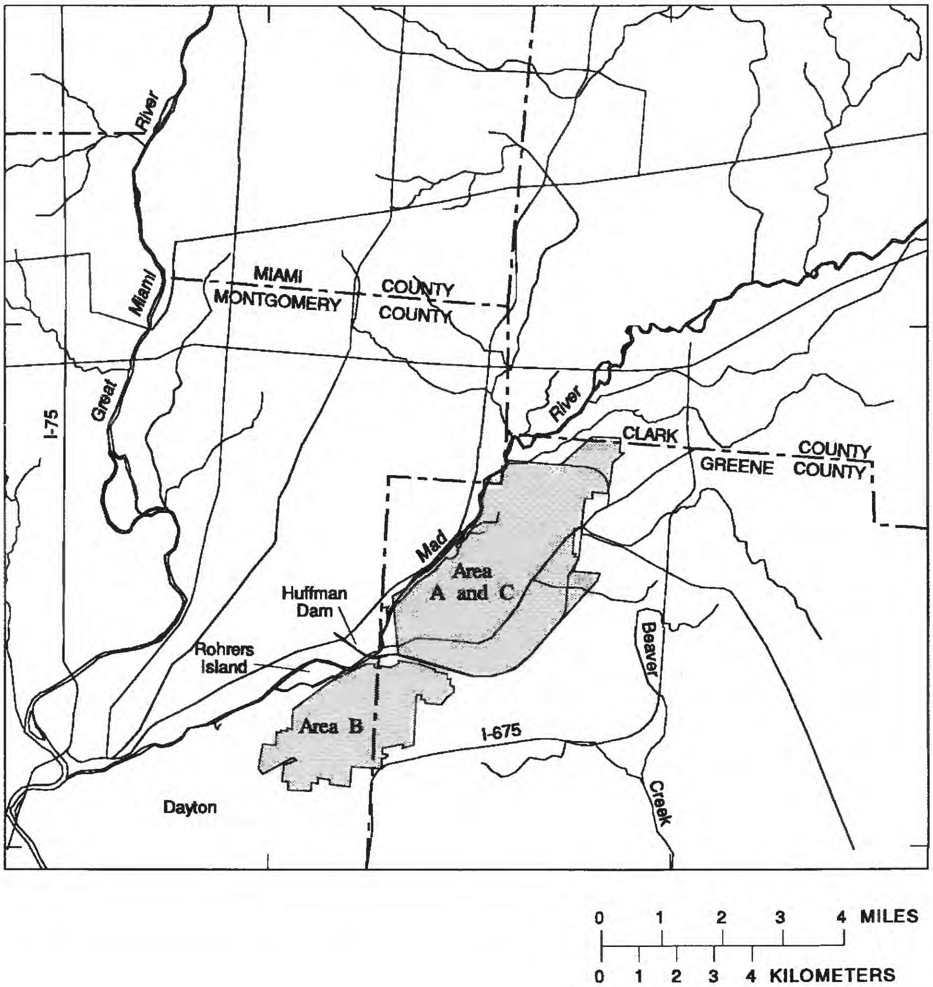
Screening For Volatile Organic Compounds In Soil And Groundwater By Use Of A Portable Gas Chromatograph During Field Investigations At An Air Force Installation In Ohio

U.S. GEOLOGICAL SURVEY
Open-File Report 95-371

U.S. DEPARTMENT OF THE INTERIOR
March 3, 1849



Prepared in cooperation with the
WRIGHT-PATTERSON AIR FORCE BASE

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U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

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CONVERSION FACTORS AND ABBREVIATED CHEMICAL AND PHYSICAL UNITS

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
ounce, avoirdupois (oz)	28.35	gram

Temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by use of the following equation:

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

Abbreviated chemical and physical units used in this report: Chemical concentrations and water temperature are given in metric units. Chemical concentration is given in milligrams per liter (mg/L) or micrograms per liter (mg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is the same as for concentrations in parts per million (ppm). Chemical concentration is also given in milligrams per kilograms (mg/kg) or micrograms per kilogram (µg/kg). Milligrams per kilogram is a unit expressing the concentration of chemical constituents as weight (milligrams) of constituent per unit weight of the solid matrix (kilograms) in which the constituent is found. Milligrams per kilogram is used to express constituent concentrations in soils. Volumes of headspace gas are given in microliters (µL). Ultraviolet radiation is given in electron volts (eV).

Screening for Volatile Organic Compounds in Soil and Groundwater by use of a Portable Gas Chromatograph during Field Investigations at an Air Force Installation in Ohio

By James M. Parnell

ABSTRACT

The use of the portable gas chromatograph for screening of soil and water samples in the field was part of the drilling program for the installation of monitoring wells for a basewide ground-water-monitoring program at Wright-Patterson Air Force Base, Ohio. Selected soil and ground-water samples were screened in the field for volatile organic compounds to determine if contamination was present, to define the vertical and lateral extent of contamination, and to aid in the placement of the well screens for optimal interception of contaminants. This report describes the screening methods, sample-collection, quality-assurance/quality-control methods, and data-interpretation procedures necessary for screening of soil and ground-water samples in the field during the water-resources investigations.

INTRODUCTION

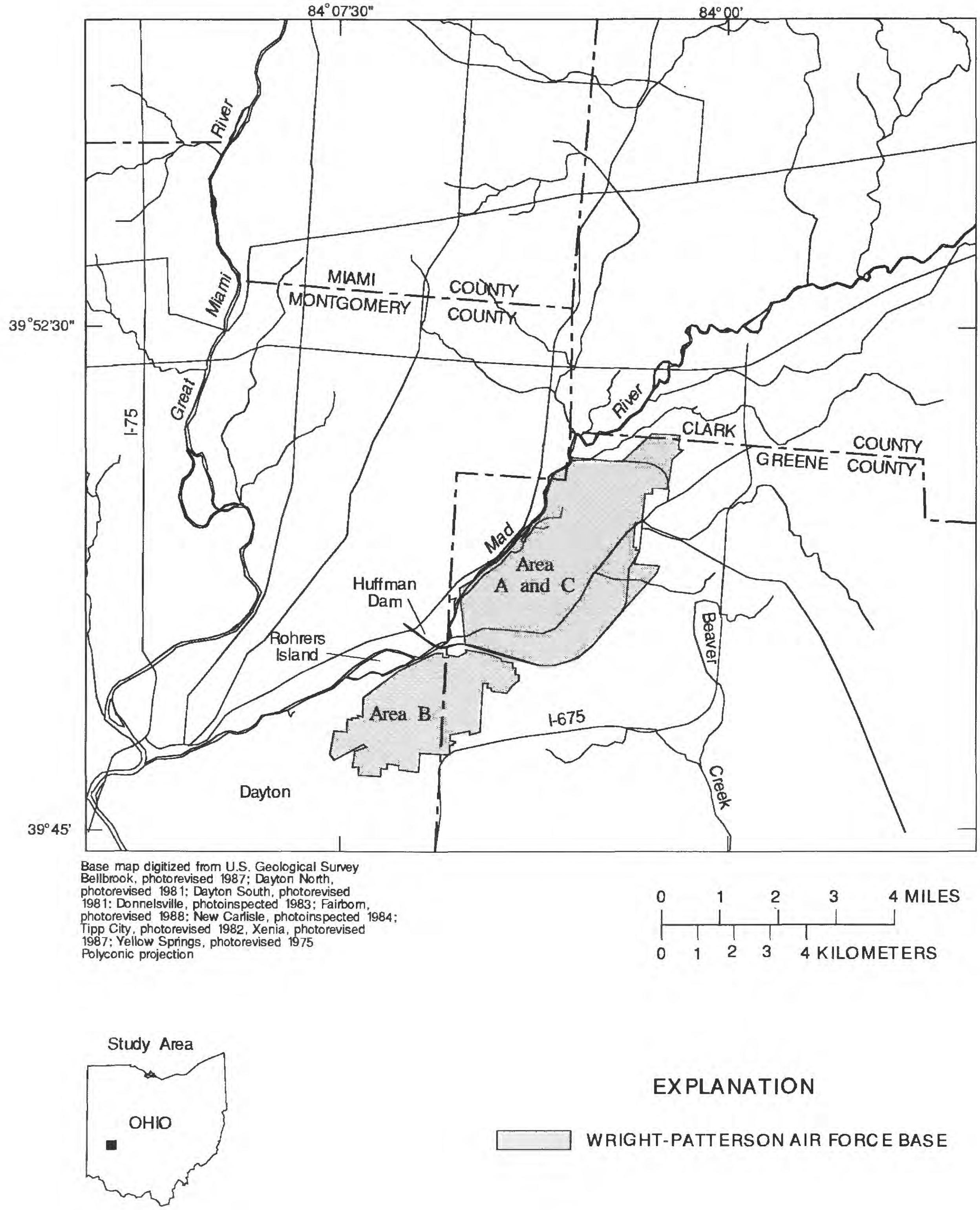
Use of the portable gas chromatograph (GC) gained in popularity during the 1980's with the increase in soil-gas surveys, which are now widely accepted for contaminant-plume delineation. Often overlooked, though, are the capabilities of the portable GC to provide a wealth of data quickly during field investigations. Semiquantitative headspace analyses of soil and water samples in the field provide real-time data needed to make decisions quickly and to avoid the delays inherently associated with laboratory analysis of samples.

Use of the portable GC for screening soil and water samples in the field was part of the drilling program for the installation of monitoring wells for a basewide ground-water monitoring program at Wright-Patterson Air Force Base (WPAFB), Ohio (fig. 1). In this report, soil is defined in engineering geology terms as any unconsolidated material above bedrock. Selected soil and ground-water samples were examined in the field to determine if contamination was present and the vertical and lateral extent of possible contamination and to also aid in the placement of the well screens for optimal interception of contaminants.

This report describes the screening methods and the sample-collection, quality-assurance/quality-control (QA/QC), and data-interpretation procedures used for screening soil and ground-water samples in the field during the water-resources investigations at WPAFB. Presented in case-study form, this report is intended as guidance for investigators who may need a rapid semi-quantitative determination of the concentration of volatile organic compounds in the subsurface to define contamination boundaries concurrently with the installation of monitoring wells.

Instrument Specifications

Concentrations of selected volatile organic compounds (VOC's) in headspace were detected by use of a portable GC equipped with a photoionization detector (PID). The GS consists of a pump, a computer with a 32-character liquid crystal display (LCD), and a microprocessor chemical library. It also contains a photoionization detector with a sealed ultraviolet



Base map digitized from U.S. Geological Survey Bellbrook, photorevised 1987; Dayton North, photorevised 1981; Dayton South, photorevised 1981: Donnelsville, photoinspected 1983; Fairborn, photorevised 1988; New Carlisle, photoinspected 1984; Tipp City, photorevised 1982, Xenia, photorevised 1987; Yellow Springs, photorevised 1975
Polyconic projection

Figure 1. Location of Wright-Patterson Air Force Base. (Modified from Dumouchelle and others, 1993, fig. 1.)

source that emits radiation at 10.6 eV, an isothermal oven, and high- frequency driver circuits for the integration of peak size and computation of compound concentrations. This analytical setup is capable of resolving complex mixtures of halogenated volatile organic and aromatic hydrocarbon compounds.

A chromatographic column with the capacity to separate these compounds was selected. A capillary column set for nonpolar analysis with precolumn autobackflush capacity was installed into the system. The GC uses a high-purity air (less than 0.1 ppm hydrocarbon contamination), usually referred to as "Ultra Zero Air," as a carrier gas. Data output is to an application card and through computer software for onscreen viewing at a computer terminal. The output can be saved on disk for later printing. The following is a list of operating conditions used at WPAFB:

TABLE 1. Gas-chromatograph operating conditions

Carrier gas	less than 0.1 part per million hydrocarbon
Carrier-gas flow rate	20 milliliters per minute
Column oven	Isothermal, set at 30 degrees Celsius
Gas chromatography analysis time	450 seconds

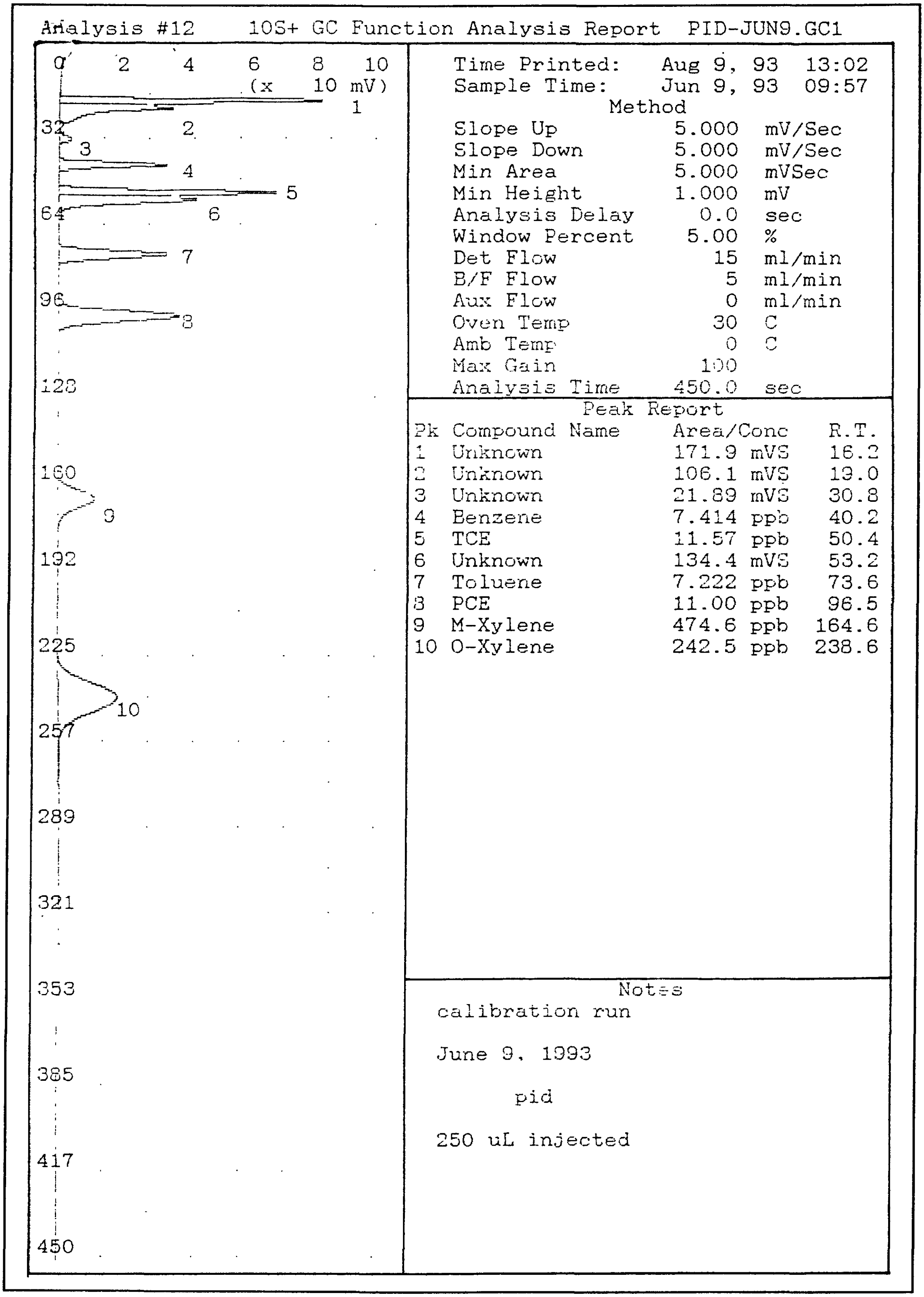
Static Headspace Analysis

Chromatography is the process of separating components of a sample by moving the sample through a medium by means of adsorption, partition, or other property which causes the different components with differing mobilities to become separated. Gas chromatography separates gases or vapor from one another by passing them over a solid. As the air sample is injected into the GC injection port, it is carried by a stream of carrier gas (mobile phase) through a heated column, where its various components interact with the column coating or packing (stationary phase) and are temporarily adsorbed then desorbed. The components within the sample are thereby separated and eluted from the column in a characteristic order known as its retention time. Each eluted component enters the ionization detector, where a signal voltage is generated and displayed on a screen, resulting in a series of peaks separated by time. An example of a chromatogram and analysis report is shown in figure 2.

Static headspace analysis consists of obtaining soil and ground-water samples, putting them into a closed container, and then analyzing the air space above the sample for the partitioned VOC's. Diffusion is the principal driving force behind VOC vapor movement through the soil matrix and for partitioning of VOC's from soil and water into the void space of a partially filled sample container. The relative ease with which a VOC partitions or moves out of a soil or water is governed by properties of soil and water and properties of the VOC, the latter of which is described for gas/liquid systems by Henry's law. The Henry's law constant can be thought of as the ratio of the abundance of a compound in the gas phase to that in the aqueous phase at equilibrium. The VOC's will partition into the air above the liquid or solid phase in proportion to the concentration in the liquid or solid according to their vapor pressure and solubility. The partition coefficient is the equilibrium distribution constant for an organic compound between two immiscible bulk phases, such as water and soil organic matter. The partition coefficient is determined by the relative solubilities of the organic compound in each bulk phase. VOC's detection in ground water and soil is governed by temperature and compound-specific air/water and air/soil partitioning coefficients. Sorption is the process of the uptake of organic compounds by solids. Sorption influences the exchange of freely dissolved concentrations of organic compounds and volatilization rates which affect the concentrations of the VOC's.

SCREENING METHODS

The method for screening in the field is based on method 3810 of the U.S. Environmental Protection Agency (USEPA) (1986), which allows for rapid screening for large numbers of samples in a relatively short time. The procedures were modified and designed to screen at moderate recovery and sufficient sensitivity for a broad spectrum of VOC's. The results of the analyses may reflect only a minimum of the amount actually present. The objective of the sampling was to determine the types and concentrations of VOC's in soil and water and to define the depth and lateral extent of the VOC's for use in placement of monitoring-well screens.



```
Analysis #12      10S+ GC Function Analysis Report  PID-JUN9.GC1

 Time Printed:    Aug 9, 93   13:02
 Sample Time:     Jun 9, 93   09:57
                    Method
 Slope Up             5.000   mV/Sec
 Slope Down           5.000   mV/Sec
 Min Area             5.000   mVSec
 Min Height           1.000   mV
 Analysis Delay         0.0   sec
 Window Percent        5.00   %
 Det Flow                15   ml/min
 B/F Flow                 5   ml/min
 Aux Flow                 0   ml/min
 Oven Temp               30   C
 Amb Temp                 0   C
 Max Gain               100
 Analysis Time        450.0   sec
                 Peak Report
Pk Compound Name        Area/Conc     R.T.
1  Unknown              171.9 mVS     16.2
2  Unknown              106.1 mVS     19.0
3  Unknown              21.89 mVS     30.8
4  Benzene              7.414 ppb     40.2
5  TCE                  11.57 ppb     50.4
6  Unknown              134.4 mVS     53.2
7  Toluene              7.222 ppb     73.6
8  PCE                  11.00 ppb     96.5
9  M-Xylene             474.6 ppb    164.6
10 O-Xylene             242.5 ppb    238.6

                      Notes
 calibration run

 June 9, 1993

         pid

 250 uL injected
```

Figure 2. Example of a chromatogram and analysis report.

Sample Collection

Separate sampling protocols were used for the collection of water samples and soil samples. Ground-water samples were collected from selected horizons during drilling by attaching a 5-ft-long well screen to the drill rods, lowering the screen to the desired depth through the drill casing, and pulling back the outer casing to expose the screen to the formation. The temporary well was then purged with a portable submersible pump to remove water added during drilling or originating from other intervals. After purging, the pump was removed, a bailer was lowered into the well, and a water sample was withdrawn. Soil samples were collected at 5-ft intervals starting at land surface and at intervals where major lithologic changes were noted during drilling from a continuous core. Additional soil samples were collected on the basis of visual and preliminary measurements made with a hand-held PID.

Sample Preparation

Preparation of water samples for analysis on the portable GC consisted of filling a 40-mL vial with a silicon-septum cap, labeling the vial, and then sending it chilled (4 °C) to the field laboratory. At the laboratory, about 15 mL of water was pipetted off, and the vial was placed in a heated water bath at 50 °C and allowed to equilibrate. After a minimum of 3 minutes in the bath, the sample was removed and then shaken by hand for 1 minute; then 250 µL of air from the headspace was withdrawn through the septum with a syringe for analysis.

For the soil analysis, 5 to 10 g of soil was collected and placed in a 40-mL vial with silicon-septum cap; the vial was labeled and sent chilled (4 °C) to the field laboratory. The soil and vial were weighed together to ±0.1 g, placed in a heated water bath (50 °C), and allowed to equilibrate. After a minimum of 3 minutes in the bath, the sample was removed and then shaken by hand for 1 minute; 250 µL of air from the headspace was then withdrawn through the septum with a syringe for analysis.

Recordkeeping

Records of all the screening data were kept in a logbook to ensure that all details of the analytical work were recorded. Information in the logbook includes QA data, the calibration curves, and calculations of response factors. Sample information such as the time, sample number, depth of sample, injection volume, and injection time was recorded and kept in a sample logbook. Records of all GC maintenance also were kept in a separate logbook. Samples of instrument logbooks for the field and QA data used for the WPAFB project are shown in figure 3.

QUALITY ASSURANCE AND QUALITY CONTROL

In the investigation at WPAFB, the ability to derive the maximum benefit from GC field data was considered to be linked directly to the development and implementation of a field-procedure and field-laboratory QA/QC program. Such a program ensures that data are accurate, reproducible, and defensible. QA/QC procedures were rigorously applied to sample collection and analysis and data interpretation to ensure that data are not misleading or misinterpreted. All information concerning the field screening of water and soil samples underwent extensive quality- assurance reviews and vigorous quality-control checks. The QA/QC measures for the field screening work done at WPAFB are summarized in table 2.

Field Procedures

Field QA/QC procedures required that samples submitted for analysis be minimally altered, chemically or physically, and free of cross-contamination. QA/QC procedures also were intended to address the problems encountered during sample collection. Sample-identification numbers, depth from which the sample was derived, and sample type were reported in the field logbook and on other appropriate forms. Quality-control samples that were collected include field air and organic-free water blanks that were taken to the field and then analyzed for VOC's.

Several types of QA/QC samples were analyzed to check precision and accuracy of the analyte recovery and to ensure minimal contamination. Instrument blanks, field blanks, syringe blanks, and sample replicates were routinely analyzed. Approximately 15 percent of the analyses done were duplicate samples, of which 5 percent were duplicate analyses on the same sample. Results of the duplicate samples should have RPD's of less than 30 percent; if not, the data were flagged to indicate a problem. Blank air samples were

Field Lab Gas Chromatograph Report

QA/QC Data

(reported in units of µg/Kg; blank column indicates compound was not detected; R--replicate; D--duplicate, MS--matrix spike)

WELL # ________ MEDIUM ________ DATE ____________

SAMPLE ID	chloro-form	1,1,1 TCA	carbon-tetra-chloride	benzene	ethyl-benzene	TCE	toluene	tetra-chloro-ethene	total xylenes	total hydro-carbons	Comments

Analyst ___________

Field Lab Gas Chromatograph Report

Field Data

(reported in units of µg/Kg; blank column indicates compound was not detected)

WELL # _______ MEDIUM _______ DATE __________

SAMPLE ID	carbon-tetra-chloride	chloro-form	1,1,1 TCA	TCE	PCE	benzene	toluene	ethyl-benzene	total xylenes	total hydro-carbons	Comments

Analyst __________

Figure 3. Sample of instrument logsheets.

TABLE 2. Summary of quality-control measures for field gas chromatography
[QA/QC, quality assurance and quality control; MS/MSD, matrix spike and matrix spike duplicate; <, less than]

QA/QC sample	Frequency	Action if value is out of control limits
Calibration:		
Initial calibration	1 per day	Calibrate instrument.
Continuing calibration	2 per day	Recalibrate instrument
Three-point calibration	as needed	Establish linear range.
Duplicates:		
Analytical	1 in 20	Check calibration; run initial calibration
Samples	1 in 10	None.
MS/MSD	1 in 20	Flag associated data.
Blanks:		
Instrument	1 per day	Flag data if <5 times blank concentration level. Note in interpretation of data.
Air/site	1 per day	Flag data if <5 times blank concentration level.
Air/lab	1 per day	

collected from the field and laboratory. Matrix spike and matrix spike duplicates (MS/MSD) were made by use of primary standards as the spiking compound. One MS/MSD was analyzed for every 20 samples screened. The acceptable percentages of recovery for the matrix spike samples were in the range of 30 to 200 percent. If spikes were out of this range, the data were flagged. The RPD of the matrix spike and matrix spike duplicate analyses was within ±100 percent.

The equipment was properly maintained to minimize contamination and ensure prompt sample analysis. Carryover of any compound into the next sample run was avoided by backflushing the equipment between analyses. Also, to prevent carryover from syringes, syringe blanks were run after thorough cleaning with methanol and air drying. Spare parts for the GC and other accessories were maintained onsite to minimize equipment downtime. The septum through which the samples were injected into the GC was replaced after 10 injections, if not more often, due to possible contamination.

Field Laboratory Procedures

The field laboratory QA/QC procedures were designed to verify the integrity of the sample being analyzed. The GC was calibrated by use of external standards from the USGS Laboratory in Arvada, Colo. The primary standards were prepared by the lab by dilution of certified pure chemicals into methanol. A quantity of each primary standard was placed into a 40-mL septum-capped vial filled with a known volume of deionized, organic-free water to make a day-to-day working standard.

Before the screening, and at intervals throughout the screening, instrument response was checked against calibration curves. Calibration curves were constructed by analyzing the same standard concentrations at three different injection volumes. For this project, the three injection volumes were 125, 250, and 500 µL, respectively. The results of the calibration curves completed before, during, and after the screening were presented as part of the field report.

Calibration of the GC was checked daily to ensure that the linear response range of the detector was within range as determined from the calibration curves. At the beginning of each day, concentration standards were run through the GC to determine the response factor for each of the target compounds (table 3). The response factor is defined as the area units of the standard peak divided by the amount of standard injected.

If the relative percent difference (RPD) for the response of an analyte changed by more than 25 percent during a 24-hour period, the detector was recalibrated, and a new response factor was determined. All RPD values are set within the established guidelines of USEPA Method 3810.

IDENTIFICATION AND QUANTIFICATION OF TARGET COMPOUNDS

The intended use of the data determines the sample design and subsequent analysis. For the screening at WPAFB, the goals of the sample design were to characterize contamination, to determine the extent of contamination, and to aid in the placement of well screens. The onsite analysis of samples was intended to reduce costs associated with monitoring-well drilling by generating real-time data that would produce and expedite a knowledge-based decision-making process.

Identification

Identification of a specific compound is based on retention times programmed into the GC library. After each analysis, the GC software compares the detected peak with those already programmed into the library. It then identifies those compounds that match retention-time values. The retention-time window is determined by evaluating the baseline movement or drift in retention time of the chemical standards in the library. Generally, the retention-time window used is ±5 percent of the retention time of each compound stored in the library.

Quantification

The GC was calibrated by use of external standards for sample quantification. Prior to the start and at intervals throughout the project, calibration standards at three different volumes (concentrations) were prepared for construction of calibration curves. The volumes, 125, 250, and 500 mL, corresponded to 0.5,

TABLE 3. Target compounds and detection limits
[μg/kg, micrograms per kilogram; μg/L, micrograms per liter]

Target compound	Detection limits[1] Soil (μg/kg)	Water (μg/L)
Halogenated volatile organics:		
Carbon tetrachloride	0.5	0.5
Chloroform	.5	.5
Tetrachloroethene	.5	.5
1,1,1-Trichloroethane	.5	.5
Trichloroethene	.5	.5
Aromatic hydrocarbons:		
Benzene	1.0	1.0
Ethylbenzene	1.0	1.0
Meta/Para-xylene[2]	1.0	1.0
Ortho-xylene[2]	1.0	1.0
Toluene	1.0	1.0
Total hydrocarbons[3]	1.0	1.0

[1] Specific detection limits are highly matrix dependent. The detection limits here are provided for guidance and may not always be achievable.

[2] Analyzed separately but recorded as total xylene.

[3] This value is derived from the subtraction of the total area units of halogenated compounds from the total area units of the hydrocarbon compounds.

1, and 2 times the concentration of each standard. The concentration of one standard was at the method detection limit. The remaining concentration limits were above and below the defined working range of the GC. Within the library, each compound can be stored at three concentration levels. Quantification of an identified peak is done after each analysis. Using the sensitivity programmed into the library, the GC calculates the concentration of the compound. The sensitivity is based on the ratio of the measured response peak (peak area) to the actual concentration of the stored compound in the library. If one concentration is stored, the GC uses the same calculated sensitivity whenever this compound is detected. If a compound is stored at a second concentration that is higher than the first, the sample concentration is calculated by use of the first sensitivity if less than the stored concentration. If the second concentration is more than the first concentration, the sensitivity is calculated from the slope of a line connecting the two (concentration, response) points. If a third concentration is stored higher than the second concentration, the sample concentration is calculated from a line connecting the stored concentration points between the second and third stored (concentration, response) points if the sample concentration is above the second stored concentration. This is called a three-point calibration curve and is shown in figure 4.

Detection limits were determined by extrapolating a three-point calibration curve to the minimum discernible peak by use of the normal peak threshold settings on the GC divided by the injection volume (250 µL) and the response factor for the particular compound of interest. Under optimum operating conditions, detection limits for halocarbons were set at 0.5 µg/kg for soil and 0.5 µg/L for water samples; detection limits for hydrocarbons were set at 1.0 µg/kg for soil samples and 1.0 µg/L for water samples (see table 3). Optimal conditions are defined as a maximum injection volume of 250 µL, a smooth baseline, and no interferences from other peaks.

Headspace-screening data for samples were not interpreted as being a 1:1 ratio of instrument reading to actual concentrations of VOC's in the sample. A variety of factors affect the results, such as soil moisture content, porosity, grain size, and adsorption capacities, as well as the relative volatility of the compound. The following equations address the factors of sample volumes, and weights were used to quantify the analyses and to improve the correlation between the screening data and sample concentrations.

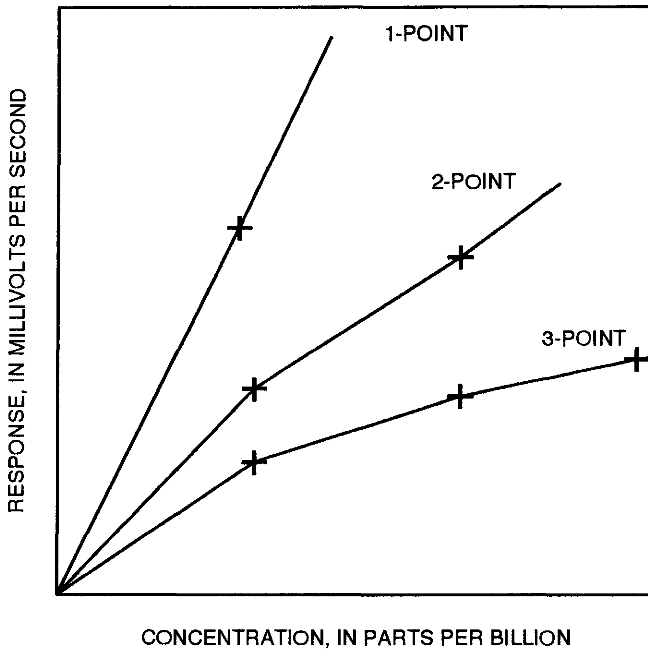


Figure 4. A generalized three-point calibration curve.

The quantity of a compound in a water sample is determined from the following equation:

$$\text{Concentration } (\mu g/L) = \frac{(S_x)\,(S)\,(V_t)\,(D)}{(S_s)\,(V_i)\,(V_s)},$$

where

S_x is response for analyte in the sample, in area units;

S is amount of standard injected, in nanograms;

V_t is volume of total headspace gas in vial, in milliliters;

D is dilution factor (if no dilution made, $D = 1$, dimensionless);

S_s is response for external standard, in area units;

V_i is volume of headspace gas injected into the GC for analysis, in milliliters; and

V_s is volume of sample extracted or purged, in milliliters.

The quantity of a compound in a water sample is determined from the following equation:

$$\text{Concentration } (\mu g/L) = \frac{(S_x)(S)(V_t)(D)}{(S_s)(V_i)(V_s)},$$

where

S_x is response for analyte in the sample, in area units;

S is amount of standard injected, in nanograms;

V_t is volume of total headspace gas in vial, in milliliters;

D is dilution factor (if no dilution made, $D = 1$, dimensionless);

S_s is response for external standard, in area units;

V_i is volume of headspace gas injected into the GC for analysis, in milliliters; and

V_s is volume of sample extracted or purged, in milliliters.

If matrix-spike and matrix-spike duplicate analyses are performed, the results are reported without correction for spike recovery. When positive identification is questionable, a maximum value is calculated, and the result is flagged to indicate that the compound is tentatively identified and the value could be significantly less than the numerical value.

APPLICABILITY OF SCREENING METHOD

A portable GC can be used for numerous field applications including soil-gas surveys, screening soil samples to optimize monitoring well-screen placement, and analyzing headspace of ground-water samples to determine the presence of VOC's. Semiquantitative headspace analysis makes it possible to characterize contamination, to better understand the distribution of contaminants, and to delineate areas for possible removal during site remediation. Contaminant boundaries can be identified concurrently with the installation of monitoring wells, eliminating unnecessary drilling and samples that would be submitted for laboratory analysis. Collection of real-time data permits the fine tuning of the investigative work plan as more knowledge of site-specific conditions generated. Efficiency and cost effectiveness of site investigation can then be maximized if contamination can be monitored onsite by headspace analysis. The applicability of the field GC screening for optimizing well-screen placement can be shown in its use at WPAFB. The ground-water-monitoring wells at WPAFB consisted of a water-table well and an initial borehole that was drilled to bedrock. Lithologic logs were compiled from the core and cuttings, and, at 5-ft intervals, soil samples were collected for field GC-screening analysis. Monitoring wells were to be placed within significant lithologic zones when encountered. If field screening results indicated contamination at any other depths, additional wells were installed to monitor these zones. The example in figure 5 shows how the GC data were compiled from the initial borehole lithologies to aid in the determination of well-screen placement. Based on lithologies and field screening data, three monitoring wells were selected at this site. (A water-table well was completed in previous work to the initial borehole drilling and was screened from 21 to 36 ft to intercept above and below the water table.) The well-screening intervals were at depths of 37 to 42 ft, based on a small sand lens containing trichloroethylene at depths of 35 and 40 ft; 118 to 128 ft, based on a sand-and-gravel layer containing tetrachloroethane at a depth of 119 ft; and 205 to 215 ft within a sand and gravel layer at a depth of 150 to 240 ft. The highest concentration of tetrachloroethane in ground-water on the sand and gravel layer was found at a depth of 210 ft. Results from the field screening of water samples (fig. 6) from the initial borehole revealed some contaminants below the detection limits and did not warrant additional monitoring wells.

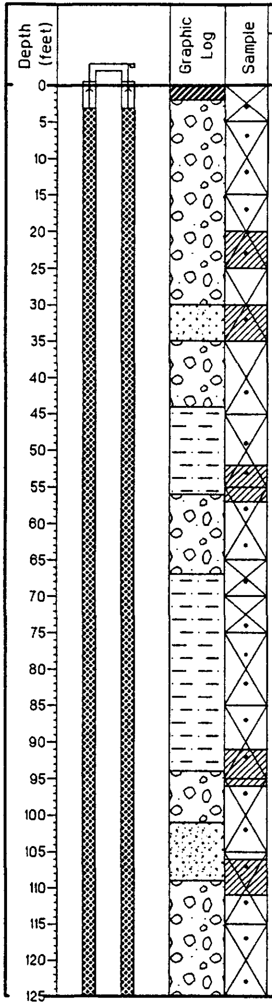
SUMMARY

The portable GC was used to screen soil and ground-water samples in the field for VOC's as part of the drilling program for the installation of monitoring wells for a basewide water-monitoring program at WPAFB. Selected soil and water samples were screened in the field to determine if contamination was present, to define the vertical and lateral extent of contamination, and to aid in the placement of the well screens for optimal interception of contaminants. Concentrations of VOC's in sample-contained headspace were detected by use of a portable GC equipped with a photoionization detector. Static headspace entailed the collection of a soil or water sample, allowing the

U.S. Geological Survey -- Ohio District

Soil GC Log: MT-239 **Map ID #: DG1**

WRIGHT-PATTERSON AIR FORCE BASE Fairborn, Ohio



SOIL HEADSPACE: GC RESULTS (ug/kg)									
CCl4	Chloro-form	TCA	TCE	PCE	Benzene	Toluene	Ethyl benzene	Total xylenes	Total Hydrocarbons
ND	ND	ND	5.6	ND	<1.0	ND	ND	<1.0	<1.0
ND	ND	ND	ND	ND	<1.0	<1.0	ND	<1.0	<1.0
ND	ND	ND	<0.5	ND	<1.0	<1.0	ND	<1.0	<1.0
ND	ND	ND	0.74	ND	ND	<1.0	ND	<1.0	<1.0
ND	ND	ND	1.8	ND	ND	<1.0	ND	<1.0	<1.0
ND	ND	ND	2.6	ND	ND	ND	ND	ND	ND
ND	ND	ND	2.5	ND	ND	ND	ND	<1.0	<1.0
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ND	ND	ND	<0.5	<0.5	ND	ND	ND	ND	ND
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ND	ND	ND	ND	<0.5	ND	ND	ND	ND	ND
ND	ND	ND	ND	<0.5	ND	ND	ND	ND	ND
ND	ND	ND	ND	<0.5	ND	ND	ND	ND	ND
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ND	ND	ND	ND	<0.5	ND	ND	ND	ND	ND
ND	ND	ND	ND	0.95	ND	ND	ND	ND	ND
ND	ND	ND	ND	<0.5	ND	ND	ND	ND	ND
ND	ND	ND	ND	1.5	ND	<1.0	ND	<1.0	<1.0
ND	ND	ND	ND	<0.5	ND	ND	ND	ND	ND

NOTE: ND = None detected. Detection limits = 0.5 ug/kg for halocarbons & 1.0 ug/kg for hydrocarbons
< ( ) = detected less than detection limit noted
Values obtained on portable Photovac 10S+ gas chromatograph

USGS GC Operator: Jim Parnell	Begin Drilling: 05/10/93	Well Name: MT-239
Drilling Method: Rotasonic	End Drilling: 05/13/93	Northing: 650733.
Borehole TD: 247	Converted to Well? Yes	Easting: 1542880.

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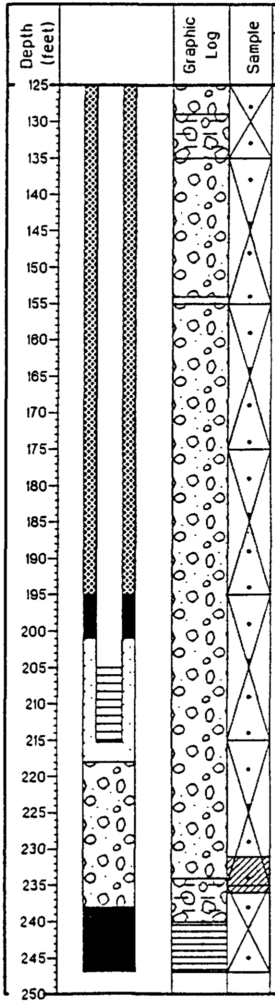
Figure 5. Sample of gas chromatography results and well lithogies.

U.S. Geological Survey -- Ohio District

Soil GC Log: MT-239 **Map ID #: DG1**

WRIGHT-PATTERSON AIR FORCE BASE Fairborn, Ohio



SOIL HEADSPACE: GC RESULTS (ug/kg)									
CCl4	Chloro-form	TCA	TCE	PCE	Benzene	Toluene	Ethyl benzene	Total xylenes	Total Hydrocarbons
ND	ND	ND	ND	<0.5	ND	ND	ND	ND	ND
ND	ND	ND	ND	<0.5	ND	ND	ND	ND	ND
ND	ND	ND	ND	<0.5	ND	ND	ND	ND	ND
ND	ND	ND	ND	<0.5	ND	ND	ND	ND	ND
ND	ND	ND	ND	<0.5	ND	ND	ND	ND	ND
ND	ND	ND	ND	<0.5	ND	ND	ND	ND	ND
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ND	ND	ND	ND	<0.5	ND	ND	ND	ND	ND
ND	ND	ND	ND	0.65	ND	ND	ND	ND	ND
ND	ND	ND	ND	0.73	ND	ND	ND	ND	ND
ND	ND	ND	ND	0.69	ND	ND	ND	ND	ND
ND	ND	ND	ND	0.62	ND	ND	ND	ND	ND
ND	ND	ND	ND	0.50	ND	ND	ND	ND	ND
ND	ND	ND	ND	0.60	ND	ND	ND	ND	ND
ND	ND	ND	ND	0.54	ND	ND	ND	ND	ND
ND	ND	ND	ND	<0.5	ND	ND	ND	ND	ND
ND	ND	ND	ND	1.2	ND	ND	ND	ND	ND
ND	ND	ND	ND	0.73	ND	ND	ND	ND	ND
ND	ND	ND	ND	<0.5	ND	ND	ND	ND	ND
ND	ND	ND	ND	<0.5	ND	ND	ND	ND	ND
ND	ND	ND	ND	<0.5	ND	ND	ND	<1.0	<1.0
ND	ND	ND	ND	<0.5	ND	ND	ND	<1.0	<1.0
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

NOTE: ND = None detected. Detection limits = 0.5 ug/kg for halocarbons & 1.0 ug/kg for hydrocarbons
< ( ) = detected less than detection limit noted
Values obtained on portable Photovac 10S+ gas chromatograph

USGS GC Operator: Jim Parnell
Begin Drilling: 05/10/93
Well Name: MT-239
Drilling Method: Rotasonic
End Drilling: 05/13/93
Northing: 650733.
Borehole TD: 247
Converted to Well? Yes
Easting: 1542880.

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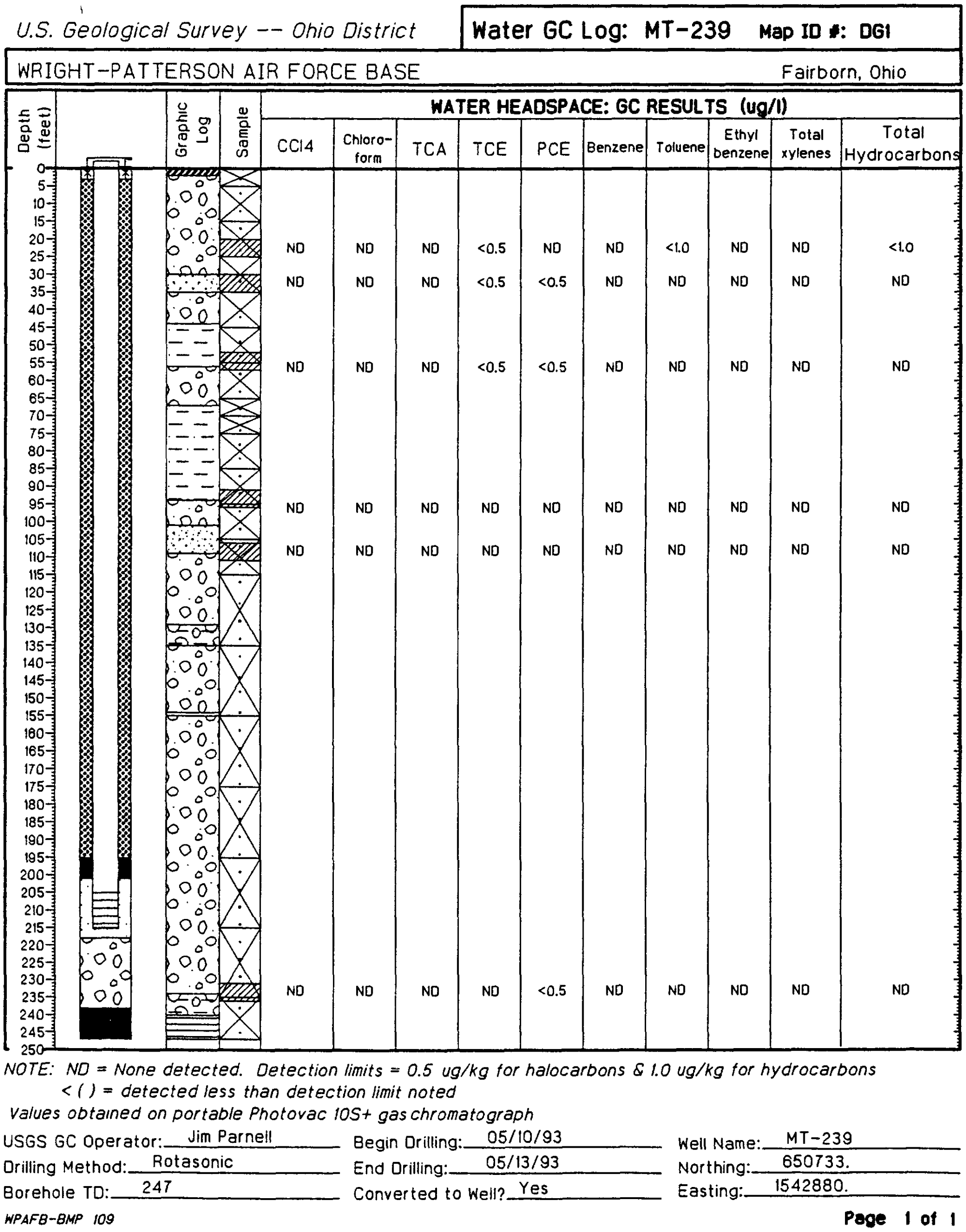
EXPLANATION

▨ SCREENED INTERVAL FOR WATER SAMPLE

☒ CORE INTERVAL

• SOIL SAMPLE

Figure 5. Sample of gas chromatography results and well lithogies--Continued.



U.S. Geological Survey -- Ohio District

Water GC Log: MT-239 Map ID #: DG1

WRIGHT-PATTERSON AIR FORCE BASE — Fairborn, Ohio

WATER HEADSPACE: GC RESULTS (ug/l)

CCl4	Chloro-form	TCA	TCE	PCE	Benzene	Toluene	Ethyl benzene	Total xylenes	Total Hydrocarbons
ND	ND	ND	<0.5	ND	ND	<1.0	ND	ND	<1.0
ND	ND	ND	<0.5	<0.5	ND	ND	ND	ND	ND
ND	ND	ND	<0.5	<0.5	ND	ND	ND	ND	ND
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ND	ND	ND	ND	<0.5	ND	ND	ND	ND	ND

NOTE: ND = None detected. Detection limits = 0.5 ug/kg for halocarbons & 1.0 ug/kg for hydrocarbons
< ( ) = detected less than detection limit noted
Values obtained on portable Photovac 10S+ gas chromatograph

USGS GC Operator: Jim Parnell
Drilling Method: Rotasonic
Borehole TD: 247
Begin Drilling: 05/10/93
End Drilling: 05/13/93
Converted to Well? Yes
Well Name: MT-239
Northing: 650733.
Easting: 1542880.

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EXPLANATION

▨ SCREENED INTERVAL FOR WATER SAMPLE

☒ CORE INTERVAL

· SOIL SAMPLE

Figure 6. Sample of gas chromatography results for water samples.

vapor concentration to equilibrate with its matrix , and analysis of the headspace to the partitioned VOC's.

Separate sampling protocols were used to collect of ground-water and soil samples. Identification of a compound was based on retention times programmed into the GC library. Using the internal library program, the GC calculated the concentration of the compound. The software then tentatively identified those compounds that matched retention-time values. Quantification (on pages 10-11) was done by using separate specific equations after each analysis. Using the sensitivity programmed into the library, the GC calculated the concentration of the compound. The sensitivity was based on the ratio of the measured response peak (peak area) to the actual concentration of the stored compound in the library. Separate specific equations for soil and water samples were then used to quantify the analyses. Records of all the screening data were kept in a logbook to ensure that all details of the analytical work were documented, including QA data, the calibration curves, and calculations of response factors. Sample information, such as the time of sample collection, sample number, depth of sample, injection volume, and injection time, was recorded.

In the investigation, the maximum benefit from GC field data was directed by the field-procedure and field-laboratory QA/QC programs. Such programs ensure that data were accurate, reproducible, defensible, and appropriately used. The data were used to determine optimal placement of well screens and to determine the vertical and lateral extent of subsurface contamination.

The use of the portable GS for screening of soil and ground-water samples in the field can be an integral part of the drilling program for a water-resources investigation. The screening methods, sample-collection, quality-assurance/quality-control and data-interpretation procedures necessary for screening of soil and water samples in the field described here can provide a rapid, semiquantitative method for determining the concentration of VOC's in ground water and soil and for defining contamination boundaries concurrently with the installation of monitoring wells.

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