RECONNAISSANCE INVESTIGATIONS OF POTENTIAL GROUND-WATER AND SEDIMENT CONTAMINATION AT THREE FORMER UNDERGROUND STORAGE TANK LOCATIONS, FORT JACKSON, SOUTH CAROLINA, 1994

By J. Frederick Robertson, Douglas D. Nagle, and Liesl C. Rhodes

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CONVERSION FACTORS, ABBREVIATIONS, AND ACRONYMS

Multiply	By	To obtain
inch (in.)	25.40	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
gallon (gal)	3.785	liter
pound	0.4536	kilogram

Temperature: In this report, temperature is given in degrees Celsius (^{o}C), which can be converted to degrees Fahrenheit (^{o}F) by the following equation:

$$^{o}F = 1.8 \times (^{o}C) + 32$$

Sea Level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Chemical concentration in water is expressed in micrograms per liter (µg/L) or milligrams per liter (mg/L). Chemical concentration in sediment is expressed in micrograms per kilogram (µg/kg) or milligrams per kilogram (mg/kg).

Volume measurements used for chemical analyses are expressed in milliliters (mL) or microliters (µL). Weight measurements used for chemical analyses are expressed in grams (g).

Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

ACRONYMS

BTEX, benzene, toluene, ethylbenzene, and xylene
GC, gas chromatograph
MDL, minimum detection limit
MTBE, methyl tertiary butyl ether
OVA, organic vapor analyzer
PVC, polyvinyl chloride
SCDHEC, South Carolina Department of Health and Environmental Control
TPH, Total Petroleum Hydrocarbons
TPH-DRO, Total Petroleum Hydrocarbons - Diesel Range Organics
TPH-GRO, Total Petroleum Hydrocarbons - Gasoline Range Organics
UST, underground storage tank

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ABSTRACT

Investigations to provide an initial qualitative delineation of petroleum hydrocarbon contamination at three former underground storage tank locations at Fort Jackson, South Carolina, were made during March 1994. Ground-water and sediment samples were collected using direct-push technology and analyzed on-site with a gas chromatograph, which provided real-time, semi-quantitative data. In addition, ground-water and sediment samples were collected at selected sites for laboratory analyses to provide a confirmation of the on-site data. These analyses provided qualitative data on the lateral distribution of petroleum hydrocarbons.

Petroleum hydrocarbons were detected by on-site analysis in ground-water samples from nine locations at Site 1062, suggesting the presence of a contaminant plume. Concentrations ranged from less than the minimum detection limit to 4,511 μg/L (micrograms per liter) for benzene, 15,594 μg/L for toluene, 16,501 μg/L for ethylbenzene, and 19,391 μg/L for total xylenes. Concentrations of Total Petroleum Hydrocarbons-Gasoline Range Organics ranged from 323 μg/L to 3,364 μg/L; Total Petroleum Hydrocarbons-Diesel Range Organics were not detected. Three samples from this site were analyzed for benzene, toluene, ethylbenzene, and total xylenes at a laboratory, and results showed concentrations ranging from less than the minimum detection limit to 1,070 μg/L for benzene, 7,930 μg/L for toluene, 6,890 μg/L for ethylbenzene, and 1,524 μg/L for total xylenes.

Petroleum hydrocarbons were detected by on-site analysis in only one sample at Site 2438. A concentration of 131,000 micrograms per kilogram Total Petroleum Hydrocarbons-Diesel Range Organics was detected in sample number GP-2-4-13.5.

Petroleum hydrocarbons were detected by on-site analysis in only one ground-water sample from Site 2444. A concentration of 3,145 μg/L Total Petroleum Hydrocarbons-Gasoline Range Organics was detected at sampling location GP-3-2.

INTRODUCTION

During the past five years, the U.S. Department of the Army has removed numerous underground storage tanks (UST's) from various locations at Fort Jackson, near Columbia, S.C. Ground-water and sediment contamination resulting from leaks and overfills has been detected at many of the former UST sites. To determine the extent of contamination at three of these sites, investigations were initiated by the U.S. Geological Survey (USGS) in cooperation with the U.S. Army Corps of Engineers, Charleston District. The results of these investigations will be presented in two reports (Phase One and Phase Two).

Purpose and Scope

The purpose of this report (Phase One), which is the first of two reports, is to present the results of reconnaissance investigations made during March 1994 designed to provide an initial qualitative delineation of petroleum hydrocarbon contamination at study Sites 1062, 2438, and 2444 (fig. 1). These results will be used to direct additional investigations (Phase Two) of a more quantitative nature. Phase Two of the investigations will provide data on the concentrations of the contaminants in the ground water and sediment and define the vertical and horizontal extent of contamination.

This report contains data collected during the investigations by using a direct-push (Geoprobe) sampling system at three former UST locations. Ground-water and sediment samples were collected for on-site analysis of petroleum hydrocarbons. At selected locations, ground-water and sediment samples also were collected for laboratory analysis as confirmation of on-site analytical results. Data interpretation is not included as part of this report.

History of Sites 1062, 2438, and 2444

Hydrogeologic investigations made at several of the former UST sites, including Site 1062, indicated that petroleum hydrocarbon contamination was present in ground water (Ebasco Services Inc., 1992); however, the extent of contamination was not determined. Additionally, preliminary testing of ground water and sediments collected during UST removal activities at Sites 2438 and 2444 suggested the possibility of hydrocarbon contamination.

Site 1062

Site 1062 was used as the main Base gas station during the 1980's. When the site was abandoned, Building 1062 was demolished, but the concrete pad was left intact. In December 1990, the three abandoned 10,000-gal storage tanks at this site were removed. One of the three tanks contained less than 6 in. of gasoline product, and the other two tanks each contained less than 6 in. of #2 fuel oil. Plastic sheeting was placed in the bottom of the excavation, and the hole was backfilled with the excavated sediment (Ebasco Services Inc., 1992). Ground-water and sediment samples collected after the tank removal were found to contain benzene, toluene, ethylbenzene, and xylene (collectively termed BTEX) in concentrations ranging from 360 to 3,500 µg/L in ground water and from 1 to 570 µg/kg in sediment (Ebasco Services Inc., 1992). To evaluate the spatial distribution of contamination, sediment borings were made at four sites, and monitoring wells were installed. Analyses of ground-water and sediment samples indicated that BTEX contamination was present; however, the extent of contamination was not determined (Ebasco Services Inc., 1992). Ground-water levels during the time of sample collection (1992) were above the screened interval in three of the monitoring wells. It is quite probable, therefore, that any free product would have gone undetected at that time.

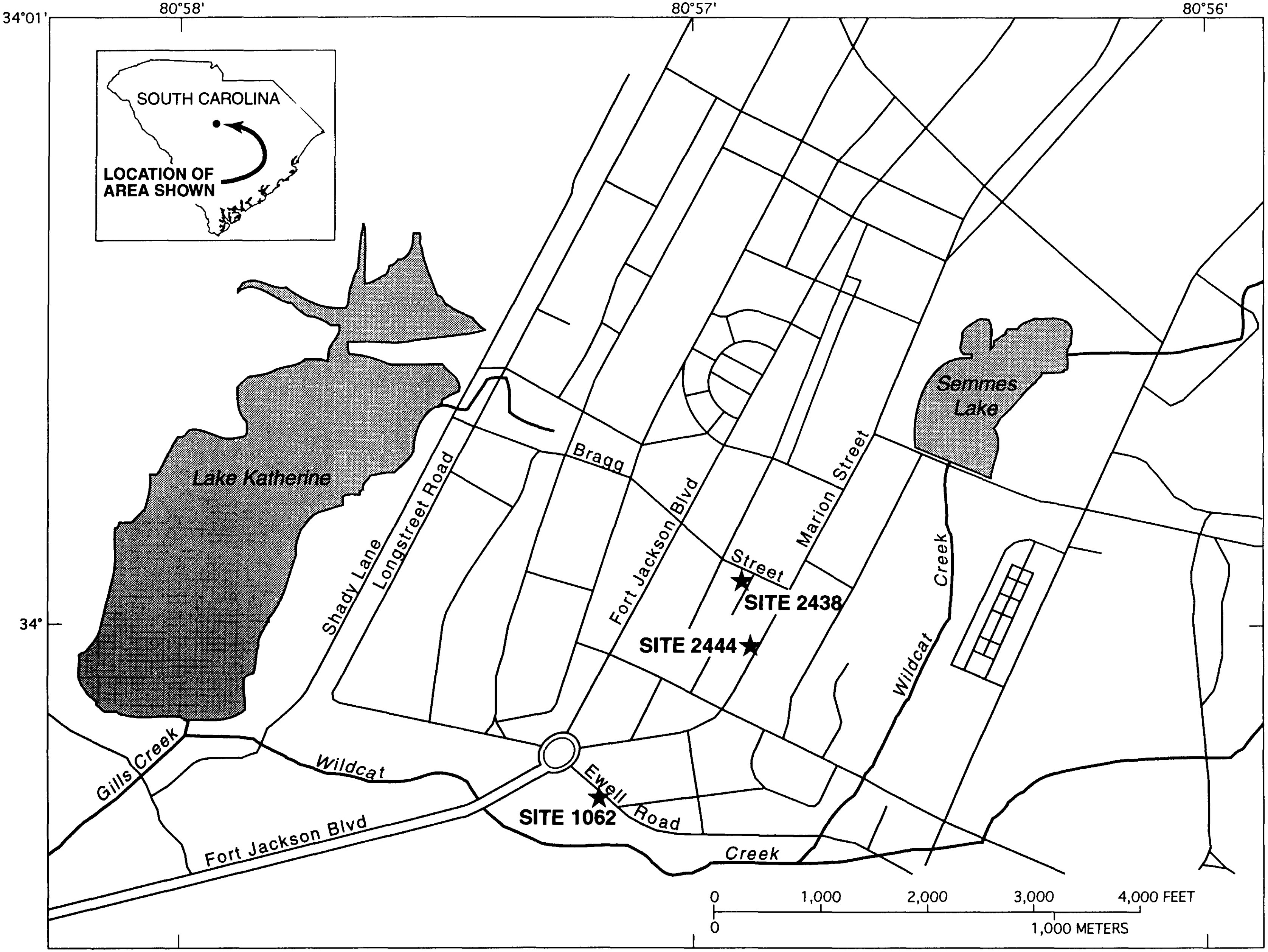

Figure 1.--General location of Sites 1062, 2438, and 2444, Fort Jackson, S.C.

Site 2438

A 1,000-gal UST was removed from Site 2438 in February 1993. Building 2438 was demolished and removed from this site in January 1994. Little historical information concerning this UST site is available. At the time of excavation, the tank was found to be full of a #2 fuel oil and water mixture. No apparent holes were discovered in the tank, and piping was not present. The dimensions of the excavation were 16 ft (length) by 12 ft (width) by 6 ft (depth). Ground water was encountered at a depth of approximately 3.5 ft. The tank, contents of the tank, and excavated sediments were properly disposed, and the hole was backfilled with clean sediment.

During excavation, petroleum contamination of the sediment was noted by visual inspection, odor, and organic vapor analyzer (OVA) readings (Mike Lamore, ETI Inc., written commun., 1993). Laboratory analysis of tank contents confirmed the presence of #2 fuel oil. Ground-water and sediment samples from the pit were collected for laboratory analysis. Analytical results of sediment samples indicated naphthalene in concentrations as much as 1,290 μg/kg, total petroleum hydrocarbons - heavy fuels or diesel range organics (TPH-DRO) concentrations as much as 727 mg/kg, and xylene concentrations as much as 412 mg/kg. A single ground-water sample contained a naphthalene concentration of 363 μg/L, a TPH-DRO concentration of 15,500 mg/L, a toluene concentration of 70 μg/L, an ethylbenzene concentration of 56 μg/L, and a xylene concentration of 190 μg/L.

Site 2444

Two 6,000-gal UST's were removed from Site 2444 in April 1992. Building 2444 remains at this site but is unused. Little historical information regarding the UST's at this site is available. Both tanks were found to be nearly full of a petroleum and water mixture and were in good condition. The tanks were situated adjacently, and a single pit measuring 27 ft (length) by 23 ft (width) by 12 ft (depth) was excavated. Following tank removal, the hole was backfilled with the excavated sediment. Ground water was encountered in the excavation; however, the depth was not noted.

Analysis of the tank contents confirmed the presence of gasoline and diesel fuel (Mike Lamore, ETI Inc., written commun., 1992). It was assumed that one tank contained gasoline, and the other tank contained diesel fuel. Visual inspection and OVA screening indicated petroleum hydrocarbon contamination of the excavated sediment. Laboratory analysis of sediment samples collected from the excavation and the excavated sediment detected concentrations of naphthalene as much as 5,700 μg/kg, total petroleum hydrocarbons - light fuels or gasoline range organics (TPH-GRO) as much as 1,580 mg/kg, TPH-DRO as much as 11,132 mg/kg, toluene as much as 40.5 μg/kg, ethylbenzene as much as 2,020 μg/kg, and xylene as much as 5,170 μg/kg. A single ground-water sample collected from the center of the pit was found to have concentrations of naphthalene at 570 μg/L, TPH-GRO at 126 mg/L, ethylbenzene at 81.5 μg/L, and xylene at 292 μg/L. Benzene, toluene, TPH-DRO, and methyl tertiary butyl ether (MTBE) were not detected in the ground-water sample.

Description of Study Area

Study area Sites 1062, 2438, and 2444 are located in the Upper Coastal Plain physiographic province and are underlain by Cretaceous and Tertiary sediments over crystalline rock. Previous sediment borings by Ebasco Services Inc. (1992) indicate that the surficial aquifer underlying Site 1062 is composed primarily of fine- to medium-grained sands with discontinuous clays.

Based on topographic features, the probable direction of ground-water flow is towards the south at Site 1062 and towards the southeast at Sites 2438 and 2444. Previous investigations (Ebasco Services Inc., 1992) have indicated that the approximate depth to water at Site 1062, relative to land surface, varies from 4 to 12 ft.

The primary surface-water feature in the vicinity of Site 1062 is Wildcat Creek, which is approximately 450 ft south of the site (fig. 1). From a point south of Site 1062, Wildcat Creek flows westwardly for approximately 0.75 mi to Lake Katherine. A north-south oriented reach of Wildcat Creek, located upstream from Site 1062, is also the primary surface-water feature in the vicinity of Sites 2438 and 2444, which are approximately 2,000 ft northwest of Wildcat Creek.

COLLECTION AND ANALYSES OF GROUND-WATER AND SEDIMENT SAMPLES

Phase One of the site investigations, a reconnaissance phase, consisted of ground-water and sediment sampling to provide an initial delineation of areas with potential contamination by petroleum hydrocarbons. Ground-water and sediment samples were obtained by using a Geoprobe, or direct-push, system. Samples were analyzed on-site with a gas chromatograph (GC), which provided real-time, semi-quantitative data. Data obtained by this method provided qualitative information concerning the lateral distribution of petroleum hydrocarbons. Limited information pertaining to the vertical extent of contamination also was provided by this method. Detection of petroleum hydrocarbons in ground-water and sediment samples obtained and analyzed in this manner can indicate potential contamination.

The method used to collect ground-water samples involved driving a small-diameter (approximately 1 in. outside diameter) temporary-well point through the unsaturated zone to the depth at which a ground-water sample was collected. The drive point was advanced through the sediment with a truck-mounted, hydraulic hammer. The stainless-steel drive point consisted of a vertically slotted screen section approximately 3 ft in length. When the desired sampling depth was attained, formation water was collected using either a stainless-steel bailer or polyethylene tubing. The polyethylene tubing was fitted with a bottom-check valve, with which an oscillating motion pumps water through the check valve and into the tubing until the desired amount of sample is collected. After use in each well, the polyethylene tubing was disposed of properly, and the stainless-steel bailer was cleaned with detergent and deionized water.

Ground-water samples were collected primarily from the water-table surface. The drive point was advanced to a depth sufficient to bracket the water-table surface with the slotted interval of the sampling device. Sample collection began in the approximate area of the former UST's and extended downgradient at increasing distances from the former tank areas until contaminants were no longer detected. Because this method provided real-time results, the data collected was used in determining locations for subsequent sampling.

Sampling locations and their corresponding identification are shown in figures 2, 3, and 4 for Sites 1062, 2438, and 2444, respectively. Sampling locations were designated by number following the prefixes GP-1-, GP-2-, and GP-3- for Sites 1062, 2438, and 2444, respectively. Designations for hand-augered holes from which samples were obtained are similar, however they begin with the prefixes AH-1-, AH-2-, and AH-3-. Samples collected with respect to depth (multiple samples from the same location) are denoted by a prefix, followed by a sampling-location number, followed by the depth from which the sample was collected. For example, sample GP-2-4-10 was collected from Site 2438, location 4, at a depth of 10 ft.

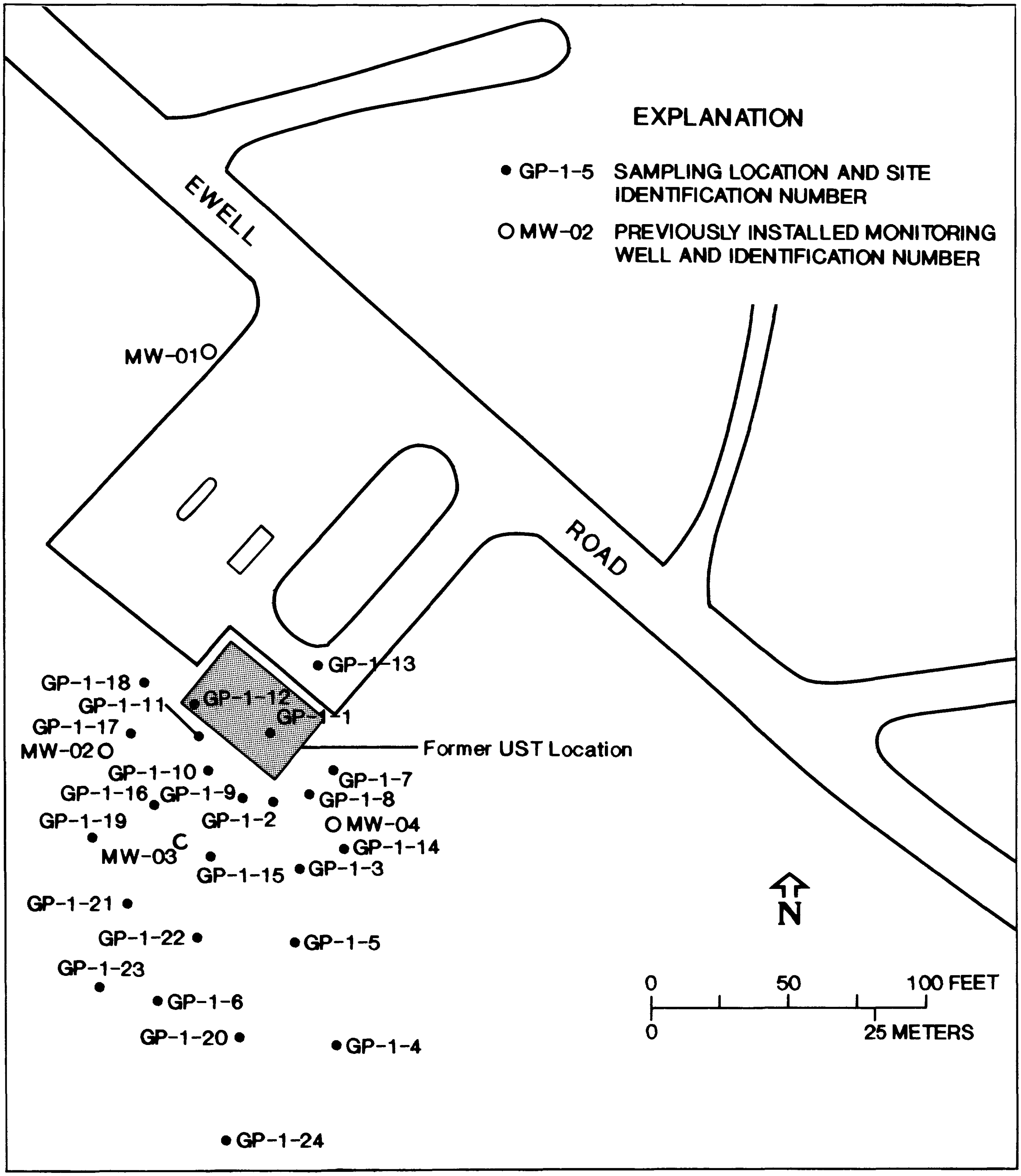

Figure 2.--Locations of sampling sites, Site 1062, Fort Jackson, S.C.

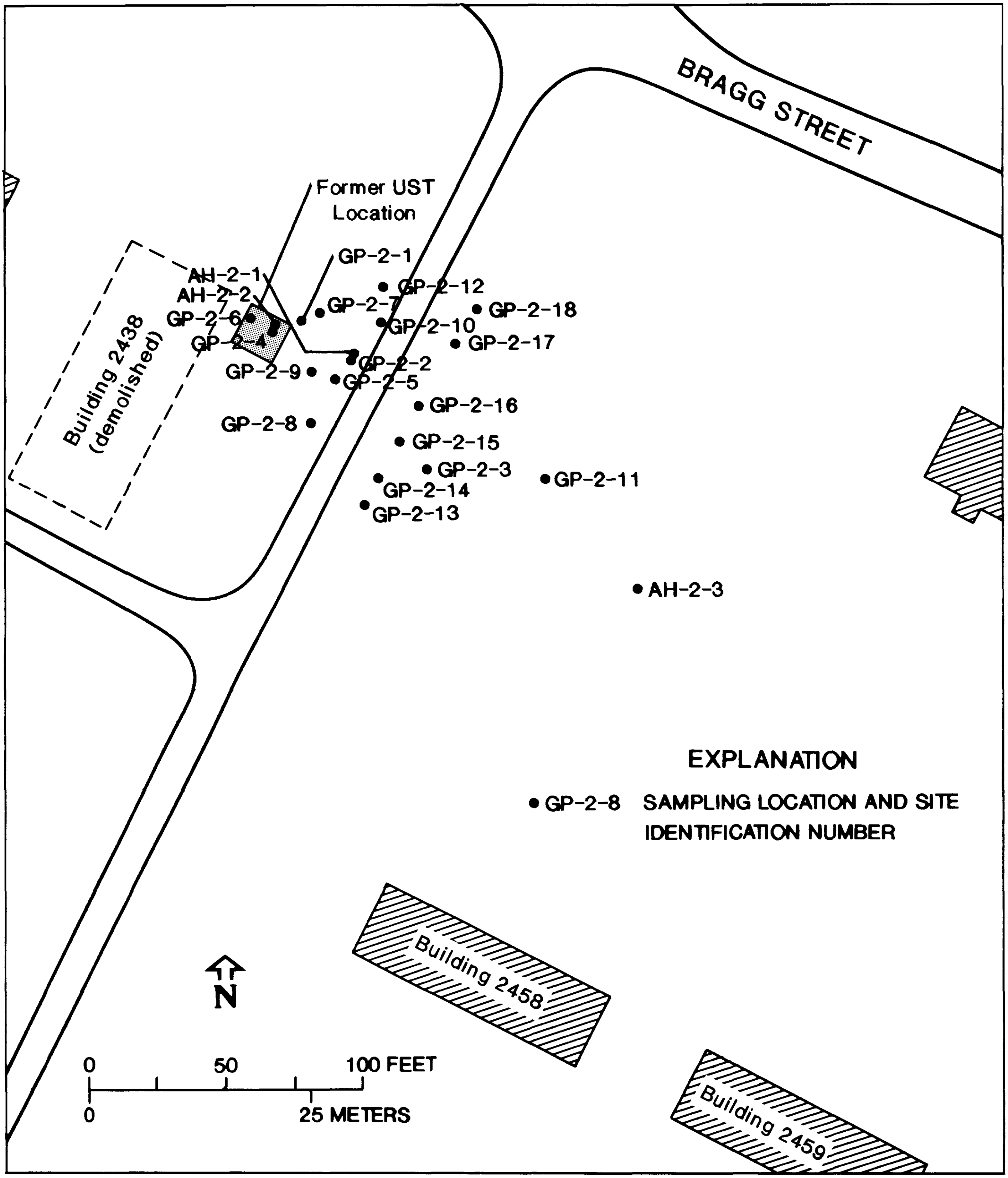

Figure 3.--Locations of sampling sites, Site 2438, Fort Jackson, S.C.

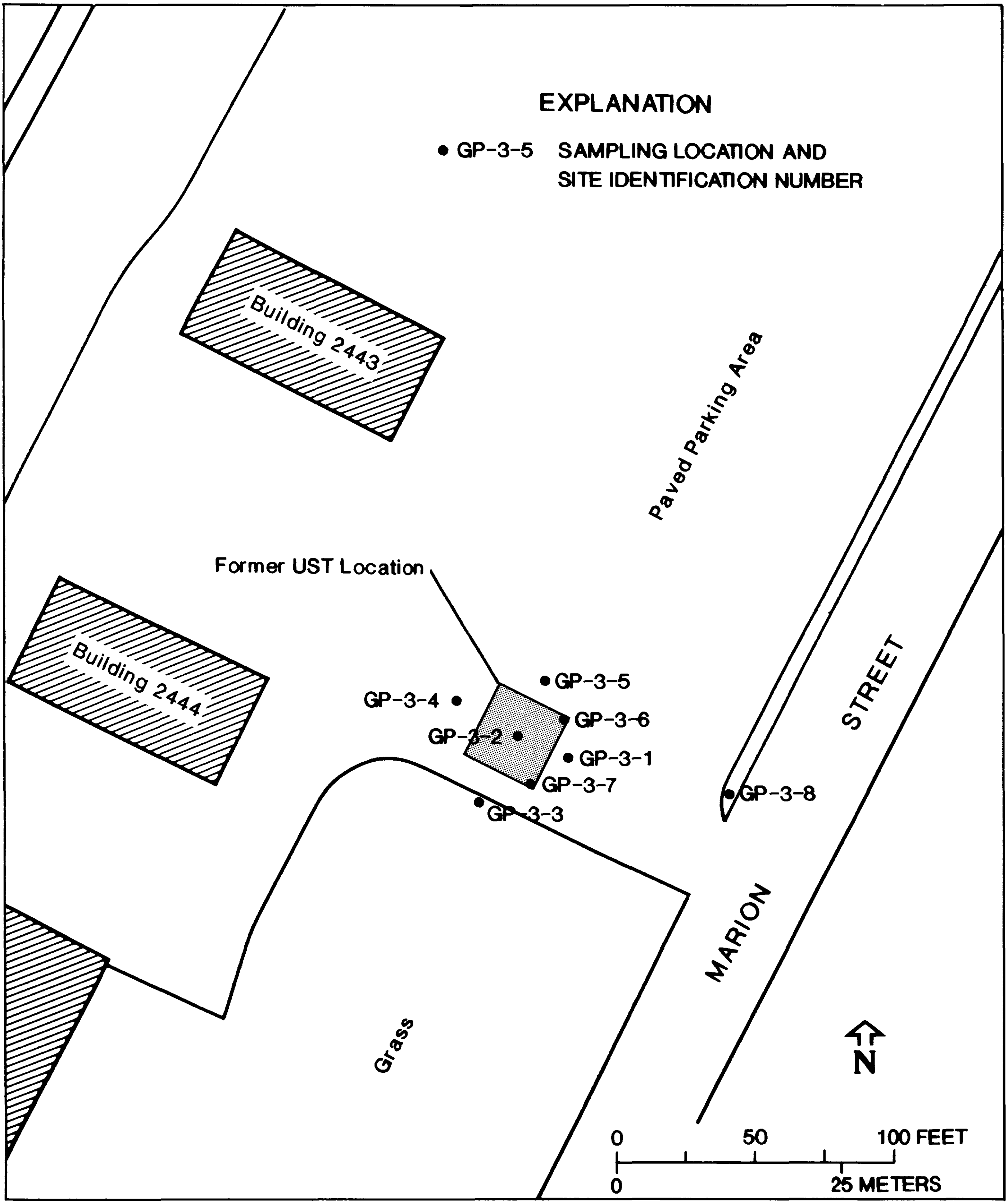

Figure 4.--Locations of sampling sites, Site 2444, Fort Jackson, S.C.

At 11 locations, particularly at Site 1062, it was necessary to place a 1 in. inside diameter polyvinyl chloride (PVC) screen into the open hole, because ground water did not flow quickly into the slotted drive point. It was assumed that the sediments comprising the surficial aquifer were not very transmissive; therefore, the PVC screens were left in place long enough to collect the amount of water needed for sampling. This period of time was typically about 1 hour. At three locations at Site 2438, holes were bored with a hand auger, and water samples were collected from the bottom of the hole.

Sediment samples were collected using a hydraulically driven coring device into which a clear, acetate liner was placed. A drive point with a locking piston was fixed to the bottom of the coring device. When the top of the desired sample interval was reached, the piston was unlocked enabling the drive point, or piston tip, to remain in place while the thin-wall coring device and inner liner were advanced approximately 2 ft into the sediment. Upon retrieval of the coring device, the acetate liner containing the sediment sample was removed, and vinyl caps were placed on the ends of the liner. All downhole equipment was thoroughly cleaned prior to successive sediment sampling. Samples for on-site analysis were obtained by cutting a small square in the acetate liner and collecting the sample with a coring syringe.

Ground-water and sediment samples were analyzed on-site for BTEX and(or) TPH-GRO, which includes all chromatographic peaks eluting between MTBE and naphthalene. The TPH-GRO analyses provided duplicate BTEX analysis, in addition to other compounds (Wisconsin Department of Natural Resources, 1993). At selected locations, samples also were analyzed for TPH-DRO. The GC used for BTEX, TPH-GRO, and TPH-DRO (ground water) analyses was equipped with both a photoionization detector and a flame ionization detector connected in series, and an in-line purge and trap system. Hydrogen was used as the carrier gas, and nitrogen was used as the sparge gas. For BTEX and TPH-GRO analyses, a sample size of 5 mL of ground water or 1 g of sediment (mixed with 5 mL of deionized water) was run through the purge and trap system. The minimum detection limit (MDL) for these analyses was 1 μg/L or μg/kg. For TPH-DRO analyses of ground water, a sample of 2 μL was directly injected into the GC column with a MDL varying from 1 to 10 mg/L.

A separate GC was used for TPH-DRO analyses of sediment samples. This GC was equipped with a flame ionization detector and a thermal desorber. The thermal desorber heats a 1 g sediment sample to 400 °C, thereby allowing for desorption of semi-volatiles from the sediment. The MDL for this method is 100 μg/kg.

Chromatographic standards were run for each analysis type at least three times a day to assure consistent compound identification and peak integration. Retention-time windows and calibration curves were stored in a library that was recalled during sample analysis.

Ground-water and sediment samples were collected at select sites for laboratory analyses as a confirmation of on-site analytical results. Three ground-water samples were collected at Site 1062 and Site 2444 for BTEX analysis using U.S. Environmental Protection Agency Method 602 (1987) at a commercial laboratory possessing South Carolina Department of Health and Environmental Control (SCDHEC) certification. At Site 2438, three ground-water samples, including one replicate sample, were collected for laboratory analysis of BTEX, and one sediment sample was collected for TPH-DRO laboratory analysis.

Depths to water relative to land surface were determined following sample collection at each hole to assist in screen placement at successive locations. All downhole equipment was thoroughly cleaned between successive sampling locations. The probe boreholes generally did not collapse or bridge after probe removal and were backfilled with bentonite to land surface to impede the vertical migration of water.

RESULTS OF RECONNAISSANCE INVESTIGATIONS

The results obtained by the on-site analysis of ground-water and sediment samples are considered to be semi-quantitative and were used only to indicate the presence or absence of petroleum hydrocarbons. Compound concentrations determined on-site do not represent the actual concentrations found in ground water and sediment and, therefore, cannot be directly compared to actual concentrations. The results of the on-site analyses may, however, be compared in a relative sense to similar data collected from surrounding sampling locations.

Site 1062

All data determined from the on-site analyses of samples collected from Site 1062 are listed in table 1. The results determined by laboratory analyses are presented in table 2. All samples collected for analysis were ground-water samples. Sediment samples (continuous core) were collected from 2 to 18 ft at sampling location GP-1-5 for lithologic information only.

Petroleum hydrocarbons were detected by on-site analysis in ground-water samples from nine locations at Site 1062. The qualitative distribution of petroleum hydrocarbons detected by on-site analysis is shown in figure 5. These results suggest the presence of a contaminant plume as indicated in figure 5.

On-site analysis of BTEX determined concentrations ranging from less than the MDL to 4,511 μg/L for benzene, 15,594 μg/L for toluene, 16,501 μg/L for ethylbenzene, and 19,391 μg/L for total xylenes. On-site analysis of TPH-GRO and TPH-DRO for three sample locations at which BTEX was detected, exhibited concentrations ranging from 323 μg/L to 3,364 μg/L for TPH-GRO, while TPH-DRO was not detected.

Three samples from Site 1062 were analyzed at a commercial laboratory for BTEX. Concentrations ranged from less than the MDL to 1,070 μg/L for benzene, 7,930 μg/L for toluene, 6,890 μg/L for ethylbenzene, and 1,524 μg/L for total xylenes. A comparison of the two analytical methods confirmed similar detection/non-detection results; however, concentrations derived by on-site analysis were consistently lower, with differences ranging from 296 to 2,620 percent.

Site 2438

All data determined by on-site analyses of samples collected from Site 2438 are listed in table 3. Location GP-2-2 was not sampled and, therefore, was not included in table 3. The results determined by laboratory analyses are presented in table 4. The qualitative distribution of petroleum hydrocarbons detected by on-site analysis is shown in figure 6. Ground-water and sediment samples were collected from this site for both analytical procedures.

Continuous cores collected from three locations indicated the presence of a dense, kaolin layer at a depth of approximately 6 ft below land surface. This clay layer is approximately 7-ft thick and appears to be laterally extensive beneath this site. Ground water was found only in a few locations above the clay, perhaps representing isolated mounding conditions. Where water was found on top of the clay, ground water was collected for analysis; however, because of generally dry conditions above the clay at most of the sampling locations, sediment samples were collected for analysis from the sand/clay contact. At the three locations where continuous cores were collected, the clay layer was penetrated, and ground water, under artesian conditions, was sampled.

Table 1.--*Concentrations of petroleum hydrocarbons at Site 1062, Fort Jackson, S.C., determined by on-site analysis, March 14-18, 1994*

[All concentrations reported in micrograms per liter (µg/L) ; --, not analyzed; ND, not detected; TPH-GRO, Total Petroleum Hydrocarbons-Gasoline Range Organics; TPH-DRO, Total Petroleum Hydrocarbons-Diesel Range Organics; GW, ground water]

Sample number (fig. 2)	Matrix	Benzene	Toluene	Ethyl-benzene	Total xylenes	TPH-GRO	TPH-DRO
GP-1-1	GW	113	464	208	411	--	--
GP-1-2	GW	4,511	15,594	16,501	19,391	--	--
GP-1-3	GW	ND	323	ND	ND	--	--
GP-1-4	GW	ND	ND	ND	ND	--	--
GP-1-5	GW	ND	ND	ND	ND	--	--
GP-1-6	GW	ND	ND	ND	ND	--	--
GP-1-7	GW	ND	ND	ND	ND	--	--
GP-1-8	GW	ND	ND	ND	ND	--	--
GP-1-9	GW	84	32	ND	ND	--	--
GP-1-10	GW	302	182	263	407	--	--
GP-1-11	GW	92	152	128	336	3,364	ND
GP-1-12	GW	ND	ND	ND	ND	--	--
GP-1-13	GW	ND	ND	ND	ND	--	--
GP-1-14	GW	ND	ND	ND	ND	--	--
GP-1-15	GW	ND	20	20	41	323	ND
GP-1-16	GW	536	1,450	585	555	1,443	ND
GP-1-17	GW	ND	ND	ND	ND	--	--
GP-1-18	GW	ND	ND	ND	ND	--	--
GP-1-19	GW	ND	ND	ND	ND	--	--
GP-1-20	GW	ND	ND	ND	ND	--	--
GP-1-21	GW	18	14	ND	21	--	--
GP-1-22	GW	ND	ND	ND	ND	--	--
GP-1-23	GW	ND	ND	ND	ND	--	--
GP-1-24	GW	ND	ND	ND	ND	--	--

Table 2.--*Concentrations of petroleum hydrocarbons at Site 1062, Fort Jackson, S.C., determined by laboratory analysis, March 14-18, 1994*

[All concentrations reported in micrograms per liter (µg/L) ; <, less than; GW, ground water]

Sample number (fig. 2)	Matrix	Benzene	Toluene	Ethylbenzene	Total xylenes
GP-1-1	GW	544	7,930	2,770	1,217
GP-1-10	GW	1,070	2,060	6,890	1,524
GP-1-20	GW	<5	<5	<5	<5

Petroleum hydrocarbons were detected in only one sample from Site 2438. At sampling site GP-2-4, located in the immediate vicinity of the former UST location, eight sediment samples were collected and analyzed with respect to depth. On-site analysis of TPH-DRO detected a concentration of 131,000 µg/kg in only the sample collected from the 13- to 15-ft horizon, which includes the contact between the confined aquifer and the upper confining clay layer. The TPH-DRO laboratory analysis of a split sample from this same horizon, however, resulted in a reported concentration of less than 10 mg/kg, the MDL. Similarly, BTEX analyses, both on-site and laboratory, of ground-water samples collected from the confined aquifer at this location indicated concentrations less than the MDL. A ground-water sample collected from GP-2-5 (upgradient from the former tank area) for laboratory analysis was reported to be less than the MDL for all BTEX compounds.

Site 2444

All data determined by on-site analyses of samples collected from Site 2444 are listed in table 5. The results determined by laboratory analyses are presented in table 6. The qualitative distribution of petroleum hydrocarbons detected by on-site analysis is shown in figure 7. All samples collected for analysis were ground-water samples. Sample GP-3-8A was collected for laboratory analysis on March 22 from an augered hole immediately adjacent to location GP-3-8, from which a sample was collected for on-site analysis. Sediment samples (continuous core) were collected from 3 to 14.5 ft at sampling location GP-3-3 for lithologic information only.

Petroleum hydrocarbons were detected in ground water from one sampling location only. TPH-GRO was detected (3,145 µg/L) by on-site analysis of a sample from GP-3-2, located at the approximate center of the former UST area. Neither BTEX nor TPH-DRO were detected by on-site analysis of the GP-3-2 sample; however, toluene was detected by laboratory analysis at a concentration of 11 µg/L. Laboratory analysis of two additional ground-water samples from Site 2444 indicated BTEX concentrations less than the MDL. On-site analysis of samples from these locations indicated no detection of TPH-GRO.

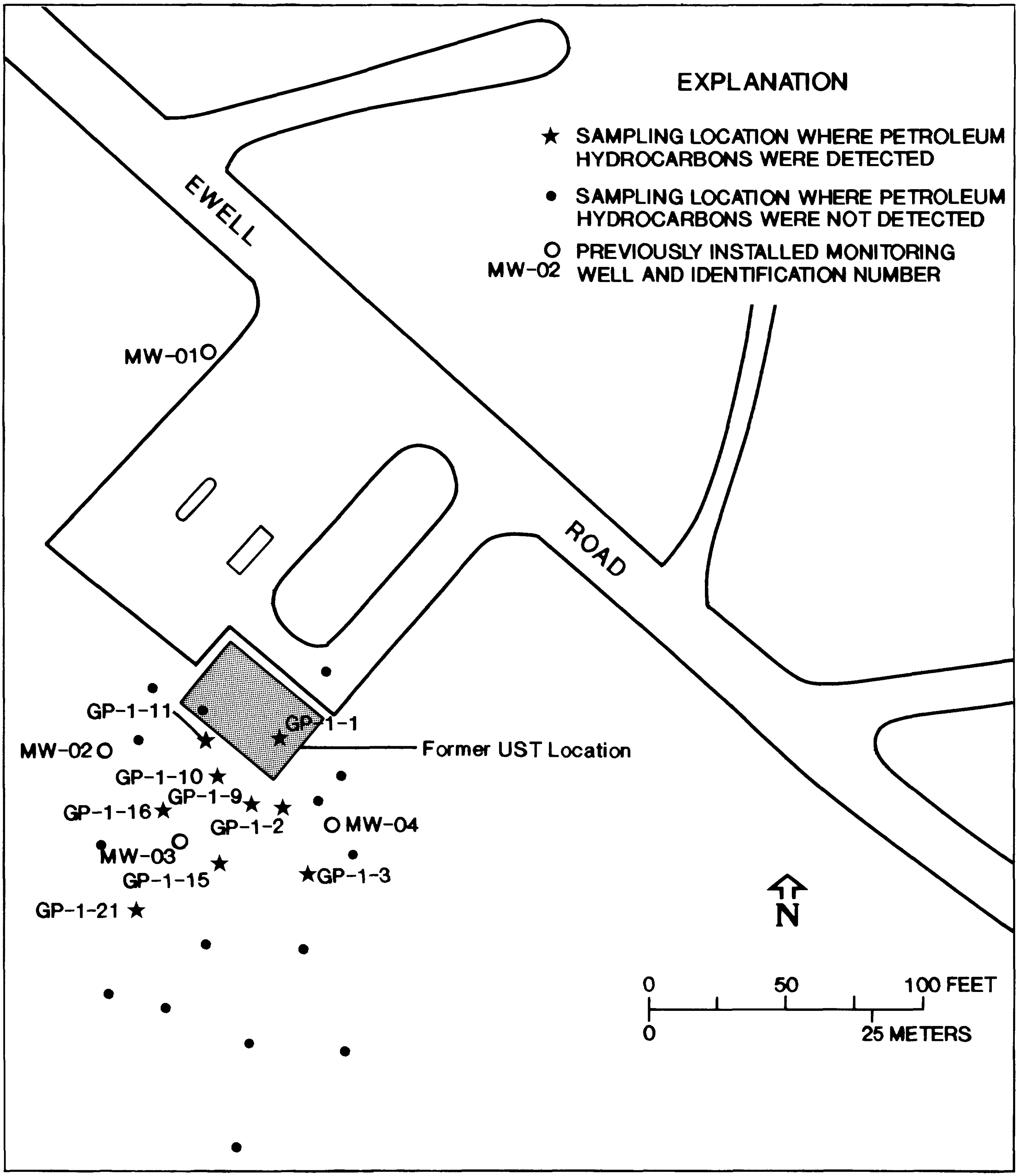

Figure 5.--Qualitative lateral distribution of petroleum hydrocarbons detected by on-site analysis, Site 1062, Fort Jackson, S.C., March 14-18, 1994.

Table 3.--*Concentrations of petroleum hydrocarbons at Site 2438, Fort Jackson, S.C., determined by on-site analysis, March 14 and 16, 1994*

[Concentrations in sediment reported in micrograms per kilogram (µg/kg); ND, not detected; --, not analyzed; TPH-GRO, Total Petroleum Hydrocarbons-Gasoline Range Organics; TPH-DRO, Total Petroleum Hydrocarbons-Diesel Range Organics; SED, sediment; GW, ground water]

Sample number (fig. 3)	Matrix	Benzene	Toluene	Ethyl-benzene	Total xylenes	TPH-GRO	TPH-DRO
GP-2-1	GW	ND	ND	ND	ND	--	--
GP-2-3	SED	--	--	--	--	ND	--
GP-2-4	GW	ND	ND	ND	ND	--	--
GP-2-4-5.5	SED	ND	ND	ND	ND	--	ND
GP-2-4-6	SED	--	--	--	--	ND	--
GP-2-4-8	SED	--	--	--	--	ND	--
GP-2-4-10	SED	--	--	--	--	ND	--
GP-2-4-12	SED	--	--	--	--	ND	--
GP-2-4-12.5	SED	--	--	--	--	ND	--
GP-2-4-13	SED	ND	ND	ND	ND	--	--
GP-2-4-13.5	SED	ND	ND	ND	ND	--	131,000
GP-2-5	GW	ND	ND	ND	ND	--	--
GP-2-5-6	SED	ND	ND	ND	ND	--	--
GP-2-6	GW	ND	ND	ND	ND	--	--
GP-2-7	SED	ND	ND	ND	ND	--	--
GP-2-8	SED	ND	ND	ND	ND	--	--
GP-2-9	SED	--	--	--	ND	ND	--
GP-2-10	SED	--	--	--	--	--	ND
GP-2-11	GW	ND	ND	ND	ND	--	--
GP-2-12	SED	ND	ND	ND	ND	--	--
GP-2-13	SED	--	--	--	--	ND	--
GP-2-14	SED	ND	ND	ND	ND	ND	ND
GP-2-15	SED	ND	ND	ND	ND	--	--
GP-2-16	SED	ND	ND	ND	ND	--	--

Table 3.--*Concentrations of petroleum hydrocarbons at Site 2438, Fort Jackson, S.C., determined by on-site analysis, March 14 and 16, 1994*--Continued

[Concentrations in sediment reported in micrograms per kilogram (µg/kg); ND, not detected; --, not analyzed; TPH-GRO, Total Petroleum Hydrocarbons-Gasoline Range Organics; TPH-DRO, Total Petroleum Hydrocarbons-Diesel Range Organics; SED, sediment; GW, ground water]

Sample number (fig. 3)	Matrix	Benzene	Toluene	Ethyl-benzene	Total xylenes	TPH-GRO	TPH-DRO
GP-2-17	SED	--	--	--	--	ND	--
GP-2-18	GW	ND	ND	ND	ND	ND	--
AH-2-1	GW	ND	ND	ND	ND	--	--
AH-2-2	GW	ND	ND	ND	ND	--	--
AH-2-3	GW	ND	ND	ND	ND	ND	--

Table 4.--*Concentrations of petroleum hydrocarbons at Site 2438, Fort Jackson, S.C., determined by laboratory analysis, March 14 and 15, 1994*

[Concentrations in ground water reported in micrograms per liter (µg/L); concentrations in sediment reported in milligrams per kilogram (mg/kg); <, less than; --, not analyzed; TPH-DRO, Total Petroleum Hydrocarbons-Diesel Range Organics; SED,sediment; GW, ground water]

Sample number (fig. 3)	Matrix	Benzene	Toluene	Ethyl-benzene	Total xylenes	TPH-DRO
GP-2-4	GW	<5	<5	<5	<5	--
GP-2-4	SED	--	--	--	--	<10
GP-2-4R	GW	<5	<5	<5	<5	--
GP-2-5	GW	<5	<5	<5	<5	--

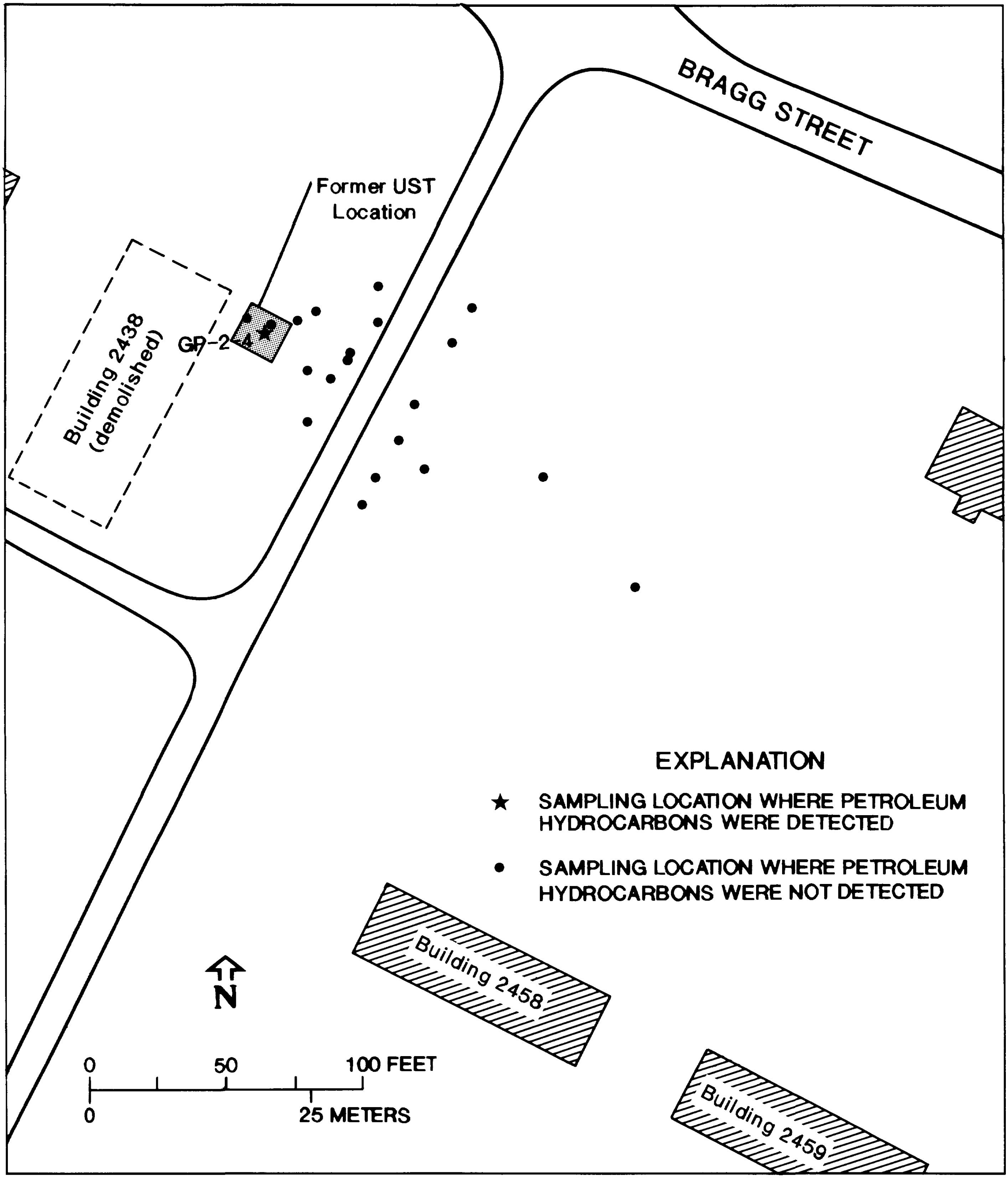

Figure 6.--Qualitative lateral distribution of petroleum hydrocarbons detected by on-site analysis, Site 2438, Fort Jackson, S.C., March 14 and 16, 1994.

Table 5.--*Concentrations of petroleum hydrocarbons at Site 2444, Fort Jackson, S.C., determined by on-site analysis, March 18 and 19, 1994*

[All concentrations reported in micrograms per liter (µg/L); ND, not detected; --, not analyzed; TPH-GRO, Total Petroleum Hydrocarbons-Gasoline Range Organics; TPH-DRO, Total Petroleum Hydrocarbons-Diesel Range Organics; GW, ground water]

Sample number (fig. 4)	Matrix	Benzene	Toluene	Ethyl-benzene	Total xylenes	TPH-GRO	TPH-DRO
GP-3-1	GW	ND	ND	ND	ND	ND	ND
GP-3-2	GW	ND	ND	ND	ND	3,145	ND
GP-3-3	GW	--	--	--	--	ND	--
GP-3-4	GW	--	--	--	--	ND	ND
GP-3-5	GW	--	--	--	--	ND	--
GP-3-6	GW	--	--	--	--	ND	--
GP-3-7	GW	--	--	--	--	ND	--
GP-3-8	GW	--	--	--	--	ND	--

Table 6.--*Concentrations of petroleum hydrocarbons at Site 2444, Fort Jackson, S.C., determined by laboratory analysis, March 18, 19, and 22, 1994*

[All concentrations reported in micrograms per liter (µg/L); <, less than; GW, ground water]

Sample number (fig.4)	Matrix	Benzene	Toluene	Ethyl-benzene	Total xylenes
GP-3-2	GW	<5	11	<5	<5
GP-3-4	GW	<5	<5	<5	<5
GP-3-8A	GW	<5	<5	<5	<5

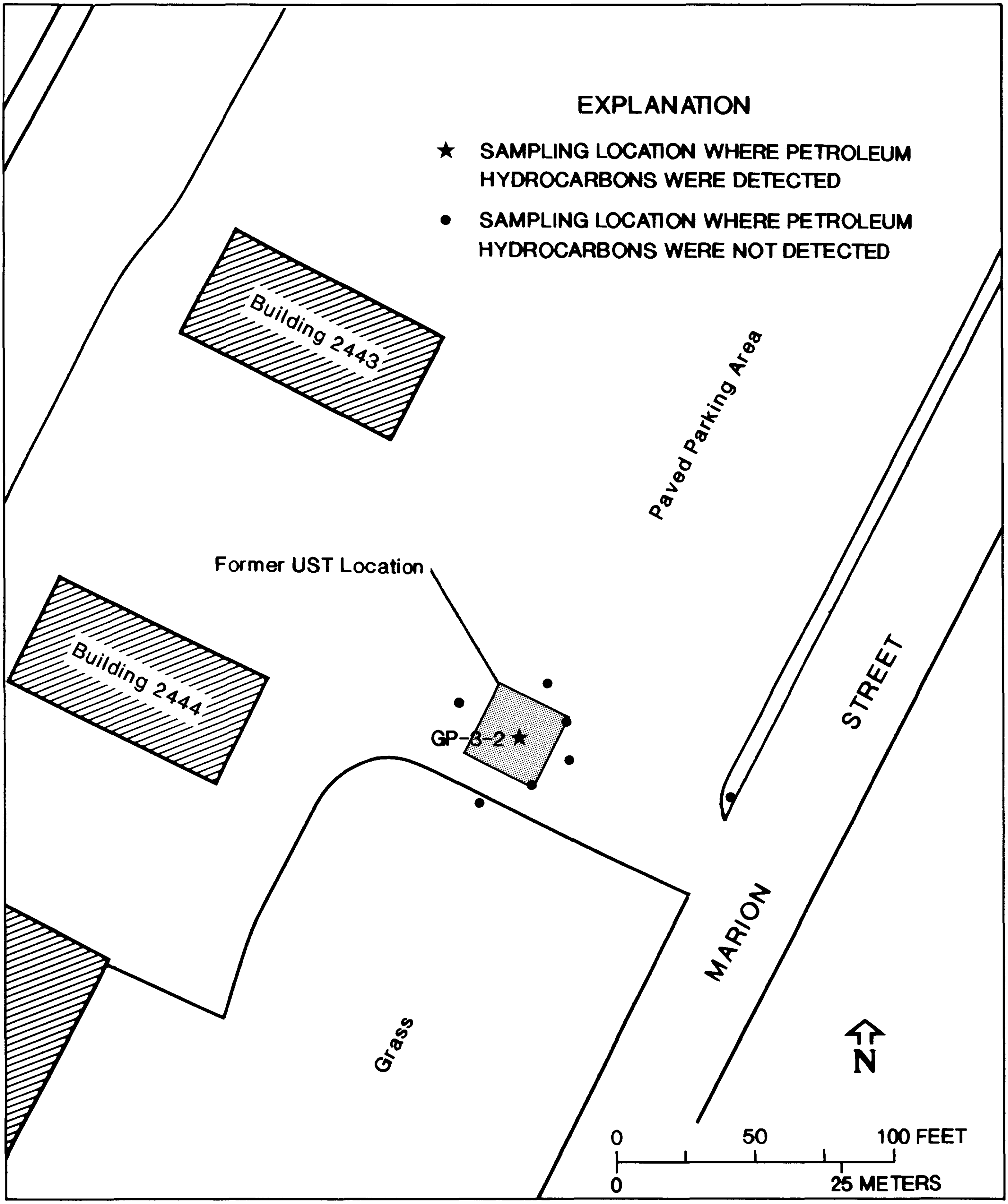

Figure 7.--Qualitative lateral distribution of petroleum hydrocarbons detected by on-site analysis, Site 2444, Fort Jackson, S.C., March 18 and 19, 1994.

SUMMARY

The Geoprobe system, in conjunction with on-site analysis of ground-water and sediment samples, provided useful information concerning the qualitative distribution of petroleum hydrocarbons at Sites 1062, 2438, and 2444. With the exception of TPH-DRO analysis of sediment from sampling location GP-2-4, the results of on-site analyses were qualitatively comparable to the results obtained by laboratory analyses.

The results obtained during this investigation suggested the presence of a contaminant plume at Site 1062. Petroleum hydrocarbons were detected by on-site analysis in ground-water samples from nine locations at Site 1062. At Site 2438, petroleum hydrocarbons were detected at one location only. TPH-DRO was detected by on-site analysis of a sediment sample from location GP-2-4, which is located at the approximate center of the former tank location. This sample (GP-2-4-13.5) was collected from a depth of 13 to 15 ft; the interval including the contact of what appears to be a confined aquifer and its upper confining unit, that appears to be laterally extensive beneath this site. A split sample from this location was analyzed for TPH-DRO at a commercial laboratory, however, concentrations were reported to be less than the MDL. In addition, BTEX was not detected by on-site analysis of a ground-water sample collected from the same interval. A definite surficial aquifer was not encountered during this investigation of Site 2438. Similar to Site 2438, petroleum hydrocarbons were detected at only one location at Site 2444, GP-3-2, which is also located at the approximate center of the former UST area.

As a preliminary screening, these investigations provided a qualitative delineation of areas of suspected contamination by petroleum hydrocarbons. If determined necessary, the data obtained during this investigation may be used to direct subsequent investigations of Sites 1062, 2438, and 2444, at Fort Jackson, S.C.

REFERENCES

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