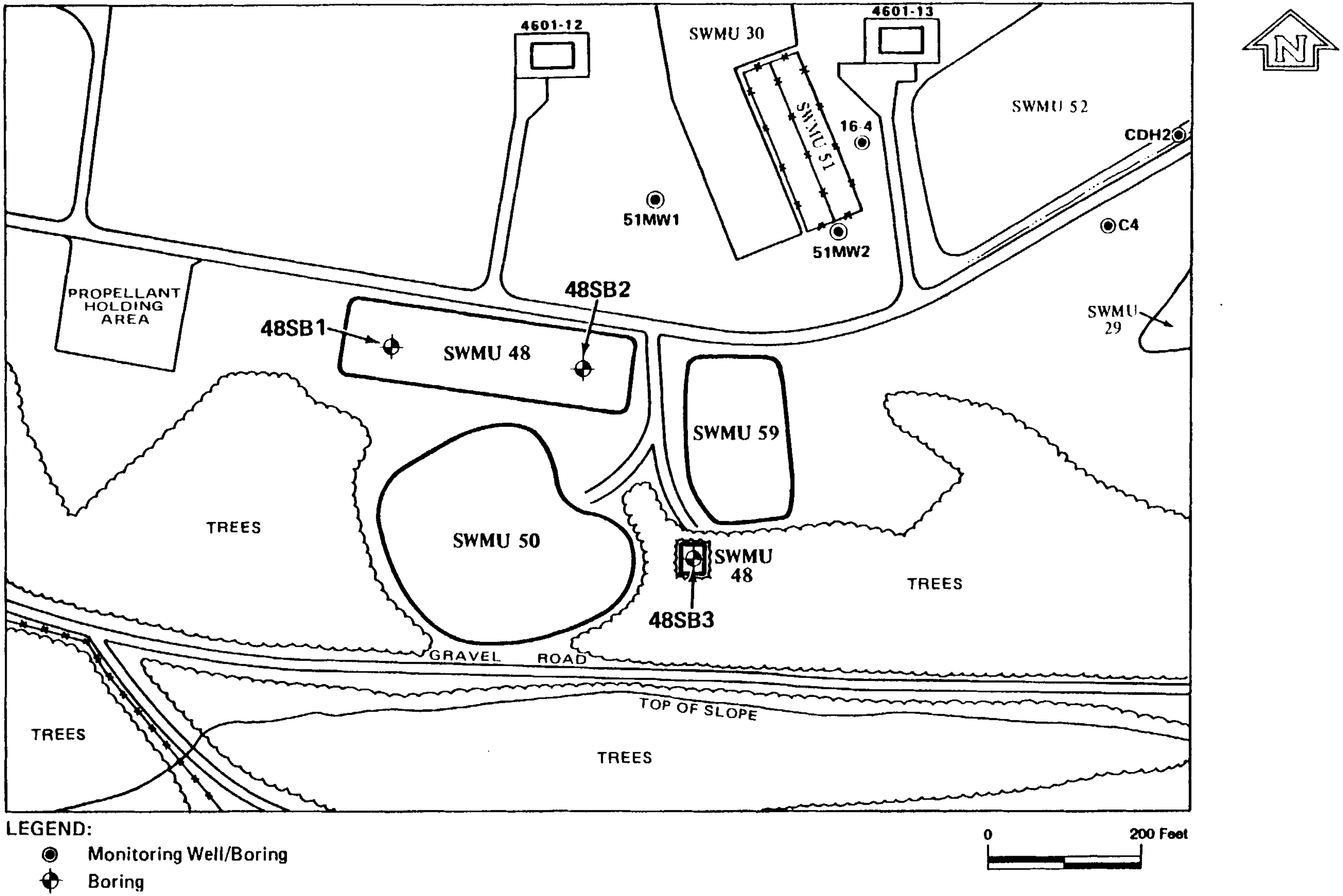

FIGURE 17-1
LOCATION MAP
SWMU 48 – OILY WASTEWATER DISPOSAL AREA
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

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depth of these borings is 22 feet. Borings 48SB1 and 48SB2 continued until at least two feet of "clean," undisturbed soil was observed. Boring 48SB3 did not intercept any oily stained soil but did encounter a fuel-like odor from 13.0 feet to the bottom of the boring at 22.0 feet. The five soil samples collected were analyzed for TAL metals, TCLP metals, VOCs, and SVOCs.

17.2 ENVIRONMENTAL SETTING

17.2.1 Topography

SWMU 48 is a long narrow raised mound which trends east to west next to the asphalt road. Ground elevation is approximately 1,830 msl. SWMU 50 is approximately 30 feet to the south of SWMU 48, and SWMU 49 is approximately 75 feet to the east. SWMU 48 and the area immediately south of it appear to be grassy areas. There is a wooded area to the southwest, and an asphalt parking lot approximately 200 feet to the west. SWMU 48 is located in the middle of the storage area where buildings, overhead power lines, and asphalt roads are numerous.

17.2.2 Geology and Soils

Subsurface conditions were investigated in the SWMU 48 area through the drilling of three soil borings to a depth of 15 to 22 feet. Soils encountered consisted of unconsolidated alluvium generally described as a yellowish brown sandy silt (ML) or a silty clay (CL). A thin layer of silty gravel (2 to 5 feet) was present at a depth of 10 to 15 feet. Bedrock was not encountered in any of the soil borings; however, based on borings performed in nearby SWMU 51, depth to bedrock is estimated to be 30 to 50 feet. Bedrock below the site likely consists of weathered limestone or dolostone of the Elbrook Formation.

17.2.3 Groundwater Conditions

Groundwater was not encountered in three borings drilled in SWMU 48. Based on groundwater conditions observed in wells installed in SWMU 51 to the northeast, groundwater should be present near the overburdened bedrock interface and flow southward following topography with discharge to the New River (Insert 2).

17.2.4 Surface Water Drainage

Based on topography, surface water from SWMU 48 is expected to flow approximately 700 feet southwest to the New River. According to RAAP utility maps, there does not appear to be any manholes, catch basins, or storm drains located in the immediate vicinity of SWMU 48.

17.3 CONTAMINATION ASSESSMENT

The VI field program at SWMU 48 included the collection of five soil samples from three soil borings in two areas of the unit. Samples from borings 48SB1 and 48SB2 were collected at depth of 9.5 and 12 feet, respectively, in soil suspected to be contaminated at the northern disposal area. At both locations, samples were also obtained from apparently "clean" soil below the suspected contamination at depths of 14 and 22 feet in 48SB1 and 48SB2, respectively. Only one sample was collected from boring 48SB3, which was located in the smaller southern disposal area. This soil sample exhibited a fuel-like odor.

17.3.1 Soil

In total, 19 metals were detected in the five soil samples collected from the Oily Waste Disposal Area. As shown in Table 17-1, soil sample concentrations of arsenic, beryllium and cobalt exceeded the HBN criteria. The concentrations of beryllium, calcium, copper, magnesium, mercury, and sodium exceeded background uplands soil concentrations in at least one sample. Beryllium and sodium were the only metals to exceed background concentrations in the underlying "clean" soil in 48SB1 and 48SB2. Sodium was found in the method blanks, and beryllium was higher in the lower "clean" samples than the upper oily samples. Because of these conditions and since they may be naturally occurring, neither metal can be attributable to the oily waste and are not considered a concern. Anomalously higher concentrations of calcium, copper, magnesium, and mercury were detected in the shallow soil samples, but only mercury has a HBN that was over seven times greater than the highest detected concentration. In the one sample from 48SB3, beryllium and sodium were the only metals detected above background comparison concentrations, but neither concentration was significantly different than the concentrations in 48SB1 and 48SB2

Table 17–1
Summary of Analytical Data For Soil Samples Collected At SWMU 48
Radford Army Ammunition Plant, Virginia

SITE ID		48SB1	48SB1	48SB2	48SB2	48SB3	
FIELD ID		RVFS*1	RVFS*2	RVFS*3	RVFS*4	RVFS*6	
S. DATE		19–aug–91	19–aug–91	16–aug–91	16–aug–91	19–aug–91	
DEPTH (ft)		9.5	14.0	12.0	22.0	20.0	
MATRIX	PQLs	CSO	CSO	CSO	CSO	CSO	HBN
UNITS (#)	UGG	UGG	UGG	UGG	UGG	UGG	UGG
TAL Inorganics							
ALUMINIUM	14.1	2940 B	12200	15700	14600	16400	230000
ARSENIC	30	[8.19]	[3.1]	[4.7]	[2.75 B]	LT 0.5 B	0.5
BARIUM	1	42.5	36.7	52.5	70.8	32.5	1000
BERYLLIUM	0.2	[0.767]	[1.73]	[2.15]	[4.98]	[2.98]	0.1
CALCIUM	100	240000	663	9740	198	LT 100	NSA
CHROMIUM	4	7.78	27.3	29.5	31.9	13.2	400
COBALT	3	[3.01]	[6.34]	[11.3]	[17.9]	[25.7]	0.8
COPPER	7	10.8	6.87 B	135	14.6	3 B	2900
IRON	1000	8550 B	21200	25800	41600	23700	NSA
LEAD	2	36.9	LT 10.5	154	LT 10.5	LT 10.5	200
MAGNESIUM	50	130000	784 B	3390	763 B	751 B	NSA
MANGANESE	0.275	222 B	195 B	278 B	547	168 B	8000
MERCURY	0.1	2.6	LT 0.05	0.23	LT 0.05	LT 0.05	20
NICKEL	3	4.91	6.57	25.6	24.5	30.8	1000
POTASSIUM	37.5	327 B	551 B	758 B	934 B	1890	NSA
SILVER	4	1.03	LT 0.589	0.855	LT 0.589	LT 0.589	200
SODIUM	150	551 B	372 B	391 B	2880	315 B	NSA
VANADIUM	0.775	8.97	30	34.3	32.9	16.8	560
ZINC	30.2	38.2	23.1	71.3	29.9	23.9	16000
Volatiles							
ETHYLBENZENE	0.005	LT 0.002	LT 0.002	LT 0.002	LT 0.002	0.047	1000
TOLUENE	0.005	LT 0.001	LT 0.001	0.001	LT 0.001	0.003	1000
XYLENES	0.005	LT 0.002	LT 0.002	LT 0.002	LT 0.002	0.252 X	1000
Volatile TICs							
1,1,3–TRIMETHYLCYCLOHEXANE	NA	ND	ND	ND	ND	0.06 S	NSA
TOTAL UNKNOWN TICs	NA	ND	(2)0.034	(1)0.009	ND	(8)0.167	NSA
Semivolatiles							
2–METHYLNAPHTHALENE	0.3	LT 0.245	LT 0.049	LT 0.049	LT 0.049	29.2	NSA
24DNT	0.3	LT 0.7	LT 0.14	[3.22]	LT 0.14	LT 2.8	1
26DNT	0.3	LT 0.425	LT 0.085	[1.22]	LT 0.085	LT 1.7	1.03
BIS(2–ETHYLHEXYL) PHTHALATE	0.3	LT 3.1	LT 0.62	1.02	LT 0.62	LT 12.4	50
DI–N–BUTYL PHTHALATE	0.3	LT 0.305	LT 0.061	2.94	0.189	LT 1.22	1000
FLUORENE	0.3	LT 0.165	LT 0.033	LT 0.033	LT 0.033	8.49	3200

Table 17-1 (Cont'd)

SITE ID		48SB1	48SB1	48SB2	48SB2	48SB3	
FIELD ID		RVFS*1	RVFS*2	RVFS*3	RVFS*4	RVFS*6	
S. DATE		19-aug-91	19-aug-91	16-aug-91	16-aug-91	19-aug-91	
DEPTH (ft)		9.5	14.0	12.0	22.0	20.0	
MATRIX	PQLs	CSO	CSO	CSO	CSO	CSO	HBN
UNITS (#)	UGG	UGG	UGG	UGG	UGG	UGG	UGG
Semivolatiles							
NAPHTHALENE	0.3	LT 0.185	LT 0.037	0.275	LT 0.037	5.64	1000
PHENANTHRENE	0.5	0.208	LT 0.033	0.127	LT 0.033	10	40
PYRENE	0.3	0.318	LT 0.033	LT 0.033	LT 0.033	LT 0.66	1000
Semivolatile TICs							
2,6,10,14-TETRAMETHYLPENTADECANE	NA	ND	ND	0.786 S	ND	169 S	NSA
EICOSANE	NA	ND	ND	ND	ND	96.9 S	NSA
HEPTADECANE	NA	ND	ND	1.31 S	ND	218 S	NSA
HEXADECANE	NA	ND	ND	1.05 S	ND	218 S	NSA
NONADECANE	NA	ND	ND	ND	ND	145 S	NSA
OCTADECANE	NA	ND	ND	ND	ND	169 S	NSA
TETRADECANE	NA	ND	ND	0.524 S	ND	242 S	NSA
TRIDECANE	NA	ND	ND	0.393 S	ND	218 S	NSA
TOTAL UNKNOWN TICs	NA	(2)14.1	ND	(12)928	(1)1.18	(15)1137	NSA
TCLP Metals (UGL)							
BARIUM	20	293	264	131	289	485	100000
LEAD	10	30.5	LT 18.6	149	LT 18.6	27	5000

Footnotes :

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CSO = Chemical soil.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

ND = Analyte was not detected.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

S = Results are based on an internal standard; flag is used for TICs detected in library scans.

TAL = Target Analyte List.

TCLP = Toxicity Characteristic Leaching Procedure.

TICs = Tentatively identified compounds that were detected in the GC/MS library scans.

UGG = Micrograms per gram.

Units(#) = Units are in UGG except for TCLP constituents, which are expressed in UGL.

X = Analyte recovery is outside of the certified range, but within acceptable limits such that a dilution is not warrented.

( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

samples. These metals do not appear to be a concern at this site. TCLP metal concentrations did not exceed RCRA waste characterization regulatory levels.

VOCs and SVOCs were detected in soil samples collected in boring 48SB2, located in the eastern portion of the main disposal area, and boring 48SB3, located in the southern disposal area. Ethylbenzene, toluene, and xylenes were detected in sample 48SB3 but toluene was detected at a concentration below the PQL, and the other two were detected at three to five orders of magnitude below the HBN. Toluene, the only known VOC found in 48SB2, was detected at a concentration equal to the detection limit and below the PQL and is not considered a concern. Nine VOC TICs were detected in sample 48SB3, but with a total concentration less than 0.23 ug/g. Two VOC TICs at a concentration less than 0.04 ug/g and one VOC TIC detected at 0.009 ug/g also were found in the deeper 48SB1 sample and the shallow 48SB2 sample, respectively.

Various SVOCs or SVOC TICs were detected in each sample except for 48SB1 (14 feet). The shallow samples from 48SB2 and 48SB3 sample were most impacted, but they appear to be chemically different. Two explosives and two phthalates were found in the 48SB2, but not in 48SB3. The soil sample from 48SB3 had many straight-chain heavy fuel hydrocarbons at high concentrations, while 48SB2 (12 feet) had few of these SVOCs and at low concentrations. Two explosives, 24DNT and 26DNT detected in the SVOC analysis, exceeded the HBN criteria in the shallow sample collected in 48SB2 at a depth of 10 feet. These nitroaromatics are relatively immobile in the environment and are not expected to impact deeper soil or groundwater at levels greater than the HBN criteria. The results of the deeper soil sample obtained from 48SB2 confirm that 24DNT and 26DNT and most other SVOCs (except DNBP) and SVOC TICs detected in the 12-foot sample have not impacted soil at a depth of 22 feet. The detected SVOC TICs are various aromatic and substituted saturated hydrocarbons which are associated with petroleum products. Although, for the 48SB3 samples, HBNs were not exceeded or were not available for SVOC constituents, it is unknown whether deeper soil or groundwater have been impacted.

17.3.2 Subsurface Gas Contamination

A subsurface soil gas survey was performed in order to further investigate apparent petroleum fuel contamination of soils encountered in soil boring 48SB3 at a depth of 13 to 22 feet (see Figure 17-2). The survey was performed in a 50-foot grid (100 feet by 100 feet), centered on the vicinity of soil boring 48SB3.

In total, eight soil gas samples were collected at a depth of 4 feet. Soil gas samples were analyzed for pentane/MTBE, benzene, toluene, ethylbenzene, meta- and para-xylene, and other xylenes in order to evaluate the presence of petroleum products. Results of the soil gas survey indicate that concentrations of subsurface vapors for the above analytes were below detectable limits (1.0 ppm) except for one sample that exhibited a total volatile concentration of 1.1 ppb, slightly above the detection limit.

The absence of detectable concentrations of petroleum volatiles during the soil gas survey correlates with the low concentrations of VOCs detected in soil samples from soil boring 48SB3. The moderately high analytical concentrations of SVOCs present at the 13- to 22-foot depth were not detectable during the soil gas survey.

17.4 BASELINE RISK ASSESSMENT

Based upon the contamination assessment presented in Section 17.3, two contaminants of concern--24DNT and 26DNT--were identified for soil at SWMU 48. Samples were not collected from surface soil or other environmental media. The potential impact of 24DNT and 26DNT in site soil to human health and the environment is discussed below in Sections 17.4.1 and 17.4.2, respectively.

17.4.1 Human Health Evaluation

24DNT and 26DNT were detected in one soil sample (48SB2) at concentrations of 3.22 and 1.22 ug/g, respectively. However, this soil samples was collected from a depth of 12 feet; soil samples were not collected from the surface and other soil samples collected did not contain 24DNT and 26DNT. Although potential soil exposure routes typically include incidental ingestion, inhalation, and dermal absorption, exposure via these routes

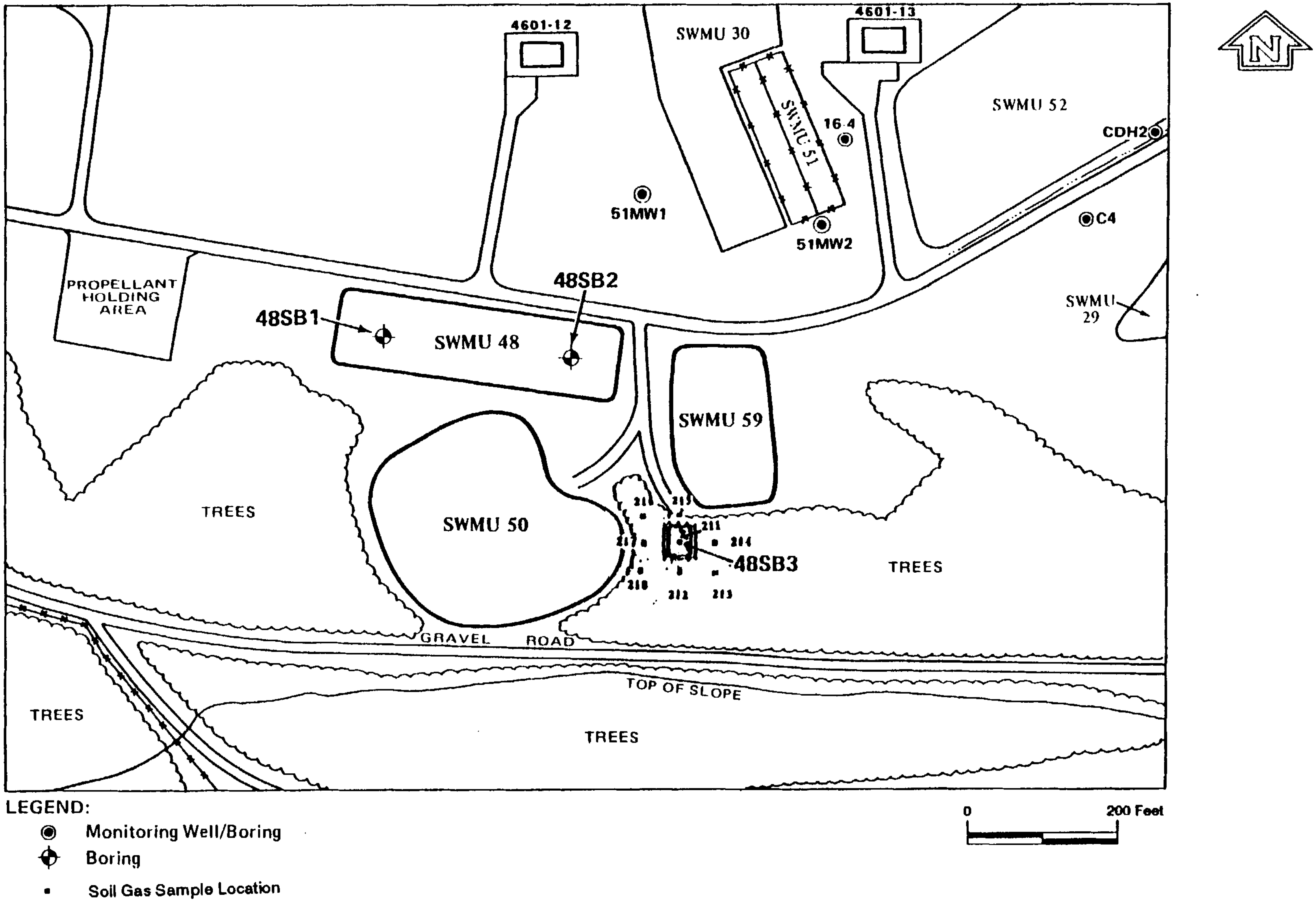

FIGURE 17-2
SOIL GAS SURVEY SAMPLE LOCATIONS
SWMU 48 – OILY WASTEWATER DISPOSAL AREA
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

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are generally limited to the top 2 feet of soil. It is highly unlikely that receptors would contact soil at depths of 12 feet. Therefore, these pathways are not considered operable exposure pathways for SWMU 48. However, these exposure pathways may be complete if surface soil was also shown to be contaminated with 24DNT and 26DNT.

As discussed in Section 17.3, it is not known if groundwater may have been impacted by SWMU 48. Groundwater would presumably flow southward toward the New River and most likely discharges to the river. No groundwater wells other than for monitoring purposes are located between SWMU 48 and the New River. Therefore, shallow groundwater would not likely migrate toward any groundwater users in the vicinity of RAAP. As discussed in Section 2.5, future land use is considered to be similar to the current land use scenario--i.e., RAAP will continue to remain an active army installation and there are no plans for future residential development of RAAP. Therefore, it is highly unlikely that groundwater wells would be installed in the future between SWMU 48 and the New River. Based on this evaluation, potential groundwater exposure pathways are not considered operable under the current or future land use scenario.

As discussed above, there is the potential for discharge of groundwater contamination to the New River. Persons boating, fishing, or swimming in the river could potentially be exposed to contaminants migrating from SWMU 48 via shallow groundwater. In addition, a drinking water intake is located 6 miles downstream of SWMU 48. However, due to the capacity of the river which would result in substantial dilution, unless significant contamination was detected in groundwater downgradient of SWMU 48, potential exposure from SWMU 48 is expected to be negligible.

17.4.2 Environmental Evaluation

As discussed above, 24DNT and 26DNT contamination was only detected at a depth of 12 feet. It is highly unlikely that environmental receptors would contact soil at these depths. However, surface soil samples were not collected at this site. If surface soil was also shown to be contaminated, then a reevaluation of potential environmental receptors would be necessary.

As discussed above, there is the potential for discharge of groundwater contamination, if any, to the New River. However, because significant dilution is expected to occur upon discharge to the New River, unless significant contamination was detected in groundwater downgradient of SWMU 48, potential exposure to environmental receptors is expected to be negligible.

17.4.3 Conclusions of Human Health and Environmental Evaluation

Although 24DNT and 26DNT were detected above their HBNs, because these detections were in a deep soil sample (12 feet) it is highly unlikely that human or environmental receptors would contact this soil. Therefore, soil exposure pathways are not considered operable. However, surface soil samples were not collected at this site. If surface soil was also shown to be contaminated, then a reevaluation of potential receptors and exposure pathways would be necessary.

Although groundwater data are not available, due to the lack of groundwater receptors and the fact that significant dilution would occur upon discharge of groundwater to the New River, unless significant groundwater contamination is present downgradient of SWMU 48, potential exposure to human and environmental receptors is expected to be negligible.

17.5 CONCLUSIONS

The VI field program at SWMU 48 included the collection and chemical analyses of five soil samples to confirm or deny the presence of contaminants in two potential oily-waste disposal areas at SWMU 48. Explosives were detected in one sample only and were the only contaminants of concern in soil as based on HBN criteria. Trace concentrations of petroleum-related SVOCs also were detected at the northern disposal area, but were below HBN criteria and limited to one sample collected at a depth of 12 feet. The explosives also were detected at a depth of 12 feet and were similarly absent in the soil sample collected at a depth of 22 feet, indicating that any downward transport of these contaminants has not impacted deeper soil at detectable levels. Based on these sample data, it is unlikely that groundwater would be impacted by these constituents. Because these constituents were detected at a depth of 12 feet, normal soil exposure pathways are not considered operable and it is unlikely that potential receptors would come in contact with these contaminants. Presently, potential surface exposure routes cannot be addressed because the near-surface soil concentrations of these constituents are not known.

Although no soil-exposure contaminants of concern were identified for the southern disposal area, the results of the chemical analyses indicated petroleum-related soil contamination at a depth of 13 feet and below in this portion of the site. Because of the moderate levels of SVOCs deep in the soil column and the presence of highly permeable sand, gravel, and limestone below the overlying soil, the potential for groundwater contamination exists below the southern disposal site. Additionally, the potential surface exposure rates cannot be presently addressed because the near-surface soil concentrations of these constituents are not known.

17.6 RECOMMENDED ACTION

Because SVOC contamination was detected in the deep soil sample 48SB3 and the potential for groundwater contamination by these constituents exists, an RFI is recommended to determine the source and extent of the fuel contamination and address the impact of these constituents on the local groundwater resources. The recommended work includes installing one upgradient and two downgradient monitoring wells around the southern disposal area of SWMU 48. Well screens should extend to a depth below the water table so that any floating fuel product would be intercepted. Groundwater from the wells would be collected and chemically analyzed by an analytical laboratory. The collection and analyses of soil samples from the well borings are also recommended to define the extent and boundaries of the area impacted by the disposed wastes. Additional soil borings and soil samples may be required to fully characterize the contamination in three dimensions. Shallow soil samples (i.e., 0.5 foot depth) would also be necessary to consider potential surface exposure routes (e.g., ingestion, inhalation, and dermal exposure, etc.). Proper site characterization is necessary to consider future potential remedial alternatives, if necessary, and to provide adequate data for pre-remedial engineering design and costing.

As part of the RFI, it is recommended that two additional soil samples be collected from one soil boring located between 48SB1 and 48SB2 to confirm or deny the presence of potentially released oily waste and explosives in the central portion of the northern disposal area of SWMU 48. These samples would be collected at approximately the depths of the VI samples and would provide information on potential wastes in the central portion of the fill not sampled during the VI. Collection of shallow soil samples (i.e., at a depth of 0.5 foot) is also recommended to consider potential surface exposure routes as well.

18.0 VERIFICATION INVESTIGATION OF SWMU 54, PROPELLANT ASH DISPOSAL AREA

18.1 SWMU 54 BACKGROUND AND INVESTIGATION PROGRAM

18.1.1 SWMU History

The Propellant Burning Ash Disposal Area (SWMU 54) is located in the easternmost section of the Horseshoe Area, just outside Gate 19-D of the RAAP fence (Figure 18-1). The disposal area is visible as an elongated triangular area of hummocky grass-covered soil, with some 2- to 4-foot-high piles and several 3- to 5-foot-deep pits. The total area of the unit is estimated to be less than 1 acre.

Ash from propellant burning operations at the Waste Propellant Burning Ground (SWMU 13) was reportedly disposed of at this unit during the late 1970s, prior to startup of the Hazardous Waste Landfill (SWMU 16) in 1980. The quantity of ash disposed of in this unit is estimated to be 10 tons (USATHAMA, 1976). According to plant personnel, disposal occurred on the surface, with no routine disposal in pits or trenches. Ash residue is visible where surface soils have been disturbed.

18.1.2 Previous Investigations

A sample of the ash disposed of in the Hazardous Waste Landfill was analyzed for RCRA metals (EP toxicity leachate analysis). Results indicated that the ash content exceeded the Virginia maximum allowable TCLP concentration for lead (51 mg/l, compared to the maximum allowable concentration of 5 mg/l) (USEPA, 1987). It may be assumed that ash disposed of in SWMU 54 exhibits similar characteristics. Therefore, the potential exists for groundwater contamination in the vicinity of SWMU 54.

18.1.3 VI Program

To evaluate whether groundwater quality has been impacted by ash disposed of in the unit, three wells were installed--one upgradient (54MW1) and two downgradient (54MW2 and 54MW3) of the disposal area. Locations for the three wells are shown in Figure 18-1. The maximum depth of these wells is 60 feet.

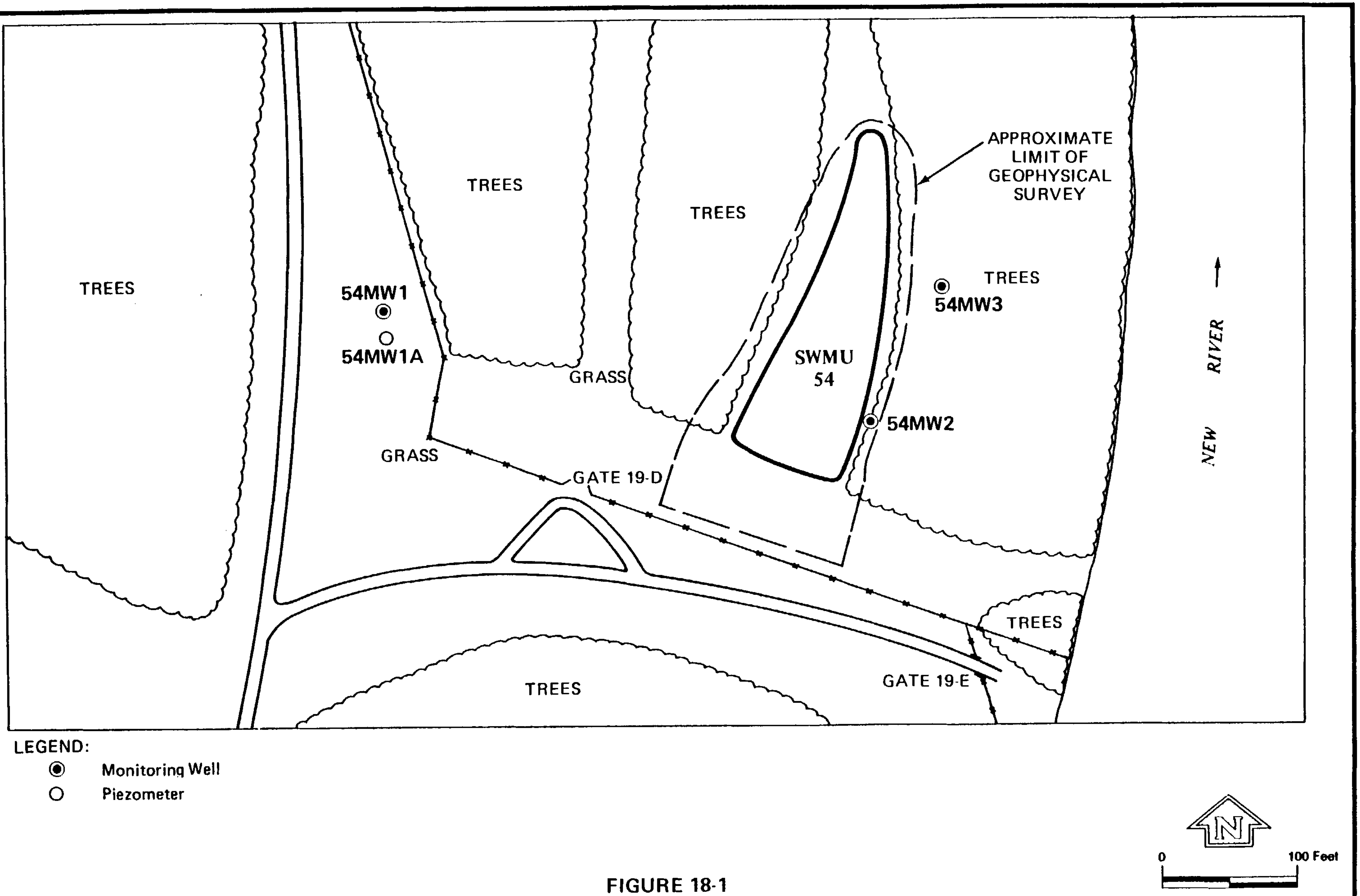

FIGURE 18-1
LOCATION MAP
SWMU 54 – PROPELLANT BURNING ASH DISPOSAL AREA
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

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During development of well 54MW1A, an abnormally high pH was noted, as well as a light colored sediment in the development water. This was possibly grout which had entered the well during well construction, so a replacement well (54MW1) was subsequently drilled.

18.1.4 Geophysical Survey

SWMU 54 was one of four areas at which geophysical methods were employed in order to delineate the boundaries of the area or locate buried materials. The following discussion summarizes the findings of the geophysical investigation, which has been included in the report as Appendix H.

EM and magnetic surveys were conducted at SWMU 54 to map possible locations of ash disposal as shown in Figure 18-2. EM and magnetic readings were measured at intervals of 15 feet along north-south transects made at 15-foot spacings. These spacings were considered appropriate given the size and physical characteristics of the site. The survey covered an area 135 feet by 300 feet.

The anomalies in the EM and magnetic data centered at the southern mound and pit appear to be from a combination of buried conductive materials and metals. This could represent an object roughly the size of 800 pounds of iron, with the surrounding soil having a high conductivity. The conductivity anomalies were never negative, which indicates that if they are caused by metal, the metal would be located relatively deeply in the ground. The anomaly in the EM data found at the northern mound and pit appears to indicate burial of non-metallic material. The pits in these two areas appear to be borrow areas for cover material for the mounds.

18.2 ENVIRONMENTAL SETTING

18.2.1 Topography

SWMU 54 is generally a flat level area with a ground surface elevation of approximately 1,700 feet msl. The SWMU is an elongated triangular grass covered area, with some 2- to 4-foot high piles of soil and ash and several 3- to 5-foot deep pits. The

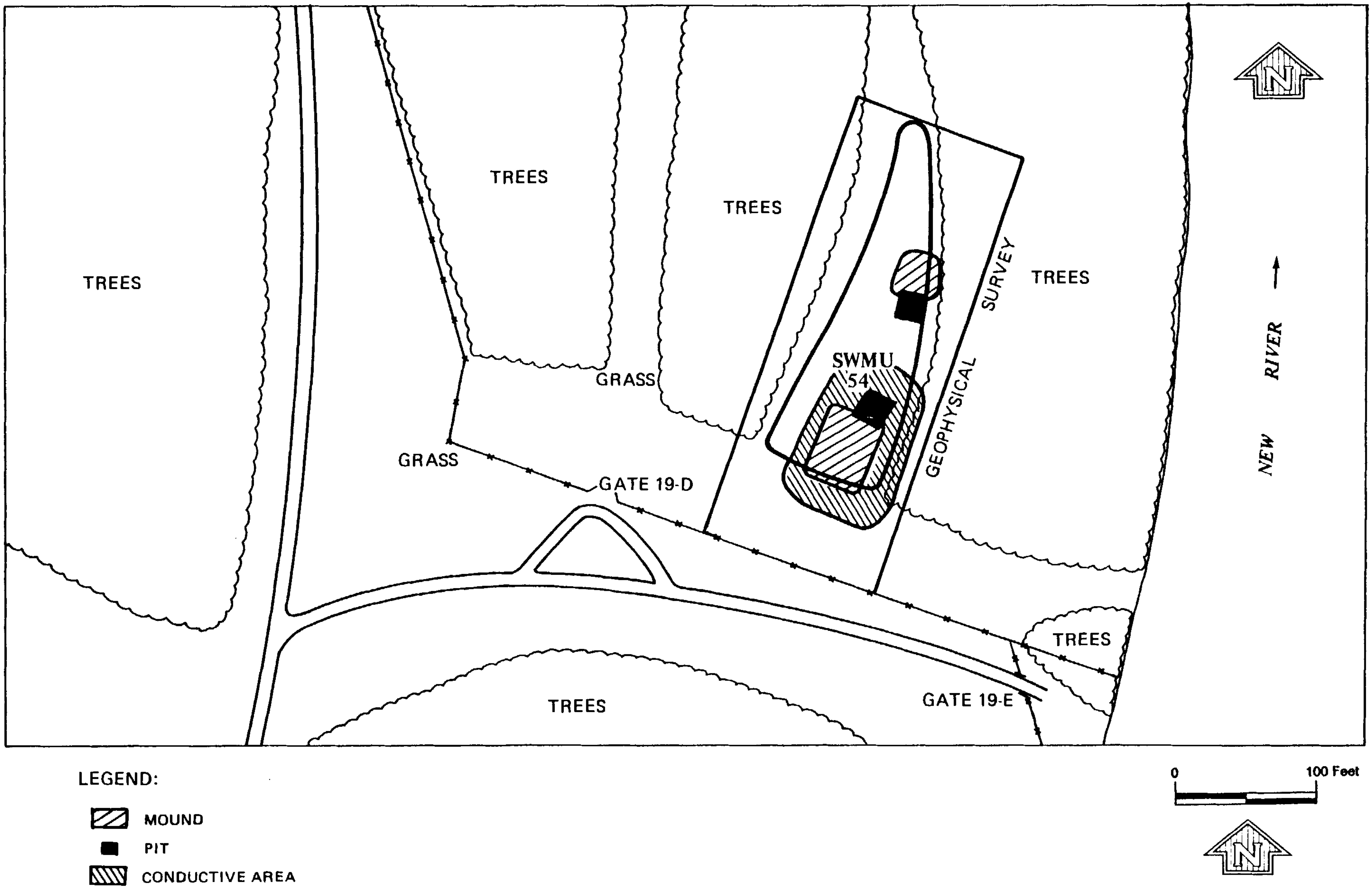

FIGURE 18-2
GEOPHYSICAL SURVEY RESULTS
SWMU 54 – PROPELLANT ASH DISPOSAL AREA
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

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SWMU is bordered to the east, west, and north by tree covered areas and to the south by a grassy flat area which turns into a tree covered area approximately 150 feet further south. The New River is located approximately 180 feet to the east. The nearest building in this area of the RAAP is several hundred feet to the west.

18.2.2 Geology and Soils

The geology of the SWMU 54 area has been explored for this VI through the drilling of four soil and rock borings (54MW1, 54MW1A, 54MW2, 54MW3) in the vicinity of SWMU 54 as shown in Figure 18-1. The subsurface conditions encountered during drilling consisted of fine-grained, loose to medium dense, micaceous silty sands (SM) underlain by a thin layer (1 to 3 feet) of silty gravel (GM) over bedrock. The silty gravel layer generally becomes thicker downgradient of SWMU 54. Greenish gray shale and limestone bedrock was encountered during drilling at approximately 19.5 to 21 feet below ground surface and was penetrated to a depth of approximately 60 feet. The shale and limestone encountered during drilling was highly interbedded, and generally soft and weathered.

18.2.3 Groundwater Conditions

A relatively shallow unconfined groundwater table was encountered during drilling within the fractured shale and limestone bedrock. Subsequent stabilized groundwater levels were measured at approximately 18.5 to 22.5 feet within the silty sand (SM) layer upgradient of SWMU 54 and within the silty gravel (GM) layer downgradient of SWMU 54. During well development and sample purging, well recharge was extremely slow for 54MW1 and only slightly better for 54MW2 and 54MW3, which generally indicates limited groundwater availability from fractures in the shale and limestone bedrock. Based on periodic water level measurements taken during the VI program, groundwater flow is eastward toward the New River (Insert 2) at a hydraulic gradient of approximately 1 to 2 percent.

18.2.4 Surface Water Drainage

Based on topography, surface water runoff is expected to flow eastward approximately 180 feet to the New River, which is flowing north to west. According to RAAP utility maps, there are no manholes, catch basins, or storm drains located in the immediate vicinity.

18.3 CONTAMINATION ASSESSMENT

The VI field program at the Propellant Ash Disposal Area included the analyses of three groundwater samples collected from one upgradient well (54MW1) and two downgradient wells (54MW2 and 54MW3). Wells 54MW2 and 54MW3 were installed directly downgradient of the disposal area and were constructed to intercept groundwater in the first water-bearing formation below the site. The results of the chemical analyses of the groundwater samples indicated that low concentrations of two explosives and one VOC were present in groundwater samples collected downgradient of the disposal area. However, these concentrations did not exceed HBN criteria and are not considered a concern. Results of the chemical analyses are presented in Table 18-1.

Eleven metals were detected in the three groundwater samples collected at SWMU 54. Four of the 11 metals (i.e., aluminum, arsenic, silver and zinc) were detected in the upgradient sample only, but were reported at levels slightly greater than the analytical detection limits. Concentrations of metals in both downgradient samples were similar to those in the upgradient sample (54MW1) and do not appear to be elevated. Concentrations of all metals were one or more orders of magnitude less than applicable HBN criteria and are not considered a concern. Two explosives, 246TNT and HMX, were detected in downgradient groundwater samples 54MW2 and 54MW3, respectively, but were not detected in the upgradient sample. The concentration of 246TNT was nearly one order of magnitude less than the HBN criterion. HMX was detected at a concentration nearly three orders of magnitude less than the HBN criterion. Carbon disulfide was the only VOC detected in all groundwater samples, but this is usually a natural VOC derived from decomposing organic matter and is not considered a concern at this SWMU since levels were below the HBN. TOC and TOX levels decreased slightly in the downgradient direction and suggest that SWMU 54 has had no impact on TOC and TOX concentrations. No primary target SVOCs were detected in any sample. Low concentrations of several SVOC TICs were reported for 54MW1 and 54MW2 but upgradient concentrations were greater.

Table 18-1
Summary of Analytical Data For Groundwater Samples Collected At SWMU 54
Radford Army Ammunition Plant, Virginia

SITE ID		54MW1	54MW2	54MW3	
FIELD ID		RDWC*39	RDWC*40	RDWC*41	
S. DATE		06-feb-92	06-feb-92	07-feb-92	
DEPTH (ft)		45.0	23.0	25.0	
MATRIX	PQLs	CGW	CGW	CGW	HBN
UNITS	UGL	UGL	UGL	UGL	UGL
TAL Inorganics					
ALUMINIUM	141	154	LT 141	LT 141	101500
ARSENIC	10	5.44	LT 2.54	LT 2.54	50
BARIUM	20	97.2	104	104	1000
CALCIUM	500	59100	71600	74000	NSA
IRON	38.1	81.7	63.6	74.5	NSA
MAGNESIUM	500	26300	34500	25000	NSA
MANGANESE	2.75	17	59.5	7.38	3500
POTASSIUM	375	1630	2320	1990	NSA
SILVER	2	0.255	LT 0.25	LT 0.25	50
SODIUM	500	3140	6350	5400	NSA
ZINC	50	23.1	LT 21.1	LT 21.1	7000
Explosives					
246TNT	0.635	LT 0.635	2.81	LT 0.635	11.7
HMX	1.21	LT 1.21	LT 1.21	3.07	1750
Volatiles					
CARBON DISULFIDE	5	1.25	7.03	13.6	4000
Semivolatiles					
	NA	None Detected	None Detected	None Detected	NSA
Semivolatile TICs					
CYCLOPENTANONE	NA	10 S	5 S	ND	NSA
MESITYL OXIDE	NA	4 S	ND	ND	NSA
TOTAL UNKNOWN TICs	NA	(1)6	ND	ND	NSA

Table 18-1 (Cont'd)

SITE ID		54MW1	54MW2	54MW3	
FIELD ID		RDWC*39	RDWC*40	RDWC*41	
S. DATE		06-feb-92	06-feb-92	07-feb-92	
DEPTH (ft)		45.0	23.0	25.0	
MATRIX	PQLs	CGW	CGW	CGW	HBN
UNITS	UGL	UGL	UGL	UGL	UGL
Other					
TOTAL ORGANIC CARBON	1000	10.5	5.45	3.67	NSA
TOTAL ORGANIC HALOGENS	1	158	138	117	NSA
pH	NA	7.29	6.99	7.02	NSA

Footnotes:

CGW = Chemical groundwater.
HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).
LT = Concentration is reported as less than the certified reporting limit.
NA = Not available; PQLs are not available for TICs detected in the library scans.
ND = Analyte was not detected.
NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.
PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.
S = Results are based on an internal standard; flag is used for TICs detected in library scans.
TAL = Target Analyte List.
TCLP = Toxicity Characteristic Leaching Procedure.
TICs = Tentatively identified compounds that were detected in the GC/MS library scans.
UGL = Micrograms per liter.
( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

18.4 BASELINE RISK ASSESSMENT

Based on the contamination assessment presented in Section 18.3, no contaminants of concern were identified for SWMU 54. However, only groundwater samples were collected from this SWMU. Because propellant ash may contain explosives that have been shown in laboratory studies to be potentially carcinogenic and/or mutagenic, there is the potential for significant soil contamination in this area.

Because analytical data are not available and the areal extent of contamination is unknown, a human health and environmental evaluation of SWMU 54 cannot be conducted. However, SWMU 54 should be recognized as an area for which potential exposure to human and environmental receptors is high. SWMU 54 is not fenced in and anyone may access this area from the river. Potential human receptors to the propellant ash and associated contaminants consist of boaters, tubers, canoers, and other recreationists that may camp/picnic in this area. Potential routes of exposure for the propellant ash may include incidental ingestion, inhalation, and dermal absorption. In addition, surface runoff may cause migration of contaminants beyond the boundaries of the waste disposal area and could cause contamination of surface water or sediment in the New River. The contaminated surface water/sediment may then be ingested or dermally absorbed by potential receptors.

Potential environmental receptors of exposed ash include deer and other wildlife that graze in the area (it has been observed that deer lick the salt crystals that form on the ash). As discussed above, surface runoff could cause contamination of surface water or sediment in the New River. Potential environmental receptors of surface water and sediment contamination include aquatic life and wildlife that may use this area of the river as a drinking water source or bathing area.

18.5 CONCLUSIONS

The VI field program at SWMU 54 included a geophysical survey to delineate the extent of buried wastes at the site and the collection and chemical analyses of three groundwater samples to confirm or deny the presence of contaminants in the underlying aquifer. Explosives were detected in two downgradient samples, but the present concentrations are not considered a concern because HBN criteria were not exceeded. One VOC and several SVOC TICs were detected in upgradient and downgradient samples, but were below HBN criteria.

The results of the investigation indicated that explosives (246TNT and HMX) have been released to the subsurface environment and the local water table and that propellant ash is present on the ground surface without any cover to prevent direct contact.

18.6 RECOMMENDED ACTION

The results of the VI indicated a release of explosives from the ash disposal area, but at levels less than HBNs at the edge of the SWMU. A corrective measures study is recommended for the purpose of defining the areal extent of ash and defining methods of removing or immobilizing the ash. Based on the known data, an RFI is not necessary since off-site migration of contaminants through the groundwater is not presently occurring at concentrations of concern. However, continued groundwater monitoring for explosives is recommended to track possible changes in explosive concentrations. Remediation of the source through a corrective measures study would alleviate the risk to humans or wildlife from accidental contact with a contaminant suspected to be a mutagen.

19.0 VERIFICATION INVESTIGATION OF SWMU 57, POND BY BUILDINGS NO. 4931 AND 4932

19.1 SWMU 57 BACKGROUND AND INVESTIGATION PROGRAM

19.1.1 SWMU History

The pond by Building Nos. 4931 and 4328 (SWMU 57) is located in the western section of the Horseshoe Area, east of the Cast Propellant Area, north of Building 4931, and northeast of Building 4928 (Figure 19-1). An underground pipe connects Building 4931 to the pond. RAAP facility drawings label this pond as an "acid settling pond." However, available construction plans for the adjacent chromic acid treatment plant do not show this pond.

The pond measures approximately 30 feet in diameter and is surrounded by a soil berm and a 5-foot chain-link fence. There is no apparent outlet from the pond, and the berm extends several feet above the natural ground surface. The origin of the liquid currently in the pond is uncertain, though precipitation is a likely source.

19.1.2 Previous Investigations

This SWMU was identified in the RCRA Facility Assessment (USEPA, 1989) as having a potential for releasing contaminants into the environment and was included in the RCRA Permit for Corrective Action and Incinerator Operation (USEPA, 1989) as warranting investigation. No site-specific investigations have been conducted at this location prior to this VI.

19.1.3 VI Program

As shown in Figure 19-1, a surface water sample (57SW1) was collected from SWMU 57 to evaluate the characteristics of the liquid in the pond. The sample was analyzed for TAL metals, VOCs, SVOCs, TOC, TOX, and pH. To evaluate the characteristics of the sediment in the pond, one sediment sample (57SE1) was collected from a depth of 0 to 12 inches below the water/sediment interface. The sample was analyzed for metals, VOCs, and SVOCs.

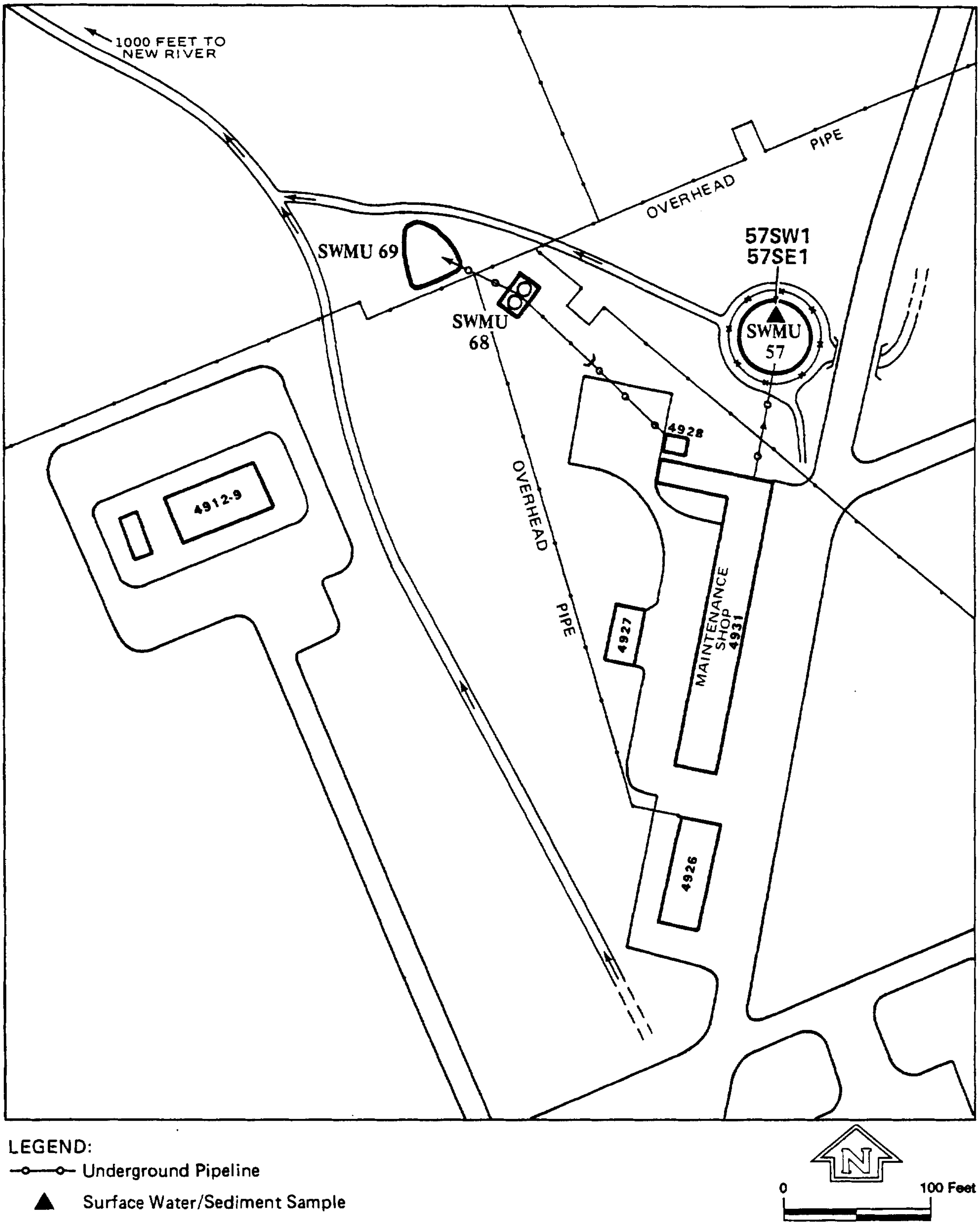


FIGURE 19-1
LOCATION MAP
SWMU 57 – POND BY BUILDINGS 4928 AND 4931
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Dames & Moore

19.2 ENVIRONMENTAL SETTING

19.2.1 Topography

The SWMU 57 pond is approximately 30 feet in diameter and is surrounded by a gravel berm with apparently no outlet. SWMU 57 is located on a plateau area above a hillside that slopes northwestward to the New River. The elevation of SWMU 57 is approximately 1,790 feet msl. There are numerous buildings, paved roads, and overhead pipes in the vicinity of SWMU 57.

19.2.2 Geology and Soils

No site-specific subsurface investigations have been conducted in this area. Soils underlying the SWMU should consist of approximately 20 feet of clay, silt, and sand, with occasional seams of cobbles and boulders. This would overlie the karstic limestone/dolomite of the Elbrook Formation.

19.2.3 Groundwater Conditions

No site-specific hydrogeologic studies have been conducted in this area. Based on groundwater conditions in similar SWMUs, groundwater should follow topography and flow northwestward, discharging into the New River.

19.2.4 Surface Water Drainage

Based on topography, the surface water in the area of SWMU 57 appears to flow northwestward to a tributary of the New River. The tributary flows north and discharges into the New River which is approximately 1,500 feet from SWMU 57. According to RAAP utility maps, there does not appear to be any manholes, catch basins, or storm drains present in the immediate vicinity of SWMU 57. The berm around the pond prevents both run-on and runoff from the pond itself, even though a surface drainage ditch flows around the pond.

19.3 CONTAMINATION ASSESSMENT

Summaries of the chemical analytical results for the samples collected at SWMU 57 are presented in Tables 19-1 and 19-2.

Table 19-1

Summary of Analytical Data For Surface Water Samples Collected At SWMU 57
Radford Army Ammunition Plant, Virginia

SITE ID		57SW1	
FIELD ID		RDWD*1	
S. DATE		10-feb-92	
DEPTH (ft)		0.0	
MATRIX	PQLs	CSW	HBN
UNITS	UGL	UGL	UGL
TAL Inorganics			
ALUMINIUM	141	871	101500
ARSENIC	10	6.29	50
BARIUM	20	23.1	1000
CALCIUM	500	16700	NSA
CHROMIUM	10	15.9	50
COPPER	60	11.8	1295
IRON	38.1	2750	NSA
LEAD	10	14.4	50
MAGNESIUM	500	6670	NSA
MANGANESE	2.75	380	3500
POTASSIUM	375	8850	NSA
SODIUM	500	14000	NSA
ZINC	50	155	7000
Volatiles	NA	None Detected	NSA
Semivolatiles	NA	None Detected	NSA
Semivolatile TICs			
1,1,2,2-TETRACHLOROETHANE	NA	6 S	NSA
TOTAL UNKNOWN TICs	NA	(3)24	NSA
Other			
TOTAL ORGANIC CARBON	1000	19400	NSA
TOTAL ORGANIC HALOGENS	1	104	NSA
pH	NA	7.46	NSA

Footnotes:

CSW = Chemical surface water.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

S = Results are based on an internal standard; flag is used for TICs detected in library scans.

TAL = Target Analyte List.

TICs = Tentatively identified compounds that were detected in the GC/MS library scans.

UGL = Micrograms per liter.

( ) = Parenthesis are used to indicate the num MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

Table 19-2
Summary of Analytical Data For Sediment Samples Collected At SWMU 57
Radford Army Ammunition Plant, Virginia

SITE ID		57SE1	
FIELD ID		RVFS*92	
S. DATE		10-feb-92	
DEPTH (ft)		0.5	
MATRIX	PQLs	CSE	HBN
UNITS	UGG	UGG	UGG
TAL Inorganics			
ALUMINIUM	14.1	30000	230000
ARSENIC	30	[4.66]	0.5
BARIUM	1	65.5	1000
CALCIUM	100	30800	NSA
CHROMIUM	4	42.5	400
COBALT	3	[4.71]	0.8
COPPER	7	12.9	2900
IRON	1000	24400	NSA
MAGNESIUM	50	18500	NSA
MANGANESE	0.275	126	8000
MERCURY	0.1	0.142	20
NICKEL	3	10.3	1000
POTASSIUM	37.5	785	NSA
SODIUM	150	532 B	NSA
VANADIUM	0.775	85	560
ZINC	30.2	61.6	16000
Volatiles	NA	None Detected	NSA
Volatile TICs			
3-METHYLPENTANE	NA	0.007 S	NSA
HEPTANE	NA	0.029 S	NSA
TOTAL UNKNOWN TICs	NA	(8)0.093	NSA
Semivolatiles	NA	None Detected	NSA

Footnotes :

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

S = Results are based on an internal standard; flag is used for TICs detected in library scans.

TICs = Tentatively identified compounds that were detected in the GC/MS library scans.

( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

CSE = Chemical sediment.
TAL = Target Analyte List.
UGG = Micrograms per gram.

19.3.1 Surface Water

In total, 13 metals were detected in surface water sample 57SW1, as shown in Table 19-1. Of these 13 metals, arsenic and copper were detected at concentrations less than their PQL, and no concentration exceeded the applicable HBN. Since this sample can be considered as a source sample, comparison to HBNs is considered appropriate. VOCs and SVOC were not detected in this sample. One known SVOC TIC, 1,1,2,2-Tetrachloroethane (TCLEA), was estimated at a concentration of 6 ug/l, but TCLEA is a VOC that was not detected during the VOC analysis. The VOC method for detecting TCLEA is more reliable since it is unlikely that TCLEA would survive the SVOC method extraction procedures. Because of these reasons, the TIC concentration of TCLEA is not considered to be valid for this sample and is not considered a concern at the site. A total of three unknown TICs, with a combined concentration of 24 ug/l, was also reported. TOC was reported within a range normally found in surface water environments and TOX was reported at a concentration of 104 ug/l. Although the TOX result may represent unknown TIC concentrations, the VOC and SVOC analyses demonstrates that it does not reflect concentrations of the toxic, primary target organic compounds.

19.3.2 Sediment

In total, 16 metals were detected in sediment sample 57SE1, as shown in Table 19-2. Since the sediment is a source sample, comparison to HBNs is appropriate for this evaluation. Of these 16, concentrations of arsenic and cobalt exceeded HBNs; however, these concentrations were less than the background criteria and likely represent natural levels of these constituents in upland soil. Although mercury was detected at a concentration greater than the soil background criteria, mercury and other target metals were reported at levels below HBN criteria. Aluminum, chromium, sodium, and vanadium were also detected at concentrations above the soil background criterion but less than 50 percent greater than background concentrations. Two hydrocarbon compounds, 3-methylpentane and heptane, were identified as VOC TICs at concentrations of 0.007 ug/g and 0.029 ug/g, respectively. Concentrations of these hydrocarbons could be the result of a small, one-time spill or release to the pond and are not considered a concern.

Additionally, eight unknown TICs with a total concentration of 0.093 ug/g were reported. However, no other VOCs or SVOCs were detected in sample 57SE1.

19.4 CONCLUSIONS

The results of the VI indicate that the concentrations of constituents found in water and sediment are not a concern at SWMU 57. Levels of arsenic and cobalt, although greater than the HBN criteria, did not exceed soil background criteria and were consistent with concentrations of these elements expected to occur naturally in soil and sediment at RAAP. Low levels of two saturated hydrocarbons and several unknown TICs in the pond sediment and water suggest that SWMU 57 has not been significantly impacted by disposal activities and is an unlikely source of contamination.

19.5 RECOMMENDED ACTION

Because constituents found in surface water and sediment are either not significantly different from background concentrations or are below HBNs, no further action is recommended for this SWMU.

20.0 VERIFICATION INVESTIGATION OF SWMU 58, RUBBLE PILE

20.1 SWMU 58 BACKGROUND AND INVESTIGATION PROGRAM

20.1.1 SWMU History

Rubble Pile (SWMU 58) is located in the south-central portion of the Horseshoe Area, approximately 2,600 feet east of the main bridge over the New River and directly west of the Inert Waste Landfill No. 1 (SWMU 32). The rubble pile is approximately 50 feet high and roughly triangular in shape with each side approximately 300 feet. Erosion of the soil cover is evident. According to facility representatives interviewed during the March 1990 facility visit, SWMU 58 was used as a one-time disposal site in approximately 1979. During clearing activities, prior to construction of the CAMBL, pine trees and surface debris were pushed into a pile and then covered with dirt and fill material. It is believed that no other materials were disposed of at SWMU 58.

20.1.2 Previous Investigations

This SWMU was identified in the RCRA Facility Assessment (USEPA, 1987) as having a potential for releasing contaminants into the environment and was included in the RCRA Permit for Corrective Action and Incineration Operation (USEPA, 1989) as warranting investigation. No site-specific investigations have been conducted at this location prior to this VI.

20.1.3 VI Program

Available information indicates that the rubble pile (Figure 20-1) consists only of brush and trees covered with excavated "clean" soil. Reportedly, no hazardous materials or other wastes were disposed of at SWMU 58. However, to evaluate the potential soil contamination in accordance with the permit requirements, three soil samples (58SS1, 58SS2, and 58SS3) were collected from beneath the cover material at the edges of the base of the rubble pile. A hand-auger sample was collected at each location from 0 to 1 foot beneath the piled materials. These samples were analyzed for metals, VOCs, and SVOCs.

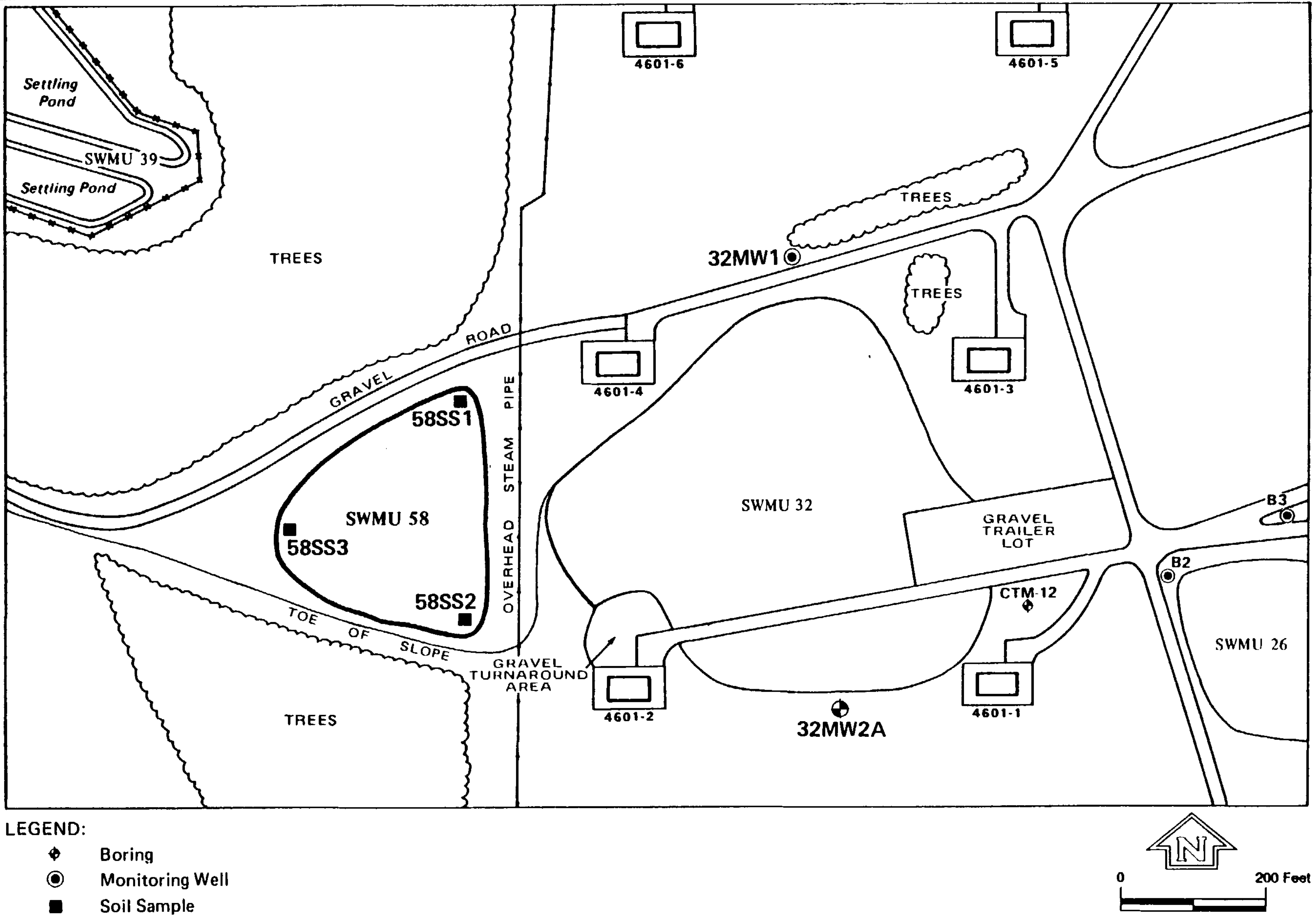


FIGURE 20-1
LOCATION MAP
SWMU 58 – RUBBLE PILE
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Dames & Moore

20.2 ENVIRONMENTAL SETTING

This SWMU is located immediately west of SWMU 32 (Section 10.1) and 800 feet west of SWMU 26 (Section 8.1). Subsurface conditions would be similar to conditions at these two SWMUs.

20.2.1 Topography

SWMU 58 is located along the lower portion of the plateau in the Horseshoe Area, at approximately 1,740 feet msl. Topography in the area of the SWMU is moderately sloping towards the north. There are several buildings, an overhead steam pipe, and gravel and paved roads in the vicinity of SWMU 58.

20.2.2 Geology and Soils

No site-specific subsurface investigations have been conducted in this area. However, this SWMU is located near SWMUs 32 and 26, and subsurface conditions are expected to be similar to these SWMUs.

20.2.3 Groundwater Conditions

No site-specific hydrogeologic investigations have been conducted in this area. However, groundwater conditions would be similar to conditions at SWMUs 26 and 32 and is expected to flow northward.

20.2.4 Surface Water Drainage

Surface water appears to flow in all directions from the pile of debris at SWMU 58 and then is expected to flow northward following topography towards the New River, approximately 600 feet south of SWMU 58. According to the RAAP utility maps, there do not appear to be any manholes, catch basins, or storm drains located in the immediate vicinity of SWMU 58.

20.3 CONTAMINATION ASSESSMENT

The VI field program included the chemical analyses of three soil samples collected beneath the cover material at the edges of the rubble pile. A summary of the chemical analyses is presented in Table 20-1. Background soil comparison criteria (Table 4-12) were exceeded for four metals--beryllium, chromium, mercury and thallium--but these exceedances were not anomalously high (more than twice the criteria). The detected concentrations are probably natural background levels associated with the disturbed soil and rock of which this SWMU is composed. Each exceedance was detected only once except for thallium (detected twice), and the thallium and mercury concentrations were less than their PQLs. Four metals (arsenic, beryllium, cobalt, and thallium) exceeded the HBN criteria, but as stated above, the levels are considered as natural background concentrations for upland soil. Additionally, only cobalt concentrations exceeded the PQL. Although low concentrations of two unidentified TICs were reported for 58SS1 and 58SS3, primary target VOCs or SVOCs were not detected in any of the soil samples collected at the site. Low concentrations of one unknown VOC and SVOC TIC were detected during the analyses of two samples.

20.4 CONCLUSIONS

The VI conducted at the Rubble Pile (SWMU 58) consisted of collecting and chemically analyzing three shallow soil samples from representative portions of the site. The results of the investigation indicated that the detected levels of metals constituents in the soil are within the expected natural background concentrations and are not likely to be a concern to human health and the environment. VOCs and SVOCs are not considered a concern because target organic compounds were not detected in the three representative soil samples. Additionally, any reported VOC or SVOC TICs were unknowns and were estimated at trace to low concentrations. These results indicate that VOCs and SVOCs are not likely to be detected at this site.

20.5 RECOMMENDED ACTION

Based on the analytical results of the soil investigation, no further action for this site is recommended.

Table 20-1

Summary of Analytical Data For Soil Samples Collected At SWMU 58

Radford Army Ammunition Plant, Virginia

SITE ID		58SS1	58SS2	58SS3	
FIELD ID		RVFS*53	RVFS*54	RVFS*55	
S. DATE		10-feb-92	10-feb-92	10-feb-92	
DEPTH (ft)		0.5	0.5	0.5	
MATRIX	PQLs	CSO	CSO	CSO	HBN
UNITS	UGG	UGG	UGG	UGG	UGG
TAL Inorganics					
ALUMINIUM	14.1	15200	18600	16400	230000
ARSENIC	30	[3.81]	[6.99]	[6.97]	0.5
BARIUM	1	69.9	49.2	67.3	1000
BERYLLIUM	0.2	LT 0.5	[1.21]	LT 0.5	0.1
CALCIUM	100	1110 B	8040	5570 B	NSA
CHROMIUM	4	42.7	38.1	27.6	400
COBALT	3	[5.99]	[20.6]	[6.22]	0.8
COPPER	7	16.2	15.5	10.9	2900
IRON	1000	24900	26900	25300	NSA
LEAD	2	LT 10.5	LT 10.5	16.3	200
MAGNESIUM	50	751 B	10300	3900	NSA
MANGANESE	0.275	465	283	453	8000
MERCURY	0.1	0.079	LT 0.05	LT 0.05	20
NICKEL	3	15.8	26.5	8.94	1000
POTASSIUM	37.5	515	2590	1350	NSA
SODIUM	150	151 B	188 B	171 B	NSA
THALLIUM	20	[11.8]	[11.4]	LT 6.62	6
VANADIUM	0.775	51.5	44.3	53.7	560
ZINC	30.2	32.6	32.9	34.2	16000
Volatiles	NA	None Detected	None Detected	None Detected	NSA
TOTAL UNKNOWN TICs	NA	(1)0.002	ND	(1)0.004	NSA

Table 20-1 (Cont'd)

SITE ID		58SS1	58SS2	58SS3	
FIELD ID		RVFS*53	RVFS*54	RVFS*55	
S. DATE		10-feb-92	10-feb-92	10-feb-92	
DEPTH (ft)		0.5	0.5	0.5	
MATRIX	PQLs	CSO	CSO	CSO	HBN
UNITS	UGG	UGG	UGG	UGG	UGG
Semivolatiles	NA	None Detected	None Detected	None Detected	NSA
TOTAL UNKNOWN TICs	NA	(1)0.347	ND	(1)0.617	NSA

Footnotes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CSO = Chemical soil.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

ND = Analyte was not detected.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

S = Results are based on an internal standard; flag is used for TICs detected in library scans.

TAL = Target Analyte List.

TICs = Tentatively identified compounds that were detected in the GC/MS library scans.

UGG = Micrograms per gram.

( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

21.0 VERIFICATION INVESTIGATION OF SWMU 59, BOTTOM ASH PILE

21.1 SWMU 59 BACKGROUND AND INVESTIGATION PROGRAM

21.1.1 SWMU History

The Bottom Ash Pile (SWMU 59) is located near SWMUs 48 and 50 in the Horseshoe Area of RAAP, approximately 3,400 feet east of the main bridge over the New River (Figure 21-1). The pile is approximately 100 feet by 50 feet in area and 20 feet high. The source of the bottom ash is one of the power plants at RAAP. Power Plant No. 2 is a coal-fired plant that uses pulverized coal and supplies steam at 150 psi to buildings in the Horseshoe Area. This plant currently uses low sulfur coal.

Bottom ash is permitted to be buried in landfills on the installation (in particular FAL No. 1). Some bottom ash is apparently stored in piles around RAAP for use on roadbeds and as landfill cover material (USEPA, 1987). It can be assumed that this pile or similar piles have existed at RAAP since operation of the power plant began.

21.1.2 Previous Investigations

This SWMU was identified in the RCRA Facility Assessment (USEPA, 1989) as having a potential for releasing contaminants into the environment and was included in the RCRA Permit for Corrective Action and Incineration Operation (USEPA, 1989) as warranting investigation. No site-specific investigations have been conducted at this location prior to this VI.

21.1.3 VI Program

Because studies have shown that coal bottom ash can leach hazardous constituents to the environment, sampling was conducted at this unit to evaluate whether soil contamination exists beneath the ash pile. A shovel was used to clear the ash away from two areas near the edge of the pile to expose the underlying soils (Figure 21-1). One soil

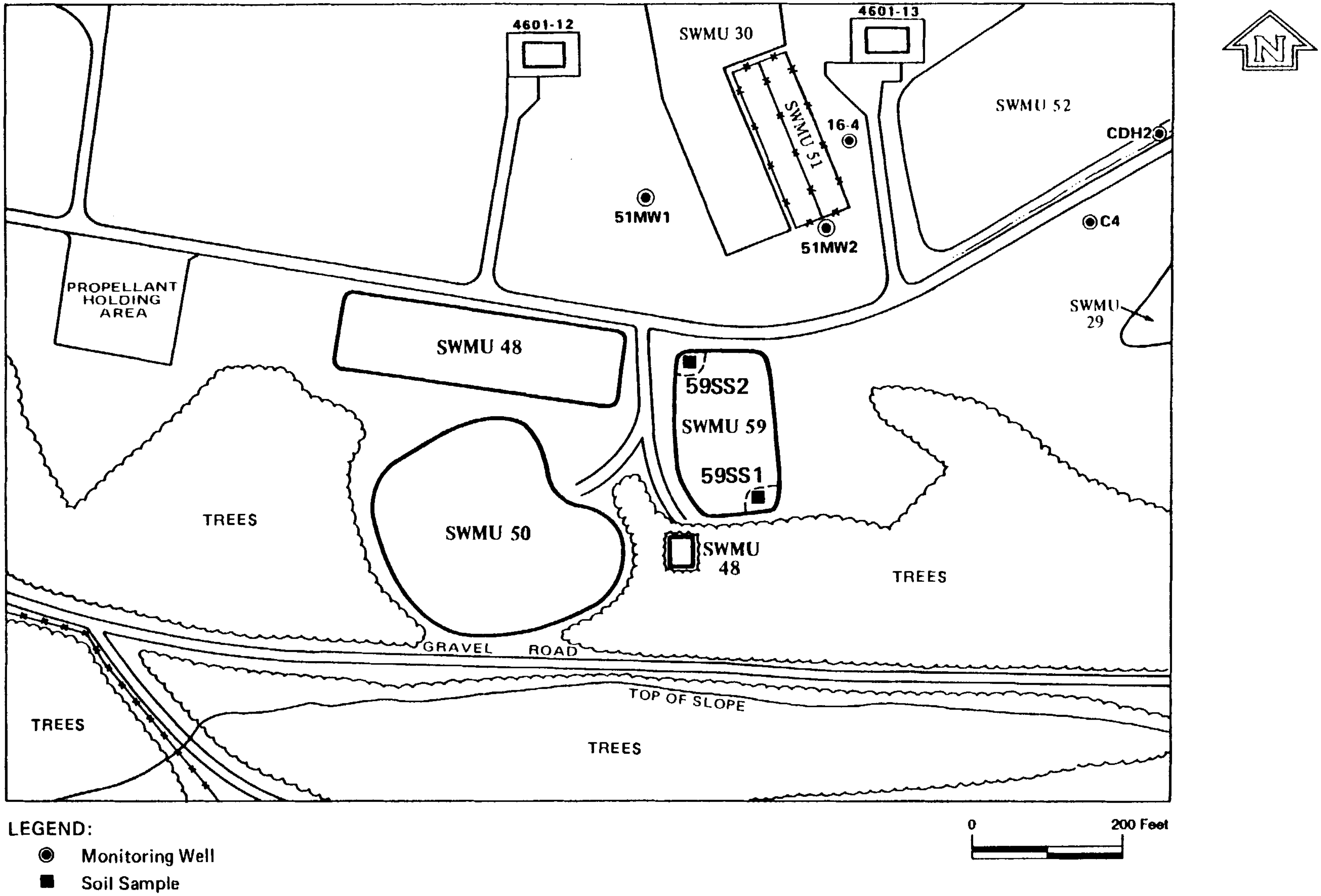


FIGURE 21-1
LOCATION MAP
SWMU 59 – BOTTOM ASH PILE
RADFORD ARMY AMMUNTION PLANT, VIRGINIA

Dames & Moore

sample was collected from each of the areas (59SS1 and 59SS2) from a depth of 0 to 1 foot. Each sample was analyzed for TAL metals and SVOCs.

21.2 ENVIRONMENTAL SETTING

21.2.1 Topography

The Bottom Ash Pile (SWMU 59) is located near SWMUs 48 and 50 in the Horseshoe Area of RAAP, approximately 3,400 feet east of the main bridge over the New River. As shown on Figure 21-1, SWMU 59 is surrounded to the west, north and east by SWMUs 48, 50, 51, 52, 29, 27, and 53. SWMU 13 is approximately 600 feet south of SWMU 59. A small section of SWMU 48 is approximately 50 feet south of SWMU 59. SWMU 59 is located on a plateau area of the eastern portion of the Horseshoe Area. The elevation of SWMU 59 is approximately 1,810 to 1,820 feet msl, gently sloping to the south. Further south, the hillside steeply slopes south towards the New River. Several buildings and paved roads are present in the vicinity of SWMU 59.

21.2.2 Geology and Soils

No site-specific subsurface investigation was performed in this area. However, this SWMU is located 200 feet east of SWMU 48 (Section 17.2.2) and would have subsurface conditions similar to this SWMU.

21.2.3 Groundwater Conditions

No site-specific hydrogeologic study was performed in this area. However, this SWMU is located 200 feet east of SWMU 48 (Section 17.2.3) and would have groundwater conditions similar to this SWMU.

21.2.4 Surface Water Drainage

Based on topography, surface water appears to flow south and southwest and discharges into the New River, approximately 500 feet south of SWMU 59. According to the RAAP utilities map, there do not appear to be any manholes, catch basins, or storm drains located in the immediate vicinity of SWMU 59.

21.3 CONTAMINATION ASSESSMENT

The VI field program included the collection of two soil samples (59SS1 and 59SS2) below the bottom ash at SWMU 59. A duplicate of sample 59SS2 was also analyzed. The results of the chemical analyses are presented in Table 21-1. Background comparison criteria (Table 4-12) were exceeded for three metals--arsenic, mercury and selenium--in sample 59SS2 (and duplicate), taken below the northwest corner of SWMU 59. The beryllium concentration for sample 59SS1 also exceeded the background criterion but only by 10 percent; however, this detection is considered as indicative of natural concentrations. The concentration of arsenic exceeded the HBN, but mercury and selenium concentrations were two to three orders of magnitude below their HBNs. Phenanthrene, a PAH commonly associated with commercial coal tar, gasoline, power plant emissions, and coal ash and cinders, was the only SVOC detected in either sample. Sample 59SS2 showed a phenanthrene concentration of 0.371 ug/g, but it is not considered a concern because the level is three orders of magnitude less than the HBN; the source may be due to runoff from the nearby asphalt road rather than the bottom ash pile. Phenanthrene readily adsorbs onto particulate matter, especially in the presence of soil organics, and is not expected to impact deeper soil or groundwater at the site.

21.4 CONCLUSIONS

The results of two soil samples collected below the bottom ash at SWMU 59 indicated concentrations of arsenic, mercury, and selenium were anomalously high and probably due to leachate from the bottom ash pile. Except for arsenic, the concentrations were below HBNs and do not pose a current risk. Phenanthrene, a SVOC commonly associated with coal ash and cinders was detected in concentrations less than HBN criteria and, therefore, is not considered a concern.

Surface placement of the bottom ash, the solid state of the material, and the relatively low contaminant concentrations detected in the soil indicate that contaminant migration through 30 to 40 feet of unsaturated soil is unlikely. Contaminants have likely accumulated in the surficial soil zone.

Table 21-1
Summary of Analytical Data For Soil Samples Collected At SWMU 59
Radford Army Ammunition Plant, Virginia

SITE ID		59SS1	59SS2	59SS2	
FIELD ID		RVFS*110	RVFS*108	RVFS*109	
S. DATE		05-mar-92	05-mar-92	05-mar-92	
DEPTH (ft)		0.5	0.5	0.5	
MATRIX	PQLs	CSO	CSO	CSO	HBN
UNITS	UGG	UGG	UGG	UGG	UGG
TAL Inorganics					
ALUMINIUM	14.1	11500	6270	8110	230000
ARSENIC	30	[1.85]	[34]	[40]	0.5
BARIUM	1	190	181	174	1000
BERYLLIUM	0.2	[1.23]	[0.736]	LT 0.5	0.1
CALCIUM	100	494 B	785 B	1390 B	NSA
CHROMIUM	4	22	14.4	22.2	400
COBALT	3	[10.1]	[3.03]	[2.84]	0.8
COPPER	7	7.08	17	11.4	2900
IRON	1000	12700	20600	22200	NSA
LEAD	2	15.3	30.6	22.7	200
MAGNESIUM	50	523 B	528 B	464 B	NSA
MANGANESE	0.275	2560	38.9	97	8000
MERCURY	0.1	LT 0.05	0.575	0.546	20
NICKEL	3	8.59	6.31	6.43	1000
POTASSIUM	37.5	377	530	402	NSA
SELENIUM	40	LT 0.25	0.646	0.751	200
SILVER	4	LT 0.589	0.701	LT 0.589	200
SODIUM	150	167 B	231 B	208 B	NSA
VANADIUM	0.775	29.8	25.3	33.3	560
ZINC	30.2	24.4	41.6	35.7	16000
Semivolatiles					
PHENANTHRENE	0.5	LT 0.033	0.371	0.245	40

Footnotes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CSO = Chemical soil.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TAL = Target Analyte List.

UGG = Micrograms per gram.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

21.5 RECOMMENDED ACTION

The collection of additional VI samples for metals analyses from the surficial soil layer, and at a depth of 5 feet, from several locations around the bottom ash pile is recommended. Samples should also be collected from the bottom ash for total and TCLP metals analyses. This additional VI effort is needed to better determine whether contaminants have migrated to areas not directly in contact with the bottom ash. If these samples indicate that areal contamination is possible, an RFI for this SWMU would be warranted.

22.0 VERIFICATION INVESTIGATION OF SWMU 68, CHROMIC ACID TREATMENT TANKS

22.1 SWMU 68 BACKGROUND AND INVESTIGATION PROGRAM

22.1.1 SWMU History

The Chromic Acid Treatment Tanks (SWMU 68) are located in the western section of the Horseshoe Area in the vicinity of Building 4931. SWMU 68 is located 100 feet northwest of SWMU 57 and almost at the point where the plateau of the Horseshoe Area starts sloping to the New River. SWMU 68 consists of two 4,000-gallon aboveground, open-top reactor vessels and associated aboveground piping (Figure 22-1). The tanks are 9 feet tall and 8.5 feet in diameter and are supported by steel legs. There is no secondary containment. A sign posted on the unit describes the tanks as the "Chromic Acid Treatment Plant."

The tanks were used prior to 1974 to treat spent chromic acid generated from the cleaning of rocket encasements (USEPA, 1987). Hexavalent chromic acid was batch treated using hydroxide precipitation. Spent hexavalent chromic acid (Cr^{+6}) was first adjusted to a pH of approximately 1.5 using sulfuric acid, and then reduced to the trivalent state (Cr^{+3}) using sodium metabisulfate as the reducer. High calcium lime was added to the solution to adjust the pH to approximately 8.6. The treated wastewater was discharged to a shallow settling pond (SWMU 69) where chromium hydroxide sludge would settle out. The pond is bermed and about 1 to 2 feet deep. It is not known whether chromium hydroxide sludge has ever been dredged from the pond. The supernatant was discharged to the New River via Outfall No. 17.

Since 1974, "Oakite 33"--an acidic rust stripper consisting of phosphoric acid and butyl cellosolve mixture--has been used instead of chromic acid to clean rocket encasements (USEPA, 1987). Spent Oakite 33 was pH adjusted to 5.0 with soda ash prior to discharge to SWMU 69 but discharge to SWMU 69 no longer occurs.

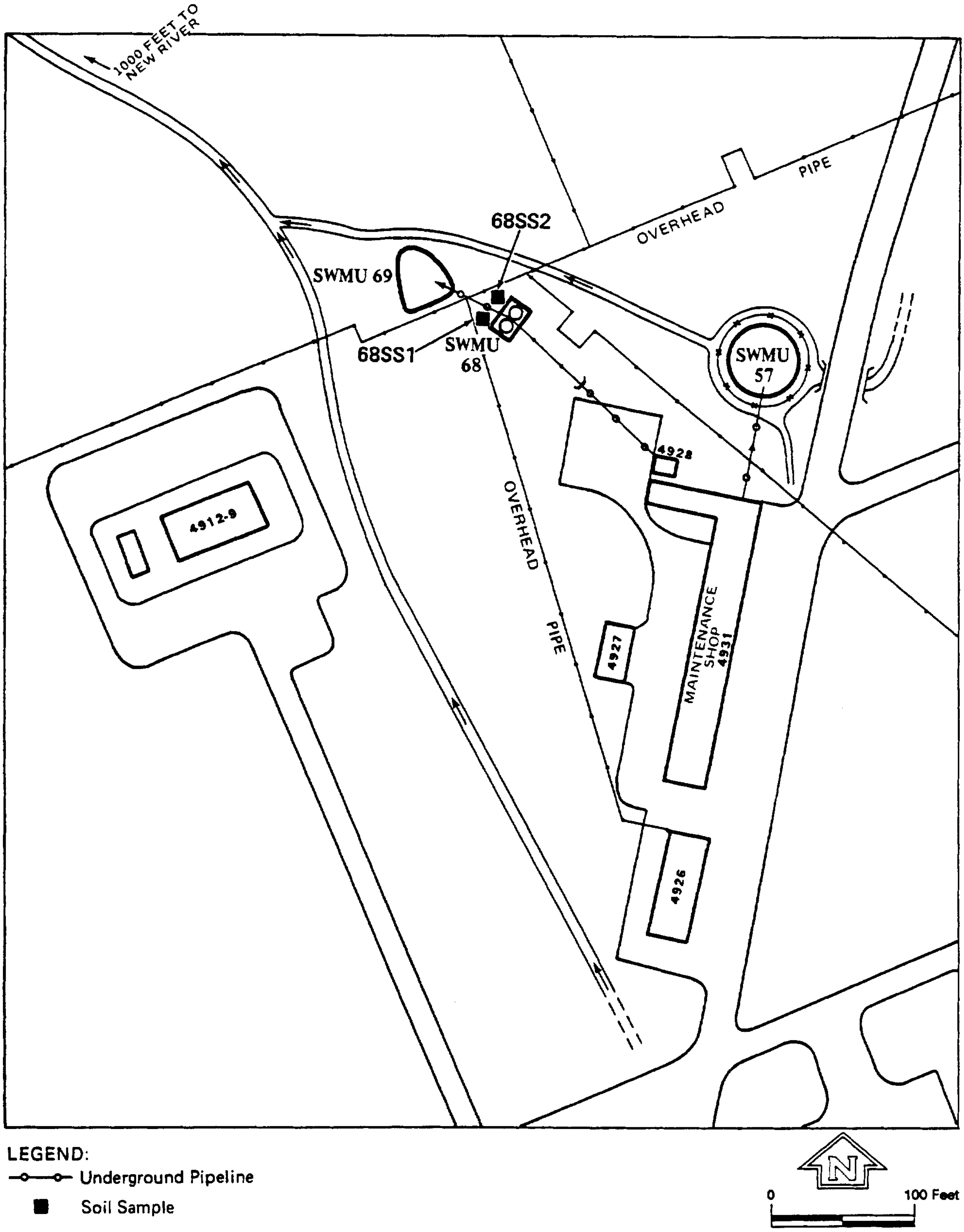


FIGURE 22-1
LOCATION MAP
SWMU 68 – CHROMIC ACID TREATMENT TANKS
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Dames & Moore

22.1.2 Previous Investigations

This SWMU was identified in the RCRA Facility Assessment (USEPA, 1987) as having a potential for releasing contaminants into the environment and was included in the RCRA Permit for Corrective Action and Incinerator Operation (USEPA, 1989) as warranting investigation. No site-specific investigations have been conducted at this location prior to this VI.

22.1.3 VI Program

To evaluate whether surface soils in the vicinity of the treatment tanks (SWMU 68) are contaminated as a result of past spills, leaks, or overflows of waste chromic acid, two surface soil samples (68SS1 and 68SS2) were collected from two locations downgradient of the tanks (Figure 22-1). The two samples were collected from a depth of 0 to 6 inches below the surface organic root zone and were analyzed for pH and TAL metals.

22.2 ENVIRONMENTAL SETTING

22.2.1 Topography

The topography in the area of SWMU 68 is moderately sloping towards the northwest. The area further north of SWMU 68 is moderately steeply sloping towards the north. The elevation at SWMU 68 is approximately 1,800 feet msl. There are buildings, paved roads, and overhead pipes in the vicinity of SWMU 68.

22.2.2 Geology and Soils

No site-specific subsurface investigations have been conducted in this area. However, this SWMU is located 100 feet northwest of SWMU 57 (Section 19.2.2) and would have similar subsurface conditions to SWMU 57.

22.2.3 Groundwater Conditions

No site-specific groundwater conditions have been conducted in this area. However, groundwater is probably found at a depth of 20 to 40 feet with flow northwestward with discharge into the New River (Insert 2).

22.2.4 Surface Water Drainage

Based on topography, the surface water in the area of SWMU 68 appears to flow westward towards a tributary of the New River. The tributary flows approximately 1,400 feet north and discharges into the New River. Based on the review of RAAP utility maps, there does not appear to be any manholes, catch basins, or storm drains present in the immediate vicinity of SWMU 68. Drainage from SWMU 68 was engineered to flow into the nearby settling pond (SWMU 69).

22.3 CONTAMINATION ASSESSMENT

The results of the chemical results for the two shallow soil samples collected at SWMU 68 are presented in Table 22-1. The chemical analyses show that the samples contained a total of 22 metals. Concentrations of antimony, barium, beryllium, cadmium, chromium, manganese, mercury, thallium, and vanadium exceeded background comparison concentrations in at least one sample. Of these 22 metals, concentrations of arsenic, beryllium, cobalt and thallium exceeded permit HBN criteria; however, arsenic and cobalt concentrations were within background levels.

Beryllium concentrations for both samples, although exceeding the HBN by an order of magnitude, only slightly exceeded (by less than twice) the background comparison level of beryllium in upland soil samples. Beryllium has a low solubility and is expected to be absorbed onto clay mineral surfaces at a low pH and to be complexed into insoluble compounds at high pH. In most natural environments, beryllium is likely to be sorbed or precipitated, rather than dissolved and is not expected to impact surface water, groundwater or underlying soil. Thallium was reported at concentrations that exceeded the HBNs by factors of 1.5 to nearly 4 for samples 68SS1 and 68SS2, respectively. However, thallium is not highly mobile in the environment and is not expected to impact surface water, groundwater or the underlying soil. Chromium, a constituent identified as a potential contaminant at this site, was reported at concentrations of 26.9 ug/g and 49.2 ug/g,, but these concentrations are similar to the upland soil background level criterion and are not

Table 22-1
Summary of Analytical Data For Soil Samples Collected At SWMU 68
Radford Army Ammunition Plant, Virginia

SITE ID		68SS1	68SS2	
FIELD ID		RVFS*59	RVFS*60	
S. DATE		04-feb-92	04-feb-92	
DEPTH (ft)		0.5	0.5	
MATRIX	PQLs	CSO	CSO	HBN
UNITS	UGG	UGG	UGG	UGG
TAL Inorganics				
ALUMINIUM	14.1	9450	18500	230000
ANTIMONY	20	LT 7.14	26.3	30
ARSENIC	30	[2.4]	[7.3]	0.5
BARIUM	1	118	61.3	1000
BERYLLIUM	0.2	[1.13]	[1.87]	0.1
CADMIUM	2	1.59	LT 0.7	40
CALCIUM	100	624 B	2270 B	NSA
CHROMIUM	4	26.9	49.2	400
COBALT	3	[11.5]	[14.6]	0.8
COPPER	7	9.96	20.1	2900
IRON	1000	12600	33900	NSA
LEAD	2	16.5	28.7	200
MAGNESIUM	50	642 B	1610	NSA
MANGANESE	0.275	1250	885	8000
MERCURY	0.1	LT 0.05	0.362	20
NICKEL	3	8.77	10.7	1000
POTASSIUM	37.5	538	1010	NSA
SILVER	4	0.779	1.1	200
SODIUM	150	650 B	188 B	NSA
THALLIUM	20	[9.62]	[21.1]	6
VANADIUM	0.775	30.5	75.8	560
ZINC	30.2	54.1	87.4	16000
Other				
pH	NA	8.52	7.37	NSA

Footnotes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CSO = Chemical soil.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TAL = Target Analyte List.

UGG = Micrograms per gram.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

expected to be a concern at this site. Other metals with HBNs were detected at levels less than the permit HBNs established for the protection of human health and the environment.

22.4 CONCLUSIONS

Chemical analysis for the two soil samples collected at SWMU 68 indicate that the samples contained a total of 22 metals. Antimony, cadmium, mercury, and thallium were detected above background concentrations for upland soils with thallium also above the HBN criterion. Therefore, these metals concentrations are considered anomalously high at this site.

22.5 RECOMMENDED ACTION

The VI samples indicate that four heavy metals, but not chromium, were detected at anomalously high concentrations; therefore, a RFI limited to investigating surface soil contamination in the site vicinity is recommended.

23.0 VERIFICATION INVESTIGATION OF SWMU 69, POND BY CHROMIC TREATMENT TANKS

23.1 SWMU 69 BACKGROUND AND INVESTIGATION PROGRAM

23.1.1 SWMU History

SWMU 69 is the pond downgradient of SWMU 68 and receives runoff from that area. The relationship between these two SWMUs and their shared history is presented in Section 22.1.1. Figure 23-1 presents the sample locations for SWMU 69.

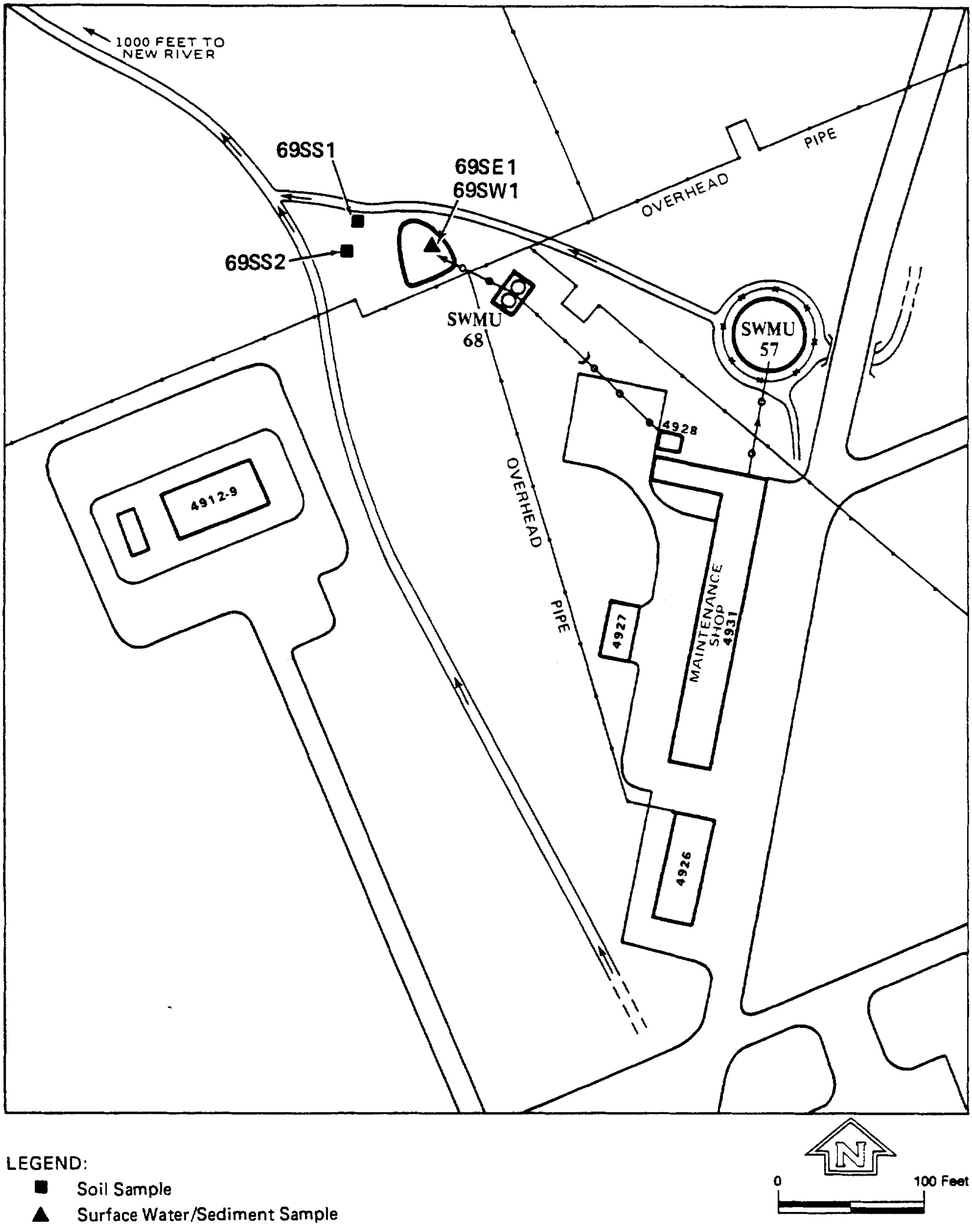
23.1.2 Previous Investigations

This SWMU was identified in the RCRA Facility Assessment (USEPA, 1987) as having a potential for releasing contaminants into the environment and was included in the RCRA Permit for Corrective Action and Incinerator Operation (USEPA, 1989) as warranting investigation. No site-specific investigations have been conducted at this location prior to this VI.

23.1.3 VI Program

To evaluate whether the pond (SWMU 69) has received hazardous constituents from past discharges from the chromium tanks at SWMU 68, one surface water sample (69SW1) and one sediment sample (69SE1) were collected from the pond. The sediment sample was collected from a depth of 0 to 1 foot below the water/sediment interface. Both the surface water and sediment sample were analyzed for pH and TAL metals. TOC and TOX were included in the surface water analytical program.

Two soil samples (69SS1 and 69SS2) also were collected downgradient of the pond to evaluate whether past overflows transported potentially hazardous constituents from the pond to the surrounding soils. The samples were collected from a depth of 0 to 6 inches below any surface organic root zone and analyzed for pH and TAL metals.



LEGEND:

■ Soil Sample

▲ Surface Water/Sediment Sample

—o—o— Underground Pipeline

FIGURE 23-1
LOCATION MAP
SWMU 69 – POND BY CHROMIC ACID TREATMENT TANKS
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Dames & Moore

23.2 ENVIRONMENTAL SETTING

23.2.1 Topography

The topography in the area of SWMU 69 is moderately sloping towards the northwest. The area further north of SWMU 69 is moderately steeply sloping towards the north. The elevation at SWMU 69 is approximately 1,790 to 1,800 feet msl. There are buildings, paved roads, and overhead pipes in the vicinity of SWMU 69.

22.2.2 Geology and Soils

No site-specific subsurface investigations have been conducted in this area. However, this SWMU is located 100 feet northwest of SWMU 57 (Section 19.2.2) and would have similar subsurface conditions to SWMU 57.

23.2.3 Groundwater Conditions

No site-specific groundwater conditions have been conducted in this area. However, groundwater is probably found at a depth of 20 to 40 feet with flow northwestward with discharge into the New River (Insert 2).

23.2.4 Surface Water Drainage

Based on topography, the surface water in the area of SWMU 69 appears to flow westward towards a tributary to the New River. The tributary flows north and discharges into the New River which is approximately 1,400 feet from SWMU 69. Based on the review of RAAP utility maps, no manholes, catch basins, or storm drains were evident in the immediate vicinity of SWMU 69. Overflow from the pond travels through a weir which discharges to the northwest. The soil samples were collected in the area of discharge.

23.3 CONTAMINATION ASSESSMENT

The surface water and sediment samples were collected from within the pond and can be considered as source samples. The soil samples were collected from an area which has the potential to be impacted by overflow from the pond and will provide data to evaluate potential contaminant migration.

23.3.1 Surface Water

A total of 19 metals were detected in surface water sample 69SW1, as shown in Table 23-1. Of these 19, concentrations of antimony, cadmium, chromium, cobalt, copper, lead, manganese, nickel and zinc exceeded HBNs by factors ranging from slightly greater than one for copper to nearly four orders of magnitude for cobalt and may be a concern at the site. Concentrations of arsenic, barium, silver and vanadium were reported in sample 69SW1 at levels below HBN criteria. Concentrations of metals without applicable health criteria indicate that the pond sample is defined as "very hard" by conventional water quality standards. TOC was reported within a range normally found in surface water environments. However, the TOX concentration for this sample appears to be elevated.

23.3.2 Sediment

A total of 20 metals were detected in sediment sample 69SE1, as shown in Table 23-2. Of these 20 metals, concentrations of antimony, arsenic, cadmium, chromium, cobalt, lead and thallium exceeded HBNs by factors ranging from slightly greater than three for thallium to greater than 25 for cobalt. Although arsenic and cobalt concentrations exceed the HBNs, the levels were less than the background soil criteria. Thus, only antimony, cadmium, chromium, lead, and thallium appear to be at elevated levels and in excess of HBNs in the pond sediment sample. Concentrations of barium, copper, silver, sodium, vanadium and zinc were also reported at elevated levels (i.e., greater than the upland soil background criteria) but were substantially below the respective HBNs. Other metals were below both HBNs and soil background criteria.

23.3.3 Soil

As shown in Table 23-3, 22 metals were detected in soil sample 69SS1, which was collected slightly downslope of the SWMU 69 settling pond. Eighteen metals were detected in a second soil sample, 69SS2, also collected downslope of the pond. Of the metals detected, concentrations of as many as six metals exceeded HBN criteria. Antimony, arsenic, beryllium, cobalt, lead and thallium exceeded the HBN criteria in one or more soil samples. However, arsenic, beryllium, and cobalt are not expected to be a concern because

Table 23-1
Summary of Analytical Data For Surface Water Samples Collected At SWMU 69
Radford Army Ammunition Plant, Virginia

SITE ID		69SW1	
FIELD ID		RDWD*2	
S. DATE		10-feb-92	
DEPTH (ft)		0.0	
MATRIX	PQLs	CSW	HBN
UNITS	UGL	UGL	UGL
TAL Inorganics			
ALUMINIUM	141	9800	101500
ANTIMONY	30	[269]	10
ARSENIC	10	3.62	50
BARIUM	20	159	1000
CADMIUM	1	[2540]	10
CALCIUM	500	268000	NSA
CHROMIUM	10	[25000]	50
COBALT	70	[1640]	0.35
COPPER	60	[1450]	1295
IRON	38.1	650000	NSA
LEAD	10	[7900]	50
MAGNESIUM	500	29300	NSA
MANGANESE	2.75	[25300]	3500
NICKEL	50	[120000]	700
POTASSIUM	375	3210	NSA
SILVER	2	5.83	50
SODIUM	500	950000	NSA
VANADIUM	40	161	245
ZINC	50	[61000]	7000
Other			
TOTAL ORGANIC CARBON	1000	22300	NSA
TOTAL ORGANIC HALOGENS	1	110	NSA
pH	NA	6.33	NSA

Footnotes:

CSW = Chemical surface water.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TAL = Target Analyte List.

UGL = Micrograms per liter.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

Table 23−2
Summary of Analytical Data for Sediment Samples Collected at SWMU 69
Radford Army Ammunition Plant, Virginia

SITE ID		69SE1	
FIELD ID		RVFS*61	
S. DATE		10−feb−92	
DEPTH (ft)		0.5	
MATRIX	PQLs	CSE	HBN
UNITS	UGG	UGG ppm	UGG
TAL Inorganics			
ALUMINIUM	14.1	10900	230000
ANTIMONY	20	[178]	30
ARSENIC	30	[2.13]	0.5
BARIUM	1	165	1000
CADMIUM	2	[610]	40
CALCIUM	100	50200	NSA
CHROMIUM	4	[2040]	400
COBALT	3	[20.7]	0.8
COPPER	7	818	2900
IRON	1000	34500	NSA
LEAD	2	[1330]	200
MAGNESIUM	50	2200	NSA
MANGANESE	0.275	621	8000
NICKEL	3	77	1000
POTASSIUM	37.5	522	NSA
SILVER	4	3.03	200
SODIUM	150	7990	NSA
THALLIUM	20	[18.5]	6
VANADIUM	0.775	25.1	560
ZINC	30.2	10000	16000
Other			
pH	NA	8.36	NSA

Footnotes:

CSE = Chemical sediment.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TAL = Target Analyte List.

UGG = Micrograms per gram.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

Table 23-3
Summary of Analytical Data For Soil Samples Collected At SWMU 69
Radford Army Ammunition Plant, Virginia

SITE ID		69SS1	69SS2	
FIELD ID		RVFS*62	RVFS*63	
S. DATE		10-feb-92	10-feb-92	
DEPTH (ft)		0.5	0.5	
MATRIX	PQLs	CSO	CSO	HBN
UNITS	UGG	UGG	UGG	UGG
TAL Inorganics				
ALUMINIUM	14.1	10500	9340	230000
ANTIMONY	20	[859]	25.3	30
ARSENIC	30	[3.27]	[6.03]	0.5
BARIUM	1	138	92.7	1000
BERYLLIUM	0.2	[0.981]	LT 0.5	0.1
CADMIUM	2	31	3.73	40
CALCIUM	100	4930 B	1620 B	NSA
CHROMIUM	4	159	145	400
COBALT	3	[9.98]	[6.49]	0.8
COPPER	7	26.6	14.7	2900
IRON	1000	20600	19100	NSA
LEAD	2	[307]	162	200
MAGNESIUM	50	6430	972	NSA
MANGANESE	0.275	765	766	8000
MERCURY	0.1	0.117	LT 0.05	20
NICKEL	3	46.6	11.7	1000
POTASSIUM	37.5	868	710	NSA
SILVER	4	0.919	LT 0.589	200
SODIUM	150	334 B	208 B	NSA
THALLIUM	20	[10.6]	LT 6.62	6
VANADIUM	0.775	36.3	36.6	560
ZINC	30.2	2500	261	16000
Other				
pH	NA	7.2	6.95	NSA

Footnotes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CSO = Chemical soil.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TAL = Target Analyte List.

UGG = Micrograms per gram.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

the levels were less than the soil background criteria and represent concentrations expected to be in native soil. Lead was detected at a concentration greater than the HBN but only slightly elevated above background. This concentration is considered to be indicative of naturally occurring levels. Thallium, one metal detected at a level greater than the HBN and background criteria, is not expected to be a concern because it is relatively immobile in the environment and is not expected to impact surface water, groundwater or the underlying soil. Because of the high concentration of antimony, this metal may be a concern. Metal concentrations that did not exceed the HBNs but were greater than the soil background criteria in one or more of the samples were barium, cadmium, chromium, mercury, nickel and zinc.

23.4 BASELINE RISK ASSESSMENT

Based on the contamination assessment presented in Section 23.3, contaminants of concern have been identified for the surface water and sediment in the settling pond and in soil samples collected directly downslope of the pond. Groundwater samples were not collected at this site. Nine contaminants of concern--antimony, cadmium, chromium, cobalt, copper, lead, manganese, nickel, and zinc--were identified for the surface water of the pond. Four metals--antimony, cadmium, chromium, and lead--were identified as contaminants of concern for the sediment of the pond. One metal--antimony--was identified as a contaminant of concern for soil downslope of the settling pond. The potential impact of these contaminants to human health and the environment is discussed below in Sections 23.4.1 and 23.4.2, respectively.

23.4.1 Human Health Evaluation

Discharge from the settling pond appears to flow in a drainage ditch to the New River located approximately 1,200 feet from the settling pond. Persons boating, fishing, or swimming in the New River could potentially be exposed to surface water/sediment contaminants migrating from SWMU 69. In addition, a drinking water intake is located 6 miles downstream of RAAP. However, due to the significant capacity of the river which would result in substantial dilution upon discharge of contaminants via the drainage ditch to the New River and the infrequent and seasonal exposure that may occur during recreational activities, potential exposure to human receptors via these pathways is considered low. Therefore, these potential exposure pathways are not considered significant.

Although, workers may be exposed to surface water and sediment contamination during dredging and cleaning operations, because these events occur infrequently and workers presumably wear protective equipment (i.e., gloves), these exposure pathways are not considered significant.

Contamination was also detected in surface soil downslope of the settling pond. Potential soil exposure routes typically include incidental ingestion, inhalation, and dermal absorption of soil contamination. Because access to RAAP is strictly controlled, and recreational activities do not occur in the vicinity of SWMU 69, direct contact with the soil and subsequent ingestion and dermal absorption of soil contaminants is not expected to occur on a regular basis. Although workers may presumably contact soil downslope of the settling pond, worker activity in this area is expected to be infrequent. Therefore, the incidental ingestion and dermal absorption of soil contaminants pathways are not considered significant.

Because antimony was detected at an elevated level in surface soil, there is the possibility of contaminated dust to become airborne and for workers in the vicinity of SWMU 69 to be exposed via inhalation of contaminated dust. The areal extent of antimony contamination downslope of the settling pond is unknown. Although the maintenance shop, which is located approximately 200 feet from the settling pond, is currently active, SWMU 69 and 68 are inactive. Exposure to workers would most likely be infrequent and limited to events of high wind erosion. Therefore, unless it is determined that antimony contamination is widespread, the potential exposure to workers is expected to be low.

An evaluation of the potential for toxic effects upon inhalation exposure to antimony indicates that only very limited data are available and potential toxic effects are not well documented. Antimony exposure to levels of 45 to 125 mg/m^3 have been associated with myocardial damage and certain types of pneumonia (USEPA, 1980). Lung tumors have been observed in rats inhaling 4.2 mg/m^3 of antimony trioxide or 17.5 mg/m^3 antimony trisulfide for 1 year (USPHS, 1990). EPA has not determined an inhalation RfD or inhalation unit risk for antimony (USEPA, 1991a), thereby precluding quantification of this pathway.

As discussed in Section 2.5, future land use is considered to be similar to the current land use scenario--i.e., RAAP will continue to remain an active army installation and there are no plans for future residential development of RAAP. Thus, potential future exposure is assumed to be similar to potential current exposure.

23.4.2 Environmental Evaluation

Aquatic life is not present in the settling pond or the drainage ditch leading to the New River; therefore, potential impacts to aquatic life are not considered for the pond and drainage ditch. Although, the settling pond is not fenced in and wildlife may have access to the pond and the surrounding soil, there is a steep dropoff from SWMU 69 to the New River, thereby precluding wildlife access via the river bank. The maintenance area is active, and it is unlikely that wildlife would frequent the area and use the pond as a main drinking water source. Therefore, potential exposure of environmental receptors the surface water/sediment contamination in the settling pond and surface soil contamination downgradient of the settling pond appears to be minimal.

As discussed above, there is the potential for discharge of surface water/sediment contamination to the New River, which could potentially impact aquatic life. Contaminant concentrations detected in pond surface water do exceed the freshwater chronic AWQC for cadmium, chromium, copper, lead, nickel, and zinc (USEPA, 1986). The freshwater chronic AWQC for these metals are 1.1, 210, 12, 3.2, 160, and 110 ug/l, respectively, compared to detected concentrations of 2,540, 25,000, 1,450, 7,900, 120,000, and 61,000 ug/l, respectively. Although these criteria are based on a hardness of 100 mg/l, because the exceedances are so large, adjustment of the criteria based on actual hardness will not alter the exceedances significantly. Although data are insufficient for establishing aquatic life criteria for antimony, the LOEL for chronic effects to freshwater aquatic life is reported as 1,600 ug/l (USEPA, 1986). AWQC are not available for manganese or cobalt.

Due to the capacity of the river, significant dilution would occur upon discharge of contaminants via the drainage ditch to the New River. In addition, because SWMU 68 is inactive, discharge to the New River most likely occurs intermittently and only during periods of heavy rain, thereby further diluting contaminant concentrations. Therefore, due to the intermittent and infrequent discharge to the New River via the drainage ditch, and the significant dilution that would be expected to occur, the impact on aquatic life is expected to be low.

23.4.3 Conclusions of the Human Health and Environmental Evaluation

Although elevated concentrations of several metals were detected in surface water and sediment of the setting pond, it is unlikely that human and environmental receptors would directly contact the surface water and sediment of the pond, except possibly on an infrequent basis. Due to the intermittent and infrequent discharge to the New River via the drainage ditch, and the significant dilution that would be expected to occur, exposure of human and environmental receptors to contamination discharging to the New River is expected to be low.

Although antimony was detected above its HBN and background levels in site soil, it is unlikely that human or environmental receptors would directly contact the soil, except possibly on an infrequent basis. Exposure to workers via inhalation of contaminated dust would most likely be infrequent and limited to events of high wind erosion. Therefore, unless it is determined that antimony contamination is widespread, the potential exposure to workers via this pathway is expected to be low.

23.5 CONCLUSIONS

In summary, antimony, cadmium, chromium and lead were detected in both surface water and sediment samples at levels which exceeded HBN criteria. These analytes are contaminants of concern in the pond sediment and surface water. Additionally, concentrations of cobalt, copper, manganese, nickel and zinc in the surface water sample exceeded the HBN criteria and are also contaminants of concern. Several other metals (i.e., barium, copper, silver and zinc) in the sediment sample were reported at levels less than the HBNs but greater than the soil background criteria.

The results of the chemical analyses of the shallow soil samples demonstrated that several metals (i.e., antimony, arsenic, beryllium, cobalt, lead and thallium) were present at levels which exceeded the HBN criteria. However, antimony is the only contaminant of concern. Arsenic and cobalt are not considered a concern because the reported concentrations were less than the background criteria and are not expected to impact surface water, groundwater or underlying soil. Elevated levels of several other metals, including chromium which was known to be released as waste at this site, were present in the soil at concentrations less than the HBNs but greater than the background criteria. This result may indicate downslope transport of wastes originating from the pond.

In the soil or sediment, the persistence of the metals depends on their leachability and ability to degrade. Many of the contaminants exceeding HBN criteria are readily sorbed to soil constituents, and the downward transport of these constituents to groundwater are expected to be inhibited by their relative immobility in soil and a deep water table. However, leachability data for samples collected at this site are not presently available. The contaminants in the pond, however, may be transported via surface water runoff or sediment movement during overflow events at the pond. The results of sample 69SS1 indicated that contaminants have impacted shallow soil downslope of the pond. Presently, the vertical and horizontal extent of contamination is not known at SWMU 69.

23.6 RECOMMENDED ACTION

SWMU 69 sediment and surface water has been shown to be contaminated with several metals at high concentrations and above HBNs. Surface soil in the area that received overflow from the pond is similarly contaminated with metals. Interim corrective measures are recommended to remove the pond water, pond sediment and the surficial soil known to be adversely impacted. Additional sampling of the surficial soil in order to delineate the impacted area may be necessary prior to corrective action on the soil.

Note This section was revised August 19, 1996 under separate cover.

24.0 VERIFICATION INVESTIGATION OF SWMU 71, FLASH BURN PARTS AREA

24.1 SWMU 71 BACKGROUND AND INVESTIGATION PROGRAM

24.1.1 SWMU History

The inactive Flash Burn Parts Area (SWMU 71) is located in the south-central portion of the Main Manufacturing Area, in the southwest corner of the Sanitary Landfill (NG Area) (SWMU 40) (Figure 24-1). It consists of an open, hard packed, gravel area, about 25 feet by 50 feet in size, where metal process pipes potentially contaminated with propellant were flash burned from about 1962 to 1982. The pipes were then reused or sold for scrap. Reportedly, oil soaked straw was used on occasion to create the burning environment for decontamination.

24.1.2 Previous Investigations

This SWMU was identified in the RCRA Facility Assessment (USEPA, 1987) as having a potential for releasing contaminants into the environment and was included in the RCRA Permit for Corrective Action and Incinerator Operation (USEPA, 1989) as warranting investigation. No site-specific investigations have been conducted at this location prior to this VI.

24.1.3 VI Program

Three surface soil samples were collected within this unit (Figure 24-1) to determine whether surface soils have been impacted through the release of hazardous constituents during flashing operations. Each sample was collected from a depth of 0 to 6 inches below any gravel or surface organic root zone and analyzed for TAL metals, explosives, and TPHs. TPH analysis, though not required by the permit, was recommended due to the use of fuel oil in the flashing operations.

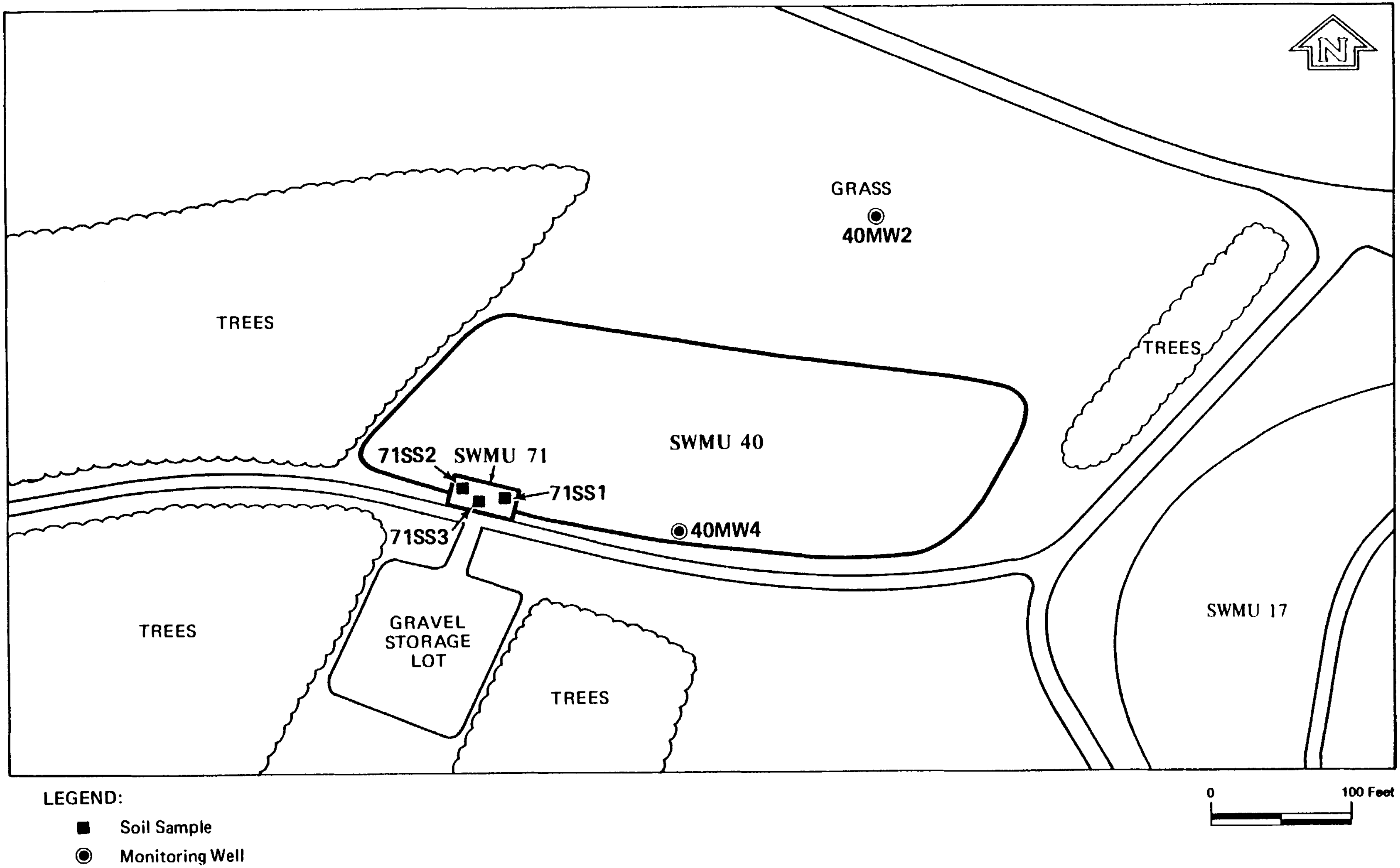


FIGURE 24-1
LOCATION MAP
SWMU 71 – FLASH BURN PARTS AREA
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

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24.2 ENVIRONMENTAL SETTING

24.2.1 Topography

The topography of SWMU 71 is generally level but is steeply sloping immediately north of SWMU 40. The elevation of SWMU 71 is approximately 1,900 feet msl. SWMU 17 is approximately 300 feet east of SWMU 71. There is a gravel storage lot to the south of SWMU 71. The area is accessible by paved roads.

24.2.2 Geology and Soils

No site-specific investigation was performed in this area. However, borings conducted at SWMU 40 indicated that bedrock is only a few feet below ground surface and consists of badly weathered and broken limestone layers. Several feet of SWMU 40 landfill material probably underlies SWMU 71 and overlies the natural ground surface.

24.2.3 Groundwater Conditions

No site-specific hydrogeologic investigation was performed in this area. However, this SWMU is located over karst limestone bedrock with a deep water table, more than 100 feet deep, with an unknown flow direction.

24.2.4 Surface Water Drainage

Based on topography, surface water runoff appears to flow generally northward and discharges into the New River. The New River is approximately 1.2 miles north of SWMU 71. According to RAAP utility maps, no manholes, catch basins, or storm drains exist in the immediate vicinity of SWMU 71.

24.3 CONTAMINATION ASSESSMENT

The VI field program at SWMU 71 included the analyses of three shallow soil samples (71SS1, 71SS2, and 71SS3) collected from the Flash Burn Parts Area (Table 24-1). The samples were obtained from the surface where metals, residual explosives and oil wastes would most likely be present.

Table 24-1

Summary of Analytical Data For Soil Samples Collected At SWMU 71

Radford Army Ammunition Plant, Virginia

SITE ID		71SS1	71SS2	71SS3	
FIELD ID		RVFS*67	RVFS*68	RVFS*69	
S. DATE		05-feb-92	05-feb-92	05-feb-92	
DEPTH (ft)		0.5	0.5	0.5	
MATRIX	PQLs	CSO	CSO	CSO	HBN
UNITS	UGG	UGG	UGG	UGG	UGG
TAL Inorganics					
ALUMINIUM	14.1	15200	4040	4880	230000
ARSENIC	30	[13]	[27]	[190]	0.5
BARIUM	1	166	155	161	1000
BERYLLIUM	0.2	[2.2]	[1.63]	[1.73]	0.1
CALCIUM	100	9130	3130 B	10100	NSA
CHROMIUM	4	40.8	19.1	14	400
COBALT	3	[13.1]	[5.48]	[2.29]	0.8
COPPER	7	53.5	40.9	46.5	2900
IRON	1000	27600	9720	32700	NSA
LEAD	2	97.2	76.6	147	200
MAGNESIUM	50	7610	1860	1240	NSA
MANGANESE	0.275	463	127	44.7	8000
MERCURY	0.1	0.227	0.372	2.7	20
NICKEL	3	18.3	11.1	7.11	1000
POTASSIUM	37.5	1620	640	1560	NSA
SELENIUM	40	LT 0.25	0.449	6.69	200
SILVER	4	1.2	0.97	1.76	200
SODIUM	150	457 B	289 B	377 B	NSA
THALLIUM	20	[25.2]	[13.9]	[32.7]	6
VANADIUM	0.775	50.9	17	22.7	560
ZINC	30.2	160	80.5	43.5	16000
Explosives	NA	None Detected	None Detected	None Detected	NSA
Other					
TOTAL PETROLEUM HYDROCARBONS	NA	61.2	55.2	79.5	NSA

Footnotes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CSO = Chemical soil.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TAL = Target Analyte List.

UGG = Micrograms per gram.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

Soil samples collected from SWMU 71 indicate that the concentrations of eight metals--arsenic, barium, beryllium, copper, mercury, selenium, sodium and thallium--were higher than background comparison criteria for uplands soil (Table 4-13). These anomalously high concentrations were present in each of the three samples for all of the metals except for selenium and sodium, which exceeded criterion in only two samples. Each concentration exceeded their PQL, and arsenic, beryllium and thallium concentrations exceeded HBNs. Beryllium, which barely exceeded criteria and may be at a natural concentration, has a low solubility and is expected to be adsorbed onto clay mineral surfaces at a low pH and to be complexed into insoluble compounds at high pH. In most natural environments, beryllium is likely to be sorbed or precipitated, rather than dissolved and is not expected to impact surface water, groundwater or the underlying soil. Thallium, which was also detected above the HBN and background criteria, is not expected to be a concern because it is relatively immobile in the environment and is not expected to impact surface water, groundwater or the underlying soil. Arsenic, due to the HBN exceedance, may be a concern in SWMU soils. Concentrations of barium, copper, mercury, selenium, and sodium were elevated above the background criteria but generally were one or more orders of magnitude less than HBN criteria and are not considered a concern. TPH concentrations of 61.2, 55.2, and 79.5 ug/g were reported for samples 71SS1, 71SS2 and 71SS3, respectively, confirming the reported use of waste oil or fuel to flash the material. Explosives were not detected in any of the samples collected from the site.

24.4 BASELINE RISK ASSESSMENT

Based on the contamination assessment presented in Section 24.3, one contaminant of concern--arsenic--has been identified in SWMU 71 soil. In addition, TPH was detected and may indicate the presence of waste oil or fuel constituents in site soil. Samples were not collected from other environmental media. The potential impact of arsenic in site soil to human health and the environment is discussed below in Sections 24.4.1 and 24.4.2, respectively.

24.4.1 Human Health Evaluation

SWMU 71 is an open gravel area, about 25 feet by 50 feet in size. The soil samples were collected from a depth of 0 to 6 inches below the gravel surface. Although potential soil exposure routes typically include incidental ingestion, inhalation, and dermal absorption of soil contamination, because the area is covered by gravel and the soil samples were collected from beneath the gravel cover, it is highly unlikely that receptors would contact this soil or that contaminants may become airborne. In addition, SWMU 71 is an inactive area and access to RAAP is strictly controlled, thereby further precluding contact by receptors. Therefore, the soil exposure pathways are not considered operable at this site. Because future land use is assumed to be similar to the current land use scenario, the soil exposure pathways are also not considered operable for the future land use scenario.

24.4.2 Environmental Evaluation

Because this SWMU is located near an active burning area and highly used road, it is unlikely that environmental receptors would often approach this site and contact this soil. Any contact would be expected to be minimal and infrequent. Therefore, potential exposure to environmental receptors is expected to be insignificant.

24.4.3 Conclusions of the Human Health and Environmental Evaluation

Arsenic was determined to be greater than its HBN and background levels, and TPH was detected, potentially indicating the presence of waste oil or fuel constituents. However, due to the unlikelihood of human or environmental receptors contacting the soil or to the unlikelihood of the hard-packed soil to become airborne, the contamination detected in SWMU 71 shallow soil does not appear to present a current or potential future human health risk or environmental threat.

24.5 CONCLUSIONS

Concentrations of eight metals exceeded background comparison criteria in three soil samples collected at the site. Elevated levels of arsenic, barium, beryllium, copper, mercury, selenium, sodium, and thallium indicate an impact on the surface soil from past site operations. Waste oil or fuel constituents may be present at the site as indicated by the results of the TPH analyses. Explosives were not detected in the soil samples and are not considered a concern. Arsenic was identified in the qualitative risk assessment as the only contaminant of concern; however, conditions are such that an imminent risk due to arsenic exposure cannot be identified.

24.6 RECOMMENDED ACTION

An additional VI sampling program is recommended for subsurface soils for the purpose of defining the vertical extent of metals contamination. The several metals detected at anomalously high concentrations in the surface soil indicate that this SWMU may require remediation. An RFI is not recommended since the areal extent and level of contamination is presently known. However, confirmation of the previously detected levels and definition of the vertical extent of potential contamination is necessary before a decision to remediate the site can be made.

25.0 VERIFICATION INVESTIGATION OF SWMU 74, INERT LANDFILL NO. 3

25.1 SWMU 74 BACKGROUND AND INVESTIGATION PROGRAM

25.1.1 SWMU History

The Inert Landfill No. 3 (SWMU 74) is located in the central portion of the Horseshoe Area, approximately 800 feet northeast of the Active Sanitary Landfill (SWMU 28) (Figure 25-1). This unlined unit was permitted by the Virginia Department of Health in May 1984 (Permit No. 433) as "Debris Landfill No. 2" to receive construction waste, demolition waste, wood, tree trimmings, stumps, and inert waste materials. The landfill is being area-filled in two lifts, with wastes pushed off the edge of existing fill from west to east. The landfill is currently about half filled. The estimated remaining life of the landfill is 2 to 3 years.

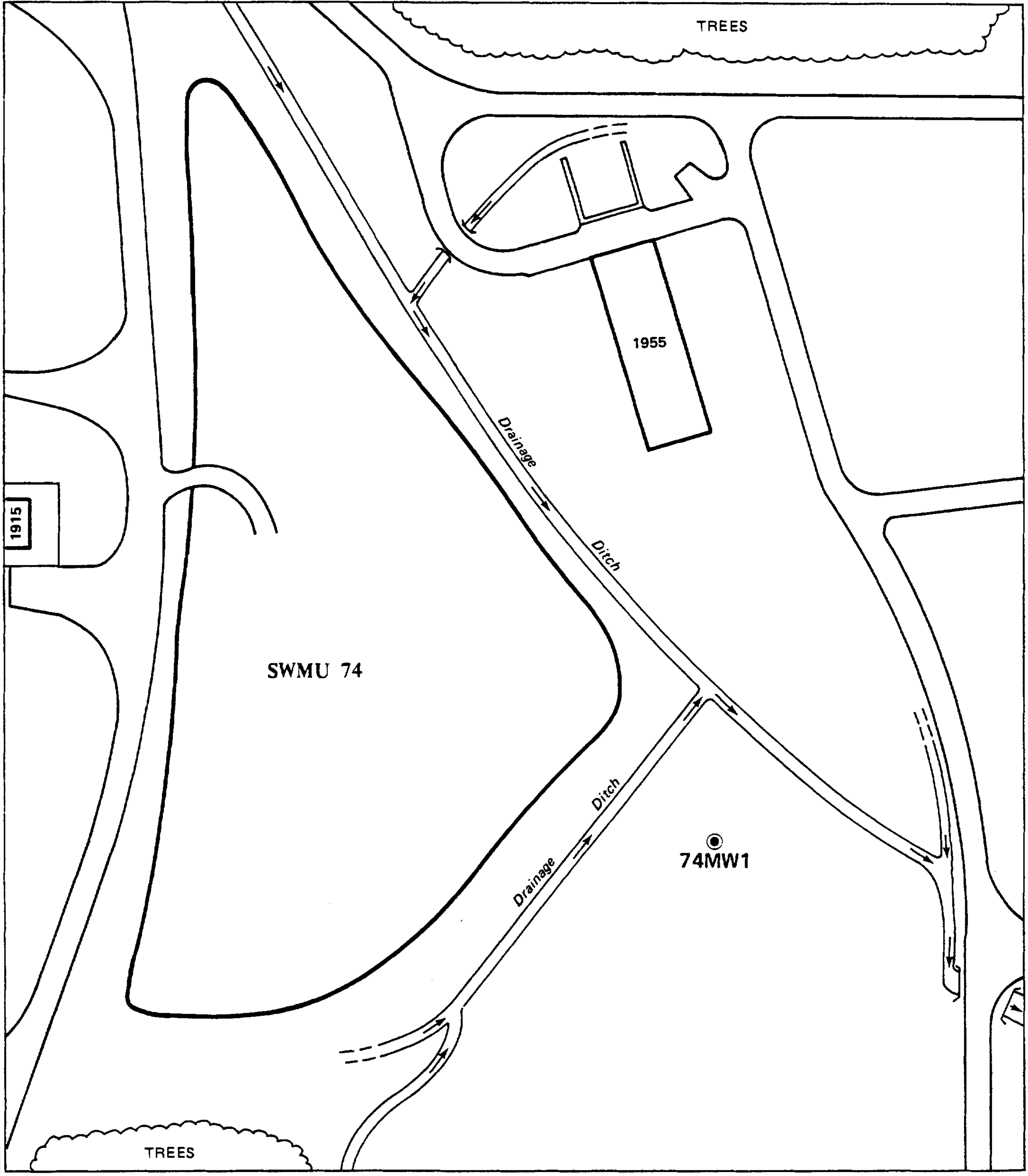
In addition to the above specific inert wastes, the following materials have been observed as being disposed of in the landfill--cardboard, fluorescent light bulbs, wet coal or asphalt, and laboratory chemical and reagent 5-gallon cans (empty).

25.1.2 Previous Investigations

This SWMU was identified in the RCRA Facility Assessment (USEPA, 1987) as having a potential for releasing contaminants into the environment and was included in the RCRA Permit for Corrective Action and Incinerator Operation (USEPA, 1989) as warranting investigation. No site-specific investigations have been conducted at this location prior to this VI.

25.1.3 VI Program

Prior to this investigation, there were no monitoring wells located in the immediate vicinity of this unit. Because this landfill is operated as an inert landfill under an existing Virginia Solid Waste Permit, it is unlikely that hazardous constituents are associated with this SWMU. However, to evaluate whether groundwater quality has been impacted by



LEGEND:

◉ Monitoring Well

FIGURE 25-1
LOCATION MAP
SWMU 74 – INERT LANDFILL No. 3
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

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waste disposed of in this unit, one well (74MW1) was installed downgradient of the landfill to a depth of 50.4 feet.

Following well installation and development, the groundwater level in the well was recorded and a sample was collected and analyzed for metals, VOCs, SVOCs, TOC, TOX and pH.

25.2 ENVIRONMENTAL SETTING

25.2.1 Topography

The topography in this area is moderately steep sloping towards the east. The maximum elevation is approximately 1,780 feet msl in the southwest portion of SWMU 74 and the minimum elevation is approximately 1,732 feet msl in the eastern portion of the site. A drainage ditch borders the southeastern and northeastern boundary of SWMU 74, and several buildings and paved roads are present in the vicinity.

25.2.2 Geology and Soils

The geology of the SWMU 74 area has been explored for this VI through the drilling of one soil and rock boring (74MW1) topographically downgradient of the landfill as shown in Figure 25-1. The subsurface conditions encountered during drilling consisted of fine- to coarse-grained, medium to very dense, alluvial flood plain deposits that generally became coarser grained with depth. Soils encountered graded from a non-plastic sandy silt (ML) to a well-graded sand (SW). Approximately 5 feet of silty gravel (GM) were encountered overlying weathered limestone bedrock. Limestone bedrock was encountered during drilling at approximately 25 feet below ground level. The limestone encountered during drilling was weathered and fractured with frequent zones of pitting and calcite healed fractures. Geologic conditions encountered in SWMU 74 are similar to other flood plain areas in the Horseshoe Area of RAAP.

25.2.3 Groundwater Conditions

A relatively shallow, unconfined groundwater table was encountered during drilling within the fractured limestone bedrock at a depth of approximately 38 feet. Subsequent stabilized groundwater levels were measured at approximately 25 feet (at the overburden soil bedrock contact). The direction of groundwater flow is eastward to the New River (Insert 2).

25.2.4 Surface Water Drainage

Based on topography, the surface water runoff appears to flow east towards the drainage ditches that border SWMU 74. The drainage ditches flow east/southeast towards the New River, approximately 1,800 feet from SWMU 74. According to the RAAP utility maps, there are no manholes, catch basins, or storm drains in the immediate vicinity of SWMU 74.

25.3 CONTAMINANT ASSESSMENT

The results of the chemical analyses (Table 25-1) of sample 74MW1 do not indicate the presence of contamination downgradient of Inert Landfill No. 3. VOCs and SVOCs were not detected in this sample. Additionally, the six metals detected in sample 74MW1 are common constituents of groundwater and were reported at levels expected to be present in groundwater flowing through limestone. All metals were detected at concentrations below the HBN criteria. TOC and TOX were reported at moderately low concentrations.

25.4 CONCLUSIONS

The results of the groundwater sample for SWMU 74 indicate that VOCs and SVOCs were not detected in the groundwater. Metals concentrations were below HBN criteria, and TOC and TOX were reported at moderately low concentrations.

Based on the above results, groundwater quality downgradient of Inert Landfill No. 3 apparently has not been impacted by waste disposed of in this unit.

25.5 RECOMMENDED ACTION

Since VOCs and SVOCs were not detected in the groundwater downgradient of SWMU 74, and metals concentrations were below HBN criteria, no further action is recommended at this site.

Table 25-1

Summary of Analytical Data For Groundwater Samples Collected At SWMU 74

Radford Army Ammunition Plant, Virginia

SITE ID		74MW1	
FIELD ID		RDWB*9	
S. DATE		01-nov-91	
DEPTH (ft)		43.0	
MATRIX	PQLs	CGW	HBN
UNITS	UGL	UGL	UGL
TAL Inorganics			
BARIUM	20	91.5	1000
CALCIUM	500	57700	NSA
MAGNESIUM	500	29100	NSA
MANGANESE	2.75	10.2	3500
POTASSIUM	375	1760	NSA
SODIUM	500	3480	NSA
Volatiles	NA	None Detected	NSA
Semivolatiles	NA	None Detected	NSA
Other			
TOTAL ORGANIC CARBON	1000	5900	NSA
TOTAL ORGANIC HALOGENS	1	10.4	NSA
pH	NA	7.37	NSA

Footnotes:

CGW = Chemical groundwater.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TAL = Target Analyte List.

UGL = Micrograms per liter.

26.0 VERIFICATION INVESTIGATION OF SWMU F, DRUM STORAGE AREA (NEAR BUILDING NO. 9387-2)

26.1 SWMU F BACKGROUND AND INVESTIGATION PROGRAM

26.1.1 SWMU History

The Drum Storage Area (SWMU F) is located 80 feet southeast of Warehouse No. 2 (9387-2), approximately 500 feet from the New River (Figure 26-1). The area is a gravel lot, about 50 feet by 50 feet in size. Empty drums from throughout RAAP were stacked on their sides in SWMU F prior to being sold for recycle. The drums were reportedly rinsed out before being stored. Storage of drums on this lot was discontinued in 1991 when a second lot was constructed 150 feet to the east, west of Building 4934-1. The new lot is approximately 60 feet by 60 feet.

26.1.2 Previous Investigations

This SWMU was identified in the RCRA Facility Assessment (USEPA, 1987) as having a potential for releasing contaminants into the environment and was included in the RCRA Permit for Corrective Action and Incinerator Operation (USEPA, 1989) as warranting investigation. No site-specific investigations have been conducted at this location prior to this VI.

26.1.3 VI Program

Although only empty, rinsed drums have reportedly been stored in this unit, visible staining of the gravel surface suggests the possibility that hazardous constituents have been released to surface soils as a result of the spillage of drum residues. To address this concern, eight surface soil samples (FSS1, FSS2, FSS3, FSS4, FSS5, FSS6, FSS7 and FSS8), as shown in Figure 26-1, were collected for chemical analysis. Samples FSS1 through FSS4 were collected at the eastern pad, which had drums stored at it during sampling. Samples FSS5 through FSS8 were collected at the western pad, which had no drums being stored at the time of sampling. Based on visible staining, eight specific sample locations were selected during sampling activities. Within each stained area, the gravel was cleared to expose

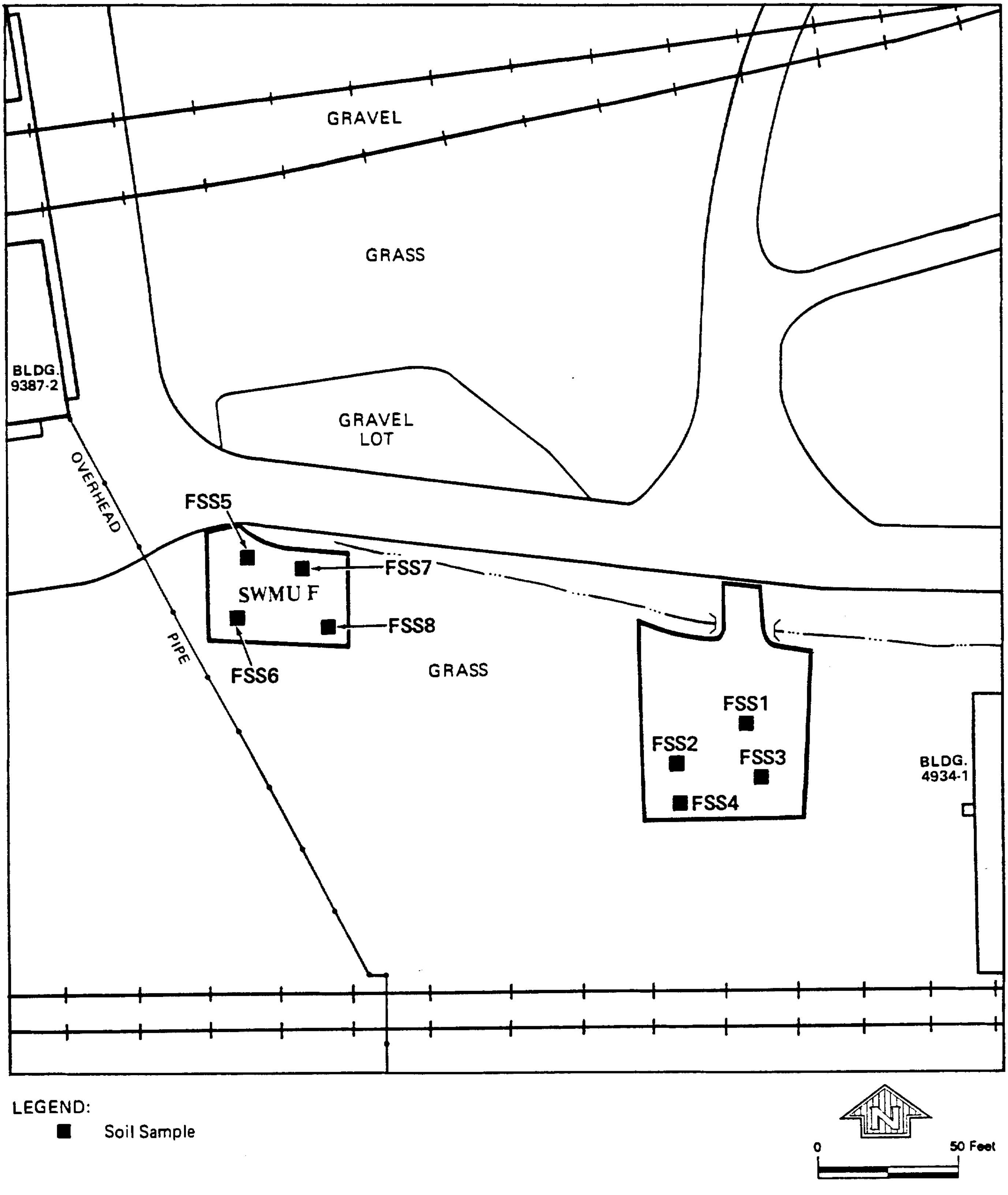

FIGURE 26-1
LOCATION MAP
SWMU F – DRUM STORAGE AREA
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

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underlying soils. Soil samples were collected at a depth of 0 to 6 inches. Each sample was analyzed for VOCs and SVOCs.

26.2 ENVIRONMENTAL SETTING

26.2.1 Topography

The topography in the area of SWMU F is generally level, sloping gently towards the north. The elevation in the two storage areas is approximately 1,700 to 1,710 feet msl. The old drum storage area is located southeast of Warehouse No. 2 (9387-2) and approximately 300 feet south of the New River. The new drum storage area is located to the west of Building 4934-1 and approximately 300 feet south of the New River.

26.2.2 Geology and Soils

No site-specific subsurface investigations have been conducted in this area. Based on subsurface conditions present in similar areas, approximately 20 to 30 feet of unconsolidated soil (clay, silt, and sand with gravel seams) should overlie fractured limestone or dolostone of the Elbrook Formation.

26.2.3 Groundwater Conditions

No site-specific hydrogeologic studies have been conducted in this area. Based on subsurface conditions present in similar areas, groundwater probably flows northward toward the New River within fractured bedrock. As seen on Insert 2, the groundwater level was estimated at an elevation of 1,690 feet msl, 10 to 20 feet below the ground surface.

26.2.4 Surface Water Drainage

Based on topography, the surface water runoff in the SWMU F vicinity appears to flow generally to the north with discharge into the New River approximately 300 feet from the site. Runoff within the site areas flows northward into a ditch along the road; flow then goes eastward into a culvert that drains northward, north of Building 4934-10. A series of culverts and drainage ditches eventually channel the water to the New River.

26.3 CONTAMINATION ASSESSMENT

The results of the chemical analyses of the soil samples collected from below the new gravel lot and former drum storage area are presented in Table 26-1. Samples FSS1 through FSS4, which were collected below the new gravel lot, contained low concentrations of several SVOC TICs. Three SVOC TICs were identified in samples FSS1 and FSS3 and concentrations of unknown SVOCs were reported for all samples. However, no primary target VOC or SVOCs were detected in any sample. The concentrations of SVOC TICs are estimated and represent an order of magnitude estimate only. The identified SVOC TICs are a natural fatty acid (hexadecanoic acid) and petroleum hydrocarbons that may be related to minor oil, lubricant or solvent spills. Low estimated concentrations of these SVOC TICs are not considered a concern at this site.

Trace concentrations of a total of three VOCs were detected in four soil samples (i.e., FSS5 through FSS8) collected at the former drum storage area. Two of the VOCs, acetone and tetrachloroethene (TCLEE), were limited to FSS7 only and were detected at less than their PQLs. Trichloroflorомethane was detected in all samples collected at the west unused lot. Detected concentrations were about twice the PQL, but were several orders of magnitude less than the HBN criteria and are not considered a concern.

26.4 CONCLUSIONS

The VI conducted at the Drum Storage Area (SWMU F) consisted of the sampling and chemical analyses of four soil samples collected below the new gravel lot and four soil samples collected at the former drum storage area. Low estimated concentrations of three known and several unknown SVOC TICs were detected in the samples from the new gravel lot. The identified SVOC TICs indicate that minor oil, lubricant or solvent spills had possibly occurred; however, the low estimated concentrations are not considered a concern at the new gravel lot. Trace concentrations of a total of three VOCs were detected in the soil samples collected at the former drum storage area. All of the detected VOC concentrations in the former drum storage area were many orders of magnitude below the HBN criteria and are not considered a concern.

Table 26–1
Summary of Analytical Data For Soil Samples Collected At SWMU F
Radford Army Ammunition Plant, Virginia

SITE ID		FSS1	FSS2	FSS3	FSS4	FSS5	FSS6
FIELD ID		RVFS*71	RVFS*72	RVFS*73	RVFS*74	RVFS*94	RVFS*95
S. DATE		05–feb–92	05–feb–92	05–feb–92	05–feb–92	18–feb–92	18–feb–92
DEPTH (ft)		0.5	0.5	0.5	0.5	0.5	0.5
MATRIX	PQLs	CSO	CSO	CSO	CSO	CSO	CSO
UNITS	UGG	UGG	UGG	UGG	UGG	UGG	UGG
Volatiles							
ACETONE	0.1	LT 0.017	LT 0.017	LT 0.017	LT 0.017	LT 0.017	LT 0.017
TETRACHLOROETHYLENE	0.005	LT 0.001	LT 0.001	LT 0.001	LT 0.001	LT 0.001	LT 0.001
TRICHLOROFLUOROMETHANE	0.005	LT 0.006	LT 0.006	LT 0.006	LT 0.006	0.012	0.012
Semivolatiles	NA	None Detected	None Detected	None Detected	None Detected	None Detected	None Detected
Semivolatile TICs							
EICOSANE	NA	0.344 S	ND	ND	ND	ND	ND
HEXADECANOIC ACID	NA	ND	ND	1.05 S	ND	ND	ND
NONADECANE	NA	0.344 S	ND	ND	ND	ND	ND
TOTAL UNKNOWN TICs	NA	(3)2301	(7)356	(2)582	(22)74.3	ND	(1)3480

Table 26-1 (Cont'd)

SITE ID		FSS8	
FIELD ID		RVFS*97	
S. DATE		18-feb-92	
DEPTH (ft)		0.5	
MATRIX	PQLs	CSO	HBN
UNITS	UGG	UGG	UGG
Volatiles			
ACETONE	0.1	LT 0.017	1000
TETRACHLOROETHYLENE	0.005	LT 0.001	100
TRICHLOROFLUOROMETHANE	0.005	0.009	1000
Semivolatiles	NA	None Detected	NSA
Semivolatile TICs			
EICOSANE	NA	ND	NSA
HEXADECANOIC ACID	NA	ND	NSA
NONADECANE	NA	ND	NSA
TOTAL UNKNOWN TICs	NA	(2)1181	NSA

Footnotes:

CSO = Chemical soil.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

ND = Analyte was not detected.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

S = Results are based on an internal standard; flag is used for TICs detected in library scans.

TICs = Tentatively identified compounds that were detected in the GC/MS library scans.

UGG = Micrograms per gram.

( ) = Parenthesis are used to indicate the number of unknown TICs that were detected in either the volatile or semivolatile GC/MS library scans. The number beside the parenthesis is the total concentration of all TICs detected in each respective scan.

26.5 RECOMMENDED ACTION

Based on the results of the field investigation, neither the former nor current drum storage area is considered to be a concern and no further investigations are recommended for these areas.

27.0 VERIFICATION INVESTIGATION OF SWMU P, SPENT BATTERY STORAGE AREA (SCRAP METAL SALVAGE YARD)

27.1 SWMU P BACKGROUND AND INVESTIGATION PROGRAM

27.1.1 SWMU History

As indicated in Figure 27-1, the Spent Battery Storage Area (SWMU P) is located along the New River, 600 feet west of the Biological Treatment Plant (SWMU 10). The entire storage area, an open lot several acres in size, is used for the storage of shredded scrap metal and decommissioned tanks. Associated with the scrap metal yard is the Spent Battery Storage Area, which is approximately 50 feet wide and 200 feet long. An estimated 20 to 30 spent batteries are generated at RAAP each month. Battery electrolyte is drained and disposed of in the RAAP acid sewer system. The cleaned batteries are accumulated in this storage area prior to shipment off post. Spent batteries are sold when 40,000 pounds have been accumulated, approximately once every 1 to 1.5 years (Pieper, 1989).

27.1.2 Previous Investigations

This SWMU was identified in the RCRA Facility Assessment (USEPA, 1987) as having a potential for releasing contaminants into the environment and was included in the RCRA Permit for Corrective Action and Incineration Operation (USEPA, 1989) as warranting investigation. No site-specific investigations have been conducted at this location prior to this VI.

27.1.3 VI Program

To evaluate whether soils at SWMU P have been impacted from the possible spillage of spent battery electrolyte, ten soil samples were collected within the fenced area. At each of five locations (Figure 27-1), the gravel was cleared to expose underlying soils. Surface soil samples were collected using a hand shovel at a depth of 0 to 6 inches. A second sample from each location was collected from a depth of 4 to 5 feet using a hand auger. Results from the deeper samples were used to evaluate the potential for vertical migration of contaminants through the underlying soils. Each sample was analyzed for TAL metals and pH.

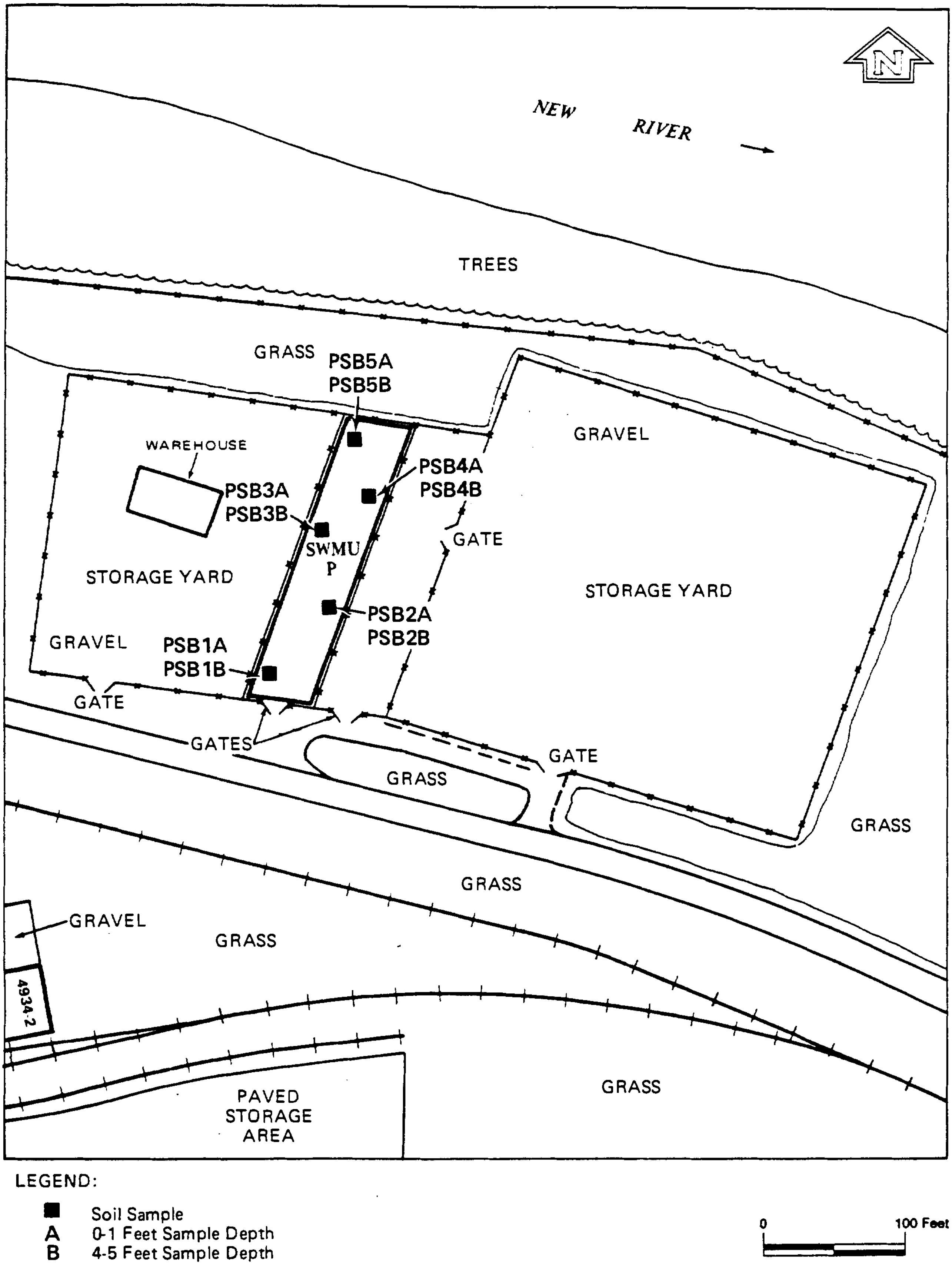

FIGURE 27-1
LOCATION MAP
SWMU P – SPENT BATTERY STORAGE AREA
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

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27.2 ENVIRONMENTAL SETTING

27.2.1 Topography

The topography in the area of SWMU P is generally level, sloping generally towards the north. The elevation is approximately 1,700 feet msl at the northeastern corner of SWMU P and approaches 1,710 feet msl along the southern border. There is a warehouse in the storage yard east of SWMU P, a paved road bordering the south of SWMU P, and railroad tracks and a paved storage area further south of the site.

27.2.2 Geology and Soils

No site-specific subsurface investigations have been conducted in this area. SWMU P is located just west of SWMU 10 along the New River, and should have similar subsurface conditions (Section 7.2.2).

27.2.3 Groundwater Conditions

No site-specific hydrogeologic studies have been conducted in this area. SWMU P is located just west of SWMU 10 along the New River, and should have similar groundwater conditions (Section 7.2.3). Groundwater has been interpreted to be at an elevation of less than 1,690 feet msl with flow northward to the New River (Insert 2).

27.2.4 Surface Water Drainage

Based on topography, the surface water runoff at SWMU P appears to flow north and discharges into the New River which is approximately 200 feet from the storage area. The New River flows east. According to RAAP utility maps, there do not appear to be any manholes, catch basins, or storm drains located in the immediate vicinity of SWMU P.

27.3 CONTAMINATION ASSESSMENT

Soil samples collected at depths of 1 foot and 5 feet showed three metals detected at concentrations greater than the HBN criteria. However, the metals (arsenic, beryllium, and cobalt) are not considered a concern because the levels were less than or only slightly greater than background criteria. Results of the chemical analyses of the soil and sediment samples are presented in Table 27-1.

The results of the chemical analyses indicated that concentrations of arsenic and cobalt exceeded the HBN criteria in all soil samples collected at the battery storage area. Beryllium was detected at concentrations greater than the HBN criterion in six samples but slightly exceeded the background criterion in one sample only. These metals are not expected to be a concern because the levels were less than or only slightly greater than the soil background criteria and represent concentrations expected to be in native soil. Beryllium, the only element elevated above the HBN (but less than 10 percent above) and background criteria, has a low solubility and is expected to be adsorbed onto clay mineral surfaces at a low pH and to be complexed into insoluble compounds at high pH. In most natural environments, beryllium is likely to be sorbed or precipitated, rather than dissolved and is not expected to impact surface water, groundwater or underlying soil. Concentrations of antimony, barium, calcium, chromium, copper, magnesium, nickel and vanadium were elevated in one or more samples but are not a concern because the levels do not exceed HBN criteria. The surface sample collected at PSB2 was the most impacted soil sample with four metals--antimony, calcium, copper, and magnesium--exceeding background concentrations. None of the concentrations exceeded HBNs. However, no significant pattern is apparent in comparing the shallow samples with the deeper samples. The results of the pH analyses indicated that the soil samples were nearly pH-neutral or slightly basic. The deeper sample at each location had lower pH than the shallow sample, contrary to what would be expected if battery acid impacted the soil.

27.4 CONCLUSIONS

The VI conducted at the Spent Battery Storage Area (SWMU P) consisted of the collection and analysis of soil samples collected at depths of 1 foot and 5 feet from five different locations. Although three metals concentrations (arsenic, cobalt, and beryllium) exceeded the HBN criteria in the soil samples, the levels were less than or only slightly greater than the soil background criteria, indicating that concentrations represent what is

Table 27-1
Summary of Analytical Data For Soil Samples Collected From SWMU P
Radford Army Ammunition Plant, Virginia

SITE ID		PSB1	PSB1	PSB2	PSB2	PSB2	PSB3	PSB3	
FIELD ID		RVFS*76	RVFS*77	RVFS*78	RVFS*105	RVFS*79	RVFS*80	RVFS*81	
S. DATE		05-mar-92	05-mar-92	05-mar-92	05-mar-92	05-mar-92	05-mar-92	05-mar-92	
DEPTH (ft)		0.5	4.2	0.5	4.3	4.3	0.5	4.3	
MATRIX	PQLs	CSO	CSO	CSO	CSO	CSO	CSO	CSO	HBN
UNITS	UGG	UGG	UGG	UGG	UGG	UGG	UGG	UGG	UGG
TAL Inorganics									
ALUMINIUM	14.1	12500	16600	3620	15300	15800	11100	18200	230000
ANTIMONY	20	LT 7.14	LT 7.14	10.5	LT 7.14	LT 7.14	LT 7.14	LT 7.14	30
ARSENIC	30	[3.37]	[1.51]	[2]	[1.5]	[1.17]	[1.75]	[1.34]	0.5
BARIUM	1	138	113	73.1	104	126	132	187	1000
BERYLLIUM	0.2	[0.607]	LT 0.5	LT 0.5	[0.745]	[0.732]	[0.779]	[0.923]	0.1
CALCIUM	100	3350 B	1330 B	150000	1540 B	2740 B	2080 B	2300 B	NSA
CHROMIUM	4	59.6	28.3	7.63	27.1	25.6	22.3	33.5	400
COBALT	3	[12.6]	[13.5]	[2.65]	[12.2]	[11.6]	[10.5]	[11.8]	0.8
COPPER	7	71.3	15.1	347	65.3	125	15.7	34.9	2900
IRON	1000	24900	27500	6880	25700	24400	19600	24700	NSA
LEAD	2	37.6	LT 10.5	105	23.5	21.9	29.1	49.2	200
MAGNESIUM	50	4110	4860	83000	4110	4720	3210	4770	NSA
MANGANESE	0.275	609	493	130	457	447	625	430	8000
NICKEL	3	33.4	18.4	9.01	17.9	16.9	13	20.3	1000
POTASSIUM	37.5	1400	1920	932	1810	1880	1260	1890	NSA
SILVER	4	LT 0.589	0.68	1.79	0.81	0.753	LT 0.589	LT 0.589	200
SODIUM	150	206 B	185 B	281 B	163 B	200 B	179 B	198 B	NSA
VANADIUM	0.775	40.3	49.8	12.1	49.6	46.4	31.3	44	560
ZINC	30.2	155	73.6	115	81.4	89.1	128	84.9	16000
Other									
pH	NA	7.66	6.9	8.68	7.56	7.6	7.82	6.89	NSA

Table 27-1 (Cont'd)

SITE ID		PSB4	PSB4	PSB5	PSB5	
FIELD ID		RVFS*82	RVFS*83	RVFS*84	RVFS*85	
S. DATE		05-mar-92	05-mar-92	05-mar-92	05-mar-92	
DEPTH (ft)		0.5	4.7	0.5	4.3	
MATRIX	PQLs	CSO	CSO	CSO	CSO	HBN
UNITS	UGG	UGG	UGG	UGG	UGG	UGG
TAL Inorganics						
ALUMINIUM	14.1	10400	6350	13200	5580	230000
ANTIMONY	20	LT 7.14	LT 7.14	LT 7.14	LT 7.14	30
ARSENIC	30	[0.923]	[0.71]	[2.44]	[0.619]	0.5
BARIUM	1	257	176	189	145	1000
BERYLLIUM	0.2	LT 0.5	LT 0.5	[0.691]	LT 0.5	0.1
CALCIUM	100	1510 B	815 B	5000 B	1120 B	NSA
CHROMIUM	4	22.7	12.7	27.7	12.6	400
COBALT	3	[10.1]	[5.8]	[11.4]	[5.76]	0.8
COPPER	7	25.1	6.65	76.2	10.3	2900
IRON	1000	17200	11600	23400	10400	NSA
LEAD	2	43.7	LT 10.5	150	LT 10.5	200
MAGNESIUM	50	3260	2000	5670	1940	NSA
MANGANESE	0.275	582	253	497	308	8000
NICKEL	3	15.9	9.09	17.2	8.91	1000
POTASSIUM	37.5	1220	996	1740	626	NSA
SILVER	4	LT 0.589	LT 0.589	0.692	LT 0.589	200
SODIUM	150	261 B	218 B	222 B	188 B	NSA
VANADIUM	0.775	27.5	17.3	41.4	15.2	560
ZINC	30.2	121	51.3	159	53.4	16000
Other						
pH	NA	7.46	7.27	7.79	7.63	NSA

Footnotes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CSO = Chemical soil.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NA = Not available; PQLs are not available for TICs detected in the library scans.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TAL = Target Analyte List.

UGG = Micrograms per gram.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

expected to be in native soil. The analytical results indicate that the battery storage area is not significantly impacted and is not considered a concern.

27.5 RECOMMENDED ACTION

Based on the analytical results of the field investigation at SWMU P, no further action is recommended.

28.0 VERIFICATION INVESTIGATION OF FORMER LEAD FURNACE AREA

28.1 FORMER LEAD FURNACE AREA BACKGROUND AND INVESTIGATION PROGRAM

28.1.1 SWMU History

According to available information and maps, a lead furnace was in operation during World War II in the southeastern portion of SWMU 17A (the Burn Pile), which is in the south-central portion of the Main Manufacturing Area. Typically, a lead furnace would function as a lead recovery operation in which lead recovered during routine operations at RAAP would be melted and cast into ingots for salvage. Based on the occurrence of lead slag, lead was probably off-loaded on the rim of the depression (see Figure 28-1) with the lead smelter at the bottom of the slope. Operations would have likely included a series of racks in which lead would be melted with an overhead heater. Molten lead would then be retained in a tank and drained into molds. It is not known precisely how long the Lead Furnace was in operation, but available maps of RAAP, dated 1968 to 1988, show the location of the Lead Furnace. The SWMU location has apparently been used for various activities since the Lead Furnace operations were discontinued. It is included in the RCRA Permit as a VI site for the most recent use as a waste oil storage and transfer location area (SWMU 76).

28.1.2 Previous Investigations

No investigation of the Former Lead Furnace has been performed prior to this VI. However, UST removal sampling at SWMU 76 was performed. The USTs at SWMU 76 were being removed in May 1991 when an oil spill occurred, necessitating the collection of soil samples prior to site remediation. In addition to total petroleum hydrocarbon (TPH) testing of site soils associated with UST removal, two samples were analyzed for total lead, TCLP lead, TCLP chromium and TCLP antimony. Total lead was reported as 3,200 and 63,000 mg/kg, TCLP lead as 2,300 and 2,900 mg/L, TCLP chromium as <0.05 mg/L in both

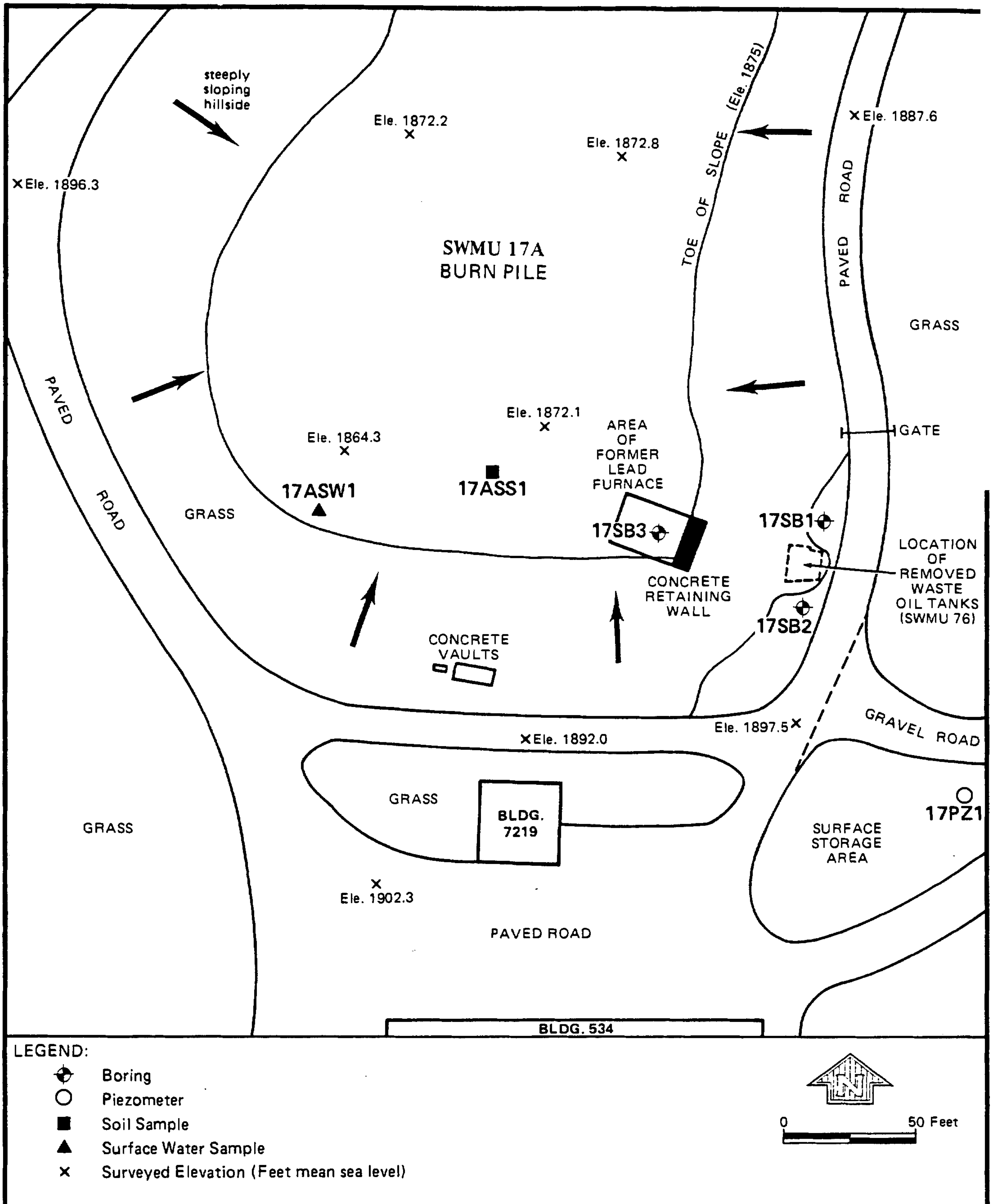

FIGURE 28-1
LOCATION MAP
FORMER LEAD FURNACE AREA
RADFORD ARMY AMMUNITION PLANT, VIRGINIA

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samples and TCLP antimony as 0.5 mg/L in both samples. TPH concentrations in four samples ranged up to 1,540 mg/kg prior to clean-up and up to 60 mg/kg after clean-up (Hercules, 1991).

28.1.3 VI Program

This SWMU was not identified in the RCRA Facility Assessment and was not included in the RCRA Permit but was added to the VI by USATHAMA in response to conditions uncovered when the waste oil tanks at SWMU 76 were removed in 1991. Solid lead slag was observed in the soil around and below the tanks, and soil samples had high lead concentrations. In response to these discoveries, USATHAMA added to the VI an exploratory program consisting of three borings (17SB1, 17SB2, and 17SB3). Borings were to be drilled to a depth of 10 feet or refusal with the collection of two soil samples from each boring. The soil samples were analyzed for TAL metals (total) and TCLP metals (leachate). Figure 28-1 presents the locations of the borings and the location of the Former Lead Furnace Area.

28.2 ENVIRONMENTAL SETTING

28.2.1 Topography

The Former Lead Furnace Area is located at the bottom of a steeply sloping hillside. The elevation of the area is approximately 1,875 feet msl. SWMU 17A is located in a depression. The location of removed waste oil tanks (SWMU 76) is upgradient to the east of the Former Lead Furnace Area at an elevation of 1,895 feet msl. Buildings 7219 and 534 are to the south of the Former Lead Furnace Area. There are paved and gravel roads in the vicinity.

28.2.2 Geology and Soils

The subsurface conditions for this area were investigated by the drilling of three shallow soil borings to a depth of 7 to 10 feet. Auger refusal was encountered in borings 17SB1 at a depth of 9 feet and 17SB3 at a depth of 7 feet. Auger refusal did not occur in boring 17SB2. Unconsolidated soils encountered consisted of surficial fill to a maximum depth of 10 feet. Bedrock below this site probably consists of very broken and weathered limestone since the depression of the site is a sinkhole.

28.2.3 Groundwater Conditions

No site-specific hydrogeologic study has been conducted at this site. However, groundwater conditions are karstic and very irregular. Depth to groundwater is approximately 100 feet and flow direction is uncertain.

28.2.4 Surface Water Drainage

Based on the topography, surface water in the area of the Former Lead Furnace Area would flow from the surrounding hillsides and collect in the areas of lower elevations of SWMU 17A. Surface water would probably percolate into the subsurface and enter the water table. According to RAAP utility maps, there are no manholes, catch basins, or storm drains in the vicinity of the Former Lead Furnace Area.

28.3 CONTAMINATION ASSESSMENT

The VI field program included the collection of six soil samples from three soil borings at the Former Lead Furnace Area. Samples were obtained at two discrete intervals and at depths no greater than 10 feet. The results of the chemical analyses indicated that samples contained several metals at concentrations greater than HBNs. Most of the metal concentrations are not considered a concern because the levels were less than or slightly greater than background criteria or did not exceed TCLP regulatory levels. However, high concentrations of lead detected near the former waste oil tanks are a concern at the site. Results of the chemical analyses are presented in Table 28-1.

The results of the chemical analyses indicated that concentrations of antimony, arsenic, beryllium, cobalt, lead, mercury and thallium in the soil samples exceeded the HBN criteria. With the exception of lead in one sample, these metals are not considered a concern because the levels were less than or only slightly greater than the soil background criteria for upland soils. These elements are not highly mobile in the environment and are not expected to impact surface water, groundwater or underlying soil as indicated by the

Table 28-1
Summary of Analytical Data For Soil Samples Collected At Former Lead Furnace Area
Radford Army Ammunition Plant, Virginia

SITE ID		17SB1	17SB1	17SB2	17SB2	17SB3	17SB3	
FIELD ID		RFIS*75	RFIS*80	RFIS*82	RFIS*83	RFIS*84	RFIS*85	
S. DATE		05-nov-91	05-nov-91	05-nov-91	05-nov-91	05-nov-91	05-nov-91	
DEPTH (ft)		8.0	9.0	5.0	10.0	5.0	7.0	
MATRIX	PQLs	CSO	CSO	CSO	CSO	CSO	CSO	HBN
UNITS (#)	UGG	UGG	UGG	UGG	UGG	UGG	UGG	UGG
TAL Inorganics								
ALUMINIUM	14.1	15800	23500	15500	7470 B	33200	42300	230000
ANTIMONY	20	LT 7.14	LT 7.14	LT 7.14	[249]	LT 7.14	LT 7.14	30
ARSENIC	30	[3.46 B]	[3.06 B]	[5.6]	[5.77]	[2.65 B]	[3.85]	0.5
BARIUM	1	93	70.9	27 B	183	73.6	107	1000
BERYLLIUM	0.2	[1.09]	[1.09]	LT 0.5	LT 0.5	[2.45]	[2.71]	0.1
CADMIUM	2	LT 0.7	LT 0.7	LT 0.7	2.57	LT 0.7	LT 0.7	40
CALCIUM	100	3910 B	2000 B	1150 B	13900 B	1860 B	3890 B	NSA
CHROMIUM	4	43.2	38.7	24.1 B	36.1	45.3	50.4	400
COBALT	3	[14.5]	[21.2]	[2.97]	[7.91]	[15.4]	[10.3]	0.8
COPPER	7	19.7	16.3	4.95 B	2260	38.2	23.8	2900
IRON	1000	20700	33900	22200	22200	45300	49000	NSA
LEAD	2	25.3	19.9	20.9	[100000]	[372]	LT 10.5	200
MAGNESIUM	50	12400	13900	846 B	11100	8880	49100	NSA
MANGANESE	0.275	426	577	130	246	453	575	8000
MERCURY	0.1	LT 0.05	LT 0.05	0.062	[64]	0.104	LT 0.05	20
NICKEL	3	22.4	25.8	4.13	52	45.3	35.2	1000
POTASSIUM	37.5	1450 B	1980 B	494 B	855 B	2580	8210	NSA
SILVER	4	0.985	0.97	LT 0.589	23.9	LT 0.589	LT 0.589	200
SODIUM	150	300 B	171 B	179 B	278 B	173 B	227 B	NSA
THALLIUM	20	[12.9]	[14.2]	LT 6.62	[96.7]	[21.5]	[26.9]	6
VANADIUM	0.775	56.6	67.2	53.8	26.5 B	83.3	90.5	560
ZINC	30.2	68.6	60	23.5 B	801	124	67.6	16000

Table 28-1 (Cont'd)

SITE ID		17SB1	17SB1	17SB2	17SB2	17SB3	17SB3	
FIELD ID		RFIS*75	RFIS*80	RFIS*82	RFIS*83	RFIS*84	RFIS*85	
S. DATE		05-nov-91	05-nov-91	05-nov-91	05-nov-91	05-nov-91	05-nov-91	
DEPTH (ft)		8.0	9.0	5.0	10.0	5.0	7.0	
MATRIX	PQLs	CSO	CSO	CSO	CSO	CSO	CSO	HBN
UNITS (#)	UGG	UGG	UGG	UGG	UGG	UGG	UGG	UGG
TCLP Metals (UGL)								
BARIUM	20	311	209	222	1240	329	220	100000
LEAD	10	LT 18.6	LT 18.6	LT 18.6	[GT 500000]	2230	63.3	5000

Footnotes:

B = Analyte was detected in corresponding method blank; values are flagged if the sample concentration is less than 10 times the method blank concentration for common laboratory constituents and 5 times for all other constituents.

CSO = Chemical soil.

GT = Greater than; detected value was greater than the maximum certified concentration.

HBN = Health based number as defined in the RCRA permit. HBNs not specified in the permit were derived using standard exposure and intake assumptions consistent with EPA guidelines (51 Federal Register 33992, 34006, 34014, and 34028).

LT = Concentration is reported as less than the certified reporting limit.

NSA = No standard (HBN) available; health effects data were not available for the calculation of a HBN. HBNs were not derived for TICs.

PQL = Practical quantitation limit; the lowest concentration that can be reliably detected at a defined level of precision for a given analytical method.

TAL = Target Analyte List.

TCLP = Toxicity Characteristic Leaching Procedure.

UGG = Micrograms per gram.

Units(#) = Units are in UGG except for TCLP constituents, which are expressed in UGL.

[ ] = Brackets indicate that the detected concentration exceeds the HBN.

results of the TCLP leachate analyses. Concentrations of aluminum, cadmium, copper, iron, magnesium, nickel, potassium, silver, vanadium and zinc exceeded the soil background criteria but are not considered a concern because they were less than HBN and TCLP criteria. These metals are not expected to impact surface water, groundwater or underlying soil. However, the lead concentration in the deepest sample collected from 17SB2 was reported to be 500 times greater than the soil HBN and background criteria and is a concern at the site. The TCLP leachate concentration for lead in this sample also exceeded the regulatory level by a factor of 100. The TCLP results demonstrated that this sample, by statute, is a hazardous waste. The results indicated that lead was mobilized at a high concentration and may have impacted underlying soil or groundwater at the site. The TCLP results for sample 17SB3 indicated that lead may be a concern in groundwater below the Former Lead Furnace Area.

28.4 <u>BASELINE RISK ASSESSMENT</u>

Based upon the contamination assessment presented in Section 28.3, one contaminant of concern--lead--was identified for soil at the Former Lead Furnace Area. Samples were not collected from other environmental media. The potential impact of lead in site soil to human health and the environment is discussed below in Sections 28.4.1 and 28.4.2, respectively.

28.4.1 <u>Human Health Evaluation</u>

Lead was detected in two soil samples (17SB2 and 17SB3) at concentrations (100,000 and 372 ug/g, respectively) elevated above the HBN for lead (200 ug/g). However, these soils samples were collected from depths of 10 and 5 feet, respectively; soil samples were not collected from the surface and other soil samples collected from this site did not contain elevated levels of lead. Although surface soil samples were not collected, surface soil is reportedly highly contaminated with lead and lead slag. Workers do not frequently enter the area; however, burn activities occur approximately once per week, trucks frequently dump in the area, and cranes operate in the area. Potential soil exposure routes typically include incidental ingestion, inhalation, and dermal absorption. Due to the nature of operations conducted in this area, the air inhalation pathway appears to be the most viable and significant exposure pathway; exposure via incidental ingestion and dermal absorption is expected to be low. Because of the high concentrations of lead apparently present in surface soil, and the frequent activity that occurs in this area, exposure to human receptors via inhalation of lead contaminated dust is expected to be moderate to high.

An evaluation of the potential for toxic effects upon inhalation exposure to lead indicates that such exposure is associated with neurological and hematological effects. Adverse hematological effects in children occur at blood levels of 10 to 15 micrograms per deciliter (ug/dl), and possibly lower (USEPA, 1991d). Irreversible chronic neuropathy, characterized by decreased glomerular filtration rates, interstitial fibrosis, mitochondrial changes, and azotemia, is sometimes found in chronically exposed workers with blood lead levels of 40 to 60 ug/dl (USEPA, 1991d). Because lead has no known toxicity threshold, EPA has not calculated RfDs for lead exposure (USEPA, 1992a); instead EPA has developed an uptake biokinetic (UBK) model for assessing exposure to lead (see Appendix D). Although lead is classified as a B2 carcinogen, inhalation carcinogenicity studies present conflicting data (USEPA, 1992a).

Based on the fact that surface soil samples are expected to be highly contaminated with lead, that workers in or near the Former Lead Furnace Area may potentially receive moderate to high exposure, and that toxic effects from lead via the inhalation pathway are well documented, the potential hazard to human receptors is estimated to be moderate to high. Even through surface soil samples were not collected from this area, the potential hazard to human receptors is estimated to be moderate to high, but cannot be quantified.

The results of the TCLP analysis indicate that lead may have impacted underlying groundwater at the site. However, no groundwater data are available and information is not available on groundwater flow direction. No groundwater wells have been identified in the vicinity of the Former Lead Furnace Area. Because it is located in a sinkhole and groundwater migration pathways are unknown, the potential for groundwater exposure cannot be evaluated.

28.4.2 Environmental Evaluation

As discussed above, lead contamination was only detected at depths of 5 and 10 feet. Although surface soil samples were not collected at this site, surface soils are reportedly highly contaminated with lead and lead slag. Because this site is located in a sinkhole at the bottom of a steep hill, it is unlikely that environmental receptors frequent this area. Therefore, potential exposure to environmental receptors is estimated to be low.

Although there is the potential for groundwater contamination at this site, because there are no surface water bodies in the vicinity of this site, discharge of contaminated groundwater to surface water is not considered an operable migration pathway. Therefore, there are no potential environmental groundwater receptors.

28.4.3 Conclusions of Human Health and Environmental Evaluation

Although only deep soil samples were collected and analyzed, surface soil is reportedly highly contaminated with lead and lead slag. Because workers in or near the Former Lead Furnace Area may potentially receive moderate to high exposure and toxic effects from lead via the inhalation pathway, the potential hazard to human receptors is estimated to be moderate to high.

Because this site is located in a sinkhole at the bottom of a steep hill, it is unlikely that environmental receptors frequent this area. Therefore, potential exposure to environmental receptors is estimated to be low.

Although the results of the TCLP analysis indicate that lead may have impacted underlying groundwater at the site, no groundwater data are available and information is not available on groundwater flow direction. Therefore, the potential for groundwater exposure can not be evaluated.

28.5 CONCLUSIONS

Results of the chemical analysis of the six samples from the three borings at the Former Lead Furnace Area indicate high levels of lead in the soil near the former waste oil tanks. The total lead concentration in the deepest sample collected from soil boring

17SB2--10 feet--was reported to be 500 times greater than the soil HBN and background criteria. The TCLP leachate concentration for lead in this sample also exceeded the regulatory level by a factor of 100. Additionally, solid lead slag was observed in the surface and near surface soils around and below the tanks. The high total and TCLP concentrations of lead encountered at a depth of 10 feet in soil boring 17SB2 indicate that the vertical extent of contamination likely extends to a depth at or near bedrock. The TCLP results also indicate that lead was mobilized at a high concentration and may have impacted underlying soil or groundwater. Because the former lead furnace and waste oil tank area are located in a depression likely overlying a sinkhole, this area collects a substantial amount of surface water runoff. Surface water infiltration in this area will likely continue to result in lead being mobilized to the subsurface potentially impacting groundwater.

28.6 RECOMMENDED ACTION

Because exploratory samples analyzed from the Former Lead Furnace Area indicate high levels of lead significantly greater than HBNs and background criteria are present in the subsurface to a depth of at least 10 feet, additional sampling is recommended to delineate both the horizontal and vertical extent of lead contamination. Once the extent and nature of lead contamination are determined, a corrective measures study should be performed to prevent further impact to the environment and potential hazards to human and environmental receptors. Interim corrective measures consisting of removal of the visually impacted soil would be appropriate prior to a corrective measures study in order to eliminate a possible continuing source of lead contamination.

Groundwater impacts cannot be measured directly through the installation and sampling of monitoring wells. The badly fractured and incompetent bedrock within this sinkhole presents conditions precluding the installation of wells. A dye tracing study for this area is recommended in order to define groundwater discharge points at which samples may be taken.

29.0 WASTE OIL STANDARD OPERATING PROCEDURES

The handling and temporary storage of waste oil in the Mobile Waste Oil Tanks (SWMU 61), Waste Oil Underground Storage Tank--Inert Gas Plant (SWMU 75), and Waste Oil Underground Storage Tanks--South of Oleum Plant (SWMU 76) provide the potential for spillage of waste oil onto surface soils at the waste oil collection and storage points. To mitigate the potential for contaminant migration from these areas, standard operating procedures (SOPs) have been developed by RAAP to routinely inspect these locations, to remove any surface soils that appear to be visually stained from routine waste handling, and to place clean fill in excavated areas.

29.1 STANDARD OPERATING PROCEDURES

29.1.1 Pumping of Underground Condensation Catch Tanks and Oil Separator

The SOPs developed by RAAP for pumping of underground condensation catch tanks and oil separators, including routine inspection, replacement, and disposal of stained surface soils, are provided in Procedure 4-27-120 (Rev. 4).

Procedure 4-27-120 includes safety materials and equipment available and/or required while pumping the underground condensation catch tanks and oil separators, or if a spill occurs. The procedure lists safety rules and precautions as well as the proper method of pumping the underground condensation catch tanks and oil separators to prevent potential spills. The procedures require inspection and cleanup of the work area before leaving the job site. The following procedures are to be used by RAAP personnel when absorbent material is used for oil spillage during transfer:

- Sprinkle a generous amount of absorbent material on spilled oil. Allow material at least 10 minutes to absorb oil and water.
- Use a broom and a shovel to place spent material in a plastic bag.
- Notify supervisor for correct method of disposal.

- Remove surface soil and/or gravel that is oil-stained from the work area, and notify supervisor when cleanup is complete.
- If necessary, replace removed soil with clean fill material.

29.1.2 Emergency Response to Chemical Spills

The Emergency Response to Chemical Spills, Procedure 4-14-44, provides the steps to be followed for the containment, cleanup, and disposal of spills in the NC Area. This procedure addresses the required protective clothing, necessary protective equipment, and warnings for handling specific spills in the NC Area. The Emergency Response Procedure addresses SOPs for acid spills (containment, neutralization, and cleanup), lubricating oil spills (containment and cleanup), and NC spills (containment and cleanup).

For an emergency oil spill, the first step of the Emergency Response Procedure is to immediately notify supervision. Next, any leaking equipment is shut down. If the source of the spill is not known, it should be determined. Spilled material should be contained by placing barriers of absorbent material. Spilled material should be prevented from reaching storm sewers or the New River. The same cleanup procedures as listed in Procedure 4-27-120 (Section 29.1.1) are followed.

29.1.3 Oil Discharge Contingency Plan

The Oil Discharge Contingency Plan (ODCP), developed by RAAP to satisfy VR-680-14-07, Section 5, summarizes general plant procedures for prevention of spills of oil, and procedures if a spill does occur. The plan includes a table describing the size, location, and contents of aboveground storage tanks containing oil products, and it lists the emergency contacts if a spill should occur. The plan describes the expected containment migration pathway of a spill, as well as the worse case oil spill scenario. The procedures that would be followed if a spill should occur are also in the ODCP. These procedures are the same as described in Section 29.1.1 and 29.1.2. The plan includes a U.S. Geological Survey (USGS) map of the facility indicating the places at which oil is handled, the Material Safety Data Sheets (MSDSs) of the oil products, preventative maintenance check sheets for equipment used to contain oil spills, preventative maintenance check sheets for oil storage tanks, and a list of employees trained in HAZ MAT 1 and Leak and Spill Training.

29.2 APPLICATION TO VI SWMUs 61, 75, AND 76

29.2.1 Mobile Waste Oil Tanks--SWMU 61

A number of oil/water separators and waste oil storage tanks located throughout RAAP are used for the collection of waste oil generated primarily from machinery and vehicle engines. On a regular basis, oil from these locations is collected in the Mobile Waste Oil Tanks (SWMU 61) for shipment off site or reuse. The waste oil was previously transported to the Waste Oil Underground Storage Tanks South of the Oleum Plant (SWMU 76). Waste oil is presently transported to aboveground tanks in Buildings 1624 and 1601 for storage until shipped off site for disposal.

Leaks and spills of waste oil during handling and collection are cleaned up before employees leave the site. Applicable procedures of the cleanup are described in Section 29.1.1 (Procedure 4-27-120). A major spill from overfilling or a leak would be cleaned up as an emergency according to procedures described by the Emergency Response Plan (Procedure 4-14-44; Section 29.1.2) and the Oil Discharge Contingency Plan (Section 29.1.3).

29.2.2 Waste Oil Underground Storage Tank (Inert Gas Plant)--SWMU 75

This underground storage tank (UST) is located in the Main Manufacturing Area, 20 feet west of the Inert Gas Compressor Building A-421. The UST is reportedly a single-walled tank with a capacity of 600 to 700 gallons. It is currently used to store waste oil and hydraulic fluids that are generated in the inert gas plant compressor house. The contents of the UST are periodically pumped out into 55-gallon drums for use as fuel at the Hazardous Waste Incinerator (USEPA, 1987).

Drips and spills around the tank access ports that occur when filling the tank are cleaned up before employees leave the job site (Procedure 4-27-120; Section 29.1.1). Contaminated soil is removed from the premises and is properly disposed. A major spill from overfilling would be treated as an emergency and procedures described by the Emergency Response Plan (Procedure 4-14-44; Section 29.1.2) are followed.

29.2.3 Waste Oil Underground Storage Tanks (South of Oleum Plant)--SWMU 76

SWMU 76 consists of two waste oil USTs that were located within the Contaminated Waste Stage and Burn Area (SWMU 17A) in the south-central part of the Main Manufacturing Area (Insert 1 and Figure 28-1). The capacity of Tank No. 1 was 5,500 gallons; the capacity of Tank No. 2 was 2,640 gallons. Waste oil from machinery and vehicle engines throughout RAAP was collected in the Mobile Waste Oil Tanks (SWMU 61) and then stored in the SWMU 76 tanks. The waste oil was then sold to an off-post firm for reclamation or used to fuel fires in the Contaminated Waste Stage and Burn Area (SWMU 17A).

The two USTs at SWMU 76 were removed in May, 1991. On May 29, 1991, a spill of oily waste water and sludge occurred while removing the 5,500-gallon UST. As the tank was being lifted by a crane from its resting place, it tilted, causing excessive strain on the discharge elbow connection, resulting in a 9-foot section of 4-inch drain line to break off. Approximately 250 gallons of the oily waste water sludge, which was not removed prior to the tank removal, drained out into a trench alongside the tank. The materials impacted were analyzed in order to determine proper disposal procedures (Hercules, 1991). The entire spill was contained within an area 20 feet long, 3.5 feet wide and 6 inches deep.

The oily waste water sludge was removed from the containment area using a suction pump and was temporarily placed in a waste oil storage tank in the solvents area for off-site treatment. The remaining material within the trench was absorbed with an absorbent compound. Approximately 13 cubic yards of dirt/absorbed material were removed from the area and disposed off-site as a hazardous waste due to lead and chromium concentrations. Approximately one cubic yard of soil was also removed from in front of the tank (Hercules, 1991).

Soil samples were collected for analysis of TPH to ensure the site was properly cleaned up. Because lead and chromium were detected in the oily waste water sludge sample, analyses for these two metals in addition to the TPH analysis were included on the soil samples taken from under the spill area. Analytical results indicated that the TPH concentration was approximately 1,600 mg/kg before the spill cleanup and less than 60 mg/kg TPH after the spill cleanup was completed (Hercules, 1991).

The soil samples taken from under the spill area showed relatively high lead content. Research into the history of this area revealed that a lead furnace was in operation during World War II in this area. This area has been included as a SWMU for the VI and the evaluation is presented in Section 28.0. The laboratory analysis at SWMU 76 from the USTs closure report was considered adequate, without further investigation, to conclude that the previous presence of the USTs no longer causes an environmental concern or threat due to petroleum hydrocarbons.

30.0 ACID AND INDUSTRIAL SEWERS SURVEY

As part of the RCRA Permit requirements, a survey of the RAAP acid/industrial sewer system is to be conducted by RAAP. This long-term effort is being conducted separately from the remainder of the VI. The VI Work Plan (Dames & Moore, 1990a) outlined an approach for the evaluation of the sewer network. A brief history of the network is defined below.

30.1 BACKGROUND

According to October 1989 calculations, RAAP currently maintains approximately 183,580 feet of industrial (general purpose) sewers and 45,057 feet of acid sewers. RAAP also maintains sanitary and storm sewers; however, these sewers are not included in the required testing program identified in the RCRA permit. Line materials consist of vitrified clay, terra cotta, ceramic tile, steel, fiberglass reinforced epoxy pipe, ductile iron and cast iron, with pipe diameters ranging from 3 to 48 inches.

Since the original plant opened at RAAP in 1941, the facility has expanded from a small gun powder factory to a complex propellant and explosive manufacturing plant. Subsequently, many acid and industrial sewer lines have been added, abandoned, and replaced.

Currently, most of the active production facilities are located south of the New River. In this portion of the facility, acids used in the production of explosives and propellants are transported from storage areas to production facilities via acid sewer lines. Spent acids and waste products are carried by industrial (general purpose) lines from the manufacturing areas to treatment facilities. Nitroglycerine, diethylene glycol dinitrate (DEGDN) and alcohol rectification wastewaters are pretreated and then combined with propellant area wastewaters for treatment in the Biological Treatment Plant (SWMU 10) located east of the New River bridge. Wastes generated in TNT production were treated at a special facility that discharged into Stroubles Creek. The TNT Area was shut down in 1986 and no discharges to the treatment facility are presently occurring.

Industrial wastes generated in the western Horseshoe Area of RAAP are carried by gravity sewers to a force-main that directs wastes south, along the New River bridge and to the Biological Treatment Plant.

A complex network of acid and industrial sewers links the production and treatment facilities throughout RAAP. Facility records of the sewers are incomplete; however, a record of changes since 1962 shows the location, length, and diameter of lines put into, and taken out of, service.

Recently installed lines are typically tested for tightness, but no formal line testing program has been implemented at RAAP.

30.2 DATA COLLECTION

As an initial step to develop testing program priorities, development of accurate sewer mapping for RAAP is important. RAAP is currently developing 2-foot contour maps for the entire facility. Upon completion, these maps will be used to develop sewer maps for the facility. The approach for the followup efforts will entail steps outlined in the VI Work Plan.

31.0 CONCLUSIONS AND RECOMMENDATIONS

Summaries of current environmental conditions for each of the 24 SWMU areas addressed by the VI are presented in Sections 5.0 through 28.0. Table 31-1 lists pertinent characteristics of each site with respect to groundwater flow direction, surface water flow direction, whether source contaminants have been detected, whether contaminants have been detected away from the source, whether there is a likely potential for off-post contaminant migration, and the location of the site with respect to the installation boundary. The levels of constituents detected with respect to background criteria or HBNs are indicated. The information provided in Table 31-1 is useful for evaluating the potential adverse impact of each site on human health and the environment and for determining whether further actions are warranted with respect to SWMU investigation and/or corrective action.

For sites where contaminants have been confirmed in site media, the suspected or confirmed groundwater and surface water flow direction indicate the direction of potential contaminant movement. Where site contamination has been confirmed, the potential for off-site migration is based on hydrogeologic and topographic conditions. The distance from the site to the installation boundary is useful to help evaluate whether contaminant concentrations will be significantly reduced by attenuation, adsorption, dissipation, or dilution prior to potentially exiting the installation.

Table 31-2 summarizes the constituents detected at each SWMU and in which medium they were detected. Also identified are whether constituent concentrations are above or below background criteria and/or HBNs. This information provides an installation-wide assessment of potential constituents of concern, location, and media.

The information provided in Sections 5.0 through 28.0 and summarized in Tables 31-1 and 31-2 was useful to develop the proposed future action recommendations provided in Table 31-3. A recommendation for future action is provided for each SWMU as follows:

Table 31–1
Summary of Environmental Conditions at SWMUs Investigated
Radford Army Ammunition Plant, Virginia

SMWU Nos.	SWMU Name	Potential Groundwater Flow Direction	Surface Water Runoff Direction	Contaminant Source Present	Contamination Detected Away from Source	Potential Media for Contaminant Migration	Distance from Installation Boundary (feet)
6	Acidic Wastewater Lagoon	Northeast	East	Yes – BHBN	No	– –	2800
8, 9, 36, 37, 38, 50 and Q	Calcium Sulfate Lagoons, Drying Beds and Disposal Areas	North (8) Northwest (9)	None South (50)	Yes – BHBN	– –	– –	100(8); 300(9); 500(50)
10, 35	Bio–Plant Equalization Basin and Calcium Sulfate Drying Bed	North	None	Yes – AHBN	Yes – AHBN	Yes – GW	100
26	Fly Ash Landfill No. 1	North/South	North	Yes – NS	Yes – ABG	Yes – GW	300
27, 29, 53	Calcium Sulfate Landfill, Fly Ash Landfill No. 2, Activated Carbon Disposal Area	Southeast	South	Yes – NS	Yes – ABG	Yes – GW, SW, SE	900
31	Coal Ash Settling Lagoons	Northwest	None	Yes – AHBN	– –	Yes – GW	100
32	Inert Waste Landfill No. 1	North	North	No – NS	No	– –	600
39	Incinerator Wastewater Ponds	North	None	Yes – AHBN	– –	Yes – GW	1000
40	Sanitary Landfill (NG Area)	Unknown	North	Unknown	Unknown	Yes – GW	3200
41	Red Water Ash Landfill Red Water Ash Landfill Lagoon	Northeast Northeast	North North	Yes – NS Yes – BHBN	Yes – AHBN No	– – – –	1100 1300
43	Sanitary Landfill (Adjacent to New River)	North	North	Yes – NS	Yes – ABG	– –	100
45	Sanitary Landfill (West of Main Bridge)	Northwest	Northwest	Yes – NS	Yes AHBN	Yes – GW	300
46	Waste Propellant Disposal Area	Northwest	None	No	Unknown	– –	300

Table 31–1 (Cont'd)

SMWU Nos.	SWMU Name	Potential Groundwater Flow Direction	Surface Water Runoff Direction	Contaminant Source Present	Contamination Detected Away from Source	Potential for Migration	Distance from Installation Boundary (feet)
48	Oily Wastewater Disposal Area	South	South	Yes – BHBN	Unknown	Yes – GW	600
54	Propellant Ash Disposal Area	East	East	Yes – NS	Yes – ABG	Yes – GW, SW, SE, SO	300
57	Pond by Buildings No. 4931 and 4932	Northwest	None	Yes – BHBN	Unknown	--	1500
58	Rubble Pile	North	North	Unknown	No	--	600
59	Bottom Ash Pile	South	South	Yes – NS	Yes – ABG	Yes – SO	700
68	Chromic Acid Treatment Tanks	Northwest	Northwest	Yes – AHBN	Unknown	Yes – SO	1300
69	Pond by Chromic Acid Treatment Tanks	Northwest	Northwest	Yes – AHBN	Yes – AHBN	Yes – SW, SE, SO	1200
71	Flash Burn Parts Area	Unknown	North	No	Yes – ABG	Yes – SO	3200
74	Inert Landfill No. 3	East	East	No – NS	No	--	1600
F	Drum Storage Area	North	North	Yes – BHBN	Unknown	--	300
P	Battery Storage Area	North	North	Yes – BHBN	Unknown	--	200
	Former Lead Furnace Area	Unknown	None	Yes – BHBN	Yes – AHBN	Yes – GW	3000

Footnotes:

ABG = Above background concentration
BHBN = Below health based number
AHBN = Above health based number
NS = Not sampled
GW = Groundwater
SW = Surface Water
SE = Sediment
SO = Soil

TABLE 31 – 2
SUMMARY OF PARAMETERS DETECTED FOR VI AT RAAP, VIRGINIA

	SWMUs																	
COMPOUND	**6**		**8,9,36,37,38,50,Q**	**10, 35**				**26**	**27, 29, 53**			**31**	**32**	**39**		**41**		
Media (a):	GW	SO	SE	GW	SW	SO	SE	GW	GW	SW	SE	SE	GW	SO	SE	GW	SW	SO
EXPLOSIVES																		
2,4–DNT	–	–	–	O	X	O	X	–	–	–	–	–	–	–	–	–	–	–
2,4,6–TNT	–	–	–	–	–	–	O	–	–	–	–	–	X	–	–	–	O	–
2,6–DNT	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–
HMX	–	–	–	X	O	–	O	–	–	–	–	–	X	–	–	–	–	–
RDX	–	–	–	–	–	–	O	–	–	–	–	–	X	–	–	–	–	–
TETRYL	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–
METALS																		
ALUMINUM	–	O	–	O	–	–	–	–	–	O	O	O	–	O	O	–	–	O
ANTIMONY	–	O	–	X	–	–	–	–	–	–	–	–	–	–	X	X	–	–
ARSENIC	–	O	O	O	–	O	X	–	–	O	O	O	–	O	X	–	–	O
BARIUM	O	O	O	O	O	O	O	O	–	O	X	O	O	O	X	O	O	O
BERYLLIUM	–	–	–	–	–	–	–	–	–	–	X	X	–	O	X	–	–	–
CADMIUM	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CALCIUM	O	O	–	O	–	–	–	O	–	O	O	O	O	O	O	O	O	O
CHROMIUM	O	O	O	X	O	O	O	–	O	–	O	O	–	O	O	–	–	O
COBALT	–	O	–	X	–	–	–	–	–	–	O	O	–	O	X	–	–	O
COPPER	–	O	–	O	–	–	–	–	–	O	O	O	–	O	X	–	–	O
IRON	–	O	–	O	–	–	–	–	O	O	O	O	O	O	O	–	O	O
LEAD	–	O	O	X	X	X	X	O	O	–	O	O	–	O	X	O	–	O
MAGNESIUM	O	O	–	O	–	–	–	O	–	O	O	O	O	O	O	O	O	O
MANGANESE	–	O	–	X	–	–	–	O	–	O	O	O	O	O	O	O	O	O
MERCURY	–	–	–	–	–	O	O	O	O	–	X	O	–	–	–	–	–	–
NICKEL	–	O	–	O	–	–	O	–	–	–	O	O	–	O	O	–	–	O
POTASSIUM	O	O	–	O	–	–	–	O	–	O	O	O	O	O	O	O	O	O
SELENIUM	–	–	–	–	–	–	–	–	–	O	O	O	O	–	–	–	–	–
SILVER	–	O	O	O	O	O	O	–	–	–	O	O	–	O	O	O	–	–
SODIUM	O	O	–	O	–	–	–	O	O	O	O	O	–	O	O	O	O	O
THALLIUM	–	O	–	–	–	–	–	–	–	–	–	O	–	O	X	–	–	–
VANADIUM	–	O	–	O	–	–	–	–	–	–	O	X	–	O	O	O	–	O
ZINC	–	O	–	O	–	–	–	–	–	–	O	O	–	O	O	O	–	O
VOCs																		
1,1,1–TRICHLOROETHANE	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1,1–DICHLOROETHYLENE	–	–	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–
1,2–DICHLOROETHANE	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1,2–DICHLOROETHENE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
ACETONE	–	–	O	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–
BENZENE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CARBON DISULFIDE	–	–	–	O	–	–	–	O	–	–	–	–	–	–	–	–	–	–
CHLOROFORM	–	–	O	O	O	–	–	–	–	–	–	–	–	–	–	–	–	–
CHLOROMETHANE	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–
ETHYLBENZENE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
TOLUENE	–	–	–	O	–	O	O	O	–	–	O	–	–	–	–	–	–	–
TRICHLOROETHYLENE	–	–	–	–	–	–	–	–	–	–	O	–	–	–	–	–	–	–
TRICHLOROFLUOROMETHANE	–	–	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–
XYLENES	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
SVOCs																		
1,2–DICHLOROBENZENE	–	–	–	–	–	–	–	–	–	–	–	O	–	–	–	–	–	–
2–METHYLNAPHTHALENE	–	–	O	–	–	O	–	–	–	–	O	O	–	–	–	–	–	–
2–NITROANILINE	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–
ACENAPHTHYLENE	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–
ANTHRACENE	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–
BENZO(K)FLUORANTHENE	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–
BIS(2–CHLOROETHYL) ETHER	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
BIS(2–ETHYLHEXYL) PHTHALATE	–	–	–	O	–	–	–	O	–	–	–	–	–	–	O	O	–	–
BUTYLBENZYL PHTHALATE	–	–	–	–	–	–	–	–	–	–	–	–	–	–	O	–	–	–
CHRYSENE	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–
DI–N–BUTYL PHTHALATE	–	–	O	–	–	O	O	–	–	–	–	–	–	–	O	–	–	–
DIBENZOFURAN	–	–	–	–	–	O	–	–	–	–	O	O	–	–	–	–	–	–
DIETHYL PHTHALATE	–	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–
FLUORANTHENE	–	–	O	–	–	O	O	–	–	–	–	O	–	–	O	–	–	–
FLUORENE	–	–	–	–	–	O	–	–	–	–	–	O	–	–	–	–	–	–
NAPHTHALENE	–	–	O	–	–	O	–	–	–	–	O	O	–	–	–	–	–	–
N–NITROSODIPHENYLAMINE	–	–	O	–	X	–	O	–	–	–	–	–	–	–	–	–	–	–
PHENANTHRENE	–	–	O	–	–	O	X	–	–	–	O	O	–	–	O	–	–	–
PYRENE	–	–	–	–	–	O	–	–	–	–	–	–	–	–	O	–	–	–
OTHER PARAMETERS																		
NITRATE–NITRITE	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–
SULFATE	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–
TOTAL PETROL. HYDROCARBONS	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

TABLE 31-2 (cont'd)

	SWMUs																		
COMPOUND	43		45	46	48	54	57		58	59	68	69			71	74	F	P	FLFA
Media (a):	GW	SW	GW	SO	SO	GW	SW	SE	SO	SO	SO	SW	SO	SE	SO	GW	SO	SO	SO
EXPLOSIVES																			
2,4-DNT	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2,4,6-TNT	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
2,6-DNT	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HMX	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
RDX	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TETRYL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
METALS																			
ALUMINUM	-	O	-	O	O	O	O	O	O	O	O	O	O	O	O	-	-	O	O
ANTIMONY	-	-	-	-	-	-	-	-	-	-	X	X	X	X	-	-	-	O	O
ARSENIC	O	O	-	O	O	O	O	O	O	X	O	O	O	O	X	-	-	O	O
BARIUM	O	O	O	O	O	O	O	O	O	O	O	O	O	O	X	O	-	O	O
BERYLLIUM	-	-	-	O	O	-	-	-	O	O	O	-	O	-	X	-	-	O	O
CADMIUM	-	-	-	-	-	-	-	-	-	-	X	X	O	X	-	-	-	-	O
CALCIUM	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	-	O	O
CHROMIUM	-	-	-	O	O	-	O	O	O	O	O	X	O	X	O	-	-	O	O
COBALT	-	-	-	O	O	-	-	O	O	O	O	X	O	O	O	-	-	O	O
COPPER	-	-	-	O	O	-	O	O	O	O	O	X	O	O	X	-	-	O	O
IRON	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	-	-	O	O
LEAD	-	-	O	-	O	-	O	-	O	O	O	X	O	X	O	-	-	O	X
MAGNESIUM	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	-	O	O
MANGANESE	O	O	O	O	O	O	O	O	O	O	O	X	O	O	O	O	-	O	O
MERCURY	-	-	-	-	O	-	-	O	O	X	X	-	O	-	X	-	-	-	O
NICKEL	-	-	-	O	O	-	-	O	O	O	O	X	O	O	O	-	-	O	O
POTASSIUM	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	-	O	O
SELENIUM	-	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-
SILVER	-	-	-	O	O	O	-	-	-	O	O	O	O	O	O	-	-	O	O
SODIUM	O	O	O	O	O	O	O	O	O	O	O	O	O	O	X	O	-	O	O
THALLIUM	-	-	-	O	-	-	-	-	O	-	X	-	O	O	X	-	-	-	O
VANADIUM	-	O	-	O	O	-	-	O	O	O	O	O	O	O	O	-	-	O	O
ZINC	-	-	-	O	O	O	O	O	O	O	O	X	O	O	O	-	-	O	O
VOCs																			
1,1,1-TRICHLOROETHANE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,1-DICHLOROETHYLENE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2-DICHLOROETHANE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2-DICHLOROETHENE	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACETONE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BENZENE	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CARBON DISULFIDE	O	O	O	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-
CHLOROFORM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CHLOROMETHANE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ETHYLBENZENE	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOLUENE	-	-	O	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TRICHLOROETHYLENE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TRICHLOROFLUOROMETHANE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-
XYLENES	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SVOCs																			
1,2-DICHLOROBENZENE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-METHYLNAPHTHALENE	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-NITROANILINE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACENAPHTHYLENE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ANTHRACENE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BENZO(K)FLUORANTHENE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BIS(2-CHLOROETHYL) ETHER	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BIS(2-ETHYLHEXYL) PHTHALATE	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUTYLBENZYL PHTHALATE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CHRYSENE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DI-N-BUTYL PHTHALATE	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DIBENZOFURAN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DIETHYL PHTHALATE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FLUORANTHENE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FLUORENE	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAPHTHALENE	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N-NITROSODIPHENYLAMINE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PHENANTHRENE	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PYRENE	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OTHER PARAMETERS																			
NITRATE-NITRITE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SULFATE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL PETROL. HYDROCARBONS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-

Footnotes :

[a] Media : GW = Groundwater SO = Soil SW = Surface Water SE = Sediment

Dashes, "-" indicate that parameters were not detected or not analyzed.

FLFA = Former Lead Furnace Area

o = Analyte was detected above the PQL but is not considered to be a concern based on a comparison with background and HBN.

x = Comparison with background and HBN indicated that analyte is of potential concern.

Table 31–3
Summary of Proposed Recommendations
Radford Army Ammunition Plant, Virginia

SMWU Nos.	SWMU Name	Proposed Action (a) No Further Action	Monitor Site	Collect Additional VI Data	Conduct VI	Conduct RFI	Interim Measures	Conduct CMS Program	Perform Dye Tracer Study
6	Acidic Wastewater Lagoon	X							
8, 9, 36, 37, 38, 50 and Q	Calcium Sulfate Lagoons, Drying Beds and Disposal Areas	X							
10, 35	Bio–Plant Equalization Basin and Calcium Sulfate Drying Bed			X					
26	Fly Ash Landfill No. 1		X						
27, 29, 53	Calcium Sulfate Landfill, Fly Ash Landfill No. 2, Activated Carbon Disposal Area			X					
31	Coal Ash Settling Lagoons				X				
32	Inert Waste Landfill No. 1	X							
39	Incinerator Wastewater Ponds				X		X		
40	Sanitary Landfill (NG Area)								X
41	Red Water Ash Landfill	X							
43	Sanitary Landfill (Adjacent to New River)						X		
45	Sanitary Landfill (West of Main Bridge)			X					
46	Waste Propellant Disposal Area	X							
48	Oily Wastewater Disposal Area					X			
54	Propellant Ash Disposal Area		X				X	X	
57	Pond by Buildings No. 4931 and 4932	X							

Table 31-3 (Cont'd)

SMWU Nos.	SWMU Name	Proposed Action (a) No Further Action	Monitor Site	Collect Additional VI Data	Conduct VI	Conduct RFI	Interim Measures	Conduct CMS Program	Perform Dye Tracer Study
58	Rubble Pile	X							
59	Bottom Ash Pile			X					
68	Chromic Acid Treatment Tanks					X			
69	Pond by Chromic Acid Treatment Tanks						X		
71	Flash Burn Parts Area			X					
74	Inert Landfill No. 3	X							
F	Drum Storage Area	X							
P	Battery Storage Area	X							
	Former Lead Furnace Area			X			X		X

Footnotes:

(a) No Further Action – VI is considered complete; no further actions appear warranted.
Monitor Site – Further actions may be warranted but not with respect to VI/RFI process.
Collect Additional VI Data – RFI appears warranted but addtional data are necessary to reach this conclusion.
Conduct VI – Waste characterization indicates VI is warranted to define magnitude and extent of contamination migration.
Conduct RFI – Results of an RFI may ultimately indicate "No Action" is warranted.
Interim Measures – Remedial measures are appropriate to improve site conditions, but a CMS appears to be unnecessary.
Conduct CMS – Results of VI are sufficient for determining the need for and initiating a CMS.
Perform Dye Tracer Study – Definition of groundwater flow pattern is necessary to determine need for a RFI, CMS, or corrective action.

- No further action--This recommendation is made for SWMUs where the VI is considered complete, a contamination problem does not exist or is considered insignificant, and no further actions appear to be warranted.
- Monitor site--This applies to SWMUs that already have been closed according to an approved closure plan and environmental conditions do not warrant further action, or to SWMUs where ongoing permitted operations require monitoring and conditions suggest monitoring in the future is appropriate to assess future impacts.
- Collect Additional VI data--Although contaminants have been detected in site media where additional VI data collection is recommended, the available data are not sufficient to confirm the need for a RFI. Therefore, the collection of additional data is recommended prior to a decision to perform a RFI.
- Conduct VI--This recommendation applies to SWMUs where waste characterization has indicated the waste to be hazardous.
- Conduct RFI--This recommendation applies to SWMUs where contaminants have been detected in site media and contaminant migration has been confirmed or the potential for migration has been identified.
- Interim Measures--Remedial measures are considered appropriate to improve site conditions, but data do not support the need for a CMS.
- Conduct CMS--This recommendation only applies to SWMUs where contaminants have been detected in site media, contaminant migration has been confirmed, or the potential for migration has been identified and the data are sufficient to initiate CMS activities without performing a RFI.
- Perform Dye Tracer Study--Better definition of groundwater flow patterns is necessary to evaluate the need for a RFI, CMS or corrective action.

Based on Table 31-3, the following recommendations are made for the 25 SWMUs:

- No further action at 10 SWMUs
- Monitoring at 2 SWMU
- Additional VI data collection at 6 SWMUs
- Conduct VI at 2 SWMUs
- Conduct RFI at 2 SWMUs
- Perform Interim Measures at 5 SWMUs
- Conduct CMS at 1 SWMU
- Perform Dye Tracer Study at 2 SWMUs.

Several SWMUs have multiple recommendations. Table 31-4 summarizes the specific recommendations provided for each SWMU where additional efforts are considered warranted.

Table 31–4
Summary of SWMU Specific Recommended Actions
Radford Army Ammunition Plant, Virginia

SMWU Nos.	SWMU Name	Proposed Action
6	Acidic Wastewater Lagoon	No further action.
8, 9, 36, 37, 38, 50 and Q	Calcium Sulfate Lagoons, Drying Beds and Disposal Areas	No further action.
10, 35	Bio–Plant Equalization Basin and Calcium Sulfate Drying Bed	1. Add wells D–2 and D–5 to VDWM monitoring program. 2. Remove/immobilize sediment in SWMU 35. 3. Investigate upgradient source of groundwater contamination. 4. Resurvey historical wells on site.
26	Fly Ash Landfill No. 1	Continue VDWM monitoring program.
27, 29, 53	Calcium Sulfate Landfill, Fly Ash Landfill No. 2, Activated Carbon Disposal Area	1. Perform VI program provided in VI Work Plan (Dames & Moore, 1990a). 2. Maintain pond and dredge sediments as appropriate.
31	Coal Ash Settling Lagoons	Conduct VI to address impact of pond sediments on groundwater quality.
32	Inert Waste Landfill No. 1	No further action.
39	Incinerator Wastewater Ponds	1. Conduct VI to address impact of pond sediments on groundwater quality. 2. Remove sediment from ponds.
40	Sanitary Landfill (NG Area)	Perform dye tracer study and reevaluate.
41	Redwater Ash Landfill	No further action.
43	Sanitary Landfill (Adjacent to New River)	Regrade site to reduce infiltration.
45	Sanitary Landfill (West of Main Bridge)	1. Perform confirmatory groundwater sampling at two wells. 2. Develop monitoring program, if warranted.
46	Waste Propellant Disposal Area	No further action.
48	Oily Wastewater Disposal Area	1. Install three wells and collect groundwater samples for SVOC. 2. Collection and analysis of soil boring samples for SVOC and explosives. 3. Collection and analysis of shallow soil samples for SVOCs.

Table 31–4 (Cont'd)

SMWU Nos.	SWMU Name	Proposed Action
54	Propellant Ash Disposal Area	1. Cover/remove/immobilize propellant ash. 2. Perform Corrective Measures Study. 3. Monitor groundwater.
57	Pond by Buildings No. 4931 and 4932	No further action.
58	Rubble Pile	No further action.
59	Bottom Ash Pile	1. Collect bottom ash samples for total and TCLP metals analyses. 2. Collect soil samples away from the ash pile and beneath pile at a depth of five feet.
68	Chromic Acid Treatment Tanks	Perform RFI limited to soil contamination.
69	Pond by Chromic Acid Treatment Tanks	Remove pond water, pond sediment and possibly surficial soil layer in overflow area. May result in possible additional sampling of surficial soil.
71	Flash Burn Parts Area	Collect additional VI soil samples below the surface layer.
74	Inert Landfill No. 3	No further action.
F	Drum Storage Area	No further action.
P	Battery Storage Area	No further action.
	Former Lead Furnace Area	1. Remove visually impacted (metal/slag) surface soil. 2. Perform additional soil sampling to delineate horizontal and vertical extent of lead contamination. 3. Perform dye tracing to define groundwater discharge locations.

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