DOE/ID-22151

CHLOROFLUOROCARBONS, SULFUR HEXAFLUORIDE, AND DISSOLVED PERMANENT GASES IN GROUND WATER FROM SELECTED SITES IN AND NEAR THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY, IDAHO, 1994-97

U.S. GEOLOGICAL SURVEY
OPEN-FILE REPORT 98-274

Prepared in cooperation with the U.S. DEPARTMENT OF ENERGY

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By: Eurybiades Busenberg, L. Niel Plummer, Roy C. Bartholomay, and Julian E. Wayland

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Open-File Report 98-274

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Idaho Falls, Idaho
August, 1998

DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Thomas J. Casadevall, Acting Director

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CONVERSION FACTORS AND ABBREVIATED UNITS

Multiply	By	To obtain
Cubic centimeters (cm^3)	0.06102	Cubic inch
Gram (g)	0.03527	Ounce
Kilogram (kg)	2.205	Pound
Kilometer (km)	0.6215	Mile
Square kilometer (km^2)	0.3861	Square mile
Meter (m)	3.281	Foot
Millimeter (mm)	0.03937	Inch
Becquerel per liter (Bq/L)	0.027	Picocuries per liter
Terrabecquerel (TBq)	27	Curries

For temperature, degrees Celcius (^oC) can be converted to degrees Fahrenheit (^oF) by using the formula F=(1.8)(C) + 32.

Abbreviated units used in report: L (liter), mL (milliliter), pg/kg (picogram per kilogram), mol (mole), fmol/L (femtomol per liter), ppt (parts per trillion), m^2/d (meter square per day).

Chlorofluorocarbons, sulfur hexafluoride, and dissolved permanent gases in ground water from selected sites in and near the Idaho National Engineering and Environmental Laboratory, Idaho, 1994-97

By Eurybiades Busenberg, L. N. Plummer, Roy C. Bartholomay, and Julian E. Wayland

ABSTRACT

From July 1994 through May 1997, the U.S. Geological Survey in cooperation with the Department of Energy, sampled 86 wells completed in the Snake River Plain aquifer at and near the Idaho National Engineering and Environmental Laboratory (INEEL). The wells were sampled for a variety of constituents including one- and two-carbon halocarbons. Concentrations of dichlorodifluoromethane (CFC-12), trichlorofluoromethane (CFC-11), and trichlorotrifluororoethane (CFC-113) were determined. The samples for halocarbon analysis were collected in 62-milliliter flame sealed borosilicate glass ampoules in the field. The data will be used to evaluate the ages of ground waters at INEEL. The ages of the ground water will be used to determine recharge rates, residence time, and travel time of water in the Snake River Plain aquifer in and near INEEL. The chromatograms of 139 ground waters are presented showing a large number of halomethanes, haloethanes, and haloethenes present in the ground waters underlying the INEEL. The chromatograms can be used to qualitatively evaluate a large number of contaminants at parts per trillion to parts per billion concentrations. The data can be used to study temporal and spatial distribution of contaminants in the Snake River Plain aquifer. Representative compressed chromatograms for all ground waters sampled in this study are available on two 3.5-inch high density computer disks. The data and the program required to decompress the data can be obtained from the U.S. Geological Survey office at Idaho Falls, Idaho. Sulfur hexafluoride (SF_6) concentrations were measured in selected wells to determine the feasibility of using this environmental tracer as an age dating tool of ground water. Concentrations of dissolved nitrogen, argon, carbon dioxide, oxygen, and methane were measured in 79 ground waters. Concentrations of dissolved permanent gases are tabulated and will be used to evaluate the temperature of recharge of ground water in and near the INEEL.

INTRODUCTION

The Idaho National Engineering and Environmental Laboratory (INEEL), encompassing about 2,300 km^2 of the eastern Snake River Plain in southeastern Idaho (fig. 1), was established in 1949 and is operated by the U.S. Department of Energy (DOE). INEEL facilities are used for the development of peacetime atomic energy applications such as nuclear safety research, defense programs, advanced energy programs, and advanced energy concepts. In the past, liquid radiochemical and chemical wastes generated at these facilities have been discharged to on site infiltration ponds, and disposal wells (Orr and Cecil, 1991; Bartholomay and others, 1997). Liquid-waste disposal has resulted in detectable concentrations of several waste

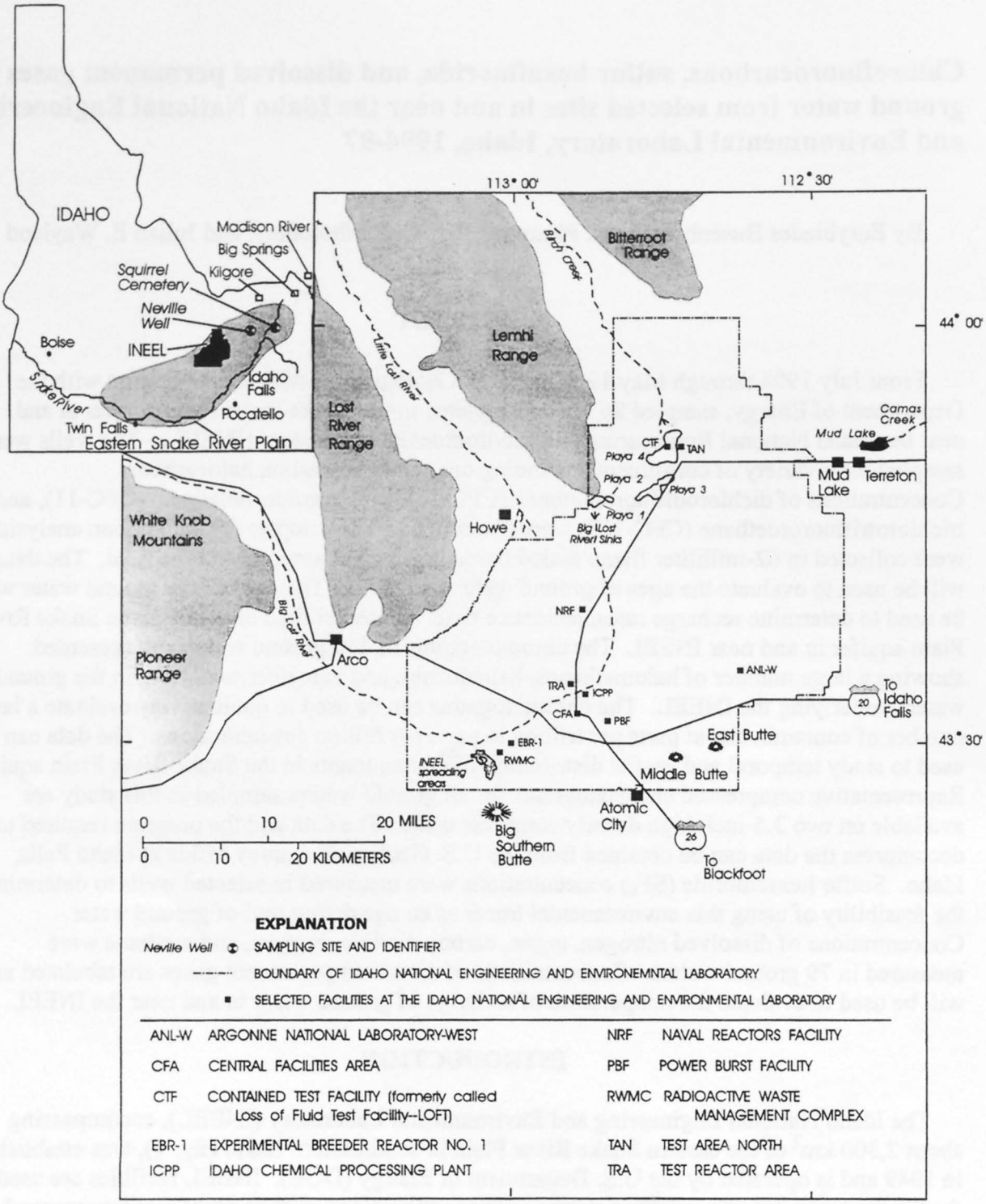

Figure 1. The Idaho National Engineering and Environmental Laboratory and selected facilities, southeastern Idaho.

constituents in the Snake River Plain aquifer underlying the INEEL facility (Robertson and others, 1974; Orr and Cecil, 1991; Bartholomay and others, 1997).

The U.S. DOE requires information about the mobility of dilute radiochemical- and chemical-waste constituents in the Snake River Plain aquifer. Waste-constituents mobility is, in part, determined by (1) the rate and direction of ground-water flow; (2) the locations, qualities and methods of waste disposal; (3) waste-constituent chemistry, and (4) the geochemical processes in the aquifer (Robertson, 1974; Robertson and others, 1974). The data presented in this report will be used to study temporal and spatial distribution of contaminants in the Snake River Plane aquifer, and age date the ground water. The study was conducted by the U.S. Geological Survey in cooperation with the U.S. DOE's Idaho Operations Office.

Purpose and Scope

This report presents the concentrations of chlorofluorocarbons, sulfur hexafluoride and dissolved gases in and near the INEEL facility. The results of the analyses from 139 samples collected from 79 wells collected from 1994 through 1997 are presented along with a brief summary of field and laboratory procedures used for collection and analyses.

Geohydrologic Setting

The eastern Snake River Plain is a northeast-trending structural basin about 320 km long and 80 to 110 km wide. The plain is underlain by a layered sequence of basaltic lava flows and cinder beds interbedded with eolian, fluvial, and lacustrine sedimentary deposits. The thickness of specific flows generally ranges from 3 to 15 m, and the average thickness may be from 6 to 7.5 m (Mundorff and others, 1964, p.143). The sedimentary deposits consist mainly of beds of sand, silt, clay, and lesser amounts of gravel. Locally, rhyolitic lava flows and tuffs are exposed at land surface or are present at depth. The basaltic lava flows and interbedded sedimentary deposits combine to form the Snake River Plain aquifer, which is the main source of water on the plain.

Ground-water movement in the Eastern Snake River Plain aquifer is from the northeast to the southwest. Recharge to the Snake River Plain aquifer is principally from ground-water inflow from the alluvium of adjoining mountain drainage basins, from infiltration of applied irrigation water, and infiltration of stream flow (Garabedian, 1992; Goodell, 1988; Lindholm, 1996). Some recharge may be from direct precipitation, although the small annual precipitation on the plain (20 cm at INEEL), evapotranspiration, and the great depth to water (in places, exceeding 275 m) probably minimize this source of recharge (Rightmire and Lewis, 1987; Bartholomay and others, 1997, p.18).

The Big Lost River drains more than 3,600 km^2 of mountainous area that includes parts of the Lost River Range and the Pioneer Range west of INEEL (fig. 1). Flow in the Big Lost River infiltrates to the Snake River Plain aquifer along its channel and at sinks and playas. Since 1958, excess runoff has been diverted to spreading areas in the southwestern part of the INEEL, where much of the water rapidly infiltrates to the aquifer. Other surface drainages that

provide recharge to the Snake River Plain aquifer at INEEL includes Birch Creek, the Little Lost River, and Camas Creek (fig.1) (Brennan and others, 1996; Harenberg and others,1993).

Water in the Snake River Plain aquifer moves principally through fractures and interflow zones in the basalt. An appreciable proportion of the ground water moves through the upper 60 to 245 m of basaltic rocks (Mann, 1986, p. 21). Ackerman (1991, p. 30) reported a range of transmissivity of basalt in the upper part of aquifer from about 0.3 to 70,000 m^2/d. The hydraulic conductivity of underlying rocks is several orders of magnitude smaller (Mann, 1986, p. 21). The effective base of the Snake River Plain aquifer at INEEL probably ranges from about 250 to 535 m below land surface (Anderson and other, 1996, p. 23).

At INEEL, depth to water in wells completed in the Snake River Plain aquifer ranges from 60 m at the northern part near the boundary of the Snake River Plain aquifer to more than 275 m in the southern part. The direction of ground-water flow within the aquifer is mainly southward and southwestward at an average hydraulic gradient of about 0.7 m/km. Ground water moves southwestward from INEEL and eventually discharges to springs along the Snake River downstream from Twin Falls, about 160 km southwest of the INEEL (Robertson and others, 1974).

Acknowledgments

The authors are grateful to Daniel J. Phelan, Michael W. Doughten, and Brennon R. Orr of the U.S. Geological Survey for technical review of the manuscript.

METHODS OF STUDY

The procedures used to collect ground-water samples and the analytical methods for chlorofluorocarbons and other volatile halocarbons, sulfur hexafluoride, and dissolved permanent gases are complex and therefore each procedure will be discussed separately in this report.

Samples were collected from 95 locations (figs. 2-3); 75 ground-water monitoring wells; 7 domestic or stock wells; 6 production wells; 2 public supply wells; 2 irrigation wells; and 3 springs. The production wells, irrigation wells, and the Arco City Well #2 were equipped with dedicated turbine pumps. The ground-water monitoring wells, domestic wells, stock wells, and the Atomic City well were equipped with dedicated submersible pumps. Data on the pumping rate, hole diameter, well depth, depth of intake, intake diameter, material of intake, perforation or open hole intervals, and the water level at the date of sampling are given in table 1.

Samples were collected from a portable sampling apparatus from the monitoring wells and from sampling ports or spigots on other wells. All portable equipment was decontaminated after each sample. Samples were collected at each site after three well-bore volumes of water were purged and measurements of pH, specific conductance, and water temperature were stable. Conditions at the sampling site during sample collection were recorded in a fieldbook.

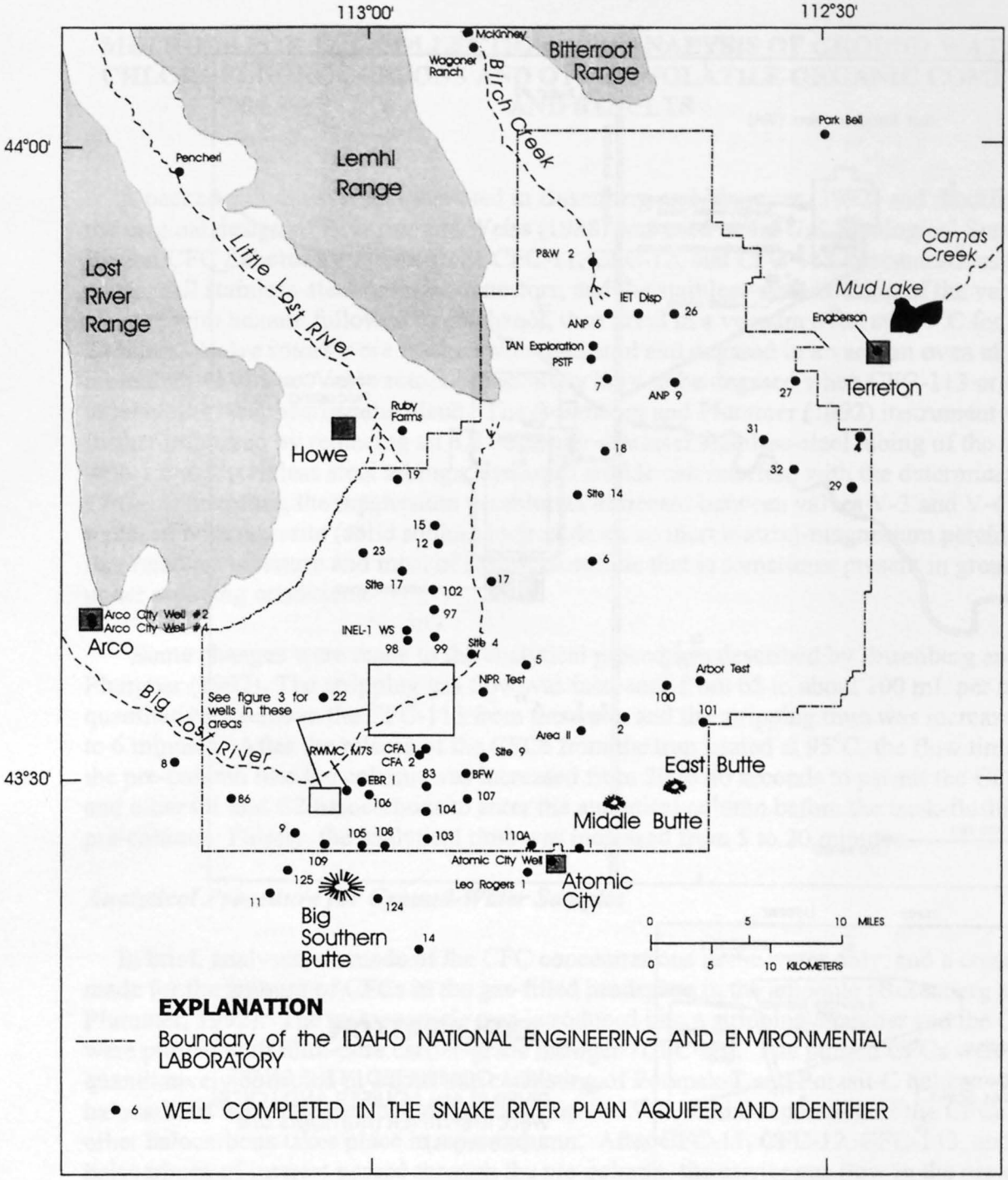

Figure 2. Location of wells sampled for chlorofluorocarbons and other constituents in and near the Idaho National Engineering and Environmental Laboratory.

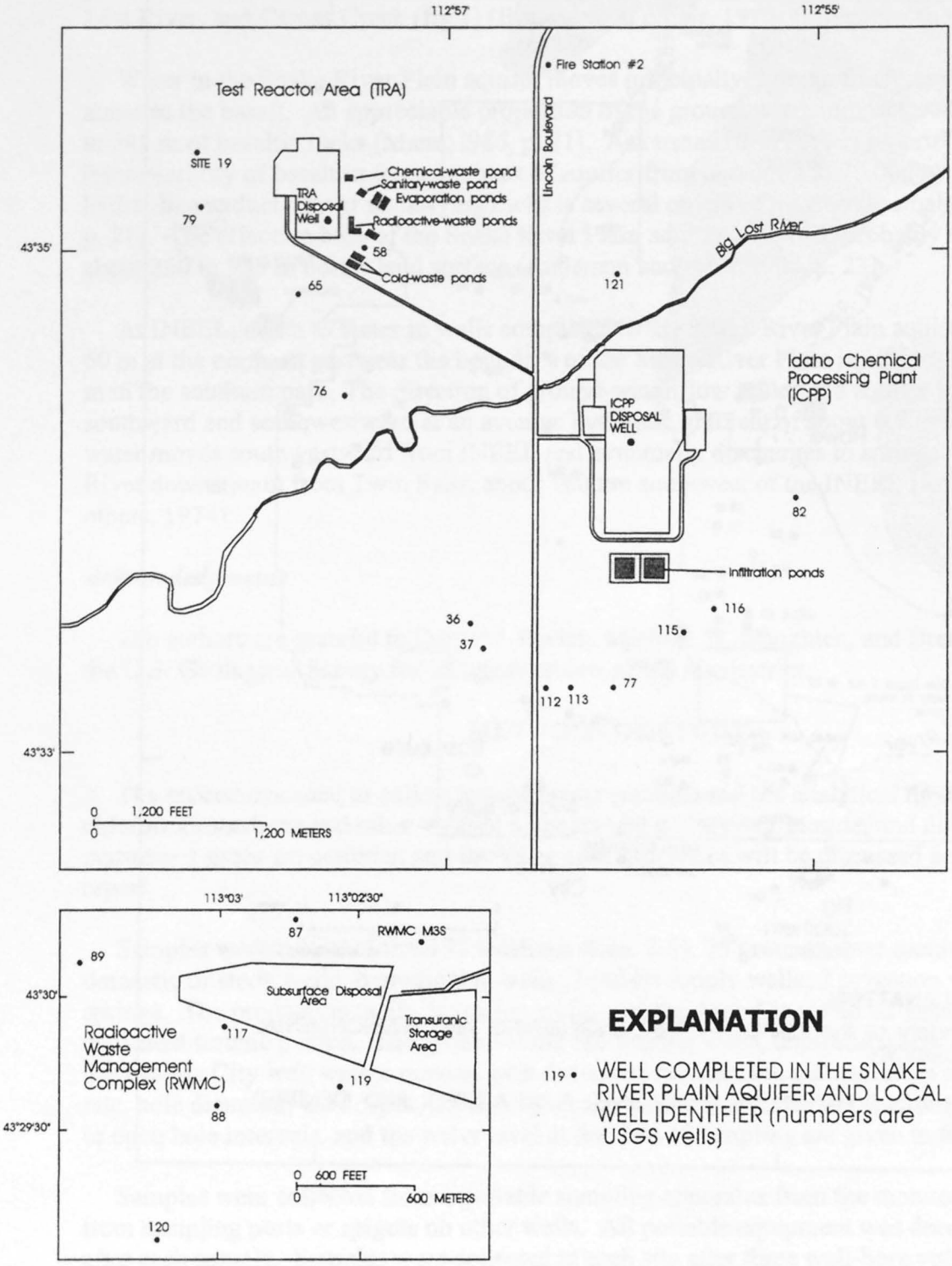

Figure 3. Location of wells sampled for chlorofluorocarbons and other constituents, Test Reactor Area, Idaho Chemical Processing Plant, and Radioactive Waste Management Complex in the Idaho National Engineering and Environmental Laboratory.

METHODS FOR THE COLLECTION AND ANALYSIS OF GROUND WATER FOR CHLOROFLUOROCARBONS AND OTHER VOLATILE ORGANIC COMPOUNDS AND RESULTS

A packed column system illustrated in Busenberg and Plummer (1992) and modified from the original design of Bullister and Weiss (1988) was used at the U.S. Geological Survey Reston CFC Laboratory to determine CFC-11, CFC-12, and CFC-113 concentrations in ground water. All stainless-steel tubing, connectors, and the stainless-steel housing of the valves were cleaned with hexane followed by methanol, then dried in a vacuum oven at 250°C for at least 24 hours. Valve rotors were washed with methanol and degased in a vacuum oven at 170°C for more than 48 hours. Valve rotors occasionally have to be degased when CFC-113 or carbon tetrachloride reappears in the blank. The Busenberg and Plummer (1992) instrument was further improved by replacing all 3.2 mm outer-diameter stainless-steel tubing of the apparatus with 1.6 mm stainless steel tubing. Hydrogen sulfide can interfere with the determination of CFC-11; therefore, the magnesium perchlorate desiccant between valves V-3 and V-4 was replaced with Ascarite (solid sodium hydroxide on an inert matrix)-magnesium perchlorate trap that removes moisture and most of hydrogen sulfide that is sometimes present in ground water under reducing conditions.

Some changes were made to the analytical procedures described by Busenberg and Plummer (1992). The stripping gas flow was increased from 65 to about 100 mL per minute to quantitatively remove the CFC-113 from the water and the stripping time was increased from 4 to 6 minutes. After the release of the CFCs from the trap heated at 95°C, the flow time through the pre-column into the column was increased from 30 to 40 seconds to permit the CFC-113 and other C1 and C2 halocarbons to enter the analytical column before the back-flushing of the pre-column. Finally, the analytical time was increased from 5 to 20 minutes.

Analytical Procedure for Ground-Water Samples

In brief, analyses are made of the CFC concentrations in the water only, and a correction made for the amount of CFCs in the gas-filled headspace in the ampoule (Busenberg and Plummer, 1992). The water sample was introduced into a stripping chamber and the CFCs were purged with ultra-pure carrier-grade nitrogen (UPC N_2). The purged CFCs were quantitatively collected in a cold trap consisting of Porapak-T and Porasil-C held at –30°C. The halocarbons were released by heating this trap to 95°C. Initial separation of the CFCs from other halocarbons takes place in a pre-column. After CFC-11, CFC-12, CFC-113, and other halocarbons of interest passed through the pre-column, the carrier gas flow in the pre-column was reversed through valves V-6 and V-7. This procedure prevented other CFCs and halocarbons with higher retention times from entering the analytical column, back-flushed the pre-column and, thus, appreciably decreased the analysis time. The concentrations of the CFCs were measured with an electron capture detector (ECD). The concentrations of CFC-11, CFC-12, and CFC-1113 in the aquifer water were calculated from the concentrations in the water sample, the water-sample temperature, the volumes of water, and headspace in the ampoules (Busenberg and Plummer, 1992; Warner and Weiss, 1988; Bu and Warner, 1995).

Calibration of the Chlorofluorocarbon Analytical System

Gas and water blanks were used extensively. The gas blanks of carrier or stripping gas were passed through the gas-sampling loops into the cold trap. The purpose of this procedure was to determine the CFC-11, CFC-12 and CFC-113 blanks of the instrument. Usually, no CFC signals were obtained from the gases. If a small concentration of CFC-12 in the blank was observed, it was an indication that the molecular-sieve traps (MS13X), through which the UPC gases were further purified, needed to be regenerated. The trap was re-generated by heating at 200 to 250°C for 6 hours as specified by Bullister and Weiss (1988). Water blanks were produced by stripping hot water in a glass flask for 2 hours with UPC N_2. This nitrogen was purified by passing through an MS13X molecular-sieve trap. After the water was cooled, the water blank was introduced into the stripping cell of the analytical system and analyzed in the same manner as a regular sample. No CFC signals were normally observed from these water blanks.

The CFC-11, CFC-12 and CFC-113 primary standards are stainless-steel tanks that contain Oregon Standard Air with known concentrations of CFC-11, CFC-12 and CFC-113 (R. A. Rasmussen, Oregon Graduate Institute, written communication, 1988; 1991; 1993), and a tank purchased from National Oceanic and Atmospheric Administration (NOAA). The tanks were calibrated with primary gravimetric standards prepared by Ray Weiss at the Scripps Institute of Oceanography (Ray Weiss, Scripps Institute of Oceanography, written communication, 1995) and by NOAA. The concentrations of the CFCs are known to remain constant for many years in stainless-steel tanks that had their internal surfaces electropolished and passivated (Rasmussen and Khalil, 1983). Calibration curves for the CFCs were prepared by injecting six different volumes of the Oregon Standard Air through the gas-sampling loops into the instrument and then constructing calibration curves for CFC-11, CFC-12 and CFC-113 by the methods described by Bullister and Weiss (1988). Calibration of the gas-chromatograph system was done from standards run at the beginning and end of each day of analysis.

Precision and Accuracy of Measurements

Standard deviation of repeated measurements for this instrument are less than 2 percent for CFC-11, CFC-12, and about 3 percent for CFC-113. The detection limits are 1 pg/kg for CFC-113 and less than 1 pg/kg for CFC-11 and CFC-12. Precision was about 50 percent at the detection limit and about 3 percent above 25 pg/kg. Eight standards and a blank were used for calibration because the ECD response does not vary linearly with concentration. The calibration ranges of the gas chromatograph was 0 to 1200 pg/kg for CFC-11, 0-2500 pg/kg for CFC-12, and 0-900 pg/kg for CFC-113. Reported concentrations beyond the above calibration limits should be considered as estimates of concentrations of the three CFCs.

Results of Measurements

CFCs were measured in at least three of the 5 to 6 ampoules collected during sampling. In a few cases, only two ampoules were analyzed because all other ampoules were broken during

shipment. The results for the CFC-11 and CFC-12 concentrations for 1991 sampling at the INEEL are given in Busenberg and others (1993). Concentrations of CFC-11, CFC-12, and CFC-113, as well as the averages of all determinations and population standard deviations for the 1994 to 1996 sampling dates are given in table 2. Concentrations of all three halocarbons in the ground water ranged from 0 pg/kg to beyond the calibration range of the gas chromatograph (0 to 1,200, 0 to 2,500, and 0-900 pg/kg for CFC-11, CFC-12 and CFC-113, respectively).

Representative chromatograms are presented in appendix A. Compressed digital chromatograms are available from samples analyzed since 1994. The chromatograms can be decompressed using the DOS program CONVERT that also is included in the package. Each chromatogram consists of approximately 20,000 points. The procedures of converting the compressed files to ASCII files that can be reprocessed or plotted are given in appendix B. The condensed files can be converted to files of more manageable length for plotting by this program.

A procedure is described in appendix C for normalizing the retention times of the various halocarbons detected by the ECD. Normalized times should be used to attempt to identify other peaks in the chromatograms. Normalized retention times for a number of halocarbons also are given in appendix C. Retention times alone are not sufficient to determine of the presence of a given halocarbon, nevertheless, the data can be used to study temporal and spatial distribution of contaminants in the Snake River Plain aquifer.

METHODS FOR THE COLLECTION AND ANALYSIS OF GROUND WATER FOR SULFUR HEXAFLUORIDE AND RESULTS

Concentration of sulfur hexafluoride (SF_6) in the 1998 troposphere is about four parts per trillion by volume or approximately 30 times less than the concentration of CFC-113 and almost 200 times less than the concentration of CFC-12 in the atmosphere. An additional complicating factor in the analysis of SF_6 is its exceedingly low solubility in water. These two factors make it necessary to extract the tracer from a large volume of ground water prior to analysis. Three different extraction procedures for SF_6 were tested in the laboratory and under field conditions, and are detailed below.

Vacuum Extraction of Sulfur Hexafluoride from Ground Water

The apparatus for the vacuum extraction of SF_6 from ground water was similar to the system described by Law and others (1994) and Wanninkhof and Ledwell (1991). The apparatus consisted of a 1-liter glass vessel and various valves that controled the flow of gases, water, and the vacuum. First, a high vacuum was pulled in the 1-liter gas stripper. The vessel was isolated from the vacuum, then the water intake valve was opened. Water was sprayed through 6 nozzles into the stripping cell. After about 100 mL of water was added into the vessel, the valve was closed and the stripper was pressurized with SF_6-free N_2. The N_2 pressure expelled the water to waste. The stripper then was re-evacuated. One liter of water was sprayed into the vacuum extracting about 90 percent of the SF_6 from the water. N_2 was introduced at the bottom of the one-liter stripping chamber through a frit and the N_2 bubbled through the water removing the remaining 10 percent of the SF_6. The stripping gas and SF_6

were dried by passing through an Ascarite-magnesium perchlorate drier and the SF_6 retained in a Porapak-Q trap, which had been pre-cooled to -79°C with dry ice. After about 6 minute of stripping, the trap was sealed and removed. The SF_6 trap was replaced, the chamber emptied, and the apparatus was prepared for the next sample.

The vacuum stripping procedure was found to work very effectively in the laboratory. The necessary vacuum was produced in about 5 minutes in the laboratory; however, in the field at air temperatures of about 0°C, 30 to 60 minutes were required to pull the necessary vacuum. This technique was used to collect 8 ground-water samples from INEEL in late October 1994.

Headspace Gas Extraction of Sulfur Hexafluoride from Water

In oceanography, high concentrations of SF_6 are added to seawater and SF_6 is used as a tracer of ocean currents. Seawater is sampled with a glass syringe and a nitrogen headspace is added. The syringe is shaken, then the headspace gas injected into a gas chromatograph. The procedure is discussed in detail by Law and others (1994), and Wanninkhof and Ledwell (1991). A variation of this procedure was used in this study.

The natural levels of SF_6 are low and the tracer had to be extracted from 4 liters of water. The 4-liter bottle was filled with a tube inserted at the bottom of the container. After the bottle was filled, it was capped and connected up to a 3-way valve (Wanninkhof and Ledwell, 1991). A headspace of known volume was created by the addition of SF_6-free nitrogen. The water was shaken and equilibrated with the ground water. The headspace gas then was removed from the bottle and was flame sealed into glass ampoules for SF_6 analysis in the laboratory. The concentration of SF_6 in the ground water was calculated from the volume of the headspace, the volume of the water, and the temperature of the water in the bottle.

Direct Measurement of Ground Water

Water samples were collected without headspace in 1-liter bottles and returned to the laboratory for SF_6 analysis. The SF_6 was vacuum extracted, collected on a trap and then injected into the analytical system.

Analytical System for Sulfur Hexafluoride

The analytical system initially built to measure SF_6 was very similar to the instrument used by Law and others (1994), which is ideally suited for high concentration measurements onboard oceanographic vessels (Maiss and others, 1994; Wanninkhof and Ledwell, 1991). The analytical system consists of 1) a gas distribution system, 2) a sample introduction system, 3) gas loops and injection system, 4) a SF_6 trapping system, and 5) a chromatogaphic system. Each of these parts of the analytical system will be briefly discussed. It soon became obvious that the system was inadequate for the measurement of very low concentrations of SF_6 normally found in ground waters. The instrument was modified to allow the stripping of much larger volumes of water. The design of the gas distribution system was critical for obtaining good chromatograms from very small signals that are obtained from natural levels of SF_6. UPC N_2 was used through out the system. The carrier gas was purified with a charcoal and an oxygen

trap. The pressure of the gas was controlled with four ultra-clean pressure regulators and the flow adjusted by three needle valves. Additional pressure and flow regulation was provided by three dummy columns and a post-column. A flow controller was placed after the ECD to maintain constant carrier flow through the detector. All these measures prevented flow and pressure fluctuation during the switching of valves, which could have caused background drift and noise, a serious problem in other instruments (see fig. 4 in Watson and others, 1987). The sample introduction system consisted of a 4-position valve. This valve selected between two gas standards, air, and gas in glass ampoules for introduction into the sampling loops at ambient, sub-ambient, or greater than atmospheric pressures. All volumes in the gas-introduction system have been precisely measured and the pressures measured with a pressure transducer. The gas injection system consisted of three valves. The volumes of the loops ranged from 0.1 to 15 mL. The loops could be directly injected into the analytical column or the SF_6 could be trapped at –75°C on the Porapak-Q trap. A valve was used to isolate the trap. After the SF_6 was trapped, the trap was isolated and heated to 95°C, the valve was switched from the back-flush position to the run position, and the trap was opened. The SF_6 entered the analytical column and the chromatogaphy began. After the SF_6 was determined, the valve was switched to the back-flush position preventing the O_2 from entering the ECD.

Calibration and Sulfur Hexafluoride Standards

The instrument was calibrated using a blank, and 0.1, 0.3, 0.5, 0.6 cc of a 100 ppt Scott gas standard. The gas was directly injected into the analytical columns or was trapped on the Porapak-Q trap and then injected onto the column. Both procedures yielded identical results indicating 100-percent efficiency in the trapping of SF_6. The system also was calibrated by using a blank, and 5, 10, 15, 30, and 45 mL of a NOAA air standard. SF_6 in air standards was trapped prior to injection into the analytical column.

Precision and Accuracy of Measurements

Standard deviations of about 3 percent were routinely obtained for repeated measurements of standards. The calibration was linear through the entire measuring range. Standards were prepared by gravimetric procedures, accuracy was better than 5 percent. For water samples, precision was about 50 percent at the detection limit of 0.02 fmol/L and about 5 percent for concentrations greater than 0.1 fmol/L.

Results of Measurements

The concentration of SF_6 in ground water from INEEL and vicinity are given in table 3. The name of the wells, date of sampling, concentration of SF_6 in fmol/L, population standard deviations, number of replicate samples, volume of water from which the SF_6 was extracted, the extraction procedure used, and location where the extraction of SF_6 was performed are presented in table 3. Concentrations of SF_6 range from 0.00 to about 18 fmol/L. Most ground-water sampled in and near the INEEL contained less than 1 fmol/L.

METHODS FOR THE COLLECTION AND ANALYSIS OF GROUND WATER FOR NITROGEN, OXYGEN, ARGON, CARBON DIOXIDE, METHANE, AND RESULTS

The sampling apparatus for dissolved gases was illustrated and described in detail elsewhere (Hobba and others, 1977; Pearson and others, 1978). Briefly, the apparatus consisted of a water chamber and a sidearm that was evacuated before sampling. The 500-mL water chamber was connected to the well with flexible Tygon tubing. The upward flow of water from the well completely filled the water chamber and removed all the air. After the chamber was thoroughly flushed, it was sealed from the atmosphere. The water chamber was then opened to the evacuated 50-mL sidearm. The sampling apparatus was allowed to equilibrate for about 3 days at room temperature. The post-1995 samples for dissolved gases were collected in 150-mL bottles that were filled without headspace in the field. A 10-mL headspace was created in the laboratory by removing some of the water using a syringe-needle and a vacuum pump. The water was allowed to equilibrate with this headspace for about 3 days at room temperature before analysis.

The sampler then was connected to a gas-chromatographic system. The pressure within the headspace was measured with a pressure transducer. Some headspace gas then was injected into two different columns in the gas chromatograph. The CTR-III column (Altech) was used to separate the Ar, N_2, and O_2, and the CTR-I column to separate the CH_4 from the CO_2. The concentrations Ar, N_2, and O_2 were measured with a thermal conductivity detector (TCD). After the separation of CH_4, and CO_2 by the second column, the gas was passed through a methanizer to convert the CO_2 to CH_4, then the gas was passed through a flame ionization detector (FID). Concentrations of Ar, N_2, O_2, CO_2, and CH_4 in the ground water were calculated from the temperature, the headspace pressure, the volumes of water and headspace, and the gas law. The partial pressures of the gases in the ground water were calculated from the temperature using Henry's law (Wilhem and others, 1977; Weiss, 1970).

A blank, a NOAA air standard, and 4 certified gas mixtures obtained from Air Products were used to calibrate the dissolved-gas system. These gravimetric gas mixtures were standardized by gas chromatography and mass spectroscopy.

Precision and Accuracy of Measurements

Standard deviations of better than 3 percent were routinely obtained for repeated measurements of standards. The calibration was linear through the entire measuring range. Precision of about 3 percent can be obtained for the five gases if the samples are sterilized by the addition of mercuric chloride. Because the addition of mercuric chloride creates a disposal problem, mercury was not added to the INEEL samples and, thus, the concentrations of O_2 and CO_2 were not stabilized. Bacterial activity in the samples was reduced by placing the samples on ice in a cooler in the field. The samples were stored at 4°C prior to analysis. In spite of these measures, results indicate that O_2 concentrations decreased and CO_2 concentrations increased during storage at 4°C. CO_2 concentrations can easily and accurately be calculated from pH and alkalinity. Dissolved O_2 concentrations can be measured in the field with a

dissolved O_2 meter. The main reason for collecting the samples was to determine the concentrations of N_2 and Ar that can be used to calculate recharge temperature of the ground water (Busenberg and others, 1993). The concentration of Ar and N_2 gases remained unchanged during storage at 4°C.

In addition to the gas standards used to calibrate the dissolved gas system, three water standards equilibrated with air at temperatures of 8.9, 16.0 and 24.3°C were run daily. The concentrations of all gases were calculated using Henry's law (Wilhem and others, 1977; Weiss, 1970), the measured temperature, the measured barometric pressure, and the known composition of air. The average of the absolute difference between the observed and the calculated temperatures was 0.33°C. The standard deviation of the absolute difference was 0.27°C. Only 1.9 percent of the samples had temperature differences more than 1°C. The temperature difference never exceeded 2°C in the water standards.

Results of Measurements

The dissolved gas results for the 1991 samples are given in Busenberg and others (1993). The results of the more recent sampling are given in table 4. Included in the table are the well names, date of sampling, concentrations of CH_4, CO_2, N_2, O_2 and Ar, as well as the number of replicates analyzed. The O_2 and CO_2 concentrations in the ground water (in parenthesis to the nearest 0.5 mg/L) were estimated from the number of days of storage and the rates of change as a function of time. Rates of O_2 consumption and CO_2 production were calculated from changes in concentration of replicate ground water from INEEL stored for different periods of time. The rates obtained were applied to all ground water from INEEL. Because concentrations of O_2 decreased and CO_2 increased with storage time, the measured concentrations reported in table 4 are for the sample with the shortest storage time rather than the average concentration of replicates. Concentrations of CH_4, N_2, and Ar do not change with storage time; thus, averages of replicates are reported in table 4.

The concentrations ranged from 3.1 to 17, from 13.74 to more than 49, from 0 to 10, and from 0.526 to 1.17 mg/L for CO_2, N_2, O_2, and Ar, respectively. The highest concentrations of N_2 and Ar were observed in USGS 104 (table 4), a well with a hole in the intake tube. This hole allows some air to mix with the ground water. Concentrations of methane were below the detection limit of 0.0002 mg/L for most samples.

SUMMARY

This report presents concentrations of three chlorofluorocarbons, (CFC-11, CFC-12, and CFC-113), sulfur hexafluoride, and dissolved permanent gases in ground water at INEEL and vicinity. A total of 139 ground waters from 79 wells were sampled for CFCs. Concentrations for CFC-11, CFC-12 and CFC-113 are presented in table 2. Concentrations of all three halocarbons in the ground water ranged from 0 pg/kg to beyond the calibration range of the gas chromatograph (0 to 1,200, 0 to 2,500, and 0-900 pg/kg for CFC-11, CFC-12 and CFC-113, respectively). Chromatograms from 139 ground water samples are given in an appendix.

Sulfur hexafluoride concentrations were measured in 72 samples representing 51 wells completed in the Snake River Plain aquifer. Concentrations of SF_6 range from 0.00 to about 18 fmol/L, but most of the ground waters in and near the INEEL contained less than 1 fmol/L.

Dissolved permanent gases were measured in 89 ground waters from 75 wells in and near the INEEL, and 3 springs. The concentrations ranged from 3.1 to 17, from 13.7 to more than 49, from 0 to 10, and from 0.526 to 1.17 mg/L for CO_2, N_2, O_2, and Ar, respectively.

Compressed digital chromatograms are available for all samples analyzed since 1994. Representative compressed chromatograms for all 139 ground waters sampled in this study are available on two 3.5-inch high density computer disks. The data and the program required to decompress the data can be obtained from the U.S. Geological Survey office at Idaho Falls, Idaho.

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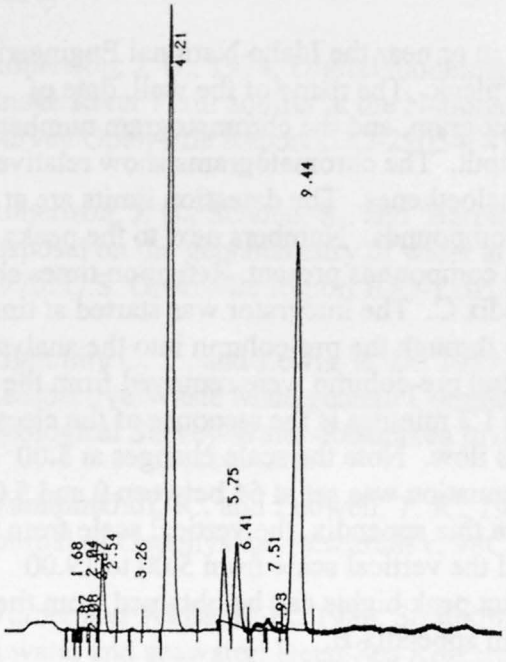
APPENDIX A

Chromatograms of 139 ground waters collected in or near the Idaho National Engineering and Environmental Laboratory, and the instrument blank. The name of the well, date of sampling, the name of the digital file of the chromatogram, and the chromatogram number for each ground water is given below the integrator output. The chromatograms show relative concentrations of halomethanes, haloethanes, and haloethenes. The detection limits are at parts per trillion to low parts per billion for the various compounds. Numbers next to the peaks represent retention times in minutes for the various compounds present. Retention times should be normalized by the procedure described in appendix C. The integrator was started at time 0.0, however the sample was injected from the trap through the pre-column into the analytical column at 0.50 minutes. At 1.30 minutes the trap and pre-column were removed from the carrier flow path. The broad peak between 0.5 and 1.3 minutes is the response of the electron capture detector to a small change in the carrier-gas flow. Note the scale changes at 5.00 minutes on the chromatograms. The integrator attenuation was set at 64 between 0 and 5.0 minutes and at 16 between 5.0 and 19.0 minutes. In this appendix, the vertical scale from 0 to 5.00 minutes is 1 centimeter equals 7 millivolts and the vertical scale from 5.00 to 19.00 minutes is 1 centimeter equals 1.66 millivolts. Exact peak hights can be obtained from the digitally reprocessed chromatograms as described in appendix B.



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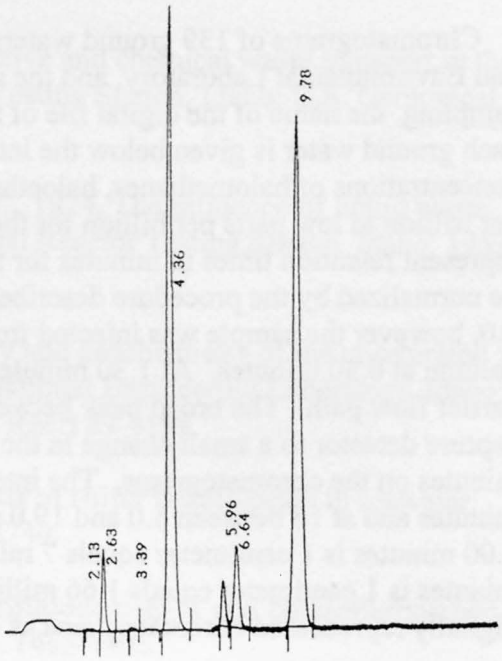

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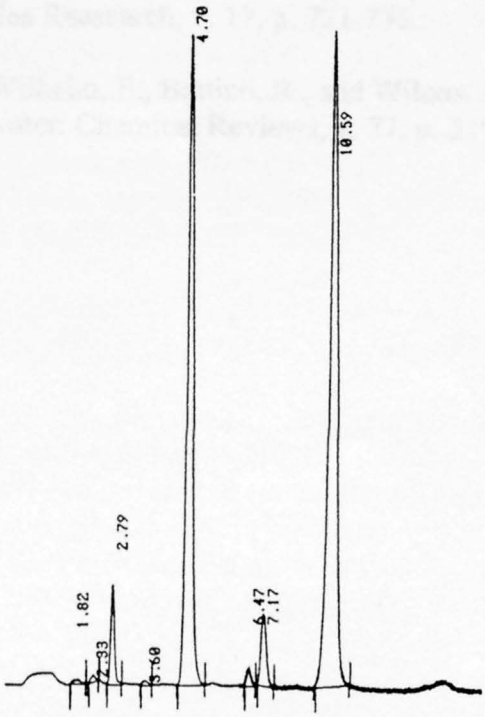

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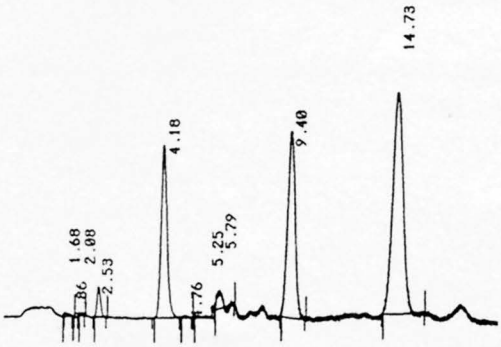

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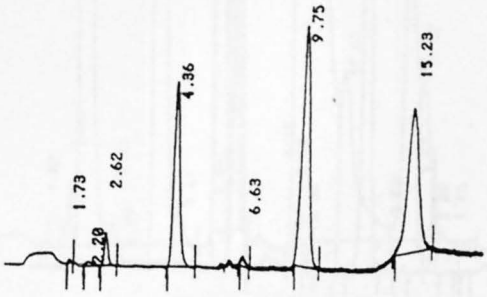

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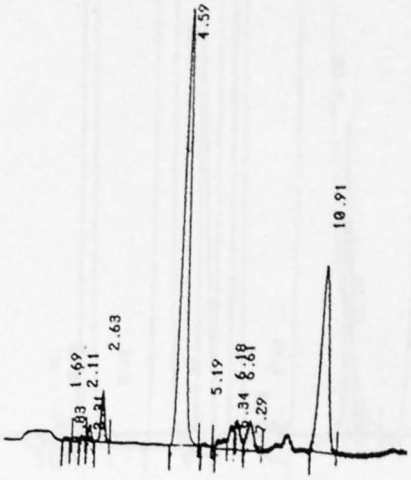

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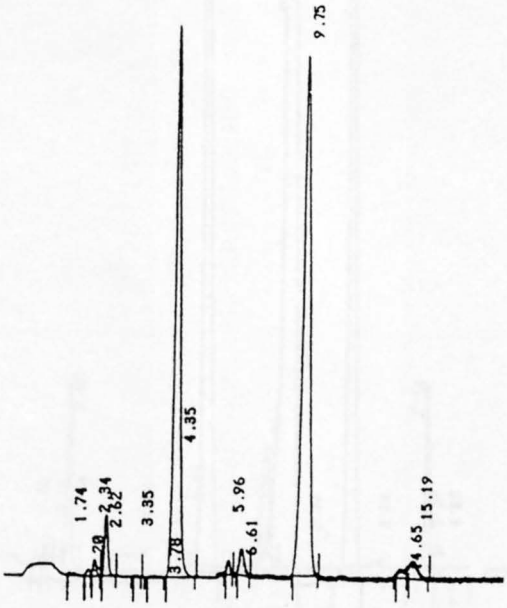

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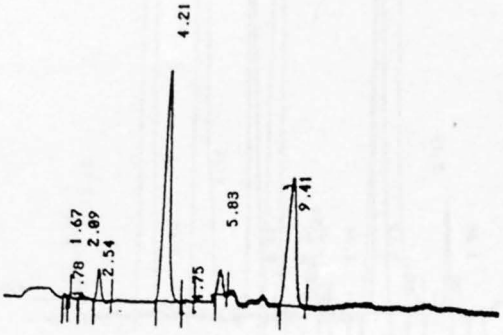

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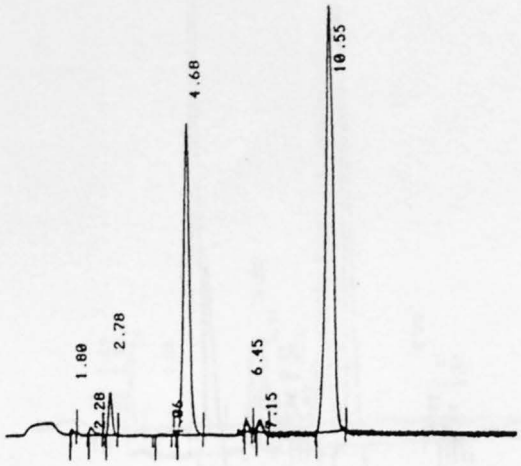

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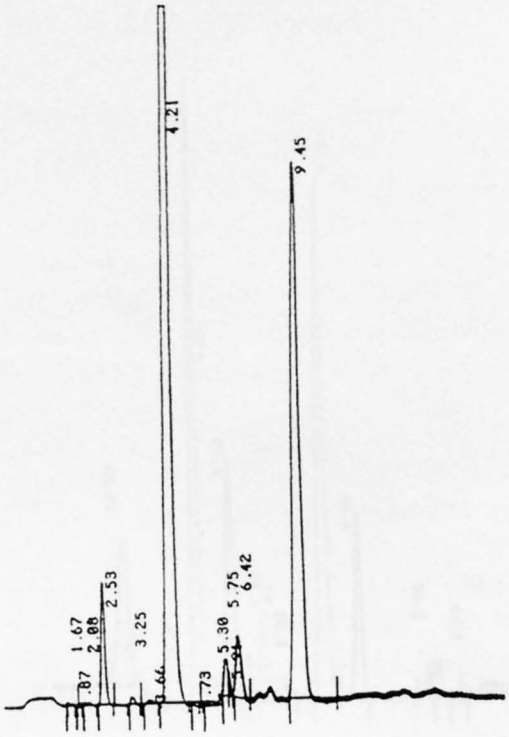

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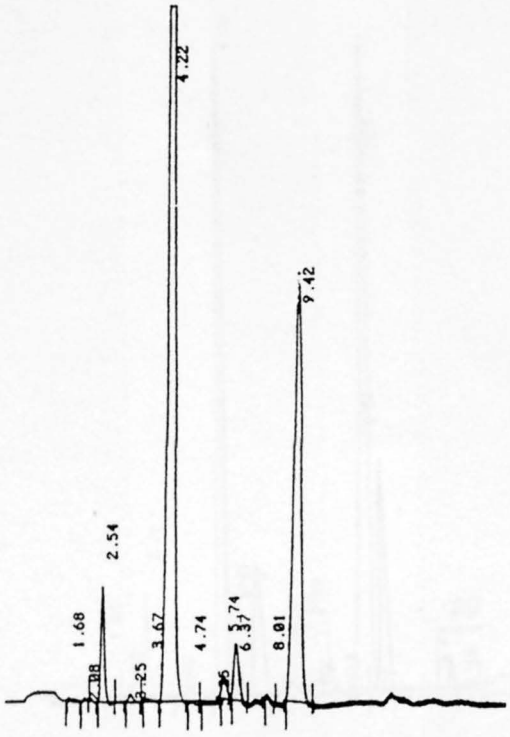

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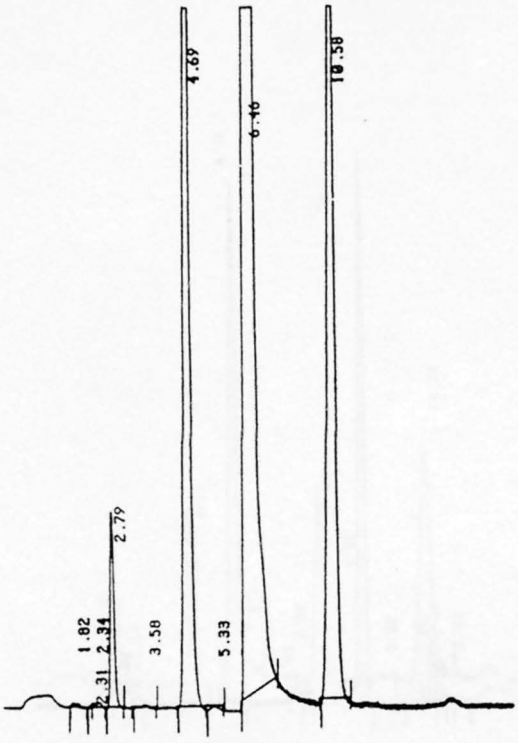

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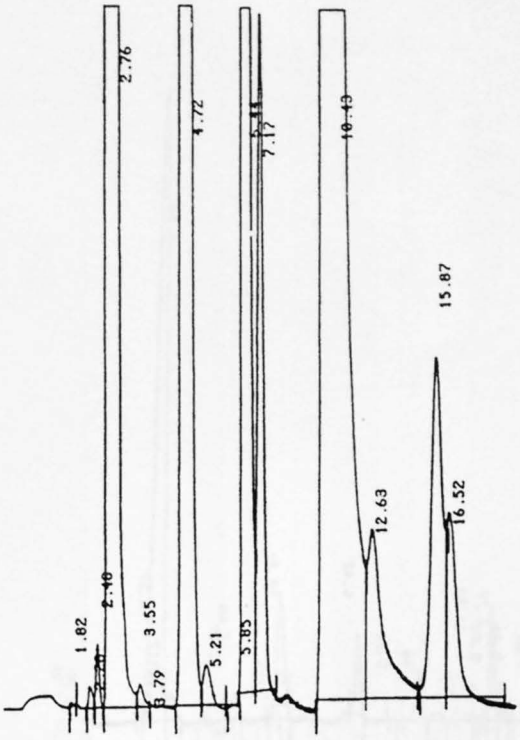

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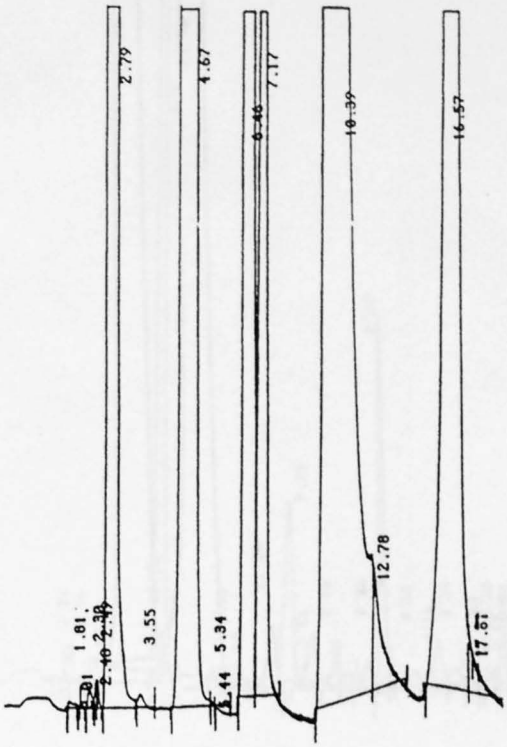

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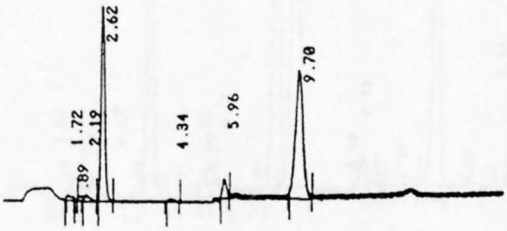

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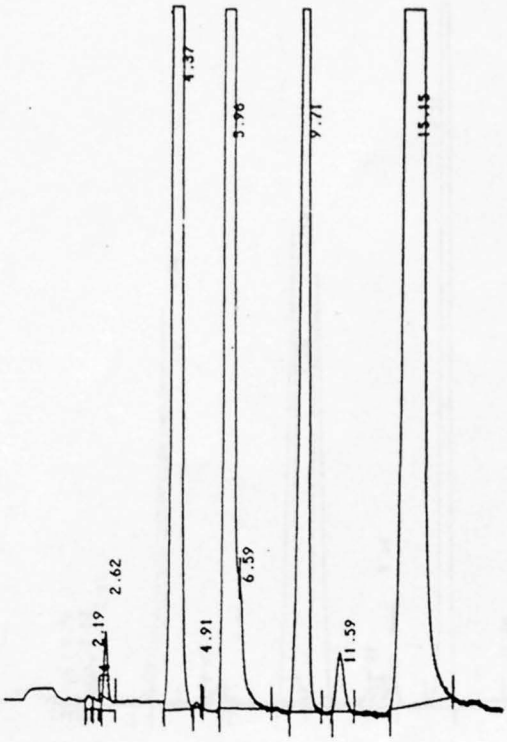

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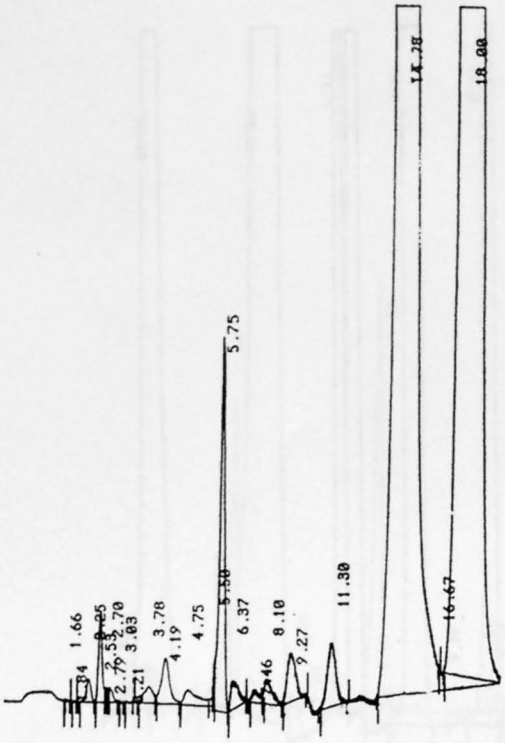

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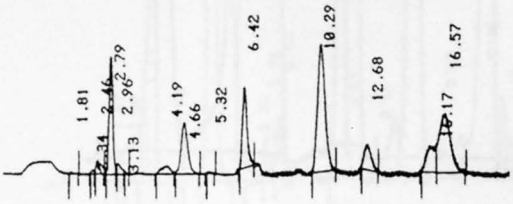

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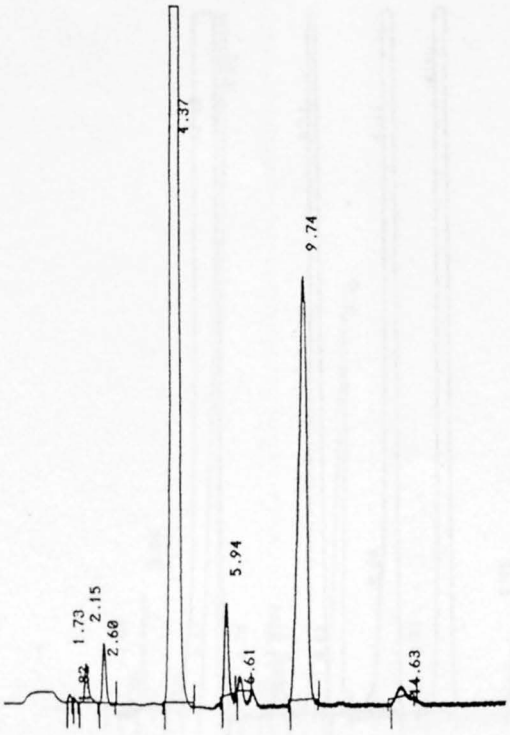

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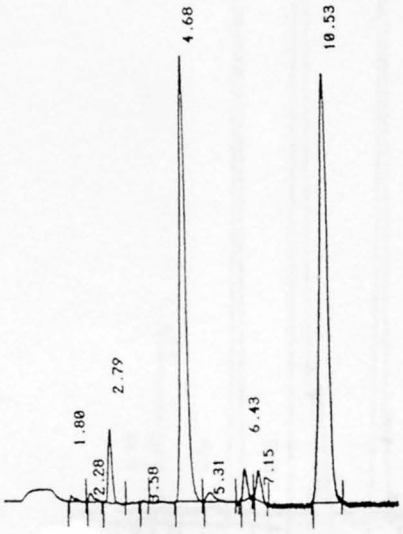

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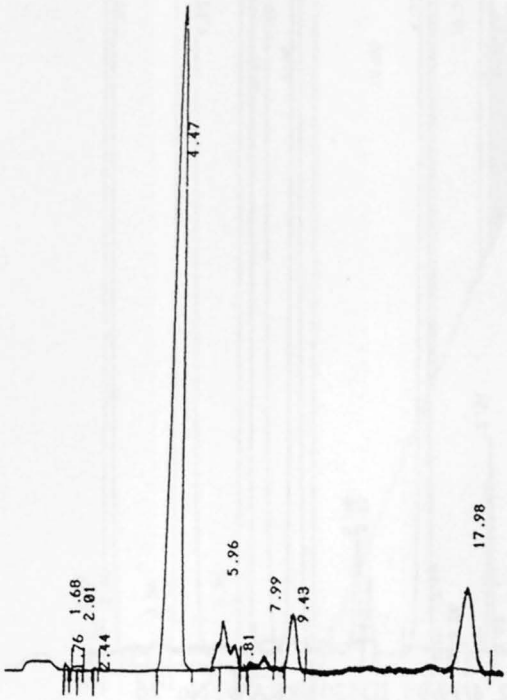

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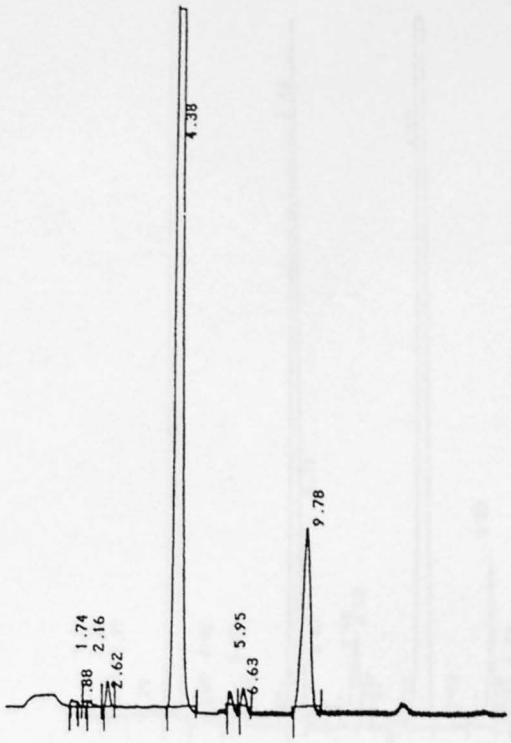

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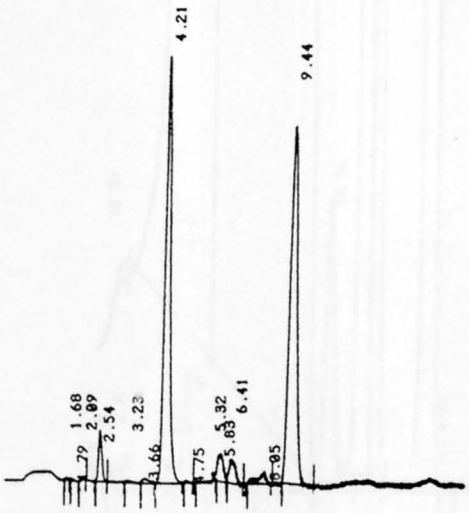

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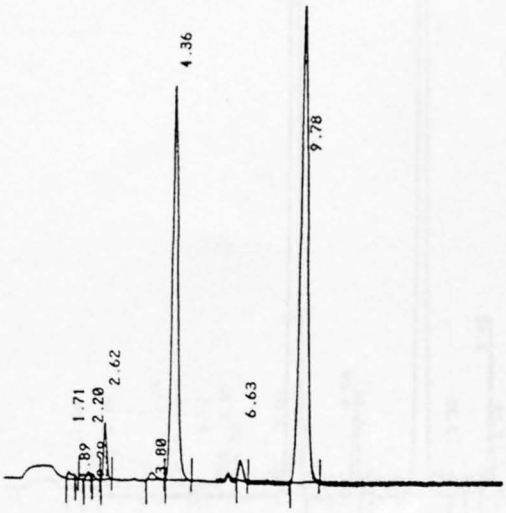

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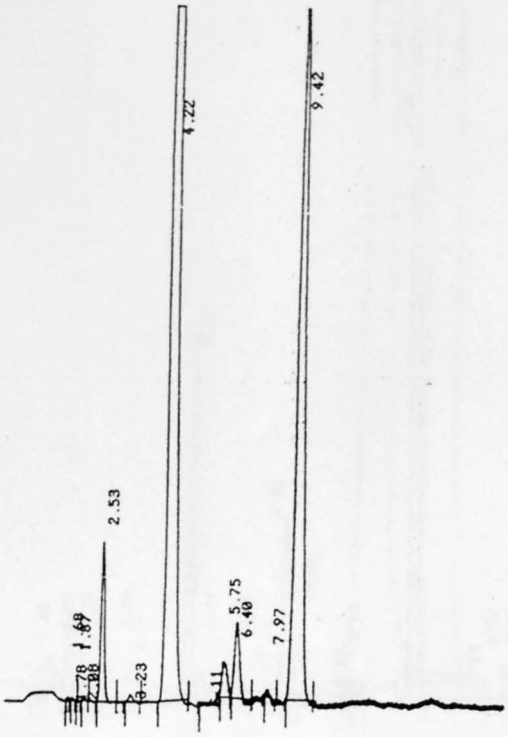

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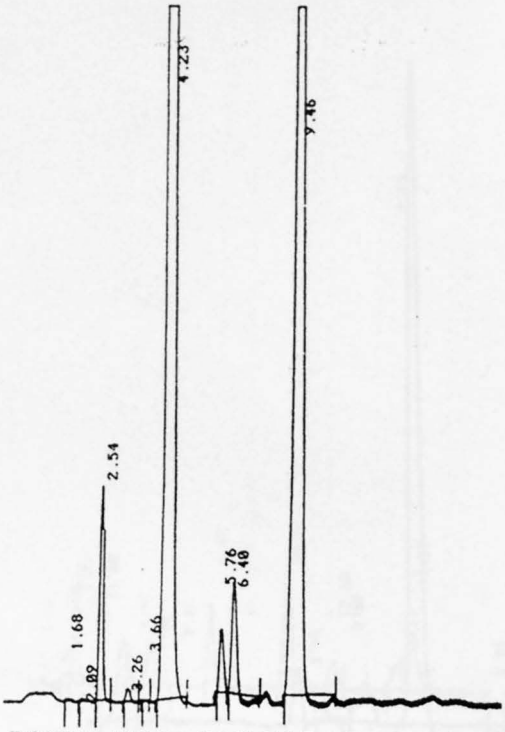

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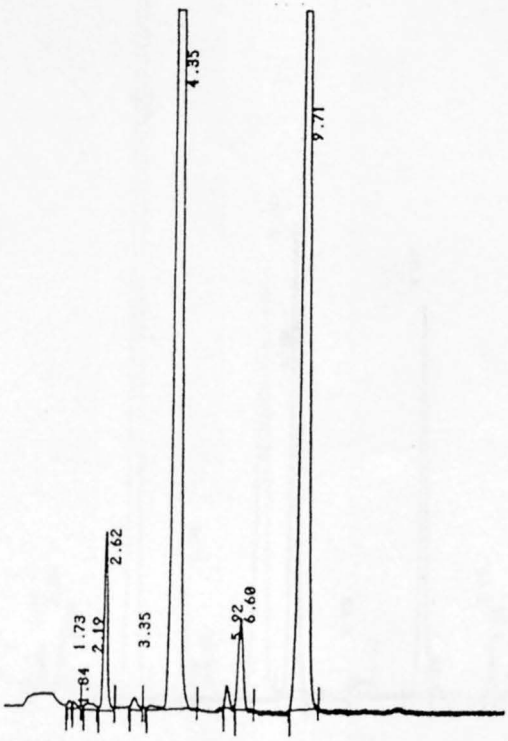

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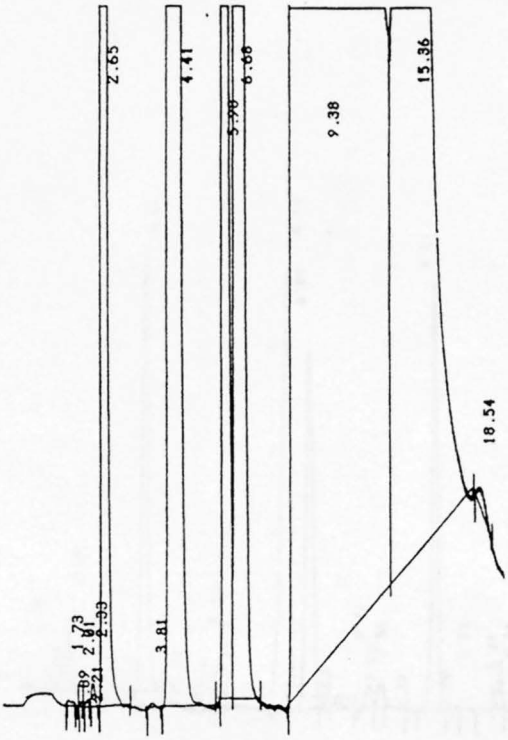

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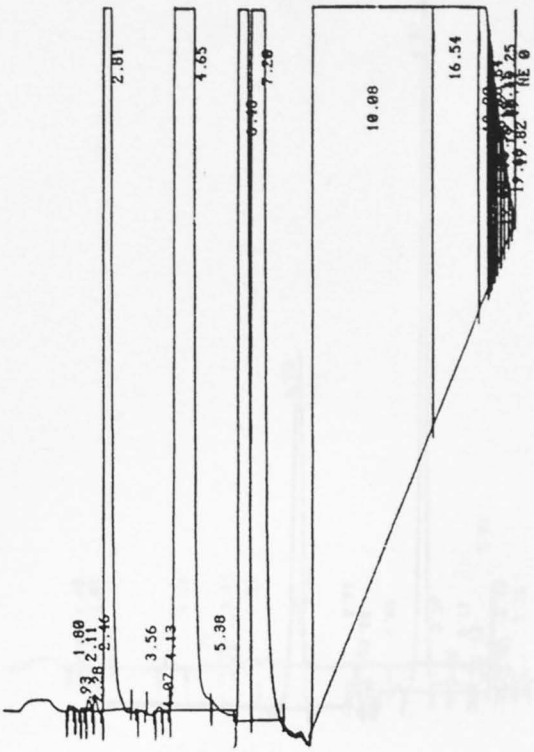

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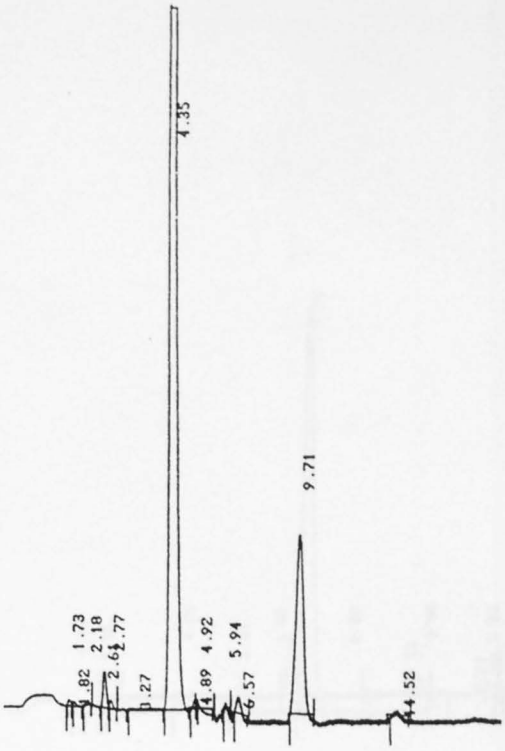

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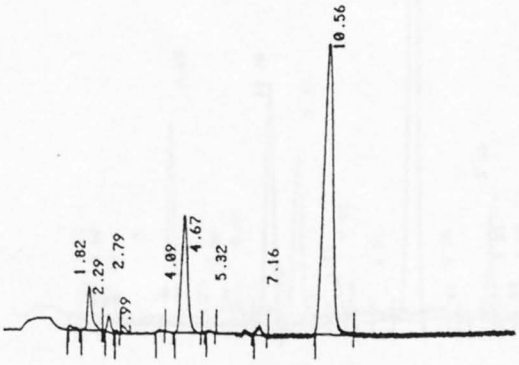

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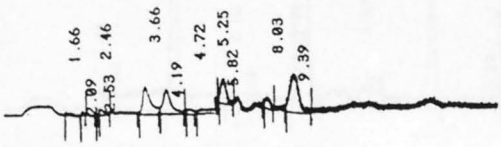

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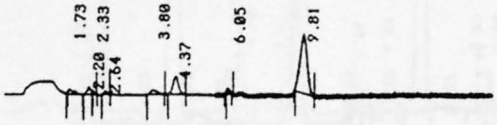

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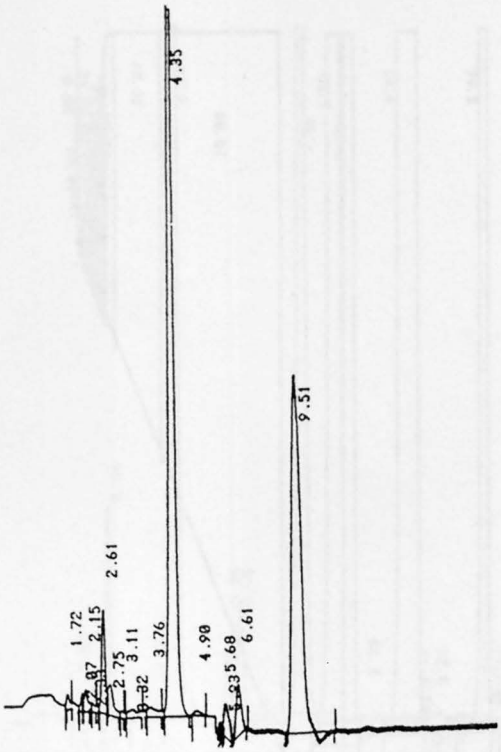

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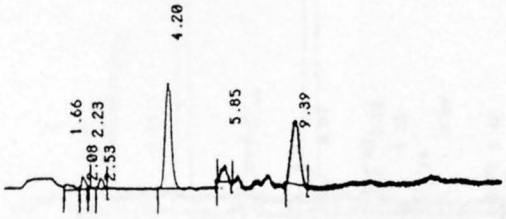

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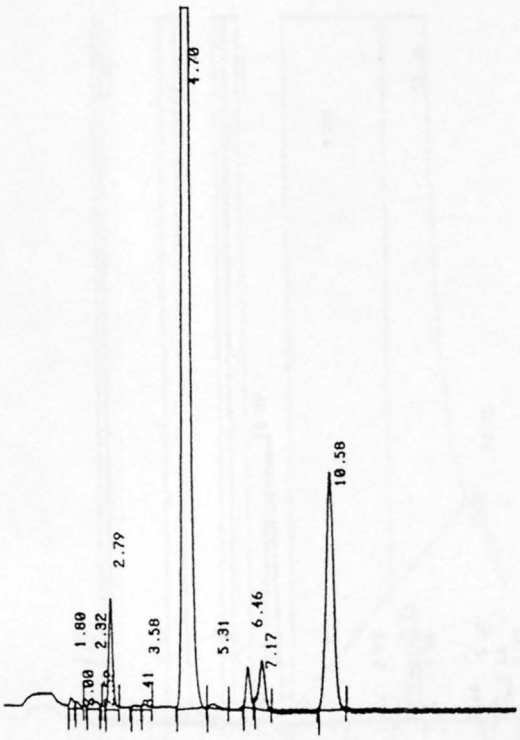

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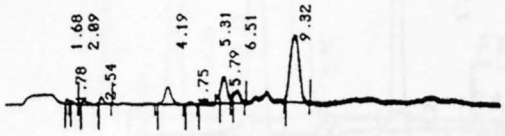

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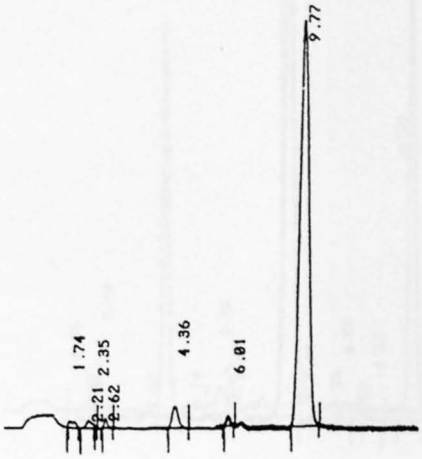

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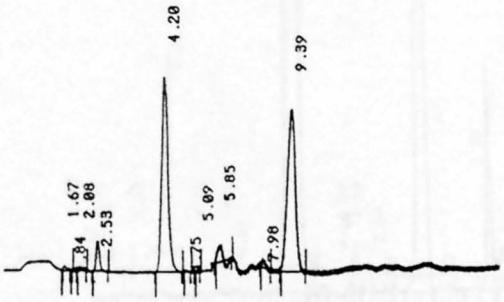

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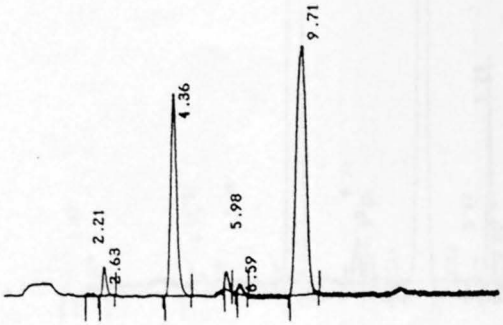

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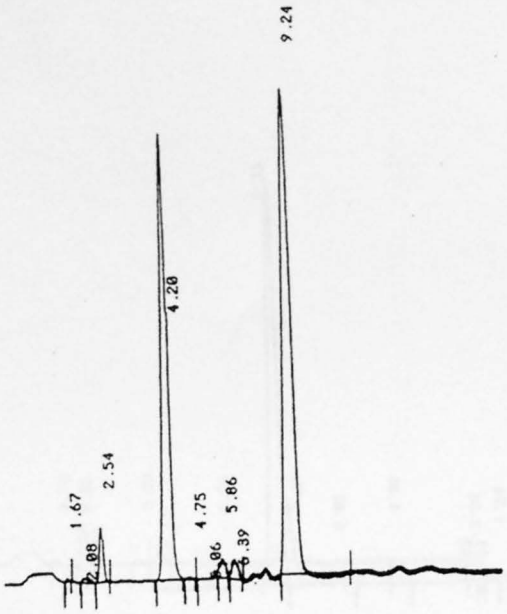

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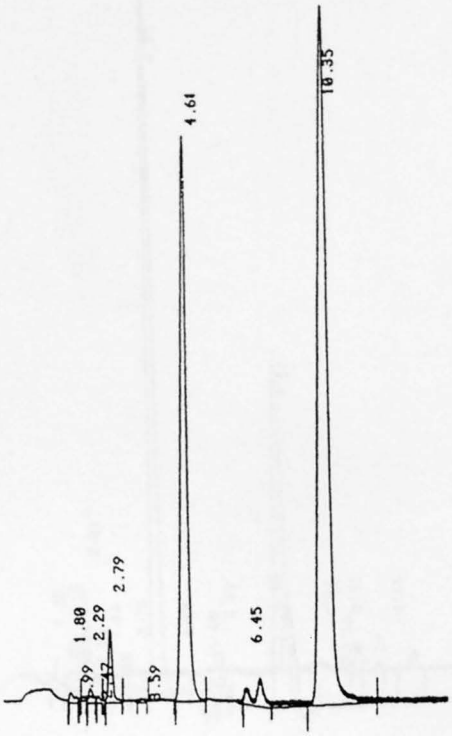

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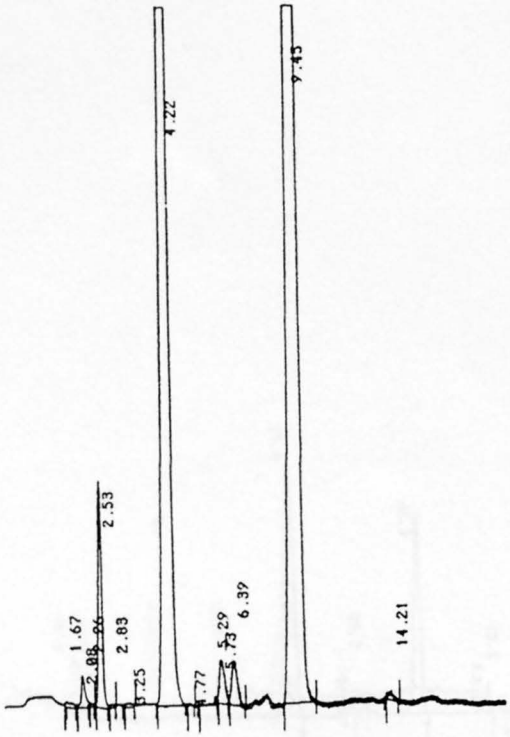

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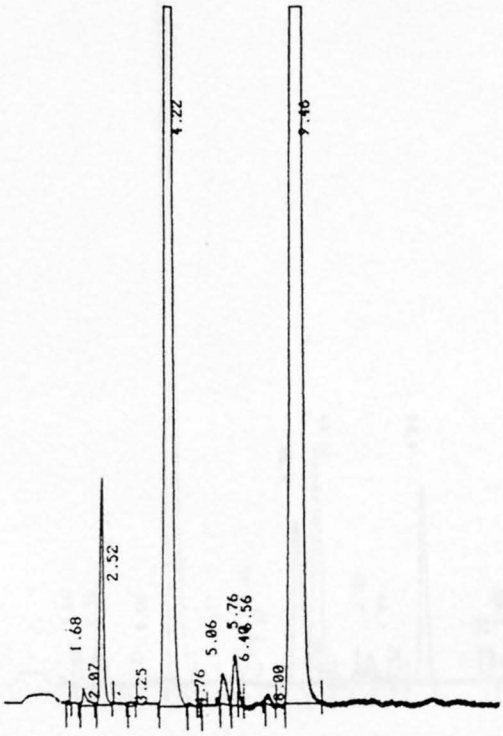

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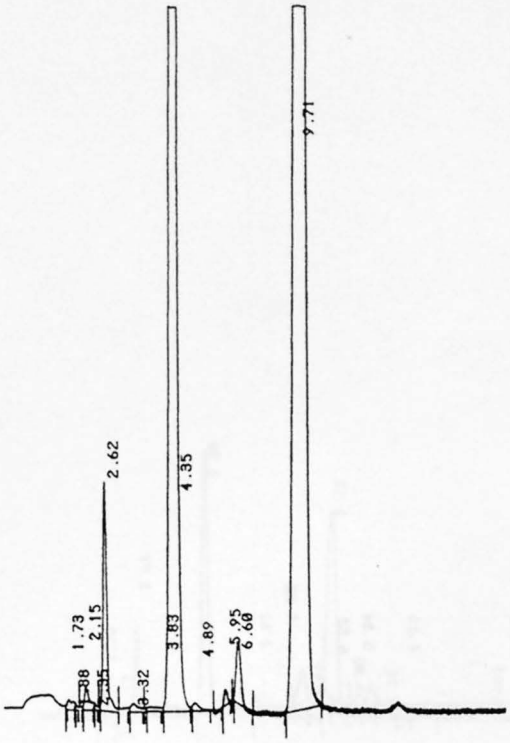

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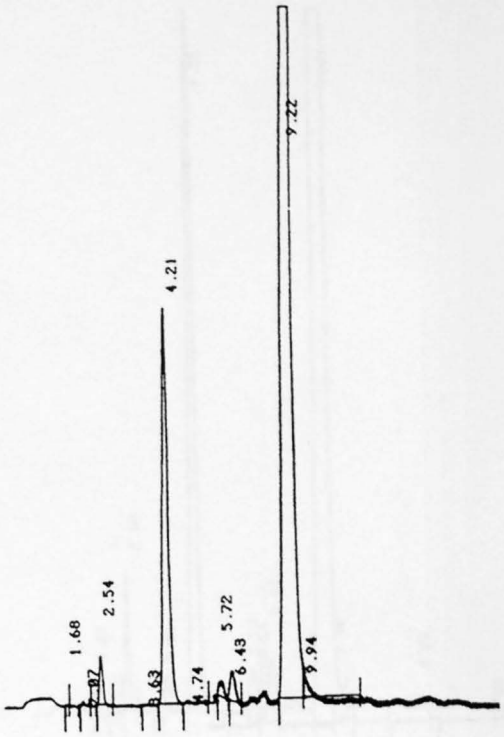

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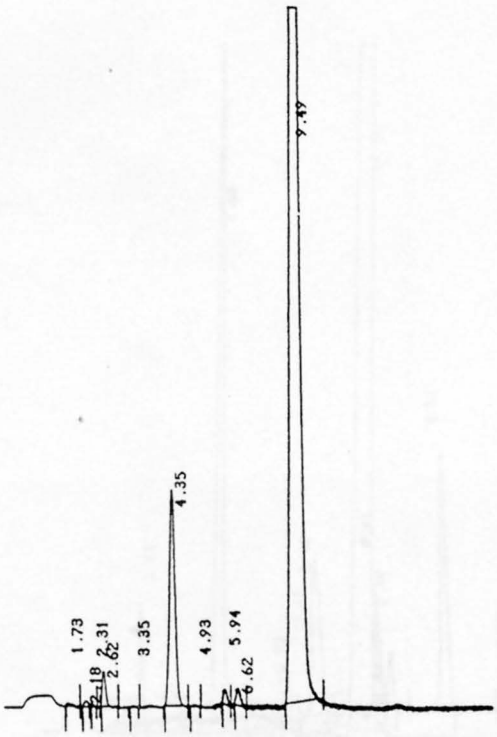

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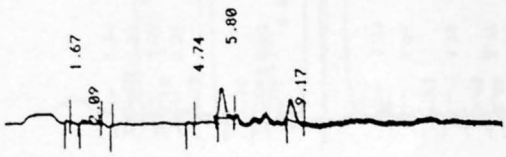

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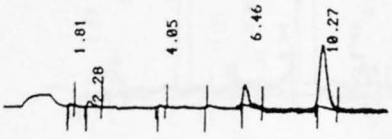

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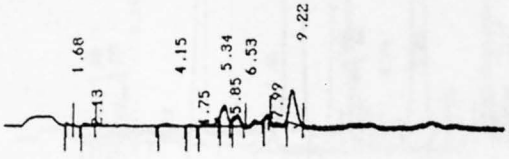

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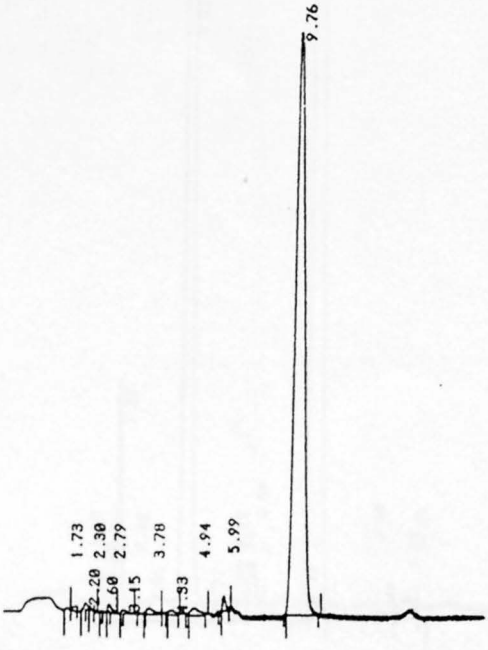

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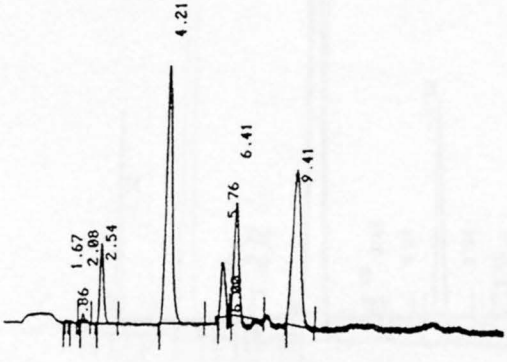

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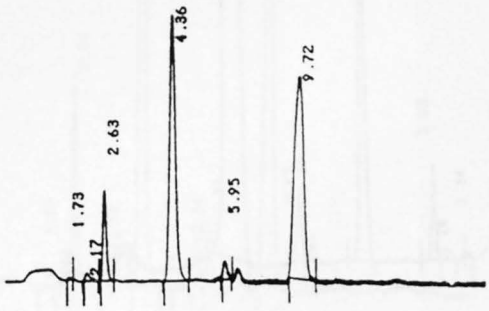

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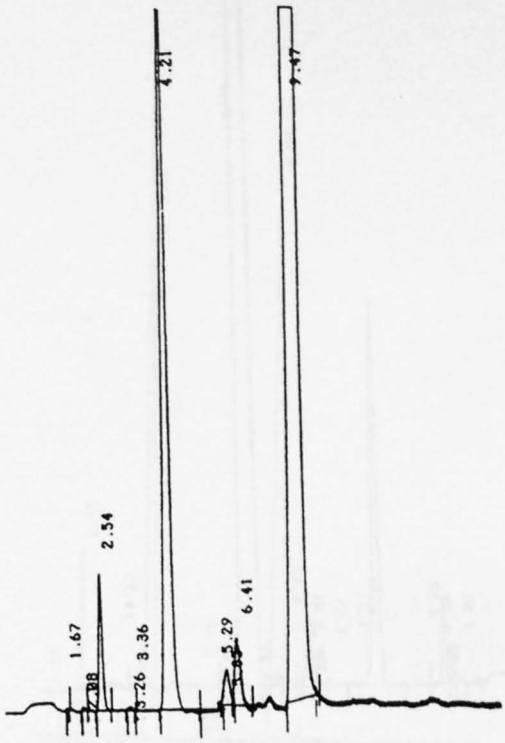

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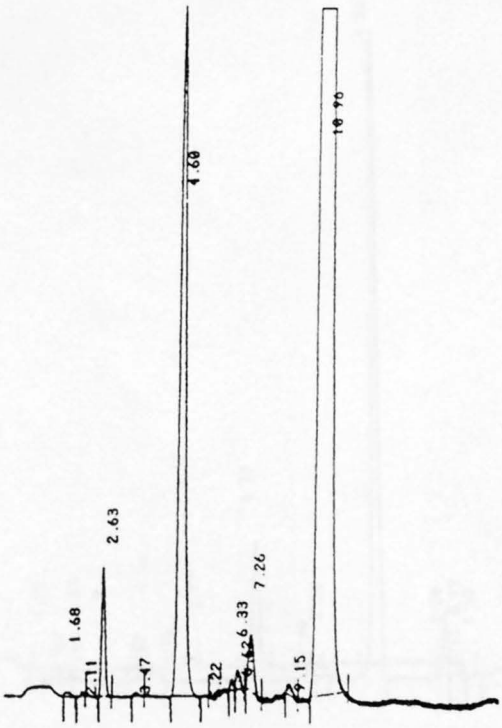

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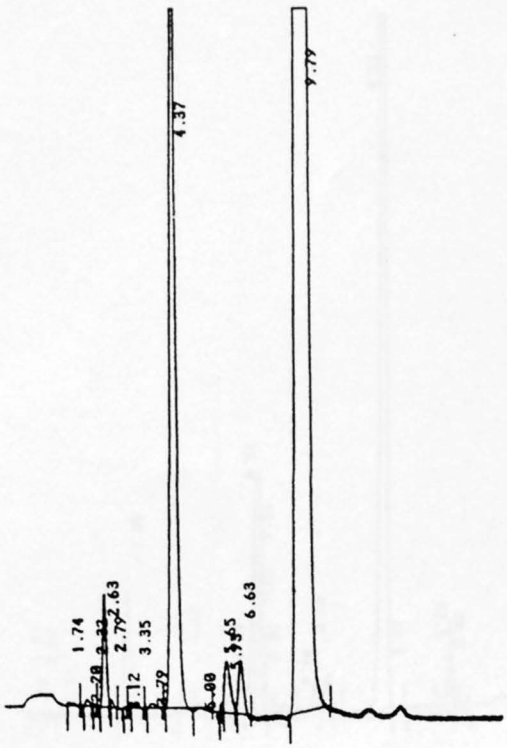

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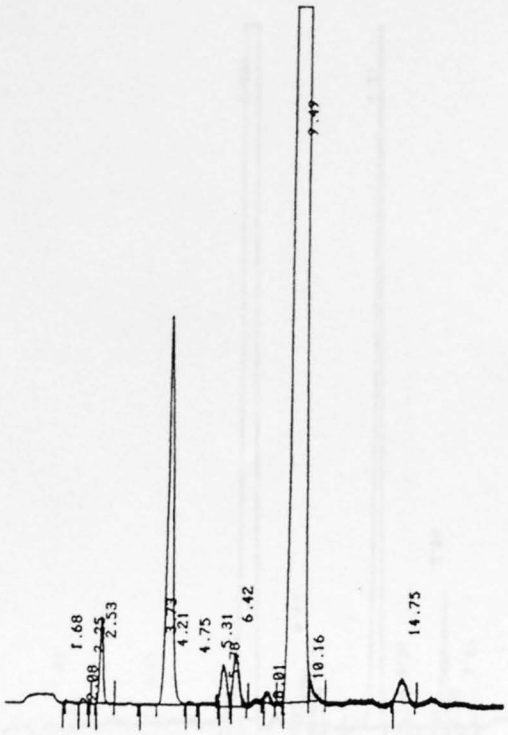

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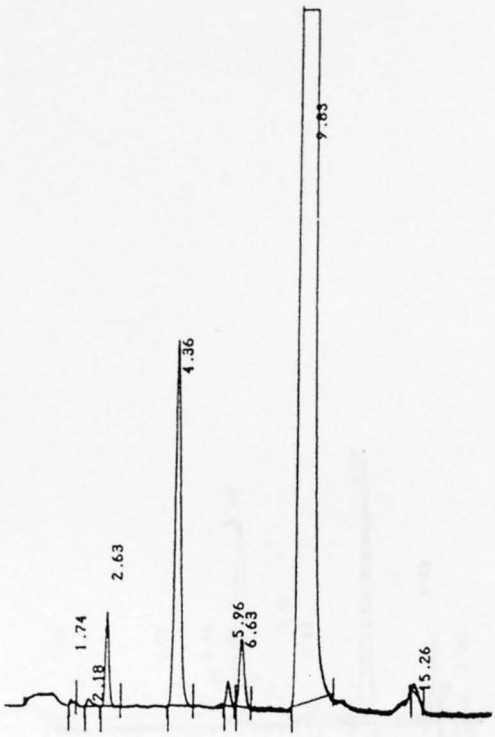

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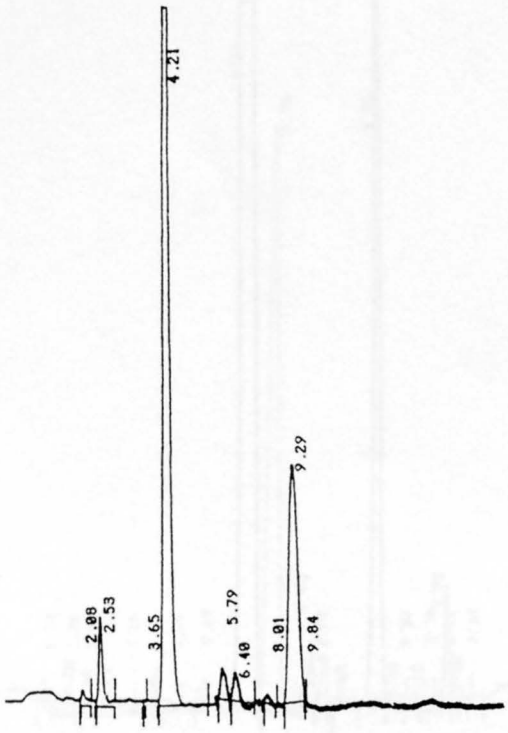

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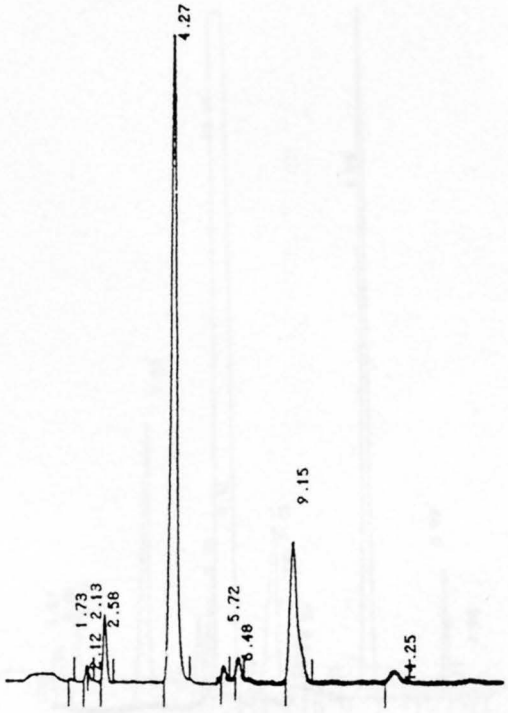

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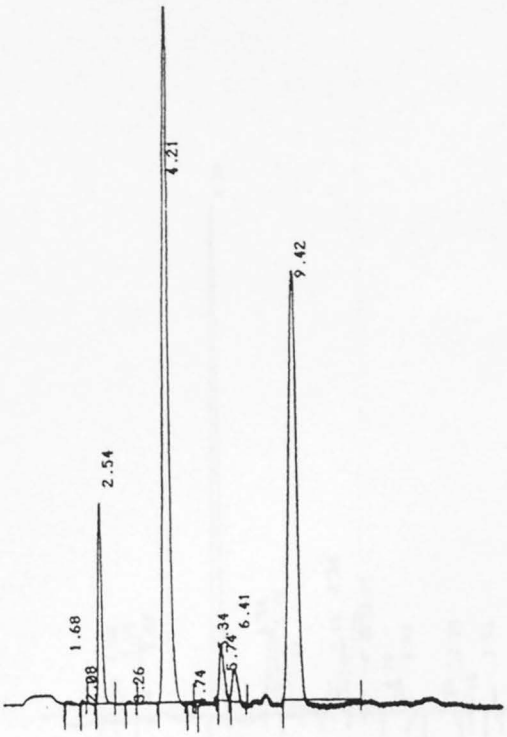

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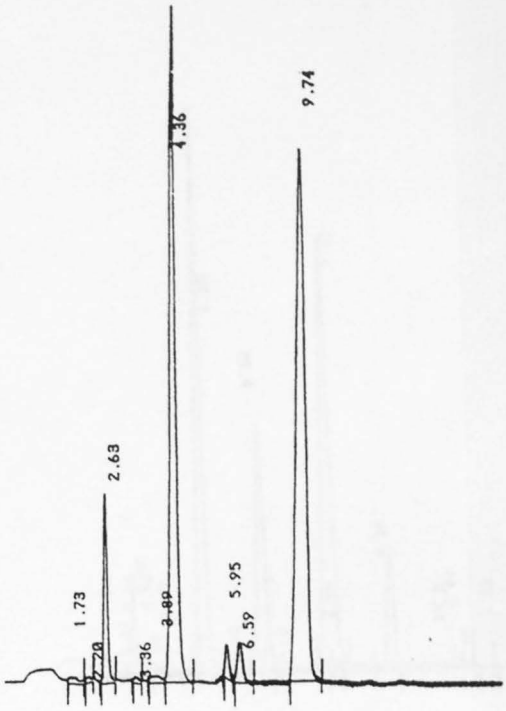

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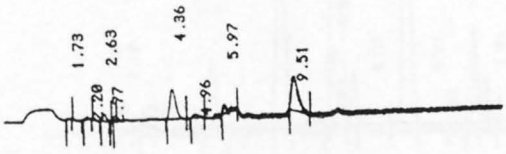

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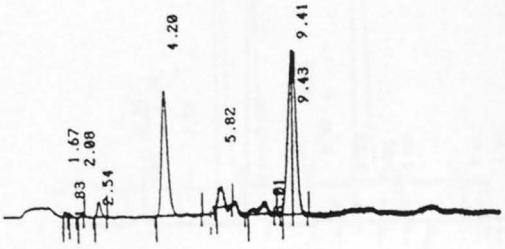

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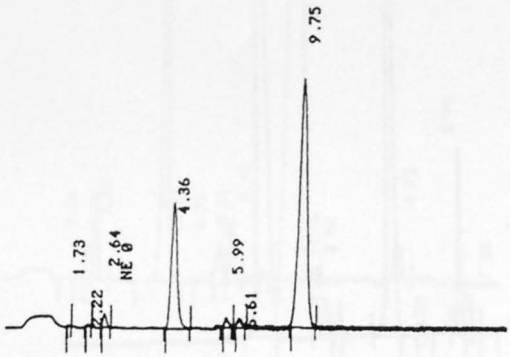

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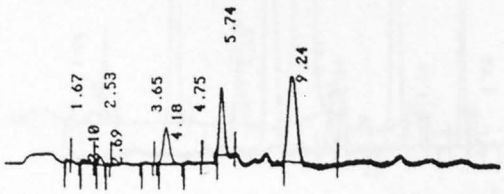

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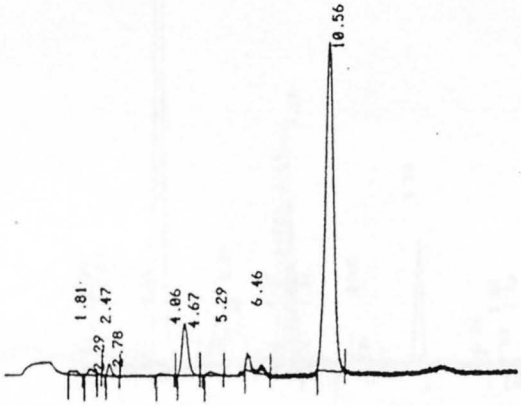

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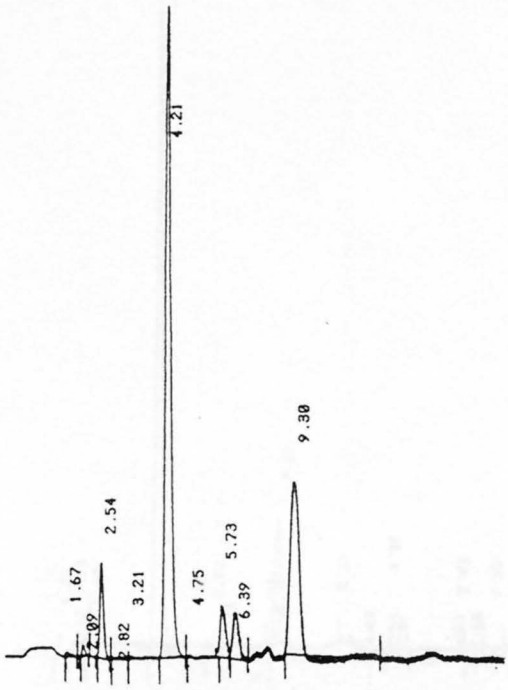

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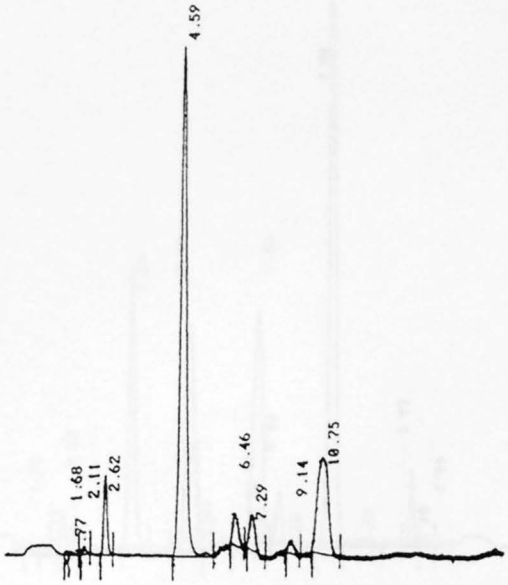

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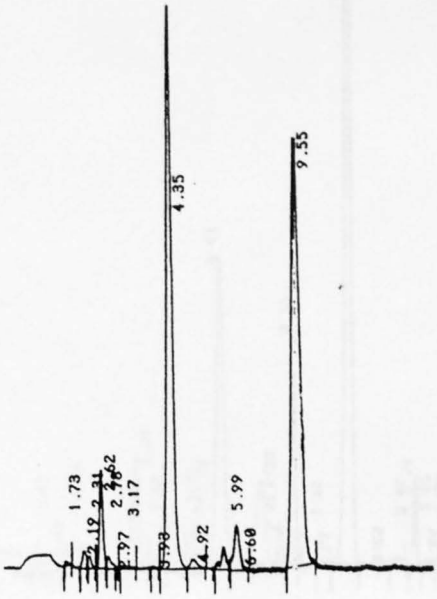

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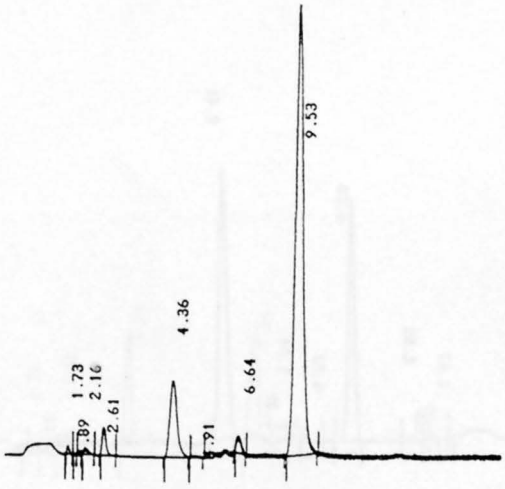

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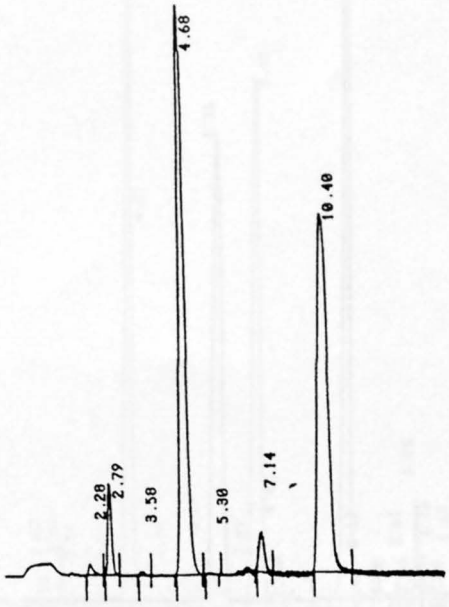

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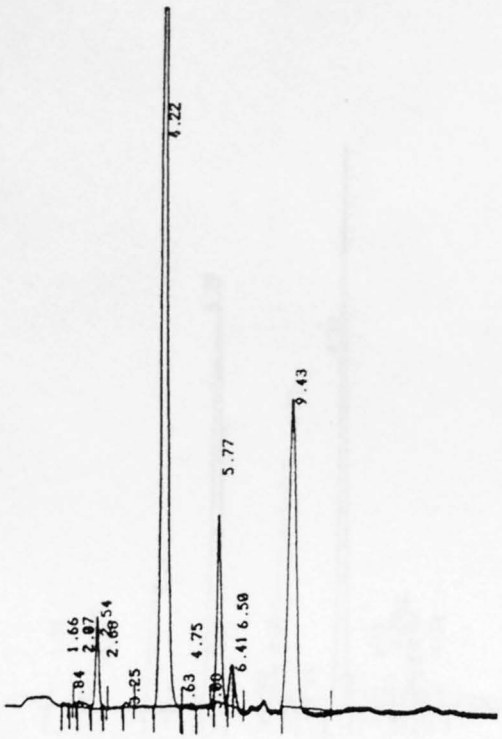

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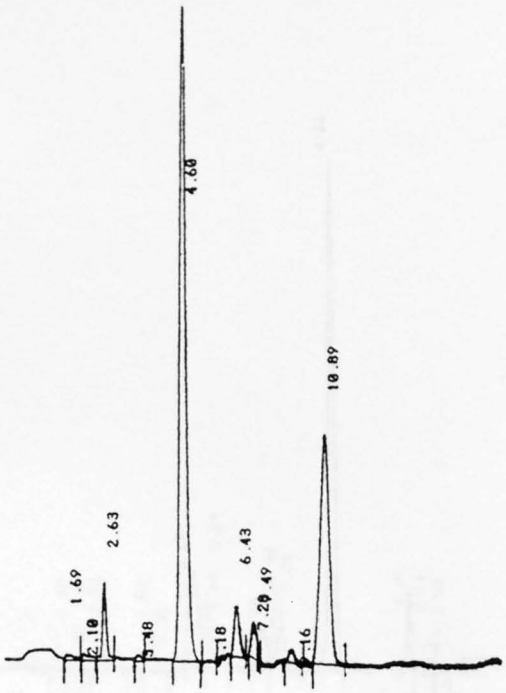

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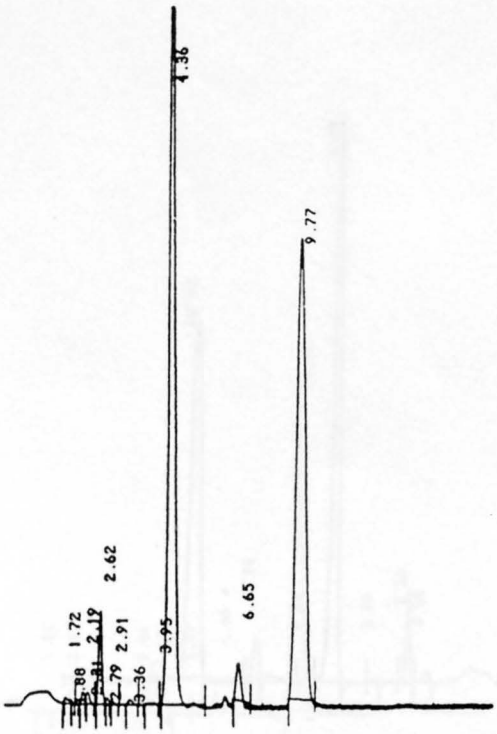

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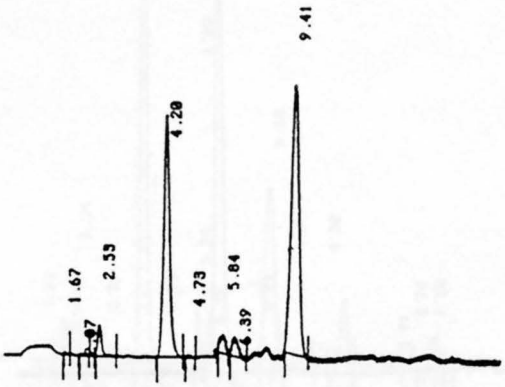

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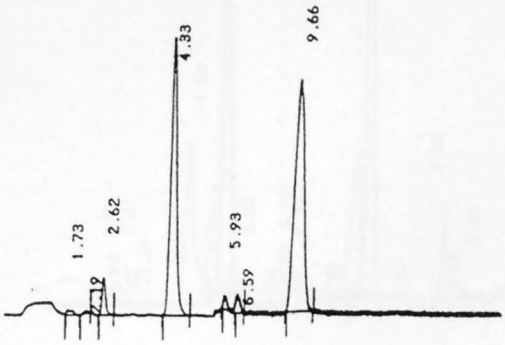

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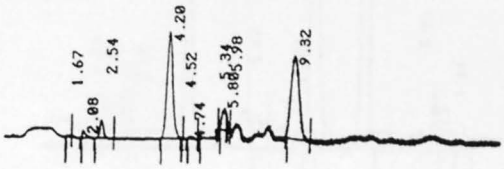

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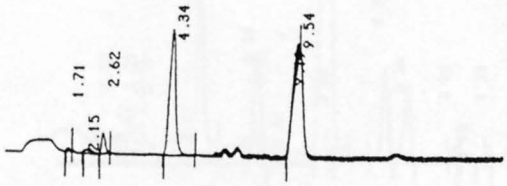

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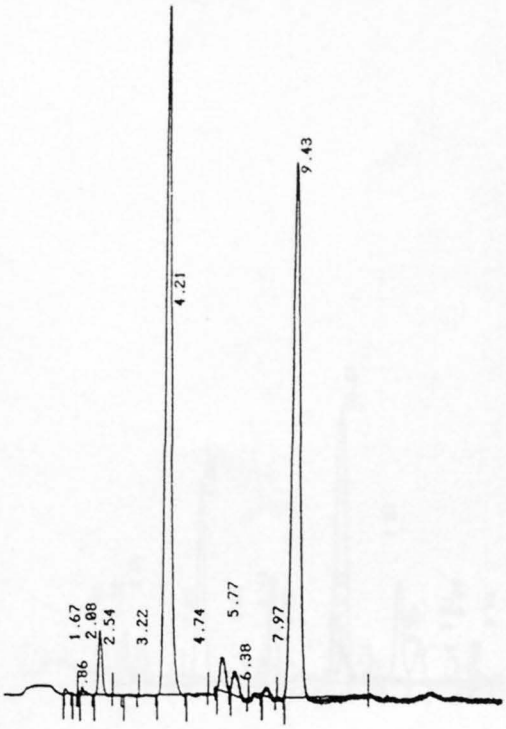

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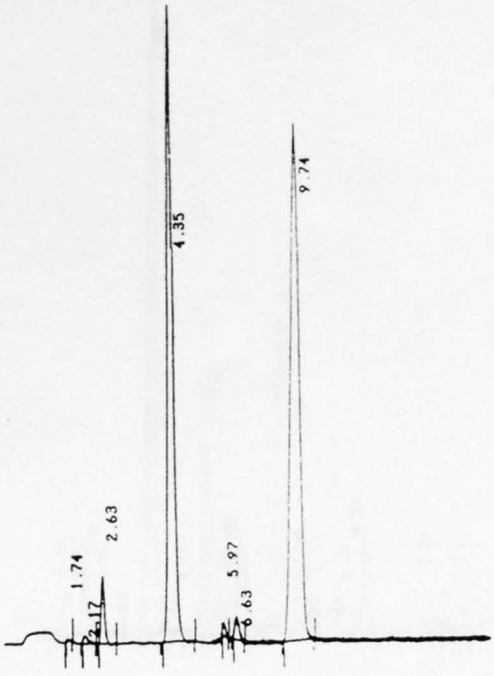

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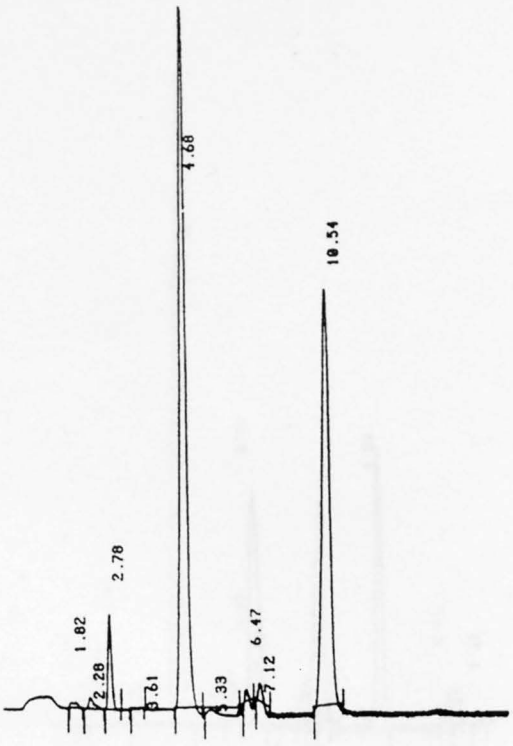

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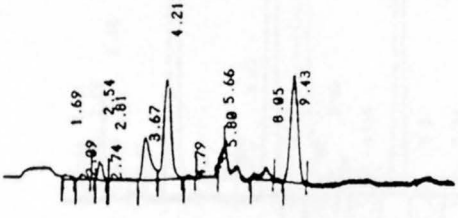

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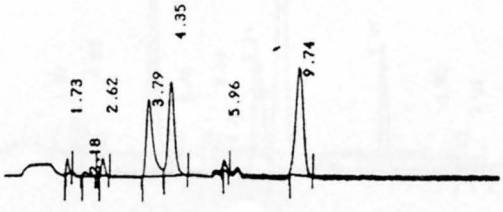

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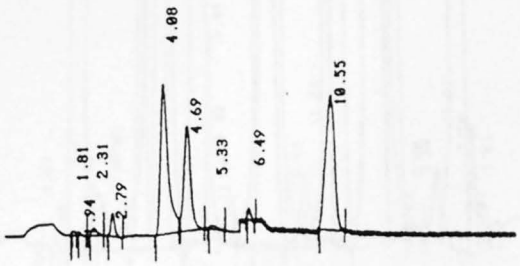

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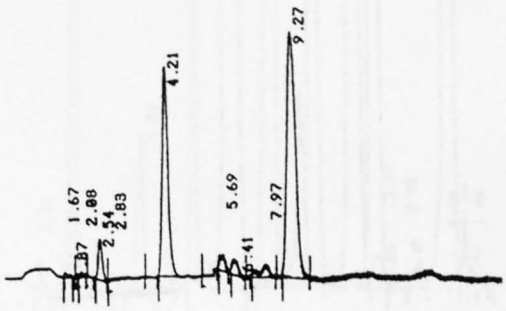

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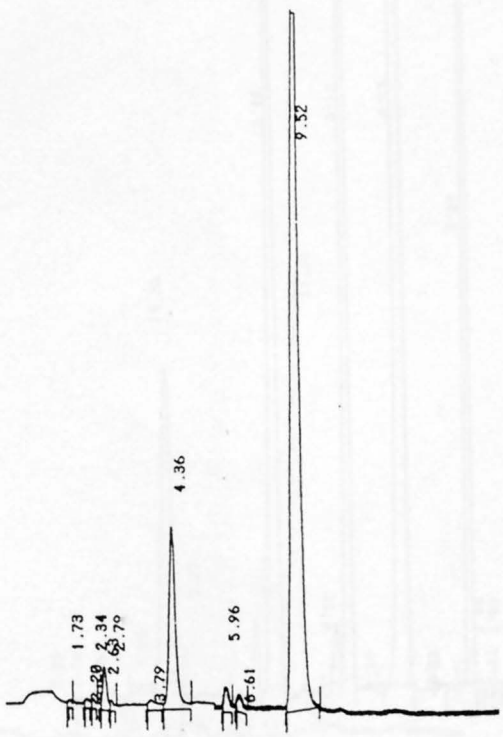

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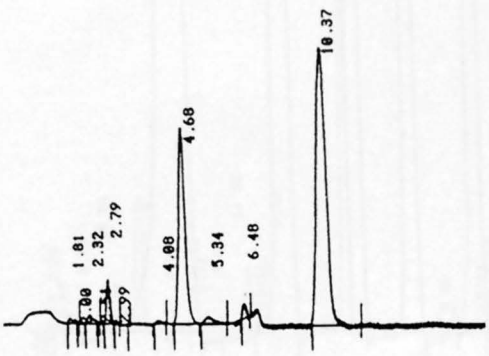

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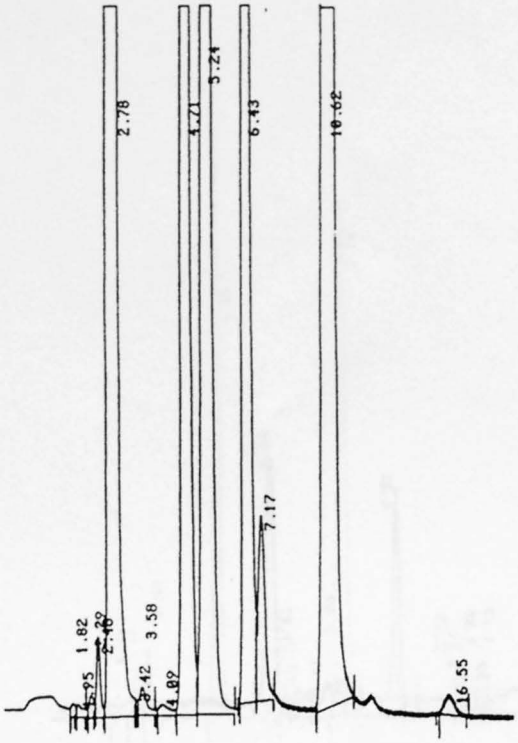

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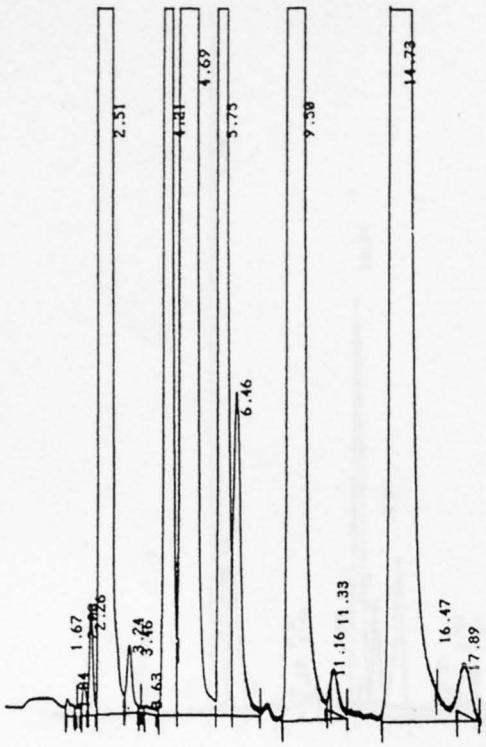

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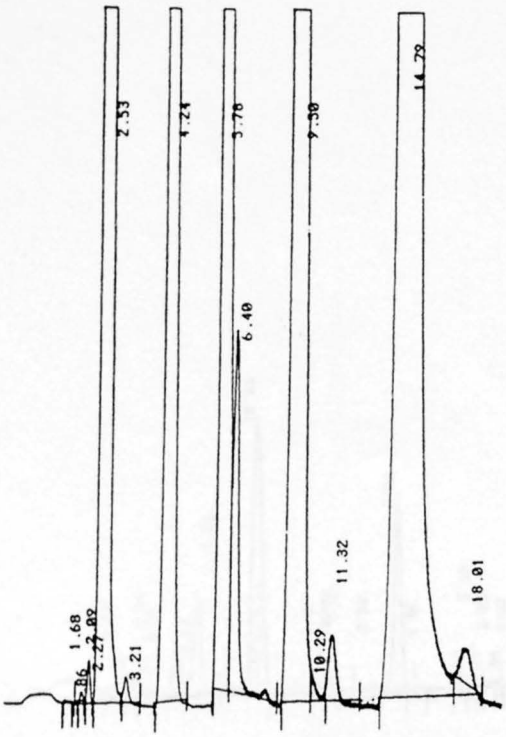

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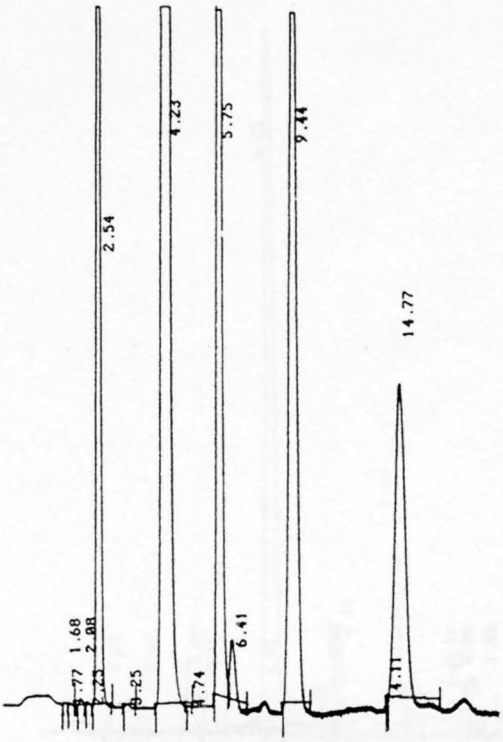

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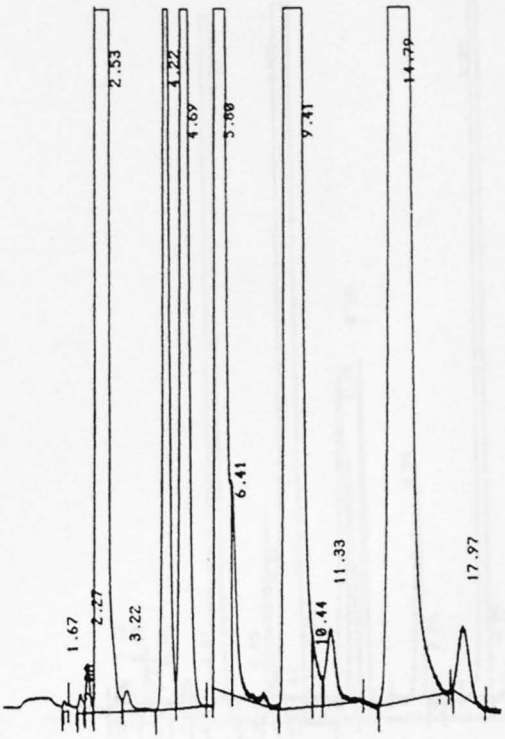

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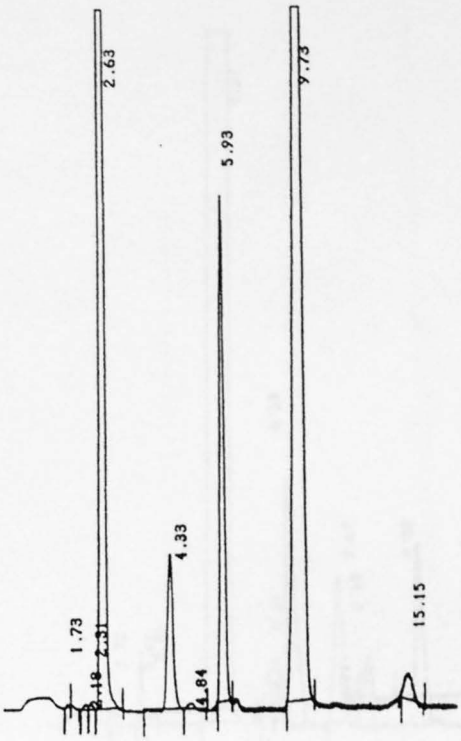

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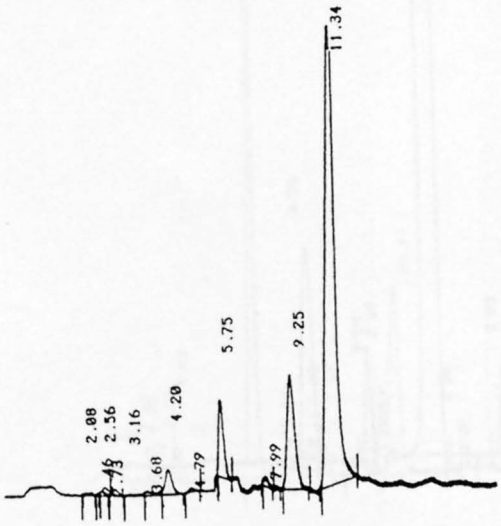

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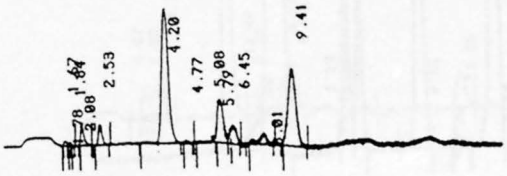

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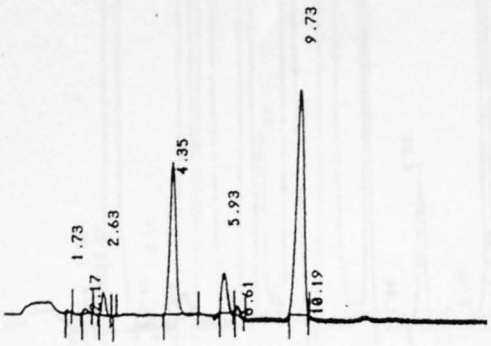

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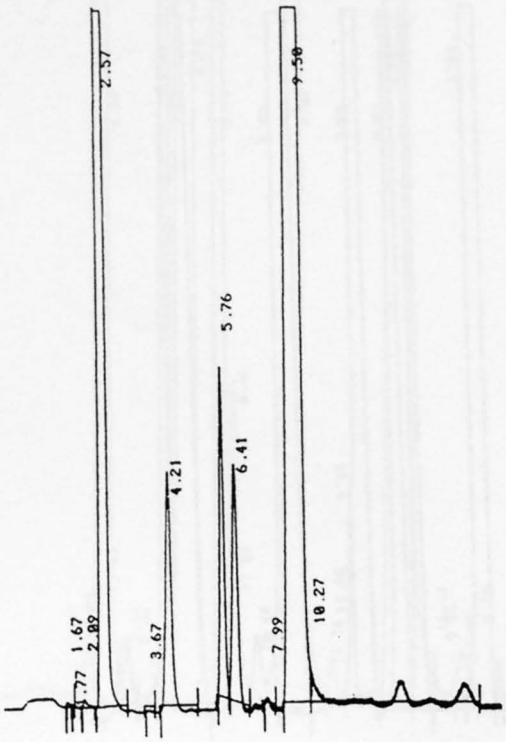

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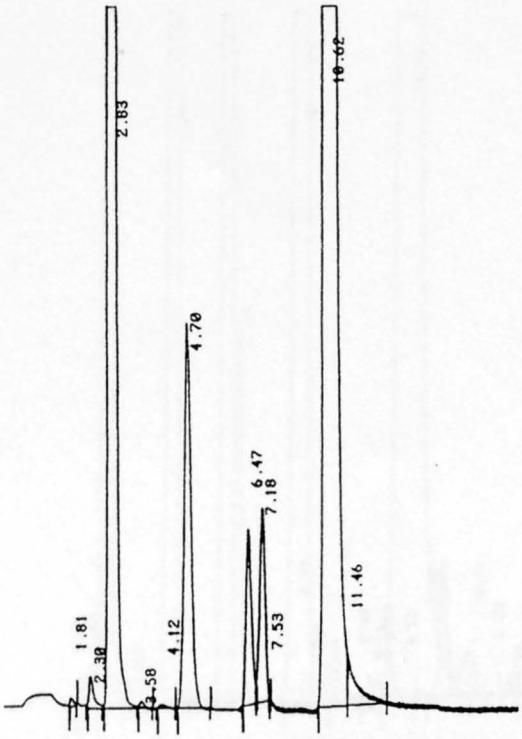

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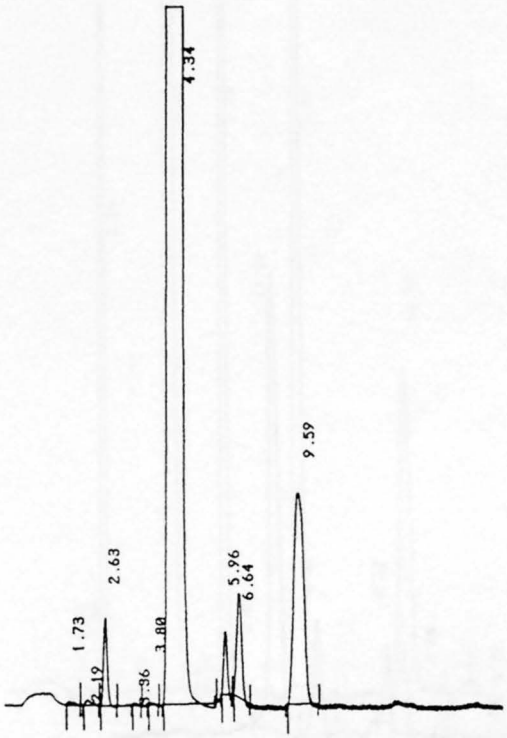

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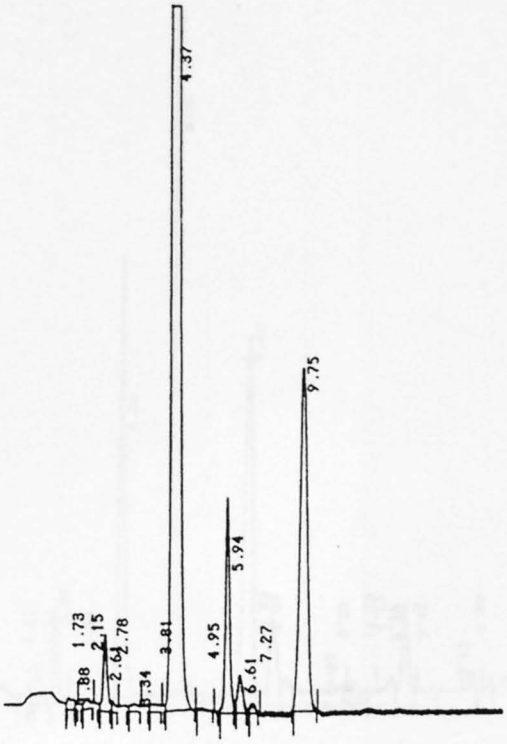

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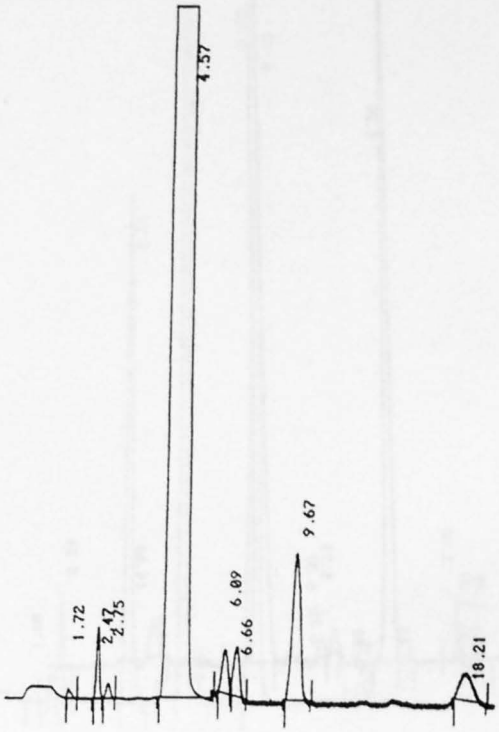

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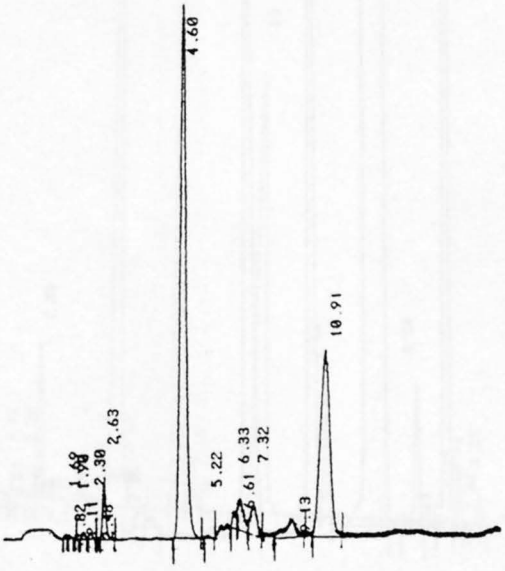

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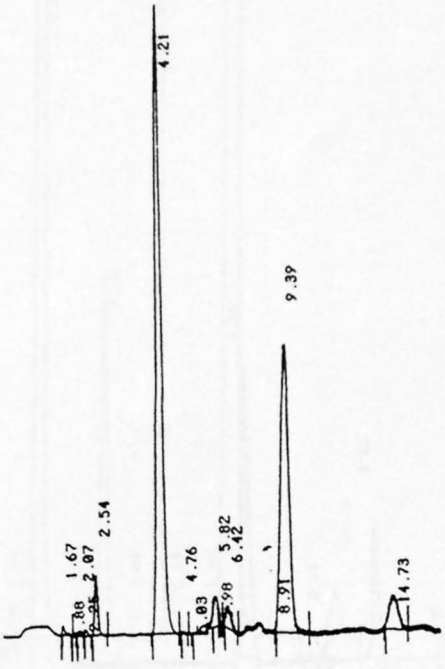

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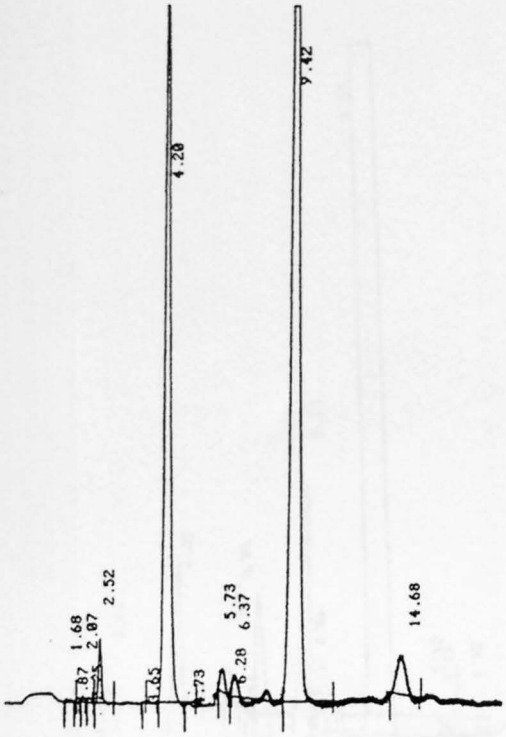

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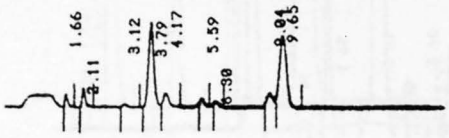

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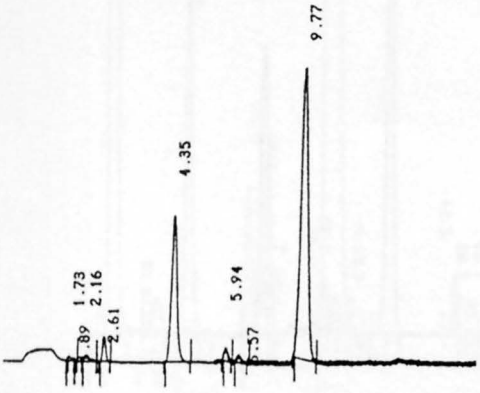

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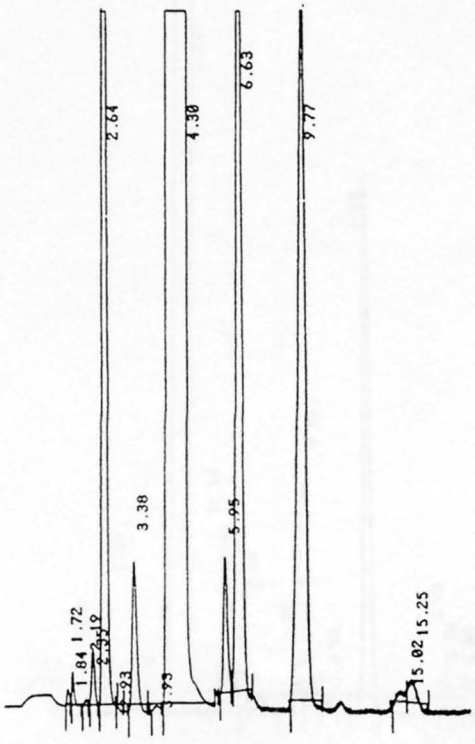

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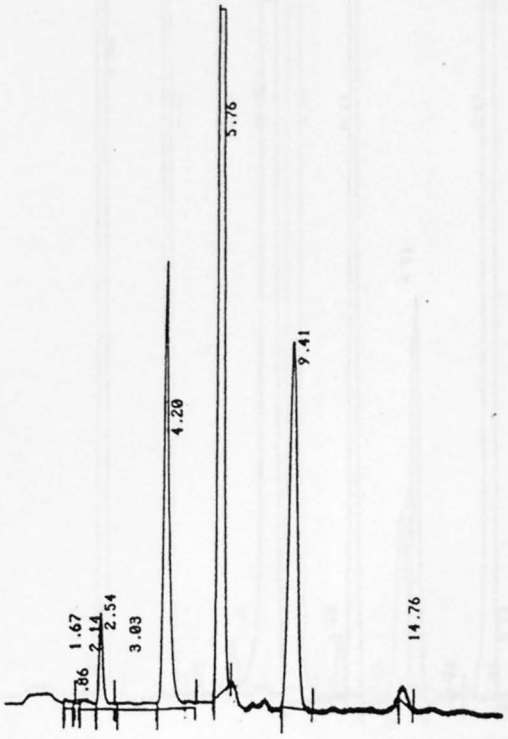

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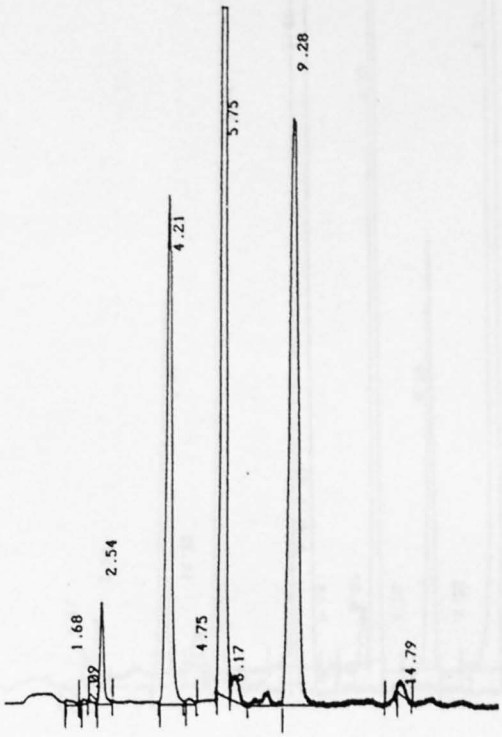

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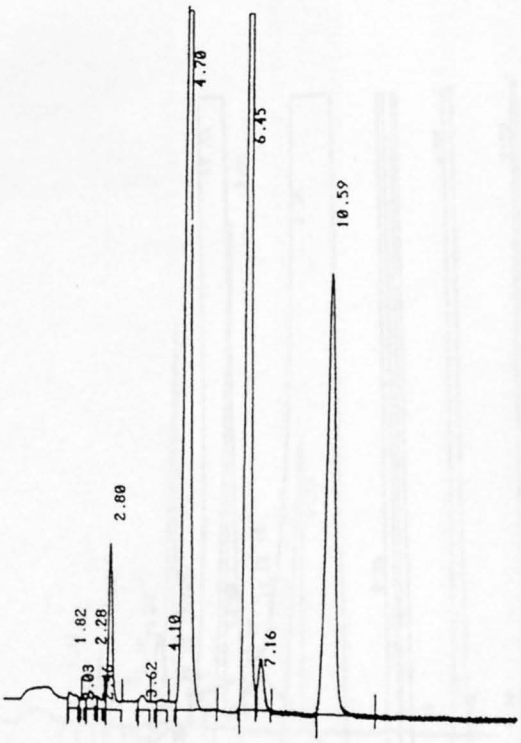

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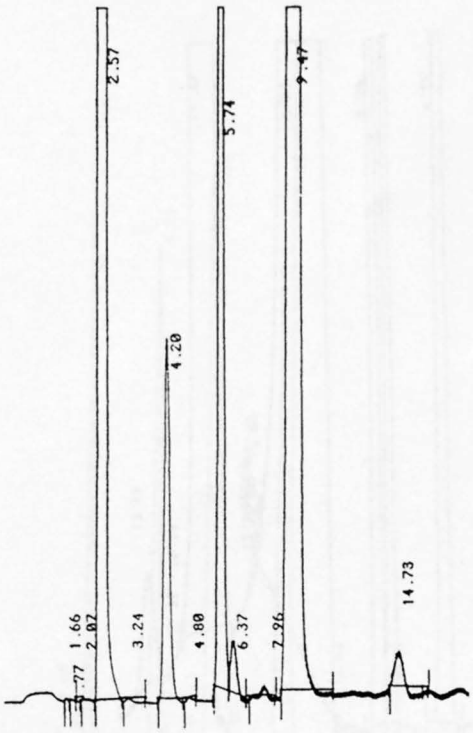

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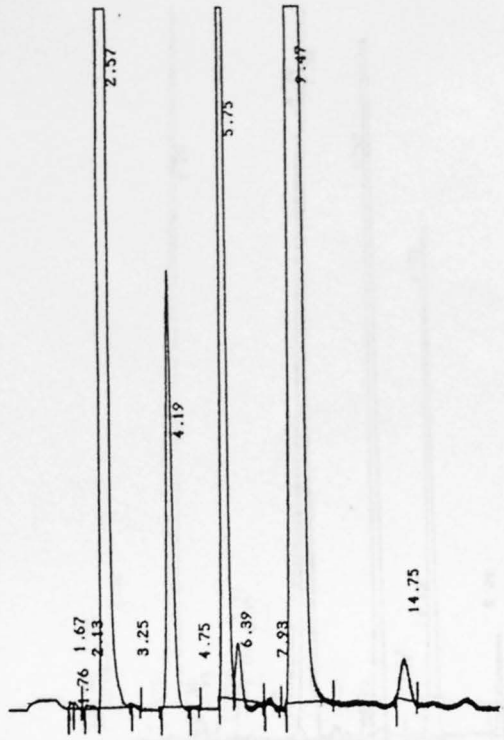

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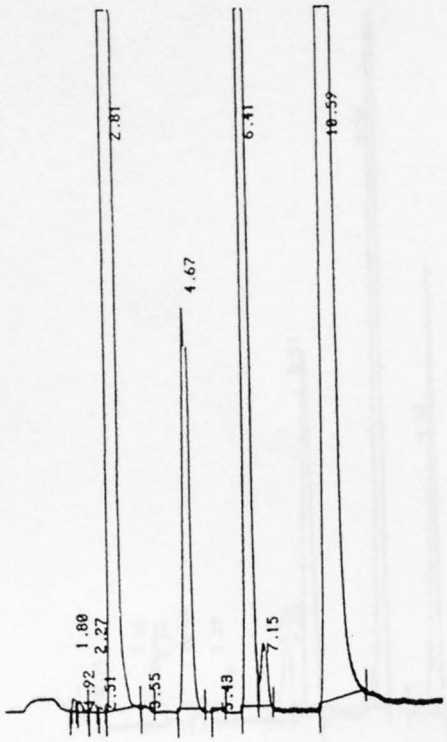

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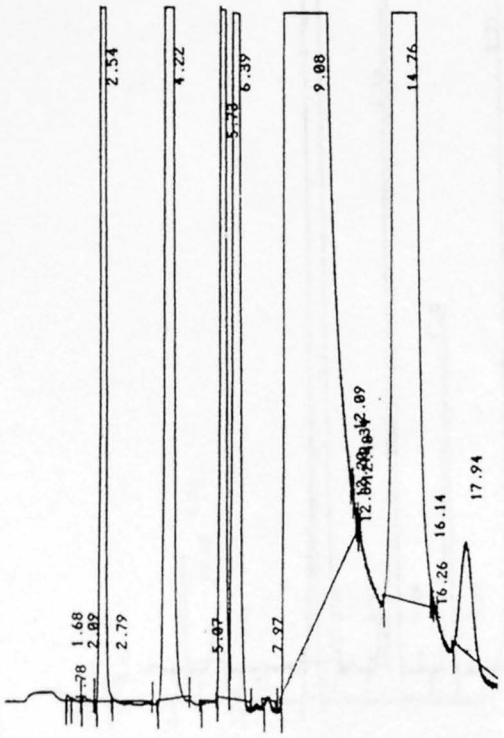

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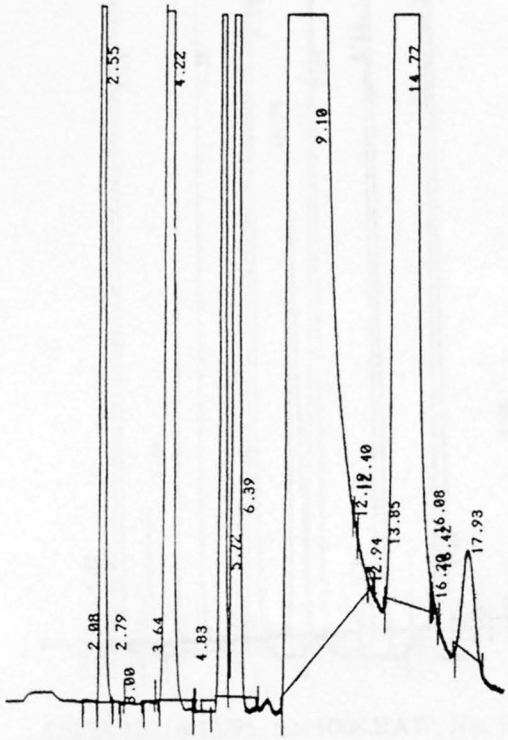

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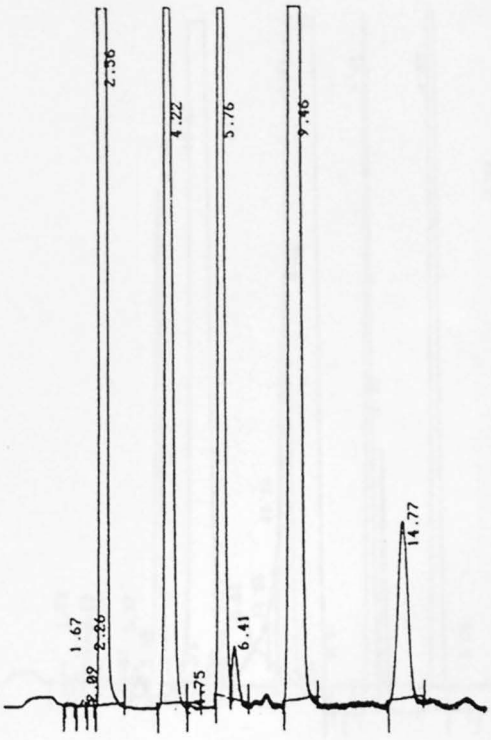

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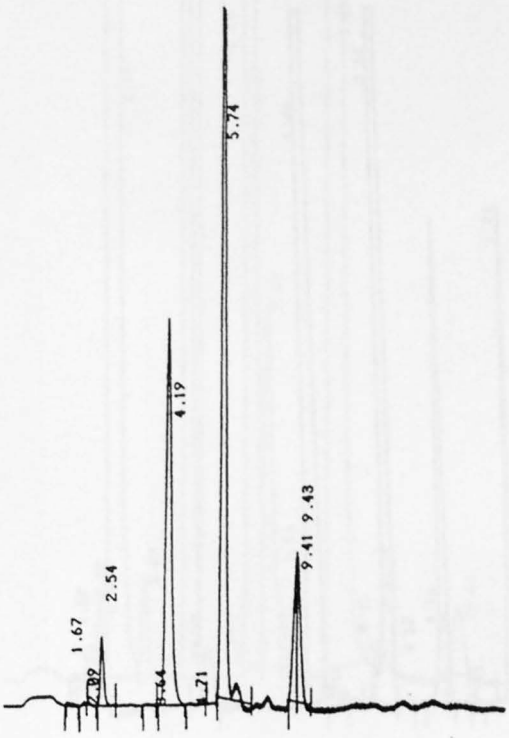

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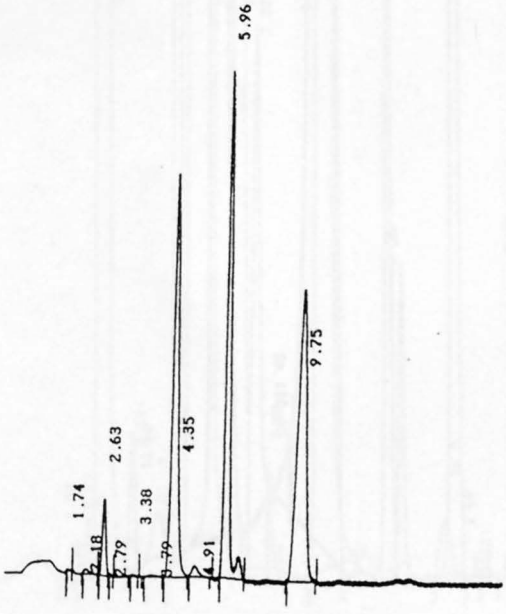

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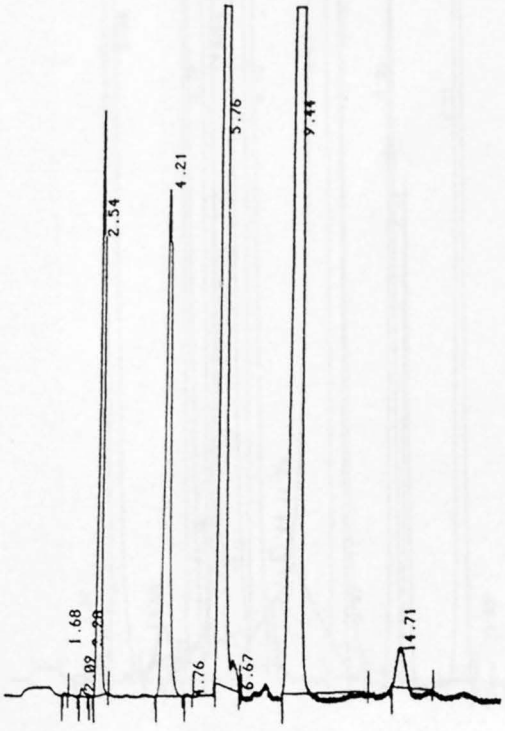

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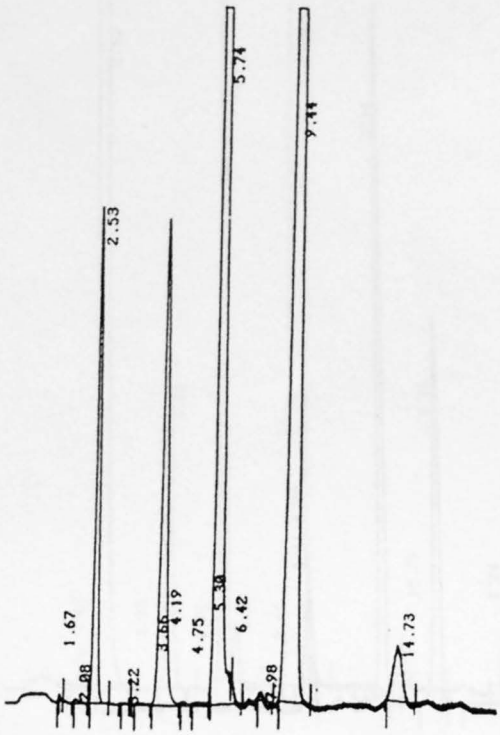

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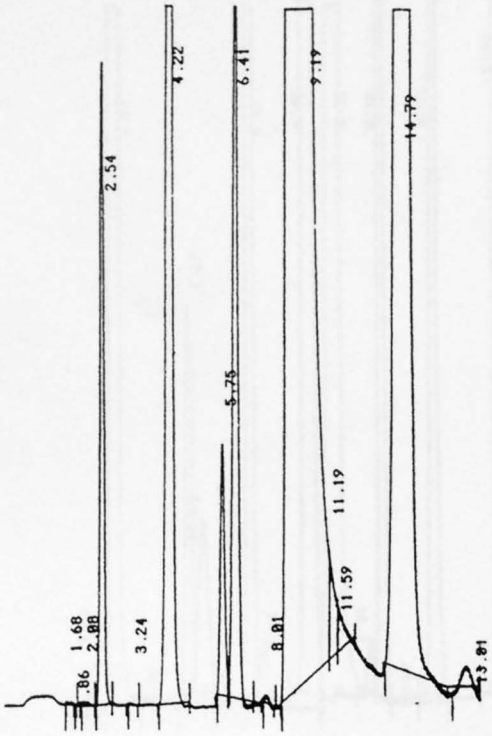

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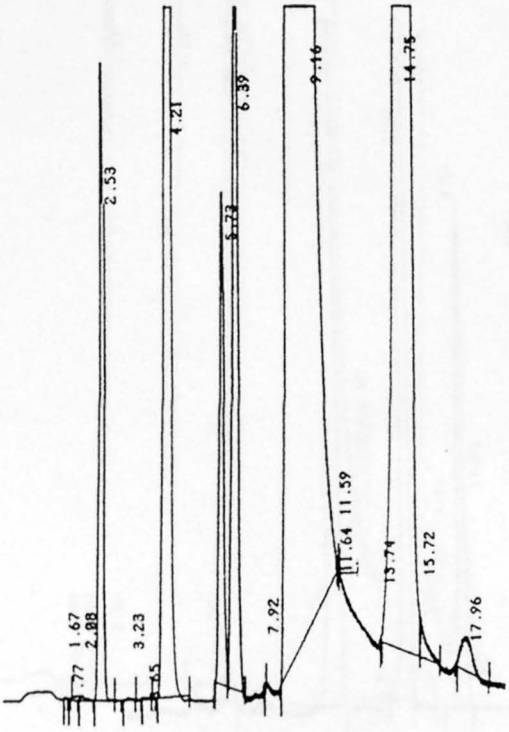

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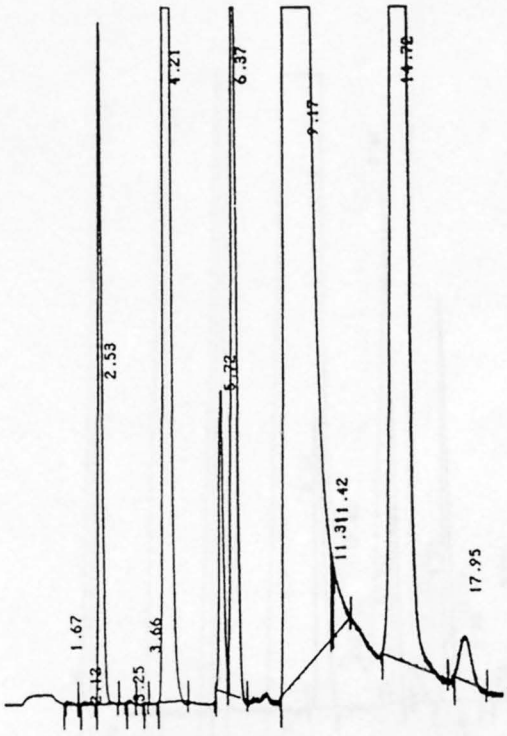

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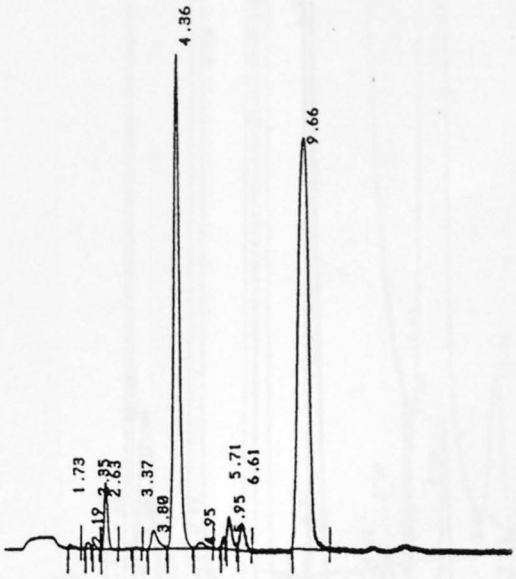

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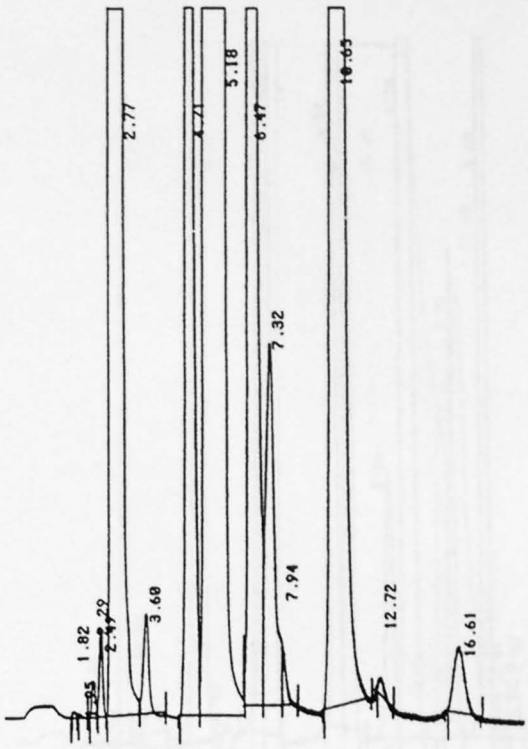

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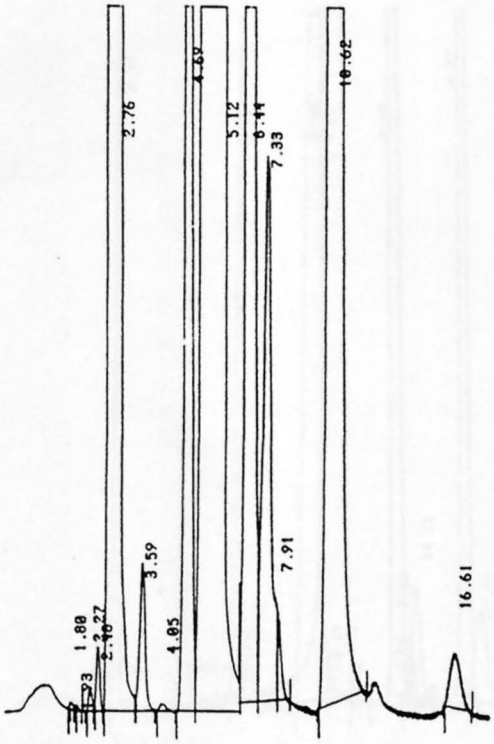

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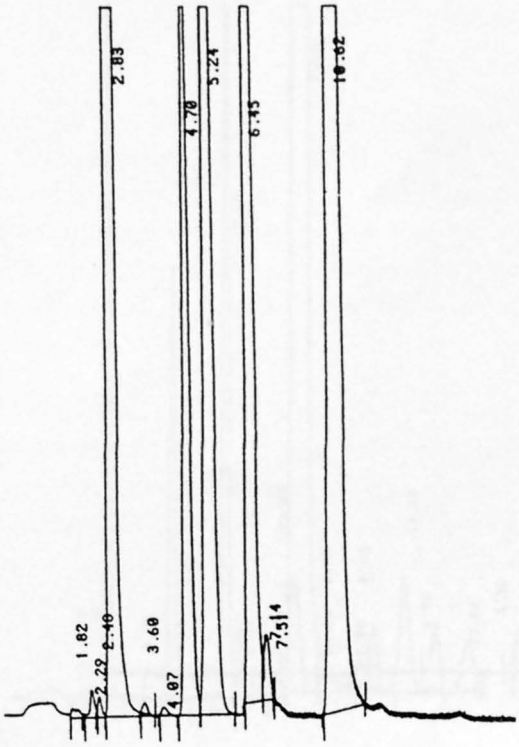

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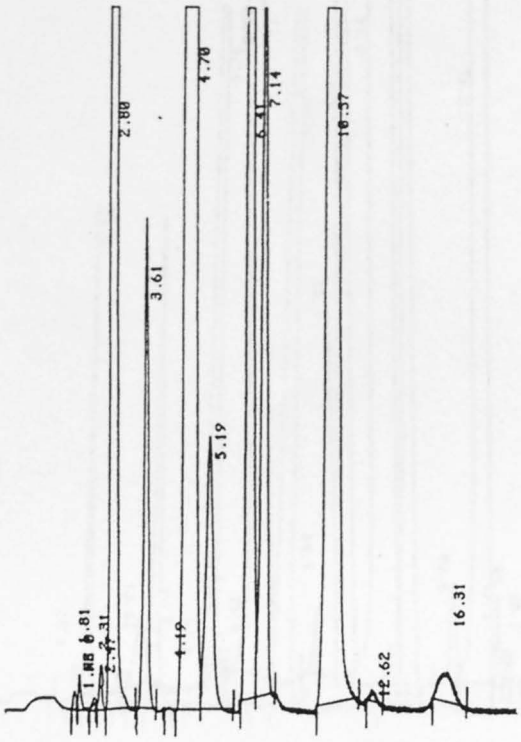

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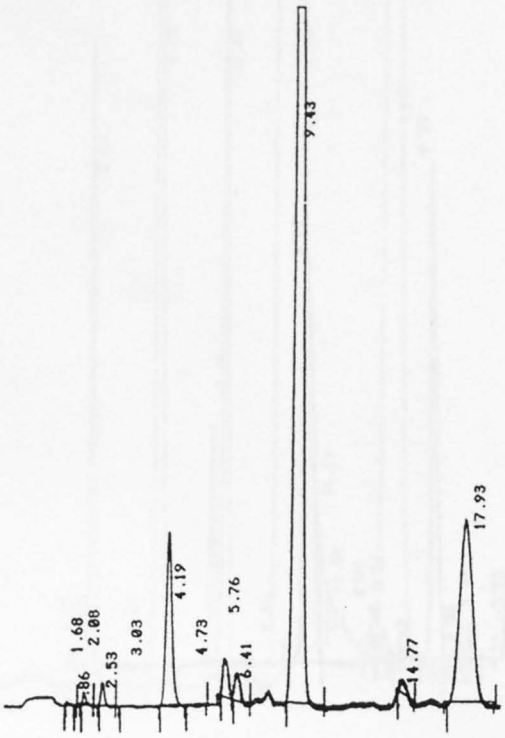

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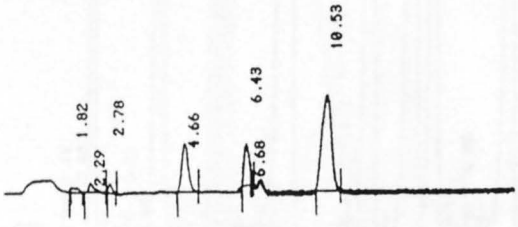

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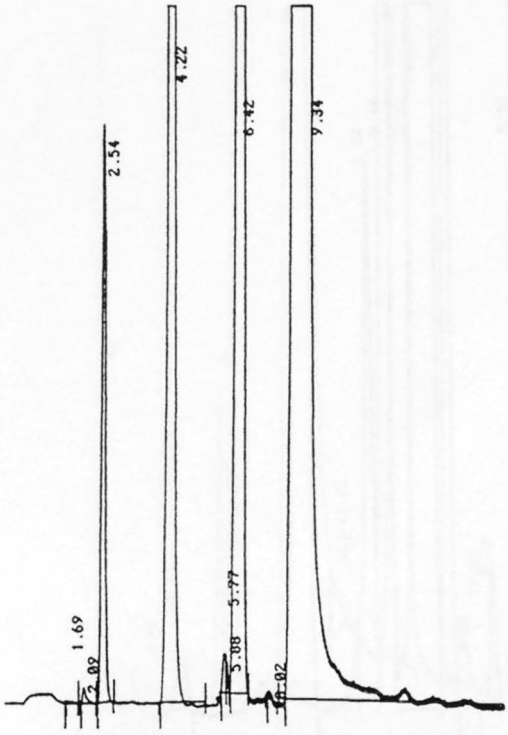

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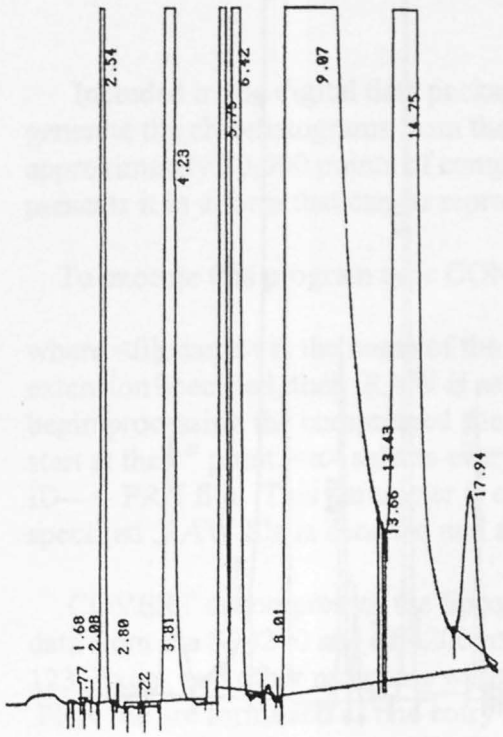

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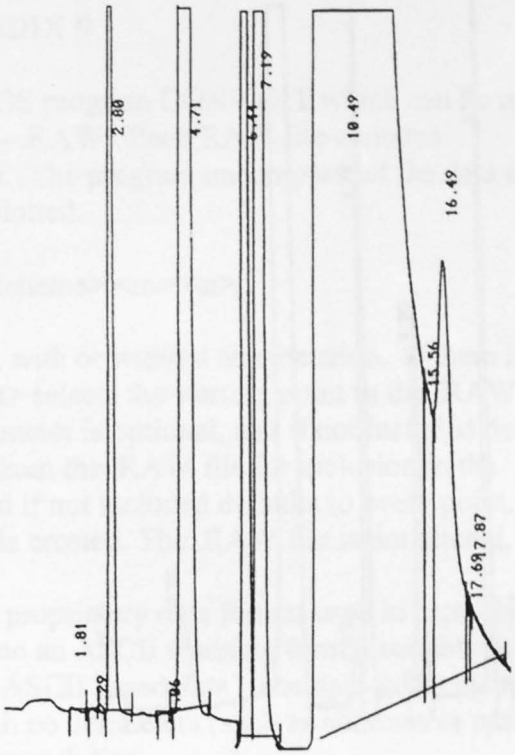

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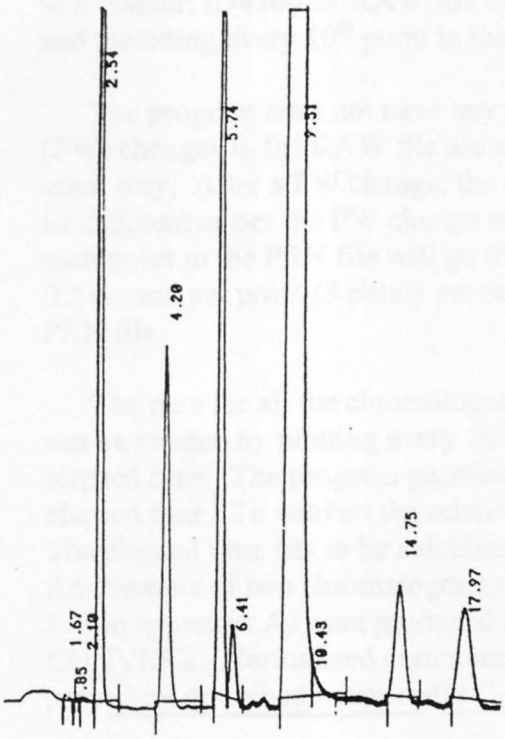

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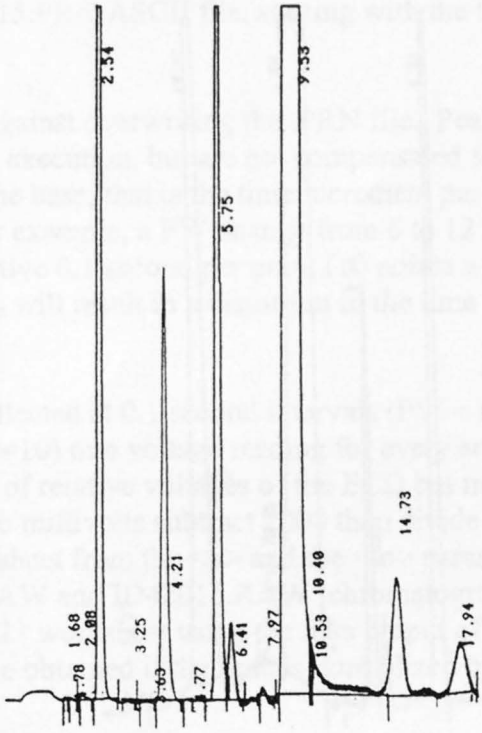

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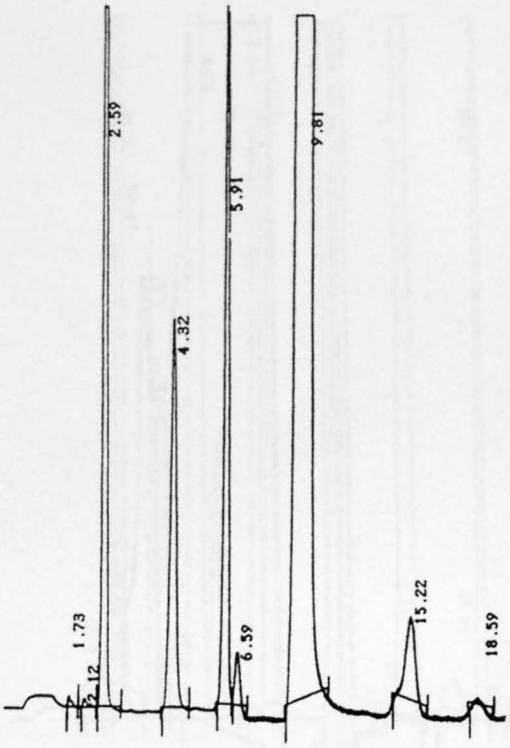

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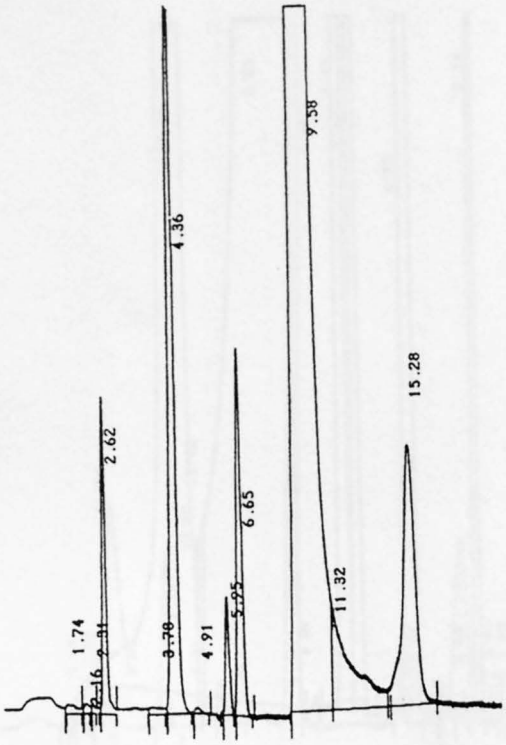
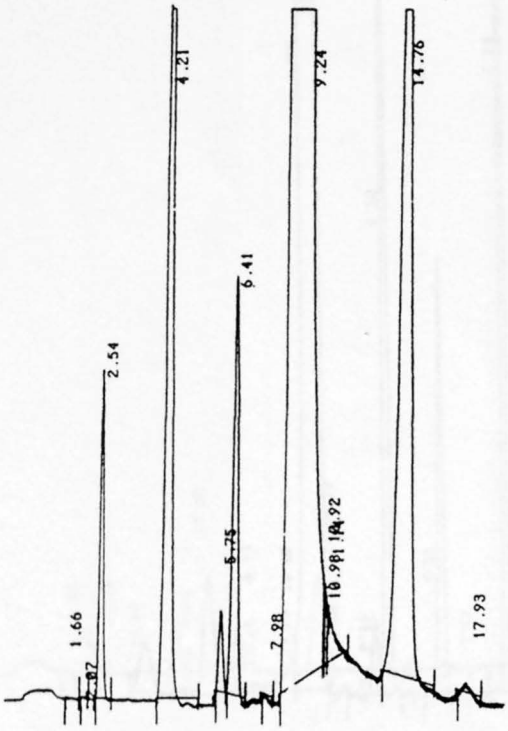


USGS 125, 6/6/95, ID46015.RAW, No. 138



USGS 125, 10/11/96, ID50012.RAW, No. 139

Blank, 6/6/95, ID45004.RAW, No. 140

APPENDIX B

Included in the digital data package is the DOS program CONVERT which can be used to generate the chromatograms from the files ID-----.RAW. Each RAW file contains approximately 20,000 points of compressed data. The program uncompressed the data and presents it in a form that can be reprocessed or plotted.

To execute this program type CONVERT <filename> <m> <n>,

where <filename> is the name of the .RAW file, with or without an extension. If there is no extension specified, then .RAW is assumed. <m> selects the starting point in the .RAW file to begin processing the compressed file. This parameter is optional, and if not included defaults to start at the 1st point. <n> selects every nth point from the .RAW file for inclusion in the ID-----.PRN file. This parameter is optional, and if not included defaults to every point. The specified .RAW file is decoded and a .PRN file is created. The .RAW file is not altered.

COVERT decompresses the Spectra-Physics proprietary data format used in capturing raw data from the SP4270 and SP4200 integrators into an ASCII readable format suitable for Lotus 123, Excel, and other programs which will read ASCII based data. The data in the created .PRN file are formatted as one entry per line with no delimeters (such as commas or spaces) other than the carriage return/line feed separating each line.

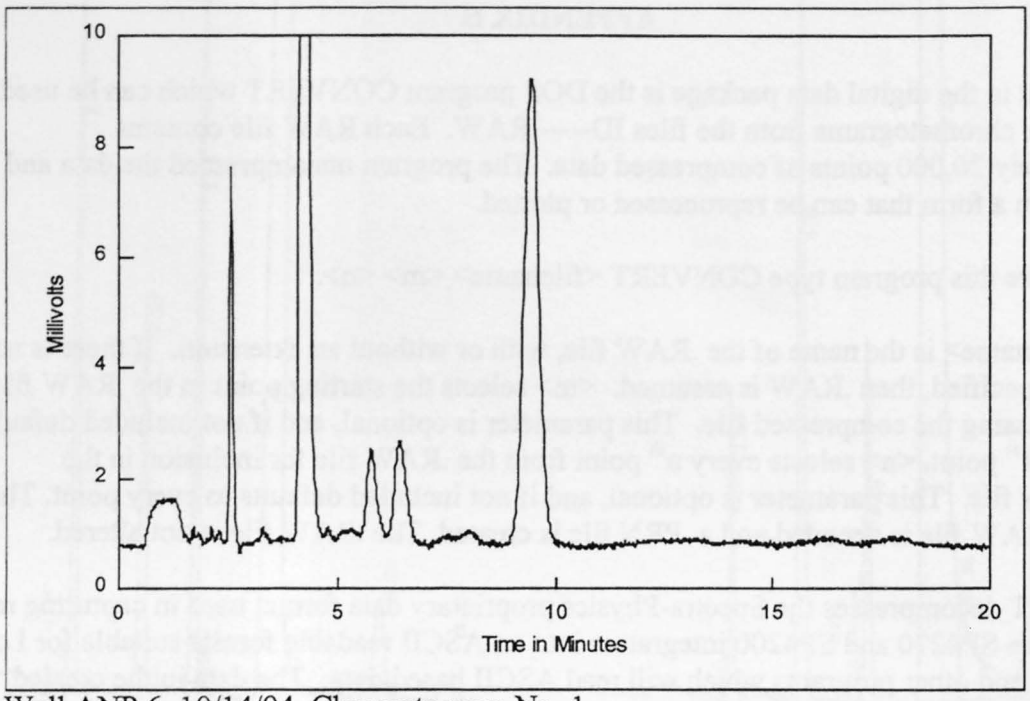
For example:

CONVERT ID450015.RAW 1 10

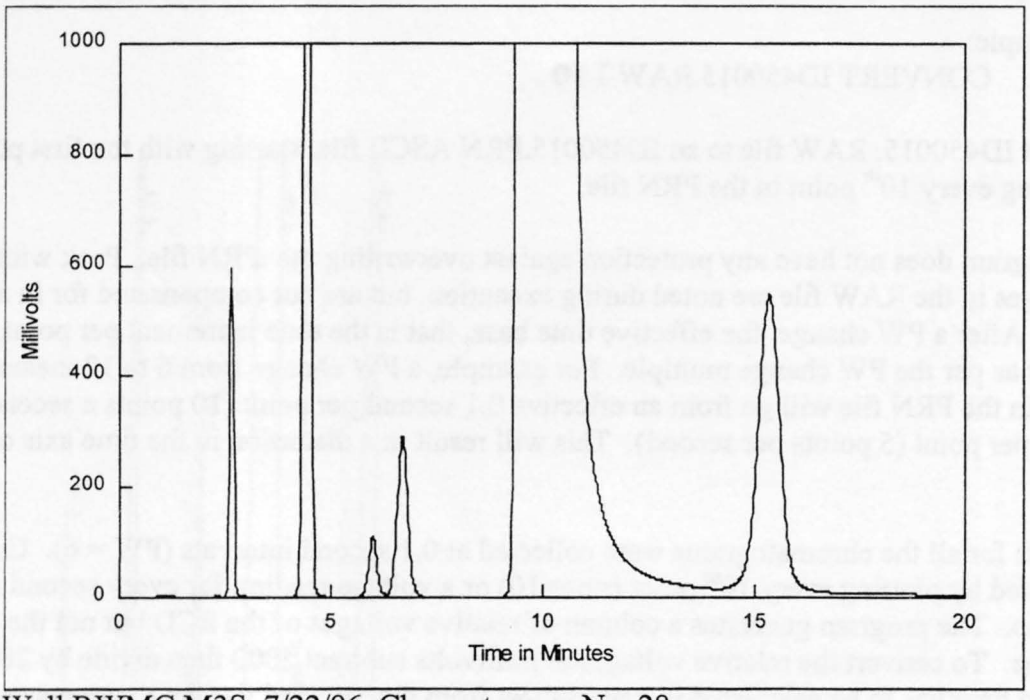
will convert ID450015. RAW file to an ID450015.PRN ASCII file, starting with the first point and including every 10th point in the PRN file.

The program does not have any protection against overwriting the .PRN file. Peak width (PW) changes in the RAW file are noted during execution, but are not compensated for in any other way. After a PW change, the effective time base, that is the time increment per point, will be different as per the PW change multiple. For example, a PW change from 6 to 12 means that each point in the PRN file will go from an effective 0.1 second per point (10 points a second) to 0.2 second per point (5 points per second). This will result in a distortion in the time axis of the PRN file.

The data for all the chromatograms were collected at 0.1 second intervals (PW = 6). Graphs can be created by plotting every 10th point (<n>=10) or a voltage reading for every second of elapsed time. The program generates a column of relative voltages of the ECD but not the elapsed time. To convert the relative voltages to millivolts subtract 2000 then divide by 200. The elapsed time has to be calculated in a worksheet from the <n> and the <m> parameters. An example of two chromatograms ID50015.RAW and ID42018.RAW (chromatogram #1 and #28 in appendix A) were produced in a Lotus 123 worksheet using the data output of CONVERT. Normalized chromatograms can be obtained if the time is normalized by the procedure described in appendix C.



Well ANP 6, 10/14/94, Chromatogram No. 1



Well RWMC M3S, 7/22/96, Chromatogram No. 28

Example of chromatographs produced from the compressed digitized data. The integrator outputs for these two ground waters are given in appendix A.

APPENDIX C

A procedure is described below that can be used to normalize the retention times of peaks in the chromatograms given in appendix A. The normalized retention times can be used to identify some of the halocarbons present in these chromatograms. Identification of halocabons based on retention times alone should be used with caution because different halocarbons can have very similar retention times. The observed retention times vary as a function of the GC oven temperature, the carrier flow rate, and other variables. Normalized retention times are corrected for all these variables. To normalize the retention time:

$$n = [(r - 0.50)f + 0.50],$$

where n is the normalized retention time, r is the observed retention time from appendix A, and f is a conversion factor. The above equation can reproduce the normalized retention time of halocarbons with the accuracy given in the table below.

Name of chromatograms	*Factor f*	*Accuracy (minutes)*
ID23---.RAW	0.987859	0.03
ID37---.RAW	.884387	.03
ID39---.RAW	.889662	.03
ID40---.RAW	.888779	.03
ID41---.RAW	.887017	.03
ID42---.RAW	.959271	.03
ID43---.RAW	.966523	.03
ID44---.RAW	.966523	.03
ID45---.RAW	.966523	.03
ID46---.RAW	.963402	.03
ID47---.RAW	.965480	.03
ID48---.RAW	.964440	.03
ID49---.RAW	1.000000	.03
ID50---.RAW	1.001119	.03
ID51---.RAW	1.001119	.03
ID52---.RAW	1.000000	.03
ID53---.RAW	1.000000	.03
SC03---.RAW	.877451	.20

The normalized retention time for selected halocarbons present is some INEEL ground waters are presented in the table below. Halocarbons identification should be confirmed by gas chromatography-mass spectroscopy because numerous other halocarbons have retention times between 4 and 20 minutes.

Halocarbon	Normalized retention time (minutes)
CFC-12	2.24
CFC-11	4.23
CH_3Cl	4.34
CFC-113	6.42
CCl_3CH_3	6.6
CH_3Br	6.8
CCl_4	9.5
CH_2Cl_2	11.9
$CHCl_3$	14.8
C_2HCl_3	15.4
C_2Cl_4	18.9

Table 1. Well production, well-construction data, and water levels of wells sampled in and near the Idaho National Engineering and Environmental Laboratory.

[All depths are below land surface; diam., diameter; galv., galvanized steel; ss, stainless steel; min, minutes; in, inches; ft, feet. Symbols: ---, not known or not applicable; ~, approximate]

Well name	Pumping rate (gallons per min)	Hole diam. (in)	Well depth (ft)	Depth of intake (ft)	Intake diam. (in)	Intake material	Perforations or open hole top (ft)	Perforations or open hole length (ft)	Perforations or open hole top (ft)	Perforations or open hole length (ft)	Depth of water level (ft)	Date month/ year
ANP 6	40	12	305	237	1.5	galv.	211	45	266	30	220	10/94
ANP 9	20	12	322	270	---	---	237	77	---	---	227	10/94
Arbor Test	20	16	790	720	1.5	galv.	680	50	737	50	682	4/95
Arco City 2	---	---	---	138	---	---	---	---	---	---	~1622	---
Arco City 4	1,500	20	250	160	---	galv.	209	8	225	17	~132	---
Area II *	14	10	877	703	1.5	ss	676	47	752	62	673	7/94
Atomic City	---	8	639	615	---	---	35	604	---	---	587	8/78
BFW	35	6	644	---	---	---	533	---	---	---	~491	---
CFA 1	1,000	16	685	---	---	---	440	245	---	---	479	---
CFA 2	1,400	20	681	---	---	---	521	130	661	20	471	12/48
EBR I	1,000	10	1,075	---	---	---	675	75	750	325	586	---
Engberson	---	6	281	275	---	galv.	109	172	---	---	---	---
Fire Station 2	400	16	518	---	---	---	427	40	501	10	420	9/57
IET 1 Disposal	40	20	324	233	1.5	galv.	219	100	---	---	214	7/94
INEL-1 WS	30	8	595	423	1.5	galv.	340	167	507	88	401	6/95
Leo Rogers 1	20	20	702	---	---	---	14	688	---	---	613	4/70
Neville	---	6	85	---	---	---	---	---	---	---	~43	---
McKinney	---	---	43	---	---	---	---	---	---	---	8.8	7/91
NPR Test	26	6	599	486	1.5	galv.	500	35	---	---	467	4/95
Park Bell	---	---	48	---	---	---	---	---	---	---	~29	---
PSTF Test	44	16	322	242	1.5	ss	190	126	---	---	214	10/94
P&W2	35	10	386	342	1.5	galv.	313	70	---	---	317	10/94
Pencheri 6	---	16	87	---	---	---	37	40	---	---	~25	---
Ruby Farms	---	---	650	---	---	---	558	92	---	---	~259	---
RWMC M3S	5	6	633	625	---	---	603	30	---	---	590	1/93
RWMC M7S	5	6	638	621	---	---	598	30	---	---	576	7/96
Squirrel Cemetery	---	---	232	---	---	---	---	---	---	---	~120	---
Site 04	500	15	496	---	---	---	422	75	---	---	401	---
Site 09	25	10	1,057	523	1.5	ss	681	376	---	---	475	7/94
Site 14	40	8-10-12	717	326	1.5	ss	535	181	---	---	276	10/94
Site 17	25	20	600	442	1.5	ss	15	585	---	---	403	6/95
Site 19**	25	18-10	865	486	1.5	galv.	472	40	532	40	471	7/96
TAN Exploration	42	12	550	242	1.5	ss	267	283	---	---	212	10/94
USGS 001	16	6	636	612	1.5	ss	600	30	---	---	590	7/95
USGS 002	16	5	704	683	1.5	ss	675	20	---	---	662	7/95
USGS 004	40	6	553	303	1.5	ss	285	30	322	231	263	4/95
USGS 005	5	6	500	488	1.5	ss	475	22	---	---	471	10/94
USGS 006	25	6	620	461	1.3	ss	532	88	---	---	417	7/94
USGS 007	45	4-6	1,200	242	1.5	ss	239	20	760	440	217	10/94
USGS 008	16	6	812	801	1.5	ss	782	30	---	---	770	10/94
USGS 009	19	8	655	635	1.5	galv.	618	30	652	2	610	10/94
USGS 011	22	12	704	687	1.5	galv.	673	31	---	---	655	4/95

* Area II has additional perforations at 854 feet with a length of 22 feet.

**Site 19 has additional perforations or open hole at 596 and 760 feet with lengths of 16 and 82 feet, respectively.

Table 1. Well production, well-construction data, and water levels of wells sampled in and near the Idaho National Engineering and Environmental Laboratory —continued

Well name	Pumping rate (gallons per min)	Hole diam. (in)	Well depth (ft)	Depth of intake (ft)	Intake diam. (in)	Intake material	Perforations or open hole top (ft)	Perforations or open hole length (ft)	Perforations or open hole top (ft)	Perforations or open hole length (ft)	Depth of water level (ft)	Date month/ year
USGS 012	32	10-12	563	358	1.5	ss	---	---	---	---	335	10/94
USGS 014	16	6	751	739	1.5	galv.	720	3	---	---	717	10/94
USGS 015	30	10-16	610	358	1.5	ss	540	70	---	---	326	6/95
USGS 017	32	6-8	498	403	1.5	ss	438	7	496	2	359	10/94
USGS 018	25	4	329	302	1.5	ss	298	24	---	---	275	7/94
USGS 019	33	6	405	322	1.5	ss	285	21	---	---	279	10/94
USGS 022	3	6	657	643	1.5	ss	644	13	619	15	614	6/95
USGS 023	25	6	467	442	1.5	ss	410	20	---	---	405	10/94
USGS 026	40	8	266	255	1.5	ss	232	35	---	---	214	10/94
USGS 027	20	8	312	262	1.5	ss	250	10	298	10	229	10/94
USGS 029	32	6	426	402	1.5	ss	363	35	398	27	359	10/94
USGS 031	40	8-10	428	284	1.5	ss	285	20	306	122	259	10/94
USGS 032	28	6-10	392	322	1.5	ss	306	18	324	68	294	10/94
USGS 036	25	6	567	521	1.5	ss	430	137	---	---	475	7/96
USGS 037	25	8	573	506	1.5	ss	507	65	---	---	475	10/94
USGS 058	26	6	503	476	1.5	galv.	218	285	---	---	460	7/91
USGS 065	7	6	498	490	1.0	galv.	456	42	---	---	469	10/94
USGS 076	25	6	718	502	1.5	galv.	487	261	---	---	477	10/94
USGS 077	25	6	610	502	1.5	ss	470	140	---	---	467	10/94
USGS 079	25	6	702	522	1.5	ss	470	140	---	---	475	7/91
USGS 082	25	8	700	508	1.5	galv.	470	50	593	107	452	7/96
USGS 083	6	6	752	606	1.0	galv.	516	236	---	---	501	4/95
USGS 086	19	8	691	678	1.5	galv.	48	643	---	---	652	4/94
USGS 089	5	6	646	620	1.0	ss	576	70	---	---	604	10/94
USGS 097	27	4	510	402	1.5	galv.	388	122	---	---	386	6/95
USGS 098	18	6	505	423	1.5	galv.	400	20	465	35	415	6/95
USGS 099	25	6	450	427	1.5	galv.	303	146	449	1	400	6/95
USGS 100	10	6	750	696	1.5	galv.	662	88	---	---	678	4/95
USGS 101	13	6	865	790	1.5	galv.	750	115	---	---	773	4/95
USGS 102	29	6	445	421	1.5	ss	359	86	---	---	378	6/95
USGS 103	21	8	760	700	1.5	galv.	575	185	---	---	586	7/94
USGS 104	21	8	700	592	1.5	galv.	550	150	---	---	558	7/94
USGS 105	19	8	800	700	1.5	galv.	400	400	---	---	672	10/94
USGS 106	22	8	760	609	1.5	galv.	400	205	605	155	590	10/94
USGS 107	25	8	690	531	1.5	ss	270	420	---	---	482	10/94
USGS 108	20	8	760	637	1.5	galv.	400	360	---	---	611	10/94
USGS 109	16	6	800	656	1.5	galv.	600	200	---	---	623	10/94
USGS 110A	24	10	644	612	1.5	ss	240	417	---	---	566	10/96
USGS 112	25	8	563	508	1.5	galv.	432	12	444	119	476	7/96
USGS 113	25	6	564	508	1.5	galv.	445	59	---	---	477	7/96
USGS 115	5	6	581	507	1.0	galv.	440	141	---	---	467	7/96
USGS 116	20	6	580	508	1.5	galv.	438	142	---	---	461	7/96
USGS 117	2	8	655	625	1.0	ss	550	105	---	---	588	10/94
USGS 119	3	8	705	685	1.5	ss	639	66	---	---	608	10/94
USGS 120	21	8	705	665	1.0	ss	638	67	---	---	617	10/94
USGS 121	8	8	475	460	1.0	ss	449	26	---	---	458	10/94
USGS 124	18	4	800	737	1.25	ss	750	50	---	---	686	7/94
USGS 125	20	10	774	700	1.5	ss	620	154	---	---	630	6/95
Wagoner Ranch	---	---	---	---	---	---	---	---	---	---	~11	---

Table 2. Concentration of chlorofluorocarbons in ground water in and near the Idaho National Engineering and Environmental Laboratory.

[The calibration range of the gas chromatograph was 0 to 1,200, 0 to 2,500, and 0-900 pg/kg for CFC-11, CFC-12 and CFC-113, respectively. Reported concentrations beyond the above calibration limits should be considered as qualitative estimates of concentrations. Location of wells is shown in figures 1, 2 and 3. CFC-11, trichlorofluoromethane; CFC-12, dichlorodifluoromethane; CFC-113, trichlorotrifluoroethane; STD, standard deviation; pg/kg, picograms per kilogram of water; time 1310, 1:10 PM; ERR, concentration could not be determined]

			Concentration in water			Average concentration			Population STD		
Well name	Sampling date	Sampling time	CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)
ANP 6	10/14/94	1130	161.2	96.0	44.0	162.6	94.1	45.9	1.0	2.9	2.0
ANP 6	10/14/94	1137	163.5	90.0	48.6						
ANP 6	10/14/94	1141	163.0	96.3	45.0						
ANP 6	06/15/95	1500	178.9	102.7	50.3	179.0	105.1	48.2	1.6	4.1	3.0
ANP 6	06/15/95	1510	181.1	110.9	50.3						
ANP 6	06/15/95	1515	177.1	101.7	44.0						
ANP 6	07/19/96	0803	182.0	95.6	38.1	191.4	103.0	42.3	18.7	7.2	5.3
ANP 6	07/19/96	0809	183.9	97.6	39.1						
ANP 6	07/19/96	0814	176.2	104.8	ERR						
ANP 6	07/19/96	0817	223.4	113.9	49.7						
ANP 9	10/14/94	1545	61.3	38.8	5.0	59.6	39.0	5.0	1.9	0.3	0.6
ANP 9	10/14/94	1549	57.0	39.4	5.8						
ANP 9	10/14/94	1600	60.5	38.9	4.2						
ANP 9	10/14/96	1615	65.6	40.8	0.0	65.4	41.9	2.9	0.2	1.8	2.0
ANP 9	10/14/96	1611	65.6	44.4	4.5						
ANP 9	10/14/96	1619	65.2	40.4	4.1						
Arbor Test	04/21/95	1100	162.8	71.0	7.2	149.1	71.1	7.0	8.8	2.2	7.2
Arbor Test	04/21/95	1110	138.2	67.6	18.7						
Arbor Test	04/21/95	1115	147.9	72.4	1.0						
Arbor Test	04/21/95	1125	147.5	73.4	1.2						
Arbor Test	10/10/96	1039	155.0	72.2	10.8	154.7	72.7	12.2	3.8	1.8	1.0
Arbor Test	10/10/96	1047	159.2	75.2	13.2						
Arbor Test	10/10/96	1051	150.0	70.7	12.6						
Area II	07/19/94	0926	83.5	38.8	6.3	81.2	40.1	3.0	2.3	1.4	2.6
Area II	07/19/94	0933	82.0	39.6	2.7						
Area II	07/19/94	0940	78.0	42.0	0.0						
Area II	07/18/96	0739	99.8	44.5	3.2	98.5	43.5	4.7	2.8	0.7	1.1
Area II	07/18/96	0746	101.1	43.4	5.2						
Area II	07/18/96	0749	94.6	42.7	5.7						
Atomic City	10/03/94	1135	268.2	138.7	31.8	271.5	137.5	32.5	7.3	1.8	2.3
Atomic City	10/03/94	1155	264.6	138.8	30.1						
Atomic City	10/03/94	1158	281.6	135.0	35.6						
Atomic City	10/09/96	1244	295.6	146.3	31.6	286.1	144.9	34.6	11.4	1.5	2.6
Atomic City	10/09/96	1254	270.1	142.8	34.2						
Atomic City	10/09/96	1258	292.6	145.7	38.0						

Table 2. Concentration of chlorofluorocarbons in ground water in and near the Idaho National Engineering and Environmental Laboratory--continued

Well name	Sampling date	Sampling time	Concentration in water CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Average concentration CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Population STD CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)
BFW	07/16/96	1034	277.3	232.8	ERR	323.4	262.1	ERR	66.0	43.1	ERR
BFW	07/16/96	1042	276.1	230.6	ERR						
BFW	07/16/96	1045	416.7	323.0	92.4						
CFA 1	07/16/96	0954	1891.0	44730.7	446.5	1856.6	42027.3	476.6	172.9	4060.2	49.7
CFA 1	07/16/96	1001	2049.0	45062.6	436.7						
CFA 1	07/16/96	1005	1629.8	36288.4	546.6						
CFA 2	07/16/96	0904	1646.6	192.9	336.9	2861.7	26423.6	831.6	1027.6	15161.6	306.7
CFA 2	07/16/96	0907	3720.5	34804.2	844.2						
CFA 2	07/16/96	0911	4026.3	34374.3	985.5						
CFA 2	07/16/96	0915	2053.2	36323.1	1159.7						
EBR I	10/16/96	1206	1.0	234.4	0.0	0.9	226.5	0.0	0.0	7.9	0.0
EBR I	10/16/96	1214	0.9	218.6	0.0						
Fire Station 2	10/16/96	1024	957.4	86.0	75.0	899.3	80.3	79.1	65.2	6.0	10.4
Fire Station 2	10/16/96	1032	932.4	82.9	68.8						
Fire Station 2	10/16/96	1036	808.2	71.9	93.4						
IET 1 Disposal	07/18/94	1236	21.3	119.4	9.3	26.7	124.2	3.1	8.0	4.5	4.4
IET 1 Disposal	07/18/94	1242	38.1	130.2	0.0						
IET 1 Disposal	07/18/94	1300	20.8	123.0	0.0						
IET 1 Disposal	07/18/96	1547	19.1	123.5	0.0	20.6	128.6	0.0	1.0	9.8	0.0
IET 1 Disposal	07/18/96	1549	20.0	122.3	0.0						
IET 1 Disposal	07/18/96	1554	21.8	148.2	0.0						
IET 1 Disposal	07/18/96	1622	20.9	124.2	0.0						
IET 1 Disposal	07/18/96	1640	21.4	125.0	0.0						
INEL 1 WS	06/12/95	1115	563.0	88.3	39.2	576.0	77.1	16.4	9.7	7.9	16.2
INEL 1 WS	06/12/95	1125	578.6	72.0	6.8						
INEL1 WS	06/12/95	1130	586.4	71.0	3.3						
Leo Rogers 1	07/17/96	1318	132.4	73.9	20.6	128.9	72.8	15.7	3.7	1.4	3.6
Leo Rogers 1	07/17/96	1326	130.6	73.7	14.8						
Leo Rogers 1	07/17/96	1329	123.8	70.8	11.8						
NPR Test	04/17/95	1700	507.8	27.7	9.8	508.0	32.1	8.6	0.2	4.4	1.2
NPR Test	04/17/95	1710	508.2	36.5	7.4						
NPR Test	10/10/96	1454	356.3	28.3	12.9	352.0	27.8	16.7	11.7	0.4	7.0
NPR Test	10/10/96	1502	363.7	27.5	10.8						
NPR Test	10/10/96	1506	336.0	27.6	26.6						
PSTF Test	10/13/94	1528	115.4	69.9	11.8	114.9	62.6	12.1	1.0	5.2	3.4
PSTF Test	10/13/94	1540	113.5	58.5	16.3						
PSTF Test	10/13/94	1544	115.7	59.4	8.1						
PSTF Test	10/14/96	1359	128.2	65.5	7.3	126.1	64.1	9.0	2.1	1.0	1.2
PSTF Test	10/14/96	1407	126.8	63.2	9.8						
PSTF Test	10/14/96	1411	123.2	63.5	9.9						
P&W 2	10/25/94	1011	402.0	202.4	43.1	390.2	192.6	42.8	13.2	7.2	2.5
P&W 2	10/25/94	1017	396.7	190.2	45.7						
P&W 2	10/25/94	1023	371.7	185.3	39.5						
P&W 2	04/19/95	1244	653.5	291.9	74.5	615.6	281.5	73.1	32.7	9.8	4.0
P&W 2	04/19/95	1249	619.7	268.4	67.7						
P&W 2	04/19/95	1253	573.8	284.0	77.2						

Table 2. Concentration of chlorofluorocarbons in ground water in and near the Idaho National Engineering and Environmental Laboratory--continued

Well name	Sampling date	Sampling time	Concentration in water CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Average concentration CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Population STD CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)
P&W 2	10/15/96	1132	466.6	222.0	55.1	451.4	213.7	54.4	16.2	8.3	0.8
P&W 2	10/15/96	1140	458.7	216.8	53.3						
P&W 2	10/15/96	1144	428.9	202.4	54.8						
RWMC M3S	07/22/96	1118	3248.2	1728.6	8192.4	2566.3	7413.2	7783.3	715.7	4019.7	292.6
RWMC M3S	07/22/96	1126	2873.0	10272.9	7631.9						
RWMC M3S	07/22/96	1129	1577.6	10238.2	7525.5						
RWMC M7S	07/22/96	1023	4503.8	1609.3	13222.0	3670.4	1664.4	12993.5	1244.7	157.5	484.4
RWMC M7S	07/22/96	1031	4596.4	1505.1	13438.6						
RWMC M7S	07/22/96	1034	1910.9	1878.8	12320.0						
Site 04	10/06/96	1402	347.6	43.0	13.6	336.6	41.4	18.6	11.0	1.5	5.0
Site 04	10/06/96	1406	325.7	39.9	23.6						
Site 09	07/22/96	1223	40.4	17.3	0.0	41.7	16.5	1.0	1.4	0.7	1.4
Site 09	07/22/96	1348	41.2	15.7	0.0						
Site 09	07/22/96	1352	43.6	16.6	3.0						
Site 14	10/13/94	1000	11.2	5.4	0.0	10.7	5.2	0.0	2.0	0.2	0.0
Site 14	10/13/94	1012	8.0	5.3	0.0						
Site 14	10/13/94	1016	12.8	5.0	0.0						
Site 14	10/14/96	0849	9.7	7.8	0.0	8.0	6.5	0.0	1.2	2.0	0.0
Site 14	10/14/96	0857	7.0	3.7	0.0						
Site 14	10/14/96	0901	7.4	7.9	0.0						
Site 17	06/16/95	1405	233.4	125.3	437.6	231.1	122.0	167.6	1.8	2.3	190.9
Site 17	06/16/95	1415	229.0	120.1	35.6						
Site 17	06/16/95	1420	230.9	120.5	29.7						
Site 19	07/21/94	1458	38.8	12.0	0.0	37.0	12.0	0.9	1.5	0.6	1.5
Site 19	07/21/94	1506	38.2	11.5	0.0						
Site 19	07/21/94	1510	35.3	11.6	0.0						
Site 19	07/21/94	1514	35.8	13.0	3.4						
Site 19	07/16/96	1219	429.4	118.8	24.4	422.7	116.0	28.3	7.0	2.2	3.8
Site 19	07/16/96	1226	425.7	113.6	33.4						
Site 19	07/16/96	1230	413.1	115.5	27.2						
TAN Expl.	10/13/94	1320	6.1	9.2	0.0	6.3	9.7	0.0	0.2	0.4	0.0
TAN Expl.	10/13/94	1332	6.6	10.0	0.0						
TAN Expl.	10/13/94	1536	6.3	9.9	0.0						
TAN Expl.	10/14/96	1205	5.6	5.6	0.0	8.3	9.8	0.0	2.2	3.1	0.0
TAN Expl.	10/14/96	1212	8.7	10.9	0.0						
TAN Expl.	10/14/96	1216	10.8	12.9	0.0						
USGS 001	10/03/94	0948	62.5	34.1	6.1	61.8	35.4	6.0	0.6	1.0	2.6
USGS 001	10/03/94	1020	62.0	36.5	9.2						
USGS 001	10/03/94	1025	60.9	35.5	2.7						
USGS 001	10/09/96	1518	71.2	38.2	6.5	72.3	38.7	8.0	1.0	0.5	3.8
USGS 001	10/09/96	1526	72.0	38.5	4.3						
USGS 001	10/09/96	1529	73.7	39.3	13.2						
USGS 002	07/19/94	1124	127.8	64.0	6.7	129.6	64.9	9.6	1.3	0.8	2.6
USGS 002	07/19/94	1133	130.9	64.9	9.1						
USGS 002	07/19/94	1142	130.1	65.9	13.0						

Table 2. Concentration of chlorofluorocarbons in ground water in and near the Idaho National Engineering and Environmental Laboratory--continued

Well name	Sampling date	Sampling time	Concentration in water CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Average concentration CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Population STD CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)
USGS 002	07/17/96	1532	160.0	76.0	10.6	156.3	73.7	10.1	4.0	1.7	1.4
USGS 002	07/17/96	1539	158.2	73.1	11.5						
USGS 002	07/17/96	1543	150.7	72.1	8.3						
USGS 004	10/24/94	1412	440.3	265.3	13.1	447.4	259.1	18.4	12.7	4.5	7.0
USGS 004	10/24/94	1440	465.3	257.5	28.3						
USGS 004	10/24/94	1447	436.8	254.7	13.9						
USGS 004	04/19/95	1455	447.4	284.0	24.1	444.8	281.7	25.5	2.7	1.6	4.2
USGS 004	04/19/95	1505	441.1	281.0	21.2						
USGS 004	04/19/95	1510	445.8	280.2	31.2						
USGS 004	10/15/96	1724	456.9	228.6	19.1	467.8	250.8	25.7	26.1	25.8	5.3
USGS 004	10/15/96	1732	503.9	287.0	32.1						
USGS 004	10/15/96	1736	442.7	236.8	25.8						
USGS 005	10/12/94	1300	111.6	69.3	16.7	109.1	65.0	15.6	1.8	3.9	3.7
USGS 005	10/12/94	1312	107.9	59.9	19.5						
USGS 005	10/12/94	1316	107.9	65.9	10.6						
USGS 005	10/10/96	1658	72.8	43.5	9.7	75.8	44.4	9.2	4.9	2.9	1.6
USGS 005	10/10/96	1702	72.1	41.3	7.0						
USGS 005	10/10/96	1706	82.7	48.3	10.9						
USGS 006	07/19/94	1456	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
USGS 006	07/19/94	1505	0.0	0.0	0.0						
USGS 006	07/19/94	1514	0.0	0.0	0.0						
USGS 006	07/18/96	1301	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
USGS 006	07/18/96	1304	0.0	0.0	0.0						
USGS 006	07/18/96	1308	0.0	0.0	0.0						
USGS 007	10/14/94	0930	0.0	0.0	3.3	0.0	0.0	1.6	0.0	0.0	1.6
USGS 007	10/14/94	0945	0.0	0.0	0.0						
USGS 007	10/14/96	1804	1.0	2.0	0.0	1.1	0.7	0.0	0.3	0.9	0.0
USGS 007	10/14/96	1812	1.5	0.0	0.0						
USGS 007	10/14/96	1817	0.8	0.0	0.0						
USGS 008	10/04/94	1010	79.9	96.6	10.0	76.0	95.7	24.7	3.1	1.2	23.6
USGS 008	10/04/94	1022	72.4	93.9	58.0						
USGS 008	10/04/94	1026	75.6	96.5	6.1						
USGS 008	10/08/96	1315	87.8	112.8	4.7	87.5	112.4	7.9	0.3	1.1	4.3
USGS 008	10/08/96	1322	87.5	113.4	5.0						
USGS 008	10/08/96	1325	87.1	110.9	14.0						
USGS 009	10/04/94	1355	288.4	201.2	47.4	226.7	180.8	42.9	35.6	12.6	3.6
USGS 009	10/04/94	1404	205.1	166.7	45.4						
USGS 009	10/04/94	1408	205.0	176.9	40.2						
USGS 009	10/04/94	1413	208.4	178.6	38.7						
USGS 009	04/20/95	1442	205.5	197.7	40.1	200.7	180.6	38.6	3.7	12.7	3.8
USGS 009	04/20/95	1446	203.2	187.6	42.8						
USGS 009	04/20/95	1450	196.8	165.8	32.5						
USGS 009	04/20/95	1454	197.5	171.1	38.9						

Table 2. Concentration of chlorofluorocarbons in ground water in and near the Idaho National Engineering and Environmental Laboratory--continued

Well name	Sampling date	Sampling time	Concentration in water CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Average concentration CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Population STD CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)
USGS 009	10/11/96	1304	546.5	276.9	72.2	333.8	198.0	58.6	150.5	55.8	14.8
USGS 009	10/11/96	1312	231.1	160.8	38.0						
USGS 009	10/11/96	1316	223.6	156.3	65.6						
USGS 011	04/20/95	1129	107.7	98.0	27.3	108.6	99.7	29.4	1.5	1.4	4.0
USGS 011	04/20/95	1137	110.8	101.4	25.9						
USGS 011	04/20/95	1141	107.4	99.7	35.0						
USGS 011	10/09/96	0833	113.9	119.0	39.8	112.8	116.3	39.3	1.2	2.4	1.8
USGS 011	10/09/96	0840	113.3	116.9	36.9						
USGS 011	10/09/96	0845	111.1	113.1	41.3						
USGS 012	10/27/94	1330	218.2	95.7	11.6	222.2	95.9	15.0	3.7	3.4	2.6
USGS 012	10/27/94	1401	221.3	100.1	15.4						
USGS 012	10/27/94	1407	227.0	91.9	17.8						
USGS 012	06/14/95	1520	228.8	101.5	10.5	229.6	98.9	10.9	0.7	2.6	0.4
USGS 012	06/14/95	1535	230.3	96.3	11.3						
USGS 014	10/26/94	1000	169.6	236.8	17.2	170.5	240.8	18.7	0.7	6.6	2.4
USGS 014	10/26/94	1022	170.4	235.5	22.1						
USGS 014	10/26/94	1036	171.4	250.1	16.9						
USGS 014	10/09/96	1016	188.8	236.0	24.4	184.2	231.6	23.2	5.9	3.2	3.6
USGS 014	10/09/96	1024	188.0	228.7	18.2						
USGS 014	10/09/96	1027	175.8	230.0	26.8						
USGS 015	06/14/95	1220	12.3	8.1	2.5	12.0	8.8	0.8	0.3	1.0	1.2
USGS 015	06/14/95	1230	12.0	10.2	0.0						
USGS 015	06/14/95	1235	11.6	8.0	0.0						
USGS 017	10/27/94	1005	45.2	18.6	3.6	44.1	19.1	2.8	1.1	0.5	0.7
USGS 017	10/27/94	1020	43.1	19.5	2.1						
USGS 017	06/13/95	1440	48.4	25.1	1.2	48.2	21.2	1.9	0.6	3.1	2.0
USGS 017	06/13/95	1450	48.9	20.8	0.0						
USGS 017	06/13/95	1455	47.3	17.6	4.6						
USGS 018	07/18/94	1451	16.3	8.9	0.0	15.3	11.3	0.0	0.9	2.2	0.0
USGS 018	07/18/94	1458	15.6	14.3	0.0						
USGS 018	07/18/94	1506	14.2	10.8	0.0						
USGS 018	07/19/96	1629	19.3	16.3	0.0	21.9	14.5	1.2	4.0	2.3	1.7
USGS 018	07/19/96	1636	18.9	11.2	3.6						
USGS 018	07/19/96	1641	27.6	15.9	0.0						
USGS 019	10/25/94	1227	153.4	101.9	47.7	232.7	133.6	38.4	108.8	42.0	10.5
USGS 019	10/25/94	1052	158.2	106.0	23.8						
USGS 019	10/25/94	1259	386.5	193.0	43.7						
USGS 019	04/19/95	1055	155.2	102.7	23.6	160.4	105.4	14.5	5.7	2.7	8.4
USGS 019	04/19/95	1058	166.8	108.7	8.7						
USGS 019	04/19/95	1102	154.4	102.6	21.9						
USGS 019	04/19/95	1106	165.3	107.6	3.8						

Table 2. Concentration of chlorofluorocarbons in ground water in and near the Idaho National Engineering and Environmental Laborator --continued

Well name	Sampling date	Sampling time	Concentration in water CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Average concentration CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Population STD CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)
USGS 019	10/15/96	0953	164.3	110.8	22.3	162.1	105.3	25.6	4.0	8.4	3.0
USGS 019	10/15/96	0957	165.6	111.7	29.6						
USGS 019	10/15/96	1001	156.4	93.5	24.9						
USGS 022	06/13/95	0940	31.0	36.0	15.5	34.9	34.7	12.0	3.6	0.9	2.7
USGS 022	06/13/95	0950	34.0	34.2	9.1						
USGS 022	06/13/95	0955	39.8	34.0	11.2						
USGS 022	07/18/96	1031	161.0	99.1	20.0	157.3	97.7	20.6	7.3	2.1	0.6
USGS 022	07/18/96	1038	163.9	99.3	21.4						
USGS 022	07/18/96	1042	147.2	94.7	20.3						
USGS 023	10/25/94	1515	193.7	105.4	23.7	193.2	104.1	23.5	3.6	1.6	0.7
USGS 023	10/25/94	1533	197.4	105.1	24.1						
USGS 023	10/25/94	1538	188.5	101.8	22.5						
USGS 023	04/19/95	0855	198.3	108.1	19.9	97.6	109.4	21.2	72.7	2.2	0.9
USGS 023	04/19/95	0900	29.3	107.7	21.6						
USGS 023	04/19/95	0905	65.1	112.4	22.1						
USGS 023	10/15/96	0824	220.2	114.1	27.1	216.5	111.7	24.4	4.9	3.0	2.1
USGS 023	10/15/96	0832	219.8	113.5	21.8						
USGS 023	10/15/96	0836	209.5	107.5	24.4						
USGS 026	10/14/94	1310	82.7	40.6	8.4	56.0	37.5	9.2	39.3	5.4	2.3
USGS 026	10/14/94	1322	0.4	30.0	12.4						
USGS 026	10/14/94	1326	84.9	42.0	6.9						
USGS 026	10/15/96	1313	81.8	46.0	8.4	85.2	44.3	12.4	2.5	1.3	5.5
USGS 026	10/15/96	1317	87.9	44.0	8.5						
USGS 026	10/15/96	1321	85.9	42.9	20.2						
USGS 027	10/11/94	0938	38.9	22.1	3.8	37.1	22.3	3.0	2.8	0.4	2.2
USGS 027	10/11/94	0950	33.1	22.8	5.4						
USGS 027	10/11/94	0954	39.3	22.1	0.0						
USGS 027	10/15/96	1454	41.5	24.7	2.2	41.4	22.5	0.7	0.4	2.6	1.1
USGS 027	10/15/96	1458	41.8	23.8	0.0						
USGS 027	10/15/96	1502	40.8	18.8	0.0						
USGS 029	10/11/94	1449	173.0	79.2	14.2	170.5	77.1	13.4	2.1	2.1	2.3
USGS 029	10/11/94	1502	167.7	74.3	15.7						
USGS 029	10/11/94	1506	170.9	78.0	10.2						
USGS 029	06/15/95	1220	185.8	81.9	8.6	185.9	83.0	10.8	0.2	2.5	1.6
USGS 029	06/15/95	1230	185.8	80.6	11.7						
USGS 029	06/15/95	1235	186.2	86.5	12.1						
USGS 029	07/19/96	1439	199.3	97.3	17.1	224.6	106.6	17.1	36.2	11.7	3.5
USGS 029	07/19/96	1446	198.7	99.4	12.9						
USGS 029	07/19/96	1450	275.8	123.1	21.4						
USGS 031	10/11/94	1130	33.8	19.9	0.0	34.9	20.0	0.0	1.1	0.2	0.0
USGS 031	10/11/94	1142	34.6	20.2	0.0						
USGS 031	10/11/94	1146	36.3	19.8	0.0						

Table 2. Concentration of chlorofluorocarbons in ground water in and near the Idaho National Engineering and Environmental Laboratory--continued

Well name	Sampling date	Sampling time	Concentration in water CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Average concentration CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Population STD CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)
USGS 031	06/15/95	0900	38.8	22.3	2.2	37.9	20.8	2.7	0.7	1.1	0.5
USGS 031	06/15/95	0910	37.6	20.6	2.6						
USGS 031	06/15/95	0915	37.3	19.6	3.3						
USGS 031	07/19/96	1150	42.9	23.2	0.0	43.0	23.3	3.7	1.9	0.5	5.2
USGS 031	07/19/96	1156	45.4	22.8	11.0						
USGS 031	07/19/96	1200	40.7	23.9	0.0						
USGS 032	10/11/94	1309	61.5	50.0	9.3	65.7	48.1	7.0	3.1	1.4	1.7
USGS 032	10/11/94	1317	67.4	47.0	6.1						
USGS 032	10/11/94	1321	68.4	47.2	5.6						
USGS 032	06/15/95	1035	66.9	47.9	7.2	65.3	46.8	6.5	1.2	1.2	0.9
USGS 032	06/15/95	1045	64.6	45.1	7.0						
USGS 032	06/15/95	1050	64.3	47.4	5.3						
USGS 032	07/19/96	1311	70.4	48.1	0.0	72.9	48.2	2.3	3.9	2.4	3.3
USGS 032	07/19/96	1319	69.8	45.4	0.0						
USGS 032	07/19/96	1322	78.5	51.2	6.9						
USGS 036	07/16/96	1518	594.9	38741.1	139.1	590.5	35415.8	120.6	10.9	2777.9	17.9
USGS 036	07/16/96	1526	601.1	35564.8	126.5						
USGS 036	07/16/96	1530	575.6	31941.6	96.3						
USGS 037	10/07/94	1122	477.4	57561.2	205.1	483.8	55372.7	218.4	8.2	3888.4	18.0
USGS 037	10/07/94	1132	495.4	49909.6	243.8						
USGS 037	10/07/94	1140	478.7	58647.3	206.3						
USGS 065	10/12/94	0952	1004.7	45531.8	227.0	1043.3	43647.2	243.2	76.4	1590.8	17.0
USGS 065	10/12/94	0956	1005.3	44790.4	268.3						
USGS 065	10/12/94	1016	988.0	42716.3	228.1						
USGS 065	10/12/94	1015	1175.1	41550.3	249.4						
USGS 076	10/12/94	1308	667.2	1985.7	46.6	652.1	1955.4	44.9	16.5	26.4	3.1
USGS 076	10/12/94	1320	629.1	1921.2	47.6						
USGS 076	10/12/94	1324	659.9	1959.3	40.5						
USGS 077	10/07/94	0938	250.4	52389.8	ERR	250.0	49339.5	ERR	1.2	3255.5	ERR
USGS 077	10/07/94	0954	251.3	44827.9	125.7						
USGS 077	10/07/94	0958	248.4	50800.9	ERR						
USGS 082	07/16/96	1418	53.6	2925.1	6.0	54.8	2830.0	4.5	1.0	341.0	1.1
USGS 082	07/16/96	1422	55.0	2373.1	3.3						
USGS 082	07/16/96	1430	56.0	3192.0	4.3						
USGS 083	04/17/95	1509	8.1	4.6	0.0	9.3	6.3	1.3	0.9	1.6	1.9
USGS 083	04/17/95	1515	9.6	8.4	0.0						
USGS 083	04/17/95	1520	10.3	6.0	3.9						
USGS 086	10/04/94	1155	38.8	18.1	5.7	46.1	23.1	7.6	6.3	3.8	2.5
USGS 086	10/04/94	1208	45.6	24.0	11.2						
USGS 086	10/04/94	1213	54.1	27.1	6.0						
USGS 086	10/11/96	1452	578.9	302.7	85.4	251.8	129.4	51.2	232.9	123.0	34.7
USGS 086	10/11/96	1504	121.7	56.0	64.5						
USGS 086	10/11/96	1512	54.6	29.5	3.6						

Table 2. Concentration of chlorofluorocarbons in ground water in and near the Idaho National Engineering and Environmental Laboratory--continued

Well name	Sampling date	Sampling time	Concentration in water CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Average concentration CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Population STD CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)
USGS 089	10/07/94	1402	86.9	9716.4	160.1	83.1	9617.3	155.7	5.7	191.8	10.7
USGS 089	10/07/94	1418	87.4	9786.4	165.9						
USGS 089	10/07/94	1422	75.1	9349.1	141.0						
USGS 089	07/17/96	0922	145.0	876.9	156.7	132.6	920.4	132.2	8.9	43.6	17.4
USGS 089	07/17/96	0929	127.9	964.0	120.3						
USGS 089	07/17/96	0933	124.8	ERR	119.4						
USGS 097	06/13/95	1120	4523.9	124.9	83.0	4255.9	122.1	71.1	203.3	2.1	8.4
USGS 097	06/13/95	1130	4212.3	121.5	64.7						
USGS 097	06/13/95	1135	4031.6	120.0	65.8						
USGS 098	06/12/95	1240	540.5	80.1	76.6	578.0	81.8	36.7	26.7	2.4	29.0
USGS 098	06/12/95	1250	593.4	80.1	8.9						
USGS 098	06/12/95	1255	600.2	85.2	24.5						
USGS 099	06/12/95	1432	4160.6	148.6	68.1	4249.6	151.9	70.8	112.6	4.2	4.8
USGS 099	06/12/95	1440	4433.6	148.7	78.6						
USGS 099	06/12/95	1445	4155.0	159.0	65.9						
USGS 099	06/12/95	1450	4249.1	151.3	70.5						
USGS 100	04/21/95	1245	166.4	74.7	12.4	164.3	72.8	14.3	4.1	1.7	2.1
USGS 100	04/21/95	1250	158.6	73.1	17.3						
USGS 100	04/21/95	1255	167.9	70.5	13.3						
USGS 100	10/10/96	1158	181.3	75.3	13.9	175.4	74.7	16.2	4.9	1.9	3.4
USGS 100	10/10/96	1204	175.3	76.6	13.8						
USGS 100	10/10/96	1208	169.4	72.1	21.0						
USGS 101	04/21/95	1405	44.3	27.6	3.4	45.5	18.5	1.1	0.8	11.4	1.6
USGS 101	04/21/95	1415	46.0	25.5	0.0						
USGS 101	04/21/95	1420	46.0	2.4	0.0						
USGS 101	10/10/96	1319	48.2	26.4	3.1	47.6	26.8	3.4	2.1	0.4	0.5
USGS 101	10/10/96	1323	44.7	26.8	4.1						
USGS 101	10/10/96	1331	49.8	27.3	3.0						
USGS 102	06/13/95	1240	6151.3	131.1	148.5	5795.6	140.8	279.7	276.1	9.7	187.4
USGS 102	06/13/95	1245	5757.6	150.5	145.8						
USGS 102	06/13/95	1250	5478.1	ERR	544.8						
USGS 103	07/20/94	1231	137.2	119.5	8.4	95.5	121.0	10.1	59.8	1.2	2.0
USGS 103	07/20/94	1235	11.0	120.9	12.8						
USGS 103	07/20/94	1239	138.3	122.5	9.0						
USGS 103	04/18/95	1113	134.8	125.4	7.8	136.4	125.3	10.7	1.7	0.7	3.5
USGS 103	04/18/95	1117	135.5	124.4	15.6						
USGS 103	04/18/95	1121	138.8	126.1	8.5						
USGS 103	07/15/96	1133	258.5	182.5	34.3	246.6	170.7	31.0	9.9	8.3	2.9
USGS 103	07/15/96	1141	247.3	165.2	31.6						
USGS 103	07/15/96	1145	234.1	164.5	27.2						
USGS 104	07/20/94	0952	131.4	21391.6	45.4	131.0	21546.0	43.6	0.3	162.6	1.4
USGS 104	07/20/94	0958	130.5	21475.5	43.2						
USGS 104	07/20/94	1004	131.1	21770.8	42.1						

Table 2. Concentration of chlorofluorocarbons in ground water in and near the Idaho National Engineering and Environmental Laboratory--continued

Well name	Sampling date	Sampling time	Concentration in water CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Average concentration CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Population STD CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)
USGS 104	04/18/95	0907	103.9	20540.3	38.9	172.6	9657.9	30.7	172.6	8402.9	22.1
USGS 104	04/18/95	0911	409.7	8351.3	52.7						
USGS 104	04/18/95	0925	4.0	82.2	0.5						
USGS 104	07/15/96	0947	124.7	3294.4	42.8	122.2	7712.8	37.8	2.5	6249.2	7.2
USGS 104	07/15/96	0955	123.0	3293.5	43.1						
USGS 104	07/15/96	0959	118.9	16550.4	27.6						
USGS 105	10/03/94	1445	503.3	2296.0	1041.0	514.1	2301.8	1031.8	21.5	105.1	19.7
USGS 105	10/03/94	1500	544.1	2433.3	1049.9						
USGS 105	10/03/94	1505	494.8	2176.0	1004.4						
USGS 105	04/18/95	1535	512.4	2472.6	961.8	457.4	2626.1	1028.8	39.8	119.4	61.1
USGS 105	04/18/95	1129	419.9	2763.8	1015.0						
USGS 105	04/18/95	1545	439.9	2641.9	1109.5						
USGS 106	10/05/94	1227	342.2	8578.1	30.0	340.1	8593.4	32.6	1.9	14.6	2.8
USGS 106	10/05/94	1242	340.5	8613.0	31.3						
USGS 106	10/05/94	1246	337.5	8589.1	36.6						
USGS 107	10/05/94	0955	112.0	80.6	13.4	100.3	73.1	11.5	14.1	10.3	2.1
USGS 107	10/05/94	1007	108.5	80.1	12.5						
USGS 107	10/05/94	1011	80.4	58.5	8.6						
USGS 107	10/09/96	1659	120.6	89.0	12.4	121.2	90.5	11.4	1.5	2.1	2.1
USGS 107	10/09/96	1707	123.3	93.6	13.3						
USGS 107	10/09/96	1711	119.6	89.0	8.6						
USGS 108	10/03/94	1700	126.2	650.4	0.0	126.9	657.4	3.7	3.1	9.6	5.2
USGS 108	10/03/94	1728	131.1	671.0	11.1						
USGS 108	10/03/94	1735	123.5	650.8	0.0						
USGS 108	04/18/95	1340	126.3	642.0	8.4	128.8	654.8	8.5	3.3	10.3	0.9
USGS 108	04/18/95	1345	133.5	667.4	7.4						
USGS 108	04/18/95	1350	126.8	655.1	9.7						
USGS 109	10/04/94	1555	304.3	791.0	455.8	321.4	802.7	443.6	12.3	8.2	13.5
USGS 109	10/04/94	1607	333.0	808.5	424.8						
USGS 109	10/04/94	1612	326.9	808.4	450.2						
USGS 109	04/20/95	1327	342.8	904.0	546.6	346.3	898.7	514.3	13.7	16.7	31.0
USGS 109	04/20/95	1338	331.6	916.0	523.9						
USGS 109	04/20/95	1342	364.6	876.2	472.5						
USGS 109	10/11/96	1142	382.9	1007.0	520.1	411.6	1005.1	553.4	64.7	16.0	23.8
USGS 109	10/11/96	1150	501.1	1023.7	565.3						
USGS 109	10/11/96	1154	350.7	984.6	574.7						
USGS 110A	10/09/96	1414	143.1	79.8	10.6	144.1	78.3	18.5	0.8	1.1	8.0
USGS 110A	10/09/96	1421	145.1	78.1	15.4						
USGS 110A	10/09/96	1425	144.2	77.1	29.5						
USGS 112	07/15/96	1304	467.1	45501.9	277.4	463.5	48253.3	244.8	11.6	2957.5	79.4
USGS 112	07/15/96	1310	475.5	46900.9	321.4						
USGS 112	07/15/96	1315	447.8	52357.1	135.4						

Table 2. Concentration of chlorofluorocarbons in ground water in and near the Idaho National Engineering and Environmental Laboratory--continued

Well name	Sampling date	Sampling time	Concentration in water CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Average concentration CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Population STD CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)
USGS 113	07/16/96	1605	408.6	6811.3	ERR	398.9	19501.6	ERR	13.5	17749.9	ERR
USGS 113	07/16/96	1612	408.3	7090.1	ERR						
USGS 113	07/16/96	1616	379.9	44603.3	130.3						
USGS 115	07/15/96	1503	172.2	28744.7	57.6	203.3	24043.8	40.8	22.1	3866.7	14.0
USGS 115	07/15/96	1507	222.0	24112.8	41.4						
USGS 115	07/15/96	1511	215.8	19273.9	23.2						
USGS 116	07/15/96	1601	236.0	1951.9	36.3	218.0	2759.0	35.9	16.1	659.2	10.5
USGS 116	07/15/96	1608	221.0	2758.6	48.6						
USGS 116	07/15/96	1612	196.9	3566.6	22.9						
USGS 117	10/05/94	1530	56.2	25.1	14.3	55.6	25.3	14.1	1.8	1.5	2.3
USGS 117	10/05/94	1541	57.4	27.3	16.9						
USGS 117	10/05/94	1546	53.2	23.7	11.2						
USGS 117	07/17/96	0804	20.8	12.2	0.0	18.5	9.1	1.3	1.8	2.6	1.8
USGS 117	07/17/96	0810	18.1	9.1	0.0						
USGS 117	07/17/96	0814	16.4	5.9	3.8						
USGS 119	10/06/94	1336	381.8	749.3	2780.2	384.4	743.8	2649.3	2.6	5.6	131.0
USGS 119	10/06/94	1340	387.0	738.2	2518.3						
USGS 120	10/06/94	1513	798.9	1401.6	1887.8	823.4	1411.3	1833.3	44.1	32.1	40.6
USGS 120	10/06/94	1528	785.9	1377.8	1821.6						
USGS 120	10/06/94	1532	885.4	1454.5	1790.4						
USGS 120	07/17/96	1033	1293.1	1484.2	3610.2	1163.1	1513.4	3404.3	147.6	21.1	253.6
USGS 120	07/17/96	1040	1239.6	1522.7	3555.8						
USGS 120	07/17/96	1044	956.7	1533.5	3047.0						
USGS 121	10/24/94	1019	381.9	12783.1	18.1	424.3	7059.6	45.2	251.3	4207.1	19.6
USGS 121	10/24/94	1027	139.9	2790.6	63.6						
USGS 121	10/24/94	1046	751.0	5605.1	54.0						
USGS 124	07/20/94	1421	116.4	1823.4	51.0	114.2	1807.8	52.8	1.6	11.1	2.3
USGS 124	07/20/94	1429	112.6	1798.2	51.4						
USGS 124	07/20/94	1437	113.7	1801.8	56.0						
USGS 124	04/20/95	0915	117.7	1813.8	ERR	117.4	1787.9	ERR	0.3	25.9	ERR
USGS 124	04/20/95	0925	117.0	1762.0	ERR						
USGS 124	04/20/95	0930	119.4	1822.6	54.0						
USGS 124	10/09/96	1135	115.2	1522.4	37.9	116.4	1587.2	40.5	1.8	47.4	1.9
USGS 124	10/09/96	1143	119.0	1605.0	41.1						
USGS 124	10/09/96	1147	115.1	1634.4	42.5						
USGS 125	06/06/95	1155	223.4	423.1	263.5	225.9	434.5	247.4	4.6	28.4	19.4
USGS 125	06/16/95	1205	222.0	406.9	220.1						
USGS 125	06/16/95	1210	232.4	473.6	258.6						
USGS 125	10/11/96	1004	247.6	470.5	276.0	237.1	458.4	266.2	9.0	17.1	7.1
USGS 125	10/11/96	1016	225.5	470.5	263.4						
USGS 125	10/11/96	1024	238.2	434.2	259.2						

Table 3. Concentration of sulfur hexafluoride (SF_6) in ground water from the Snake River Plain aquifer in and near at the Idaho National Engineering and Environmental Laboratory.

[Location of wells is shown in figures 1, 2 and 3. The volume of water processed is given in liters. STD, standard deviation; fmol/L, femtomole per liter; HS, headspace extraction of SF_6; P&T, purge and trap extraction of SF_6; Field, field processed sample; Lab., laboratory processed sample; ----, not determined]

Well name	Date sampled	SF_6 (fmol/L)	Population STD	Number of replicates	Water volume	Extraction procedure	Location of processing
ANP 6	06/15/95	0.18	0.00	2	4	HS	Field
ANP 9	10/14/96	.59	----	1	1	P&T	Lab.
Arbor Test	04/21/95	.22	----	1	4	HS	Field
Arbor Test	10/10/96	.61	----	1	1	P&T	Lab.
Atomic City	10/09/96	.72	----	1	1	P&T	Lab.
EBR I	10/16/96	.81	----	1	1	P&T	Lab.
Fire Station 2	10/16/96	.06	----	1	1	P&T	Lab.
INEL 1 WS	06/12/95	.15	.01	2	4	HS	Field
NPR Test	04/17/95	2.83	----	1	4	HS	Field
NPR Test	10/10/96	1.52	----	1	1	P&T	Lab.
P&W 2	10/25/94	.61	----	1	1	P&T	Field
P&W 2	04/19/95	.61	----	1	4	HS	Field
P&W 2	10/15/96	.46	----	1	1	P&T	Lab.
Site 04	10/16/96	.29	----	1	1	P&T	Lab.
Site 14	10/14/96	3.40	----	1	1	P&T	Lab.
Site 17	06/17/95	.77	.01	3	4	HS	Field
TAN Expl.	10/14/96	.02	----	1	1	P&T	Lab.
USGS 001	10/09/96	.42	----	1	1	P&T	Lab.
USGS 004	10/24/94	.49	----	1	1	P&T	Field
USGS 004	04/19/95	.27	----	1	4	HS	Field
USGS 004	10/15/96	.23	----	1	1	P&T	Lab.
USGS 005	10/10/96	.80	----	1	1	P&T	Lab.
USGS 007	10/14/96	17.83	----	1	1	P&T	Lab.
USGS 008	10/08/96	.73	.06	2	1	P&T	Lab.
USGS 009	04/20/95	.30	----	1	4	HS	Field
USGS 009	10/11/96	.29	----	1	1	P&T	Lab.
USGS 011	04/20/95	.67	----	1	4	HS	Field
USGS 011	10/09/96	.36	----	1	1	P&T	Lab.
USGS 012	10/27/94	.42	----	1	1	P&T	Field
USGS 012	06/14/95	.11	.01	1	4	HS	Field
USGS 014	10/24/94	.97	----	1	1	P&T	Field
USGS 014	10/09/96	.80	----	1	1	P&T	Lab.
USGS 015	06/14/95	1.70	----	1	4	HS	Field
USGS 017	10/27/94	.06	----	1	1	P&T	Field
USGS 017	06/13/95	.00	----	1	4	HS	Field

Table 3. Concentration of sulfur hexafluoride (SF_6) in ground waters from the Snake River Plain aquifer in and near the Idaho National Engineering and Environmental Laboratory--continued

Well name	Date sampled	SF_6 (fmol/L)	Population STD	Number of replicates	Water volume	Extraction procedure	Location of processing
USGS 018	07/19/96	4.04	0.00	2	1	P&T	Lab.
USGS 019	10/25/94	3.12	----	1	1	P&T	Field
USGS 019	04/19/95	3.99	----	1	4	HS	Field
USGS 019	10/15/96	2.28	----	1	1	P&T	Lab.
USGS 022	06/13/95	.05	.00	2	4	HS	Field
USGS 023	10/25/94	14.62	----	1	1	P&T	Field
USGS 023	04/19/95	8.60	----	1	4	HS	Field
USGS 023	10/15/96	5.21	----	1	1	P&T	Lab.
USGS 026	10/15/96	13.40	----	1	1	P&T	Lab.
USGS 027	10/15/96	.72	.07	2	1	P&T	Lab.
USGS 029	06/15/95	.20	.03	2	4	HS	Field
USGS 031	06/15/95	.38	.03	2	4	HS	Field
USGS 031	10/15/96	.94	.11	2	1	P&T	Lab.
USGS 032	06/15/95	.12	----	1	4	HS	Field
USGS 083	04/17/95	.07	----	1	4	HS	Field
USGS 086	10/11/96	.64	----	1	1	P&T	Lab.
USGS 097	06/13/95	.11	.00	2	4	HS	Field
USGS 098	06/12/95	.13	.01	2	4	HS	Field
USGS 099	06/12/95	.16	----	1	4	HS	Field
USGS 100	04/21/95	.48	----	1	4	HS	Field
USGS 100	10/10/96	.28	----	1	1	P&T	Lab.
USGS 101	04/21/95	.21	.02	2	4	HS	Field
USGS 101	10/10/96	.20	----	1	1	P&T	Lab.
USGS 102	06/13/95	.10	.00	2	4	HS	Field
USGS 103	04/18/95	.32	----	1	4	HS	Field
USGS 104	04/18/95	1.95	----	1	4	HS	Field
USGS 105	04/18/95	.50	----	1	4	HS	Field
USGS 107	10/09/96	.57	.14	2	1	P&T	Lab.
USGS 108	04/18/95	.29	.04	2	4	HS	Field
USGS 109	04/20/95	.47	----	1	4	HS	Field
USGS 109	10/11/96	.43	----	1	1	P&T	Lab.
USGS 110A	10/09/96	.43	----	1	1	P&T	Lab.
USGS 121	10/24/94	.29	----	1	1	P&T	Field
USGS 124	04/20/95	.86	----	1	4	HS	Field
USGS 124	10/09/96	.74	----	1	1	P&T	Lab.
USGS 125	06/16/95	.13	.02	4	4	HS	Field
USGS 125	10/11/96	.33	----	1	1	P&T	Lab.

Table 4. Concentration of dissolved gases in ground waters from the Snake River Plain aquifer in and near the Idaho National Engineering and Environmental Laboratory.

[Location of wells shown in figures 1, 2 and 3. Oxygen and carbon dioxide concentrations change during storage; the estimated concentrations in the ground water are given in parentheses. See text for details. mg/L, milligrams per liter. Symbols: ---, not known]

Well name	Date sampled	Methane (mg/L)	Carbon dioxide (mg/L)	Nitrogen (mg/L)	Oxygen (mg/L)	Argon (mg/L)	Number of replicates
ANP 6	07/19/96	0.000	8.5 (7.0)	15.52	1.6 (4.5)	0.554	1
ANP 9	10/14/96	.002	4.6 (3.0)	18.05	5.2 (8.5)	0.616	1
Arbor Test	04/21/95	.000	3.3 (2.5)	16.63	7.8 (9.0)	0.596	1
Arbor Test	10/10/96	.000	3.2 (2.5)	15.61	6.1 (8.5)	0.569	2
Arco City 4	5/13/97	.000	5.5 (4.5)	18.68	6.5 (9.5)	0.665	2
Area 2	07/18/96	.000	5.0 (3.5)	16.49	3.7 (6.5)	0.551	1
Atomic City	10/09/96	.000	5.9 (4.0)	14.59	1.6 (6.0)	0.540	1
Badging Facility	07/16/96	.000	6.6 (5.0)	15.15	2.3 (5.5)	0.568	2
Big Springs	5/22/97	.000	18 (17)	16.26	7.6 (9.5)	0.598	2
CFA 1	07/16/96	.000	4.4 (4.0)	17.13	9.0 (9.5)	0.614	2
CFA 2	07/16/96	.000	8.7 (7.0)	17.58	3.0 (6.0)	0.602	2
Condie Hot Spr.	5/22/97	.021	52 (52)	11.87	0.9 (0.9)	0.445	1
EBR 1	10/16/96	.000	2.3 (1.0)	17.44	4.7 (8.0)	0.578	2
Engberson	5/14/97	.000	14 (13)	19.48	5.8 (8.0)	0.671	2
Fire Station 2	10/16/96	.000	6.9 (5.0)	16.09	5.1 (8.5)	0.590	1
IET Disposal	01/06/00	.000	6.5 (5.0)	26.75	0.3 (---)	0.750	2
Leo Rogers 1	07/17/96	.000	5.9 (4.5)	14.82	2.3 (5.5)	0.557	2
Lidy Hot Spring	5/14/97	.015	24 (24)	9.39	0.5 (---)	0.392	1
Neville	5/14/97	.000	3.5 (3.0)	16.27	6.6 (9.0)	0.598	2
NPR Test	04/17/95	.003	5.7 (5.0)	18.40	8.3 (8.5)	0.645	1
NPR Test	10/10/96	.001	4.6 (4.0)	17.58	6.2 (8.5)	0.619	2
Pencheri 6	5/13/97	.000	5.8 (5.5)	17.35	8.1 (9.5)	0.635	2
Park Bell	5/21/97	.003	2.7 (2.7)	16.46	0.0 (---)	0.578	2
PSTF Test	10/14/96	.000	4.1 (3.0)	17.27	6.9 (9.0)	0.597	2
P&W 2	04/19/95	.000	4.1 (4.0)	16.73	9.4 (10)	0.636	1
P&W 2	10/15/96	.000	5.9 (4.0)	16.29	6.0 (10)	0.611	1
RWMC M3S	07/22/96	.000	6.7 (5.0)	16.91	2.4 (5.0)	0.583	1
RWMC M7S	07/22/96	.000	5.3 (5.0)	16.08	2.4 (5.0)	0.562	1
Site 04	10/16/96	.000	5.1 (4.0)	16.49	7.0 (8.0)	0.589	2
Site 09	7/22/96	.000	6.1 (5.0)	15.97	0.7 (3.5)	0.585	1
Site 14	10/14/96	.000	4.0 (4.0)	16.50	4.9 (6.5)	0.592	2
Site 19	07/16/96	.000	8.3 (7.0)	14.90	2.1 (5.5)	0.537	1
Squirrel Cemetery	5/21/97	.000	14 (12)	21.40	4.2 (5.5)	0.720	1
TAN Exploration	10/14/96	.000	2.8 (2.5)	29.38	11 (11)	0.934	1
USGS 001	10/09/96	.002	6.4 (---)	15.47	0.8 (---)	0.559	1
USGS 002	07/17/96	.000	8.1 (---)	14.85	0.2 (---)	0.562	1
USGS 004	04/19/95	.000	16 (14)	16.81	7.0 (9.0)	0.615	1
USGS 004	10/15/96	.000	17 (15)	16.67	3.7 (7.0)	0.622	1
USGS 005	10/10/96	.000	5.8 (4.0)	16.50	2.1 (6.0)	0.593	1
USGS 006	07/18/96	.000	4.9 (---)	18.43	0.0 (---)	0.636	1
USGS 007	10/14/96	.000	3.2 (3.0)	16.02	1.2 (4.0)	0.593	2
USGS 008	10/08/96	.002	8.4 (---)	17.02	0.5 (---)	0.602	1
USGS 009	10/11/96	.000	3.8 (2.0)	17.22	4.7 (8.5)	0.619	1

Table 4. Concentration of dissolved gases in ground waters from the Snake River Plain aquifer in and near the Idaho National Engineering and Environmental Laboratory—continued

Well name	Date sampled	Methane (mg/L)	Carbon dioxide (mg/L)	Nitrogen (mg/L)	Oxygen (mg/L)	Argon (mg/L)	Number of replicates
USGS 011	04/20/95	0.000	3.6 (---)	20.14	8.1 (---)	0.687	1
USGS 011	10/09/96	Trace	7.3 (---)	15.93	0.5 (---)	0.583	1
USGS 014	10/09/96	.001	7.6 (6.0)	23.31	2.7 (7.0)	0.679	1
USGS 015	06/14/95	.000	3.6 (3.0)	16.88	5.5 (7.0)	0.636	1
USGS 015	05/13/97	.000	4.3 (3.0)	16.81	6.0 (8.5)	0.629	2
USGS 018	07/19/96	.000	6.2 (5.0)	15.12	1.5 (4.0)	0.561	1
USGS 019	10/15/96	Trace	8.5 (8.0)	13.74	4.6 (5.6)	0.526	2
USGS 022	7/18/96	.000	2.8 (---)	15.32	0.0 (---)	0.524	1
USGS 023	04/19/95	.001	5.2 (4.0)	14.51	6.1 (8.0)	0.541	1
USGS 023	10/15/96	.001	6.7 (4.0)	14.07	3.0 (8.0)	0.526	1
USGS 026	10/15/96	.002	7.2 (6.0)	16.01	3.2 (7.0)	0.579	1
USGS 027	10/15/96	Trace	5.5 (4.0)	17.46	1.9 (5.0)	0.615	1
USGS 029	07/18/96	.000	7.9 (7.0)	16.26	1.5 (4.0)	0.594	1
USGS 031	06/15/95	.000	4.0 (3.5)	16.63	7.0 (8.0)	0.604	1
USGS 031	07/19/96	.000	7.2 (4.0)	15.85	1.4 (8.0)	0.583	1
USGS 032	06/15/95	.000	4.8 (4.0)	15.21	7.5 (8.0)	0.573	1
USGS 032	07/19/96	.000	10 (---)	15.09	0.0 (---)	0.565	1
USGS 036	07/16/96	.000	8.9 (7.0)	15.72	2.1 (5.0)	0.566	1
USGS 082	07/16/96	.000	8.4 (7.0)	19.98	1.5 (5.0)	0.662	1
USGS 083	04/17/95	.003	3.1 (---)	19.42	8.3 (---)	0.670	1
USGS 086	10/11/96	.000	3.0 (---)	24.92	8.5 (---)	0.818	2
USGS 089	07/17/96	.000	3.0 (---)	19.91	0.8 (---)	0.714	2
USGS 097	06/13/95	.000	7.1(7.0)	16.70	8.4 (9.0)	0.601	1
USGS 098	06/12/95	.000	4.9 (4.5)	18.42	9.1 (9.5)	0.643	1
USGS 099	06/12/95	.000	6.8 (6.0)	16.19	8.2 (9.0)	0.595	1
USGS 100	10/10/96	.000	5.0 (3.0)	15.72	3.9 (8.0)	0.580	1
USGS 101	10/10/96	.000	3.9 (2.0)	15.83	4.9 (8.0)	0.579	1
USGS 102	06/13/95	.000	6.9 (6.0)	17.22	8.7 (9.0)	0.613	1
USGS 103	04/18/95	.002	4.5 (3.0)	15.00	6.1 (8.0)	0.566	1
USGS 103	07/15/96	.000	5.5 (4.5)	15.26	1.8 (4.0)	0.501	1
USGS 104	07/15/96	.000	8.1 (---)	49.61	10 (---)	1.168	1
USGS 107	10/09/96	.000	7.2 (5.0)	14.57	1.4 (5.0)	0.539	1
USGS 108	04/18/95	.000	3.8 (3.0)	15.32	8.0 (9.0)	0.575	1
USGS 109	10/11/96	.000	4.5 (3.0)	16.48	5.2 (8.5)	0.603	1
USGS 110A	10/09/96	.000	7.9 (---)	14.68	0.0 (---)	0.541	1
USGS 112	07/15/96	.000	8.2 (6.0)	15.18	2.1 (5.0)	0.561	2
USGS 113	07/16/96	.000	8.0 (5.0)	15.10	2.4 (5.0)	0.549	1
USGS 115	07/15/96	.000	7.8 (6.0)	20.19	2.6 (6.0)	0.675	2
USGS 116	07/15/96	.000	7.7 (6.0)	16.76	1.3 (4.5)	0.584	2
USGS 117	07/17/96	.000	5.4 (---)	18.24	0.7 (---)	0.622	1
USGS 120	07/17/96	.000	6.7 (5.0)	17.12	2.1 (5.0)	0.599	1
USGS 124	04/20/95	.001	5.0 (4.0)	15.84	6.9 (8.0)	0.590	1
USGS 124	10/09/96	.001	7.5 (5.0)	15.82	1.2 (6.0)	0.575	1
USGS 125	6/16/95	.000	3.3 (2.5)	16.60	7.8 (9.0)	0.599	1
USGS 125	10/11/96	.000	5.3 (3.0)	15.88	4.1 (8.)	0.593	1
Wagoner Ranch	5/22/97	.000	9.0 (8.0)	17.45	5.6 (8.5)	0.596	2