Report of Findings

Landfill No. 3, Parcel 80(6)

Fort McClellan
Calhoun County, Alabama

Volume I of IV: Text, Tables, and Figures

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Executive Summary

In accordance with Contract Number DACA21-96-D-0018, Task Order CK09, Shaw Environmental, Inc. conducted supplemental remedial investigation activities at Landfill No. 3, Parcel 80(6), at Fort McClellan (FTMC) in Calhoun County, Alabama. The investigation was conducted to define the nature and extent of groundwater contamination and to better understand the geology and hydrogeology in the area. This report of findings presents the results of the investigation.

Landfill No. 3 is located in the northwestern portion of the FTMC Main Post. The approximately 23-acre landfill was the Main Post sanitary landfill from 1946 to 1967. A complete list of wastes disposed at the landfill is not available; however, it has been reported that empty pesticide containers, burned ammunition pallets or crates, paint containers, fluorescent bulbs and ballasts, waste oil, and construction debris have been disposed at the landfill. The landfill was not capped when it was closed in 1967 and settling is occurring.

Previous investigations conducted at Landfill No. 3 indicated that contamination is present as a result of historical Army activities. Chlorinated volatile organic compounds (VOC) were detected in groundwater at concentrations that warranted further investigation. Supplemental remedial investigation activities were conducted in phases from 2000 to 2003 and included the collection and analysis of 220 groundwater samples from 52 wells, including 47 monitoring wells, three privately-owned wells, and two municipal supply wells. Shaw installed 29 groundwater monitoring wells to facilitate groundwater sample collection and to provide site-specific geologic and hydrogeologic characterization information. Eighteen existing monitoring wells at Landfill No. 3 were also sampled. Three deep soil borings were also advanced to evaluate the potential influence of the bedrock structure on groundwater flow direction and contaminant movement in the vicinity of Landfill No. 3. In addition, geophysical logging was conducted at 19 well locations to assist in determining the subsurface geological formation. Discrete groundwater samples were collected from six monitoring wells to provide preliminary information on the vertical and horizontal extent of contamination. Other site-related activities conducted at Landfill No. 3 included fill area characterization activities, a wetlands determination, a water well and spring user survey, and a landfill gas investigation.

Chemical analysis of samples collected indicated that metals, VOCs, semivolatile organic compounds (SVOC), pesticides, and one explosive compound were detected in groundwater. To evaluate the nature and extent of contamination, the analytical results were compared to human health site-specific screening levels (SSSL) and background screening values for FTMC.

Several metals were detected in groundwater at concentrations exceeding SSSLs and background, namely, aluminum, antimony, barium, copper, iron, lead, manganese, thallium, and vanadium. Chromium, mercury, and nickel also exceeded their respective SSSLs in a limited number of samples, but background values were not available for these metals.

Organic compounds detected in groundwater were VOCs, SVOCs, pesticides, and one explosive compound. One SVOC (bis[2-ethylhexyl] phthalate), two pesticides (4,4'-dichlorodiphenyl-trichloroethane [DDT] and heptachlor), and one explosive compound (1,3-dinitrobenzene) exceeded their respective SSSLs in one sample each. In addition, the pesticide beta-hexachlorocyclohexane (BHC) exceeded its SSSL in two samples. However, the most significant groundwater contamination was chlorinated VOCs. A total of 31 VOCs were detected in groundwater, and 13 compounds exceeded their respective SSSLs: trichloroethene, 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, vinyl chloride, acetone, tetrachloroethene, 1,1-dichloroethene, cis-1,2-dichloroethene, chloroform, dibromochloromethane, bromodichloromethane, 1,2-dichloroethene, and carbon tetrachloride.

Isoconcentration maps of total chlorinated VOCs indicate that the groundwater contamination is primarily located along the western boundary of the landfill and within the median of Alabama State Highway 21. The horizontal and vertical extent of groundwater contamination has been defined.

Fill area definition activities were conducted at Landfill No. 3 to determine the horizontal and vertical extent of fill and to characterize the fill material. Exploratory trenching revealed fill material in all of the trenches, including plastic sheeting, glass, wood, paper, electrical wire, bricks, scrap metal, bottles/cans, cardboard and other household items, and construction debris. Based on the trenching results, the extent of the southern boundary was enlarged; the landfill is now estimated to cover approximately 23 acres. The average depth to the fill material is estimated to be approximately 17 feet below ground surface.

The wetland determination identified the entire creek channel around the western and northern boundaries of the landfill as jurisdictional waters of the United States. In addition, a forested wetland area was identified immediately outside of the southwestern portion of the landfill. Some isolated, non-jurisdictional wetland pockets were also observed on the landfill.

The water well and spring user survey identified the locations and uses of water supply wells and springs in the vicinity of Landfill No. 3. A total of 20 wells and three springs were identified within an approximately one-mile radius of Landfill No. 3. Four of these wells and one spring are used for potable water. Closer to the landfill, six wells were identified within approximately 1,600 feet of Landfill No. 3, but none are used for potable water.

The landfill gas investigation determined that the landfill is not producing significant landfill gases (e.g., methane). Based on this and the length of time the landfill has been inactive (over 36 years), it was concluded that further landfill gas investigation was not warranted.

1.0 Introduction

The U.S. Army has selected Fort McClellan (FTMC), located in Calhoun County, Alabama, for closure by the Base Realignment and Closure (BRAC) Commission under Public Laws 100-526 and 101-510. The 1990 Base Closure Act, Public Law 101-510, established the process by which U.S. Department of Defense (DOD) installations would be closed or realigned. The BRAC Environmental Restoration Program requires investigation and cleanup of federal properties prior to transfer to the public domain. The U.S. Army is conducting environmental studies of the impact of suspected contaminants at parcels at FTMC under the management of the U.S. Army Corps of Engineers (USACE)-Mobile District. The USACE contracted Shaw Environmental, Inc. (Shaw) (formerly IT Corporation [IT]) to perform supplemental remedial investigation (RI) activities at Landfill No. 3, Parcel 80(6), under Contract Number DACA21-96-D-0018, Task Order CK09.

This report presents the results of the investigation conducted by Shaw at Parcel 80(6), including a structural geology investigation, field sampling and analysis, monitoring well installation, and fill area definition activities. Other site-related activities included a landfill gas investigation, a wetlands determination, and a water well and spring user survey.

1.1 Project Description

Landfill No. 3 was identified as an area to be investigated prior to property transfer. The site was classified as a Category 6 parcel in the *Final Environmental Baseline Survey, Fort McClellan, Alabama* (EBS) (Environmental Science and Engineering, Inc. [ESE], 1998). Category 6 parcels are areas where release, disposal, and/or migration of hazardous substances has occurred but required actions have not been implemented.

Shaw performed a long-term groundwater sampling and analysis event at Landfill No. 3 in 1998. Seventeen groundwater samples were collected from existing monitoring wells during this sampling event. Detected constituent concentrations were compared to human health site-specific screening levels (SSSL) and background screening values for FTMC (IT, 2000a). Thirteen volatile organic compounds (VOC) were detected in groundwater and six exceeded their respective SSSLs, including 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, and trichloroethene, 1,2-dichloroethane, acetone, and tetrachloroethene. On the basis of these results, VOCs were considered the primary constituents of potential concern (COPC) at Landfill No. 3. The 1998 groundwater data are included in this report.

A fill area definition report documented investigation activities at Landfill No. 3 (IT, 2002a). This was followed by an engineering evaluation/cost analysis that summarized the site characterization and provided a streamlined risk assessment (SRA) for human health and a screening-level ecological risk assessment (SLERA) in accordance with criteria of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (IT, 2002b).

The SRA evaluated surface soil, surface water, and sediment data previously collected by Science Applications International Corporation (SAIC), as well as the groundwater data collected by Shaw in 1998. A recreational site-user and resident were deemed the most appropriate receptor scenarios for current and future land use at Landfill No. 3. Although the streamlined (limited or qualitative) risk assessment described in guidance of the U.S. Environmental Protection Agency (EPA) for landfills is not identical to the SRA method using SSSLs that is generally performed for FTMC sites, the SRA method lends itself very well to the types of risk assessments prescribed in the landfill guidance. The SRA concluded that Landfill No. 3 poses no cancer risk or noncancer hazard to the recreational site-user. However, surface soil presents an unacceptable noncancer hazard to a resident, while the groundwater presents an unacceptable cancer risk to a resident. Future groundwater conditions were evaluated using current groundwater constituents of potential concern and total soil. The SRA concluded that further leaching is unlikely to result in unacceptable risk or hazard to future groundwater use by residents (IT, 2002b).

Additionally, the engineering evaluation/cost analysis presented the results of the SLERA, which evaluated surface soil, surface water, and sediment data collected by SAIC at Landfill No. 3. Constituents of potential ecological concern identified in the SLERA were metals, polynuclear aromatic hydrocarbons (PAH), and pesticides. It was concluded that low levels of constituents exceeding ecological screening values in surface soil, surface water, and sediment would not present significant ecological risk to the aquatic ecosystems at Landfill No. 3. This conclusion was primarily based on the low-quality aquatic habitat in the man-made drainage ditch along the western and northern boundaries of the landfill that are frequently dry during extended portions of the year (IT, 2002b).

In 2000, Shaw conducted a structural geology investigation of Landfill No. 3 (IT, 2000b). Three deep borings were drilled, and bedrock cores were collected to help determine the geological and hydrogeological influence of the bedrock structure on groundwater flow direction and contaminant movement in the vicinity of Landfill No. 3. In addition, the structural geology investigation aided in the placement of monitoring wells during subsequent supplemental RI field activities. A site-specific work plan, consisting of a monitoring well installation and field sampling plan (SFSP) and a site-specific safety and health plan, was finalized in April 2001 (IT, 2001). The work plan described monitoring well installation and groundwater sampling activities to further define the nature and extent of groundwater contamination. SFSP addenda for additional monitoring well installation and sampling activities were prepared in January 2002 (IT, 2002c) and November 2002 (IT, 2002d). The site-specific work plans were prepared to provide technical guidance for field investigation activities at Landfill No. 3 and were used as attachments to the installation-wide work plan (IT, 1998) and the installation-wide sampling and analysis plan (SAP) (IT, 2000c; IT, 2002e). The SAP includes the installation-wide safety and health plan and quality assurance plan.

Supplemental RI activities consisted of the installation and sampling of 29 monitoring wells at the landfill and surrounding area. A total of 220 groundwater samples were collected from the 29 newly installed wells, 18 existing wells at Landfill No. 3, and 5 off-site wells. In addition, fill area definition activities were performed and consisted of fill material boring installation and sampling and exploratory trenching. Other site-related activities included a wetland determination, a landfill gas investigation, and a water well and spring water survey.

1.2 Purpose and Objectives

The purpose of the supplemental RI activities was to delineate the nature and extent of groundwater contamination at Landfill No. 3 and vicinity and to monitor the contaminant plume. Environmental samples were collected from site media to provide a defensible level of data and information in sufficient detail to determine the nature and extent of groundwater contamination. Conclusions are based on the comparison of the analytical results to SSSLs and background screening values for FTMC. The SSSLs were developed by Shaw as part of human health and ecological risk evaluations associated with investigations being performed under the BRAC Environmental Restoration Program at FTMC. The SSSLs are presented in the *Final Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000a). Background metals screening values are presented in the *Final Background Metals Survey Report, Fort McClellan, Alabama* (SAIC, 1998).

1.3 Site Description and History

Landfill No. 3, Parcel 80(6), is located in the northwest corner of the Main Post (Figure 1-1). The landfill is bounded by woods near the Anniston-Jacksonville Highway (Route 21) to the west, Gobbler Road to the east, the Post boundary to the north, and Cave Creek farther to the south. A drainage ditch is located along the western and northern boundaries of Landfill No. 3. However, the ditch is apparently dry throughout the majority of the year and only transmits water during periods of significant rainfall. Landfill No. 4, Parcel 81(5), is adjacent to the southeast corner of Landfill No. 3 (Figure 1-2).

Landfill No. 3 was the Main Post sanitary landfill from 1946 to 1967 (ESE, 1998). The landfill was constructed using a series of 49 trenches that extend east-west across the site. The waste was placed in the trenches and subsequently covered with topsoil. A complete list of wastes disposed at Landfill No. 3 is not available; however, it has been reported that empty pesticide containers and burned ammunition pallets or crates were placed in the landfill (ESE, 1998). The pesticide containers were reportedly triple-rinsed prior to disposal. Other waste materials may have included paint containers, fluorescent bulbs and ballasts, waste oil, and construction debris (ESE, 1998). The landfill was not capped when it was closed in 1967, and settling is occurring. The landfill is currently covered with trees and thick vegetation.

The original Comprehensive Environmental Response Facilitation Act (CERFA) parcel boundary for Landfill No. 3 reportedly was 21 acres. However, based on the fill area definition activities conducted in 2000, including exploratory trenching and fill material boring activities, the fill area covers approximately 22.8 acres.

2.0 Previous Investigations

An EBS was conducted by ESE to document current environmental conditions of all FTMC property (ESE, 1998). The objective of the study was to identify sites that, based on available information, have no history of contamination and comply with DOD guidance for fast-track cleanup at closing installations. The EBS also provides a baseline picture of FTMC properties by identifying and categorizing the properties by seven criteria:

1. Areas where no storage, release, or disposal of hazardous substances or petroleum products has occurred (including no migration of these substances from adjacent areas).

2. Areas where only release or disposal of petroleum products has occurred.

3. Areas where release, disposal, and/or migration of hazardous substances has occurred, but at concentrations that do not require a removal or remedial response.

4. Areas where release, disposal, and/or migration of hazardous substances has occurred, and all removal or remedial actions to protect human health and the environment have been taken.

5. Areas where release, disposal, and/or migration of hazardous substances has occurred, and removal or remedial actions are underway, but all required remedial actions have not yet been taken.

6. Areas where release, disposal, and/or migration of hazardous substances has occurred, but required actions have not yet been implemented.

7. Areas that are not evaluated or require additional evaluation.

The EBS was conducted in accordance with CERFA protocols (Public Law 102-426) and DOD policy regarding contamination assessment. Record searches and reviews were performed on all reasonably available documents from FTMC, the Alabama Department of Environmental Management (ADEM), EPA Region 4, and Calhoun County, as well as a database search of substances regulated under CERCLA, petroleum products, and facilities regulated under the Resource Conservation and Recovery Act. Available historical maps and aerial photographs were reviewed to document historical land uses. Personal and telephone interviews of past and present FTMC employees and military personnel were conducted. In addition, visual site inspections were conducted to verify conditions of specific property parcels.

Landfill No. 3, Parcel 80(6), was classified as a CERFA Category 6 parcel in the EBS. Category 6 parcels are areas of known release, disposal, and/or migration of CERCLA-regulated hazardous substances, but required actions have not yet been implemented. Previous investigations have been conducted at Parcel 80(6) and are discussed below.

U.S. Army Environmental Hygiene Agency (1986). The U.S. Army Environmental Hygiene Agency (USAEHA) initiated groundwater monitoring at the site in 1986 with the installation of five monitoring wells (OLF-G01 through OLF-G05) along the perimeter of the landfill (Figure 2-1). Groundwater samples were collected from the wells and analyzed for VOCs, semivolatile organic compounds (SVOC), pesticides/polychlorinated biphenyls (PCB), and metals. Water quality parameters were also measured. Tetrachloroethene, methylene chloride, 1,1-dichloroethane, trans-1,2-dichloroethene, benzene, and bis(2-ethylhexyl)phthalate were detected in the samples at concentrations ranging from 4 to 110 micrograms per liter (μg/L) (SAIC, 1993).

SAIC Site Investigation (1992). In 1992, SAIC installed five monitoring wells (OLF-G06 through OLF-G10) and collected ten groundwater samples (five from existing wells and five from the newly installed wells). In addition, one surface water and sediment sample (OLF-W01/D01) was collected from Cave Creek, just southwest of Landfill No. 3. The samples were analyzed for VOCs, SVOCs, pesticides/PCBs, metals, explosives, and chemical warfare material (CWM) breakdown compounds. VOCs, SVOCs, pesticides, metals, and explosive compounds were detected in the groundwater samples. Two pesticides (alpha-hexachloro-cyclohexane [BHC] and isodrin) were detected in the surface water sample (OLF-W01). However, these compounds were also detected in an associated field blank or laboratory sample. CWM breakdown compounds were not detected in any of the samples. Based upon the site investigation data collected, an RI was deemed necessary (SAIC, 1995).

SAIC Remedial Investigation (1994-1995). In 1994 and 1995, eight additional monitoring wells were installed at Landfill No. 3. Five wells (OLF-G11, OLF-G13, OLF-G15, OLF-G16, and OLF-G17) were installed in 1994 and three wells (OLF-G12, OLF-G18, and OLF-G19) were installed within the median of Alabama State Highway 21 in February and March 1995 (Figure 2-1). Monitoring well OLF-G14 was not installed because an existing well LF4-MW01 (located between Landfill No. 3 and Landfill No. 4) was present at that location. Groundwater samples were collected from 19 monitoring wells (ten existing wells, eight newly installed wells, and LF4-MW01). Groundwater samples were analyzed for VOCs, SVOCs, metals, pesticides/PCBs, explosives, and CWM breakdown compounds. Metals, VOCs, SVOCs, and pesticides were detected in groundwater. VOCs detected in groundwater included chlorobenzene (OLF-G08), 1,1-dichloroethane (OLF-G04), trichloroethene (OLF-G06 and OLF-G12), 1,1,2,2-tetrachloroethane (OLF-G04 and OLF-G07), and pentachlorophenol (OLF-G07, OLF-G08, OLF-G09, OLF-G12, and OLF-G15) (SAIC, 2000).

Twelve soil samples were collected from eight sample locations (OLF-S11, OLF-S13, OLF-S16, OLF-S17, OLF-S20, OLF-S21, OLF-S22, and OLF-S23) at Landfill No. 3 (Figure 2-1). The exact locations of four samples (OLF-S11, OLF-S13, OLF-S16, and OLF-S17) could not be determined from available SAIC documents. Surface soil samples were analyzed for VOCs, SVOCs, metals, pesticides/PCBs, and explosives. VOCs, metals, pesticides, and PAH compounds were detected in the soil samples.

Metals detected in surface soil samples included arsenic (2.9 to 9.1 micrograms per gram [μg/g]) in samples OLF-S17 and OLF-S22 and mercury (0.11 μg/g) in sample OLF-S22. PAH compounds were detected in surface soil samples within the landfill, including benzo(a)anthracene (0.80 to 0.12 μg/g), chrysene (0.08 to 0.63 μg/g), fluoranthene (0.12 to 0.89 μg/g), phenanthrene (0.87 to 0.23 μg/g), and pyrene (0.21 to 1.2 μg/g) (SAIC 2000). The pesticides 4,4'-dichlorodiphenyldichloroethane (DDD), 4,4'-dichlorodiphenyldichloroethene (DDE), and chlordane were detected at soil sample locations OLF-S11, OLF-S13, and OLF-S21. Metals, one pesticide (4,4'-DDE), and one SVOC (benzyl alcohol) were detected in subsurface soils.

Four surface water samples (OLF-W02 through OLF-W05) were collected at Landfill No. 3 (Figure 2-1). One sample (OLF-W02) was collected southwest of the landfill where Cave Creek exits FTMC. The remaining three surface water samples (OLF-W03, OLF-W04, and OLF-W05) were collected from the intermittent drainage ditch along the northern and western landfill boundary. Surface water samples were analyzed for VOCs, SVOCs, biological oxygen demand, metals, pesticides/PCBs, CWM breakdown products, and explosive compounds. Constituents detected in surface water included lead (70.8 μg/L) in OLF-W05, 1,1,1-trichloroethane (1.2 and 6.2 μg/L) in OLF-W03 and OLF-W04, respectively, trichloroethene (1.3 μg/L) in OLF-W04, and a total of three pesticides in OLF-W01, OLF-W03, and OLF-W04.

Sediment samples were collected from two locations (OLF-D02 and OLF-D03) (Figure 2-1). Sediment samples were analyzed for VOCs, SVOCs, pesticides/PCBs, metals, and explosive compounds. Several metals were detected in both samples. PAHs were detected in OLF-D02 and one pesticide (4,4'-DDE) was detected in OLF-D03.

Based on the results of the RI, including a human health baseline risk assessment and a SLERA, SAIC recommended delineation of the off-Post component of groundwater contamination and identification of potential non-landfill sources (SAIC, 2000).

3.0 Study Area Investigation

3.1 Introduction

This chapter summarizes field investigation activities conducted by Shaw at Landfill No. 3, Parcel 80(6), including a structural geology investigation, environmental sampling and analysis, groundwater monitoring well installation, and fill area definition activities. Shaw conducted supplemental RI field activities in several phases from 2000 to 2003:

- Structural Geology Investigation in 2000 – (IT, 2000b)
- Phase I for the supplemental RI in 2001 – (IT, 2001)
- Phase II for the supplemental RI in 2002 – (IT, 2002c)
- Phase III for the supplemental RI in 2003 – (IT, 2002d).

Other site-related activities, including a wetland determination, a landfill gas investigation, and a water well and spring user survey, are also discussed in this chapter.

3.1.1 Structural Geology Investigation

The purpose of the structural geology investigation was to evaluate the potential influence of the bedrock structure on groundwater flow direction and contaminant movement in the vicinity of Landfill No. 3. Results from the investigation were used to aid in the placement of groundwater monitoring wells. Three borings (GS80-SB01, GS80-SB02, and GS80-SB03), ranging in depth from 228 to 282 feet below ground surface (bgs), were drilled to acquire bedrock cores. The spatial distribution of the borings was staggered to obtain optimum information on local dip and bedrock structure. The three borings were logged using borehole geophysical logging techniques, including caliper logging, natural gamma ray logging, resistivity logging, and acoustic televiewer logging. The structural geology investigation was conducted in April and May 2001. The results of the structural geology investigation are briefly discussed in Chapter 4.0 of this report and are described in detail in Appendix A of the *Final Site-Specific Groundwater Monitoring Well Installation and Field Sampling Plan Attachment, Landfill No. 3, Parcel 80(6), Fort McClellan, Calhoun County, Alabama* (IT, 2001).

3.1.2 Supplemental RI (Phase I)

Nine monitoring wells (OLF-G20 through OLF-G28) were installed and 29 groundwater samples were collected from 15 existing wells, 9 newly installed wells, and monitoring well LF4-MW01. Groundwater samples were also collected from two City of Weaver wells (Weaver No. 2 and No. 3) and two private wells (Medders and Lowery wells). Four monitoring wells (OLF-G21, OLF-

G22, OLF-G23, and OLF-G24) were installed in the median of Alabama State Highway 21, two monitoring wells (OLF-G25 and OLF-G26) in a City of Anniston church parking lot, two monitoring wells (OLF-G27 and OLF-G28) within the City of Weaver right-of-way along Blarney Drive, and one well (OLF-G20) on Army property, west of Landfill No. 3 (Figure 3-1). The nine monitoring wells were installed from May through July 2001, and groundwater sample collection was completed in August 2001. Borehole geophysical logging was conducted on six wells (OLF-G20, OLF-G21, OLF-G22, OLF-G23, OLF-G25 and OLF-G27) using caliper logging, natural gamma ray logging, resistivity logging, and dipmeter logging. The borehole geophysical logs are presented in Appendix A.

3.1.3 Supplemental RI (Phase II)

The supplemental RI demonstrated the need to further define the extent of contamination (namely, chlorinated VOCs) in groundwater. Therefore, additional investigative activities were conducted in 2002 that included the installation of ten monitoring wells (OLF-G29 through OLF-G38). The proposed field activities and monitoring well installation rationale were discussed and agreed upon at the December 2001 BRAC Cleanup Team (BCT) meeting. Drilling of the monitoring wells began in January 2002, and well installation was completed in May 2002. Five of the wells (OLF-G29, OLF-G30, OLF-G31, OLF-G32, and OLF-G33) were installed on private property (Brown property), four wells (OLF-G33, OLF-G34, OLF-G35, and OLF-G36) within the median of State Highway 21, and one well (OLF-G38) on Army property north of Landfill No. 3. Groundwater sampling of the 10 newly installed wells and 25 existing wells at Parcel 80(6) was conducted in April and May 2002. Samples were not collected from wells OLF-G06 and OLF-G16 because these wells did not produce enough water. Monitoring well OLF-G07 was resampled on July 2, 2002, to confirm VOC results. In addition, groundwater samples were collected from the two City of Weaver wells (Weaver No. 2 and No. 3). Prior to well installation, borehole geophysical logging was conducted at seven well locations (OLF-G30, OLF-G32, OLF-G34, OLF-G35, OLF-G36, OLF-G37, and OLF-G38). Borehole geophysical logs are presented in Appendix A.

3.1.4 Supplemental RI (Phase III)

Phase III activities were conducted to further delineate the extent of chlorinated VOCs in groundwater. The proposed field activities and monitoring well installation rationale were discussed and agreed upon at the September and October 2002 BCT meetings. Ten additional monitoring wells (OLF-G39 through OLF-G48) were installed at Landfill No. 3 and surrounding off-site properties. Six of the monitoring wells (OLF-G39, OLF-G40, OLF-G41, OLF-G42, OLF-G45, and OLF-G46) were installed on Army property surrounding Landfill No. 3, two wells (OLF-G43 and OLF-G44) were installed on Midway Lane (one on the City of Anniston right-of-way and one on private property), and the remaining two wells (OLF-G47 and OLF-G48) were installed within the median of State Highway 21. Prior to installing the monitoring wells, borehole geophysical logging was conducted at six well locations (OLF-G39, OLF-G40, OLF-G41, OLF-G44, OLF-G46, and OLF-G48). Borehole geophysical logs are presented in Appendix A. Monitoring well drilling began in January 2003 and was completed in June 2003. During drilling activities, discrete groundwater samples were collected from six well locations (OLF-G39, OLF-G40, OLF-G41, OLF-G44, OLF-G46 and OLF-G48). Groundwater sampling of the 10 newly installed wells and 36 existing wells was conducted from April through June 2003. In addition, groundwater samples were collected from the two City of Weaver wells (Weaver No. 2 and No. 3) and one privately owned well (Lowery well). An insufficient volume of groundwater was present in monitoring well OLF-G16; therefore, a groundwater sample was not collected. It should be noted that a groundwater sample was collected from a second private well (Waldrop well) on July 14, 2003.

3.2 Environmental Sampling

Environmental sampling performed during the supplemental RI at Parcel 80(6) included the collection of groundwater samples (including discrete screening samples) and fill material soil samples for chemical analysis. Sample locations were determined by observing site physical characteristics during site walkovers, reviewing historical documents pertaining to historical site activities, and based on previous investigation results at Parcel 80(6). The structural geology investigation provided detailed information for placement of groundwater monitoring wells. The sample locations, media, and rationale are summarized in Table 3-1. Sampling locations are shown on Figure 3-1. Samples were submitted for laboratory analysis of site-related parameters listed in Section 3.8.

3.2.1 Discrete Groundwater Sampling

As part of the Phase III supplemental RI, discrete groundwater samples were collected from six monitoring well locations (OLF-G39, OLF-G40, OLF-G41, OLF-G44, OLF-G46, and OLF-G48) for screening purposes. The samples were typically collected at 20-foot intervals, although the interval was adjusted during drilling operations at the discretion of the Shaw site manager and field geologist due to formation collapse, changes in lithology, etc. The discrete groundwater analytical results were used to provide vertical contaminant profiling to aid in the appropriate and accurate placement of the permanent well screens. The permanent well screens were placed at depths to determine the lateral and vertical extent of groundwater contamination. The sample locations and rationale are included in Table 3-1.

At each well location, the borehole was advanced using a 4- or 6-inch diameter sonic core barrel, 10 or 20 feet at a time. The inner core barrel acted as both the center bit and sampler. An outer 6-inch or 8-inch temporary sonic casing was advanced over the inner core to hold the boring open. For discrete groundwater sampling, the inner core was mechanically raised by the drill head and a 5- or 10-foot long, 2-inch inside diameter (ID) stainless-steel screen was set at the bottom of the borehole with the lead rod and a K-packer. The outer casing was mechanically vibrated back 10 or 20 feet, exposing the screen to the formation and allowing groundwater to infiltrate into the screen. Groundwater samples were collected through a decontaminated stainless-steel submersible pump equipped with a Teflon®-coated polyethylene discharge line and with an inflatable packer above the pump to seal off the upper casing. The pump was lowered to the top of the lead rod (approximately 5 or 10 feet long by 3.5 inches diameter) to keep excessive sediment out of the screen when the casing was pulled back. The K-packer was attached to the upper end of the lead rod to prevent sand from entering the space between the screen and drill casing.

Prior to collecting a discrete groundwater sample, five volumes of water were removed from the isolated sampling zone. However, in sampling zones of slow groundwater recharge, a minimum of one volume of groundwater was removed. Groundwater samples were screened for field parameters including pH, temperature, and specific conductivity, and a representative sample was sent to an off-site laboratory for a 24 to 48-hour turnaround time for VOC analysis. The entire sampling device was retrieved with a wire line and overshot coupler. Discrete groundwater sampling results are discussed in Chapter 5.0. Sample collection logs are included in Appendix B.

3.2.2 Monitoring Well Installation

A total of 29 monitoring wells, including 5 residuum/transition wells and 24 bedrock wells, were installed at Landfill No. 3, Parcel 80(6). The monitoring well locations are shown on Figure 3-1, and the well construction details are summarized in Table 3-2. The well construction logs are presented in Appendix A.

3.2.2.1 Residuum Monitoring Wells

The 5 residuum/transition monitoring wells (OLF-G24, OLF-G26, OLF-G28, OLF-G40, and OLF-G41) were installed using a rotosonic drill rig. During Phase I of the supplemental RI, three wells (OLF-G24, OLF-G26, and OLF-G28) were drilled using a 6-inch core barrel with 8-inch temporary casing and sonic bit. During Phase III, two wells (OLF-G40 and OLF-G41) were drilled using a 4-inch core barrel and 6-inch temporary casing and sonic bit. The wells were installed in accordance with procedures outlined in the SAP.

A four-inch monitoring well was installed at each location. The well casing consisted of 4-inch ID, threaded, flush-joint, Schedule 80 polyvinyl chloride (PVC) pipe. A 15- or 20-foot section of threaded, flush joint, 0.010-inch continuous wrap PVC well screen was attached to the bottom of the well casing and a sump (or 4-inch end cap), approximately 5 feet long, was attached to the bottom of the screen. After the casing and screen materials were lowered into the boring, a filter pack consisting of Number 1 filter sand (environmentally safe, clean fine sand, sieve size 20 to 40) was tremied into place from the bottom of the sump (or end cap) to approximately 5 feet above the top of the screen. A minimum 5-foot-thick extra-fine sand seal (sieve size 30 to 65) was tremied on top of filter sand. A minimum 5-foot-thick bentonite seal was placed on top of the extra fine sand seal. The remaining annular space was grouted with a bentonite-cement mixture tremied in place from the top of the bentonite seal to ground surface.

Two residuum/transition wells (OLF-G40 and OLF-G41) installed during Phase III were constructed using the procedures for bedrock wells described in Section 3.2.2.2. However, both wells are categorized as residuum\bedrock (transition) wells because of alternating zones of highly weathered clay, shale, dolomite, and mudstone encountered during drilling. Discrete groundwater samples were collected at 20-foot intervals during drilling activities using a single- or double-packer system. The methodology was previously described in Section 3.2.1. The exact depth of the well and screen interval was based upon the discrete groundwater results and geologic material present. The well casing consisted of 2.5-inch ID, threaded, flush-joint, Schedule 80 PVC casing. A 20-foot section of threaded, flush joint, 0.010-inch continuous wrap PVC well screen was attached to the bottom of the PVC casing.

3.2.2.2 Bedrock Monitoring Wells

Twenty-four bedrock monitoring wells were installed during the field investigations using a combination of hollow-stem auger, air rotary, ODEX® (or other hammer bit), and rotosonic drilling techniques, following procedures outlined in the SAP.

The 6 bedrock monitoring wells (OLF-G20, OLF-G21, OLF-G22, OLF-G23, OLF-G25, OLF-G27) installed during Phase I of the supplemental RI were installed using a combination of rotosonic drilling and bedrock coring techniques, following procedures outlined in the SAP. Prior to installing the bedrock monitoring wells, subsurface soil samples were collected using a

6-inch diameter sonic core barrel with an 8-inch diameter temporary sonic casing until competent bedrock was reached. The 6-inch core barrel acted as both the center bit and sampler. Soil samples were collected continuously from ground surface to the top of competent bedrock to provide a detailed lithologic log (Appendix A). Soil samples were retrieved in 5- or 10-foot sections and placed in clear plastic sleeves. No soil samples were submitted for laboratory analysis.

The borehole at each location was over-drilled with a 10-inch temporary casing and sonic bit 5 feet into competent bedrock. Nominal 8-inch carbon steel International Pipe Standard outer casing was installed through the 10-inch temporary casing and grouted in place. After the grout had cured for a minimum of 48 hours, bedrock coring commenced from the bottom of the 8-inch outer casing until the target depth was reached. Continuous bedrock coring was performed with a PQ wireline triple-tube core barrel with a longitudinally split inner tube. Bedrock cores were described in accordance with methods outlined in USACE South Atlantic Division Manual DM 1110-1-1 (USACE, 1983). After bedrock coring, the borehole was reamed with a 7⅞-inch sonic core bit to the total depth of the borehole.

A four-inch monitoring well was installed through the 8-inch outer casing at each location. The well casing consisted of 4-inch ID, threaded, flush-joint, Schedule 80 PVC pipe. A 10- to 20-foot section of threaded, flush joint, 0.010-inch continuous wrap PVC well screen was attached to the bottom of the PVC well casing, and a sump approximately 5 feet long was attached to the bottom of the screen. After the casing and screen materials were lowered into the boring, a filter pack consisting of Number 1 filter sand (environmentally safe, clean fine sand, sieve size 20 to 40) was tremied into place from the bottom of the sump to approximately 5 feet above the top of the screen. A Number 0 extra fine sand seal (sieve size 30 to 65), approximately 5 feet thick, was tremied in place on top of the filter pack. A minimum 5-foot- thick bentonite seal was tremied in placed on top of the extra fine sand seal. The remaining annular space was grouted with a bentonite-cement mixture tremied in place from the top of the bentonite seal to ground surface.

Ten bedrock wells were installed during Phase II of the supplemental RI. Five of the wells (OLF-G29, OLF-G30, OLF-G31, OLF-G32, and OLF-G37) were installed on private property, and four wells (OLF-G33, OLF-G34, OLF-G35, and OLF-G36) were installed in the median of State Highway 21. Bedrock well OLF-G38 was installed north of Landfill No. 3 on Army property, adjacent to existing monitoring well OLF-G15.

The four wells in the median of Highway 21 were installed using a rotosonic drill rig. The drilling and well installation activities essentially followed procedures outlined above, except two monitoring wells (OLF-G33 and OLF-G34) were installed as single-cased wells without the use of 10-inch temporary sonic casing and 8-inch outer casing.

Shaw contracted Miller Drilling Company to install the remaining 6 wells (OLF-G29, OLF-G30, OLF-G31, OLF-G32, OLF-G37, and OLF-G38) using a combination of hollow-stem auger, bedrock coring, air-rotary, and ODEX drilling techniques. The boreholes at two locations (OLF-G30 and OLF-G38) were advanced with a 4¼-inch ID hollow-stem auger from ground surface to top of competent bedrock. During hollow-stem auger drilling, a 2-foot long, 2-inch ID carbon steel split spoon sampler was driven at 5-foot intervals to collect residuum for observing and describing lithology. The split-spoon samplers were logged to determine lithologic changes and approximate depth of groundwater encountered during drilling. The on-site geologist constructed a detailed lithologic log for each soil boring (Appendix A). Soil characteristics were described using the "Burmeister Identification System" described in Hunt (1986) and the Unified Soil Classification System as outlined in the American Society for Testing and Materials (ASTM) Method D 2488 (ASTM, 2000). Upon refusal on bedrock, an air-rotary rig equipped with an 8-inch ODEX percussion bit was used to advance 8-inch outer casing 5 feet into competent bedrock. The 8-inch outer casing was grouted in place using procedures previously described. Bedrock coring was performed from the bottom of the 8-inch outer casing to the target depth. Continuous coring was performed with a PQ wireline triple-tube core barrel with a longitudinally split inner tube. Bedrock cores were described using methods in USACE manual DM 1110-1-1 (USACE, 1983). An air-rotary rig equipped with a 7⅝-inch or 7⅞-inch percussion bit or roller bit was used to ream the borehole to the total depth. Monitoring wells OLF-G29, OLF-G31, OLF-G32, and OLF-G37 were drilled using the same techniques, except split-spoon soil samples and bedrock core samples were not collected. During air rotary drilling, the on-site geologist logged the drill cuttings and provided a detailed description from the drill cuttings as drilling progressed to the target depth. Four-inch PVC monitoring wells were installed through the 8-inch outer casing at each location, as previously described.

Eight bedrock monitoring wells (OLF-G39, OLF-G42, OLF-G43, OLF-G44, OLF-G45, OLF-G46, OLF-G47, and OLF-G48) were installed during Phase III using a combination of rotosonic drilling with sonic coring techniques. Continuous coring using a PQ wireline triple-tube core barrel with a longitudinally split inner tube was attempted at two wells (OLF-G46 and OLF-G48). However, the bedrock was extremely weathered, fractured, and broken, which prevented accurate core recovery. Therefore, PQ wireline coring was discontinued and rotosonic coring was used to the target depth. The monitoring wells were installed using a 4-inch sonic core barrel with 6-inch temporary sonic casing. Discrete groundwater samples were collected during drilling operations at four wells (OLF-G39, OLF-G44, OLF-G46, and OLF-G48) using a single or double-packer system described in Section 3.2.1. The monitoring wells were installed using essentially the same procedures described above, except that the wells were single-cased, consisting of 2.5-inch ID, threaded, flush-joint, Schedule 80 PVC pipe. A 2.5-inch ID, 0.010-inch continuous wrap PVC well screen, 15 or 20 feet long, was attached to the bottom of the PVC casing.

3.2.3 Well Development

The monitoring wells were developed by surging and pumping with a submersible pump in accordance with methodology outlined in the SAP. The submersible pump used for well development was moved in an up-and-down fashion to encourage any residual well installation materials to enter the well. These materials were then pumped out of the well to re-establish the natural hydraulic flow conditions. Development continued until the water turbidity was less than or equal to 20 nephelometric turbidity units (NTU), for a maximum of 12 hours, or until the well was repeatedly pumped dry and allowed to recover. The well development logs are included in Appendix C.

3.2.4 Water Level Measurements

The depth to groundwater was measured in the wells at Landfill No. 3 and vicinity on several occasions, following procedures outlined in the SAP. Water level measurements were collected following procedures outlined in the SAP. Depth to groundwater was measured with an electronic water-level meter. The meter probe and cable were cleaned before use at each well following decontamination methodology presented in the SAP. Measurements were referenced to the top of the PVC well casing, as summarized in Table 3-3.

3.2.5 Groundwater Sampling

A total of 220 groundwater samples were collected from 52 wells at Landfill No. 3 and vicinity, including 47 monitoring wells, 2 City of Weaver wells (Weaver No. 2 and No. 3), and 3 private wells (Lowery well, Medders well, and Waldrop well). All monitoring wells were sampled at least twice, except monitoring wells OLF-G06 and OLF-G13, which were sampled once each, and OLF-G16. Monitoring well OLF-G16 was consistently dry or had an insufficient volume of groundwater and therefore was not sampled. The groundwater sample locations and rationale are listed in Table 3-1, and the sample designations and analytical parameters are listed in Table 3-4.

Sample Collection. At all wells except the Weaver wells, the groundwater samples were collected using a mechanical pump (i.e., a peristaltic, bladder, or centrifugal pump equipped with Teflon tubing) and/or a Teflon bailer, following procedures outlined in the SAP. Samples for VOC analysis were collected using either a Teflon bailer or a peristaltic pump via the "tube evacuation" method described in the SAP (IT, 2002e). Groundwater was sampled after purging a minimum of three well volumes and after field parameters (i.e., temperature, pH, dissolved oxygen, specific conductivity, oxidation-reduction potential, and turbidity) stabilized. Field parameters were measured using a calibrated water-quality meter. Field parameter readings are summarized in Table 3-5. The Weaver wells were sampled by collecting water from a spigot connection on the wellhead after purging for approximately 10 minutes. Sample collection logs are included in Appendix B. The samples were analyzed for the parameters listed in Table 3-4 using methods outlined in Section 3.8.

3.3 Fill Area Definition Activities

Shaw conducted fill area definition activities at Landfill No. 3 in March 2000 to determine the extent of waste fill and to characterize the fill material. Field activities consisted of installing soil borings within the fill and performing exploratory trenching. The fill material boring and trench locations are shown on Figure 3-1.

3.3.1 Trenching

Five exploratory trenches (T80-1 through T80-5) were excavated at Landfill No. 3 to characterize the horizontal and vertical extent of the fill material. Trenches were excavated to depths ranging from 5 to 15 feet bgs at the locations shown on Figure 3-1. Trench locations T80-1 and T80-2 were used to further characterize the fill material within the landfill. Trenches T80-3, T80-4, and T80-5 were completed to further characterize the southern horizontal extent of the fill area.

Trenching activities were conducted in Level C personal protective equipment (PPE). Trenches were excavated using a track-mounted excavator with a bucket approximately 3 feet wide. Soil and fill materials were stockpiled adjacent to the trench to allow field personnel access for inspection. The on-site geologist recorded the soil lithology and fill material observed in the trenches. Upon completion of inspection of the soil and fill materials, the trenches were backfilled with the excavated material and compacted with the excavator. The trench locations are shown on Figure 3-1 and the trench logs are presented in Appendix A. The trench data are summarized in Table 3-7.

Fill material was observed in all the trenches and included plastic sheeting, glass, wood, paper, metal cans, electrical wire, bricks, shaving cream bottles/cans, scrap metal, cloth, 55-gallon drum lids, beer cans/bottles, ash, tin cans, aluminum foil, newspaper, two metal chairs, cardboard, aerosol cans, concrete, medical bottle with septum, light bulbs, bones, shoes, metal bucket, steel rebar, building tiles, cinder blocks, and concrete bollards shaped like bombs.

Based on the results of the exploratory trenching at Landfill No. 3, the southern horizontal extent of the waste fill was redefined. The fill area boundary is estimated to be 22.8 acres. The maximum fill depth was 15 feet bgs in Trench T80-3.

3.3.2 Fill Material Borings

Five soil borings (FA-80-SB01 through FA-80-SB05) were advanced using an all-terrain vehicle drill rig to determine the vertical extent of fill. Soil borings were installed to depths ranging from 14 to 24 feet bgs. Soil samples were collected from each of the borings at depths ranging from 8 to 22 feet bgs in the unsaturated zone. The borings were advanced and soil samples collected using a direct-push technology sampling system, following procedures specified in the SAP. The boring logs are included in Appendix A, and the sample collection logs are included in Appendix B. The samples were analyzed for the parameters listed in Table 3-6 using methods outlined in Section 3.8. Fill material boring information is summarized in Table 3-8.

3.4 Wetland Determination

An assessment of wetlands located within approximately 200 feet outside the perimeter of Landfill No. 3 was performed in December 2002. The wetland determination was conducted in accordance with the *Corps of Engineers Wetlands Delineation Manual* (USACE, 1987) to determine the extent of federally regulated jurisdictional wetlands and waters of the United States. The USACE-Mobile District approved the wetland determination for a 5-year period on April 2, 2003.

The entire creek channel around the western and northern boundaries of the fill area was identified as jurisdictional waters of the United States. A forested wetland area that drains into the creek channel was also identified southwest of the fill area. Pooled water in depressional troughs was observed on top of the fill area. Some isolated, nonjurisdictional wetland pockets were also observed on the fill area. Detailed information on the wetlands study is provided in the *Wetland Determination, Landfills and Fill Areas, Fort McClellan, Calhoun County, Alabama* (Shaw, 2003a).

3.5 Water Well and Spring User Survey

Shaw performed a water well and spring user survey to identify the location and use of active and inactive water supply wells and springs north of Landfill No. 3. A total of 20 wells and three springs were identified within an approximately one-mile radius of Landfill No. 3. Four of these wells and one spring are used for potable water. Closer to the landfill, six wells were identified within approximately 1,600 feet of Landfill No. 3, but none are used for potable water. The results of the survey are provided in Appendix D.

3.6 Landfill Gas Investigation

Shaw performed a landfill gas investigation at Landfill No. 3, Parcel 80(6), in June and October 2003. Field activities included surface emissions screening (using a flame ionization detector), subsurface soil gas screening, and screening of nearby monitoring wells and storm drains (i.e., within 200 feet of the perimeter of the landfill) for the presence of landfill gases. In addition, a gas sample was collected from the subsurface soil screening location with the highest measured concentration of methane to confirm the presence of volatile compounds detected during screening activities.

The surface emissions screening at Parcel 80(6) did not indicate the presence of any VOCs along the perimeter or above the surface of the landfill. Methane was not detected in any of the nearby monitoring wells or storm drains. Methane was detected at a trace level at one subsurface soil gas screening location. A subsurface soil gas sample was collected from this location in October 2003. The analytical results revealed very low concentrations of three VOCs. It was concluded that further landfill gas investigation is not warranted at Landfill No. 3, based on the age of the landfill and the absence of methane. Detailed information on the landfill gas screening methodology, sample locations, and results is provided in the *Landfill Gas Investigation Report, Landfills and Fill Areas, Parcels 78(6), 79(6), 80(6), 227(7), 126(7), and 229(7), Fort McClellan, Calhoun County, Alabama* (Shaw, 2003b).

3.7 Surveying of Sample Locations

Sample locations were surveyed using global positioning system and conventional civil survey techniques described in the SAP. Horizontal coordinates were referenced to the U.S. State Plane Coordinate System, Alabama East Zone, North American Datum of 1983. Elevations were referenced to the North American Vertical Datum of 1988. Horizontal coordinates and elevations are included in Appendix E.

3.8 Analytical Program

Samples collected during the field investigations were analyzed for various chemical parameters based on potential site-specific chemicals historically at the site and EPA, ADEM, FTMC, and USACE requirements. Target analyses for groundwater samples collected at Landfill No. 3 included the following parameters using EPA SW-846 methods, including Update III methods where applicable:

- Target analyte list metals – EPA Methods 6010B/7000
- Target compound list (TCL) VOCs – EPA Method 8260A/B
- TCL SVOCs – EPA Method 8270B/C
- Nitroaromatic and nitramine explosives – EPA Method 8330
- Pesticides/PCBs – EPA Method 8081
- Chlorinated pesticides – EPA Method 8081A
- Chloride, nitrate, phosphate, and sulfate – EPA Method 300.0
- Alkalinity – EPA Method 310.1
- Total dissolved solids – EPA Method 160.2.

Groundwater samples collected during the Phase II and Phase III investigations were analyzed for VOCs only using EPA Method 8260B.

The fill material soil samples were analyzed for the following parameters:

- TCL VOCs – EPA Method 8260B
- TCL SVOCs – EPA Method 8270C
- Target analyte list metals – EPA Method 6010B/7471A
- PCBs – EPA Method 8082
- Chlorinated pesticides – EPA Method 8081A
- Organophosphorus pesticides – EPA Method 8141A
- Chlorinated herbicides – EPA Method 8151A
- Nitroaromatic and nitramine explosives – EPA Method 8330.

3.9 Sample Preservation, Packaging, and Shipping

Sample preservation, packaging, and shipping followed requirements specified in the SAP. Sample containers, sample volumes, preservatives, and holding times for the analyses performed in this investigation are listed in the SAP. Sample documentation and chain-of-custody records were completed as specified in the SAP.

Completed analysis request and chain-of-custody records (Appendix B) were included with each shipment of sample coolers to either Quanterra Environmental Services in Knoxville, Tennessee, or EMAX Laboratories, Inc. in Torrance, California. Discrete groundwater samples were shipped to Accura Analytical Laboratory, Inc. in Norcross, Georgia.

3.10 Investigation-Derived Waste Management and Disposal

Investigation-derived waste (IDW) was managed and disposed as outlined in the SAP. The IDW generated during the field investigations at Landfill No. 3, Parcel 80(6), was segregated as follows:

- Soil boring cuttings
- Decontamination fluids and purge water from well development and sampling
- PPE and spent well materials.

Solid IDW was stored in lined roll-off bins at Landfill No. 3 or inside the fenced area surrounding the Shaw field office at FTMC prior to characterization and final disposal. Solid IDW was characterized using toxicity characteristic leaching procedure analysis. Based on the results, drill cuttings, spent well materials, and PPE generated during the field activities were disposed as nonhazardous waste at either the FTMC Industrial Waste Landfill (prior to January 2002) or the Three Corners Landfill located in Piedmont, Alabama.

Liquid IDW generated prior to September 2002 was contained in the 20,000-gallon sump associated with the Building T-338 vehicle washrack. Liquid IDW was characterized by VOC, SVOC, and metals analyses. Based on the analyses, liquid IDW was discharged as nonhazardous waste to the FTMC Wastewater Treatment Plant on the Main Post.

The on-site treatment of IDW was discussed and approved by ADEM at the FTMC BCT meeting on September 18-19, 2002. Liquid IDW generated after September 18, 2002, was contained in a 20,000-gallon frac tank or sump associated with the Building 202 vehicle washrack. Authorization to discharge IDW water onto the ground surface, following carbon treatment, sampling, and review of the analyses by the ADEM Water Quality Division, was a secondary option. If the analytical results indicated nondetectable levels of VOCs, IDW water was discharged onto the ground surface. However, if the analyses indicated VOCs were present, then the IDW was discharged into the City of Anniston's Wastewater Treatment Plant. Liquid IDW was characterized by VOC, SVOC, and metals analyses. IDW analytical results are maintained at the Shaw field office at FTMC.

3.11 Variances and Nonconformances

Ten variances to the SFSPs were recorded during completion of the field investigation at Landfill No. 3, Parcel 80(6). The variances did not alter the intent of the investigation or the sampling rationale presented in the SFSPs. The variances are summarized in Table 3-9, and the variance reports are included in Appendix F.

No nonconformances to the SFSP were recorded during completion of the investigation.

3.12 Data Quality

The field sample analytical data are presented in tabular form in Appendix G. The field samples were collected, documented, handled, analyzed, and reported in a manner consistent with the site-specific work plans, the FTMC SAP and quality assurance plan, and standard, accepted methods and procedures. Data were reported and evaluated in accordance with USACE South Atlantic Savannah Level B criteria (USACE, 2001) and the stipulated requirements for the generation of definitive data presented in the SAP. Chemical data were reported by the laboratory via hard-copy data packages using Contract Laboratory Program-like forms.

Data Validation. The reported analytical data (excluding the discrete groundwater sample data) were validated in accordance with EPA National Functional Guidelines by Level III criteria. The data validation summary reports are presented in Appendix H. Selected results were rejected or otherwise qualified based on the implementation of accepted data validation procedures and practices. These qualified parameters are highlighted in the reports. The validation-assigned qualifiers were added to the FTMC ShawView™ database for tracking and reporting. The data presented in this report, except where qualified, meet the principle data quality objective for this investigation.

4.0 Site Characterization

This chapter presents information on regional and site-specific geology and hydrogeology at Landfill No. 3, Parcel 80(6).

4.1 Regional and Site Geology

4.1.1 Regional Geology

Calhoun County includes parts of two physiographic provinces: the Piedmont Upland Province and the Valley and Ridge Province. The Piedmont Upland Province occupies the extreme eastern and southeastern portions of the county and is characterized by metamorphosed sedimentary rocks. The generally accepted range in age of these metamorphics is Cambrian to Devonian.

The majority of Calhoun County, including the Main Post of FTMC, lies within the Appalachian fold-and-thrust structural belt (Valley and Ridge Province), where southeastward-dipping thrust faults with associated minor folding are the predominant structural features. The fold-and-thrust belt consists of Paleozoic sedimentary rocks that have been asymmetrically folded and thrust-faulted, with major structures and faults striking in a northeast-southwest direction.

Northwestward transport of the Paleozoic rock sequence along the thrust faults has resulted in the imbricate stacking of large slabs of rock referred to as thrust sheets. Within an individual thrust sheet, smaller faults may splay off the larger thrust fault, resulting in imbricate stacking of rock units within an individual thrust sheet (Osborne and Szabo, 1984). Geologic contacts in this region generally strike parallel to the faults, and repetition of lithologic units is common in vertical sequences. Geologic formations within the Valley and Ridge Province portion of Calhoun County have been mapped by Warman and Causey (1962), Osborne and Szabo (1984), and Moser and DeJarnette (1992) and vary in age from Lower Cambrian to Pennsylvanian.

The basal unit of the sedimentary sequence in Calhoun County is the Cambrian Chilhowee Group. The Chilhowee Group consists of the Cochran, Nichols, Wilson Ridge, and Weisner Formations (Osborne and Szabo, 1984), but in Calhoun County it is either undifferentiated or divided into the Cochran and Nichols Formations and an upper, undifferentiated Wilson Ridge and Weisner Formation. The Cochran is composed of poorly sorted arkosic sandstone and conglomerate with interbeds of greenish gray siltstone and mudstone. Massive to laminated greenish gray and black mudstone makes up the Nichols Formation, with thin interbeds of siltstone and very fine-grained sandstone (Osborne et al., 1988). These two formations are mapped only in the eastern part of the county.

The Wilson Ridge and Weisner Formations are undifferentiated in Calhoun County and consist of both coarse-grained and fine-grained clastics. The coarse-grained facies appears to dominate the unit and consists primarily of coarse-grained, vitreous quartzite and friable, fine- to coarse-grained, orthoquartzitic sandstone, both of which locally contain conglomerate. The fine-grained facies consists of sandy and micaceous shale and silty, micaceous mudstone, which are locally interbedded with the coarse clastic rocks. The abundance of orthoquartzitic sandstone and quartzite suggests that most of the Chilhowee Group bedrock in the vicinity of FTMC belongs to the Weisner Formation (Osborne and Szabo, 1984).

The Cambrian Shady Dolomite overlies the Weisner Formation northeast, east, and southwest of the Main Post and consists of interlayered bluish gray or pale yellowish gray sandy dolomitic limestone and siliceous dolomite with coarsely crystalline, porous chert (Osborne et al., 1989). A variegated shale and clayey silt have been included within the lower part of the Shady Dolomite (Cloud, 1966). Material similar to this lower shale unit was noted in core holes drilled by the Alabama Geologic Survey on FTMC (Osborne and Szabo, 1984). The character of the Shady Dolomite in the FTMC vicinity and the true assignment of the shale at this stratigraphic interval are still uncertain (Osborne, 1999).

The Rome Formation overlies the Shady Dolomite and locally occurs to the northwest and southeast of the Main Post, as mapped by Warman and Causey (1962) and Osborne and Szabo (1984), and immediately to the west of Reilly Airfield (Osborne and Szabo, 1984). The Rome Formation consists of variegated, thinly interbedded grayish red-purple mudstone, shale, siltstone, and greenish red and light gray sandstone, with locally occurring limestone and dolomite. Weaver Cave, located approximately one mile west of the northwest boundary of the Main Post, is situated in gray dolomite and limestone mapped as the Rome Formation (Osborne et al., 1997). The Conasauga Formation overlies the Rome Formation and occurs along anticlinal axes in the northeastern portion of Pelham Range (Warman and Causey, 1962; Osborne and Szabo, 1984) and the northern portion of the Main Post (Osborne et al., 1997). The Conasauga Formation is composed of dark gray, finely to coarsely crystalline, medium- to thick-bedded dolomite with minor shale and chert (Osborne et al., 1989).

Overlying the Conasauga Formation is the Knox Group, which is composed of the Copper Ridge and Chepultepec dolomites of Cambro-Ordovician age. The Knox Group is undifferentiated in

Calhoun County and consists of light medium gray, fine to medium crystalline, variably bedded to laminated, siliceous dolomite and dolomitic limestone that weather to a chert residuum (Osborne and Szabo, 1984). The Knox Group underlies a large portion of the Pelham Range area.

The Ordovician Newala and Little Oak Limestones overlie the Knox Group. The Newala Limestone consists of light to dark gray, micritic, thick-bedded limestone with minor dolomite. The Little Oak Limestone is comprised of dark gray, medium- to thick-bedded, fossiliferous, argillaceous to silty limestone with chert nodules. These limestone units are mapped as undifferentiated at FTMC and in other parts of Calhoun County. The Athens Shale overlies the Ordovician limestone units. The Athens Shale consists of dark gray to black shale and graptolitic shale with localized interbedded dark gray limestone (Osborne et al., 1989). These units occur within an eroded "window" in the uppermost structural thrust sheet at FTMC and underlie much of the developed area of the Main Post.

Other Ordovician-aged bedrock units mapped in Calhoun County include the Greensport Formation, Colvin Mountain Sandstone, and Sequatchie Formation. These units consist of various siltstones, sandstones, shales, dolomites, and limestones and are mapped as one, undifferentiated unit in some areas of Calhoun County. The only Silurian-age sedimentary formation mapped in Calhoun County is the Red Mountain Formation. This unit consists of interbedded red sandstone, siltstone, and shale with greenish gray to red silty and sandy limestone.

The Devonian Frog Mountain Sandstone consists of sandstone and quartzitic sandstone with shale interbeds, dolomudstone, and glauconitic limestone (Osborne, et al., 1988). This unit locally occurs in the western portion of Pelham Range.

The Mississippian Fort Payne Chert and the Maury Formation overlie the Frog Mountain Sandstone and are composed of dark to light gray limestone with abundant chert nodules and greenish gray to grayish red phosphatic shale, with increasing amounts of calcareous chert towards the upper portion of the formation (Osborne and Szabo, 1984). These units occur in the northwestern portion of Pelham Range. Overlying the Fort Payne Chert is the Floyd Shale, also of Mississippian age, which consists of thin-bedded, fissile brown to black shale with thin intercalated limestone layers and interbedded sandstone. Osborne and Szabo (1984) reassigned the Floyd Shale, which was mapped by Warman and Causey (1962) on the Main Post of FTMC, to the Ordovician Athens Shale based on fossil data.

The Pennsylvanian Parkwood Formation overlies the Floyd Shale and consists of a medium to dark gray, silty clay, shale, and mudstone with interbedded light to medium gray, very fine to fine grained, argillaceous, micaceous sandstone. Locally the Parkwood Formation also contains beds of medium to dark gray, argillaceous, bioclastic to cherty limestone and beds of clayey coal up to a few inches thick (Raymond et al., 1988). The Parkwood Formation in Calhoun County is generally found within a structurally complex area known as the Coosa deformed belt. In the deformed belt, the Parkwood Formation and Floyd Shale are mapped as undifferentiated because their lithologic similarity and significant deformation make it impractical to map the contact (Thomas and Drahovzal, 1974; Osborne et al., 1988). The undifferentiated Parkwood Formation and Floyd Shale are found throughout the western quarter of Pelham Range.

The Jacksonville thrust fault is the most significant structural geological feature in the vicinity of the Main Post of FTMC, both for its role in determining the stratigraphic relationships in the area and for its contribution to regional water supplies. The trace of the fault extends northeastward for approximately 39 miles between Bynum, Alabama, and Piedmont, Alabama. The fault is interpreted as a major splay of the Pell City fault (Osborne and Szabo, 1984). The Ordovician sequence that makes up the Eden thrust sheet is exposed at FTMC through an eroded window, or fenster, in the overlying thrust sheet. Rocks within the window display complex folding, with the folds being overturned and tight to isoclinal. The carbonates and shales locally exhibit well-developed cleavage (Osborne and Szabo, 1984). The FTMC window is framed on the northwest by the Rome Formation; north by the Conasauga Formation; northeast, east, and southwest by the Shady Dolomite; and southeast and southwest by the Chilhowee Group (Osborne et al., 1997). Two small klippen of the Shady Dolomite, bounded by the Jacksonville fault, have been recognized adjacent to the Pell City fault at the FTMC window (Osborne et al., 1997).

The Pell City fault serves as a fault contact between the bedrock within the FTMC window and the Rome and Conasauga Formations. The trace of the Pell City fault is also exposed approximately nine miles west of the FTMC window on Pelham Range, where it traverses northeast to southwest across the western quarter of Pelham Range. Here, the trace of the Pell City fault marks the boundary between the Pell City thrust sheet and the Coosa deformed belt.

The eastern three-quarters of Pelham Range is located within the Pell City thrust sheet, while the remaining western quarter of Pelham Range is located within the Coosa deformed belt. The Pell City thrust sheet is a large-scale thrust sheet containing Cambrian and Ordovician rocks and is relatively less structurally complex than the Coosa deformed belt (Thomas and Neathery, 1982).

The Pell City thrust sheet is exposed between the traces of the Jacksonville and Pell City faults along the western boundary of the FTMC window and along the trace of the Pell City fault on Pelham Range (Thomas and Neathery, 1982; Osborne et al., 1988). The Coosa deformed belt is a narrow northeast-to-southwest-trending linear zone of complex structure (approximately 5 to 20 miles wide and approximately 90 miles in length) consisting mainly of thin imbricate thrust slices. The structure within these imbricate thrust slices is often internally complicated by small-scale folding and additional thrust faults (Thomas and Drahovzal, 1974).

4.1.2 Site-Specific Geology

The soil at Landfill No. 3, Parcel 80(6), is classified as Cumberland gravelly loam, 2 to 6 percent slopes, eroded (CoB2) (U.S. Department of Agriculture, 1961). The thickness of the alluvium ranges from 2 to 15 feet or more and in some areas overlies beds of gravel and sand. These soils have developed in old general alluvium that washed from soil derived mainly from limestone and cherty limestone and, to some extent, shale and sandstone. Rounded chert, sandstone, and quartz gravel, as large as 3 inches in diameter, is on and in the soil.

Landfill No. 3 is located on the footwall block (Pell City thrust sheet) of the Jacksonville fault, approximately 1 mile west of the leading edge of the fault and approximately 0.6 mile north of the FTMC structural window where rocks of Ordovician age (Athens Shale and Little Oak/Newala Formations) are exposed (Osborne et al., 1997).

The most recent field interpretation by the Alabama Geological Survey shows the geologic contact between the Rome and Conasauga Formations as transecting Landfill No. 3 in a northeast-southwest direction (Figure 4-1). Direct confirmation of the presence of the Rome or Conasauga by outcrops, however, is not possible at Landfill No. 3 because only residuum and fill are present at the surface. Two outcrops, one located roughly 2,100 feet north of the landfill and one opposite the landfill southwest of OLF-G25, are consistent with the interpretation of the Rome Formation as a source for surface residuum over much of the landfill. The lithology at the outcrops is identified as grayish red-purple and pale olive mudstone and siltstone with occasional thin-bedded sandstone, typical of the Rome Formation (IT, 2000b). The Conasauga Formation does not outcrop in the immediate vicinity of Landfill No. 3.

Information regarding the contact between the Cambrian-age Rome and Conasauga Formations at Landfill No. 3 was provided by three deep borings drilled by Shaw in 2000. Boring 1, located on the eastern side of the landfill (Figure 4-1), encountered a sequence of dolomite and limestone beds with zones of interbedded mudstone, consistent with the Conasauga Formation. Probable

Conasauga lithology was also encountered during the drilling of monitoring wells OLF-G39, OLF-G40, and OLF-G41. Boring 1 was terminated at 228 feet in calcareous black mudstone typical of the Athens Shale. The sequence of Cambrian-age Conasauga strata overlying Ordovician-age rock (Athens Shale) encountered in the boring suggests the likelihood that the boring crossed the Pell City thrust fault. Borings 2 and 3, drilled to the north and west of the landfill, respectively, encountered bedrock consisting of dark red and reddish brown mudstone with occasional interbeds of gray limestone. This lithology is characteristic of the Rome Formation.

Breccia zones and intensely deformed bedding were observed in the bedrock cores from all three borings. The breccia zones and other evidence of deformation in the cores are consistent with fault activity and the degree of deformation that might be expected in an area bounded by two major thrust faults (Jacksonville and Pell City). Based on the borings and existing monitoring well data, two northeast-southwest-trending thrust faults are interpreted west of the landfill (Figure 4-1). In addition to the known tectonic setting of the area, a small splay fault is inferred adjacent to the landfill, based on the apparent vertical displacement of a carbonate unit between Boring 2 and Boring 3, numerous breccia zones and other indications of deformation observed in the borings, and lithologic data from existing monitoring wells (IT, 2001). A second thrust fault, farther to the west, is inferred to account for the difference in depth to bedrock between monitoring well OLF-G37 and the Rome outcrop cited earlier, and the top of bedrock in OLF-G25 and Boring 3. The intervening thrust is interpreted as similar in origin to a backlimb thrust typical in an area of intense asymmetric folding (Dahlstrom, 1969). Both faults strike northeast-southwest and dip to the southeast. The horizontal separation is less than 200 feet in the vicinity of OLF-G12 and widens to the northeast, where the separation may be as great as 1,000 feet.

Site-specific geologic conditions at Landfill No. 3, Parcel 80(6), were assessed using lithologic data collected during the investigation. The geologic map from Osborne et al. (1997) was revised to reflect these data, and the interpretation is shown on Figure 4-1. The locations of geologic cross sections constructed from the data are also shown on Figure 4-1.

Geologic cross section A-A' (Figure 4-2) cuts west to east, perpendicular to the strike of the two splay faults shown on Figure 4-1. Monitoring wells OLF-G29 and OLF-G30 are located in an area mapped as Rome Formation by both Warman and Causey (1962) and Osborne et al. (1997) and are assumed to represent a localized sequence dominated by carbonates. The dolomite, dolomitic limestone, and limestone found in these wells is replaced to the east by more typical mudstone and siltstone of the Rome Formation. The cross section continues to the east across

Landfill No. 3 and the inferred contact between the Rome Formation and eastward-dipping Conasauga Formation. Geologic cross section B-B' (Figure 4-3) runs southwest to northeast, basically parallel to the strike of the two splay faults. The cross section overlaps part of cross section A-A' from OLF-G20 though OLF-G22. Where possible, lithologic correlation of individual thin units described on the boring logs was made between wells. To the northeast, the interpretation of the top of bedrock in wells is tenuous. In addition, in the northern area the sequence of bedrock shown as mudstone on the cross section was occasionally described as large intervals of clay with reddish brown, hard to soft, angular to decomposed mudstone gravel. It is unlikely to encounter thick intervals of clay at depths in excess of 200 to 300 feet.

4.2 Site Hydrology

4.2.1 Surface Hydrology

Precipitation in the form of rainfall averages about 53 inches annually in Anniston, Alabama, with infiltration rates annually exceeding evapotranspiration rates (U.S. Department of Commerce, 1998). The major surface water features at the Main Post of FTMC include Remount Creek, Cane Creek, and Cave Creek. These waterways flow in a general northwesterly to westerly direction towards the Coosa River on the western boundary of Calhoun County.

Surface runoff at the site in the form of rainfall infiltrates into the uncapped landfill through man-made trenches oriented east to west across the site. During periods of heavy precipitation, surface water collects in the trenches and flows into the man-made drainage ditch located along the western boundary of Landfill No. 3. The ditch carries surface water runoff through a culvert beneath Gobbler Road at the northeastern corner of the landfill. No perennial surface water is present in the immediate vicinity of Landfill No. 3. Cave Creek, located approximately 1,500 feet south of Landfill No. 3, is the nearest significant surface water body.

4.2.2 Hydrogeology

4.2.2.1 Regional Hydrogeology

The hydrogeology of Calhoun County has been investigated by the Geologic Survey of Alabama (GSA) (Moser and DeJarnette, 1992) and by the U.S. Geological Survey in cooperation with the GSA (Warman et al., 1960) and ADEM (Planert and Pritchette, 1989). Groundwater in the vicinity of FTMC occurs in residuum derived from bedrock decomposition, within fractured bedrock, along fault zones, and from the development of karst frameworks. Groundwater flow may be estimated to be toward major surface water features. However, because of the impacts of differential weathering and variable fracturing and the potential for conduit flow development, the use of surface topography as an indicator of groundwater flow direction in the area must be exercised with caution. Areas with well-developed residuum horizons may subtly reflect the surface topography, but the groundwater flow direction also may exhibit the influence of pre-existing structural fabrics or the presence of perched water horizons on unweathered ledges or impermeable clay lenses. Because of the various geologic factors described above, the extension of groundwater elevation contours over distances on the size and scale of FTMC is not practical without closely spaced control points (SAIC, 2000).

Precipitation and subsequent infiltration provide recharge to the groundwater flow system in the region. The main recharge areas for the aquifers in Calhoun County are located in the valleys. The ridges generally consist of sandstones, quartzite, and slate, which are resistant to weathering, relatively unaffected by faulting, and therefore relatively impermeable. The ridges have steep slopes and thin to no soil cover, which enhances runoff to the edges of the valleys (Planert and Pritchette, 1989).

The thrust fault zones typical of the county form large storage reservoirs for groundwater. Points of discharge occur as springs, effluent streams, and lakes. Coldwater Spring is the largest spring in the State of Alabama, with a discharge of approximately 32 million gallons per day. This spring is the main source of water for the Anniston Water Department, from which FTMC buys its water. The spring is located approximately 5 miles southwest of Anniston and discharges from the brecciated zone of the Jacksonville Fault (Warman et al., 1960).

Shallow groundwater on FTMC occurs principally in the residuum developed from Cambrian sedimentary and carbonate bedrock units of the Weisner Formation and the Shady Dolomite and locally in Lower Ordovician carbonates. The residuum may yield adequate groundwater for domestic and livestock needs but may go dry during prolonged dry weather. Groundwater within the residuum serves as a recharge reservoir for the underlying bedrock aquifers. Bedrock permeability is locally enhanced by fracture zones associated with thrust faults and by the development of solution (karst) features.

Two major aquifers were identified by Planert and Pritchette (1989), the Knox-Shady and Tuscumbia-Fort Payne aquifers. The continuity of the aquifers has been disrupted by the complex geologic structure of the region, such that each major aquifer occurs repeatedly in different areas. The Knox-Shady aquifer group occurs over most of Calhoun County and is the main source of groundwater in the county. It consists of Cambrian- and Ordovician-aged quartzite and carbonates. The Conasauga Formation is the most utilized unit of the Knox-Shady aquifer, with twice as many wells drilled as any other unit (Moser and DeJarnette, 1992).

The Tuscumbia-Fort Payne aquifer occurs in the extreme northwestern portion of the county. This aquifer consists of Mississippian-age carbonates and shales. Because of its limited outcrops in the recharge area and the rugged terrain of the outcrop area, the Tuscumbia-Fort Payne aquifer is not considered a major groundwater supply in Calhoun County (Moser and DeJarnette, 1992). However, it is an important source of groundwater in counties to the west (Planert and Pritchette, 1989).

Regional groundwater flow in the bedrock was approximated for the FTMC vicinity by the U.S. Geological Survey (Scott et al., 1987). Regional groundwater elevation ranged from 800 feet above mean sea level (msl) on the main Base to about 600 feet above msl to the west on Pelham Range, based on water depths in wells completed across multiple formations. Groundwater elevation contours suggest that regional groundwater flow from the Main Post is to the northwest; a similar direction of regional groundwater flow is expected to occur across Pelham Range. There is not enough groundwater data to support this interpretation. Scott et al. (1987) concluded that the groundwater surface broadly coincides with the surface topography and that the regional aquifers are hydraulically connected. Groundwater flow on a local scale may be more complex and may be affected by geological structures such as the shallow thrust faults, rock fracture systems, and karst development in soluble formations.

Shallow groundwater occurs in weathered residuum derived from the bedrock and thin sediment deposits that are very similar to the decomposed rock. The shallow groundwater more closely follows the local topography.

4.2.2.2 Site-Specific Hydrogeology

Static groundwater levels were measured semiannually from March 2000 through September 2003 in monitoring wells at Landfill No. 3 and the vicinity (Table 3-3). Groundwater elevation maps were constructed for both the residuum and bedrock aquifers, as shown on Figures 4-4 through 4-7. The two groundwater measurement events selected were intended to capture data from a typical above-average period of precipitation (March 2003) and from a below-average period of precipitation (September 2003). The residuum flow maps include data from both residuum and transitional wells. Transitional wells are screened in the uppermost part of the highly weathered bedrock and are sufficiently close to the base of the residuum to be in direct hydraulic communication.

Based on the water level data collected, the overall groundwater flow direction in the residuum aquifer system is to the northwest. As shown on Figures 4-4 and 4-6, however, two areas of low-relief groundwater mounding and radial flow interrupt the overall flow. One area occupies the southern two-thirds of the landfill, and the other area is present northeast of the landfill. In the bedrock aquifer, the overall groundwater flow direction appears to be to the north-northeast (Figures 4-5 and 4-7). Flow direction in the bedrock adjacent to the western edge of the landfill is to the northwest, into the axis of a northeast-striking groundwater trough. On the opposite side of the trough, flow is towards this same axis. The axis of the trough gently dips towards the northeast. This groundwater sink is believed to occur in response to intense bedrock fracturing along the north-northeast strike of the thrust fault shown on Figure 4-1.

Horizontal hydraulic gradients were calculated for both the residuum and bedrock aquifers using the 2003 water level data (Table 4-1). In residuum, the gradients ranged from 0.028 foot per foot (ft/ft) to 0.172 ft/ft, with an arithmetic mean of 0.083 ft/ft. In bedrock, horizontal gradients ranged from 0.005 ft/ft to 0.048 ft/ft, with an arithmetic mean of 0.022 ft/ft. The low gradients in bedrock occur in an axial position in the groundwater trough and the higher values are on the east side, adjacent to the landfill.

Vertical hydraulic gradients were calculated for head differences in six residuum/bedrock well clusters and in four bedrock well clusters (Table 4-2). Vertical gradients in the residuum/transitional aquifer system were generally positive, indicating a downward (positive gradient) component to groundwater flow in the residuum. Positive gradients were weak to moderate and ranged from 0.0008 to 0.08 ft/ft. All but one of the gradient pairs determined for the bedrock well clusters indicate an upward (negative gradient) flow; calculated values ranged from -0.001 to -0.125 ft/ft, and 0.009 to 0.013 ft/ft.

Slug tests were not performed by Shaw at Landfill No. 3; therefore, hydraulic conductivity values could not be determined.

5.0 Summary of Analytical Results

This chapter discusses the results of the chemical analysis of samples collected at Landfill No. 3, Parcel 80(6). Sample results indicate that metals, VOCs, SVOCs, and pesticides were detected in site media. In addition, one explosive compound was detected in one groundwater sample, and one PCB compound was detected in three fill material soil samples. To evaluate the nature and extent of contamination, the analytical results were compared to human health SSSLs for FTMC. The SSSLs were developed for human health risk evaluations as part of the ongoing investigations conducted under the BRAC Environmental Restoration Program at FTMC. Metals results exceeding the SSSLs were subsequently compared to metals background screening values to determine if the metals concentrations are within natural background concentrations (SAIC, 1998).

5.1 Discrete Groundwater Sampling Results

A total of 59 discrete groundwater screening samples were collected during the drilling of six monitoring wells for Phase III of the supplemental RI. The samples were analyzed for VOCs only. VOCs detected in the screening samples are summarized in Table 5-1, and total VOCs detected are presented on Figure 5-1. Complete analytical results are provided in Appendix G.

5.2 Groundwater Analytical Results

A total of 220 groundwater samples were collected from 52 wells, including 47 monitoring wells, two City of Weaver wells, and three privately owned wells from February 1998 through October 2003. The well locations are shown on Figure 3-1. Analytical results were compared to residential human health SSSLs and metals background concentrations, as presented in Table 5-2.

Metals. Forty-seven of the 220 groundwater samples were analyzed for metals. A total of 21 metals were detected in the samples. The concentrations of nine metals exceeded their respective SSSLs and background concentrations:

- Aluminum (2.45 to 28.1 milligrams per liter [mg/L]) exceeded its SSSL (1.56 mg/L) and background (2.34 mg/L) in seven samples from six wells. The majority of the concentrations were flagged with a "J" data qualifier, signifying that the compound was positively identified but the concentrations were estimated.

- Antimony (0.0344 mg/L) exceeded its SSSL (0.0006 mg/L) and background (0.0031 mg/L) at OLF-G22. However, the antimony result was flagged with a "B" data qualifier, indicating that antimony was also detected in an associated laboratory or field blank sample.

- Barium (0.15 to 0.58 mg/L) exceeded its SSSL (0.11 mg/L) and background (0.13 mg/L) in four wells.

- Copper (0.08 and 0.09 mg/L) exceeded its SSSL (0.06 mg/L) and background (0.03 mg/L) in two wells.

- Iron (7.31 to 42.6 mg/L) exceeded its SSSL (0.47 mg/L) and background (7.04 mg/L) in seven samples from six wells.

- Lead (0.016 to 0.028 mg/L) exceeded its SSSL (0.015 mg/L) and background (0.008 mg/L) in 4 wells.

- Manganese (0.70 to 9.33 mg/L) exceeded its SSSL (0.07 mg/L) and background (0.58 mg/L) in ten samples from eight wells.

- Thallium (0.005 to 0.0066 mg/L) exceeded its SSSL (0.0001 mg/L) and background (0.0015 mg/L) in four wells. However, two of the thallium results were "B" flagged, indicating that thallium was also detected in an associated laboratory or field blank sample.

- Vanadium (0.063 mg/L) exceeded its SSSL (0.011 mg/L) and background (0.017 mg/L) at OLF-G13.

Metals exceeding SSSLs and background in groundwater are shown on Figure 5-2. It should be noted that background values are not available for chromium, mercury, and nickel, which exceeded their respective SSSLs in five samples, two samples, and three samples, respectively. It is also noted that the samples collected at OLF-G15 and LF4-MW01 were moderately to highly turbid (35.8 NTUs and 999 NTUs), which may have caused the elevated metals results.

Volatile Organic Compounds. All of the groundwater samples were analyzed for VOCs. A total of 31 VOCs were detected in the samples. VOC concentrations in groundwater ranged from 0.00013 to 1.4 mg/L. The concentrations of 13 VOCs exceeded their respective SSSLs:

- 1,1,2,2-Tetrachloroethane (0.0006 to 0.82 mg/L) exceeded its SSSL (0.0002 mg/L) in 37 samples from 10 wells.

- 1,1,2-Trichloroethane (0.00075 to 0.0085 mg/L) exceeded its SSSL (0.00072 mg/L) in 26 samples from 4 wells (OLF-G07, OLF-G12, OLF-G22, and OLF-G23).

- 1,1-Dichloroethene (0.00015 to 0.00023 mg/L) exceeded its SSSL (0.00009 mg/L) in five samples from three wells (OLF-G04, OLF-G20, and OLF-G25).

- 1,2-Dichloroethene (total) (0.02 mg/L) exceeded its SSSL (0.01 mg/L) in one well (OLF-G12).

- Acetone (0.26 to 1.4 mg/L) exceeded its SSSL (0.16 mg/L) in nine samples from five wells. However, the majority of the acetone results were flagged with a "J" data qualifier, signifying that the compound was positively identified but the concentrations were estimated.

- Bromodichloromethane (0.0018 and 0.0012 mg/L) exceeded its SSSL (0.0011 mg/L) in two wells (OLF-G28 and OLF-G45).

- Carbon tetrachloride (0.0005 mg/L) exceeded its SSSL (0.0004 mg/L) in one well (OLF-G27).

- Chloroform (0.0027 and 0.0053 mg/L) exceeded its SSSL (0.0012 mg/L) in two wells (OLF-G45 and OLF-G28).

- cis-1,2-Dichloroethene (0.017 to 0.033 mg/L) exceeded its SSSL (0.015 mg/L) in four samples from one well (OLF-G12).

- Dibromochloromethane (0.00081 and 0.0011 mg/L) exceeded its SSSL (0.00079 mg/L) in two wells (OLF-G28 and OLF-G45).

- Tetrachloroethene (0.0013 to 0.004 mg/L) exceeded its SSSL (0.0013 mg/L) in eight samples from three wells (OLF-G03, OLF-G12, and OLF-G23).

- Trichloroethene (0.0054 to 0.31 mg/L) exceeded its SSSL (0.0045 mg/L) in 46 samples from ten wells.

- Vinyl chloride (0.0005 to 0.0069 mg/L) exceeded its SSSL (0.00003 mg/L) in 18 samples from seven wells.

VOCs exceeding SSSLs in groundwater are presented on Figure 5-3. Isopleth maps (Figures 5-4 through 5-9) were constructed using the 2003 analytical data to show the concentrations of total chlorinated VOCs, 1,1,2,2-tetrachloroethane, and trichloroethene in both the residuum and bedrock aquifers. Figures 5-10 and 5-11 present cross sectional views of total chlorinated VOCs in groundwater in 2003. The greatest distribution of contamination (primarily chlorinated VOCs) in groundwater is located within the median of Alabama Highway 21 (at well cluster OLF-G12 and OLF-G22) and along the western boundary of Landfill No. 3 (at well cluster OLF-G07 and OLF-G20). The highest concentrations of seven chlorinated VOCs (1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, 1,2-dichloroethene, cis-1,2-dichloroethene, tetrachloroethene, trans-1,2-dichloroethene, and trichloroethene) were detected in monitoring well OLF-G12.

Semivolatile Organic Compounds. Forty-six of the 220 groundwater samples were analyzed for SVOCs. A total of four SVOCs (4-chloroaniline, bis[2-ethylhexyl]phthalate, diethylphthalate, and di-n-butylphthalate) were detected in the samples. All SVOC results except one (bis[2-ethylhexyl]phthalate) were flagged with a "J" data qualifier, signifying that the compounds were positively identified but the concentrations were estimated. SVOC concentrations in groundwater ranged from 0.00076 to 0.024 mg/L.

All SVOC results were below SSSLs, except for bis(2-ethylhexyl)phthalate, which was detected at a concentration (0.024 mg/L) exceeding its SSSL (0.004 mg/L) in one well (Lowery). However, bis(2-ethylhexyl)phthalate is a common sample contaminant and is not believed to be site related.

Pesticides. Forty-six of the 220 groundwater samples were analyzed for pesticides. A total of three pesticides (4,4'- dichlorodiphenyltrichloroethane [DDT], beta-BHC, and heptachlor epoxide) were detected in five wells. 4,4'-DDT (0.000021 and 0.00019 mg/L) was detected in two wells (OLF-G25 and OLF-G26), and one result exceeded the SSSL (0.00011 mg/L). However, the result was flagged with a "B" data qualifier, indicating the compound was also detected in an associated laboratory or field blank sample. Beta-BHC was detected in three wells (OLF-G04, OLF-G20 and OLF-G21); two of the results (0.000044 and 0.000054 mg/L), in wells OLF-G20 and OLF-G04, exceeded the SSSL (0.000036 mg/L). The remaining pesticide (heptachlor epoxide) was detected in one well (OLF-G21) at an estimated concentration (0.000032 mg/L) exceeding its SSSL (0.000006 mg/L).

Explosives. Forty-six of the 220 groundwater samples were analyzed for explosive compounds. One compound (1,3-dinitrobenzene) was detected in one well (OLF-G26) at an estimated concentration (0.00021 mg/L) that slightly exceeded its SSSL (0.00016 mg/L)

Polychlorinated Biphenyls. Seventeen of the 220 groundwater samples were analyzed for PCBs. PCBs were not detected in the samples.

Alkalinity. Twenty-nine of the 220 groundwater samples were analyzed for alkalinity. Alkalinity concentrations ranged from 5 to 246 mg/L, as summarized in Appendix G.

Total Dissolved Solids. Twenty-nine of the 220 groundwater samples were analyzed for total dissolved solids, which ranged in concentration from 27 to 360 mg/L, as summarized in Appendix G.

Sulfate. Twenty-nine of the 220 groundwater samples were analyzed for sulfate. Sulfate was detected in 26 samples at concentrations ranging from 0.419 to 28.4 mg/L, as summarized in Appendix G.

Chloride. Twenty-nine of the 220 groundwater samples were analyzed for chloride. Chloride concentrations ranged from 1.28 to 71.7 mg/L, as summarized in Appendix G.

Nitrate. Twenty-nine of the 220 groundwater samples were analyzed for nitrate. Nitrate was detected in 15 samples at concentrations ranging from 0.034 to 1.3 mg/L, as summarized in Appendix G.

Phosphate. Twenty-nine of the 220 groundwater samples were analyzed for phosphate. Phosphate was detected in nine samples at concentrations ranging from 0.033 to 0.272 mg/L, as summarized in Appendix G.

Quarterly Groundwater Analytical Results. Groundwater samples were collected and analyzed for VOCs during the investigation to monitor the groundwater contaminant plume (namely, chlorinated VOCs). VOCs detected in groundwater samples collected during the 2003 quarterly monitoring are shown on Figure 5-12. It should be noted that groundwater monitoring was also conducted in February 1998 and January 2002.

5.3 Fill Material Soil Analytical Results

Five fill material soil samples were collected for chemical analysis at Landfill No. 3. Fill material samples were collected at depths greater than 1 foot bgs at the locations shown on Figure 3-1. The samples were analyzed for metals, VOCs, SVOCs, pesticides, herbicides, PCBs, and explosives. The analytical results were compared to background screening values, where available, as presented in Table 5-3.

Metals. A total of 22 metals were detected in the fill material soil samples. The concentrations of 10 metals exceeded their respective background concentrations in one or more samples: cadmium, calcium, copper, lead, magnesium, mercury, potassium, silver, thallium, and zinc.

Volatile Organic Compounds. A total of 21 VOCs were detected in the fill material soil samples. VOC concentrations in the samples ranged from 0.0008 to 0.7 milligrams per kilogram [mg/kg].

Semivolatile Organic Compounds. A total of 16 SVOCs, including 14 PAH compounds, were detected in the fill material soil samples. The majority of the SVOC results were flagged with a "J" data qualifier, signifying that the compounds were positively identified but the concentrations were estimated. SVOC concentrations in the samples ranged from 0.049 to 3.1 mg/kg.

Pesticides. A total of 12 pesticides (4,4'-DDD, 4,4'-DDE, 4,4'-DDT, aldrin, beta-BHC, chlordane, delta-BHC, endosulfan II, endrin, gamma-BHC, heptachlor, and heptachlor epoxide) were detected in the fill material soil samples. The pesticide concentrations ranged from 0.00063 to 0.55 mg/kg.

Herbicides. Herbicides were not detected in the fill material soil samples.

Explosives. Explosive compounds were not detected in the fill material soil samples.

Polychlorinated Biphenyls. One PCB (Aroclor 1242) was detected in three fill material soil samples (locations FA-80-SB01, FA-80-SB02, and FA-80-SB04). The Aroclor 1242 concentrations ranged from 0.11 to 0.41 mg/kg.

6.0 Summary and Conclusions

This chapter summarizes the investigation conducted by Shaw at Landfill No. 3 and presents the major conclusions.

6.1 Geology and Hydrogeology

Landfill No. 3 is located on the footwall block (Pell City thrust sheet) of the Jacksonville fault, approximately 1 mile west of the leading edge of the fault and approximately 0.6 mile north of the FTMC structural window where Ordovician-age rocks (Athens Shale and Little Oak/Newala Formations) are exposed (Osborne et al., 1997).

Three deep borings were drilled to obtain information regarding the contact between the Cambrian-age Rome and Conasauga Formations at Landfill No. 3. Boring 1, located on the eastern side of the landfill, encountered a sequence of dolomite and limestone beds with zones of interbedded mudstone, which is consistent with the Conasauga Formation. Boring 1 was terminated in calcareous black mudstone typical of the Athens Shale. The sequence of Cambrian-age Conasauga strata overlying Ordovician-age rock (Athens Shale) encountered in Boring 1 suggests that the boring crossed the Pell City thrust fault. Borings 2 and 3, drilled to the north and west of the landfill, respectively, encountered bedrock consisting of red and reddish-brown mudstone with occasional interbeds of gray limestone. This lithology is characteristic of the Rome Formation.

Breccia zones and intensely deformed bedding were observed in the bedrock cores from all three borings, which is consistent with fault activity and the degree of deformation that might be expected in an area bounded by two major thrust faults (Jacksonville and Pell City faults). Two inferred thrust faults are present west of the landfill. Both faults strike northeast-southwest and dip to the southeast. The horizontal separation is less than 200 feet in the vicinity of OLF-G12 and widens to the northeast, where the separation may be as great as 1,000 feet.

Dolomite, dolomitic limestone, and limestone found in wells OLF-G29 and OLF-G30 (west of State Highway 21) are replaced to the east by more typical mudstone and siltstone of the Rome Formation. Both monitoring wells are located in an area mapped as Rome Formation by Warman and Causey (1962) and Osborne et al. (1997) and are assumed to represent a localized sequence dominated by carbonates. To the northeast, the interpretation of the top of bedrock is tenuous. It should be noted that in the northern area the sequence of bedrock shown as mudstone on the cross section B-B' was logged on some boring logs with large intervals of clay with reddish brown, decomposed mudstone gravel. It is unlikely to encounter clay tens of feet thick at depths in excess of 200 to 300 feet.

Groundwater elevation data were collected from monitoring wells at Parcel 80(6) from 2000 to 2003. Groundwater elevation maps were prepared for periods of above-average and below-average precipitation in 2003. Groundwater flow in the residuum is generally to the northwest. However, two areas of low-relief groundwater mounding and radial flow interrupt the overall flow. One area occupies the southern two-thirds of the landfill, and the other area is present northeast of the landfill. In bedrock, overall groundwater flow is to the north-northeast. West of the landfill, however, groundwater flows northwest into the axis of a northeast-striking groundwater trough. The axis of the trough dips towards the northeast. The groundwater sink appears to exist as a result of intense bedrock fracturing along the north-northeast strike of the thrust fault. Calculated horizontal gradients averaged 0.083 ft/ft in residuum and 0.022 ft/ft in bedrock. Vertical hydraulic gradients were calculated for six well clusters. Vertical gradients in the residuum/transition aquifer system indicated a weak to moderate downward flow. Vertical gradients in the bedrock showed an upward flow, except at one well cluster.

6.2 Groundwater Contaminant Distribution

A total of 220 groundwater samples were collected from 52 wells at Landfill No. 3 and the surrounding area, including three private wells and two municipal supply wells. Several metals were detected in groundwater samples at concentrations exceeding SSSLs and background, namely, aluminum, antimony, barium, copper, iron, lead, manganese, thallium, and vanadium. Chromium, mercury, and nickel also exceeded their respective SSSLs in a limited number of samples, but background values were not available for these metals.

Organic compounds detected in groundwater were VOCs, SVOCs, pesticides, and one explosive compound. One SVOC (bis[2-ethylhexyl] phthalate), two pesticides (4,4'-DDT and heptachlor), and one explosive compound (1,3-dinitrobenzene) exceeded their respective SSSLs in one sample each. In addition, the pesticide beta-BHC exceeded its SSSL in two samples. However, the most significant groundwater contamination was chlorinated VOCs. A total of 31 VOCs were detected in the groundwater samples. Of the VOCs detected, the following compounds exceeded their respective SSSLs (in order of frequency of detection, most frequent first): trichloroethene, 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, vinyl chloride, acetone, tetrachloroethene, 1,1-dichloroethene, cis-1,2-dichloroethene, chloroform, dibromochloromethane, bromodichloro-methane, 1,2-dichloroethene, and carbon tetrachloride.

With the exception of acetone, bromodichloromethane, and dibromochloromethane, the compounds that exceeded SSSLs are all chlorinated solvents.

Isoconcentration maps of total chlorinated VOCs indicate that the greatest distribution of contamination in groundwater is located along the western boundary of the landfill (at well cluster OLF-G07 and OLF-G20) and within the median of State Highway 21 (at well cluster OLF-G12 and OLF-G22), just outside the western boundary of the landfill. The horizontal and vertical extent of these chlorinated VOCs in groundwater has been defined.

6.3 Fill Area Definition

Fill area definition activities were conducted at Landfill No. 3 to determine the horizontal and vertical extent of fill and to characterize the fill material (IT, 2002a). Five borings were installed within the fill material at depths ranging from 14 to 24 feet bgs, and five exploratory trenches were excavated at depths ranging from 5 to 15 feet bgs. Fill material was observed in all of the trenches and included plastic sheeting, glass, wood, paper, metal cans, electrical wire, bricks, scrap metal, bottles/cans, cardboard, and other household items and construction debris. Based on the fill area definition activities, the southern extent of the landfill was slightly enlarged and the landfill is now estimated to cover approximately 23 acres.

6.4 Wetland Determination

A wetland determination was conducted at Landfill No. 3 to determine the extent of federally regulated jurisdictional wetlands and waters of the United States (Shaw, 2003a). The study, conducted in accordance with USACE guidance, was performed within an area extending approximately 200 feet beyond the perimeter of the landfill. Based on the results, the entire creek channel around the western and northern boundaries of the landfill was designated as jurisdictional waters of the United States. In addition, a forested wetland area was identified adjacent to the southwest corner of the landfill. Some isolated, non-jurisdictional wetlands pockets were also observed on the landfill.

6.5 Water Well and Spring User Survey

A water well and spring user survey was conducted to identify the locations and use of water supply wells and springs in the vicinity of Landfill No. 3 (Appendix D). A total of 20 wells and three springs were identified within an approximately one-mile radius of Landfill No. 3. Four of the wells and one spring are used for potable water. Six wells were identified within approximately 1,600 feet of the landfill but none are used for potable water.

6.6 Landfill Gas Investigation

A landfill gas investigation was performed at Landfill No. 3 to determine whether the site is producing landfill gases (Shaw, 2003b). Field activities included a surface gas emissions screening, subsurface soil gas screening and sampling, and screening of nearby structures and monitoring wells for the presence of methane. The investigation determined that the landfill is not producing significant landfill gases (e.g., methane). Based on this and the length of time the landfill has been inactive (36 years), it was concluded that no further landfill gas investigation is warranted.

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ATTACHMENT 1

LIST OF ABBREVIATIONS AND ACRONYMS

List of Abbreviations and Acronyms

2,4-D	2,4-dichlorophenoxyacetic acid
2,4,5-T	2,4,5-trichlorophenoxyacetic acid
2,4,5-TP	2,4,5-trichlorophenoxypropionic acid
3D	3D International Environmental Group
AB	ambient blank
AbB3	Anniston gravelly clay loam, 2 to 6 percent slopes, severely eroded
AbC3	Anniston gravelly clay loam, 6 to 10 percent slopes, severely eroded
AbD3	Anniston and Allen gravelly clay loams, 10 to 15 percent slopes, eroded
ABLM	adult blood lead model
Abs	skin absorption
ABS	dermal absorption factor
AC	hydrogen cyanide
ACAD	AutoCadd
AcB2	Anniston and Allen gravelly loams, 2 to 6 percent slopes, eroded
AcC2	Anniston and Allen gravelly loams, 6 to 10 percent slopes, eroded
AcD2	Anniston and Allen gravelly loams, 10 to 15 percent slopes, eroded
AcE2	Anniston and Allen gravelly loams, 15 to 25 percent slopes, eroded
ACGIH	American Conference of Governmental Industrial Hygienists
AdE	Anniston and Allen stony loam, 10 to 25 percent slope
ADEM	Alabama Department of Environmental Management
ADPH	Alabama Department of Public Health
AEC	U.S. Army Environmental Center
AEDA	ammunition, explosives, and other dangerous articles
AEL	airborne exposure limit
AET	adverse effect threshold
AF	soil-to-skin adherence factor
AHA	ammunition holding area
AL	Alabama
ALARNG	Alabama Army National Guard
ALAD	δ-aminolevulinic acid dehydratase
ALDOT	Alabama Department of Transportation
amb.	amber
amsl	above mean sea level
ANAD	Anniston Army Depot
AOC	area of concern
AP	armor piercing
APEC	areas of potential ecological concern
APT	armor-piercing tracer
AR	analysis request
ARAR	applicable or relevant and appropriate requirement
AREE	area requiring environmental evaluation
AS/SVE	air sparging/soil vapor extraction
ASP	Ammunition Supply Point
ASR	Archives Search Report
AST	aboveground storage tank
ASTM	American Society for Testing and Materials
AT	averaging time
atm-m^3/mol	atmospheres per cubic meter per mole
ATSDR	Agency for Toxic Substances and Disease Registry
ATV	all-terrain vehicle
AUF	area use factor
AWARE	Associated Water and Air Resources Engineers, Inc.
AWQC	ambient water quality criteria
AWWSB	Anniston Water Works and Sewer Board
'B'	Analyte detected in laboratory or field blank at concentration greater than the reporting limit (and greater than zero)
BCF	blank correction factor; bioconcentration factor
BCT	BRAC Cleanup Team
BERA	baseline ecological risk assessment
BEHP	bis(2-ethylhexyl)phthalate
BFB	bromofluorobenzene
BFE	base flood elevation
BG	Bacillus globigii
BGR	Bains Gap Road
bgs	below ground surface
BHC	hexachlorocyclohexane
BHHRA	baseline human health risk assessment
BIRTC	Branch Immaterial Replacement Training Center
bkg	background
bls	below land surface
BOD	biological oxygen demand
Bp	soil-to-plant biotransfer factors
BRAC	Base Realignment and Closure
Braun	Braun Intertec Corporation
BSAF	biota-to-sediment accumulation factors
BSC	background screening criterion
BTAG	Biological Technical Assistance Group
BTEX	benzene, toluene, ethyl benzene, and xylenes
BTOC	below top of casing
BTV	background threshold value
BW	biological warfare; body weight
BZ	breathing zone; 3-quinuclidinyl benzilate
C	ceiling limit value
Ca	carcinogen
$CaCO_3$	calcium carbonate
CAA	Clean Air Act
CAB	chemical warfare agent breakdown products
CACM	Chemical Agent Contaminated Media
CAMU	corrective action management unit
CBR	chemical, biological, and radiological
CCAL	continuing calibration
CCB	continuing calibration blank
CCV	continuing calibration verification
CD	compact disc
CDTF	Chemical Defense Training Facility
CEHNC	U.S. Army Engineering and Support Center, Huntsville
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERFA	Community Environmental Response Facilitation Act
CESAS	Corps of Engineers South Atlantic Savannah
CF	conversion factor
CFC	chlorofluorocarbon
CFDP	Center for Domestic Preparedness
CFR	Code of Federal Regulations
CG	phosgene (carbonyl chloride)
CGI	combustible gas indicator
ch	inorganic clays of high plasticity
CHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
CIH	Certified Industrial Hygienist
CK	cyanogen chloride
cl	inorganic clays of low to medium plasticity
Cl	chlorinated
CLP	Contract Laboratory Program
cm	centimeter
CN	chloroacetophenone
CNB	chloroacetophenone, benzene, and carbon tetrachloride
CNS	chloroacetophenone, chloropicrin, and chloroform
CO	carbon monoxide
CO_2	carbon dioxide
Co-60	cobalt-60
CoA	Code of Alabama
COC	chain of custody; chemical of concern
COE	Corps of Engineers
Con	skin or eye contact
COPC	chemical of potential concern
COPEC	constituent of potential ecological concern
CPOM	coarse particulate organic matter
CPSS	chemicals present in site samples
CQCSM	Contract Quality Control System Manager
CRDL	contract-required detection limit
CRL	certified reporting limit
CRQL	contract-required quantitation limit
CRZ	contamination reduction zone
Cs-137	cesium-137
CS	ortho-chlorobenzylidene-malononitrile
CSEM	conceptual site exposure model
CSM	conceptual site model
CT	central tendency
ctr.	container
CWA	chemical warfare agent; Clean Water Act
CWM	chemical warfare material; clear, wide mouth
CX	dichloroformoxime
'D'	duplicate; dilution
D&I	detection and identification
DAAMS	depot area agent monitoring station

DAF	dilution-attenuation factor
DANC	decontamination agent, non-corrosive
ºC	degrees Celsius
ºF	degrees Fahrenheit
DCA	dichloroethane
DCE	dichloroethene
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethane
DEH	Directorate of Engineering and Housing
DEHP	di(2-ethylhexyl)phthalate
DEP	depositional soil
DFTPP	decafluorotriphenylphosphine
DI	deionized
DID	data item description
DIMP	di-isopropylmethylphosphonate
DM	dry matter; adamsite
DMBA	dimethylbenz(a)anthracene
DMMP	dimethylmethylphosphonate
DNAPL	dense nonaqueous-phase liquid
DO	dissolved oxygen
DOD	U.S. Department of Defense
DOJ	U.S. Department of Justice
DOT	U.S. Department of Transportation
DP	direct-push
DPDO	Defense Property Disposal Office
DPT	direct-push technology
DQO	data quality objective
DRMO	Defense Reutilization and Marketing Office
DRO	diesel range organics
DS	deep (subsurface) soil
DS2	Decontamination Solution Number 2
DSERTS	Defense Site Environmental Restoration Tracking System
DWEL	drinking water equivalent level
E&E	Ecology and Environment, Inc.
EB	equipment blank
EBS	environmental baseline survey
EC_{20}	effects concentration for 20 percent of a test population
EC_{50}	effects concentration for 50 percent of a test population
ECBC	Edgewood Chemical Biological Center
ED	exposure duration
EDD	electronic data deliverable
EF	exposure frequency
EDQL	ecological data quality level
EE/CA	engineering evaluation and cost analysis
Elev.	elevation
EM	electromagnetic
EMI	Environmental Management Inc.
EM31	Geonics Limited EM31 Terrain Conductivity Meter
EM61	Geonics Limited EM61 High-Resolution Metal Detector
EOD	explosive ordnance disposal
EODT	explosive ordnance disposal team
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
EPIC	Environmental Photographic Interpretation Center
EPRI	Electrical Power Research Institute
EPT	Ephemeroptera, Plecoptera, Trichoptera
ER	equipment rinsate
ERA	ecological risk assessment
ER-L	effects range-low
ER-M	effects range-medium
ESE	Environmental Science and Engineering, Inc.
ESL	ecological screening level
ESMP	Endangered Species Management Plan
ESN	Environmental Services Network, Inc.
ESV	ecological screening value
ET	exposure time
EU	exposure unit
Exp.	Explosives
EXTOXNET	Extension Toxicology Network
E-W	east to west
EZ	exclusion zone
FAR	Federal Acquisition Regulations
FB	field blank
FBI	Family Biotic Index
FD	field duplicate
FDC	Former Decontamination Complex
FDA	U.S. Food and Drug Administration
Fe^{+3}	ferric iron
Fe^{+2}	ferrous iron
FedEx	Federal Express, Inc.
FEMA	Federal Emergency Management Agency
FFCA	Federal Facilities Compliance Act
FFE	field flame expedient
FFS	focused feasibility study
FI	fraction of exposure
Fil	filtered
Flt	filtered
FMDC	Fort McClellan Development Commission
FML	flexible membrane liner
f_{oc}	fraction organic carbon
FOMRA	Former Ordnance Motor Repair Area
FOST	Finding of Suitability to Transfer
Foster Wheeler	Foster Wheeler Environmental Corporation
FR	Federal Register
Frtn	fraction
FS	field split; feasibility study
FSP	field sampling plan
ft	feet
ft/day	feet per day
ft/ft	feet per foot
ft/yr	feet per year
FTA	Fire Training Area
FTMC	Fort McClellan
FTRRA	FTMC Reuse & Redevelopment Authority
g	gram
g/m^3	gram per cubic meter
G-856	Geometrics, Inc. G-856 magnetometer
G-858G	Geometrics, Inc. G-858G magnetic gradiometer
GAF	gastrointestinal absorption factor
gal	gallon
gal/min	gallons per minute
GB	sarin (isopropyl methylphosphonofluoridate)
gc	clay gravels; gravel-sand-clay mixtures
GC	gas chromatograph
GCL	geosynthetic clay liner
GC/MS	gas chromatograph/mass spectrometer
GCR	geosynthetic clay liner
GFAA	graphite furnace atomic absorption
GIS	Geographic Information System
gm	silty gravels; gravel-sand-silt mixtures
gp	poorly graded gravels; gravel-sand mixtures
gpm	gallons per minute
GPR	ground-penetrating radar
GPS	global positioning system
GRA	general response action
GS	ground scar
GSA	General Services Administration; Geologic Survey of Alabama
GSBP	Ground Scar Boiler Plant
GSSI	Geophysical Survey Systems, Inc.
GST	ground stain
GW	groundwater
gw	well-graded gravels; gravel-sand mixtures
H&S	health and safety
HA	hand auger
HC	mixture of hexachloroethane, aluminum powder, and zinc oxide (smoke producer)
HCl	hydrochloric acid
HD	distilled mustard (bis-[dichloroethyl]sulfide)
HDPE	high-density polyethylene
HE	high explosive
HEAST	Health Effects Assessment Summary Tables
Herb.	herbicides
HHRA	human health risk assessment
HI	hazard index

H_2O_2	hydrogen peroxide
HPLC	high-performance liquid chromatography
HNO_3	nitric acid
HQ	hazard quotient
HQ_{screen}	screening-level hazard quotient
hr	hour
HRC	hydrogen releasing compound
HSA	hollow-stem auger
HSDB	Hazardous Substance Data Bank
HTRW	hazardous, toxic, and radioactive waste
'I'	out of control, data rejected due to low recovery
IASPOW	Impact Area South of POW Training Facility
IATA	International Air Transport Authority
ICAL	initial calibration
ICB	initial calibration blank
ICP	inductively-coupled plasma
ICRP	International Commission on Radiological Protection
ICS	interference check sample
ID	inside diameter
IDL	instrument detection limit
IDLH	immediately dangerous to life or health
IDM	investigative-derived media
IDW	investigation-derived waste
IEUBK	Integrated Exposure Uptake Biokinetic
IF	ingestion factor; inhalation factor
ILCR	incremental lifetime cancer risk
IMPA	isopropylmethyl phosphonic acid
IMR	Iron Mountain Road
in.	inch
Ing	ingestion
Inh	inhalation
IP	ionization potential
IPS	International Pipe Standard
IR	ingestion rate
IRDMIS	Installation Restoration Data Management Information System
IRIS	Integrated Risk Information Service
IRP	Installation Restoration Program
IS	internal standard
ISCP	Installation Spill Contingency Plan
IT	IT Corporation
ITEMS	IT Environmental Management System™
'J'	estimated concentration
JeB2	Jefferson gravelly fine sandy loam, 2 to 6 percent slopes, eroded
JeC2	Jefferson gravelly fine sandy loam, 6 to 10 percent slopes, eroded
JfB	Jefferson stony fine sandy loam, 0 to 10 percent slopes have strong slopes
JPA	Joint Powers Authority
K	conductivity
K_d	soil-water distribution coefficient
kg	kilogram
KeV	kilo electron volt
K_{oc}	organic carbon partioning coefficient
K_{ow}	octonal-water partition coefficient
$KMnO_4$	potassium permanganate
L	liter; Lewisite (dichloro-[2-chloroethyl]sulfide)
L/kg/day	liters per kilogram per day
l	liter
LAW	light anti-tank weapon
lb	pound
LBP	lead-based paint
LC	liquid chromatography
LCS	laboratory control sample
LC_{50}	lethal concentration for 50 percent population tested
LD_{50}	lethal dose for 50 percent population tested
LEL	lower explosive limit
LOAEL	lowest-observed-advserse-effects-level
LOEC	lowest-observable-effect-concentration
LRA	land redevelopment authority
LT	less than the certified reporting limit
LUC	land-use control
LUCAP	land-use control assurance plan
LUCIP	land-use control implementation plan
max	maximum
MB	method blank
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MCPA	4-chloro-2-methylphenoxyacetic acid
MCPP	2-(2-methyl-4-chlorophenoxy)propionic acid
MCS	media cleanup standard
MD	matrix duplicate
MDC	maximum detected concentration
MDCC	maximum detected constituent concentration
MDL	method detection limit
mg	milligrams
mg/kg	milligrams per kilogram
mg/kg/day	milligram per kilogram per day
mg/kgbw/day	milligrams per kilogram of body weight per day
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
mh	inorganic silts, micaceous or diatomaceous fine, sandy or silt soils
MHz	megahertz
µg/g	micrograms per gram
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µmhos/cm	micromhos per centimeter
MeV	mega electron volt
min	minimum
MINICAMS	miniature continuous air monitoring system
ml	inorganic silts and very fine sands
mL	milliliter
mm	millimeter
MM	mounded material
MMBtu/hr	million Btu per hour
MNA	monitored natural attenuation
MnO_4-	permanganate ion
MOA	Memorandum of Agreement
MOGAS	motor vehicle gasoline
MOUT	Military Operations in Urban Terrain
MP	Military Police
MPA	methyl phosphonic acid
MPC	maximum permissible concentration
MPM	most probable munition
MQL	method quantitation limit
MR	molasses residue
MRL	method reporting limit
MS	matrix spike
mS/cm	millisiemens per centimeter
mS/m	millisiemens per meter
MSD	matrix spike duplicate
MTBE	methyl tertiary butyl ether
msl	mean sea level
MtD3	Montevallo shaly, silty clay loam, 10 to 40 percent slopes , severely eroded
mV	millivolts
MW	monitoring well
MWI&MP	Monitoring Well Installation and Management Plan
Na	sodium
NA	not applicable; not available
NAD	North American Datum
NAD83	North American Datum of 1983
$NaMnO_4$	sodium permanganate
NAVD88	North American Vertical Datum of 1988
NAS	National Academy of Sciences
NCEA	National Center for Environmental Assessment
NCP	National Contingency Plan
NCRP	National Council on Radiation Protection and Measurements
ND	not detected
NE	no evidence; northeast
ne	not evaluated
NEW	net explosive weight
NFA	No Further Action
NG	National Guard
NGP	National Guardsperson
ng/L	nanograms per liter
NGVD	National Geodetic Vertical Datum
Ni	nickel

NIC	notice of intended change
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NLM	National Library of Medicine
NO_3^-	nitrate
NOEC	no-observable-effect-concentration
NPDES	National Pollutant Discharge Elimination System
NPW	net present worth
No.	number
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no-observed-adverse-effects-level
NR	not requested; not recorded; no risk
NRC	National Research Council
NRCC	National Research Council of Canada
NRHP	National Register of Historic Places
NRT	near real time
ns	nanosecond
N-S	north to south
NS	not surveyed
NSA	New South Associates, Inc.
nT	nanotesla
nT/m	nanoteslas per meter
NTU	nephelometric turbidity unit
nv	not validated
O_2	oxygen
O_3	ozone
O&G	oil and grease
O&M	operation and maintenance
OB/OD	open burning/open detonation
OD	outside diameter
OE	ordnance and explosives
oh	organic clays of medium to high plasticity
OH●	hydroxyl radical
ol	organic silts and organic silty clays of low plasticity
OP	organophosphorus
ORC	Oxygen Releasing Compound
ORP	oxidation-reduction potential
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OVM-PID/FID	organic vapor meter-photoionization detector/flame ionization detector
OWS	oil/water separator
oz	ounce
PA	preliminary assessment
PAH	polynuclear aromatic hydrocarbon
PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity
Parsons	Parsons Engineering Science, Inc.
Pb	lead
PBMS	performance-based measurement system
PC	permeability coefficient
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-p-dioxins
PCDF	polychlorinated dibenzofurans
PCE	perchloroethene
PCP	pentachlorophenol
PDS	Personnel Decontamination Station
PEF	particulate emission factor
PEL	permissible exposure limit
PERA	preliminary ecological risk assessment
PERC	perchloroethene
PES	potential explosive site
Pest.	pesticides
PETN	pentaerythritoltetranitrate
PFT	portable flamethrower
PG	professional geologist
PID	photoionization detector
PkA	Philo and Stendal soils local alluvium, 0 to 2 percent slopes
PM	project manager
POC	point of contact
POL	petroleum, oils, and lubricants
POTW	publicly owned treatment works
POW	prisoner of war
PP	peristaltic pump; Proposed Plan
ppb	parts per billion
ppbv	parts per billion by volume
PPE	personal protective equipment
ppm	parts per million
PPMP	Print Plant Motor Pool
ppt	parts per thousand
PR	potential risk
PRA	preliminary risk assessment
PRG	preliminary remediation goal
PS	chloropicrin
PSSC	potential site-specific chemical
pt	peat or other highly organic silts
PVC	polyvinyl chloride
QA	quality assurance
QA/QC	quality assurance/quality control
QAM	quality assurance manual
QAO	quality assurance officer
QAP	installation-wide quality assurance plan
QC	quality control
QST	QST Environmental, Inc.
qty	quantity
Qual	qualifier
R	rejected data; resample; retardation factor
R&A	relevant and appropriate
RA	remedial action
RAO	remedial action objective
RBC	risk-based concentration; red blood cell
RBRG	risk-based remedial goal
RCRA	Resource Conservation and Recovery Act
RCWM	Recovered Chemical Warfare Material
RD	remedial design
RDX	cyclotrimethylenetrinitramine
ReB3	Rarden silty clay loams
REG	regular field sample
REL	recommended exposure limit
RFA	request for analysis
RfC	reference concentration
RfD	reference dose
RGO	remedial goal option
RI	remedial investigation
RL	reporting limit
RME	reasonable maximum exposure
ROD	Record of Decision
RPD	relative percent difference
RR	range residue
RRF	relative response factor
RRSE	Relative Risk Site Evaluation
RSD	relative standard deviation
RTC	Recruiting Training Center
RTECS	Registry of Toxic Effects of Chemical Substances
RTK	real-time kinematic
RWIMR	Ranges West of Iron Mountain Road
SA	exposed skin surface area
SAD	South Atlantic Division
SAE	Society of Automotive Engineers
SAIC	Science Applications International Corporation
SAP	installation-wide sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act
sc	clayey sands; sand-clay mixtures
Sch.	schedule
SCM	site conceptual model
SD	sediment
SDG	sample delivery group
SDWA	Safe Drinking Water Act
SDZ	safe distance zone; surface danger zone
SEMS	Southern Environmental Management & Specialties, Inc.
SF	cancer slope factor
SFSP	site-specific field sampling plan
SGF	standard grade fuels
Shaw	Shaw Environmental, Inc.
SHP	installation-wide safety and health plan
SI	site investigation

SINA	Special Interest Natural Area
SL	standing liquid
SLERA	screening-level ecological risk assessment
sm	silty sands; sand-silt mixtures
SM	Serratia marcescens
SMDP	Scientific Management Decision Point
s/n	signal-to-noise ratio
SO_4^{-2}	sulfate
SOD	soil oxidant demand
SOP	standard operating procedure
SOPQAM	U.S. EPA's *Standard Operating Procedure/Quality Assurance Manual*
sp	poorly graded sands; gravelly sands
SP	submersible pump
SPCC	system performance calibration compound
SPCS	State Plane Coordinate System
SPM	sample planning module
SQRT	screening quick reference tables
Sr-90	strontium-90
SRA	streamlined human health risk assessment
SRI	supplemental remedial investigation
SRM	standard reference material
Ss	stony rough land, sandstone series
SS	surface soil
SSC	site-specific chemical
SSHO	site safety and health officer
SSHP	site-specific safety and health plan
SSL	soil screening level
SSSL	site-specific screening level
SSSSL	site-specific soil screening level
STB	supertropical bleach
STC	source-term concentration
STD	standard deviation
STEL	short-term exposure limit
STL	Severn-Trent Laboratories
STOLS	Surface Towed Ordnance Locator System®
Std. units	standard units
SU	standard unit
SUXOS	senior UXO supervisor
SVOC	semivolatile organic compound
SW	surface water
SW-846	U.S. EPA's *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*
SWMU	solid waste management unit
SWPP	storm water pollution prevention plan
SZ	support zone
TAL	target analyte list
TAT	turn around time
TB	trip blank
TBC	to be considered
TCA	trichloroethane
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCDF	tetrachlorodibenzofurans
TCE	trichloroethene
TCL	target compound list
TCLP	toxicity characteristic leaching procedure
TDEC	Tennessee Department of Environment and Conservation
TDGCL	thiodiglycol
TDGCLA	thiodiglycol chloroacetic acid
TEA	triethylaluminum
Tetryl	trinitrophenylmethylnitramine
TERC	Total Environmental Restoration Contract
THI	target hazard index
TIC	tentatively identified compound
TLV	threshold limit value
TN	Tennessee
TNB	trinitrobenzene
TNT	trinitrotoluene
TOC	top of casing; total organic carbon
TPH	total petroleum hydrocarbons
TR	target cancer risk
TRADOC	U.S. Army Training and Doctrine Command
TRPH	total recoverable petroleum hydrocarbons
TRV	toxicity reference value
TSCA	Toxic Substances Control Act
TSDF	treatment, storage, and disposal facility
TWA	time-weighted average
UCL	upper confidence limit
UCR	upper certified range
'U'	not detected above reporting limit
UIC	underground injection control
UF	uncertainty factor
URF	unit risk factor
USACE	U.S. Army Corps of Engineers
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
USAEC	U.S. Army Environmental Center
USAEHA	U.S. Army Environmental Hygiene Agency
USACMLS	U.S. Army Chemical School
USAMPS	U.S. Army Military Police School
USATCES	U.S. Army Technical Center for Explosive Safety
USATEU	U.S. Army Technical Escort Unit
USATHAMA	U.S. Army Toxic and Hazardous Material Agency
USC	United States Code
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
UTL	upper tolerance level; upper tolerance limit
UXO	unexploded ordnance
UXOQCS	UXO Quality Control Supervisor
UXOSO	UXO safety officer
V	vanadium
VC	vinyl chloride
VOA	volatile organic analyte
VOC	volatile organic compound
VOH	volatile organic hydrocarbon
VQlfr	validation qualifier
VQual	validation qualifier
VX	nerve agent (O-ethyl-S-[diisopropylaminoethyl]-methylphosphonothiolate)
WAC	Women's Army Corps
Weston	Roy F. Weston, Inc.
WP	installation-wide work plan
WRS	Wilcoxon rank sum
WS	watershed
WSA	Watershed Screening Assessment
WWI	World War I
WWII	World War II
XRF	x-ray fluorescence
yd^3	cubic yards