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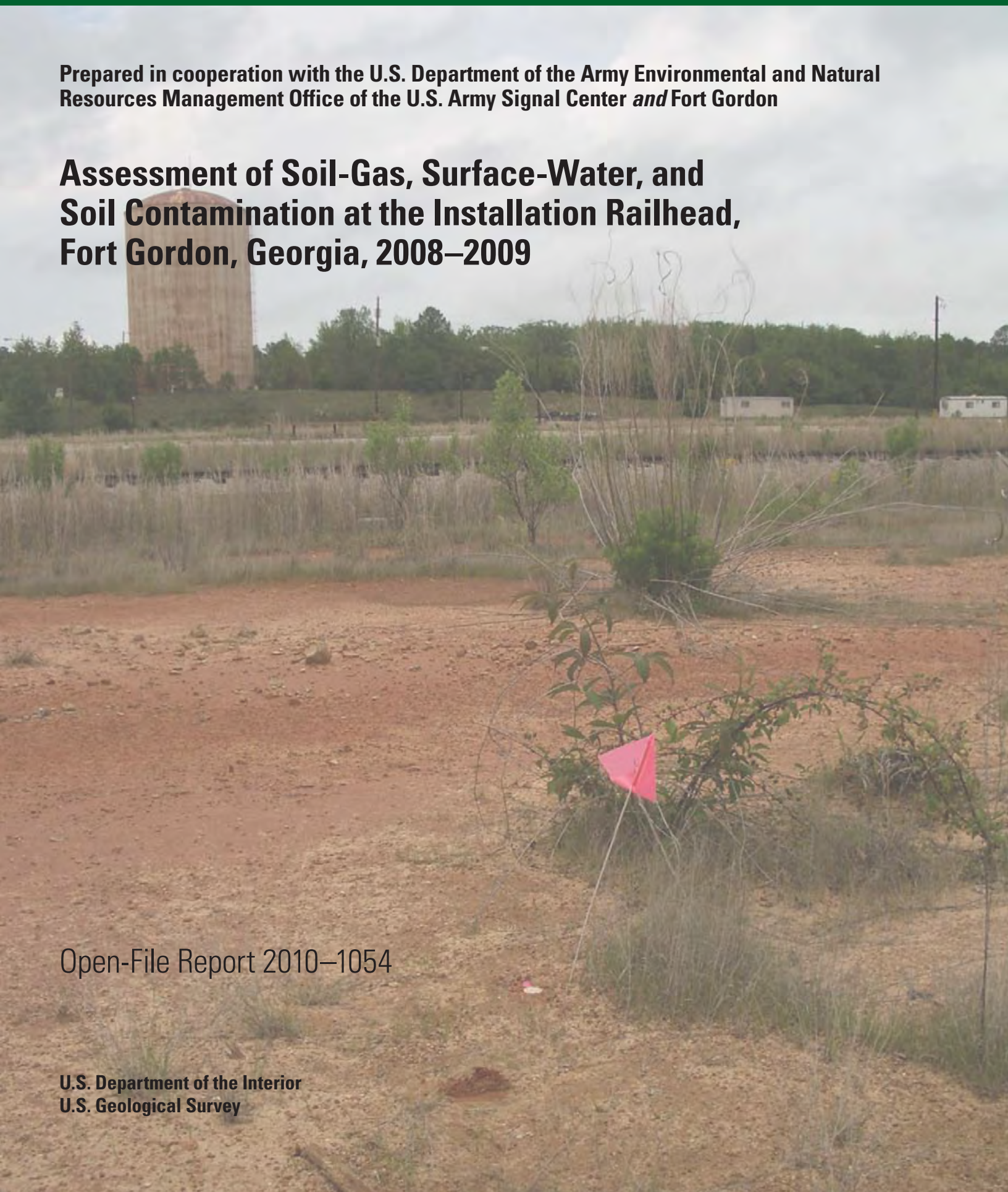
Assessment of Soil-Gas, Surface-Water, and Soil Contamination at the Installation Railhead, Fort Gordon, Georgia, 2008–2009



Open-File Report 2010–1054

U.S. Department of the Interior
U.S. Geological Survey

Cover photograph. Soil-gas sampler located at the Installation Railhead, Fort Gordon, Georgia, May 5, 2009.

Assessment of Soil-Gas, Surface-Water, and Soil Contamination at the Installation Railhead, Fort Gordon, Georgia, 2008–2009

By James E. Landmeyer, Larry G. Harrelson, W. Hagan Ratliff, and John B. Wellborn

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U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
mile, nautical (nmi)	1.852	kilometer (km)
yard (yd)	0.9144	meter (m)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm^2)
acre	0.004047	square kilometer (km^2)

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Selected acronyms and abbreviations used in this report include:

BTEX	Benzene, toluene, ethylbenzene, and xylene (total)
GC/MS	Gas chromatography/mass spectroscopy
IR	Installation Railhead
mg/kg	milligram per kilogram
µg/g	microgram per gram
µg/L	microgram per liter
MCL	Maximum contaminant level
MDL	Method detection level
MTBE	Methyl *tert*-butyl ether
NPDWS	National Primary Drinking Water Standard
NSDWS	National Secondary Drinking Water Standard
PAH	Polycyclic aromatic hydrocarbon
PCE	Perchloroethylene (also known as tetrachloroethylene)
RCRA	Resource Conservation and Recovery Act
RSL	Regional Screening Level
SC DHEC	South Carolina Department of Health and Environmental Control
SVOC	Semivolatile organic compound
TCE	Trichloroethylene
TPH	Total Petroleum Hydrocarbons
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	Volatile organic compound

Assessment of Soil-Gas, Surface-Water, and Soil Contamination at the Installation Railhead, Fort Gordon, Georgia, 2008–2009

By James E. Landmeyer,[1] Larry G. Harrelson,[1] W. Hagan Ratliff,[2] and John B. Wellborn[3]

Abstract

The U.S. Geological Survey, in cooperation with the U.S. Department of the Army Environmental and Natural Resources Management Office of the U.S. Army Signal Center and Fort Gordon, assessed soil gas, surface water, and soil for contaminants at the Installation Railhead (IR) at Fort Gordon, Georgia, from October 2008 to September 2009. The assessment included delineation of organic contaminants present in soil-gas samples beneath the IR, and in a surface-water sample collected from an unnamed tributary to Marcum Branch in the western part of the IR. Inorganic contaminants were determined in a surface-water sample and in soil samples. This assessment was conducted to provide environmental contamination data to Fort Gordon personnel pursuant to requirements of the Resource Conservation and Recovery Act Part B Hazardous Waste Permit process.

Soil-gas samples collected within a localized area on the western part of the IR contained total petroleum hydrocarbons; benzene, toluene, ethylbenzene, and total xylenes (referred to as BTEX); and naphthalene above the method detection level. These soil-gas samples were collected where buildings had previously stood. Soil-gas samples collected within a localized area contained perchloroethylene (PCE). These samples were collected where buildings 2410 and 2405 had been. Chloroform and toluene were detected in a surface-water sample collected from an unnamed tributary to Marcum Branch but at concentrations below the National Primary Drinking Water Standard maximum contaminant level (MCL) for each compound. Iron was detected in the surface-water sample at 686 micrograms per liter (µg/L) and exceeded the National Secondary Drinking Water Standard MCL for iron. Metal concentrations in composite soil samples collected at three locations from land surface to a depth of 6 inches did not exceed the U.S. Environmental Protection Agency Regional Screening Levels for industrial soil.

Introduction

Fort Gordon is a U.S. Department of the Army (Army) facility located in east-central Georgia, approximately 10 miles southwest of Augusta, Georgia (fig. 1). A cantonment (military housing) area is located at the northwestern boundary of Fort Gordon. Part of the cantonment area consists of a currently unused railhead and various buildings; this approximately 20-acre area is called the Installation Railhead (IR). The IR was used to mobilize military personnel and supplies, and to support installation activities from the 1940s through the 1970s. Since the 1970s, previously existing buildings have been razed, and new buildings have been constructed to accommodate changes in the Army's operations.

The effects of past activities at the IR on environmental resources are currently unknown. This assessment was conducted to provide environmental contamination data to Fort Gordon personnel to comply with the requirements of the Resource Conservation and Recovery Act (RCRA) Part B Hazardous Waste Permit process. An initial investigation to assess potential environmental effects is warranted because the IR is located in the outcrop area of the Dublin and Midville aquifer systems used for drinking water by the towns of Augusta and Hephzibah (Willams, 2007). Moreover, recharge and runoff at the IR may supply ephemeral streams with water that could flow from Fort Gordon.

Purpose and Scope

This initial assessment was conducted to provide environmental contamination data to personnel at Fort Gordon. The initial assessment was composed of a passive soil-gas sample survey and the collection of soil and water samples. The report gives the results of analyses of these samples and delineates areas of contamination in the study area.

Description of Study Area

Fort Gordon (the Fort) is an Army facility located in east-central Georgia, approximately 10 miles southwest of Augusta, Georgia (fig. 1). The Fort lies in the northern part of the Coastal Plain Physiographic Province and south of the Fall Line. Surficial soil and sediments are characterized by unconsolidated sands, indurated sands and semiconsolidated sandstones, and layers of clay that include kaolinite (Gregory and others, 2001).

Methods

Passive Soil-Gas Survey

The passive soil-gas survey used the GORE™ Module (module), a commercially available media based on GORE-TEX® membrane technology (U.S. Environmental Protection Agency, 1998; W.L. Gore and Associates, Inc., 2004;

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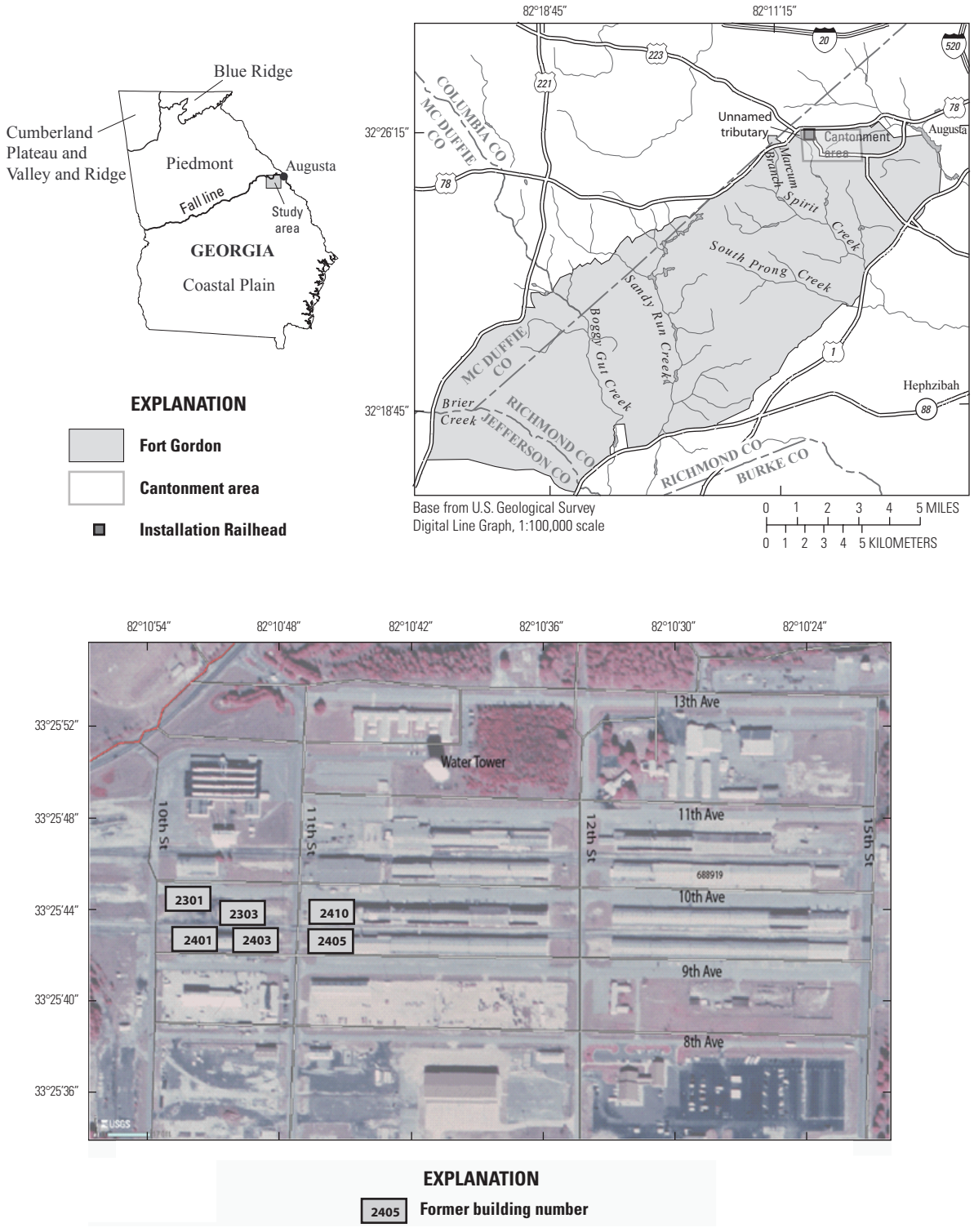


Figure 1. Location of Installation Railhead, Fort Gordon, Georgia (aerial photograph taken about 1990).

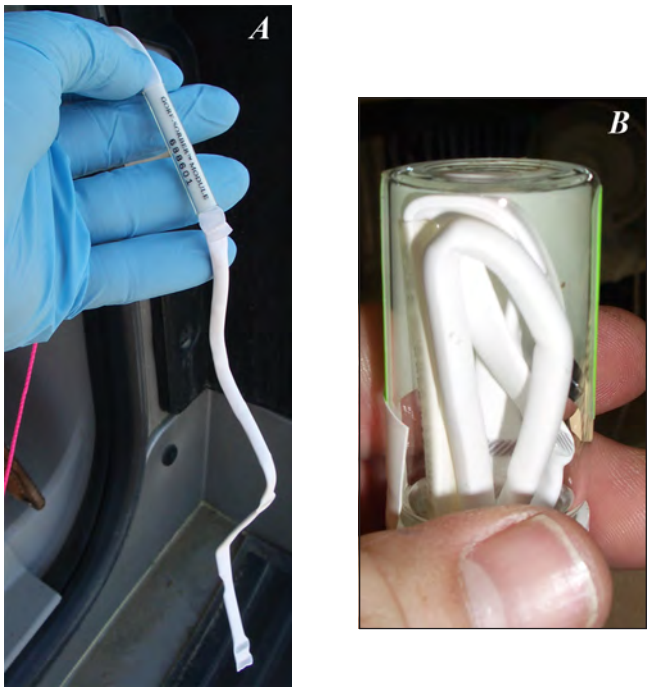
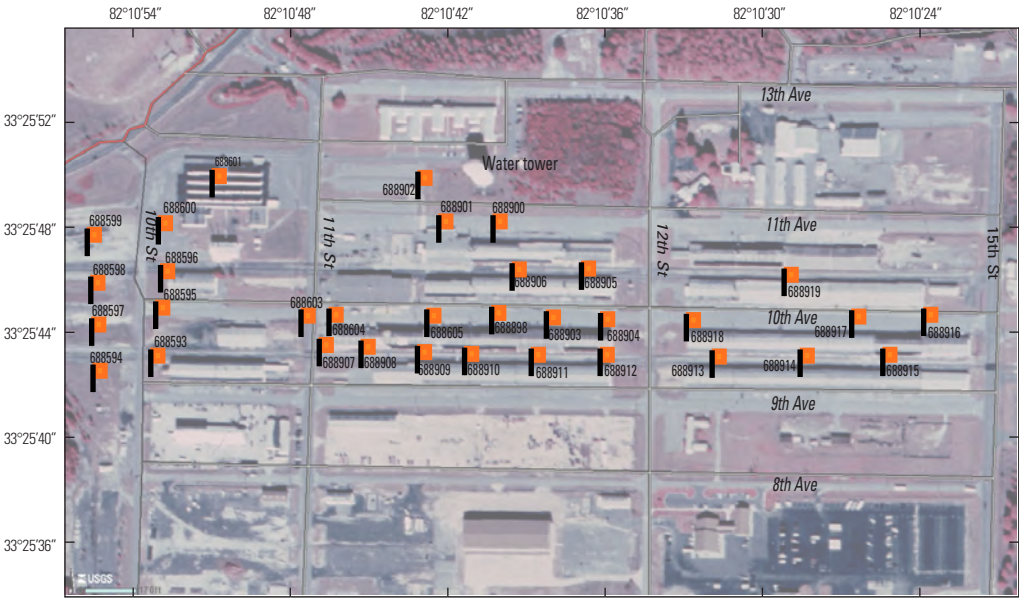


Figure 2. GORE™ module (*A*) prior to being installed in a shallow borehole, and (*B*) following retrieval from a borehole and prior to shipping to laboratory for analysis.

ASTM, 2006). The module consists of an adsorbent material placed inside a shoestring-shaped GORE-TEX® tube (fig. 2*A*). The adsorbent material can adsorb a wide variety of volatile organic compounds (VOCs), including solvents such as perchloroethylene (PCE; also known as tetrachloroethylene); trichloroethylene (TCE); benzene, toluene, ethylbenzene, and xylenes (collectively referred to as BTEX); methyl *tert*-butyl ether (MTBE); semivolatile organic compounds (SVOCs); total petroleum hydrocarbons (TPH); and polycyclic aromatic hydrocarbons (PAHs) such as naphthalene. The modules are tied to a string, attached to a cork plug to prevent the entrance of surface water and ambient surface sources of contamination, and inserted into a shallow borehole. The modules then are removed from the field after 10 to 14 days, placed in 20-milliliter gas-tight vials (fig. 2*B*), and sent to the commercial laboratory (W.L. Gore and Associates, Inc.) for analysis by gas chromatography/mass spectroscopy using a modification of U.S. Environmental Protection Agency (USEPA) method 8260/8270 to include thermal desorption of the sample. The laboratory is in compliance with Good Laboratory Practices and ISO Guide 25 (International Organization for Standardization, 1990). The soil-gas contaminant results are expressed as mass of contaminant (micrograms) and provide screening-level data.

Passive soil-gas results can indicate the presence of particular contaminants. The results do not, however, reveal if the detection was derived from free product, from residual-phase adsorbed material or vapors in the unsaturated zone, or from the dissolved-phase in shallow and deep groundwater (unless the module is placed in water). In general, higher soil-gas mass in a sample tends to be related to the presence of residual contamination or free product that is close to the land surface where the soil-gas sampler is located. If such source material is located at greater depths, however, the soil-gas contaminant mass will generally be lower. A lower value near known sources may be due to various attenuation processes that affect the soil-gas mass prior to detection. In both cases, however, the modules help to rapidly indicate the presence or absence of contaminants. The passive soil-gas approach was approved for use at the IR site by the Hazardous Waste Management Branch, Georgia Environmental Protection Department (William Powell, P.E., Environmental Engineer, Department of Defense Remediation Unit, oral commun., December 10, 2008).

A passive soil-gas survey was conducted at the IR site during April–June 2009. Thirty-five soil-gas samplers (modules) were deployed (fig. 3). The soil-gas samplers were placed in a grid pattern to cover the generalized extent of the western part of the IR; care was taken to not place samplers too near the northeastern corner of the IR where a fire had



EXPLANATION

688594 **Soil-gas sample location and identification**

Figure 3. Locations of soil-gas sampling sites and sample identification numbers, Installation Railhead, Fort Gordon, Georgia, 2008–2009.

recently destroyed an empty warehouse. Two additional soil-gas samplers were used as trip-blank samplers and were not deployed. Each sampler was placed in a borehole that was 2.5 centimeter (cm) in diameter, 75 cm long, and created by a stainless steel ship-auger attached to a cordless drill. This depth is similar to that recommended by the USEPA for soil-gas investigations (U.S. Environmental Protection Agency, 1998). The auger was cleaned with a paper towel between boreholes. The 35 modules were installed on April 23, 2009, and May 5, 2009. Thirty-three samplers (two samplers could not be found) were removed on June 1, 2009, placed in 20-milliliter gas-tight vials, and sent to the W.L. Gore and Associates, Inc., laboratory for analysis.

Surface-Water Sample

A water-quality sample was collected on July 27, 2009, in duplicate, from an unnamed tributary to Marcum Branch located to the west of and downgradient from the IR. The surface-water sample essentially represented the discharge of locally recharged groundwater or runoff that may have been in contact with the material beneath or at land surface of the IR, respectively. The water sample was analyzed for 85 VOCs, 18 SVOCs such as PAHs, and 22 metals, including seven of the eight RCRA metals.

Soil Samples

Composite soil samples were collected on July 27, 2009, after soil-gas results were received, from land surface to a depth of 6 inches (in.) at three locations. These soil samples were analyzed for 37 metals, including 6 of the 8 RCRA metals (selenium and mercury were excluded).

Results

Passive Soil-Gas Survey

All soil-gas samplers (modules) collected had TPH concentrations greater than the method detection level of 0.02 microgram (µg) (fig. 4; table 1). The highest soil-gas TPH mass was 21.34 µg and was located in the northwestern corner of the IR where a large building had previously stood. Soil-gas TPH mass from 11 to 20 µg and between 5 and 10 µg also were detected in two samplers south of this area. A smaller area of TPH soil-gas mass between 5 and 10 µg is located in the eastern side of the IR, along 10th Avenue. Because all soil-gas module locations contained soil-gas TPH mass at levels greater than the method detection level of 0.02 µg, additional samples would be required to fully delineate the contaminant boundary with respect to TPH. The detections in the samples were higher than the reported detections of TPH in the two trip blanks of 0.03 and 0.04 µg, respectively.

Some soil-gas samples had BTEX mass greater than the method detection level of 0.01 µg (fig. 5; table 1). BTEX mass in soil gas between 0.01 and 0.1 µg were detected across the middle of the IR, between 9th and 10th Avenues. The highest soil-gas BTEX mass (greater than 1 µg) was detected in the western part of the IR, near the intersection of 11th Street with 10th Avenue. This location of high BTEX soil-gas mass coincides with a location of high soil-gas TPH mass (fig. 4). Moreover, the soil-gas mass of naphthalene at this location was greater than 1 µg (fig. 6). These areas of elevated soil-gas mass coincide with the footprint of a building that had been in the northwestern corner of the IR,

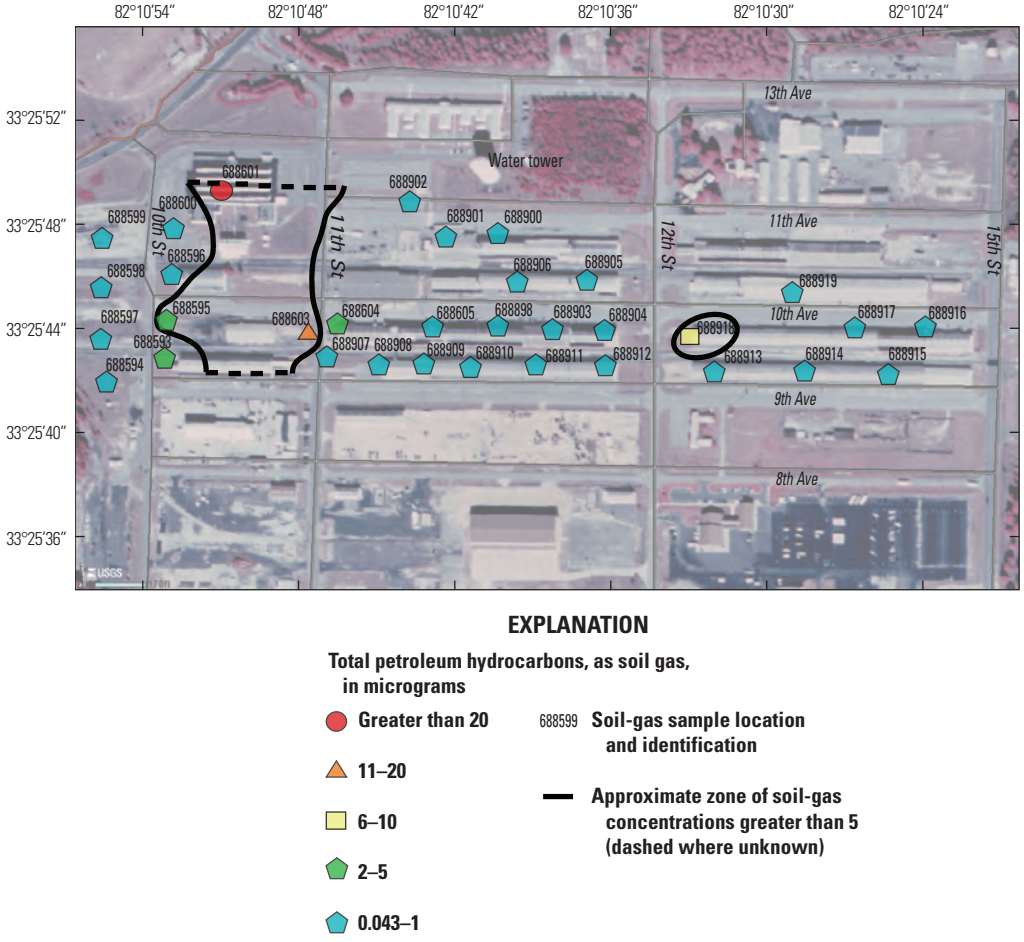


Figure 4. Total petroleum hydrocarbon (TPH) mass in soil-gas samples, Installation Railhead, Fort Gordon, Georgia, 2008–2009. Method detection level is 0.02 microgram.

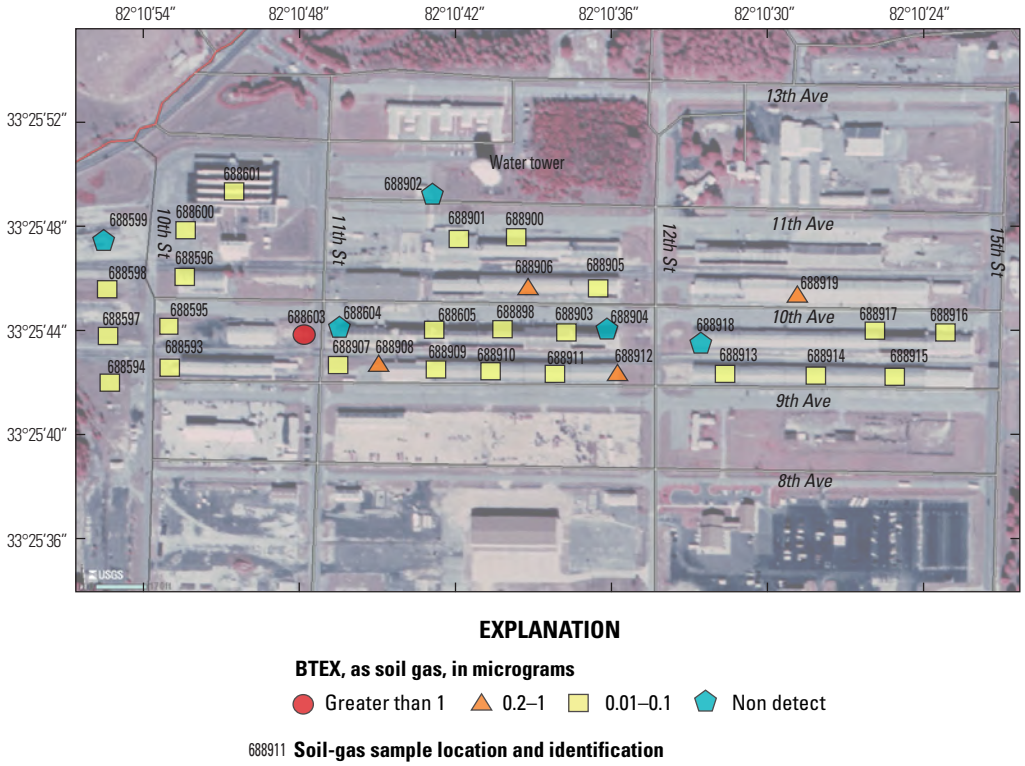


Figure 5. Benzene, toluene, ethylbenzene, and xylenes (BTEX) mass in soil-gas samples, Installation Railhead, Fort Gordon, Georgia, 2008–2009. Method detection level is 0.01 microgram.

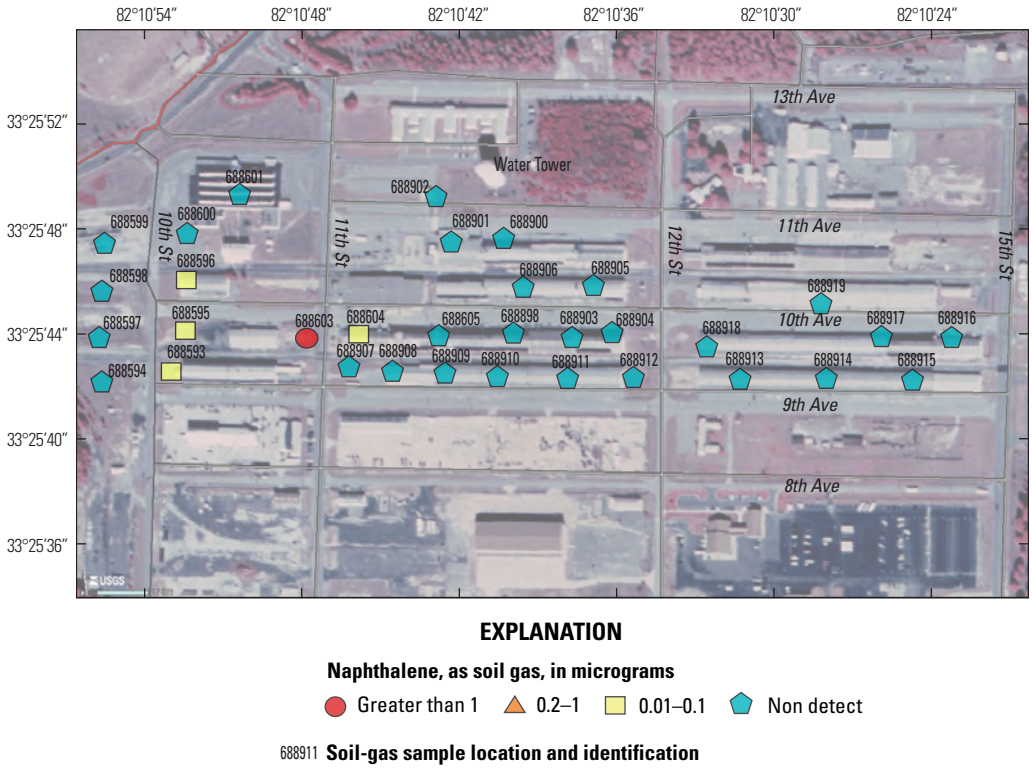


Figure 6. Naphthalene mass in soil-gas samples, Installation Railhead, Fort Gordon, Georgia, 2008–2009. Method detection level is 0.01 microgram.

and with former buildings 2301, 2303, 2401, and 2403. The BTEX detections also were higher than the reported detection of BTEX (0.01 µg) in one of the two trip blanks.

Most of the soil-gas modules installed had no PCE mass above the method detection level of 0.01 µg (fig. 7); however, soil-gas PCE greater than 0.5 µg was detected in samples collected from near the intersections of 11th Street with 9th and 10th Avenues (fig. 7). These elevated PCE soil-gas masses are located in an area where buildings 2410 and 2405 had been located.

For all soil-gas results, the presence of a contaminant above the method detection level at a particular soil-gas sample location suggests an environmental effect. Moreover, because all soil-gas samplers were installed to the same depth, a higher result in microgram for a particular contaminant in soil gas suggests closer proximity to a contaminant source.

Surface-Water Sample

A water sample was collected (in duplicate) from the unnamed tributary to Marcum Branch west of the IR (fig. 8) and was analyzed for 85 VOCs, 18 SVOCs including PAHs, and 22 metals (tables 2–4). For VOCs, only toluene and chloroform were detected; both detections were at levels below the National Primary Drinking Water Standard (NPDWS) maximum contaminant level (MCL). The variability between results for VOCs and SVOCs for the duplicate samples was less than 1 percent (data not listed in table 3). The surface-water sample collected may be more representative of groundwater discharge rather than runoff because the sample was collected during a dry period.

The surface-water sample also was analyzed for inorganic compounds, including 7 of the 8 RCRA metals (mercury was excluded). The water sample contained a concentration of iron that was 686 µg/L and exceeded the NSDWS MCL of 300 µg/L (table 4). The variability between results for inorganic compounds for the duplicate sample was less than 4 percent (data not listed in table 4).

Soil Samples

Composite soil samples were collected from land surface to 6 in. below land surface at three locations characterized by elevated soil-gas contaminants (fig. 8). The samples were analyzed for 37 metals, including 6 of the RCRA metals (selenium and mercury were excluded). Soil-sample metal concentrations were compared to the USEPA Regional Screening Levels (RSLs) for Industrial Soils (U.S. Environmental Protection Agency, 2009) to determine the extent of contamination (tables 5–7). Soil-sample metal concentrations also were compared to values for ambient, uncontaminated (background) levels for soils across the adjacent State of South Carolina (South Carolina Department of Health and Environmental Control, 2002) because no similar values were available from Georgia. The comparison remains valid because Georgia and South Carolina are composed of similar physiographic provinces.

At all three locations, metal concentrations in soil samples did not exceed the RSLs (tables 5–7). Some metal concentrations were, however, higher than background conditions reported for similar Coastal Plain sediments in South Carolina. Concentrations higher than background concentrations in South Carolina include results for aluminum, arsenic, barium, calcium, chromium, copper, iron, lead, nickel, potassium, sodium, and zinc (tables 5–7).

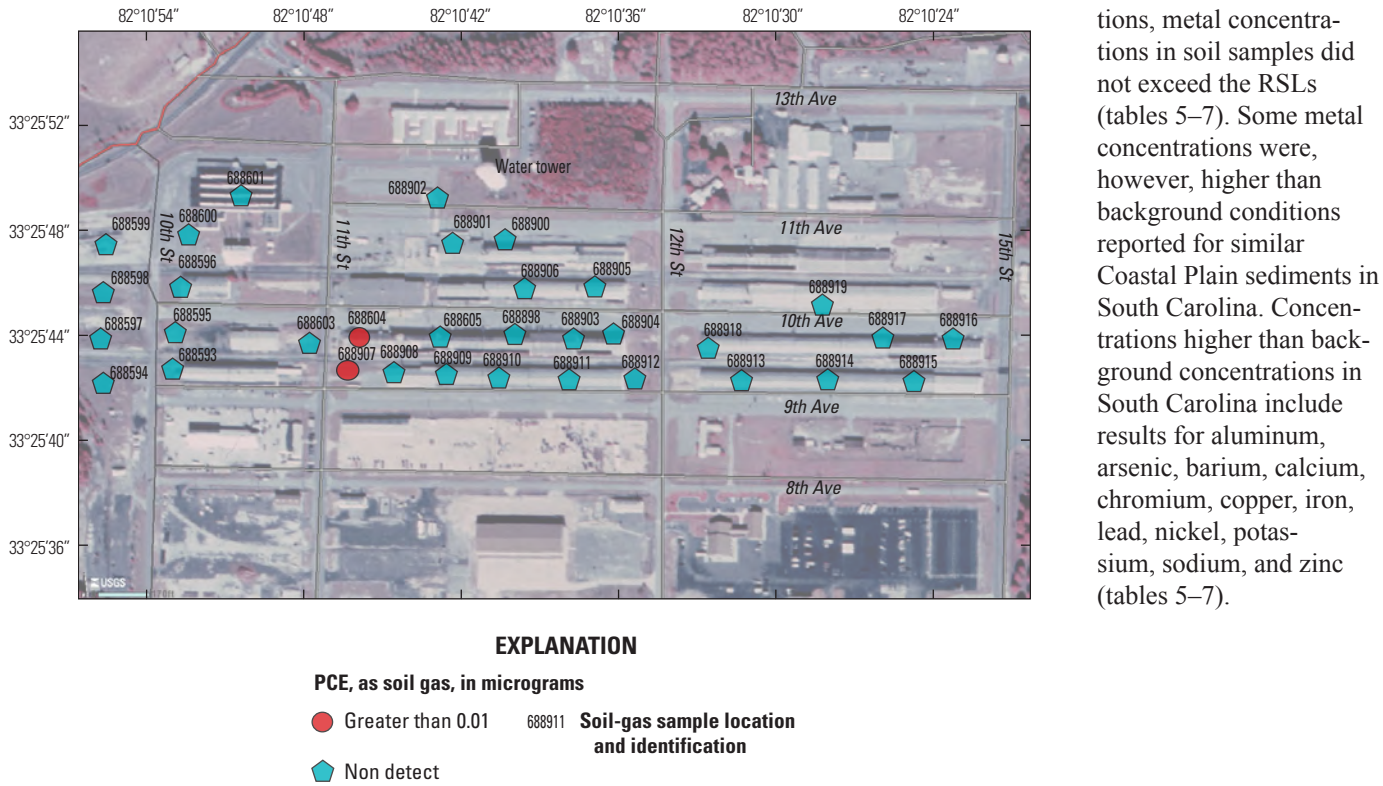


Figure 7. Perchloroethylene (PCE) mass in soil-gas samples, Installation Railhead, Fort Gordon, Georgia, 2008–2009. PCE is also known as tetrachloroethylene. Method detection level is 0.01 microgram.

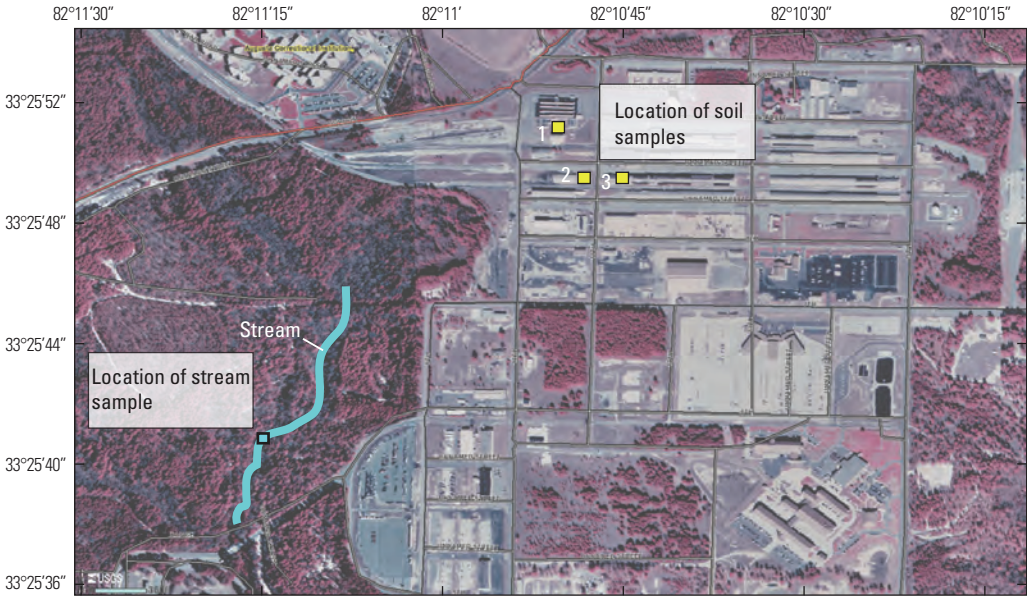


Figure 8. Locations of surface-water and soil sampling sites, Installation Railhead, Fort Gordon, Georgia, 2008–2009.

Summary

The U.S. Geological Survey, in cooperation with the Environmental and Natural Resources Management Office of the U.S. Army Signal Center and Fort Gordon, Georgia, assessed soil gas, surface water, and soil for contaminants at the Installation Railhead (IR) on Fort Gordon, Georgia, from October 2008 to September 2009. Soil-gas samples collected within a localized area on the western part of the IR had elevated masses above the method detection level for total petroleum hydrocarbons; benzene, toluene, ethylbenzene, and total xylenes (BTEX); and naphthalene. These soil-gas samples were collected where buildings had previously stood, such as buildings 2301, 2303, 2401, and 2403. Because all soil-gas module locations contained soil-gas TPH mass at levels greater than the method detection level of 0.02 microgram, additional samples would be required to fully delineate the contaminant boundary with respect to TPH. Soil-gas samples collected within a localized area had elevated masses of perchloroethylene (PCE). These samples were collected where buildings 2410 and 2405 had been. Duplicate surface-water samples were collected from an unnamed tributary to Marcum Branch and contained concentrations of toluene and acetone below the National Primary Drinking Water Standard maximum contaminant level (MCL) for each compound. Iron was detected in the surface-water sample at 686 micrograms per liter and exceeded the National Secondary Drinking Water Standard. Metal concentrations in soil samples did not exceed the U.S. Environmental Protection Agency Regional Screening Level for industrial soil.

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Table 1. Mass of volatile organic compounds detected in soil-gas samples collected from the Installation Railhead, Fort Gordon, Georgia, 2008–2009.

[MDL, method detection level; µg, micrograms; nd, not detected; **688934** and **688935** are trip blanks; TPH, total petroleum hydrocarbons; BTEX, benzene, toluene, ethylbenzene, and xylenes; MTBE, methyl *tert*-butyl ether; TCA, trichloroethene; DCA, dichloroethane; TCE, trichloroethylene; DCE, dichloroethylene; PCE, perchloroethylene; DCB, dichlorobenzene; –, not applicable]

Sample number	TPH (µg)	BTEX (µg)	Benzene (µg)	Toluene (µg)	Ethylbenzene (µg)	m-,p-Xylene (µg)	o-Xylene (µg)
MDL =	**0.02**	**–**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
688593	2.63	0.02	nd	nd	nd	0.01	0.01
688594	0.58	0.03	nd	nd	nd	0.02	0.01
688595	5.94	0.06	0.05	nd	nd	nd	0.01
688596	0.40	0.03	nd	0.03	nd	nd	nd
688597	0.62	0.02	nd	0.02	nd	nd	nd
688598	0.40	0.01	nd	0.01	nd	nd	nd
688599	0.29	nd	nd	nd	nd	nd	nd
688600	0.38	0.03	0.03	nd	nd	nd	nd
688601	21.34	0.06	nd	0.05	nd	0.01	nd
688603	11.11	1.47	nd	0.02	0.05	0.44	0.96
688604	2.11	nd	nd	nd	nd	nd	nd
688605	0.28	0.03	0.03	nd	nd	nd	nd
688898	0.60	0.08	nd	0.08	nd	nd	nd
688900	0.36	0.09	0.05	0.04	nd	nd	nd
688901	0.51	0.11	nd	0.11	nd	nd	nd
688902	1.14	nd	nd	nd	nd	nd	nd
688903	0.30	0.17	0.15	0.02	nd	nd	nd
688904	0.20	nd	nd	nd	nd	nd	nd
688905	0.22	0.12	0.08	0.04	nd	nd	nd
688906	0.49	0.23	0.15	0.06	0.02	nd	nd
688907	0.21	0.06	nd	0.01	0.01	0.03	0.01
688908	1.55	0.50	0.28	0.10	0.08	0.03	0.01
688909	0.11	0.09	0.04	0.02	nd	0.03	nd
688910	1.23	0.03	0.02	0.01	nd	nd	nd
688911	0.51	0.05	0.03	0.02	nd	nd	nd
688912	0.87	0.26	0.20	0.04	nd	0.02	nd
688913	0.43	0.05	0.05	nd	nd	nd	nd
688914	0.72	0.03	0.03	nd	nd	nd	nd
688915	1.57	0.01	nd	0.01	nd	nd	nd
688916	0.30	0.14	0.10	0.04	nd	nd	nd
688917	0.27	0.09	0.05	0.04	nd	nd	nd
688918	7.22	nd	nd	nd	nd	nd	nd
688919	1.25	0.26	0.10	0.10	0.02	0.03	0.01
688934	**0.03**	**0.01**	**nd**	**0.01**	**nd**	**nd**	**nd**
688935	**0.04**	**nd**	**nd**	**nd**	**nd**	**nd**	**nd**

Table 1. Mass of volatile organic compounds detected in soil-gas samples collected from the Installation Railhead, Fort Gordon, Georgia, 2008–2009.—Continued

[MDL, method detection level; µg, micrograms; nd, not detected; 688934 and 688935 are trip blanks; TPH, total petroleum hydrocarbons; BTEX, benzene, toluene, ethylbenzene, and xylenes; MTBE, methyl *tert*-butyl ether; DCA, dichloroethane; TCA, trichloroethene; DCA, dichloroethane; TCE, trichloroethylene; DCE, dichloroethylene; PCE, perchloroethylene; DCB, dichlorobenzene]

Sample number	Naphthalene (µg)	2-Methyl-Naphthalene (µg)	MTBE (µg)	Octane (µg)
MDL =	**0.01**	**0.01**	**0.01**	**0.01**
688593	0.02	0.02	nd	nd
688594	nd	nd	nd	nd
688595	0.19	0.21	nd	nd
688596	0.02	0.01	nd	nd
688597	nd	nd	nd	nd
688598	nd	nd	nd	nd
688599	nd	nd	nd	nd
688600	nd	nd	nd	nd
688601	nd	nd	nd	nd
688603	1.46	1.23	nd	0.01
688604	0.15	0.14	nd	nd
688605	nd	nd	nd	nd
688898	nd	nd	nd	nd
688900	nd	nd	nd	nd
688901	nd	0.01	nd	nd
688902	nd	nd	nd	nd
688903	nd	nd	nd	nd
688904	nd	nd	nd	nd
688905	nd	nd	nd	nd
688906	nd	nd	nd	0.02
688907	nd	nd	nd	nd
688908	nd	nd	nd	0.03
688909	nd	nd	nd	nd
688910	nd	nd	nd	nd
688911	nd	nd	nd	nd
688912	nd	nd	nd	0.01
688913	nd	nd	nd	nd
688914	nd	nd	nd	nd
688915	nd	nd	nd	nd
688916	nd	nd	nd	0.01
688917	nd	nd	nd	nd
688918	nd	nd	nd	nd
688919	nd	nd	nd	0.02
688934	**nd**	**nd**	**nd**	**nd**
688935	**nd**	**nd**	**nd**	**nd**

Table 1. Mass of volatile organic compounds detected in soil-gas samples collected from the Installation Railhead, Fort Gordon, Georgia, 2008–2009.—Continued

[MDL, method detection level; µg, micrograms; nd, not detected; **688934** and **688935** are trip blanks; TPH, total petroleum hydrocarbons; BTEX, benzene, toluene, ethylbenzene, and xylenes; MTBE, methyl *tert*-butyl ether; DCA, dichloroethane; TCA, trichloroethene; DCA, dichloroethane; TCE, trichloroethylene; DCE, dichloroethylene; PCE, perchloroethylene; DCB, dichlorobenzene; –, not applicable]

Sample number	C_{11}, C_{13}, & C_{15} (µg)	Undecane (µg)	Tridecane (µg)	Pentadecane (µg)
MDL =	–	**0.01**	**0.01**	**0.01**
688593	0.05	0.01	0.02	0.02
688594	nd	nd	nd	nd
688595	0.01	0.01	nd	nd
688596	0.01	0.01	nd	nd
688597	nd	nd	nd	nd
688598	nd	nd	nd	nd
688599	nd	nd	nd	nd
688600	nd	nd	nd	nd
688601	0.03	0.01	0.01	0.01
688603	0.14	0.11	0.02	0.01
688604	nd	nd	nd	nd
688605	nd	nd	nd	nd
688898	nd	nd	nd	nd
688900	nd	nd	nd	nd
688901	0.01	0.01	nd	nd
688902	nd	nd	nd	nd
688903	nd	nd	nd	nd
688904	nd	nd	nd	nd
688905	nd	nd	nd	nd
688906	nd	nd	nd	nd
688907	nd	nd	nd	nd
688908	nd	nd	nd	nd
688909	nd	nd	nd	nd
688910	nd	nd	nd	nd
688911	nd	nd	nd	nd
688912	nd	nd	nd	nd
688913	nd	nd	nd	nd
688914	0.05	0.02	0.02	0.01
688915	nd	nd	nd	nd
688916	nd	nd	nd	nd
688917	nd	nd	nd	nd
688918	nd	nd	nd	nd
688919	nd	nd	nd	nd
688934	**nd**	**nd**	**nd**	**nd**
688935	**nd**	**nd**	**nd**	**nd**

Table 1. Mass of volatile organic compounds detected in soil-gas samples collected from the Installation Railhead, Fort Gordon, Georgia, 2008–2009.—Continued

[MDL, method detection level; µg, micrograms; nd, not detected; **688934** and **688935** are trip blanks; TPH, total petroleum hydrocarbons; BTEX, benzene, toluene, ethylbenzene, and xylenes; MTBE, methyl *tert*-butyl ether; DCA, dichloroethane; TCA, trichloroethene; DCA, dichloroethane; TCE, trichloroethylene; DCE, dichloroethylene; PCE, perchloroethylene; DCB, dichlorobenzene; –, not applicable]

Sample number	Trimethyl benzenes (µg)	1,2,4-Trimethyl benzene (µg)	1,3,5-Trimethyl benzene (µg)	1,1-DCA (µg)	Chloroform (µg)	1,1,1-TCA (µg)	1,2-DCA (µg)
MDL =	–	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
688593	0.02	0.01	0.01	nd	nd	nd	nd
688594	0.01	0.01	nd	nd	nd	nd	nd
688595	0.06	0.04	0.02	nd	0.03	nd	nd
688596	0.04	0.03	0.01	nd	nd	nd	nd
688597	0.03	nd	0.03	nd	nd	nd	nd
688598	nd	nd	nd	nd	nd	nd	nd
688599	nd	nd	nd	nd	nd	nd	nd
688600	0.01	0.01	nd	nd	nd	nd	nd
688601	nd	nd	nd	nd	nd	nd	nd
688603	1.30	1.06	0.24	nd	nd	nd	nd
688604	0.03	0.03	nd	nd	nd	nd	nd
688605	nd	nd	nd	nd	nd	nd	nd
688898	nd	nd	nd	nd	nd	nd	nd
688900	nd	nd	nd	nd	nd	nd	nd
688901	nd	nd	nd	nd	nd	nd	nd
688902	nd	nd	nd	nd	nd	nd	nd
688903	nd	nd	nd	nd	nd	nd	nd
688904	nd	nd	nd	nd	nd	nd	nd
688905	nd	nd	nd	nd	nd	nd	nd
688906	nd	nd	nd	nd	nd	nd	nd
688907	0.04	0.03	0.01	nd	nd	nd	nd
688908	0.02	0.01	0.01	nd	nd	nd	nd
688909	0.06	0.05	0.01	nd	nd	nd	nd
688910	0.01	nd	0.01	nd	nd	nd	nd
688911	nd	nd	nd	nd	nd	nd	nd
688912	0.02	0.01	0.01	nd	nd	nd	nd
688913	0.04	nd	0.04	nd	nd	nd	nd
688914	nd	nd	nd	nd	nd	nd	nd
688915	nd	nd	nd	nd	nd	nd	nd
688916	nd	nd	nd	nd	nd	nd	nd
688917	nd	nd	nd	nd	nd	nd	nd
688918	nd	nd	nd	nd	nd	nd	nd
688919	nd	nd	nd	nd	nd	nd	nd
688934	**nd**	**nd**	**nd**	**nd**	**nd**	**nd**	**nd**
688935	**nd**	**nd**	**nd**	**nd**	**nd**	**nd**	**nd**

Table 1. Mass of volatile organic compounds detected in soil-gas samples collected from the Installation Railhead, Fort Gordon, Georgia, 2008–2009.—Continued

[MDL, method detection level; µg, micrograms; nd, not detected; **688934** and **688935** are trip blanks; TPH, total petroleum hydrocarbons; BTEX, benzene, toluene, ethylbenzene, and xylenes; MTBE, methyl *tert*-butyl ether; DCA, dichloroethane; TCA, trichloroethene; DCA, dichloroethane; TCE, trichloroethylene; DCE,dichloroethylene; PCE, perchloroethylene; DCB, dichlorobenzene; c, cis; t, trans; –, not applicable]

Sample number	TCE (µg)	c,t-1,2-DCE (µg)	t-1,2-DCE (µg)	c-1,2-DCE (µg)	PCE (µg)
MDL =	**0.01**	–	**0.03**	**0.01**	**0.01**
688593	nd	nd	nd	nd	nd
688594	nd	nd	nd	nd	nd
688595	nd	nd	nd	nd	nd
688596	nd	nd	nd	nd	nd
688597	nd	nd	nd	nd	nd
688598	nd	nd	nd	nd	nd
688599	nd	nd	nd	nd	nd
688600	nd	nd	nd	nd	nd
688601	nd	nd	nd	nd	nd
688603	nd	nd	nd	nd	nd
688604	nd	nd	nd	nd	0.64
688605	nd	nd	nd	nd	nd
688898	nd	nd	nd	nd	nd
688900	nd	nd	nd	nd	nd
688901	nd	nd	nd	nd	nd
688902	nd	nd	nd	nd	nd
688903	nd	nd	nd	nd	nd
688904	nd	nd	nd	nd	nd
688905	nd	nd	nd	nd	nd
688906	nd	nd	nd	nd	nd
688907	0.02	nd	nd	nd	0.57
688908	nd	nd	nd	nd	nd
688909	nd	nd	nd	nd	nd
688910	nd	nd	nd	nd	nd
688911	nd	nd	nd	nd	nd
688912	nd	nd	nd	nd	nd
688913	nd	nd	nd	nd	nd
688914	nd	nd	nd	nd	nd
688915	nd	nd	nd	nd	nd
688916	nd	nd	nd	nd	nd
688917	nd	nd	nd	nd	nd
688918	nd	nd	nd	nd	nd
688919	nd	nd	nd	nd	nd
688934	**nd**	**nd**	**nd**	**nd**	**nd**
688935	**nd**	**nd**	**nd**	**nd**	**nd**

Table 1. Mass of volatile organic compounds detected in soil-gas samples collected from the Installation Railhead, Fort Gordon, Georgia, 2008–2009.—Continued

[MDL, method detection level; µg, micrograms; nd, not detected; **688934** and **688935** are trip blanks; TPH, total petroleum hydrocarbons; BTEX, benzene, toluene, ethylbenzene, and xylenes; MTBE, methyl *tert*-butyl ether; DCA, dichloroethane; TCA, trichloroethene; DCA, dichloroethane; TCE, trichloroethylene; DCE, dichloroethylene; PCE, perchloroethylene; DCB, dichlorobenzene]

Sample number	1,4-DCB (µg)	CCl_4 (µg)	1,1,2-TCA (µg)	Chlorobenzene (µg)	1,1,1,2-Tetra-chloro-ethane (µg)	1,1,2,2-Tetra-chloro-ethane (µg)
MDL =	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
688593	nd	nd	nd	nd	nd	nd
688594	nd	nd	nd	nd	nd	nd
688595	nd	nd	nd	nd	nd	nd
688596	nd	nd	nd	nd	nd	nd
688597	nd	nd	nd	nd	nd	nd
688598	nd	nd	nd	nd	nd	nd
688599	nd	nd	nd	nd	nd	nd
688600	nd	nd	nd	nd	nd	nd
688601	nd	nd	nd	nd	nd	nd
688603	nd	nd	nd	nd	nd	nd
688604	nd	nd	nd	nd	nd	nd
688605	nd	nd	nd	nd	nd	nd
688898	nd	nd	nd	nd	nd	nd
688900	nd	nd	nd	nd	nd	nd
688901	nd	nd	nd	nd	nd	nd
688902	nd	nd	nd	nd	nd	nd
688903	nd	nd	nd	nd	nd	nd
688904	nd	nd	nd	nd	nd	nd
688905	nd	nd	nd	nd	nd	nd
688906	nd	nd	nd	nd	nd	nd
688907	0.01	nd	nd	0.01	nd	nd
688908	nd	nd	nd	nd	nd	nd
688909	nd	nd	nd	nd	nd	nd
688910	nd	nd	nd	nd	nd	nd
688911	nd	nd	nd	nd	nd	nd
688912	nd	nd	nd	nd	nd	nd
688913	nd	nd	nd	nd	nd	nd
688914	nd	nd	nd	nd	nd	nd
688915	nd	nd	nd	nd	nd	nd
688916	nd	nd	nd	nd	nd	nd
688917	nd	nd	nd	nd	nd	nd
688918	nd	nd	nd	nd	nd	nd
688919	nd	nd	nd	nd	nd	nd
688934	**nd**	**nd**	**nd**	**nd**	**nd**	**nd**
688935	**nd**	**nd**	**nd**	**nd**	**nd**	**nd**

Table 1. Mass of volatile organic compounds detected in soil-gas samples collected from the Installation Railhead, Fort Gordon, Georgia, 2008–2009.—Continued

[MDL, method detection level; µg, micrograms; nd, not detected; **688934** and **688935** are trip blanks; TPH, total petroleum hydrocarbons; BTEX, benzene, toluene, ethylbenzene, and xylenes; MTBE, methyl *tert*-butyl ether; DCA, dichloroethane; TCA, trichloroethene; DCA, dichloroethane; TCE, trichloroethylene; DCE, dichloroethylene; PCE, perchloroethylene; DCB, dichlorobenzene]

Sample number	1,3-Dichlorobenzene (µg)	1,2-Dichlorobenzene (µg)
MDL =	**0.01**	**0.01**
688593	nd	nd
688594	nd	nd
688595	nd	nd
688596	nd	nd
688597	nd	nd
688598	nd	nd
688599	nd	nd
688600	nd	nd
688601	nd	nd
688603	nd	nd
688604	nd	nd
688605	nd	nd
688898	nd	nd
688900	nd	nd
688901	nd	nd
688902	nd	nd
688903	nd	nd
688904	nd	nd
688905	nd	nd
688906	nd	nd
688907	nd	0.05
688908	nd	nd
688909	nd	nd
688910	nd	nd
688911	nd	nd
688912	nd	nd
688913	nd	nd
688914	nd	nd
688915	nd	nd
688916	nd	nd
688917	nd	nd
688918	nd	nd
688919	nd	nd
688934	**nd**	**nd**
688935	**nd**	**nd**

Table 2. Organic constituents detected in the stream to the west of the Installation Railhead, collected July 27, 2009.

[µg/L, micrograms per liter; MCL, maximum contaminant level for National Primary Drinking Water Standards (NPDWS); E, estimated; <, less than; –, not applicable]

Parameter	Result (µg/L)	MCL (µg/L)
1,1,1,2-Tetrachloroethane	<0.04	–
1,1,1-Trichloroethane	<0.02	200
1,1,2,2-Tetrachloroethane	<0.1	–
1,1,2-Trichloroethane	<0.06	5
1,1,2-Trichlorotrifluoroethane	<0.04	–
1,1-Dichloroethane	<0.04	–
1,1-Dichloroethylene	<0.02	–
1,1-Dichloropropene	<0.04	–
1,2,3,4-Tetramethylbenzene	<0.08	–
1,2,3,5-Tetramethylbenzene	<0.08	–
1,2,3-Trichlorobenzene	<0.06	–
1,2,3-Trichloropropane	<0.12	–
1,2,3-Trimethylbenzene	<0.08	–
1,2,4-Trichlorobenzene	<0.04	70
1,2,4-Trimethylbenzene	<0.04	–
1,2-Dibromo-3-chloropropane	<1	–
1,2-Dibromoethane	<0.04	–
1,2-Dichlorobenzene	<0.02	–
1,2-Dichloroethane	<0.06	5
1,2-Dichloropropane	<0.02	–
1,3,5-Trimethylbenzene	<0.04	–
1,3-Dichlorobenzene	<0.02	75
1,3-Dichloropropane	<0.06	–
1,4-Dichlorobenzene	<0.02	–
2,2-Dichloropropane	<0.06	–
2-Butanone	<1.6	–
2-Chlorotoluene	<0.02	–
2-Hexanone	<0.6	–
3-Chloropropene	<0.08	–
4-Chlorotoluene	<0.02	–
4-Isopropyl-1-methylbenzene	<0.06	–
4-Methyl-2-pentanone	<0.4	–
Acetone	<4	–
Acrylonitrile	<0.4	–
Benzene	<0.016	5
Bromobenzene	<0.02	–
Bromochloromethane	<0.06	–
Bromodichloromethane	<0.04	–

Table 2. Organic constituents detected in the stream to the west of the Installation Railhead, collected July 27, 2009.—Continued

[µg/L, micrograms per liter; MCL, maximum contaminant level for National Primary Drinking Water Standards (NPDWS); E, estimated; <, less than; –, not applicable]

Parameter	Result (µg/L)	MCL (µg/L)
Bromoethene	<0.12	–
Bromoform	<0.1	–
Bromomethane	<0.4	–
Butylbenzene	<0.08	–
Carbon disulfide	<0.04	–
Chlorobenzene	<0.02	–
Chloroethane	<0.1	–
Chloroform	0.017(E)	–
Chloromethane	<0.14	–
cis-1,2-Dichloroethylene	<0.02	–
cis-1,3-Dichloropropene	<0.1	–
Dibromochloromethane	<0.12	–
Dibromomethane	<0.04	–
Dichlorodifluoromethane	<0.1	–
Dichloromethane	<0.04	–
Diethyl ether	<0.12	–
Diisopropyl ether	<0.06	–
Ethyl methacrylate	<0.14	–
Ethyl *tert*-butyl ether	<0.04	–
Ethylbenzene	<0.04	–
Hexachlorobutadiene	<0.06	–
Hexachloroethane	<0.14	–
Isopropylbenzene	<0.04	–
m- and p-Xylene	<0.08	–
Methyl acrylate	<0.6	–
Methyl acrylonitrile	<0.2	–
Methyl iodide	<0.8	–
Methyl methacrylate	<0.2	–
Naphthalene	<0.2	–
n-Propylbenzene	<0.04	–
o-Ethyl toluene	<0.02	–
o-Xylene	<0.04	10,000
sec-Butylbenzene	<0.02	–
Styrene	<0.04	–
tert-Butyl methyl ether	<0.1	–
tert-Butylbenzene	<0.06	–
tert-Pentyl methyl ether	<0.06	–

Table 2. Organic constituents detected in the stream to the west of the Installation Railhead, collected July 27, 2009.—Continued

[µg/L, micrograms per liter; MCL, maximum contaminant level for National Primary Drinking Water Standards (NPDWS); E, estimated; <, less than; –, not applicable]

Parameter	Result (µg/L)	MCL (µg/L)
Tetrachloroethylene (PCE; perchloroethylene)	<0.04	5
Tetrachloromethane	<0.06	–
Tetrahydrofuran	<1.4	–
Toluene	0.053(E)	1,000
trans-1,2-Dichloroethylene	<0.018	–
trans-1,3-Dichloropropene	<0.1	–
trans-1,4-Dichloro-2-Butene	<0.4	–
Trichloroethylene	<0.02	5
Trichlorofluoromethane	<0.08	–
Vinyl chloride	<0.08	2

Table 3. Semivolatile organic constituents detected in the stream to the west of the Installation Railhead, collected July 27, 2009.

[µg/L, micrograms per liter; ISWQS, Georgia In-Stream Water-Quality Standard, acute freshwater; MCL, maximum contaminant level for National Primary Drinking Water Standards (NPDWS); MCL_s, maximum contaminant level for National Secondary Drinking Water Standards (NSDWS); <, less than; –, not applicable]

Parameter	Result (µg/L)	ISWQS (µg/L)	MCL (µg/L)	MCL_s (µg/L)
Acenaphthene	<0.28	–	–	–
Acenaphthylene	<0.30	–	–	–
Anthracene	<0.39	–	–	–
Benzo (a) anthracene	<0.26	–	–	–
Benzo (a) pyrene	<0.33	–	0.2	–
Benzo (b) fluoranthene	<0.40	–	–	–
Benzo (ghi) perylene	<0.40	–	–	–
Benzo (k) fluorathene	<0.40	–	–	–
Chrysene	<0.33	–	–	–
Dibenz (a,h) anthracene	<0.40	–	–	–
Fluoranthene	<0.40	–	–	–
Fluoranthene	<0.30	–	–	–
Fluorene	<0.33	–	–	–
Indenol (1,2,3-cd) pyrene	<0.40	–	–	–
Naphthalene	<0.32	–	–	–
Nitrobenzene	<0.21	–	–	–
Phenanthrene	<320	–	–	–
Pyrene	<0.35	–	–	–

Table 4. Inorganic constituents detected in the stream to the west of the Installation Railhead, collected July 27, 2009.

[µg/L, micrograms per liter; ISWQS, Georgia In-Stream Water-Quality Standard, acute freshwater; MCL, maximum contaminant level for National Primary Drinking Water Standards (NPDWS); MCL_s, maximum contaminant level for National Secondary Drinking Water Standards (NSDWS); 686, exceedence; E, estimated; *, Resource Conservation and Recovery Act (RCRA) metal; –, not applicable]

Parameter	Result (µg/L)	ISWQS (µg/L)	MCL (µg/L)	MCL_s (µg/L)
Aluminum	49.6	–	–	50 to 200
Arsenic*	0.36	340	10	–
Barium*	10.3	–	2,000	–
Beryllium	<0.2	–	4	–
Cadmium*	0.118	2	5	–
Calcium	383	–	–	–
Chromium*	0.27(E)	320	100	–
Cobalt	0.605	–	–	–
Copper	<4.0	7	–	1,000
Iron	686	–	–	300
Lead*	0.357	30	15	–
Lithium	0.537	–	–	–
Magnesium	0.370	–	–	–
Manganese	9.57	–	–	50
Molybdenum	<0.1	–	–	–
Nickel	0.63	260	–	–
Potassium	120(E)	–	–	–
Selenium*	<0.12	–	50	–
Silver*	<0.06	–	–	100
Sodium	2,040	–	–	–
Strontium	4.54	–	–	–
Zinc	4.5	65	–	5,000

Table 5. Inorganic constituents detected in soil, land surface to 6 inches, Site 1, July 27, 2009.

[US EPA RSL, U.S. Environmental Protection Agency Regional Screening Level, Industrial Soil; mg/kg, milligrams per kilogram; µg/g, micrograms per gram; SC DHEC, South Carolina Department of Health and Environmental Control; <, less than; for soil, 1 µg/g is equivalent to 1 mg/kg, and 1 mg/kg is equivalent to 1 part per million (ppm); 42.6, higher than SC background; Note: selenium and mercury were not analyzed; *, Resource Conservation and Recovery Act (RCRA) metal; –, not applicable]

Parameter	Result (µg/g)	US EPA RSL (mg/kg)	SC DHEC background (mg/kg)
Aluminum	34,300	990,000	13,528
Antimony	1.1	410	–
Arsenic*	5.2	260	6.1
Barium*	112	190,000	38
Beryllium	0.6	2,000	0.6
Bismuth	89.6	–	–
Cadmium*	0.68	800	1
Calcium	935	–	699
Cerium	101	–	–
Cesium	3.8	–	–
Chromium*	42.6	1,500,000	16
Cobalt	2.8	300	4
Copper	14.1	41,000	9
Gallium	9.4	–	–
Iron	13,000	720,000	15,608
Lanthanum	40.7	–	–
Lead*	240	800	16
Lithium	18	2,000	–
Magnesium	975	–	988
Manganese	74.9	23,000	120
Molybdenum	1.4	5,100	–
Nickel	17.8	47,000	6
Niobium	9.8	–	–
Phosphorus	229	–	–
Potassium	982	–	856
Rubidium	17.1	–	–
Scandium	4.4	–	–
Silver*	<1	5,100	4
Sodium	209	–	194
Strontium	37.8	610,000	–
Thallium	0.21	–	4.5
Thorium	11	–	–
Titanium	3,400	–	–
Uranium	2.27	–	–
Vanadium	44.6	5,200	–
Yttrium	10.6	–	–
Zinc	111	310,000	23

Table 6. Inorganic constituents detected in soil, land surface to 6 inches, Site 2, July 27, 2009.

[US EPA RSL, U.S. Environmental Protection Agency Regional Screening Level, Industrial Soil; mg/kg, milligrams per kilogram; µg/g, micrograms per gram; SC DHEC, South Carolina Department of Health and Environmental Control; <, less than; for soil, 1 µg/g is equivalent to 1 mg/kg, and 1 mg/kg is equivalent to 1 part per million (ppm); 42.6, higher than SC background; Note: selenium and mercury were not analyzed; *, Resource Conservation and Recovery Act (RCRA) metal; –, not applicable]

Parameter	Result (µg/g)	US EPA RSL (mg/kg)	SC DHEC Background (mg/kg)
Aluminum	20,700	990,000	13,528
Antimony	0.36	410	–
Arsenic*	9.6	260	6.1
Barium*	101	190,000	38
Beryllium	0.4	2,000	0.6
Bismuth	5.16	–	–
Cadmium*	0.009	800	1
Calcium	312	–	699
Cerium	54.9	–	–
Cesium	1.2	–	–
Chromium*	31.8	1,500,000	16
Cobalt	0.98	300	4
Copper	7.3	41,000	9
Gallium	6.6	–	–
Iron	17,800	720,000	15,608
Lanthanum	26	–	–
Lead*	13.6	800	16
Lithium	7.1	2,000	–
Magnesium	391	–	988
Manganese	44.6	23,000	120
Molybdenum	0.94	5,100	–
Nickel	7.6	47,000	6
Niobium	6.4	–	–
Phosphorus	289	–	–
Potassium	582	–	856
Rubidium	6.7	–	–
Scandium	2.7	–	–
Silver*	<1	5,100	4
Sodium	243	–	194
Strontium	51.2	610,000	–
Thallium	0.16	–	4.5
Thorium	5.53	–	–
Titanium	2,230	–	–
Uranium	1.2	–	–
Vanadium	37.4	5,200	–
Yttrium	3	–	–
Zinc	11.3	310,000	23

Table 7. Inorganic constituents detected in soil, land surface to 6 inches, Site 3, July 27, 2009.

[US EPA RSL, U.S. Environmental Protection Agency Regional Screening Level, Industrial Soil; mg/kg, milligrams per kilogram; µg/g, micrograms per gram; SC DHEC, South Carolina Department of Health and Environmental Control; <, less than; for soil, 1 µg/g is equivalent to 1 mg/kg, and 1 mg/kg is equivalent to 1 part per million (ppm); 42.6, higher than SC background; Note: selenium and mercury were not analyzed; *, Resource Conservation and Recovery Act (RCRA) metal; –, not applicable]

Parameter	Result (µg/g)	US EPA RSL (mg/kg)	SC DHEC Background (mg/kg)
Aluminum	47,300	990,000	13,528
Antimony	0.64	410	–
Arsenic*	7.2	260	6.1
Barium*	112	190,000	38
Beryllium	0.5	2,000	0.6
Bismuth	8.45	–	–
Cadmium*	<0.007	800	1
Calcium	371	–	699
Cerium	115	–	–
Cesium	2	–	–
Chromium*	55.7	1,500,000	16
Cobalt,	1.5	300	4
Copper	12.2	41,000	9
Gallium	13.4	–	–
Iron	27,000	720,000	15,608
Lanthanum	57.1	–	–
Lead*	22.1	800	16
Lithium	8.8	2,000	–
Magnesium	547	–	988
Manganese	99.5	23,000	120
Molybdenum	1.5	5,100	–
Nickel	11	47,000	6
Niobium	12	–	–
Phosphorus	294	–	–
Potassium	705	–	856
Rubidium	9.6	–	–
Scandium	6.4	–	–
Silver*	<1	5,100	4
Sodium	89	–	194
Strontium	72.9	610,000	–
Thallium	0.12	–	4.5
Thorium	11.6	–	–
Titanium	3,420	–	–
Uranium	1.49	–	–
Vanadium	76	5,200	–
Yttrium	3.6	–	–
Zinc	18	310,000	23

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