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BIOVENTING FEASIBILITY STUDY AT EIELSON AIR FORCE BASE, ALASKA

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14. Abstract This program consisted of two separate, but integrated, projects. The first project consisted of U.S. Air Force-initiated bioventing activities on a JP-4 jet fuel spill at Eielson Air Force Base, Alaska in July 1991. The objective of the Air Force project was to install and operate an in situ soil bioremediation system to investigate the feasibility of using bioventing technology to remediate JP-4 jet fuel contamination in a subarctic environment. The Air Force component of the project comprised three test plots: (1) a passive warming test plot in which plastic sheeting was placed over the ground surface of the test plot during the spring and summer months to capture solar heat and passively warm the soil; (2) a surface warming test plot in which heat tape was installed in the test plot to heat the soil directly; and (3) a control test plot, which received air injection, but no soil warming. The second project was an outgrowth of the U.S. EPA Bioremediation Field Initiative coupled with previous discussions with the Air Force. The objective of the EPA project was to actively increase soil temperature at a JP-4 jet fuel-contaminated bioventing site Continued on reverse side

15. Subject Terms Bioventing, biodegradation, bioremediation, passive warming, vadose zone, JP-4, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene, and xylenes (BTEX)

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to determine to what degree increased soil temperature can enhance the biodegradation rates of JP-4 jet fuel contaminants in soil. The study involved actively increasing the soil temperature by circulating groundwater through an electric heater and reapplying the heated water below the ground surface in an area of known JP-4 jet fuel contamination.

PREFACE

This study, entitled "Bioventing Feasibility Study Eielson AFB Site ," was initiated under Contract F08635-90-C-0064 from the Battelle Memorial Institute, Columbus, Ohio, with the Armstrong Laboratory Environics Directorate (AL/EQ), Tyndall Air Force Base, Florida 32403-5323. this work was performed between July 1991 and September 1995.

This final report describes investigations to determine the influence of soil warming on the biodegradation rates of JP-4 jet fuel contaminants in soil.

The AL/EWQ technical project officer was Ms. Catherine M. Vogel.

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EXECUTIVE SUMMARY

This program consisted of two separate, but integrated, projects. The first project consisted of U.S. Air Force-initiated bioventing activities on a JP-4 jet fuel spill at Eielson Air Force Base (AFB), Alaska, in July 1991. This work was funded by Eielson AFB's Installation Restoration Program and was conducted under contract to the Environics Directorate of the Air Force Armstrong Laboratory. The project was supported by the U.S. Air Force Center for Environmental Excellence. The objective of the Air Force project was to install and operate an in situ soil bioremediation system to investigate the feasibility of using bioventing technology to remediate JP-4 jet fuel contamination in a subarctic environment. The Air Force component of the project comprised three test plots: (1) a passive warming test plot in which plastic sheeting was placed over the ground surface of the test plot during the spring and summer months to capture solar heat and passively warm the soil; (2) a surface warming test plot in which heat tape was installed in the test plot to heat the soil directly; and (3) a control test plot, which received air injection, but no soil warming. An uncontaminated background location also received air injection, but no soil warming. Natural background respiration rates were monitored using this system.

The second project was an outgrowth of the U.S. EPA Bioremediation Field Initiative coupled with previous discussions with the Air Force. This project was conducted and funded by the U.S. Environmental Protection Agency (EPA) and provided for additional bioventing studies that were not included in the scope of the Air Force-sponsored project. These studies were designed to add value to the Air Force project without supplanting or interfering with the original Air Force scope. The objective of the EPA project was to actively increase soil temperature at a JP-4 jet fuel-contaminated bioventing site to determine to what degree increased soil temperature can enhance the biodegradation rates of JP-4 jet fuel contaminants in soil. The study involved actively increasing the soil temperature by circulating groundwater through an electric heater and reapplying the heated water below the ground surface in an area of known JP-4 jet fuel contamination. These efforts sought to maximize the biodegradation rates of JP-4 jet fuel-contaminated soils while minimizing the volatilization process.

This study was conducted at Eielson AFB, which is an active Air Force base located in the Alaskan Interior region approximately 25 miles southeast of Fairbanks, Alaska. The base serves a large variety of aircraft and maintains a relatively high volume of traffic. The climate is characterized as subarctic with low annual precipitation and an average annual temperature near 0°C (32°F). Temperatures in the region cover a broad range, with winter lows falling below −30°C (-22°F) and summer highs exceeding +30°C (86°F).

Groundwater at the site is contaminated with petroleum hydrocarbons. A hydrocarbon sheen was visible in the groundwater monitoring wells of the three original test plots (active warming, passive warming, and control). Initial soil samples showed contamination as high as 1,500 mg of total petroleum hydrocarbons (TPH)/kg.

The bioventing system consisted of an air blower plumbed to the air injection/withdrawal (bioventing) wells in the test plots and background area. Operation of the bioventing system involved introducing oxygen into the vadose zone (i.e., unsaturated zone) by injecting atmospheric air into the contaminated subsurface with the blowers. Air was injected at a rate of 10 cubic feet per minute (cfm) into each injection well.

Each test plot contained thermocouples for soil temperature monitoring, soil gas monitoring points for monitoring oxygen delivery and soil gas sampling during in situ respiration tests, and air injection wells. An uncontaminated area was located approximately 200 ft southwest of the contaminated site. One vent well and two soil gas monitoring points were installed in the background area.

The field tests conducted for this project consisted of (1) surface emissions testing; (2) a helium tracer study; (3) stable carbon isotope ratio analyses; (4) soil gas permeability testing; (5) soil vapor extraction testing; and (6) soil vapor extraction with reinjection testing. System monitoring included laboratory analyses of soil gas contaminants, regular field soil gas sampling and soil temperature analysis, in situ respiration tests, initial and final groundwater sampling, and initial and final soil sampling.

Differences in soil temperatures have been significant among the four test plots. The active warming test plot consistently maintained higher temperatures than the other test plots during the winter months. The plastic sheeting greatly increased soil temperature in the passive warming test plot, with average soil temperatures as high as 18°C (64°F) during the summer months. Throughout the year, the passive warming test plot was warmer than the control test plot.

Respiration rates in the passive warming test plot were observed to increase nearly 1 order of magnitude as soil temperature increased during the summer months, indicating the success of the use of plastic sheeting to promote soil warming. In contrast, the control test plot remained 5°C (9°F) to 6°C (11°F) cooler than the passive warming test plot, yet had similar respiration rates. It is possible that, because the level of contamination was not uniform throughout the site, a higher level of contamination in the control test plot may have resulted in high respiration rates.

Respiration rates measured in the active warming test plot were higher than those measured in the passive warming or control test plot when the warm water circulation was operating. However, the high soil moisture content in the active warming test plot limited oxygen transport and often made sampling difficult, limiting the number of usable soil gas monitoring points. In general, the deeper monitoring points, where the most contamination existed, were the most difficult to sample. Typically, higher respiration rates would be found at these points; therefore, average respiration rates reported for the active warming test plot that do not include rates from the deeper points would appear to be lower than the actual rate. After the warm water circulation was discontinued and the soil temperature dropped, no significant microbial activity could be measured in the test plot until soil temperature increased during the summer.

The surface warming test plot shows promise as a form of soil warming. Soil temperatures were higher than soil temperatures in either the passive warming or control test plot. Respiration rates in the surface warming test plot were much higher than those measured in the passive warming or control test plot and were similar to those measured in the active warming test plot during warm water circulation. These results indicate that the use of heat tape may prove to be a more efficient means of soil warming, because the problem of high soil moisture content is avoided.

Based on the results during the study period, it can be concluded that the bioventing process did stimulate biodegradation. Assuming an average biodegradation rate over the entire area of 2.5 mg/kg/day, and assuming a 1-acre site contaminated to a depth of 6 ft, this would correspond to approximately 9,800 gallons of fuel biodegraded since startup of the bioventing system.

Surface emissions at the site appear to be minimal. Averaging the data from the seven different sampling events, an average emission of benzene is calculated at 0.00035 lb/day during air injection, assuming a 1-acre test site area. This emission rate is well below regulatory limits of 2 lbs benzene/day and illustrates that bioventing in air injection mode created no significant air emission problems.

Measurement of stable carbon isotope ratios substantiated biodegradation in the field. Carbon dioxide produced by hydrocarbon degradation may be distinguished from that produced by other processes based on the carbon isotopic compositions characteristic of the source material and/or the fractionation accompanying microbial metabolism. The $\delta^{13}C$ values of soil gas carbon dioxide from the uncontaminated location at the test site were within the range of typical values observed for plant respiratory carbon dioxide from local vegetation and decaying organic matter, whereas the $\delta^{13}C$ values of soil gas carbon dioxide from the contaminated areas are representative of values from hydrocarbon degradation. These results provided evidence that microbial metabolism of hydrocarbons was occurring.

Initial groundwater samples contained significant concentrations of total hydrocarbons. Benzene and toluene were the predominant contaminants found in the groundwater samples. The average initial concentrations of TPH and benzene, toluene, ethylbenzene, and xylenes (BTEX) were 16 mg/L and 9.4 mg/L, respectively. The average final TPH concentration was 2.2 mg/L. No benzene or ethylbenzene could be detected in the final groundwater samples, while toluene and xylenes were present in small quantities (0.038 and 0.092 mg/L, respectively).

Soil TPH concentration was seen to decrease at nearly all depths, whereas final BTEX concentrations were several orders of magnitude lower than concentrations in the initial soil samples. These results indicate that significant contaminant removal has occurred since the initiation of bioventing, with high removals of the more volatile components such as BTEX.

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ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
BTEX	benzene, toluene, ethylbenzene, and xylenes
cfm	cubic feet per minute
EPA	U.S. Environmental Protection Agency
EVW	east of the vent well
GC	gas chromatography
HC	hydrocarbon
HLA	Harding Lawson Associates
HP	horsepower
IRP	Installation Restoration Program
k	soil gas permeability
NRMRL	National Risk Management Research Laboratory
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
R_I	radius of influence
SCH	Schedule
TKN	total Kjeldahl nitrogen
TOC	total organic carbon
TP	total phosphorus
TPH	total petroleum hydrocarbon
UWRL	Utah Water Research Laboratory
VOC	volatile organic compound

SECTION I
OVERVIEW

This program consisted of two separate, but integrated, projects. The first project consisted of U.S. Air Force-initiated in situ bioremediation (bioventing) activities on a JP-4 jet fuel spill at Eielson Air Force Base (AFB), Alaska, in July 1991. This work was funded by Eielson AFB's Installation Restoration Program and was conducted under contract to the Environics Directorate of the Air Force Armstrong Laboratory. The project was supported by the U.S. Air Force Center for Environmental Excellence (AFCEE). The second project is an outgrowth of the U.S. Environmental Protection Agency (EPA) Bioremediation Field Initiative coupled with previous discussions with the Air Force. This project was conducted and funded by the EPA and provided for additional bioventing studies that were not included in the scope of the Air Force-sponsored project. These studies were designed to add value to the Air Force project without supplanting or interfering with the original Air Force scope. The EPA project was conducted by the EPA National Risk Management Research Laboratory (NRMRL), Cincinnati, Ohio, with Battelle, of Columbus, Ohio, as the prime contractor. Battelle also was the prime contractor for the Air Force's component of the joint program.

This report was developed for the U.S. Air Force and summarizes results generated from both the Air Force and the EPA projects.

SECTION II
SCOPE OF AIR FORCE PROJECT

The objective of the Air Force project was to install and operate an in situ soil bioremediation system to investigate the feasibility of using bioventing technology to remediate JP-4 jet fuel contamination in a subarctic environment. The Air Force component of the project comprised three test plots: (1) a passive warming test plot in which plastic sheeting was placed over the ground surface of the test plot during the spring and summer months to capture solar heat and passively warm the soil; (2) a surface warming test plot in which heat tape was installed in the test plot to heat the soil directly; and (3) a control test plot, which received air injection, but no soil warming. In addition, an uncontaminated background location also received air injection, but no soil warming and was used to monitor natural background respiration rates. The major tasks for the Air Force portion of the study included an initial site characterization to adequately define the extent of contamination, installation of the three test plots and background well described above, monitoring of soil gas to assess biodegradation rates, monitoring of surface emissions, verification of biodegradation through stable carbon isotope testing and a soil vapor extraction test, and a final site investigation to define the extent of remediation.

The objective of the EPA project was to actively increase soil temperature at a JP-4 jet fuel-contaminated bioventing site to determine to what degree increased soil temperature can enhance the biodegradation rates of JP-4 jet fuel contaminants in soil. The study involved actively increasing soil temperature by circulating groundwater through an electric heater and reapplying the heated water below the ground surface in an area of known JP-4 jet fuel contamination. These efforts sought to maximize the biodegradation rates of JP-4 jet fuel-contaminated soils while minimizing the volatilization process. The major tasks for the EPA portion of the study included an initial site characterization of the active warming test plot to adequately define the extent of contamination, installation of a low-intensity JP-4 jet fuel bioremediation system with an active soil warming component, monitoring of soil gas to assess biodegradation rates in the active warming test plot, and a final site investigation to define the extent of remediation.

The total surface area for the EPA/Air Force program, including the background area, is approximately 1 acre (Figure 1). A comparison of the EPA and Air Force project scopes is shown in Table 1. The intent was to integrate the data from the Air Force and EPA projects to evaluate bioremediation under active warming, passive warming, surface warming, and ambient soil temperature test conditions. A schedule of the activities performed through the completion of the study in July 1994 is presented in Table 2. An additional in situ respiration test was conducted in January 1995 after completion of this study, and is included in Table 2.

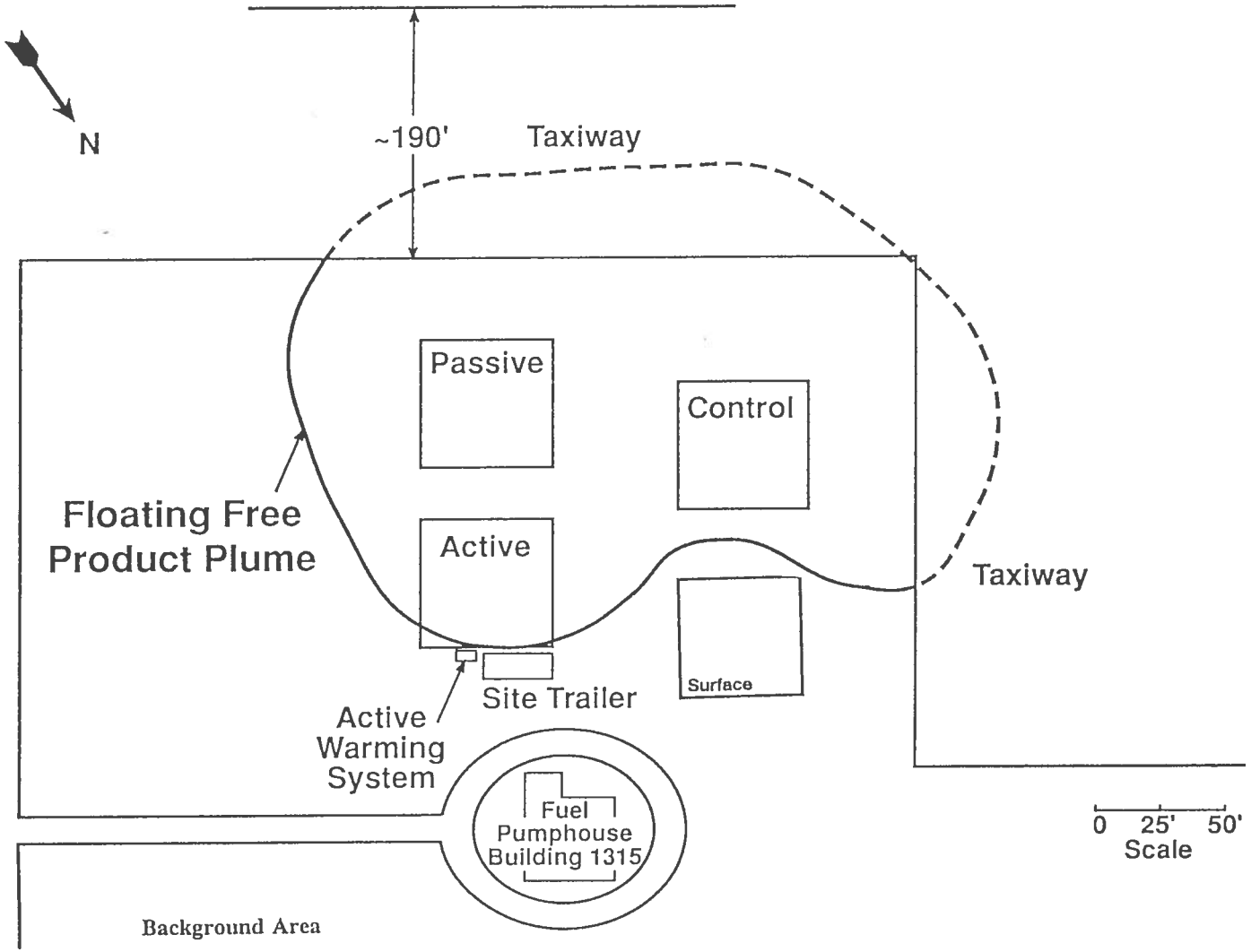


Figure 1. Schematic Diagram of Site 20, Eielson AFB, Alaska.

TABLE 1. AIR FORCE/EPA BIOVENTING PROGRAM COMPONENT SUMMARIES.

Air Force Project	EPA Value-Added Project
Air injection/withdrawal	Actively heated soil treatment
Three treatments: passive solar, surface warming, and control	Intensive temperature monitoring/determination of thermal effects
In situ respiration tests • Year 1 (12) • Year 2 (12) • Year 3 (12)	In situ respiration tests • Year 1 (12) • Year 2 (12) • Year 3 (12)
Analysis of stable carbon isotopes	Annual progress reports
Optimize biodegradation/minimize volatilization	
Monitor surface emissions in control zone	

TABLE 2. SCHEDULE OF ACTIVITIES THROUGH FEBRUARY 1995.

Air Force Contract Award	July 1, 1991
Site Characterization	July 16 to 29, 1991
Verbal Presentation of Work Plan	July 22, 1991
Verbal Approval of Work Plan	July 22, 1991
Initiation of Construction	July 30, 1991
Initiation of Water Circulation	August 18, 1991
Initiation of Air Injection	August 22, 1991
First In Situ Respiration Test (Full)	October 1 to 7, 1991
Initiation of Soil Heating	October 10, 1991
Second In Situ Respiration Test (Abbreviated)	November 10 to 14, 1991
Third In Situ Respiration Test (Abbreviated)	December 7 to 14, 1991
Fourth In Situ Respiration Test (Full)	January 28 to February 2, 1992
Fifth In Situ Respiration Test (Abbreviated)	March 17 to 23, 1992
Sixth In Situ Respiration Test (Abbreviated)	April 18 to 23, 1992
Insulation Removed From Passive Warming Test Plot and Replaced With Plastic Sheeting	April 21, 1992
Seventh In Situ Respiration Test (Abbreviated)	June 13 to 20, 1992
In-Line Water Heaters for Active Warming Test Plot Turned Off	June 1992
Eighth In Situ Respiration Test (Full)	August 9 to 19, 1992
Air Injection Turned Off During Installation	September 12, 1992
Installation of Surface Warming Test Plot	September 12, 1992
Installation of Deep Bioventing Wells	September 12 to 14, 1992
Installation of Additional Soil Gas Monitoring Points and Thermocouples	September 1992
Replacement of In-Line Water Heaters With New Units	September 1992
Inspection of Soaker Hoses	September 1992

TABLE 2. SCHEDULE OF ACTIVITIES THROUGH FEBRUARY 1995 (CONTINUED).

Air Injection Reinitiated	October 3, 1992
Ninth In Situ Respiration Test (Full)	October 30 to November 9, 1992
Tenth In Situ Respiration Test (Full)	January 13 to 24, 1993
Surface Emissions Sampling and Stable Carbon Isotopic Composition Analyses	January 1993
Eleventh In Situ Respiration Test (Abbreviated)	February 24 to March 3, 1993
Twelfth In Situ Respiration Test (Abbreviated)	March 24 to 31, 1993
Insulation Removed From Passive Warming Test Plot and Clear Plastic Added to Promote Solar Warming	April 27, 1993
Thirteenth In Situ Respiration Test (Abbreviated)	May 7 to 13, 1993
Active Warming Test Plot Heating Turned Off	July 3, 1993
Fourteenth In Situ Respiration Test (Abbreviated)	July 7 to 11, 1993
Insulation Removed From Active Warming Test Plot	July 22, 1993
Surface Emissions Sampling and Stable Carbon Isotopic Composition Analyses	July 1993
Fifteenth In Situ Respiration Test (Full)	July 24 to 28, 1993
Soil gas permeability Testing	August 1993
Soil Vapor Extraction Testing	August 1993
Insulation of Passive Warming Test Plot	September 26, 1993
Soil Vapor Extraction with Reinjection Testing	September 1993
Helium Tracer Testing	September 1993
Surface Emissions Sampling	September 1993
Sixteenth In Situ Respiration Test (Abbreviated)	October 24 to 26, 1993
Seventeenth In Situ Respiration Test (Full)	November 16 to 21, 1993
Surface Emissions Sampling	November 1993
Eighteenth In Situ Respiration Test (Abbreviated)	December 21 to 28, 1993
Stable Carbon Isotopic Composition Analyses	December 1993
Surface Emissions Sampling	January 1994
Nineteenth In Situ Respiration Test (Full)	January 8 to 15, 1994

TABLE 2. SCHEDULE OF ACTIVITIES THROUGH FEBRUARY 1995 (CONTINUED).

Twentieth In Situ Respiration Test (Abbreviated)	February 19 to 24, 1994
Twenty-First In Situ Respiration Test (Abbreviated)	March 24 to 30, 1994
Stable Carbon Isotopic Composition Analyses	April 1994
Surface Emissions Sampling	April 1994
Insulation Removed From Passive Warming Test Plot and Clear Plastic Added to Promote Solar Warming	April 6, 1994
Twenty-Second In Situ Respiration Test (Full)	April 16 to 24, 1994
Twenty-Third In Situ Respiration Test (Abbreviated)	May 8 to 12, 1994
Twenty-Fourth In Situ Respiration Test (Abbreviated)	June 6 to 11, 1994
Stable Carbon Isotopic Composition Analyses	July 1994
Surface Emissions Sampling	July 1994
Twenty-Fifth In Situ Respiration Test (Full)	July 2 to 9, 1994
Plastic Sheeting Removed From Passive Warming Test Plot	July 8, 1994
Final Soil and Groundwater Sampling	July 1994
Twenty-Sixth In Situ Respiration Test (Abbreviated)	January 27 to February 1, 1995

SECTION III
INTRODUCTION TO BIOVENTING

Bioventing is the process of aerating subsurface soils to stimulate in situ bioremediation. Bioventing is related to soil venting processes such as soil vacuum extraction, soil gas extraction, and in situ soil stripping. However, there is a significant difference in the objectives of soil venting and bioventing. Soil venting is designed and operated to maximize volatilization of low-molecular-weight compounds. In most soil venting remediations, some biodegradation does occur. In contrast, bioventing is designed to maximize biodegradation of any aerobically biodegradable compound, regardless of molecular weight, while minimizing volatilization. Although both technologies involve venting of air through the subsurface, the difference in objectives results in significantly different design and operation of the remedial systems.

A. BIOVENTING BACKGROUND

Petroleum distillate fuel hydrocarbons such as JP-4 jet fuel generally are biodegradable if naturally occurring microorganisms are provided an adequate supply of oxygen and basic nutrients (Atlas, 1986). Natural biodegradation does occur and, at many sites, eventually may mineralize most fuel contamination. However, the process is dependent upon natural oxygen diffusion rates (Ostendorf and Kampbell, 1989), and as a result frequently works too slowly to prevent the spread of contamination. Such sites may require remediation of the contaminant source to protect sensitive aquifers. At these sites, acceleration or enhancement of the natural biodegradation process may prove to be the most effective remediation.

An understanding of the distribution of contaminants is important in any in situ remediation effort. Much of the residue of hydrocarbons at a fuel-contaminated site is found in the unsaturated zone soils, in the capillary fringe, and immediately below the water table. Typically, seasonal water table fluctuations spread residues in the area immediately above and below the water table. Any successful bioremediation effort must treat these areas. Bioventing can provide oxygen to unsaturated zone soils.

B. CONVENTIONAL ENHANCED BIODEGRADATION

Over the past two decades, the practice of enhanced biodegradation has increased, particularly for treating soluble fuel components in groundwater (Lee et al., 1988). Less emphasis has been given to enhancing biodegradation in the unsaturated zone. The current conventional enhanced bioreclamation process uses water to carry oxygen or an alternative electron acceptor to the contamination, whether it occurs in the groundwater or in the unsaturated zone.

Hydrogen peroxide has been used as an oxygen source in several field studies because it is more soluble than pure oxygen; however, certain limitations are associated with its use. In a field experiment at a jet fuel-contaminated site, the use of infiltration galleries and spray irrigation to introduce oxygen (as hydrogen peroxide), nitrogen, and phosphorus to unsaturated, sandy soils proved unsuccessful because of rapid hydrogen peroxide decomposition and the resulting poor oxygen distribution (Hinchee et al., 1989). A study conducted by the EPA and the U.S. Coast Guard at Traverse City, Michigan, used deep well injection to raise the water table in order to supply oxygen-enriched water to the contaminated soils. Although results indicate better hydrogen peroxide stability than achieved by Hinchee et al. (1989), it was concluded that much of the hydrogen peroxide

decomposed rapidly and was lost as bubbles (Huling et al., 1990). Some degradation of aromatic hydrocarbons appears to have occurred; however, no change in total hydrocarbon contamination levels was detected in the soils (Ward, 1988).

In most cases where water is used as the oxygen carrier, oxygen is the limiting factor for biodegradation. If pure oxygen is used and 40 mg/L of dissolved oxygen is achieved, approximately 80,000 kg of water must be delivered to the formation to degrade a single kilogram of hydrocarbon. Approximately 13,000 kg of water is required if 500 mg/L of hydrogen peroxide is to be delivered successfully. Therefore, even if hydrogen peroxide can be used successfully, substantial volumes of water must be pumped through the contaminated formation to deliver sufficient quantities of oxygen.

C. BIOVENTING

A system that uses forced air as the oxygen source to increase the microbial biodegradation of fuel hydrocarbons in the vadose zone is a cost-effective alternative to conventional systems. This process stimulates indigenous soil microorganisms to aerobically metabolize fuel hydrocarbons in unsaturated soils. Depending on air flow rates, volatile compounds may be simultaneously removed from contaminated soils.

When using air as the oxygen source, the minimum stoichiometric ratio of air to hydrocarbon on a mass basis is approximately 13 to 1. This ratio compares with a ratio of more than 10,000 to 1, water to hydrocarbon, for a conventional waterborne-enhanced bioreclamation process. An additional advantage of using an airborne process is that gases have greater diffusivity than liquids. At many sites, geologic heterogeneities present a problem for a waterborne oxygen source because fluid pumped through the formation is channeled into the more permeable pathways. For example, in an alluvial soil with interbedded sand and clay, initially all of the fluid flow will take place in the sand. As a result, oxygen must be delivered to the less-permeable clay lenses through diffusion. In a gaseous system (as is found in unsaturated soils), this diffusion can be expected to take place at a rate several orders of magnitude greater than in a liquid system (as is found in saturated soils). Although it is not realistic to expect diffusion to aid significantly in water-based bioreclamation, in an air-based application, diffusion may be a significant mechanism for oxygen delivery to less-permeable zones.

To the author's knowledge, the first documented evidence of unsaturated zone biodegradation resulting from forced aeration was reported by the Texas Research Institute, Inc., in a study for the American Petroleum Institute. A large-scale model experiment was conducted to test the effectiveness of a surfactant treatment to enhance recovery of spilled gasoline. The experiment accounted for only 30 L of the 250 L originally spilled and raised questions about the fate of the gasoline. A subsequent column study was conducted to determine a diffusion coefficient for soil venting. This column study evolved into a biodegradation study, in which it was concluded that as much as 38% of the fuel hydrocarbon was biologically mineralized. Researchers concluded that venting would not only remove gasoline by physical means, but also could enhance microbial activity (Texas Research Institute, 1980, 1984).

The first actual bioventing field experiments apparently were conducted in 1983 by Jack van Eyk, working for Shell Oil. At his direction, Delft Geotechnics in The Netherlands initiated a series of experiments to investigate the effectiveness of bioventing for treatment of gasoline-contaminated soils. These studies are reported in a series of papers (Anonymous, 1986; Staatsuitgeverij, 1986; van Eyk and Vreeken, 1988, 1989a, 1989b).

Wilson and Ward (1986) suggested that using air as a carrier for oxygen could be 1,000 times more efficient than transferring oxygen to water, especially in deep, hard-to-flood unsaturated zones. They made the connection between soil venting and biodegradation by observing that "soil venting uses the same principle to remove volatile components of the hydrocarbon." In a general overview of the soil venting process, Bennedsen et al. (1987) concluded that soil venting provides large quantities of oxygen to the unsaturated zone (vadose zone), possibly stimulating aerobic biodegradation. They suggested that additions of water and nutrients would be required for significant biodegradation and encouraged further investigation into this area.

Biodegradation enhanced by soil venting has been observed at several field sites. Investigators at a soil venting site for remediation of gasoline-contaminated soil claim significant biodegradation as measured by a temperature rise when air was supplied. Investigators pulsed air through a pile of excavated soil and observed a consistent temperature rise that they attributed to biodegradation. They claimed that the pile was remediated during the summer primarily by biodegradation (Conner, 1988). However, they did not control for natural volatilization from the aboveground pile, and not enough data were published to critically review the biodegradation claim.

Researchers at Traverse City, Michigan, measured toluene concentration in vadose zone soil gas as an indicator of fuel contamination in the vadose zone. They assumed absence of advection and attributed the toluene loss to biodegradation. The investigators concluded that, because toluene concentrations decayed near the oxygenated ground surface, soil venting is an attractive remediation alternative for biodegrading light volatile hydrocarbon spills (Ostendorf and Kampbell, 1989).

Ely and Heffner (1988) working for the Chevron Research Company, patented a process for the in situ biodegradation of spilled hydrocarbons through soil venting. The experimental design and data are not provided, but their findings are presented graphically. At a gasoline- and diesel oil-contaminated site, a slightly higher rate of removal through biodegradation than through evaporation was observed. At a gasoline-contaminated site, results indicated that about ⅔ of the hydrocarbon removal was by volatilization and ⅓ by biodegradation. At a site containing only fuel oils, approximately 75 liters/well/day were biodegraded, whereas vapor pressures were too low for removal by volatilization. Ely and Heffner claimed that the process is more advantageous than strict soil venting because removal does not depend only on vapor pressure. In the examples stated in the patent, carbon dioxide was maintained between 6.8% and 11% and oxygen between 2.3% and 11% in vented air. The patent suggests that the addition of water and nutrients may not be acceptable because of flushing to the water table, but nutrient addition is claimed as part of the patent. The patent recommends flow rates between 50 and 420 m^3/min per well and states that air flowrates higher than those required for volatilization may be optimum for biodegradation.

The U.S. Air Force initiated its research and development program in bioventing in 1988 with a study at Hill AFB, Utah. In the course of this study, it became apparent that bioventing had great potential for remediation of JP-4 jet fuel-contaminated soils. It also was apparent that further research was required before the technology could be applied routinely in the field. The work was supported initially by the U.S. Air Force Civil Engineering Support Agency (AFCESA), now known as the Armstrong Laboratory Environics Directorate. Subsequently, the Environics Directorate was joined by the U.S. AFCEE and later by Hill and Eielson AFBs in research and development support of the technology. Following the Hill AFB study, a more controlled bioventing study was completed at Tyndall AFB in Florida.

The Air Force currently is supporting a number of field programs to further improve and demonstrate the technology. At Hill AFB, after completion of the study at the initial site, a low-intensity bioreclamation research program was initiated in late 1989. The Eielson AFB field demonstration of bioventing in a subarctic environment was initiated in the summer of 1991. The RREL has become interested in the Air Force's program and jointly funded and technically supported the work at both Hill and Eielson AFBs. Additionally, the Armstrong Laboratory Environics Directorate is supporting a well-documented bioventing demonstration at a cold weather site, where fieldwork began in the fall of 1992.

D. APPLICATIONS

The use of an air-based oxygen supply to enhance biodegradation relies on air flow through hydrocarbon-contaminated soils at rates and configurations that will both ensure adequate oxygenation for aerobic biodegradation and minimize or eliminate the production of a hydrocarbon-contaminated off-gas. The addition of nutrients and moisture may be desirable to increase biodegradation rates; however, field research to date does not support this (Dupont et al., 1991; Miller et al., 1991). Dewatering may be necessary at times, depending on the distribution of contaminants relative to the water table. However, because dewatering is already required at many fuel hydrocarbon-contaminated sites, this is not likely to present a problem. A key feature of bioventing is the narrowly screened soil gas monitoring points that sample only a short vertical section of the soil. These points are required to determine local oxygen concentrations, because the oxygen levels measured in the vent well are not representative of local conditions.

A bioventing system may be configured in several different ways to enhance biodegradation. The optimal configuration for any given site will depend on site-specific conditions and remedial objectives.

A conventional soil venting installation, where air is drawn from a vent well in the area of greatest contamination, is a possible configuration for bioventing. The advantage of this configuration is that it generally requires the least amount of air pumping and allows straightforward monitoring of the contaminant biodegradation. The disadvantages are that the hydrocarbon off-gas concentration probably is maximized and all of the capillary fringe contamination may not be treated.

Air injection also may be used for bioventing. Air injection is the lowest cost configuration, but careful consideration must be given to the fate of injected air. The objective is to degrade hydrocarbons, resulting in carbon dioxide emissions at some distance from the injection point. If a building or subsurface structure exists within the radius of influence, hydrocarbon vapors may be forced into that structure. Therefore, protection of subsurface structures may be required.

Alternatively, a system may be constructed in which air is injected (the injection may be by passive wells) into the contaminated zone and withdrawn from clean soils. This configuration allows the more volatile hydrocarbons to degrade prior to being withdrawn, thereby eliminating contaminated off-gases.

A configuration that may alleviate the threat to subsurface structures while achieving the same effect as air injection alone would involve extracting soil gas near the structure of concern and reinjecting it at a safe distance. If necessary, make-up air can be added before injection.

The significant features of the bioventing technology include the following:

- Optimizing air flow to reduce volatilization while maintaining aerobic conditions for biodegradation.
- Monitoring local soil gas conditions to ensure aerobic conditions, not just monitoring vent gas composition.
- Manipulating the water table as required for air/contaminant contact.

SECTION IV
SITE DESCRIPTION

Eielson AFB is an active Air Force base located in the Alaskan Interior region approximately 25 miles southeast of Fairbanks, Alaska. The base serves a large variety of aircraft and maintains a relatively high volume of traffic.

A. CLIMATE

The climate is characterized as subarctic with low annual precipitation and an average annual temperature near 0°C (32°F). Temperatures in the region cover a broad range, with winter lows falling below −30°C (-22°F) and summer highs exceeding +30°C (86°F). Figures 2 through 4 illustrate the mean annual precipitation and the mean minimum and mean maximum temperatures in January, respectively. General engineering design criteria for the region include the ability to withstand both wind and snow loads of 30 lb/ft^2 and high and low temperatures of +32 and −54°C (90 and -65°F), respectively (Hartman and Johnson, 1984).

B. GEOLOGIC SETTING

The base topography is predominated by the Tanana-Kuskokwim Lowland. Soils consist primarily of glaciofluvial deposits derived from glacial outwash from the Alaskan Mountain Range. The general lithology consists of a thin layer of sandy loam overlying a 200- to 300-ft-thick sequence of sand and gravel (Harding Lawson Associates, 1989). Permafrost is present in some areas on the base. Groundwater on the base typically is encountered at 5 to 15 ft. The aquifer underlying the base is characterized as a sole-source aquifer with generally good groundwater quality, but with a few contaminated areas (Harding Lawson Associates, 1989).

Investigation activities at the bioventing site show surface soils consisting of interbedded layers of loose sand and gravel, with silt concentration increasing with depth to approximately 6 ft. Groundwater measurements taken at the site from July 1992 to December 1992 have been relatively constant, with the groundwater level at approximately 9.5 ft near the background area and 7 ft in the contaminated area. Permafrost does not occur at the bioventing site.

Groundwater at the site was contaminated with petroleum hydrocarbons (Table 3), and a hydrocarbon sheen was visible in the groundwater monitoring wells of the three original test plots (active warming, passive warming, and control). The initial soil and groundwater samples that were collected are provided in Appendix A along with the analytical methods.

C. INSTALLATION DETAILS AND TEST PLOT DESCRIPTIONS

Four test plots and a background area were installed at the site at Eielson AFB. A schematic diagram of the entire site is shown in Figure 5. The test site was centered over two pressurized petroleum lines that intersect the site and are suspected to be the source of the release that caused the contamination, the assumption being that this area is the most highly and uniformly contaminated part of the site.

The bioventing system consisted of an air blower plumbed to the air injection/withdrawal (bioventing) wells in the test plots and background area. Operation of the bioventing system involved

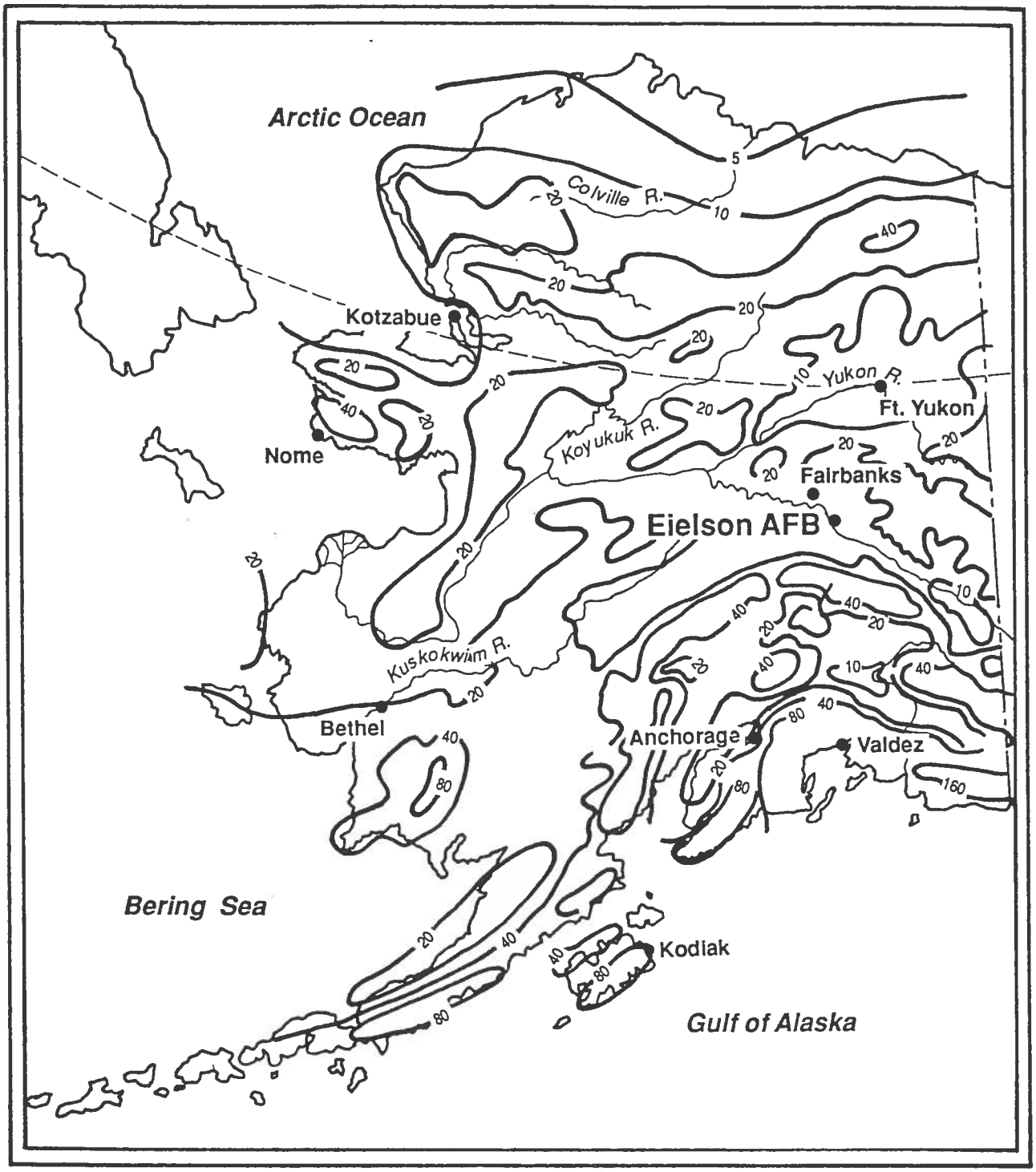


Figure 2. Mean Annual Precipitation (Inches of Water)(Hartman and Johnson, 1984).

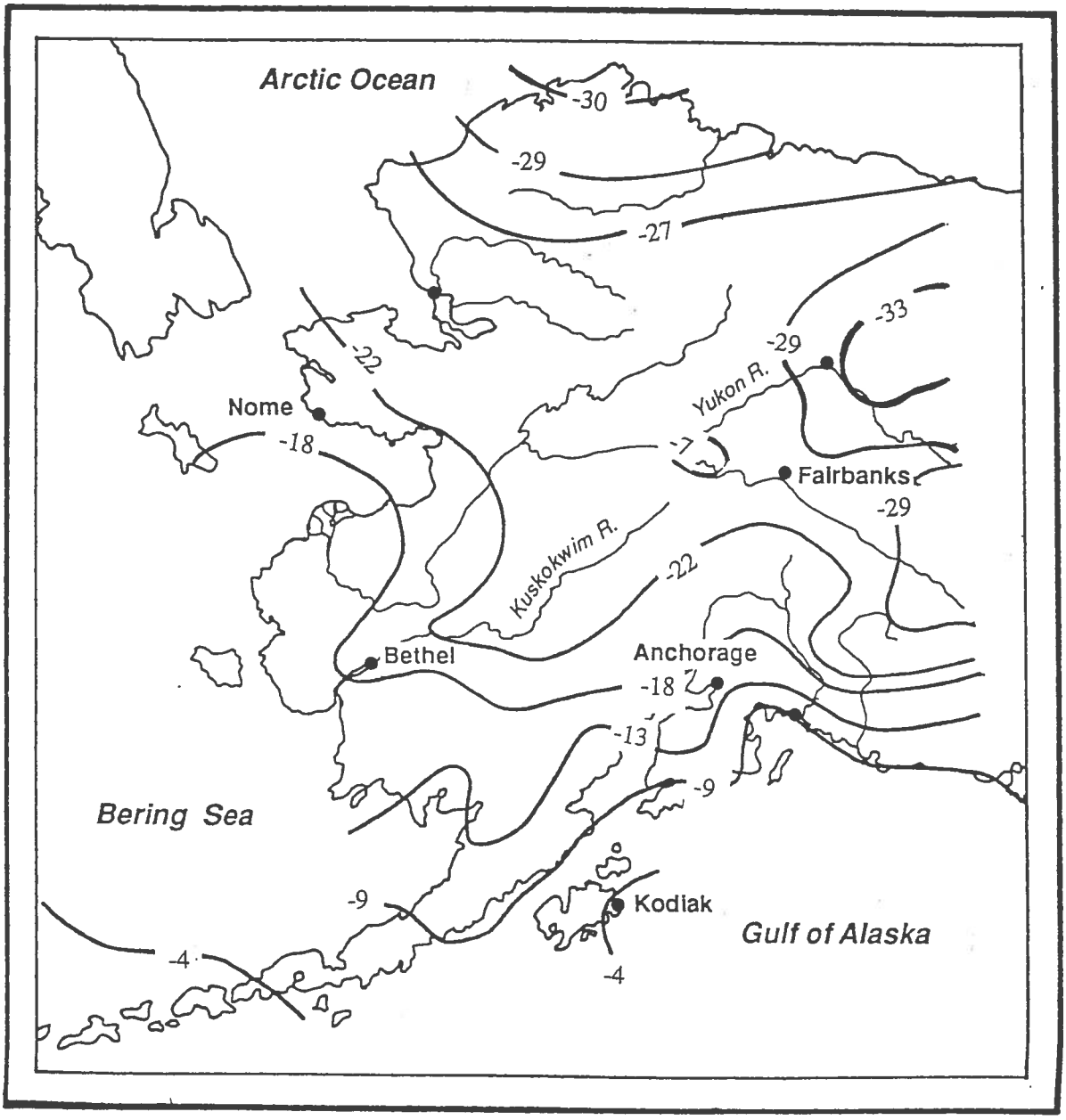


Figure 3. Mean Minimum Temperatures (°C) in January.

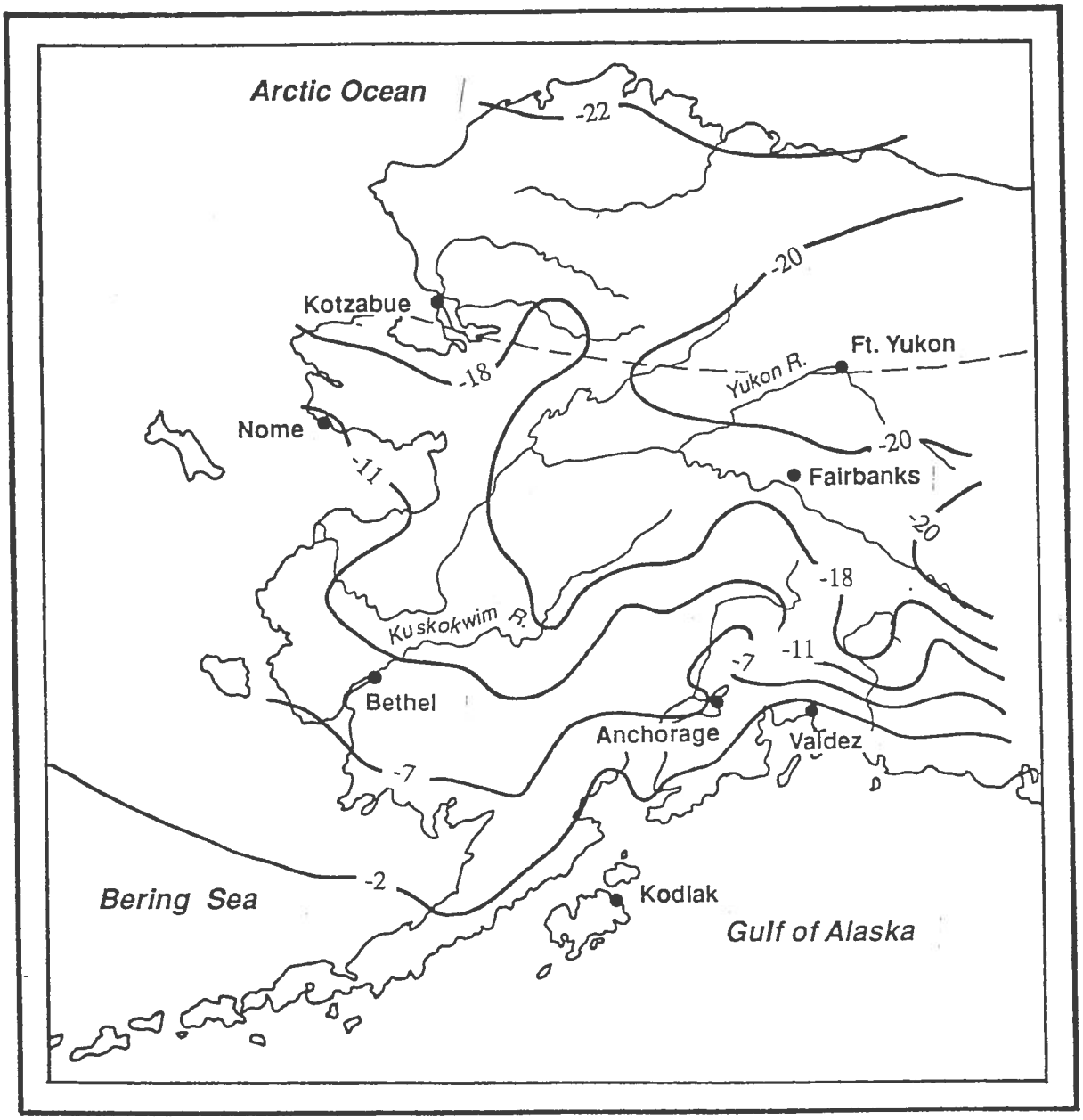


Figure 4. Mean Maximum Temperatures (°C) in January.

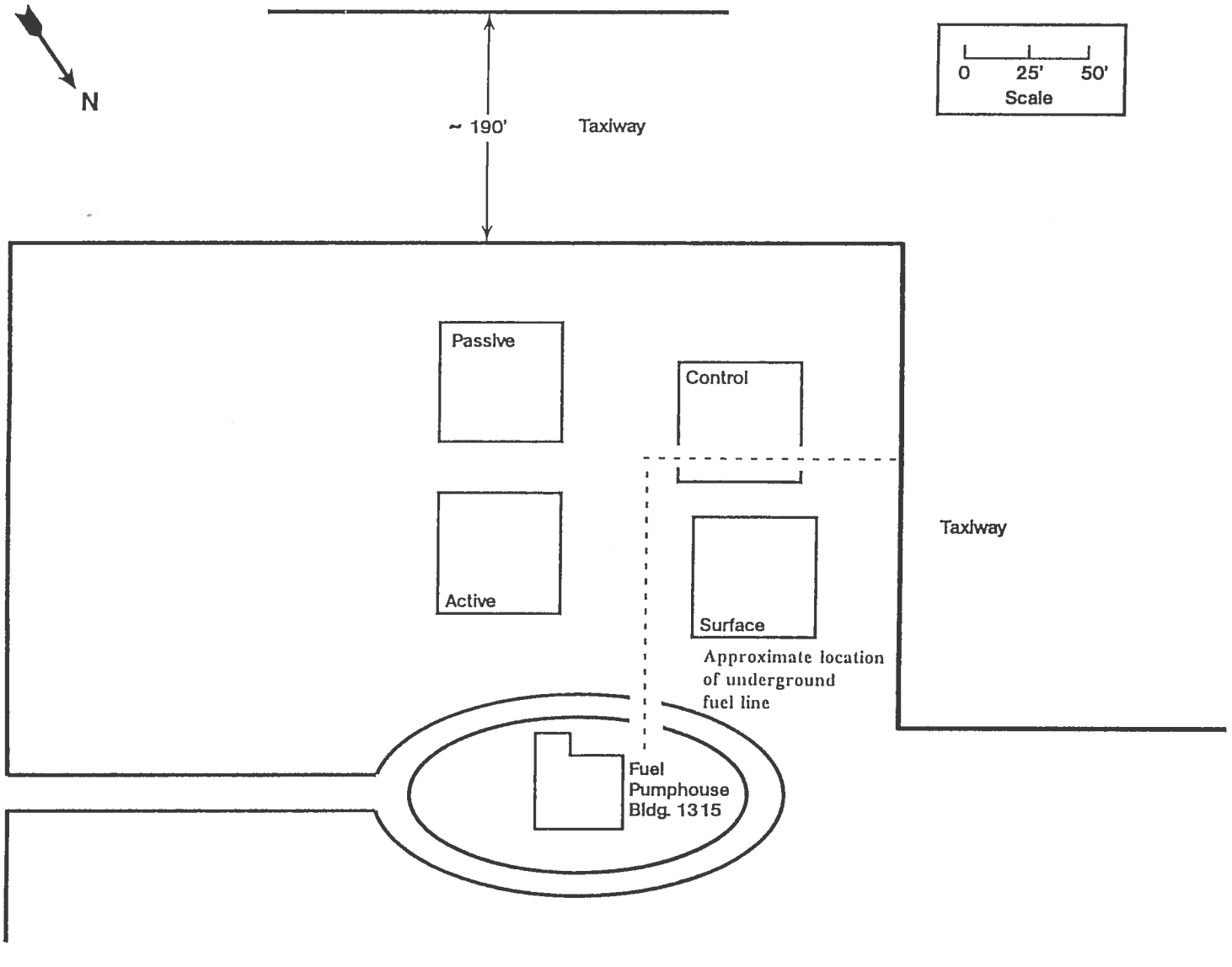


Figure 5. Schematic Diagram of Eielson AFB Bioventing Site.

TABLE 3. TOTAL PETROLEUM HYDROCARBON CONCENTRATION IN GROUNDWATER SAMPLES[1], AUGUST 1991.

Location	TPH Concentration (mg/L)
Background	<0.0002
Extraction Well	20
Active Warming Test Plot	17[2]
Passive Warming Test Plot	15[2]
Control Test Plot	15[2]

1 Methanol extraction.
2 Average of two samples.

introducing oxygen into the vadose zone by injecting atmospheric air into the contaminated subsurface with the blowers. Air was injected at a rate of 10 cubic feet per minute (cfm) into each vent well. The Operating Manual for this system is provided in Appendix B.

A brief description of the installation details of each test plot is given in the following sections.

1. Thermocouple Installation

Type J thermocouples were installed in groups of three at depths of 2, 4.25, and 5.25 ft (thermocouples designated as A) or 2, 4, and 6 feet (thermocouples designated as B). Specific locations of the thermocouples are described in Sections IV.C.5 through IV.C.9. A total of 79 thermocouples were installed. The thermocouples are monitored using a programmable data logger to record temperature data. Two data loggers were used at the site; thermocouples were numbered 1 through 40 to correspond with the data logger numbering system. To distinguish between thermocouples, each thermocouple also was designated as A or B, to correspond with the data logger to which it was attached. The Operating Manual for the data logger is provided in Appendix B.

2. Construction Detail of Bioventing Wells

During the first year of operation (1991), 2-inch-diameter bioventing wells were installed to 6 ft in depth with 3 ft of 10-slot screen and 4 ft of schedule 40 polyvinyl chloride (PVC) casing finished 1 ft above grade. A medium-grade silica sand filter pack was installed across the screened interval, and bentonite chips were used to fill the remaining annular space to grade.

During the second year of operation (1992), additional bioventing wells were installed at deeper depths in the center of each test plot to treat the capillary fringe where much of the contamination was found. The new wells were 2-inch-diameter bioventing wells installed to 13 ft, with 6.5 ft of 10-slot screen and 7.5 ft of schedule 40 PVC casing finished 1 ft above grade. A

medium-grade silica sand filter pack was installed across the screened interval, and bentonite chips were used to fill the remaining annular space to grade.

Appendix C contains the soil boring logs and well construction details for these wells.

3. Construction Details of Soil Gas Monitoring Points

During the first year of operation (1991), three-level soil gas monitoring points were installed in each test plot using a two-person power auger equipped with a 2-inch-diameter solid stem auger. For each three-level sampling point, probes were labeled A, B, and C with corresponding depths of 5.25 ft, 4.25 ft, and 2.0 ft. The probes were constructed of ¼-inch-diameter schedule 80 PVC. All three monitoring points were placed in the same borehole, and 6-inch sand filter packs were installed at the base of each monitoring point. A bentonite chip vapor barrier was used to fill the remaining space between the probes.

During the second year of operation (1992), additional soil gas monitoring points were installed. Three-level soil gas monitoring points were installed using a truck-mounted drill rig equipped with a 4¼-inch inside diameter hollow stem auger. For each three-level sampling point, probes were labeled A, B, and C with corresponding depths of 7.5 ft, 4.5 ft, and 2.5 ft at all monitoring points except monitoring point P7 (passive warming test plot), which was installed at depths of 7.8 ft, 4.8 ft, and 2.8 ft. The monitoring points consisted of ¼-inch-diameter tube to the specified depth with a screen approximately 6 inches long and 1 inch in diameter. All three probes were placed in the same borehole in the center of a sand filter pack. A bentonite chip vapor barrier was used to fill the remaining space between the probes.

4. Construction Details of Groundwater Monitoring Wells

During the first year of operation (1991), four 2-inch-diameter PVC groundwater monitoring wells were installed at the site. The monitoring wells were installed to a depth of 10 ft with 5 ft of 10-slot screen and 5 ft of schedule 40 PVC casing. The annular space outside the monitoring well was filled with a medium-grade silica sand filter pack from 4.5 ft to 10.0 ft. The remaining annular space was sealed to the surface with a bentonite plug. Appendix C contains the soil boring logs/well construction details for these wells.

5. Active Warming Test Plot

A schematic diagram of the active warming test plot is shown in Figure 6. During the first 2 years of operation, the active warming test plot was warmed by circulating heated groundwater through soaker hoses buried in the test plot. The warm water percolated through the soil, heating the soil. The test plot was covered with insulation during this time. In July 1993, the active warming system was turned off and the insulation was removed in order to compare microbial activity in this test plot without heating to microbial activity with heating. A description of the construction details of the active warming test plot is given below.

The following items were installed in the active warming test plot:

- four shallow bioventing wells (installed in 1991, the first year of operation)

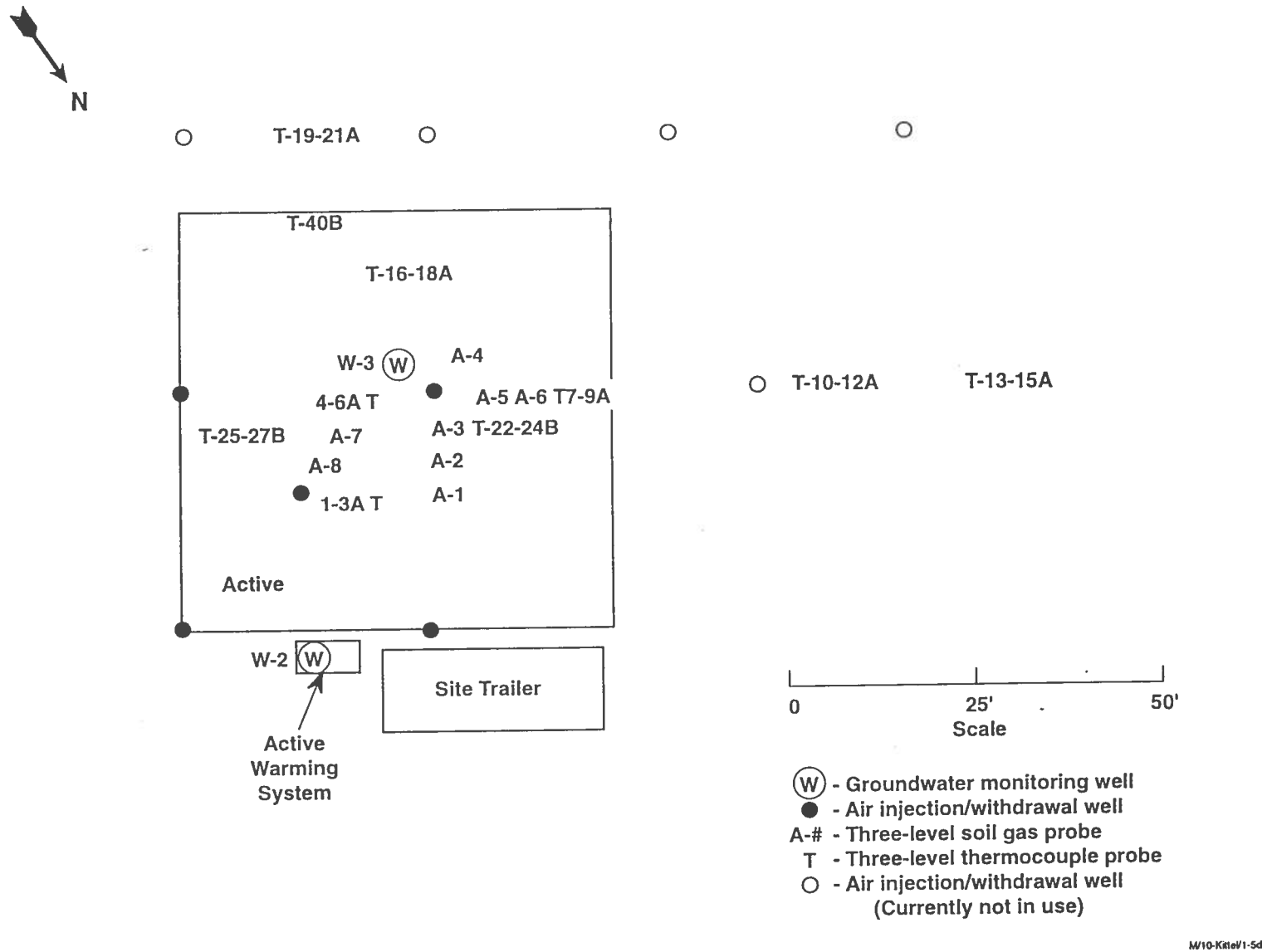


Figure 6. Schematic Diagram of the Active Warming Test Plot.

- one deep bioventing well (installed in 1992, the second year of operation)
- 6 three-level thermocouples, plus one thermocouple placed next to the soaker hoses at a depth of 2 ft
- six shallow three-level soil gas monitoring points (installed the first year of operation)
- two deep three-level soil gas monitoring points (installed the second year of operation)
- one groundwater monitoring well
- one groundwater well for circulating groundwater throughout the site (described below)
- soaker hoses for distributing groundwater throughout the site (described below).

Commercially available rubber soaker hoses were installed inside five 50-ft lengths of perforated sewer pipe. Each sewer pipe contained two 50-ft lengths of soaker hose connected together on one end (in effect a 100-ft loop) (Figure 7). Heat tape was placed in each sewer pipe to protect it from freezing. The sewer pipes were placed in 50-ft-long trenches dug 2.5 ft deep, with 10-ft spacing across the active warming test plot.

The monitoring well used for the active warming water supply was installed using a truck-mounted drill rig equipped with a hollow-stem auger of 6-inch inner diameter. The auger was advanced to a depth of 20 ft for installation of the 4-inch-diameter PVC monitoring well. The well consisted of a 10-ft length of 10-slot PVC well screen and 10 ft of schedule 40 PVC well casing.

Figure 8 illustrates the construction details of the active warming system extraction well. Water was pumped from the well using a 0.75-horsepower (HP) submersible pump. The water was pumped through a coarse filter to three in-line instantaneous water heaters connected in parallel. A pressure gauge was installed in-line to monitor water pressure. Heated water was pumped out through a dispersion manifold constructed of 1-inch-diameter polyethylene pipe and into one of the open ends of the soaker hose in each sewer pipe. The water circulated through the loop of the soaker hose, back out of the sewer pipe through a return manifold, and back to the well. The volume of water injected into the active warming test plot was controlled through the use of two gate valves, one on the influent side of the active warming test plot with a bypass back to the well for excess flow, and the other on the effluent line just prior to returning to the well. The volume of heated water injected into the site was increased when the pressure on the soaker hoses was increased.

The extraction well, pump, and water heaters were installed below the ground surface so that contaminated groundwater was never pumped to the surface. An hour meter was installed in series with the extraction pump to calculate electricity consumption for the water heaters and extraction pump based on the manufacturer-stated usage rates.

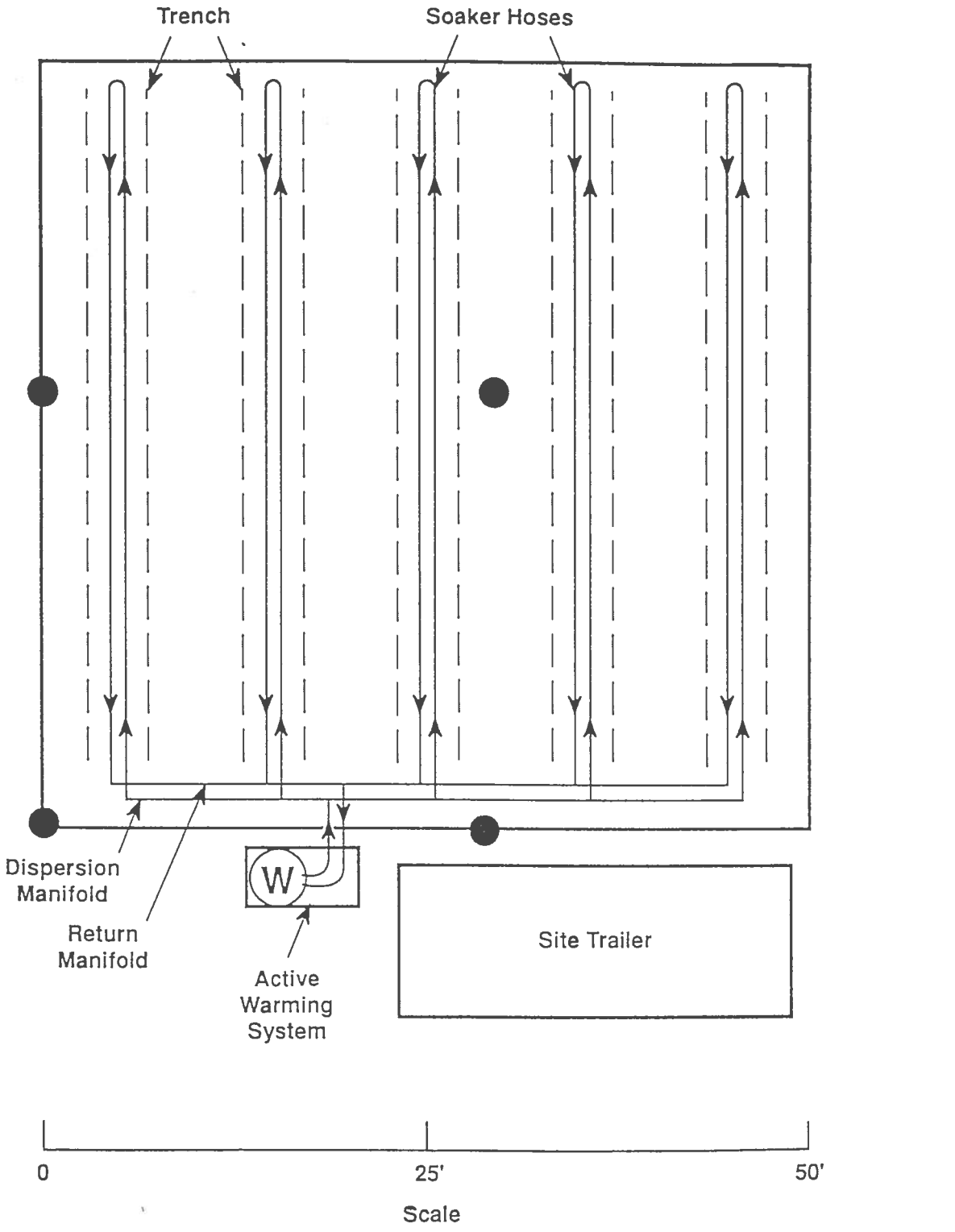


Figure 7. Schematic Diagram of the Active Warming System Soaker Hose Layout.

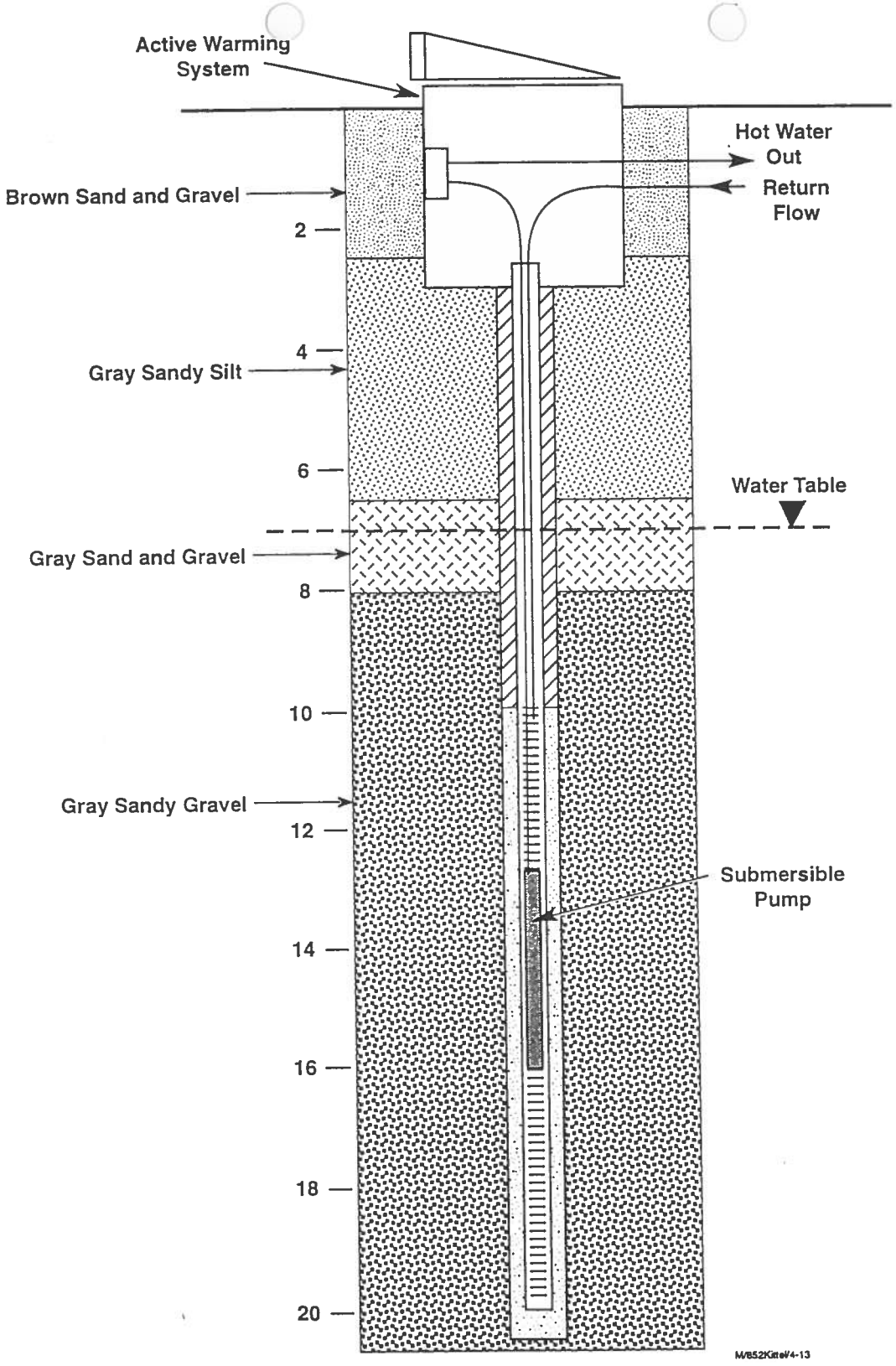


Figure 8. Schematic Diagram of the Construction Detail of the Active Warming Test Plot Extraction Well.

The active warming test plot was thermally isolated from the adjacent test plots by approximately 30-ft spacing. The surface area of the active warming test plot was insulated with Styrofoam™ insulation to help retain heat. A cross-section of the active warming test plot is shown in Figure 9.

6. Passive Warming Test Plot

The passive warming test plot was designed to maximize solar warming to promote soil heating. During the winter months, the test plot was insulated with Styrofoam™ insulation, and during the summer months, the test plot was covered with clear plastic to promote passive solar warming. During the second year of operation, black weed stopper was placed underneath the clear sheeting to reduce plant growth. A schematic diagram of the test plot is shown in Figure 10. The following items were installed in the passive warming test plot:

- four shallow bioventing wells (installed the first year of operation)
- one deep bioventing well (installed the second year of operation)
- five three-level Type J thermocouples
- six shallow three-level soil gas monitoring points (installed the first year of operation)
- two deep three-level soil gas monitoring points (installed the second year of operation)
- one groundwater monitoring well.

7. Control Test Plot

The control test plot was designed to compare microbial activity in an untreated area with that in heated areas. This plot received air injection, but was not covered with insulation and was not heated. A schematic diagram of the test plot is shown in Figure 11. The following items were installed in the control test plot:

- four shallow bioventing wells (installed the first year of operation)
- one deep bioventing well (installed the second year of operation)
- four three-level Type J thermocouples (two three-level thermocouples were installed in the same borehole and at the same depth as monitoring points C7 and C8)
- six shallow three-level soil gas monitoring points (installed the first year of operation)
- two deep three-level soil gas monitoring points (installed the second year of operation)

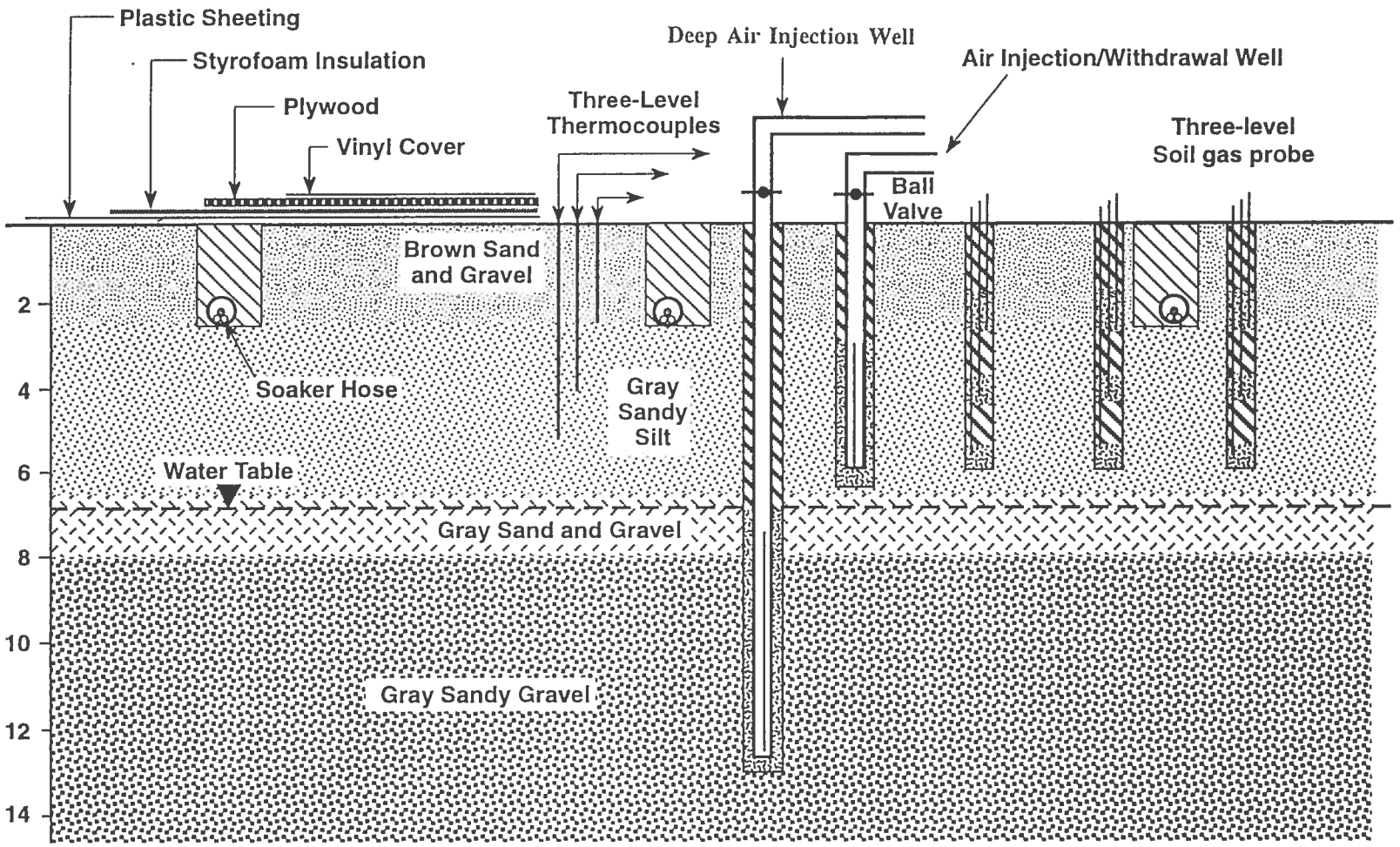


Figure 9. Cross Section of the Active Warming Test Plot.

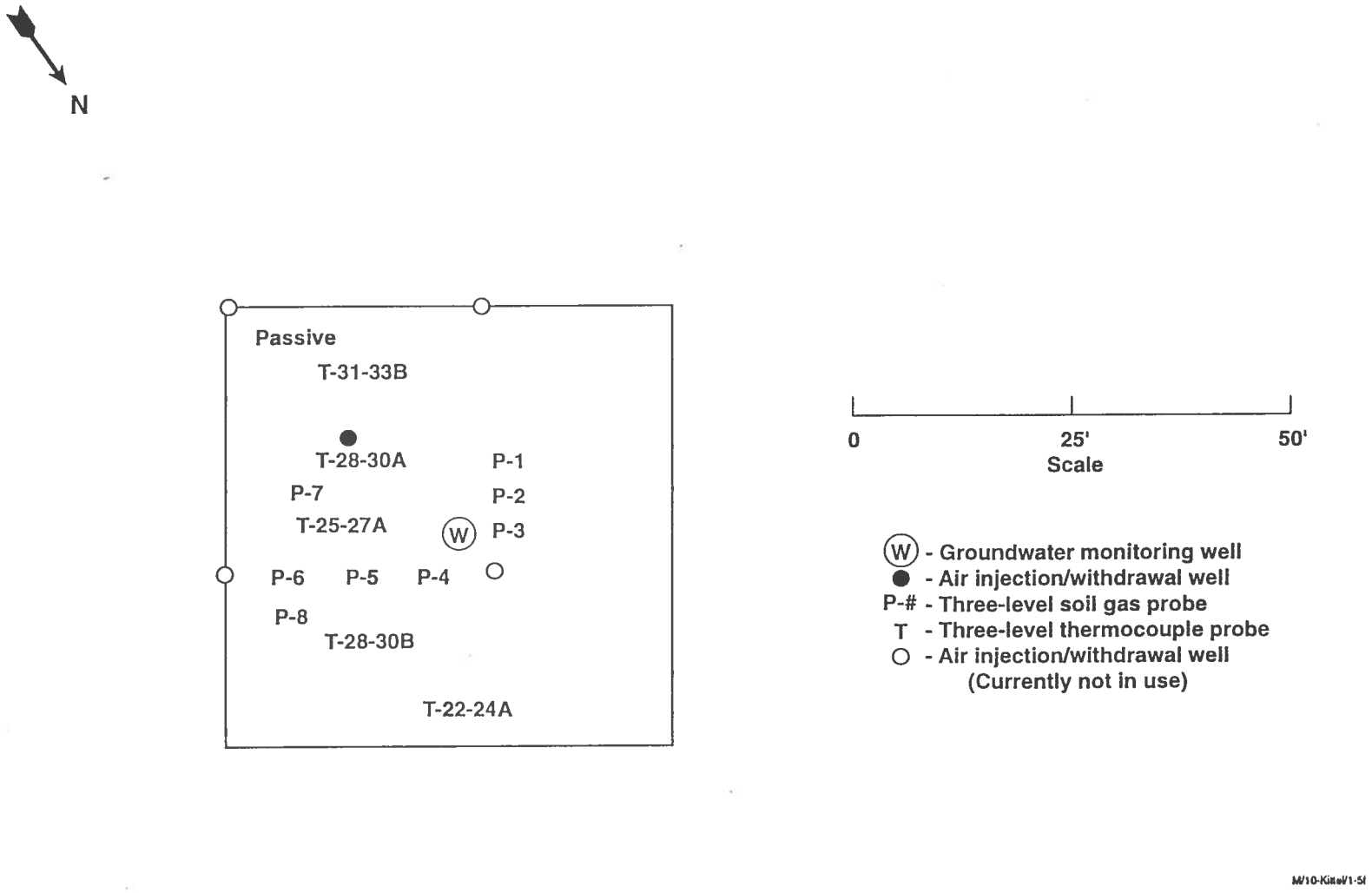


Figure 10. Schematic Diagram of the Passive Warming Test Plot.

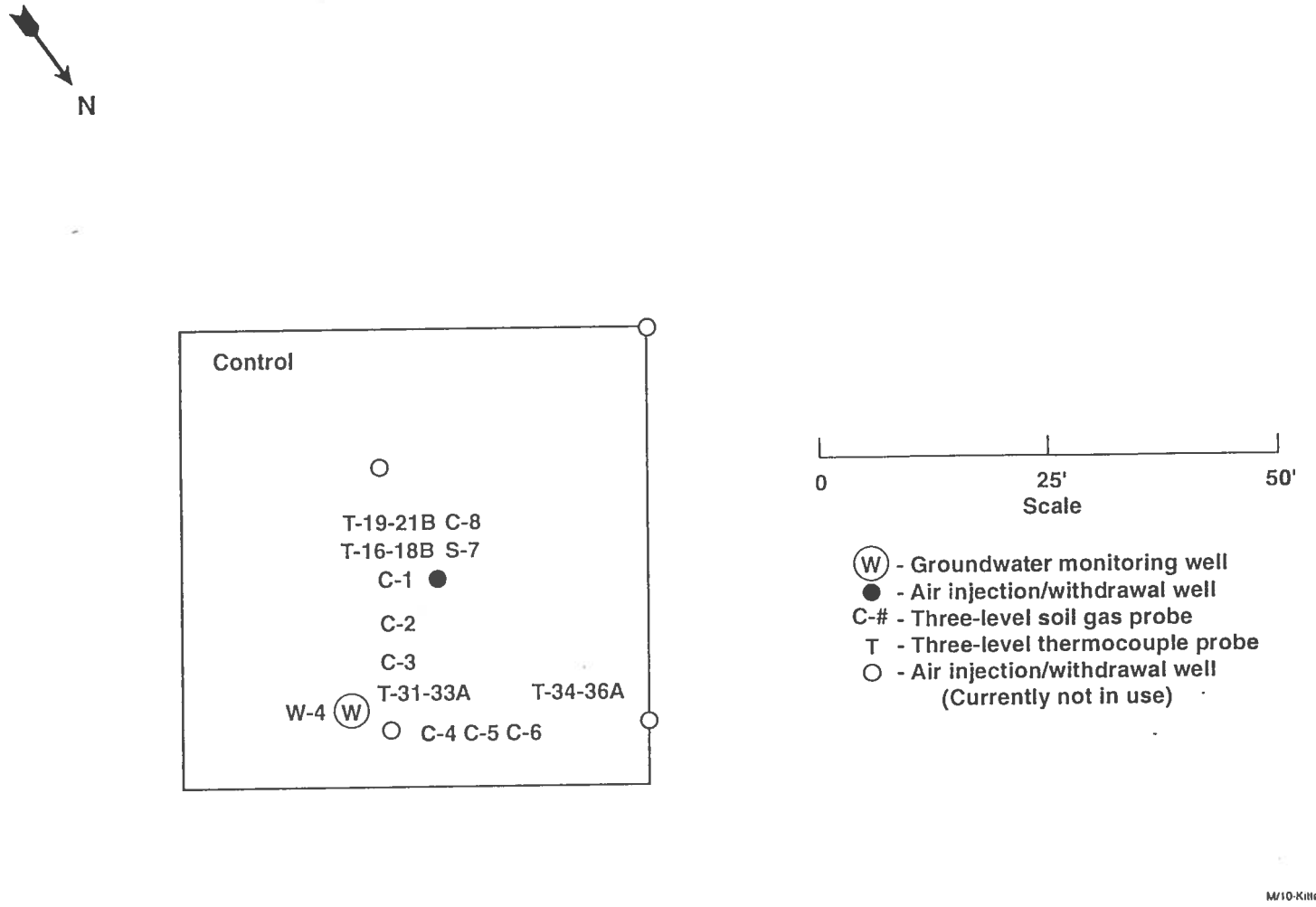


Figure 11. Schematic Diagram of the Control Test Plot.

- one groundwater monitoring well.

8. Surface Warming Test Plot

The surface warming test plot was installed in August 1992 to examine a different form of soil warming. Heat tape was buried at a depth of 3 feet to warm the soil. The test plot was covered with insulation to retain heat. A schematic diagram of the test plot is shown in Figure 12. Specific details of the construction at this test plot are given below. The following items were installed in the surface warming test plot:

- five shallow bioventing wells (construction detail given below; one vent well was installed just outside of the test plot)
- one deep bioventing well
- five three-level Type J thermocouples (thermocouples 1B through 9B were installed in groups of three in the same boreholes and at the same depths as monitoring points 1, 2, and 6; thermocouples 10B through 15B were installed in groups of three at depths of 2, 4, and 6 ft, and one thermocouple was placed directly next to the heat tape at a depth of 3 ft)
- six deep three-level soil gas monitoring points (except for monitoring point 4 where probes were installed at depths of 2, 4, and 7 ft).

Two strips of heat tape were installed in serpentine fashion to provide nine rows 5 ft apart at a depth of 3 ft. The first and last rows were located 5 ft from the border of the test plot and each row terminated 5 ft from the border of the test plot, so that a 40′ × 40′ area was covered. The two strips of heat tape were overlapped so that one strip could be disconnected if the soil temperature were to rise too high, yet relatively even heating of the test plot could be maintained.

In August 1992, two additional bioventing wells were installed to 6-ft depth, with 3 ft of 10-slot screen and 4 ft of schedule 40 PVC casing finished 1 ft above grade. A medium-grade silica sand filter pack was installed across the screened interval, and bentonite chips were used to fill the remaining annular space to grade.

In July 1993, two additional bioventing wells were installed for use during the soil vapor extraction test. One well was installed inside the test plot to 6-ft depth, with 5 ft of 10-slot screen and 2 ft of schedule 40 PVC casing finished 1 ft above grade. The well just outside the test plot was installed to 6-ft depth, with 4 ft of 10-slot screen and 3 ft of schedule 40 PVC casing finished 1 ft above grade. For both wells, a medium-grade silica sand filter pack was installed across the screened interval, and bentonite chips were used to fill the remaining annular space to grade.

9. Background and Perimeter Area

An uncontaminated area was located approximately 200 ft southwest of the contaminated site. One vent well and two soil gas monitoring points were installed in the background area. The background area was not insulated. One monitoring point was installed at a depth of only

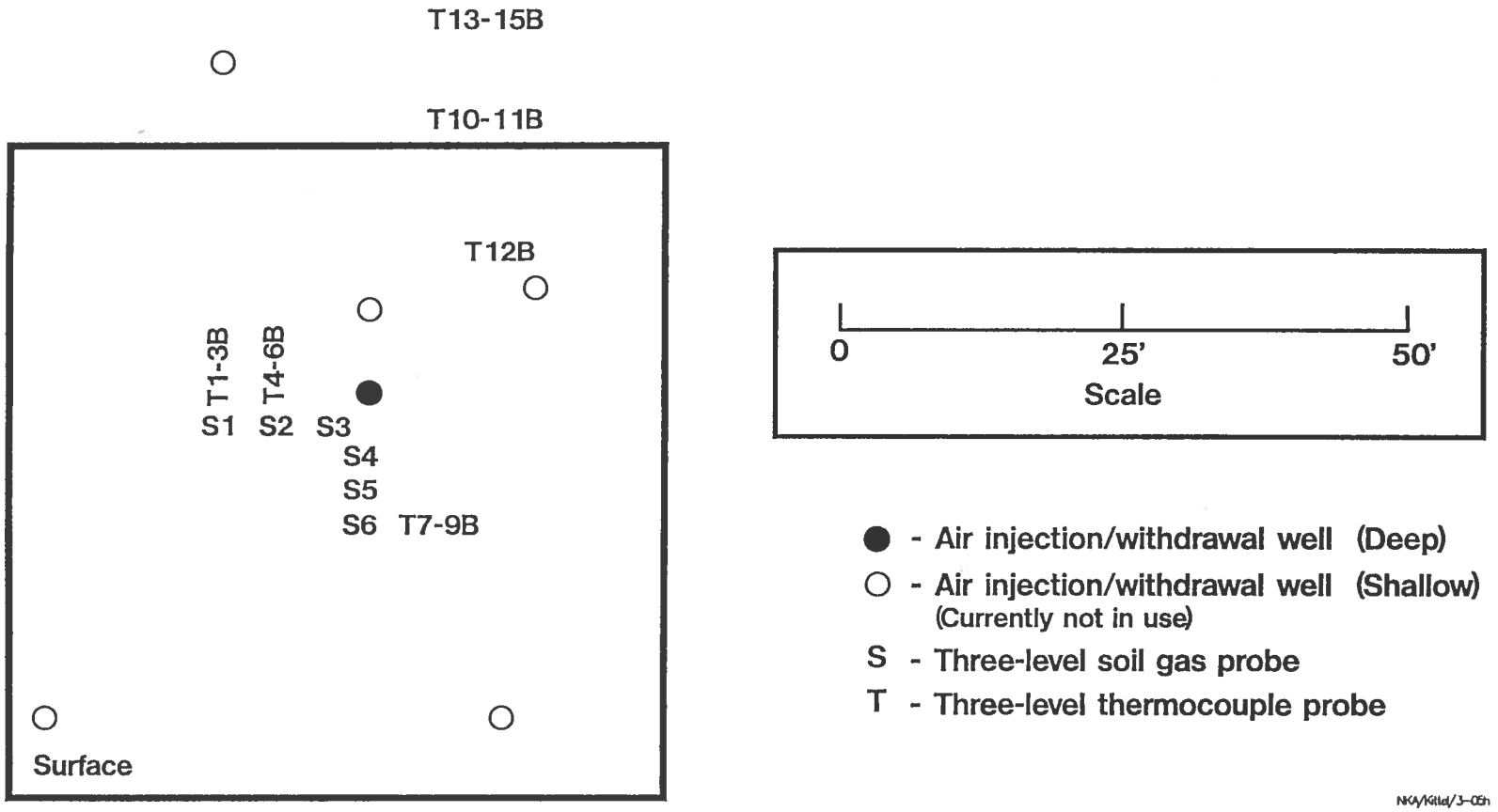


Figure 12. Schematic Diagram of the Surface Warming Test Plot.

3.5 ft, and one three-level soil gas monitoring point was installed during the second year of operation at depths of 2.5, 4.5, and 7.5 ft. One three-level thermocouple was installed in the background area at the same depths as the three-level monitoring point.

An additional 10 three-level soil gas monitoring point locations (including background area) are situated outside of the test plots to monitor soil gas concentrations across the E-7 area (Figure 13). Monitoring point locations PP-4, PP-9, and PP-10 have only two probes installed at 2.0 and 4.25 ft. One three-level thermocouple was installed between the passive warming and the control test plot, two three-level thermocouples were installed between the active and surface warming test plot, one three-level thermocouple was installed between the active and passive warming test plot, and two three-level thermocouples were installed between the surface warming test plot and the control test plot.

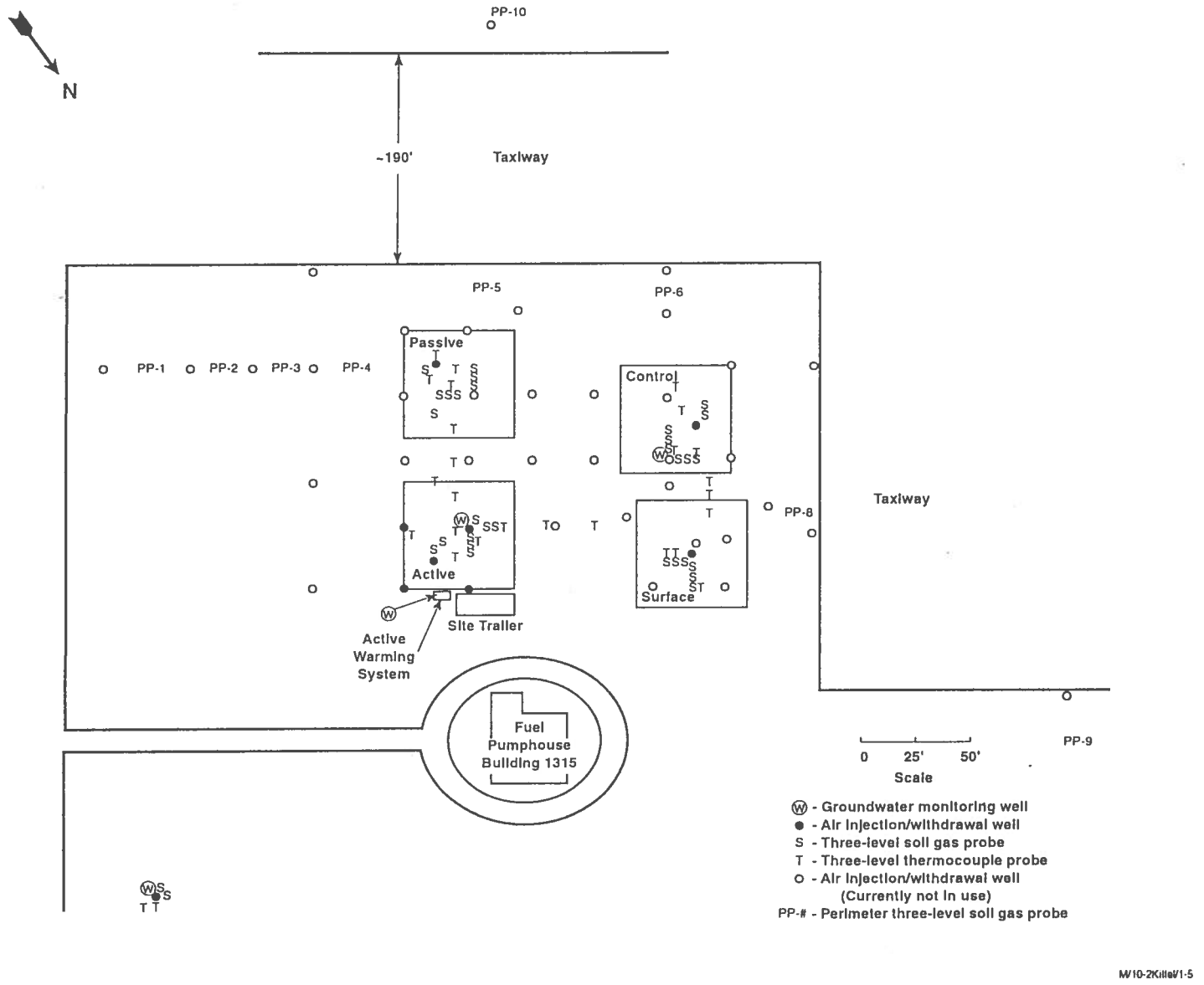


Figure 13. **Schematic Diagram of the Bioventing Site Showing Thermocouples, Soil Gas Monitoring Points, Bioventing Wells, and Groundwater Wells.**

SECTION V
METHODS FOR FIELD TESTS AND SYSTEM MONITORING

The field tests conducted for this project consisted of (1) surface emissions testing; (2) a helium tracer study; (3) stable carbon isotope ratio analyses; (4) soil gas permeability testing; (5) soil vapor extraction testing; and (6) soil vapor extraction with reinjection testing. System monitoring included laboratory analyses of soil gas contaminants, regular field soil gas sampling and soil temperature analysis, in situ respiration tests, initial and final groundwater sampling, and initial and final soil sampling. All field operations were performed in accordance with the General Site Health and Safety Plan and the Quality Assurance Project Plan. Copies of these plans are provided in Appendices D and E, respectively.

A. SURFACE EMISSIONS TESTING

One of the concerns over the implementation of bioventing as a means of soil remediation is the possibility of transferring soil contaminants to the atmosphere through air-stripping of organics. To determine if there is any significant release of volatile organic compounds (VOCs) to the atmosphere during bioventing, surface emissions testing was performed. The sampling and analytical methodologies for these tests are presented in the following sections.

1. Dynamic Surface Emissions Sampling Methodology

A dynamic surface emissions sampling methodology was used at Eielson AFB. This method involved enclosing an area of soil under an inert box designed to allow the purging of the enclosure with high-purity air (Dupont, 1987). The purging removed ambient air from the region above the soil and allowed an equilibrium to be established between the hydrocarbons emitted from the soil and the organic-free air. The air stream was then sampled by drawing a known volume of the hydrocarbon/pure air mixture through a tube packed with sorbent materials. The sorbents retained any organics associated with surface emissions. The sample tube was thermally desorbed, and the organics were resolved and quantified by gas chromatography (GC). These measured concentrations were then used to calculate the emission rates for the hydrocarbons from the soil to the atmosphere.

A schematic diagram of the surface emissions sampling system is shown in Figure 14. The system consisted of a square Teflon™ box that covered a surface area of 0.45 m^2. The box was fitted with inlet and outlet ports for the entry and exit of high-purity air. Inside the box was a manifold that delivered the air supply uniformly across the soil surface. The same type of manifold was fitted to the exit port of the box. This configuration delivered an even flow of air across the entire soil surface under the box so that a representative sample was being generated.

The air exiting the Teflon™ box was directed to a heated sampling box. This box contained the sorbent tube and an SKC personal monitoring pump, Model #224-PCXR7. Also attached to the heated box was a purge line that accommodated the excess flow from the Teflon™ box that was not drawn into the sorbent tube. A Magnehelic™ gauge indicated if zero pressure was being maintained on the entire system.

In all cases, a totally inert system was employed. Teflon™ tubing and stainless steel fittings assured that there was no contribution to or removal of organics from the air stream. The

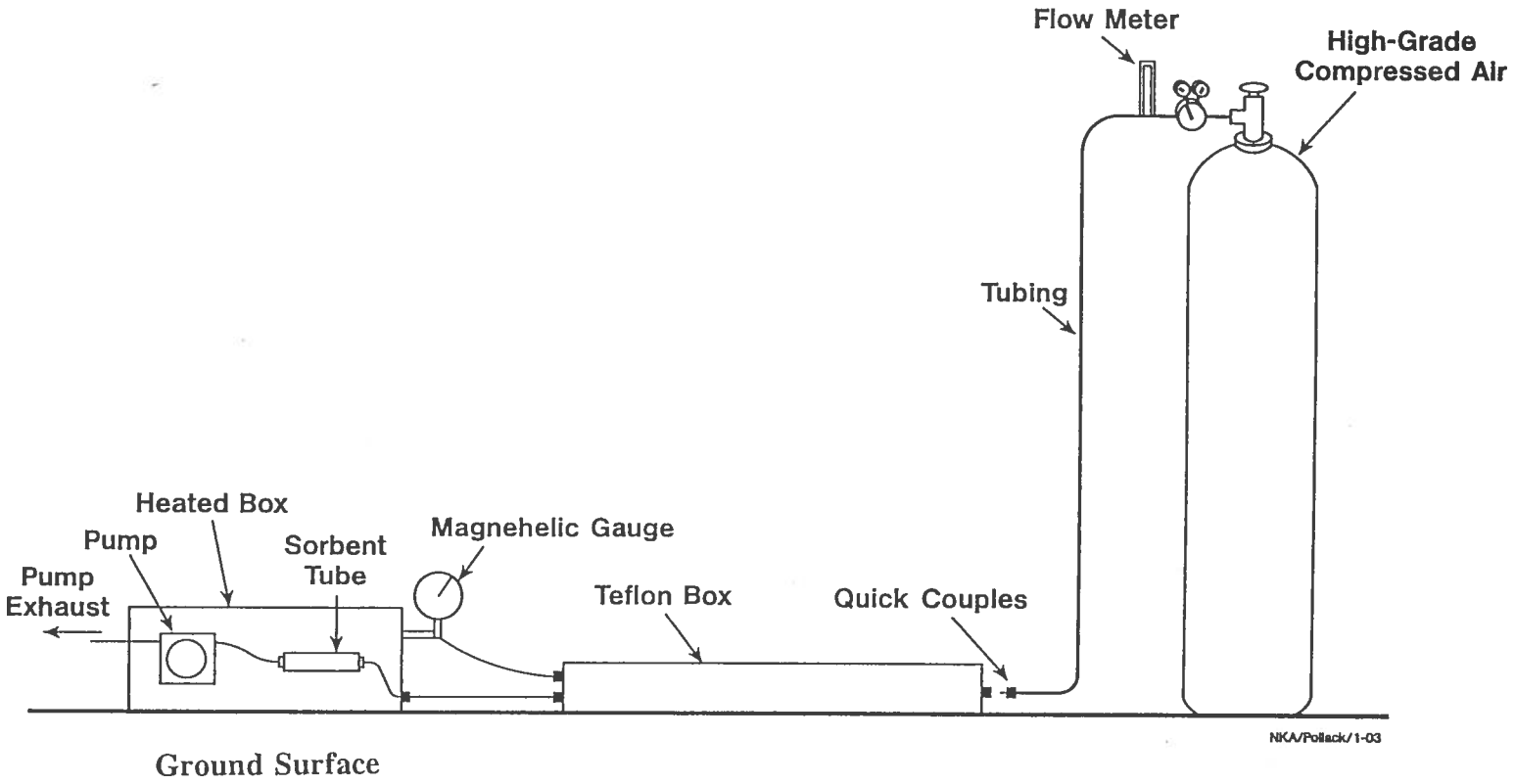


Figure 14. Schematic Diagram of the Surface Emissions Sampling System.

pump was located on the back side of the sorbent trap so that it was not in a position to contaminate the sample flow.

Detailed descriptions of the field sampling technique and the quality assurance/quality control (QA/QC) sample results and analytical precision are presented in Appendix F.

2. Sampling Schedule

Seven surface emission sampling events were performed at the bioventing site at Eielson AFB during 1993 and 1994. Sampling conditions for each of these events are described in the following sections.

a. January 1993

The January 1993 sampling event was the first time that the dynamic surface emissions methodology was used at Eielson AFB. This was looked upon as an opportunity to identify collection parameters to be used in subsequent sampling efforts along with generating an initial data set for surface emissions. General sampling locations at the control and background plots were identified and flow rates for loading the sorbent tubes and total sample volumes were investigated.

Because of the uncertainty of the organic loading that actually would be delivered to the sorbents, flow rates of 15 mL/minute and 125 mL/minute were employed. In both cases, 20-minute collection times were used, resulting in 300-mL and 2,500-mL total sample volumes, respectively. These "low" and "high" loadings were used to ensure that sufficient vapor was collected to allow for contaminant detection.

Samples were collected at the control test plot and at the background area both during air injection and without air injection. At the control plot, samples were collected at 5, 11, and 19 ft east of the vent well (EVW). At the background area, samples were collected 15 ft EVW. Additionally, four trip blanks and one ambient air sample were analyzed. The surface emissions samples were collected with the Teflon™ box resting on the existing snowpack. Ambient temperatures during the sampling period ranged from -23 to -32°C (−10 to −25°F).

Only the low-volume samples data are reported, because performance information for the sorbent tubes obtained after the January sampling indicates that loading rates of greater than 100 mL/minute may not have allowed sufficient residence time of the organics in the tube for quantitative adsorption.

b. July 1993

During July 1993, samples were collected at the control test plot and the background area both with and without air injection. Based on the results from the January sampling, a flow rate of 50 mL/minute for 10 minutes was used to produce a 500-mL sample volume. At the control plot, samples were collected at 8-, 11-, and 19-ft east of the vent well (EVW). A sample of the high-grade air also was collected to verify the cleanliness of the purge gas. A trip blank was reserved to identify any background artifacts from the sorbent materials. During sampling, the Teflon™ box was positioned directly upon the soil surface, and the ambient air temperature ranged from 21 to 29°C (70 to 85°F).

c. September 1993

The September sampling event was coordinated with the helium tracer study and monitored the emissions from the control test plot only during air injection. A cylinder air blank and a trip blank were included in this sampling set. A flow rate of 50 mL/minute for 10 minutes was used to produce a 500-mL sample volume. Samples were collected 8-, 13- , and 19-ft east of the vent well. During this sampling period, the Teflon™ box was in contact with the soil surface, and the ambient air temperature ranged from 16 to 21°C (60 to 70°F).

d. November 1993

Surface emissions sampling was conducted in November to examine the effect of different air injection rates on surface emissions. The first test was conducted with air injection at 5.0 cfm into the deep injection well in the control test plot. The second was at 2.5 cfm. The third test was conducted with the blower off. One set of background area samples was collected during air injection.

An ambient air sample was collected during each of the three tests. A cylinder air blank was collected and a trip blank tube was reserved. A flow rate of 50 mL/minute for 10 minutes was used to produce a 500-mL sample volume. Samples were collected at the same locations as during the September 1993 sampling event. During sampling, the Teflon™ box was positioned on a layer of snow, and the ambient air temperature ranged from -12 to -0.6°C (10 to 31°F).

e. January 1994

During January 1994, the Teflon™ box rested on an existing snowpack of approximately 24 inches, with ambient air temperatures ranging from -37 to -29°C (−35 to −20°F). A flow rate of 50 mL/minute for 10 minutes was used to produce a 500-mL sample volume. A total of 21 sorbent tubes were collected for analysis: 4 were ambient air samples; 2 were duplicate samples from the control plot; 2 were cylinder gas air blanks; 1 was a trip blank; and the remainder were from the 8-, 11-, and 19-ft sampling locations at the control test plot and the background area with and without air injection.

f. April 1994

Surface emission sampling was performed again at the control test plot and the background area. The Teflon™ box was positioned on a residual snowpack during sampling with air injection. High winds and blowing snow were observed. During sampling with the blowers off, temperatures had increased so that the box was resting on melting snow. A flow rate of 50 mL/minute for 10 minutes was used to produce a 500-mL sample volume. Samples were collected at the same locations as during the January 1994 sampling event. Ambient temperatures ranged from -14 to 12°C (7 to 54°F). Ambient air, trip blanks, cylinder purge gas, and duplicate surface emissions samples were included in the sample set.

g. July 1994

The final surface emissions samples were collected in conjunction with the July 1994 in situ respiration test. Samples with and without air injection were collected at the control test plot and the background area. During sampling, the Teflon™ box was in direct contact with the soil, and ambient temperatures ranged from 11 to 27°C (51 to 81°F). A flow rate of 50 mL/minute for 10 minutes was used to produce a 500-mL sample volume. Samples were collected at the same locations as during the January 1994 sampling event. Ambient air, trip blanks, cylinder gas, and duplicate surface emission samples were collected.

B. HELIUM TRACER STUDY

The helium tracer study was conducted in September 1993. The purpose of this test was to trace the flow of air through the soil and through the surface using helium as a conservative tracer. Plastic sheeting was placed over the control test plot to monitor helium emitted from the ground surface. The edges of the plastic sheeting were placed in an approximately 1-ft-deep trench and weighed down with soil. Five ½-horsepower diaphragm pumps were placed outside the sheeting and connected by tubing underneath the sheeting to pump the air from underneath the plastic covering. The total flow rate from the five pumps was 2.6 cfm. The soil gas from the pumps was merged together into one effluent to measure the flow rate and the helium and TPH concentration. A schematic diagram of the plastic-covered area for the helium tracer study is shown in Figure 15.

Air/helium flow was initiated on September 6, 1993, at a flow rate of 2.5 cfm into the deep injection well in the control test plot with a helium concentration of approximately 5.4%. Helium injection was continued for approximately 8 days. Raw data from this test are presented in Appendix G.

C. STABLE CARBON ISOTOPE TESTING

Stable carbon isotope measurements were conducted to provide verification of the biodegradation of petroleum compounds in situ. Measurement of stable carbon isotope ratios may help substantiate biodegradation in the field (Aggarwal and Hinchee, 1991). Carbon dioxide produced by hydrocarbon degradation may be distinguished from that produced by other processes based on the carbon isotopic compositions characteristic of the source material and/or the fractionation accompanying microbial metabolism (McMahon et al., 1990; Stahl, 1980; Suchomel et al., 1990).

Stable carbon isotope ratio analyses in soil gas carbon dioxide were conducted five times during 1993 and 1994. Soil gas was collected in 280-mL vacuum samplers during in situ respiration testing. Soil gas samples were collected from the active, passive, and surface warming test plots as well as from the background area. Stable carbon isotopic ratios were measured by Global Geochemistry Corporation in Canoga Park, California using standard techniques.

Isotopic composition of a sample (x) is reported in the conventional δ notation as parts per thousand (per mil, ‰) deviation from the Peedee belemnite (PDB) standard (Craig, 1957):

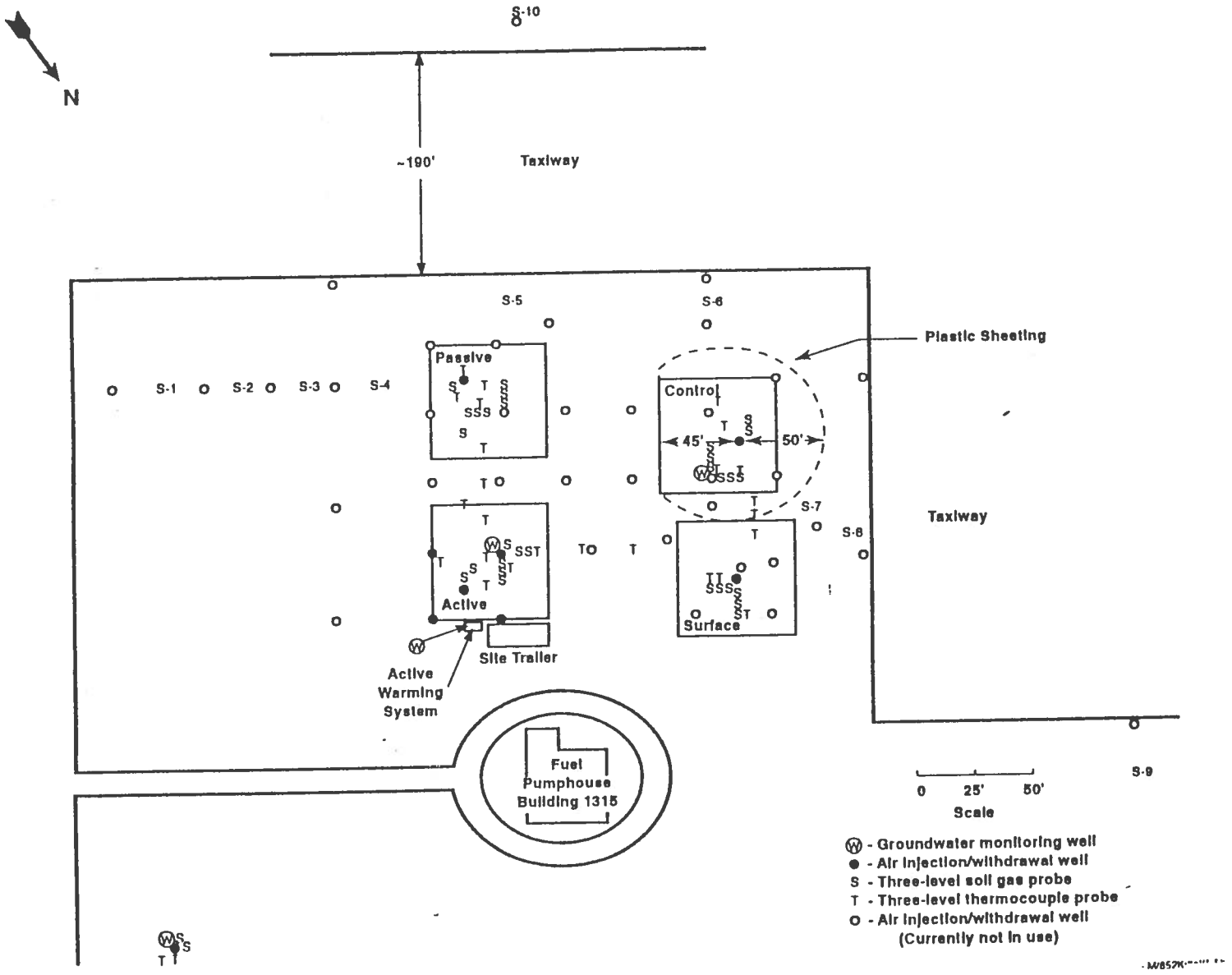


Figure 15. Schematic Diagram of the Helium Tracer Study Setup.

$$\delta_x\ (‰) = \frac{R_x - R_s}{R_s} \times 100 \qquad (1)$$

where R is the ratio of $\delta^{13}C$:^{12}C in the sample or the standard. The reproducibility of isotopic values is better than $\pm 0.3‰$ for samples with more than a few tenths of a percent carbon dioxide and approximately $\pm 1‰$ for samples with approximately 0.1% or less carbon dioxide.

D. SOIL GAS PERMEABILITY TESTING

1. Soil Gas Permeability and Radius of Influence

Soil gas permeability, k, or intrinsic permeability, can be defined as a soil's capacity for fluid flow, and varies according to grain size, soil uniformity, porosity, and moisture content. The value of k is a physical property of the soil; k does not change with different extraction/injection rates or different pressure levels. Soil gas permeability generally is expressed in the units cm^2 or darcy (1 darcy = 1×10^{-8} cm^2). As with hydraulic conductivity, soil gas permeability may vary by more than 1 order of magnitude on the same site due to soil variability.

The radius of influence, R_I, is defined as the maximum distance from the air extraction or injection well where measurable vacuum or pressure (soil gas movement) occurs. The radius of influence is a function of soil properties, but also is dependent on the configuration of the venting well and extraction or injection flow rates, and is altered by soil stratification. On sites with shallow contamination, the radius of influence can be increased by impermeable surface barriers such as asphalt or concrete. These paved surfaces may or may not act as vapor barriers. Without a tight seal to the native soil surface, the pavement will not significantly impact soil gas flow.

Battelle developed a protocol for the AFCEE to conduct field treatability tests for bioventing at multiple sites. The protocol (Hinchee et al., 1992) includes a detailed section on the performance of soil gas permeability and radius of influence testing. The field testing performed at Site 20, Eielson AFB was performed according to the Air Force protocol.

The bioventing research project being performed at Site 20 has been centered around an investigation of the efficacy of soil warming techniques at enhancing in situ bioremediation of hydrocarbon-contaminated soils during bioventing. When the system was installed in the summer of 1991, the placement and spacing of the bioventing wells were based on the configuration of the soil warming test plot, soil sampling objectives, and a conservative assumption of an R_I of 15 ft at the site. The original bioventing well configuration consisted of four vent wells, screened from 3 to 6 ft in depth and spaced 30 ft apart in each 50-ft by 50-ft test plot. This configuration allowed each test plot to be adequately and uniformly aerated, ensuring that soil temperature would be the only system variable between the plots. In the summer of 1992, a fifth vent well was added at the approximate center of each test plot. These wells were screened deeper (from 6.5 to 13 ft below ground level) into the groundwater table to ensure that the soils were aerated at a sufficient depth.

Although the conservative rationale used for placing the bioventing wells was sufficient for conducting the soil warming study, a more cost-efficient, systematic approach must be taken when designing a full-scale bioventing system. The soil gas permeability testing described

below was conducted at Site 20 to calculate k and R_I to help characterize the optimum well placement configuration for the design of a full-scale bioventing system.

2. Soil Gas Permeability Test Procedures

The procedures for conducting soil gas permeability testing are discussed in detail in the protocol (Hinchee et al., 1992). The general procedures used at Site 20 are presented in the following paragraphs.

A soil gas permeability test was conducted in each test plot (active, passive, and surface warming, and the control). In each test, the single deep vent well was used for the soil gas permeability test and the other wells in the test plot were closed. Soil gas permeability testing was conducted in air injection mode in all four test plots. In the control test plot, the soil gas permeability test also was conducted in extraction mode to investigate the effect of air extraction on radius of influence compared to the effect of air injection. The air extraction test used a well screened to 6 ft adjacent to the deep screened well to avoid extraction of groundwater during the test.

All soil gas permeability testing was conducted using the bioventing system blower housed in the Site 20 bioventing field trailer. For the air injection soil gas permeability tests conducted at each test plot, air was injected into the single deep screened well in the center of the plot. Changes in soil gas pressure were monitored over time using a Magnehelic™ gauge at six 3-level soil gas monitoring points located at different radii from the bioventing well. The tests were discontinued when no significant pressure change could be observed in any of the monitoring points. The air extraction soil gas permeability test differed only in that soil gas was extracted from a 6-ft-deep bioventing well located near the center of the test plot.

a. Active Warming Test Plot (Injection)

The following 3-level soil gas monitoring points were monitored during the soil gas permeability test conducted in the active warming test plot: A7 (11.0 ft radius from bioventing well), A4 (21.5 ft), A6 (23.5 ft), P8 (65.0 ft), P1 (84.5 ft), and C1 (110.5 ft). Air injection was initiated at 4.6 cfm with a blower injection pressure of 57 inches of water. Pressure monitoring was initiated at 1-minute intervals for the first 10 minutes of the test, and then at less frequent time intervals as changes in pressure became less rapid. The test was discontinued after 100 minutes. The raw data for the active warming test plot soil gas permeability test are presented in Appendix H.

b. Passive Warming Test Plot (Injection)

The following 3-level soil gas monitoring points were monitored during the soil gas permeability test conducted at the passive warming test plot: P5 (12.1 ft radius from bioventing well), P1 (13.6 ft), P8 (19.75 ft), A4 (69.5 ft), A7 (74.25 ft), and C1 (107.5 ft). Air injection was initiated at 8.2 cfm with a blower injection pressure of 7.5 inches of water. Pressure monitoring was initiated at 1-minute intervals for the first 10 minutes of the test, and then at less frequent time intervals as changes in pressure became less rapid. The test was discontinued after 30 minutes. The raw data for the passive warming test plot soil gas permeability test are presented in Appendix H.

c. Control Test Plot (Injection)

The following 3-level soil gas monitoring points (1 vent well was also monitored) were monitored during the soil gas permeability test conducted at the control test plot: C7 (4.0 ft radius from bioventing well), C1b and C1c (7.75 ft), C2a (10.25 ft), C5 (14.7 ft), passive vent well (28.25 ft), S3 (60.0 ft), and P1 (96.75 ft). Air injection was initiated at 4.5 cfm with a blower injection pressure of 30 inches of water. Pressure monitoring was initiated at 1-minute intervals for the first 10 minutes of the test, and then at less frequent time intervals as changes in pressure became less rapid. The test was discontinued after 30 minutes. The raw data for the control test plot soil gas permeability test are presented in Appendix H.

d. Surface Warming Test Plot (Injection)

The following 3-level soil gas monitoring points were monitored during the soil gas permeability test conducted at the surface warming test plot: S3 (4.0 ft radius from bioventing well), S1 (12.3 ft), passive vent well (31.0 ft), C3 (44.5 ft), P7 (45.5 ft), and C1b and C1c (50.75 ft), and C2a (53.5 ft). Air injection was initiated at 1.6 cfm with a blower injection pressure of 58 inches of water. Pressure monitoring was initiated at 1-minute intervals for the first 10 minutes of the test, and then at less frequent time intervals as changes in pressure became less rapid. The test was discontinued after 90 minutes. The raw data for the surface warming test plot soil gas permeability test are presented in Appendix H.

e. Control Test Plot (Extraction)

The following 3-level soil gas monitoring points (1 vent well also was monitored) were monitored during the soil gas permeability test conducted at the control test plot: C1b and C1c (6.0 ft radius from bioventing well), C2a (8.9 ft), passive vent well (14.7 ft), C5 (14.75 ft), C7 (20.0 ft), PP8 (77 ft), and P1 (96.75 ft). Air extraction was initiated at 5.0 cfm with a blower extraction vacuum of 36 inches of water. Vacuum monitoring was initiated at 1-minute intervals for the first 10 minutes of the test, and then at less frequent time intervals as changes in pressure became less rapid. The test was discontinued after 40 minutes. The raw data for the control test plot soil gas permeability test are presented in Appendix H.

3. Soil Gas Permeability and Radius of Influence Calculations

Two methods, the dynamic method and the steady-state method, are recommended for calculating soil gas permeability (k) (Hinchee et al., 1992). Both calculations are based on the modified field drawdown method described by Johnson et al. (1990). The dynamic method requires careful measurement of pressure changes over time while injecting air at a constant rate. The computer program Hyperventilate™ has been developed to calculate k and R_I using the dynamic method. The second method for calculating k is the steady-state method. This method is best suited for sites where pressure changes during injection or extraction tests are rapid and reach equilibrium quickly. The data collected during the soil gas permeability testing at Eielson AFB is best suited for the steady-state method. The calculation for the steady-state method is presented in Equation (2).

$$k = \frac{Q\ \mu\ \ln\left(\frac{R_w}{R_I}\right)}{H\ \pi\ P_{atm}\left[1 - \left(\frac{P_{atm}}{P_w}\right)^2\right]} \qquad (2)$$

where:

Q	=	the volumetric flow rate from the vent well (cm^3/s)
μ	=	viscosity of air (1.8×10^{-4}g/cm-s at 18°C (64°F))
R_w	=	the radius of the venting well (cm)
H	=	depth of screen (cm)
R_I	=	the maximum radius of venting influence at steady state (cm)
P_{atm}	=	ambient pressure (at sea level 1.013×10^6 g/cm-s^2)
P_w	=	the absolute pressure at the venting well (g/cm-s^2)

Equation (2) applies only to vent wells operating under a vacuum. If air is being injected into the vent well, the equation is modified as shown in Equation (3):

$$k = \frac{Q\ \mu\ \ln\left(\frac{R_w}{R_I}\right)}{H\ \pi\ P_{atm}\left[1 - \left(\frac{P_w}{P_{atm}}\right)^2\right]} \qquad (3)$$

Values for k are expressed in darcy (1×10^{-8} cm^2).

E. SOIL VAPOR EXTRACTION TESTING

The bioventing system was configured to extract air from a shallow vent well from each of the four test plots, with the same line used for the control and the surface warming test plots. The system was set up to allow for sampling of soil gas concentrations of oxygen, carbon dioxide, and hydrocarbons from the extracted gas from each test plot as well as the concentrations of the total extracted soil gas. The passive vent wells shown in Figure 16 were open during the test. A schematic diagram of the soil gas extraction lines is shown in Figure 16.

Soil gas extraction was initiated on August 3, 1993. Prior to initiating air flow, soil gas concentrations of oxygen, carbon dioxide, and TPH were measured at each monitoring point. After

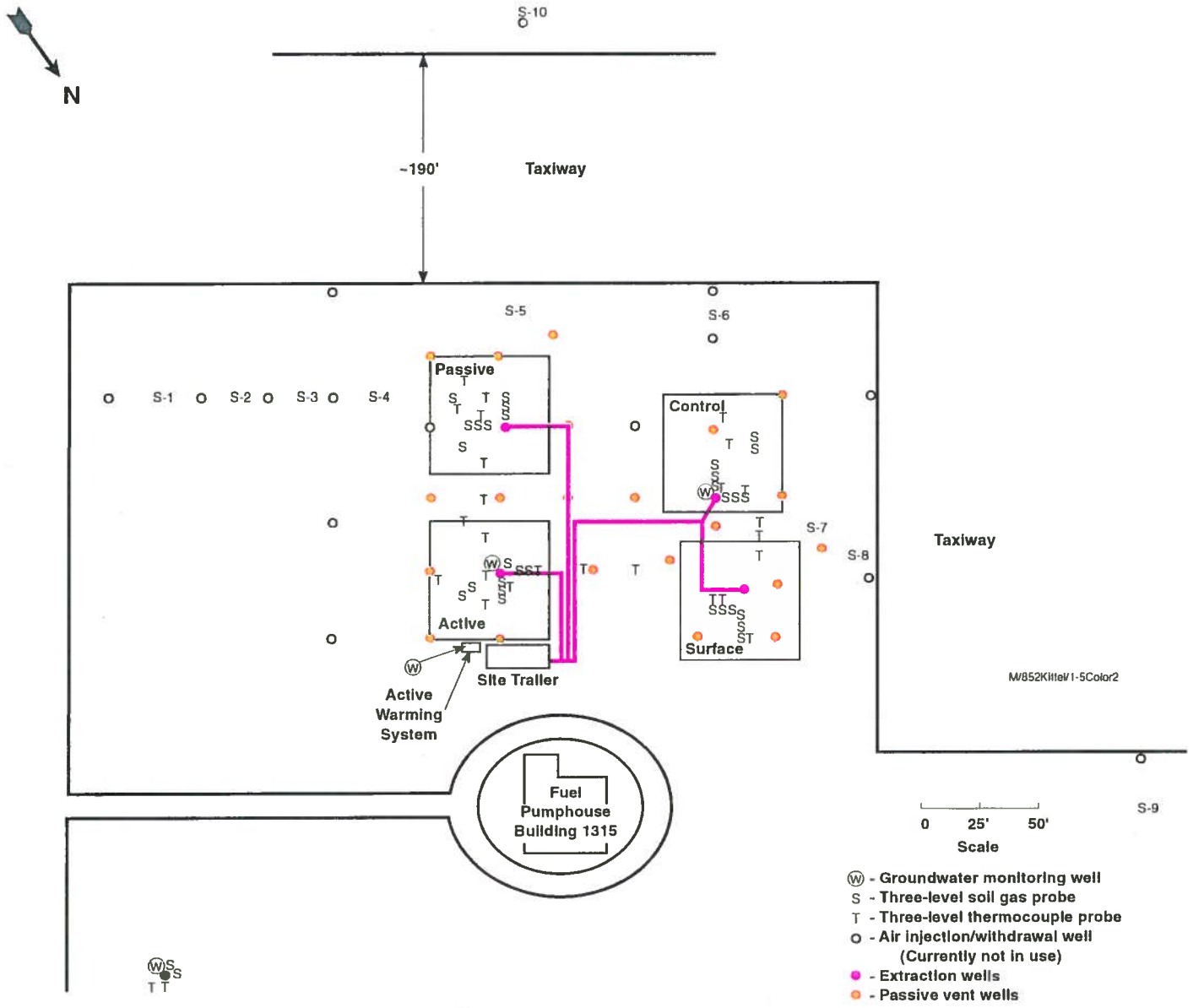


Figure 16. Schematic Diagram of the Soil Gas Extraction Test Setup.

initiation of soil gas extraction, soil gas concentrations were measured in the extracted off-gas and at the monitoring points. The pressure and flow rate were measured at each extraction line. Raw data from this test are presented in Appendix I. Off-gas concentrations of TPH were low; therefore, the off-gas was emitted to the atmosphere.

F. SOIL VAPOR EXTRACTION WITH REINJECTION

In September 1993, the site was reconfigured for a 5-day test of soil vapor extraction with reinjection of the extracted off-gas. The bioventing system was configured to extract air from each of the four test plots, with reinjection of the extracted soil gas into the deep center wells in each test plot. The extracted soil gas from all test plots was mixed prior to reinjection. The system was set up to allow for sampling of soil gas concentrations of oxygen, carbon dioxide, and hydrocarbons from the extracted gas from each test plot, and from the combined soil gas from the test plot. The passive vent wells were not open during this test. A schematic diagram of the soil vapor extraction and reinjection lines is shown in Figure 17.

Soil vapor extraction with reinjection was initiated on August 30, 1993, and continued for 5 days. Oxygen, carbon dioxide, and TPH concentrations were measured in the extracted soil gas from each test plot, in the combined extracted soil gas from the entire site, and at each monitoring point. Raw data from this test are presented in Appendix J.

G. COLLECTION AND LABORATORY ANALYSIS OF SOIL GAS SAMPLES

Soil gas samples were collected from the passive warming test plot, from the background area, and from ambient air approximately quarterly throughout this study. Soil gas samples were collected in canisters prepared by Utah Water Research Laboratory (UWRL). Each soil gas sample was labeled according to the location and depth of the sample. The time, date sampled, and sampler's initials were recorded on the sample label. Samples were recorded on a chain-of-custody sheet and shipped on ice to UWRL for analysis. Soil gas samples were analyzed by GC at UWRL. Samples were analyzed for petroleum contamination using EPA method 8020. Specific compounds measured were TPH, benzene, *n*-butylbenzene, *n*-decane, 2,4-dimethylpentane, *n*-dodecane, ethylbenzene, *n*-heptane, *n*-hexane, 2-methylbutane, 2-methylpentane, 1-methylnaphthalene, naphthalene, nonane, *n*-octane, *n*-pentadecane, *n*-pentane, *n*-propylbenzene, *n*-tetradecane, toluene, *n*-tridecane, undecane, and *p*-xylene. Raw data from these analyses are presented in Appendix K. Quality assurance/quality control methods are presented in Appendix E.

H. SOIL GAS AND TEMPERATURE MEASUREMENTS

The soil gas sampling was conducted approximately weekly and analyzed in the field for oxygen, carbon dioxide, and TPH. Occasionally, the soil moisture content prevented sampling from some soil gas monitoring points; however, adequate samples could be collected from the majority of the monitoring points. Raw data from these analyses are presented in Appendix L.

Soil temperature data were collected two or three times daily with an automatic data logger. Due to the relatively large quantity of temperature data collected and to the fairly slow change in soil temperature, only one data point from every two to four days is presented in the figures shown in Appendix M. Each figure in Appendix M illustrates the soil temperature at each depth at one three-level thermocouple.

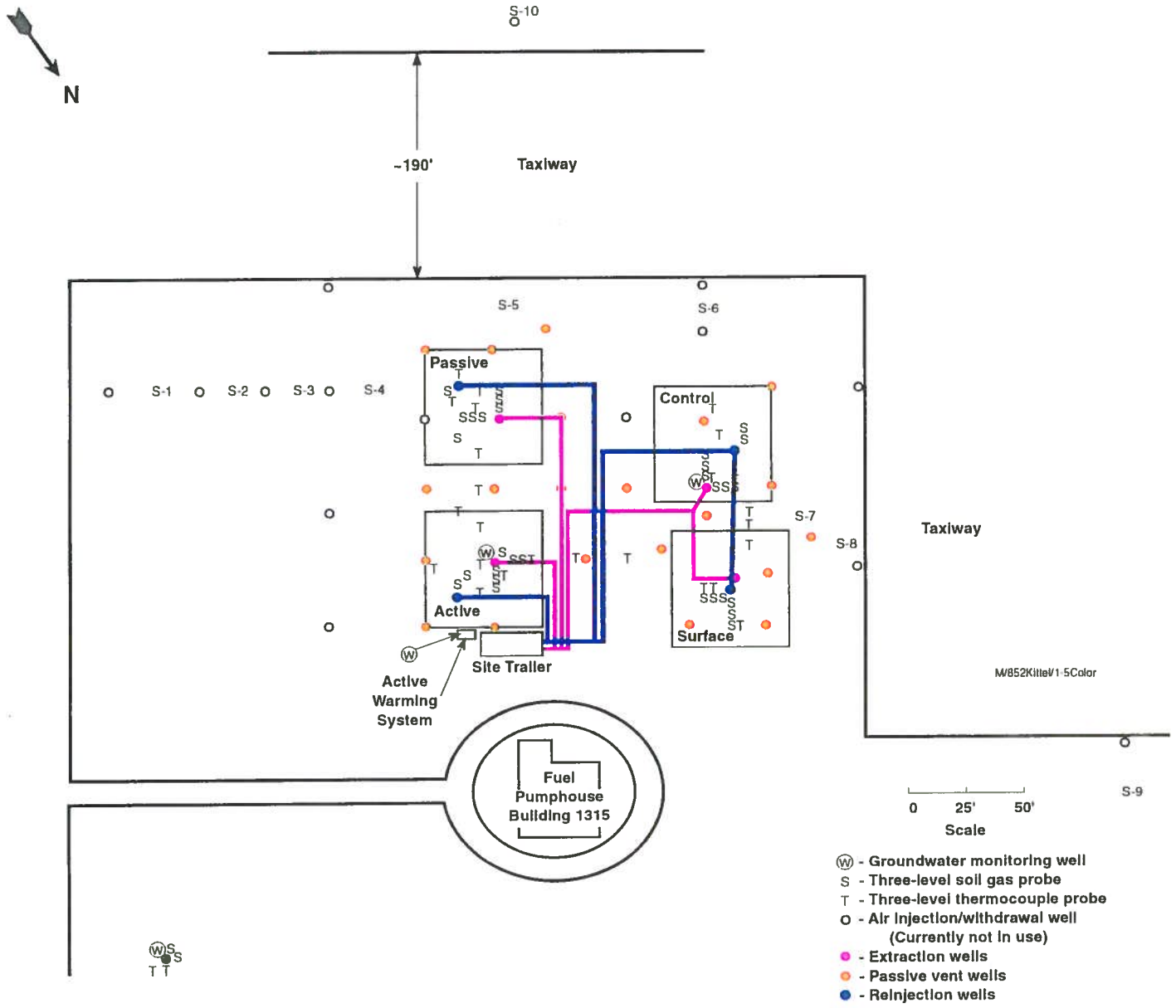


Figure 17. Schematic Diagram of the Soil Vapor Extraction with Reinjection Setup.

I. IN SITU RESPIRATION TESTING

In situ respiration tests were conducted monthly. These tests are based on the method described by Hinchee and Ong (1992). A full in situ respiration test involving all soil gas points and intensive sampling was conducted quarterly. During other months, an abbreviated in situ respiration test was conducted. This test generally involved sampling only 21 selected points, which were monitored at a lower frequency. The soil gas monitoring points that were monitored varied depending on the ability to collect a good soil gas sample. In general, all soil gas monitoring points that could be sampled in the active warming test plot were sampled, and two three-level soil gas monitoring points from each of the other test plots were sampled.

The in situ respiration testing consisted of monitoring soil gas oxygen and carbon dioxide concentrations during air injection, then turning off the air injection and monitoring the oxygen and carbon dioxide concentrations periodically over time. From these measurements, oxygen consumption and carbon dioxide production were determined. The experiment usually was terminated when either the oxygen concentration of the soil gas fell below 5% or after 5 to 7 days, whichever occurred sooner. Carbon dioxide and oxygen concentrations were measured using a GasTechtor Model 32520X. Oxygen utilization rates typically were calculated as zero order, based on the initial linear portion of the decay curve.

To relate respiration rates and the resulting biodegradation rates to active bioventing measurements and to other sites in the literature, a stoichiometric relationship of the oxidation of the fuel is required. Hexane (C_6H_{14}) is used as the representative hydrocarbon for the jet fuel when comparing the carbon dioxide and oxygen rates. The stoichiometric relationship is given by:

$$C_6H_{14} + 9.5O_2 \rightarrow 6CO_2 + 7H_2O \qquad (4)$$

Based on oxygen utilization rates (%/day), biodegradation rates in terms of mg/kg/day can be estimated using the following equation and assuming a soil bulk density of 1,440 kg/m^3 and an air-filled porosity of 0.30:

$$K_\beta = \frac{-K_o A D_o C}{100\%} \times \frac{24\,hr}{day} \qquad (5)$$

where:

K_β = biodegradation rate (mg/kg/day)

K_o = oxygen utilization rate (%/hr)

A = Volume of air/kg of soil (L/kg) in this case 300/1,440 = 0.21

D_o = density of oxygen gas (mg/L), assumed to be 1,330 mg/L

C = Mass ratio of hydrocarbon to oxygen required for mineralization, assumed to be 1:3.5 from Equation 4

Oxygen and carbon dioxide concentrations measured during both the full and the abbreviated tests are presented in Appendix N.

J. COLLECTION AND ANALYSIS OF GROUNDWATER SAMPLES

Initial and final groundwater samples were collected from each of the five wells with Teflon™ bailers and were poured into glass sample containers and sealed with Teflon™-lined caps. Sample containers were labeled with the monitoring well label, sampling time and date, and sampler's initials. One trip blank sample was included. Samples were recorded on a chain-of-custody sheet and shipped on ice to UWRL for analysis.

Groundwater samples were analyzed by GC at UWRL. Samples were analyzed for petroleum contamination using EPA method 8020. Specific compounds measured were TPH, benzene, *n*-butylbenzene, *n*-decane, 2,4-dimethylpentane, *n*-dodecane, ethylbenzene, *n*-heptane, *n*-hexane, 2-methylbutane, 2-methylpentane, 1-methylnaphthalene, naphthalene, nonane, *n*-octane, *n*-pentadecane, *n*-pentane, *n*-propylbenzene, *n*-tetradecane, toluene, *n*-tridecane, undecane, and *p*-xylene. Raw data from these analyses and analytical methods are presented in Appendix A. Quality assurance/quality control methods are presented in Appendix E.

K. COLLECTION AND ANALYSIS OF SOIL SAMPLES

Initial soil sampling activities in 1991 were concentrated on the active warming, passive warming, and control test plots and the background area. Three soil borings in the center of each test plot were sampled continuously using a 2-ft-long splitspoon sampler. Two soil samples from each splitspoon were collected for chemical analyses (sleeves 0.5 to 1.0 ft and 1.5 to 2.0 ft from the bottom of the sampler). The remaining two samples were disposed of with the soil cuttings. Sample sleeves being saved for analysis were capped with plastic end covers and sealed with electrical tape. Each soil sample was labeled according to boring number and sample depth. The time, date sampled, and sampler's initials were all recorded on the sample label. Samples were recorded on a chain-of-custody sheet and shipped on ice to UWRL for analysis. Soil samples were analyzed by GC at UWRL. Samples were analyzed for petroleum contamination using EPA method 8020. Specific compounds measured were TPH, benzene, *n*-butylbenzene, *n*-decane, 2,4-dimethylpentane, *n*-dodecane, ethylbenzene, *n*-heptane, *n*-hexane, 2-methylbutane, 2-methylpentane, 1-methylnaphthalene, naphthalene, nonane, *n*-octane, *n*-pentadecane, *n*-pentane, *n*-propylbenzene, *n*-tetradecane, toluene, *n*-tridecane, undecane, and *p*-xylene. Raw data from these analyses and analytical methods are presented in Appendix A. Soil boring logs are presented in Appendix C. Quality assurance/quality control methods are presented in Appendix E.

Three soil samples, each from a different depth, were analyzed from each test plot and the background area to determine soil characteristics. The analyses conducted included total Kjeldahl nitrogen (TKN), total phosphorus (TP), pH, alkalinity, and total organic carbon (TOC).

Additional soil samples were collected in September 1992, because the 1991 soil sampling event did not include samples from deeper depths where much of the contamination was found. Soil sampling activities were concentrated on the four test plots and the background area. The soil borings in each test plot were sampled continuously with a 2-ft-long splitspoon sampler from 5 ft below ground level to 9 ft. Sample sleeves that were saved for analysis were capped with plastic end covers

and sealed with electrical tape. Each soil sample was labeled according to boring number and sample depth. The time, date sampled, and sampler's initials were recorded on the sample label. Samples were recorded on a chain-of-custody sheet and shipped on ice to UWRL for analysis. Soil samples were analyzed by GC at UWRL as described previously. Soil boring logs are presented in Appendix C.

The final soil sampling was conducted in July 1994. Soil sampling activities were concentrated on the four test plots and the background area. The soil borings in each test plot were sampled continuously with a 2-ft-long splitspoon sampler from 5 ft below ground level to 9 ft. Sample sleeves that were saved for analysis were capped with plastic end covers and sealed with electrical tape. Each soil sample was labeled according to boring number and sample depth. The time, date sampled, and sampler's initials were recorded on the sample label. Samples were recorded on a chain-of-custody sheet and shipped on ice to UWRL for analysis. Soil samples were analyzed by GC at UWRL as described previously. Soil boring logs are presented in Appendix C.

SECTION VI
RESULTS AND DISCUSSION OF FIELD TESTS AND SYSTEM MONITORING

This section provides a presentation and discussion of the results from the various field tests that were conducted during this study, as well as a discussion of results from the system monitoring. Major conclusions from these studies are discussed in this section and are summarized in Section VIII.

A. VERIFICATION OF LOW SURFACE EMISSIONS DURING BIOVENTING

One of the concerns over the implementation of bioventing as a means of soil remediation is the possibility of transferring soil contaminants to the atmosphere through air-stripping of organics. To determine if there was significant atmospheric loading of volatile petroleum contaminants during bioventing, surface emissions testing was performed. Surface emissions were measured through application of two separate techniques: dynamic surface emissions testing and a helium tracer study. Results from these tests are presented in the following sections, followed by a discussion of the correlations between the two techniques.

1. Analytical Results From Surface Emissions Sampling

The complete analytical data results from the surface emissions sampling at Eielson AFB are presented in Appendix F. These data are presented temporally, reflecting the seven sampling events at the site. For each of these events, the following data were generated:

- Flux values in μg compound emitted into the atmosphere per 0.45 m^2 per minute. These data reflect the mass of each of the BTEX compounds that were emitted from the soil during the bioventing activities.

- Results from the analysis of the sorbent tubes that were used as trip blanks, purge air blanks, and ambient air samples. The trip blanks were used to identify artifact occurrences that could have led to elevated values for the BTEX compounds and the TPH values. The cylinder air blank samples were used to confirm the quality of the purge gas and to show that this air source was not affecting the reported values for the BTEX species. The ambient air samples were collected as reference concentrations of the emission levels to the existing air quality.

- GC calibration data so that the precision of the sampling/analytical method and the instrument itself could be determined.

To calculate the actual emission rates of organic compounds from the soil surface into the atmosphere, the following formula for dynamic enclosure techniques was employed (McVeety, 1991):

$$F = \frac{C\ V_r}{S} \qquad (6)$$

where: F = flux in mass/area-time ($\mu g/m^2/min$)

C = the concentration of the gas in units of mass/volume ($\mu g/m^3$)

V_r = volumetric flow rate of sweep gas (m^3/min)

S = soil surface covered by enclosure (m^2)

The results from the surface emissions tests are shown in Tables 4 through 10. In these tables, the emissions levels at the three sampling locations from the bioventing wells have been extrapolated to reflect atmospheric loadings in pounds/acre/day. These extrapolations depict a worst-case scenario, because an emissions measurement for a 0.45-m^2 surface area is being projected over a 1-acre plot.

In general, surface emissions of BTEX and TPH at the control test plot did increase during air injection. At each location and for each compound, the emissions levels were higher when the blower was operating compared to no air injection. However, even during air injection, surface emissions rates were comparable to rates measured at the background area. These results indicate that, at the locations sampled, the bioventing system is not creating a pronounced level of increased emissions over natural surface emissions at the site.

The single exception is that an apparent hot spot exists at the 19-ft location of the control test plot. A surface spill may have occurred here and may be contributing to the surface emissions.

During the November 1993 sampling, two injection rates (2.5 cfm and 5.0 cfm) were examined to determine the impact on surface emissions rates. At the control test plot, the samples collected 8 ft and 13 ft from the bioventing well, although variable, generally indicated that these low air injection flow rates resulted in minimal impact on surface emissions. This is based upon the similar values reported at the background area with the blower off (Table 7).

In general, surface emission levels were highest during the November 1993 sampling event (Table 7). This was true for both the control test plot and the background area. During this test, ambient air concentrations for BTEX and TPH also were at their highest levels. It may have been that aircraft activities contributed to elevated atmospheric levels of organics which resulted in deposition to the snowpack on which the surface emissions were performed.

Some seasonal variation of surface emissions rates were observed during the four sampling periods. Major differences were observed during the two warm and the two cold periods at Eielson AFB. During 1993 sampling, higher BTEX and TPH surface emissions levels were reported during July and September than were seen in January and November. These higher levels could be attributed to several factors. First, the sampling box was in direct contact with the soil during the warm months compared to being placed on snow during the cold months. This sampling variable

TABLE 4. EIELSON AFB SURFACE EMISSIONS SAMPLING, JANUARY 1993 FLUX VALUES.

Test	Location	Contaminant Concentration (lb/acre/day)					
		Benzene	Toluene	Ethylbenzene	*m*- & *p*-Xylene	*o*-Xylene	TPH
Control test plot during air injection	5′ EVW	0.00054	0.0057	0.0041	0.013	0.0039	0.11
	11′ EVW	0.000070	0.013	0.011	0.036	0.017	0.49
	19′ EVW	0.00065	0.0049	0.0029	0.0091	0.0025	0.13
Background area during air injection	15′ EVW	0.00026	0.0036	0.0026	0.0088	0.0025	0.039
Control test plot without air injection	11′ EVW	<0.00010	0.0019	0.0014	0.0047	0.0014	0.034
	19′ EVW	<0.00010	0.0014	0.00098	0.0034	0.00093	0.031
Background area without air injection	15′ EVW	0.00067	0.0070	0.0047	0.016	0.0044	0.12

TABLE 5. EIELSON AFB SURFACE EMISSIONS SAMPLING, JULY 1993 FLUX VALUES.

Test	Location	Contaminant Concentration (lb/acre/day)					
		Benzene	Toluene	Ethylbenzene	*m*- & *p*-Xylene	*o*-Xylene	TPH
Control test plot during air injection	8′ EVW	0.00020	0.00010	<0.00010	0.00016	<0.00010	0.020
	11′ EVW	0.00013	<0.00010	<0.00010	0.00012	<0.00010	0.0098
	19′ EVW	0.0011	0.021	0.067	0.021	0.0088	7.8
Background area during air injection	5′ EVW	0.00020	<0.00010	<0.00010	0.00015	<0.00010	0.020
	11′ EVW	0.00023	<0.00010	<0.00010	<0.00010	<0.00010	0.0098
	19′ EVW	0.00015	<0.00010	<0.00010	0.00011	<0.00010	0.0098
Control test plot without air injection	8′ EVW	0.00060	0.00018	<0.00010	0.00023	<0.00010	0.0020
	11′ EVW	0.00025	0.00010	<0.00010	0.00020	<0.00010	0.013
	19′ EVW	0.00039	0.0034	0.013	0.0012	0.0047	0.39
Background area without air injection	5′ EVW	0.00023	<0.00010	<0.00010	0.00013	<0.00010	0.0098
	11′ EVW	0.00022	<0.00010	<0.00010	<0.00010	<0.00010	0.0098
	19′ EVW	0.00016	<0.00010	<0.00010	<0.00010	<0.00010	0.020

TABLE 6. EIELSON AFB SURFACE EMISSIONS SAMPLING, SEPTEMBER 1993 FLUX VALUES.

Test	Location	Contaminant Concentration (lb/acre/day)					
		Benzene	Toluene	Ethylbenzene	*m*- & *p*-Xylene	*o*-Xylene	TPH
Control test plot during air injection	8′ EVW	0.00020	0.00022	0.00039	<0.00010	<0.00010	0.054
	13′ EVW	0.00014	<0.00010	0.0012	0.00010	<0.00010	0.098
	19′ EVW	0.00023	0.88	0.24	0.49	0.15	34

TABLE 7. EIELSON AFB SURFACE EMISSIONS SAMPLING, NOVEMBER 1993 FLUX VALUES.

Test	Location	Contaminant Concentration (lb/acre/day)					
		Benzene	Toluene	Ethylbenzene	*m*- & *p*-Xylene	*o*-Xylene	TPH
Control test plot at 5.0 cfm injection	8′ EVW	<0.00010	0.00015	<0.00010	0.00015	<0.00010	0.52
	13′ EVW	0.00015	0.00013	<0.00010	<0.00010	<0.00010	0.44
	19′ EVW	0.00020	0.00024	0.028	0.0088	0.0026	70
Background area at 2.5 cfm injection	8′ EVW	<0.00010	<0.00010	0.0022	0.00096	0.00026	3.6
	13′ EVW	<0.00010	0.00013	0.00023	0.00028	<0.00010	0.60
	19′ EVW	0.00018	0.0016	0.025	0.0060	0.0017	47
Control test plot without air injection	8′ EVW	0.00036	<0.00010	0.00047	0.00026	<0.00010	1.7
	13′ EVW	0.00013	0.00013	0.00015	0.00020	<0.00010	0.70
	19′ EVW	<0.00010	0.00018	0.0029	0.00096	0.00028	3.9
Background area without air injection	8′ EVW	<0.00010	<0.00010	0.00028	0.00013	<0.00010	0.78
	13′ EVW	<0.00010	<0.00010	0.00047	0.00023	<0.00010	0.85
	19′ EVW	0.0013	0.00028	0.00026	0.00013	<0.00010	1.1

TABLE 8. EIELSON AFB SURFACE EMISSIONS SAMPLING, JANUARY 1994 FLUX VALUES.

Test	Location	Contaminant Concentration (lb/acre/day)					
		Benzene	Toluene	Ethylbenzene	*m*- & *p*-Xylene	*o*-Xylene	TPH
Control test plot during air injection	8′ EVW	0.00025	0.00030	0.00018	0.00038	<0.00010	0.024
	11′ EVW	0.00019	0.00015	<0.00010	0.00015	<0.00010	0.0056
	19′ EVW	0.00023	0.00019	<0.00010	0.00017	<0.00010	0.0061
Background area during air injection	8.5′ EVW	0.00021	0.00014	<0.00010	<0.00010	<0.00010	0.0086
	11′ EVW	0.00018	0.00012	<0.00010	<0.00010	<0.00010	0.0026
	19′ EVW	0.00018	0.00012	<0.00010	<0.00010	<0.00010	0.0031
Control test plot without air injection	8′ EVW	0.00043	0.00033	<0.00010	0.00035	<0.00010	0.0074
	11′ EVW	0.00022	<0.00010	<0.00010	0.00026	<0.00010	0.0078
	19′ EVW	0.00021	0.00035	0.00031	0.00050	0.00015	0.016
Background area without air injection	8.5′ EVW	0.00012	0.00017	<0.00010	0.00021	<0.00010	0.0045
	11′ EVW	0.00022	0.00010	<0.00010	0.00017	<0.00010	0.0034
	19′ EVW	0.00040	0.00045	0.00012	0.00029	<0.00010	0.027

TABLE 9. EIELSON AFB SURFACE EMISSIONS SAMPLING, APRIL 1994 FLUX VALUES.

Test	Location	Contaminant Concentration (lb/acre/day)					
		Benzene	Toluene	Ethylbenzene	*m*- & *p*-Xylene	*o*-Xylene	TPH
Control test plot during air injection	8′ EVW	0.00010	0.00013	<0.00010	<0.00010	<0.00010	0.0078
	11′ EVW	0.00010	<0.00010	<0.00010	0.00034	<0.00010	0.0074
	19′ EVW	0.00028	0.0026	0.00016	0.00028	<0.00010	0.020
Background area during air injection	8.5′ EVW	0.00010	<0.00010	0.0011	0.00023	<0.00010	0.0069
	11′ EVW	0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.0033
	19′ EVW	0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.0041
Control test plot without air injection	8′ EVW	0.00026	0.00016	<0.00010	<0.00010	<0.00010	0.0083
	11′ EVW	0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.0038
	19′ EVW	0.00016	0.00018	<0.00010	0.00013	<0.00010	0.0050
Background area without air injection	8.5′ EVW	0.00016	0.00010	<0.00010	<0.00010	<0.00010	0.0047
	11′EVW	0.00013	0.00018	<0.00010	<0.00010	<0.00010	0.0085
	19′ EVW	0.00057	0.00016	<0.00010	0.00023	<0.00010	0.0094

TABLE 10. EIELSON AFB SURFACE EMISSIONS SAMPLING, JULY 1994 FLUX VALUES.

Test	Location	Contaminant Concentration (lb/acre/day)					
		Benzene	Toluene	Ethylbenzene	*m*- & *p*-Xylene	*o*-Xylene	TPH
Control test plot during air injection	8′ EVW	0.00036	0.00016	<0.00010	0.00010	<0.00010	0.0091
	11′ EVW	0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.0049
	19′ EVW	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.0054
Background area during air injection	8.5′ EVW	<0.00010	<0.00010	<0.00010	0.00013	<0.00010	0.0073
	11′ EVW	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.0039
	19′ EVW	<0.00010	0.00065	<0.00010	<0.00010	<0.00010	0.0013
Control test plot without air injection	8′ EVW	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.0010
	11′ EVW	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.0013
	19′ EVW	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.0018
Background area without air injection	8.5′ EVW	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.0031
	11′ EVW	<0.00010	0.00016	<0.00010	<0.00010	<0.00010	0.0018
	19′ EVW	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.0031

likely resulted in the surface emissions being more efficiently collected during direct soil contact. Second, the warmer temperatures would be expected to enhance the mobility of any volatile soil contaminants and therefore increase emissions rates.

This seasonal variability was not as evident during the 1994 sampling. In general, the emissions rates at the control and background plots were consistently low for the BTEX and TPH values. These emission levels would tend to indicate either that organic compounds were being retained more efficiently in the soil profile during 1994 or that soil gas concentrations had diminished and therefore were not available for contributions to atmospheric loading.

Averaging the data for the seven different sampling events at the control plot's three sampling locations, the benzene emission rate was 0.00082 lb/day during air injection assuming a 1-acre test site area. The average benzene emissions rate at the control test plot with the blower turned off was 0.00021 lb/day for a 1-acre plot. In comparison, at the background area, the average benzene emission was 0.00021 lb/acre/day. This rate is similar to that measured at the control test plot without air injection. These results indicate that air injection associated with bioventing did result in an increased surface emissions rate above noninjection and background levels. However, the levels associated with air injection are well below regulatory limits of 2 lbs benzene/day and illustrate that bioventing at the Eielson AFB test site did not result in surface emissions that would require remedial actions.

2. Results From the Helium Tracer Study

Air/helium flow was initiated on September 6, 1993, at a flow rate of 2.5 cfm and with a helium concentration of approximately 5.4%. Helium injection was conducted for approximately 8 days. Helium appeared rapidly in the monitoring points, as shown in Figure 18. Typically, at the closer monitoring points, the helium concentration at the monitoring points reached the injection concentration within 2 hours. As the distance from the vent well increased, the concentration of helium increased more slowly. Likewise, the helium concentration at most of the shallow monitoring points (2.0 ft in depth) did not approach the injection helium concentration. However, at the mid-level and deep depth, all monitoring points that were measured had helium levels equivalent to the injection concentration within 30 hours. Mean travel times were calculated as the geometric mean and are shown in Table 11. Figures showing helium concentration over time at the monitoring points are presented in Appendix G.

The helium measured from the ground surface was low and never reached the injection helium concentration (Figure 19). A maximum of approximately 2% helium was measured from the surface area. This represents approximately 35% of the helium which was injected, indicating that the radius of influence for this bioventing well is greater than the 50-ft radius surface area that was measured. The TPH concentration in the soil gas in equilibrium with the ground surface was 340 ppm. Measured at a flow rate of 2.6 cfm and with a surface area of approximately 7,900 ft^2, this flowrate corresponds to an emissions rate of approximately 1.5 lb/acre/day.

3. Comparison of Results From the Surface Emissions Studies

Results from the dynamic surface emissions testing and the helium tracer test were compared to see if emissions rates were similar between the two methods. Using the dynamic surface emissions, the TPH emissions during the summer months averaged 3.5 lb/acre/day compared to an

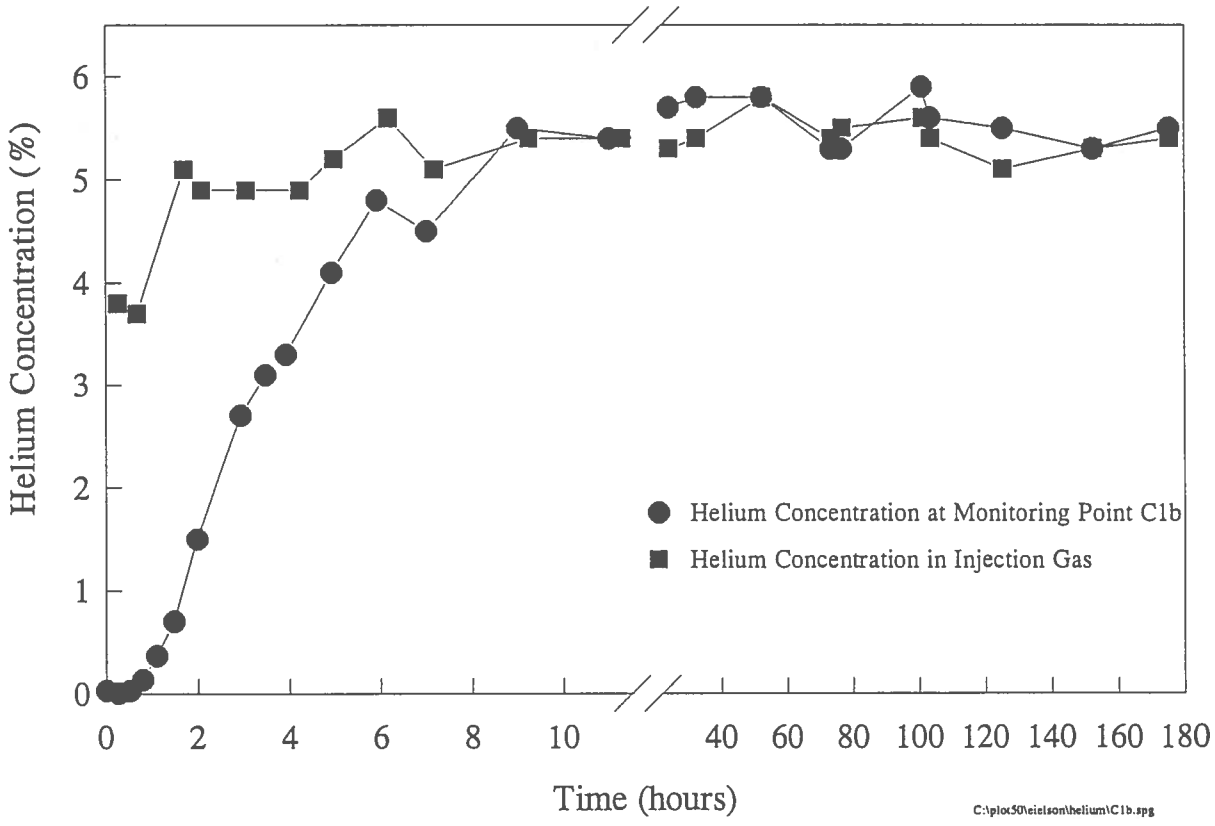


Figure 18. Helium Concentration Over Time at Monitoring Point C1b.

TABLE 11. MEAN TRAVEL TIMES OF HELIUM AT MONITORING POINTS.

Monitoring Point	Depth (ft)	Distance from Vent Well	Mean Travel Time (hours)
C1b	4.25	7′10″	1.92
C1c	2.0	7′10″	>175[1]
C2a	5.5	10′5″	0.82
C2c	2.0	10′5″	>175[1]
C3b	4.25	13′3″	0.82
C3c	2.0	13′3″	2.2
C4b	4.25	15′1″	1.92
C4c	2.0	15′1″	2.8
C5a	5.5	14′11″	1.92
C5b	4.25	14′11″	3.3
C5c	2.0	14′11″	>175[1]
C6a	5.5	15′4″	0.69
C6b	4.25	15′4″	3.3
C6c	2.0	15′4″	>175[1]
C7b	4.5	3′10″	0.69
C7c	2.5	3′10″	>175[1]
PP7a	5.5	51′4″	24.9

[1] This value reflects those monitoring points where the helium concentration did not approach the injection helium concentration during the 8 days of helium injection.

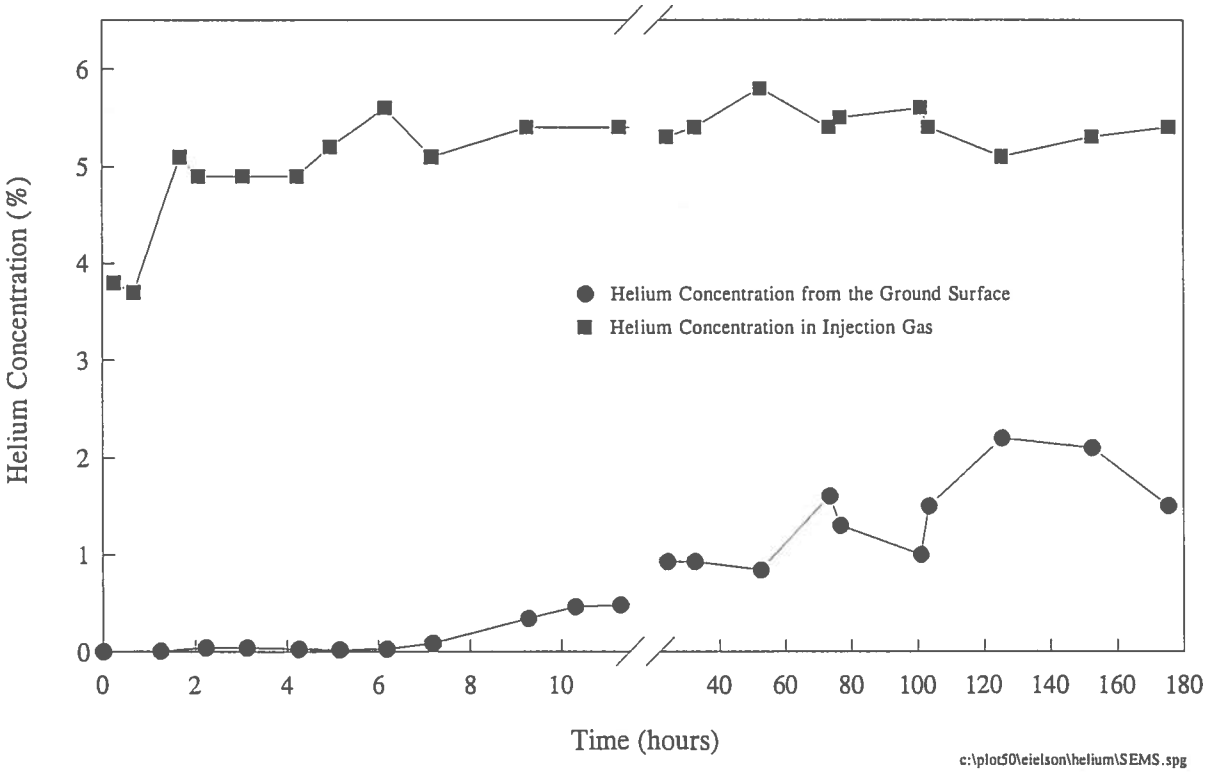


Figure 19. **Helium Concentration Measured from the Ground Surface During the Helium Tracer Study.**

emissions rate of 1.5 lb/acre/day using the helium tracer method. These results indicate that the techniques used for measuring surface emissions in this study provide a precise method for measuring surface emissions.

B. VERIFICATION OF PETROLEUM BIODEGRADATION THROUGH MEASUREMENT OF STABLE CARBON ISOTOPIC RATIOS

Carbon isotopic compositions of soil gas carbon dioxide from the two sampling events are given in Table 12. A graphical representation of the data from August 1993 is shown in Figure 20. As shown, $\delta^{13}C$ values of soil gas carbon dioxide from the uncontaminated location at the test site were within the range of typical values observed for plant respiratory carbon dioxide from local vegetation and decaying organic matter (Amundson et al., 1988; Cerling, 1984; Parada et al., 1993; Rightmire and Hanshaw, 1971), whereas the $\delta^{13}C$ values of soil gas carbon dioxide from the contaminated areas are representative of values from hydrocarbon degradation. Results of the carbon isotopic ratios analysis were similar between the two sampling events, with values ranging from $-18.40‰$ to $-29.16‰$ in the contaminated areas and from $-10.12‰$ to $-19.12‰$ in the background area. Ambient air values typically ranged from $-12.58‰$ to $-14.39‰$; however, two measurements taken during warmer months were significantly higher at $-21.94‰$ and $-23.30‰$. Due to the limited data, it is difficult to speculate on the reasons for these different results. Sampling error must be considered, since the isotopic composition of the atmosphere should be relatively stable.

These results provided good evidence that microbial metabolism of hydrocarbons does take place in the contaminated area at the bioventing site. Soil gas samples collected from the contaminated area have consistently shown values representative of hydrocarbon biodegradation, whereas samples collected from the background area have shown values representative of natural organic matter metabolism.

C. SOIL GAS PERMEABILITY AND RADIUS OF INFLUENCE RESULTS AND DISCUSSION

Estimates of the soil's permeability to fluid flow and the radius of influence of venting wells provide important inputs to a full-scale bioventing design. On-site testing provides the most accurate estimate of the soil gas permeability. On-site testing also can be used to determine the radius of influence that can be achieved for a given well configuration and its flow rate and air pressure. These data are used to design full-scale systems, specifically to space venting wells, to size blower equipment, and to ensure that the entire site receives a supply of oxygen-rich air to sustain in situ biodegradation. Results from the soil gas permeability testing conducted during this study are presented in the following discussion.

Pressure changes were monitored at 2, 4, and 6 ft depths during the soil gas permeability tests at each test plot. As can be expected, the values for radius of influence generally are greater at the 6-ft depth. The difference is due in part because, at the shallower depths, short-circuiting of air flow to the surface can occur more rapidly. Site investigation studies at the Eielson AFB test site have shown that nearly all of the site contamination is present below 6-ft depth; therefore, only the 6-ft-deep soil gas permeability data are considered in this discussion.

TABLE 12. CARBON ISOTOPIC COMPOSITIONS OF SOIL GAS CARBON DIOXIDE.

Test Plot or Area	Monitoring Point	$\delta^{13}C$, ‰ (PDB)				
		January 1993	August 1993	December 1993	April 1994	July 1994
Active Warming	2B	-23.89	−24.47	−24.81		
	4B	−29.16	−28.50	−28.87	−28.11	
	6A				−27.75	−28.94
	6B	−28.56	−26.44	−26.54		
	8C					−21.45
Passive Warming	3A				−24.98	
	5B				−24.89	−25.54
	6A	−26.75	−20.83	−25.47		
	6B					−23.97
	6C			−24.53		
	8B				−25.10	−23.19
Control	2A					−26.98
	4B					−25.35
	6B				−26.31	
	7B				−18.40	
Surface Warming	1B	−23.90	−22.36	−22.49		
		−24.01				
		−24.06				
	1C	−28.35				
	5C	−25.82	−26.26			
	6B			−24.64		
Background	2A	−14.15	−10.12			
	2B	−13.55	−12.94	−16.33	−19.12	−14.00
	2C	−13.18	−13.54	−15.17	−17.17	−13.30
Ambient		−14.39	−21.94		−23.30	−12.97
		−13.44				
		−12.58				

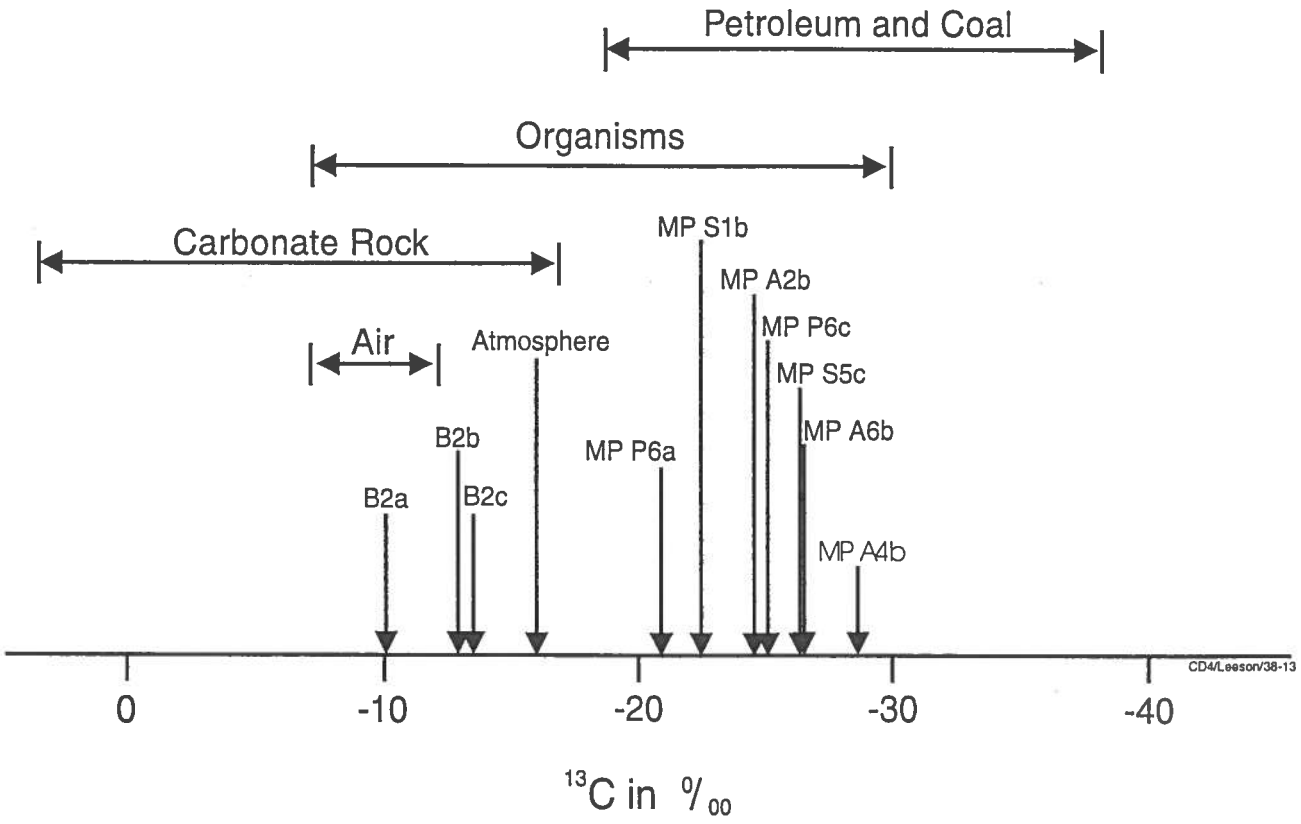


Figure 20. Stable Carbon Isotopic Ratios Measured During August 1993.

1. Soil Gas Permeability and Radius of Influence Results for Air Injection Tests

Soil gas permeability, or k, is a physical property of the soil and should be relatively consistent across a site if other physical properties of the site are uniform. The data from the four test plots indicate that soil characteristics across the site are quite uniform. Permeability values for the 6-ft depths ranged from 0.56 darcy in the control test plot to 1.0 darcy in the active warming test plot (Table 13). It does not appear that any of the soil warming techniques had a significant impact on soil permeability. In fact, the active warming test plot, which involved pumping heated groundwater into the vadose zone to warm the soil, exhibited the highest permeability. Although the groundwater was no longer being pumped into the plot during the soil gas permeability testing, residual moisture likely would have reduced the value of k.

The radius of influence at a particular site is a function of soil properties, but also is dependent on vent well configuration and the extraction or injection flow rates. For this study, radius of influence was defined as the radial distance from the vent well where a change of 0.1-inch water pressure could be observed. The radius of influence observed for the four test plots at the 6-ft depth ranged from 40 ft for the passive warming test plot to 77 ft for the surface warming test plot (Table 13). The average radius of influence at the 6-ft depth for the four tests was approximately 61 ft. An example of the estimation of the radius of influence at the passive warming test plot at the 6-ft depth is shown in Figure 21.

These measurements of the radius of influence correlate with helium flow patterns observed during the tracer study[1]. During the tracer study, only approximately 35% of the injected helium was recovered from the ground surface, indicating that the radius of influence was greater than the 50-ft radial area that was measured.

Radius of influence is just one factor in the determination of bioventing well location for optimum site coverage. Other site conditions that must be considered include location and depth of underground structures that could act as barriers or conduits to fluid flow, proximity of adjacent buildings, surface structures, and surface activities. Based on the data for Eielson Site 20, and taking a conservative approach by using the smallest radius of influence measured (40 ft), bioventing well spacing of 80 ft may be sufficient for site coverage. At the 80-ft spacing, approximately 9 wells would be sufficient to treat more than 1 acre of site surface area.

2. Control Test Plot Soil Gas Permeability Results: Injection Versus Extraction

Bioventing systems can be designed to operate as air injection systems or as soil gas vapor extraction systems. Either method can be used to aerate subsurface soils to facilitate bioventing. Selection of the system configuration must be based on several factors. Vapor extraction systems allow for control and capture of hydrocarbon-contaminated soil vapor, and may be desirable at sites adjacent to possible vapor receptors such as basements and storm sewers. Extraction systems, however, result in a point source emission that may require permitting and treatment. Engineering requirements for condensate collection, storage, and disposal also must be considered. One important factor often overlooked in selecting injection verses extraction design is the effect the selected configuration will have on fluid (vapor) flow.

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[1] Refer to Section VI.A.2 for a discussion of the helium tracer study results.

TABLE 13. SOIL GAS PERMEABILITY AND RADIUS OF INFLUENCE VALUES.

Test Plot	Mode	Depth (ft)	Permeability (darcy)	Radius of Influence (ft)
Active	Injection	2	0.64	5
	Injection	4	1.0	52
	Injection	6	1.0	58
Passive	Injection	2	0.76	29
	Injection	4	0.81	42
	Injection	6	0.80	40
Control	Injection	2	NR	<7.0
	Injection	4	0.53	45
	Injection	6	0.56	68
Surface	Injection	2	NR	<4.0
	Injection	4	0.80	46
	Injection	6	0.86	77
Control	Extraction	2	NR	<6.0
	Extraction	4	0.27	34
	Extraction	6	0.27	42

NR = No response.

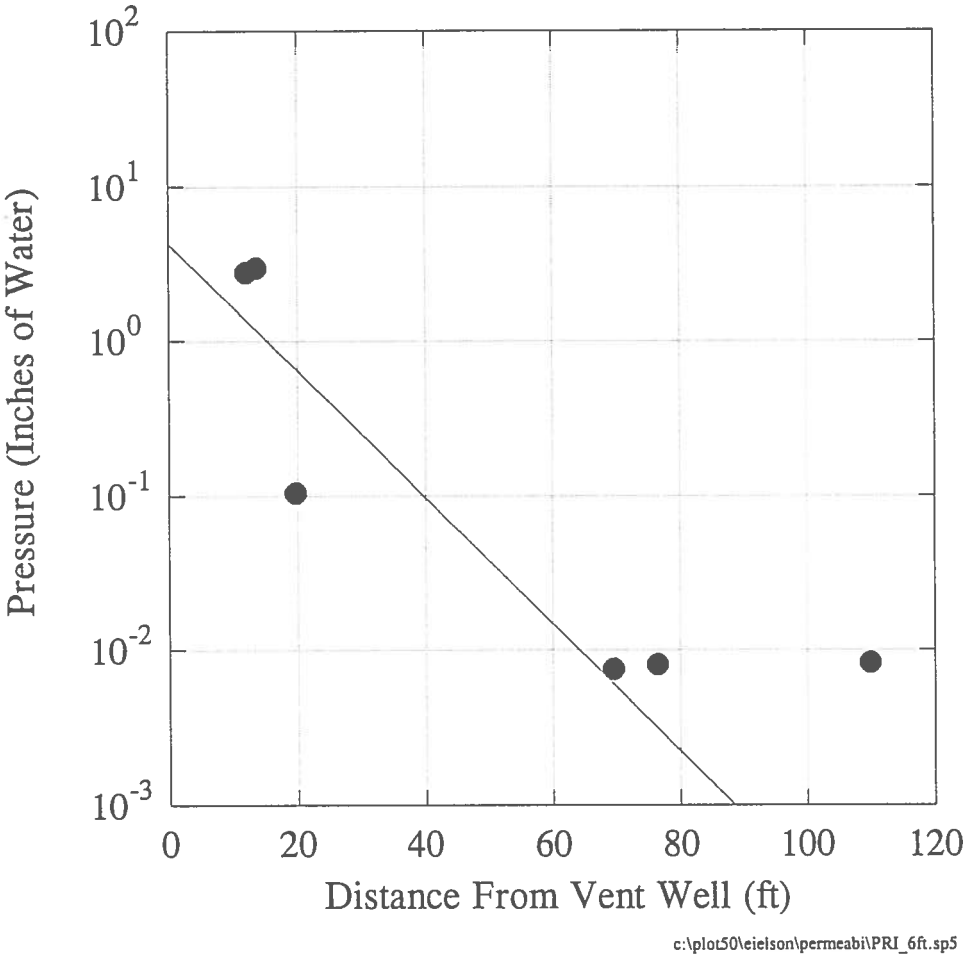


Figure 21. Radius of Influence in the Passive Warming Test Plot at a Depth of 6 Feet.

The extraction soil gas permeability test was conducted on the control test plot to observe the effect of the bioventing blower system configuration on the site soil gas permeability and bioventing well radius of influence. Table 14 compares the results of the extraction and injection tests on the control test plot. The permeability (k) calculated for the extraction test was 0.27 darcy, approximately one-half the result for the air injection test. The radius of influence observed at the 6-ft monitoring depth also was reduced approximately one-third to 42 ft (Figure 22).

TABLE 14. PERMEABILITY AND RADIUS OF INFLUENCE VALUES IN THE CONTROL TEST PLOT: INJECTION AND EXTRACTION MODE.

Depth (ft)	Permeability (darcy)		Radius of Influence (ft)	
	Injection	Extraction	Injection	Extraction
2	NR	NR	<7.0	<6.0
4	0.53	0.27	45	34
6	0.56	0.27	68	42

NR = No response.

The most likely cause of the reduction in soil gas permeability and radius of influence is the effect negative pressure in the vent well had on the shallow water table at the Eielson site. When air is injected in a bioventing well, positive pressure develops in the well and the surrounding formation. The magnitude of this positive pressure depends on both site soil characteristics and the blower injection pressure. At Eielson AFB where the water table is shallow, this positive pressure results in depression of the water table in the vicinity of the bioventing well. As the water table is depressed, previously saturated (and possibly contaminated) soils are dewatered, exposing additional unsaturated pores to air flow. The cumulative effect is to increase both the permeability of the soils surrounding the bioventing well and the air/contaminant contact. When air is extracted from the vent well the opposite effect can be expected. A negative pressure develops in the extraction well and the surrounding formation. The groundwater table mounds in the vicinity of the well and saturates previously unsaturated contaminated soils. Fewer soil pores in the contaminated zone are available for soil gas flow; thus, the soil permeability is decreased adjacent to the extraction well.

Based on the comparison of data from the extraction and injection tests at the control test plot, it is apparent that, in the absence of the necessity for soil gas plume control, air injection will provide better air flow to the contaminated zone than will air extraction.

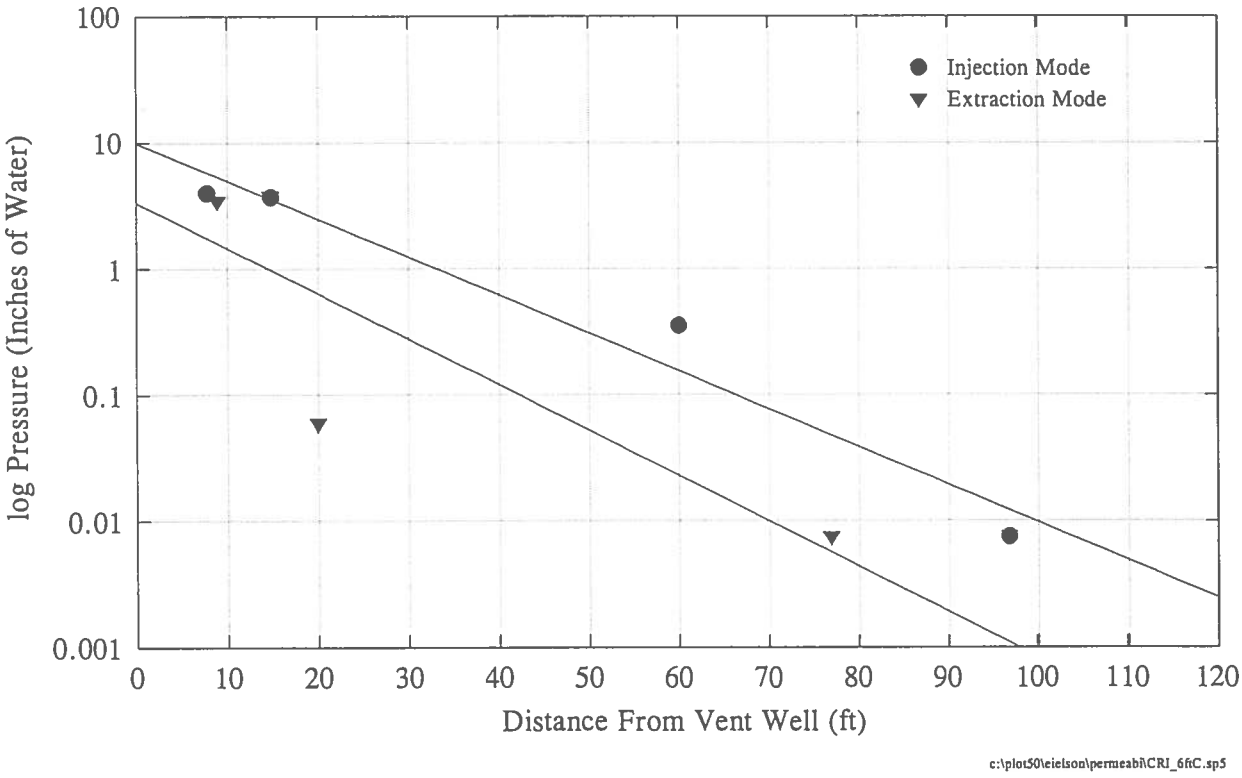


Figure 22. **Radius of Influence in the Control Test Plot at a Depth of 6 Feet Air Injection and Air Extraction Mode.**

D. DETERMINATION OF BIODEGRADATION VERSUS VOLATILIZATION OF PETROLEUM HYDROCARBONS AND IMPLICATIONS OF AIR INJECTION VERSUS AIR EXTRACTION

1. Results From Soil Vapor Extraction Testing

The bioventing system at Eielson AFB was reconfigured for air extraction during August 1993 for a short-term extraction test. The purpose of the test was to determine the efficiency of the bioventing system in terms of the quantity of hydrocarbons degraded versus the quantity of hydrocarbons volatilized. In addition, this test was used to determine the efficiency of extraction compared to injection for aerating the site.

Prior to initiating air extraction, soil gas concentrations of oxygen, carbon dioxide, and TPH were measured at each monitoring point. After initiation of soil gas extraction, soil gas concentrations were measured in the extracted off-gas and at the monitoring points. Pressure and flow rate were measured at each extraction line; these results are shown in Table 15.

TABLE 15. PRESSURE AND FLOW RATES DURING THE EXTRACTION TEST.

Test Plot	Flow Rate (cfm)	Vacuum (inch H_2O)
Active	<0.1	30
Passive	5.0	13
Control	0.6	17
Surface	4.6	17
Total	10.2	

The flow rate from the active warming test plot was negligible, but soil gas concentrations in the extracted soil gas did change during the course of the test (Figure 23), with an increase in oxygen concentration. Similar results were obtained in the passive warming and the control test plot, with rapid increases in oxygen concentration after initiation of extraction (Figures 24 and 25, respectively). Oxygen levels in the surface warming test plot were not significantly depleted, and little change in oxygen concentration was observed (Figure 26). Oxygen and TPH concentrations in soil gas from the entire site are shown in Figure 27.

Using the equilibrium oxygen and TPH concentrations, the mass of TPH biodegraded and volatilized at the site was calculated. Extraction removal rates for each test plot and for the entire site are shown in Table 16. The total amount of hydrocarbons biodegraded was 6.2 lb/day, whereas the total amount of hydrocarbons volatilized was 0.60 lb/day. Therefore, in extraction mode, approximately 1 order of magnitude more hydrocarbons are biodegraded than are volatilized from the site. The difference between biodegradation and volatilization of hydrocarbons is likely to be even greater if the bioventing system is operated in injection mode, because the opportunity for biodegradation is greater. In injection mode, the vapors are pushed through the contaminated zone

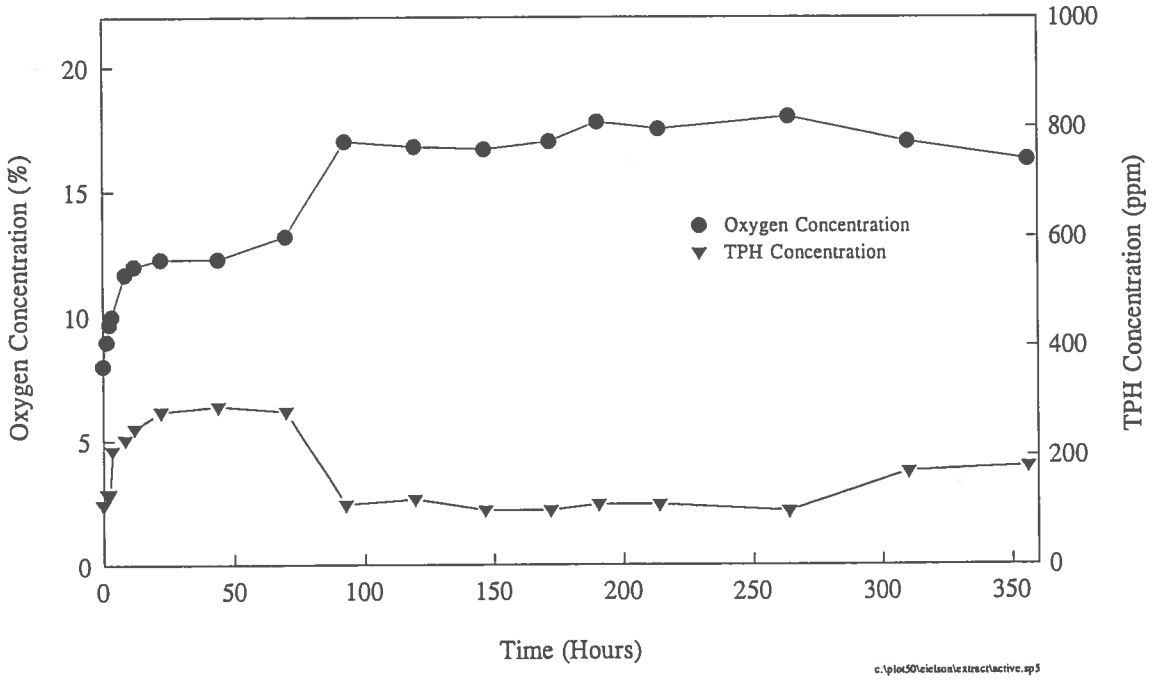


Figure 23. **Oxygen and TPH Concentration in Soil Gas From the Active Warming Test Plot During Soil Gas Extraction.**

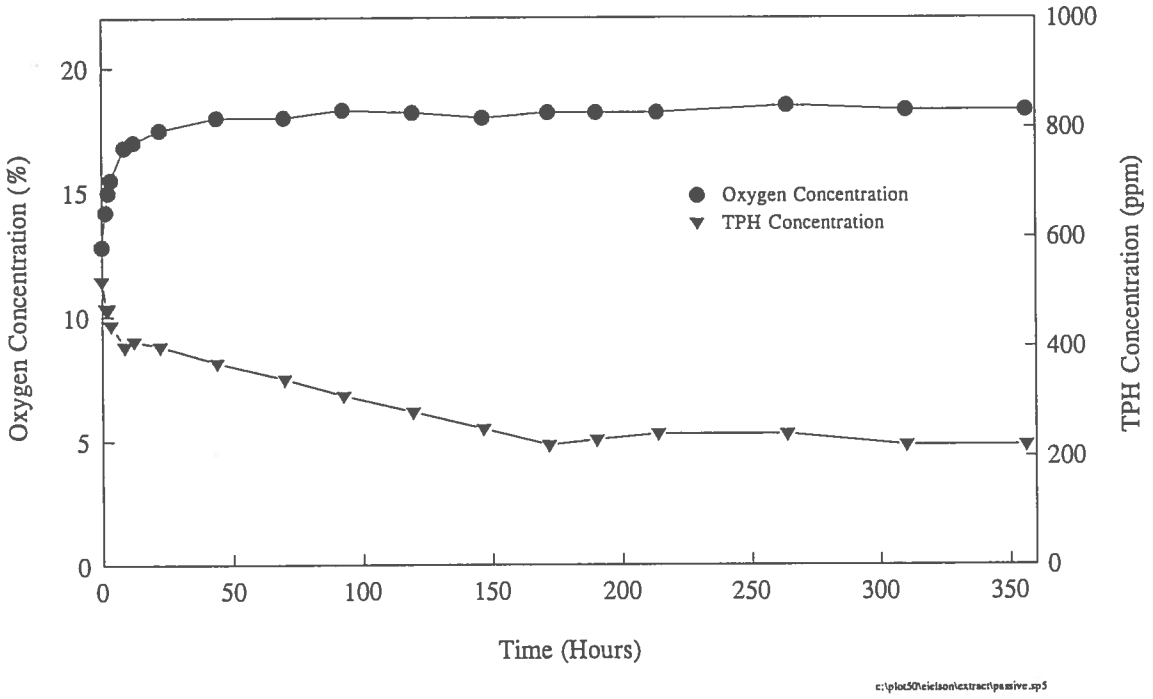


Figure 24. **Oxygen and TPH Concentration in Soil Gas From the Passive Warming Test Plot During Soil Gas Extraction.**

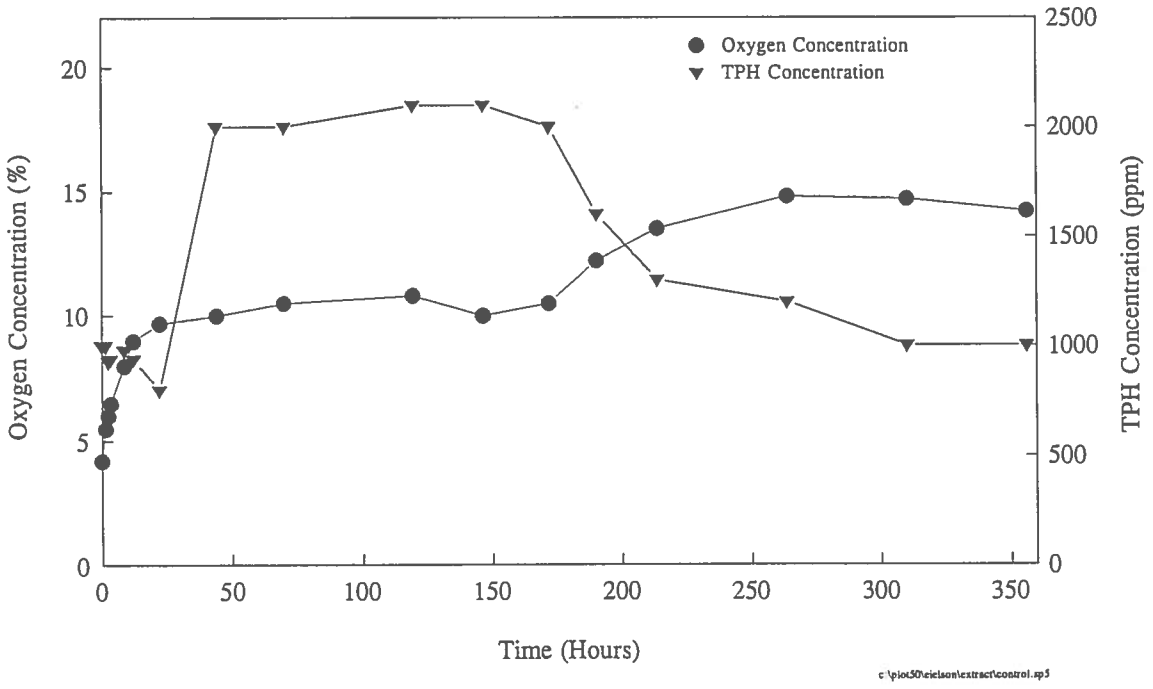


Figure 25. **Oxygen and TPH Concentration in Soil Gas From the Control Test Plot During Soil Gas Extraction.**

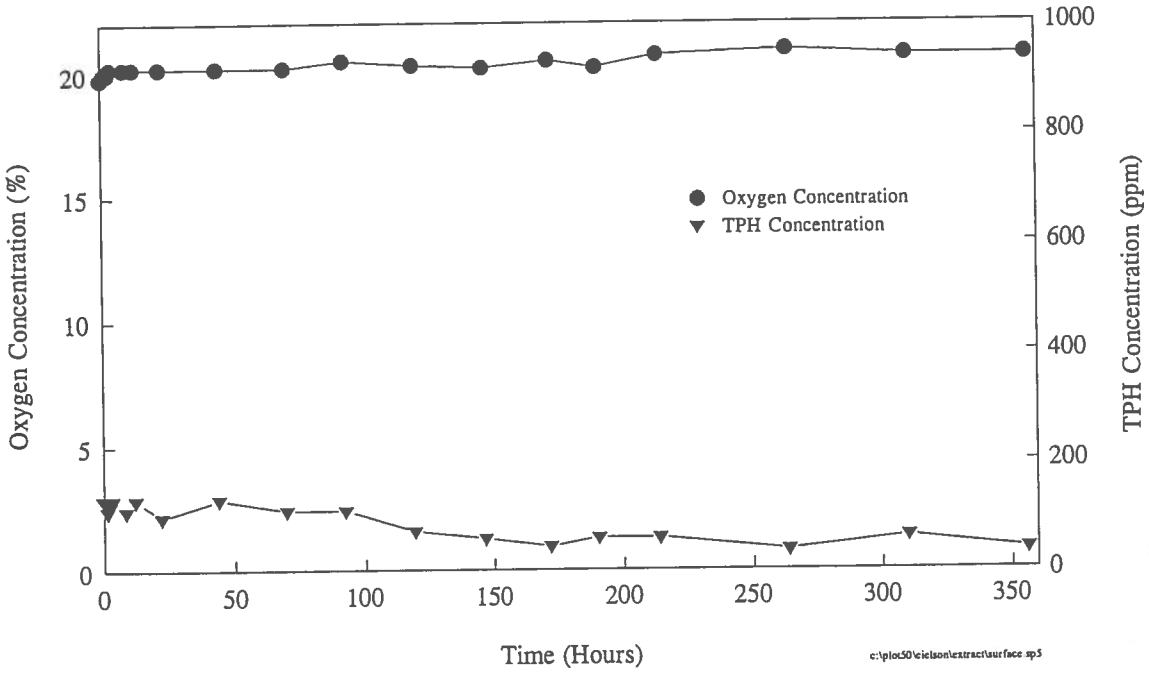


Figure 26. **Oxygen and TPH Concentration in Soil Gas From the Surface Warming Test Plot During Soil Gas Extraction.**

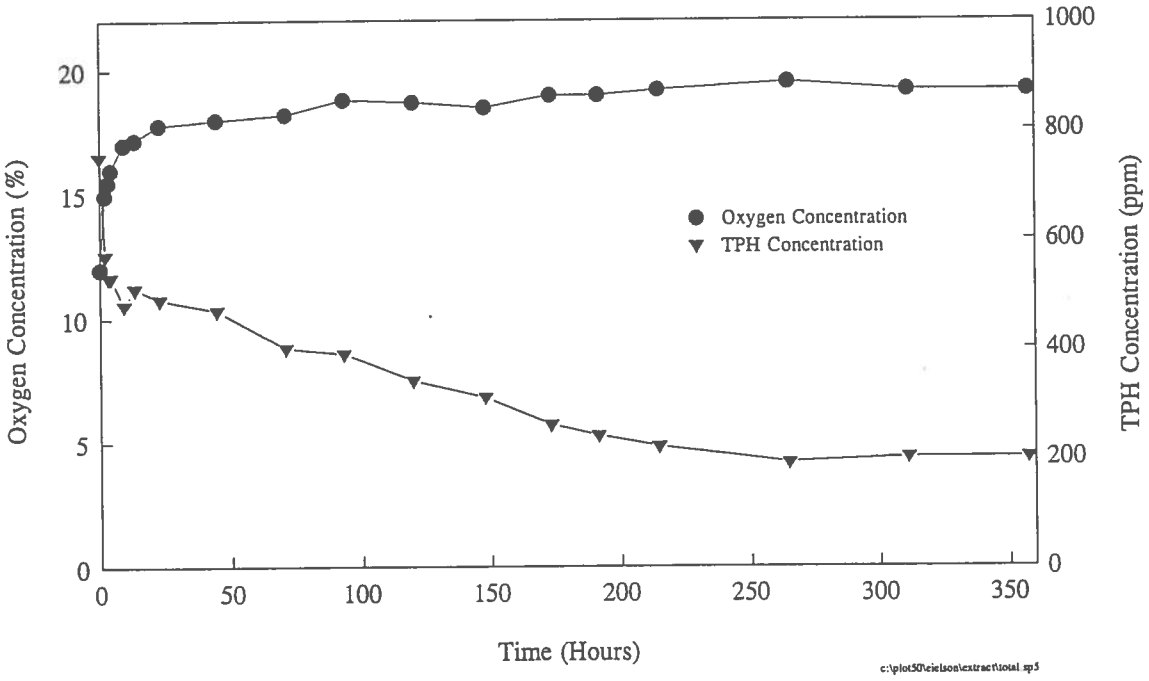


Figure 27. **Oxygen and TPH Concentration in Soil Gas Extracted From the Bioventing Site During the Extraction Test.**

TABLE 16. EXTRACTION REMOVAL RATES (LB/DAY).

Test Plot	Biodegradation	Volatilization
Active	0.078[1]	0.0028
Passive	4.4	0.35
Control	1.4	0.19
Surface	0.31	0.055
Total	6.2	0.60

[1] A flow rate of 0.05 cfm was estimated for this test plot.

into the uncontaminated zone, allowing for additional biodegradation. However, when the system is operated in extraction mode, these vapors are instead removed from the soil before biodegradation can occur.

2. Air Injection Versus Air Extraction Considerations

The key operating parameter for a bioventing system is to minimize the volatilization of contaminants while maximizing biodegradation. Air injection as opposed to air extraction offers greater potential for maximizing biodegradation because an expanded bioreactor is created (Figure 28). An expanded bioreactor is defined as an area in which the effective treatment area has been expanded by pushing vapors into surrounding soils where biodegradation may still occur. Given that air injection results in an expanded bioreactor, the total mass of contaminants biodegraded may be substantially greater than for systems such as air extraction in which an expanded bioreactor is not created.

Additional contaminated soil may be exposed to biodegradation through water table depression. As air is injected into the vadose zone, a positive pressure is created resulting in depression of the water table. Figure 29 illustrates the water table depression observed at Site 20 during the soil gas permeability test. This water table depression has important implications. At many sites, the capillary fringe is highly contaminated, and by depressing the water table, the capillary fringe will be more effectively treated. In addition, this dewatering effect frequently results in an increased radius of influence and greater soil gas permeability.

Air injection is the preferred bioventing configuration; however, air extraction may be necessary at sites where movement of vapors into subsurface structures or air emissions are difficult to control. If a building or other structure is located within the radius of influence of a site, or if the site is near a property boundary beyond which hydrocarbon vapors cannot be pushed, air extraction may be considered. A significant disadvantage of the air extraction configuration is that biodegradation is limited to the contaminated soil because vapors do not move outward creating an expanded bioreactor. The result is less biodegradation and more volatilization. In general, increasing

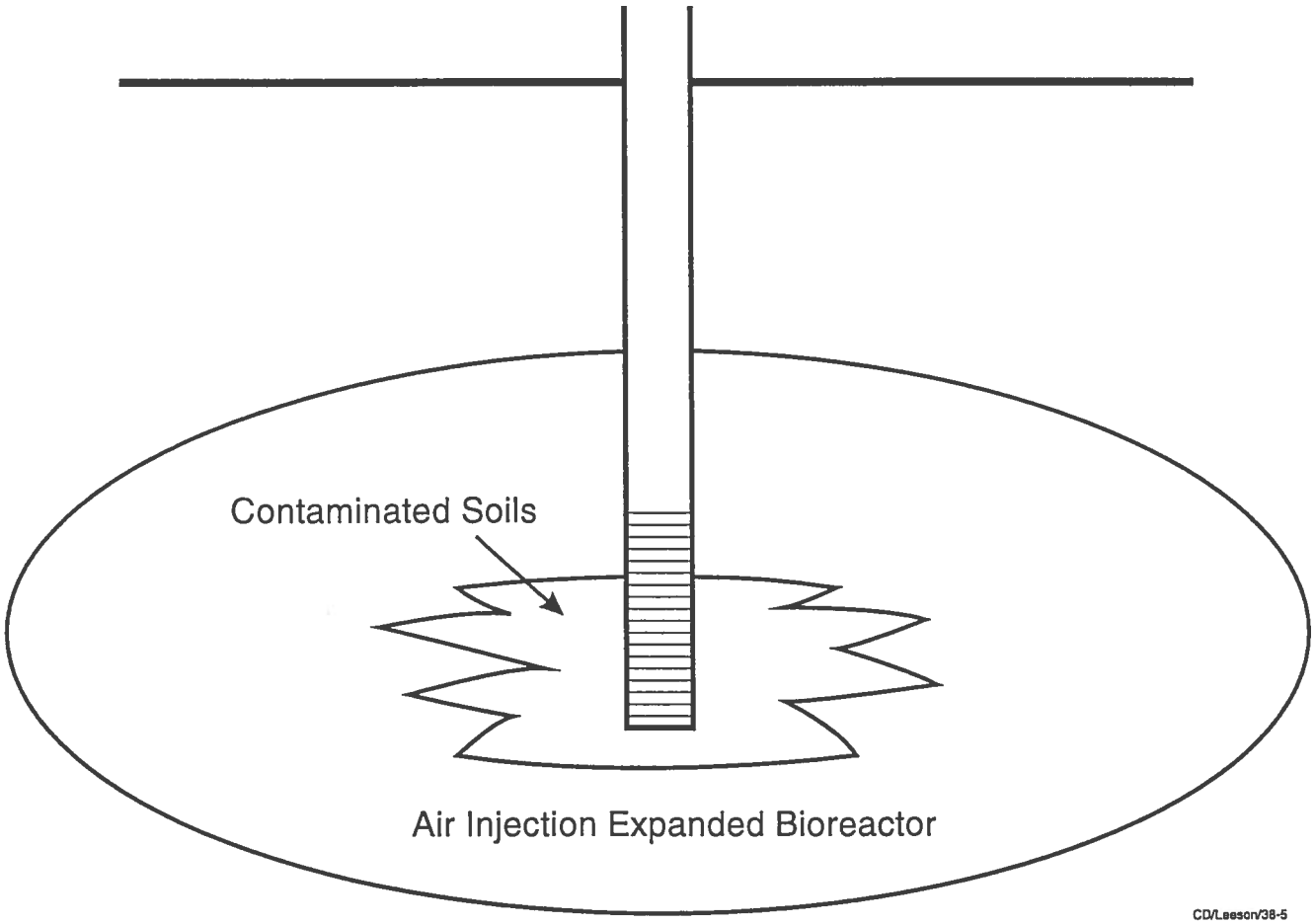


Figure 28. Schematic Diagram of an Expanded Bioreactor.

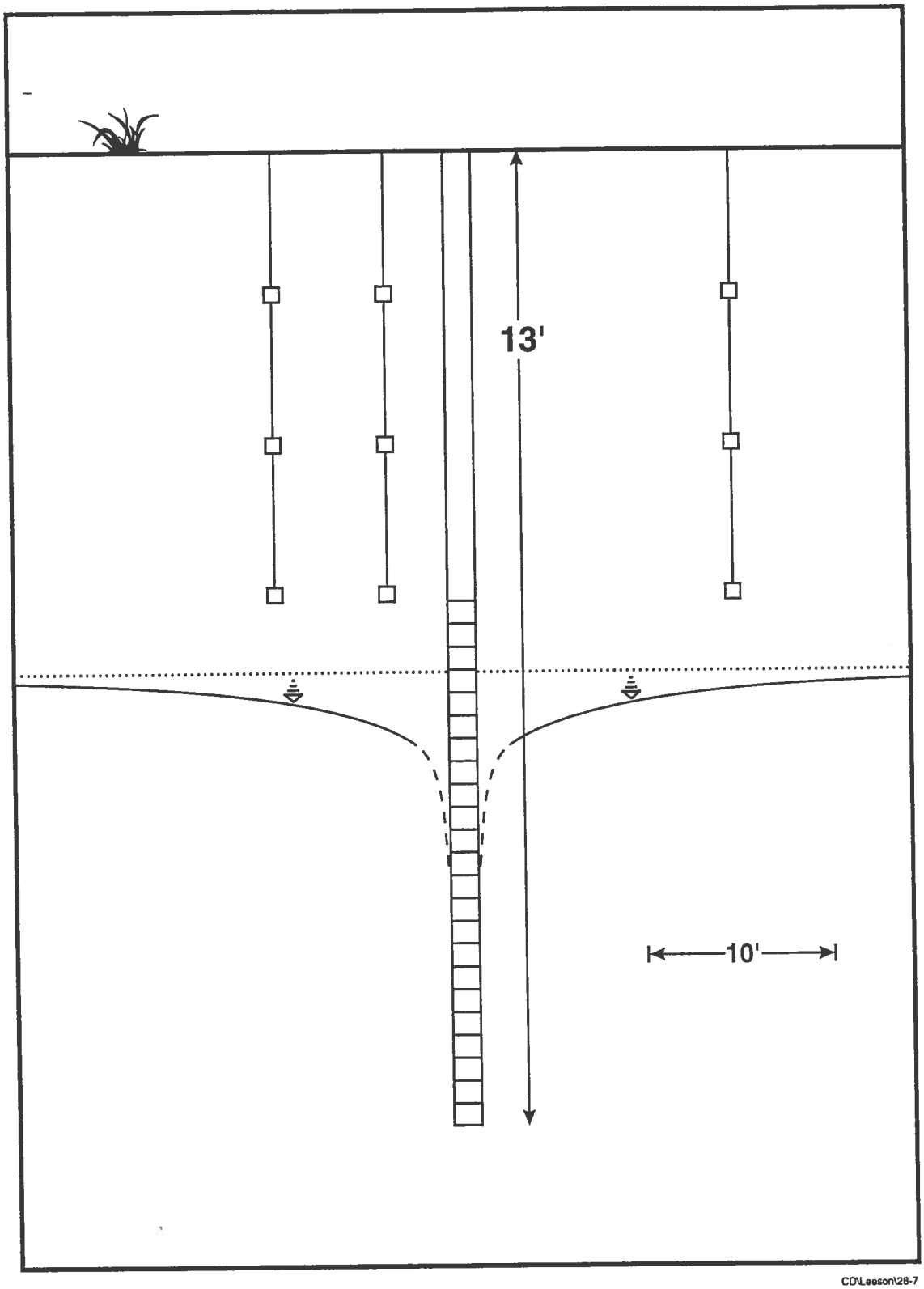


Figure 29. Water Table Depression During Air Injection.

extraction rates will increase both volatilization and biodegradation rates until the site becomes aerated, above which the rate of biodegradation no longer increases.

Air extraction creates a partial vacuum in the soil resulting in a water table rise or upwelling. This phenomenon has been illustrated in the soil venting literature (Johnson et al., 1990). The water table rise (upconing) observed during the extraction soil gas permeability test is illustrated in Figure 30. Because the bulk of contamination is often several inches or feet above or below the water table (smear zone), this upconing can saturate much of the contaminated soil, reducing treatment efficiency. The upconing also will increase soil moisture in the capillary fringe and thus reduce the soil gas permeability and radius of influence.

This effect was illustrated during the extraction soil gas permeability test. The permeability (k) calculated for the extraction test was 0.27 darcy, approximately one-half the result for the air injection test. The radius of influence observed at the 6-ft monitoring depth also was reduced approximately one-third to 42 ft.

In contrast to an injection system, an explosion-proof blower with explosion-proof wiring normally is required for air extraction. Extracted soil gas typically contains moisture at or near saturation and a knockout (air water separator) usually is required to collect condensate, which must be treated or disposed of. Also, in winter months, insulation and/or heat tape is essential to maintain piping at temperatures above freezing to avoid clogged pipes. Air extraction systems usually will result in point source emissions that may require permitting and treatment. Air treatment will impact remediation costs significantly.

E. RESULTS FROM SOIL VAPOR EXTRACTION WITH REINJECTION

In September 1993, the site was reconfigured for a 5-day test of soil vapor extraction with reinjection of the extracted off-gas. The purpose of this test was to determine the efficiency of soil vapor extraction with reinjection for aerating the site.

Oxygen, carbon dioxide, and TPH concentrations were measured in the extracted soil gas from each test plot, in the combined extracted soil gas from the entire site, and at each monitoring point. Figures showing oxygen and TPH concentration over time at each monitoring point, in each extraction line, and in the reinjection line are shown in Appendix J.

In general, the site was aerated nearly as rapidly as during the soil vapor extraction test. Soil gas concentrations measured at the extraction wells were similar to those observed during the extraction test (Figure 31). Localized soil gas concentrations at specific monitoring points appeared to become oxygenated more rapidly, as seen at monitoring point A6a (Figure 32).

These tests indicate that soil vapor extraction with reinjection of the off-gas may be a feasible alternative for configuration of the bioventing system. This configuration offers the advantage of eliminating point-source emissions as seen with the extraction test; however, soil vapor extraction could pose operational problems during the winter months when moisture extracted from the ground could cause freezing in the lines to occur.

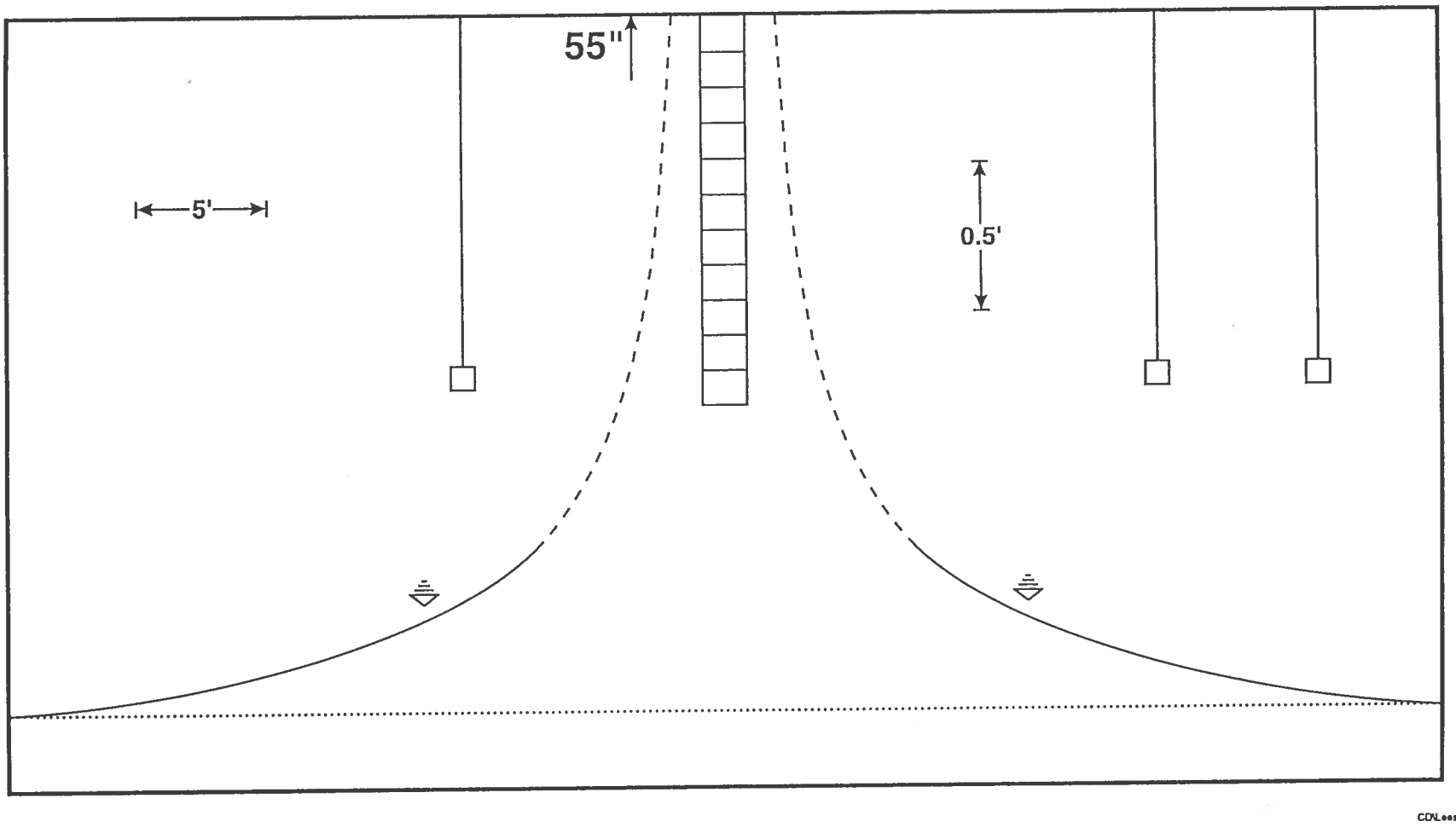


Figure 30. Water Table Upconing During Air Extraction at Site 20, Eielson AFB.

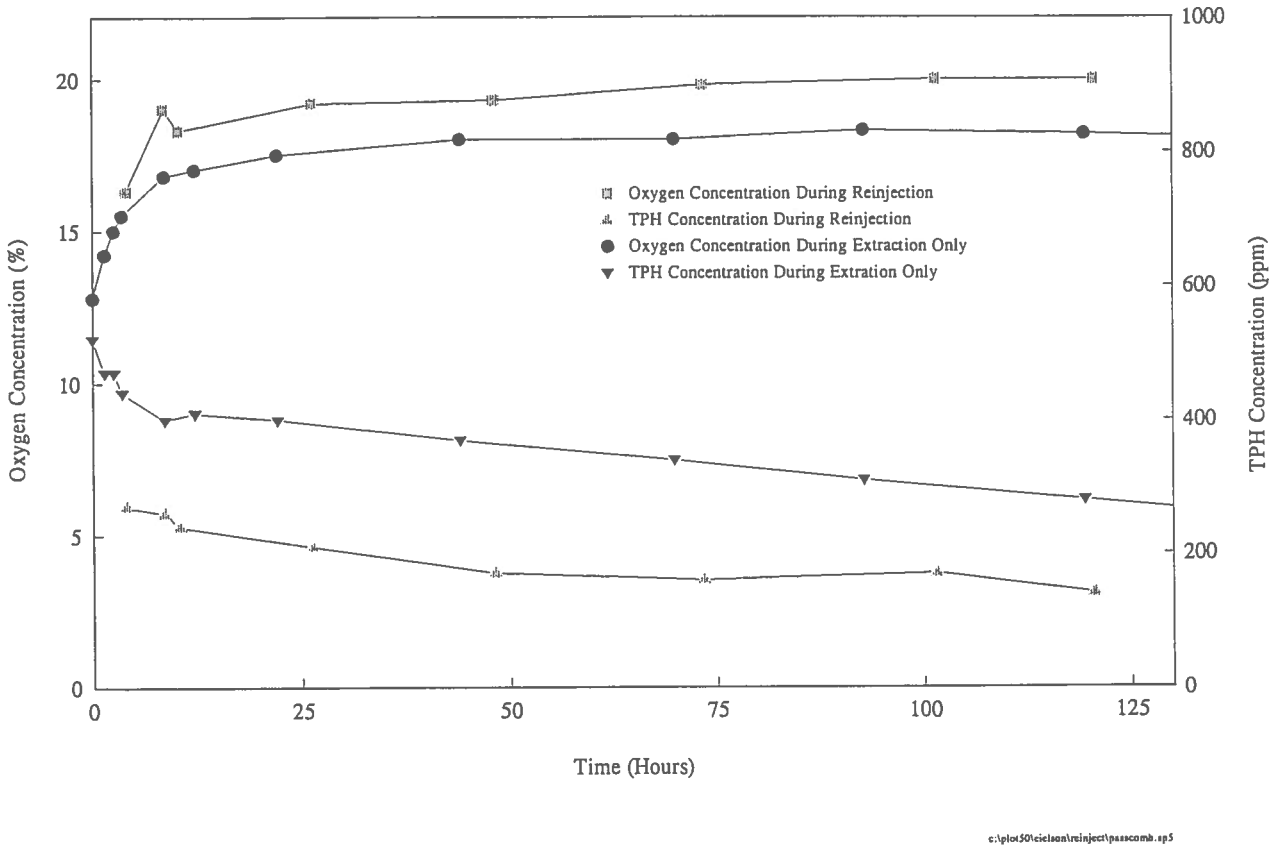


Figure 31. **Oxygen and TPH Concentration at the Passive Warming Test Plot Extraction Line During the Extraction Test and During the Extraction with Reinjection Test.**

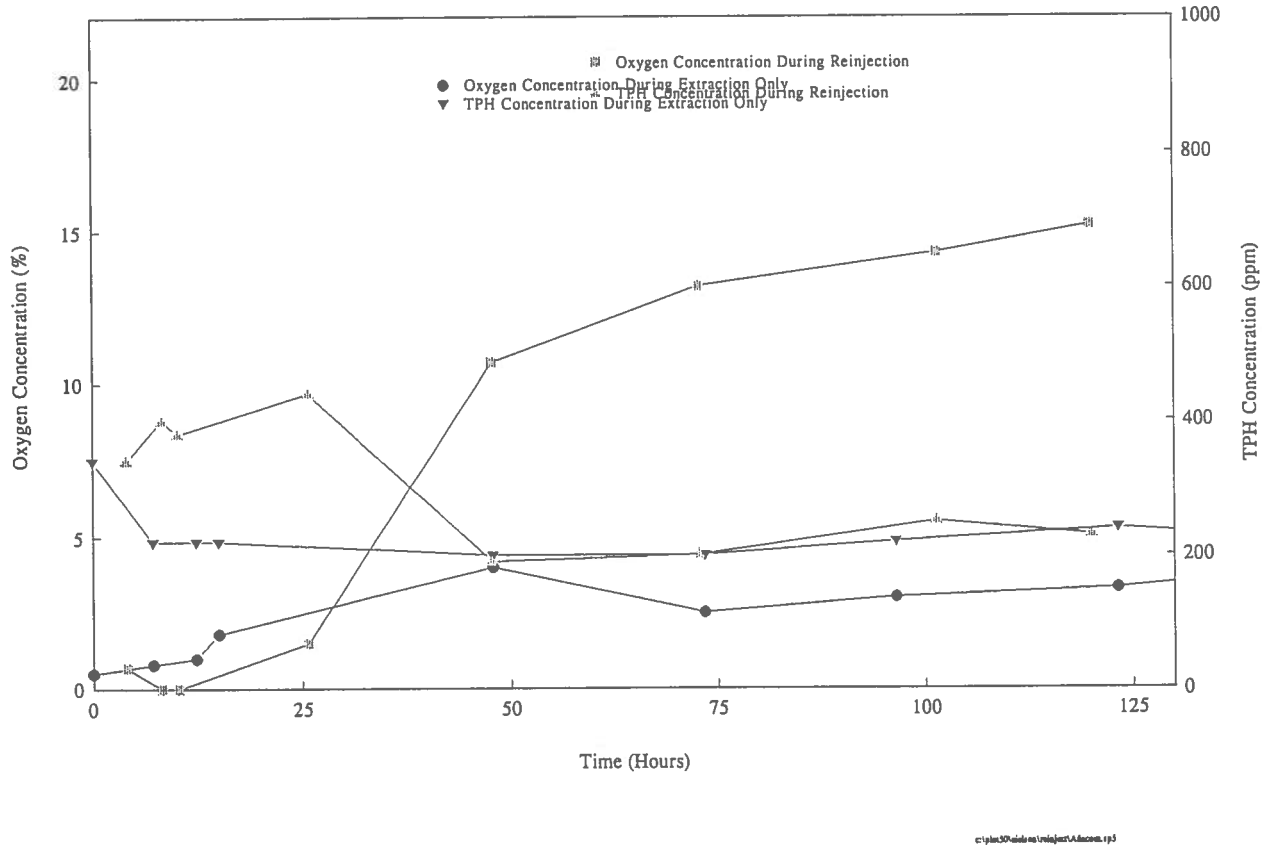


Figure 32. **Oxygen and TPH Concentration at Monitoring Point A6a During the Extraction Test and During the Extraction with Reinjection Test.**

F. RESULTS FROM ANALYTICAL TESTING OF SOIL GAS SAMPLES

Results of the soil gas analyses are presented in Appendix K. In nearly all cases, total hydrocarbon and specific compound concentrations were significantly lower in samples taken after more than 1-year of operation than during initial sampling. However, these results cannot be used as a direct indication of contaminant removal due to various physical/chemical processes. Thus, any decrease in soil hydrocarbon concentration must be confirmed with soil sampling.

In practice, at equilibrium the concentration of most petroleum hydrocarbon compounds of interest in the aqueous or gaseous phase is driven by the immiscible phase, if present, and the sorbed phase, if the immiscible phase is not present. If no immiscible phase is present, and all sorption sites on the solid soil matrix are not occupied[1], the vapor- or aqueous-phase concentration is a function of the sorbed concentration. This relationship typically follows a Langmuir-type curve. If the soil concentration is in excess of the sorption capacity of the soil[2], the aqueous-phase and gaseous-phase concentrations are Raoult's law-driven and are independent of the hydrocarbon concentration in the soil. This is an important concept in attempting to interpret soil gas or groundwater data. For example, in a sandy site at which free product has been detected, the highest soil hydrocarbon concentrations may exceed 25,000 mg/kg. Yet 99% remediation to 250 mg/kg may not affect the equilibrium soil gas or groundwater hydrocarbon concentrations.

G. RESULTS FROM WEEKLY SOIL GAS SAMPLING

Relatively low concentrations of oxygen were found in soil gas monitoring points taken before initiation of air injection on August 22, 1991, with oxygen concentrations ranging from 0% to 18%, although most oxygen levels were less than 10% (Figure 33). Carbon dioxide and total hydrocarbon concentrations were correspondingly high, with many sampling points containing greater than 10% carbon dioxide and greater than 5,000 ppm total hydrocarbon. Once air injection was initiated, oxygen concentrations increased with a corresponding drop in hydrocarbon concentration in most soil gas monitoring points. Appendix L contains weekly sampling data collected for oxygen, carbon dioxide, and total hydrocarbon concentrations, as well as soil pressure readings.

Oxygen levels in the active warming test plot typically have been low compared to levels in the other test plots, possibly due to a combination of the high moisture content of the soil and higher microbial activity. Reducing the amount of warm water flowing into the plot generally results in an increase in oxygen levels in the soil gas; however, oxygen levels are still low compared to those in the other test plots. Since water circulation was turned off in July 1993 the oxygen levels have increased slightly, but this test plot still has lower oxygen concentrations than the other test plots.

Oxygen concentrations in the passive warming test plot typically have remained high, whereas oxygen concentrations in the control test plot generally range from 10% to 20%. Oxygen concentrations in the surface warming test plot were found to be low prior to initiation of air injection. After air injection, oxygen concentrations generally were greater than 19%; however, due

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[1] In most soils, this is probably at a concentration of less than 100 to 1,000 mg/kg.

[2] Greater than 100 to 1,000 mg/kg in most soils.

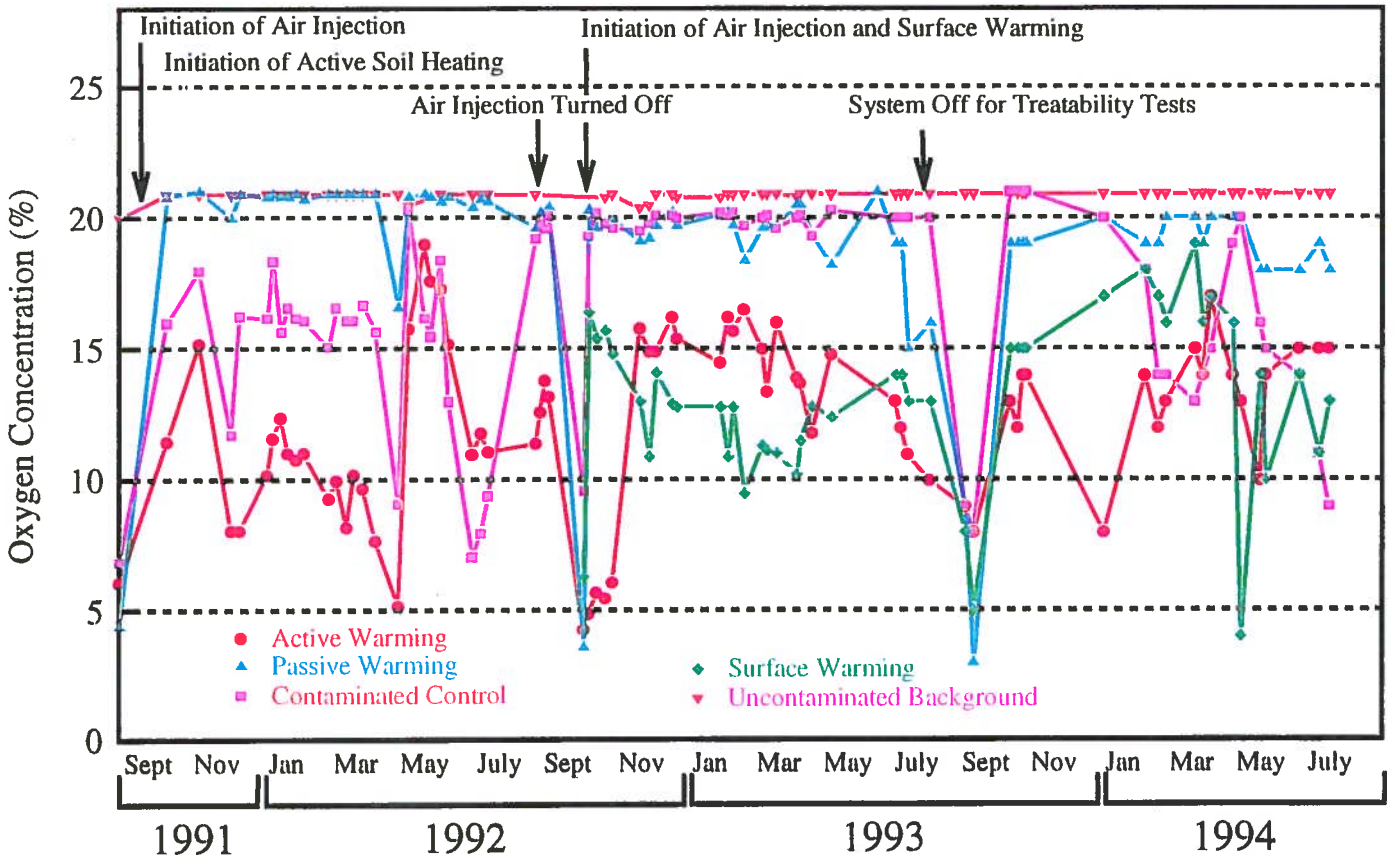


Figure 33. Average Oxygen Concentration Versus Time in Four Test Plots and Background Area.

to the moisture content in this low-lying area of the test site, many of the monitoring points could not be sampled.

H. RESULTS FROM SOIL TEMPERATURE MEASUREMENTS

Soil temperature data were collected two to three times daily with an automatic data logger. Due to the relatively large quantity of temperature data collected and to the fairly slow change in soil temperature, only one data point from every 2 to 4 days is presented in Figure 34 and Appendix M. The average soil temperatures from the active warming (thermocouples 1a through 6a), passive warming (thermocouples 25a through 30a), surface warming (thermocouples 1b through 9b), and control test plots (thermocouples 31a through 36a), and from the background area (thermocouples 37a through 39a) are shown in Figure 34. Occasionally, these thermocouple designations were changed because of electronic malfunctions over the life of the thermocouple unit. However, every effort was made to either repair the malfunctioning thermocouple or to choose a different thermocouple to represent the average temperature for a given plot. The method used to select representative thermocouples for average plot values was based on the location and depth of each thermocouple.

Soil temperature measurements have demonstrated a significant difference between the active warming, passive warming, surface warming, and control test plots. During the first 2 years of operation, the active warming test plot, which was covered with insulation and had warm water circulating through it, maintained higher temperatures overall than the other test plots, with an average temperature during the winter months of 10°C (50°F). During the winter of 1993, after the warm water circulation was turned off, soil temperatures dropped steadily. In late 1993 the average soil temperature in the active warming test plot continued to decrease and fell below temperatures exhibited by the passive warming test plot. Average temperatures in the active warming test plot remained 2 to 3°C (4 to 5°F) colder than in the passive warming test plot for the remainder of the study (July 1994) and followed the seasonal trend which the control test plot and background area exhibited due to changes in ambient air temperature.

After the first season of solar warming, soil temperatures in the passive warming test plot remained 1 to 2°C (3 to 4°F) higher than soil temperatures in the control test plot. This trend is seen throughout the winter months and into spring, when soil temperatures rose sharply with the installation of the plastic sheeting. In comparison, average soil temperatures in the control test plot remained below freezing until June, when temperatures began to rise; however, soil temperatures in the control test plot remained 5 to 6°C (9 to 11°F) colder than in the passive warming test plot after the installation of the plastic sheeting in the passive warming test plot. As the ambient air temperature decreased seasonally, the difference in soil temperature between the two test plots decreased; however, the passive warming test plot remained slightly warmer than the control test plot.

In the control test plot, soil temperatures were significantly higher than in the background area during the winter months. This was particularly true during the first winter season of bioventing when contamination and microbial activity were high. This difference in temperature is likely due to heat generated by microbial activity in the control test plot.

Soils in the surface warming test plot responded immediately to the activation of the heat tape in the soil. Initial temperatures in the surface warming test plot were approximately 5°C (41°F), comparable to the soil temperature in the control test plot. An immediate rise in soil temperature was

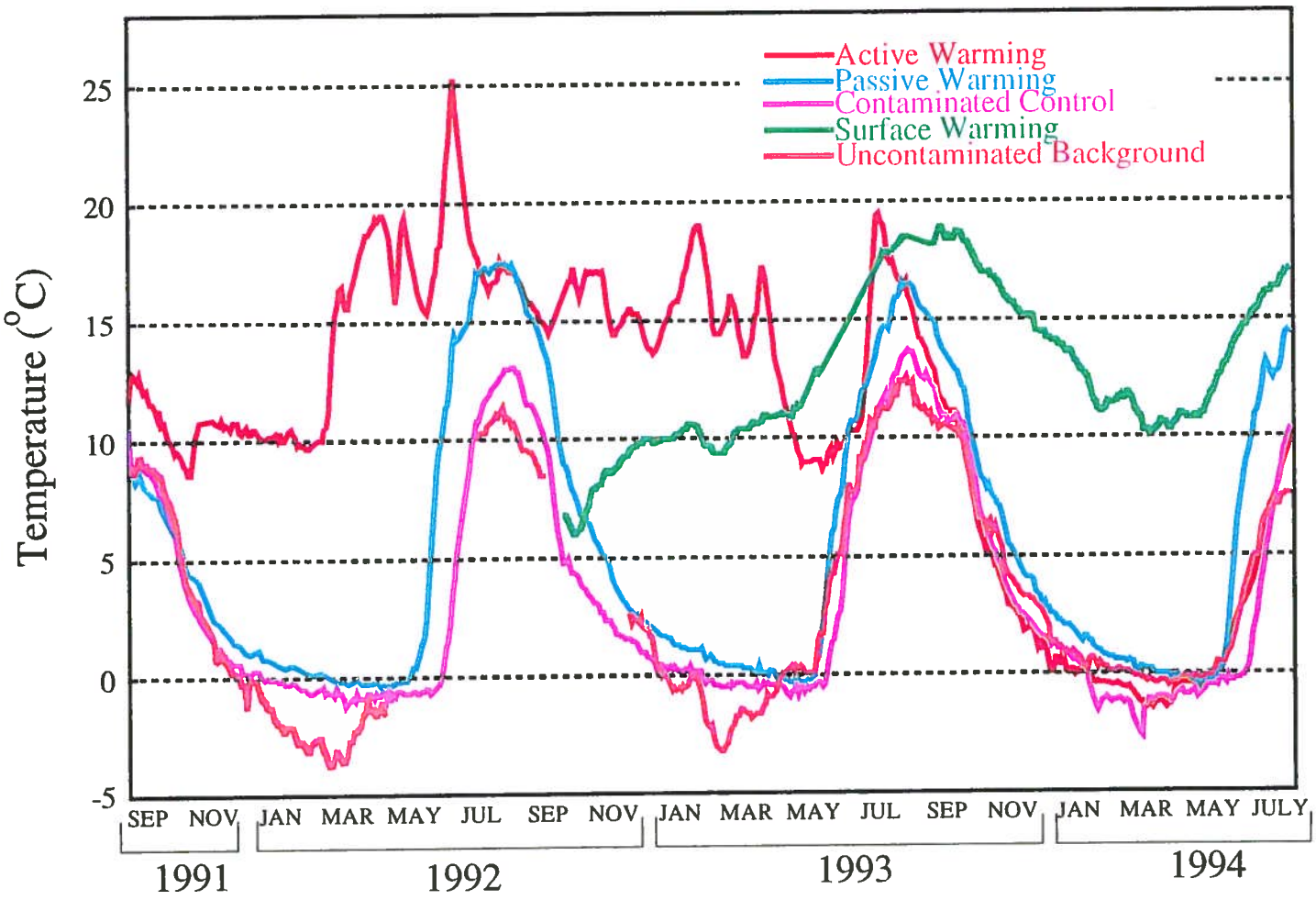


Figure 34. Soil Temperature in Four Test Plots and Background Area.

observed once the heat tape was activated, with the average temperature reaching a maximum of 18.1°C (65°F) in August 1993. Average soil temperatures in this plot decreased and increased seasonally with the fall and rise of ambient air temperature during late 1993 and the first half of 1994, respectively. Average temperatures in the surface warming test plot during January 1994 were 13.3°C (56°F), whereas all other plots and the background area remained in the −1.0 to +2.0°C (30 to 36°F) range. In mid-July 1994, the average temperature in the surface warming test plot reached 17.8°C (64°F), approximately 3.5 to 4.0°C (6 to 7°F) warmer than in the passive warming test plot.

I. IN SITU RESPIRATION TESTING AND INFLUENCE OF SOIL TEMPERATURE ON MICROBIAL ACTIVITY

1. Results From In Situ Respiration Tests

Full in situ respiration tests were conducted during October 1991; January, August, and October/November 1992; January, July, and November 1993; and January, April, and July 1994. Oxygen and carbon dioxide concentrations measured during both the full and the abbreviated tests are presented in Appendix N. Oxygen utilization rates in the active warming, passive warming, control, and surface warming test plots are shown in Tables 17 through 20, respectively. Figure 35 illustrates the average biodegradation rates in the four test plots over the study period.

Occasionally, high soil moisture content reduced the number of soil gas monitoring points that could be sampled. In general, the deeper soil gas monitoring points were the most difficult to monitor. The inability to measure soil gas concentrations at the deeper monitoring points may have led to the calculation of lower average biodegradation rates for a given test plot, because the contamination is greater at the deeper depths and thus greater biodegradation rates generally were recorded.

The first full in situ respiration test was conducted in October 1991. The average temperature in the active warming test plot was approximately 11°C (52°F). This was 4 to 5°C (7 to 9°F) warmer than in the other two test plots (passive warming and control test plots), and the average oxygen utilization rate for the active warming test plot at this time was 0.35 %/hr. This rate was approximately 3 to 4 times greater than that recorded for the passive warming and control test plots, indicating greater microbial activity in the warmer active warming test plot. In October, the control test plot exhibited slightly greater oxygen utilization rates than the passive warming test plot, even though they were of similar temperature. The increased activity in the control test plot probably was due to the elevated concentration of contaminants in this plot compared to the concentration in the passive warming test plot.

In January 1992, average oxygen utilization rates among the three test plots decreased. It is unlikely that this was due to temperature in the case of the active warming test plot, because average temperatures were approximately the same as those in October. The low values reported for the active warming test plot may best be explained by the inability to measure the deeper probes because of high soil moisture content. This resulted in the calculation of lower averages for the entire test plot.

The frigid temperatures in January 1992 also brought about decreased activity in the control and passive warming test plots. However, microbial activity was still apparent in both test plots, as soil biota continued to consume oxygen and produce carbon dioxide. Oxygen utilization

TABLE 17. OXYGEN UTILIZATION RATES IN THE ACTIVE WARMING TEST PLOT.

Soil Gas Monitoring Point	Oxygen Utilization Rate (%/hr)										
	October 1991	January 1992	April 1992	August 1992	November 1992	January 1993	July 1993	November 1993	January 1994	April 1994	July 1994
1A	ND[2]	ND[1]	NS	0.420	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	NS	NS
1B	0.690	0.180	NS	0.410	ND[1]	ND[1]	ND[1]	ND[2]	ND[1]	NS	0.030
1C	ND[1]	0.023	NS	NS	ND[1]	ND[1]	0.001	0	0	0.005	NS
2A	ND[1]	ND[1]	NS	NS	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	NS	NS
2B	0.440[3]	0.24	NS	NS	ND[1]	0.350	0.330	0.004	ND[1]	NS	0.064
2C	0.230[3]	0.087	NS	NS	ND[1]	ND[1]	ND[1]	0	ND[1]	NS	NS
3A	0.240[3]	ND[1]	0.470	NS	ND[1]	ND[1]	0.230	ND[1]	ND[1]	NS	NS
3B	ND[1]	0.095	0.120	NS	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	NS	0.010
3C	0.150[3]	0.110	NS	NS	ND[1]	ND[1]	0.093	0	0	NS	NS
4A	ND[1]	ND[1]	NS	NS	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	NS	NS
4B	0.800	0.051	NS	NS	ND[1]	0.250	ND[2]	ND[2]	ND[1]	0.004	ND[1]
4C	ND[2]	ND[1]	0.210	NS	ND[1]	ND[1]	0.010	0	0	0.015	ND[1]

NS Not sampled.
ND Not determined.
Q Monitoring point did not exist at this time.
1 High moisture content prevented the collection of adequate soil gas samples.
2 Concentration <5% at beginning of test.
3 Data analyzed from 0 to 33 hours. Little activity after 33 hours.

TABLE 17. OXYGEN UTILIZATION RATES IN THE ACTIVE WARMING TEST PLOT (CONTINUED).

Soil Gas Monitoring Point	Oxygen Utilization Rate (%/hr)										
	October 1991	January 1992	April 1992	August 1992	November 1992	January 1993	July 1993	November 1993	January 1994	April 1994	July 1994
5A	ND[1]	ND[1]	NS	NS	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	NS	NS
5B	0.310[3]	0.024	NS	NS	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	NS	0.004
5C	ND[1]	0.039	0.210	NS	ND[1]	ND[1]	ND[1]	0	ND[1]	NS	ND[3]
6A	0.140	0.032	0.240	0.250	ND[1]	0.140	ND[2]	0	ND[2]	0.031	0.012
6B	0.160	ND[1]	0.220	0.240	ND[1]	0.130	ND[2]	0	ND[2]	0.012	ND[3]
6C	ND[2]	ND[1]	0.150	NS	ND[1]	0.180	ND[2]	0	0	0.031	0.010
7A	NS	NS	NS	NS	0.410	ND[1]	0.170	ND[1]	ND[1]	NS	NS
7B	Q	Q	Q	Q	Q	ND[1]	ND[1]	ND[2]	ND[1]	0.018	NS
7C	Q	Q	Q	Q	Q	ND[1]	ND[1]	0	0	0.017	ND[3]
8A	Q	Q	Q	Q	Q	ND[1]	0.065	ND[1]	ND[1]	NS	NS
8B	Q	Q	Q	Q	Q	ND[1]	ND[1]	ND[1]	ND[1]	NS	NS
8C	Q	Q	Q	Q	Q	ND[2]	ND[2]	ND[2]	ND[1]	0.019	0.125

NS No Sample.
ND Not determined.
Q Monitoring point did not exist at this time.
1 High moisture content prevented the collection of adequate soil gas samples.
2 Concentration <5% at beginning of test.
3 Data analyzed from 0 to 33 hours. Little activity after 33 hours.

TABLE 18. OXYGEN UTILIZATION RATES IN THE PASSIVE WARMING TEST PLOT.

Soil Gas Monitoring Point	Oxygen Utilization Rate (%/hr)										
	October 1991	January 1992	April 1992	August 1992	November 1992	January 1993	July 1993	November 1993	January 1994	April 1994	July 1994
1A	0.048	0.024	NS	0.110	0.057	0.050	0.200	0.140	0.063	ND	0.226
1B	0.037	0.022	NS	0.130	0.045	0.031	0.140	0.060	0.044	0.040	0.118
1C	0.030	0.017	NS	0.230	0.020	0.031	0.095	0.015	0.001	0.024	0.104
2A	0.028	0.027	NS	NS	0.048	ND[1]	0.082	0.043	ND[1]	NS	ND[1]
2B	0.041	0.021	NS	0.220	0.053	0.046	0.160	0.054	0.036	0.042	0.110
2C	0.014	0.017	NS	0.160	0.022	ND[1]	0.110	0.013	0.012	0.033	0.059
3A	0.023	0.025	NS	0.200	0.072	0.062	0.150	0.065	0.050	0.064	0.120
3B	0.034	0.024	NS	0.220	0.075	ND[1]	0.180	0.063	0.045	NS	0.120
3C	0.016	0.015	NS	0.170	0.021	0.043	0.120	0.020	0.017	NS	0.064
4A	0.040	0.025	NS	0.140	0.066	0.062	0.140	0.062	0.042	0.045	ND[1]
4B	0.049	0.030	0.040	0.270	0.110	0.110	ND[1]	ND[1]	ND[1]	0.030	0.134
4C	0.039	0.020	0.024	NS	0.028	0.060	ND[1]	ND[1]	ND[1]	NS	NS

NS Not sampled.
ND Not determined.
1 High moisture content prevented the collection of adequate soil gas samples.
2 Concentration <5% at beginning of test.

TABLE 18. OXYGEN UTILIZATION RATES IN THE PASSIVE WARMING TEST PLOT (CONTINUED).

Soil Gas Monitoring Point	Oxygen Utilization Rate (%/hr)										
	October 1991	January 1992	April 1992	August 1992	November 1992	January 1993	July 1993	November 1993	January 1994	April 1994	July 1994
5A	0.038	0.025	0.030	0.072	0.051	0.046	0.085	0.044	0.040	NS	0.227
5B	0.056	0.027	NS	0.310	0.093	0.100	0.320	0.088	0.060	0.066	0.126
5C	0.045	0.023	NS	0.190	0.093	0.046	0.200	0.023	0.025	0.031	0.171
6A	0.035	0.023	0.028	NS	0.044	0.043	0.091	0.050	0.053	NS	NS
6B	0.070	0.030	0.025	0.130	0.068	ND[1]	ND[1]	0.140	0.060	NS	0.216
6C	0.053	0.021	0.016	0.220	0.030	0.038	0.170	0.033	0.020	NS	0.158
7A	NS	NS	NS	NS	0.044	0.018	0.080	ND[1]	ND[1]	NS	0.100
7B	Q	Q	Q	Q	Q	0.014	0.073	0.035	0.025	NS	NS
7C	Q	Q	Q	Q	Q	0.006	0.095	0.019	0.013	0.016	0.095
8A	Q	Q	Q	Q	Q	ND[1]	ND[1]	ND[1]	ND[1]	NS	NS
8B	Q	Q	Q	Q	Q	0.035	ND[2]	ND[2]	0.020	0.036	ND[1]
8C	Q	Q	Q	Q	Q	ND[1]	ND[2]	ND[2]	0.031	NS	ND[1]

NS Not sampled.
ND Not determined.
1 High moisture content prevented the collection of adequate soil gas samples.
2 Concentration <5% at beginning of test.

TABLE 19. OXYGEN UTILIZATION RATES IN THE CONTROL TEST PLOT.

Soil Gas Monitoring Point	Oxygen Utilization Rate (%/hr)										
	October 1991	January 1992	April 1992	August 1992	November 1992	January 1993	July 1993	November 1993	January 1994	April 1994	July 1994
1A	0.096	0.038	NS	NS	0.063	0.046	ND[1]	ND[1]	ND[1]	0.012	NS
1B	0.073	0.040	0.089	0.290	0.077	0.060	0.140	0.034	0.030	NS	NS
1C	ND[1]	ND[1]	NS	0.110	0.031	0.005	0.020	0.026	0.001	0.016	ND[3]
2A	0.071	0.029	0.047	0.072	0.059	0.035	0.100	0.040	0.030	0.040	0.054
2B	ND[1]	ND[1]	NS	NS	NS	ND[1]	ND[1]	ND[1]	ND[1]	NS	NS
2C	ND[1]	ND[1]	NS	0.110	0.032	0.011	0.010	0.020	0.0004	0.018	0.003
3A	0.040	0.037	NS	NS	NS	ND[1]	ND[1]	ND[1]	ND[1]	NS	0.117
3B	ND[1]	0.120	NS	0.310	NS	ND[1]	0.270	0.046	0.021	NS	ND[2]
3C	ND[1]	ND[1]	NS	0.130	0.027	ND[1]	0.026	0.014	0.011	0.020	ND[2]
4A	0.065	0.031	NS	NS	NS	ND[1]	ND[1]	ND[1]	ND[1]	NS	0.020
4B	0.032[3]	0.086	NS	0.280	NS	ND[1]	0.200	ND[1]	ND[1]	NS	ND[2]
4C	ND[1]	ND[1]	NS	0.110	0.041	ND[1]	0.028	0.014	0.043	0.007	ND[2]

NS Not sampled.
ND Not determined.
Q Monitoring point did not exist at this time.
1 High moisture content prevented the collection of adequate soil gas samples.
2 Concentration <5% at beginning of test.
3 Concentration varied <5% over duration of test.

TABLE 19. OXYGEN UTILIZATION RATES IN THE CONTROL TEST PLOT (CONTINUED).

Soil Gas Monitoring Point	Oxygen Utilization Rate (%/hr)										
	October 1991	January 1992	April 1992	August 1992	November 1992	January 1993	July 1993	November 1993	January 1994	April 1994	July 1994
5A	0.099	ND[1]	NS	NS	NS	ND[1]	0.092	ND[1]	0.011	NS	0.020
5B	ND[1]	ND[1]	NS	NS	0.053	0.032	0.100	ND[1]	0.010	NS	ND[2]
5C	ND[1]	0.043	NS	0.120	0.037	ND[1]	0.042	0.021	ND[1]	0.019	ND[3]
6A	0.110	0.036	0.033	NS	0.060	0.042	0.100	ND[1]	ND[1]	NS	NS
6B	ND[1]	ND[1]	NS	0.190	0.042	0.040[2]	0.050	0.023	0.014	0.045	ND[2]
6C	ND[1]	ND[1]	NS	0.14	0.027	0.18[2]	0.033	0.022	0.010	0.044	ND[3]
7A	Q	Q	Q	Q	Q	ND[1]	ND[1]	ND[1]	ND[1]	NS	NS
7B	Q	Q	Q	Q	Q	ND[1]	0.076	0.024	0.020	0.030	NS
7C	Q	Q	Q	Q	Q	0.070[2]	0.060	0.009	0.001	0.016	ND[3]
8A	NS	NS	NS	NS	0.039	0.031	0.090	0.032	ND[1]	NS	NS
8B	NS	NS	NS	NS	0.041	0.027	ND[1]	ND[1]	ND[1]	NS	NS
8C	Q	Q	Q	NS	Q	0.012[3]	ND[1]	ND[1]	0.001	0.010	NS

NS Not sampled.
ND Not determined.
Q Monitoring point did not exist at this time.
1 High moisture content prevented the collection of adequate soil gas samples.
2 Concentration <5% at beginning of test.
3 Concentration varied <5% over duration of test.

TABLE 20. OXYGEN UTILIZATION RATES IN THE SURFACE WARMING TEST PLOT.

Soil Gas Monitoring Point	Oxygen Utilization Rate (%/hr)						
	November 1992	January 1993	July 1993	November 1993	January 1994	April 1994	July 1994
1A	0.260	0.190	0.130	0.120	ND[1]	ND[1]	NS
1B	0.360	0.340[2]	0.480	0.260	0.170	ND[1]	NS
1C	0.067	ND[1]	0.052	ND[1]	ND[1]	ND[1]	0.004
2A	0.140	0.280	0.145	0.140	0.001	ND[1]	0.016
2B	0.120	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	NS
2C	Q	0.055	ND[1]	ND[1]	0.007	ND[1]	NS
3A	0.057	ND[1]	0.150	ND[1]	ND[1]	ND[1]	NS
3B	Q	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]
3C	Q	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	0.020
4A	0.120	0.110	0.071	ND[1]	ND[1]	ND[1]	NS
4B	0.120	0.250	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]
4C	0.044	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	0.010

NS Not Sampled.
ND Not determined.
Q Monitoring point did not exist at this time.
[1] High moisture content prevented the collection of adequate soil gas samples.
[2] Concentration <5% at beginning of test.

TABLE 20. OXYGEN UTILIZATION RATES IN THE SURFACE WARMING TEST PLOT (CONTINUED).

Soil Gas Monitoring Point	Oxygen Utilization Rate (%/hr)						
	November 1992	January 1993	July 1993	November 1993	January 1994	April 1994	July 1994
5A	Q	ND[1]	0.054	ND[1]	ND[1]	ND[1]	NS
5B	Q	0.230	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]
5C	Q	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	0.013
6A	Q	ND[1]	0.140	ND[1]	ND[1]	ND[1]	NS
6B	Q	ND[3]	ND[3]	ND[1]	ND[1]	ND[1]	ND[1]
6C	Q	0.010	ND[1]	ND[1]	ND[1]	ND[1]	0.059

NS Not Sampled.
ND Not determined.
Q Monitoring point did not exist at this time.
1 High moisture content prevented the collection of adequate soil gas samples.
2 Concentration <5% at beginning of test.

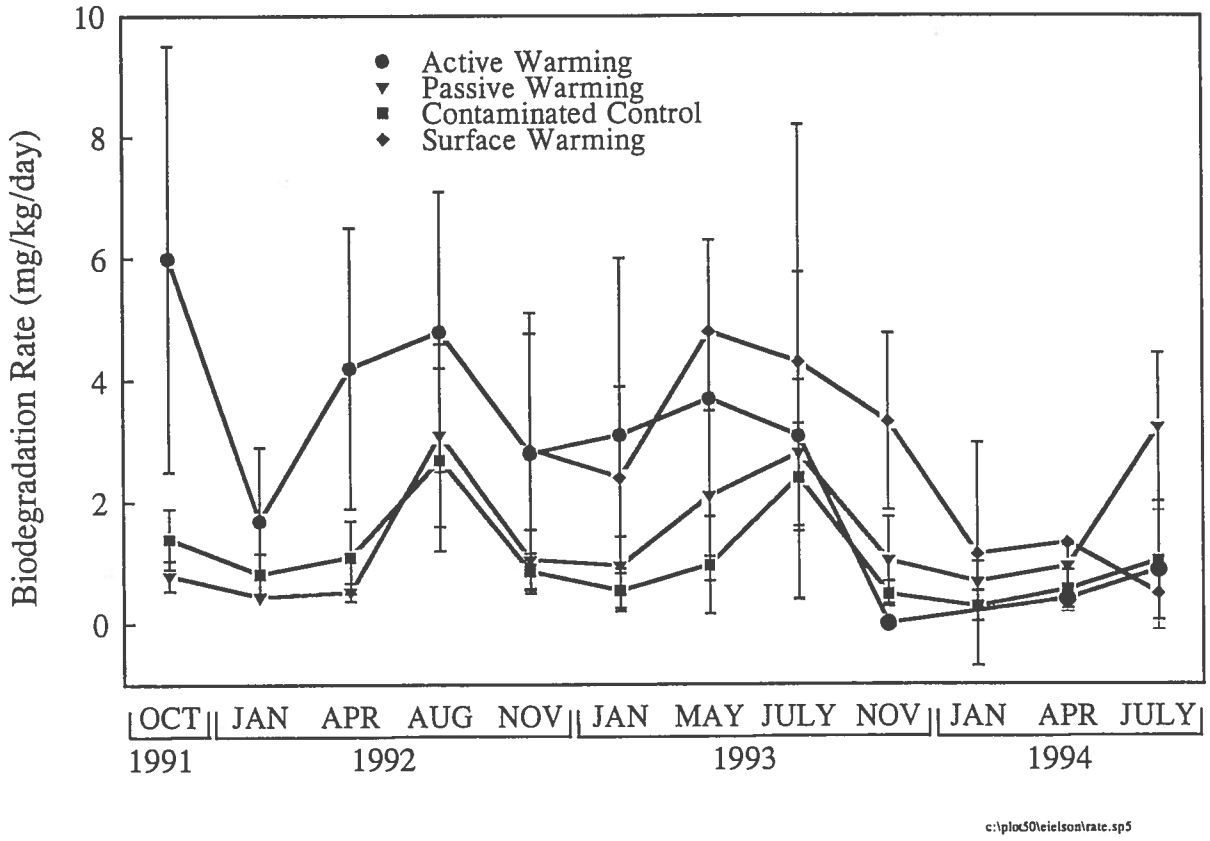


Figure 35. Average Biodegradation Rates in the Four Test Plots.

rates in the control test plot continued to exceed rates in the passive warming test plot, with average values of-0.051 and 0.023% oxygen per hour, respectively.

In the spring, when the plastic sheeting was applied to the passive warming test plot, oxygen utilization rates increased by nearly an order of magnitude. In late spring and early summer, oxygen utilization rates in the passive warming test plot were slightly greater than in the control test plot. The rates in the active warming test plot increased in the summer as well, with average oxygen utilization rates being 0.23 %/hr in the spring and increasing to 0.33 %/hr in the summer.

Soil temperatures in the passive warming test plot in November 1992 were a few degrees warmer overall than at the same time in 1991 due to the plastic sheeting that covered the test plot during the summer. Slightly higher respiration rates also were observed during November 1992, with an average respiration rate of 0.55% oxygen per hour as compared to an average rate of 0.039% oxygen per hour during October 1991. Respiration rates in the active warming test plot were low in November 1992 due to high soil moisture at the monitoring points and the inability to measure the soil gas accurately.

Respiration rates in the surface warming test plot were measured for the first time in November 1992. Respiration rates ranged from 0.044 up to 0.36% oxygen per hour, with an average respiration rate of 0.15% oxygen per hour (Table 20). This rate was comparable to the rate exhibited by the active warming test plot, indicating that the use of heat tape may be a more useful method for soil warming than the active warming process. The use of heat tape seemed to eliminate the sampling problems associated with high soil moisture content.

As average temperatures in the passive warming test plot remained a few degrees warmer than in the control test plot, so did oxygen utilization rates remain slightly greater in this plot during the winter period in 1993. The plastic sheeting which entrapped heat during the spring and summer months was effective in keeping soil temperatures higher than in the control test plot on into the winter months and resulted in increased microbial activity when ambient air temperatures were extremely low. The active and surface warming test plots had similar oxygen utilization rates during this time (0.21 and 0.18 %/hr, respectively). During this period, high soil moisture content was exhibited during sampling in the surface warming test plot. Although the heat tape method contributed less to soil moisture content, the plot itself is situated in a low-lying area and flooding previous to the winter of 1993 caused significant difficulties in the collection of adequate soil gas samples.

During the summer of 1993, oxygen utilization rates in the passive warming test plot remained greater than in the control test plot, with average oxygen utilization rates of 0.14 and 0.08% per hour, respectively. Passive warming oxygen utilization rates were similar to values recorded in July 1992.

Interesting results were observed during the November 1993 in situ respiration test in the active warming test plot after the active warming system was shut down and average soil temperatures decreased. No respiration rates could be measured in this test plot during November 1993 (Figure 35). Apparently, due to the decrease in soil temperature, the microorganisms within this test plot were not active, perhaps having adapted to the higher soil temperatures. During this period, the passive warming and control test plots continued to exhibit the familiar seasonal

biodegradation trend with oxygen utilization rates decreasing to 0.05 and 0.01% per hour, respectively.

The results for the full in situ respiration test conducted in January 1994 exhibited a similarity to results for the January 1993 full in situ respiration test for the passive warming and control test plots. The passive warming test plot had oxygen utilization rates greater than those in the control test plot; however, rates for both plots were less than the values reported the previous year, although the corresponding average soil temperatures for these plots were very similar to the values reported in 1993. This reduction in rates is likely due to a reduction in contaminant level. Rates in the active and surface warming plots remained low due to the inability to draw an adequate soil gas sample because of high soil moisture.

Average oxygen utilization rates in the active warming test plot began to increase again in the spring and early summer of 1994 with increased soil temperature. This increase indicated that the microbial flora in the active warming test plot must have adapted to the warmer temperatures and were incapable of metabolism under ambient winter conditions. In fact, oxygen utilization rates were similar to rates exhibited by the control test plot, with average oxygen utilization rates of 0.036% oxygen per hour for the active warming test plot and 0.043% oxygen per hour for the control test plot in July 1994. Average oxygen utilization rates in the passive warming test plot were relatively high in July (i.e., 0.13% oxygen per hour). Results for the surface warming test plot exhibited very low and unseasonal oxygen utilization rates for this plot (i.e., 0.02% oxygen per hour, Figure 35). However, this was due to an inability to collect adequate soil gas samples due to flooding in this plot in late April 1994.

After the project ended in July 1994, an abbreviated in situ respiration test was conducted in January 1995 at Site 20. The test was conducted to determine whether microorganisms in the active warming test plot had readapted and were able to metabolize fuel contaminants at low temperatures as in the control test plot. While microbial activity was low in the active warming test plot, measurable activity could be measured, with an average rate of 0.035% O_2/hr. Rates measured in the control test plot were comparable, with an average rate of 0.061% O_2/hr. These results indicate that the microorganisms in the active warming test plot were able to readapt to growth at normal soil temperatures.

2. Temperature Effects on Microbial Activity and Implications for the Bioventing Process

Soil temperature may significantly affect the bioremediation process. Microbial activity has been reported at temperatures varying from −12 to 100°C (10 to 212°F) (Brock et. al, 1984); however, the optimal range for biodegradation of most contaminants generally is much narrower. An individual microorganism may tolerate a temperature range of up to approximately 40°C (104°F). However, a microorganism's optimal growth temperature may vary depending on the climate. For example, microorganisms in a subarctic environment may exhibit optimal growth at 10°C (50°F), whereas microorganisms in a subtropical environment may exhibit optimal growth at 30°C (86°F). In extreme cold environments such as at Eielson AFB, heat addition may substantially improve bioremediation processes.

It has been generally observed that biodegradation rates double for every 10°C (18°F) temperature increase, up to some inhibitory temperature. The van't Hoff-Arrhenius equation expresses this relationship quantitatively as:

$$K_T = K_o e^{\frac{-E_a}{RT}} \quad (7)$$

where:

K_T = temperature-corrected biodegradation rate (% O_2/day)

K_o = baseline reaction rate (% O_2/day)

E_a = activation energy (cal/mol)

R = gas constant (1.987 cal/°K-mol)

T = absolute temperature (°K)

Figure 36 illustrates the relationship between oxygen utilization rate and temperature observed at Site 20. Individual oxygen utilization rates are graphed versus soil temperature measured at the thermocouple nearest to the monitoring point. In order to calculate the van't Hoff-Arrhenius constant for this relationship, the log of the oxygen utilization rate was calculated versus the inverse of the temperature. The activation energy for these data was calculated to be 13.4 kcal/mol. This value is similar to values reported by Miller (1990) for in situ biodegradation of jet fuel.

As is illustrated in Figure 36, higher soil temperatures have resulted in higher oxygen utilization rates. The effect on total hydrocarbon removal can be dramatic, as illustrated in Figure 37. The cumulative hydrocarbon removal was calculated for each test plot based on average biodegradation rates per season. The cumulative hydrocarbon removal is an order of magnitude higher in the active warming test plot than in the passive warming or control test plot. Cumulative hydrocarbon removal in the surface warming test plot also is high, but does not compare to the results from the active warming test plot due to the shorter operation period. These results illustrate the potential for reduction in remediation time when soil heating methods are implemented. The decision to apply soil heating methods to decrease total remediation time must generally be balanced with the cost to implement and maintain a soil heating system.

J. RESULTS FROM GROUNDWATER ANALYSES

Initial groundwater samples contained significant concentrations of total hydrocarbons. Benzene and toluene were the predominant contaminants found in the groundwater samples. Five wells were sampled, four of which had concentrations of benzene and/or toluene above 3.0 mg/L. No detectable compounds were found in the background well (Appendix A). The average initial TPH and BTEX concentrations were 16 mg/L and 9.4 mg/L, respectively. The average final TPH concentration was 2.2 mg/L. No benzene or ethylbenzene could be detected in the final groundwater samples, while only small concentrations of toluene and xylenes were detected (0.038 and 0.092 mg/L, respectively).

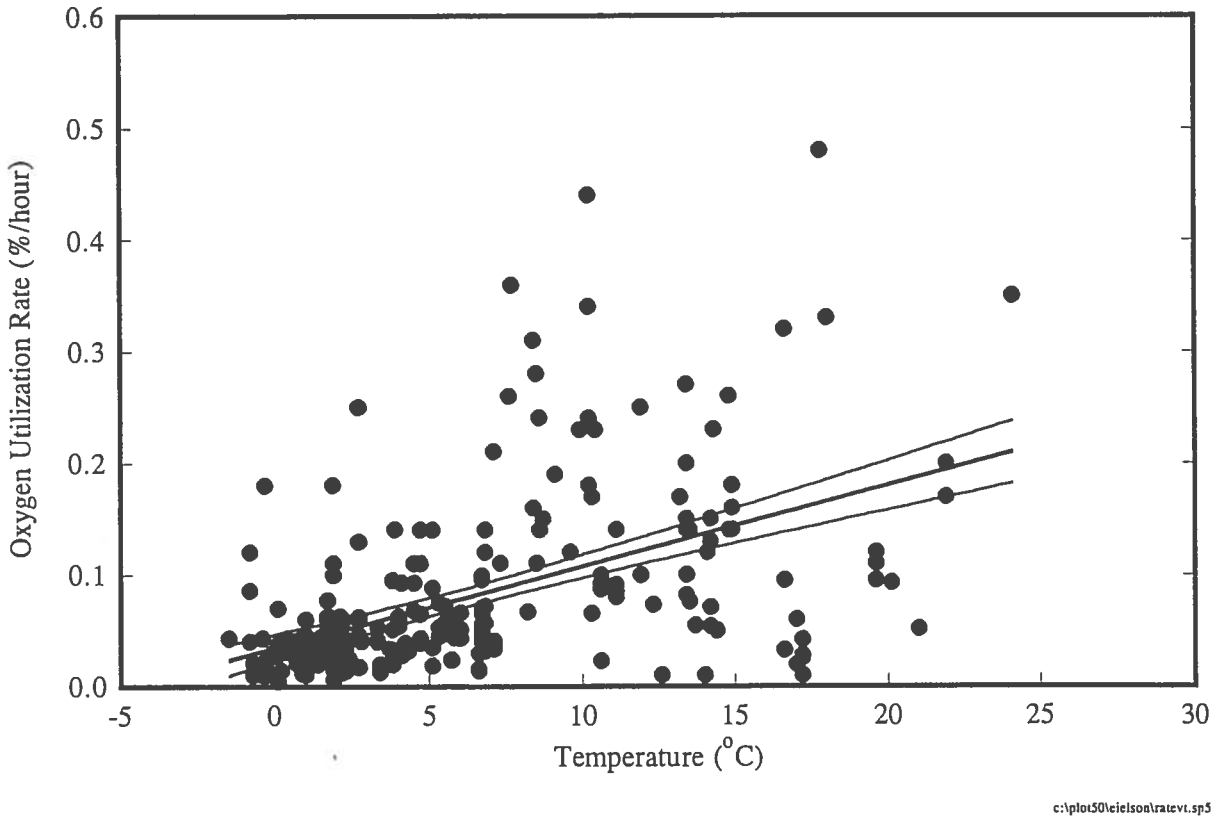


Figure 36. Soil Temperature Versus Biodegradation Rate at Site 20, Eielson AFB, Alaska.

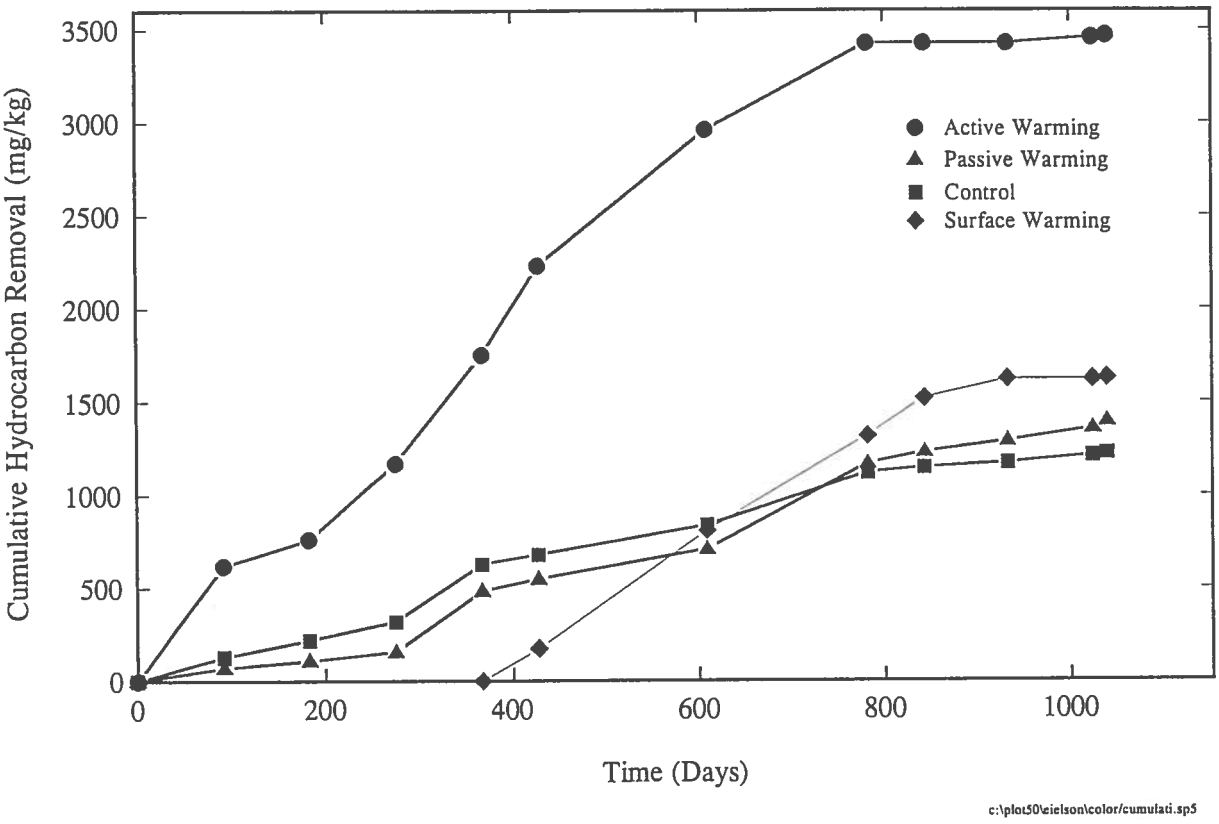


Figure 37. Cumulative Hydrocarbon Removal in Four Test Plots.

K. RESULTS FROM SOIL SAMPLING

Initial soil samples were collected during 1991 and 1992. In general, the highest initial contaminant levels were found in the control test plot, which had concentrations greater than 1,500 mg/kg from 5.0 to 6.0 ft and concentrations dropping with increasing depth. Concentrations of total hydrocarbon (HC) were relatively high also in the passive warming test plot, where, unlike the control test plot, total HC concentration increased with increasing depth. At a depth of 8.0 to 8.5 ft, total HC concentrations were greater than 3,000 mg/kg. Total HC concentrations in the active and surface warming test plots were relatively low by comparison, with average concentrations around 100 mg/kg in the active warming test plot and less than 100 mg/kg in the surface warming test plot. The most common contaminants found in the initial soil samples were *n*-octane, *n*-dodecane, *n*-heptane, and toluene. Due to the large volume of material, complete data are presented in Appendix A.

Initial and final average TPH and BTEX concentrations by depth are presented in Figures 38 and 38. TPH concentrations were seen to decrease at nearly all depths, while final BTEX concentrations were below detection limits at most sample locations. These results indicate that significant contaminant removal has occurred since the initiation of bioventing, with high removals of the more volatile components, such as BTEX.

Three soil samples, each from a different depth, were analyzed from each test plot and the background area to determine soil characteristics. The analyses conducted included total Kjeldahl nitrogen (TKN), total phosphorus (TP), pH, alkalinity, and total organic carbon (TOC). The analytical results are presented in Appendix A. In general, TKN ranged from 100 to 450 mg/kg, with the deeper soils containing lower concentrations. In the background area, TKN was a relatively uniform 100 mg/kg at all depths. Total phosphorus ranged from 260 to 750 mg/kg, pH ranged from 7.0 to 7.6, and alkalinity ranged from 102 to 231 mg/kg $CaCO_3$. TOC in the background area ranged from 0.15 to 0.21 wt%.

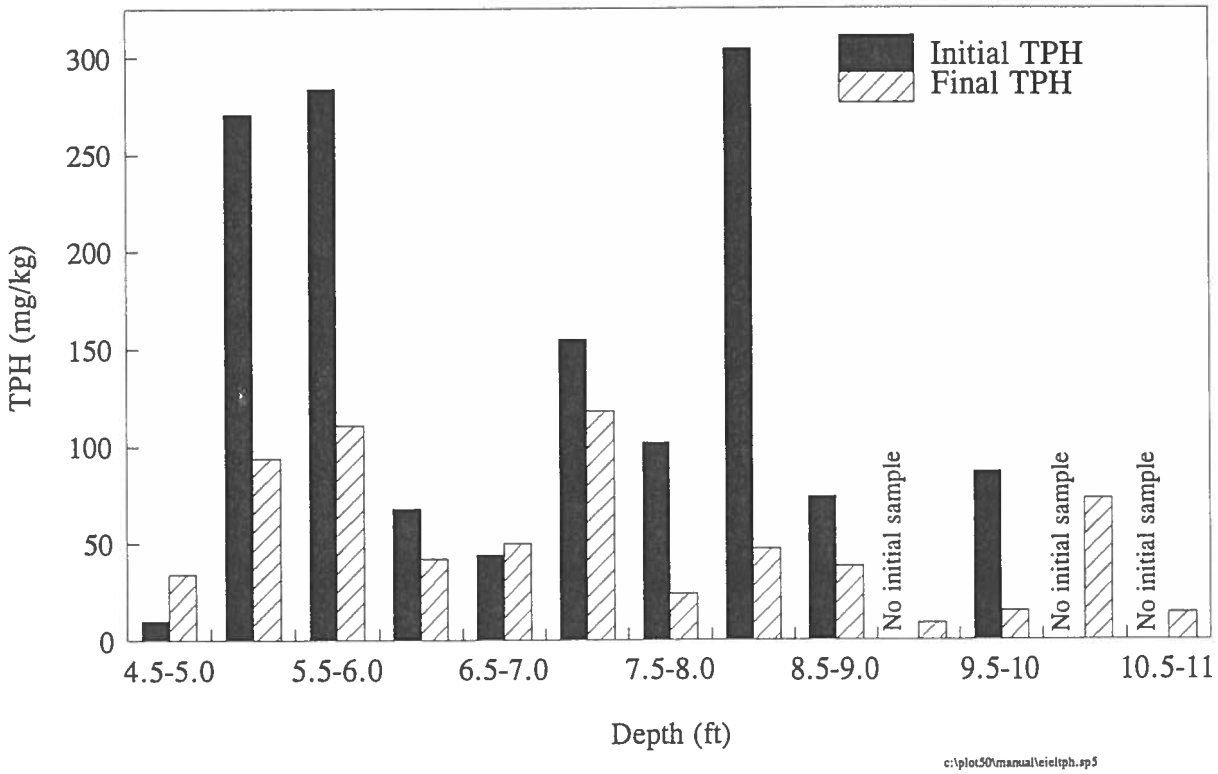


Figure 38. Initial and Final Average TPH Soil Concentrations by Depth.

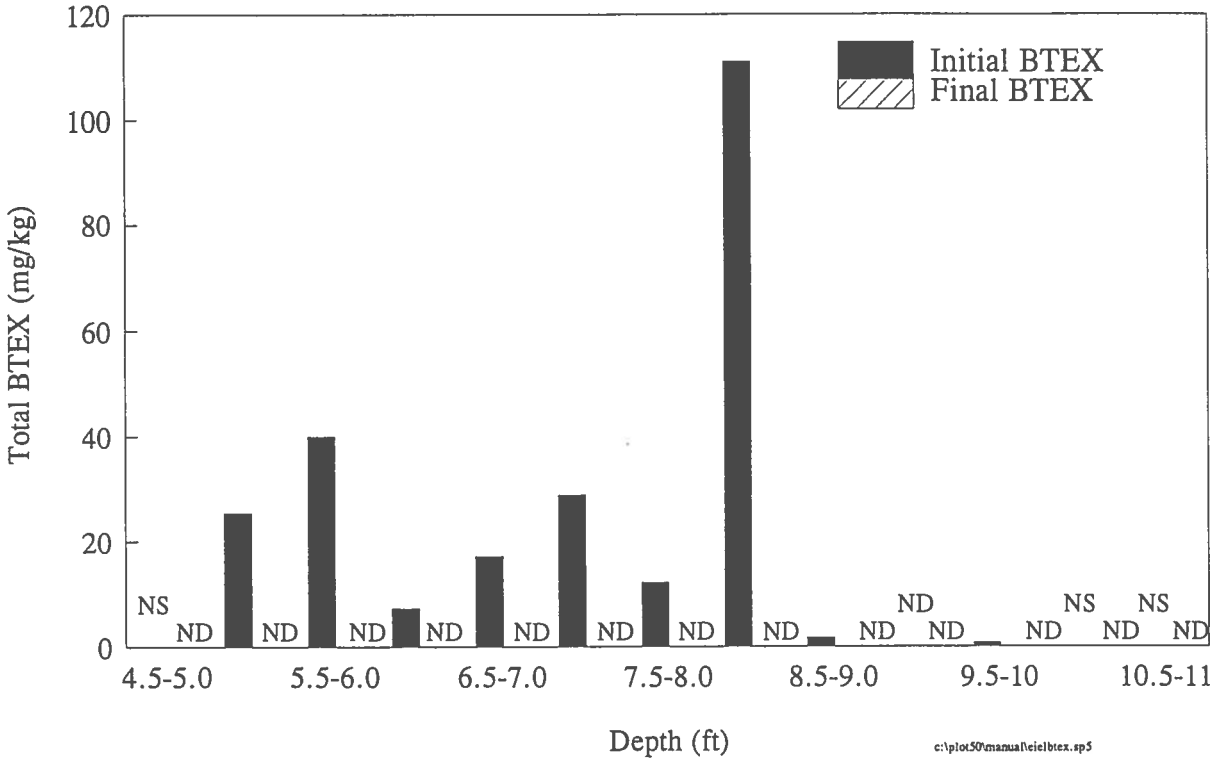


Figure 39. Initial and Final Average BTEX Soil Concentrations by Depth.

SECTION VII
COST EVALUATION AND COMPARISON

This cost evaluation and comparison provides generic installation and operating costs for the soil warming systems studied at Eielson AFB. This cost evaluation does not reflect actual costs for this study, because most of the systems were modified and improved during the course of the study. Instead, this cost evaluation is based on standard bioventing costs as presented by Downey and Hall (1994), with modifications as necessary to reflect the various soil warming methods.

Operating costs for bioventing systems with different warming devices were estimated based on a site with 5,000 yd^3 of contaminated soil. A basic bioventing system included the installation of four air injection wells drilled to 15 ft.

Four bioventing test plots were evaluated at the Eielson AFB bioventing site. The three soil warming techniques evaluated were (1) active warming using reinjection of heated groundwater, (2) passive solar warming in the spring and summer, and (3) "surface heating" with buried electrical heat tape. A control plot was installed to evaluate bioventing at ambient soil temperatures, that is, with no soil warming.

Major cost categories are identified below and include labor and material costs. Material costs for soil warming equipment were based on the actual cost of materials used for the Eielson AFB bioventing study. Rough estimates for minor electricity usages are incorporated into the above primary assumptions.

The installation costs for the four bioventing systems are based on optimum site logistics. It should be understood that site-specific factors such as nearby buildings, underground utilities, surface structures and activities, and access to electrical power will affect costs dramatically and may make all three heating options impossible to implement. Traditional bioventing with no soil warming can be designed for practical implementation in most cases.

These estimates are provided for planning purposes. They do not constitute a cost proposal.

Present worth costs for each of the soil warming techniques plus basic bioventing are presented in Table 21. Because soil warming significantly reduces remediation times, the number of years to remediate the site varies according to the soil warming method. For example, the site with a basic bioventing system installed would require 9.4 years for remediation, while a site with an active warming system installed would require only 2.8 years. Thus, the basic bioventing system will have higher operation and maintenance costs. However, lower operation and maintenance costs for the warming systems tend to be offset by higher capital costs. The result is the actual cost per cubic yard of contaminated soil is very similar for all bioventing systems evaluated.

The decision to implement a soil heating option in conjunction with bioventing is determined entirely by site-specific factors. In most cases, bioventing with no soil heating will be the most cost-effective and practical approach to in situ remediation of petroleum-contaminated soil. Although it is true that biodegradation rates can be improved with soil warming, it has been demonstrated in this study that bioventing without soil warming is practical even in the winter months in Alaska. In some instances, risk concerns may indicate the need to speed the remediation process by implementing soil warming.

TABLE 21. ESTIMATED PRESENT WORTH COSTS FOR SOIL WARMING TECHNIQUES.[1]

Task	Basic	Active Warming	Solar Warming	Heat Tape
Site Visit/Planning	5,000	5,000	5,000	5,000
Work Plan Preparation	6,000	6,000	6,000	6,000
Pilot Testing	27,000	27,000	27,000	27,000
Regulatory Approval	3,000	6,000	3,000	3,000
Full-Scale Construction				
Design	7,500	7,500	7,500	7,500
Drilling/Sampling	15,000	20,000[2]	15,000	15,000
Installation/Start Up	4,000	26,000	10,500	13,000
Remediation Time Required[3]	9.4 years	2.8 years	6.9 years	3.4 years
Monitoring	30,550	9,800	24,150	11,050
Power	13,160	9,800	9,660	17,000
Final Soil Sampling	13,500	13,500	13,500	13,500
Cost per yd^3	$23.37	$25.65	$23.24	$24.03

1 Based on total operation time required at a 5,000 yd^3 site for site remediation, given an average contaminant level of 4,000 mg/kg.

2 Requires installation and development of one well.

3 Estimated based on average biodegradation rates in 4 test plots at Site 20.

SECTION VIII
SUMMARY AND CONCLUSIONS

Differences in soil temperatures have been significant among the four test plots. The active warming test plot consistently maintained higher temperatures than the other test plots during the winter months. The plastic sheeting greatly increased soil temperature in the passive warming test plot, with average soil temperatures as high as 18°C (64°F) during the summer months. Throughout the year, the passive warming test plot has been warmer than the control test plot.

Respiration rates in the passive warming test plot were observed to increase nearly 1 order of magnitude as the soil temperature increased during the summer months, indicating the success of the use of plastic sheeting to promote soil warming. In contrast, the control test plot remained 5 to 6°C (9 to 11°F) cooler than the passive warming test plot, yet had similar respiration rates. It is possible that, because the level of contamination was not uniform throughout the site, a higher level of contamination in the control test plot may have resulted in high respiration rates.

Respiration rates measured in the active warming test plot were higher than those measured in the passive warming or control test plot when the warm water circulation was operating. However, the high soil moisture content in the active warming test plot often made sampling difficult and limited the number of soil gas monitoring points that were monitored. In general, it was the deeper monitoring points where the most contamination existed that were the most difficult to sample. Typically, the higher respiration rates would be found at these points; therefore, average respiration rates reported for the active warming test plot that do not include these rates would appear to be lower than the actual rates. After the warm water circulation was discontinued and the soil temperature dropped, no significant microbial activity could be measured in the test plot until the soil temperature increased during the summer.

The surface warming test plot has shown promise as a form of soil warming. Soil temperatures in the surface warming test plot were higher than soil temperatures in either the passive warming or control test plot. Respiration rates in the surface warming test plot were much higher than those measured in the passive warming or control test plot and were similar to those measured in the active warming test plot during warm water circulation. These results indicate that the use of heat tape may prove to be a more efficient means of soil warming, because the problem of high soil moisture content is avoided.

Based on the results from the study period, the following can be concluded:

1. The bioventing process is stimulating biodegradation. Over the course of this project, the average respiration rates in the four test plots were 3.1 mg/kg/day in the active warming test plot, 1.3 mg/kg/day in the passive warming test plot, 0.86 mg/kg/day in the contaminated control test plot, and 2.9 mg/kg/day in the surface warming test plot. Since the initiation of bioventing, these rates correspond to an estimated 3,400 mg/kg hydrocarbon removal in the active warming test plot, 1,400 mg/kg in the passive warming test plot, 940 mg/kg

in the contaminated control test plot, and 2,100 mg/kg in the surface warming test plot[1].

Assuming an average biodegradation rate over the entire area of 2.5 mg/kg/day, and assuming a 1-acre site contaminated to a depth of 6 ft, these values would correspond to approximately 9,800 gallons of fuel biodegraded since startup of the bioventing system.

2. Spatial variability in contaminant distribution and biodegradation rates makes direct comparison between the test plots difficult; however, the results from the active, surface, and passive warming test plots clearly demonstrate that these forms of soil warming have increased biological activity in these areas. In the active and surface warming test plot, despite problems due to high soil moisture content, biodegradation rates consistently were higher than those measured in either the passive warming or control test plot, even though the control test plot appeared to be more heavily contaminated than the active warming test plot. In the passive warming test plot, biodegradation rates were seen to increase by 1 order of magnitude during the spring and summer months when plastic sheeting was installed to promote solar warming. Soil temperatures rose nearly 8°C (12°F) within 1 month, approximately 6 weeks before soil temperatures rose above freezing in the control test plot.

3. Surface emissions at the site appear to be minimal. Averaging the data from the seven different sampling events, an average emission of benzene is calculated at 0.00035 lb/day during air injection, assuming a 1-acre test site area. This emission rate is well below regulatory limits of 2 lbs benzene/day and illustrates that bioventing in air injection mode created no significant air emission problems.

4. Measurement of stable carbon isotope ratios may help substantiate biodegradation in the field. Carbon dioxide produced by hydrocarbon degradation may be distinguished from that produced by other processes based on the carbon isotopic compositions characteristic of the source material and/or the fractionation accompanying microbial metabolism. The $\delta^{13}C$ values of soil gas carbon dioxide from the uncontaminated location at the test site were within the range of typical values observed for plant respiratory carbon dioxide from local vegetation and decaying organic matter, whereas the $\delta^{13}C$ values of soil gas carbon dioxide from the contaminated areas are representative of values from hydrocarbon degradation. These results provide good evidence that there is microbial metabolism of hydrocarbons in the contaminated area at the bioventing site.

5. Permeability values for the 6-ft depths ranged from 0.56 darcy in the control test plot to 1.0 darcy in the active warming test plot. It does not appear that

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[1] The surface warming test plot was initiated in September 1992; therefore, the total mass removed is lower.

any of the soil warming techniques had a significant impact on soil permeability. The radius of influence observed for the four test plots at the 6-ft depth ranged from 40 ft for the passive warming test plot to 77 ft for the surface warming test plot. The average radius of influence at the 6-ft depth for the four tests was approximately 61 ft.

6. The air extraction permeability test was conducted on the control test plot to observe the effect of the bioventing blower system configuration on the site soil gas permeability and bioventing well radius of influence. The permeability (k) calculated for the extraction test was 0.27 darcy, approximately one-half the result for the air injection test. The radius of influence observed at the 6-ft monitoring depth also was reduced approximately one-third to 42 ft. Based on the comparison of data from the air extraction and air injection tests at the control test plot, it is apparent that, in the absence of the necessity for soil gas plume control, air injection will provide better air flow to the contaminated zone than will air extraction.

7. The soil vapor extraction test provided a means to quantify hydrocarbons biodegraded and volatilized at the bioventing site. The total amount of hydrocarbons biodegraded was 2.3 lb/day, whereas the total amount of hydrocarbons volatilized was 0.26 lb/day. Therefore, in extraction mode, approximately 1 order of magnitude more hydrocarbons are biodegraded than are volatilized from the site.

8. During the soil vapor extraction with reinjection test (see Section VI.E), the site was aerated nearly as rapidly as during the air extraction test. Soil gas concentrations measured at the vapor extraction wells were similar to those observed during the air extraction test. Localized soil gas concentrations at specific monitoring points appeared to become oxygenated more rapidly. These tests indicate that soil vapor extraction with reinjection of the off-gas may be a feasible alternative for configuration of the bioventing system when necessary. This configuration offers the advantage of eliminating point-source emissions as seen with the extraction test; however, soil vapor extraction could pose operational problems during the winter months when moisture extracted from the ground could cause freezing in the lines to occur.

9. Initial groundwater samples contained significant concentrations of total hydrocarbons. Benzene and toluene were the predominant contaminants found in the groundwater samples. The average initial TPH and BTEX concentrations were 16 mg/L and 9.4 mg/L, respectively. The average final TPH concentration was 2.2 mg/L. No benzene or ethylbenzene could be detected in the final groundwater samples, while only small concentrations (<0.1 mg/L) of toluene and xylenes were detected.

10. The soil TPH concentration was seen to decrease at nearly all depths, whereas the final BTEX concentrations were several orders of magnitude lower than concentrations in the initial soil samples. These

results indicate that significant contaminant removal has occurred since the initiation of bioventing, with high removals of the more volatile components, such as BTEX.

SECTION IX
REFERENCES

Aggarwal, P.K. and R.E. Hinchee. 1991. "Monitoring In Situ Biodegradation of Hydrocarbons by Using Stable Carbon Isotopes." *Environmental Science & Technology*, 25:1178-1180.

Amundson, R.G., O.A. Chadwick, J.M. Sowers, and H.E. Doner. 1988. *Quat. Res.* 28:245-54.

Anonymous. 1986. "In Situ Reclamation of Petroleum Contaminated Sub-Soil by Subsurface Venting and Enhanced Biodegradation." *Research Disclosure*, 26233:92-93.

Atlas, R.M. 1986. "Microbial Degradation of Petroleum Hydrocarbons: An Environmental Perspective." *Microbiol. Rev.* 45:180-209.

Bennedsen, M.B., J.P. Scott, and J.D. Hartley. 1987. "Use of Vapor Extraction Systems for In Situ Removal of Volatile Organic Compounds From Soil." *Proceedings of National Conference on Hazardous Wastes and Hazardous Materials*, Washington, DC, pp. 92-95.

Brock, T.D., D.W. Smith, and M.T. Madigan. 1984. Biology of Microorganisms, 4th Edition, Prentice-Hall, Inc., Englewood Cliffs, NJ.

Cerling, T.E. 1984. "The Stable Isotopic Composition of Modern Soil Carbonate and its Relationship to Climate." *Earth Planet. Sci. Lett.* 71:229-240.

Craig, H. 1957. *Geochim. Cosmochim. Acta* 12:133-149.

Conner, J.S. 1988. "Case Study of Soil Venting." *Pollution Engineering* 7:74-78.

Downey, D.C. and J.F. Hall. 1994. "Cost and Performance Summary," Report prepared by Parsons Engineering Science for the U.S. Air Force Center for Environmental Excellence, Brooks AFB, Texas.

Dupont, R.R. 1987. "Measurement of Volatile Hazardous Organic Emissions from Land Treatment Facilities." *JAPCA*, 37:168-176.

Dupont, R.R., W. Doucette, and R.E. Hinchee. 1991. "Assessment of In Situ Bioremediation Potential and the Application of Bioventing at a Fuel-Contaminated Site." In: R.E. Hinchee and R.F. Olfenbuttel (Eds.), *In Situ Bioreclamation*, Butterworth-Heinemann, Stoneham, Massachusetts, pp. 262-282.

Ely, D.L. and D.A. Heffner. 1988. "Process for In Situ Biodegradation of Hydrocarbon-Contaminated Soil." U.S. Patent Number 4,765,902.

Harding Lawson Associates (HLA). 1989. "Draft Remedial Investigation/Feasibility Study." Installation Restoration Program Remedial Investigation/Feasibility Study, Eielson AFB.

Hartman, C.W. and P.R. Johnson. 1984. *Environmental Atlas of Alaska*. University of Alaska, Fairbanks, Alaska.

Hinchee, R.E., D.C. Downey, J.K. Slaughter, and M. Westray. 1989. *Enhanced Biorestoration of Jet Fuels; A Full Scale Test at Eglin Air Force Base, Florida*. Air Force Engineering and Services Center Report ESL/TR/88-78.

Hinchee, R.E. and S.K. Ong. 1992. "A Rapid In Situ Respiration Test for Measuring Aerobic Biodegradation Rates of Hydrocarbons in Soil." *J. Air and Waste Management Association* 42:1305-1312.

Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, and R. Frandt. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing* (Rev. 2), Report prepared by Battelle Columbus Operations, U.S. Air Force Center for Environmental Excellence, and Engineering Sciences, Inc. for the U.S. Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas.

Huling, S.G., B.E. Bledsoe, and M.V. White. 1990. *Enhanced Biodegradation Utilizing Hydrogen Peroxide as a Supplemental Source of Oxygen: A Laboratory and Field Study*. EPA/600-290-006. U.S. Environmental Protection Agency.

Johnson, P.C., M.W. Kemblowski, and J.D. Colthart. 1990. "Quantitative Analysis for the Cleanup of Hydrocarbon-Contaminated Soils by In-Situ Soil Venting." *Ground Water* 28(3), May-June.

Lee, M.D., J.N. Thomas, R.C. Borden, P.B. Bedient, C.H. Ward, and J.T. Wilson. 1988. "Biorestoration of Aquifers Contaminated With Organic Compounds." *CRC Critical Reviews in Environmental Control*, 18(1):29-89.

McMahon, P.B., D.F. Williams, and J.T. Morris. 1990. *Ground Water* 28:693-702.

McVeety, B.D. 1991. *Current and Developing Analytical Technologies for Quantifying Biogenic Gas Emissions*. Report on Contract 600/3-91/044 from Pacific Northwest Laboratory to U.S. Environmental Protection Agency, Corvallis, Oregon, NTIS Report #PB91-216523, June.

Miller, R.N. 1990. "Field Scale Investigation of Enhanced Petroleum Hydrocarbon Biodegradation in the Vadose Zone Combining Soil Venting as an Oxygen Source with Moisture and Nutrient Additions." Ph.D. Dissertation. Utah State University, Logan, Utah.

Miller, R.N., C. Vogel, and R.E. Hinchee. 1991. "A Field-Scale Investigation of Petroleum Hydrocarbon Biodegradation in the Vadose Zone Enhanced by Soil Venting at Tyndall AFB, Florida." In: R.E. Hinchee and R. F. Olfenbuttel (Eds.), *In Situ and On-Site Bioreclamation*, Vol. 1. Butterworth-Heinemann, Stoneham, Massachusetts, pp. 283-302.

Ostendorf, D.W. and D.H. Kampbell. 1989. "Vertical Profiles and Near Surface Traps for Field Measurement of Volatile Pollution in the Subsurface Environment." *Proceedings of NWWA Conference on New Techniques for Quantifying the Physical and Chemical Properties of Heterogeneous Aquifers*, Dallas, Texas.

Parada, C.B., A. Long, and S.N. Davis. 1993. *Isot. Geosci.* 1:219-236.

Rightmire, C.T. and B.B. Hanshaw. 1971. *Water Resour. Res.* 9:958-966.

Staatsuitgeverij. 1986. Proceedings of a Workshop, 20-21 March, 1986. "Bodembeschermings-reeeks" No. 9; *Biotechnologische Bodemsanering*, pp. 31-33. Rapportnr. 851105002, ISBN 90-12-054133, Ordernr. 250-154-59; Staatsuitgeverij Den Haag: The Netherlands.

Stahl, W.J. 1980. *Geochim. Cosmochim. Acta* 44:1903-1907.

Suchomel, K.H., D.K. Kreamer, and A. Long. 1990. *Environ. Sci. Technol.* 24:1824-1831.

Texas Research Institute. 1980. *Laboratory Scale Gasoline Spill and Venting Experiment*. American Petroleum Institute, Interim Report No. 7743-5:JST.

Texas Research Institute. 1984. *Forced Venting to Remove Gasoline Vapor From a Large-Scale Model Aquifer*. American Petroleum Institute, Final Report No. 8210l-F:TAV.

van Eyk, J. and E. Vreeken. 1988. "Venting-Mediated Removal of Petrol from Subsurface Soil Strata as a Result of Stimulated Evaporation and Enhanced Biodegradation." *Med. Fac. Landbouww. Riiksuniv. Gent* 534b:1873-1884.

van Eyk, J. and C. Vreeken. 1989a. "Model of Petroleum Mineralization Response to Soil Aeration to Aid in Site-Specific, In Situ Biological Remediation." In: Jousma et al. (Eds.), *Groundwater Contamination: Use of Models in Decision-Making, Proceedings of an International Conference on Groundwater Contamination*, Kluwer, Boston/London, pp. 365-371.

van Eyk, J. and C. Vreeken. 1989b. "Venting-Mediated Removal of Diesel Oil from Subsurface Soil Strata as a Result of Stimulated Evaporation and Enhanced Biodegradation." In: *Hazardous Waste and Contaminated Sites, Envirotech Vienna, Vol. 2, Session 3*, ISBN 389432-009-5: Westarp Wiss, Essen, pp. 475-485.

Ward, C.H. 1988. "A Quantitative Demonstration of the Raymond Process for In Situ Biorestoration of Contaminated Aquifers." *Proceedings of NWWA/API Conference on Petroleum Hydrocarbons and Organic Chemicals in Groundwater*, pp. 723-746.

Wilson, J.T. and C.H. Ward. 1986. "Opportunities for Bioremediation of Aquifers Contaminated With Petroleum Hydrocarbons." *J. Ind. Microbiol.* 27:109-116.

APPENDIX A

SOIL AND GROUNDWATER SAMPLING RESULTS

Table A1. Total Hydrocarbon Concentration in 1991 Soil Samples from Active Warming Test Plot: Methylene Chloride Extraction

Location	Depth (ft)	TPH (mg/kg)	
		C-5 to C-15	C-6
S7	0.5-1.0	190	190
	1.5-2.0	32[1]	32[1]
	2.5-3.0	41	41
	3.5-4.0	53	54
	4.5-5.0	43[1]	43[1]
	5.5-6.0	38	38
	6.5-7.0	41	42
	7.5-8.0	21	21
	8.5-9.0	21	21
	9.5-10.0	<0.59	<0.60
S8	0.5-1.0	32	32
	1.5-2.0	22	22
	2.5-3.0	27	27
	3.5-4.0	<0.59	<0.60
	4.5-5.0	31	32
	5.5-6.0	82	83
	6.5-7.0	<0.59	<0.60
	7.5-8.0	240	240
	8.5-9.0	11	11
	9.5-10.0	<0.59	<0.60
S9	0.5-1.0	<0.59	<0.60
	1.5-2.0	<0.59	<0.60
	2.5-3.0	390	390
	3.5-4.0	<0.59	<0.60
	4.5-5.0	<0.59	<0.60
	5.5-6.0	<0.59	<0.60
	6.5-7.0	31	32
	7.5-8.0	44[1]	44[1]
	8.5-9.0	33	33
	9.5-10.0	450	460

[1] - Average of two samples.

Table A2. Total Hydrocarbon Concentration in 1991 Soil Samples From Passive Plot: Methylene Chloride Extraction

Location	Depth (ft)	TPH (mg/kg)	
		C-5 to C-15	C-6
S18	0.5-1.0	<0.59	<0.60
	1.5-2.0	<0.59	<0.60
	2.5-3.0	<0.59	<0.60
	3.5-4.0	<0.59	<0.60
	4.5-5.0	<0.59	<0.60
	5.5-6.0	<0.59	<0.60
	6.5-7.0	<0.59	<0.60
	7.5-8.0	470[1]	470[1]
S19	0.5-1.0	<0.59	<0.60
	1.5-2.0	<0.59	<0.60
	2.5-3.0	<0.59	<0.60
	3.5-4.0	<0.59	<0.60
	4.5-5.0	<0.59	<0.60
	5.5-6.0	<0.59	<0.60
	6.5-7.0	5.2	5.3
	7.5-8.0	7.1[1]	7.2[1]
S20	0.5-1.0	<0.59	<0.60
	1.5-2.0	<0.59	<0.60
	2.5-3.0	<0.59	<0.60
	3.5-4.0	130	130
	4.5-5.0	<0.59	<0.60
	5.5-6.0	<0.59	<0.60
	6.5-7.0	<0.59	<0.60
	7.5-8.0	9.7[1]	9.8[1]

[1] - Average of two samples.

Table A3. Total Hydrocarbon Concentration in 1991 Soil Samples From Control Test Plot: Methylene Chloride Extraction

Location	Depth (ft)	TPH (mg/kg)	
		C-5 to C-15	C-6
S27	0.5-1.0	<0.59	<0.60
	1.5-2.0	<0.59	<0.60
	2.5-3.0	<0.59	<0.60
	3.5-4.0	<0.59	<0.60
	4.5-5.0	24	24
	5.5-6.0	<0.59	<0.60
	6.5-7.0	<0.59	<0.60
	7.5-8.0	<0.59	<0.60
	8.5-9.0	<0.59	<0.60
	9.5-10. <0.59	<0.59	<0.60
S29	0.5-1.0	<0.59	<0.60
	1.5-2.0	1.0	1.0
	2.5-3.0	<0.59	<0.60
	3.5-4.0	<0.59	<0.60
	4.5-5.0	<0.59	<0.60
	5.5-6.0	<0.59	<0.60
	6.5-7.0	<0.59	<0.60
	7.5-8.0	<0.59	<0.60
	8.5-9.0	<0.59	<0.60
	9.5-10. <0.59	<0.60	<0.60

Table A4. Total Hydrocarbon Concentration in 1991 Soil Samples From Active Warming Test Plot: Methanol Extraction

Location	Depth (ft)	TPH (mg/kg)	
		C-5 to C-15	C-6
S7	7.5-8.0	59.0[1]	59.5[1]
	8.5-9.0	<0.04	<0.04
	9.5-10.0	238	240
S8	7.5-8.0	77.1	77.8
	8.5-9.0	<0.04	<0.04
	9.5-10.0	<0.04	<0.04
S9	7.5-8.0	260	262
	8.5-9.0	656	662
	9.5-10.0	10.1	10.2

[1] - Average of three samples.

Table A5. Total Hydrocarbon Concentration in 1991 Soil Samples From Passive Warming Test Plot: Methanol Extraction

Location	Depth (ft)	TPH (mg/kg)	
		C-5 to C-15	C-6
S18	4.5-5.0	<0.04	<0.04
	5.5-6.0	<0.04	<0.04
	6.5-7.0	<0.04	<0.04
	7.5-8.0	25.3	25.5
S19	4.5-5.0	21.4	21.5
	5.5-6.0	<0.04	<0.04
	6.5-7.0	325	328
	7.5-8.0	210	211
S20	4.5-5.0	<0.04	<0.04
	5.5-6.0	1.8	1.9
	6.5-7.0	52.5	53.0
	7.5-8.0	125	126

[1] - Average of two samples.

Table A6. Total Hydrocarbon Concentration in 1991 Soil Samples From Control Test Plot: Methanol Extraction

Location	Depth (ft)	TPH (mg/kg)	
		C-5 to C-15	C-6
S27	6.5-7.0	16.0	16.2
	7.5-8.0	25.8	26.1
	8.5-9.0	<0.04	<0.04
S29	6.5-7.0	<0.04	<0.04
	7.5-8.0	86.9	87.7
	8.5-9.0	16.2	16.4

Table A7. Distribution of Contaminants in 1991 Soil Samples by Depth From Active Warming Test Plot: Methanol Extraction

Compound	Concentration (mg/kg) by Depth ft					
	7.5-8.0			8.5-9.0		9.5-10.0
	S7	S8	S9	S7	S9	S9
1-Methylnaphthalene	0.33	2.98	0.95	0.42	7.6	<0.004
Ethylbenzene	<0.004	<0.004	0.49	1.29	8.6	<0.004
Naphthalene	0.74	0.18	2.0	0.88	4.3	<0.004
n-Butylbenzene	0.49	0.21	1.4	6.47	7.9	0.15
n-Decane	1.68	0.58	9.0	22.5	12.5	0.39
n-Dodecane	8.7	5.19	<0.003	2.04	19.0	<0.003
n-Heptane	1.38	<0.005	16.9	17.7	31.7	1.3
n-Hexane	0.25	<0.005	<0.005	0.59	4.6	<0.005
n-Octane	3.75	<0.004	37.4	0.47	59.8	1.7
n-Pentadecane	0.47	0.52	0.87	7.32	0.47	<0.003
n-Propylbenzene	0.23	<0.003	1.7	2.4	5.1	<0.003
n-Tetradecane	1.47	4.31	0.05	3.8	2.0	<0.001
n-Tridecane	6.95	9.78	5.5	<0.004	12.9	<0.004
p-Xylene	0.55	<0.003	4.8	<0.003	8.8	<0.003
Toluene	1.04	<0.003	18.3	<0.003	1.4	0.79

Table A8. Distribution of Contaminants in 1991 Soil Samples by Depth From Passive Warming Test Plot: Methanol Extraction

Compound	Concentration by Depth (mg/kg)			
	5.5-6.0 ft	6.5-7.0 ft	7.5-8.0 ft	
	S19	S19	S18	S19
1-Methylnaphthalene	<0.004	0.67	0.80	0.63
Ethylbenzene	<0.004	3.20	1.51	2.80
Naphthalene	<0.004	1.30	0.39	6.10
n-Butylbenzene	0.75	2.50	1.10	3.70
n-Decane	0.83	11.6	7.50	5.50
n-Dodecane	5.60	9.40	5.60	18.5
n-Heptane	<0.005	10.8	1.50	12.1
n-Hexane	<0.005	<0.005	2.50	<0.005
n-Octane	<0.004	49.5	39.1	24.5
n-Pentadecane	<0.003	<0.003	0.27	1.10
n-Propylbenzene	<0.003	2.40	2.20	0.88
n-Tetradecane	1.40	0.57	0.10	0.27
n-Tridecane	4 20	1.80	3.00	5.90
p-Xylene	<0.003	9.20	5.70	3.20
Toluene	<0.003	22.0	14.6	12.1

Table A9. Distribution of Contaminants in 1991 Soil Samples by Depth From Control Test Plot: Methanol Extraction

Compound	Concentration by Depth (mg/kg)				
	6.5-7.0 ft	7.5-8.0 ft			8.5-9.0 ft
	S28	S27	S28	S29	S29
1-Methylnaphthalene	0.16	<0.004	0.26	0.70	<0.004
Ethylbenzene	<0.004	<0.004	<0.004	1.40	<0.004
Naphthalene	<0.004	<0.004	0.41	0.97	0.56
n-Butylbenzene	18.7	<0.003	0.38	1.20	0.52
n-Decane	0.58	0.15	1.20	3.70	0.99
n-Dodecane	1.40	<0.003	2.30	9.00	2.80
n-Heptane	<0.005	<0.005	0.16	2.20	0.44
n-Octane	0.48	<0.004	1.60	7.70	1.80
n-Pentadecane	2.40	<0.003	2.50	0.42	<0.003
n-Propylbenzene	<0.003	<0.003	0.13	0.51	0.08
n-Tetradecane	0.92	<0.001	1.10	0.57	0.37
n-Tridecane	2.00	<0.004	3.20	3.70	1.60
p-Xylene	<0.003	<0.003	0.23	1.40	0.26
Toluene	<0.003	<0.003	0.43	3.30	0.73

Table A10. Eielson AFB Soil Analyses Results (Samples Collected 7/26 to 7/29/91)

Plot (Sample #)	Depth (ft)	TKN (mg/kg)	TP (mg/kg)	pH	Alkalinity (mg/kg $CaCO_3$)	TOC (wt%)
Active (#8)	1.5 - 2.0	400	350	7.1	(a)	(a)
	5.5 - 6.0	250	610	7.0	128	(a)
	7.5 - 8.0	100	550	7.1	(a)	(a)
Passive (#28)	1.5 - 2.0	450	600	7.2	191	(a)
	5.5 - 6.0	100	590	7.5	102	(a)
	7.5 - 8.0	100	460	7.6	(a)	(a)
Control (#18)	1.5 - 2.0	400	560	7.1	154	(a)
	5.5 - 6.0	300	750	7.2	231	(a)
	7.5 - 8.0	100	490	7.1	(a)	(a)
Background (#42)	1.5 - 2.0	100	490	7.5	(a)	0.15
	5.5 - 6.0	100	280	7.6	(a)	0.21
	7.5 - 8.0	150	260	7.6	(a)	0.21

TKN - Total Kjeldahl Nitrogen
TP - Total Phosphorus
TOC - Total Organic Carbon
(a) - Some samples were not analyzed for alkalinity and TOC due to low sample volume.

Table A11. Total Hydrocarbon Concentration in 1992 Soil Samples From Active Warming TestPlot: Methylene Chloride Extraction

Location	Depth	TPH (mg/kg)	
		C-5 to C-15	C-6
Active Plot - Vent Well	5.0 - 5.5	<0.16	<0.19
	5.5 - 6.0	<0.16	<0.19
	6.0 - 6.5	<0.16	<0.19
	7.0 - 7.5	<0.16	<0.19
	7.5 - 8.0	<0.16	<0.19
	8.0 - 8.5	<0.16	<0.19
Active Plot - Monitoring Point 1	5.0 - 5.5	<0.16	<0.19
	5.5 - 6.0	<0.16	<0.19
	7.0 - 7.5	<0.16	<0.19
	7.5 - 8.0	<0.16	<0.19
	8.0 - 8.5	<0.16	<0.19
Active Plot - Monitoring Point 2	5.0 - 5.5	<0.16	<0.19
	5.0 - 5.5	<0.16	<0.19
	5.5 - 6.0	<0.16	<0.19
	6.0 - 6.5	<0.16	<0.19
	7.0 - 7.5	17	21
	7.5 - 8.0	<0.16	<0.19
	8.0 - 8.5	<0.16	<0.19

Table A12. Total Hydrocarbon Concentration in 1992 Soil Samples From Passive Warming Test Plot: Methylene Chloride Extraction

Location	Depth	TPH (mg/kg)	
		C-5 to C-15	C-6
Passive Plot - Vent Well	5.0 - 5.5	<0.16	<0.19
	5.5 - 6.0	<0.16	<0.19
	5.5 - 6.0	<0.16	<0.19
	6.0 - 6.5	<0.16	<0.19
	7.0 - 7.5	220	260
	7.5 - 8.0	44	48
	8.0 - 8.5	320	360
Passive Plot - Monitoring Point 1	5.0 - 5.5	<0.16	<0.19
	5.5 - 6.0	<0.16	<0.19
	6.0 - 6.5	<0.16	<0.19
Passive Plot - Monitoring Point 2	5.0 - 5.5	<0.16	<0.19
	5.5 - 6.0	<0.16	<0.19
	6.0 - 6.5	<0.16	<0.19
	6.0 - 6.5	<0.16	<0.19
	7.0 - 7.5	<0.16	<0.19
	7.5 - 8.0	250	280

Table A13. Total Hydrocarbon Concentration in 1992 Soil Samples From the Surface Warming Test Plot: Methylene Chloride Extraction

Location	Depth	TPH (mg/kg)	
		C-5 to C-15	C-6
Surface Warming Plot - Vent Well	5.0 - 5.5	32	45
	5.5 - 6.0	<0.16	<0.19
	6.0 - 6.5	<0.16	<0.19
	7.0 - 7.5	61	67
	7.5 - 8.0	16	18
	8.0 - 8.5	<0.16	<0.19
Surface Warming Plot - Monitoring Point 3	5.0 - 5.5	<0.16	<0.19
	5.0 - 5.5	<0.16	<0.19
	5.5 - 6.0	<0.16	<0.19
	6.0 - 6.5	<0.16	<0.19
	7.0 - 7.5	<0.16	<0.19
	7.5 - 8.0	<0.16	<0.19
Surface Warming Plot - Monitoring Point 4	5.0 - 5.5	<0.16	<0.19
	5.5 - 6.0	<0.16	<0.19
	6.0 - 6.5	<0.16	<0.19
	7.0 - 7.5	<0.16	<0.19

Table A14. Total Hydrocarbon Concentration in 1992 Soil Samples From Control Test Plot: Methylene Chloride Extraction

Location	Depth	TPH (mg/kg)	
		C-5 to C-15	C-6
Control Plot - Vent Well	5.0 - 5.5	150	180
	5.0 - 5.5	85	100
	5.5 - 6.0	1,500	1,900
	7.0 - 7.5	74	85
Control Plot - Monitoring Point 1	5.0 - 5.5	900	1,000
	5.5 - 6.0	260	310
	5.5 - 6.0	490	580
	6.0 - 6.5	150	170
	7.0 - 7.5	280	330
	7.5 - 8.0	27	30
Control Plot - Monitoring Point 2	5.0 - 5.5	440	600
	5.5 - 6.0	1,700	2,200
	5.5 - 6.0	2,700	3,500
	7.0 - 7.5	72	81
	7.5 - 8.0	100	110

Table A15. Total Hydrocarbon Concentration in 1992 Soil Samples From Background Area: Methylene Chloride Extraction

Location	Depth	TPH (mg/kg)	
		C-5 to C-15	C-6
Background Area	5.0 - 5.5	<0.16	<0.19
	5.5 - 6.0	<0.16	<0.19
	7.0 - 7.5	<0.16	<0.19
	7.5 - 8.0	<0.16	<0.19
	7.5 - 8.0	<0.16	<0.19

Table A16. Total Hydrocarbon Concentration in 1992 Soil Samples From the Active Warming Test Plot: Methanol Extraction

Location	Depth	TPH (mg/kg)	
		C-5 to C-15	C-6
Active Plot - Vent Well	5.0 - 5.5	17	22
	5.5 - 6.0	43	56
	6.0 - 6.5	18	21
	7.0 - 7.5	15	17
	7.5 - 8.0	26	29
	8.0 - 8.5	15	16
Active Plot - Monitoring Point 1	5.0 - 5.5	20	25
	5.5 - 6.0	370	410
	7.0 - 7.5	100	120
	7.5 - 8.0	27	29
	8.0 - 8.5	10	11
Active Plot - Monitoring Point 2	5.0 - 5.5	160	220
	5.5 - 6.0	36	480
	6.0 - 6.5	180	200
	6.0 - 6.5	270	290
	7.0 - 7.5	190	220
	7.5 - 8.0	100	110
	8.0 - 8.5	52	56

Table A17. Total Hydrocarbon Concentration in 1992 Soil Samples From the Passive Warming Test Plot: Methanol Extraction

Location	Depth	TPH (mg/kg)	
		C-5 to C-15	C-6
Passive Plot - Vent Well	5.0 - 5.5	0.20	0.21
	5.5 - 6.0	8.8	9.2
	5.5 - 6.0	3.3	3.4
	6.0 - 6.5	5.6	5.9
	7.0 - 7.5	650	730
	7.5 - 8.0	270	280
	8.0 - 8.5	3,100	3,300
Passive Plot - Monitoring Point 1	5.0 - 5.5	220	240
	5.5 - 6.0	67	71
	6.0 - 6.5	41	44
Passive Plot - Monitoring Point 2	5.0 - 5.5	23	32
	5.5 - 6.0	12	13
	6.0 - 6.5	190	200
	6.0 - 6.5	110	120
	7.0 - 7.5	350	380
	7.5 - 8.0	330	360

Table A18. Total Hydrocarbon Concentration in 1992 Soil Samples From Surface Warming Test Plot: Methanol Extraction

Location	Depth	TPH (mg/kg)	
		C-5 to C-15	C-6
Surface Warming Plot - Vent Well	5.0 - 5.5	8.5	11
	5.5 - 6.0	8.4	11
	6.0 - 6.5	9.5	11
	7.0 - 7.5	210	220
	7.5 - 8.0	32	34
	8.0 - 8.5	1.1	1.2
Surface Warming Plot - Monitoring Point 3	5.0 - 5.5	17	23
	5.5 - 6.0	20	22
	6.0 - 6.5	55	60
	7.0 - 7.5	4.9	5.8
	7.5 - 8.0	6.9	7.5
Surface Warming Plot - Monitoring Point 4	5.0 - 5.5	4.5	6.2
	5.5 - 6.0	17	19
	6.0 - 6.5	0.68	0.73
	7.0 - 7.5	0.49	0.56

Table A19. Total Hydrocarbon Concentration in 1992 Soil Samples From the Control Test Plot: Methanol Extraction

Location	Depth	TPH (mg/kg)	
		C-5 to C-15	C-6
Control Plot - Vent Well	5.0 - 5.5	1,200	1,400
	5.5 - 6.0	3,400	4,000
	7.0 - 7.5	200	220
	7.5 - 8.0	68	74
Control Plot - Monitoring Point 1	5.0 - 5.5	2,600	2,800
	5.5 - 6.0	1,400	1,600
	6.0 - 6.5	190	200
	7.0 - 7.5	720	810
	7.5 - 8.0	25	27
Control Plot - Monitoring Point 2	5.0 - 5.5	740	960
	5.5 - 6.0	4,200	5,100
	5.5 - 6.0	3,800	4,700
	6.0 - 6.5	470	510
	7.0 - 7.5	570	620
	7.5 - 8.0	80	85

Table A20. Total Hydrocarbon Concentration in 1992 Soil Samples From Background Area: Methanol Extraction

Location	Depth	TPH (mg/kg)	
		C-5 to C-15	C-6
Background Area	5.0 - 5.5	49	51
	5.5 - 6.0	24	26
	7.0 - 7.5	3.6	4.0
	7.5 - 8.0	22	22

Table A21. Distribution of Contaminants in 1992 Soil Samples by Depth From Active Warming Test Plot, Vent Well Borehole: Methanol Extraction

Compound	Concentration (mg/kg) by Depth (ft)					
	5.0 - 5.5	5.5 - 6.0	6.0 - 6.5	7.0 - 7.5	7.5 - 8.0	8.0 - 8.5
Benzene	0.39	1.7	0.41	0.64	0.10	0.24
n-Butylbenzene	<0.003	0.44	0.080	<0.003	<0.003	<0.003
n-Decane	<0.003	0.40	0.36	<0.003	0.12	0.060
2,4-Dimethylpentane	<0.007	1.2	0.86	1.2	0.47	0.34
n-Dodecane	<0.003	0.78	<0.003	<0.003	<0.003	<0.003
Ethylbenzene	<0.004	2.5	0.46	<0.004	0.59	0.30
n-Heptane	1.0	1.7	0.56	0.82	0.51	0.32
n-Hexane	2.9	1.3	0.33	<0.005	0.36	0.26
2-Methylbutane	5.0	11	1.8	<0.007	9.6	1.9
1-Methylnaphthalene	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
2-Methylpentane	<0.007	5.8	3.4	6.4	3.5	2.9
Naphthalene	<0.004	<0.004	0.29	0.38	0.35	0.18
Nonane	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
n-Octane	<0.004	0.76	<0.004	<0.004	0.36	0.22
n-Pentadecane	<0.003	0.51	0.11	<0.003	<0.003	<0.003
n-Pentane	3.6	13	1.1	7.0	14	8.8
n-Propylbenzene	<0.003	0.57	0.19	<0.003	0.14	0.090
n-Tetradecane	<0.001	0.23	0.55	0.30	0.13	0.060
Toluene	<0.003	2.9	0.35	0.40	0.30	0.19
n-Tridecane	<0.004	<0.004	0.36	<0.004	<0.004	<0.004
n-Undecane	<0.004	0.40	0.13	0.10	<0.004	<0.004
p-Xylene	<0.003	3.5	<0.003	<0.003	<0.003	<0.003

Table A22. Distribution of Contaminants in 1992 Soil Samples by Depth From Active Warming Test Plot, Monitoring Point 7 Borehole: Methanol Extraction

Compound	Concentration (mg/kg) by Depth (ft)					
	5.5 - 6.0	6.0 - 6.5	6.0 - 6.5	7.0 - 7.5	7.5 - 8.0	8.0 - 8.5
Benzene	<0.0052	1.3	1.6	3.1	0.42	0.65
n-Butylbenzene	<0.003	1.4	2.0	0.15	<0.003	<0.003
n-Decane	0.090	0.33	4.8	1.7	0.39	0.50
2,4-Dimethylpentane	0.21	2.8	4.4	6.9	1.0	1.0
n-Dodecane	<0.003	1.3	1.9	0.68	<0.003	<0.003
Ethylbenzene	<0.004	1.5	1.9	2.8	0.57	1.1
n-Heptane	0.13	0.22	0.17	0.090	2.4	0.63
n-Hexane	0.12	5.0	7.1	8.1	1.5	0.62
2-Methylbutane	5.2	3.5	4.9	7.9	10	4.4
1-Methylnaphthalene	<0.004	0.30	0.44	0.30	<0.004	<0.004
2-Methylpentane	1.5	1.7	2.1	4.2	4.1	4.4
Naphthalene	0.30	6.6	6.5	4.2	1.0	0.59
Nonane	<0.004	0.38	0.57	0.18	0.60	0.83
n-Octane	<0.004	0.12	25	15	2.5	<0.004
n-Pentadecane	<0.003	0.84	<0.003	1.0	0.31	<0.003
n-Pentane	14	37	70	39	41	1.3
n-Propylbenzene	0.070	0.87	1.3	0.44	<0.003	<0.003
n-Tetradecane	<0.001	0.86	2.6	0.40	0.53	0.65
Toluene	0.26	8.8	0.32	0.34	0.73	2.8
n-Tridecane	<0.004	2.0	3.0	2.6	0.40	0.45
n-Undecane	<0.004	1.1	5.6	1.8	0.36	0.51
p-Xylene	<0.003	1.6	2.3	0.73	<0.003	0.20

Table A23. Distribution of Contaminants in 1992 Soil Samples by Depth From Active Warming Test Plot, Monitoring Point 8 Borehole: Methanol Extraction

Compound	Concentration (mg/kg) by Depth (ft)				
	5.0 - 5.5	5.5 - 6.0	7.0 - 7.5	7.5 - 8.0	8.0 - 8.5
Benzene	0.81	0.80	0.29	0.28	0.080
n-Butylbenzene	<0.003	1.2	0.16	0.48	<0.003
n-Decane	<0.003	4.1	0.99	0.10	0.040
2,4-Dimethylpentane	1.8	9.0	4.0	0.38	0.43
n-Dodecane	<0.003	2.7	1.2	0.83	<0.003
Ethylbenzene	<0.004	3.2	0.33	0.35	<0.004
n-Heptane	1.1	30	9.4	0.36	0.28
n-Hexane	0.96	16	6.2	0.27	0.22
2-Methylbutane	5.2	27	3.0	5.0	<0.007
1-Methylnaphthalene	<0.004	1.4	<0.004	<0.004	<0.004
2-Methylpentane	6.4	12	2.9	2.0	0.48
Naphthalene	<0.004	1.2	<0.004	2.8	0.11
Nonane	<0.004	0.13	1.6	<0.004	<0.004
n-Octane	<0.004	36	11	0.41	0.28
n-Pentadecane	<0.003	2.7	0.98	1.4	0.070
n-Pentane	1.7	44	1.5	8.3	<0.008
n-Propylbenzene	<0.003	1.5	0.16	<0.003	<0.003
n-Tetradecane	<0.001	3.4	1.1	1.4	0.060
Toluene	0.56	2.1	1.0	0.56	0.23
n-Tridecane	<0.004	7.1	1.3	1.1	<0.004
n-Undecane	<0.004	1.5	1.1	0.44	<0.004
p-Xylene	<0.003	2.3	0.72	<0.003	<0.003

Table A24. Distribution of Contaminants in 1992 Soil Samples by Depth From Passive Warming Test Plot, Vent Well Borehole: Methanol Extraction

Compound	Concentration (mg/kg) by Depth (ft)						
	5.0-5.5	5.5-6.0	5.5-6.0	6.0-6.5	7.0-7.5	7.5-8.0	8.0-8.5
Benzene	<0.005	<0.005	<0.005	<0.005	15	1.6	2.7
n-Butylbenzene	<0.003	<0.003	<0.003	<0.003	3.1	1.4	10
n-Decane	0.19	0.64	0.36	<0.003	3.3	3.7	25
2,4-Dimethylpentane	<0.007	<0.007	<0.007	<0.007	<0.007	4.2	37
n-Dodecane	<0.003	<0.003	<0.003	<0.003	3.3	0.040	57
Ethylbenzene	<0.004	0.81	0.68	<0.004	34	2.2	62
n-Heptane	<0.005	<0.005	<0.005	<0.005	40	26	260
n-Hexane	<0.005	<0.005	<0.005	<0.005	<0.005	8.9	79
2-Methylbutane	<0.007	<0.007	<0.007	<0.007	<0.007	4.2	8.1
1-Methylnaphthalene	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	23
2-Methylpentane	<0.007	<0.007	<0.007	<0.007	2.9	2.1	17
Naphthalene	<0.004	<0.004	<0.004	<0.004	5.6	<0.004	57
Nonane	<0.004	<0.004	<0.004	<0.004	1.1	0.51	50
n-Octane	<0.004	<0.004	<0.004	<0.004	0.69	0.24	300
n-Pentadecane	<0.003	0.24	<0.003	0.29	2.1	2.9	15
n-Pentane	<0.008	3.3	0.92	2.5	0.18	3.1	7.8
n-Propylbenzene	<0.003	<0.003	<0.003	<0.003	2.6	<0.003	10
n-Tetradecane	<0.001	<0.001	<0.001	<0.001	2.0	3.2	20
Toluene	<0.003	1.1	1.0	<0.003	40	20	130
n-Tridecane	<0.004	<0.004	<0.004	<0.004	1.5	2.3	33
n-Undecane	<0.004	0.39	0.28	<0.004	1.5	5.8	40
p-Xylene	<0.003	<0.003	<0.003	<0.003	7.2	2.3	25

Table A25. Distribution of Contaminants in 1992 Soil by Depth From Passive Warming Test Plot, Monitoring Point 7 Borehole: Methanol Extraction

Compound	Concentration (mg/kg) by Depth (ft)		
	5.0 - 5.5	5.5 - 6.0	6.0 - 6.5
Benzene	0.35	0.60	<0.005
n-Butylbenzene	0.12	<0.003	0.42
n-Decane	1.6	0.64	<0.003
2,4-Dimethylpentane	3.0	0.45	3.0
n-Dodecane	2.2	0.48	<0.003
Ethylbenzene	4.5	0.34	<0.004
n-Heptane	21	0.77	<0.005
n-Hexane	6.7	1.2	<0.005
2-Methylbutane	6.4	13	10
1-Methylnaphthalene	<0.004	0.11	<0.004
2-Methylpentane	1.3	0.32	1.4
Naphthalene	0.010	0.15	<0.004
Nonane	3.0	0.29	0.50
n-Octane	26	0.97	<0.004
n-Pentadecane	3.2	4.6	<0.003
n-Pentane	5.4	14	22
n-Propylbenzene	0.27	<0.003	<0.003
n-Tetradecane	3.1	3.5	<0.001
Toluene	11	0.75	<0.003
n-Tridecane	1.7	1.7	<0.004
n-Undecane	1.9	0.37	<0.004
p-Xylene	1.9	0.54	<0.003

Table A26. Distribution of Contaminants in 1992 Soil Samples by Depth From Passive Warming Test Plot, Monitoring Point 8 Borehole: Methanol Extraction

Compound	Concentration (mg/kg) by Depth (ft)					
	5.0-5.5	5.5-6.0	6.0 - 6.5	6.0 - 6.5	7.0 - 7.5	7.5 - 8.0
Benzene	1.2	<0.005	<0.005	<0.005	0.69	0.31
n-Butylbenzene	<0.003	<0.003	1.8	1.7	0.91	0.53
n-Decane	0.63	0.28	4.0	3.5	5.1	8.6
2,4-Dimethylpentane	<0.007	<0.007	<0.007	<0.007	3.2	<0.007
n-Dodecane	<0.003	<0.003	20	14	9.9	10
Ethylbenzene	0.66	0.27	0.93	0.78	4.4	13
n-Heptane	1.2	0.53	2.0	2.0	26	30
n-Hexane	<0.005	<0.005	0.70	0.66	7.6	5.0
2-Methylbutane	9.5	<0.007	7.2	<0.007	5.4	6.9
1-Methylnaphthalene	<0.004	<0.004	7.2	<0.004	1.3	4.1
2-Methylpentane	<0.007	<0.007	<0.007	<0.007	1.7	1.1
Naphthalene	<0.004	<0.004	8.9	<0.004	1.7	<0.004
Nonane	<0.004	<0.004	3.1	3.5	8.6	16
n-Octane	<0.004	0.32	10	10	40	68
n-Pentadecane	<0.003	<0.003	5.4	1.9	1.4	0.41
n-Pentane	<0.008	1.1	2.9	1.8	<0.008	<0.008
n-Propylbenzene	<0.003	<0.003	0.67	0.64	4.1	2.3
n-Tetradecane	<0.001	<0.001	7.3	3.6	0.60	0.31
Toluene	1.4	0.58	0.71	0.28	5.1	3.0
n-Tridecane	<0.004	<0.004	11	4.7	2.2	1.2
n-Undecane	0.35	0.18	10	8.8	6.8	0.66
p-Xylene	0.93	0.33	1.7	1.7	5.3	28

Table A27. Distribution of Contaminants in 1992 Soil Samples by Depth From Surface Warming Test Plot, Vent Well Borehole: Methanol Extraction

Compound	Concentration (mg/kg) by Depth (ft)					
	5.0 - 5.5	5.5 - 6.0	6.0 - 6.5	7.0 - 7.5	7.5 - 8.0	8.5 - 9.0
Benzene	0.29	1.1	<0.005	3.4	<0.005	<0.005
n-Butylbenzene	<0.003	0.90	<0.003	0.56	0.23	<0.003
n-Decane	0.65	0.38	0.65	2.5	0.85	0.31
2,4-Dimethylpentane	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
n-Dodecane	0.47	<0.003	0.32	3.4	0.56	<0.003
Ethylbenzene	<0.004	1.5	<0.004	1.7	0.49	<0.004
n-Heptane	0.62	0.13	0.58	<0.005	0.11	<0.005
n-Hexane	<0.005	<0.005	<0.005	3.4	0.44	<0.005
2-Methylbutane	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
1-Methylnaphthalene	<0.004	<0.004	<0.004	1.6	<0.004	<0.004
2-Methylpentane	<0.007	<0.007	<0.007	0.27	<0.007	<0.007
Naphthalene	<0.004	<0.004	<0.004	2.6	<0.004	<0.004
Nonane	<0.004	<0.004	0.43	0.55	0.17	<0.004
n-Octane	1.3	0.53	1.2	0.27	3.0	<0.004
n-Pentadecane	<0.003	0.90	1.2	1.5	1.6	0.34
n-Pentane	1.8	<0.008	<0.008	<0.008	<0.008	<0.008
n-Propylbenzene	<0.003	0.23	<0.003	0.64	<0.003	<0.003
n-Tetradecane	0.56	0.37	1.5	3.2	1.9	0.30
Toluene	0.45	1.7	1.0	13	1.9	<0.003
n-Tridecane	0.50	<0.004	1.3	5.2	2.8	<0.004
n-Undecane	0.68	<0.004	<0.004	5.6	1.3	0.28
p-Xylene	<0.003	0.35	0.83	1.9	<0.003	<0.003

Table A28. Distribution of Contaminants in 1992 Soil Samples by Depth From Surface Warming Test Plot, Monitoring Point 3 Borehole: Methanol Extraction

Compound	Concentration (mg/kg) by Depth (ft)				
	5.0 - 5.5	5.5 - 6.0	6.0 - 6.5	7.0 - 7.5	7.5 - 8.0
Benzene	<0.005	<0.005	0.58	<0.005	<0.005
n-Butylbenzene	<0.003	<0.003	0.22	<0.003	<0.003
n-Decane	0.65	0.60	1.3	0.39	0.47
2,4-Dimethylpentane	<0.007	<0.007	<0.007	<0.007	<0.007
n-Dodecane	0.53	<0.003	1.7	0.28	<0.003
Ethylbenzene	<0.004	<0.004	0.20	<0.004	1.0
n-Heptane	0.27	<0.005	2.3	0.31	<0.005
n-Hexane	<0.005	<0.005	0.40	<0.005	<0.005
2-Methylbutane	38	9.8	<0.007	<0.007	<0.007
1-Methylnaphthalene	<0.004	<0.004	0.49	<0.004	<0.004
2-Methylpentane	<0.007	<0.007	<0.007	<0.007	<0.007
Naphthalene	<0.004	<0.004	6.9	<0.004	<0.004
Nonane	<0.004	<0.004	1.4	<0.004	<0.004
n-Octane	<0.004	<0.004	4.8	0.33	<0.004
n-Pentadecane	<0.003	<0.003	2.0	0.49	<0.003
n-Pentane	<0.008	<0.008	0.63	1.4	1.7
n-Propylbenzene	<0.003	<0.003	0.21	<0.003	0.12
n-Tetradecane	0.96	<0.001	3.3	0.59	<0.001
Toluene	<0.003	<0.003	2.4	<0.003	0.67
n-Tridecane	1.5	<0.004	5.9	0.46	<0.004
n-Undecane	1.4	0.35	0.57	0.37	0.34
p-Xylene	<0.003	<0.003	0.21	<0.003	<0.003

Table A29. Distribution of Contaminants in 1992 Soil by Depth From Surface Warming Test Plot, Monitoring Point 4 Borehole: Methanol Extraction

Compound	Concentration (mg/kg) by Depth (ft)			
	5.0 - 5.5	5.5 - 6.0	6.0 - 6.5	7.0 - 7.5
Benzene	<0.005	1.7	<0.005	<0.005
n-Butylbenzene	<0.003	0.31	<0.003	<0.003
n-Decane	0.47	0.66	0.26	0.28
2,4-Dimethylpentane	<0.007	<0.007	<0.007	<0.007
n-Dodecane	<0.003	<0.003	<0.003	<0.003
Ethylbenzene	<0.004	2.7	<0.004	<0.004
n-Heptane	<0.005	0.11	0.10	<0.005
n-Hexane	<0.005	0.86	<0.005	<0.005
2-Methylbutane	<0.007	<0.007	<0.007	<0.007
1-Methylnaphthalene	<0.004	<0.004	<0.004	<0.004
2-Methylpentane	<0.007	<0.007	<0.007	<0.007
Naphthalene	<0.004	<0.004	<0.004	<0.004
Nonane	<0.004	<0.004	<0.004	<0.004
n-Octane	<0.004	0.88	<0.004	<0.004
n-Pentadecane	<0.003	<0.003	<0.003	<0.003
n-Pentane	2.6	<0.008	<0.008	<0.008
n-Propylbenzene	<0.003	0.57	<0.003	<0.003
n-Tetradecane	<0.001	<0.001	<0.001	<0.001
Toluene	<0.003	3.0	0.090	<0.003
n-Tridecane	<0.004	<0.004	<0.004	<0.004
n-Undecane	0.33	0.52	0.23	0.24
p-Xylene	<0.003	<0.003	<0.003	<0.003

Table A30. Distribution of Contaminants in 1992 Soil Samples by Depth From Control Test Plot, Vent Well Borehole: Methanol Extraction

Compound	Concentration (mg/kg) by Depth (ft)			
	5.0 - 5.5	5.5 - 6.0	7.0 - 7.5	7.5 - 8.0
Benzene	3.5	<0.005	3.3	0.82
n-Butylbenzene	3.6	16	1.4	<0.003
n-Decane	15	37	1.1	1.7
2,4-Dimethylpentane	7.6	<0.007	<0.007	<0.007
n-Dodecane	31	22	2.3	0.83
Ethylbenzene	9.0	170	7.4	2.2
n-Heptane	67	120	11	7.1
n-Hexane	7.3	<0.005	2.6	2.4
2-Methylbutane	20	<0.007	<0.007	5.3
1-Methylnaphthalene	13	25	1.1	<0.004
2-Methylpentane	2.9	<0.007	<0.007	2.0
Naphthalene	7.6	22	2.4	2.2
Nonane	22	110	4.4	2.2
n-Octane	95	560	21	10
n-Pentadecane	<0.003	12	3.3	<0.003
n-Pentane	310	12	3.2	56
n-Propylbenzene	3.3	20	2.5	0.27
n-Tetradecane	13	22	2.4	2.8
Toluene	22	130	9.1	4.4
n-Tridecane	11	16	2.1	3.6
n-Undecane	21	36	2.0	1.8
p-Xylene	14	63	1.4	0.33

Table A31. Distribution of Contaminants in 1992 Soil by Depth From Control Test Plot, Monitoring Point 7 Borehole: Methanol Extraction

Compound	Concentration (mg/kg) by Depth (ft)				
	5.0 - 5.5	**5.5 - 6.0**	**6.0 - 6.5**	**7.0 - 7.5**	**7.5 - 8.0**
Benzene	5.2	1.5	<0.005	4.7	0.30
n-Butylbenzene	14	12	3.5	2.7	0.16
n-Decane	22	15	2.0	3.3	0.79
2,4-Dimethylpentane	<0.007	<0.007	<0.007	11	<0.007
n-Dodecane	9.6	16	4.1	4.0	0.44
Ethylbenzene	67	53	3.8	6.5	0.23
n-Heptane	120	23	0.10	81	1.6
n-Hexane	<0.005	<0.005	<0.005	28	0.34
2-Methylbutane	0.40	12	<0.007	<0.007	<0.007
1-Methylnaphthalene	14	14	2.1	3.0	<0.004
2-Methylpentane	<0.007	<0.007	<0.007	5.4	<0.007
Naphthalene	23	20	7.5	2.8	3.4
Nonane	11	7.2	0.92	1.7	0.64
n-Octane	3.8	2.2	13	1.1	<0.004
n-Pentadecane	5.6	<0.003	<0.003	2.6	1.1
n-Pentane	5.9	17	<0.008	0.16	<0.008
n-Propylbenzene	23	14	0.94	1.7	<0.003
n-Tetradecane	11	15	3.7	3.2	1.8
Toluene	92	11	4.1	54	1.6
n-Tridecane	7.3	7.7	1.8	2.5	1.6
n-Undecane	13	9.5	1.7	2.8	0.25
p-Xylene	34	21	3.0	7.6	0.12

Table A32. Distribution of Contaminants in 1992 Soil Samples by Depth From Control Test Plot, Monitoring Point 8 Borehole: Methanol Extraction

Compound	Concentration (mg/kg) by Depth (ft)					
	5.0 - 5.5	5.5 - 6.0	5.5 - 6.0	6.0 - 6.5	7.0 - 7.5	7.5 - 8.0
Benzene	<0.005	1.3	<0.005	1.9	1.1	1.1
n-Butylbenzene	4.8	23	19	1.8	1.6	0.67
n-Decane	25	85	79	9.8	7.0	2.0
2,4-Dimethylpentane	<0.007	<0.007	<0.007	<0.007	2.8	<0.007
n-Dodecane	10	90	92	23	16	3.8
Ethylbenzene	12	120	110	12	4.8	0.52
n-Heptane	18	31	26	3.0	56	0.17
n-Hexane	<0.005	<0.005	<0.005	1.1	15	0.46
2-Methylbutane	5.8	7.4	<0.007	<0.007	<0.007	<0.007
1-Methylnaphthalene	5.1	25	32	4.1	3.0	0.74
2-Methylpentane	<0.007	<0.007	<0.007	<0.007	2.6	<0.007
Naphthalene	21	33	68	5.4	4.3	<0.004
Nonane	39	220	200	19	13	2.7
n-Octane	110	750	700	57	78	11
n-Pentadecane	3.4	14	16	6.3	3.9	1.2
n-Pentane	1.0	4.7	1.4	<0.008	0.15	<0.008
n-Propylbenzene	6.1	40	57	3.1	<0.003	0.37
n-Tetradecane	8.6	14	33	11	5.6	2.0
Toluene	1.7	48	43	6.5	41	5.9
n-Tridecane	10	39	29	14	5.2	2.1
n-Undecane	29	74	74	15	10	3.2
p-Xylene	19	520	110	11	7.8	1.4

Table A33. Distribution of Contaminants in 1992 Soil Samples by Depth From Background Area: Methanol Extraction

Compound	Concentration (mg/kg) by Depth (ft)				
	5.0 - 5.5	5.5 - 6.0	7.0 - 7.5	7.0 - 7.5	7.5 - 8.0
Benzene	1.5	1.4	<0.005	<0.005	<0.005
n-Butylbenzene	<0.003	0.34	<0.003	<0.003	<0.003
n-Decane	0.59	0.64	0.30	0.42	0.54
2,4-Dimethylpentane	<0.007	<0.007	<0.007	<0.007	<0.007
n-Dodecane	0.16	<0.003	<0.003	<0.003	0.79
Ethylbenzene	0.94	3.3	<0.004	<0.004	0.28
n-Heptane	1.5	0.88	<0.005	<0.005	0.55
n-Hexane	1.2	0.50	<0.005	<0.005	<0.005
2-Methylbutane	18	4.6	<0.007	<0.007	3.5
1-Methylnaphthalene	<0.004	<0.004	<0.004	<0.004	<0.004
2-Methylpentane	0.88	<0.007	<0.007	<0.007	<0.007
Naphthalene	0.44	<0.004	<0.004	<0.004	<0.004
Nonane	0.56	0.53	<0.004	<0.004	0.43
n-Octane	1.0	0.78	<0.004	<0.004	1.8
n-Pentadecane	0.57	0.28	<0.003	0.30	1.5
n-Pentane	31	4.2	1.6	7.0	3.1
n-Propylbenzene	0.090	0.69	<0.003	<0.003	<0.003
n-Tetradecane	0.30	<0.001	<0.001	<0.001	1.1
Toluene	1.7	3.3	0.20	0.39	0.43
n-Tridecane	0.18	<0.004	<0.004	<0.004	0.24
n-Undecane	0.40	0.42	0.28	0.27	0.55
p-Xylene	1.3	4.4	<0.003	<0.003	<0.003

Table A34. Total Hydrocarbon Concentration in 1994 Soil Samples From Active Warming Test Plot: Methylene Chloride Extraction

Location	Depth (ft)	TPH (mg/Kg)	
		C-6 to C-15	C-6
Active Plot - AF-1	5.5 - 6.0	1.3	1.7
	6.0 - 6.5	5.3	6.9
	6.5 - 7.0	25.1	32.4
	7.5 - 8.0	8.3	10.7
	8.0 - 8.5	85.6	110
	8.5 - 9.0	185	239
	9.5 - 10.0	11.4	14.6
	10.0 - 10.5	8.6	11.1
	10.5 - 11.0	3.6	4.7
Active Plot - AF-2	5.5 - 6.0	0.73	0.94
	6.0 - 6.5	13.6	17.5
	6.5 - 7.0	1.5	1.9
	7.5 - 8.0	1.6	2.1
	8.0 - 8.5	116	149
	8.5 - 9.0	55.2	71.2
	10.0 - 10.5	13.3	17.1
	10.5 - 11.0	5.0	6.4
Active Plot - AF-3	5.5 - 6.0	329	435
	6.0 - 6.5	82.1	106
	6.5 - 7.0	152	196
	8.5 - 9.0	31.5	40.7
	9.5 - 10.0	46.0	59.3
	10.0 - 10.5	479	618
	10.5 - 11.0	2.8	3.6

Table A35. Total Hydrocarbon Concentration in 1994 Soil Samples From Passive Warming Test Plot: Methylene Chloride Extraction

Location	Depth (ft)	TPH (mg/Kg)	
		C-6 to C-15	C-6
Passive Plot - PF-1	5.5 - 6.0	0.0	0.0
	6.0 - 6.5	0.81	1.0
	6.5 - 7.0	10.9	14.0
	8.0 - 8.5	26.3	33.9
	8.5 - 9.0	18.1	23.4
	9.5 - 10.0	31.5	40.6
	10.0 - 10.5	0.0	0.0
	10.5 - 11.0	56.2	72.5
Passive Plot - PF-2	5.5 - 6.0	164	212
	6.0 - 6.5	14.4	18.5
	6.5 - 7.0	9.5	12.2
	7.5 - 8.0	17.5	22.5
	8.0 - 8.5	43.8	56.5
	8.5 - 9.0	10.2	13.1
Passive Plot - PF-3	6.0 - 6.5	31.9	41.1
	6.5 - 7.0	1.5	1.9
	7.5 - 8.0	12.5	16.1
	8.0 - 8.5	9.6	12.4
	8.5 - 9.0	1.1	1.4
	9.0 - 9.5	15.4	19.9
	9.5 - 10.0	15.4	19.9
	10.0 - 10.5	2.9	3.8
	10.5 - 11.0	1.0	1.2

Table A36. Total Hydrocarbon Concentration in 1994 Soil Samples From Surface Warming Test Plot: Methylene Chloride Extraction

Location	Depth (ft)	TPH (mg/Kg)	
		C-6 to C-15	C-6
Surface Warming Plot - HF-1	5.5 - 6.0	7.6	9.8
	6.0 - 6.5	18.3	23.6
	6.5 - 7.0	23.4	30.2
	7.5 - 8.0	2.8	3.6
	8.0 - 8.5	1.1	1.5
	8.5 - 9.0	2.8	3.6
	9.5 - 10.0	0.80	1.0
	10.0 - 10.5	0.65	0.84
	10.5 - 11.0	2.0	2.5
Surface Warming Plot - HF-2	4.5 - 5.0	19.0	24.5
	5.0 - 5.5	0.0	0.0
	5.5 - 6.0	2.8	3.6
	6.5 - 7.0	4.3	5.5
	7.0 - 7.5	3.7	4.8
	7.5 - 8.0	0.32	0.42
Surface Warming Plot - HF-3	4.5 - 5.0	0.15	0.20
	5.0 - 5.5	3.4	4.4
	5.5 - 6.0	0.0	0.0
	7.0 - 7.5	28.0	36.1
	7.5 - 8.0	2.0	2.6
	8.5 - 9.0	3.2	4.1
	9.0 - 9.5	1.8	2.3
	9.5 - 10.0	2.0	2.6

Table A37. Total Hydrocarbon Concentration in 1994 Soil Samples From Control Test Plot: Methylene Chloride Extraction

Location	Depth (ft)	TPH (mg/Kg)	
		C-6 to C-15	C-6
Control Plot - CF-1	6.0 - 6.5	170	219
	6.5 - 7.0	71.2	91.7
	8.5 - 9.0	30.6	39.4
	10.0 - 10.5	5.7	7.4
	10.5 - 11.0	25.5	32.8
Control Plot - CF-2	4.5 - 5.0	92.2	118.9
	5.0 - 5.5	72.3	93.2
	5.5 - 6.0	265	342
	6.5 - 7.0	110	142
	7.0 - 7.5	153	197
	7.5 - 8.0	31.8	41.0
	9.0 - 9.5	1.2	1.5
	9.5 - 10.0	2.3	2.9
Control Plot - CF-3	4.5 - 5.0	24.9	32.1
	5.0 - 5.5	301	388
	5.5 - 6.0	339	437
	6.5 - 7.0	139	179
	7.0 - 7.5	288	371
	7.5 - 8.0	138	177
	9.0 - 9.5	17.3	22.3
	9.5 - 10.0	10.4	13.4

Table A38. Total Hydrocarbon Concentration in 1994 Soil Samples From Background Area: Methylene Chloride Extraction

Location	Depth (ft)	TPH (mg/Kg)	
		C-6 to C-15	C-6
Background Area	6.0 - 6.5	2.8	3.6
	6.5 - 7.0	4.9	6.3
	8.0 - 8.5	4.8	6.1
	8.5 - 9.0	1.8	2.4
	10.0 - 10.5	1.1	1.5
	10.5 - 11.0	2.5	3.2

Table A39. Distribution of Contaminants in 1994 Soil Samples by Depth From the Active Warming Test Plot: AF-1: Methylene Chloride Extraction

Compound	Concentration (mg/Kg) by Depth (ft)								
	5.5-6.0	6.0-6.5	6.5-7.0	7.5-8.0	8.0-8.5	8.5-9.0	9.5-10.0	10.0-10.5	10.5-11.0
n-Dodecane	<0.003	<0.003	0.11	<0.003	18.7	32.7	2.4	1.8	<0.003
1-Methylnaphthalene	<0.004	<0.004	<0.004	<0.004	0.12	23.4	2.7	1.4	<0.004
n-Pentadecane	<0.003	<0.003	7.0	<0.003	11.5	<0.003	<0.003	<0.003	<0.003
n-Tetradecane	<0.001	<0.001	7.1	<0.001	16.5	33.9	2.4	1.8	<0.001
n-Tridecane	<0.004	<0.004	3.8	<0.004	19.3	32.1	2.1	1.4	<0.004

Table A40. Distribution of Contaminants in 1994 Soil Samples by Depth From the Active Warming Test Plot, AF-2: Methylene Chloride Extraction

Compound	Concentration (mg/Kg) by Depth (ft)				
	5.5-6.0	6.0-6.5	6.5-7.0	10.0-10.5	10.5-11.0
n-Dodecane	<0.003	<0.003	<0.003	0.80	<0.003
1-Methylnaphthalene	<0.004	<0.004	<0.004	0.51	<0.004
n-Pentadecane	<0.003	<0.003	<0.003	0.50	<0.003
n-Tetradecane	0.39	14.3	1.6	0.58	<0.001
n-Tridecane	<0.004	<0.004	<0.004	<0.004	<0.004

Table A41. Distribution of Contaminants in 1994 Soil Samples by Depth From the Active Warming Test Plot, AF-3: Methylene Chloride Extraction

Compound	Concentration (mg/Kg) by Depth (ft)						
	5.5-6.0	6.0-6.5	6.5-7.0	8.5-9.0	9.5-10.0	10.0-10.5	10.5-11.0
n-Dodecane	23.7	19.8	37.9	9.2	9.8	66.4	1.2
1-Methylnaphthalene	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
n-Pentadecane	38.7	6.0	22.6	4.6	5.4	46.2	<0.003
n-Tetradecane	71.8	12.3	29.2	5.8	7.6	75.4	0.72
n-Tridecane	42.5	14.7	29.6	7.8	8.4	77.7	0.83

Table A42. Distribution of Contaminants in 1994 Soil Samples by Depth From the Passive Warming Test Plot, PF-1: Methylene Chloride Extraction

Compound	Concentration (mg/Kg) by Depth (ft)							
	5.5-6.0	6.0-6.5	6.5-7.0	8.0-8.5	8.5-9.0	9.5-10.0	10.0-10.5	10.5-11.0
n-Dodecane	<0.003	<0.003	<0.003	3.2	<0.003	<0.003	<0.003	<0.003
1-Methylnaphthalene	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
n-Pentadecane	<0.003	0.35	4.4	4.2	1.5	1.2	<0.003	<0.003
n-Tetradecane	<0.001	<0.001	2.1	4.9	<0.001	<0.001	<0.001	<0.001
n-Tridecane	<0.004	<0.004	<0.004	3.7	<0.004	0.93	<0.004	<0.004

Table A43. Distribution of Contaminants in 1994 Soil Samples by Depth From the Passive Warming Test Plot, PF-2: Methylene Chloride Extraction

Compound	Concentration (mg/Kg) by Depth (ft)					
	5.5-6.0	6.0-6.5	6.5-7.0	7.5-8.0	8.0-8.5	8.5-9.0
n-Dodecane	<0.003	<0.003	<0.003	<0.003	11.0	1.9
1-Methylnaphthalene	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
n-Pentadecane	<0.003	9.4	0.52	11.8	5.1	5.1
n-Tetradecane	165	<0.001	<0.001	<0.001	1.5	1.5
n-Tridecane	<0.004	<0.004	<0.004	<0.004	1.9	1.9

Table A44. Distribution of Contaminants in 1994 Soil Samples by Depth From the Passive Warming Test Plot, PF-3: Methylene Chloride Extraction

Compound	Concentration (mg/Kg) by Depth (ft)							
	6.0-6.5	6.5-7.0	7.5-8.0	8.0-8.5	8.5-9.0	9.5-10.0	10.0-10.5	10.5-11.0
n-Dodecane	<0.003	<0.003	2.8	3.0	<0.003	0.51	<0.003	<0.003
1-Methylnaphthalene	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
n-Pentadecane	31.5	<0.003	2.2	1.5	0.09	<0.003	<0.003	<0.003
n-Tetradecane	<0.001	1.5	2.2	3.0	<0.001	<0.001	<0.001	<0.001
n-Tridecane	<0.004	<0.004	2.2	2.2	<0.004	0.85	<0.004	<0.004

Table A45. Distribution of Contaminants in 1994 Soil Samples by Depth From the Surface Warming Test Plot, HF-1: Methylene Chloride Extraction

Compound	Concentration (mg/Kg) by Depth (ft)								
	5.5-6.0	6.0-6.5	6.5-7.0	7.5-8.0	8.0-8.5	8.5-9.0	9.5-10.0	10.0-10.5	10.5-11.0
n-Dodecane	<0.003	5.1	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
1-Methylnaphthalene	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
n-Pentadecane	0.17	<0.003	<0.003	<0.003	0.11	<0.003	<0.003	0.12	<0.003
n-Tetradecane	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
n-Tridecane	<0.004	5.2	<0.004	<0.004	0.73	<0.004	<0.004	<0.004	<0.004

Table A46. Distribution of Contaminants in 1994 Soil Samples by Depth From the Surface Warming Test Plot, HF-2: Methylene Chloride Extraction

Compound	Concentration (mg/Kg) by Depth (ft)					
	4.5-5.0	5.0-5.5	5.5-6.0	6.5-7.0	7.0-7.5	7.5-8.0
n-Dodecane	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
1-Methylnaphthalene	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
n-Pentadecane	<0.003	<0.003	<0.003	<0.003	1.6	<0.003
n-Tetradecane	<0.001	<0.001	<0.001	<0.001	1.8	0.25
n-Tridecane	<0.004	<0.004	<0.004	<0.004	0.18	<0.004

Table A47. Distribution of Contaminants in 1994 Soil Samples by Depth From the Surface Warming Test Plot, HF-3: Methylene Chloride Extraction

Compound	Concentration (mg/Kg) by Depth (ft)							
	4.5-5.0	5.0-5.5	5.5-6.0	7.0-7.5	7.5-8.0	8.5-9.0	9.0-9.5	9.5-10.0
n-Dodecane	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
1-Methylnaphthalene	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
n-Pentadecane	<0.003	<0.003	<0.003	<0.003	0.13	0.35	0.26	<0.003
n-Tetradecane	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
n-Tridecane	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004

Table A48. Distribution of Contaminants in 1994 Soil Samples by Depth From the Control Test Plot, CF-1: Methylene Chloride Extraction

Compound	Concentration (mg/Kg) by Depth (ft)				
	6.0-6.5	6.5-7.0	8.5-9.0	10.0-10.5	10.5-11.0
n-Dodecane	<0.003	<0.003	<0.003	0.13	6.0
1-Methylnaphthalene	<0.004	<0.004	<0.004	<0.004	<0.004
n-Pentadecane	26.9	35.8	13.5	1.1	5.5
n-Tetradecane	36.5	5.7	7.3	1.2	7.5
n-Tridecane	32.0	<0.004	1.5	0.73	6.8

Table A49. Distribution of Contaminants in 1994 Soil Samples by Depth From the Control Test Plot, CF-2: Methylene Chloride Extraction

Compound	Concentration (mg/Kg) by Depth (ft)							
	4.5-5.0	5.0-5.5	5.5-6.0	6.5-7.0	7.0-7.5	7.5-8.0	9.0-9.5	9.5-10.0
n-Dodecane	8.4	6.2	<0.003	6.4	6.9	5.3	0.14	0.16
1-Methylnaphthalene	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
n-Pentadecane	20.4	12.6	45.7	14.8	27.3	6.3	0.10	0.16
n-Tetradecane	25.7	17.0	68.8	21.0	37.2	7.8	0.16	0.79
n-Tridecane	15.6	16.3	37.8	21.4	34.8	7.4	0.08	0.15

Table A50. Distribution of Contaminants in 1994 Soil Samples by Depth From the Control Test Plot, CF-3: Methylene Chloride Extraction

Compound	Concentration (mg/Kg) by Depth (ft)							
	4.5-5.0	5.0-5.5	5.5-6.0	6.5-7.0	7.0-7.5	7.5-8.0	9.0-9.5	9.5-10.0
n-Dodecane	<0.003	56.5	51.2	20.9	56.0	21.3	2.6	2.9
1-Methylnaphthalene	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
n-Pentadecane	7.6	40.1	41.8	14.7	32.4	15.3	5.8	2.2
n-Tetradecane	11.0	44.1	58.9	20.9	40.4	22.0	5.4	2.6
n-Tridecane	7.2	51.9	47.6	21.3	46.7	22.6	3.2	2.8

Table A51. Distribution of Contaminants in 1994 Soil Samples by Depth From the Background Area, BF-1: Methylene Chloride Extraction

Compound	Concentration (mg/Kg) by Depth (ft)					
	6.0-6.5	6.5-7.0	8.0-8.5	8.5-9.0	10.0-10.5	10.5-11.0
n-Dodecane	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
1-Methylnaphthalene	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
n-Pentadecane	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
n-Tetradecane	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
n-Tridecane	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004

Table A52. Total Hydrocarbon Concentration in 1991 Groundwater Samples: Methanol Extraction

Location	Concentration (mg/L)	
	C-5 to C-15	C-6
Background (Sample 1)	<0.0002	<0.0002
Background (Sample 2)	<0.0002	<0.0002
Active Warming Extraction Well (Sample 1)	20.2	20.4
Active Warming Test Plot (Sample 1)	17.1	17.3
Active Warming Test Plot (Sample 2)	17.6	17.7
Control Test Plot (Sample 1)	11.3	11.4
Control Test Plot (Sample 2)	18.5	18.6
Passive Warming Test Plot (Sample 1)	12.1	12.2
Passive Warming Test Plot (Sample 2)	17.3	17.5

Table A52. Total Hydrocarbon Concentration in 1991 Groundwater Samples: Methylene Chloride Extraction

Location	Concentration (mg/L)	
	C-5 to C-15	C-6
Background	1.5	1.5
Extraction Well	6.4[1]	6.4[1]
Active Plot	11[1]	11[1]
Control Plot	6.9[1]	7.0[1]
Passive Plot	<0.052	<0.052

[1] - Average of two samples.

Table A53. Distribution of Contaminants in 1991 Groundwater Samples[1]: Methanol Extraction

Compound	Concentration (mg/L)[2]				
	Well 2[3]	Well 3	Well 4	Well 5	Well 6
Benzene	5.5	7.8	3.0	3.8	0.021
n-Butylbenzene	0.0099	0.0018	0.0091	0.0075	<0.0005
n-Decane	0.087	0.037	0.039	0.010	0.0014
2,4-Dimethylpentane	0.76	0.33	0.60	0.51	<0.0006
n-Dodecane	0.040	<0.0006	<0.0006	0.0074	<0.0006
Ethylbenzene	0.086	0.43	0.063	0.21	0.0032
n-Heptane	0.25	<0.0004	0.054	0.0056	<0.0004
n-Hexane	0.093	0.021	0.035	0.066	<0.0004
1-Methylnaphthalene	0.026	0.029	<0.0009	<0.0009	<0.0009
2-Methylpentane	0.32	0.11	0.22	0.25	<0.0016
Naphthalene	0.021	0.025	0.043	0.0040	<0.0009
n-Octane	0.066	0.023	0.036	0.012	<0.0008
n-Pentadecane	0.0032	0.0010	<0.0006	<0.0006	<0.0006
n-Propylbenzene	0.00030	0.016	0.036	0.025	<0.0008
n-Tetradecane	<0.0006	0.0018	0.00090	<0.0006	0.0047
Toluene	0.011	5.6	4.6	3.3	0.017
n-Tridecane	<0.0006	<0.0006	0.0078	<0.0007	<0.0006
p-Xylene	1.8	0.14	1.2	0.24	0.0039

[1] - No compounds were detected in background.
[2] - Average of two replicate samples unless noted.
[3] - Represents one sample (1 replicate).

Table A54. **Total Hydrocarbon Concentration in 1994 Groundwater Samples: Methylene Chloride Extraction.**

	Concentration (mg/L)	
	C-6 to C-15	**C-6**
Background	0.0052	0.0068
Active Plot	0.270	0.348
Control Plot	0.0391	0.0504
Passive Plot	1.632	2.104

Table A55. **Total Hydrocarbon Concentration in 1994 Groundwater Samples: Methanol Extraction.**

	Concentration (mg/L)	
	C-6 to C-15	**C-6**
Background	0.0025	0.00325
Active Plot	0.0024	0.0031
Control Plot	6.636	8.657
Passive Plot	0.00395	0.000515

Table A56. Distribution of Contaminants in 1994 Groundwater Samples: Methylene Chloride Extraction

Compound	Concentration (mg/L)			
	Background	Active Plot	Passive Plot	Control Plot
Benzene	<0.0003	<0.0003	<0.0003	<0.0003
n-Butylbenzene	<0.0005	<0.0005	<0.0005	<0.0005
n-Decane	<0.0006	<0.0006	<0.0006	<0.0006
2,4-Dimethylpentane	<0.0006	<0.0006	<0.0006	<0.0006
n-Dodecane	<0.0006	<0.0006	<0.171	<0.0006
Ethylbenzene	<0.0002	<0.0002	<0.0002	<0.0002
n-Heptane	<0.0004	<0.0004	<0.0004	<0.0004
n-Hexane	<0.0004	<0.0004	<0.0004	<0.0004
1-Methylnaphthalene	<0.0004	<0.0004	<0.0793	<0.0009
2-Methylpentane	<0.0016	<0.0016	<0.0016	<0.0016
Naphthalene	<0.0009	<0.0009	<0.0009	<0.0009
n-Octane	<0.0008	<0.0008	<0.0008	<0.0008
n-Pentadecane	<0.0006	<0.0515	<0.199	<0.0026
n-Propylbenzene	<0.0008	<0.0008	<0.0008	<0.0008
n-Tetradecane	<0.0006	0.0762	0.315	<0.0006
Toluene	<0.002	<0.002	<0.002	<0.002
n-Tridecane	<0.0006	0.0523	0.410	<0.0007
p-Xylene	<0.0019	<0.0019	<0.0019	<0.0019

Table A57. Distribution of Contaminants in 1994 Groundwater Samples: Methanol Extraction

Compound	Concentration (mg/L)			
	Background	Active Plot	Passive Plot	Control Plot
Benzene	<0.0003	<0.0003	<0.0003	<0.0003
n-Butylbenzene	<0.0005	<0.0005	<0.0005	0.0007
n-Decane	<0.0006	<0.0006	<0.0006	<0.0006
2,4-Dimethylpentane	<0.0006	<0.0006	<0.0006	1.142
n-Dodecane	<0.0006	<0.0006	<0.0006	0.015
Ethylbenzene	<0.002	<0.002	<0.002	<0.002
n-Heptane	<0.0004	<0.0004	<0.0004	0.0088
n-Hexane	<0.0004	<0.0004	<0.0004	0.0100
1-Methylnaphthalene	<0.0004	<0.0004	<0.0009	<0.0009
2-Methylpentane	<0.0016	<0.0016	<0.0016	0.307
Naphthalene	<0.0009	<0.0009	<0.0009	0.043
n-Octane	<0.0008	<0.0008	<0.0008	0.018
n-Pentadecane	<0.0006	<0.0006	<0.0006	<0.0006
n-Pentane	<0.0006	<0.0006	<0.0006	0.0101
n-Propylbenzene	<0.0008	<0.0008	<0.0008	<0.0008
n-Tetradecane	<0.0006	<0.0006	<0.0006	<0.0006
Toluene	<0.002	<0.002	<0.002	0.111
n-Tridecane	<0.0006	<0.0006	<0.0006	<0.0007
1,2,3 - Trimethylbenzene	<0.0007	<0.0007	<0.0007	0.045
1,2,4 - Trimethylbenzene	<0.0012	<0.0012	<0.0012	0.010
1,3,5 - Trimethylbenzene	<0.0003	<0.0003	<0.0003	0.007
Undecane	<0.001	<0.001	<0.001	0.017
p-Xylene	<0.0019	<0.0019	<0.0019	0.274

APPENDIX B

OPERATING MANUAL FOR BIOVENTING SYSTEM AT SITE 20, EIELSON AFB

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OPERATING MANUAL FOR BIOVENTING SYSTEM AT SITE 20, EIELSON AFB

Four test plots and a background area were installed at the site at Eielson AFB. A schematic diagram of the entire site is shown in Figure 1. The test site was centered over two pressurized petroleum lines that intersect the site and are suspected to be the source of the release that caused the contamination, the assumption being that this area is the most highly and uniformly contaminated part of the site.

The bioventing system consists of an air blower plumbed to the air injection/withdrawal (bioventing) wells in the test plots and background area. Operation of the bioventing system involves introducing oxygen into the vadose zone by injecting atmospheric air into the contaminated subsurface with the blower. Air is injected at a rate of 10 cubic ft per minute (cfm).

The following sections provide information on system operation and monitoring.

1.0 AIR INJECTION SYSTEM

1.1 Overall Operation

One blower is used to supply the four test plots with injection air and an additional blower is installed next to the background well for air injection into the background area. The blower is turned on by starter box number three on the north wall of the trailer. Injection pressure may be adjusted with the by-pass valve located on the west end of the air injection manifold. Flow rates into each injection supply line are controlled by the valves located on the south side of the trailer below the rotometers. Injection pressures for each plot may be measured using a Magnehelic™ gauge mounted on the south wall of the trailer. The gauge may be connected to the plot supply lines through an air fitting in the vertical PVC tubing on the south side of the trailer. Currently, the flow rate into each test plot is set at 10 cfm.

1.2 Trouble Shooting

a. The pressure during injection on the heat tape plot and control plot may be so low it will be difficult to read with the Magnehelic™ gauge. This is a normal event with these two plot. If one believes these low readings may be due to a break in the PVC pipe they can use the ball valves to isolate different sections of pipe.

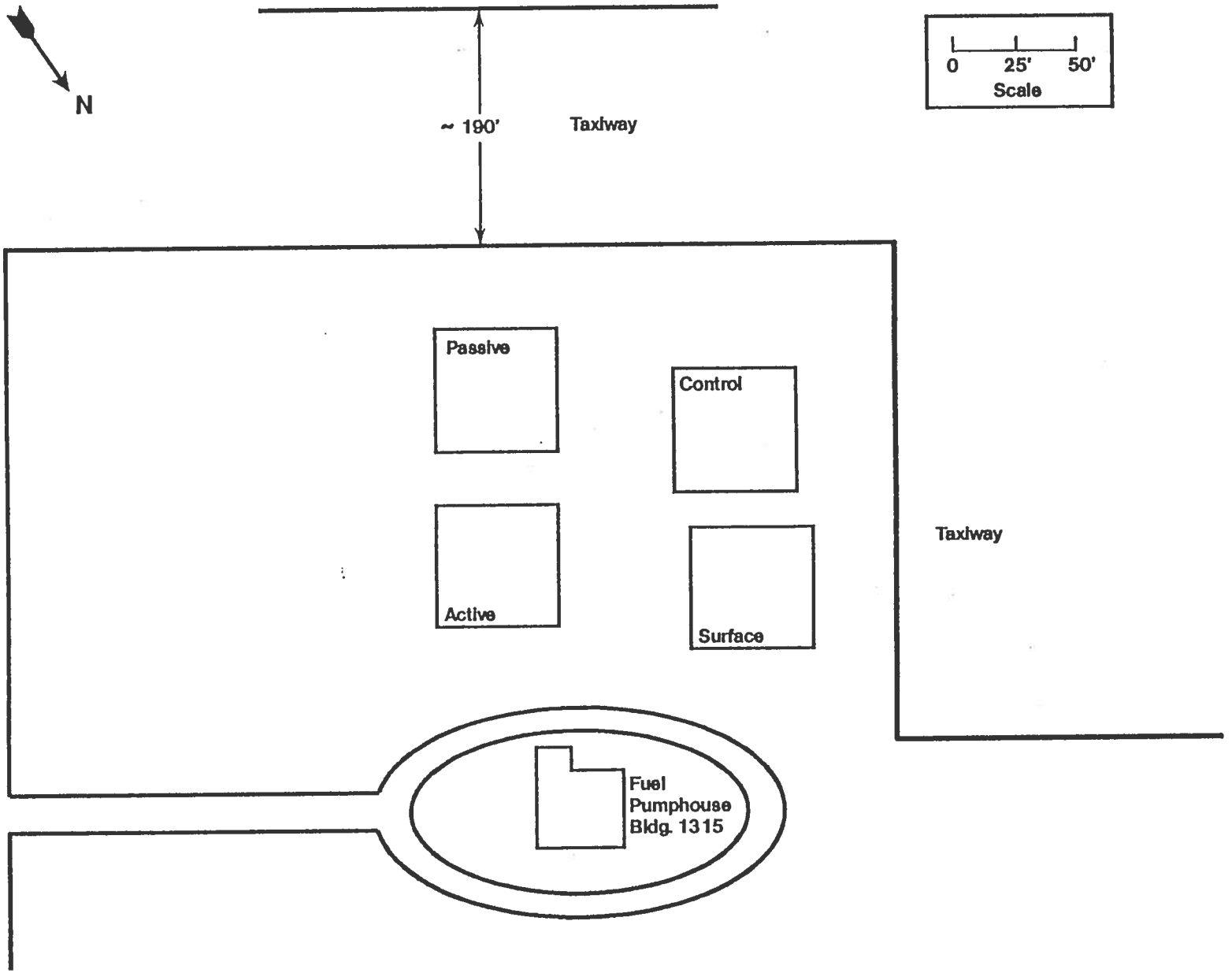


Figure 1. Schematic Diagram of Eielson AFB Bioventing Site

b. After an in situ respiration test or prolonged system shutdown, flow rates may fluctuate upon restart. This is especially apparent in the spring and summer when the water table is high. Flow rates will stabilize over time.

c. If the blower shuts down frequently during the summer, it may be due to over heating. One can reduce the load on the blower by increasing the amount of by-pass air. After the by-pass air has been adjusted, one will need to adjust the flow rates into each test plot.

2.0 ACTIVE WARMING TEST PLOT

2.1 System Components

A schematic diagram of the active warming test plot is shown in Figure 2. During the first 2 years of operation, the active warming test plot was warmed by circulating heated groundwater through soaker hoses buried in the test plot. The warm water percolated through the soil, heating the soil. The test plot was covered with insulation during this time. In July 1993, the active warming system was turned off and the insulation was removed in order to compare microbial activity in this test plot without heating. A description of the construction details of the active warming test plot is given below.

The following items were installed in the active warming test plot:

- four shallow bioventing wells (installed in 1991, the first year of operation)
- one deep bioventing well (installed in 1992, the second year of operation)
- 19 three-level thermocouples, with one thermocouple directly next to the soaker hoses at a depth of 2 ft
- six shallow three-level soil gas monitoring points (installed the first year of operation)
- two deep three-level soil gas monitoring points (installed the second year of operation)
- one groundwater monitoring well
- one groundwater well for circulating groundwater throughout the site (described below)

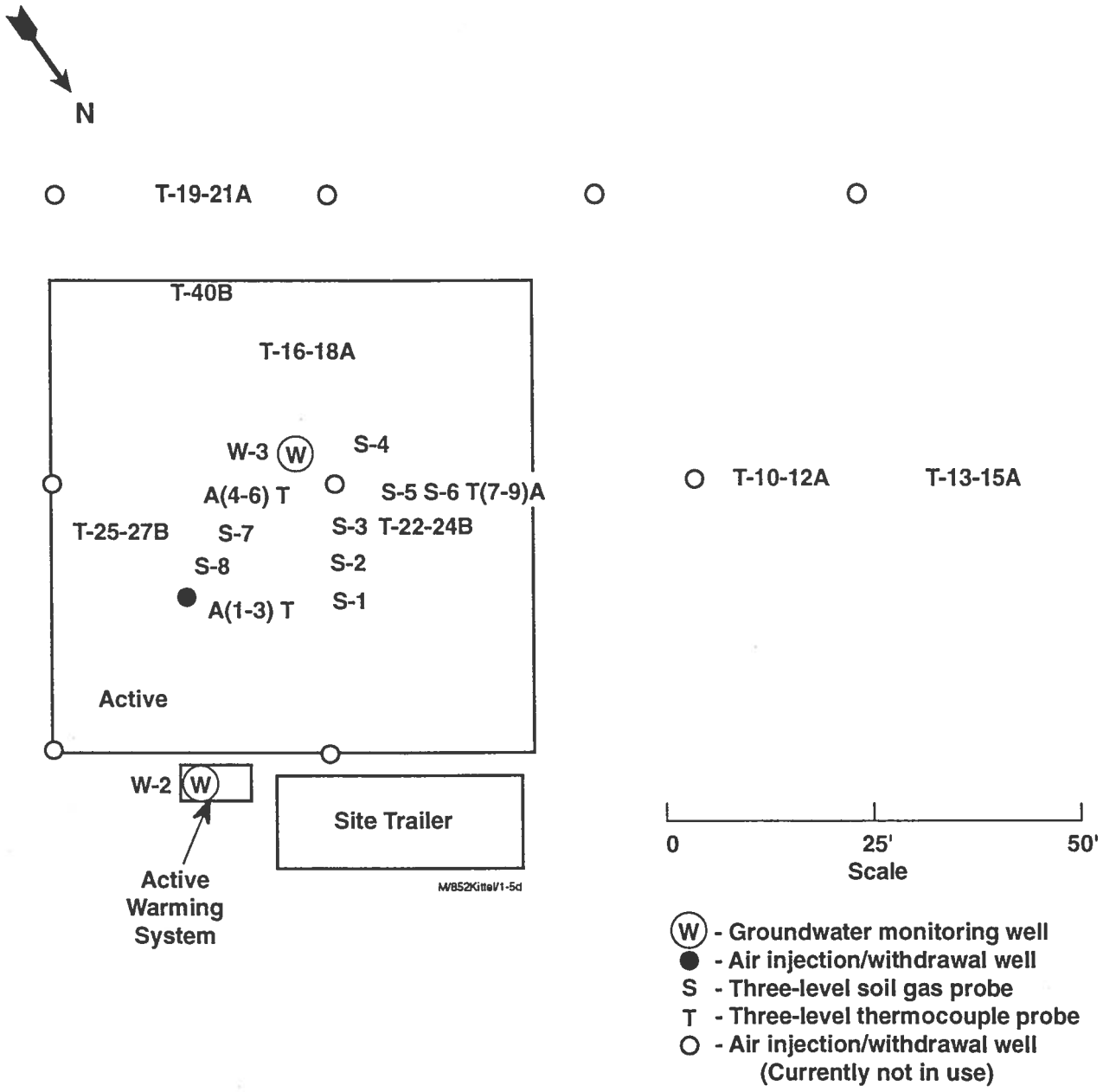


Figure 2. Schematic Diagram of the Active Warming Test Plot

- soaker hoses for distributing groundwater throughout the site (described below).

Commercially available rubber soaker hoses were installed inside five 50-ft lengths of perforated sewer pipe. Each sewer pipe contained two 50-ft lengths of soaker hose connected together on one end (in effect a 100-ft loop). Heat tape was placed in each sewer pipe to protect against freezing. The sewer pipes were placed in 50-ft-long trenches dug 2.5 ft deep, with 10-ft spacing across the active warming test plot.

The monitoring well used for the active warming water supply was installed using a truck-mounted drill rig equipped with a hollow-stem auger of 6 inch inner diameter. The auger was advanced to a depth of 20 ft for installation of the 4-inch-diameter PVC monitoring well. The well consisted of a 10-ft length of 10 slot PVC well screen and 10 ft of schedule 40 PVC well casing.

Figure 3 illustrates the construction details of the active warming system extraction well. Water was pumped from the well using a 0.75-horsepower (HP) submersible pump. The water was pumped through a coarse filter and then to three in-line instantaneous water heaters connected in parallel. A pressure gauge was installed in-line to monitor water pressure. Heated water was pumped out through a dispersion manifold constructed of 1-inch-diameter polyethylene pipe and into one of the open ends of the soaker hose in each sewer pipe. The water circulated through the loop of soaker hose and then back out of the sewer pipe through a return manifold and back to the well. The volume of water injected into the active warming test plot was controlled through the use of two gate valves, one on the influent side of the active warming test plot with a bypass back to the well for excess flow, and the other on the effluent line just prior to returning to the well. The volume of heated water injected into the site was increased when the pressure on the soaker hoses was increased.

The extraction well, pump, and water heaters were installed below the ground surface so that contaminated groundwater was never pumped to the surface. An hour meter was installed in series with the extraction pump to calculate electricity consumption for the water heaters and extraction pump based on the manufacturer-stated usage rates.

The active warming test plot was thermally isolated from the adjacent test plots by approximately 30-ft spacing. The surface area was insulated with Styrofoam™ insulation to help retain heat. A cross-section of the active warming test plot is shown in Figure 4.

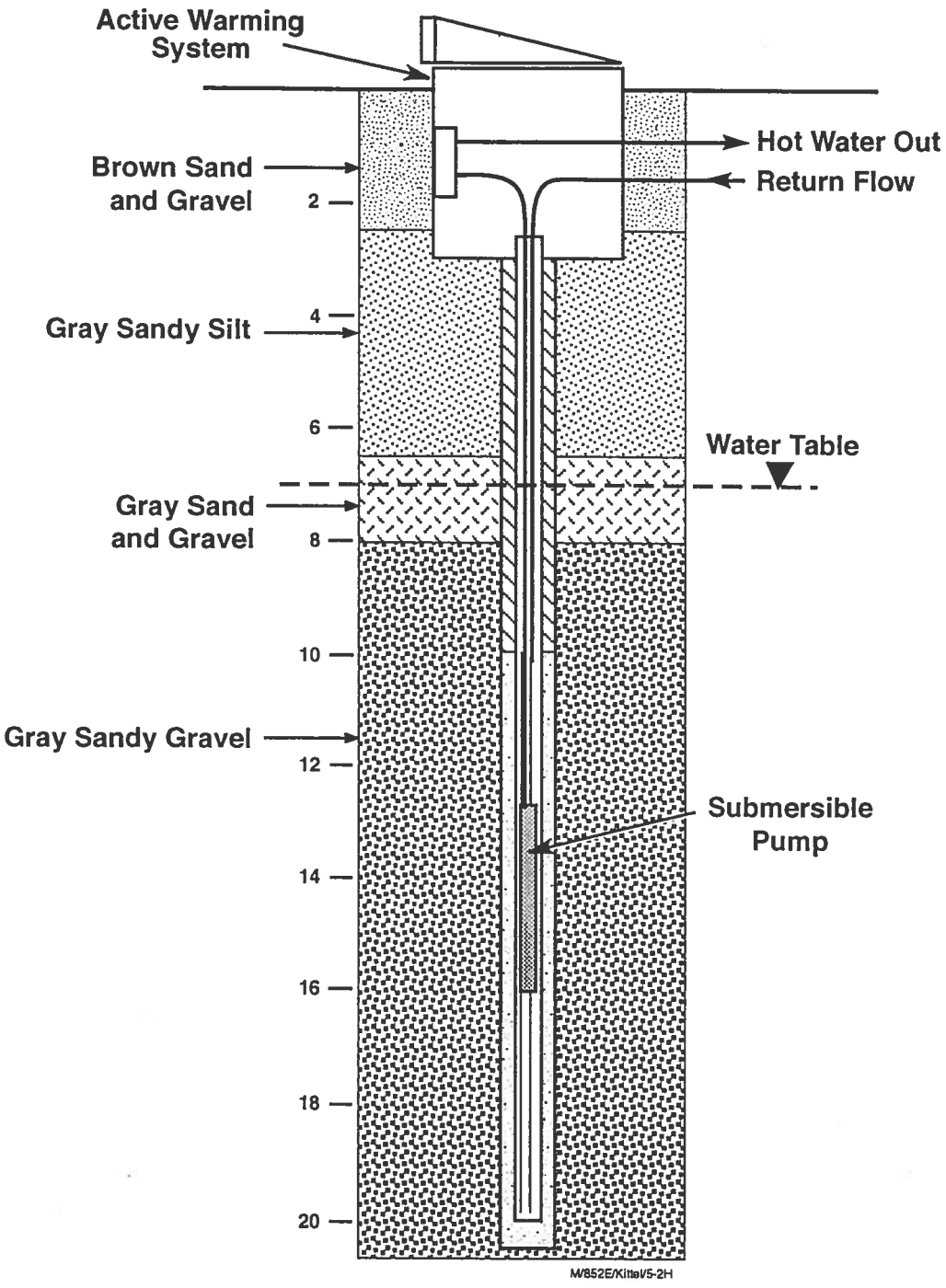


Figure 3. Schematic Diagram of the Construction Detail of the Active Warming Test Plot Extraction Well

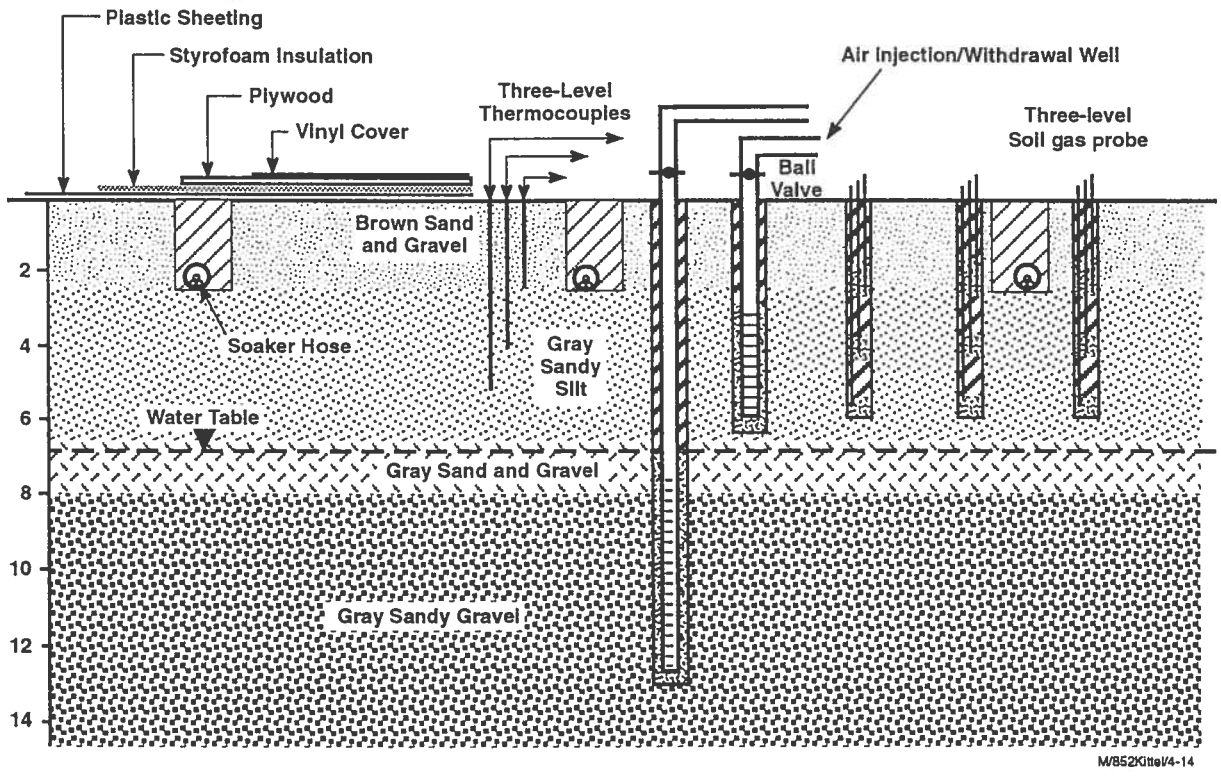


Figure 4. Cross-Section of the Active Warming Test Plot

2.2 Warm Water Heating System Operation

The hot water system is located in the sunken box east of the trailer. The pump for water circulation may be turned on by switching the breaker in the fuse box inside the trailer. The heaters for the system may be turned on at the power pole on the north side of the trailer. The flow is adjusted by increasing or reducing the return water which flows back into the well. It may be necessary to let the well run with out a sediment filter in-line to flush out excess silt. If one doesn't let the well flush out the filters will only last a matter of minutes before it clogs and stops the flow of water. General operating pressure for the system is approximately 25-30 psi on the gauge in the box. One heater is usually sufficient to heat the active plot even in winter. The other heaters may be brought on line by opening the water valves leading to each heater. The primary heater is labeled number one. A small room heater is placed in the water system box during the winter to prevent freezing.

2.3 Trouble Shooting

a. The box which the heating system is located in will flood in the spring due to snow melt. The power should be switch off prior to the spring thaw to avoid damage from electrical shorts.

b. The life of the sediment filters will vary with the seasons. One will have to check the filter on a weekly basis to insure adequate warming of the soil in the active plot.

3.0 PASSIVE WARMING TEST PLOT

3.1 System Components

The passive warming test plot was designed to maximize solar warming to promote soil heating. During the winter months, the test plot was insulated with Styrofoam™ insulation, and during the summer months, the test plot was covered with clear plastic to promote passive solar warming. During the second year of operation, black weed stopper was placed underneath the clear sheeting to reduce plant growth. A schematic diagram of the test plot is shown in Figure 5.

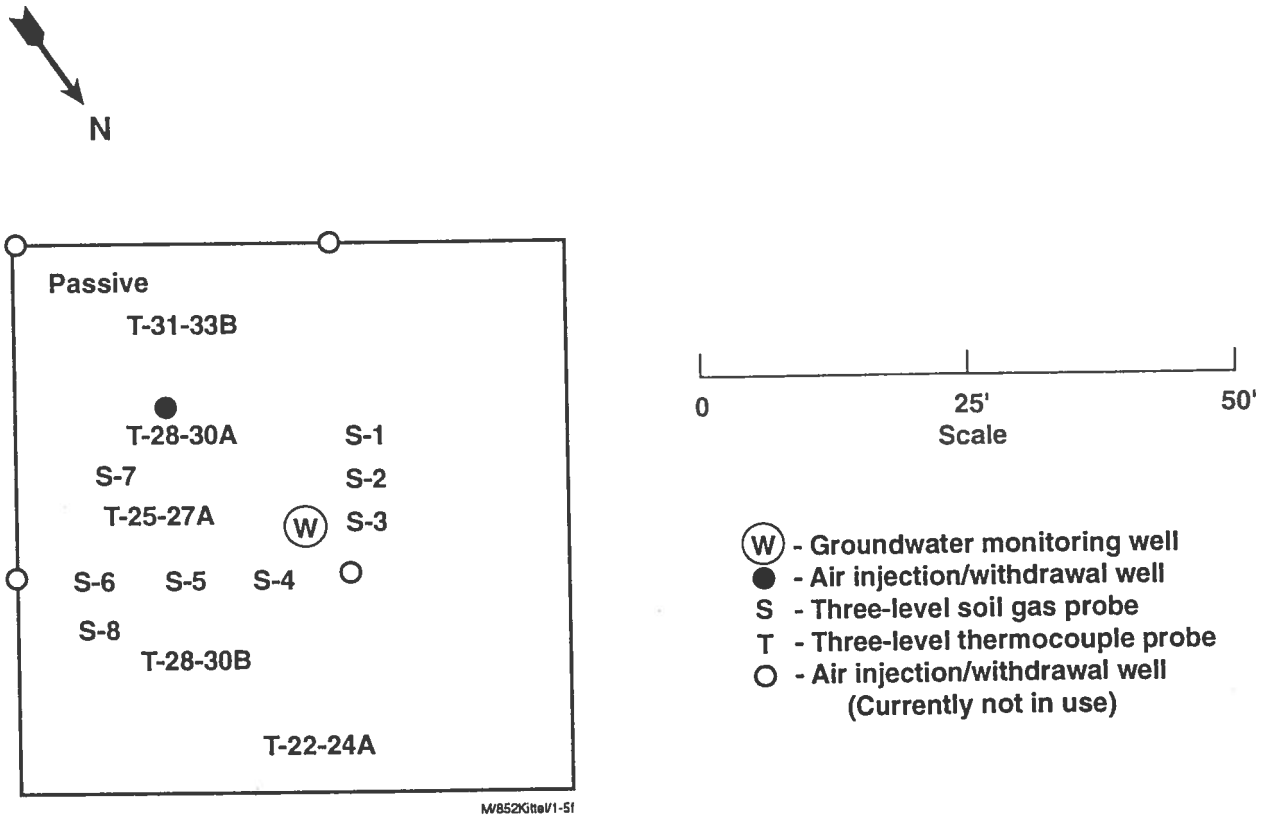


Figure 5. Schematic Diagram of the Passive Warming Test Plot

The following items were installed in the passive warming test plot:

- four shallow bioventing wells (installed the first year of operation)
- one deep bioventing well (installed the second year of operation)
- 15 three-level Type J thermocouples
- six shallow three-level soil gas monitoring points (installed the first year of operation)
- two deep three-level soil gas monitoring points (installed the second year of operation)
- one groundwater monitoring well.

3.2 Passive Warming Test Plot Preparations

The passive plot is covered with a layer of black landscaping cloth followed by heavy clear plastic in the spring and summer. A net work of light rope and boards is placed on the plastic to prevent the wind from blowing it around. In the fall prior to the first snow Cortex insulation is placed on top of the clear plastic. Nylon tarps are placed over the insulation. A network of light rope and boards is used to hold the tarps in place.

3.3 Trouble Shooting

The clear plastic will break down due to the sun. The plastic will usually last only one year. The plastic will probably make it part way through the summer after it has been uncovered in the spring before it needs to be replaced.

4.0 CONTROL TEST PLOT

The control test plot was designed to compare microbial activity in an untreated area with that in heated areas. This plot received air injection, but was not covered with insulation and was not heated. A schematic diagram of the test plot is shown in Figure 6.

The following items were installed in the control test plot:

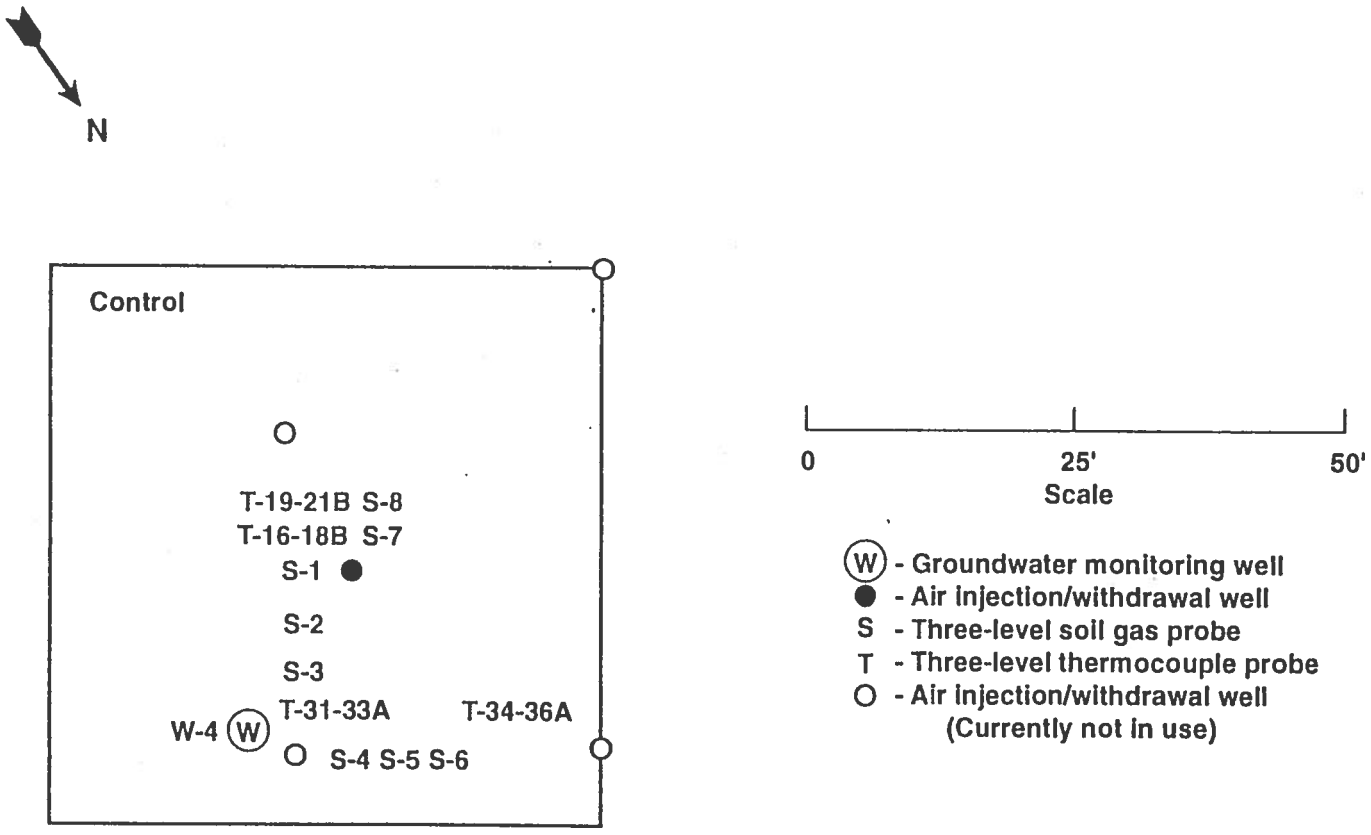


Figure 6. Schematic Diagram of the Control Test Plot

- four shallow bioventing wells (installed the first year of operation)
- one deep bioventing well (installed the second year of operation)
- 12 three-level Type J thermocouples (two three-level thermocouples were installed in the same borehole and at the same depth as monitoring points C7 and C8)
- six shallow three-level soil gas monitoring points (installed the first year of operation)
- two deep three-level soil gas monitoring points (installed the second year of operation)
- one groundwater monitoring well.

There are no specific operational components of the control test plot which need to be monitored.

5.0 SURFACE WARMING TEST PLOT

The surface warming test plot was installed in August 1992 to examine a different form of soil warming. Heat tape was buried at a depth of three feet to warm the soil. The test plot was covered with insulation to retain heat. A schematic diagram of the test plot is shown in Figure 7. Specific details of the construction at this test plot are given below.

The following items were installed in the surface warming test plot:

- four shallow bioventing wells (construction detail given below; one vent well was installed just outside of the test plot)
- one deep bioventing well
- 15 three-level Type J thermocouples (thermocouples 1B through 9B were installed in groups of three in the same boreholes and at the same depths as monitoring points 1, 2, and 6; thermocouples 10B through 15B were installed in groups of three at depths of 2, 4, and 6 ft, and one thermocouple was placed directly next to the heat tape at a depth of 3 ft)
- six deep three-level soil gas monitoring points (except for monitoring point 4 where probes were installed at depths of 2, 4, and 7 ft)

Two strips of heat tape were installed in serpentine fashion to provide nine rows 5 ft apart at a depth of 3 ft. The first and last rows were located 5 ft from the border of the test plot and each row terminated 5 ft from the border of the test plot, so that a 40′ x 40′ area was covered. The two

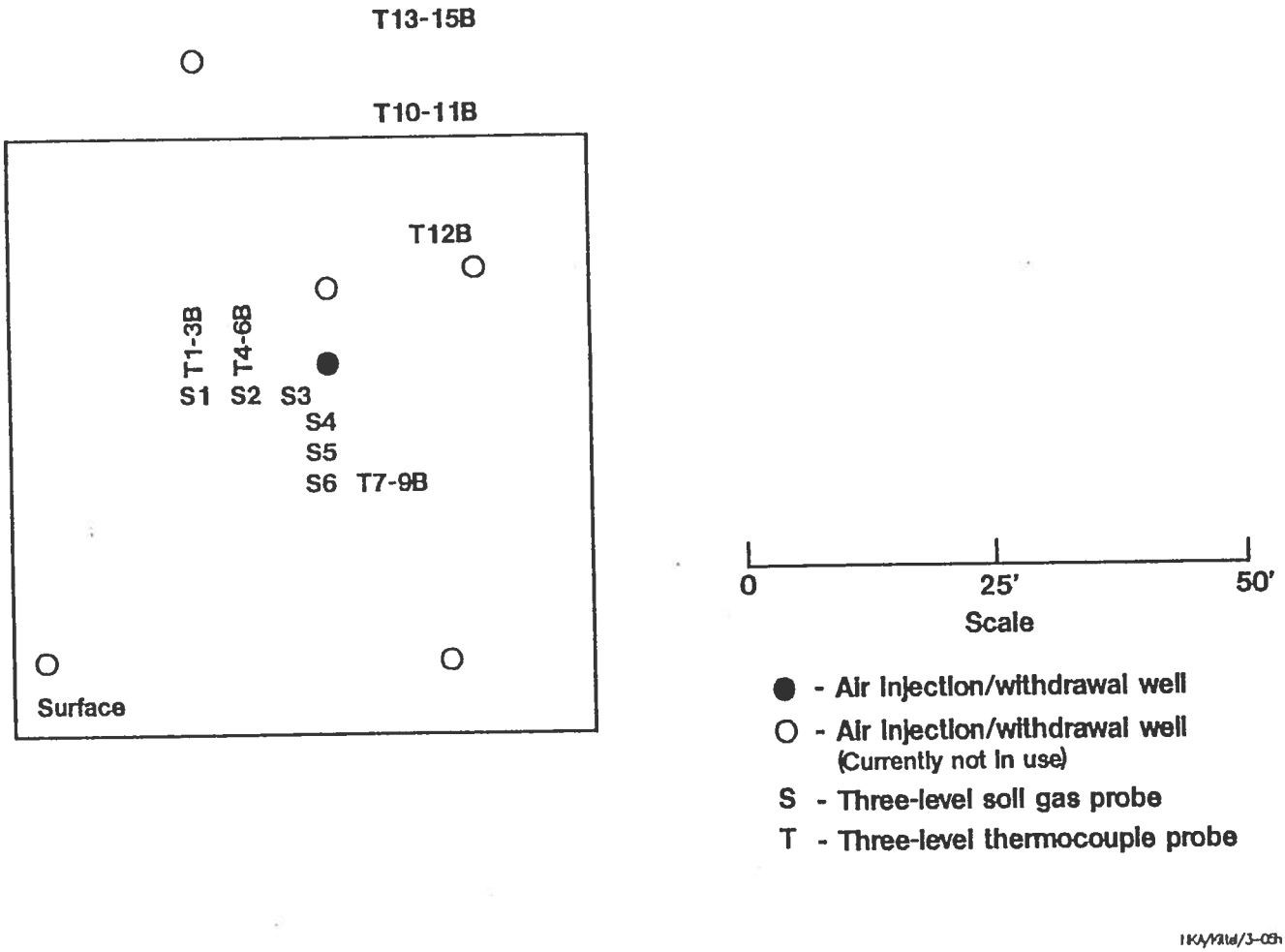


Figure 7. Schematic Diagram of the Surface Warming Test Plot

strips of heat tape were overlapped so that one strip can be disconnected if the soil temperature rises too high, yet relatively even heating of the test plot can be maintained.

In August 1992, two additional bioventing wells were installed at 6 ft, with 3 ft of 10 slot screen and 4 ft of schedule 40 PVC casing finished 1 ft above grade. A medium-grade silica sand filter pack was installed across the screened interval, and bentonite chips were used to fill the remaining annular space to grade.

In July 1993, two additional bioventing wells were for use during the soil vapor extraction test. The well installed inside the test plot was installed at 6 ft, with 5 ft of 10 slot screen and 2 ft of schedule 40 PVC casing finished 1 ft above grade. The well installed just outside the test plot was installed at 6 ft, with 4 ft of 10 slot screen and 3 ft of schedule 40 PVC casing finished 1 ft above grade. For both wells, a medium-grade silica sand filter pack was installed across the screened interval, and bentonite chips were used to fill the remaining annular space to grade.

The surface warming plot is turned on at the fuse box at the west end of the site trailer. It has two monitoring circuits on individual breakers and two 240 volt breakers.

6.0 BACKGROUND AND PERIMETER AREA

An uncontaminated area was located approximately 200 feet southwest of the contaminated site. One vent well and two soil gas monitoring points were installed in the background area. The background area was not insulated. One monitoring point was installed at a depth of only 3.5 ft, and one three-level soil gas monitoring point was installed during the second year of operation. One three-level thermocouple was installed in the background area.

An additional ten three-level soil gas probe locations (including background area) are situated outside of the test plots to monitor soil gas concentrations across the E-7 area (Figure 1). The probe locations S-4, S-9, and S-10 have only two probes installed at 2.0 and 4.25 ft. One three-level thermocouple was installed between the passive warming and the control test plot, two three-level thermocouples were installed between the active and surface warming test plot, one three-level thermocouple was installed between the active and passive warming test plot, and two three-level thermocouples were installed between the surface warming and the control test plot.

7.0 TEMPERATURE DATA LOGGER (OMEGA OM-5000)

Type J thermocouples were installed in groups of three at depths of either 2, 4.25, and 5.25 feet (thermocouples designated as A) or 2, 4, and 6 feet (thermocouples designated as B). A total of 79 thermocouples have been installed. The thermocouples are monitored using a programmable data logger to record temperature data.

The data logger reads the thermocouples every twelve hours and prints a hard copy as well as saving it to ROM memory. The memory may be downloaded to a computer through a 9 pin serial port cable. The operating manual and software are kept in the lower right hand drawer of the desk near the door of the trailer.

If temperatures read extremely high or low, this is probably due to corrosion of the connections for the thermocouples in the plots.

8.0 PROCEDURES FOR IN SITU RESPIRATION TESTING

8.1 Field Instrumentation and Measurement

8.1.1 Oxygen and Carbon Dioxide

Gaseous concentrations of carbon dioxide and oxygen are analyzed using a GasTech model 3252OX carbon dioxide/oxygen analyzer. The battery charge level is checked to ensure proper operation. The air filters are checked and, if necessary, cleaned or replaced before the experiment is started. The instrument is turned on and equilibrated for at least 30 minutes before conducting calibration or obtaining measurements. The sampling pump of the instrument is checked to ensure that it is functioning. Low flow of the sampling pump can indicate that the battery level is low or that some fines are trapped in the pump or tubing.

Meters are calibrated each day prior to use against purchased carbon dioxide and oxygen calibration standards. These standards are selected to be in the concentration range of the soil gas to be sampled. The carbon dioxide calibration is performed against atmospheric carbon dioxide (0.05%) and a 5% standard. The oxygen is calibrated using atmospheric oxygen (20.9%) and against a 5% and 0% standard. Standard gases are purchased from a specialty gas supplier. To calibrate the instrument with standard gases, a Tedlar™ bag (capacity ~ 1 l) is filled with the standard gas, and the

valve on the bag is closed. The inlet nozzle of the instrument is connected to the Tedlar™ bag, and the valve on the bag is opened. The instrument is then calibrated against the standard gas according to the manufacturer's instructions. Next, the inlet nozzle of the instrument is disconnected from the Tedlar™ bag and the valve on the bag is shut off. The instrument is rechecked against atmospheric concentration. If recalibration is required, the above steps is repeated. The Operating Manual for this instrument is provided in Attachment A.

8.1.2 Hydrocarbon Concentration

Petroleum hydrocarbon concentrations are analyzed using a GasTech Trace-Techtor™ hydrocarbon analyzer (or equivalent) with range settings of 100 ppm, 1,000 ppm, and 10,000 ppm. The analyzer is calibrated against two hexane calibration gases (500 ppm and 4,400 ppm). The Trace-Techtor™ has a dilution fitting that can be used to calibrate the instrument in the low-concentration range.

Calibration of the GasTech Trace-Techtor™ is similar to the GasTech Model 32402X, except that a mylar bag is used instead of a Tedlar™ bag. The oxygen concentration must be above 10% for the Trace-Techtor™ analyzer to be accurate. When the oxygen drops below 10%, a dilution fitting must be added to provide adequate oxygen for analysis. The Operating Manual for this instrument is provided in Attachment B.

Hydrocarbon concentrations can also be determined with a flame ionization detector (FID), which can detect low (below 100 ppm) concentrations. A photoionization detector (PID) is *not* acceptable.

8.2 In Situ Respiration Test Procedures

The oxygen, carbon dioxide, and total hydrocarbon levels is measured at the monitoring points before turning off air injection. After system shutdown, the soil gas is measured for oxygen, carbon dioxide, and total hydrocarbon. Soil gas is extracted from the contaminated area with a soil gas sampling pump system. Typically, measurement of the soil gas is conducted at 2, 4, 6, and 8 hours and then every 4 to 12 hours, depending on the rate at which the oxygen is utilized. If oxygen uptake is rapid, more frequent monitoring is required. If it is slower, less frequent readings is acceptable.

At shallow monitoring points, there is a risk of pulling in atmospheric air in the process of purging and sampling. Excessive purging and sampling may result in erroneous readings. There is no benefit in over sampling, and when sampling shallow points, care is taken to minimize the volume of air extraction. In these cases, a low-flow extraction pump of about 0.03 to 0.07 cfm (2.0 to 4.0 cfh) is used. Field judgment is required in determining the sampling frequency.

The in situ respiration test is terminated when the oxygen level is about 5%, or after 5 days of sampling.

INSTRUCTION MANUAL
TRACE-TECHTOR
PORTABLE HYDROCARBON VAPOR TESTER

G E M

GASTECH
ENVIRONMENTAL
MONITORS

DIVISION OF GAS TECH INC
8445 Central Avenue, Newark, CA 94560
Phone (510) 745-8700 FAX (510) 794-6201

WARNING

EXPLOSIVE GAS MIXTURES CAN MAIM, DISFIGURE, AND KILL. TOXIC VAPORS CAN CAUSE IMPAIRMENT OF HEALTH. IT IS ESSENTIAL THAT USERS OF THIS INSTRUMENT READ, UNDERSTAND, AND FOLLOW THE INSTRUCTIONS FOR OPERATION AND MAINTENANCE, AND THE PRECAUTIONS CONTAINED IN THIS MANUAL TO INSURE THAT THE INSTRUMENT IS USED IN A PROPER AND SAFE MANNER.

THE SENSOR USED IN THIS INSTRUMENT REQUIRES OXYGEN TO OPERATE. THIS INSTRUMENT IS INTENDED FOR MONITOR WELL TESTING, INTERSTITIAL SPACE TESTING, SOIL VAPOR ANALYSIS AND OTHER APPLICATIONS OF HYDROCARBON GAS OR VAPOR DETECTION IN AIR. DO NOT USE TO CHECK HYDROCARBON VAPOR LEVELS IN VESSELS THAT HAVE BEEN PURGED, WITH CO_2 OR OTHER INERT GAS, WITHOUT THE USE OF A DILUTION FITTING OR OTHER METHOD OF INTRODUCING OXYGEN INTO THE SAMPLE. LIKEWISE, USE OF THE INSTRUMENT IN OXYGEN ENRICHED MIXTURES IS BEYOND THE NORMAL SCOPE OF ITS INTENDED APPLICATION.

THIS DEVICE IS SAFE FOR TESTING MOST MIXTURES OF COMBUSTIBLE GAS IN AIR. IT IS CERTIFIED BY THE MANUFACTURER TO BE INTRINSICALLY SAFE IN CLASS I, DIVISION 1, GROUP C AND D ENVIRONMENTS.

VERSIONS OF THIS INSTRUMENT WHICH HAVE "NOT FOR METHANE USE" PRINTED ON THE METER DIAL DO NOT RESPOND TO METHANE OR NATURAL GAS. THESE INSTRUMENTS MUST NOT BE USED FOR DETECTION OF METHANE OR NATURAL GAS.

EXPLOSIVE MIXTURES OF ACETYLENE OR HYDROGEN IN AIR (GROUP A AND B ATMOSPHERES) ARE UNSUITABLE ENVIRONMENTS FOR PERSONNEL AND FOR ELECTRICALLY OPERATED INSTRUMENTS. THIS INSTRUMENT WAS NOT DESIGNED FOR USE UNDER SUCH CONDITIONS AND IS NOT CERTIFIED INTRINSICALLY SAFE FOR GROUP A AND B ATMOSPHERES.

DO NOT SAMPLE OR TEST OXYGEN-ACETYLENE MIXTURES AS FOUND IN OXY-ACETYLENE WELDING AND CUTTING EQUIPMENT. DO NOT USE FOR DETECTION OF TOXIC GASES OTHER THAN ORGANIC VAPORS IN THE TOXIC RANGE.

SPECIFICATIONS
GASTECH ENVIRONMENTAL MONITORS
TRACE-TECHTOR

			Standard	(Optional)
Serial No:	GT012	Ranges:	0-100 ppm	0-500
			0-1000 ppm	0-5000
			0-10,000 ppm	0-5,000
Sensor Type:	Catalytic	ALARMS:	100 ppm	500
			1000 ppm	2000
			2000 ppm	10,000
Calibration:	Hexane			

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PARTS LIST 17

I. INTRODUCTION

The Trace-Techtor is a portable instrument for detection of hydrocarbon vapors over a broad range. It includes the following features:

- Rugged water-resistant case
- Sample-drawing configuration for testing confined spaces
- Audible alarms for
  - Low battery charge
  - Low flow rate (also lights LED on control panel)
  - High level of hydrocarbon vapor
- Three ranges of detection
- High-stability catalytic combustion sensor

An excellent application of the Trace-Techtor is to determine concentrations of petroleum-based hydrocarbon vapors in industrial and environmental operations. It can be useful for testing UST monitoring wells, soil samples, fugitive emissions, and many other applications where total petroleum hydrocarbon vapor levels need to be detected.

The Trace-Techtor is typically calibrated to hexane, which provides readings representative of total petroleum hydrocarbons. The standard unit is designed to have no response to methane (natural gas), to avoid unwanted and confusing readings from this gas. If methane response is desired, the Trace-Techtor can be supplied in a version that will respond to methane. Units which say "NOT FOR METHANE USE" on the lower right hand side of the meter dial do not respond to methane.

The "FULL RESPONSE" version of the Trace-Techtor is a good instrument to use for fugitive emissions testing, or as a general purpose hydrocarbon gas or vapor monitor. This version does respond to natural gas (methane) and therefore does not say "NOT FOR METHANE USE" on the meter dial. Standard calibration is hexane unless specified otherwise when ordered.

II. DESCRIPTION

A. Housing

The Trace-Techtor has a fiberglass case which is durable, shock resistant, and water resistant. The lower half contains the battery, sensor, and sample drawing system; the upper half contains all of the electronic circuitry. A large handle makes the Trace-Techtor easy to carry and pick up. The lip of the upper case overlaps the lower, to shed water. Upper half is clamped to lower by a knurled screw.

B. Combustible Gas Sensor

The combustible gas sensor is installed in an anodized aluminum reaction chamber by means of a threaded ring, and sealed by an o-ring gasket. The sample enters the chamber from the lower front, flows over the detector, and then exits the chamber.

The active detector element is coated with a platinum catalyst. An identical but non-catalytic reference element is mounted in the same environment to stabilize the measurement and compensate for effects of non-combustible gases, temperature variation, etc. Elements are protected by a sintered stainless steel flame arrestor, which prevents outward propagation of flame should an explosive atmosphere be sampled. Flame arrestor also acts as a diffuser to isolate elements from flow fluctuations.

Detector assembly connects to the circuit board at three screw terminals, accessible when upper half of housing is removed.

C. Meter

Hydrocarbon concentrations are displayed on a meter, visible through a window on the top face of the instrument case. The standard meter readout has a detection range of 0-100 ppm. When the selector switch is in the ppm range, meter readings are the actual gas concentrations. When the selector switch is in the PPM x 10 range, add one zero to the meter reading to get the actual PPM concentration. In the PPM x 100 range, add two zeroes to the meter reading to get the actual concentration.

A mark on the scale, "BATT CK" represents the minimum permissible battery voltage, as an indication of the state of charge of the battery.

D. Controls and Indicators

There are only two controls that are used during normal operation of the instrument—the selector switch and the zero adjustment. The selector switch turns the instrument on and off, selects the desired range, and tests the battery condition. The zero adjustment is used to adjust the meter to read zero in fresh air.

Additional internal potentiometer controls for span, coarse zero, and alarm settings are accessible on the circuit board and are described in later sections of this manual.

A red indicator light labeled "LOW FLOW" is located near the center of the control panel. If the sample flow ever drops below an acceptable level, this light will be lit and a steady audible alarm will sound. This function can be tested by blocking the sample probe inlet momentarily with your finger after the unit is warmed up.

E. Recorder Output

Recorder output jacks are provided to connect to a recorder or data logging device, if desired. The output is 0-1.0 VDC, with 1.0 VDC corresponding to full-scale meter deflection on any of the three ranges available.

F. Buzzer

The buzzer is mounted inside the instrument, and it sounds a steady or pulsed tone for the following conditions:

STEADY	PULSED
Low Battery	Vapor Alarm
Low Flow	
Improperly zeroed sensor	
Defective or disconnected sensor	

The pulsed vapor alarms may be disabled by the alarm cutout switch, which is a dip switch located directly behind the three alarm potentiometers on the circuit board. To disable, push switch #1 away from the #1 marking on the circuit board to the side of the switch labeled "ALM OFF". The steady tone alarms cannot be silenced since they are an indication that something is not working properly.

G. Batteries

The battery pack, consisting of seven 3.5 ampere-hour nickel-cadmium cells in series, is secured within lower half of case. The cells are sealed as a unit, either with threaded bushings in bottom for clamping to instrument case, or with holes all the way through to accommodate 3" long screws and a hold-down bar. Power output (red and black) leads extend from front end of pack, and terminate in a plastic plug connector which mates with a connector wired to the main circuit board. A third orange wire is also present but has no function on this model. A similar connector at rear connects to the charger socket, so that battery may be unplugged at both ends for convenient removal. Current limiting resistors sealed into the pack limit maximum current that can be drawn on short circuit. Battery pack will power the instrument for approximately 10 hours. A "polyfuse", which operates as a fuse but which recovers when the overload is removed, is also sealed within the pack, and serves as an added protection against short circuit or overload. Some versions of battery pack contain a replaceable one amp fuse instead of a "polyfuse". To replace fuse, remove red fuseholder with screwdriver and replace with 1 amp 3AG fuse.

H. Circuit Board

All circuit components are arranged on two epoxy glass printed circuit boards. The main board includes the power supply, the amplifier and alarm circuits, and associated controls. A second board (the switch board), is installed above the main board. The switch board is primarily related to the selector switch and is connected to the main board by three socketed ribbon cables. This board is inaccessible while the instrument is assembled, and it contains no user adjustments.

1. Five miniature adjustment potentiometers are provided on the underside of the main circuit card, available for user adjustment when the case is opened, by use of a small screwdriver.

a) PPM SPN, located near the front of the board, is used to adjust the PPM span or sensitivity, so that the instrument reads properly on a known gas sample. See CALIBRATION in section V. A. of this manual.

b) CRS ZER, located next to the PPM SPN potentiometer near the front of the board, is a coarse zero adjustment which is used if the sensor offset is out of range of the external zero adjustment. See ZERO ADJUSTMENT in section V.B. of this manual.

c) ALM (PPM x 1, PPM x 10, PPM x 100) adjustments are used to adjust the alarm settings in each of the gas ranges. See ALARM ADJUSTMENT in section V.C.2. in this manual.

2. Two miniature switches are also available. These are:

a) ALM ADJ switch, located in the center of the circuit board, is used when checking or adjusting alarm levels. See Alarm Level Verification and Adjustment in section V.C. of this manual.

b) Alarm cutout switch, labeled "ALM OFF" on one side and 1234 on the other, is located directly behind the three alarm potentiometers. This is a small four-pole dip switch. Only poles 1 and 2 are used in this version of the instrument. The pulsing audible vapor alarm is active when the small lever in position 1 is pushed towards the "1" imprinted onto the circuit board. The vapor alarms will be disabled if the lever is pushed away from the "1", to the far side of the switch labeled "ALM OFF" towards the instrument control panel. Pole 2 must remain in the far side position at all times for this instrument version.

WARNING

DO NOT LEAVE SWITCH 1 IN THE DISABLED POSITION IF AN AUDIBLE ALARM IS DESIRED.

I. Sample System

Sample system consists of the components in flow path:

1. Probe is a 10" long 1/4" OD plastic tube with a dust filter chamber at the upper end, forming a handle. This filter chamber is transparent plastic, so the filter condition is easily visible. To replace filter, unscrew filter chamber where it connects to the knurled base.

2. Hose is a 5' flexible polyurethane tube. It has a male quick-connect coupling on one end to match inlet fitting of instrument. The opposite end has a threaded fitting to connect the probe.

3. Hydrophobic filter attaches directly to the front of the instrument with a quick connect fitting. It should always be used if there is any danger of sucking liquid into the unit. The hydrophobic filter stops water-based liquids, and also doubles as an additional dust filter. The hydrophobic filter is a disposable item. If it gets filled with water it can be removed, the water shaken out, and the filter can be re-used. If it gets clogged with dust or hydrocarbon liquids are sucked into it, the filter must be replaced. **Since the filter will not stop gasoline or other hydrocarbon liquids, care must be taken not to suck these liquids into the unit, since they can damage or contaminate flow components.**

4. Inlet fitting is a quick-connect female coupling on front of instrument. To release, pull back on the knurled outer ring and pull hose or hydrophobic filter out of the fitting.

5. Internal filter is a 0.2 micron dust filter and also is hydrophobic, which prevents it from passing dust or water that may damage the pump, flow switch, or sensor.

6. Pump is a DC motor driven diaphragm type. It operates directly from the battery whenever power switch is on.

7. Reaction chamber, is an anodized aluminum block that holds the detector in flow path of sample. Flexible tubes connect chamber to other internal flow components.

8. Flow switch is located on the upper side of the circuit board, and sample flow is routed to it with a tube to the upper case. The flow switch has no user adjustable parts and will trigger the circuitry to sound a continuous low flow alarm if the flow rate ever drops below about 0.25 cc/minute (0.5 scfh). To verify flow switch operation, temporarily block probe inlet with finger and alarm should sound. Alarm will clear when blockage is removed and flow resumes.

J. Charger

The battery charger plugs into a polarized socket in the rear of the case. Charger provides a high current charge to the battery pack for a 16 hour period, and then cuts back to a sustaining charge. An amber light shows that the battery is receiving a charge. When complete, a green light shows that the battery is fully charged and ready for use.

K. Continuous Operation

Instrument can be operated continuously from a 12 volt DC source, such as a 12 volt vehicle battery, by use of a Continuous Operation Adapter. This is a power cord with with a mating plug to fit the charger socket. When connected to instrument and to a 12 volt source, it will carry the load and tend to recharge the battery. It may also be used as a DC charger.

Adapter is furnished with a cigarette lighter plug to fit any negative-grounded vehicle with 12 volt battery. Order part number 47-1501.

An adapter for operation from 115V AC is also available. Order part number 49-2037.

WARNING

THE INTRINSIC SAFETY RATING OF THE TRACETECHTOR DOES NOT APPLY WHILE BEING OPERATED FROM AN EXTERNAL POWER SOURCE, OR WHILE CHARGING.

III. OPERATION

A. Start Up

1. Attach hydrophobic filter, hose and probe to the inlet fitting on front of instrument.

2. Turn rotary switch to BATT CK. position and allow a 5 minute warm-up. Meter reading should be above the BATT CK. mark on the meter. If close to or below this mark, recharge battery before use.

3. Alarms heard during warm-up should be investigated. If pulsed alarm sounds, turn selector switch to PPM x 100 range and zero meter reading with external zero adjustment. If a steady alarm sounds, check for the following:

   a) Low battery. Turn selector switch to the BATT CK. position, and verify that meter reading is above the BATT CK. mark on the meter. If not, recharge battery before use.

   b) Below zero reading. Turn selector switch to PPM x 100 range and note if meter reading is below zero. If so, re-zero with external zero adjustment. If out of range of external adjustment, use internal coarse zero adjustment (see section V.B. of this manual).

   c) Defective sensor. If unit cannot be zeroed, sensor may be open or need replacement. Replace sensor and try again.

   d) Low flow. If the LOW FLOW light on side panel is lit, the flow is too low for the instrument to operate properly. Possible causes for a low flow condition are as follows:

      1) Clogged external filter or sample line. Disconnect the external hydrophobic filter and see if flow alarm silences. If it does, clear the hydrophobic filter of any water present by disconnecting it from the hose and shaking out any liquid. Also check that the hose or probe does not contain any dirt or other blockage. Replace filter if needed.

      2) Clogged internal filter. Remove and check the internal hydrophobic filter for water or dust clogging. Replace if required.

      3) Dirty or malfunctioning pump. If filter and tubing are all clear then pump may need to be cleaned, rebuilt, or replaced.

      4) If a non-water based liquid has been sucked into the unit recently, it is possible that the flow switch is damaged. To check flow switch connect a flow meter to the inlet and verify flow is less than 0.25 cc/minute (0.5 scfh). If flow switch is damaged, unit should be repaired before further use.

4. Test that flow system is fully functional by placing finger over inlet and verify that low flow alarm activates. Inlet should be checked with all sampling accessories connected (hose, probe, and hydrophobic filter), and finger placed over the probe tip. Allow a few seconds for flow alarm to activate when blocking inlet.

5. Adjust zero. After a five minute warm-up, or when reading in PPM range has stabilized, adjust the external zero knob to obtain a "0" reading. This must be done with selector switch in the PPM range, and with the probe sampling from a gas free location. If impossible to adjust the zero within the range of the external zero adjust potentiometer, adjust internal coarse zero adjustment (see section V.B. of this manual.).

6. Turn selector switch to desired range and hold hose inlet at point to be tested. Watch meter and note highest reading obtained. If meter reads over full scale, then move selector switch to the next position to change range to a less sensitive one. If reading rises above the alarm set point, a pulsed audible alarm will start, and will continue as long as reading remains above alarm point. After completing readings, purge instrument with fresh air before turning off.

Note

Because of the very high sensitivity of this instrument, the meter will tend to drift until sensor is thoroughly warmed up. Always let it run for 5 minutes or more, whenever possible, before operating on the PPM and PPM x 10 ranges. Take readings immediately after zeroing, and observe maximum deflection when sampling. It may be necessary to re-zero in fresh air periodically if using the instrument for many tests or for longer term testing throughout the day.

IV. INTERPRETATION OF GAS OR VAPOR READINGS

The PPM range is a very sensitive range, obtained by amplification of the signal from the catalytic element. Sensitivity is set for a direct reading in PPM of the gas for which the instrument is calibrated.

Even though the sensing element is compensated to minimize the effect of non-combustible gases, a residual effect is still observable in the sensitive ranges. The instrument may need to be re-zeroed if exposed to a gross change in humidity, or to a change in background level of CO_2 or other inert gas.

Most hydrocarbon gases or vapors will cause a response on the meter, but may not be direct reading. A hexane calibration provides a conservative reading representative of total petroleum hydrocarbon vapors present. If comparing these readings to another type of meter such as an FID or PID, you will find that the readings can be either higher or lower depending on several factors, such as the constituents of the hydrocarbon vapors, type of filters or lamps used, and gas used to calibrate the instruments. In general, the readings are a good indication of the level of hydrocarbon vapor contamination of the space being tested. When absolute levels are needed, samples must be tested in a qualified laboratory.

Soil contamination by hydrocarbon liquids can be tested by measuring the head space in a closed container half-full of soil. This test with any portable gas sensing instrument should be used only as a crude field indication of whether or not the soil is contaminated, and a soil sample should be sent to a laboratory for a more accurate determination of the contamination level. Any field gas detection instrument cannot be expected to provide the same reading as a laboratory tested soil sample, because they are not measuring the same thing. The gas or vapor detector can only measure hydrocarbons that have volatized or "evaporated" into a vapor state. Heavy hydrocarbons such as diesel or fuel oil do not fully evaporate at normal temperatures, so they will produce only relatively low levels of vapor (as compared to gasoline). A laboratory tested sample of diesel contaminated soil generally will indicate a much higher level of total hydrocarbons than a field vapor test may reveal, because the chemical extraction methods used for the laboratory test can also pick up the heavy hydrocarbons. Likewise, recent gasoline spills may reveal a higher field vapor reading than a laboratory soil sample test will produce.

V. CALIBRATION AND ADJUSTMENT

A. Calibration

Calibration of the Trace-Techtor should be checked periodically to assure proper response. Frequency of calibration depends on frequency and type of use the instrument receives. There is no set frequency of calibration that is correct for all users, so it is recommended that the unit be check fairly frequently at first (perhaps weekly) until a reasonable calibration need pattern is developed for your usage. For example, if the meter is used only once a month, then even monthly checks are not likely to be needed. The other extreme would be an instrument that is used constantly every day, and where the data accuracy is critical. Such frequent use in a critical application might demand the calibration be checked daily. Hexane is the recommended calibration gas, since it provides a conservative response representative of total petroleum hydrocarbon vapors present.

If the sensor is damaged or replaced, the unit should be recalibrated.

To calibrate:

1. Turn instrument on and allow at least a five minute warm up period. Verify battery is charged.
2. Open instrument case by loosening captive screw at front. Lift upper half of case slightly and move it 1/4" forward to disengage rear clamp, then separate the two halves. Locate the potentiometer on the front corner of the circuit board marked PPM SPN. This is the span adjustment.
3. Attach hose, probe, and hydrophobic filter to the instrument as it would be in normal operation.
4. Turn to PPM range and zero the meter using the external ZERO adjustment knob. If zero cannot be adjusted with the external adjustment, use the internal coarse zero adjustment. (See Section V. B.)
5. Attach upper end of flowmeter to the probe with the short piece of tubing included in the calibration kit. Note flowmeter reading.
6. Attach valve to cylinder and flowmeter to valve with the remaining tubing. Open valve just enough so that flow is the same as observed in step 5.
7. Watch meter and note highest reading. The desired reading is the PPM value marked on the calibration gas cylinder. (Selector switch should be in the appropriate position to read the concentration marked on the cylinder.) If the reading does not match the cylinder value, turn PPM SPN adjustment to give desired reading.

   Calibration kits and replacement cylinders are available from Gastech Environmental Monitors. The recommended cylinder is part number 81-0007E, which is a cylinder of nominal 40% LEL hexane marked with its PPM value, nominally 4400 PPM.

   Calibrate the unit with a concentration in excess of 1000 ppm, to minimize any calibration error that may occur due to humidity effects caused by the dry air which comes out of a compressed gas cylinder.
8. If zero cannot be adjusted, or if reading cannot be set high enough, replace detector.

B. Zero Adjustment

This instrument contains both an external fine zero adjustment and an internal coarse zero adjustment. Generally the external adjustment is all that is needed, but when replacing sensor or as sensor ages, it may become necessary to adjust the internal coarse zero. This potentiometer is accessible with the instrument opened and is located on the front of the circuit board labeled CRS ZER. Adjust as follows:

1. Turn instrument on and allow at least a five minute warm-up period.
2. Turn the external zero adjustment to the center of its adjustment range. This is a 10 turn adjustment, so count 5 turns from one end of its range. (First turn it fully clockwise and then back it off 5 full turns counterclockwise.)
3. Turn selector switch to PPM range.
4. Turn internal CRS ZER adjustment to bring the meter to a zero reading. Turning the adjustment clockwise increases the reading.
5. If unable to adjust meter to zero with the CRS ZER adjustment, sensor wires may be loose or sensor may need replacement

C. Alarm Level Verification and Adjustment

The Trace-Techtor contains individually adjustable gas or vapor alarms for each of the three ranges. These alarms are inactive for the first 30 seconds following turn on. See the Specifications at the front of this manual for alarm setting for this instrument.

Note

2000 ppm for hexane is roughly the same as 20% LEL hexane. Both versions of this instrument have a 2000 ppm alarm to alert the user that the concentration is approaching a flammable condition.

WARNING

ON THE 50,000 PPM UNIT, THE 10,000 PPM ALARM POINT INDICATES THE SAMPLE MAY BE TO A FLAMMABLE LEVEL ALREADY. USE EXTREME CAUTION WHEN SAMPLING SUCH AREAS TO AVOID POSSIBLE IGNITION OF THE TEST SPACE. ANY POSSIBLE IGNITION SOURCE, SUCH AS SPARKS, MATCHES, TORCHES, CIGARETTES, VEHICLES, ETC. MUST NOT BE USED NEAR A FLAMMABLE AREA.

The Trace-Techtor is designed to be intrinsically safe for use in Class I, Div. 1, Group C and D hazardous atmospheres, so if used properly it cannot be a source of ignition in these atmospheres.

1. Alarm Verification

Alarm levels can be checked with the ALM ADJ switch. It is located in the center of the circuit board, accessible when the instrument is open. To check alarm levels:

a) Separate top and bottom halves of instrument housing by loosening the large knurled screw near the front of the housing.

b) Turn instrument on and allow to warm-up.

c) Move selector switch to PPM range, and then press and hold the ALM ADJ switch.

d) Observe meter reading. Meter reading will read the level at which the alarm point is set.

e) Turn the selector switch to PPM x 10 and PPM x 100, and repeat the above (press ALM ADJ switch and observe meter reading) for these ranges.

2. Alarm Adjustment

Alarm levels are adjustable with the ALM ADJ switch and the ALM potentiometers. Alarm levels are factory-set at the levels shown in Specifications, but can be field adjusted as follows:

a) Follow steps a through d of the preceding Alarm Verification section.

b) While observing meter reading of alarm set point for PPM range, turn the adjustment potentiometer marked PPM x 1 located directly behind the ALM ADJ switch. Turning this adjustment will move the meter dial to a new alarm setting. Stop turning when meter displays the desired alarm level setting.

c) Repeat step b for PPM x 10 and PPM x 100 ranges; move the selector switch to those ranges and turn their respective alarm adjustment potentiometers to display the desired settings.

3. Alarm Cutout

An alarm cutout switch is provided in the event the instrument will be used as a survey tool only and no gas level alarms are desired. The alarm cutout switch is unlabeled and is located directly behind the three alarm adjustment potentiometers. This is a small four pole switch which utilizes only poles 1 and 2. The pulsing audible vapor alarm is active when the small lever in position 1 is pushed near the "1" imprinted onto the circuit card. The vapor alarms will be disabled if the lever is pushed away from the "1" to the far side of the switch labeled "ALM OFF", towards the instrument control panel. Pole "2" must remain in the ALM OFF position at all times for this instrument version.

WARNING

DO NOT LEAVE THE SWITCH IN THE DISABLED POSITION IF AUDIBLE VAPOR ALARMS ARE DESIRED.

VI. MAINTENANCE

A. Batteries

1. To check battery voltage, turn the selector switch to BATT. Recharge before voltage reads minimum. To charge:

   a) Turn selector switch to BATT position and note meter reading.

   b) Plug charger into power source and then into the socket on the rear of the Trace-Techtor. The meter reading should rise slightly as soon as charger is connected. If it does not, verify that AC outlet is active. If outlet is active but meter does not rise when charger is attached, charger may be defective.

   c) If meter reading does rise, turn instrument off and leave on charge for 16 hours.

   Note

   Do not attempt to charge while instrument is turned on.

   Charger provides a dual rate, timed charge. The amber LED lights when the instrument is charging. After 16 hours the green LED on the charger will light, indicating that charging cycle is complete.

2. If sufficient voltage cannot be obtained after charging, open instrument and :

   a) Check voltage output with a voltmeter, between red and black wires (unplug connector to gain access to pins). Voltage should be about 8.5 volts.

   b) If battery voltage is too low, and cannot be brought up by overnight charging, battery probably needs replacement. To remove, take out the two screws holding it to bottom of case, and unplug black and orange wire connector and charging end.

   c) If battery has no output and is the fused version, replace fuse. Remove existing fuse by unscrewing the red fuse holder on the battery with a screwdriver. Replace only with 1 AMP 3AG type fuse.

B. Combustible Detector

1. Sensor assembly may require replacement if:

   a) Meter cannot be set to zero within range of internal coarse zero potentiometer.

   b) Meter cannot be set to desired level within range of SPAN adjust.

2. To Replace Detector:

   a) Open instrument case.

   b) Disconnect the red, green and white wires at terminals on main circuit board, noting color coding.

   c) Unscrew knurled retaining cap at reaction chamber.

d) Pull out original detector and install new one. Be sure that o-ring is in place, under flange of detector.

e) Connect wires to terminals, turn power on, zero and calibrate new sensor after warm up.

C. Meter

If meter is damaged it can be removed for repair or replacement as follows:

1. With upper half of instrument removed from lower half and inverted, remove three screws holding circuit board to case.

2. Gently lift circuit board with meter out of case. Circuit board will remain attached to case by three ribbon cables.

3. Remove two nuts holding meter to circuit board, then remove meter.

4. Re-install new meter in reverse order of the above steps.

D. Circuit Board

Main circuit board can be removed by following the above steps 1-3 for meter removal and adding these additional steps:

1. Remove three connecting ribbon cables by unplugging from sockets on main board. Prying loose from sockets carefully with a small screwdriver can aid this step.

2. Remove tubing to bottom case at the quick disconnect fittings located in the bottom case. To remove, push the red flange into the fitting while pulling tube with other hand. Take note of which tube goes where.

3. Return defective circuit board to the factory for repair, or purchase new circuit card for replacement.

Note

When returning to factory for repair, please be sure problem has been narrowed down to the main circuit board, otherwise it is better to send in the complete top case assembly or the entire instrument for checkout.

E. Filters

There are three filtering stages used in the Trace-Techtor. They should all be maintained in good condition because their function is to protect other internal components from damage or unnecessary maintenance.

1. Probe filter is a cotton ball located in the clear plastic portion of the probe. It captures dust and other debris to prevent it from entering the hose. It is not a moisture trap. Periodically inspect to verify that this cotton ball is clean. To replace, unscrew probe body from probe base, remove dirty cotton ball, insert a new cotton ball and re-assemble. Cotton balls may be purchased from Gastech Environmental Monitors or any drug store.

2. External hydrophobic filter attaches directly to the front of the instrument with a quick connect fitting, and the hose attaches to the hydrophobic filter. This filter prevents water-based liquids from entering the instrument and possibly damaging the sensor or other internal components. It also further filters dust particles from the gas stream.

   This disposable filter should be replaced it if collects excessive amounts of dust, if hydrocarbon liquid is sucked into it, or if it is physically damaged. If water is sucked into it, remove the filter, shake the water out, and then re-install filter.

3. Internal hydrophobic filter is located in the lower portion of the instrument and is accessible when the instrument is open. The purpose of this filter is to provide one last filtering stage for both water and dust before the sample flow passes on to the pump, sensor, and flow switch.

   This filter can be replaced by disconnecting it from the yellow tubing sections and re-installing a new one. When installing new one, be sure the side of the filter marked "INLET" is facing towards the front of the unit and is connected to the hose leading to the inlet fitting.

CAUTION

Gasoline or other hydrocarbon based liquids can cause damage to hose, filters, and internal components.

F. Pump

Pump used is a DC motor driven diaphragm type. It should have long life, (several years in normal operation) but it may lose efficiency if dirt or liquid is drawn in and collects under the valves. Verify proper pump operation periodically by taking a sample and observing time for initial gas response to occur. This should be within 5 seconds for a 5' hose. It may also be checked with the flowmeter provided as a calibration accessory. Normal pump flow is generally about 2.0 SCFH.

If pump needs servicing, remove it by unscrewing two small screws holding it in the bottom of the case. Pump can be returned for repair on an exchange basis or it can be disassembled and cleaned. Replacement pump head assemblies are also available.

VII. PRECAUTIONS AND NOTES ON OPERATION

A. Heated Samples

When sampling spaces that are warmer than the instrument (hot tanks), condensation can occur as the sample passes through the cooler sample line. Water vapor condensed in this way can block the flame arrestor and interfere with pump operation, unless a hydrophobic filter is used.

If heated hydrocarbon vapors of the heavier hydrocarbons (flash point 90 degrees Fahrenheit or above) are present, they may also condense in the sample line and fail to reach the filament. Thus an erroneous low reading may be obtained.

B. Filament Poisoning

Certain substances have the property of desensitizing the catalytic surface of the platinum filament. These substances are termed "catalyst poisons" and can result in reduced sensitivity or in failure to give a reading on samples containing combustible gas. The most commonly encountered catalyst poisons are the silicone vapors, and samples containing such vapors even in small proportions should be avoided.

Occasional calibration checks on known gas samples are desirable, especially if the possibility exists of exposure to silicones.

C. Other Gases and Vapors

The instrument is designed and calibrated specifically for hexane unless specified differently in the original order. It can be recalibrated and used on other gases and vapors, by proper use of the calibration control while sampling a known gas-air mixture.

Note

The Trace-Techtor cannot be used for methane or natural gas detection unless specifically provided for that use by the factory.

D. Oxygen Deficient Mixtures

Samples which do not have the normal proportion of oxygen may tend to read low because there is not enough oxygen to react with all combustible gas present in the sample. As a general rule, samples containing 10% oxygen or more have enough oxygen to give a full reading on any combustible gas sample up to 10,000 PPM. For lower concentrations of flammable gas, lower levels of oxygen are required for full response. If oxygen deficiency is suspected of a test space, a dilution fitting (Part No. 80-0403) should be used in order to get an accurate measurement.

E. Arson Investigation

Flammable liquids (gasoline, kerosene or paint solvent) are often used in starting intentional fires. Investigation of such fires can be greatly aided if the presence and location of such liquids can be determined at the site, as soon as possible after the fire is extinguished. The Trace-Techtor can be of great assistance in making this determination.

In testing for residual flammable liquids, look for places where the liquid could have been trapped and where it might remain even after the fire. Naturally, if the entire structure has been consumed there is little likelihood of any liquid or vapors remaining. Conversely, the earlier the fire has been extinguished, the greater the chance of finding significant amounts of liquid remaining.

To check for residual volatile liquids, set the instrument up in accordance with the preceding instructions and, allow it to run for at least 5 minutes. Then turn to PPM range and balance zero carefully immediately before taking the test.

Hold end of probe at point where vapors may be present, and watch meter carefully for any sign of a deflection. Check at joints or cracks between boards, for example, under baseboards or plates in contact with flooring. Pry boards up to form a small crack where hose or probe may be inserted. Check also under unburned portions of rug or upholstery, or any point where liquid might logically have soaked in and remained.

If a positive indication is obtained, trace it to the point of maximum reading. This is the point where samples should be taken for further lab analysis.

VIII. PARTS LIST

Stock No.	Description
07-6010	O-Ring Seal, hose (probe end)
07-6115	O-Ring Seal, combustible detector
30-0018	Pump, Gilian
30-0018E	Pump, Gilian, exchange
30-0021	Repair kit for Gilian Pump
33-0153	Filter, internal, hydrophobic
33-1031	Filter for probe, pkg of 24 cotton balls
47-1501	12 VDC Adapter/Charger
49-1571	Battery Pack, encapsulated with Ni-Cad batteries
49-2037	115 VAC Continuous Operation Adapter
49-2133	Battery Charger, 115 volts, dual-rate time controlled
49-2034	Battery Charger, 230 volts, for Ni-Cad batteries (single rate)
49-2134	Battery Charger, 230 volts, dual rate time controlled (user to provide AC plug)
49-8051	Battery Pack, Ni-Cad, replaceable cell type
50-5801E-A2	Meter, 0-100 PPM scale (No CH_4)
50-5801E-A4	Meter, 0-500 PPM scale (No CH_4)
61-0120TT	Detector Ass'y Catalytic, selected for Trace-Techtor
80-0150	10" Probe
80-0155	Probe, 30", aluminum
80-0224	Filter, external, hydrophobic w/ quick disconnect ftgs.
80-0403	Dilution fitting, 50/50
80-0800E-5	Hose, Polyurethane, inlet 5'
80-0800E-10	Hose, Polyurethane, inlet 10'
80-0800E-15	Hose, Polyurethane, inlet 15'
80-0800E-20	Hose, Polyurethane, inlet 20'
81-0007E	Spare cylinder of 4400 PPM hexane
81-0012E	Cylinder of 25,000 ppm methane in air
81-0086E	Cylinder of 5000 ppm methane in air
81-0221E-2	Calibration Kit for Trace-Techtor, w/2 cyl. of 4400 PPM hexane

SERVICE POLICY

GasTech Inc. maintains an instrument service facility at the factory. Some GasTech distributors also have repair facilities; however, **GasTech assumes no liability for service performed by other than GasTech personnel.** Should your instrument require non-warranty repair, you may contact the distributor from which it was purchased, or you may contact GasTech directly.

If GasTech is to do the repair work for you, you may send the instrument, prepaid to GasTech Inc. 8445 Central Avenue, Newark, CA 94560, Attn: Service Department. Always include your address, purchase order number, shipping and billing information and a description of the defect as you perceive it. If you wish to set a limit to the authorized repair cost, state a "not to exceed" figure. If you must have a price quotation before you can authorize the repair cost, so state, but understand that this involves extra cost and extra handling delay. GasTech's policy is to perform all needed repairs to restore the instrument to full operating condition, including reactivation of all out-of-warranty electrochemical cells.

To expedite the repairs operation, it is preferable to call in advance to GasTech Instrument Service, (510) 794-7015, obtain a Return Authorization Number (RA#), describe the nature of the problem and provide a purchase order number.

If this is the first time you are dealing directly with the factory, you will be asked to provide credit references or prepay, or authorize COD shipment.

Pack the instrument and all its accessories (preferably in its original packing). Enclose your Purchase Order, shipping and billing information, RA#, and any special instructions.

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STANDARD WARRANTY

GAS DETECTION INSTRUMENTS

We warrant gas alarm equipment manufactured and sold by us to be free from defects in materials, workmanship and performance for a period of one year from date of shipment from Gas Tech Inc. Any parts found defective within that period will be repaired or replaced, at our option, free of charge, f.o.b. factory. This warranty does not apply to those items which by their nature are subject to deterioration or consumption in normal service, and which must be cleaned, repaired or replaced on a routine basis. Such items may include:

a) Lamp bulbs and fuses

b) Pump diaphragms and valves

c) Absorbent cartridges

d) Filter elements

e) Batteries

f) Most catalytic and electrochemical sensors are covered by a separate warranty of 12 or 24 months.

Warranty is voided by abuse including rough handling, mechanical damage, and alteration or repair procedures not in accordance with instruction manual. This warranty indicates the full extent of our liability, and we are not responsible for removal or replacement costs, local repair costs, transportation costs, or contingent expenses incurred without our prior approval.

Gas Tech Inc.'s obligation under this warranty shall be limited to repairing or replacing, and returning any product which Gas Tech Inc. Material Review Board examination shall disclose to its satisfaction to have been defective. To receive warranty consideration, all products must be returned to Gas Tech Inc. at its manufacturing facilities with transportation charges prepaid.

This warranty is expressly in lieu of any and all other warranties and representations, expressed or implied, and all other obligations or liabilities on the part of Gas Tech Inc. including but not limited to, the warranty of fitness for a particular purpose. In no event shall Gas Tech Inc. be liable for direct, incidental or consequential loss or damage of any kind connected with the use of its products or failure of its product to function or operate properly.

This warranty covers instruments and parts sold (to users) only by authorized distributors, dealers and representatives as appointed by Gas Tech Inc.

Sls/Eng Rev. 1/90

4539-052589-0

INSTRUCTION MANUAL

GASTECHTOR

CARBON DIOXIDE/OXYGEN INDICATOR

MODEL 3252OX

SERIALS: L 0213

CO_2 DETECTION RANGE: 0-5% CO_2

OXYGEN DETECTION RANGE: 0-25% O_2

ALARM SETTINGS:
CO_2: 0.5% CO_2 (Rising)
O_2: 19.5% O_2 (Falling)
O_2: 25% O_2 (Rising)

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Made By:

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8445 CENTRAL AVENUE
NEWARK, CALIFORNIA 94560 USA
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WARNING

Carbon dioxide is a colorless, odorless and tasteless gas that can produce a debilitating effect on humans, including impaired breathing. This gas is heavier than air and it seeks the lowest levels, displacing normal air. Where carbon dioxide is known to exist in locations such as manholes, tanks and tunnels, a test for excess carbon dioxide or sufficient oxygen content should be made before personnel enter the area. Entry into an oxygen (air) depleted space can cause immediate unconsciousness, followed soon by death by suffocation if resuscitation is not carried out promptly after loss of consciousness.

INSTRUCTION MANUAL

GasTechtor Portable Carbon Dioxide/Oxygen Indicator

Model 32520X

I. INTRODUCTION

The Model 32520X GasTechtor is a portable gas detection instrument designed to determine carbon dioxide and oxygen content of the air around various industrial processes. It reads carbon dioxide over the range 0-5% CO_2, actuating a characteristic alarm whenever reading exceeds a preset level, and oxygen over the range of 0-25% O_2, actuating an alarm when O_2 reading falls below a preset level.

Instrument is ruggedly constructed to withstand rough handling in industrial environments.

Samples of the atmosphere under test are drawn through a hose by means of a built-in pump and analyzed for CO_2 in a simplified NDIR (Non-Dispersive Infrared) cell and then for oxygen in an electrochemical cell. Solid-state amplifiers are used to amplify indications of the elements to give adequate voltage to drive the meter and the alarm circuits.

Power for the instrument is provided by a built-in rechargeable battery pack. An extension hose and probe permits withdrawal of sample from the space under test. The audible alarm sounds whenever CO_2 concentration exceeds, or O_2 concentration falls below, preset levels. An audible signal is also given in case of malfunction or a dead battery.

II. DESCRIPTION, DETAILED

A. Housing

The Model 32520X is housed in a fiberglass case which is durable, shock-resistant and protected against entry of water. The lower half, containing the batteries, oxygen sample chamber and sampling system, has no openings near the bottom and hence can safely be placed in mud or water up to 3 cm depth without hazard to the internal components.

The upper half contains all of the electronic circuitry plus the infrared cell for CO_2 detection, and is provided with a substantial carrying handle. The lip of the upper case overlaps the lower to shed water. Upper half is clamped to lower by means of a heavy-duty knurled thumbscrew.

2. The oxygen potentiometers are:

   a. OXY ZERO, to balance the oxygen circuit for Zero output when the detector is surrounded by oxygen-free gas such as nitrogen. Potentiometer is forwardmost of the three.

   b. DWN ALM Threshold, to set the oxygen concentration at which the low oxygen alarm is actuated. This alarm is actuated by falling O_2 concentration. It is the center of the three potentiometers.

   c. UP ALM Threshold, to set the oxygen concentration at which the high oxygen alarm is actuated. This alarm is initially set at 25% O_2 concentration. Potentiometer is located at the rear corner of the board.

I. Charger

A separate battery charger is provided, which plugs into socket in rear of case. This charger is the No. 49-2133 (49-2134 for 220-240V AC) dual-rate timed charger, which provides a full charge over a 16 hour period, then automatically cuts back to a sustaining rate. An amber light shows that battery is receiving a charge; when complete, the green light indicates that the battery is ready to use.

J. Sample system

Sample system consists of the flow path, from probe to sample inlet to pump to oxygen chamber to CO_2 reaction chamber. These components are further described below.

1. Probe, a 28" long, 1/4" OD stainless steel tube with transparent-bodied filter housing in handle. The cotton-ball filter element is readily replaced by unscrewing the filter housing from the threaded base. Filter should be inspected frequently and replaced when it becomes discolored. Probe is cross-drilled 4" from the end, to prevent water from being drawn into the instrument.

2. Hose, a 5' polyethylene lined tube with threaded connectors at each end, to mate with the probe and the inlet fitting on instrument.

3. Inlet fitting, a threaded male coupling on front of instrument.

4. Filter, a transparent-bodied disposable assembly with 1/4" nipples on inlet and outlet. Filter removes dust and liquid water from incoming sample, thus preventing interfering particles from entering the sensors. It is installed inside instrument housing.

5. Pump is of the motor driven diaphragm type, with a brushless DC motor having no commutator or sparking contacts. It operates from an internal voltage regulator whenever power switch is on.

6. Infrared cell, a tubular chamber with inlet and outlet fittings to allow the filtered sample to pass through it. Windows at each end allow infrared energy to pass through while at the same time keeping the sample confined within the cell. The sample flow discharges from the CO_2 cell to the oxygen chamber.

7. Oxygen chamber is an anodized aluminum block having inlet and outlet fittings and containing a diffusion cavity into which the oxygen cell is clamped. Cell is held in place by a metal retaining strap and sealed with an O-ring. The flow discharges through an opening at front of instrument after it has passed through cell.

K. Continuous Operation

Instrument can be opèrated continuously from a 12 volt DC source, such as a 12 volt vehicle battery, by use of a Continuous Operation Adapter. This is a power cord with plug to fit charger socket. When connected to instrument and to a 12 volt source, it will carry the load and tend to recharge the battery. It may also be used as a DC charger.

Adapter is normally supplied with a cigarette lighter plug, which is polarized correctly for a grounded-negative vehicle. Order Part No. 47-1501. If a separate battery is to be used, order an adapter with plus and minus spring clips, and be sure to observe polarity. An adapter for operation from 115V AC is also available. Order Part No. 49-2037.

B. Carbon Dioxide Sensor

Gas detection by the infrared method is based on the principle that every gas absorbs infrared energy of a characteristic frequency. In this instrument a broad-band infrared source (a heated filament) emits energy which is filtered to produce a narrow range of frequencies characteristic of CO_2, and passed through an enclosed chamber containing the gas sample to be analyzed. Any carbon dioxide in the sample selectively absorbs energy of that frequency, resulting in reduced infrared energy reaching the solid state sensor. This change in energy can be detected, amplified and used as an indication of CO_2 concentration, displayed on a meter and arranged to sound a alarm at a preset level.

Calibration and alarm settings are adjustable, using the potentiometers marked SPAN and ALARM respectively. Span can be set while a known gas sample is admitted to instrument. Alarm can be set as described in Section IV.B., calibration and adjustment.

C. Oxygen Sensor

The oxygen sensor is an electrochemical cell in which gold and lead electrodes are immersed in an alkaline electrolyte, and covered by a permeable fluorocarbon membrane. Oxygen from the surrounding atmosphere diffuses through the membrane and enters into an electrochemical reaction whose rate is directly proportional to the partial pressure of oxygen, the end product of this reaction being lead oxide. The current generated by this reaction is amplified and used to drive the meter and the alarm circuit. The detector is clamped into a cavity in an anodized aluminum block, through which the sample flows after it leaves the pump. Oxygen cell connects to circuit board by a 7-pin plug connector.

D. Meter

Indications of the instrument are displayed on a meter, visible through a window on top face of instrument case. Meter has two sets of graduations and reads carbon dioxide or oxygen concentration directly, depending on whether range switch is in the CO_2 or O_2 position. A mark on scale, "BATT CK", represents the minimum permissible battery voltage, as an indication of state of charge of the battery.

E. Controls and Indicators

The six controls that are used in normal operation of the instrument are arranged on the left side of instrument as viewed from the rear. These controls are recessed to minimize possibility of accidental operation.

1. POWER switch, an alternate-action pushbutton switch which energizes circuit when pressed. An orange indicator dot is exposed when the switch is in the ON position, serving as a mechanical pilot light.

2. BATT. CK. switch, a momentary push button switch, when pressed connects meter as a voltmeter for battery condition check. Instrument must be in CO_2 range for battery check switch to function.

3. Range, an alternate-action push button switch which selects the range displayed on the meter, either carbon dioxide in the "OUT" position or oxygen in the "IN" position. A colored indicator dot shows when the switch is "IN".

4. CO_2 ZERO, a slotted-shaft potentiometer which is used to adjust circuit to read zero in the absence of carbon dioxide.

5. OXY CAL, a slotted-shaft potentiometer which is used to adjust circuit to display 21% on the meter when detector is surrounded by known normal air.

6. ALARM switch, which when pushed in will silence the audible tone. It is an alternate-action push button switch similar to the POWER switch. When in the IN (alarm off) position an orange indicator dot shows.

7. Alarm lights, red (CO_2) and amber (O_2), illuminate when the corresponding channel is in alarm condition. Alarm lights operate regardless of the position of the Range and Alarm Switches.

F. Buzzer

A solid-state electronic buzzer is mounted at the rear of instrument, behind perforations which permit transmission of sound. The buzzer gives a characteristic pulsed tone on alarm in either range (rising CO_2, falling O_2) with O_2 alarm giving an alternating long-short pulse signal and CO_2 giving a series of long pulses. A continuous tone sounds in case of malfunction, either low battery voltage or downscale drift of meter, in case of high oxygen reading or when both ranges indicate an alarm condition simultaneously.

G. Batteries

The battery pack, consisting of seven 3.5 ampere-hour nickel-cadmium cells in series, is secured within lower half of case. The cells are sealed as a unit, either with threaded bushings in bottom for clamping to instrument case, or with holes all the way through to accommodate 3"-long screws and a hold-down bar. Power output (red, orange and

black) leads extend from front end of pack, and terminate in a plastic plug connector which mates with a connector on the main circuit board. A similar connector at rear connects to the charger socket, so that battery may be unplugged at both ends for convenient removal. Current limiting resistors sealed into the pack limit maximum current that can be drawn on short circuit. Battery pack will power the instrument for approximately 6 hours. A protective fuse (type 3AG 1 amp) is installed in a recessed fuseholder set into top surface of pack, and serves as an added protection against short circuit or overload.

GasTechtor instruments may be supplied with the 49-8051 Battery Pack with replaceable cells. This design was developed for the convenience of replacing any cell that may fail, in lieu of having to replace an entire battery pack. This battery pack is permanently secured by two screws through the bottom of the case.

An optional pack (49-8052) designed specifically for disposable batteries is also available. This battery pack will take alkaline or carbon flashlight type cells. This pack does not have a charger connection.

H. Circuit Boards

All circuit components are arranged on two epoxy-glass printed circuit boards, the main CO_2 board and the smaller O_2 board located above it. The CO_2 board includes the power supply, the gas detection amplifier and alarm circuits and associated controls for CO detection. The O_2 board includes similar components for O_2 detection, except it uses power from the CO_2 board.

Six adjustment potentiometers, three for CO_2 on the CO_2 board and three for O_2 on the O_2 board, are provided on underside of circuit boards, available for user adjustment when case is opened. Oxygen potentiometers are circular in shape and clustered together in line near the rear of the O_2 board. Potentiometers for the CO_2 circuitry are square and are spread across the CO_2 board.

1. The CO_2 potentiometers are:

   a. SPAN, near center of board, to set sensitivity of CO_2 circuit to required value to produce a correct reading on a known calibrating sample.

   b. ALARM Threshold, at the front end of board, to set the gas concentration at which the CO_2 alarm is actuated.

   c. Coarse ZERO, at the rear end of board, to extend the range of the external ZERO for CO_2.

III. OPERATION

A. Normal Operation

To use instrument, carry out the following steps:

1. Connect probe and hose to fitting on front of instrument.

2. Press POWER switch to turn instrument on, with orange indicator dot showing. Meter will initially deflect upscale and pulsing alarm signal will sound. Audible hum of pump will be noticed.

3. With range select switch in CO_2 (OUT) position, press BATT CK button and note meter reading. If reading is below BATT CHECK mark on meter, turn off instrument and recharge batteries.

4. Allow to warm up in CO_2 range until meter stabilizes (about a minute). With probe inlet in a normal air location, turn CO_2 ZERO shaft to bring meter to halfway between 0 and the first increment on the CO_2 scale (approximately 0.05%).

5. Next, put range switch in OXY (IN) position. Verify that probe is in a normal-air location; then turn OXY CAL control to bring meter to 21% (CAL) indication.

6. Verify normal operations by breathing out through your mouth and letting the probe sample your expired breath.

   Oxygen reading should move downscale and activate the alarm at 19.5%. In CO_2 range, reading should come up to about 2.5%. Both alarm lights and a steady audible alarm tone should come on during this test.

7. To take a reading, select meter range with range switch either CO_2 or O_2. Place tip of probe at point to be tested, and watch meter. Any CO_2 or O_2 abnormality present will indicate on the scale, when in appropriate range. If reading exceeds CO_2 alarm setting (see cover) pulsed red light and audible alarm will commence and will continue until source of CO_2 is removed. If reading falls below oxygen alarm setting (normally 19.5%) pulsed amber light and audible alarm will commence, and will continue until normal oxygen content is restored.

   An atmosphere containing more than the normal 21% oxygen will produce an increased oxygen reading. A steady tone will sound when reading reaches or exceeds 25% O_2. Light does not accompany this high oxygen alarm.

8. Monitoring for carbon dioxide and for oxygen is continuous and simultaneous, independent of range switch position. If either condition goes off-normal, corresponding alarm light and audible signal will sound. If both abnormal gas conditions exist simultaneously, both lights will blink in their normal pattern but the buzzer will sound continuously.

B. Abnormal Indications

1. If battery voltage drops below the designed value (about 8 volts), the low battery alarm will sound. This is a continuous audible tone. To verify the cause of the alarm, press BATT CK switch and note that the meter reads below check mark. Instrument will operate for about 20 minutes after it goes into low battery alarm.

2. If CO_2 zero drifts or moves below 0 by 5% or more, the low limit alarm will sound. This is also a continuous tone, and the cause can be recognized by a glance at the meter. The following are possible causes for downscale meter movement:

   a. Incorrect zero adjustment

   b. Defect in infrared analysis cell.

3. Note that the instrument is equipped with a "live zero" in which the OFF or rest position of meter is about 5% of scale below the zero position. Thus a glance at the meter will show that the instrument is active. CO_2 Zero drift as far down as the OFF mark will actuate the malfunction alarm.

4. If oxygen cell output declines or deteriorates, as is likely toward the end of cell life, this will produce a reduced reading, and a low oxygen alarm.

5. If oxygen detector is unplugged, or if one of the wires connecting it internally is broken, reading will go to zero, and low oxygen alarm will sound.

6. The steady audible tone sounds when the oxygen reading exceeds 25%. This characteristic is provided to warn against the increased fire hazard due to excess oxygen. It also serves as a warning in case of oxygen cell failure in the high-output mode, which can occur occasionally. It further precludes accidental or intentional incorrect adjustment of the oxygen calibrate control to an abnormally high level above 25%.

IV. CALIBRATION AND ADJUSTMENT

A. Carbon Dioxide Calibration

The following steps should be carried out with the range switch in CO_2 OUT position.

To check and adjust calibration on a known gas sample:

1. Turn instrument on and allow it to warm up and stabilize, preferably for at least 5 minutes. Be sure batteries are charged sufficiently to read above the check mark, then adjust zero to give a reading of 0.05% (halfway between 0 and first mark on the upper scale) if setting is fresh air, or to 0.0 if detector is exposed to a known CO_2-free sample.

2. Open instrument case by loosening captive knurled screw at front. Lift upper half of case slightly, move 1/4" to rear to disengage rear clamp; then separate the two halves. Locate CO_2 SPAN potentiometer on underside of circuit board near middle.

3. Connect instrument inlet to a known calibrating gas sample. If the sample exists within a large container at atmospheric pressure, the hose inlet may be inserted into the container. Watch meter carefully, and when it reaches its maximum reading, adjust to match known CO_2 concentration of sample. To adjust, turn SPAN potentiometer using a small screwdriver. Clockwise rotation increases reading. This is a single-turn potentiometer.

4. If GasTech Calibration kit is to be used to introduce gas into the instrument, proceed as above but:

   a. Screw dispensing valve onto the calibrating gas cylinder and attach it to one branch of the plastic "Y" connector on the gas collecting bag. Attach the probe of the instrument to the other branch of the "Y" connector. Make attachments with the flexible plastic tubing provided in the kit.

   b. While instrument is operating, open dispensing valve until collecting bag remains partly distended.

   c. Make the SPAN adjustment as in Step 3 above.

5. If calibration cannot be completed successfully, replace infrared detector, (see MAINTENANCE, Section V.)

B. Carbon Dioxide Alarm Threshold

The reading at which the alarm is actuated can be set by use of the ALARM Threshold potentiometer. To set:

1. Turn ZERO to bring meter to desired alarm setting.

2. Turn ALARM Threshold potentiometer to the point where alarm just operates. Clockwise rotation will raise alarm setting. Verify setting by turning ZERO to bring meter into and out of alarm zone.

C. Oxygen Zero Adjustment

The following steps should be carried out with range switch in OXY IN position, to check and adjust zero on a known oxygen-free sample.

1. While instrument is still open, identify oxygen ZERO potentiometer, which is the forward-most of the three located at the rear of the oxygen circuit board.

2. Admit a known oxygen-free sample, such as nitrogen, argon or helium, to sample inlet.

3. Watch meter carefully. If reading does not go exactly to zero, adjust it by turning ZERO potentiometer. Counterclockwise rotation will decrease reading.

4. If zero adjust cannot be made, replace oxygen cell.

5. After zero adjustment has been completed, return probe inlet to normal atmospheric air. Readjust OXY CAL control as necessary to bring meter reading to 21%.

6. If reading cannot be set high enough, replace oxygen cell.

D. Oxygen Alarm Threshold

The readings at which the alarms are actuated can be set by use of the alarm threshold potentiometers. To set:

1. Turn OXY CAL control to bring meter needle down to desired alarm setting, for example 19.5%.

2. Locate DWN ALM threshold potentiometer, center of the group of three at the rear of circuit board.

3. Turn DWN ALM threshold potentiometer to the point where alarm just operates. Clockwise rotation will raise alarm setting. Verify setting by turning OXY CAL control to bring meter needle into and out of alarm zone.

4. High oxygen alarm is set by repeating steps 1 through 3 above, but adjust the UP ALM potentiometer located at the rear corner of the O_2 board. A setting of 25% is suggested.

5. To complete the oxygen circuit settings, turn the OXY CAL control as necessary to bring meter needle to the 21% position on the scale.

V. MAINTENANCE

A. Batteries

1. Check battery voltage periodically by pressing BATTERY CHECK switch. This check must be done while range switch is in CO_2 OUT position. Recharge before voltage reaches minimum.

   When connecting charger, always follow these steps:

   a. Confirm that the plug is inserted in the correct way, with the THIS SIDE UP label upwards. The socket is polarized, with the pins offset below the centerline, but can sometimes be forced on the wrong way, particularly if it has become worn with use.

   b. Verify that a charge is actually entering battery, by confirming that amber light is on. Leave connected until green light comes on, indicating that 16 hour charge is completed.

2. If sufficient voltage cannot be obtained after charging, open instrument and:

   a. Check battery voltage output with a voltmeter, between red and black wires (unplug connector to gain access to pins). Voltage should be about 8.5 volts.

   b. If no output voltage can be obtained, check battery fuse by unscrewing recessed cap, marked "FUSE", and removing fuse. It can be checked visually or with an ohmmeter. If burned out, replace with a new one, but be sure to attempt to identify the cause of the overload or short circuit. Fuse must be type 3AG-1A.

   c. If battery voltage is too low, and cannot be brought up by overnight charging, it probably needs replacement. To remove, take out the two screws holding it to bottom of case, and unplug black and orange wire connector at charging end.

3. If the replaceable cell battery pack has been installed and is found defective, open the pack and check the voltage of each individual cell with a voltmeter. To open remove two screws on the top of the pack with a 1/8" Allen wrench. The lid is spring loaded and may be held down by hand to ease the screw removal. Carefully remove the lid and the individual cells.

   a. The cells supplied are the Stock No. 49-1501 rechargeable D-size nickel-cadmium type, 3.5-4.0 AH, and when charged, measure about 1.35 volts. Discard and replace faulty cells.

b. Examine the battery cavity and carefully clean out all foreign substances. Reinsert the cells into the pack in accordance with the diagram on the lid. (Negative end to springs, button end to rivets.) Leave the proper space open for the fuse cartridge.

c. Place the lid onto the cells, press down firmly and insert screws. The convoluted case will assure cell alignment. Tighten the screws snugly, do not overtorque. It may be necessary to spring sides of instrument case apart slightly to clear battery lid.

d. Join all loose connectors, reassemble instrument and charge battery as required.

e. If normal operation from disposable batteries is desired, use the Stock No. 45-8052 battery pack instead of the 49-8051 pack. The spring-loaded top is held down by two knurled thumb screws. When replacing, tighten both screws at the same time to assure even compression of the springs and proper battery contact. Duracell* type disposable batteries are recommended for a proper fit.

This battery pack has no charger connection, so there is no danger of inadvertent charging of disposable cells. It can be used with rechargeable cells, but they must be charged separately.

B. CO_2 Coarse Zero

If CO_2 circuit cannot be set to zero within the span of the external ZERO control, then use the Coarse Zero control, marked ZERO, near edge of circuit board.

1. Set external ZERO shaft to the middle of its travel.

2. Adjust Coarse Zero control to bring meter to zero while testing a CO_2-free atmosphere. Clockwise rotation moves meter upscale.

C. Filters

1. The disposable plastic filter within housing is intended to remove dust particles and liquid droplets which might otherwise reach the sensors. Inspect it periodically, and replace it when the element becomes visibly dirty.

2. The probe handle contains a replaceable cotton-ball filter element and should be inspected frequently. Remove old cotton-ball by unscrewing end from housing and loosely inserting fresh cotton-balls as needed; do not pack tightly.

* Durcell is a trade name for Duracell, Inc., Bethel, CT 06801

D. Meter

If meter is damaged, it can be removed for repairs or replacement, as follows:

1. With upper half of instrument removed from lower half and inverted, loosen internal lock nuts from POWER and VOLT CK switch bushings.
2. Remove Zero Adj. potentiometer lock nut.
3. Remove face nuts from switch bushings and potentiometer
4. Remove three screws holding circuit board into case.
5. Remove two nuts from meter studs.
6. Pull circuit board out of case as far as connecting wires permit. *Zero adj. potentiometer will come free from its mounting hole, held to the circuit board by its wires.
7. Lift out meter.

E. If buzzer fails, it can be removed by first taking out circuit board (Steps D.1-D.6) and unsoldering red and black wires at alarm switch. Then remove retaining screws and nuts.

Note: Before replacement, first verify that buzzer is actually defective. Connect to a 6 volt battery (Red +, Black -). A good buzzer will give a steady tone.

F. Circuit Board

Main circuit board can be removed entirely from instrument by steps D.1-D.6, plus disconnection of pump and battery wires at connectors, and disconnection of wires from oxygen board at connectors.

Oxygen board can then be removed following removal of retaining nuts from remaining two switches and OXY CAL potentiometer, along with buzzer and the two threaded hex standoffs. *OXY CAL potentiomenter will come free from its mounting hole, held to the board by its wires.

G. Infrared Cell

To remove infrared cell, first complete steps D.1-D.7, then:

1. Disconnect inlet and outlet tubes from nipples.
2. Unsolder the three pins extending from cell header board at main circuit board.
3. Unsolder red and black wires, at circuit board. Cell can then be removed.
4. Cell is not field-repairable. Return to factory or order a new one.

*When replacing boards, each potentiometer must be installed before its respective board. Install potentiometers square with the instrument, with the wires extending toward the front. Be sure ground lug is in place on OXY CAL potentiometer.

H. Oxygen Cell

1. Oxygen Sensor assembly may require repair if:

   a. Meter cannot be set to desired level on air within range of OXY CAL Adjust.

   b. Meter cannot be set to zero on inert gas within range of ZERO potentiometer.

2. If oxygen cell requires repair, it should be sent to factory for reactivation, on an exchange basis. Alternatively, a complete new sensor can be ordered. To replace oxygen sensor:

   a. Open instrument case. Locate oxygen cell.

   b. Swing retainer clamp clockwise and remove it to release cell.

   c. Tilt cell upward and pull it out of case. Unplug cell wire at socket.

   d. Reinstall newly reactivated cell in same position. Before installing, remove protective seal from face of cell. Verify that cell is seated against its O-ring seal when installed.

   e. Oxygen cell is an electrochemical device similar to a battery which gradually depletes itself, regardless of usage of the cell. It requires periodic reactivation, consisting of replacement of the electrolyte and the membrane, plus cleaning and inspection of the electrodes. This is most economically done at the factory.

      New or reactivated cells are guaranteed usable for one year, and any cells returned for reactivation within that time period will be inspected and tested for operability. If found to have failed prematurely, they will be reactivated at a pro-rated cost. Cells are internally date-coded.

I. Pump

Pump used is a diaphragm type, driven by a DC motor. It should have long life, several years in normal operation, but it may lose efficiency if dirt is drawn in and collects under the valves. Verify proper pump operation periodically by taking a sample and observing time for gas response to occur. This should be within 5 seconds for a 3' hose.

If pump needs servicing, it can be removed by taking out the clamp retaining screw in bottom. Pump can be returned for repair on an exchange basis or it can be disassembled and cleaned. Replacement pump head assemblies are also available, as well as replacement valve sets and replacement diaphragms.

VI. PARTS LIST

Stock No.	Description
07-6216	O-ring, oxygen cell
14-3502	Retainer strap, oxygen cell
30-0017	Pump, rotary DC
30-0340	Pump head, replacement
30-0341	Pump diaphragm, replacement
30-0342	Pump valves, replacement, set of 2
33-0141	Filter, internal, Balston DFU-BQ
33-1031	Filter elements, probe
43-4140	Fuse, battery, 3AG 1A
45-8051	Battery pack, replaceable, rechargeable cell, less batteries
45-8052	Battery Pack, replaceable, disposable cell less batteries
49-1201	Battery, alkaline size D disposable
49-1501	Battery, Ni-Cad, rechargeable
49-1571	Battery Pack, Ni-Cad batteries
49-2133	Battery Charger, dual rate, time-controlled, 115 volts, for Ni-Cad batteries
49-2134	Battery Charger, dual rate, time-controlled, 230 volts, for Ni-Cad batteries
49-8051	Battery Pack, replaceable, rechargeable cell, with batteries
50-12XX	Meter, Dual range, CO_2 and oxygen, specify Job 4539
52-1005	Buzzer
57-8055M	Circuit board, oxygen, specify Job 4539
65-0601	Oxygen cell, new
65-0601E	Oxygen cell, reactivated
65-7001	Infrared cell, replacement
80-0006	Hose, Polyethylene-lined, 6'
80-0155M	Probe assembly, 28"

When ordering part, please specify Model 3252OX and Serial Number

SERVICE POLICY

GasTech Inc. maintains an instrument service facility at the factory. Some GasTech distributors also have repair facilities; however, **GasTech assumes no liability for service performed by other than GasTech personnel.** Should your instrument require non-warranty repair, you may contact the distributor from which it was purchased, or you may contact GasTech directly.

If GasTech is to do the repair work for you, you may send the instrument, prepaid, to GasTech Inc., 8445 Central Avenue, Newark, CA 94560, Attn: Service Department. Always include your address, purchase order number, shipping and billing information and a description of the defect as you perceive it. If you wish to set a limit to the authorized repair cost, state a "not to exceed" figure. If you must have a price quotation before you can authorize the repair cost, so state, but understand that this involves extra cost and extra handling delay. GasTech's policy is to perform all needed repairs to restore the instrument to full operating condition, including reactivation of all out-of-warranty electrochemical cells.

To expedite the repairs operation, it is preferable to call in advance to GasTech Instrument Service, (415)794-7015, obtain a Return Authorization Number (PA#), describe the nature of the problem and provide a purchase order number.

If this is the first time you are dealing directly with the factory, you will be asked to provide credit references or prepay, or authorize COD shipment.

Pack the instrument and all its accessories (preferably in its original packing). Enclose your Purchase Order, shipping and billing information, RA#, and any special instructions.

Rev. 9/89

GasTech Inc.

Standard Warranty

Gas Detection Instruments

We warrant gas alarm equipment manufactured and sold by us to be free from defects in materials, workmanship and performance for a period of one year from date of shipment from GasTech Inc. Any parts found defective within that period will be repaired or replaced, at our option, free of charge, f.o.b. factory. This warranty does not apply to those items which by their nature are subject to deterioration or consumption in normal service, and which must be cleaned, repaired or replaced on a routine basis. Such items may include:

a) Lamp bulbs and fuses

b) Pump diaphragms and valves

c) Absorbent cartridges

d) Filter elements

e) Batteries

f) Most catalytic and electrochemical sensors are covered by a separate warranty of 12 or 24 months.

Warranty is voided by abuse including rough handling, mechanical damage, and alteration or repair procedures not in accordance with instruction manual. This warranty indicates the full extent of our liability, and we are not responsible for removal or replacement costs, local repair costs, transportation costs, or contingent expenses incurred without our prior approval.

GasTech Inc.'s obligation under this warranty shall be limited to repairing or replacing, and returning any product which GasTech Inc. Material Review Board examination shall disclose to its satisfaction to have been defective. To receive warranty consideration, all products must be returned to GasTech Inc. at its manufacturing facilities with transportation charges prepaid.

This warranty is expressly in lieu of any and all other warranties and representations, expressed or implied, and all other obligations or liabilities on the part of GasTech Inc. including but not limited to, the warranty of fitness for a particular purpose. In no event shall GasTech Inc. be liable for direct, incidental or consequential loss or damage of any kind connected with the use of its products or failure of its product to function or operate properly.

This warranty covers instruments and parts sold (to users) only by authorized distributors, dealers and representatives as appointed by Gas Tech.

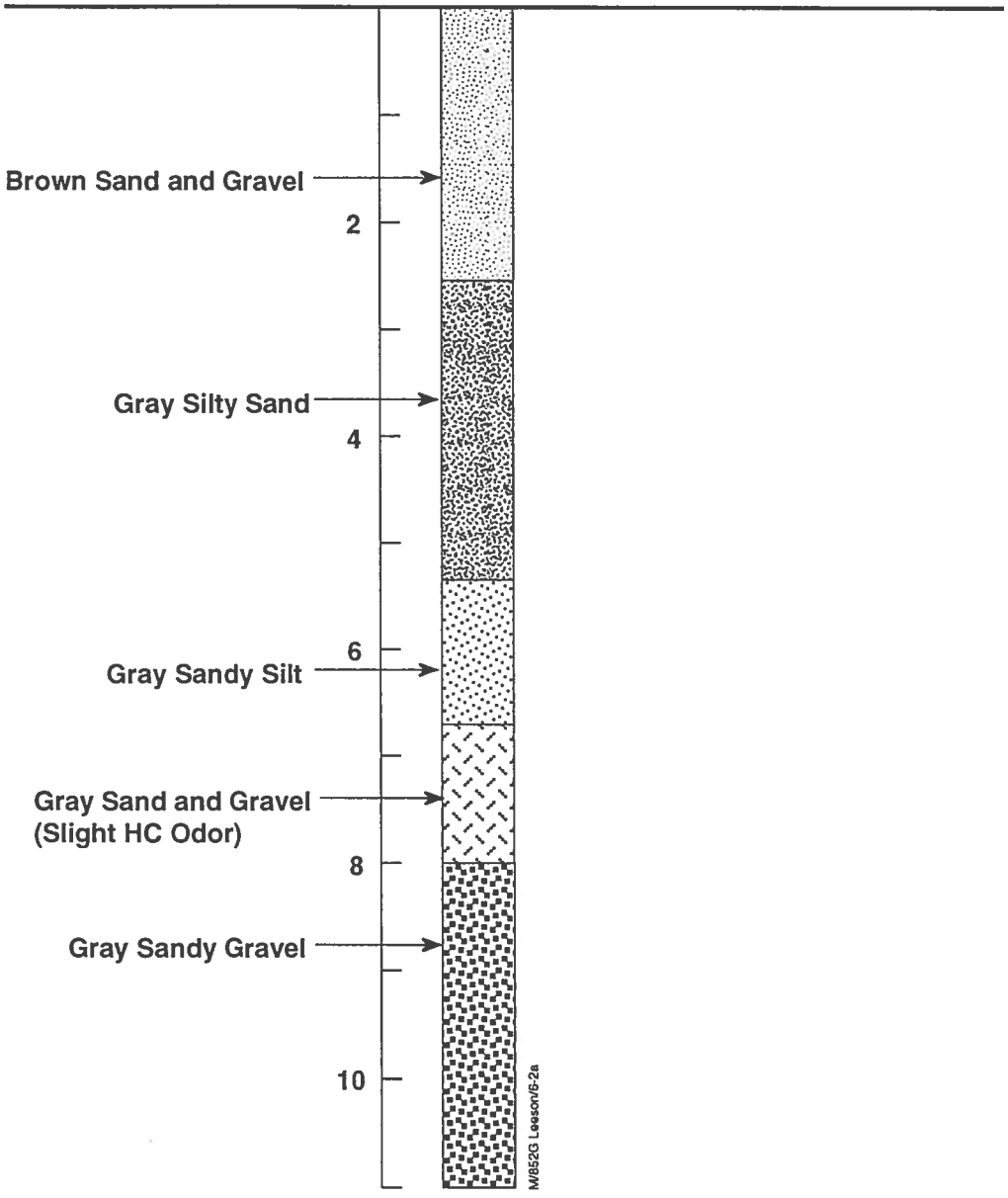
Sls/Eng Rev. 1/90

APPENDIX C

SOIL BORING LOGS

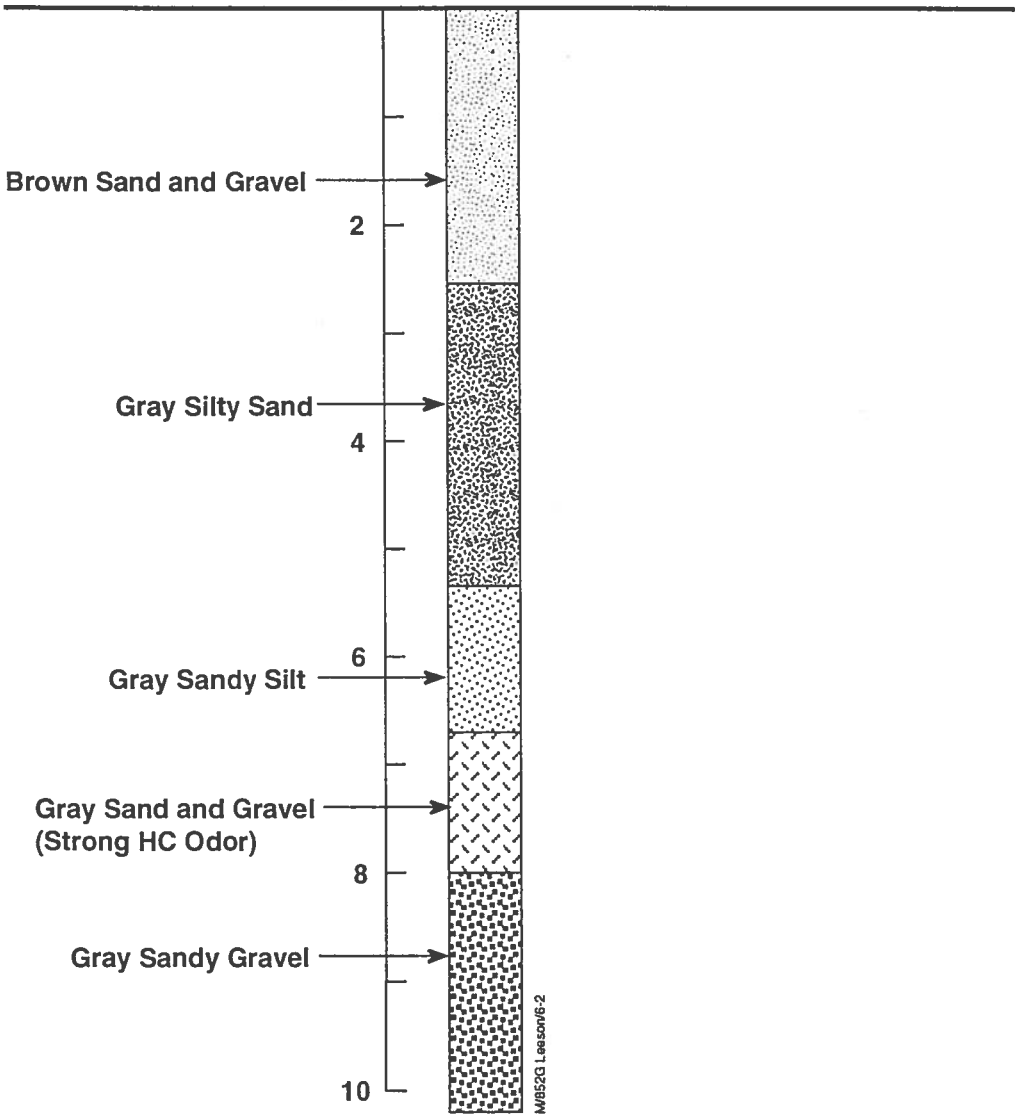
1994 FINAL SOIL SAMPLING
SOIL BORING LOGS

Surface Warming Plot
HF-1 Boring Log



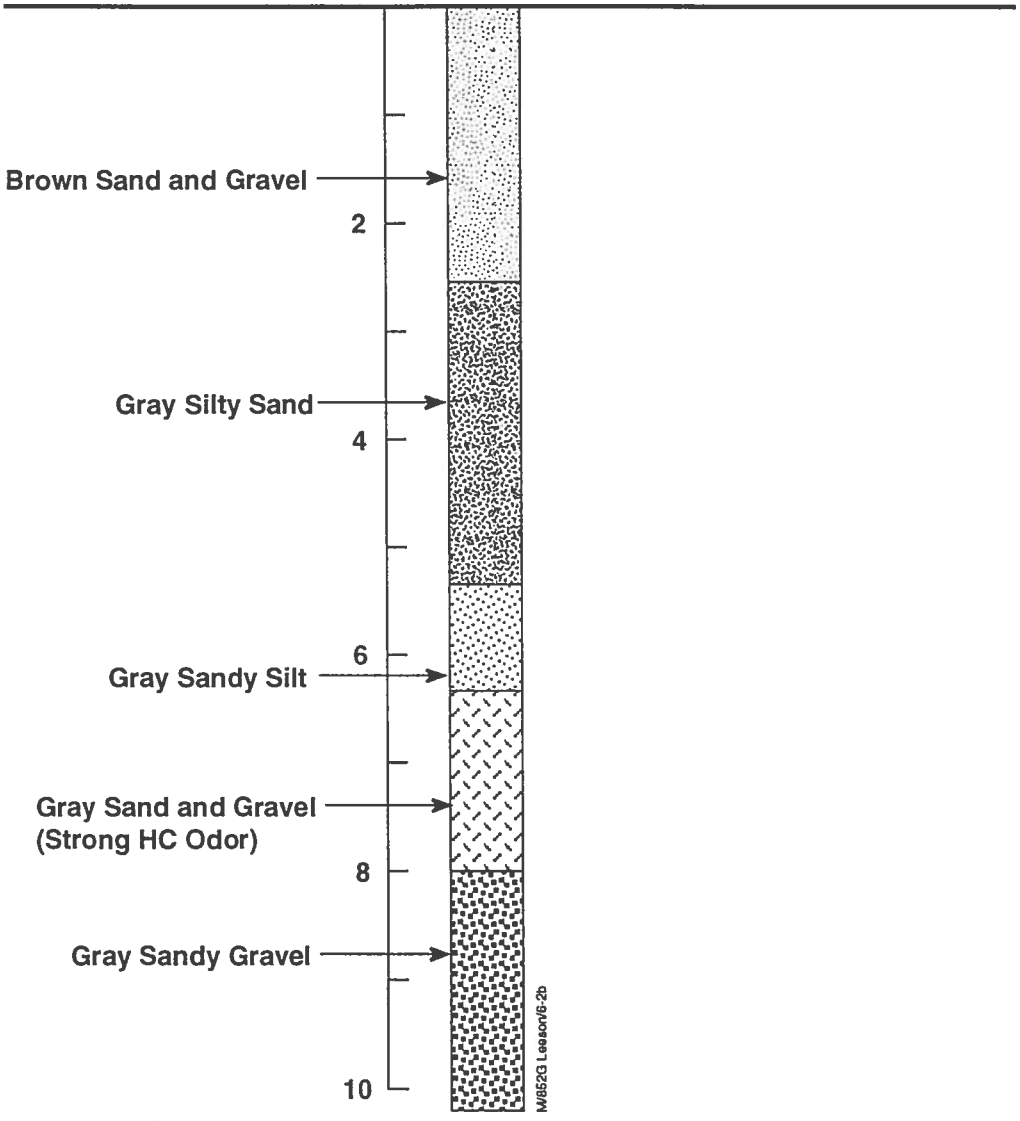
Soil Samples taken for TPH analysis at 5.5-6.0 ft, 6.5-7.0 ft, 7.5-8.0 ft, 8.0-8.5 ft, 8.5-9.0 ft, 9.5-10.0 ft, 10.0-10.5 ft, and 10.5-11.0 ft.

Surface Warming Plot
HF-2 Boring Log



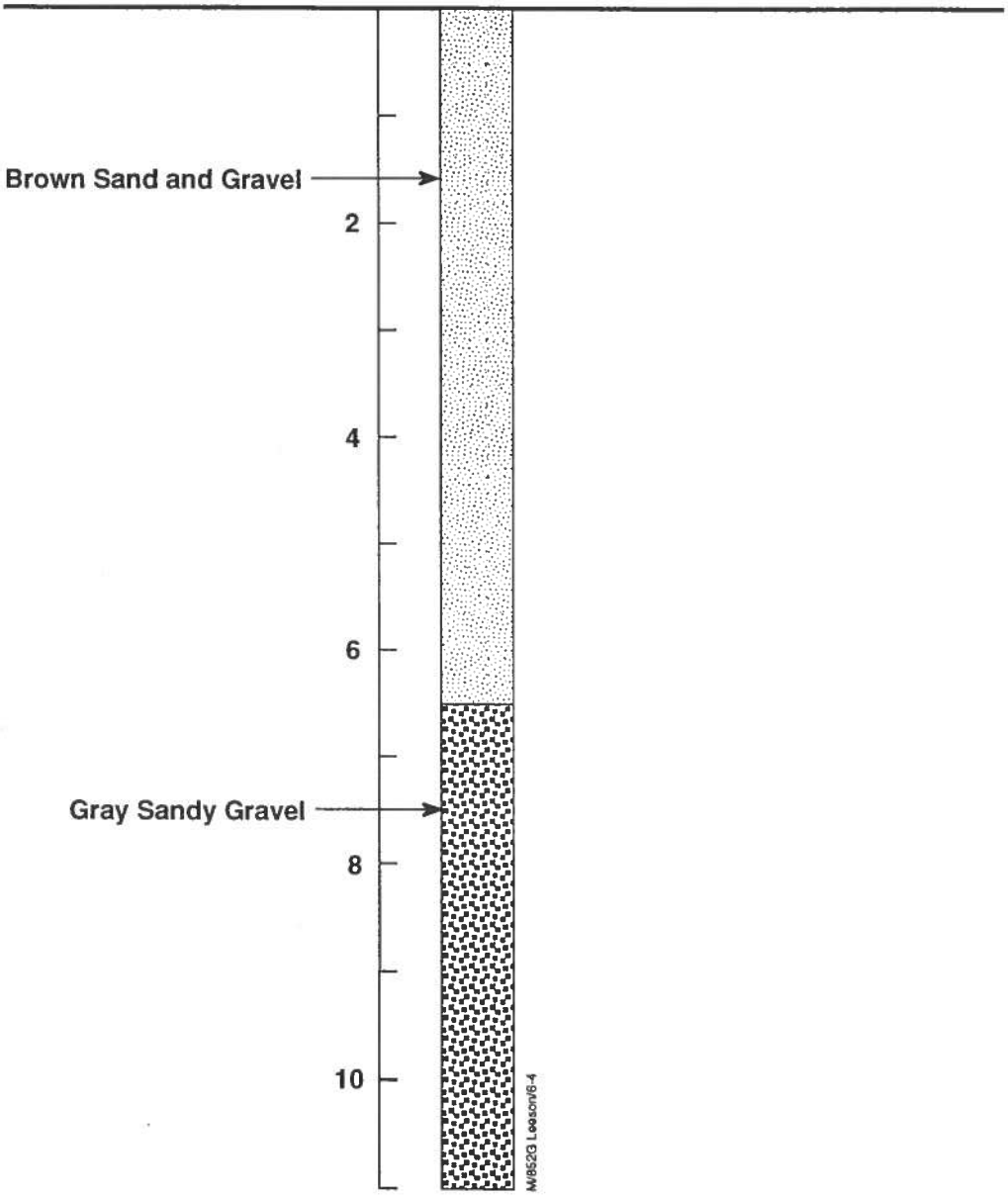
Soil Samples taken for TPH analysis at 4.5-5.0 ft, 5.0-5.5 ft, 5.5-6.0 ft, 6.5-7.0 ft, 7.0-7.5 ft, and 7.5-8.0 ft.

Surface Warming Plot
HF-3 Boring Log



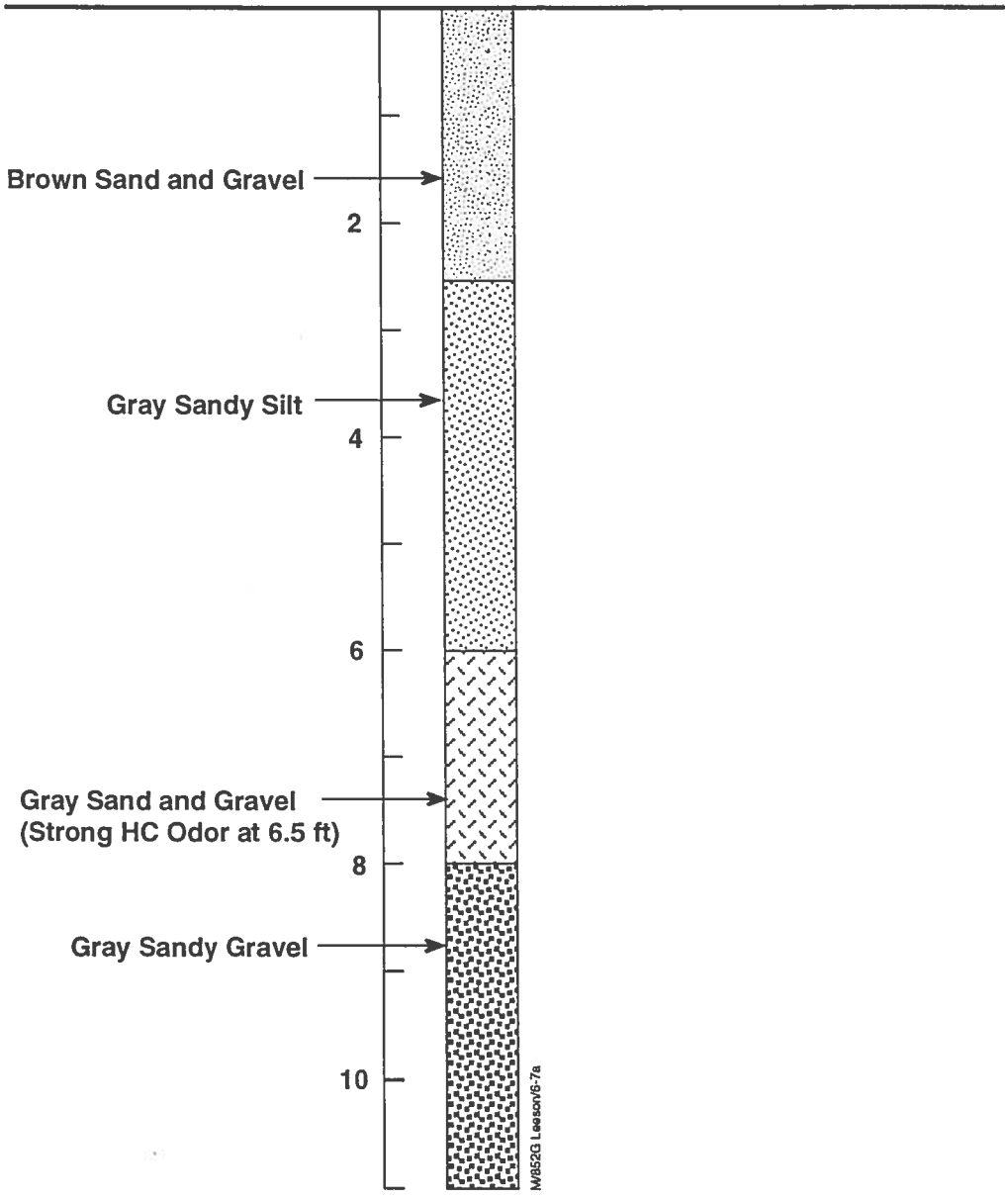
Soil Samples taken for TPH analysis at 4.5-5.0 ft, 5.0-5.5 ft, 5.5-6.0 ft, 7.0-7.5 ft, 7.5-8.0 ft, 8.0-8.5 ft, 8.5-9.0 ft, 9.0-9.5 ft, 9.5-10.0 ft.

Background Plot
BF-1 Boring Log



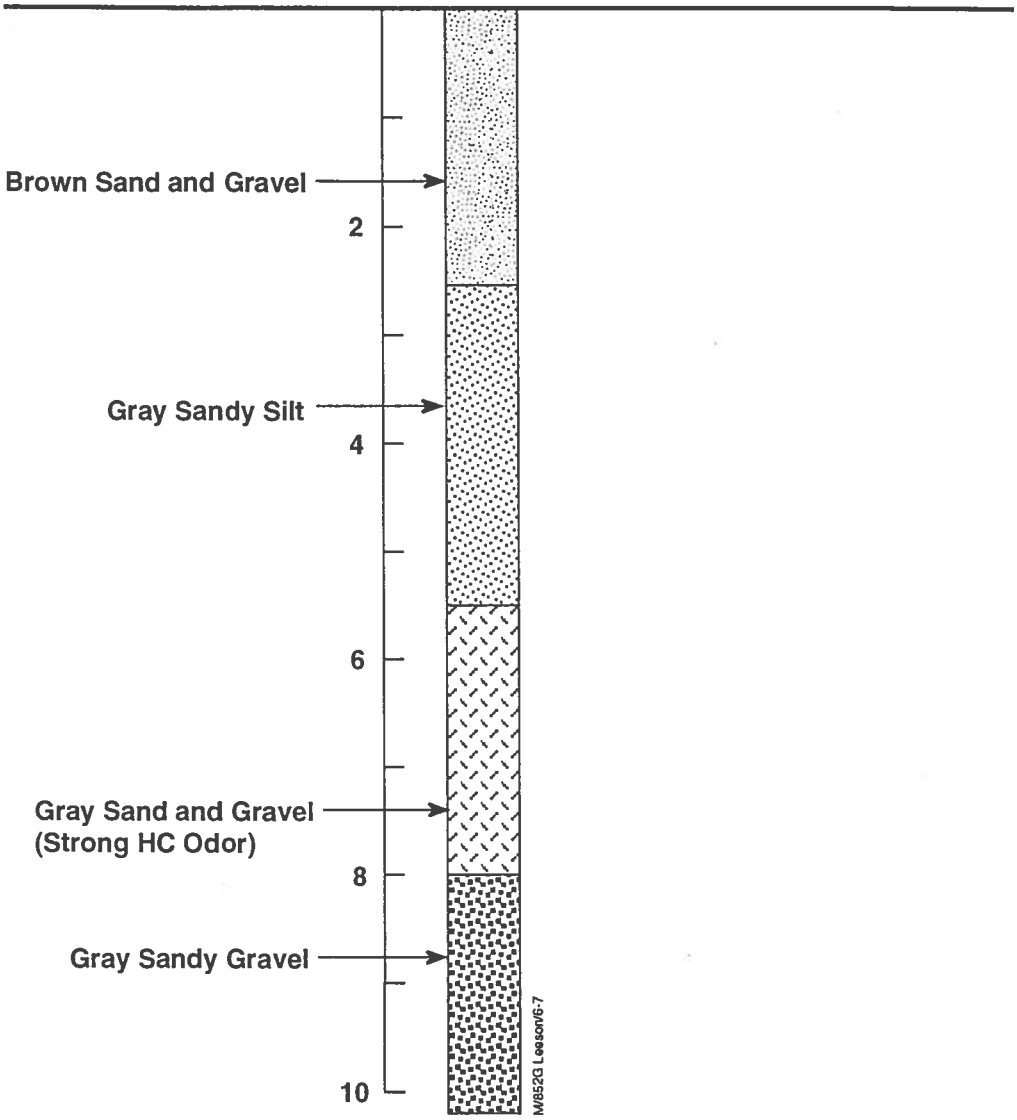
Soil Samples taken for TPH analysis at 6.0-6.5 ft, 6.5-7.0 ft, 8.0-8.5 ft, 8.5-9.0 ft, 10.0-10.5 ft, and 10.5-11.0 ft.

Passive Warming Plot
PF-1 Boring Log



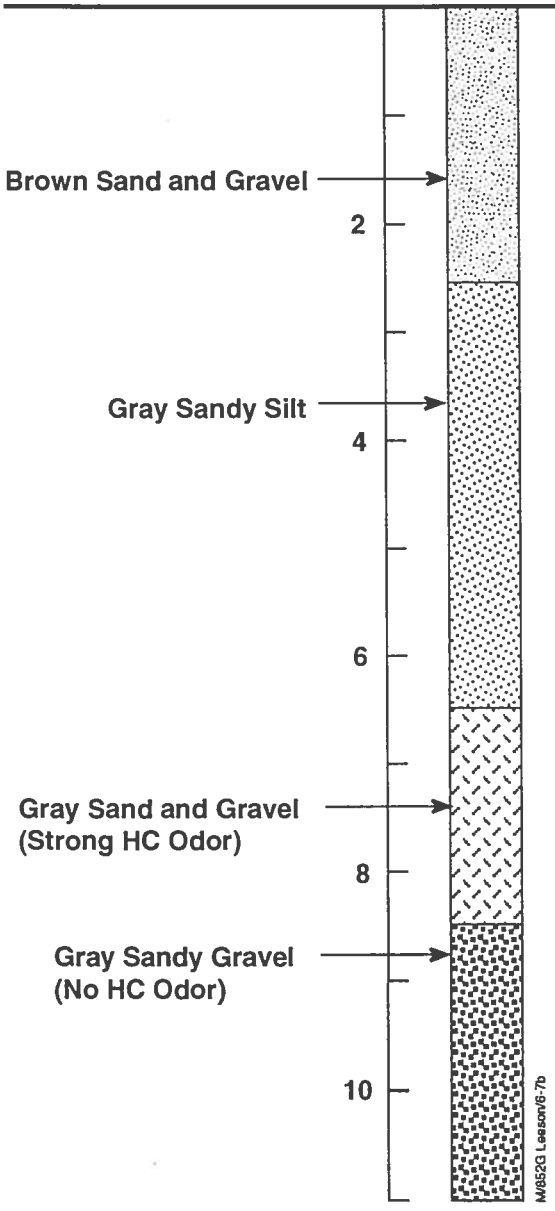
Soil Samples taken for TPH analysis at 5.5-6.0 ft, 6.0-6.5 ft, 6.5-7.0 ft, 8.0-8.5 ft, 8.5-9.0 ft, 9.5-10.0 ft, 10.0-10.5 ft, and 10.5-11.0 ft.

Passive Warming Plot
PF-2 Boring Log



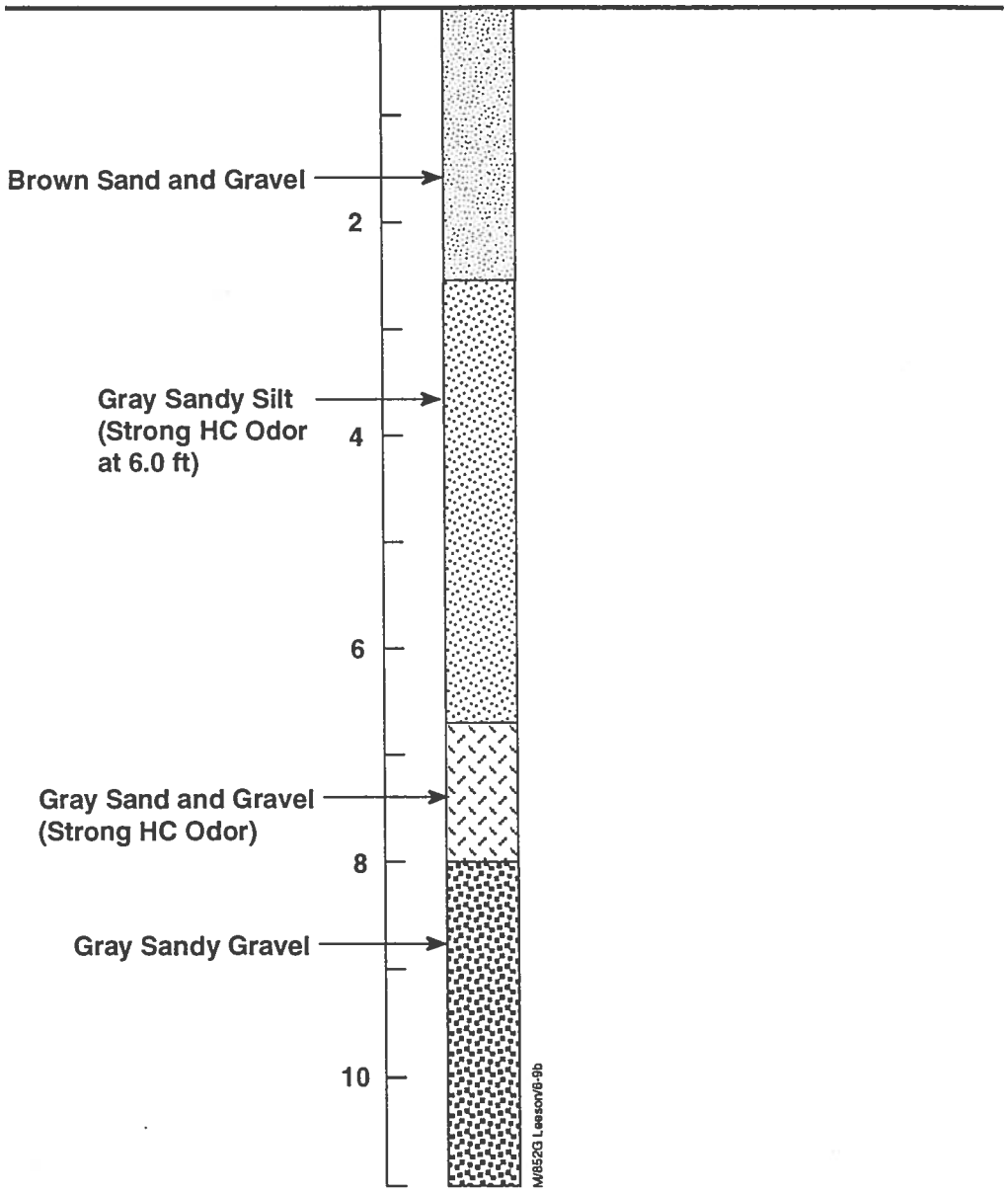
Soil Samples taken for TPH analysis at 5.5-6.0 ft, 6.0-6.5 ft, 6.5-7.0 ft, 7.5-8.0 ft, 8.0-8.5 ft, and 8.5-9.0 ft.

Passive Warming Plot
PF-3 Boring Log



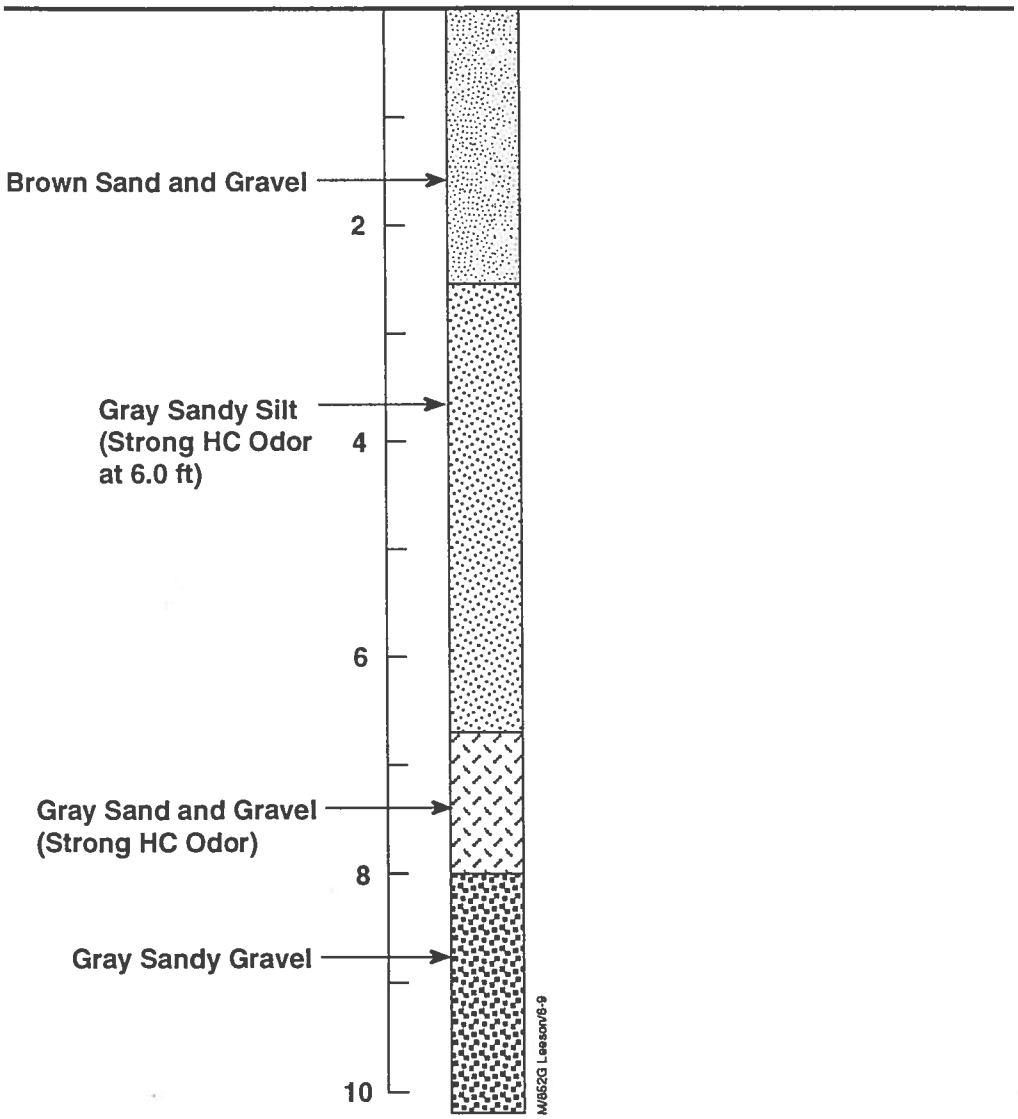
Soil Samples taken for TPH analysis at 6.0-6.5 ft, 6.5-7.0 ft, 7.5-8.0 ft, 8.0-8.5 ft, 8.5-9.0 ft, 9.5-10.0 ft, 10.0-10.5 ft, and 10.5-11.0 ft.

Control Plot
CF-1 Boring Log



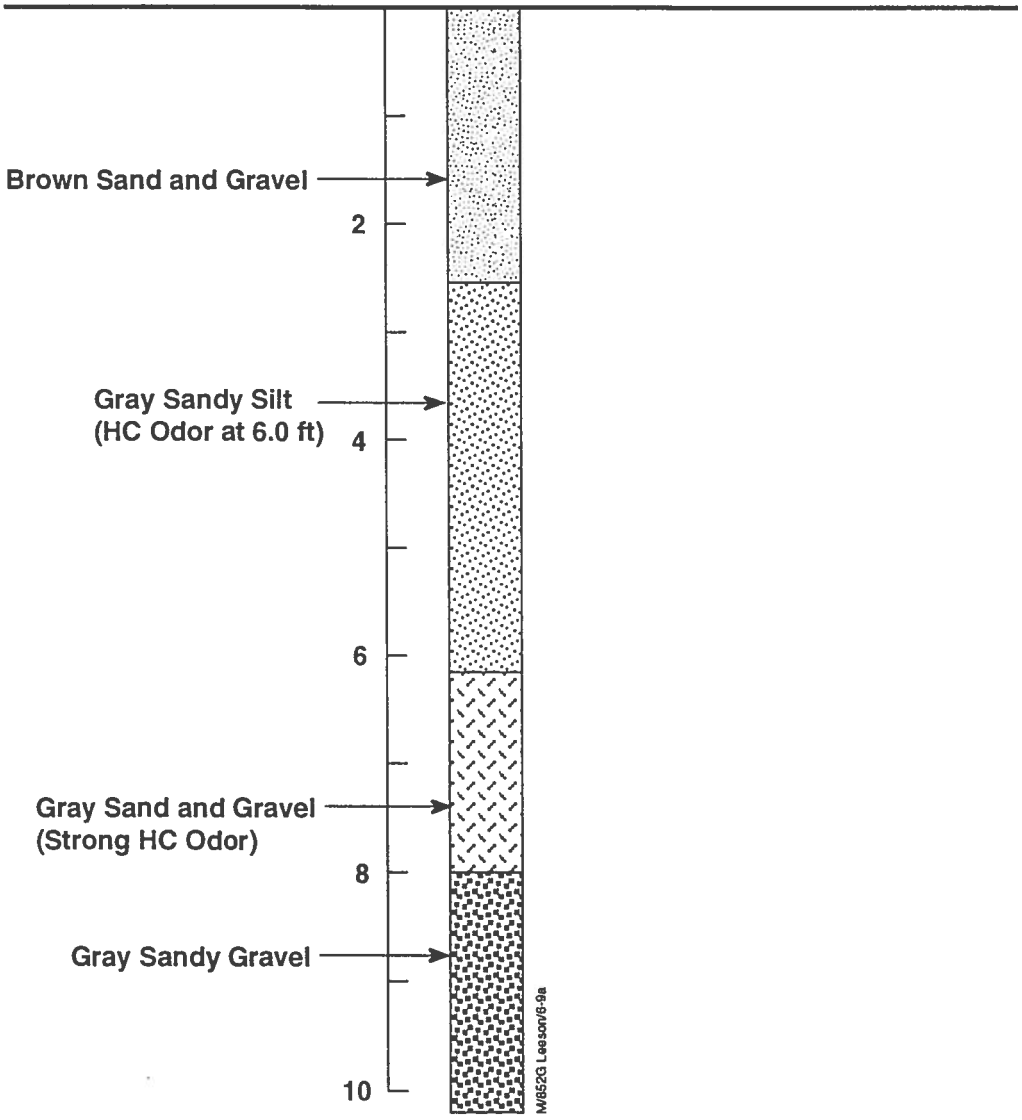
Soil Samples taken for TPH analysis at 6.0-6.5 ft, 6.5-7.0 ft, 8.0-8.5 ft, 8.5-9.0 ft, 10.0-10.5 ft, and 10.5-11.0 ft.

Control Plot
CF-2 Boring Log



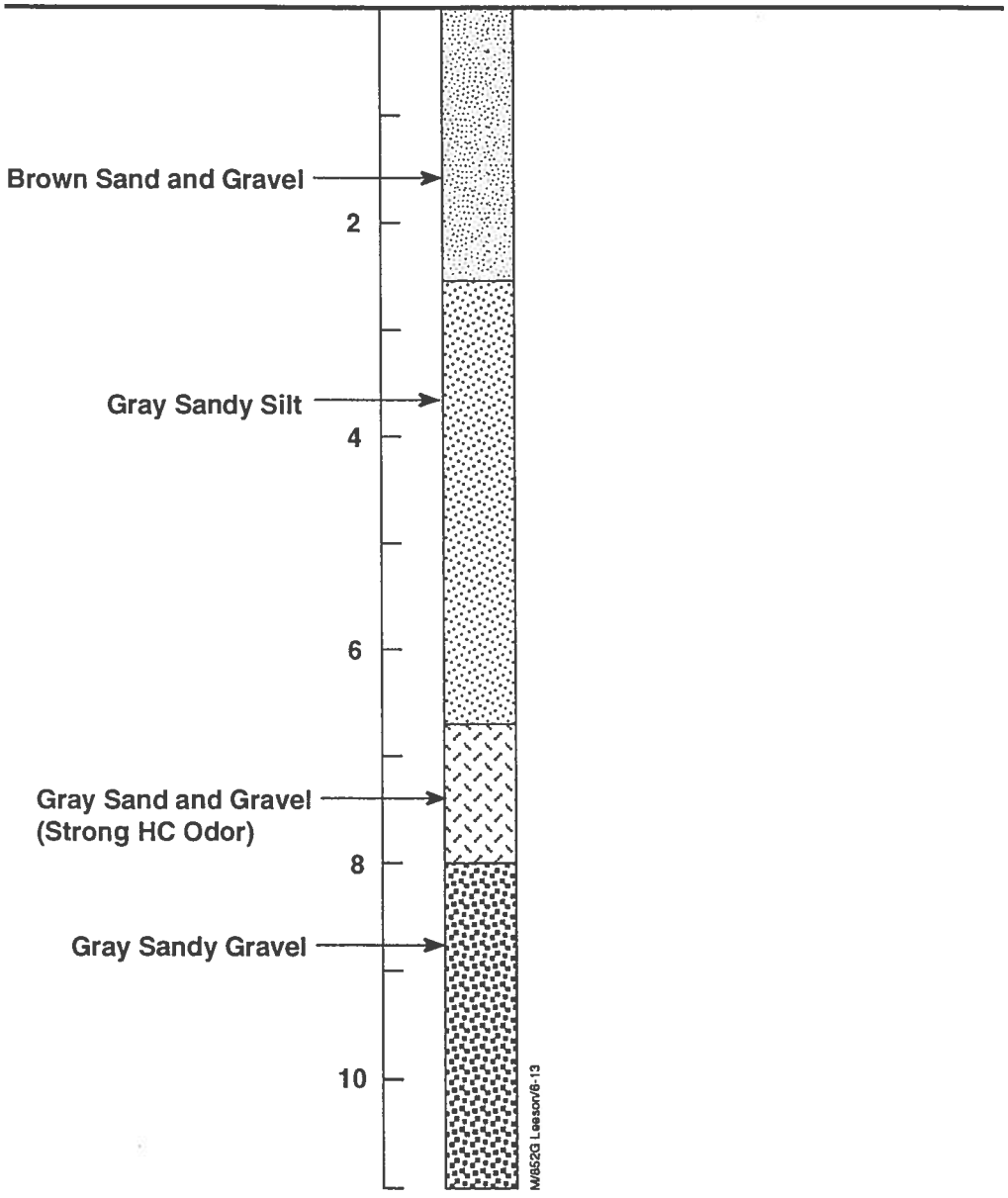
Soil Samples taken for TPH analysis at 4.5-5.0 ft, 5.0-5.5 ft, 5.5-6.0 ft, 6.5-7.0 ft, 7.0-7.5 ft, 7.5-8.0 ft, 9.0-9.5 ft, and 9.5-10.0 ft.

Control Plot
CF-3 Boring Log



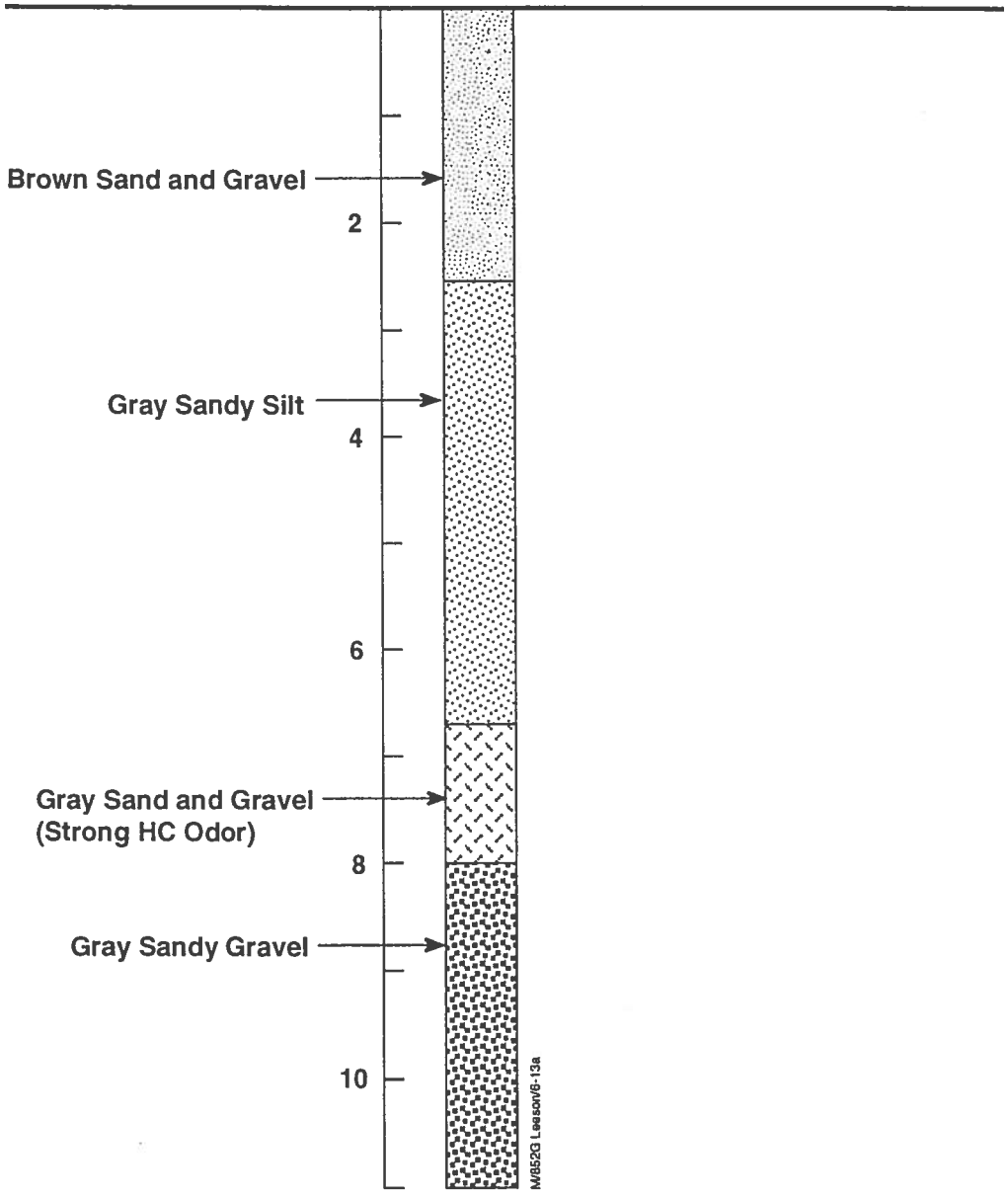
Soil Samples taken for TPH analysis at 4.5-5.0 ft, 5.0-5.5 ft, 5.5-6.0 ft, 6.5-7.0 ft, 7.0-7.5 ft, 7.5-8.0 ft, 9.0-9.5 ft, and 9.5-10.0 ft.

Active Warming Plot
AF-1 Boring Log



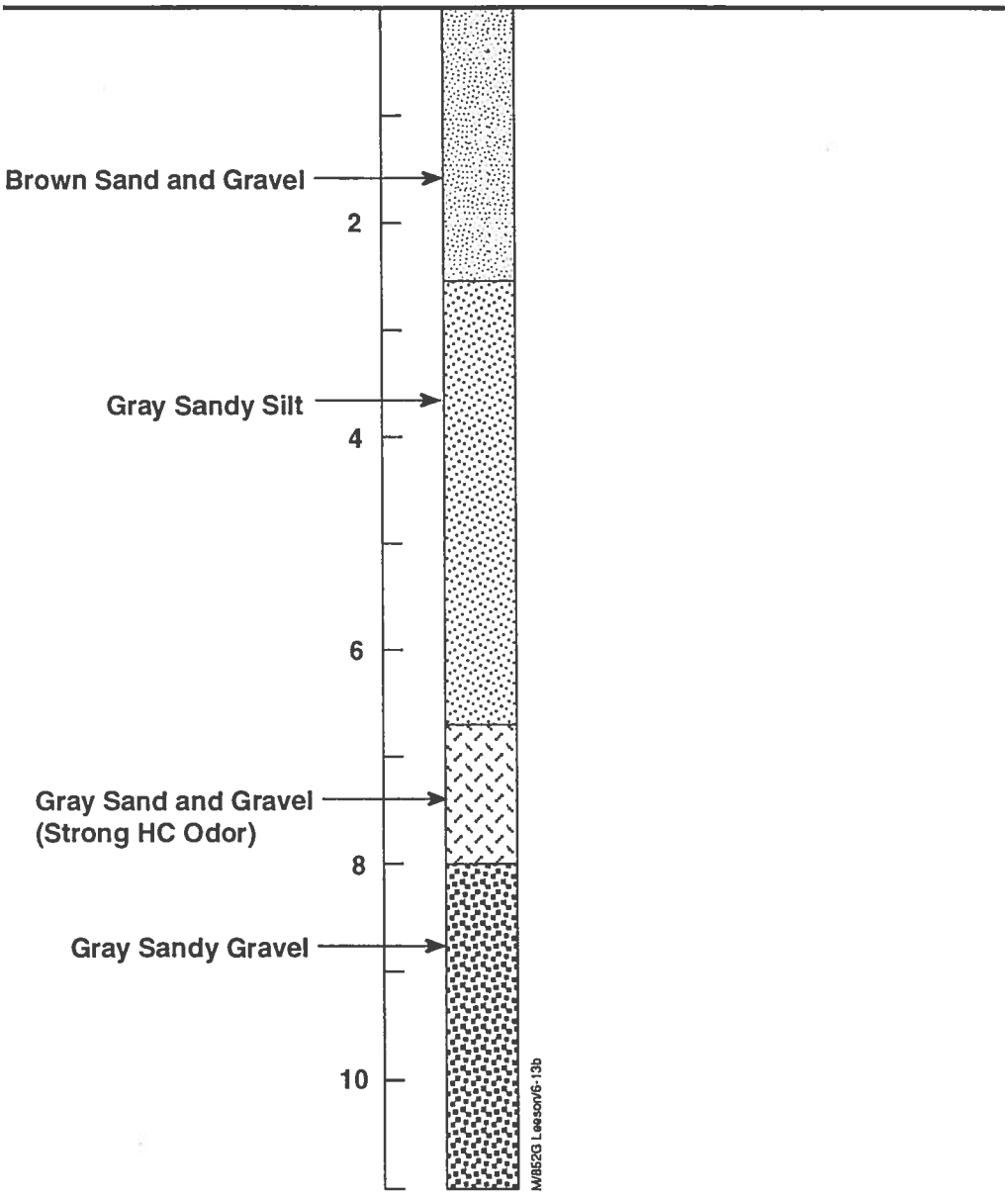
Soil Samples taken for TPH analysis at 5.5-6.0 ft, 6.0-6.5 ft, 6.5-7.0 ft, 7.5-8.0 ft, 8.0-8.5 ft, 8.5-9.0 ft, 9.5-10.0 ft, 10.0-10.5 ft, and 10.5-11.0 ft.

Active Warming Plot
AF-2 Boring Log



Soil Samples taken for TPH analysis at 5.5-6.0 ft, 6.0-6.5 ft, 6.5-7.0 ft, 7.5-8.0 ft, 8.0-8.5 ft, 8.5-9.0 ft, 10.0-10.5 ft, and 10.5-11.0 ft.

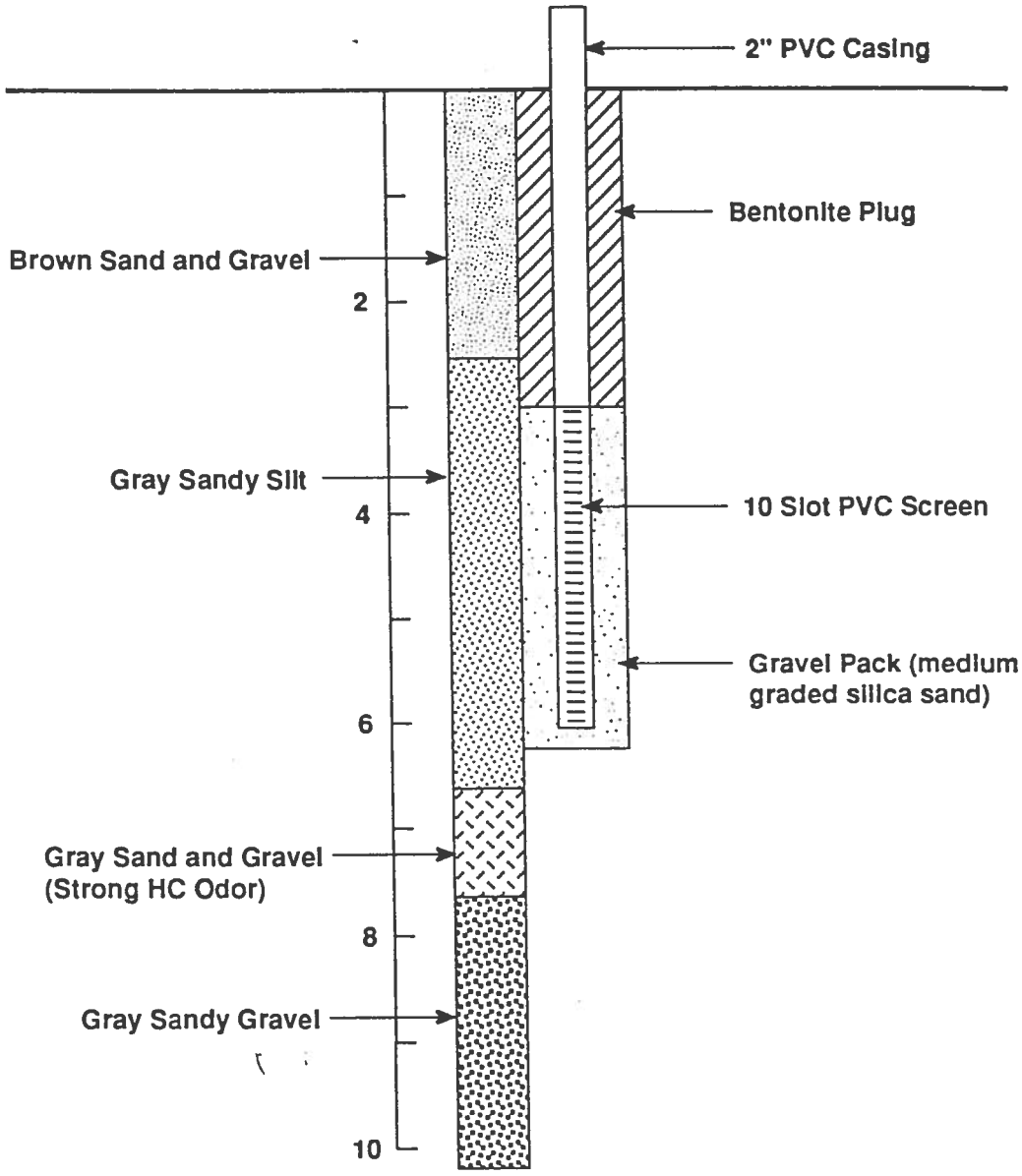
Active Warming Plot
AF-3 Boring Log



Soil Samples taken for TPH analysis at 5.5-6.0 ft, 6.0-6.5 ft, 6.5-7.0 ft, 8.5-9.0 ft, 9.5-10.0 ft, 10.0-10.5 ft, and 10.5-11.0 ft.

1991 AND 1992 SOIL BORING LOGS

Well Construction Diagram
Boring #7

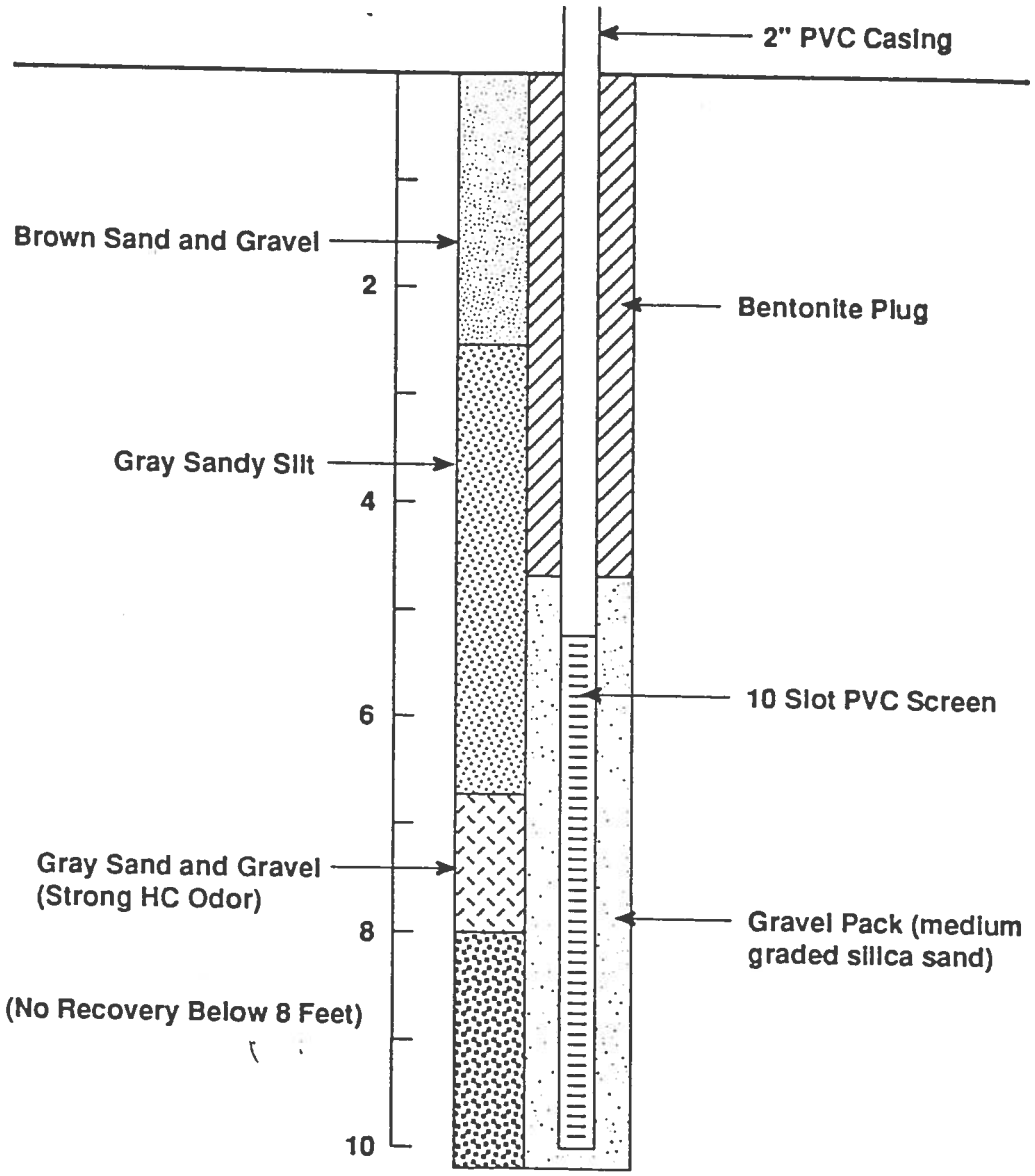


2-inch diameter PVC bioventing well installed.

Soil Samples taken for TPH analysis at 0.5 - 1.0 ft, 1.5 - 2.0 ft, 2.5 - 3.0 ft, 3.5 - 4.0 ft, 4.5 - 5.0 ft, 5.5 - 6.0 ft, 6.5 - 7.0 ft, 7.5 - 8.0 ft, and 8.5 - 9.0 ft.

Please refer to the figure at the end of this Appendix for soil boring locations.

Well Construction Diagram
Boring #8 (W #3)



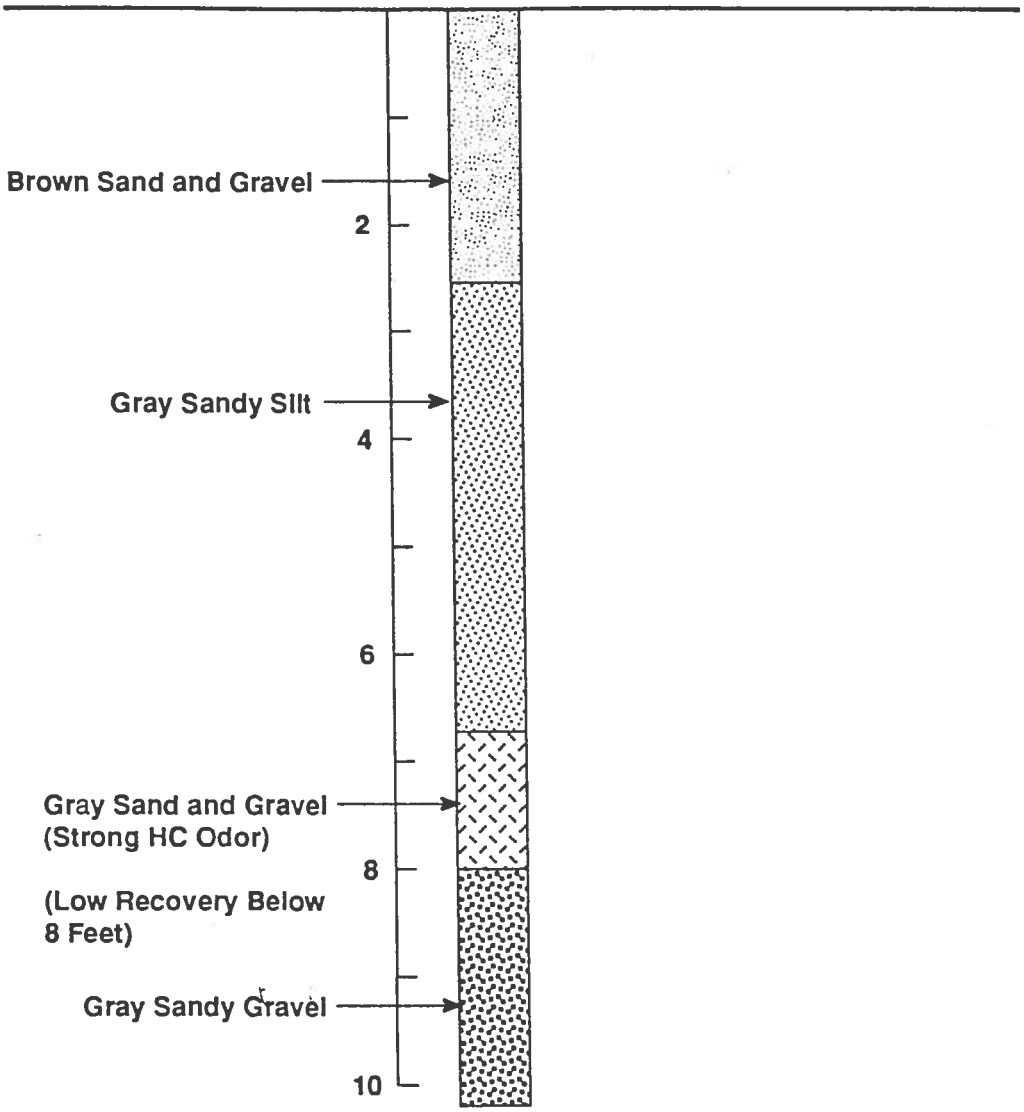
2-inch diameter PVC monitoring well installed.

Soil Samples taken for TPH analysis at 0.5 - 1.0 ft, 1.5 - 2.0 ft, 2.5 - 3.0 ft, 3.5 - 4.0 ft, 4.5 - 5.0 ft, 5.5 - 6.0 ft, 6.5 - 7.0 ft, 7.5 - 8.0 ft, and 8.5 - 9.0 ft.

Top of casing surveyed at 547.12 ft based on Eielson vertical datum as noted on base survey control sheet.

Please refer to the figure at the end of this Appendix for soil boring locations.

Boring #9

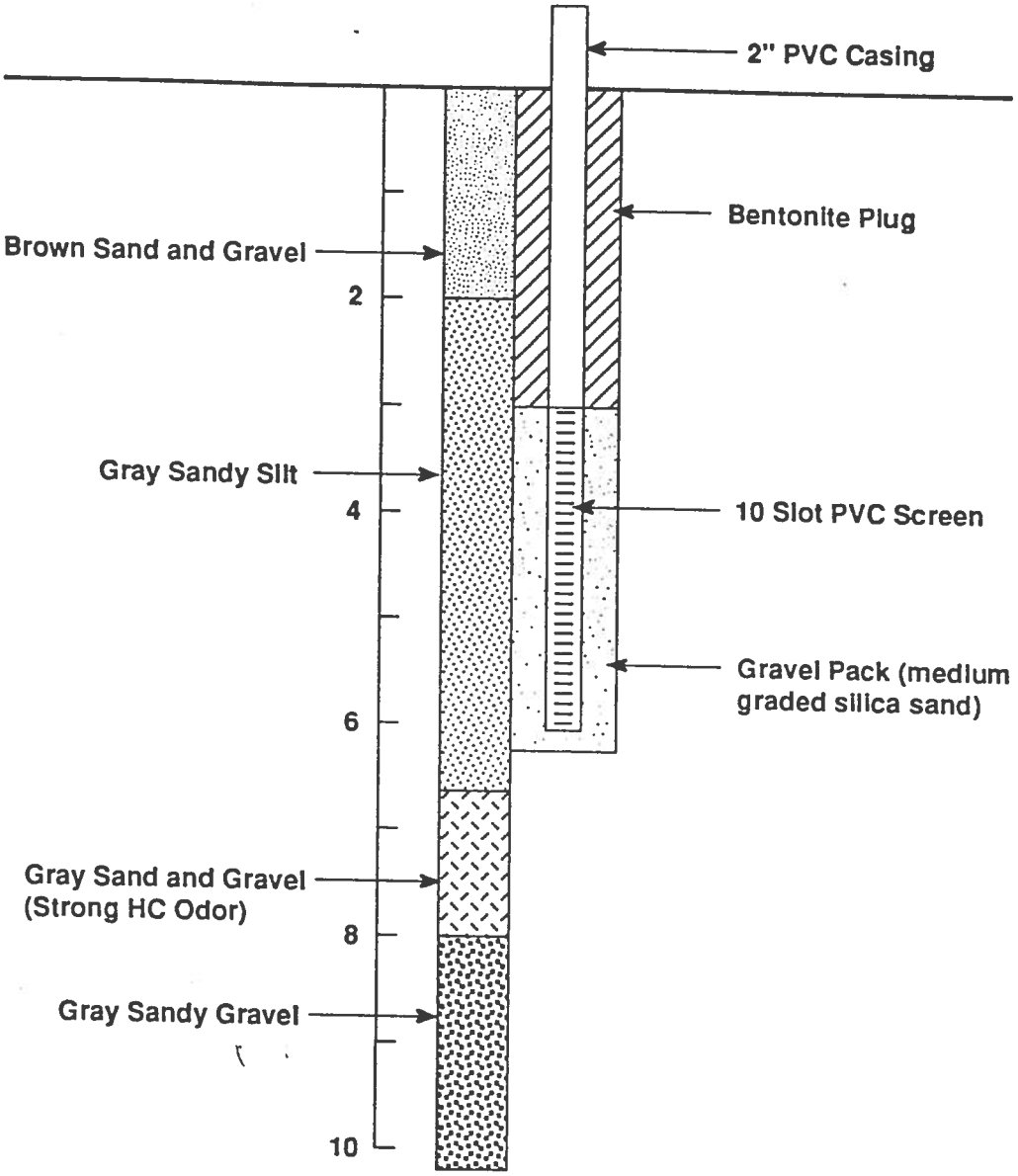


Boring backfilled with cuttings and abandoned.

Soil Samples taken for TPH analysis at 0.5 - 1.0 ft, 1.5 - 2.0 ft, 2.5 - 3.0 ft, 3.5 - 4.0 ft, 4.5 - 5.0 ft, 5.5 - 6.0 ft, 6.5 - 7.0 ft, 7.5 - 8.0 ft,8.5 ft - 9.0 ft and 9.5 - 10.0 ft.

Please refer to the figure at the end of this Appendix for soil boring locations.

Well Construction Diagram
Boring #18

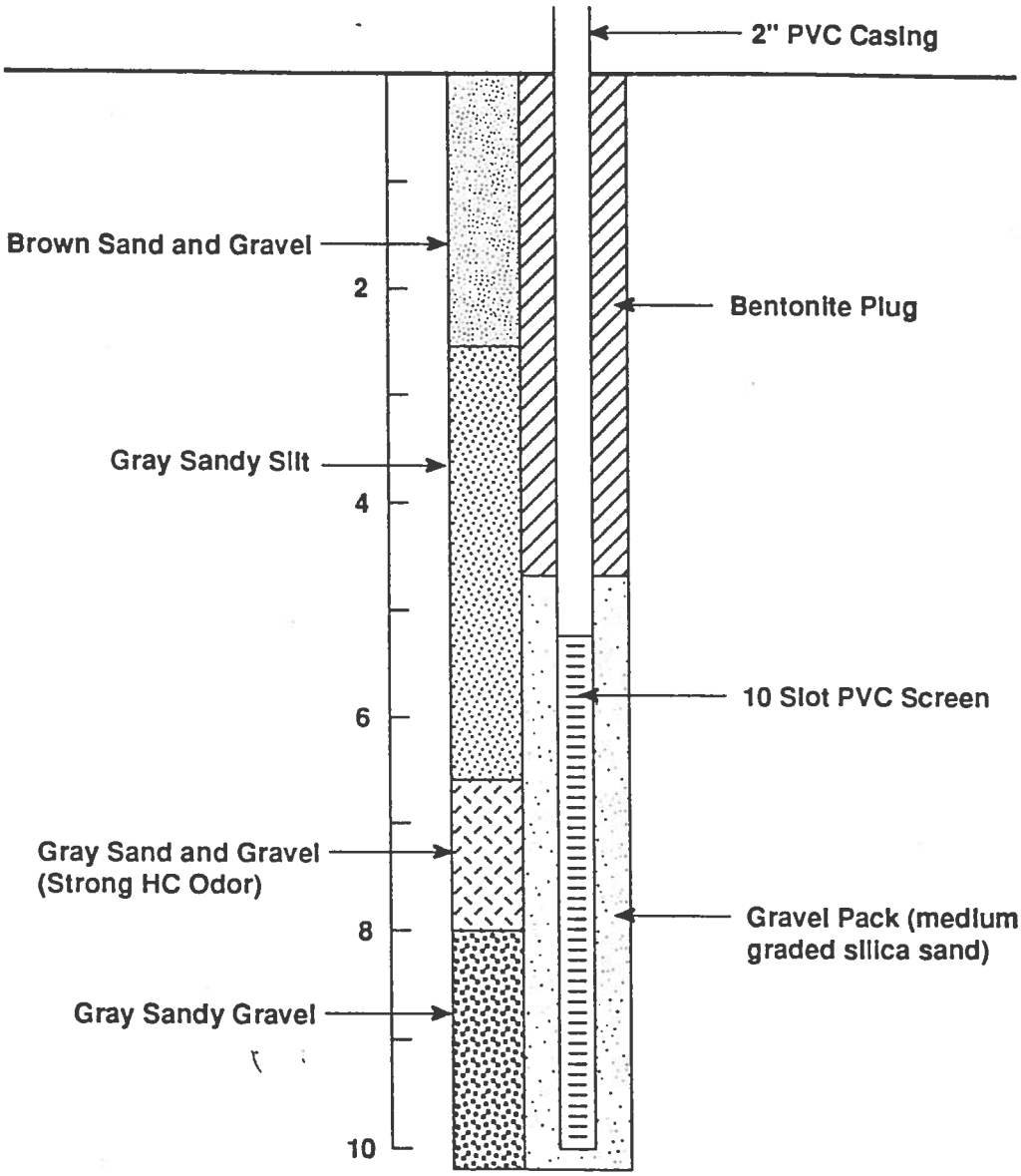


2-inch diameter PVC bioventing well installed.

Soil Samples taken for TPH analysis at 0.5 - 1.0 ft, 1.5 - 2.0 ft, 2.5 - 3.0 ft, 3.5 - 4.0 ft, 4.5 - 5.0 ft, 5.5 - 6.0 ft, 6.5 - 7.0 ft, and 7.5 - 8.0 ft.

Please refer to the figure at the end of this Appendix for soil boring locations.

Well Construction Diagram
Boring #19 (W #4)



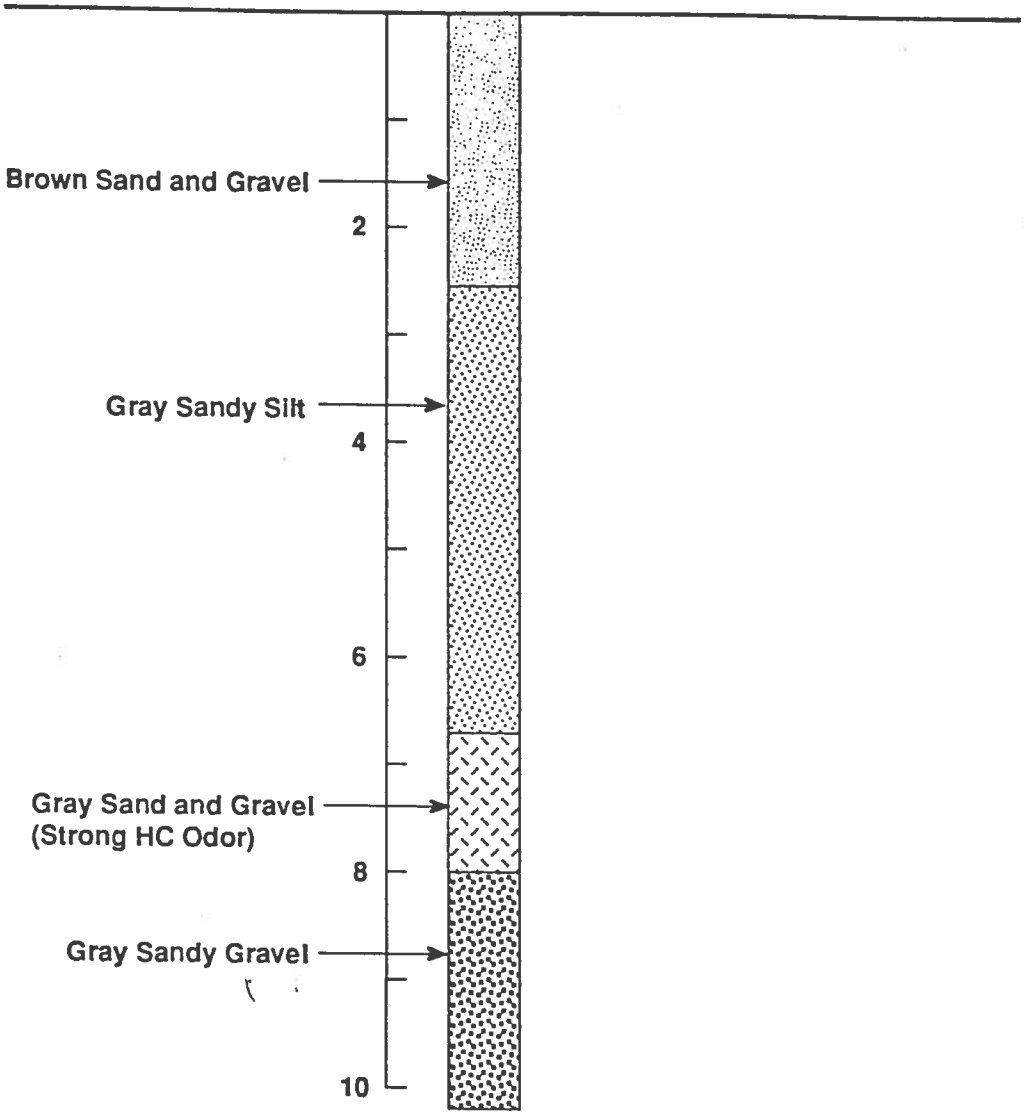
2-inch diameter PVC monitoring well installed.

Soil Samples taken for TPH analysis at 0.5 - 1.0 ft,
1.5 - 2.0 ft, 2.5 - 3.0 ft, 3.5 - 4.0 ft, 4.5 - 5.0 ft,
5.5 - 6.0 ft, 6.5 - 7.0 ft, and 7.5 - 8.0 ft.

Top of casing surveyed at 547.49 ft based on Eielson vertical datum as noted on base survey control sheet.

Please refer to the figure at the end of this Appendix for soil boring locations.

Boring #20

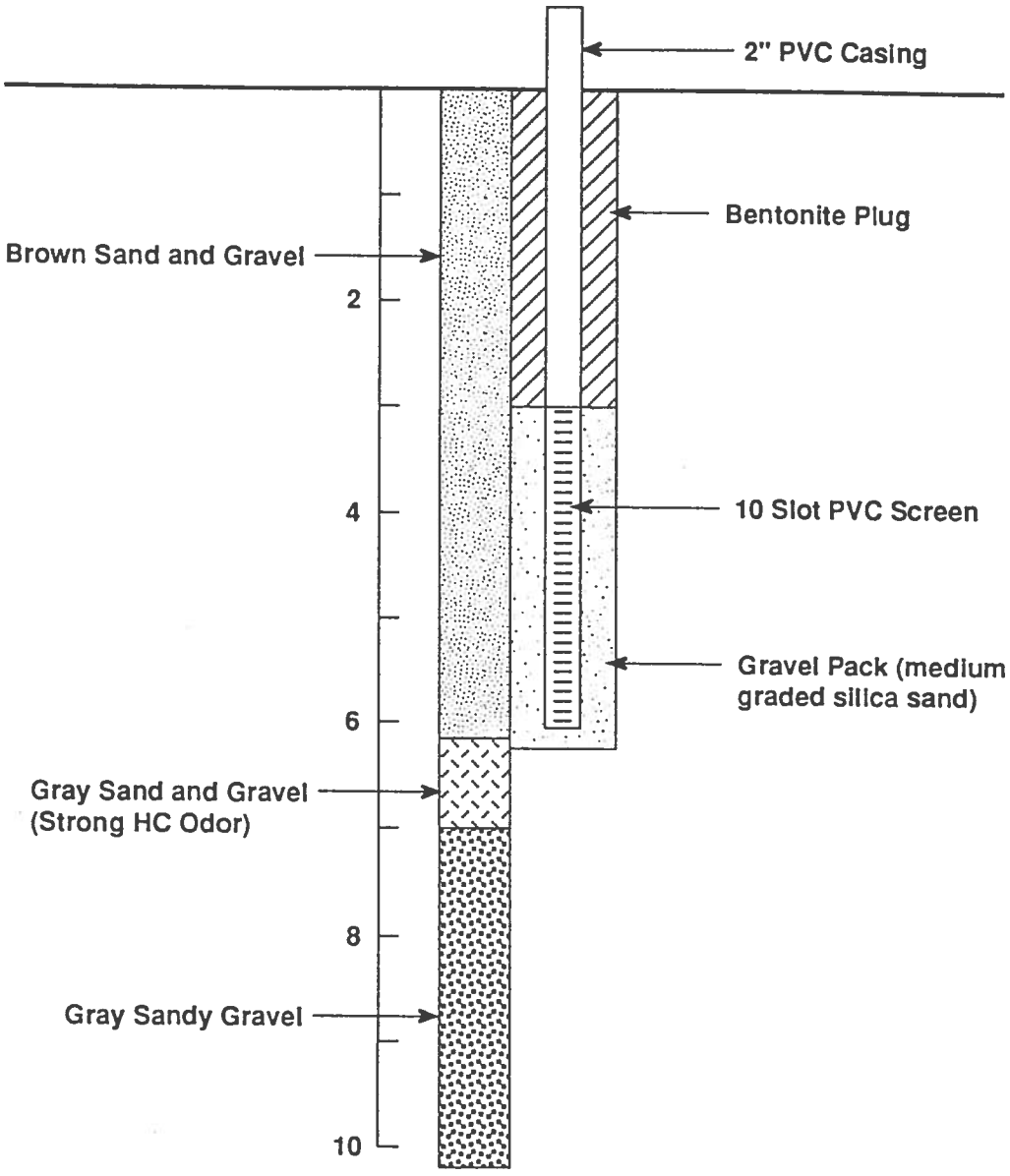


Boring backfilled with cuttings and abandoned.

Soil Samples taken for TPH analysis at 0.5 - 1.0 ft, 1.5 - 2.0 ft, 2.5 - 3.0 ft, 3.5 - 4.0 ft, 4.5 - 5.0 ft, 5.5 - 6.0 ft, 6.5 - 7.0 ft, and 7.5 - 8.0 ft.

Please refer to the figure at the end of this Appendix for soil boring locations.

Well Construction Diagram
Boring #27

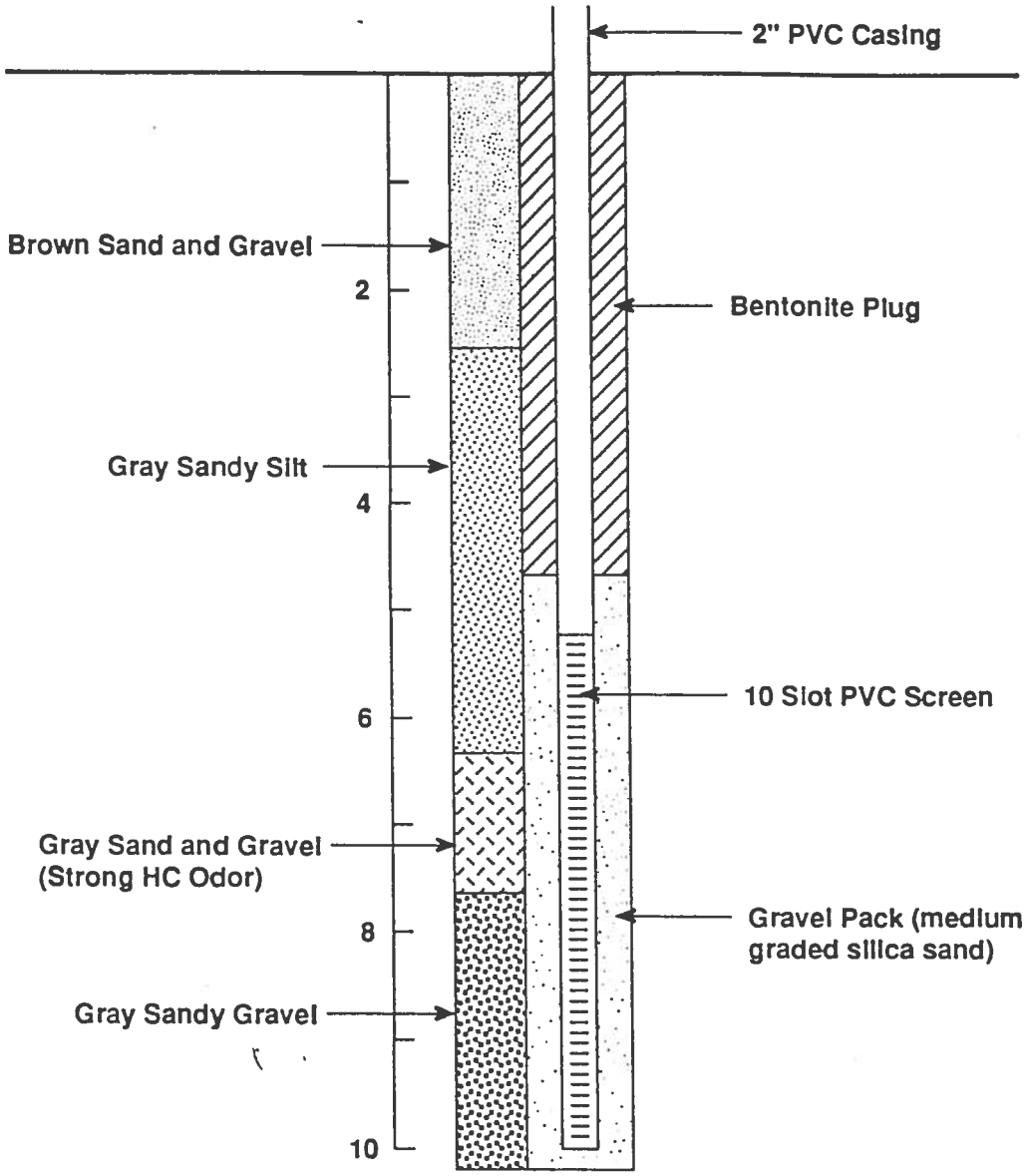


2-inch diameter PVC bioventing well installed.

Soil Samples taken for TPH analysis at 0.5 - 1.0 ft, 1.5 - 2.0 ft, 2.5 - 3.0 ft, 3.5 - 4.0 ft, 4.5 - 5.0 ft, 5.5 - 6.0 ft, 6.5 - 7.0 ft, and 7.5 - 8.0 ft.

Please refer to the figure at the end of this Appendix for soil boring locations.

Well Construction Diagram
Boring #28 (W #5)



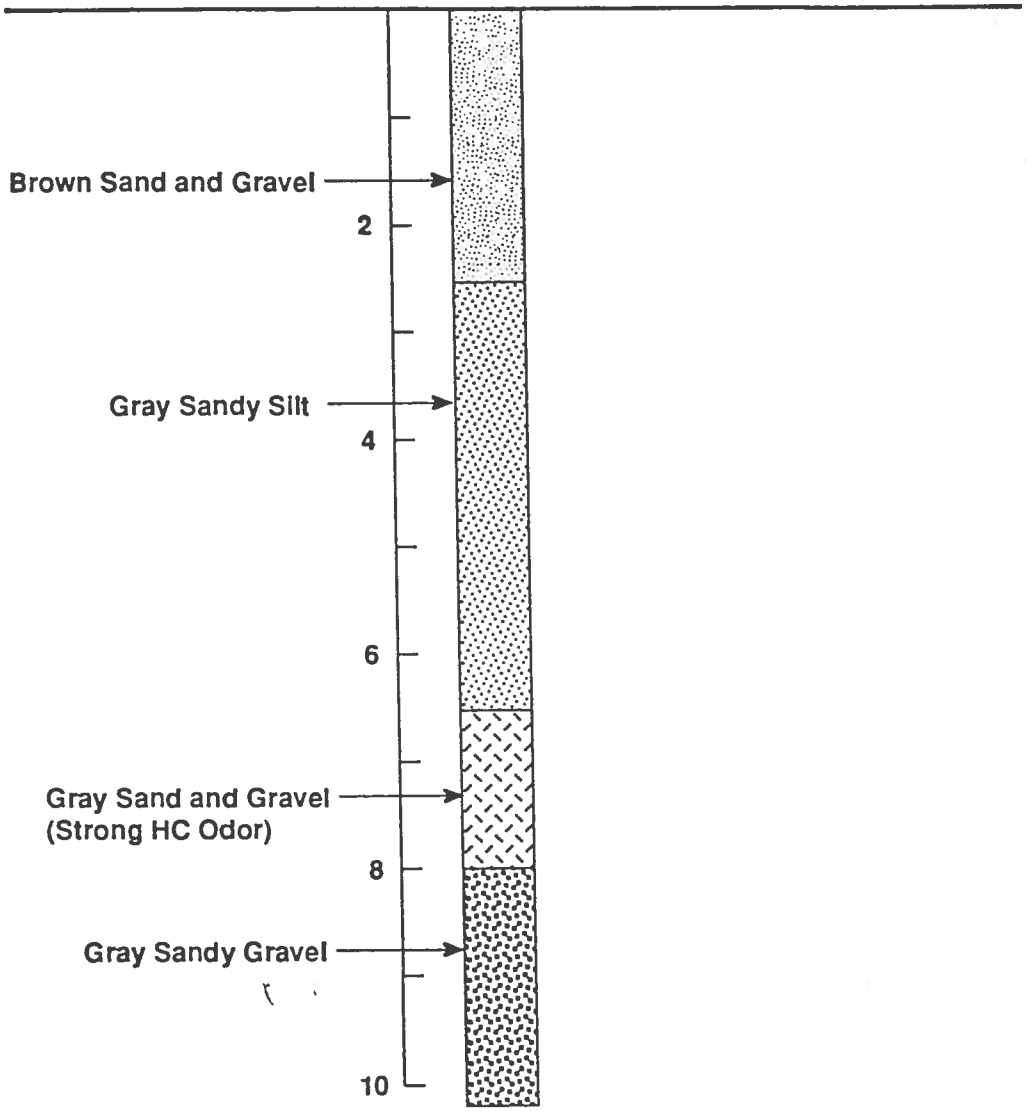
2-inch diameter PVC monitoring well installed.

Soil Samples taken for TPH analysis at 0.5 - 1.0 ft, 1.5 - 2.0 ft, 2.5 - 3.0 ft, 3.5 - 4.0 ft, 4.5 - 5.0 ft, 5.5 - 6.0 ft, 6.5 - 7.0 ft, and 7.5 - 8.0 ft.

Top of casing surveyed at 547.66 ft based on Eielson vertical datum as noted on base survey control sheet.

Please refer to the figure at the end of this Appendix for soil boring locations.

Boring #29

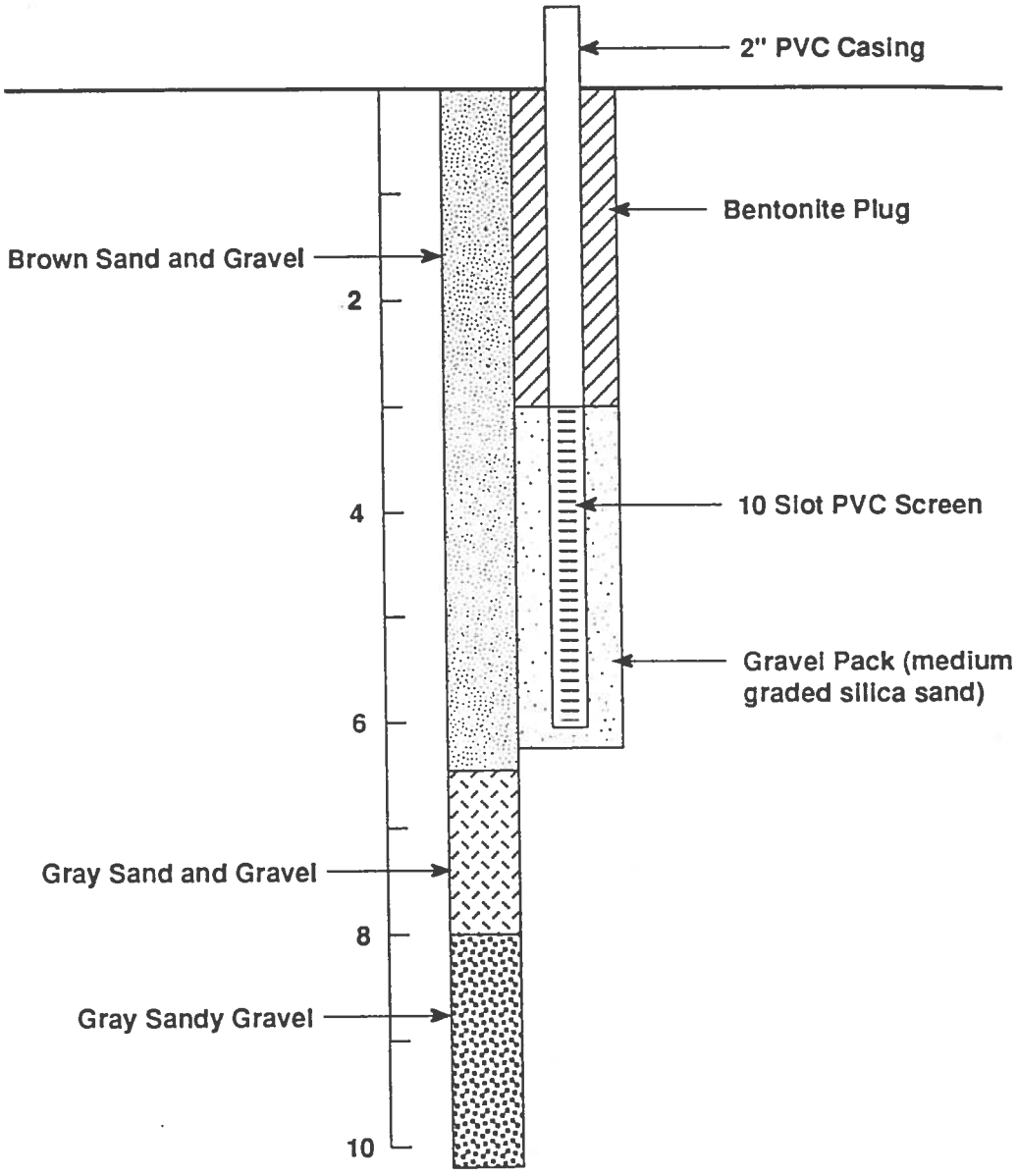


Boring backfilled with cuttings and abandoned.

Soil Samples taken for TPH analysis at 0.5 - 1.0 ft,
1.5 - 2.0 ft, 2.5 - 3.0 ft, 3.5 - 4.0 ft, 4.5 - 5.0 ft,
5.5 - 6.0 ft, 6.5 - 7.0 ft, 7.5 - 8.0 ft, and 8.5 ft - 9.0 ft.

Please refer to the figure at the end of this Appendix for soil boring locations.

Well Construction Diagram
Boring #41

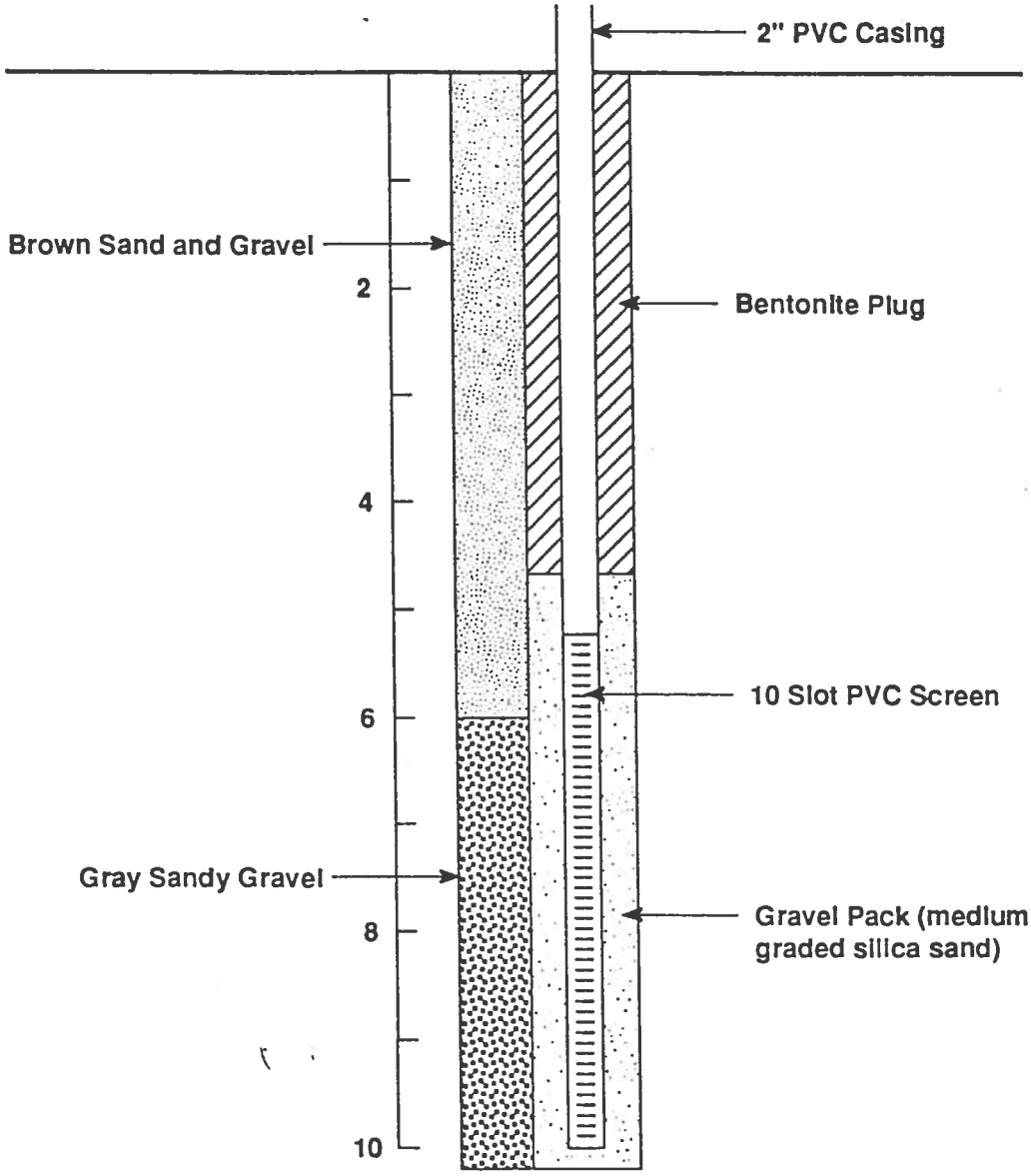


2-inch diameter PVC bioventing well installed.

Soil Samples taken for TPH analysis at 1.5 - 2.0 ft, 5.5 - 6.0 ft, and 7.5 - 8.0 ft.

Please refer to the figure at the end of this Appendix for soil boring locations.

Well Construction Diagram
Boring #42 (W #1)



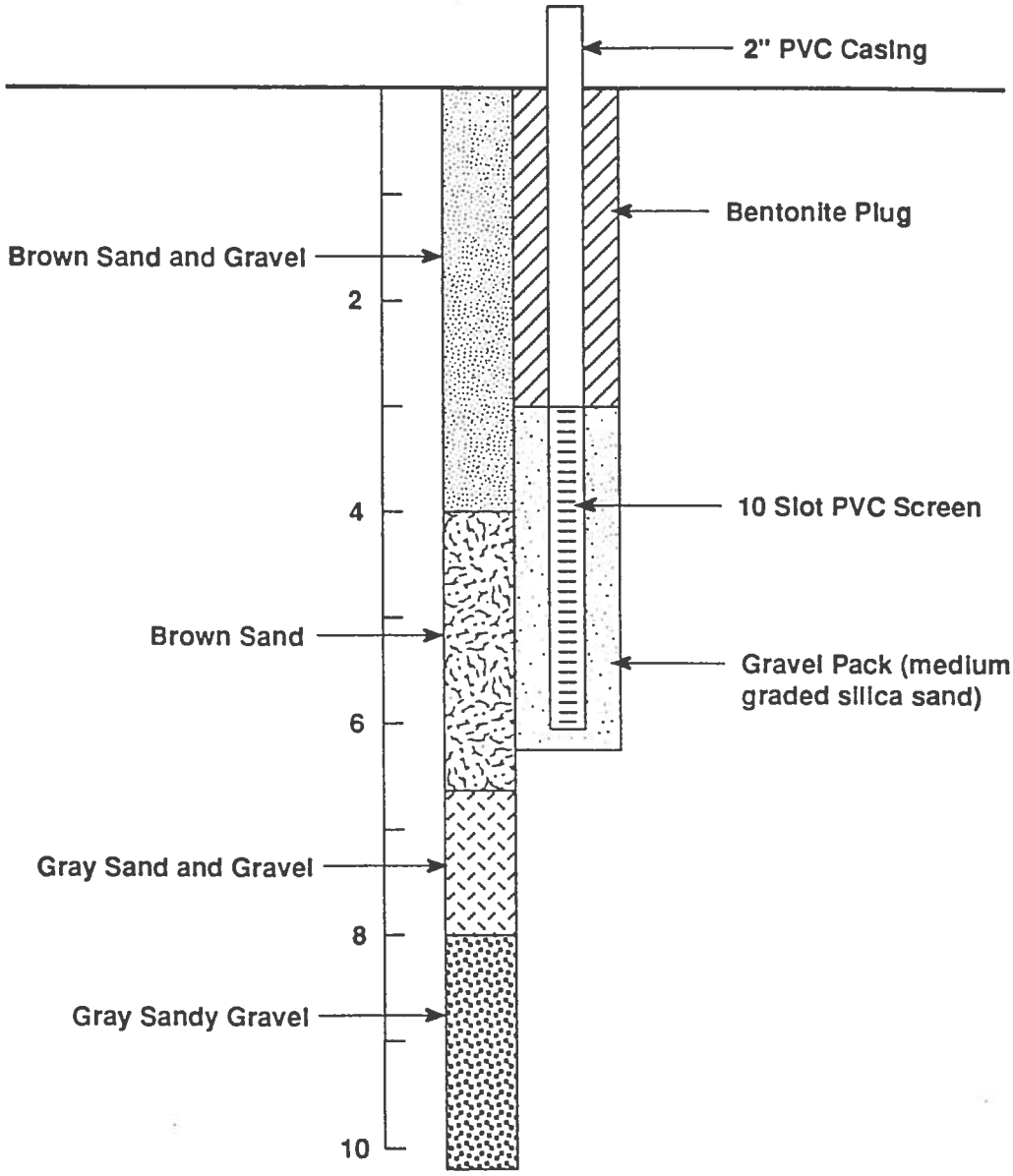
2-inch diameter PVC monitoring well installed.

Soil Samples taken for TPH analysis at
1.5 - 2.0 ft, 5.5 - 6.0 ft, and 7.5 - 8.0 ft.

Top of casing surveyed at 547.15 ft based on Eielson vertical datum as noted on base survey control sheet.

Please refer to the figure at the end of this Appendix for soil boring locations.

Well Construction Diagram
Boring #44

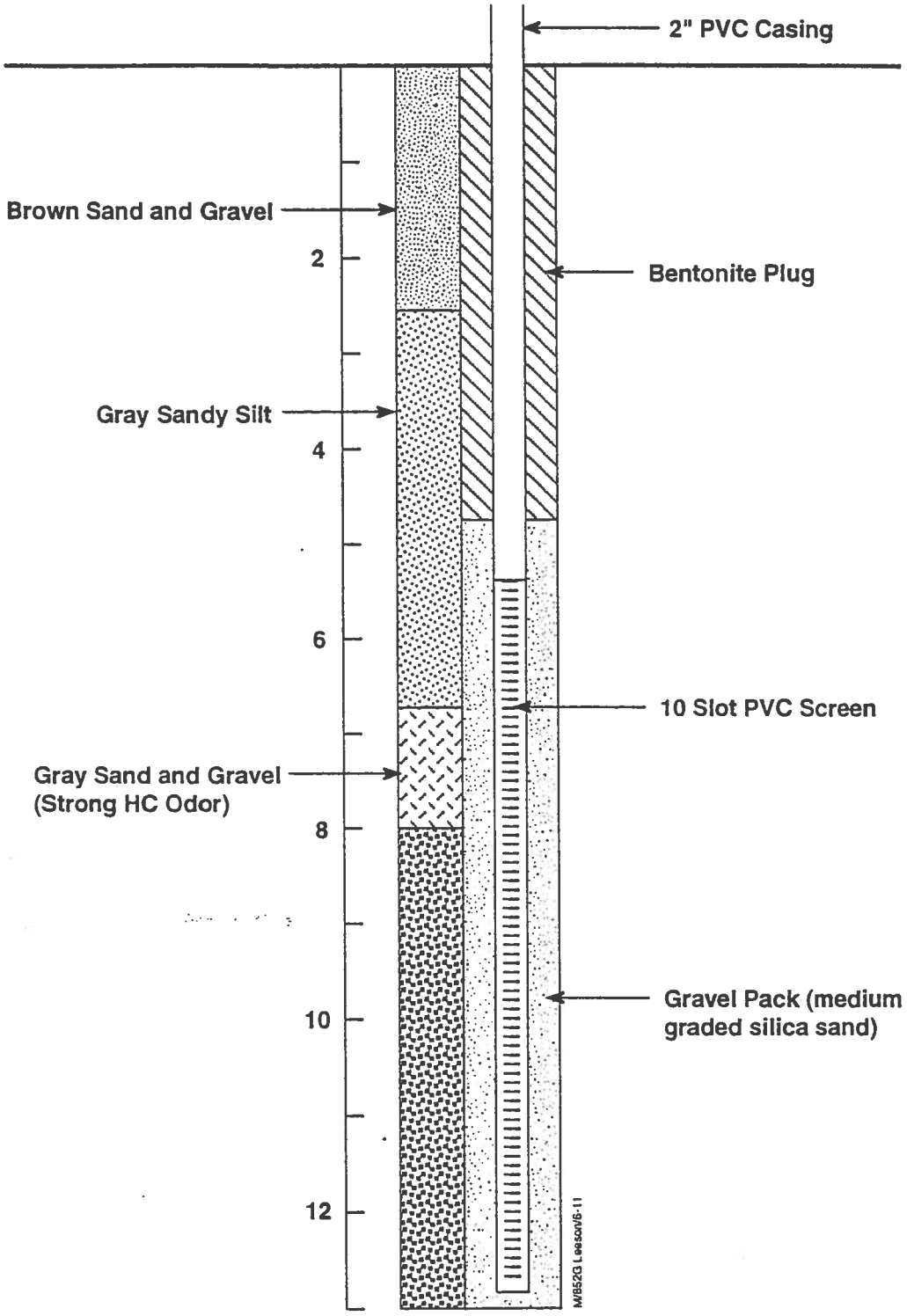


2-inch diameter PVC bioventing well installed.

Soil Samples taken for TPH analysis at 1.5 - 2.0 ft, 5.5 - 6.0 ft, and 7.5 - 8.0 ft.

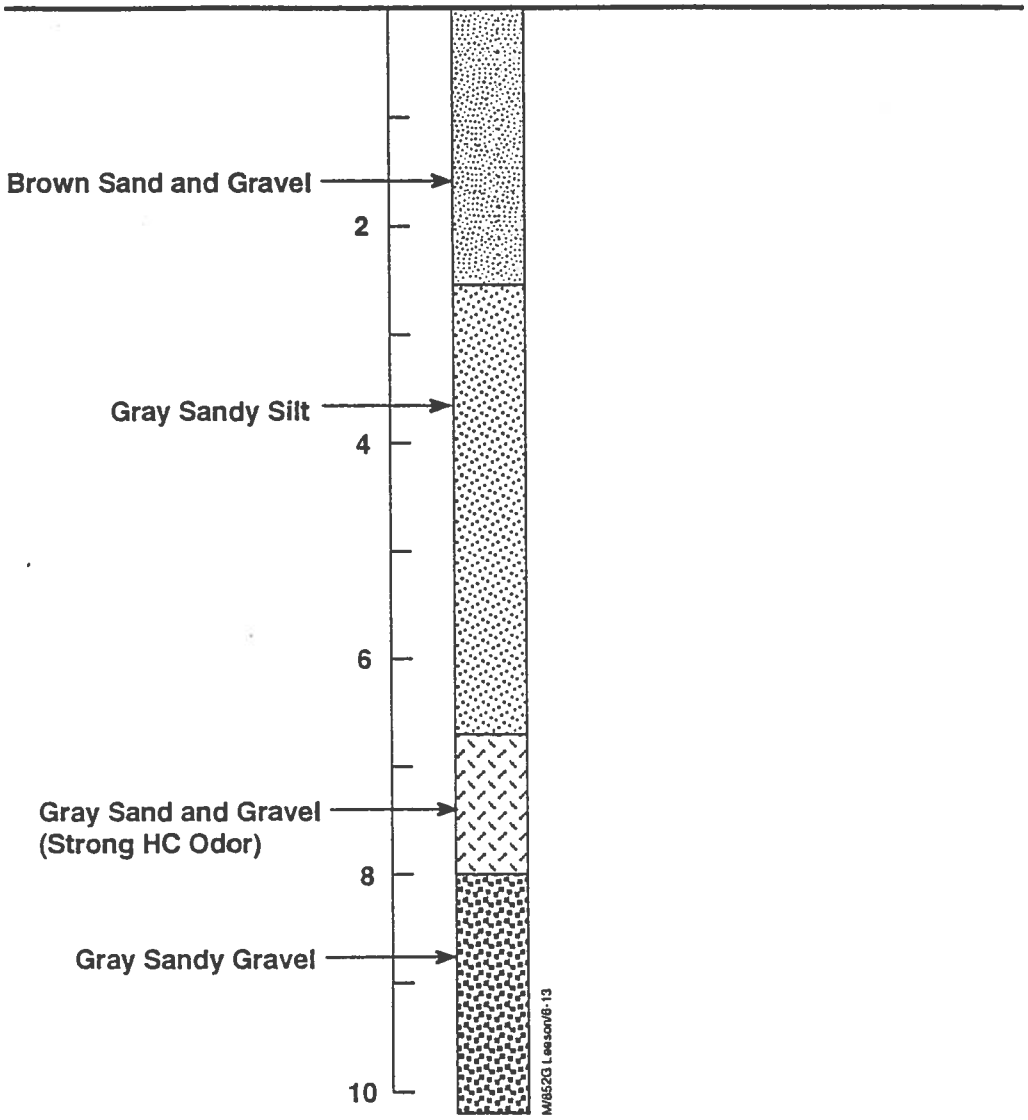
Please refer to the figure at the end of this Appendix for soil boring locations.

Active Warming Plot
Vent Well Construction Diagram



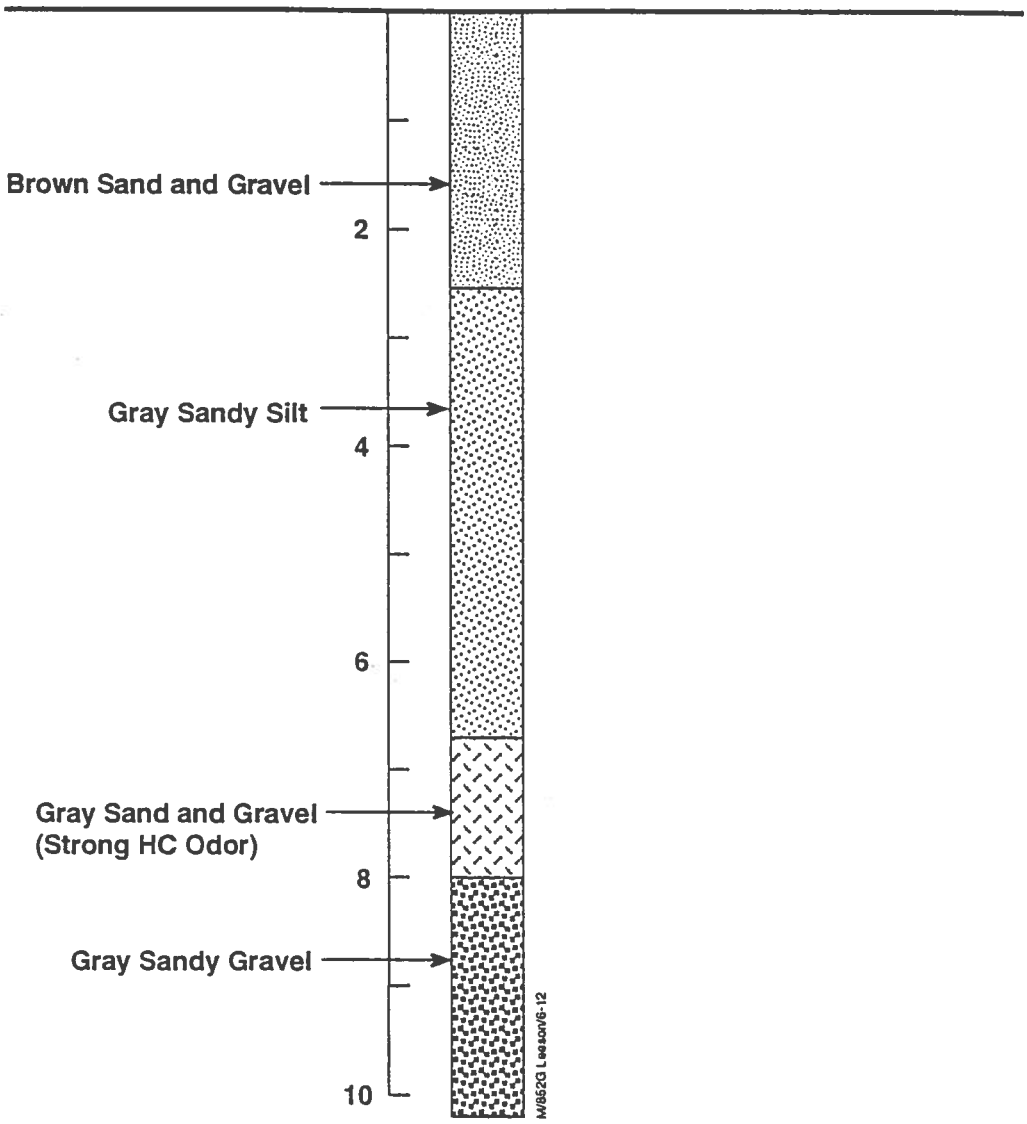
Soil Samples taken for TPH analysis at 5.5 - 6.0 ft,
6.0 - 6.5, 6.5 - 7.0 ft, 7.5 - 8.0 ft, 8.0 - 8.5 ft, and 8.5 - 9.0 ft.

Active Warming Plot
MP-7 Boring Log



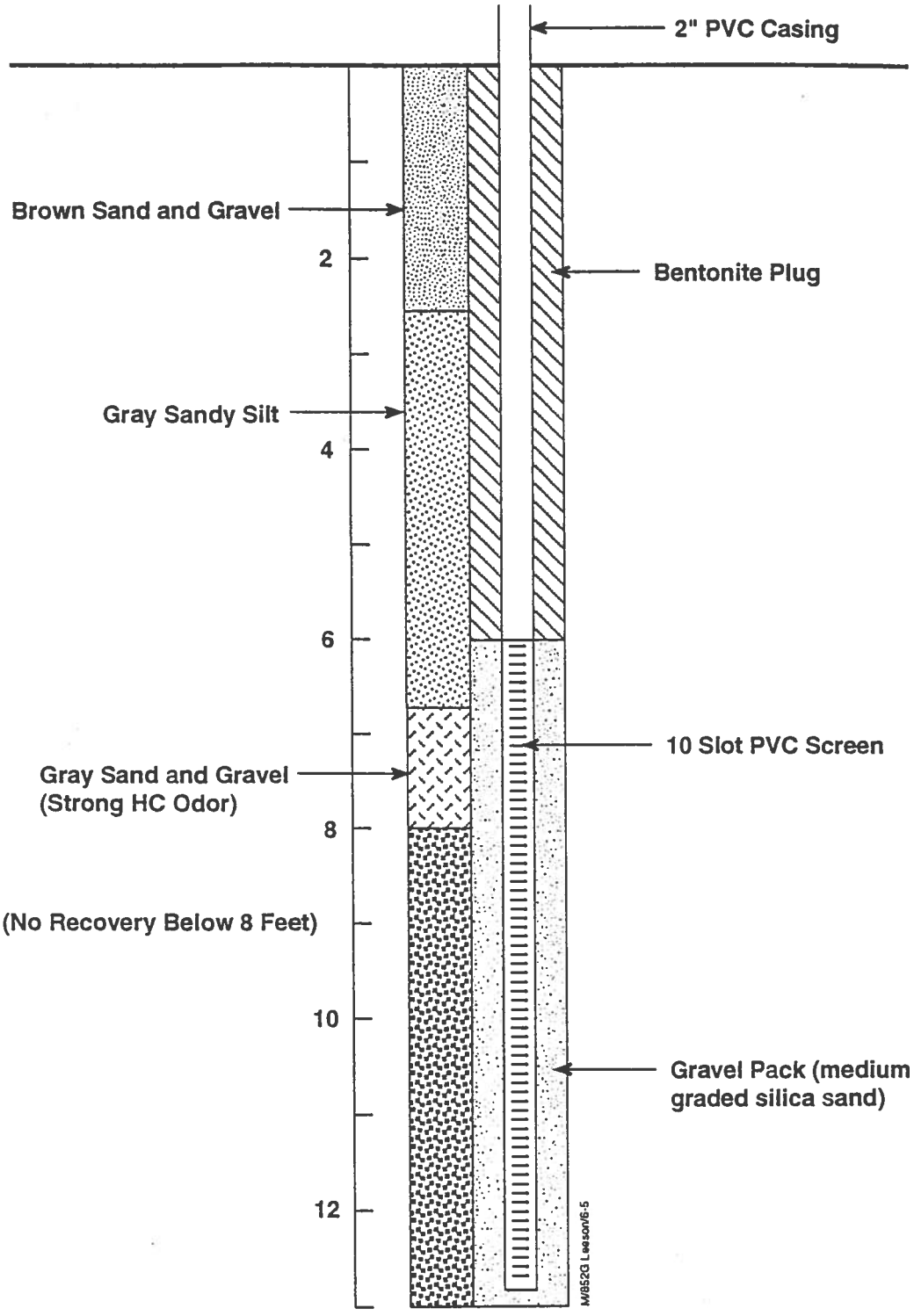
Soil Samples taken for TPH analysis at 6.0 - 6.5 ft, 6.5 - 7.0 ft, 7.5 - 8.0 ft, 8.0 - 8.5, and 8.5 - 9.0.

Active Warming Plot
MP-8 Boring Log



Soil Samples taken for TPH analysis at 5.5 - 6.0 ft,
6.0 - 6.5 ft, 6.5 - 7.0 ft, 7.5 - 8.0 ft, 8.0 - 8.5 ft, and 8.5 - 9.0 ft.

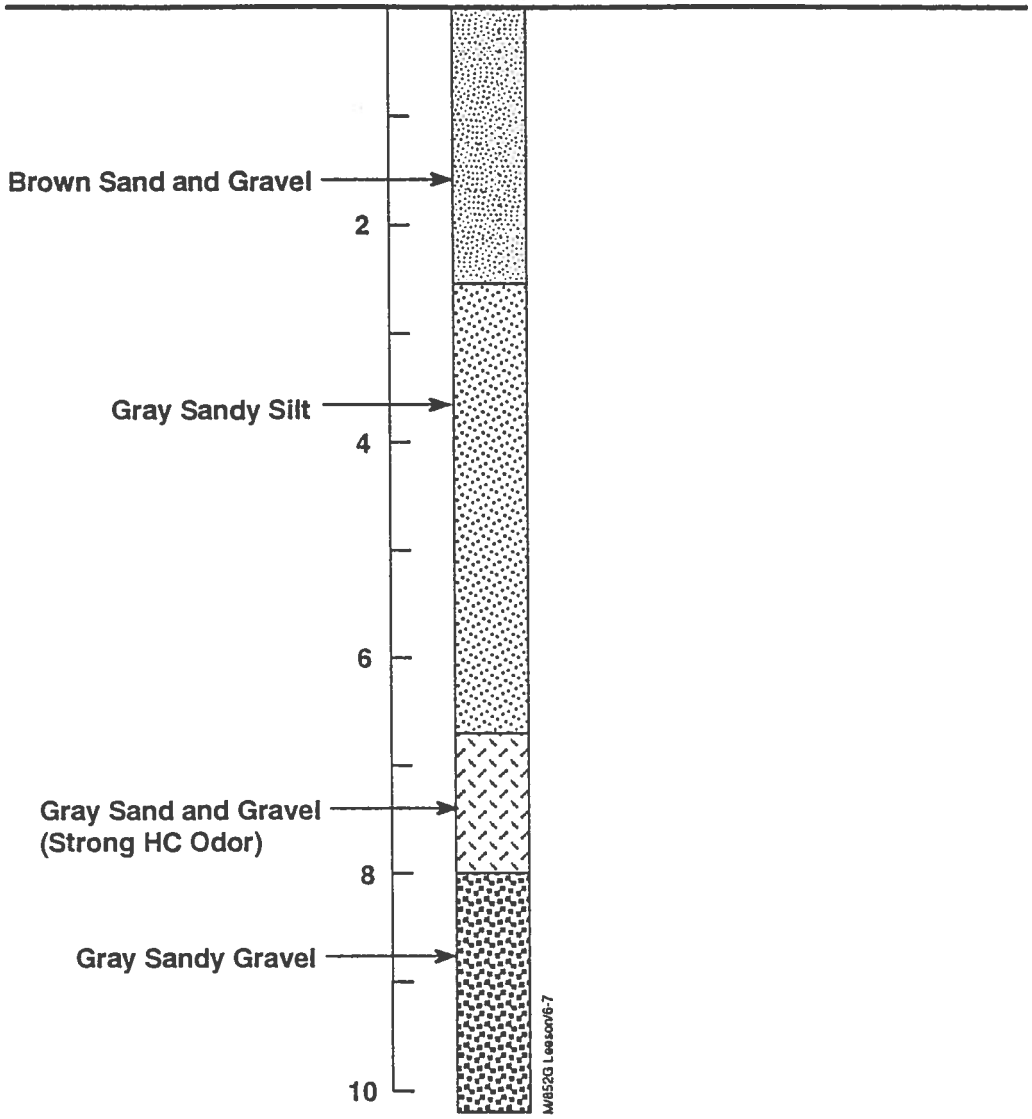
Passive Warming Plot
Vent Well Construction Diagram



2-inch diameter PVC bioventing well installed.

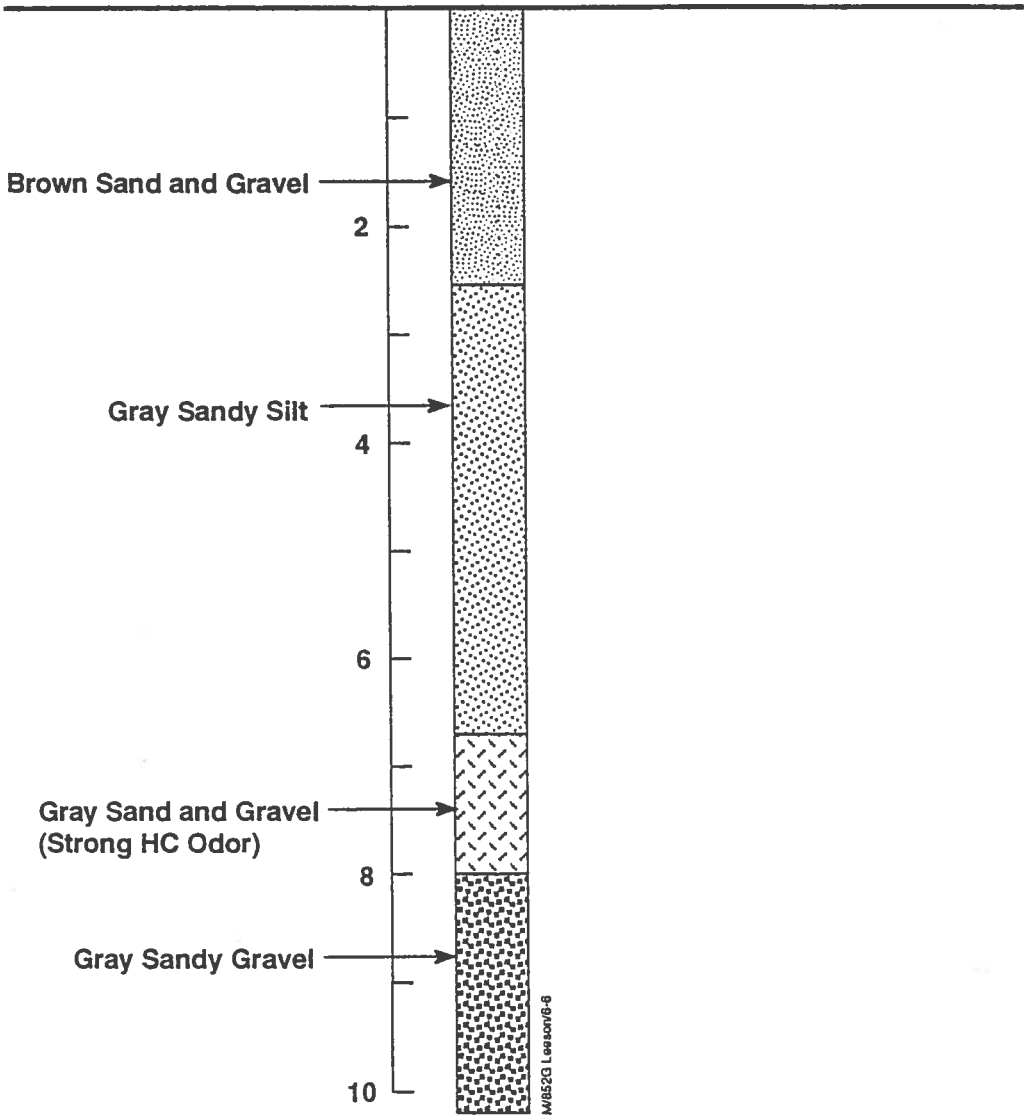
Soil Samples taken for TPH analysis at 5.5 - 6.0 ft,
6.0 - 6.5, 6.5 - 7.0 ft, 7.5 - 8.0 ft, 8.0 - 8.5, and 8.5 - 9.0 ft.

Passive Warming Plot
MP-7 Boring Log



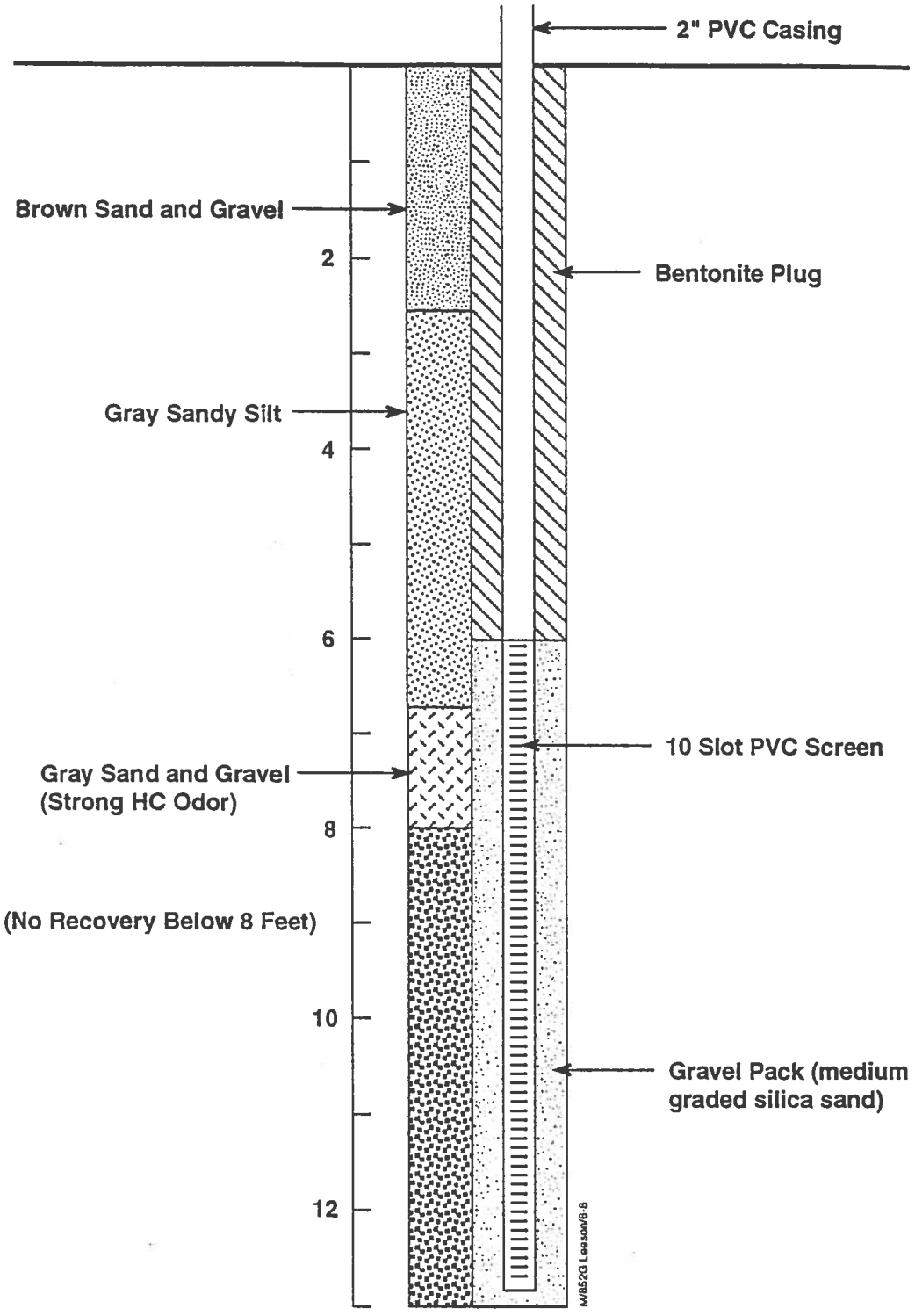
Soil Samples taken for TPH analysis at
5.5 - 6.0 ft, 6.0 - 6.5 ft, and 6.5 - 7.0 ft.

Passive Warming Plot
MP-8 Boring Log



Soil Samples taken for TPH analysis at 5.5 - 6.0 ft, 6.0 - 6.5 ft, 6.5 - 7.0 ft, 8.0 - 8.5 ft, and 8.5 - 9.0 ft.

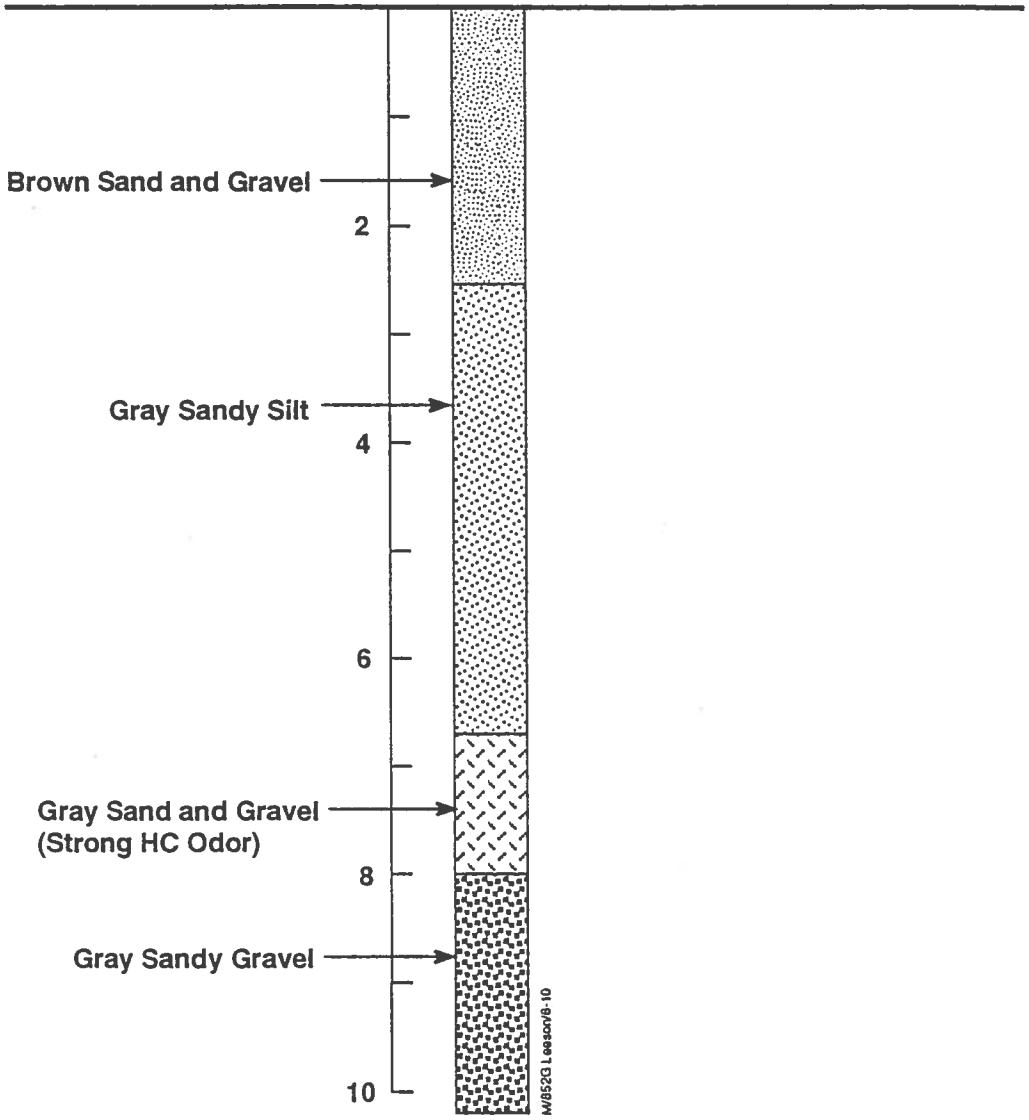
Control Plot
Vent Well Construction Diagram



2-inch diameter PVC bioventing well installed.

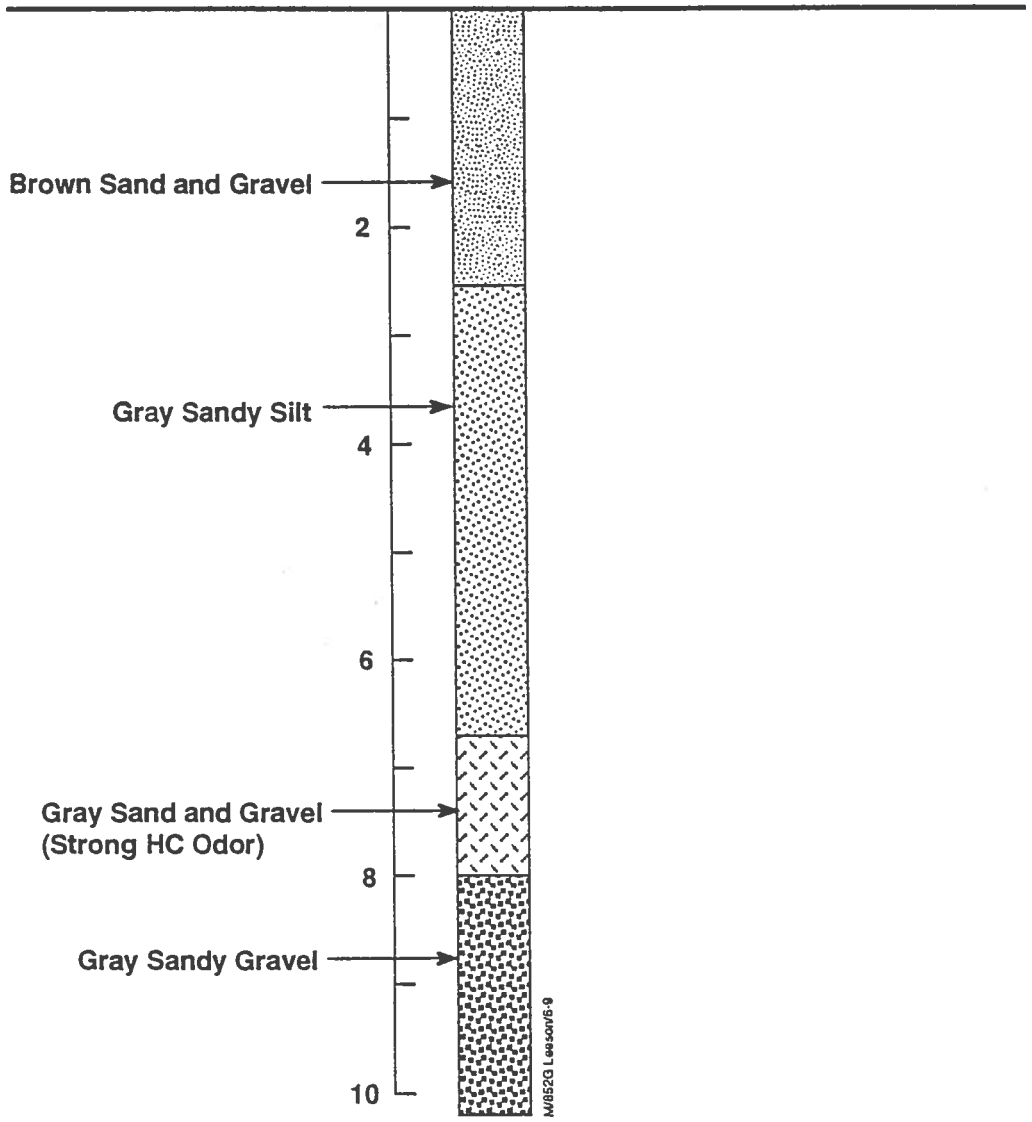
Soil Samples taken for TPH analysis at 6.0 - 6.5, 6.5 - 7.0 ft, 8.0 - 8.5, and 8.5 - 9.0 ft.

Control Plot
MP-7 Boring Log



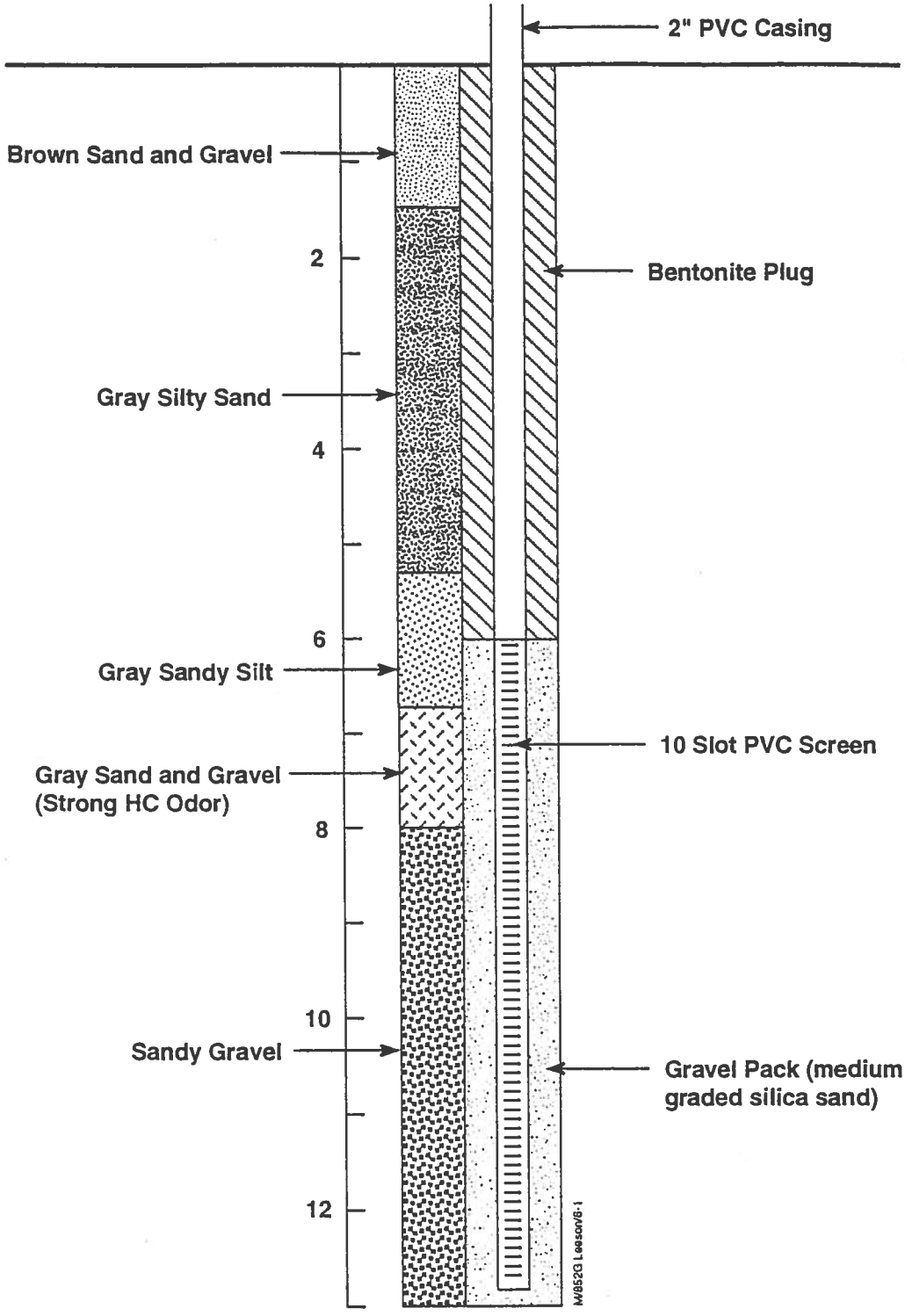
Soil Samples taken for TPH analysis at 5.5 - 6.0 ft, 6.0 - 6.5 ft, 6.5 - 7.0 ft, 8.0 - 8.5, and 8.5 - 9.0.

Control Plot
MP-8 Boring Log



Soil Samples taken for TPH analysis at 5.5 - 6.0 ft, 6.0 - 6.5 ft, 6.5 - 7.0 ft, 8.0 - 8.5 ft, and 8.5 - 9.0 ft.

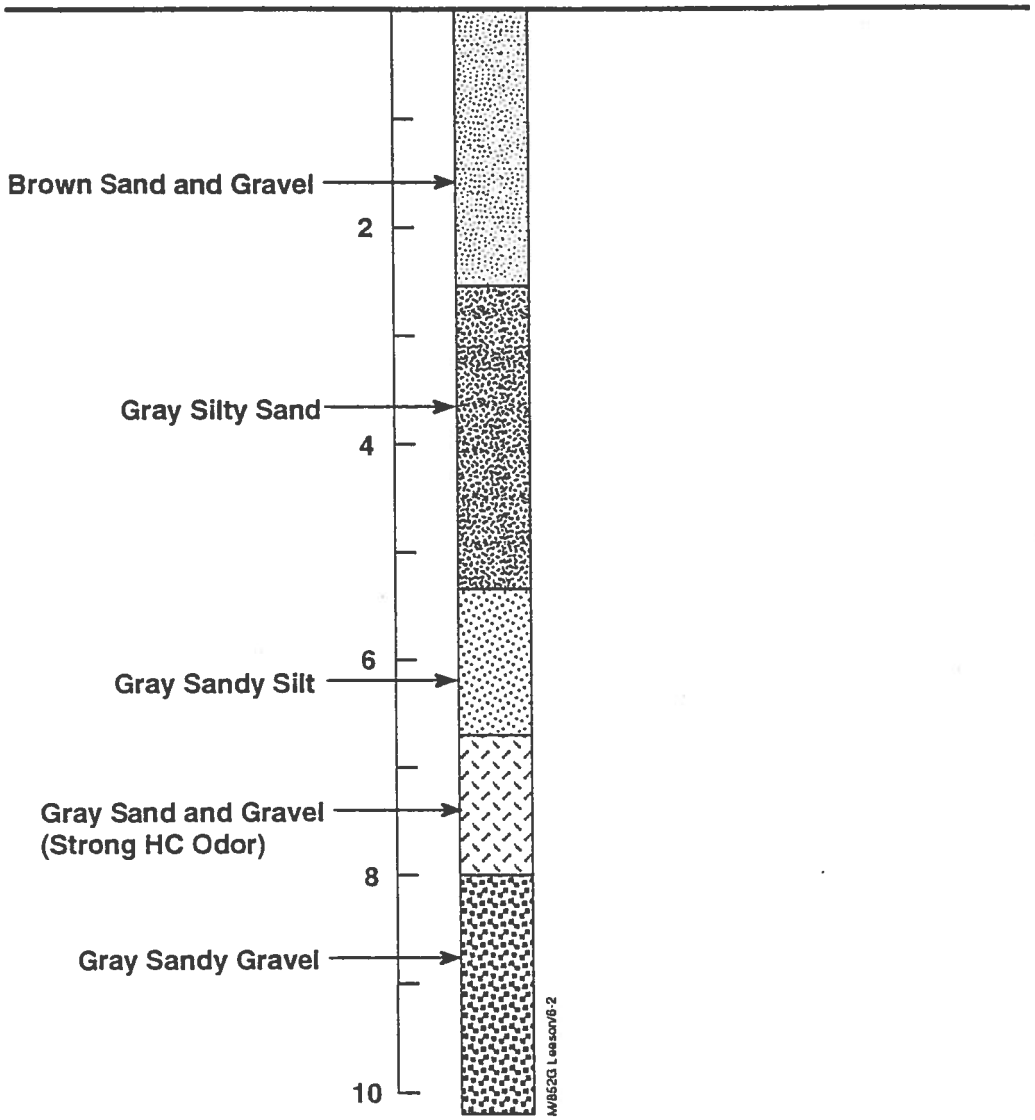
Surface Warming Plot
Vent Well Construction Diagram



2-inch diameter PVC bioventing well installed.

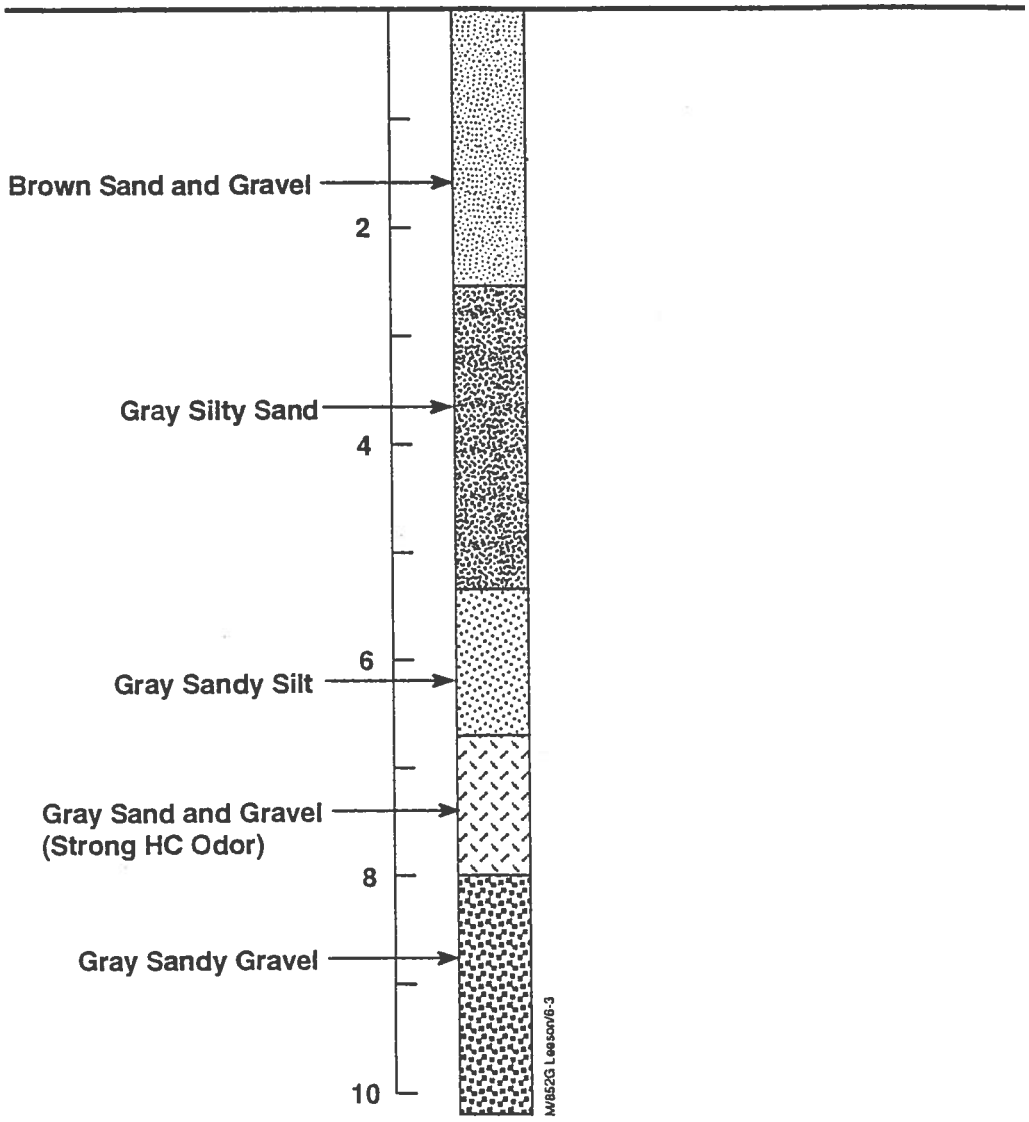
Soil Samples taken for TPH analysis at 5.5 - 6.0 ft,
6.0 - 6.5, 6.5 - 7.0 ft, 7.5 - 8.0 ft, 8.0 - 8.5, and 8.5 - 9.0 ft.

Surface Warming Plot
MP-3 Boring Log



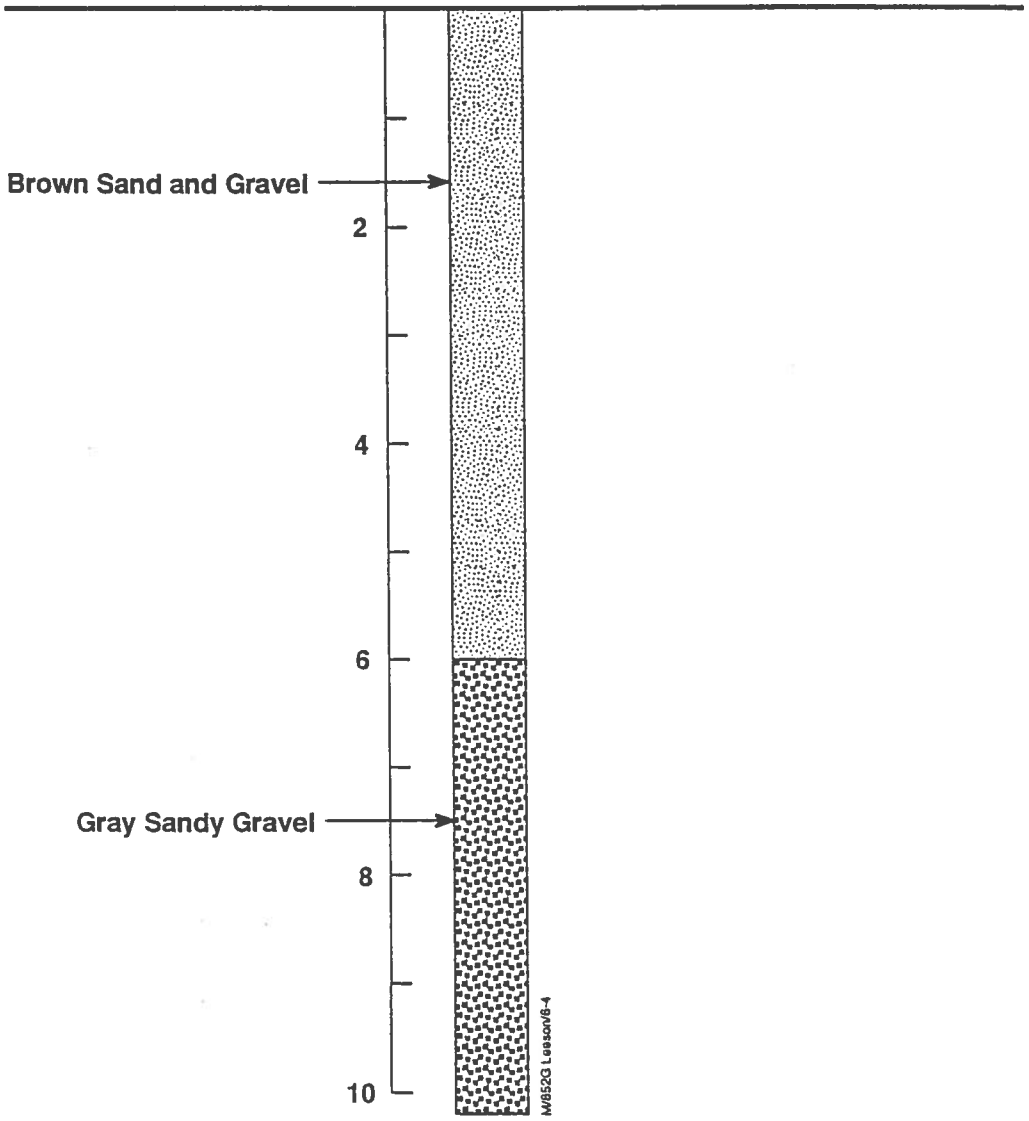
Soil Samples taken for TPH analysis at 5.5 - 6.0 ft, 6.0 - 6.5 ft, 6.5 - 7.0 ft, 8.0 - 8.5 ft, and 8.5 - 9.0 ft.

Surface Warming Plot
MP-4 Boring Log

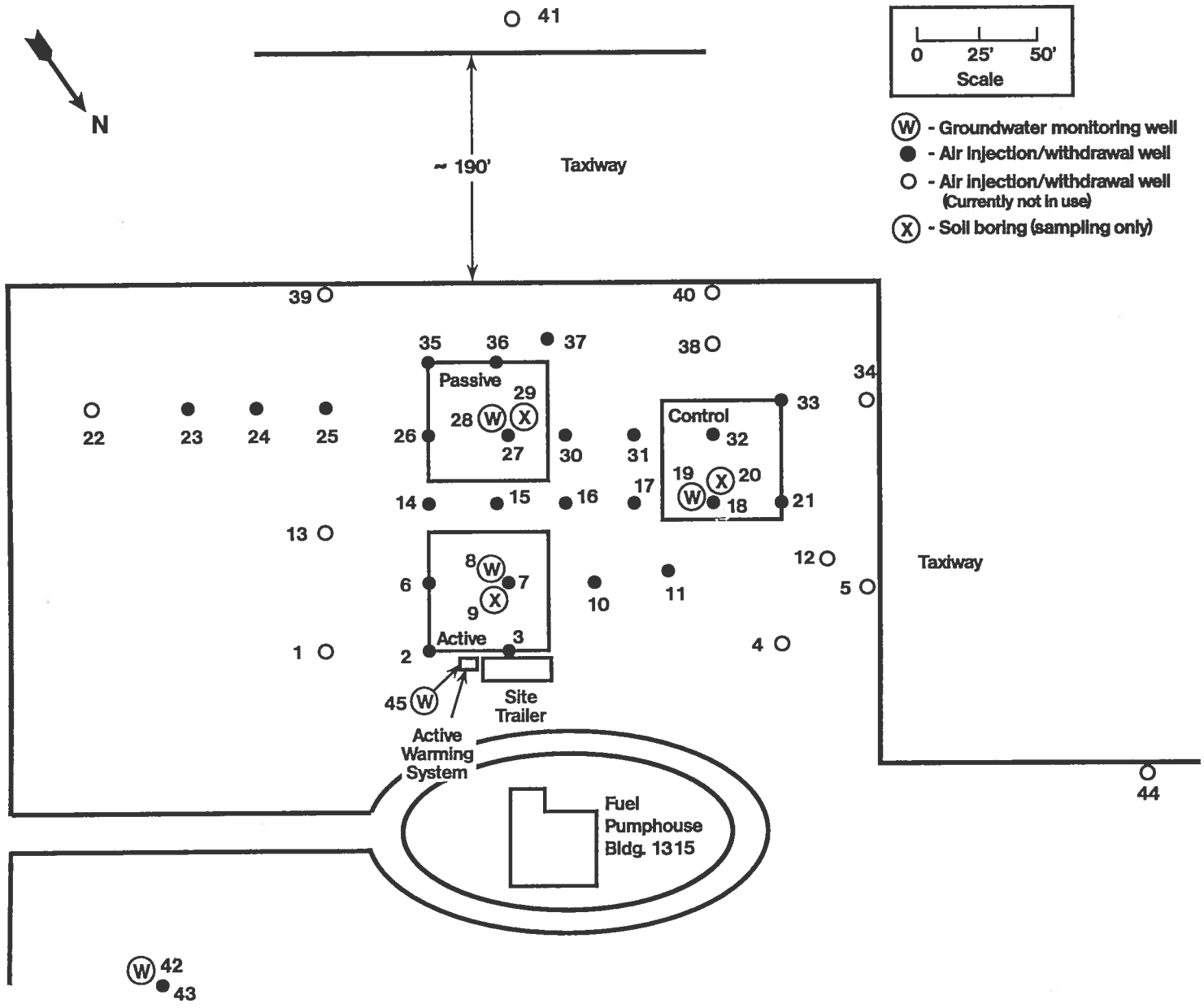


Soil Samples taken for TPH analysis at 5.5 - 6.0 ft, 6.0 - 6.5 ft, 6.5 - 7.0 ft, and 8.5 - 9.0 ft.

Background Plot
MP-2 Boring Log



Soil Samples taken for TPH analysis at 6.0 - 6.5 ft, 6.5 - 7.0 ft, 8.0 - 8.5 ft, and 8.5 - 9.0 ft.



Location of Soil Borings at Eielson AFB Bioventing Site

APPENDIX D

GENERAL SITE HEALTH AND SAFETY PLAN

GENERAL SITE HEALTH and SAFETY PLAN
for
ENVIRONMENTAL PROJECT ACTIVITIES
EIELSON AFB, ALASKA

1.0 INTRODUCTION

This Health and Safety Plan (HASP) is designed to address potential health and safety risks associated with the environmental project activities to be performed at Eielson AFB, Alaska. Refer to the draft Project Work Plan for a detailed description of planned project activities.

1.1 Implementation of the HASP

This HASP will be posted in the site control center (office/lab). All site personnel and visitors will be required to read and understand the HASP prior to admission to the project site. During all project activities the Health and Safety Officer, or his designate, will be responsible for implementation of the HASP.

2.0 PROJECT DESCRIPTION

The Eielson AFB project will consist of: (1) site investigation activities; (2) the installation of the bioventing system; and, (3) the operation of the bioventing system.

2.1 Site Investigation

The site investigation is being conducted to further define the horizontal and vertical extent of JP-5 contamination in the test area to be used for the remediation project. The overall objective of this investigation is to collect sufficient site specific data to develop a project plan for the design a field pilot bioventing based, in-situ bioreclamation system to treat jet fuel contaminated soil.

The site investigation activities will consist of the following tasks outlined as follows:

(1) Advancement of soil borings with the installation of monitoring wells. Soil samples for hydrocarbon analysis will be collected from the borings, and the wells will be developed and groundwater samples will be taken.

(2) Performance of soil gas surveys. Soil gas samples will be collected and field analysis will be conducted for petroleum hydrocarbons, oxygen, and carbon dioxide.

(3) Bioventing in-situ respiration tests will be conducted.

At the completion of the project a final site characterization will be conducted to be analogous to the initial sampling.

2.2 Installation of the Bioventing System

The installation of the bioventing system will involve the advancement of soil borings for the installation of pvc wells. Approximately 1/2 of the wells will be used as groundwater monitoring wells. The rest of the wells will be used as air injection/air withdrawal wells and will be plumbed to the bioventing system blowers with pvc pipe.

The selected site at Eielson will be separated into three test plots divided by a insulative barrier. The barrier will be installed in trenches to a depth of approximately 6 ft.

2.3 Operation of the Bioventing System

System operation will consist of operating the bioventing blowers to either withdraw soil gas or inject air through the injection/withdrawal wells. Soil gas samples will be taken and in-situ respiration tests will be performed.

2.4 Key Personnel and Responsibilities

- Dr. Robert E. Hinchee, Research Leader, is an Environmental Engineer and is the Project Manager for the Eielson AFB bioremediation project.

- Dr. Say Kee Ong, Research Scientist, is an Environmental Engineer with experience in vadose zone processes. He will be involved in bioventing system design and process monitoring plan design.

- Dr. Lawrence Smith, Research Scientist, is an Engineer and will be involved in the design of the active and passive soil warming systems.

- Jeffrey A. Kittel, Researcher, has experience in site assessment and remediation projects for petroleum release sites and is the Health and Safety Officer for the Eielson AFB project. He will be responsible for coordination of Battelle's field activities relating to the site investigation and the remediation system installation. He has completed OSHA's 40-hour Hazardous Waste Operations Training Course plus the annual 8-hour refresher courses.

- Gregory L. Headington, Senior Research Technician, has more than 10 years of field sampling experience and will be involved in soil and groundwater sampling activities. He has completed OSHA's 40-hour Hazardous Waste Operations Training Course plus the annual 8-hour refresher courses.

3.0 ANTICIPATED WEATHER CONDITIONS

The climate in the Eielson area is characterized as sub-arctic. Summer high temperatures are typically in the low to mid-eighties. Winter low temperatures are typically well below zero with moderate snowfall.

Performance of project activities could extend into the summer or winter months. All personnel will be equipped with clothing/gear which is appropriate to the weather conditions. A heated control center will be accessible to all personnel.

4.0 JOB HAZARD ANALYSIS

Preparation of this HASP was based on the proposed scope of project activities at Eielson AFB and the available analytical data regarding the chemical contamination at the site. The soils in the area of the proposed sites are known to be contaminated with JP-4.

4.1 Site Investigation

The site investigation will involve the use of a drilling rig to advance soil borings and install monitoring wells. Soil and groundwater samples will be taken.

Possible hazards include: objects striking head (overhead hazard posed by drilling rig), exposure to organic vapors or free phase petroleum, objects striking feet, objects striking eyes, exposure to the elements, and possible fire/explosion.

4.2 System Installation

The installation of the bioventing system will involve the use of a drilling rig to advance soil borings for the installation of monitoring wells. The wells will be plumbed at the surface to the bioventing system blowers. An insulative barrier will be installed to depth of approximately 6-ft to separate test areas. Confined space entry is not anticipated.

Possible hazards include: objects striking head (overhead hazard posed by drilling rig), exposure to organic vapors or free phase petroleum, objects striking feet, objects striking eyes, electrical shock, exposure to the elements.

4.3 System Operation

Operation of the system will include soil gas sampling and analysis, in-situ respiration tests, and minor maintenance repairs.

Possible hazards include: exposure to organic vapors or free phase petroleum, objects striking feet, objects striking eyes, electrical shock, exposure to the elements, and possible fire/explosion.

4.4 Primary Health Hazards

The contaminated soil and groundwater in the area of the proposed sites contains a variety of organic compounds:

- Total Petroleum Hydrocarbons (TPH)
- Benzene
- Toluene
- Xylenes
- JP-4 (jet fuel)

The most significant of these in terms of possible health effects are TPH and benzene. In addition, free-phase (liquid) JP-4 may contain higher concentrations of the above constituents and could present a fire hazard.

The primary potential health hazards associated with exposure to the chemical substances identified in detectable concentrations are provided in Table 1. Applicable employee 8-hour permissible exposure limits (PELs) and threshold limit values (TLVs) are also indicated in Table 1. The PELs are defined by the United States Department of Labor, Occupational Safety and Health Administration (OSHA), in the Code of Federal Regulations (CFR), Title 29, Labor, Section 1910.10, or other appropriate section.

The TLVs listed are recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). TLVs refer to airborne concentrations of substances and represent conditions which it is believed nearly all workers may be repeatedly exposed, 8 hours per day, day after day, for a 40-year working lifetime, without adverse effect. Because of wide variation in individual susceptibility, however, a small percentage of workers may experience discomfort to chemical substances at concentrations equal to or below TLV. A still smaller percentage of persons may be affected more seriously from exposures at or below TLV due to aggravation of a pre-existing condition or the development of an occupational illness. TLVs are based on the best available information from industrial experience, from human and animal studies, and when possible from a combination of the three sources.

The time-weighted average TLV (TLV-TWA) represents a time weighted average exposure for an 8-hour day, 40-hour work week. The majority of TLVs are expressed as TLV-TWAs. Certain substances have a skin notation following the TLV which implies that the overall exposure to a substance is enhanced by skin, mucous membrane, and/or eye exposure. Some substances have a ceiling value designated by the letter "C." Ceiling values should not be exceeded at any time during the work day.

4.5 Potential Safety Hazards and Required Control Measures

In addition to the hazards associated with exposure to the organic contaminants present on site, there are general potential hazards associated with conduction of site investigation activities and the installation and operation of the remediation system. The following potential hazards and required

control measures have been identified for the proposed scope of environmental project activities to be conducted at the AFB.

- Flying particulate: Safety glasses will be worn by all site personnel.
- Objects striking head: Hard hats will be worn in the vicinity of overhead hazards (i.e.-drilling rig).
- Objects striking foot: Steel-toed boots will be worn.
- Slips, trips, falls: Attempts will be made to minimize slips, trips, and falls by providing clear footing.
- Exposure to organic contaminants: Disposable gloves, coveralls, and boot covers will be worn when sampling contaminated soil, water, or free product.
- Exposure to organic vapors: Negative pressure, NIOSH approved, cartridge respirators will be available to site personnel should conditions warrant.
- Electrical Shock: All major electrical work (i.e. wiring, control panel construction, etc.) will be subcontracted to a qualified electrical contractor. Care will be taken to de-energize and ground any electrical equipment prior to any necessary repair work. Prior to any repair work the energy source will either be permanently disconnected or temporarily tagged and locked to prevent the equipment from accidentally energizing.
- Fire: Open flame ignition sources will be restricted from the work area (i.e. smoking, etc.). Any free-phase petroleum will be stored in appropriate containers. Signs indicating flammable liquids will be posted where appropriate. Appropriate fire extinguishers will be available to site personnel during drilling activities. Fire extinguisher will be permanently located in the site office/lab building.
- Noise: Ear plugs/ear muffs will be worn as warranted by site conditions.

5.0 RISK ASSESSMENT SUMMARY

The project activities will involve minimal disturbance of contaminated soils. Free-phase product and groundwater will essentially be handled in closed systems (i.e. bailers, tanks, etc.). No risk to the communities at or near the site or to the environment is anticipated as a result of the project activities. All free-phase petroleum will be handled in a appropriate manner. The source of exposure to the workers will be from organic vapors when drilling boreholes, installing monitoring

wells, digging trenches, emptying sample devices, and filling sample bottles. The bioventing system is expected to vent minimal organic vapors and will be designed to discharge vapors away from the work area. The total organic vapor exposure as a result of project activities is not expected to approach the concentration limits of an 8-hour, time-weighted average as listed in Table 1.

6.0 MEDICAL PROGRAM

Based on the risk assessment that exposure to organic vapors will be minimal, an aggressive medical surveillance program is not necessary. Should any site personnel exhibit symptoms of overexposure to organic vapors (i.e.- dizziness, nausea, irritated eyes and nose, etc.), they will be removed from the project site to fresh air. If symptoms persist the individual will be taken to the base clinic.

7.0 EXPOSURE MONITORING PLAN

Volatile organic hydrocarbon (VOC) emissions will be monitored in the breathing zone using a field calibrated organic vapor monitor (i.e. OVA, HNU, etc.). A total organic VOC emissions action level of 50 ppm will be set. If VOC's exceed 50 ppm above background for 5 minutes, work will be interrupted until the VOC level returns to near background concentrations.

8.0 PERSONAL PROTECTIVE EQUIPMENT

Based upon the risk assessment that exposure to vapor concentrations of hydrocarbons during the project activities will be below applicable exposure threshold limit values, level D personal protective equipment shall be worn by all persons entering the work site. The level D equipment includes the following:

- Coveralls
- Steel-toed boots

- Gloves
- Safety glasses

In addition, Level C equipment shall be available in the event that upgrading of the protection level is required. This equipment will include outer disposable coveralls; chemical-protective gloves and boots; and negative pressure, NIOSH-approved cartridge respirators, in addition to level D equipment. Level C personal protective equipment will be donned if unusual odors are detected or if any irritation of the eyes, nose, or throat is detected.

9.0 WORK PRACTICES

Whenever possible workers will remain upwind of all activities that are expected to result in the potential release of airborne contaminants. This includes soil boring and sampling activities and groundwater sampling activities.

No eating, drinking, chewing of gum or tobacco, or smoking will be permitted in the work area.

Any skin contact with contaminated or potentially contaminated surfaces, samples, or equipment shall be avoided.

Removal of materials from protective clothing or equipment by blowing, shaking, or any other means that could disperse contaminated materials is prohibited.

In addition, all applicable Eielson AFB procedures will be followed.

10.0 SITE CONTROL

As Figure 1 indicates, the proposed project sites are in an active area near the AFB taxiway. The base security personnel control access to the proposed sites, limiting access to the project facilities to persons cleared for access to the area. Signs will be posted limiting access to the project site to authorized personnel. The control center will be used to house portable equipment and will be locked when authorized personnel are not on site.

An area will be designated for equipment and personnel decontamination. This area will be located between the project field and the control center to limit the spread of any contamination.

11.0 DECONTAMINATION PROCEDURES

All disposable materials, including disposable gloves, paper towels, etc., will be placed in appropriately marked containers (e.g. plastic bags) and disposed of appropriately. Sampling equipment will be decontaminated with a laboratory grade detergent solution followed by a distilled water rinse. Decontamination activities will be conducted in a designated area with plastic sheeting covering the ground to avoid contact with the ground surface. Waste water will be handled in accordance with the base procedures.

12.0 WASTE DISPOSAL

Liquid, solid, and gaseous wastes will be generated as a result of environmental project activities at Eielson AFB. It is anticipated that the only regulated substances that will be encountered during project activities will be petroleum constituents of JP-4 jet fuel. All generated wastes will be disposed in accordance with base policy.

12.1 Liquid Waste

Contaminated groundwater will be withdrawn from the subsurface during development and purging of the monitoring wells. The contaminated groundwater will be containerized on site pending approval of a wastewater treatment permit. When the permit is issued all contaminated groundwater will be passed through a activated charcoal treatment system prior to discharge to the ground surface. Any free phase petroleum will be stored on site in a steel containers to await final disposition. The liquid petroleum will be recycled or disposed by the base in accordance to Air Force procedures.

12.2 Solid Waste

Waste that has not been contaminated with petroleum hydrocarbons (e.g., scrap paper, office supplies waste, etc.) will be disposed through the normal base waste disposal system.

Waste that has been contaminated with petroleum hydrocarbons (including any soil boring cuttings or excavated soils) will be appropriately contained and disposed in accordance to base procedures.

12.3 Gaseous Waste

Treatment of extracted soil gas is not anticipated. The soil gas will be discharged to the open atmosphere unless benzene discharge is in excess of 2 lbs/day.

13.0 EMERGENCY PROCEDURES

There are three primary scenarios for emergencies occurring during project activities: 1) personal injury requiring medical treatment; 2) an uncontrolled release of a dangerous substance (i.e., petroleum spill); and, 3) a fire or explosion. In the event of any emergency the base Environmental Director will be immediately notified.

Site specific emergency information (phone numbers, emergency care facility, etc.) will be filled in on the attached Emergency Information Form. Appropriate site maps will be added when site activities begin.

EMERGENCY INFORMATION FORM

Hospital: Acute Car (Clinic) Eielson AFB 377-8896
(Ambulance response time < 15 minutes)

Bassett Army Hospital (Ft. Wainwright) 353-5143
(Ambulance response time 35-45 minutes)

683rd Med Evac Unit 353-5143
(Ambulance response time 20 minutes)

(Also see attached Emergency Telephone Number Sheet and Route Map)

_____ (Department of _____) was contacted at _____ am/pm and briefed on the site of the potential hazards and substances involved. A map of the routes to the hospital will be available at the Command Post.

Local ambulance service is available from Acute Care Clinic at 377-2296. Their response time is 15 minutes. When necessary, arrangements will be made for on-site standby.

Firs aid equipment is available at the following locations:

First Air Kit — Davis Constructors Command Center
Emergency Eye Wash — Davis Constructors Command Center
Emergency Shower — Davis Constructors Command Center

Emergency medical information for substances present:

Substance	Exposure Symptoms	First Aid
Gasoline vapor	Dizziness, headache, pulmonary edema	Fresh air, artificial respiration, medial attention
Gasoline liquid	Dermatitis, conjunctiva	Cleanse site, physician
Gasoline liquid	Ingestion of liquid	Contact physician

Emergency Phone Number List

Police 377-5130
Airport 479-4266
Fire 377-4266
Hospital 377-2296/353-5143
D.E.C. 451-2365

EMERGENCY INFORMATION

The following information will be obtained by the Site Safety Officer prior to beginning operations:

Emergency Contacts

Hospital Emergency Room: _____ _____

Point of Contact: _____ _____

Fire Department: _____ _____

Emergency Unit: _____ _____

Security: _____ _____

Explosives Unit _____ _____

Community Emergency
Response Coordinator: _____ _____

Other: _____ _____

Program Contacts

Air Force: _____

Battelle: _____

Other: _____

Emergency Routes

Hospital (maps attached): _____

_____

_____

Other: _____

_____

APPENDIX E

QUALITY ASSURANCE PROJECT PLAN

QUALITY ASSURANCE PROJECT PLAN

BIOREMEDIATION OF HAZARDOUS WASTE SITES AT CERCLA AND RCRA SITES: EIELSON AFB SITE

OPTIMIZING BIOVENTING IN SHALLOW VADOSE ZONES AND COLD CLIMATES

1.0 INTRODUCTION

This Quality Assurance Project Plan (QAPP) establishes the quality assurance guidelines to be utilized during EPA Work Assignment #17, Task No. 1 - Bioremediation of Hazardous Wastes at CERCLA and RCRA Sites: Eielson AFB Site, Eielson AFB, Alaska. This QAPP includes quality assurance (QA) guidelines for the concurrent Air Force bioventing project at Eielson AFB, Alaska.

This QAPP has been developed to address the USEPA requirements for precision, accuracy, representativeness, completeness, and comparability of water, soil, vapor, and temperature data collected and generated during the bioremediation project. The QAPP also provides the quality assurance requirements for data handling, manipulation, and reporting. It has been designed to ensure the quality of the data gathered and generated, as well as the conclusions and recommendations reached from the use of the data.

For the purpose of this QAPP the EPA and Air Force efforts will be considered as a singular project. This will help ensure that data quality objectives are consistent for both components of the study. In practice, this QAPP will be applied equally to both the EPA and the Air Force components of the study.

2.0 PROJECT OBJECTIVES

The purpose of this project is to evaluate the efficacy of bioventing for enhancing the degradation of JP-4 contaminants in soil in a sub-arctic environment. A bioventing system will be designed to supply atmospheric oxygen to the vadose zone of a contaminated site at Eielson AFB, Alaska. The selected site will be divided into three test areas: (1) bioventing with ambient soil temperature conditions (control area); (2) bioventing with passive solar warming of

the soil (passive warming area); and, (3) bioventing with active warming of the vadose zone soils by releasing heated groundwater to the subsurface (active warming area). The intent is to integrate the data from the Air Force and EPA efforts to evaluate bioremediation under active warming, passive warming, and ambient soil temperature conditions.

The specific objectives to be accomplished by this project are:

(1) To enhance biodegradation of petroleum contaminants in soil by supplying oxygen to the vadose zone through bioventing.

(2) To evaluate the effectiveness of passive and active soil warming techniques for increasing the soil temperature in the vadose zone.

(3) To evaluate the efficacy of soil warming (both passive and active) for increasing biodegradation rates.

3.0 EXPERIMENTAL DESIGN

The data collection activities for the Eielson bioventing project can be divided into two categories: (1) initial site characterization and final site characterization; and, (2) system operation. The study Daft Work Plan describes the different phases of the project. The following section describes critical and noncritical measurements for each data collection category of the study. Field personnel should refer to each device's operation manual for proper use of analytical or measurement equipment.

3.1 Field Measurements: Groundwater

Groundwater quality will be assessed by taking pH, specific conductance, and temperature measurements prior to taking samples for chemical analysis. Depth to groundwater measurements will be taken using a oil/water interface probe. The field GC may be used to analyze for petroleum hydrocarbons in groundwater. Groundwater field measurements are noncritical.

pH: Measurements will be taken using an Orion Model SA 230 portable pH meter (or equivalent). The pH meter will be calibrated each day using at least two buffer solutions (4.0, 7.0, or 9.0). The pH meter response will be periodically checked against a standard buffer solution in the field and will be recalibrated when response drifts more than 0.2 pH units.

Conductivity: Measurements will be taken using a Yellow Springs Instruments model 33 (or similar device). The specific conductance meter will be calibrated daily against a standard solution of know conductance.

Temperature: Measurements will be taken using the Orion Model SA 230 meter (or similar device) in the temperature read mode. Temperature probe response will be periodically checked in ice water.

Depth to groundwater: Depth to groundwater measurements will be taken from developed monitoring wells using a ORS Oil/Water Interface Probe (or equivalent). The ORS probe can distinguish between water and free phase petroleum (liquid JP-4). The presence and thickness of any free phase petroleum will be recorded in a daily drilling report form.

Petroleum hydrocarbons: The field GC may be used in the purge and trap mode to directly analyze ground water for petroleum hydrocarbons via GC FID. The GC will be calibrated against prepared standards for the analytes of interest. This analysis would likely only be performed to support regulatory compliance.

3.2 Field Measurements: Soil

Soil Borings: Boring logs (or well log) will be recorded in the field by the field geologist. Soils will be characterized based on color, consistency, texture, and degree of saturation. Daily drilling report forms will be filled out for each soil boring and monitoring well (see Attachment A). The daily drilling report form will be incorporated into the Project Record Book (see Documentation section). Measurements of soil characteristics are noncritical.

3.3 Field Measurements: Soil Gas

Soil gas will be field analyzed for percent carbon dioxide, percent oxygen, and concentration petroleum hydrocarbon (as ppm hexane). Soil gas analysis will be conducted during soil gas (site) surveys, in-situ respiration tests, and bioventing system operation. Soil

gas petroleum hydrocarbon concentrations may also be analyzed by field GC as ppm hexane. Soil gas analysis is a critical measurement.

CO_2 and O_2: Percent CO_2 will be analyzed using two GasTech model 3252OX CO_2/O_2 analyzers. Both meters read percent oxygen from 0 to 25%. One meter has a percent CO_2 range of 0 to 5% and the other meter has a range of 0 to 25 % CO_2. Meters will be calibrated each day prior to use against purchased CO_2 and O_2 calibration standards. Calibration standards will be selected to be in the concentration range of the soil gas vapor being sampled.

Hydrocarbon concentration: Concentration of petroleum hydrocarbons will be analyzed using a GasTech Trace-Techtor hydrocarbon analyzer (or similar). The Trace-Techtor will be calibrated against two purchased hexane calibration gases (500 ppm and 4400 ppm). The instrument has three range settings, 100 ppm, 1000 ppm, and 10,000 ppm. The Trace-Techtor has a dilution fitting which can be used to calibrate the instrument in the low concentration range.

The field GC may also be used to analyze for total petroleum hydrocarbons (as hexane). The GC will be set to use the FID detector and will be calibrated against the same calibration gases used for the Trace-Techtor.

3.4 Laboratory Chemical Measurements

Soil and groundwater samples will be sent under chain of custody to Utah State University Water Research Laboratory (UWRL) for chemical analysis. Samples will be analyzed using EPA Standard Methods or Modified Standard Methods for petroleum hydrocarbons. A copy of the UWRL QA guidelines used for EPA projects is in Attachment A of the Draft Work Plan. Soil and groundwater laboratory analyses are critical measurements.

3.5 System Operation Measurements

Measurements taken during system operation will include soil gas analysis (for system monitoring and in-situ respiration testing, as described above), soil and water temperature, benzene concentration in the blower offgas, air injection/withdrawal volume, water flow in the

active warming system, and electrical consumption by the active warming system. All system operation measurements are critical except for water temperature.

Soil and water temperature: Water temperature and in-situ soil temperature will be monitored using Omega Type J thermocouples. The thermocouples will be connected to a Omega OM-400 Thermocouple Thermometer Data Logger (or similar) to record temperature data at regular intervals. The relative response of each thermocouple will be normalized against ice water and ambient air temperature prior to installation.

Benzene concentration: If hydrocarbon vapors are detectable in the bioventing blower offgass, a grab sample will be taken for benzene analysis. Samples will be collected directly from the blower offgass in pre-evacuated sample canisters. Samples will be analyzed via EPA modified Standard Methods at UWRL (or similar). Samples will also be taken and analyzed at the request of state regulatory officials.

Air injection/withdrawal volume: The volume of vapor (soil gas or atmospheric air) being moved through each active injection/withdrawal well will be quantified using flow rotometers in the appropriate flow range.

Water flow: Water flow into the water heaters will be measured with a in-line rotometer. The rotometer will be checked periodically to assure proper operation of the pump.

Electrical consumption: An hour counter will be used to record hours of operation for the water heaters. Power consumption will be calculated based on hours of operation and the heaters power usage rating.

4.0 ORGANIZATION AND RESPONSIBILITIES OF KEY PERSONNEL

The EPA point of contact is Mr. Richard Brenner. The Air Force point of contact is Capt. Cathy Vogel. Battelle's Program Manager is Dr. Jeffrey Means. The Project Leader is Dr. Robert Hinchee, a Environmental Engineer with extensive experience designing and implementing in-situ bioremediation field and pilot-scale research projects. Dr. S.K. Ong, an Environmental Engineer, and Dr. Lawrence Smith, an Engineer, will assist Dr. Hinchee as Technical Advisors. Dr. Ong will support bioventing system design and Dr. Smith will support the design of the active warming system.

Jeffrey A. Kittel, Researcher, has experience in site assessment and remediation projects for petroleum release sites. Mr. Kittel will be responsible for coordinating Battelle's field activities relating to the site characterization and system installation activities. Mr. Kittel will be the project QA/QC officer.

Mr. Gregory Headington, a Senior Research Technician with 12 years experience field sampling and remediation system construction, will be involved in sampling and construction activities.

5.0 DATA QUALITY OBJECTIVES

Battelle has subcontracted the analysis of soil and groundwater samples to UWRL. UWRL will establish data quality objectives similar to those outlined in Attachment A of the draft Work Plan. The data quality objectives established below will be applied by Battelle during field sampling and analysis and during data handling and reduction. It should be noted that most field analytical equipment being used for this study is designed for assessing relative changes in analyte concentrations. QA objectives as applied in a analytical lab are not obtainable or necessary for the planned field activities. Calibration of field analytical equipment is quick, effective, and will be used liberally as the predominant control measure for obtaining data quality objectives.

The quality assurance activities incorporated in the project will be used to maintain the accuracy and the precision of the system demonstration and the field analytical techniques. These activities include frequent equipment calibration, field blank samples (for shipment to UWRL), and field laboratory sample blanks. The quality assurance activities are designed to trigger corrective action activities and diagnose potential sources of error.

Accuracy: The percent accuracy is calculated from the general equation:

(1)

where X is the parameter measured

X_a is the parameter's known value

The accuracy claimed by each field instrument manufacturer will be compared with the percent accuracy as measured from standard samples. If the percent accuracy is less than the required accuracy then corrective action will be initiated.

Precision: There are no procedures to assess precision on a routine basis. The collection and analysis of sufficient replicate samples required to assess precision for field analytical techniques is beyond the scope and budget of this project.

Precision for laboratory analytical procedures will be assessed by UWRL on a on going basis. Battelle will review all analytical data to ensure that any questions concerning data validity are addressed at the earliest time possible.

Completeness: Percent completeness is defined by the general equation:

(2)

where D_o = quantity of data obtained

D_s = quantity of data scheduled to be obtained

Completeness in meeting the scheduled data recovery objectives will increase throughout the project as the experience base in equipment operation characteristics increases. The completeness objective for operations at Eielson AFB is 90 % for each test parameter.

6.0 CORRECTIVE ACTIONS

Corrective action will be undertaken whenever circumstances arise that threaten the generation and quality of data. Because much time and effort will be invested in starting the bioventing systems and the need to operate these systems over a relatively long period of time, extreme vigilance in recognizing the need for corrective action will be used to ensure their ongoing performance. The analysis of samples, being an integral part of system operation, requires the same vigilance to ensure the quality of data output. The responsibility for maintaining vigilance and initiating corrective action will be primarily with the system operators. Corrective action, however, may be initiated by the project officer.

The specific nature of all corrective actions and the operating limits that would trigger the need for corrective action for all aspects of the remediation system and analytical operations are to numerous to anticipate here. Most corrective actions will be empirical in nature as the following specific examples show.

Problem	Corrective Action
Analysis of standard sample indicated field GC accuracy has drifted outside established limits.	- Perform replicate standard analysis. - Verify instrument parameters - Recalibrate instrument.
CO_2 measured in soil gas is off-scale for the high range analyzer.	- Check calibration - Dilute sample stream using appropriate flow control device.
Flow meter on groundwater heating system indicates groundwater flow has stopped.	- Check pump effluent hose for leaks. - Check power to pump - Check water level in extraction well.
Benzene concentration in bioventing off-gass is in excess of regulatory limits.	- Reconfigure system to inject air or to withdraw soil gas from uncontaminated zone.

7.0 DATA COLLECTION

7.1 Sampling Frequency

An initial site characterization will be performed to establish baseline contaminant concentrations in soil and groundwater, as described in the EPA project DRAFT WORK PLAN.

Sampling conducted in support of regulatory compliance will be performed in accordance to the frequency dictated by the wastewater discharge permit. The system vapor discharge will be periodically monitored for the presence of volatile hydrocarbons using hand

held monitoring equipment. Grab sampling of the vapor discharge for benzene analysis will be performed when volatile hydrocarbons are detected.

Soil gas sampling and in-situ respiration tests will be performed at scheduled intervals and on a as needed basis during system operation.

A final site characterization will be performed at the completion of the project to be analogous to the initial soil and groundwater sampling.

7.2 Sample Collection Techniques

Samples will be collected in a manner consistent with the sample matrix and the parameters being analyzed. Samples will be of groundwater, soil, or soil gas.

Water samples will be collected in teflon bailers for immediate transfer to cleaned sample bottles (I-Chem 200 series). Preservation of samples will be in accordance with applicable EPA procedures, but will generally be limited to refrigeration. VOC samples will be collected in 40 mL glass vials with teflon cap liners. Care will be taken to minimize volatilization by avoiding sample agitation and filling sample vials to the top with no headspace.

Soil gas samples will be drawn from soil gas sampling tubes (permanent and temporary). The tubes will first be purged using a secondary pump. The portable field vapor analyzers (all have built-in sample pumps) will then be used to draw and analyze soil vapor directly from sample ports. Vapor samples for on-site GC analysis will be drawn using clean glass syringes. Vapor samples to be analyzed off-site will be collected in evacuated sample canisters.

Soil samples will be collected using 2-ft. stainless steel split-spoons lined with four 6-inch brass liners. Liners will be removed from the split-spoon and immediately sealed with plastic caps.

All sample collection devices will be cleaned and prepared in accordance to applicable EPA procedures prior to each use.

7.3 Sample Identification Procedures

Each sample will be identified with a unique sample number coded to correlate to the sampling location and assigned by the sample collector at the time of collection. Each sample container will be labeled at the time of collection with, at a minimum, the following:

Date/Time of Collection:
Sample Number:
Analyses to be Performed:
Collector's Initials:

Each sample will be logged in the Project Record Book (see section on Documentation) with the information recorded on the sample container label and a brief sample description. All samples being shipped off-site for analysis will be logged on a chain-of-custody log sheet to be sent with the samples to document sample receipt.

8.0 DOCUMENTATION AND RECORD KEEPING

A chronological record on the installation and operation of the soil bioremediation system will be maintained in the Project Record Books (separate record books will be kept for EPA and Air Force components). The record books will be used to record events pertaining to systems operation, including sampling, changes in process conditions (flow and temperature), preventative maintenance, equipment failures, corrective actions, operators initials and dating. The Project Record Book will be reviewed, initialed, and dated on a regular basis by the project officer or project researcher.

Quality assurance will be implemented throughout this study through quality planning, quality control, and quality assessment.

Quality planning for this project includes the preparation of this QAPP.

Each field analytical instrument will be calibrated daily prior to use, and as needed as determined by calibration checks.

Quality assessment activities for this study include a review of all operations and procedures by Jeff Kittel at Battelle to ensure compliance with EPA method and quality guidelines. Monthly reports to Richard Brenner at EPA Cincinnati will include any significant quality assurance problems and recommended solutions.

9.0 DATA REDUCTION, VALIDATION, AND REPORTING

9.1 Data Reduction

Battelle researchers and technicians will be responsible for data reduction, as required to make adjustments to the remediation system. This reduction will consist of calculating biodegradation rates from soil gas concentrations. Changes in system configuration may be made to optimize system operation. Data will retain all significant digits so that round-off errors will not be propagated through the calculations. Peer checks of data recording and data reduction will be used to reduce personal errors.

9.2 Data Validation

Data validation will be conducted by process operators and will consist of comparing the data against standard curves and control limits for each analyte. Control limits and standard curves for each field analytical method and analyte will be set as described in the operation manual for each field instrument.

9.3 Data Reporting

The final report will be submitted to the EPA Project Officer. This report will include analytical data, the results of the QA/QC activities, and a summary of the operational characteristics of the soil bioremediation system. An evaluation of the relative effectiveness of soil warming techniques for increasing biodegradation rates will be made.

10.0 QUALITY ASSURANCE PROJECT PLAN APPROVAL

The QAPP approval form is presented in Attachment C.

Attachment

UWRL Quality Assurance/Quality Control Plan

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Project Quality Assurance/Quality Control Plan
for
Subsurface Monitoring for Assessing In Situ Biocontainment of Petroleum Contaminated Ground Water Plumes

Introduction

This quality assurance/quality control (QA/QC) plan contains the basic components of accuracy, precision, completeness, representativeness, and comparability as described in Test Methods for Evaluating Solid Waste, SW 846 (EPA, 1986d), and the Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans (EPA, 1980).

Project Organization and Responsibility

Data Users/Requestors

The individual project members responsible for the establishment of data needs required for the successful completion of the proposed project include the Principal Investigator (R. R. Dupont: .Associate Professor, Civil and Environmental Engineering and Assistant Director, Utah Water Research Laboratory) and project Co-Principal Investigators (D. L. Sorensen: Research Associate Professor, Utah Water Research Laboratory, Civil and Environmental Engineering, and Biology; and M. Kemblowski: Professor, Civil and Environmental Engineering, Utah Water Research Laboratory). These individuals will serve to establish data requirements, data collection schedules, and data collection priorities throughout the duration of the laboratory and field components of the proposed project. The Principal Investigator will be the primary contact with the EPA Project Leader in assuring coordination between the UWRL and EPA in terms of data collection requests.

Individuals primarily responsible for generating data in the proposed project include: Laboratory Research Technicians trained for specific analyses within the UWRL Environmental Quality Laboratory (EQL), and graduate Research Assistants within the Environmental Engineering Graduate Program in the Department of Civil and Environmental Engineering at Utah State University. Field data generation will also be carried out by R. R. Dupont and D. L. Sorensen.

Data Reviewers/Approvers

Responsibility for data review will be assigned to the Quality Assurance Officer (J. E. McLean: Quality Assurance Officer, UWRL, EQL). The QA Officer has broad authority to approve or disapprove project plans, specific analyses, and final reports. The QA Officer is outside the normal operations of the project and will be in a position to provide independent and objective evaluation and assessment of the QA program and to provide timely feedback and recommendations to the Project Team regarding project QA/QC. The QA Officer is responsible for reviewing and advising on all aspects of QA/QC, including: (1) making on-site evaluations and submitting audit samples to assist in reviewing QA/QC procedures; and, (2) if problems are detected, making recommendations to the data generators for their resolution.

Field sample monitoring will be the responsibility of D. L. Sorensen, who will ensure that appropriate field sampling equipment and sample containers are utilized throughout the field activities of the project. In addition, Dr. Sorensen will be responsible for insuring that proper sample preservation, handling, transport and storage practices are utilized, and that all field sample documentation is correct. Dr. Sorensen will have primary responsibility in the proper training of field personnel related to field sampling and sample labeling protocol so that a high degree of QC can maintained during project field sampling activities.

Research Technicians have responsibility for quality control monitoring in their specified expertise areas. Their responsibilities include: (1) training and qualifying

additional personnel in specific laboratory QC and analytical procedures; (2) receiving samples from the field and verifying that incoming samples correspond to the sample custody forms; (3) maintaining records of all incoming samples, and tracking those samples through subsequent processing and analysis; (4) verifying that laboratory QC and analytical procedures are being followed as specified in the work plans; (5) reviewing sample and QC data during the course of analyses; (6) if questionable data exist, determining which repeat sample of analyses are needed; (7) preparing quality control samples for analysis prior to and during the program; (8) preparing QC and sample data for review by the laboratory manager, Dr. W J. Doucette; and, (9) preparing QC and sample data for transmission and entry into a computer.

QA Objectives for Measurement Data in Terms of Precision, Accuracy, Completeness, Representativeness, and Comparability

Methods for analysis will be conducted using standard methods from SW 846 (US EPA, 1986d) and Standard Methods for the Examination of Water and Wastewater (APHA, 1989) when available. The analytical procedures for determining all parameters to be monitored in this study are listed in Table 4.

All data have measures by which their quality can be judged and certain criteria which will determine whether or not the data being collected are acceptable for their intended use. The goal of the QA/QC program is to provide data of such quality to allow for confidence in quantitative results and to allow reporting comparisons to be made as data are collected over time. The raw data and precision and accuracy checks on the raw data will be organized in a form to permit defense of the data and conclusions drawn from them.

Precision and Accuracy

Precision and accuracy for audit and check samples: laboratory operation QC. Check samples and audit samples will provide a means of evaluating instrument performance, instrument calibration, and technician performance. This is the first step in the QC plan to ensure that basic laboratory operations are in control.

Chemical analyses performed with check samples and audit samples are expected to be within the accuracy and precision limits specified in EPA (1986d, 1984b), and EPA QC sample data sheets. All accuracy data are acceptable if they are within the listed 95% confidence interval for a particular QC sample. All duplicate analyses of check or audit samples will be within ± 20 relative percent difference. The analysis is determined to be out-of-control when the above criteria are exceeded. At this point, action will be taken to bring the analysis back into control.

Check samples will be obtained for all chemical parameters measured. These check samples will be analyzed on a daily basis, at the start of any analytical run, at least every 20 samples within a run and at the end of the run (EPA 1986d). EPA QC samples, in addition to the performance audits, are daily checks to ensure that the accuracy and precision objectives for an instrumental analysis are met. Performance audits will be conducted by the QA Officer. All laboratory personnel involved in chemical analysis will run audit samples prior to the start of the project, monthly throughout the project, and at the end of the project.

Precision and accuracy objectives for an analyte in sample matrix: procedural QC. The check and audit samples, while providing routine monitoring of instrument and technician performance, do not provide information on expected precision and accuracy obtainable for an analyte in samples with unknown matrix effects. Precision and accuracy are sample dependent and will vary as the sample matrix and concentration of the analyte varies. Actual precision and accuracy must be determined as part of the QA/QC Plan (APHA 1989). The procedure used to

monitor the actual precision and accuracy of any analytical parameter throughout the project will be those specified by the EPA (1986d, 1984b) and by APHA (1989). These established guidelines include the use of replicates, spikes, and control charts. The quality of the data generated by any project will be within the general limits for precision and accuracy listed for each analyte in SW 846 (EPA, 1986d) when available, and will be such that the data will support the quality objectives as stated above.

Completeness

Completeness will be ensured by maintaining QC over field sampling, handling, transport and storage activities through the efforts of the Field Sampling Monitor. QC objectives for completeness are to assure the analysis of at least 95 percent of the samples intended for any analyte. Completeness will be checked by the project QA Officer as part of the monthly project audit.

Representativeness

Appropriate procedures will be required by the Field Sampling Monitor to ensure that all samples collected are statistically representative of the site, i.e., all samples are randomly drawn from the population of possible samples within the sampling area, and are collected, handled, transported and stored according to standard procedures that ensure results are representative of actual field conditions from which they came.

Comparability

Use of standardized field sampling procedures and methods of analysis will ensure the comparability of results. Standardized spreadsheet data formats for data

input, and calculation and reporting of results will also facilitate the generation of comparable data.

Sampling Procedures

Quality assurance and quality control guidelines for sampling procedures will be developed in the initial phase of the study for all soil, ground water and soil gas samples to be collected in the project. Sampling protocol will specify the statistical procedures to be used in order to insure collection of representative field samples, and will be determined in coordination with the EPA Project Leader. The Field Sampling Monitor will be the primary UWRL Research Team member coordinating this Sampling Plan, and will define specific sample collection procedures including equipment to be used for sample collection, sample equipment decontamination, sample storage and transport, and methods for sample preservation and to minimize contamination. Trip blanks and field blanks will be used to monitor standard handling protocol to assure representative field sample data generation.

Documentation of sample collection will include field notebooks, which will be used to record samples collected, site descriptions and analyses to be performed. All samples will be labelled with a unique sample number, date and time of collection along with a sample description. Sample custody forms (Figure A-1) will be utilized for the tracking of all field samples collected in this study through transport, storage, analysis, data recording and final result reporting.

Sample Custody

The field Tracking Report to be used in this project is shown in Figure A-2. Each person having custody of the samples recorded on the tracking report will sign and date the form certifying transfer of custody or receipt of the samples. Personnel accepting custody of the samples are to have them in his/her physical possession or

SAMPLE CUSTODY FORM

Sample Name _____ Sample Number _____
Vacuum Before Sampling _____ Ambient Temp. _____
Vacuum After Sampling _____ Sampling Pt. Temp. _____
Vacuum After Analysis _____ Analysis Temp. _____

Analyses to be Conducted _____

VOC, O2, CO2 _____

GC GC/MS _____

Sampled By _____ Analyzed By _____
Sample Date _____ Analysis Date _____

Blank YES NO Spiked Blank YES NO

Figure A-1. Sample Custody Form to be utilized for all samples collected in this project.

in his/her sight at all times. Custody of the samples will begin with the Field Sampling Monitor. One copy of the tracking form will remain with the Field Sampling Monitor's records, while the original and one copy will be transmitted with the samples. The last person to sign the form should be the laboratory technician in charge of the analysis. Upon arrival in the laboratory and completion of log-in procedures, the original tracking form will be transmitted to the Quality Assurance Officer, and a copy will remain with the laboratory technician's records.

Calibration Procedures and Frequency

Each instrument will be calibrated in a manner consistent with standard operating procedures referenced in Table 4. Calibration will be documented in a

UTAH STATE UNIVERSITY
FIELD TRACKING REPORT

SITE:_____

SAMPLE NUMBER	BRIEF DESCRIPTION	DATE	TIME(S)	SAMPLER	REMARKS

Custody: Signature	Date / Time
Relinquished by:	
Received by:	
Relenquished by:	

Figure A-2. Sample Field Tracking Report to be utilized for all samples collected in this project.

calibration log for that particular instrument and calibration checks will be documented using the forms shown in Figures A-3 to A-7. Calibration controls, using calibration check samples, will be required for all analytical operations for this project.

The project QA Officer will check each instrument calibration record as part of the monthly project audit to verify that instrumental operation is in control. Analytical problems with the calibration procedure will result in corrective actions recommended by Dr. Doucette, the Laboratory Director, and the project QA officer before analysis continues.

Analytical Procedures

Inorganic Analyses

Atomic absorption spectrophotometry. Instruments will be calibrated daily and each time each instrument is set-up. The daily standard curves will consists of a blank and at least three standards. Initial calibration verification using the calibration check sample must fall within the control limits of 90 to 110% of the known value, or corrective action will be initiated.

For continuing verification calibration, the calibration check sample and the calibration blank will be analyzed at a minimum frequency of 10% or every 2 hours, whichever is more frequent, and after the last sample analyzed. The analyzed concentration of the calibration check sample must be within 90 to 110% of the known value, or corrective action will be initiated. A record will be made of the verification using the form in Figure A-7. A record of calibration blank results will be kept using the form shown in Figure A-8. The calibration blank must be less than the contract required detection limits CRDL (contract required detection limits), or corrective action will be initiated.

Initial Calibration Data
Volatile HSL Compounds

Case No: _____ Instrument I D: _____

Laboratory Name _____ Calibration Date: _____

Minimum $\overline{RF}$ for SPCC is 0.300 (0.25 for Bromoform) Maximum % RSD for CCC is 30%

Laboratory ID								
Compound	RF_{20}	RF_{50}	RF_{100}	RF_{150}	RF_{200}	$\overline{RF}$	% RSD	CCC* SPCC**

Initial Calibration Data
Semivolatile HSL Compounds
(Page 1)

Case No _____ Instrument ID _____

Laboratory Name _____ Calibration Date _____

Minimum $\overline{RF}$ for SPCC is 0.050 Maximum % RSD for CCC is 30%

Laboratory ID								
Compound	RF_{20}	RF_{50}	RF_{80}	RF_{120}	RF_{160}	$\overline{RF}$	% RSD	CCC* SPCC**

Continuing Calibration Check
Volatile HSL Compounds

Case No. _____ Calibration Date _____

Laboratory Name _____ Time _____

Contract No. _____ Laboratory ID. _____

Instrument ID. _____ Initial Calibration Date. _____

Minimum RF for SPCC is 0.300 (0.25 for Bromoform)

Maximum %D for CCC is 25%

Compound	RF	RF_{50}	% D	CCC	SPCC

Continuing Calibration Check
Semivolatile HSL Compounds
(Page 1)

Case No: _____ Calibration Date: _____

Laboratory Name_____ Time: _____

Laboratory ID: _____

Instrument ID: _____ Initial Calibration Date: _____

Minimum RF for SPCC is 0.050 Maximum %D for CCC is 25%

Compound	$\overline{RF}$	RF_{50}	% D	CCC	SPCC

Q. C. Report No. _____

INITIAL AND CONTINUING CALIBRATION VERIFICATION[3]

LAB NAME _____ CASE NO. _____

SOW NO. _____

DATE _____ UNITS: ug/L

Compound	Initial Calib.[1]			Continuing Calibration[2]					
Metals:	True Value	Found	%R	True Value	Found	%R	Found	%R	Method[4]
1. Aluminum									
2. Antimony									
3. Arsenic									
4. Barium									
5. Beryllium									
6. Cadmium									
7. Calcium									
8. Chromium									
9. Cobalt									
10. Copper									
11. Iron									
12. Lead									
13. Magnesium									
14. Manganese									
15. Mercury									
16. Nickel									
17. Potassium									
18. Selenium									
19. Silver									
20. Sodium									
21. Thallium									
22. Vanadium									
23. Zinc									
Other: _____									
Cyanide									

[1] Initial Calibration Source _____ [2] Continuing Calibration Source _____

[3] Control Limits: Mercury and Tin 80-120; Other Metals 90-110; Cyanide 85-115

[4] Indicate Analytical Method Used: P - ICP; A - Flame AA; F - Furnace AA

Figure A-7. Inorganic compound Initial and Continuing Calibration Verification data sheet to be utilized in this study.

Q. C. Report No. _____

BLANKS

LAB NAME _____ CASE NO. _____

DATE _____ UNITS _____

Compound	Initial Calibration Blank Value	Continuing Calibration Blank Value 1	2	3	4	Preparation Blank Matrix: 1	Matrix: 2
Metals:							
1. Aluminum							
2. Antimony							
3. Arsenic							
4. Barium							
5. Beryllium							
6. Cadmium							
7. Calcium							
8. Chromium							
9. Cobalt							
10. Copper							
11. Iron							
12. Lead							
13. Magnesium							
14. Manganese							
15. Mercury							
16. Nickel							
17. Potassium							
18. Selenium							
19. Silver							
20. Sodium							
21. Thallium							
22. Vanadium							
23. Zinc							
Other:							
Cyanide							

[1] Reporting Units: aqueous, ug/L; solid mg/kg

Figure A-8. Inorganic compound Calibration Blank data sheet to be utilized in this study.

Inductively coupled argon plasma emission spectrophotometry. Calibration procedures for the inductively coupled argon plasma emission spectrophotometer (ICP) will be followed as outlined in the calibration procedure for atomic absorption (AA) spectrophotometer analysis.

Standards for both the AA and ICP will be prepared from commercially purchased 1,000 mg/L stock standards. Stock standards will be diluted, using Class A volumetric glassware, to the appropriate concentrations for generating a standard curve. Standards will be prepared on a quarterly basis for flame AA and ICP analysis. Standards for flameless AA analysis will be prepared on a weekly basis. Calibration check samples will be prepared from stock solutions not used for making standards. Reference solutions provided by the EPA will commonly be used for this purpose.

Spectrophotometers. Spectrophotometers will be employed for the analysis of Fe^{2+}, Mn^{2+}, phosphorus and ammonia. These instruments will be calibrated in a fashion similar to that described for the calibration of the AA.

Ion chromatography. Ion chromatography will be employed for the analysis of Cl, SO_4^{2-}, HCO_3^-, CO_3^{2-}, and NO_3^- anions. The calibration procedure of the instrument will follow that described for AA analysis.

Organic Analyses

Identification and quantification of organic compounds using gas chromatographic procedures will be performed using authentic standards of each analyte. Initially, calibration curves for GC analyses will be generated using a minimum of five different concentrations of each analyte. One standard will be at a concentration near the detection limit. The other standards will cover the expected range of concentrations found in the samples. Initial calibration data will be recorded on the forms shown in Figures A-3 or A-4.

On a daily basis a verification of organic analyte calibration curves will be made using one or more standards and a calibration check sample. During an analytical run, continued frequency of verification is detector dependent. Records of calibration checks will be kept using forms shown in Figures A-5 or A-6. If the response for any analyte varies from the predicted response by more than ±15%, a new standard curve will be prepared.

Miscellaneous Laboratory Equipment

All pH meters will be calibrated daily using commercially purchased pH 7 and pH 9 buffer solutions. Conductivity bridges will be calibrated using a 0.0100 M potassium chloride solution. The temperature of the standard and samples will be taken at the time of analysis so that EC can be corrected to standard temperature, 25°C. The calibration of each measurement will be checked every 20 samples using a calibration check sample. Reference solutions are available from the EPA for pH and EC. If calibration check samples are not within 90 to 110% of the known value, corrective action will be initiated. A record will be made of initial calibration and calibration verification data using forms similar to these shown in Figure A-7.

Analytical balances will be calibrated on a routine basis with a set of certified weights and records will be kept in the project logbook. Service contracts on all balances will be maintained during the duration of this project. Daily logs of oven and refrigerator temperature will also be maintained.

Data Reduction, Validation, and Reporting

The data reduction schemes for analytical measurements, including all equations used to calculate concentration or values of measured parameters and reporting units are contained in the standard methods referenced in Table 4.

All measurement data will be promptly recorded in bound laboratory notebooks, dated, and signed by the authorized project personnel making the measurements. All data generated will then be transferred to a computer for storage of the raw data and for further data calculations. All data collected during the study will be entered into computer data files using spreadsheet and/or data base management software on Apple Macintosh personal computers. Electronically stored data will be kept in replicate copies with at least one archive copy that will be updated weekly. Printed copies of the data files will also be kept. These data are transferable to other computer formats (e. g., IBM, Dec VAX, etc.). Computerized statistical computation software packages will be used for all statistical calculations.

Relative percent difference and percent recovery results will be calculated from analyses of replicates and spiked samples and results will be reported and included in the weekly QA/QC report. All daily precision and accuracy data will be used to construct analyte control charts.

Daily calibration curves and data from the analysis of calibration check and blank samples will be recorded, stored in the computer and compared to the true values. Analyses in which any measures of QC parameters fall out of control of the data quality objectives as outlined above, will be flagged, will be declared outliers and all samples in that analytical batch will be repeated. All raw and QC data will be reported in quarterly technical progress reports. Also as part of the monthly project audit, the project QA Officer will examine all data records to verify completeness of data by comparison with the appropriate analytical data quality objectives.

Internal Quality Control Checks and Frequency

Laboratory Certification

The Environmental Quality Laboratory is certified by the Utah Department of Health, Bureau of Laboratory Improvement for analysis of environmental samples.

The certification program will be maintained during the duration of this project, with analysis of bi-annual audit samples distributed by the State of Utah, Department of Environmental Quality.

Laboratory Operations QC

Performance audits will be conducted by the QA Officer. All laboratory personnel involved in chemical analyses will run audit samples and blanks prior to the start of any new procedure, on a monthly basis, and at the end of the study period. Calculation of precision and accuracy data for these samples will demonstrate the ability of laboratory personnel to perform these analyses and determine whether the analyses meet the project's QA/QC objectives for accuracy and precision.

When results are out of control, steps will be taken to determine the cause. First, calculations will be checked. Then the instrument will be evaluated for proper set-up. The technician will be interviewed by the QA Officer to determine whether the technician fully understands the procedures used. The technician will be retrained if necessary. All analyses under question will be re-analyzed, and all extraction, concentration and analysis procedures will be reviewed by the QA Officer until QA/QC objectives are successfully met.

Duplicates and Spikes

In all analyses, 50% of duplicate samples will be spiked with standard material. From these duplicate data, percent recovery and relative error will be calculated to demonstrate whether the analysis is performed with the required precision and accuracy to satisfy QA/QC objectives. The objective of duplicate spiking of samples is to determine the extent of matrix bias or interferences on analyte recovery (accuracy) and sample-to-sample precision (EPA, 1986d).

On a daily basis, spiking and duplicate analyses will be performed on a minimum of 10% of the samples, or once in every analytical batch of less than 10 samples, in an effort to insure accurate results. For organic analyses when one to ten samples per month are being analyzed, one spiked sample will be run during the month. The choice of the samples for spiking will be selected in a random, unbiased manner.

The spiking procedure is as follows:

For inorganics, a small volume, less than 500 µL, of standard solution will be added to a known volume of sample (10 mL typically). The concentration of the spiking solution will be such that the final concentration of the analyte in the spiked sample will be approximately 1.5 to 2 times the concentration of the analyte in the unspiked solution and will cover the linear range of the analysis.

For organic analysis, spiking solutions will be prepared as described in Methods 3500 and 8000 of SW 846 (EPA, 1986d).

Spike sample recoveries, %R, will be calculated as:

$$\%R=[(SSR-SR)/SA]*100 \qquad \text{(A-1)}$$

where SSR is the spiked sample concentration, SR is the unspiked sample concentration and SA is the concentration of spiked added. Duplicate and sample spike data will be reported using forms similar to those shown in Figures A-9 and A-10, respectively.

All daily spiking data should agree with control limits specified in SW 846 (EPA, 1986d) and those generated for each sample matrix using control charts. Results that are outside of the control limit will be flagged and corrective action will be initiated.

When a result is out of control, steps will be taken to determine the cause. First, calculations will be checked. Then the instrument will be checked for proper set-up. The sample(s) will be reanalyzed. If these steps do not bring the sample into control,

DUPLICATES

LAB NAME _____ CASE NO. _____

DATE _____ Sample No. _____

Lab Sample ID No. _____

Units _____

Matrix _____

Compound	Control Limit[1]	Sample(S)	Duplicate(D)	RPD[2]
Metals:				
1. Aluminum				
2. Antimony				
3. Arsenic				
4. Barium				
5. Beryllium				
6. Cadmium				
7. Calcium				
8. Chromium				
9. Cobalt				
10. Copper				
11. Iron				
12. Lead				
13. Magnesium				
14. Manganese				
15. Mercury				
16. Nickel				
17. Potassium				
18. Selenium				
19. Silver				
20. Sodium				
21. Thallium				
22. Vanadium				
23. Zinc				
Other:				
Cyanide				

* Out of Control

[1] To be added at a later date.

[2] RPD = [|S - D|/((S + D)/2)] x 100

NC - Non calculable RPD due to value(s) less than CRDL

Figure A-9. Duplicate sample data sheet to be utilized in this study.

SPIKE SAMPLE RECOVERY

LAB NAME _____ CASE NO. _____

Sample No. _____

DATE _____ Lab Sample ID No. _____

Units _____

Matrix _____

Compound	Control Limit %R	Spiked Sample Result (SSR)	Sample Result (SR)	Spiked Added (SA)	%R[1]
Metals:					
1. Aluminum					
2. Antimony					
3. Arsenic					
4. Barium					
5. Beryllium					
6. Cadmium					
7. Calcium					
8. Chromium					
9. Cobalt					
10. Copper					
11. Iron					
12. Lead					
13. Magnesium					
14. Manganese					
15. Mercury					
16. Nickel					
17. Potassium					
18. Selenium					
19. Silver					
20. Sodium					
21. Thallium					
22. Vanadium					
23. Zinc					
Other:					
Cyanide					

[1] %R = [(SSR - SR)/SA] x 100

"N" - out of control

"NR" - Not required

Comments: _____

Figure A-10. Spiked Sample Recovery data sheet to be utilized in this study.

the spiked sample will be prepared again and analyzed. It may be necessary at that time to prepare fresh standards. If all of the above procedures do not bring the analysis into control, then the QC Officer is to be notified. All samples analyzed in the batch with a sample out of control will be re-analyzed via the procedure used to bring the sample results back into control.

Duplicate sample results will be reported as the relative percent deviation (RPD), which is calculated as follows:

$$RPD=[S-D]/((S+D)/2)]*100 \qquad (A-2)$$

where S is the concentration of analyte in the sample and D is the concentration of the analyte in the duplicate sample.

QA/QC goals for precision are listed in SW 846 (EPA, 1986d) and will be generated for a particular matrix using control charts for each analyte. When a result falls outside of the control limit, the value will be flagged. Steps will then be taken to determine the cause. First, calculations will be checked. Then instrument performance will be evaluated. The samples will be re-analyzed. If these procedures do not bring the samples back into control, then all samples in the analytical batch will be prepared again and analyzed. If none of these procedures bring the analysis back into control, the laboratory manager, Dr W. J. Doucette and the QA Officer will be notified to determine further action to bring the analysis back into control.

Blanks

Blanks samples will include: field blanks, trip blanks, and reagent blanks. Field and trip blanks, when appropriate, will be processed along with all other soil sample. To ensure that contamination from glassware, other materials, or reagents is not interfering with sample analysis, a reagent blank will be run prior to any sample run. For this reagent blank, all analytical operations using the specified

materials and reagents will be performed in the absence of sample substrate. A reagent blank will be run every 20 samples or in any batch of less than 20 samples.

If the reagent blank shows significant interferences, that is if the concentration of the reagent blank is above the contract required detection limit, CRDL, materials and reagents will be replaced before additional samples are prepared. Samples out of control will be flagged. Samples prepared with contaminated reagents will be discarded, and fresh samples will be reprocessed. Records of all blank analyses will be made on forms similar to those shown in Figures A-8 or A-11, and will be retained for the duration of the proposed project.

Calibration Check Samples

Each analytical batch of 20 samples will contain a calibration check sample (CCS). The CCS is a blank which has been spiked with the analyte from an independent source in order to monitor the execution of the analytical method. The CCS is carried through the same sample preparation, extraction procedures and analysis as the actual samples. Methods 3500 and 8000 (EPA, 1986d) lists the procedures for preparing check sample for organic analysis. For inorganics, CCS will be prepared using EPA QC samples or other sources of the analyte independent of the solutions used to prepare calibration curve standards.

All precision and accuracy results for the CCSs must meet the QC acceptance criteria listed in SW 846 (EPA, 1986d) and generated using control charts. Records of CCS analyses will be retained on forms similar to those shown in Figures A-5 to A-7 for the duration of the proposed project.

Instrument Set-Up

Requirements and procedures are instrument and method dependent. Analytical instrumentation will be set-up in accordance with requirements which are specific to the instrumentation procedures employed.

METHOD BLANK SUMMARY

Case No. _____ Laboratory Name _____

FILE ID	DATE OF ANALYSIS	FRACTION	MATRIX	CONC. LEVEL	INST. ID	CAS NUMBER	COMPOUND (HSL, TIC OR UNKNOWN)	CONC.	UNITS	CRQL

Comments:

_____

_____

_____

_____

_____

Figure A-11. Method Blank Summary data sheet to be utilized in this study.

Calibration

Analytical instrumentation shall be calibrated in accordance with requirements which are specific to the instrument employed. Standard curves used in the determination of all parameters shall be prepared as follows (EPA, 1986d):

> Calibration controls, using check samples, will be required for all analytical operations. Each instrument will be calibrated in a manner consistent with standard operating procedures referenced in Table 4. Calibration will be documented in a calibration log for that particular instrument.
>
> The project QA Officer will check each instrument calibration record, as part of the monthly project audit, to verify that instrumental operation is in control. Analytical problems with the calibration procedure will result in corrective actions recommended by Dr W J. Doucette, the laboratory manager and the project QA Officer, before analysis continues.

Detection Limits and Quantification Limits

The detection limit is the lowest concentration of an analyte that the analytical procedure can reliably detect. The quantification limit is the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions.

As stated in SW 846 (EPA, 1986d), detection limits, sensitivity, and linear range of the analyte will vary with the sample matrix. Contract required detection limits will not exceed those specified for each analyte in SW 846 (EPA, 1986d).

The actual detection limit and quantification limit of each parameter will be evaluated for each new matrix, i.e., extracting solution, encountered. Multiple determinations (at least 20 readings) of a given solution type with no detectable analyte will be used to establish the noise level. The method of standard additions will then be used to determine the calibration curve using this extracting solution. The slope of the calibration curve, m, will be used to calculate the detection limit and the quantification limit for that media using the following relations:

$$MDL = K \bullet S_B / m \qquad \text{(A-3)}$$

where m=slope of the calibration curve; S_B=standard deviation of the average noise level. For K=3; MDL = method detection limit, while for K=5; MQL = method quantification limit. The instrument detection limits for the various parameters in each matrix will be reported using standard forms similar to that shown in Figure A-12.

Specific QC for Organic Analyses

Surrogate compounds. For laboratory organic analyses, 10% of every blank, standard, and sample will be spiked with a surrogate compound prior to extraction. Surrogate spikes must fall within the control limits specified for each method in SW 846 (EPA, 1986d). A surrogate is an organic compound which is similar to the analyte in terms of extraction and analysis, but is not found in the environmental samples. Preparation of surrogate samples is given in Method 3500 in SW 846 (EPA, 1986d). Results of percent recovery of the surrogate will be recorded on standard forms similar to that shown in Figure A-10.

Clean-up: column check sample and column check blank. All batches of absorbents (Florisil, alumina, silica gel, etc.) to be used in organic clean-up procedures will be checked for analyte recovery and contamination. A column check sample and a column check blank will be run after activation or deactivation of a batch of absorbent.

Specific QC for ICP analysis

Whenever a new sample matrix is encountered, a subset of the samples will be (1) serially diluted, (2) spiked, and (3) analyzed using standard addition, as specified in Method 6010, SW 846 (EPA, 1986d). These procedures will ensure that interferences are not affecting the reported results.

INSTRUMENT DETECTION LIMITS AND

LABORATORY CONTROL SAMPLE

LAB NAME _____ CASE NO. _____ DATE _____

LCS NO. _____

Compound	Required Detection Limits (CRDL)-ug/l	Instrument Detection Limits (IDL)-ug/l ICP/AA ID# _____	Instrument Detection Limits (IDL)-ug/l Furnace ID# _____	Lab Control Sample ug/L mg/kg (circle one) True	Found	%R
Metals:						
1. Aluminum						
2. Antimony						
3. Arsenic						
4. Barium						
5. Beryllium						
6. Cadmium						
7. Calcium						
8. Chromium						
9. Cobalt						
10. Copper						
11. Iron						
12. Lead						
13. Magnesium						
14. Manganese						
15. Mercury						
16. Nickel						
17. Potassium						
18. Selenium						
19. Silver						
20. Sodium						
21. Thallium						
22. Vanadium						
23. Zinc						
Other: _____						
Cyanide		NR	NR			

NR - Not required

Figure A-12. Instrument Detection Limits and Laboratory Control Sample data sheet to be utilized in this study.

The Environmental Quality Laboratory uses a Perkin Elmer Model 6000 sequential ICP. When spectral interferences are encountered at a specific wavelength a new wavelength without the interference will be selected making the need for inter-element correction unnecessary.

Performance and System Audits

The Quality Assurance Officer will carry out performance and system audits to ensure that data of known and defensible quality are produced during the project. System audits are qualitative evaluations of all components of field and laboratory quality control measurement systems. They determine if the measurement systems are being used appropriately. The audit will be carried out before all systems are operational, during the program on a monthly basis, and after the completion of the project. Such audits will involve a comparison of the activities given in the QA/QC Plan with those actually scheduled or performed.

The performance audit is a quantitative evaluation of the measurement systems of the project. It will require testing the measurement systems with samples of known composition to evaluate precision and accuracy. The performance audit will be carried out by the QA Officer without notifying the technicians involved in the analysis. Audits will be conducted at the beginning of the project, monthly during the project, and at the end of the project.

Preventive Maintenance

An established preventive maintenance program is in place within the EQL for each instrument to be used in this project which was developed according to the manufacturer's recommendations. This program includes an inventory of spare parts (fuses, pH electrodes, conductivity cells, nebulizers, aspirating tubing, graphite furnaces, analytical columns, etc.). Less frequently required parts can be obtained from instrument manufactures within three working days in most cases. The UWRL has an equipment maintenance fund which is used for supplies and salaries

for staff personnel or manufacturers representative to perform equipment maintenance activities.

Corrective Action

The need for corrective action will be identified by system and/or performance audits and by standard QC procedures. The essential steps in the corrective action system employed within the EQL are:

1. Identification and definition of the problem:
   Corrective action will be required if and when analytical data are determined to be out-of-control. An analytical batch will be considered to be out-of-control when replicate samples, spiked samples, calibration blanks, reagent blanks, field or trip blanks, standard curve, calibration check samples, laboratory check samples or audit samples fail to meet the QC objectives established for the project, or when a system audit shows deviation from the QA/QC Plan.

2. Assignment of responsibility for investigating the problem.
   The project QA Officer will be the responsible for initiating required corrective action and for investigating the analytical problem.

Investigation and Determination Of The Cause Of the Problem

When an analysis is determined to be out-of-control, steps will be taken to determine the cause. First, calculations will be checked, then the instruments used in the analysis will be checked to see if they are performing to specifications. The indicators of being out-of-control will be used to determine the nature of the problem. For example, inaccurate check sample readings may indicate the instrument is not properly set-up or standards are bad; if duplicates are not within precision limits there may be problems with an extraction procedure or sample contamination; if a spike recovery is outside acceptable limits, matrix interferences may be expected; or if blanks are too high, contamination may have occurred.

Determination of a Corrective Action to Eliminate a Problem

System audits. Dr W. J. Doucette, the EQL Laboratory Manager, will meet with the QA Officer to determine why the project has deviated from the goals outlined in the QA/QC Plan. Immediate steps will be taken to correct discrepancies.

Performance audits and calibration check samples. If results of a performance audit or of the daily calibration check sample are out-of-control, causes may include instrument malfunction or improper set-up, bad standards, or technician error. The first step will be to check instrument performance. The instrument will be set-up again under direct supervision of the QA Officer. If this does not bring the system back into control, then standards will be re-made and analyzed. If the problem is technician error, the technician will be re-trained and put through a rigorous QC check before he/she can continue with sample analyses.

Accuracy. When a result is out-of-control for spiked samples, calculations will first be checked. Then the instrument will be checked for proper set-up. The sample(s) will be reanalyzed. If these steps do not bring the sample into control, then the spiked sample will be prepared again and re-analyzed. It may be necessary at this time to prepare fresh standards. If all of the above procedures do not bring the analysis into control, then the QA Officer is to be notified. The QA Officer will decide whether matrix interference problems can be dealt with using such procedures as sample dilution or artificial matrix, etc. (EPA, 1986d). If no alternative method is available, analyses will be performed by standard addition. All samples analyzed in the batch with a sample out-of-control will be re-analyzed using the procedure(s) used to bring the sample back into control.

Precision. When a result for duplicate analyses appear out-of-control, calculations will be checked first. Instrument performance will then be evaluated. Finally, the samples will be re-analyzed. If these procedures do not bring the samples back into control, all samples in the analytical batch will be prepared again and re-analyzed. If none of these procedures bring the analysis back into control, the Laboratory Manager, Dr W. J. Doucette, and the project QA Officer will be notified to decide on further action.

Blank contamination. If either the field or trip blanks show signs of being contaminated, the source of contamination will be investigated and corrective action taken. All samples collected on the day that contamination occurred will be re-sampled. If more than one set of field or trip blanks show signs of contamination, sampling will be stopped until the source of contamination can be found and eliminated. If reagent blanks show contamination during analysis, materials and reagents used to make that blank will be replaced before additional samples are prepared. Also glassware and sample preparation will be re-evaluated to ensure that contamination is not occurring for these processes. Samples prepared with contaminated reagents will be discarded, and samples will be reprocessed.

Laboratory check sample analysis. The inability of the laboratory to analyze a LCS is indicative of analytical problems related to the digestion/extraction/sample preparation procedures and/or instrumentation operations. If the calibration check sample is out-of-control within the same analytical batch, this would indicate that the problem may be with the instrument or technician performance. Corrective action will be taken as described under "Performance audits and calibration check samples." If the calibration check sample is within control limits, the problem may be with the digestion/extraction procedure. At this point the LCS will be prepared again and re-analyzed. If this fails to bring the measurement back into control, the procedure will be reevaluated to determine whether there are points within the procedure likely to lead to contamination or loss of the analyte. If none of these procedures bring the analysis back into control, the Laboratory Manager, Dr. W .J. Doucette, and the project QA Officer will be notified to decide on further action. All samples analyzed in the batch with the sample out-of-control will be re-analyzed by the procedure(s) used to bring the sample back into control.

Implementing the corrective action and evaluating its effectiveness. A technician will carry out the corrective action and will evaluate its effectiveness using standard QC procedures. The status of corrective action effectiveness will be documented by the technician, and will be submitted to the QA Officer as closure on the QA/QC problem. The QA Officer will then make this documentation part of the routine QA/QC report for this project.

Verifying the corrective action has eliminated the problem. If quality control criteria can be consistently met, the analysis is back in control. The QA Officer will consult with the technician to ensure that all corrective action policies are being followed, that the analysis is truly back in control, and that the problem which led to the corrective action has been resolved.

Quality Assurance Reports

QA Project Plan Reports will provide a mechanism for quarterly reporting to the Laboratory Manager, Dr. W. J. Doucette, and to the Data Requesters on the performance of the measurement system and data quality. At a minimum, these quarterly reports will include:

1. Results of assessments of measurement quality indicators, i.e., data accuracy and precision, and completeness;
2. Results of performance audits;
3. Results of system audits; and
4. Significant QA problems occurring that quarter, recommended corrective actions, corrective actions actually taken, and effectiveness of these corrective actions in eliminating the QA problem.

All QA Project Plan Reports will become part of technical progress reports submitted to the EPA Project Leader throughout the duration of the project, and will be summarized in the Project Final Report in a section entitled "Project QA/QC Performance."

MEMORANDUM

State of Alaska

DEPARTMENT OF ENVIRONMENTAL CONSERVATION

TO: Rielle Markey

DATE: July 12, 1991

FILE NO:

TELEPHONE NO: 451-2360

FROM: Clara Jodwalis

SUBJECT: Bioventing QA/QC Plan

I have spent a couple hours reviewing the document titled **QA/QC PLAN USED FOR EPA PROJECTS** in appendix A of **WORK PLAN for the RESEARCH PROJECT: BIOREMEDIATION OF JP-4 IN THE SUB-ARCTIC**, July 3, 1991. Following are comments and recommendations.

* On page 8 of the **WORK PLAN** it states that samples will be analyzed for petroleum contamination using modified standard EPA methods. Which EPA methods and how will they be modified?

* The last sentence on page 56 references the QA/QC Plan (APHA 1989). This reference is not listed at the end of this QA/QC plan.

* Quality assurance and quality control guidelines for sampling procedures will be developed in the initial phase of the study. This is according to the **"Sampling Procedures"** section.

* Table 4 is referenced a few times throughout this QA/QC plan, but is not provided.

* I recommend that the control limits for spiking data be listed in this QA/QC plan.

* The list of references at the end of this QA/Q plan appears to be missing a page or more.

Responses to Comments
from Clara Jodwalis, Alaska DEC
Regarding the Sample
QA/QC Plan for EPA Projects

1. References to Table were a recurring questions because this table was included in the full text of the report from which this QA/QC plan was extracted. This Table summarizes the analytical methods to be used for a specific EPA project for which this QA/QC plan was written, and is attached for clarity. A table such as this would be included in a project specific QA/QC plan, summarizing only those analyses that were to be completed for that specific project.

2. As indicated in Table 4, petroleum hydrocarbon measurements are generally conducted using EPA Method 5030 and a modified 8020 Method. The modifications to standard EPA methods include the use of a wide-bore capillary Petrocol column rather than the packed column specified by EPA because of improved GC separation and quantitation ability, and the use of methanol (mentioned in the EPA method as an alternative solvent) rather than ethylene glycol for purge and trap analysis based on the lab's experience over the past eight years with purge and trap quantitation of petroleum contaminated soils and sludges.

3. The question regarding references can be answered in the same fashion as Question 1. The references were located in a reference section of the full text, and have been attached here for clarity.

4. The question (statement?) regarding QA/QC guidelines for field sampling was done so because of the nature of the proposal for which this QA/QC plan was written. This proposal was written with the UWRL responsible for field sampling as well as sample analysis. It was also written for a field site which has yet to be chosen, and for which extensive field data, sample wells, etc., may or may not be available. For most projects, field sampling is generally more well defined, and as such, more detail and decisions regarding field sampling methodology, preservation methods, etc., would be included in the QA/QC plan.

5. As a matter of policy, we utilized control charts for the determination of sample QC rather than specify a given control limit for each analysis. These control charts provide a more analysis-specific indicator of quality control than an arbitrary % deviation from the mean, or other a priori control levels. Our experience for many analyses have indicated that the use of control charts and Upper Warning and Control level indicators of data quality are more rigorous than pre-set control limits.

Table 4. Analytical methods to be used for groundwater, soil gas and soil core samples collected during the study.

Sample Type	Measurement	Method Type	Reference Method
Groundwater	O_2	Winkler titration	4500-O D, APHA (1989)†
	CO_2	Alkalinity titration calculation	4500-CO_2 B, APHA (1989)†
	CH_4	Lab GC††	TCD††† Alltech column (36254L)
	Fe^{2+}	Colorimetry	Lovely & Phillips (1987)†
	Mn^{2+}	Colorimetry	Lovely & Phillips (1988)†
	Major cations Na, Ca, Mg, K	ICP††††	6010, U.S. EPA (1986d)
	Cl, SO_4^{2-}, HCO_3^- CO_3^{2-}, NO_3^-	IC•	300.0, U.S. EPA (1989)
	pH	Glass electrode	4500-H^+ B, APHA (1989)†
	Eh	Calculation	Stumm & Morgan (1981) Dever (1982) Lindberg & Runnels (1984)
	Aromatic HCs††††	Lab GC	5030, Modified 8020 using FID•• & Petrocol column, U.S. EPA (1986e)
	Total HCs	Lab GC	
	Boiling point splits	Lab GC	
Soil gas	O_2	O_2 Meter	Gastechtor Model 3250X
	CO_2	CO_2 Meter	
	O_2	Lab GC	TCD Alltech column (36254L)
	CO_2	Lab GC	
	CH_4	Lab GC	TCD Detector Alltech column (36254L)
	Aromatic HCs•••	Lab GC	5030, Modified 8020 using FID & Petrocol column, U.S. EPA (1986e)
	Total HCs	Lab GC	
	Boiling point splits	Lab GC	
Soil core	Available Fe	Extraction/color.	Lovely & Phillips (1987)†
	Available Mn	Extraction/AA	Lovely & Phillips (1988)†
	Carbonate	Inorganic Carbon	Nelson (1982)
	Organic carbon	Acid chromate oxidation	Nelson & Sommers (1982)
	pH	1:1/glass electrode	4500-H^+ B, APHA (1989)†
	Kjeldahl-N	Digestion/ distillation	4500-N_{org} B, APHA (1989)†
	Extractable P	Extraction/color.	Olsen & Sommers (1982)
	Texture	% sand/silt/clay	Gee & Bauder (1986)
	Aromatic HCs	Lab GC	5030, Modified 8020 using FID & Petrocol column, U.S. EPA (1986e)
	Total HCs	Lab GC	
	Boiling point splits	Lab GC	

†Method utilizing a Hach field kit; ††GC = gas chromatography; †††TCD = thermal conductivity detector; ††††ICP = inductively coupled plasma arc spectrophotometer; •IC = ion chromatography; ••FID = flame ionization detector, ••• HCs = hydrocarbons

References

APHA. 1989. Standard methods for the examination of water and wastewater. 19th edition. American Public Health Association, Washington, D.C.

AWWA. 1985. Confluence: containing ground water contamination. J. American Water Works Assoc. 77(5):89-91.

Blegen, R. P., J. W. Hess, and J. E. Denne. 1988. Field comparison of ground-water sampling devices. Presented at the NWWA Second Annual Outdoor Action Conference, Las Vegas, NV. May.

Dever, J. I. 1982. The geochemistry of natural waters. Prentice-Hall, Englewood Cliffs, NJ.

Downey, D. C., R. E. Hinchee, M. S. Westray, and J. K. Slaughter. 1988. Combined biological and physical treatment of a jet fuel-contaminated aquifer. Proceedings of Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention Detection and Restoration, November 9-11, 1988, Houston, Texas. pp. 627-645.

Dragun, J. 1988. Microbial degradation of petroleum products in soil. p. 289-300. In E. J., Calabrese, and P. T. Kostecki. 1988. Soils contaminated by petroleum - environmental and public health effects. John Wiley & Sons, Inc., New York, New York.

Dupont, R. R., W. J. Doucette, and R. E. Hinchee. 1991. Assessment of in situ bioremediation potential and the application of bioventing at a fuels-contaminated site. Proceedings, In Situ and On-Site Bioreclamation: An International Symposium, San Diego, California. March 19-21, 1991.

Eklund, B. 1985. Detection of hydrocarbons in ground water by analysis of shallow soil gas/vapor. API Publication No. 4394, Environmental Affairs Department, American Petroleum Institute, Washington, D.C. 81 pp.

Evans, R. B., and G. E. Schweitzer. 1984. Assessing hazardous waste problems. Environmental Science and Technology 18(11):330A.

Gan, D. R., and R. R. Dupont. 1989. Multiphase and multicompound measurements of batch equilibrium distribution coefficients of six volatile organic compounds. Hazardous Waste and Hazardous Materials 6(4):363-383.

Gee, G. W., and J. W. Bauder. 1986. Particle-size analysis. p. 383-411 *In* A. Klute (ed.) Methods of soil analysis, part 1. Physical and mineralogical methods. Second edition. American Society of Agronomy, Madison, WI.

Glaccum, R., M. Nowl, and L. McMillan. 1983. Correlation of geophysical and organic vapor analyzer data over a conductive plume containing volatile organics. In Proceedings of the 3rd National Symposium on Aquifer Restoration and Ground Water Monitoring, National Water Well Association. pp. 421-727.

Hinchee, R. E., D. C. Downey, and E. J. Coleman. 1987. Enhanced bioreclamation, soil venting and ground water extraction: cost effectiveness and feasibility comparison. Proceedings of Petroleum Hydrocarbons and Organic Chemicals in Ground Water - Prevention, Detection and Restoration: A Conference and Exposition. November 1987, Houston, Texas.

Hinchee, R. E., D. C. Downey, R. R. Dupont, P. Aggarwal, and R. E. Miller. 1991. Enhancing Biodegradation of Petroleum Hydrocarbons Through Soil Venting. Journal of Hazardous Materials. In Press.

Klopp, R. A., A. M. Petsonk, and B.-A. Torstensson. 1988. In-situ penetration testing for delineation of ground water contaminant plumes. Presented at the NWWA Second Annual Outdoor Action Conference, Las Vegas, NV. May.

Kreamer, D. K. 1983. An evaluation of selected halocarbons and trace gases for potential use as indicators of source contaminant and ground water movement in the vadose zone. Completion report for the U.S. Department of Interior, Project No. A-111-ARIZ. 26 pp.

Lindberg, R. D., and D. D. Runnells. 1984. Ground water redox reactions: an analysis of equilibrium state applied to Eh measurements and geochemical modeling. Science 225:925-927.

Lovely, D. R., and E. J. P. Phillips. 1986. Availability of ferric iron for microbial reduction in bottom sediments of the freshwater tidal potomac river. Appl. and Environ. Microbiol. 52:751-757

Lovely, D. R., and E. J. P. Phillips. 1987. Rapid assay for microbially reducible ferric iron in aquatic sediments. Appl. and Environ. Microbiol. 53:1536-1540

Lovely, D. R. and E. J. P. Phillips. 1987. Competitive mechanisms for inhibition of sulfate reduction and methane production in the zone of ferric iron reduction in sediments. Appl. Environ. Microbiol. 53:2636-2641.

Lovely, D. R., and E. J. P. Phillips. 1988. Novel mode of microbial energy metabolism: Organic carbon oxidation coupled to dissimilatory reduction of iron or manganese. Appl. and Environ. Microbiol. 54:1472-1480

Lovely, D. R., M. J. Baedecker, D. J. Lonergan, I. M. Cozzarelli, E. J. P. Phillips, and D. I. Siegel. 1989. Oxidation of aromatic contaminants coupled to microbial iron reduction. Nature 339:297-300.

Miralles-Wilhelm, F., L. W. Gelhar, and V. Kapoor. 1990. Effects of heterogeneities on field-scale biodegradation in groundwater. Presented to the 1990 Annual AGU Meeting, December 3 to 7.

Morgan, C., and C. Klingler. 1987. The soil gas survey as a preliminary investigative tool for hydrocarbon releases: cost-effective field techniques and an evaluation of factors influencing the effectiveness of the survey. Proceedings of: Petroleum Hydrocarbons and Organics Chemicals in Ground Water: Prevention, Detection and Restoration - A Conference and Exposition. November 1987, Houston, Texas. pp. 347-355.

Nelson, D. W., and L. E. Sommers. 1982. Total carbon, organic carbon, and organic matter. p. 539-579 *In* A. L. Page (ed.) Methods of soil analysis, part 2. Chemical and microbiological properties. Second edition. American Society of Agronomy, Madison, WI.

Nelson, R. E. 1982. Carbonate and gypsum. p. 181-198 *In* A. L. Page (ed.) Methods of soil analysis, part 2. Chemical and microbiological properties. Second edition. American Society of Agronomy, Madison, WI.

Olsen, S. R., and L. E. Sommers. 1982. Phosphorus. p. 403-430 *In* A. L. Page (ed.) Methods of soil analysis, part 2. Chemical and microbiological properties. Second edition. American Society of Agronomy, Madison, WI.

Schmidt, C., and E. Balfour. 1983. Direct gas measurement techniques and the utilization of emissions data from hazardous waste sites. Proceedings of the 1983 ASCE National Specialty Conference on Environmental Engineering, Boulder, Colorado. pp. 690-699.

Smythe, J. E., P. B. Bedient, R. A. Kloop, and C. Y. Chiang. 1988. An advanced technology for the in-situ measurements of heterogeneous aquifers.. Presented at the NWWA Second Annual Outdoor Action Conference, Las Vegas, NV. May.

Stumm, W., and J. J. Morgan. 1981. Aquatic chemistry. Second edition. John Wiley and Sons, New York, NY.

U. S. EPA. 1980. Interim guidelines and specifications for preparing quality assurance project plans. QAMS-005/80. U. S. Environmental Protection Agency, Washington D.C.

U.S. EPA. 1984a. Ground water protection strategy. Office of Ground Water Protection, Washington, D.C.

U. S. EPA. 1984b. Methods for chemical analysis of water and waste. EPA-600/4-84-017. U. S. Environmental Protection Agency, Cincinnati, OH.

U.S. EPA. 1986a. Underground tank leak detection methods: a state-of-the-art review. Office of Research and Development, Hazardous Waste Engineering Research Laboratory, Cincinnati, Ohio.

U.S. EPA. 1986b. RCRA ground-water monitoring: technical enforcement guidance document (TEGD). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER-9950.1

U. S. EPA. 1986c. Permit guidance manual on unsaturated zone monitoring for hazardous waste land treatment units. Office of Solid Waste and Emergency Response, Washington, D.C. EPA/530-SW-86-040.

U. S. EPA. 1986d. Test methods for evaluating solid waste, vol. 1A. Office of Solid Waste and Emergency Response, Washington, D.C. SW-846. Third edition.

U.S. EPA. 1986e. Test methods for evaluating solid waste, vol. 1B. Office of Solid Waste and Emergency Response, Washington, D.C. SW-846. Third edition.

U. S. EPA. 1989. Test method. The determination or inorganic anions in water by ion chromatography--method 300.0. U. S. Environmental Protection Agency, Cincinnati, OH.

U.S. EPA. 1990. Measurement of hydraulic conductivity distributions: a manual of practice. U.S. Environmental Protection Agency, ORD, RSKERL, Ada, OK. EPA/600/8-90/046.

Zdeb, T. F. 1987. Multi-depth soil gas analyses using passive and dynamic sampling techniques. Proceedings of: Petroleum Hydrocarbons and Organics Chemicals in Ground Water: Prevention, Detection and Restoration - A Conference and Exposition. November 1987, Houston, Texas. pp. 329-343.

APPENDIX F

SAMPLING AND ANALYSIS OF SURFACE EMISSIONS

SAMPLING AND ANALYSIS OF SURFACE EMISSIONS

1.0 INTRODUCTION

One of the concerns over the implementation of bioventing as a means of soil remediation is the possibility of taking a terrestrial contamination problem and transferring it to the atmosphere through the process of air stripping organics from the soil. To determine if there is any atmospheric loading of volatile organic compounds (VOCs) from a bioventing operation, the surface emissions associated with the remediation must be measured. The sampling/analytical methodology for conducting surface emission measurements is presented below.

2.0 DYNAMIC SURFACE EMISSION SAMPLING METHODOLOGY

2.1 Principle

An area of soil is enclosed under an inert box designed to allow the purging of the enclosure with high-purity air (DuPont, 1987). The purging activity removes ambient air from the region above the soil and allows an equilibrium to be established between hydrocarbons emitted from the soil and the organic-free air. The airstream is then sampled by drawing a known volume of the hydrocarbon/pure air mixture through a tube packed with sorbent materials. The sorbents retain any organics associated with the soil surface. The sample tube is thermally desorbed, and the organics are resolved and quantified by gas chromatography. These measured concentrations are then applied to a formula that makes it possible to calculate the hydrocarbon emission rates from the soil to the atmosphere.

2.2 Sampling System

The system for surface emissions sampling consists of a square Teflon™ box that covers a surface area of 0.453 m^2 (Figure 1). The box is fitted with inlet and outlet ports for the entry and exit of the high-purity air. Inside the box is a manifold that delivers the air supply uniformally across the soil surface. The same type of manifold is fitted to the exit port of the box. This configuration delivers an even flow of air across the soil surface so that a representative sample is being generated. The air exiting the Teflon™ box is exhausted through Teflon™ tubing and is available for sampling.

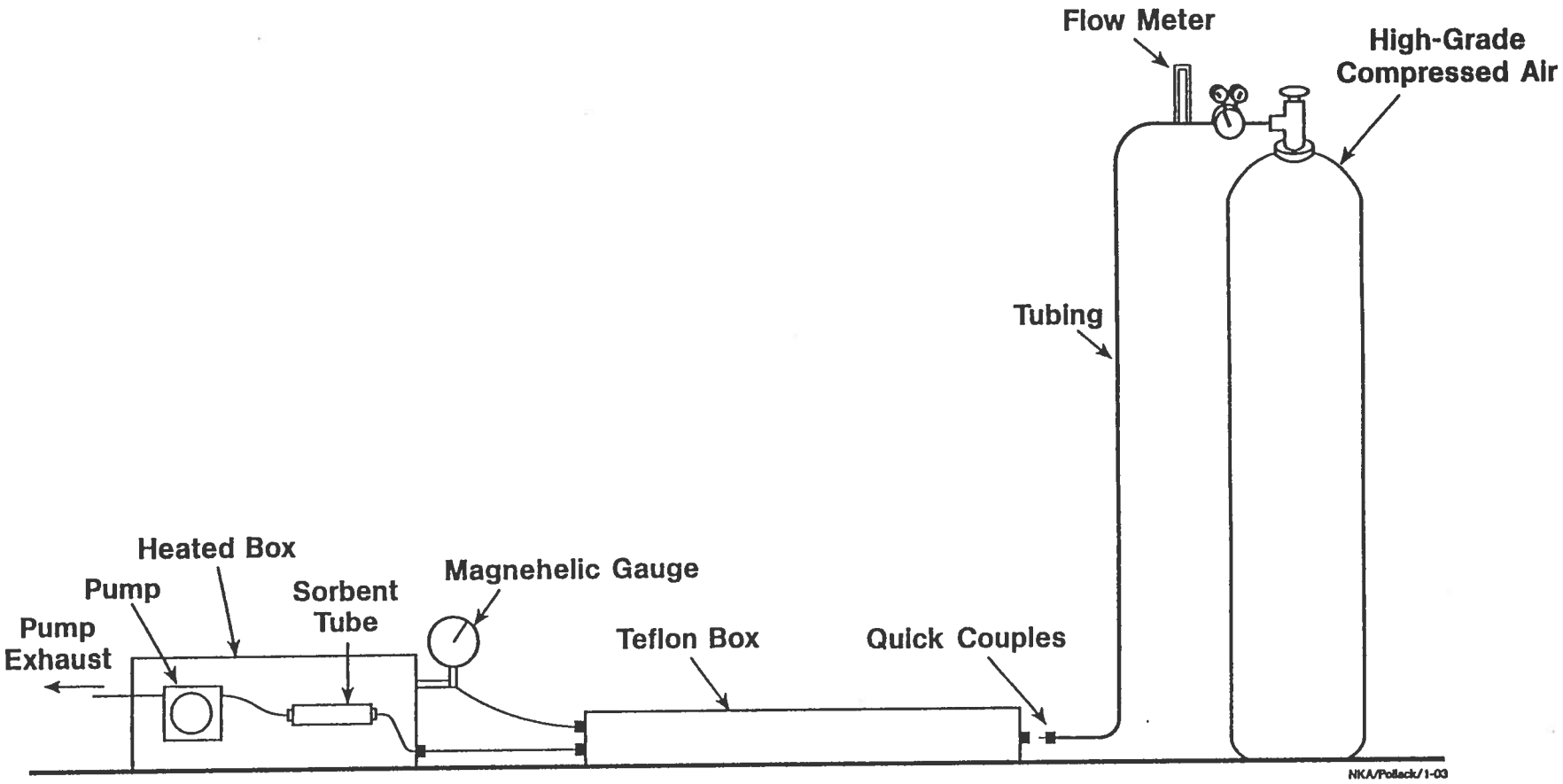


Figure 1. Surface Emission Sampling Components

In all cases, a totally inert system is employed. Teflon™ tubing and stainless steel fittings assure that there is no contribution to or removal of organics from the airstream. A personal monitoring pump (SKC Model #224-PCXR7) is located on the back side of the sorbent tube, which is connected to the exhaust line for sampling.

2.3 Sorbent Sampling Tubes

The compounds of interest during surface emissions testing are branched and straight-chained hydrocarbons, and aromatics. A total petroleum hydrocarbon (TPH) value also is monitored. To capture these compounds efficiently, a three-phased carbon-based sorbent bed (Supelco, Carbotrap 300 Cat.#2-0370) is employed (Figure 2). This configuration has been examined extensively at Battelle (Pollack and Gordon, 1993) in conjunction with ambient air sampling and has been shown to be very efficient at capturing and retaining a wide range of VOCs. This carbon-based sorbent bed typically displays very low background artifact levels.

The air samples are pulled through the tube in a direction such that the air passes from the weakest sorbent (Carbotrap C) to the moderately strong material (Carbotrap) and finally onto the strongest sorbent (Carbosieve S-III). This three-phased arrangement makes it possible to capture a wide range of molecular-weight VOCs while still allowing efficient desorption. Tube desorbing is done by backflushing the organics off the sorbent bed while heating the tube.

Prior to using a sampling tube, the tube is baked out at 350°C for a period of 1 hour with a helium purge flow of 50 mL/minute. This process assures that the sorbents are clean and ready for use.

2.4 Field Sampling Technique

The collection of surface emission samples involves the following activities:

1. Assure that the sorbent tubes have been conditioned prior to their use in the sampling program.

2. Set flow of SKC pump to ~50 mL/minute using a Mini-Buck gas flow calibrator (Model #APB-M5). Install a spare sorbent tube in line such that air is being pulled through it by the pump in the sampling direction identified on the tube. Connect the Mini-Buck calibrator to the inlet end of the sorbent tube and adjust the flowrate of the

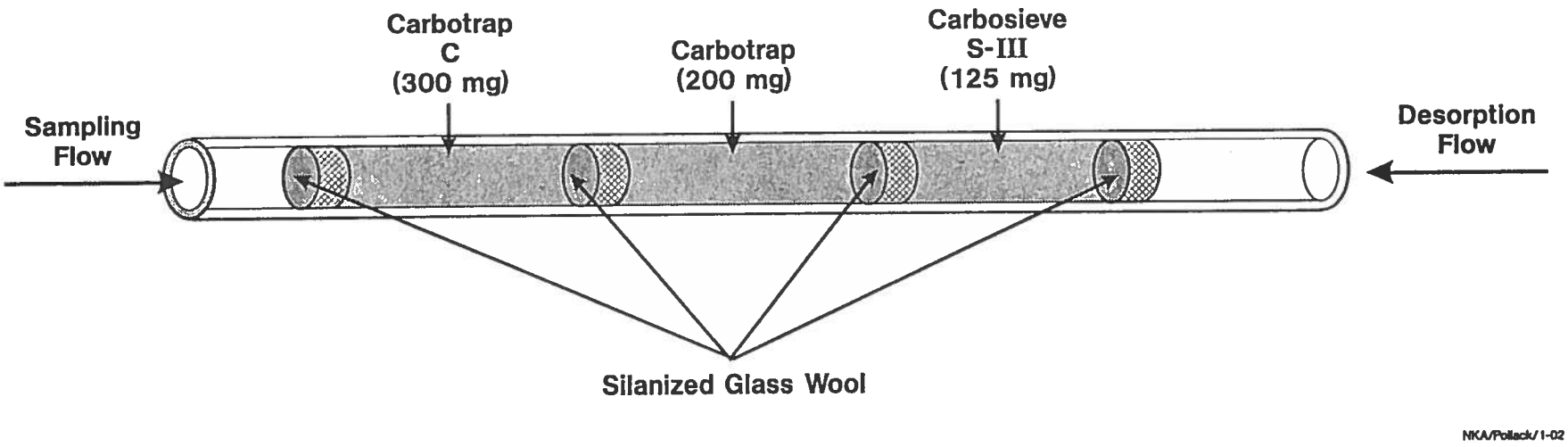


Figure 2. Sorbent Sampling Tube

pump so that the airflow through the tube is 50 mL/minute. Remove the sorbent tube and measure the pump flow once again. This is the flowrate necessary to pull a 50-mL/minute rate through the packed tube (in the range of ~60 mL/minute). This flow setting tube is not used for sampling.

3. Install the regulator and flowmeter on the high-grade air cylinder and set a flowrate of 2 L/minute, once again using the Mini-Buck calibrator. The cylinder delivery pressure should be set to ~60 psig prior to adjusting the flow.

4. Check all of the tubing and fittings on the Teflon™ box. Repair or replace as necessary.

5. Position the Teflon™ box soil enclosure unit at the location where the sampling is to be done. It may be necessary to loosen the soil around the perimeter of the box to allow it to be in continuous contact with the soil. In all cases, the surface of the soil is disturbed as little as possible and any soil observations at the site are recorded.

6. The inlet tubing on the Teflon™ box is connected to the air cylinder and the exhaust tubing is checked to confirm that there is no restriction of flow. The 2-hour purge is then started, to obtain equilibrium between surface emissions and the high-grade air.

7. At the end of the 2-hour purge time, a clean sorbent tube is connected to the sample line with the SKC pump connected to the back side of the tube. The pump is started and run for a timed period of 10 minutes. This results in a 500-mL volume of air being passed through the sorbent sampling tube.

8. The sorbent tube is removed from the sampling train and returned to its storage tube. The sample tube number, sampling location, date, time, and any observations are recorded in the notebook.

9. The Teflon™ box is then repositioned at the next location, and the purge/sampling procedure is repeated.

10. In addition to the individual site samples, duplicate samples, blanks from the high-grade air cylinder, ambient air samples, and "trip blanks," where no sample is loaded onto a conditioned tube, may be collected. These extra samples are used as quality control samples.

2.5 Analytical Technique for Processing the Sorbent Sampling Tubes

The organic compounds retained by the sorbent materials in the sampling tubes are thermally desorbed, refocused, and analytically resolved via gas chromatography. A calibration mixture that contains the compounds of interest also is processed to establish retention times for these compounds.

Quantitation may be based on the response factors for specific compounds or calculated by applying a hexane response factor with correction for the number of carbons actually present in each compound.

2.5.1 Instrumentation

The instrumentation and analytical technique used to process the sorbent tubes is based on U.S. EPA Method TO-14 that is employed to identify toxic organics in ambient air (EPA, 1988). This method involves (1) the collecting of VOCs in a gas sample on a cryogenically cooled glass bead trap; (2) the transfer of the trapped organics by ballistically heating the cold trap; and (3) the delivery of the organics to a gas chromatograph for qualitative/quantitative analysis. The modification to the method when using sorbent tubes is the extra step of heating the tube to deliver the remotely collected organics to the cold glass bead trap. For compound detection, a flame ionization detector (FID) replaces the mass selective detector (MSD).

The automated gas chromatograph (GC) system (Figure 3) consists of a Hewlett-Packard Model 5890 GC with an FID. A Hewlett-Packard 3396A integrator in conjunction with a 9122 disk drive receives detector output signals and stores data. The disk drive also provides access to the program used to automate processing. A modified NuTech Model 320 sample preconcentration unit is used to focus the organics from the tube. The unit contains two subsystems: (1) an electronic console that regulates various temperature zones, and (2) the sample-handling subassembly containing a 6-port valve and trap. The console controls the temperatures of the valve body (120°C), sample transfer lines (120°C), and the refocusing trap. The trap temperature is regulated by the controlled release of liquid nitrogen via a solenoid valve. The trap temperature during sample transfer from the sorbent tube is maintained at -150°C. The trap is heated to 130°C for delivery of organics to the GC.

Sample flow from the sorbent tube to the refocusing trap is controlled using: (1) a Tylan™ readout control unit, Model R032-b; (2) a Tylan™ zero to 100 standard cm^3/min mass flow controller, Model MFC-260; (3) a Thomas™ dual diaphragm pump; and (4) a Perma Pure Dryer, Model MD-125-48F. The readout control unit, in conjunction with the mass flow controller, regulates the sample transfer flow rate from the sorbent tube to the trap. The Perma Pure Dryer with a tubular hygroscopic ion-exchange membrane (Nafion) is used to selectively remove any water vapor from the sorbent sample. The Nafion™ tube size is 30 cm × 0.1 cm ID, embedded within a shell of Teflon™ tubing of 0.25 cm ID. A countercurrent flow of dry zero air (300 mL) is used to purge the shell.

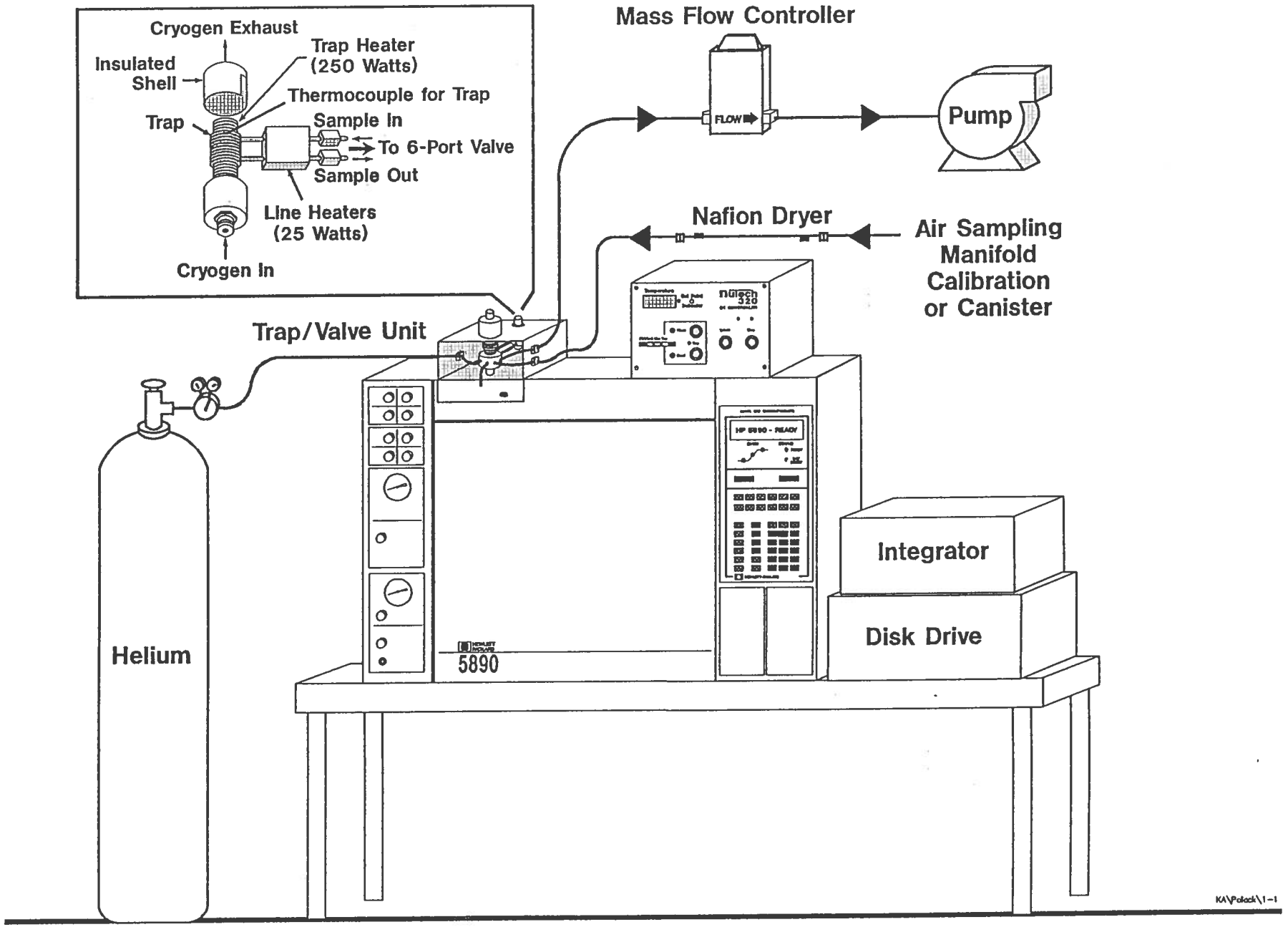


Figure 3. Automated Gas Chromatograph

This type of dryer has been shown to have no affinity for the BTEX compounds or straight-chained/branched petroleum hydrocarbons (Pliel et al., 1987).

A Dynatherm™ Model 10 sorbent tube conditioner/desorber is used to heat the sorbent tube to deliver the organics to the analytical system. A desorption temperature of 250°C with a helium purge gas flow of 20 mL/min is used during the desorption process. The desorption time for a tube is set at 15

minutes, resulting in a total helium backflush volume of 300 mL.

Separations chemistry is accomplished using two 30-m HP-1 series capillary columns joined with a zero dead-volume butt connector. The internal diameter of the capillary is 0.53 mm with a 2.65 μm film thickness. The optimal chromatographic resolution is obtained by temperature programming the GC oven from -50°C to 200°C at a rate of 8 degrees per minute. An FID chromatogram of 19 compounds that are typically associated with JP-4 fuel is presented in Figure 4.

The method detection limit for each of the aromatics is 0.50 parts per billion by volume (ppbv) for the 500 mL surface emission sample collected on the sorbent tube.

2.5.2 Calculation of Surface Emission Flux Rates

To calculate the actual emission rates of organic compounds from the soil surface into the atmosphere, the following formula for dynamic enclosure techniques is employed (McVeety, 1993):

$$F = \frac{C\ V_r}{S} \qquad (1)$$

where: F = flux in mass/area-time

C = the concentration of the gas in units of mass/volume

V_r = volumetric flowrate of sweep gas

S = soil surface covered by enclosure.

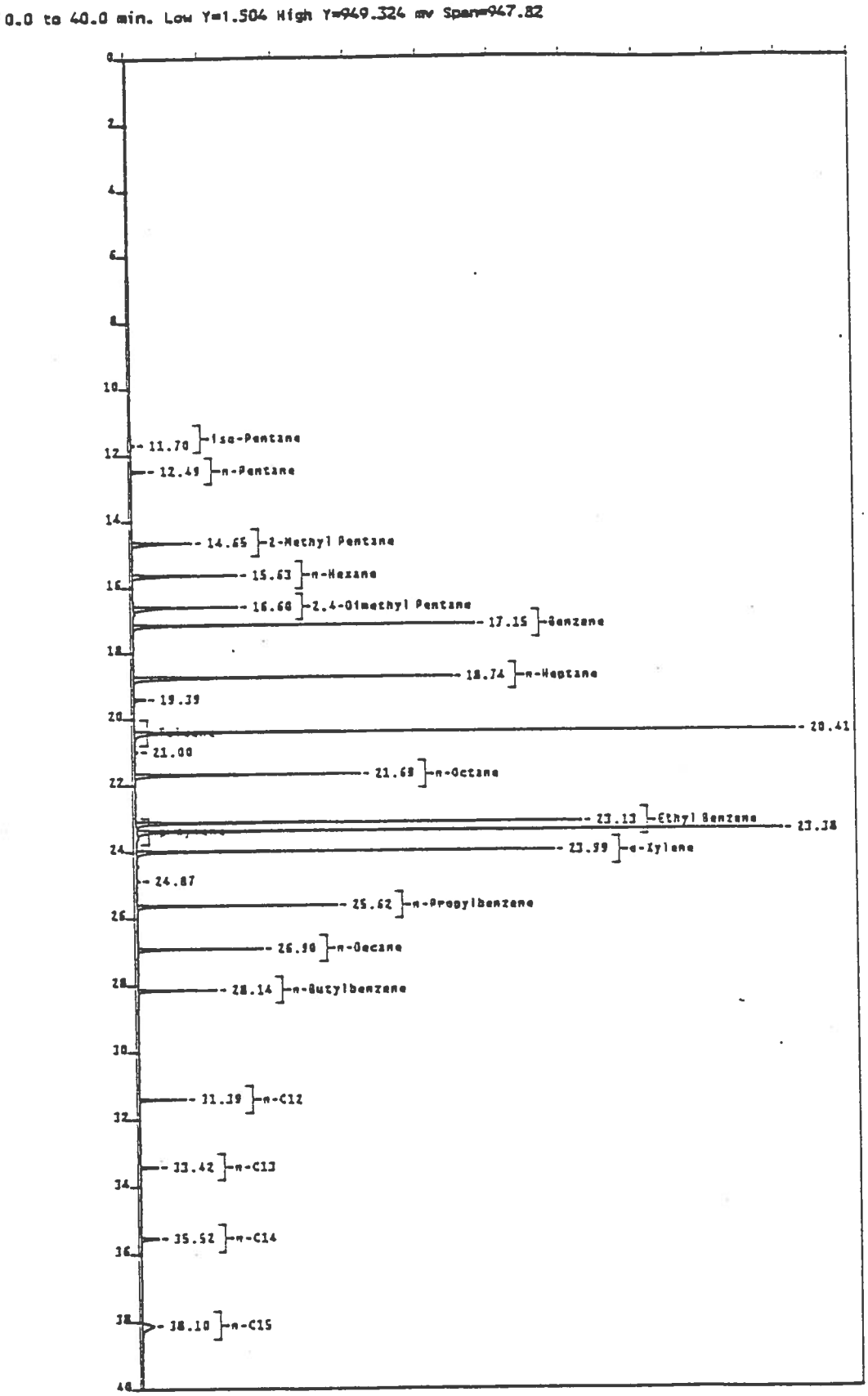


Figure 4. FID Chromatogram of Compounds Typically Associated With JP-4 Jet Fuel

3.0 REFERENCES

DuPont, R.R., 1987. Measurement of Volatile Hazardous Organic Emissions, *JAPCA*, Vol. 37:2, 168-176.

EPA, 1988. "Compendium Method TO-14." In *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, EPA-600/4-84-041, Quality Assurance Division, U.S. Environmental Protection Agency, Research Triangle Park, NC, May.

McVeety, B.D., 1993. *Current Developing Analytical Technologies for Quantifying Biogenic Gas Emissions*, NTIS Report #PB91-216523, June.

Pliel, J.D., K.D. Oliver, and W.A. McClenny, 1987. "Enhanced Performance of Nafion Dryers in Removing Water from Air Samples Prior to Gas Chromatographic Analysis," *JAPCA* 37:244.

Pollack, A.J., and S.M. Gordon, 1993. "Evaluation of a Portable Multisorbent Tube Sampler for Monitoring Airborne Organic Compounds," Presented at Proceedings of the 1993 U.S. EPA/A&WMA International Symposium, VIP #34.

Table F1. Eielson AFB, AK Surface Emission Sampling January 1993 Flux Values (μg/0.453 m^2/minute)

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH[1]
CONTROL PLOT BLOWER ON							
10915	5'EVW	0.021	0.218	0.157	0.488	0.148	4.4
10925	11'EVW	0.044	1.15	1.02	3.31	1.67	19
10914	11'EVW	0.022	0.138	0.104	0.342	0.101	4.4
10922	11'EVW	0.015	0.182	0.150	0.483	0.140	4.3
10919	19'EVW	0.025	0.188	0.112	0.349	0.097	5.2
BACKGROUND PLOT BLOWER ON							
10903	15'EVW	0.010	0.144	0.101	0.339	0.097	1.8
CONTROL PLOT BLOWER OFF							
10901	11'EVW	<0.004	0.063	0.053	0.182	0.054	1.6
10911	11'EVW	<0.004	0.076	0.053	0.177	0.050	1.1
10929	11'EVW	0.008	0.080	0.056	0.183	0.053	1.2
10904	19'EVW	<0.004	0.055	0.038	0.130	0.037	1.2
BACKGROUND PLOT BLOWER OFF							
10921	15'EVW	0.026	0.266	0.179	0.611	0.176	5.0

[1] TPH calculated as hexane.

Table F2. Eielson AFB, AK Surface Emission Sampling January 1993 (Concentrations Reported in Parts Per Billion by Volume [ppbv])

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH[1]
CONTROL PLOT BLOWER ON							
10915	5'EVW	3.30	28.9	18.1	56.2	17.1	613
10925	11'EVW	6.90	153	117	382	195	2690
10914	11'EVW	3.45	18.4	12.0	39.4	11.6	617
10922	11'EVW	2.30	24.2	17.3	55.6	16.1	598
10919	19'EVW	3.96	25.0	12.9	40.2	11.2	728
BACKGROUND PLOT BLOWER ON							
10903	15'EVW	1.56	19.1	11.66	39.1	11.12	251
CONTROL PLOT BLOWER OFF							
10901	11'EVW	<0.50	8.42	6.07	21.0	6.22	226
10911	11'EVW	<0.50	10.2	6.09	20.4	5.80	160
10929	11'EVW	1.27	10.7	6.39	21.1	6.07	166
10904	19'EVW	0.84	7.36	4.37	15.0	4.22	174
BACKGROUND PLOT BLOWER OFF							
10921	15'EVW	4.12	35.4	20.6	70.4	20.0	695

[1] TPH calculated as hexane.

Table F3. Eielson AFB, AK Surface Emission Sampling January 1993 (Concentrations Reported in Parts Per Billion by Volume [ppbv])

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH[1]
10926	Trip Blnk	1.57	<0.50	<0.50	<0.50	<0.50	14
10932	Trip Blnk	0.70	0.79	<0.50	<0.50	<0.50	33
10928	Trip Blnk	<0.50	<0.50	<0.50	<0.50	<0.50	8.0
10910	Trip Blnk	<0.50	<0.50	<0.50	<0.50	<0.50	7.0
10918	Trip Blnk	1.1	11	7.6	26	7.6	29

[1] TPH calculated as hexane.

Table F4. Eielson AFB, AK Surface Emission Sampling January 1993 Analytical System's Calibration Runs

FID AREA COUNTS						
Date	**Description**	**Benzene**	**Toluene**	**Ethylbenzene**	***m&p* Xylene**	***o*-Xylene**
01/25/93	Cal Run	15237	14929	14563	14297	18677
01/25/93	Cal Run	15197	14954	14419	14155	18779
01/26/93	Cal Run	15075	14690	14066	13774	17741
01/27/93	Cal Run	15285	14992	14553	14358	18732
01/28/93	Cal Run	15229	14773	14184	13927	18064
01/29/93	Cal Run	15261	14907	14255	14136	18324
02/01/93	Cal Run	15246	14899	14223	13993	18116
02/02/93	Cal Run	15298	15022	14525	14310	18703
02/03/93	Cal Run	15309	15046	14605	14385	18851
	Mean	15297	14912	14388	14148	18410
	R.F.	0.000173	0.000152	0.000149	0.000139	0.000120
	ppbv	2.64	2.27	2.15	1.97	2.21

Table F5. Eielson AFB, AK Surface Emissions Sampling July 1993 Flux Values (μg/0.453 m^2/minute)

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH[1]
CONTROL PLOT BLOWER ON							
10918	8'EVW	0.008	0.004	<0.004	0.006	<0.004	0.775
10919	11'EVW	0.005	<0.004	<0.004	0.005	<0.004	0.488
10912	19'EVW	0.044	0.822	0.822	0.826	0.340	309
BACKGROUND PLOT BLOWER ON							
10911	5'EVW	0.008	<0.004	<0.004	0.006	<0.004	0.711
10926	11'EVW-1	0.012	<0.004	<0.004	<0.004	<0.004	0.553
10915	11'EVW-2	0.006	<0.004	<0.004	<0.004	<0.004	0.524
10924	19'EVW	0.006	<0.004	<0.004	0.004	<0.004	0.481
CONTROL PLOT BLOWER OFF							
10920	8'EVW	0.023	0.007	<0.004	0.009	<0.004	0.868
10932	11'EVW-1	0.006	0.005	<0.004	0.007	<0.004	0.488
10923	11'EVW-2	0.006	<0.004	<0.004	0.005	<0.004	0.474
10933	11'EVW-3	0.017	0.005	<0.004	0.011	<0.004	0.603
10934	19'EVW	0.015	0.136	0.497	0.048	0.184	15.3
BACKGROUND PLOT BLOWER OFF							
10935	5'EVW	0.009	<0.004	<0.004	0.005	<0.004	0.409
10929	11'EVW-1	0.007	<0.004	<0.004	<0.004	<0.004	0.474
10925	11'EVW-2	0.011	<0.004	<0.004	<0.004	<0.004	0.524
10922	19'EVW	0.006	<0.004	<0.004	<0.004	<0.004	0.617

[1] TPH calculated as hexane.

Table F6. Eielson AFB, AK Surface Emission Sampling July 1993 (Concentrations Reported in Parts Per Billion by Volume [ppbv])

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH
CONTROL PLOT BLOWER ON							
10918	8'EVW	1.2	0.54	<0.50	0.74	<0.50	110
10919	11'EVW	0.79	<0.50	<0.50	0.53	<0.50	68
10912	19'EVW	6.9	110	95	95	39	43,000
BACKGROUND PLOT BLOWER ON							
10911	5'EVW	1.2	<0.50	<0.50	0.65	<0.50	99
10926	11'EVW-1	1.8	<0.50	<0.50	<0.50	<0.50	77
10915	11'EVW-2	0.97	<0.50	<0.50	<0.50	<0.50	73
10924	19'EVW	0.89	<0.50	<0.50	0.51	<0.50	67
CONTROL PLOT BLOWER OFF							
10920	8'EVW	3.6	0.95	<0.50	1.0	<0.50	14
10932	11'EVW-1	0.98	0.65	<0.50	0.78	<0.50	68
10923	11'EVW-2	0.97	<0.50	<0.50	0.60	<0.50	66
10933	11'EVW-3	2.7	0.70	<0.50	1.3	<0.50	84
10934	19'EVW	2.4	18	57	5.5	21	2,100
BACKGROUND PLOT BLOWER OFF							
10935	5'EVW	1.4	<0.50	<0.50	0.60	<0.50	57
10929	11'EVW-1	1.0	<0.50	<0.50	<0.50	<0.50	66
10925	11'EVW-2	1.7	<0.50	<0.50	<0.50	<0.50	73
10922	19'EVW	0.97	0.50	<0.50	<0.50	<0.50	86

Table F7. Eielson AFB, AK Surface Emission Sampling July 1993 (Concentrations Reported in Parts Per Billion by Volume [ppbv])

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH
10917	Trip Blnk	1.48	<0.50	<0.50	0.72	<0.50	39
10930	Trip Blnk	0.97	<0.50	<0.50	<0.50	<0.50	34
10914	Cyl Blnk	0.85	<0.50	<0.50	<0.50	<0.50	30
10927	Cyl Blnk	1.61	<0.50	<0.50	<0.50	<0.50	44
10921	Amb Air	1.46	0.96	0.50	<0.50	<0.50	78

Table F8. Eielson AFB, AK Surface Emission Sampling July 1993 Analytical System's Calibration Runs

FID AREA COUNTS							
		Benzene	**Toluene**	**Ethylbenzene**	***m&p* Xylene**	***o*-Xylene**	**Total**
08/09/93	Cal Run	15895	14930	14463	14095	18296	382006
08/10/93	Cal Run	16009	15384	15218	14864	19659	366815
08/11/93	Cal Run	15967	15162	14889	14498	19063	346404
08/12/93	Cal Run	15942	15280	15116	14750	19349	361827
	Mean	15953	15189	14922	14552	19092	364263
	R.F.	0.000165	0.000149	0.000144	0.000135	0.000116	
	ppbv	2.64	2.27	2.15	1.97	2.21	

Table F9. Eielson AFB, AK Surface Emission Sampling September 1993 Flux Values: μg/0.453 m^2/minute

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH
CONTROL PLOT BLOWER ON							
10935	8′EVW	0.006	0.008	0.018	<0.004	<0.004	2.58
10929	8′EVW	0.009	0.008	0.013	<0.004	<0.004	1.90
10925	13′EVW	0.006	0.015	0.049	<0.004	<0.004	4.46
10934	13′EVW	0.008	0.013	0.041	<0.004	<0.004	3.70
10932	19′EVW	0.397	35.9	10.1	21.1	6.06	1.440
10922	19′EVW	0.298	33.2	8.48	18.4	4.88	1.210

Table F10. Eielson AFB, AK Surface Emission Sampling September 1993 (Concentrations Reported in Parts Per Billion by Volume [ppbv])

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH
CONTROL PLOT BLOWER ON							
10935	8′EVW	0.99	1.1	2.0	<0.50	<0.50	360
10929	8′EVW	1.4	1.1	1.5	<0.50	<0.50	260
10925	13′EVW	0.92	2.1	5.6	<0.50	<0.50	620
10934	13′EVW	1.2	1.8	4.7	<0.50	<0.50	520
10932	19′EVW	60	4,800	1,200	2,400	700	200,000
10922	19′EVW	46	4,500	980	2,100	560	170,000

Table F11. Eielson AFB, AK Surface Emission Sampling September 1993 (Concentrations Reported in Parts Per Billion by Volume [ppbv])

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH
10924	Trip Blnk	<0.50	<0.50	<0.50	<0.50	<0.50	6.0
10923	Cyl Blnk**	<0.50	2.2	32	1.9	1.2	170,000

** = Sampled after 19′ sampling, may be showing carry-over.

Table F12. Eielson AFB, AK Surface Emission Sampling September 1993 Analytical System's Calibration Runs

FID AREA COUNTS							
		Benzene	**Toluene**	**Ethylbenzene**	***m&p* Xylene**	***o*-Xylene**	**Total**
09/15/93	Cal Run	15915	14894	14961	13589	18232	348770
09/16/93	Cal Run	15869	15124	14729	14038	18863	339037
	Mean	15892	15009	14845	13814	18548	343904
	R.F.	0.000166	0.000151	0.000144	0.000142	0.000119	
	ppbv	2.64	2.27	2.15	1.97	2.21	

Table F13. Eielson AFB, AK Surface Emissions Sampling November 1993 Flux Values: μg/0.453 m^2/minute

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH
CONTROL PLOT BLOWER ON							
10917	8'EVW	<0.004	0.006	<0.004	0.006	<0.004	0.517
10927	13'EVW	0.006	0.005	<0.004	<0.004	<0.004	0.445
10918	19'EVW	0.008	0.009	1.09	0.341	0.102	70.1
BACKGROUND PLOT BLOWER ON							
10925	8'EVW	<0.004	0.011	0.087	0.037	0.010	3.69
10926	13'EVW	<0.004	0.005	0.009	0.011	<0.004	0.603
10912	19'EVW	0.007	0.062	0.994	0.234	0.067	47.0
CONTROL PLOT BLOWER OFF							
10901	8'EVW	0.014	<0.004	0.018	0.010	<0.004	1.71
10913	13'EVW	0.005	0.005	0.006	0.008	<0.004	0.711
10911	19'EVW	0.004	0.007	0.108	0.037	0.011	4.03
BACKGROUND PLOT BLOWER OFF							
10932	8'EVW	<0.004	0.004	0.011	0.005	<0.004	0.782
10934	13'EVW	0.004	0.004	0.018	0.009	<0.004	0.883
10905	19'EVW	0.052	0.011	0.010	0.005	<0.004	1.15

Table F14. Eielson AFB, AK Surface Emissions Sampling November 1993 (Concentrations Reported in Parts Per Billion by Volume [ppbv])

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH
CONTROL PLOT 5.0 cfm							
10917	8'EVW	<0.50	0.80	<0.50	0.70	<0.50	72
10927	13'EVW	0.97	0.71	<0.50	<0.50	<0.50	62
10918	19'EVW	1.3	12	130	39	12	9,800
BACKGROUND PLOT 2.5 cfm							
10925	8'EVW	<0.50	1.4	10	4.3	1.1	510
10926	13'EVW	<0.50	0.64	1.0	1.3	<0.50	84
10912	19'EVW	1.1	8.2	110	27	7.7	6,600
CONTROL PLOT BLOWER OFF							
10901	8'EVW	2.3	<0.50	2.0	1.2	<0.50	240
10913	13'EVW	0.80	0.67	0.71	0.94	<0.50	99
10911	19'EVW	0.68	0.99	12	4.2	1.2	560
BACKGROUND PLOT BLOWER OFF							
10932	5'EVW	<0.05	0.57	1.2	0.60	<0.50	110
10934	13'EVW	0.57	0.56	2.1	0.99	<0.50	120
10905	19'EVW	8.1	1.5	1.1	0.56	<0.50	160

Table F15. Eielson AFB, AK Surface Emissions Sampling November 1993 (Concentrations Reported in Parts Per Billion by Volume [ppbv])

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH
AMBIENT AIR AT CONTROL PLOT DURING 5.0 cfm TEST							
10914	13'EVW	3.4	10	5.1	5.0	1.0	1,100
AMBIENT AIR AT CONTROL PLOT DURING 2.5 cfm TEST							
10904	13'EVW	1.5	4.1	2.1	2.2	<0.05	390
AMBIENT AIR AT CONTROL PLOT DURING 0 cfm TEST							
10929	13'EVW	1.4	0.55	<0.50	<0.50	<0.50	6.0
AMBIENT AIR AT BACKGROUND PLOT PLOT BLOWER ON							
10933	13'EVW	2.5	<0.50	<0.50	<0.50	<0.50	64
CYLINDER BLANK							
10903		0.52	0.77	<0.50	<0.50	<0.50	33
TRIP BLANK							
10935		<0.50	<0.50	<0.50	<0.50	<0.50	82

Table F16. Eielson AFB, AK Surface Emission Sampling November 1993 Analytical System's Calibration Runs

FID AREA COUNTS							
		Benzene	**Toluene**	**Ethylbenzene**	***m&p* Xylene**	***o*-Xylene**	**Total**
11/11/93	Cal Run	15898	15158	14825	14122	19639	316746
11/23/93	Cal Run	15104	15374	13875	12959	17630	525227
11/24/93	Cal Run	16114	15044	15044	13834	19129	351771
11/29/93	Cal Run	16124	15065	15065	14143	19626	343923
	Mean	15810	15160	15160	13764	19006	384417
	R.F.	0.000167	0.000150	0.000150	0.000143	0.000116	
	ppbv	2.64	2.27	2.27	1.97	2.21	

Table F17. Eielson AFB Surface Emissions Sampling, January 1994 Flux Values (μg/0.45 m^2/min)

Test	Location	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH
Control Test plot during air injection	8'EVW	0.010	0.012	0.007	0.015	<0.004	0.961
	11'EVW	0.007	0.006	<0.004	0.006	<0.004	0.217
	19'EVW	0.009	0.007	<0.004	0.006	<0.004	0.236
Background area during air injection	8.5'EVW	0.008	0.005	<0.004	<0.004	<0.004	0.333
	11'EVW	0.007	0.005	<0.004	<0.004	<0.004	0.100
	19'EVW	0.007	0.005	<0.004	<0.004	<0.004	0.122
Control test plot without air injection	8'EVW	0.017	0.013	<0.004	0.013	<0.004	0.287
	11'EVW	0.009	<0.004	<0.004	0.010	<0.004	0.305
	19'EVW	0.008	0.014	0.012	0.020	0.006	0.621
Background area without air injection	8.5'EVW	0.005	0.007	<0.004	0.008	<0.004	0.176
	11'EVW-1	0.008	0.004	<0.004	0.007	<0.004	0.131
	19'EVW	0.016	0.017	0.005	0.011	<0.004	1.06

Table F18. Eielson AFB, AK Surface Emission Sampling January 1994 (Concentrations Reported in Parts Per Billion by Volume [ppbv])

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH
CONTROL PLOT BLOWER ON							
10912	8'EVW	1.5	1.6	0.82	1.7	<0.50	130
10906	11'EVW	1.2	0.80	<0.50	0.66	<0.50	30
10934	19'EVW	1.4	0.97	<0.50	0.75	<0.50	33
10935	19'EVW	1.4	0.97	<0.50	<0.50	<0.50	25
10905	19'EVW	1.3	0.69	<0.50	<0.50	<0.50	22
BACKGROUND PLOT BLOWER ON							
10926	8.5'EVW	1.3	0.72	<0.50	<0.50	<0.50	46
10929	11'EVW	1.1	0.62	<0.50	<0.50	<0.50	14
10920	19'EVW	1.1	0.61	<0.50	<0.50	<0.50	17
CONTROL PLOT BLOWER OFF							
10927	8'EVW	2.6	1.7	<0.50	1.6	<0.50	40
10911	11'EVW	1.4	<0.50	<0.50	1.2	<0.50	42
10918	19'EVW	1.3	1.8	1.4	2.3	0.67	86
BACKGROUND PLOT BLOWER OFF							
10904	8.5'EVW	0.73	0.89	<0.50	0.93	<0.50	24
10933	11'EVW	1.3	0.52	<0.50	0.78	<0.50	18
10931	19'EVW	2.4	2.3	0.54	1.3	<0.50	150

Table F19. Eielson AFB, AK Surface Emission Sampling January 1994 (Concentrations Reported in Parts Per Billion by Volume [ppbv])

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH
10913	Trip Blnk	0.58	<0.50	<0.50	<0.50	<0.50	17
10932	Cyl Blnk	<0.50	<0.50	<0.50	<0.50	<0.50	11
10903	Cyl Blnk	1.2	0.65	<0.50	<0.50	<0.50	10
10931	Amb Air	1.0	0.8	<0.50	0.53	<0.50	19
10919	Amb Air	0.88	9.9	<0.50	<0.50	<0.50	27
10930	Amb Air	1.8	2.0	<0.50	1.4	<0.50	49
10925	Amb Air	0.60	<0.50	<0.50	<0.50	<0.50	15

Table F20. Eielson AFB, AK Surface Emission Sampling January 1994 Analytical System's Calibration Runs

FID AREA COUNTS							
		Benzene	**Toluene**	**Ethylbenzene**	***m&p* Xylene**	***o*-Xylene**	**Total**
01/20/94	Cal Run	12227	11590	11360	10847	15093	279649
01/21/94	Cal Run	12184	11713	11527	11113	15430	254864
01/24/94	Cal Run	12287	11552	11486	11052	15356	253268
01/25/94	Cal Run	12362	11708	11607	11094	15246	255094
	Mean	12265	11641	11495	11026	15281	260719
	R.F.	0.000215	0.000195	0.000187	0.000179	0.000145	
	ppbv	2.64	2.27	2.15	1.97	2.21	

Table F21. Eielson AFB Surface Emissions Sampling, April 1994 Flux Values (μg/0.45 m^2/min)

Test	Location	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH
Control Test plot during air injection	8'EVW	0.004	0.005	<0.004	<0.004	<0.004	0.300
	11'EVW	0.004	<0.004	<0.004	0.013	<0.004	0.287
	19'EVW	0.011	0.010	0.006	0.011	<0.004	0.768
Background area during air injection	8.5'EVW	0.004	<0.004	0.042	0.009	<0.004	0.266
	11'EVW	0.004	<0.004	<0.004	<0.004	<0.004	0.129
	19'EVW	0.004	<0.004	<0.004	<0.004	<0.004	0.157
Control test plot without air injection	8'EVW	0.010	0.006	<0.004	<0.004	<0.004	0.320
	11'EVW	0.004	<0.004	<0.004	<0.004	<0.004	0.145
	19'EVW	0.006	0.007	<0.004	0.005	<0.004	0.192
Background area without air injection	8.5'EVW	0.006	0.004	<0.004	<0.004	<0.004	0.181
	11'EVW-1	0.005	0.007	<0.004	<0.004	<0.004	0.327
	19'EVW	0.022	0.006	<0.004	0.009	<0.004	0.363

Table F22. Eielson AFB, AK Surface Emission Sampling April 1994 (Concentrations Reported in Parts Per Billion by Volume [ppbv])

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH
CONTROL PLOT BLOWER ON							
10919	8′EVW	0.57	0.72	<0.50	<0.50	<0.50	42
10920	11′EVW	0.55	<0.50	<0.50	1.5	<0.50	40
10917	19′EVW-1	1.7	1.4	0.71	1.3	<0.50	110
10904	19′EVW-2	13	2.3	0.98	1.9	<0.50	150
10929	19′EVW-3	4.5	1.4	1.2	2.1	0.61	110
BACKGROUND PLOT BLOWER ON							
10926	8.5′EVW	0.51	<0.50	<0.50	<0.50	<0.50	32
10913	11′EVW	0.62	<0.50	<0.50	<0.50	<0.50	18
10911	19′EVW	0.64	<0.50	<0.50	<0.50	<0.50	22
CONTROL PLOT BLOWER OFF							
10905	8′EVW	1.5	0.75	<0.50	<0.50	<0.50	44
10918	11′EVW	0.55	<0.50	<0.50	<0.50	<0.50	20
10925	19′EVW	0.88	0.90	<0.50	0.59	<0.50	27
BACKGROUND PLOT BLOWER OFF							
10912	8.5′EVW	0.92	0.53	<0.50	<0.50	<0.50	25
10924	11′EVW	0.73	0.93	<0.50	<0.50	<0.50	46
10933	19′EVW	3.5	0.81	<0.50	1.0	<0.50	51

Table F23. Eielson AFB, AK Surface Emission Sampling April 1994 (Concentrations Reported in Parts Per Billion by Volume [ppbv])

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH
10903	Trip Blnk	<0.50	<0.50	<0.50	<0.50	<0.50	11
10932	Cyl Blnk	3.7	1.2	<0.50	<0.50	<0.50	57
10927	Amb Air	1.6	0.14	<0.50	<0.50	<0.50	17
10934	Amb Air	2.2	1.0	<0.50	1.1	<0.50	120
10930	Amb Air	0.89	0.54	<0.50	<0.50	0.71	26
10935	Amb Air	8.0	3.8	0.50	1.8	<0.50	120

Table F24. Eielson AFB, AK Surface Emission Sampling April 1994 Analytical System's Calibration Runs

FID AREA COUNTS							
		Benzene	**Toluene**	**Ethylbenzene**	***m&p* Xylene**	***o*-Xylene**	**Total**
04/29/94	Cal Run	10894	10458	10350	9959	10954	229651
05/02/94	Cal Run	11164	10888	10571	10382	11499	247442
05/03/94	Cal Run	10538	10172	9821	9376	10140	222795
	Mean	10865	10506	10247	9906	10864	233296
	R.F.	0.000242	0.000216	0.000209	0.000198	0.000208	
	ppbv	2.64	2.27	2.15	1.97	2.21	

Table F25. Eielson AFB Surface Emissions Sampling, July 1994 Flux Values (μg/0.45 m^2/min)

Test	Location	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH
Control Test plot during air injection	8'EVW	0.014	<0.006	<0.004	0.004	<0.004	0.35
	11'EVW	0.004	<0.004	<0.004	<0.004	<0.004	0.19
	19'EVW	<0.004	<0.004	<0.004	<0.004	<0.004	0.21
Background area during air injection	8.5'EVW	<0.004	<0.004	<0.004	0.005	<0.004	0.28
	11'EVW	<0.004	<0.004	<0.004	<0.004	<0.004	0.15
	19'EVW	<0.004	0.025	<0.004	<0.004	<0.004	0.05
Control test plot without air injection	8'EVW	<0.004	<0.004	<0.004	<0.004	<0.004	0.04
	11'EVW	<0.004	<0.004	<0.004	<0.004	<0.004	0.05
	19'EVW	<0.004	<0.004	<0.004	<0.004	<0.004	0.07
Background area without air injection	8.5'EVW	<0.004	<0.004	<0.004	<0.004	<0.004	0.12
	11'EVW-1	<0.004	0.006	<0.004	<0.004	<0.004	0.07
	19'EVW	<0.004	<0.004	<0.004	<0.004	<0.004	0.12

Table F26. Eielson AFB, AK Surface Emission Sampling July 1994 (Concentrations Reported in Parts Per Billion by Volume [ppbv])

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH
CONTROL PLOT BLOWER ON							
10922	8'EVW	2.12	0.78	<0.50	<0.50	<0.50	49
10934	11'EVW	0.66	<0.50	<0.50	<0.50	<0.50	27
10920	19'EVW-1	<0.50	<0.50	<0.50	<0.50	<0.50	29
10935	19'EVW-2	<0.50	0.56	<0.50	0.52	<0.50	39
A-15	19'EVW-3	<0.50	<0.50	<0.50	<0.50	<0.50	21
BACKGROUND PLOT BLOWER ON							
A-7	8.5'EVW	<0.50	<0.50	<0.50	<0.50	<0.50	6.8
A-1	11'EVW	<0.50	<0.50	<0.50	<0.50	<0.50	14
A-6	19'EVW	<0.50	3.35	<0.50	<0.50	<0.50	13
CONTROL PLOT BLOWER OFF							
A-18	8'EVW	<0.50	<0.50	<0.50	<0.50	<0.50	5.8
A-14	11'EVW	<0.50	<0.50	<0.50	<0.50	<0.50	6.3
A-4	19'EVW	<0.50	<0.50	<0.50	<0.50	<0.50	9.1
BACKGROUND PLOT BLOWER OFF							
A-2	8.5'EVW	<0.50	<0.50	<0.50	<0.50	<0.50	16
A-17	11'EVW	<0.50	0.77	<0.50	<0.50	<0.50	9.4
A-5	19'EVW	<0.50	<0.50	<0.50	<0.50	<0.50	16.4

Table F27. Eielson AFB, AK Surface Emission Sampling July 1994 (Concentrations Reported in Parts Per Billion by Volume [ppbv])

Tube ID	Site ID	Benzene	Toluene	Ethylbenzene	*m&p* Xylene	*o*-Xylene	TPH
A-8	Trip Blnk	<0.50	<0.50	<0.50	<0.50	<0.50	0.83
A-11	Cyl Blnk	<0.50	<0.50	<0.50	<0.50	<0.50	16
10930	Amb Air	<0.50	<0.50	<0.50	<0.50	<0.50	3.8
A-10	Amb Air	<0.50	<0.50	<0.50	<0.50	<0.50	2.4
A-3	Amb Air	<0.50	<0.50	<0.50	<0.50	<0.50	7.5
A-13	Amb Air	<0.50	<0.50	<0.50	<0.50	<0.50	1.5

Table F28. Eielson AFB, AK Surface Emission Sampling July 1994 Analytical System's Calibration Runs

FID AREA COUNTS							
		Benzene	**Toluene**	**Ethylbenzene**	***m&p* Xylene**	***o*-Xylene**	**Total**
07/15/94	Cal Run	62888	60624	59719	57857	61874	1327137
07/20/94	Cal Run	62116	59212	58210	56241	60005	1298621
	Mean	62505	59918	58964	57049	60940	1312879
	R.F.	0.000211	0.000190	0.000183	0.000173	0.000182	
	ppbv	1.32	11.4	10.8	9.9	11.1	

APPENDIX G

HELIUM TRACER STUDY DATA

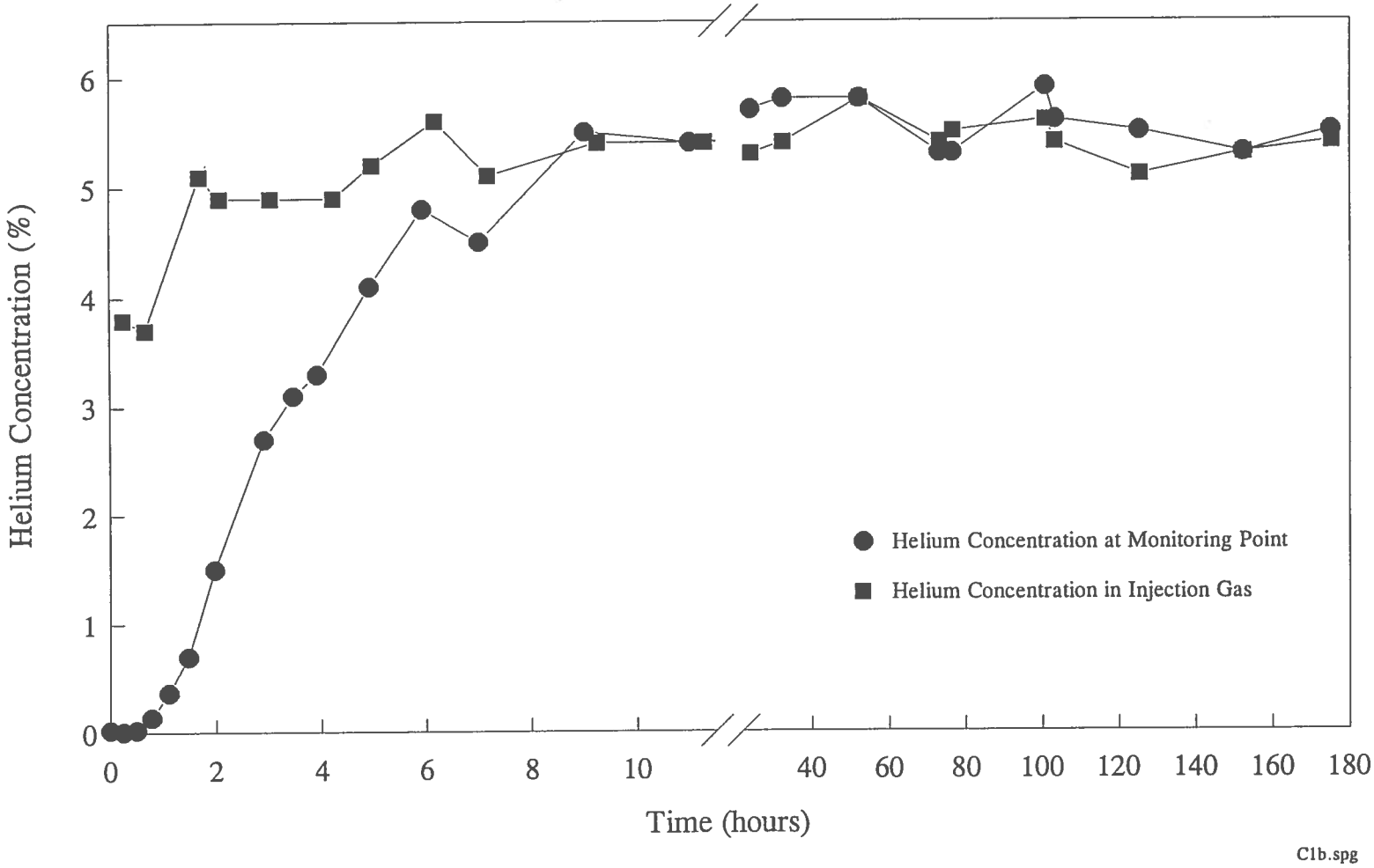


Figure G1. Helium Concentration over Time at Monitoring Point C1b

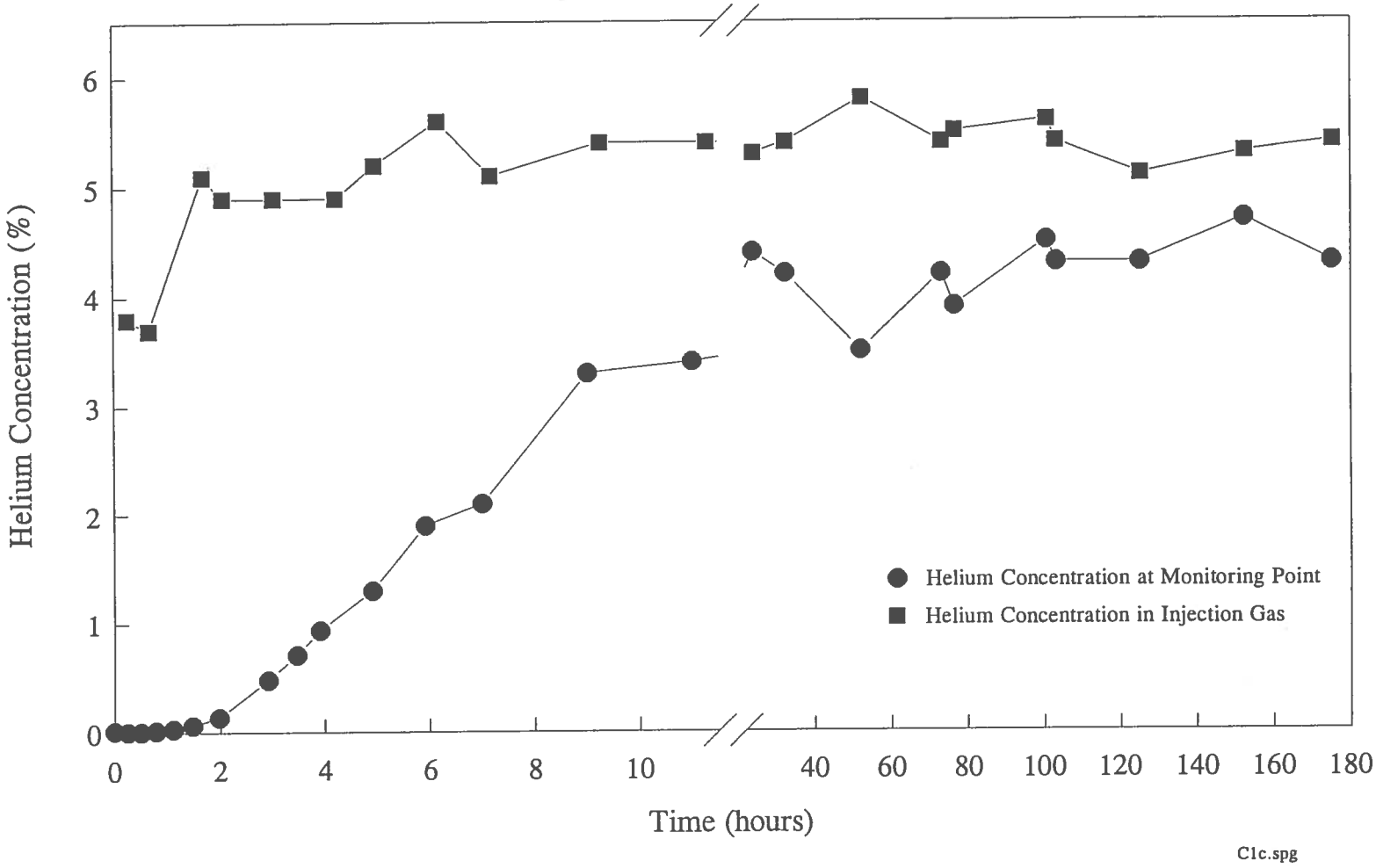


Figure G2. Helium Concentration over Time at Monitoring Point C1c

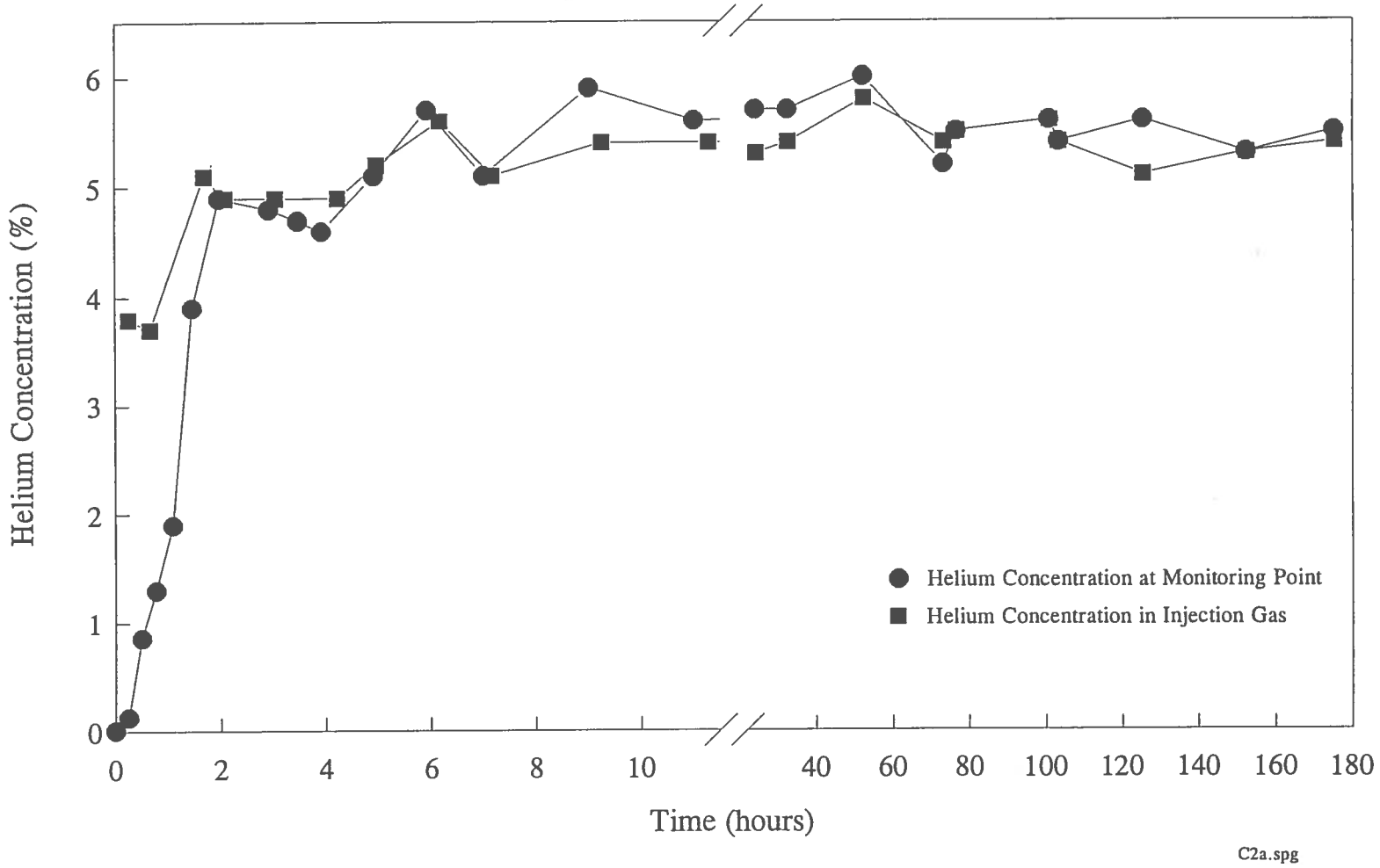


Figure G3. Helium Concentration over Time at Monitoring Point C2a

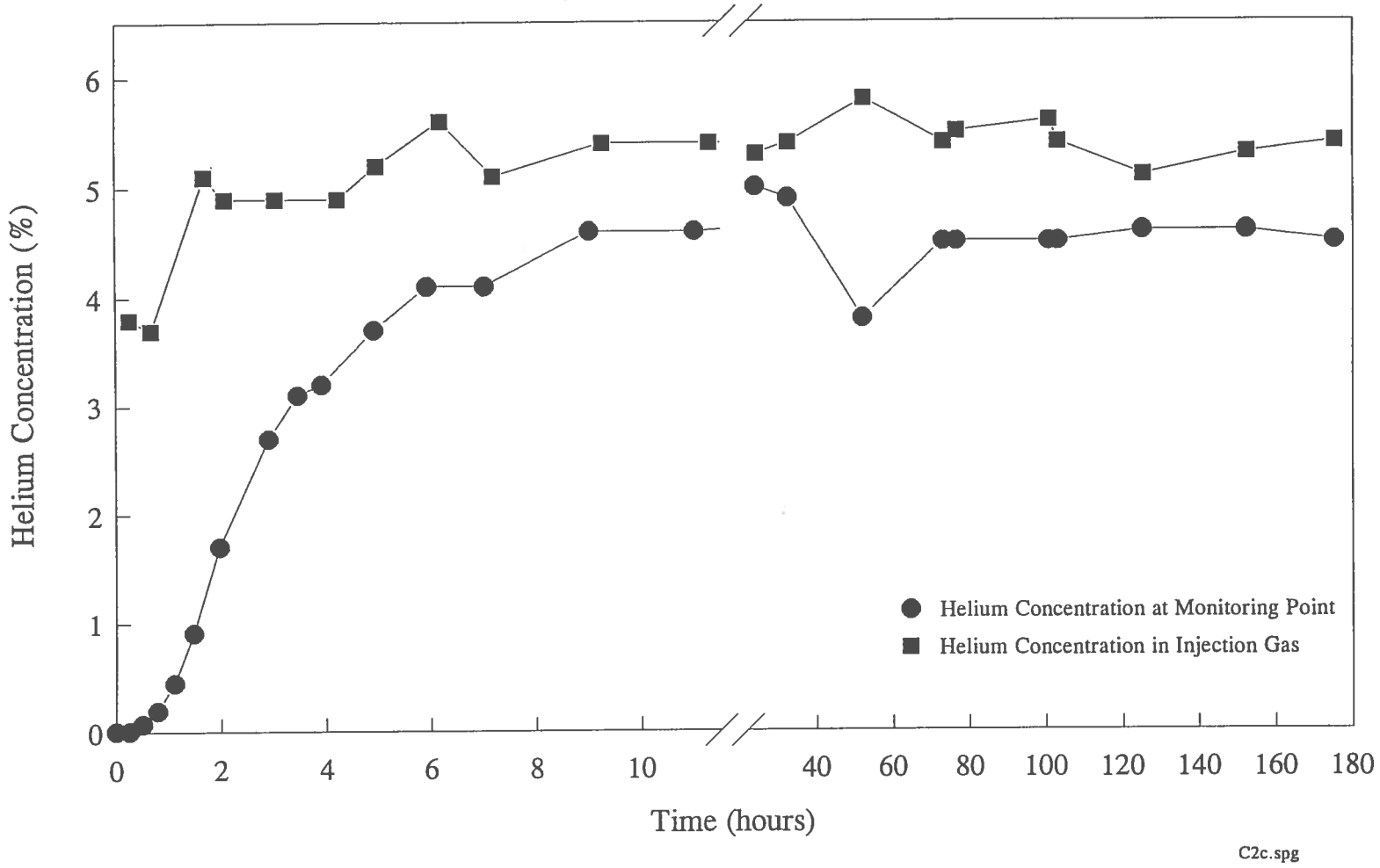


Figure G4. Helium Concentration over Time at Monitoring Point C2c

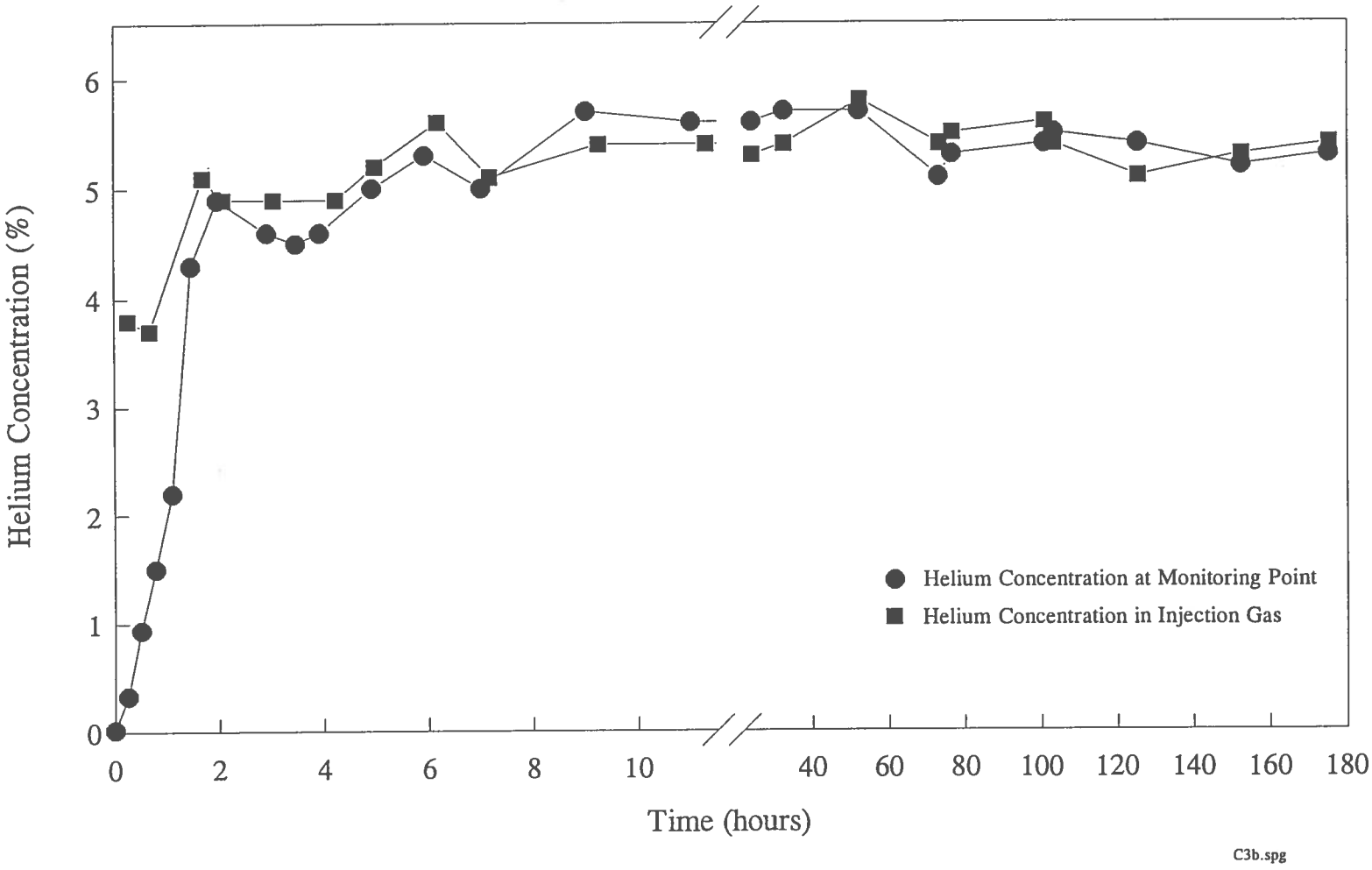


Figure G5. Helium Concentration over Time at Monitoring Point C3b

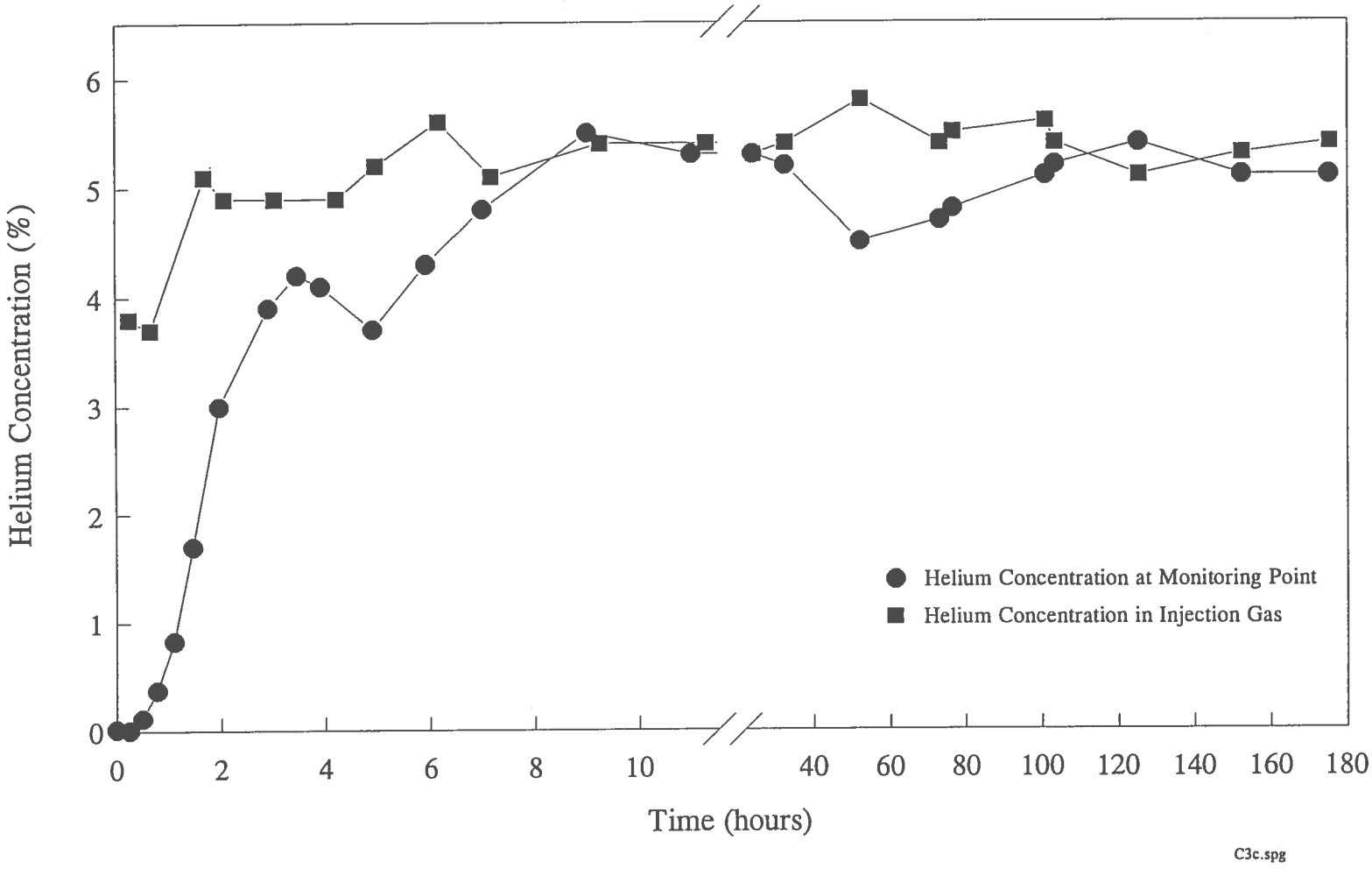


Figure G6. Helium Concentration over Time at Monitoring Point C3c

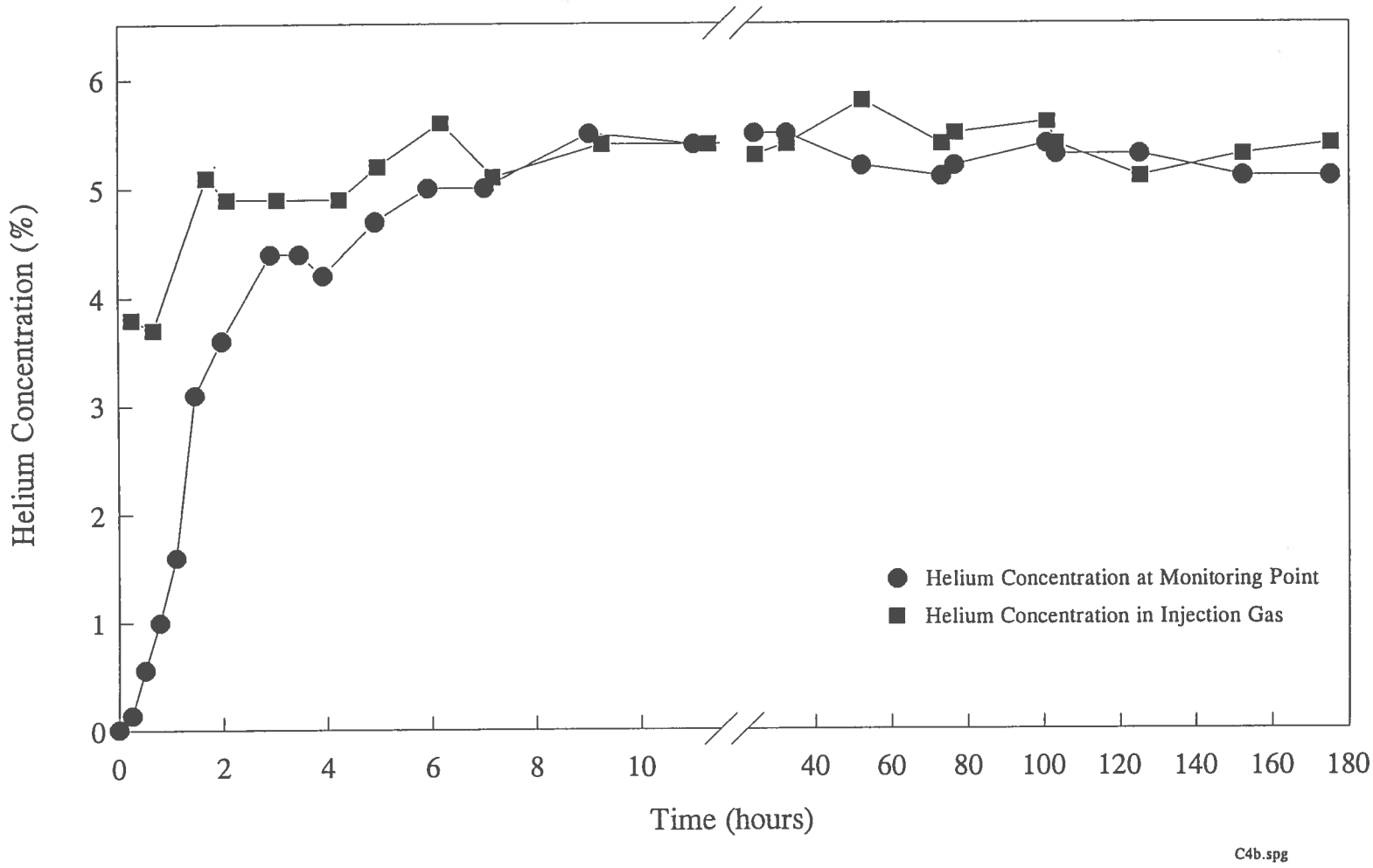


Figure G7. Helium Concentration over Time at Monitoring Point C4b

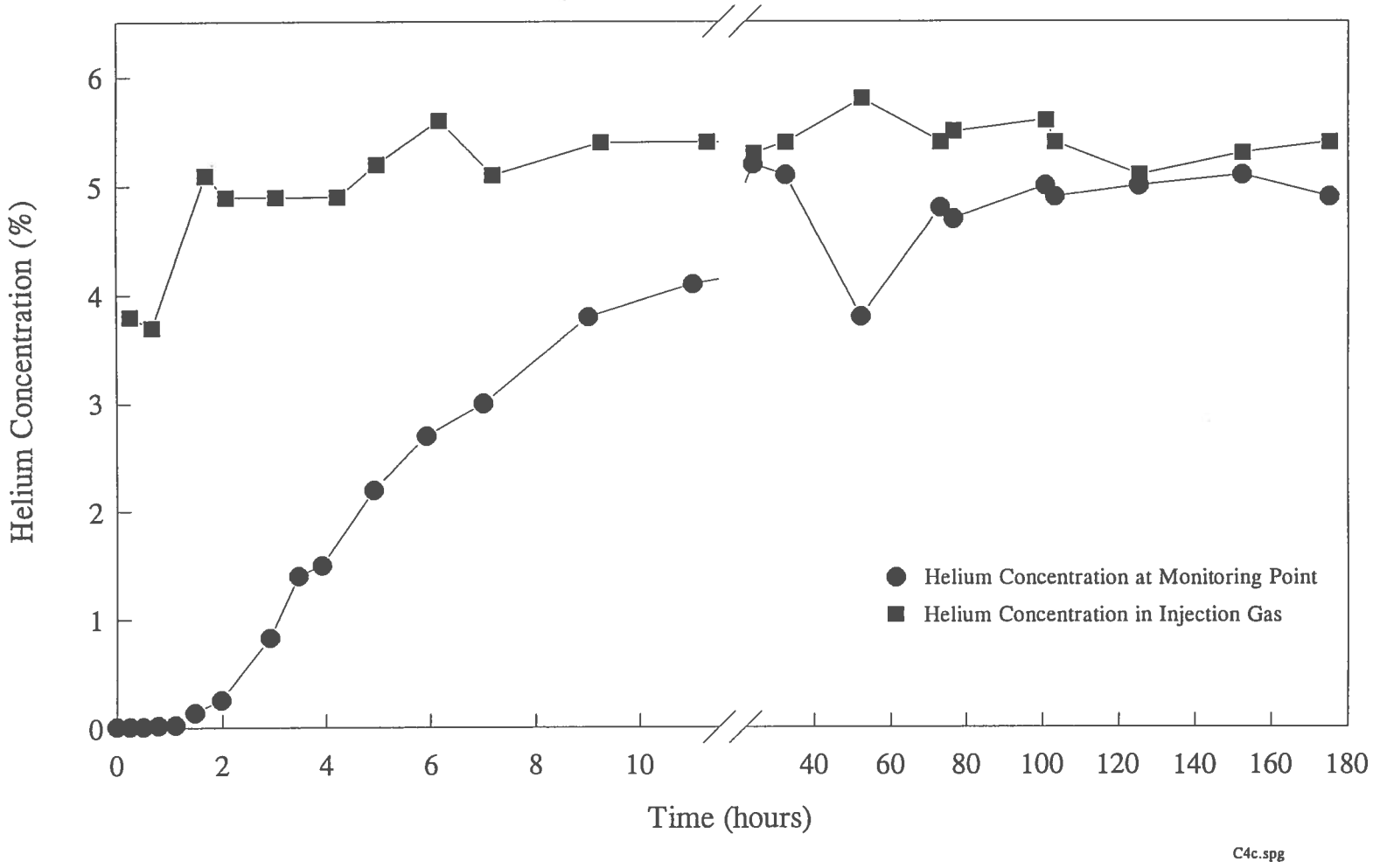


Figure G8. Helium Concentration over Time at Monitoring Point C4c

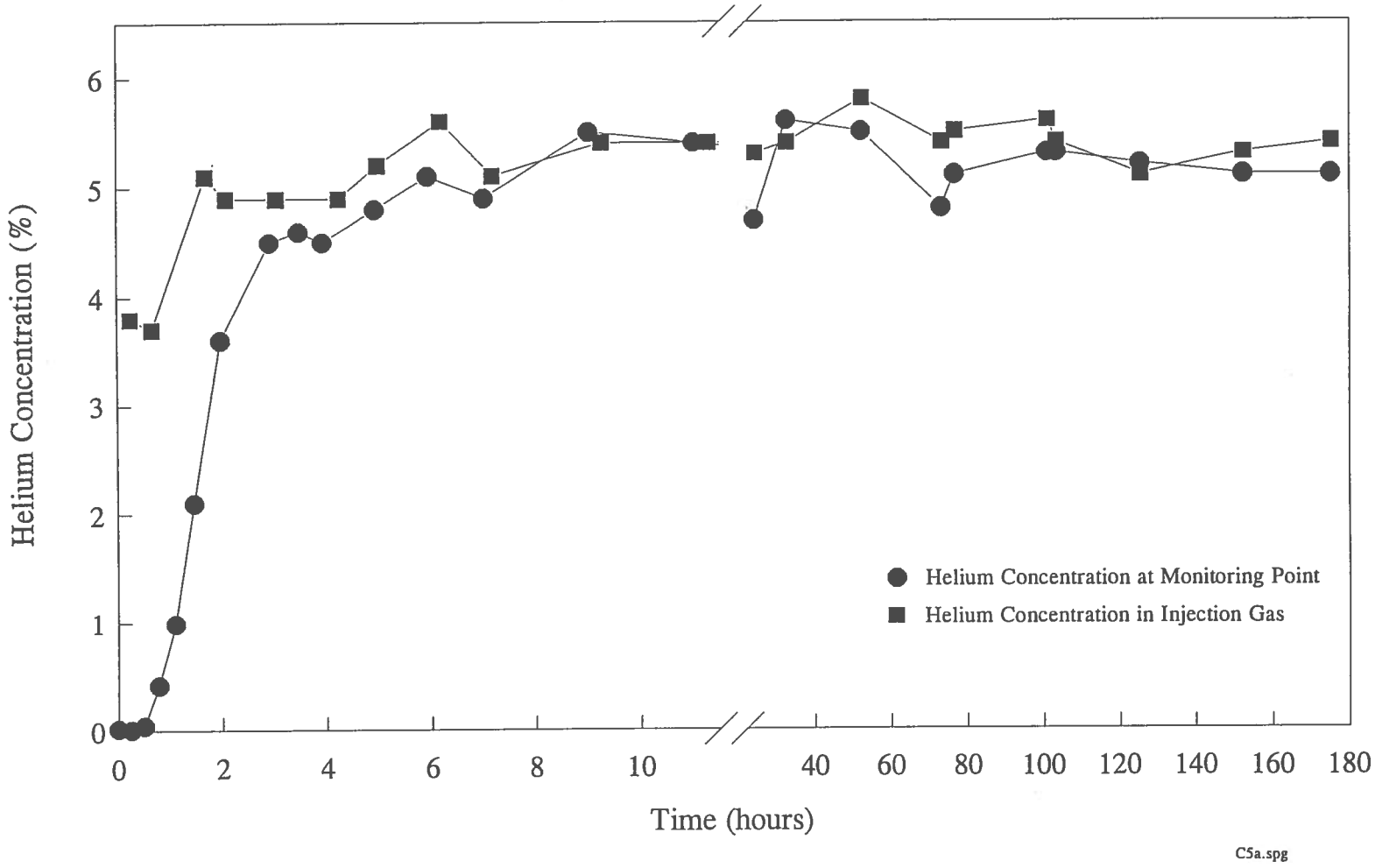


Figure G9. Helium Concentration over Time at Monitoring Point C5a

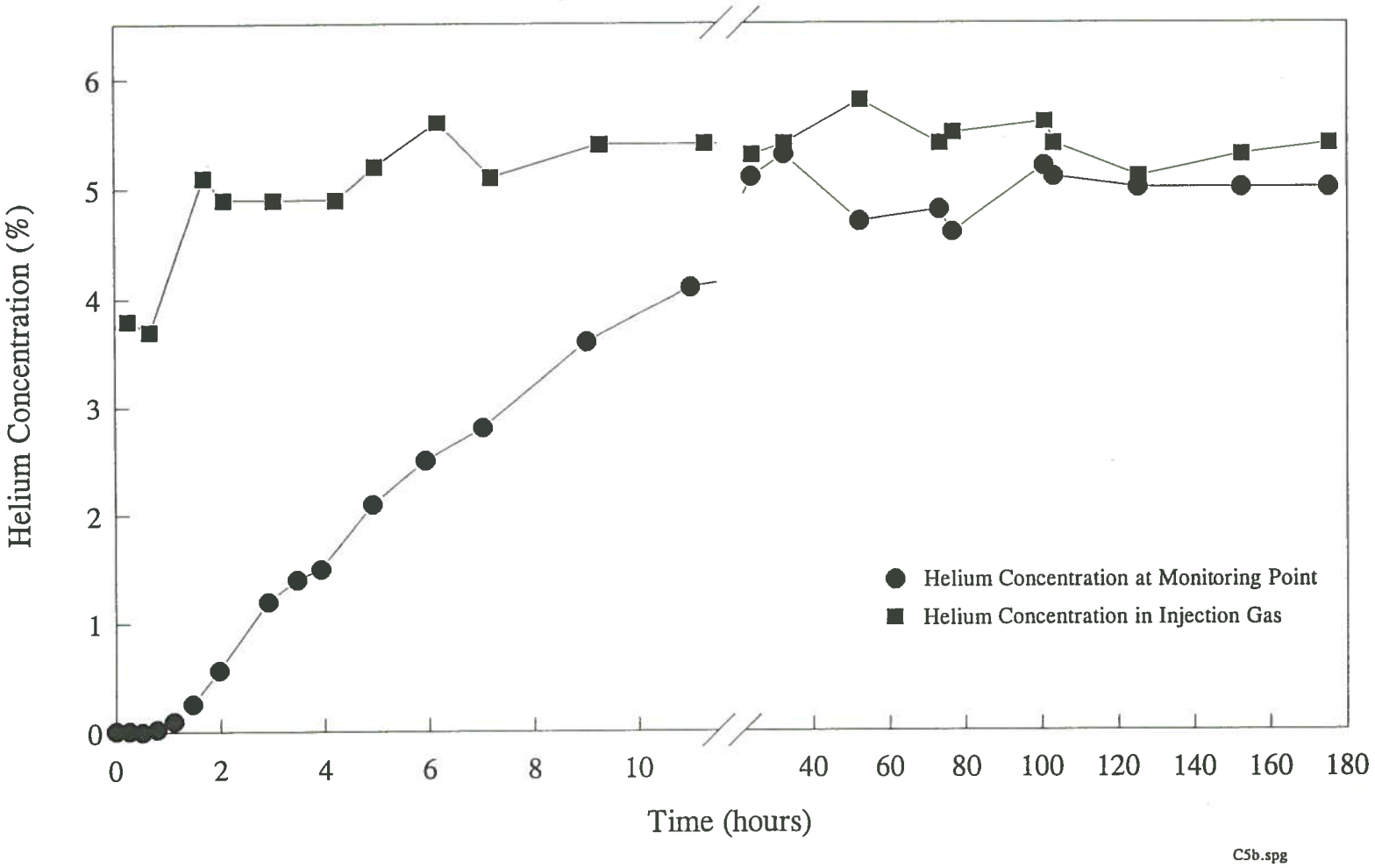


Figure G10. Helium Concentration over Time at Monitoring Point C5b

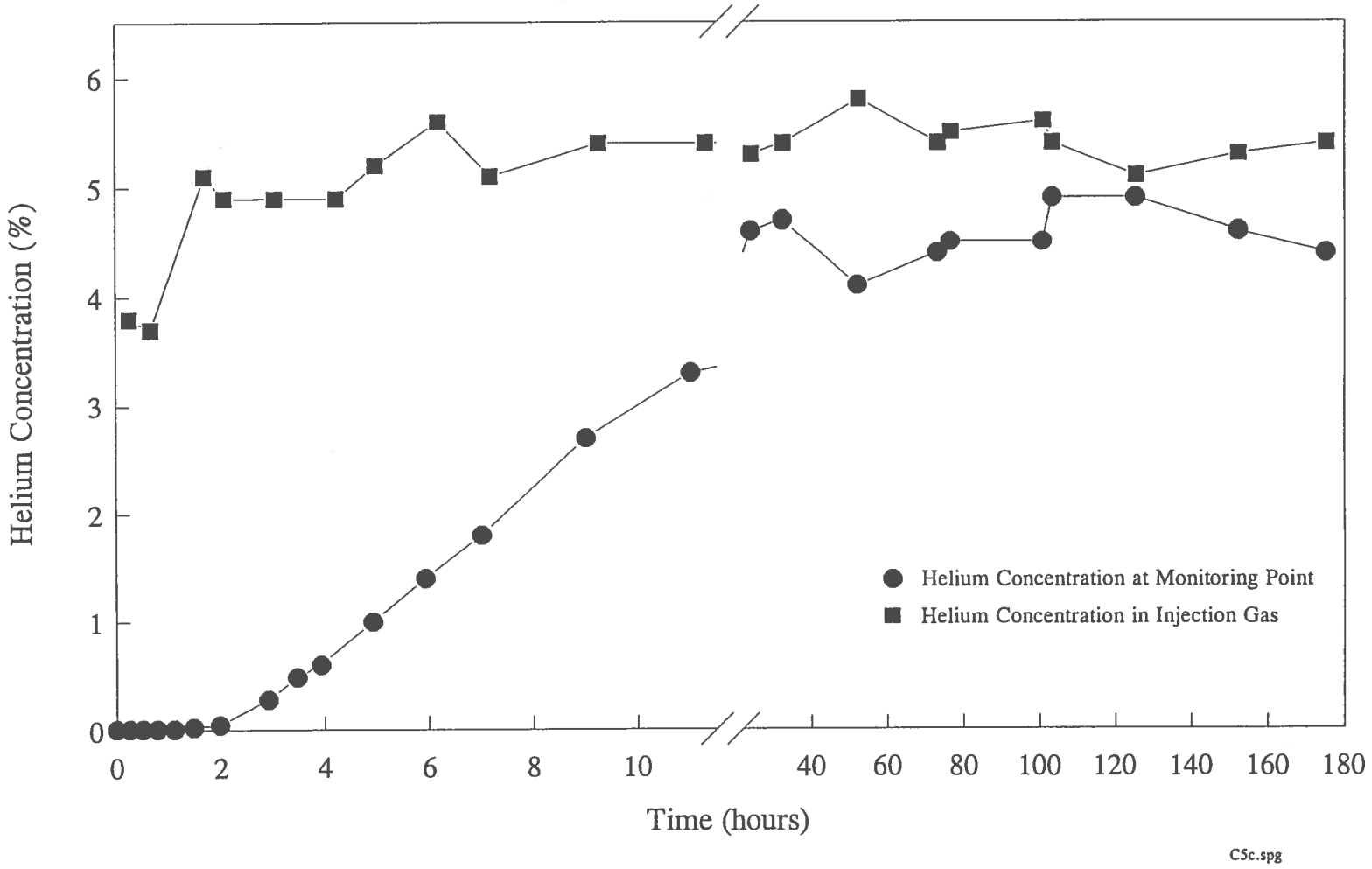


Figure G11. Helium Concentration over Time at Monitoring Point C5c

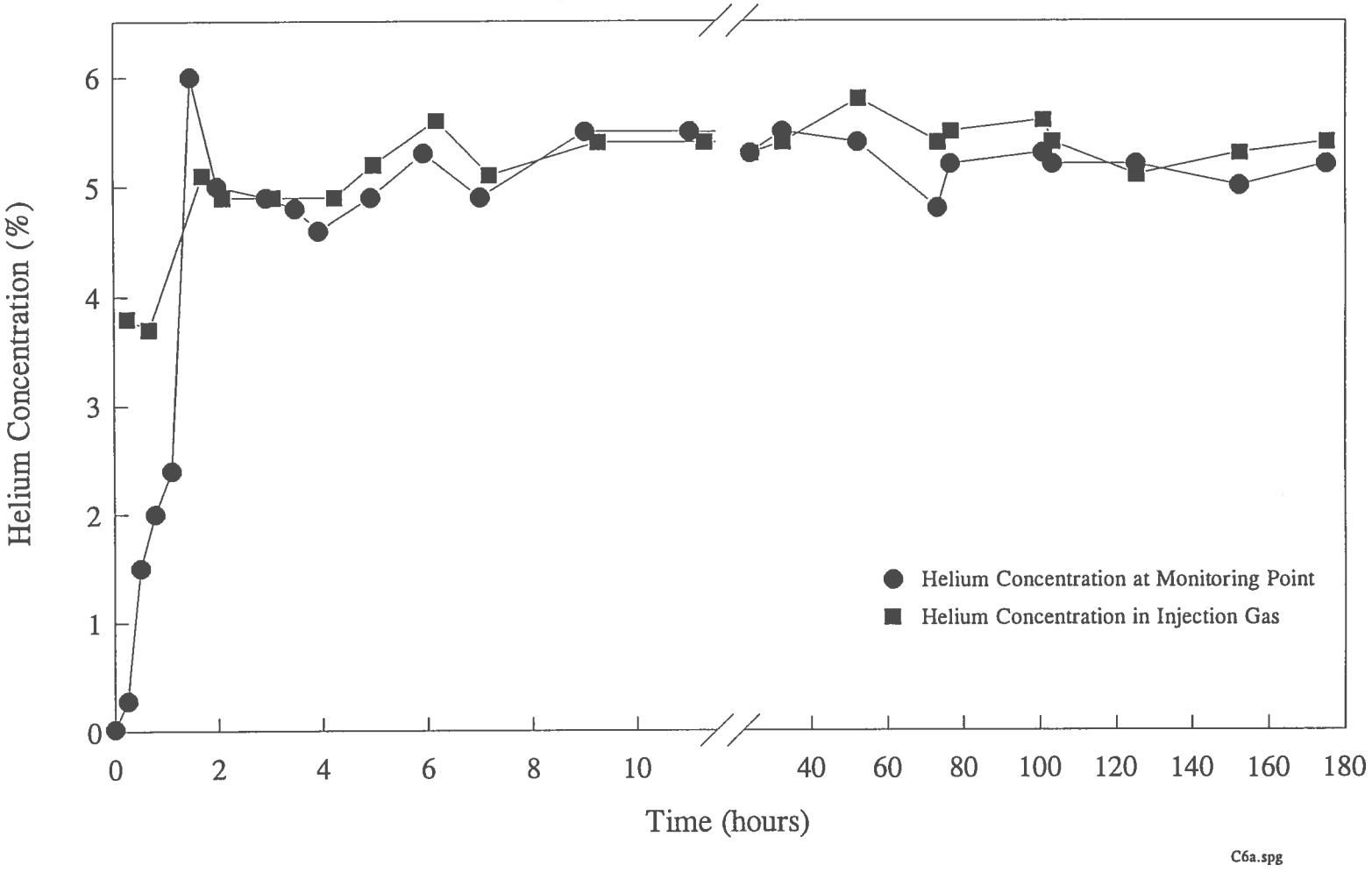


Figure G12. Helium Concentration over Time at Monitoring Point C6a

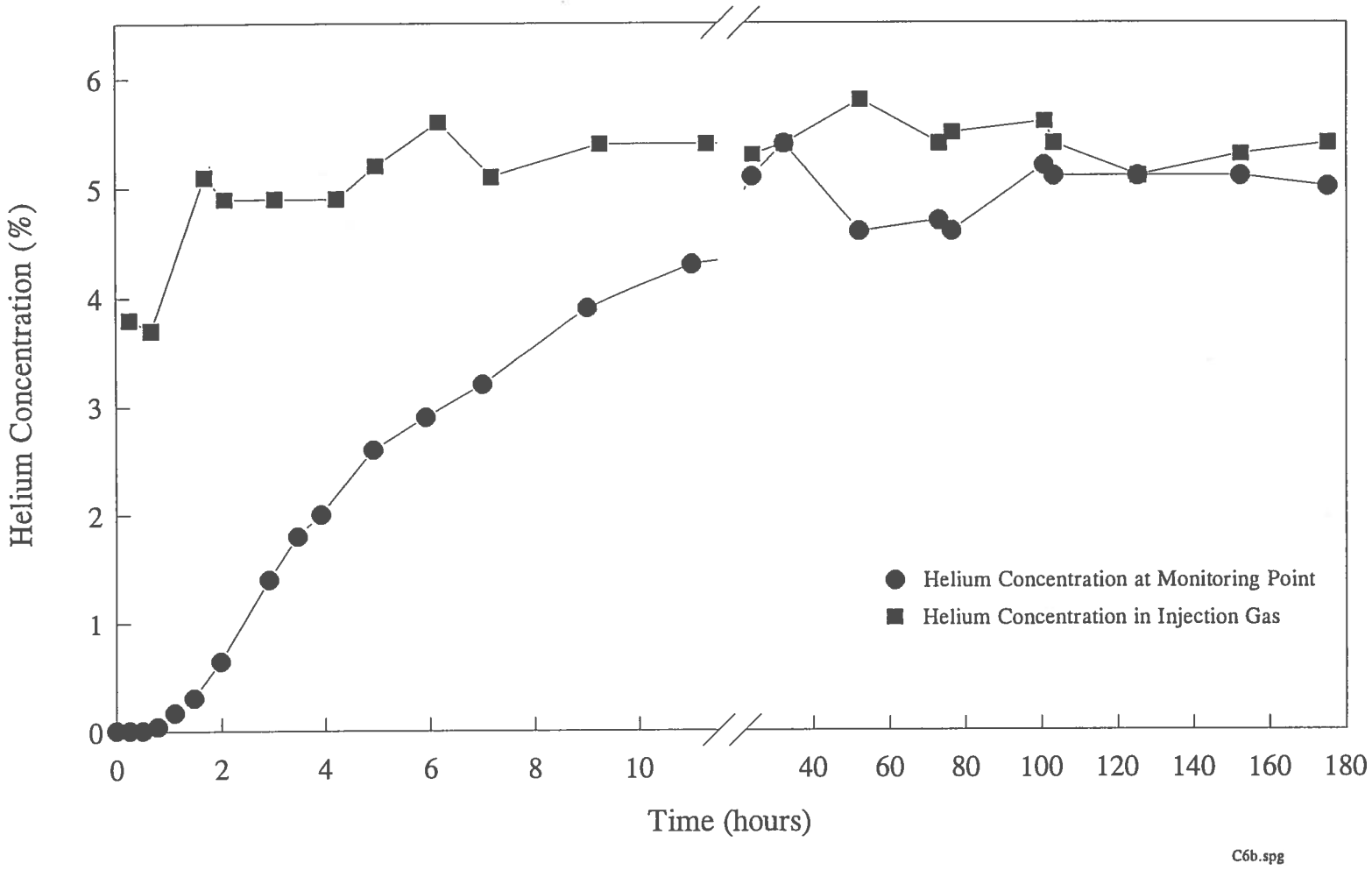


Figure G13. Helium Concentration over Time at Monitoring Point C6b

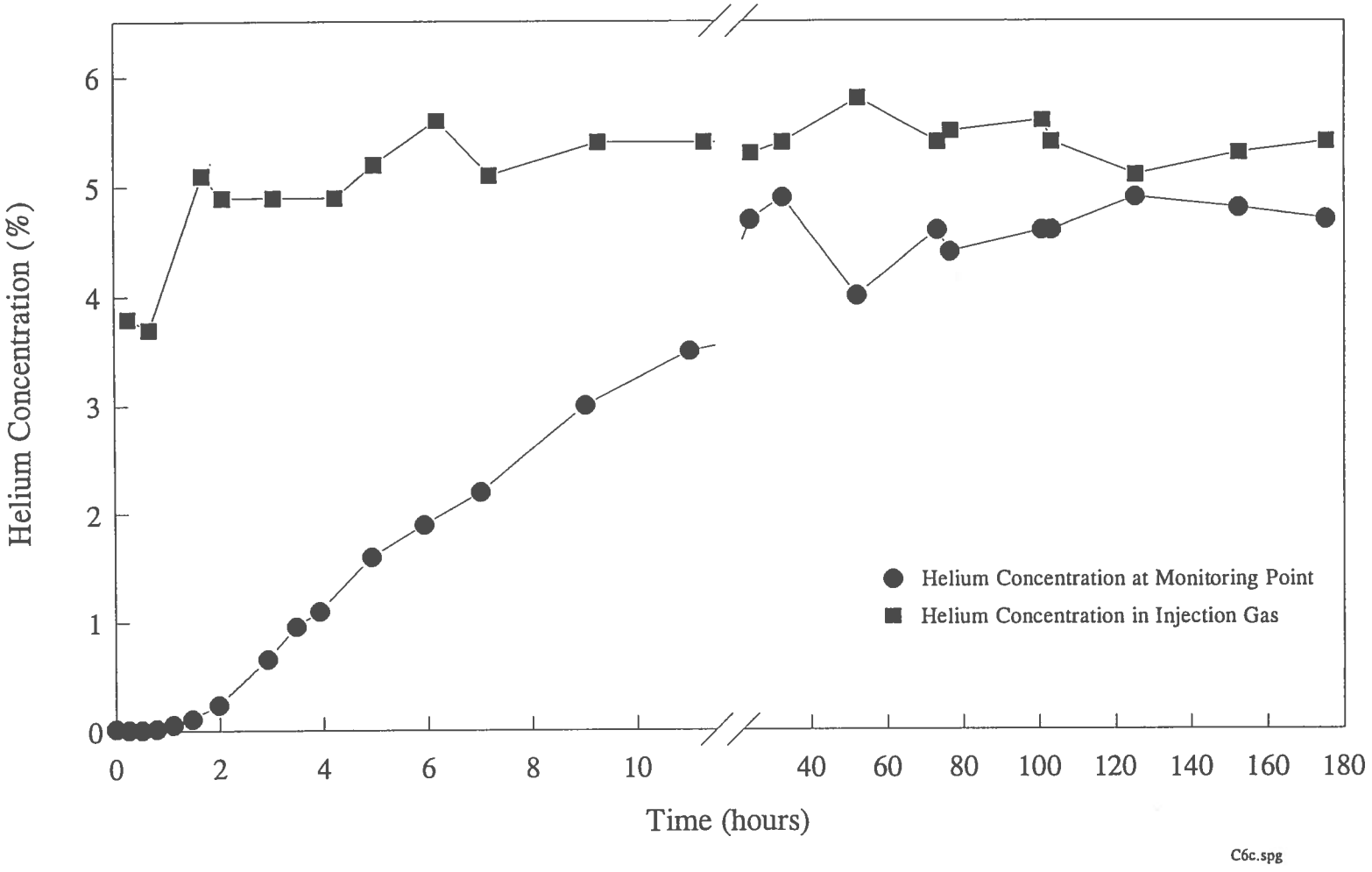


Figure G14. Helium Concentration over Time at Monitoring Point C6c

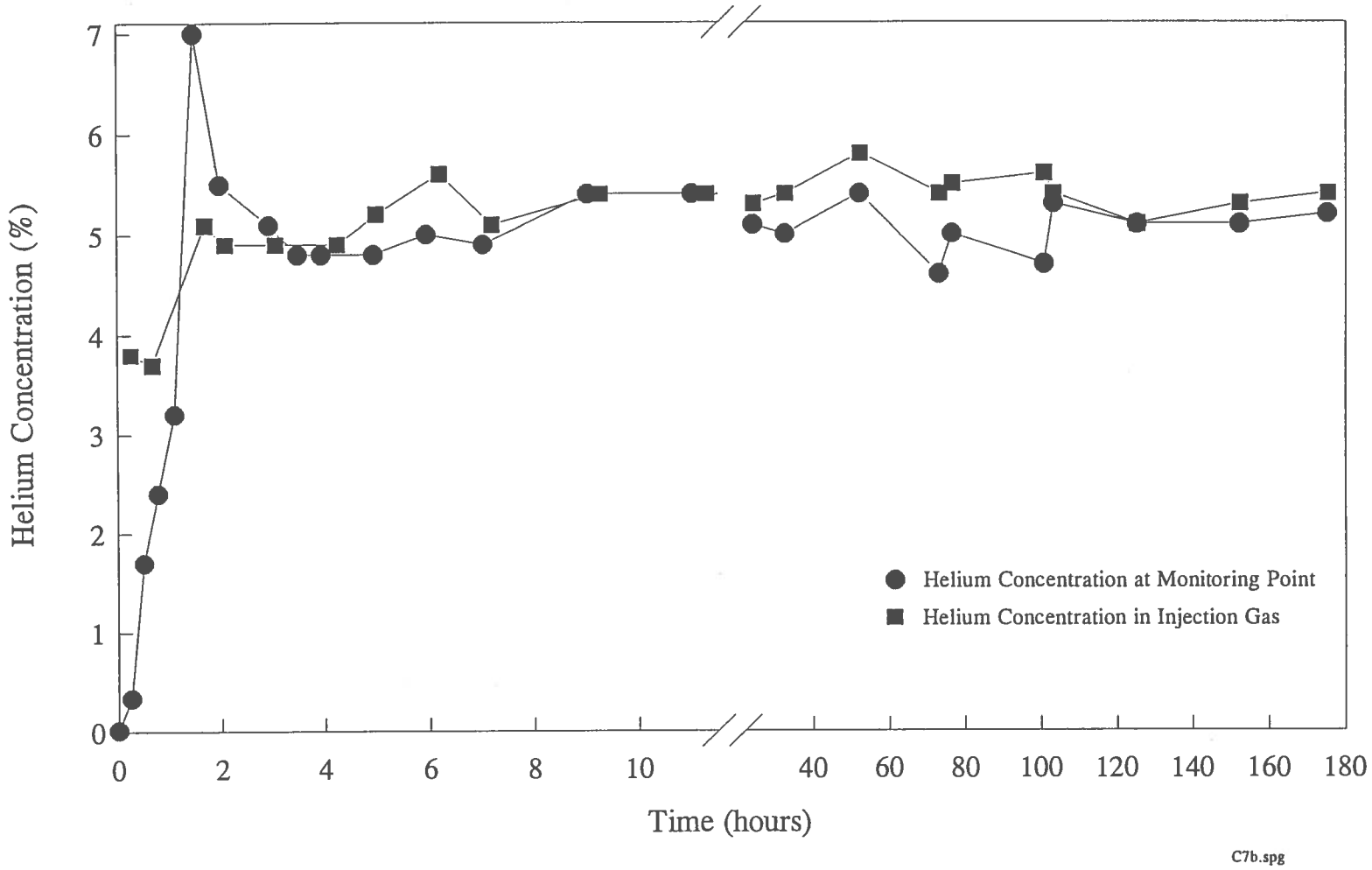


Figure G15. Helium Concentration over Time at Monitoring Point C7b

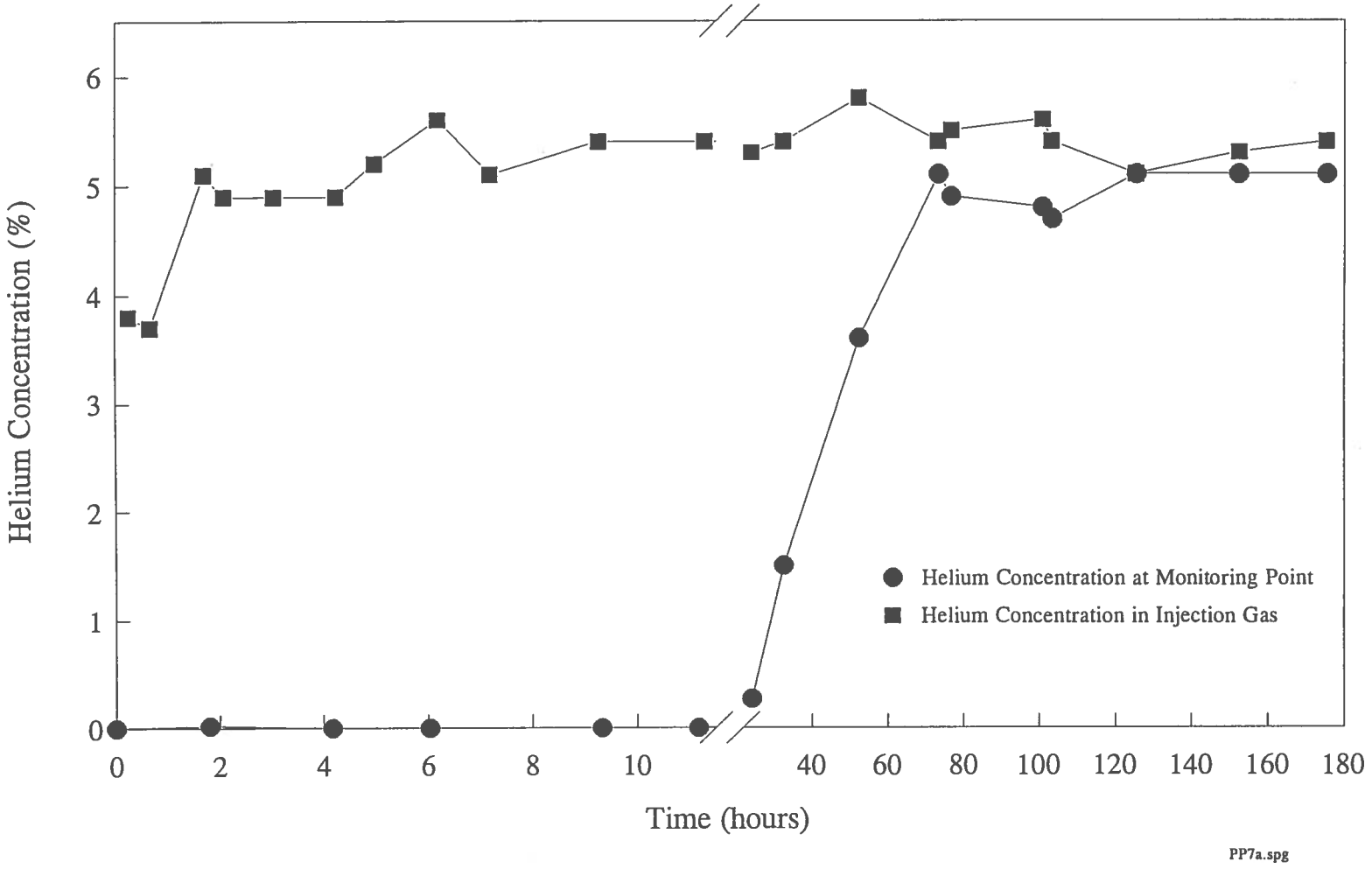


Figure G16. Helium Concentration over Time at Monitoring Point PP7a

APPENDIX H

AIR PERMEABILITY TEST DATA

Table H1. Air Permeability Test in the Active Warming Test Plot: Monitoring Point A7, 11 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.0	0.0	0.0	21	0.03	0.3	24.1
1	0.0	3.5	8.0	25	0.03	3.7	24.0
2	0.071	6.0	12.1	30	0.03	1.5	24.0
3	0.03	8.2	15.2	35	0.03	6.5	24.2
4	0.03	9.7	17.2	40	0.03	3.7	24.4
5	0.03	11.3	19.7	45	0.03	2.5	24.4
6	0.04	17.5	20.9	50	0.03	2.6	24.5
7	0.05	13.5	21.9	55	0.03	0.5	24.4
8	0.03	14.9	21.9	60	0.03	0.2	24.6
9	0.03	14.0	21.9	65	0.03	0.8	24.8
10	0.03	25.5	27.1	70	0.03	0.7	24.5
12	0.03	9.5	23.0	75	0.03	0.75	24.4
14	0.03	4.8	23.5	80	0.03	4.0	24.8
16	0.03	8.5	23.8	90	0.03	7.20	24.4
18	0.03	6.6	24.0	100	0.055	3.8	24.8
20	0.03	2.5	24.11				

Table H2. Air Permeability Test in the Active Warming Test Plot: Monitoring Point A4, 21.5 ft from the Vent Well: Active Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.10	0.093	0.10	23	0.12	0.45	0.11
1	0.11	0.11	0.14	26	0.13	0.55	0.11
2	0.11	0.11	0.11	29	0.12	0.60	0.11
3	0.12	0.13	0.10	32	0.12	0.65	0.12
4	0.11	0.14	0.11	35	0.12	0.70	0.12
5	0.12	0.16	0.10	38	0.12	0.75	0.11
6	0.12	0.17	0.11	40	0.12	0.80	0.12
7	0.11	0.18	0.11	45	0.12	0.90	0.11
8	0.12	0.19	0.11	50	0.12	0.95	0.12
9	0.12	0.20	0.11	55	0.12	1.05	0.10
10	0.12	0.21	0.11	60	0.12	1.10	0.11
12	0.12	0.24	0.11	70	0.12	1.20	0.11
14	0.13	0.25	0.11	80	0.13	1.35	0.11
16	0.13	0.30	0.11	90	0.13	1.45	0.11
18	0.13	0.035	0.11	100	0.13	1.50	0.11
20	0.12	0.40	0.12				

Table H3. Air Permeability Test in the Active Warming Test Plot: Monitoring Point A6, 23.5 ft. from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.046	0.045	0.042	20	0.110	0.168	0.250
1	0.050	0.051	0.050	23	0.120	0.185	0.270
2	0.050	0.058	0.060	26	0.135	0.220	0.300
3	0.050	0.060	0.075	30	0.150	0.240	0.349
4	0.054	0.062	0.080	35	0.168	0.255	0.39
5	0.058	0.065	0.085	40	0.183	0.257	0.43
6	0.058	0.065	0.090	45	0.192	0.30	0.48
7	0.060	0.070	0.100	50	0.20	0.325	0.52
8	0.060	0.070	0.098	55	0.215	0.34	0.56
9	0.060	0.070	0.098	60	0.24	0.37	0.61
10	0.060	0.072	0.105	70	0.245	0.40	0.675
12	0.067	0.085	0.130	80	0.249	0.45	0.750
14	0.080	0.120	0.190	90	0.250	0.490	0.800
16	0.092	0.140	0.240	100	0.250	0.500	0.849
18	0.100	0.160	0.245				

Table H4. Air Permeability Test in the Active Warming Test Plot: Monitoring Point P8, 65 ft from the Vent Well: Active Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.04	0.045	0.025	20	0.06	0.065	0.12
1	0.065	0.07	0.06	23	0.065	0.065	0.115
2	0.065	0.07	0.065	26	0.065	0.07	0.105
3	0.065	0.07	0.07	29	0.065	0.075	0.10
4	0.06	0.07	0.075	32	0.065	0.075	0.105
5	0.065	0.065	0.07	35	0.07	0.08	0.105
6	0.065	0.065	0.075	40	0.065	0.08	0.11
7	0.065	0.065	0.075	45	0.06	0.07	0.085
8	0.065	0.07	0.075	50	0.065	0.07	0.09
9	0.06	0.07	0.075	60	0.065	0.07	0.09
10	0.06	0.065	0.08	70	0.065	0.07	0.085
12	0.06	0.065	0.08	80	0.065	0.08	0.09
14	0.06	0.065	0.08	90	0.08	0.085	0.10
16	0.06	0.07	0.08	100	0.07	0.075	0.085
18	0.06	0.065	0.12				

Table H5. Air Permeability Test in the Active Warming Test Plot: Monitoring Point P1, 84.5 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.045	0.045	0.035	18	0.05	0.05	0.05
1	0.05	0.05	0.05	20	0.05	0.05	0.05
2	0.05	0.05	0.05	23	0.05	0.05	0.05
3	0.045	0.045	0.05	26	0.05	0.05	0.05
4	0.05	0.05	0.05	29	0.05	0.05	0.05
5	0.05	0.05	0.05	32	0.05	0.05	0.05
6	0.05	0.05	0.05	35	0.05	0.05	0.05
7	0.05	0.05	0.05	40	0.05	0.05	0.05
8	0.05	0.05	0.05	45	0.05	0.05	0.05
9	0.05	0.05	0.05	50	0.05	0.05	0.05
10	0.05	0.05	0.05	60	0.05	0.05	0.05
12	0.05	0.05	0.05	75	0.050	0.050	0.055
14	0.05	0.05	0.05	80	0.050	0.05	0.5
16	0.05	0.05	0.05	90	0.055	0.055	0.16

Table H6. Air Permeability Test in the Active Warming Test Plot: Monitoring Point C1B, C1C, C2A, 110 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.055	0.05	0.0425	18	0.0525	0.05	0.0475
1	0.0525	0.0525	0.05	20	0.0525	0.05	0.0475
2	0.055	0.0525	0.05	23	0.0525	0.05	0.0475
3	0.0525	0.05	0.05	26	0.0525	0.05	0.0475
4	0.0525	0.05	0.0475	29	0.0525	0.05	0.0475
5	0.0525	0.05	0.0475	32	0.055	0.055	0.0475
6	0.0525	0.05	0.0475	35	0.0525	0.05	0.0475
7	0.0525	0.05	0.05	40	0.0525	0.0525	0.05
8	0.0525	0.05	0.0475	45	0.0525	0.0475	0.0425
9	0.0525	0.05	0.0475	50	0.0525	0.05	0.0475
10	0.0525	0.05	0.0475	60	0.0525	0.05	0.0475
12	0.0525	0.05	0.0475	70	0.0525	0.05	0.0475
14	0.0525	0.05	0.0475	80	0.055	0.0525	0.05
16	0.0525	0.05	0.0475	90	0.06	0.0525	0.045

Table H7. Air Permeability Test in the Passive Warming Test Plot: Monitoring Point P5, 12.1 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0	0	0	9	0.50	1.50	2.75
1	0.45	1.40	2.5	10	0.50	1.50	2.75
2	0.50	1.45	2.75	12	0.50	1.50	2.75
3	0.50	1.45	2.75	14	0.50	1.50	2.75
4	0.50	1.475	2.75	16	0.50	1.50	2.75
5	0.50	1.475	2.75	18	0.50	1.50	2.75
6	0.50	1.475	2.75	20	0.475	1.50	2.75
7	0.50	1.475	2.75	30	0.475	1.475	2.75
8	0.50	1.475	2.75				

Table H8. Air Permeability Test in the Passive Warming Test Plot: Monitoring Point P1, 13.6 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.50	0.05	0.05	9	0.60	1.80	2.5
1	0.50	1.75	1.0	10	0.50	1.80	3.0
2	0.50	0.75	1.0	12	0.50	1.80	3.0
3	0.50	0.75	2.0	14	0.50	1.80	3.0
4	0.60	0.75	2.5	16	0.50	1.80	3.0
5	0.60	1.80	3.5	18	0.50	1.80	3.0
6	0.60	1.85	3.5	20	0.50	1.80	3.0
7	0.65	1.80	3.0	30	0.50	1.80	3.0
8	0.50	1.75	1.5				

Table H9. Air Permeability Test in the Passive Warming Test Plot: Monitoring Point P8, 19.75 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.055	0.06	0.06	9	0.16	0.18	2.0
1	0.055	0.065	0.6	10	0.166	0.21	2.0
2	0.07	0.09	1.0	12	0.15	0.2	2.05
3	0.12	0.15	1.78	14	0.145	0.2	2.05
4	0.16	0.20	2.0	16	0.14	0.19	2.05
5	0.18	0.2	2.0	18	0.145	0.185	2.05
6	0.16	0.2	2.0	20	0.135	0.16	2.05
7	0.16	0.2	2.0	25	0.12	0.15	2.05
8	0.16	0.2	2.0	30	0.115	0.16	2.1

Table H10. Air Permeability Test in the Passive Warming Test Plot: Monitoring Point A4, 69.5 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.05	0.085	0.05	8	0.055	0.08	0.05
1	0.05	0.085	0.05	12	0.055	0.085	0.05
2	0.055	0.085	0.05	16	0.06	0.095	0.065
3	0.055	0.085	0.05	20	0.055	0.07	0.05
4	0.055	0.09	0.05	26	0.055	0.085	0.05
5	0.055	0.085	0.05	30	0.055	0.085	0.05
6	0.055	0.085	0.5				

Table H11. Air Permeability Test in the Passive Warming Test Plot: Monitoring Point A7, 74.25 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.06	0.06	1.07	14	0.05	0.065	0.875
1	0.06	0.06	1.0	16	0.05	0.060	0.875
3	0.05	0.07	1.0	18	0.05	0.060	0.850
3	0.05	0.07	1.0	20	0.05	0.025	0.800
4	0.055	0.06	1.0	22	0.05	0.05	0.755
5	0.055	0.05	0.98	24	0.05	0.06	0.750
6	0.05	0.045	0.95	26	0.05	0.05	0.750
10	0.05	0.065	0.95	28	0.05	0.065	0.750
12	0.05	0.070	0.90	30	0.05	0.045	0.700

Table H12. Air Permeability Test in the Passive Warming Test Plot: Monitoring Point C1B, C1C, C2A, 107.5 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.051	0.047	0.04	9	0.046	0.048	0.046
1	0.038	0.045	0.04	10	0.05	0.05	0.05
2	0.041	0.05	0.045	12	0.05	0.05	0.04
3	0.04	0.048	0.03	14	0.05	0.05	0.05
4	0.05	0.047	0.014	16	0.05	0.05	0.05
5	0.045	0.041	0.045	18	0.051	0.053	0.05
6	0.045	0.046	0.047	20	0.045	0.045	0.48
7	0.05	0.047	0.047	30	0.05	0.05	0.05
8	0.046	0.043	0.045				

Table H13. Air Permeability Test in the Control Injection Warming Test Plot: Monitoring Point C7, 4 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.245	0.235	0.22	10	0.45	9.5	0.05
1	0.25	7.0	0.35	12	0.45	9.5	0.35
2	0.40	7.5	0.15	14	0.45	9.5	0.05
3	0.30	8.0	0.24	16	0.45	9.5	0.10
4	0.45	8.5	0.25	18	0.40	9.5	0.15
5	0.45	8.5	0.30	20	0.40	9.5	0.05
6	0.45	8.75	0.15	23	0.35	9.5	0.30
7	0.45	9.0	0.05	26	0.40	9.5	0.10
8	0.45	9.0	0.05	30	0.45	9.5	0.04
9	0.45	9.0	0.05				

Table H14. Air Permeability Test in the Control Injection Warming Test Plot: Monitoring Point C1B C1C and C2A, 7.75 and 10.25 ft. from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.05	0.05	0.05	10	0.10	0.50	3.5
1	0.07	0.35	1.85	12	0.10	0.55	3.5
2	0.08	0.40	2.5	14	0.10	0.55	4.0
3	0.095	0.48	2.6	16	0.10	0.55	3.9
4	0.095	0.50	3.0	18	0.10	0.55	4.0
5	0.095	0.50	3.4	20	0.10	0.55	4.0
6	0.09	0.50	3.5	23	0.11	0.60	4.0
7	0.095	0.51	3.5	26	0.105	0.60	4.0
8	0.10	0.51	3.5	30	0.10	0.60	4.0
9	0.10	0.50	3.5				

Table H15. Air Permeability Test in the Control Injection Warming Test Plot: Monitoring Point C5, 14.75 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.06	0.0525	0.06	10	0.085	0.12	3.50
1	0.065	0.09	1.60	12	0.075	0.12	3.50
2	0.0725	0.10	2.00	14	0.08	0.13	3.50
3	0.08	0.12	2.50	16	0.0875	0.13	3.50
4	0.085	0.12	2.75	18	0.09	0.135	3.50
5	0.085	0.125	2.75	20	0.0925	0.135	3.75
6	0.08	0.12	3.00	23	0.090	0.14	3.75
7	0.09	0.125	3.00	26	0.0875	0.14	3.75
8	0.09	0.12	3.25	30	0.0875	0.1325	3.75
9	0.08	0.12	3.25				

Table H16. Air Permeability Test in the Control Injection Warming Test Plot: Passive Vent Well, 28.25 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)	Time (min)	Depth (ft)
	3 to 6		3 to 6
0	0.05	10	0.0925
1	0.055	12	0.10
2	0.06	14	0.105
3	0.075	16	0.105
4	0.08	18	0.105
5	0.08	20	0.1025
6	0.085	23	0.1025
7	0.085	26	0.1025
8	0.09	29	0.1025
9	0.09		

Table H17. Air Permeability Test in the Control Injection Warming Test Plot: Monitoring Point 3, 60 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0	0	0	10	0.01	0.03	0.30
1	0	0	0.04	12	0.015	0.03	0.30
2	0	0	0.02	14	0.02	0.035	0.35
3	0	0.005	0.12	16	0.01	0.035	0.35
4	0	0.01	0.15	18	0.01	0.035	0.35
5	0	0.01	0.185	20	0.01	0.03	0.35
6	0.005	0.01	0.20	23	0.01	0.03	0.35
7	0.007	0.02	0.23	26	0.01	0.035	0.35
8	0.009	0.02	0.24	29	0.01	0.03	0.355
9	0.01	0.03	0.255				

Table H18. Air Permeability Test in the Control Injection Warming Test Plot: Monitoring Point P1, 96.75 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0	0	0	9	0	0	0
1	0	0	0	10	0	0	0
2	0	0	0	12	0	0	0
3	0	0	0	14	0	0	0
4	0	0	0	16	0	0	0
5	0	0	0	18	0	0	0
6	0	0	0	20	0	0	0
7	0	0	0	30	0	0	0
8	0	0	0				

Table H19. Air Permeability Test in the Surface Warming Test Plot: Monitoring Point H3, 4 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.01	0.03	0.017	18	0.02	11.0	20.0
1	0.02	4.0	10.0	20	0.02	11.0	20.0
2	0.02	5.0	12.0	23	0.02	11.0	20.0
3	0.02	6.0	13.0	26	0.02	11.0	21.0
4	0.02	7.0	14.0	29	0.02	11.0	21.0
5	0.02	8.0	15.0	32	0.02	11.0	21.5
6	0.02	8.0	16.0	35	0.02	11.0	21.5
7	0.02	6.0	16.0	40	0.02	11.0	22.0
8	0.02	9.0	16.0	45	0.02	11.0	22.0
9	0.02	9.0	17.0	50	0.02	11.0	22.0
10	0.02	10.0	17.0	55	0.02	11.0	22.5
12	0.02	10.0	18.0	65	0.02	11.0	22.5
14	0.02	10.0	19.0	75	0.02	11.0	23.0
16	0.02	11.0	20.0	90	0.02	11.0	23.0

Table H20. Air Permeability Test in the Surface Warming Test Plot: Monitoring Point H1, Remeasure ft. from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.045	0.045	0.045	18	0.055	8.5	20.0
1	0.05	5.0	11.5	20	0.05	8.75	20.0
2	0.05	4.0	13.0	23	0.05	9.0	21.0
3	0.05	4.5	14.0	26	0.05	9.0	21.5
4	0.05	5.0	14.5	29	0.055	9.5	22.0
5	0.055	5.5	15.0	32	0.05	9.5	22.0
6	0.05	6.0	15.5	35	0.05	9.5	22.0
7	0.055	6.5	16.0	40	0.05	9.75	23.0
8	0.055	7.0	16.5	45	0.05	10.0	23.0
9	0.055	7.5	17.25	55	0.05	10.5	24.0
10	0.055	7.5	18.0	65	0.045	10.5	24.0
12	0.055	7.5	18.5	75	0.045	10.75	24.0
14	0.055	8.0	19.0	90	0.04	10.75	24.2
16	0.055	8.0	19.5				

Table H21. Air Permeability Test in the Surface Warming Test Plot: Passive Vent Well, 31 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)	Time (min)	Depth (ft)
	3 to 6		3 to 6
0	0.05	18:30	0.0978
1	0.06	20	0.101
2	0.065	23	0.1075
3	0.07	26	0.1075
4	0.071	29	0.115
5	0.0725	32	0.12
6	0.0725	35	0.1225
7	0.0725	40	0.1225
8	0.08	45	0.135
9	0.0825	55	0.135
10	0.0825	65	0.138
12	0.088	75	0.145
14	0.09	90	0.150
16	0.0925		

Table H22. Air Permeability Test in the Surface Warming Test Plot: Monitoring Point PI7, 43.5 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0	0	0	20	0	0.08	0.54
1	0	0	0.075	23	0	0.09	0.58
2	0	0	0.12	26	0	0.09	0.63
3	0	0.01	0.16	29	0	0.13	0.68
4	0	0.01	0.2	32	0	0.13	0.69
5	0	0.01	0.22	35	0	0.16	0.73
6	0	0.01	0.25	40	0	0.16	0.84
7	0	0.01	0.26	45	0	0.17	0.85
8	0	0.02	0.3	55	0	0.2	0.97
9	0	0.02	0.32	60	0	0.23	7.04
10	0	0.05	0.34	65	0	0.22	7.05
12	0	0.04	0.36	70	0	0.23	7.11
14	0	0.05	0.41	75	0	0.24	1.16
16	0	0.055	0.44	80	0	0.26	1.21
18	0	0.08	0.5	90	0.02	0.29	7.31

Table H23. Air Permeability Test in the Surface Warming Test Plot: Monitoring Point C5, 44.5 ft from the Vent Well: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.0	0.0	0.04	16	0.01	0.01	0.45
1	0.005	0.005	0.11	18	0.0075	0.0075	0.50
2	0.005	0.005	0.16	20	0.01	0.0125	0.525
3	0.005	0.005	0.20	23	0.005	0.0075	0.55
4	0.005	0.005	0.23	26	0.01	0.015	0.65
5	0.005	0.005	0.25	30	0.01	0.01	0.675
6	0.0025	0.0025	0.275	37	0.01	0.02	0.75
7	0.005	0.005	0.30	40	0.015	0.015	0.775
8	0.0025	0.0025	0.325	45	0.015	0.015	0.825
9	0.005	0.005	0.335	55	0.0175	0.0175	0.90
10	0.0075	0.0075	0.35	65	0.0125	0.02	0.975
12	0.01	0.01	0.375	75	0.0275	0.03	1.025
14	0.0075	0.0075	0.40	90	0.025	0.03	1.15

Table H24. Air Permeability Test in the Surface Warming Test Plot: Monitoring Point C1B, C1C and C2A, 50.75 and 53.5 ft from the Vent Well, Respectively: Air Injection

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.01	0.01	0.045	16	0.02	0.06	0.40
1	0.02	0.04	0.08	18	0.0175	0.06	0.42
2	0.02	0.04	0.14	20	0.0175	0.065	0.45
3	0.02	0.04	0.155	23	0.02	0.07	0.49
4	0.015	0.05	0.18	26	0.02	0.075	0.58
5	0.015	0.04	0.21	30	0.025	0.10	0.58
6	0.01	0.03	0.22	35	0.02	0.10	0.60
7	0.02	0.035	0.23	40	0.025	0.085	0.62
8	0.015	0.045	0.30	45	0.03	0.10	0.68
9	0.02	0.045	0.33	55	0.03	0.105	0.75
10	0.02	0.05	0.33	70	0.025	0.105	0.80
12	0.015	0.05	0.33	80	0.025	0.105	0.85
14	0.025	0.05	0.35	90	--	--	0.90

Table H25. Air Permeability Test in the Control Test Plot: Monitoring Point C1B, C1C and C2A, 6 and 8.9 ft. from the Vent Well, Respectively: Air Extraction

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.05	0.05	0.07	12	0.1125	0.75	6.0
1	0.10	0.70	7.0	14	0.10	0.65	5.25
2	0.11	0.85	7.5	16	0.0975	0.575	4.25
3	0.11	0.85	7.25	18	0.0925	0.5	4.0
4	0.11	0.825	6.75	20	0.0875	0.475	3.75
5	0.11	0.775	6.75	23	0.08	0.45	3.75
6	0.11	0.75	7.0	26	0.075	0.45	3.75
7	0.115	0.35	7.25	30	0.0775	0.45	3.75
8	0.12	0.90	7.75	35	0.0825	0.45	3.50
9	0.1175	0.875	7.25	40	0.0775	0.45	3.5
10	0.1175	0.825	6.75	90	0.0775	0.45	3.5

Table H26. Air Permeability Test in the Control Test Plot: Passive Vent Well, 14.7 ft from the Vent Well: Air Extraction

Time (min)	Depth (ft)	Time (min)	Depth (ft)
	3 to 6		3 to 6
0	0.05	12	0.1575
1	0.14	14	0.15
2	0.155	16	0.1325
3	0.1575	18	0.13
4	0.1575	20	0.1325
5	0.165	24	0.1175
6	0.1575	26	0.11
7	0.1575	30	0.11
8	0.1625	35	0.11
9	0.1725	40	0.11
10	0.1675	90	0.11

Table H27. Air Permeability Test in the Control Test Plot: Monitoring Point C5, 14.75 ft from the Vent Well: Air Extraction

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.055	0.055	0.065	12	0.105	0.185	6.4
1	0.7	0.195	7.0	14	0.1	0.16	5.5
2	0.11	0.2	7.3	16	0.09	0.135	4.5
3	0.095	0.2	7.4	18	0.09	0.145	4.3
4	0.095	0.19	6.8	20	0.082	0.12	4.0
5	0.105	0.185	6.6	23	0.085	0.135	4.0
6	0.105	0.175	6.3	26	0.085	0.132	3.9
7	0.115	0.19	7.0	30	0.082	0.125	3.8
8	0.115	0.2	7.5	35	0.085	0.125	3.8
9	0.115	0.21	7.5	40	0.09	0.13	3.8
10	0.115	0.195	7.0	90	0.09	0.13	3.8

Table H28. Air Permeability Test in the Control Test Plot: Monitoring Point C7, 20 ft from the Vent Well: Air Extraction

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0	0	0	12	0.15	2.0	0.05
1	0.10	1.1	0	14	0.15	1.75	0.03
2	0.25	1.5	0.5	16	0.15	1.70	0.03
3	0.30	1.75	0.7	18	0.12	1.50	0.01
4	0.30	1.85	0.10	20	0.12	1.40	0.03
5	0.30	1.90	0.05	23	0.07	1.30	0
6	0.10	1.85	0.03	26	0.10	1.25	0.05
7	0.10	1.90	0.01	30	0.10	1.25	0.05
8	0.10	2.0	0.01	35	0.05	1.20	0.07
9	0.15	2.25	0.03	40	0.05	1.20	0.06
10	0.10	2.0	0.03	90	0.05	1.20	0.06

Table H29. Air Permeability Test in the Control Test Plot: Monitoring Point P1, 96.75 ft from the Vent Well: Air Extraction

Time (min)	Depth (ft)			Time (min)	Depth (ft)		
	2	4	6		2	4	6
0	0.01	0.02	0.02	12	0.01	0.03	0.55
1	0.01	0.195	0.19	14	0.01	0.03	0.54
2	0.01	0.025	0.40	16	0.01	0.3	0.46
3	0.01	0.01	0.50	18	0.01	0.025	0.40
4	0.01	0.04	0.60	20	0.01	0.025	0.38
5	0.01	0.015	0.58	23	0.01	0.028	0.35
6	0.01	0.035	0.55	26	0.01	0.03	0.35
7	0.01	0.03	0.55	30	0.01	0.028	0.35
8	0.01	0.03	0.55	35	0.01	0.03	0.35
9	0.01	0.03	0.55	40	0.01	0.03	0.35
10	0.01	0.04	0.58	90	0.01	0.03	0.35

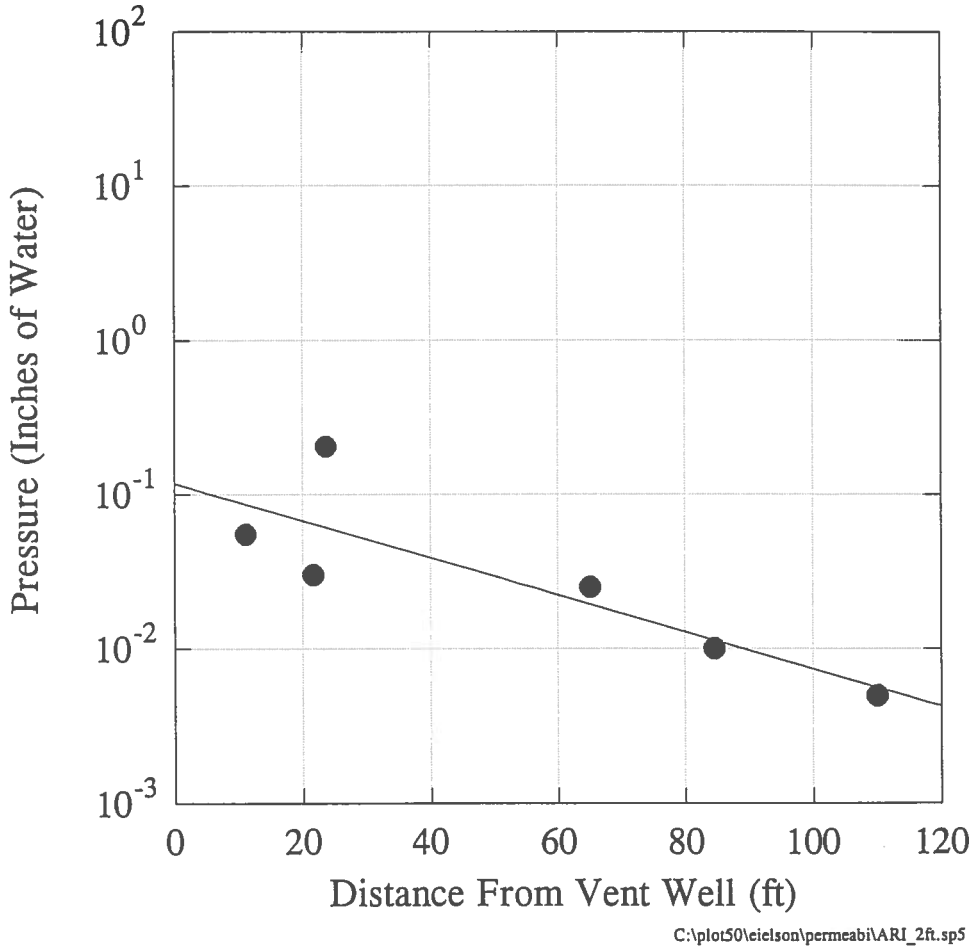


Figure H1. Pressure Versus Distance From Vent Well in the Active Warming Test Plot at a Depth of 2 ft

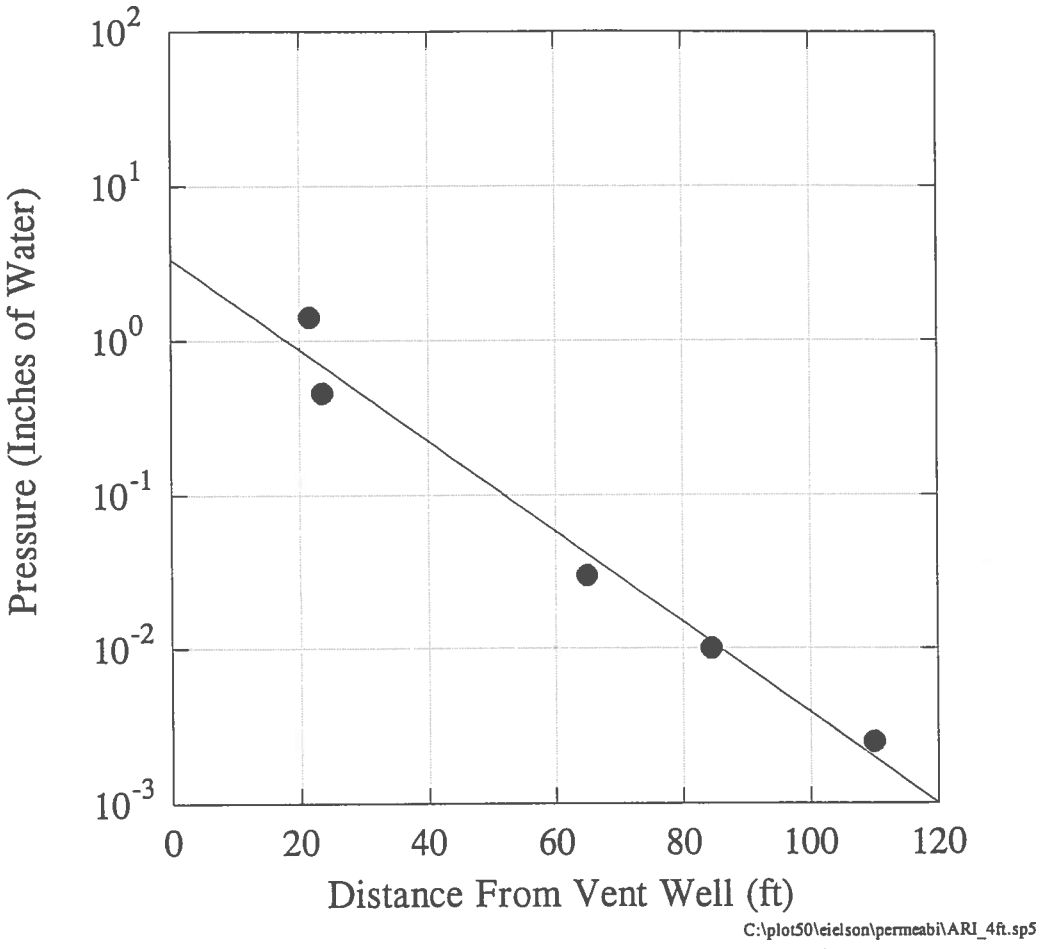


Figure H2. Pressure Versus Distance From Vent Well in the Active Warming Test Plot at a Depth of 4 ft

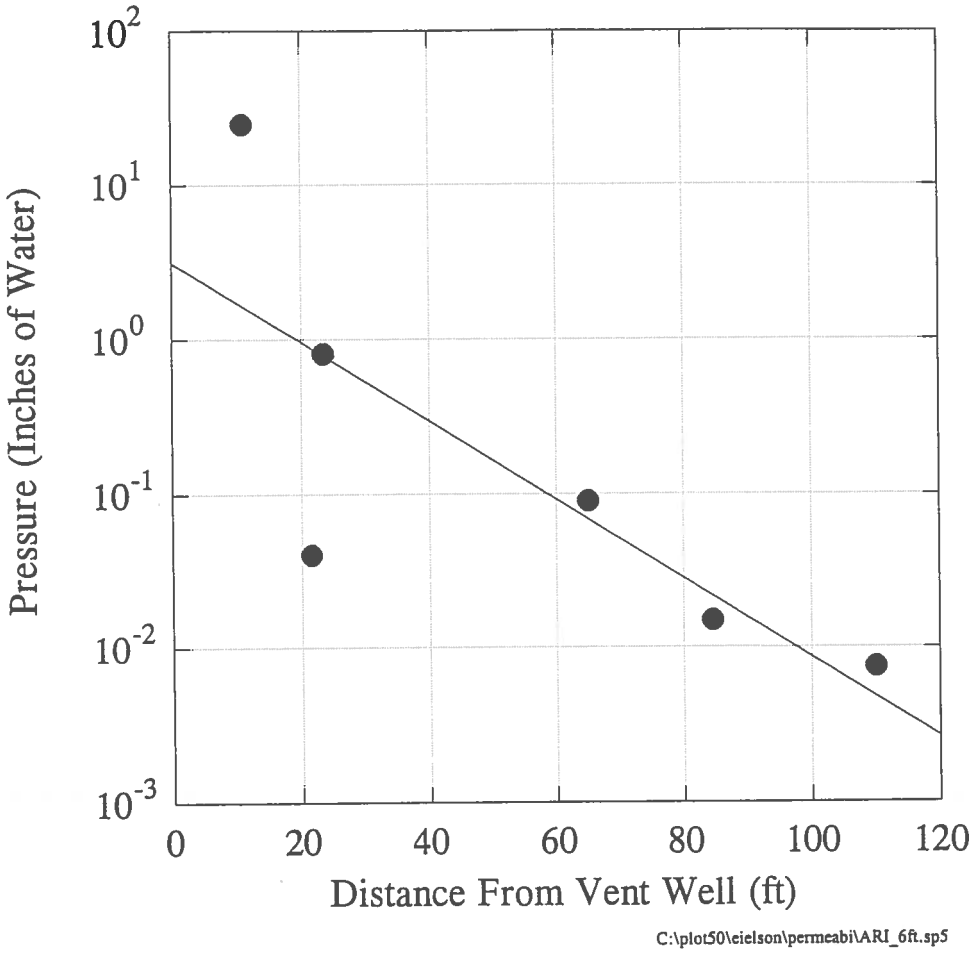


Figure H3. Pressure Versus Distance From Vent Well in the Active Warming Test Plot at a Depth of 6 ft

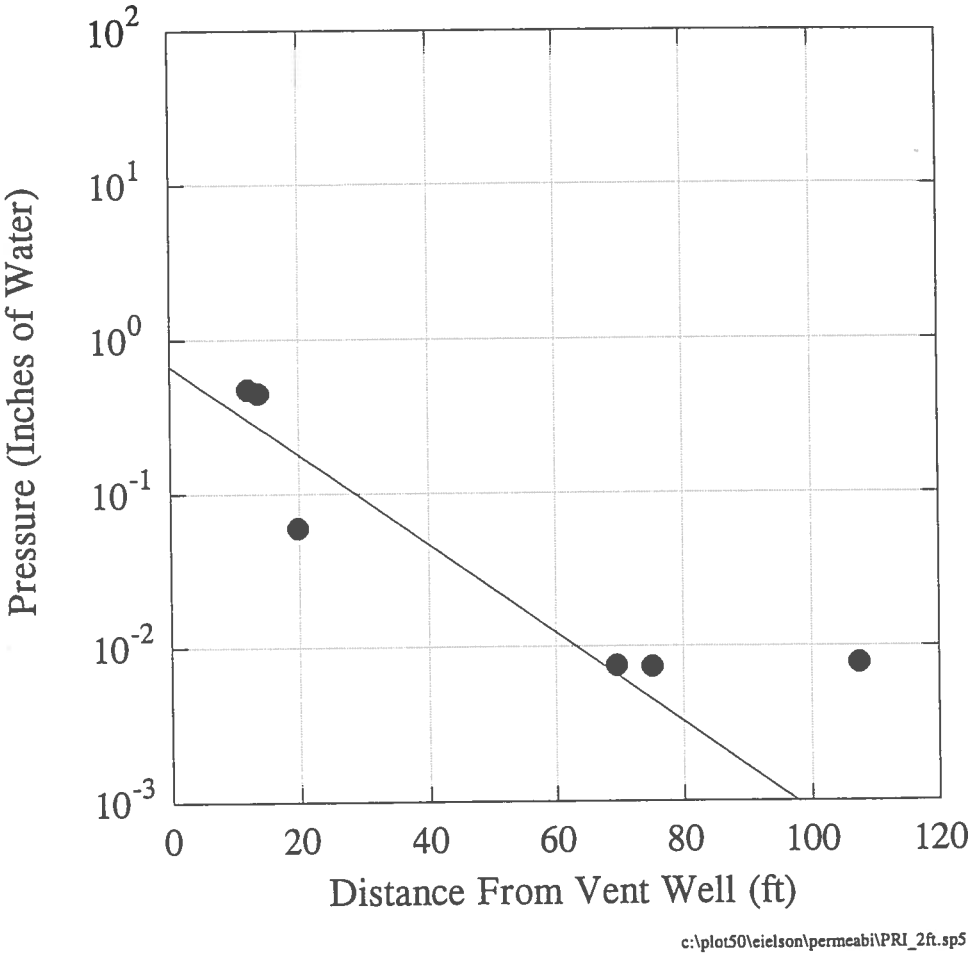


Figure H4. Pressure Versus Distance From Vent Well in the Passive Warming Test Plot at a Depth of 2 ft

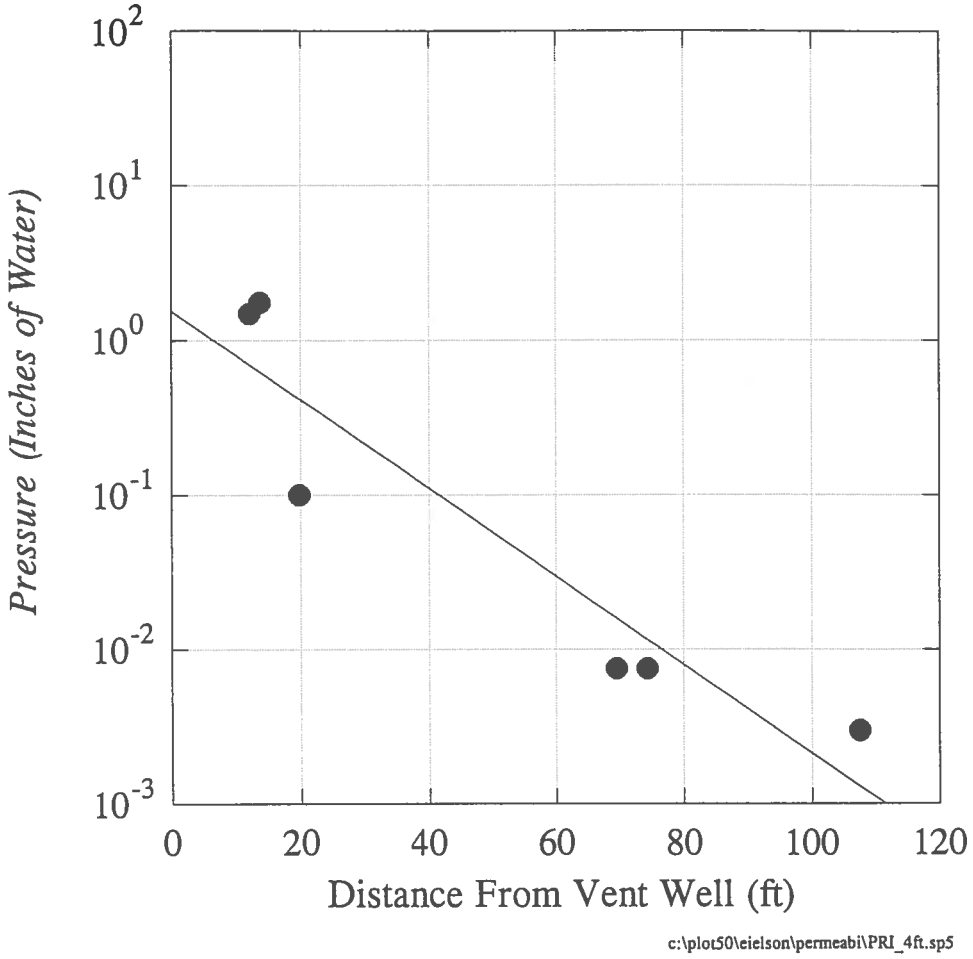


Figure H5. Pressure Versus Distance From Vent Well in the Passive Warming Test Plot at a Depth of 4 ft

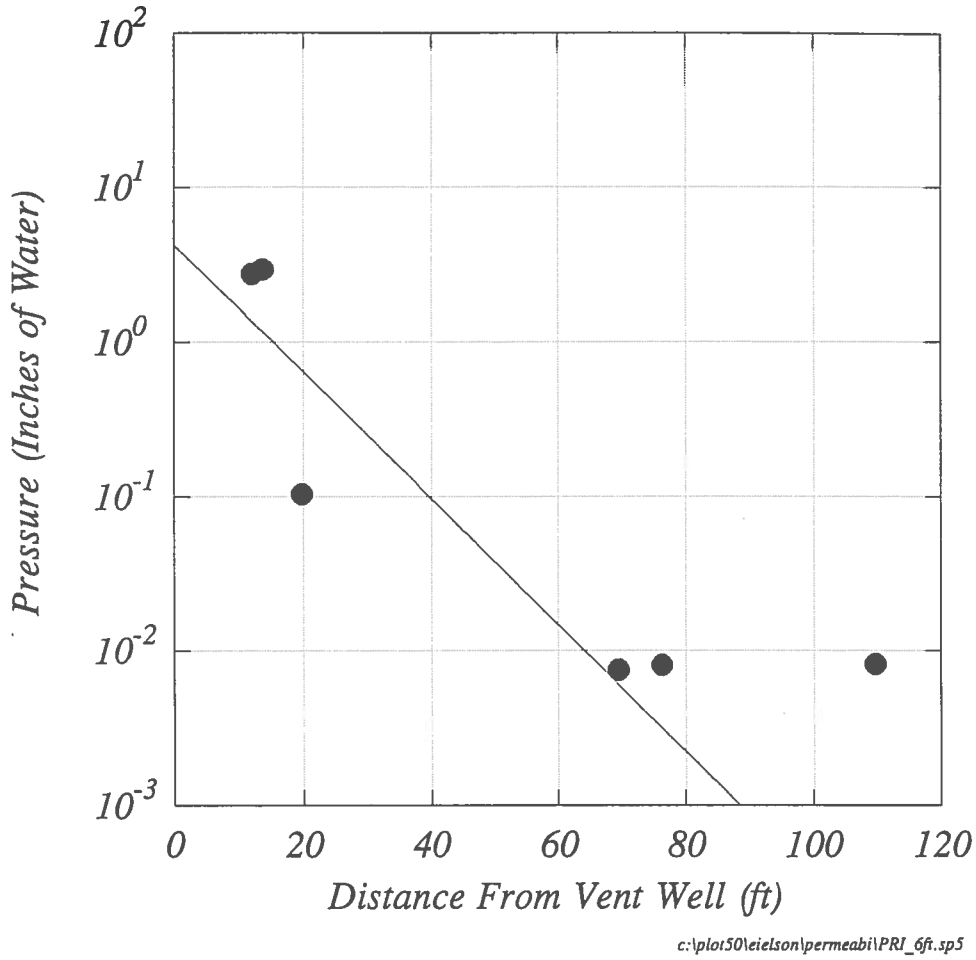


Figure H6. Pressure Versus Distance From Vent Well in the Passive Warming Test Plot at a Depth of 6 ft

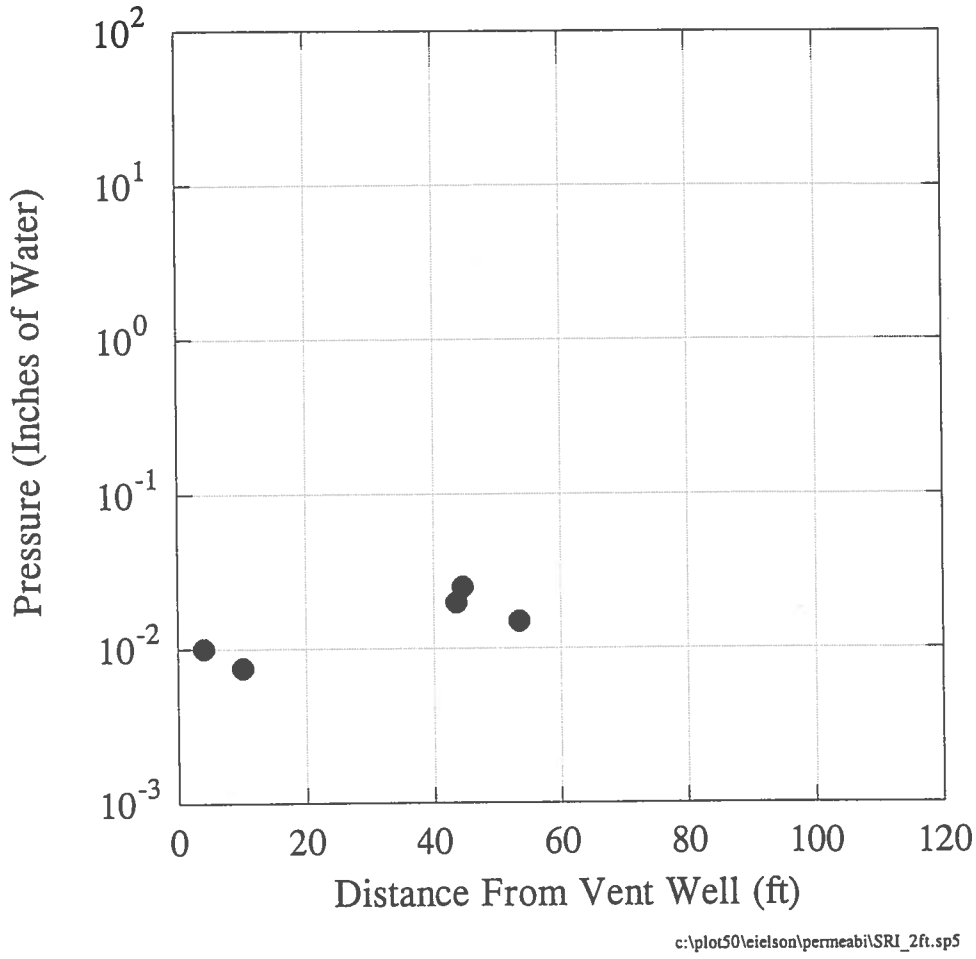


Figure H7. Pressure Versus Distance From Vent Well in the Surface Warming Test Plot at a Depth of 2 ft

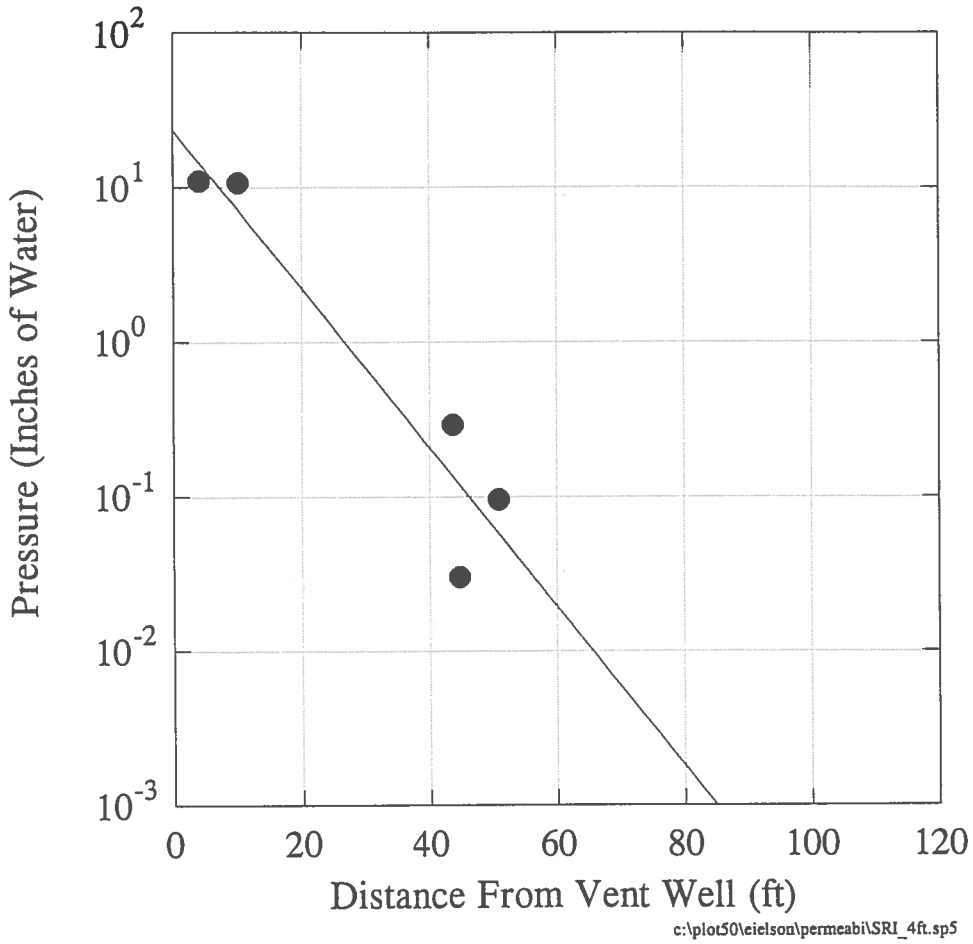


Figure H8. Pressure Versus Distance From Vent Well in the Surface Warming Test Plot at a Depth of 4 ft

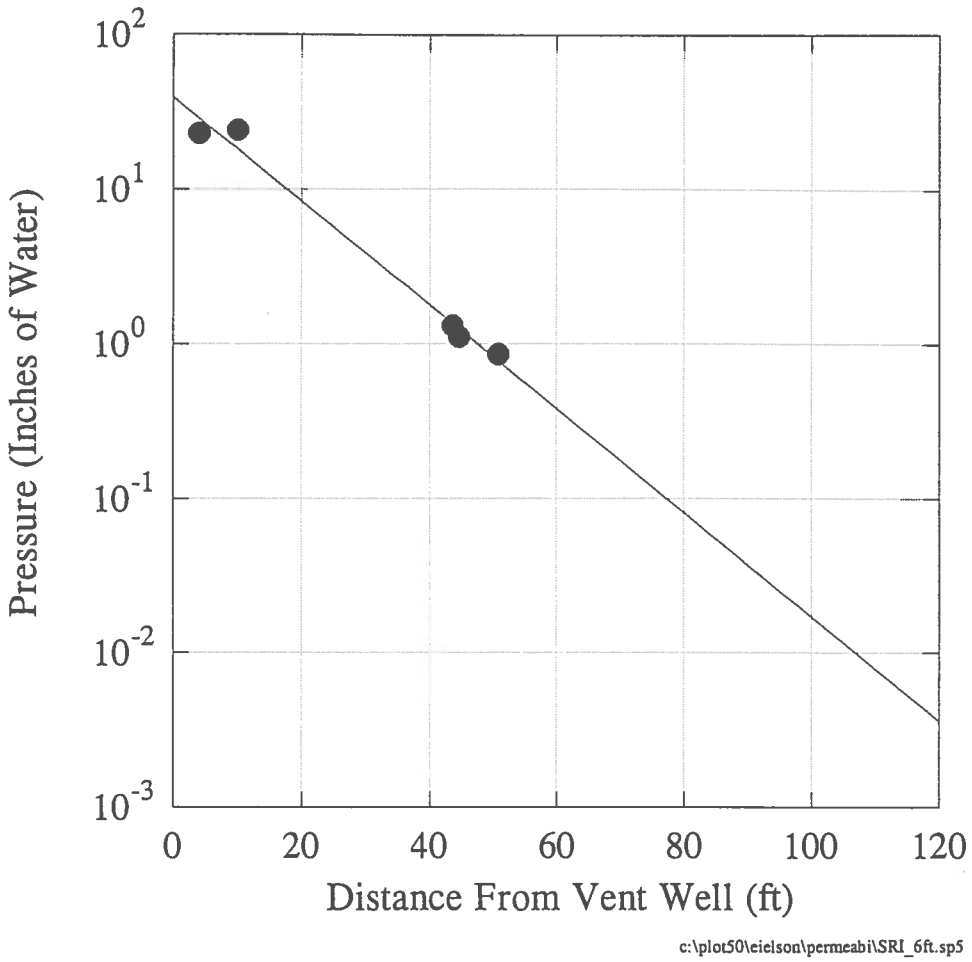


Figure H9. Pressure Versus Distance From Vent Well in the Surface Warming Test Plot at a Depth of 6 ft

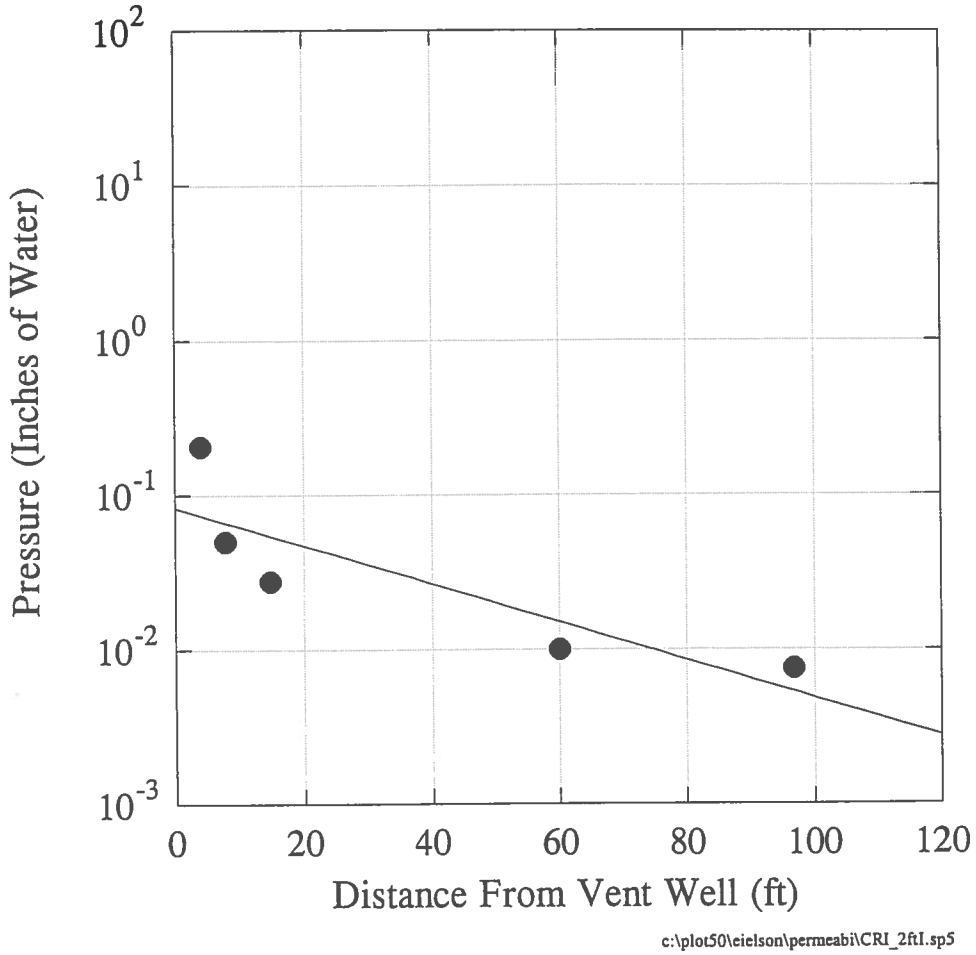


Figure H10. **Pressure Versus Distance From Vent Well in the Control Test Plot at a Depth of 2 ft: Air Injection Mode**

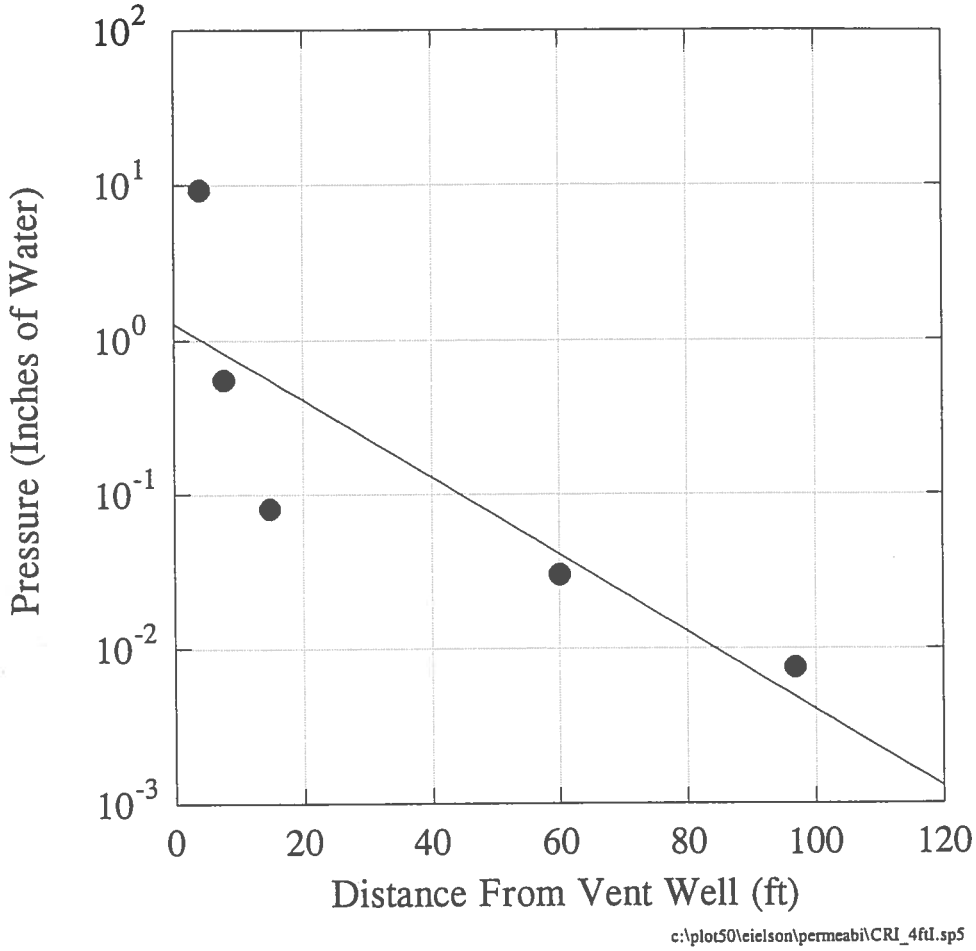


Figure H11. **Pressure Versus Distance From Vent Well in the Control Test Plot at a Depth of 4 ft: Air Injection Mode**

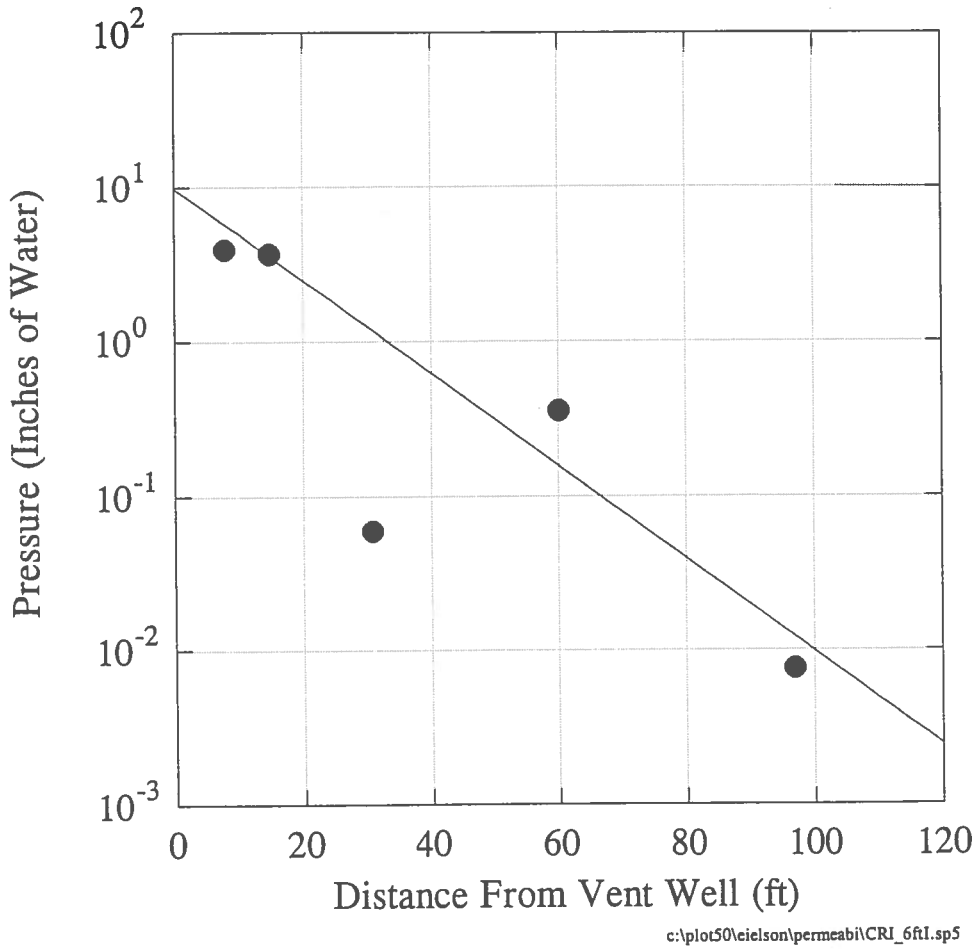


Figure H12. **Pressure Versus Distance From Vent Well in the Control Test Plot at a Depth of 6 ft: Air Injection Mode**

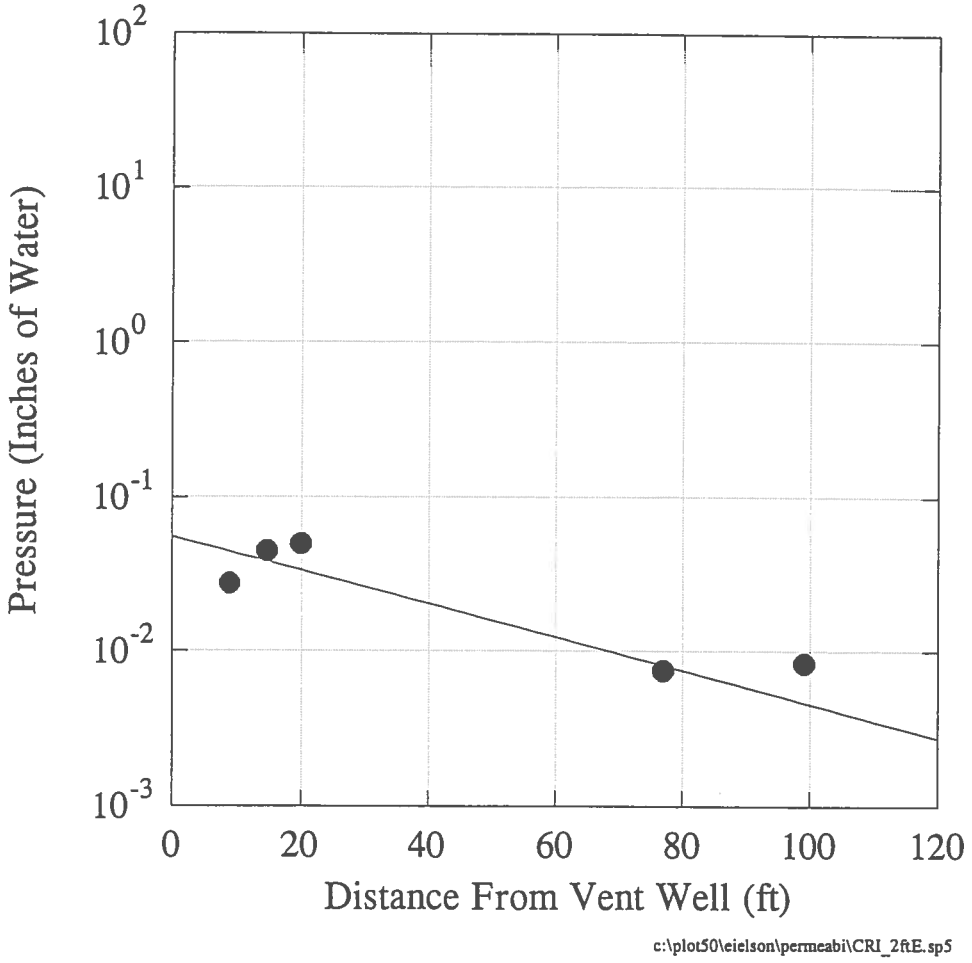


Figure H13. **Pressure Versus Distance From Vent Well in the Control Test Plot at a Depth of 2 ft: Air Extraction Mode**

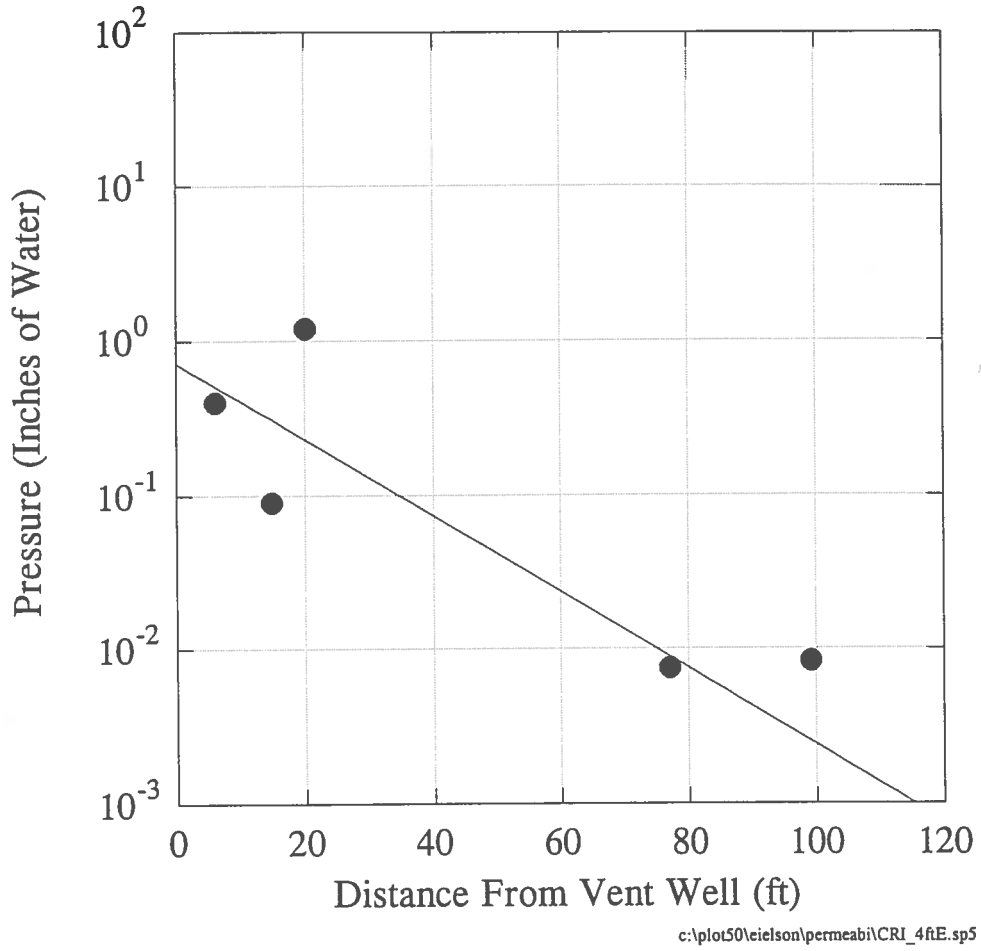


Figure H14. **Pressure Versus Distance From Vent Well in the Control Test Plot at a Depth of 4 ft: Air Extraction Mode**

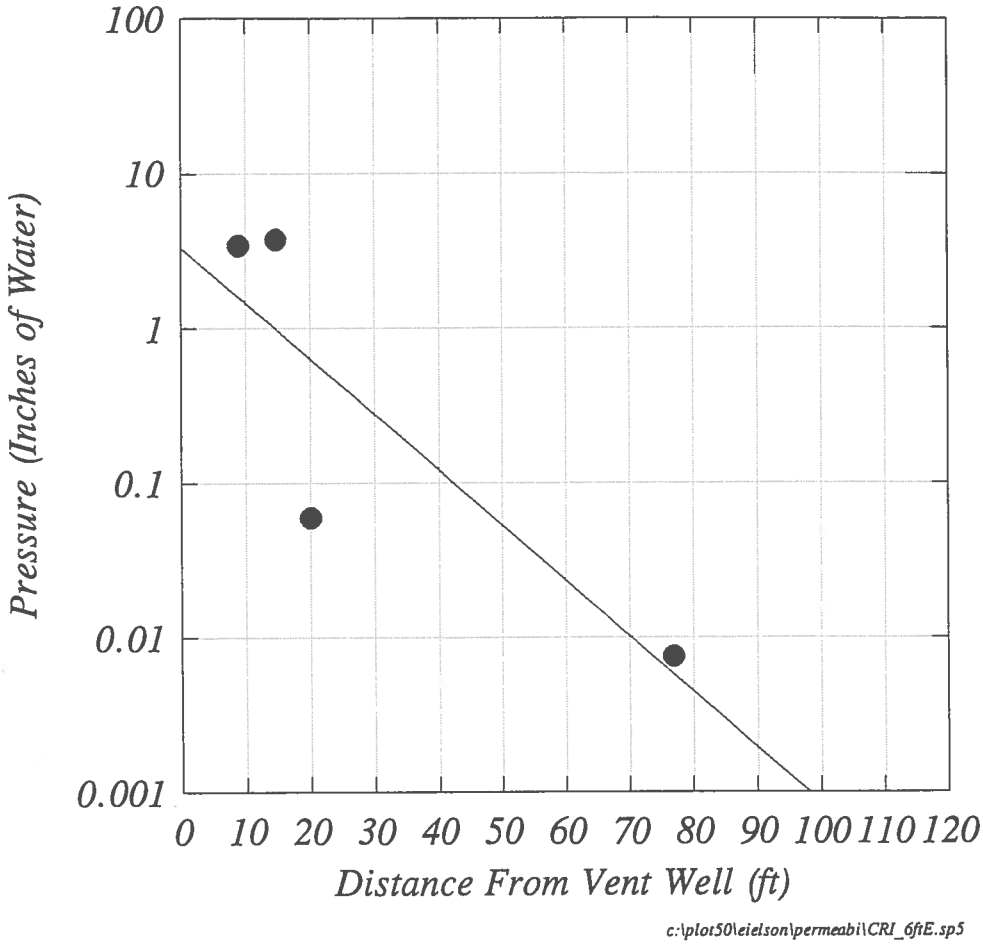


Figure H15. **Pressure Versus Distance From Vent Well in the Control Test Plot at a Depth of 6 ft: Air Extraction Mode**

APPENDIX I

EXTRACTION TEST DATA

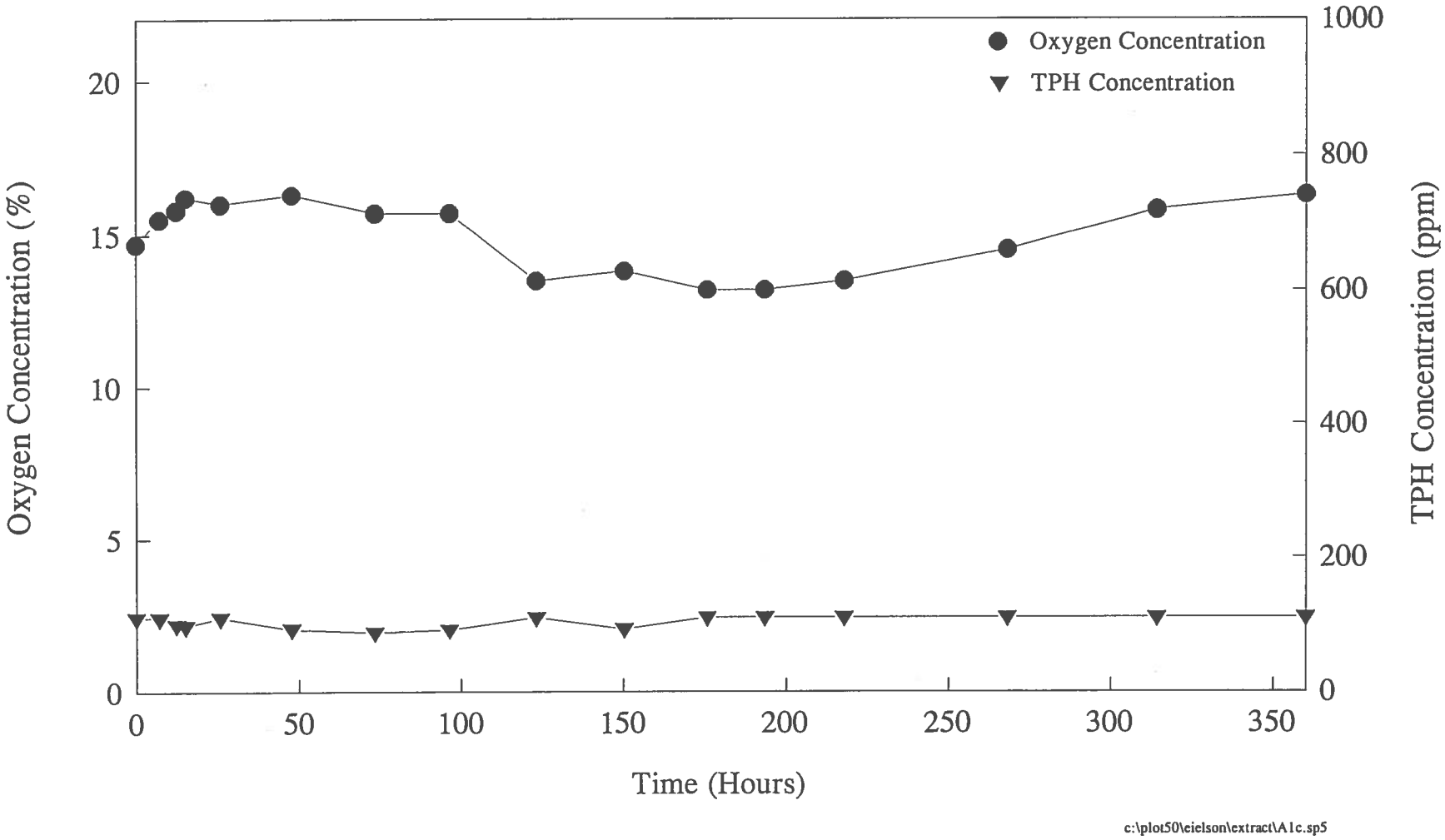


Figure I1. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point A1c

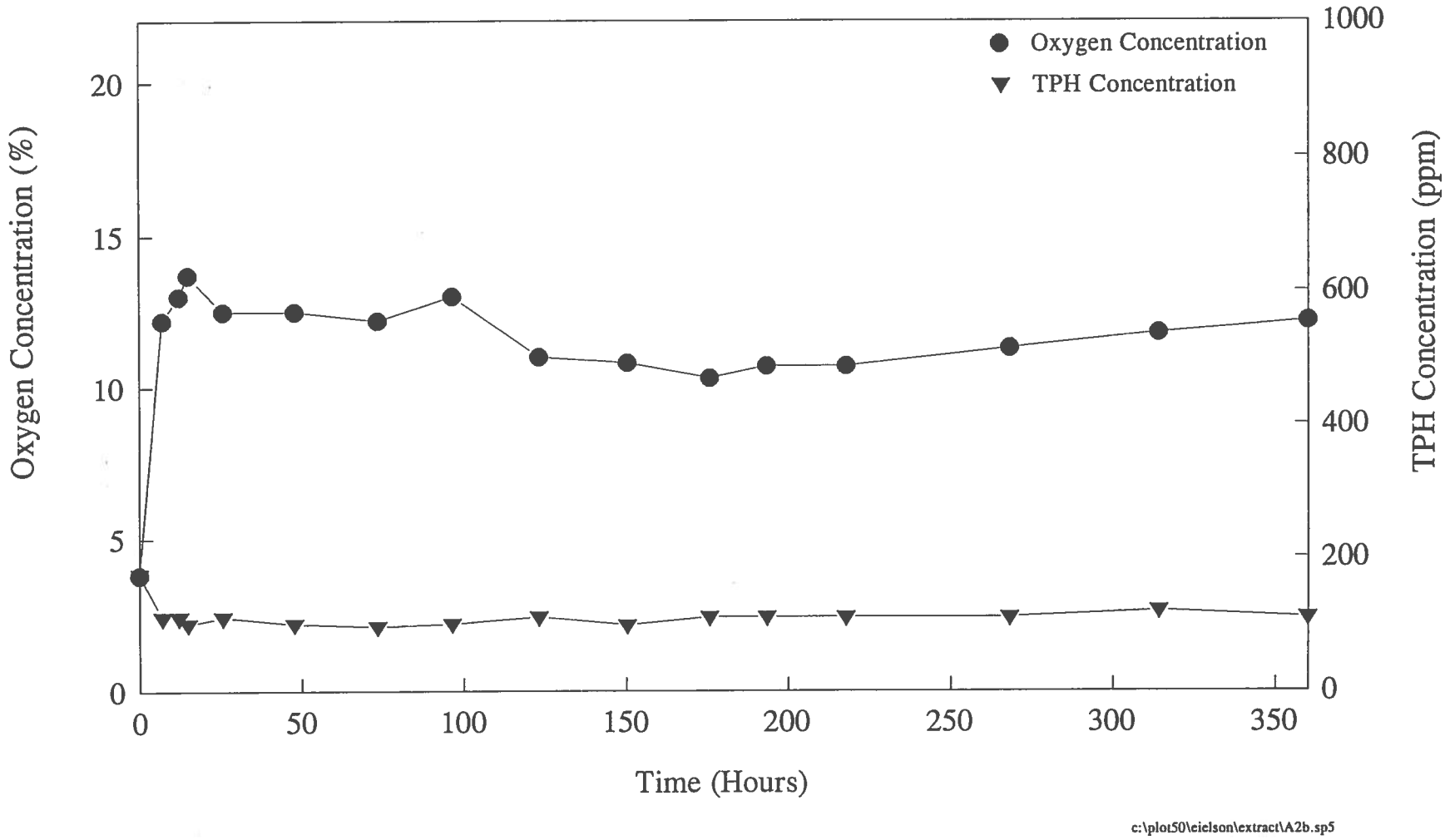


Figure I2. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point A2b

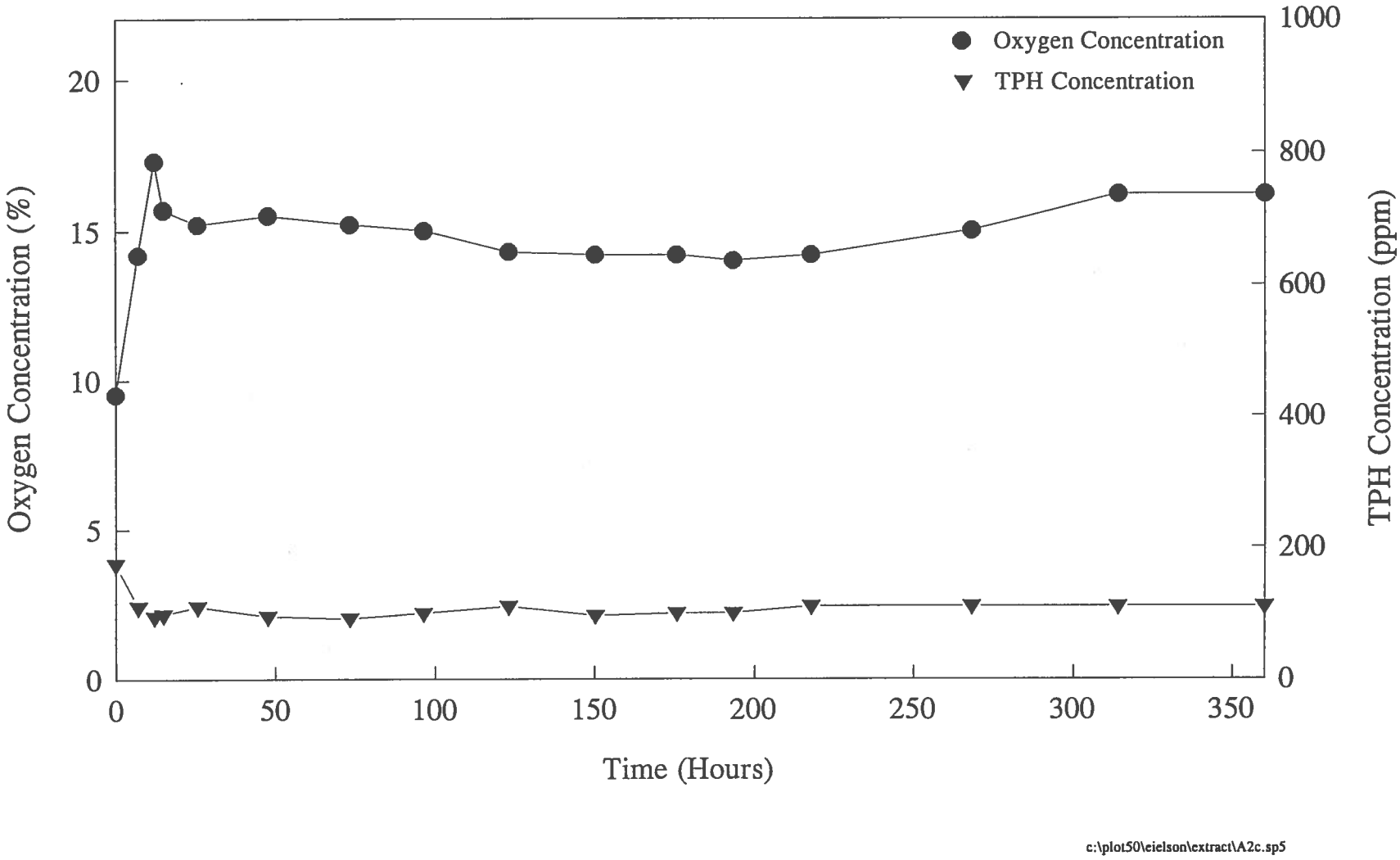


Figure I3. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point A2c

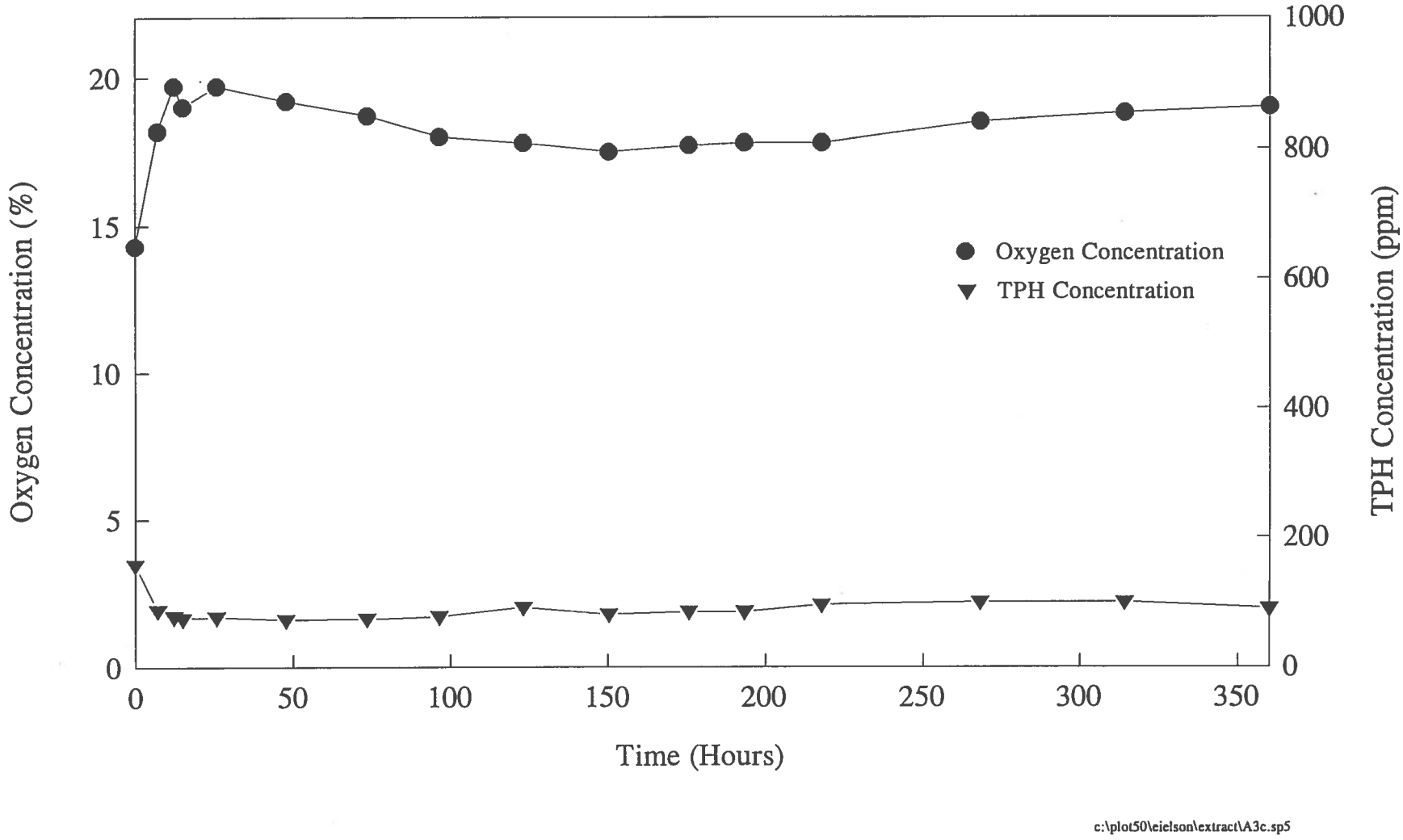


Figure I4. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point A3c

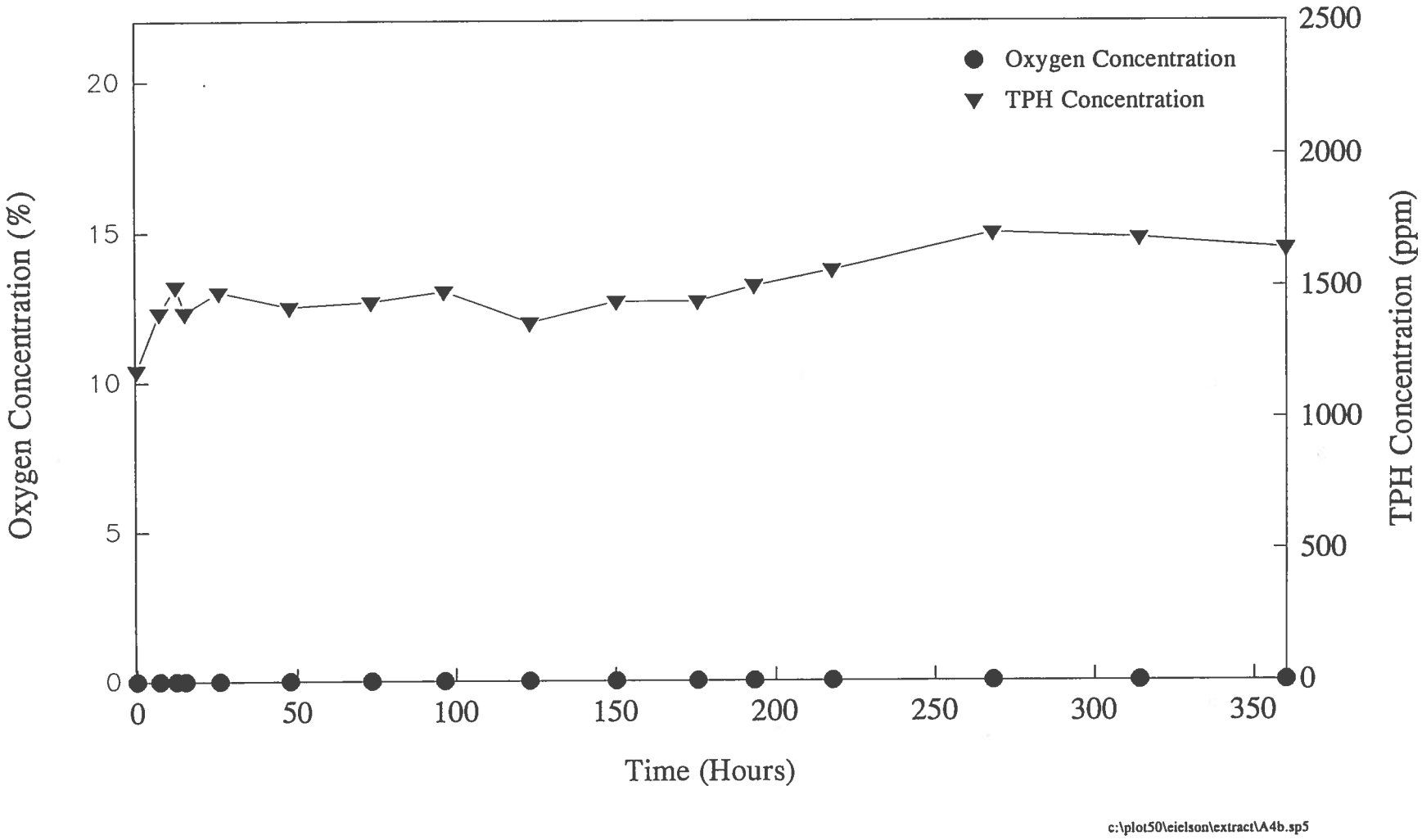


Figure I5. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point A4b

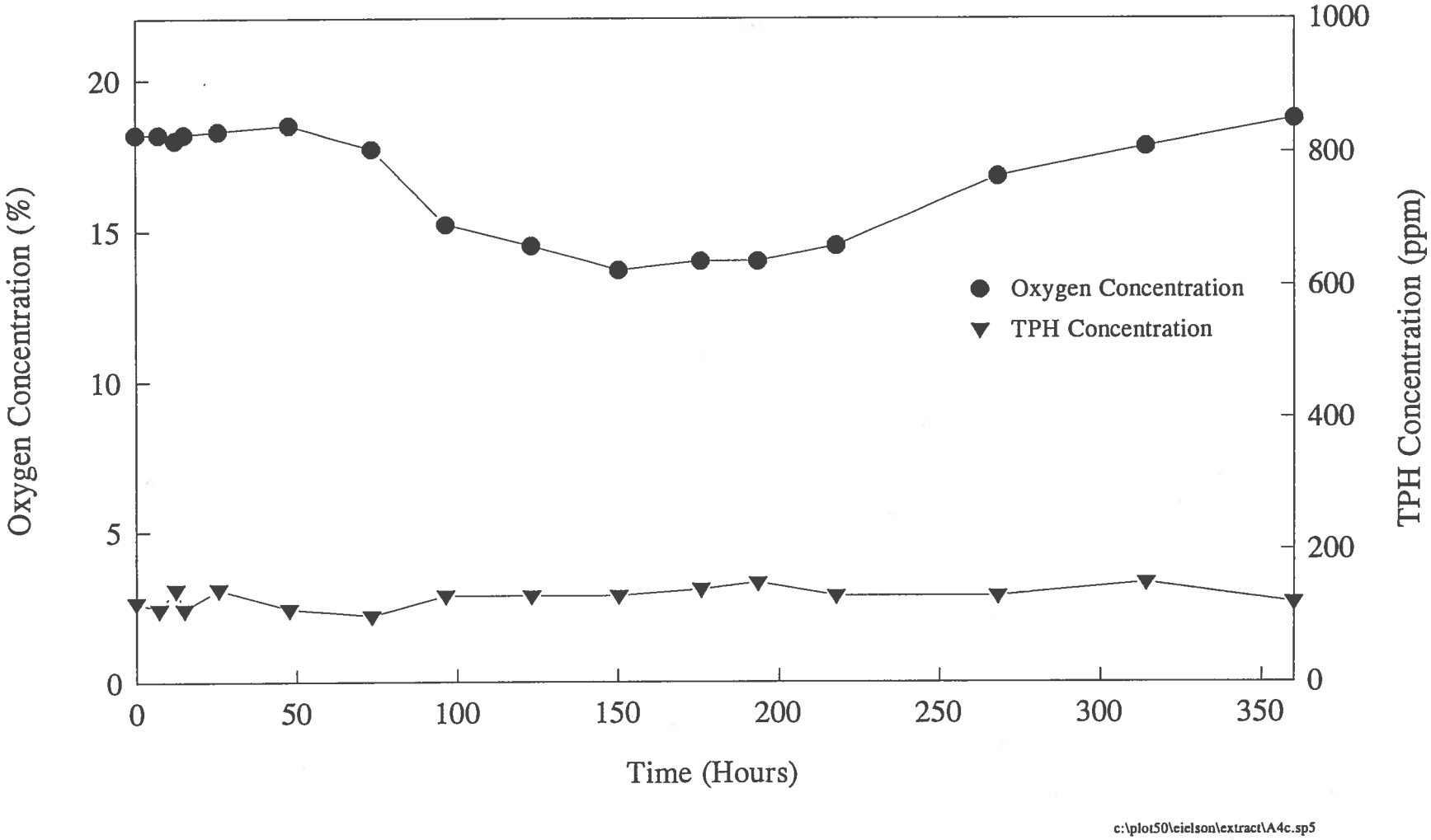


Figure I6. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point A4c

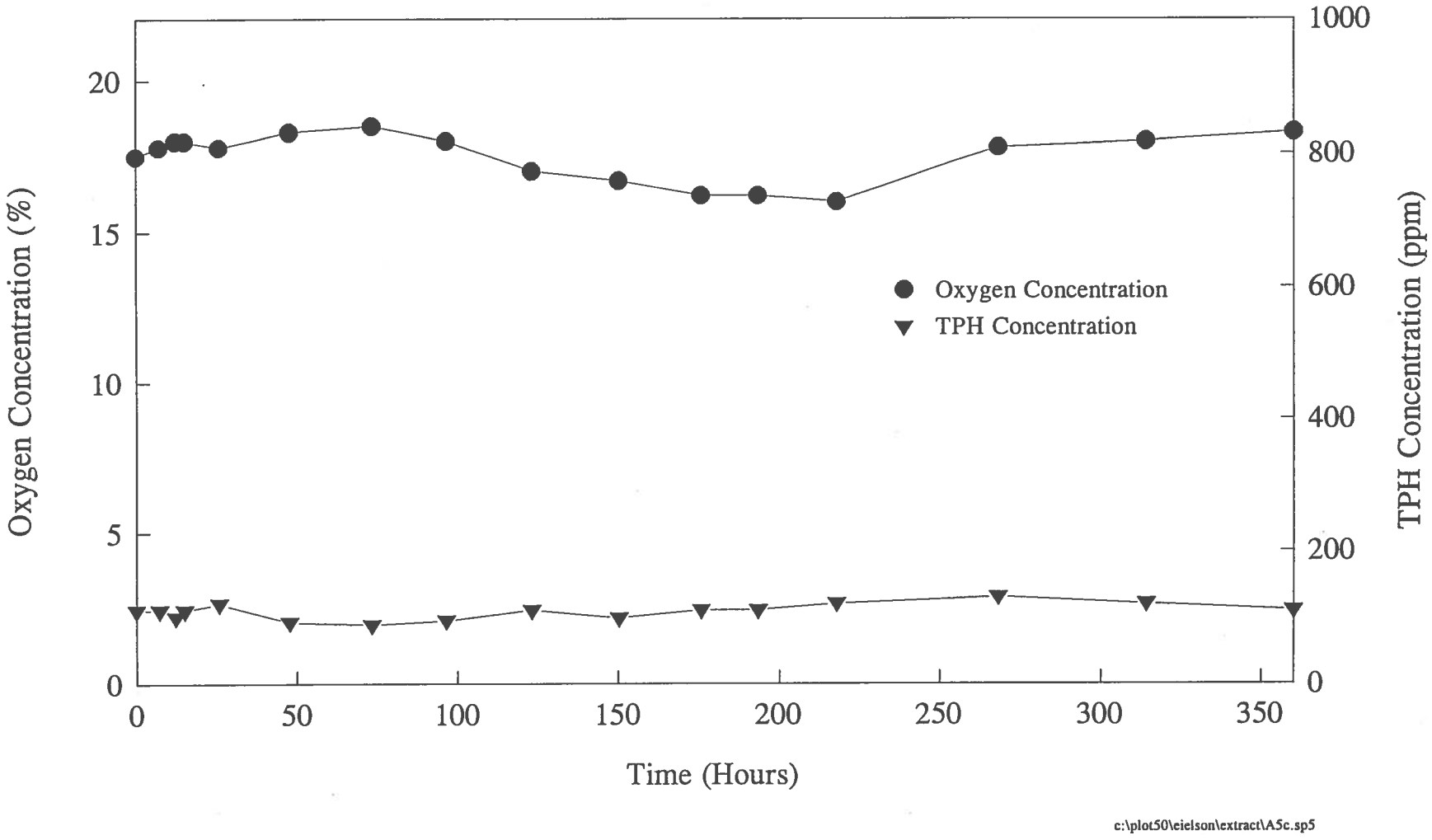


Figure I7. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point A5c

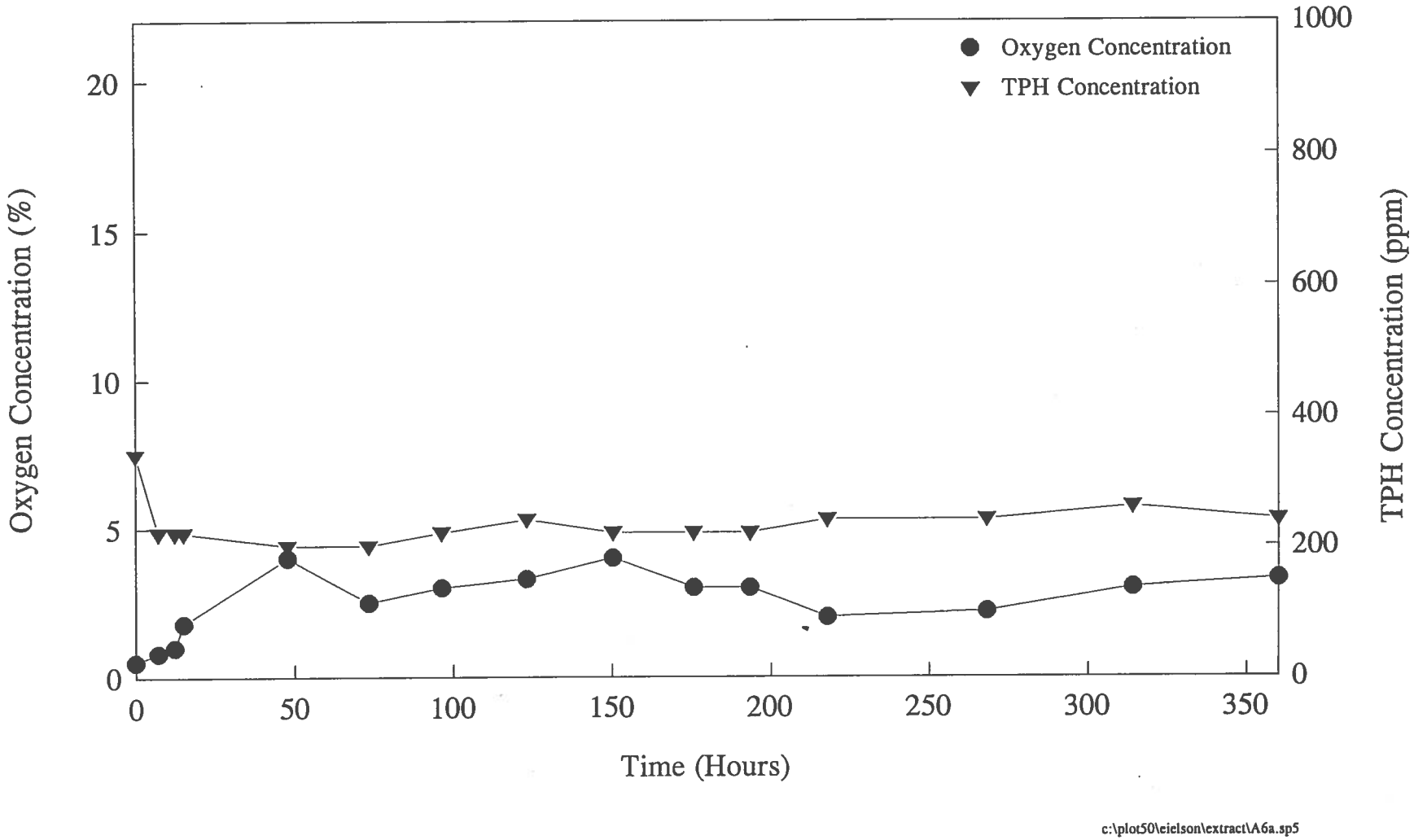


Figure I8. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point A6a

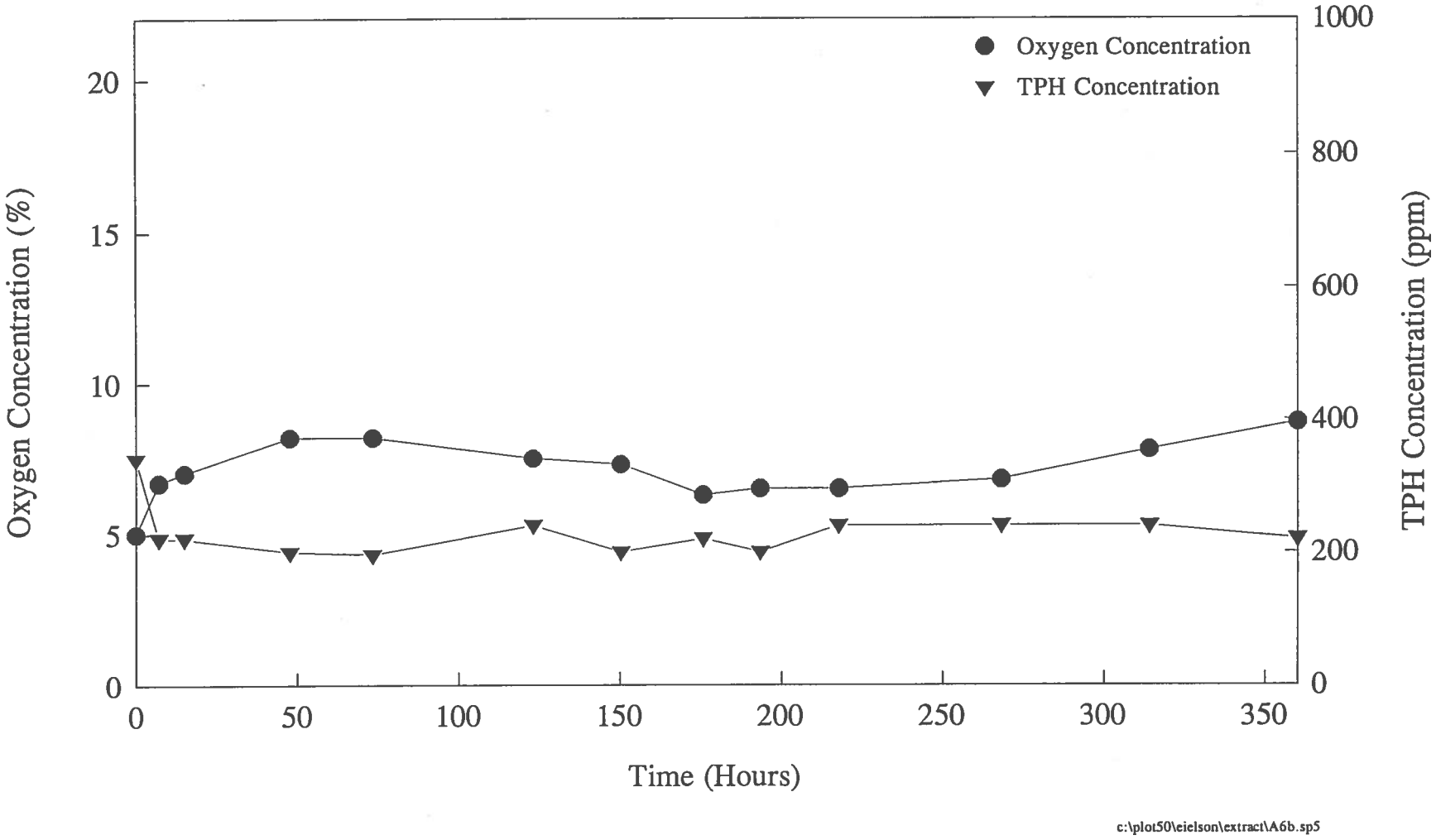


Figure I9. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point A6b

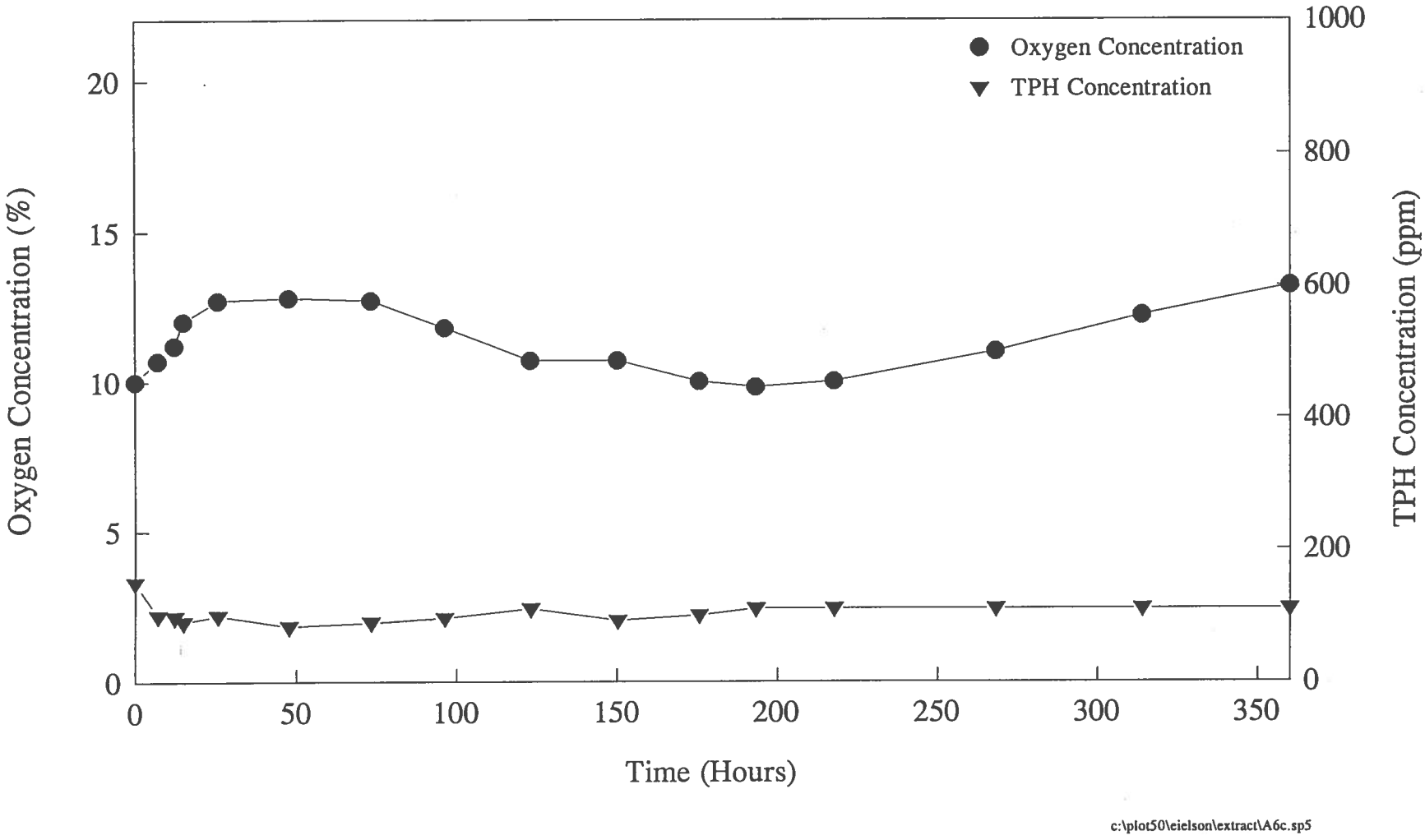


Figure I10. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point A6c

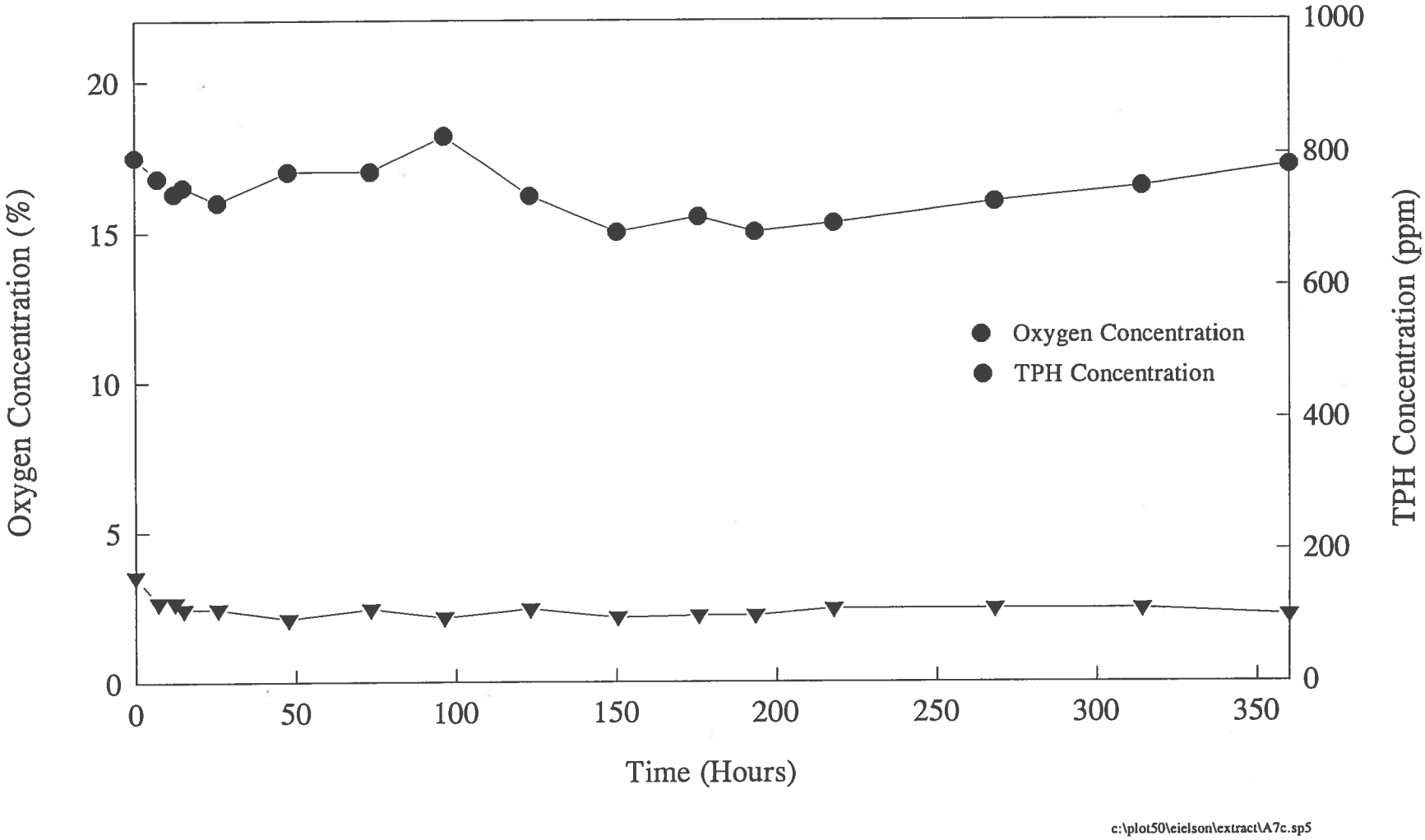


Figure I11. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point A7c

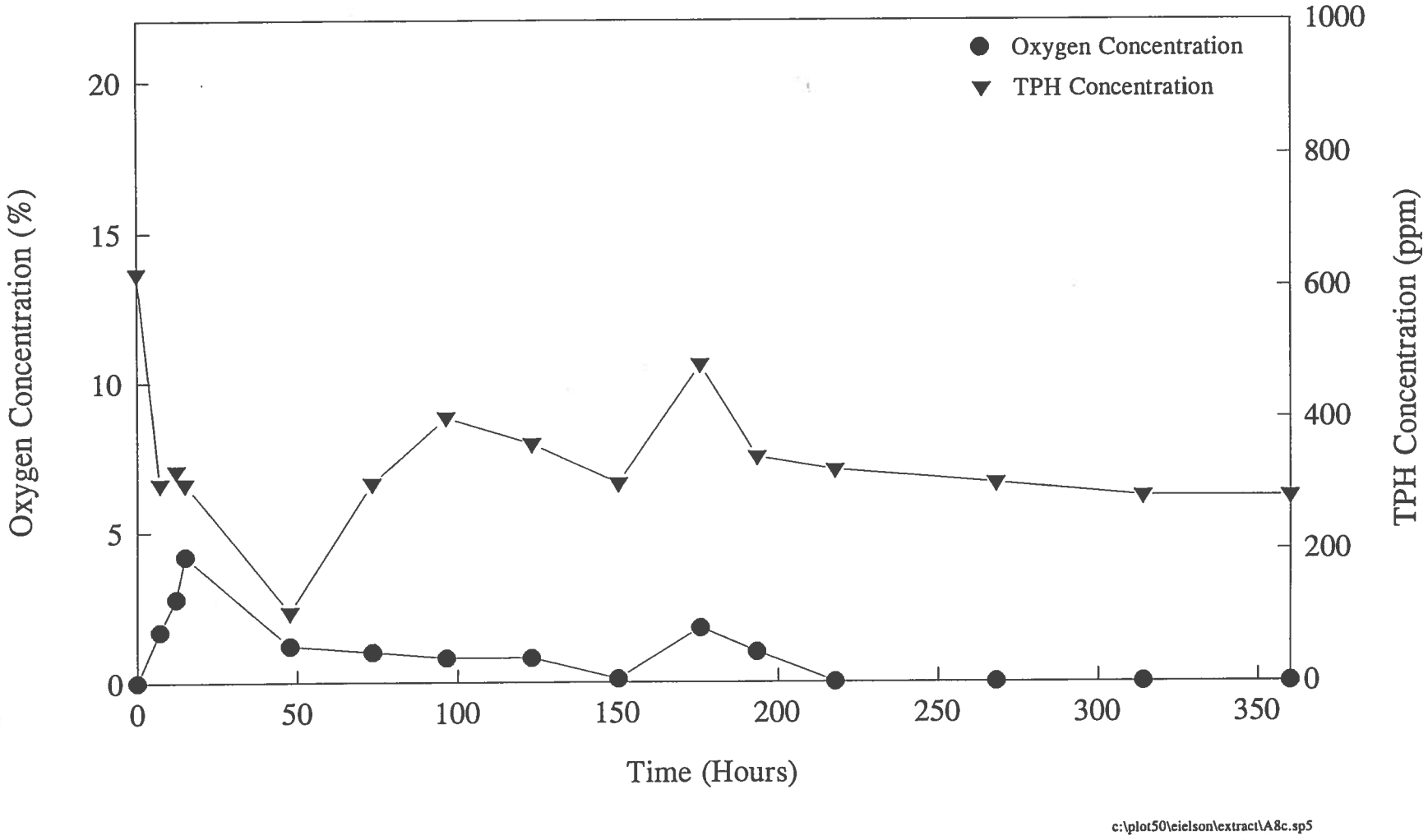


Figure I12. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point A8c

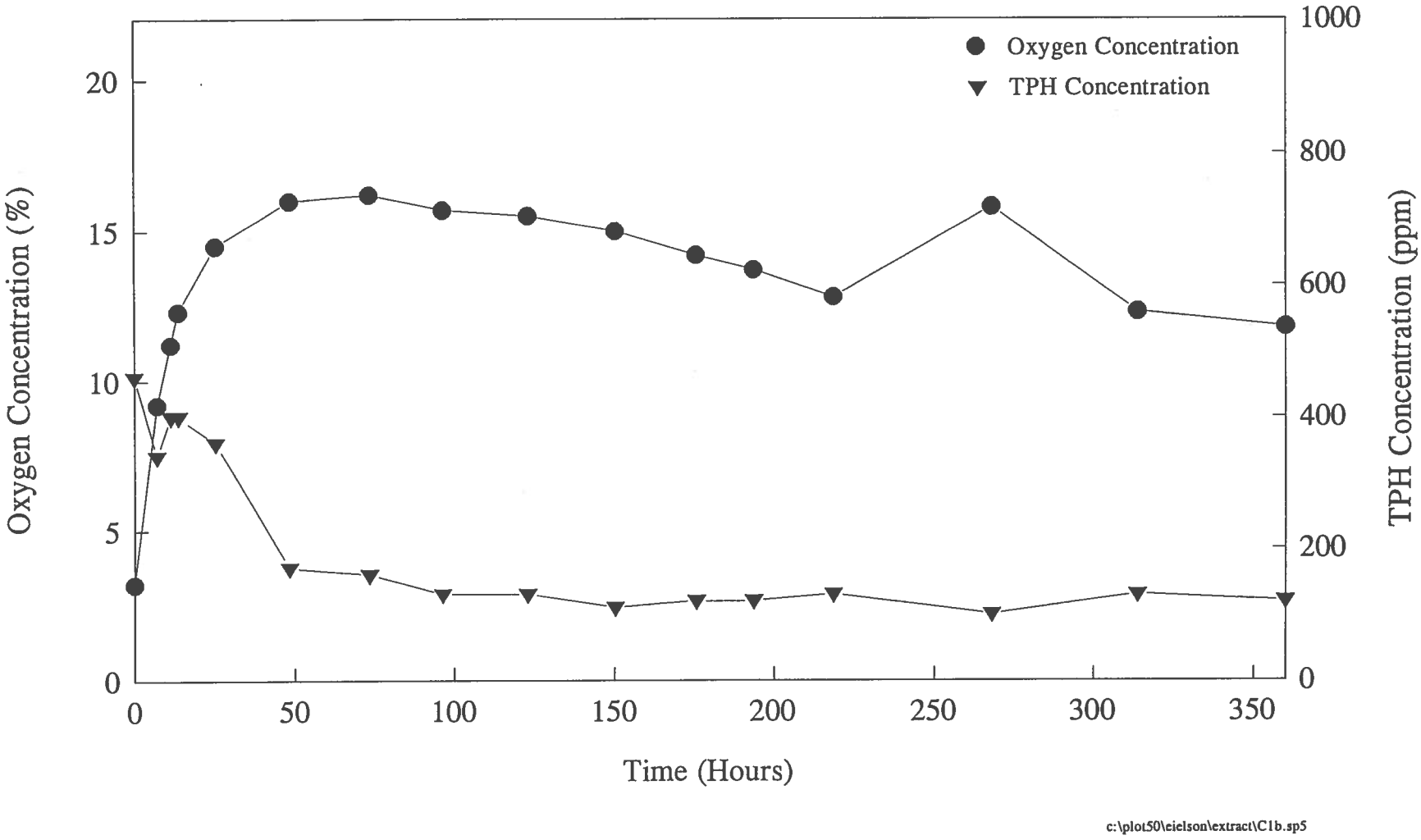


Figure I13. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point C1b

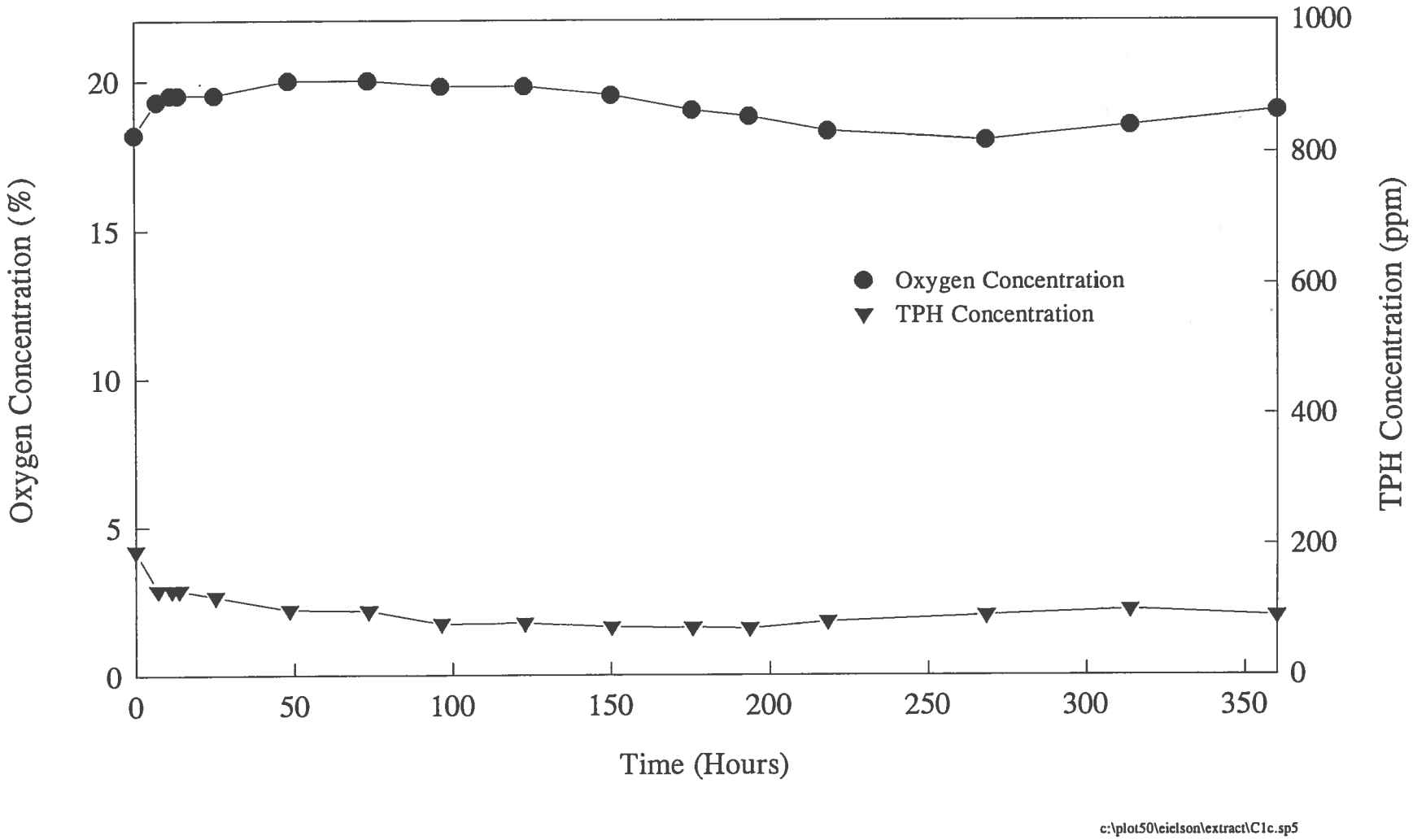


Figure I14. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point C1c

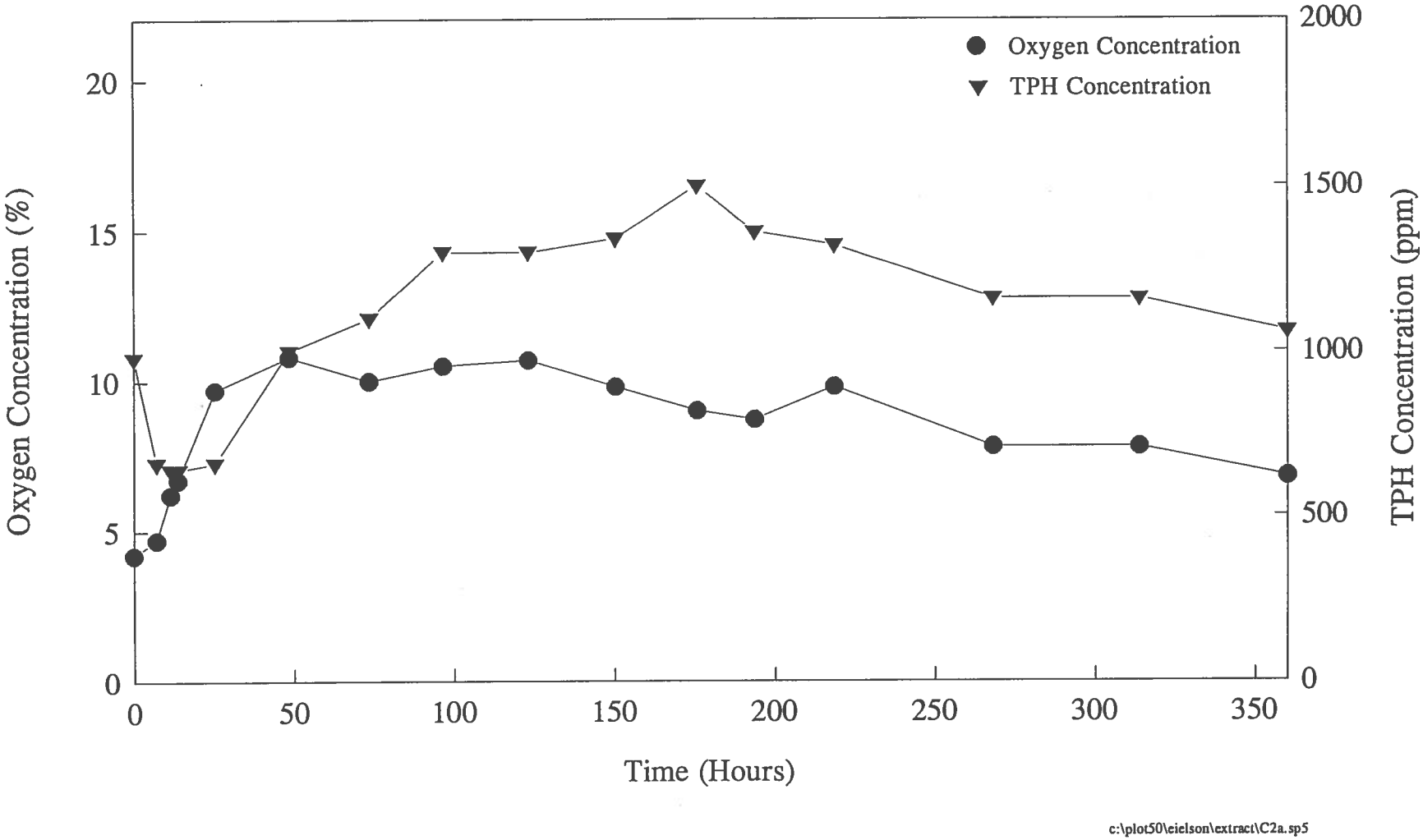


Figure I15. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point C2a

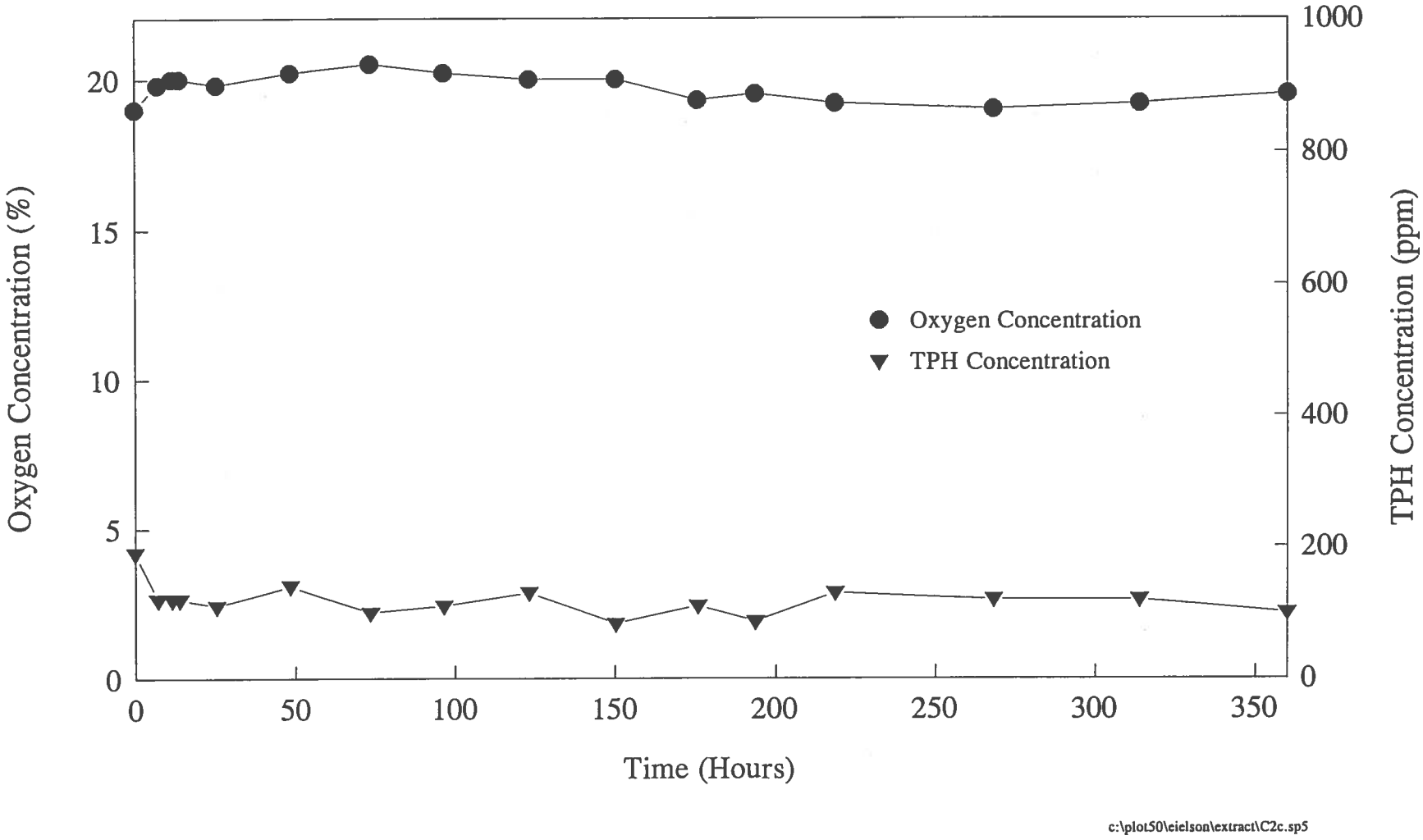


Figure I16. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point C2c

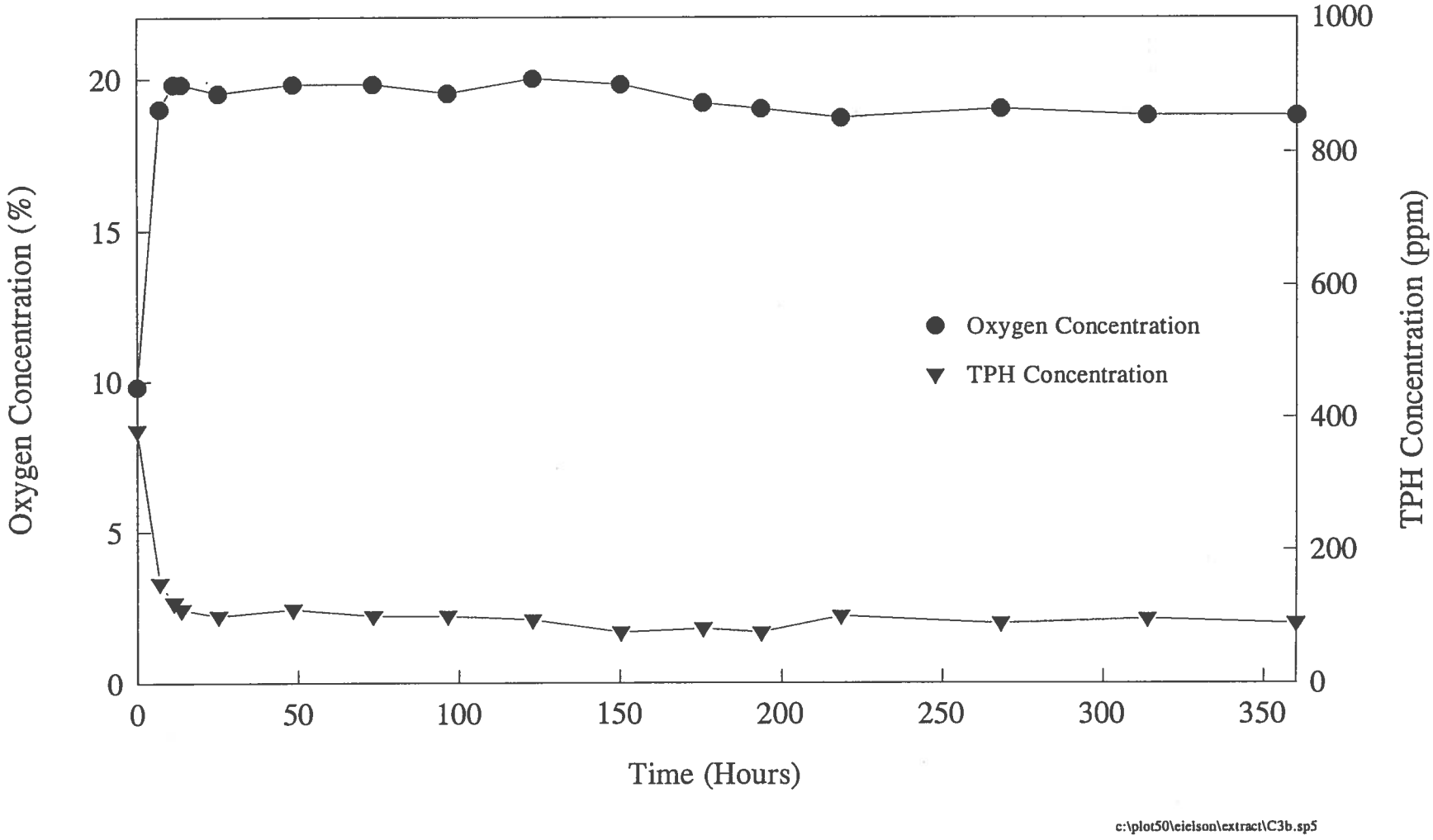


Figure I17. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point C3b

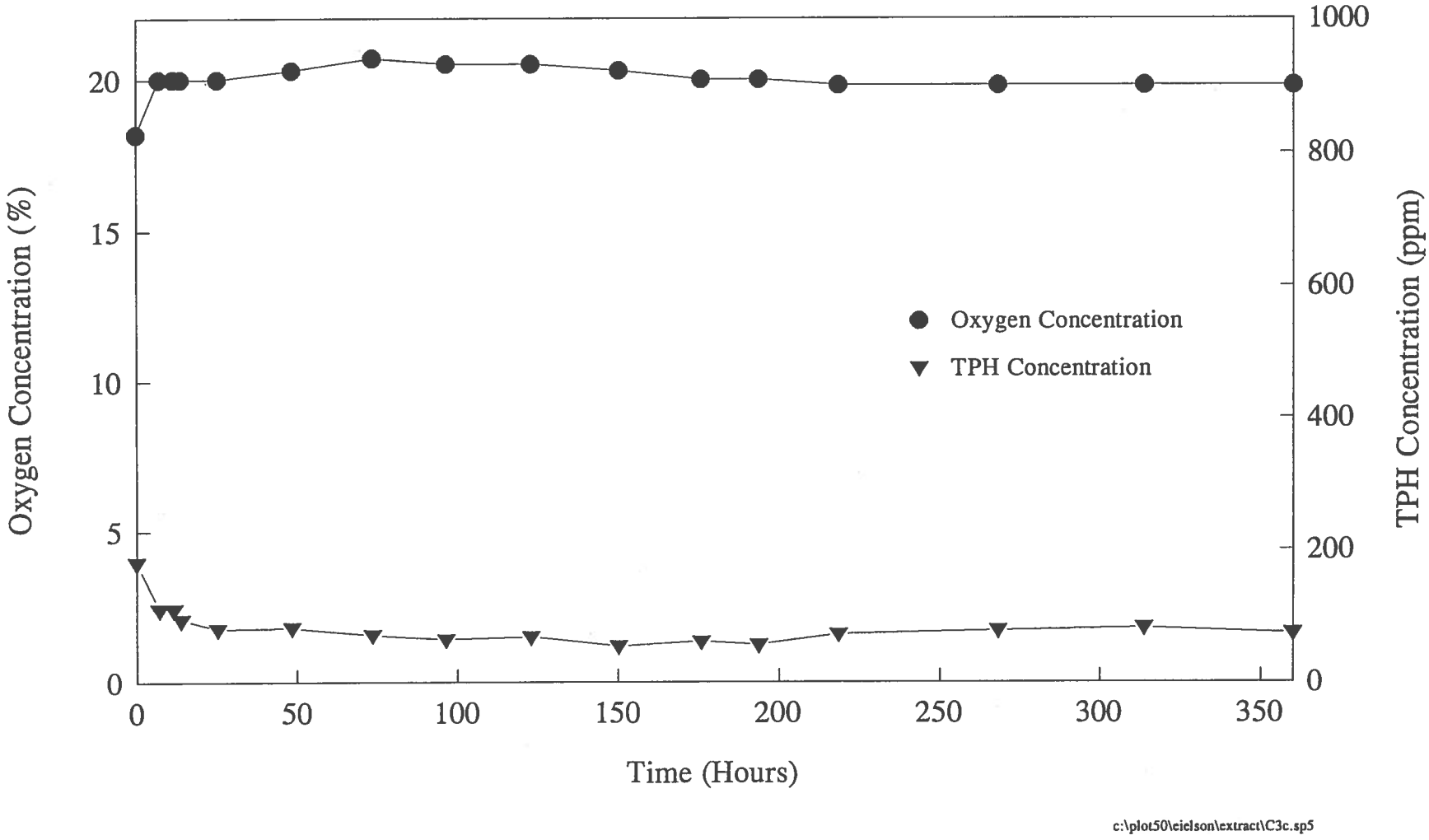


Figure I18. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point C3c

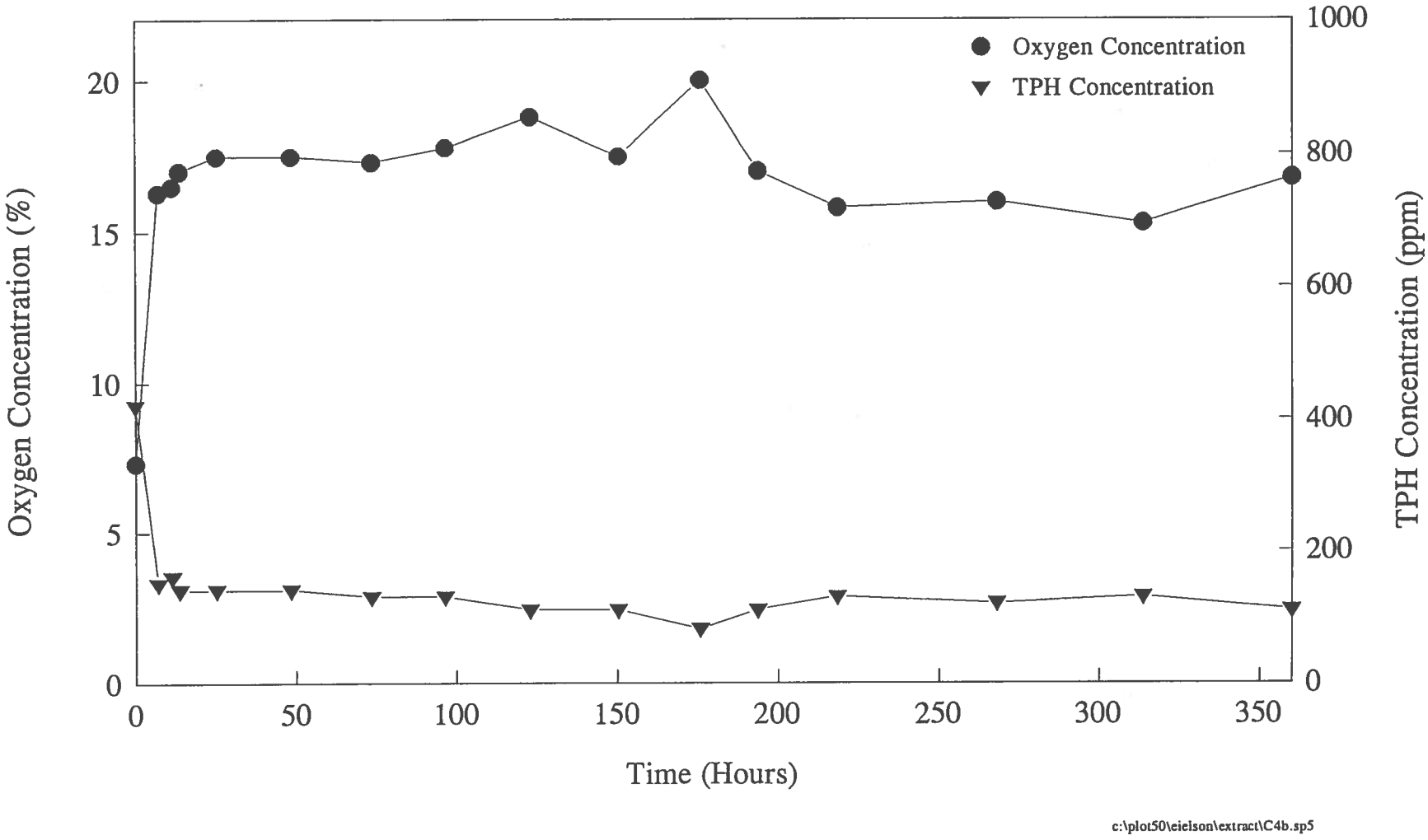


Figure I19. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point C4b

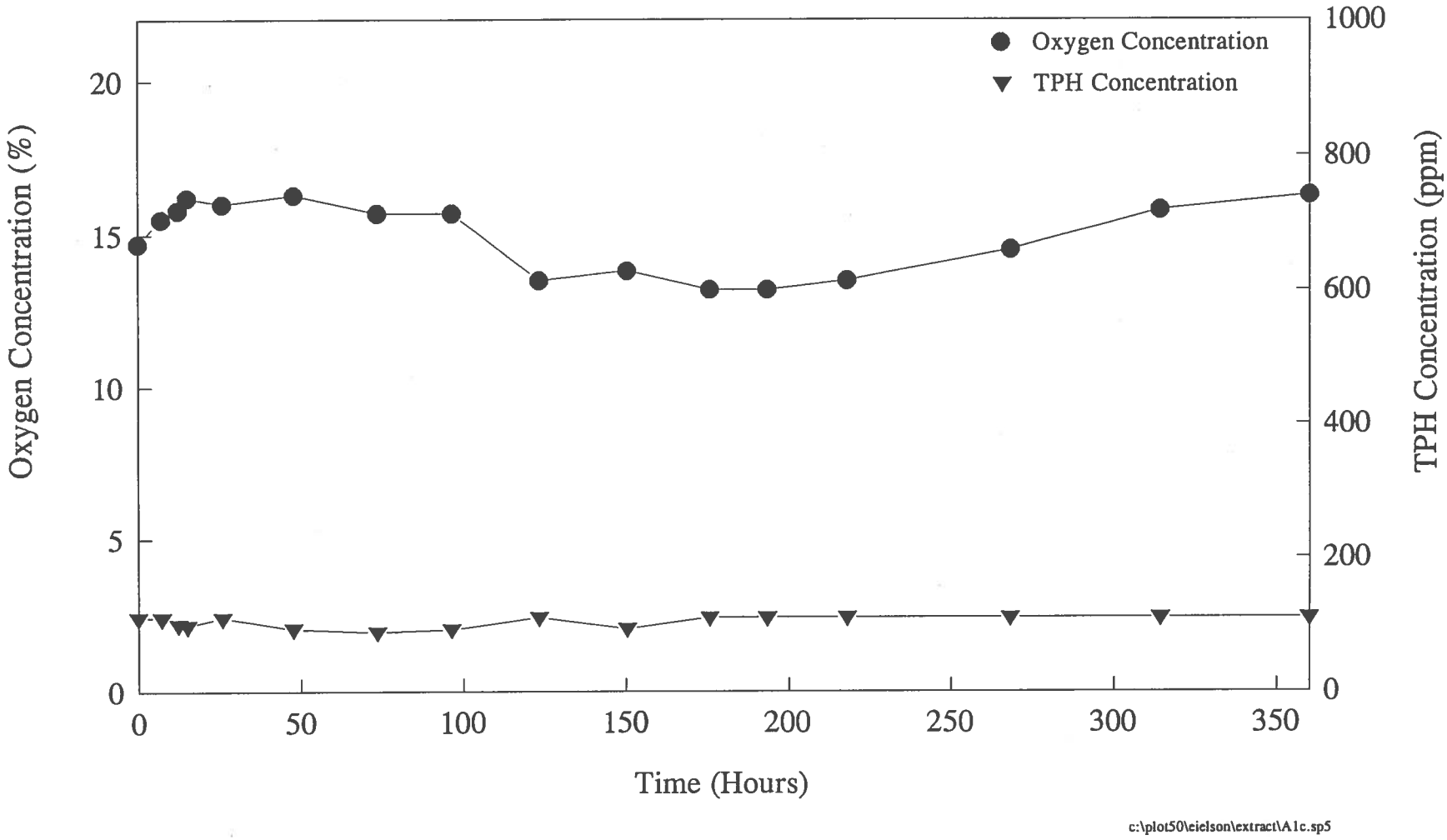


Figure I20. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point A1c

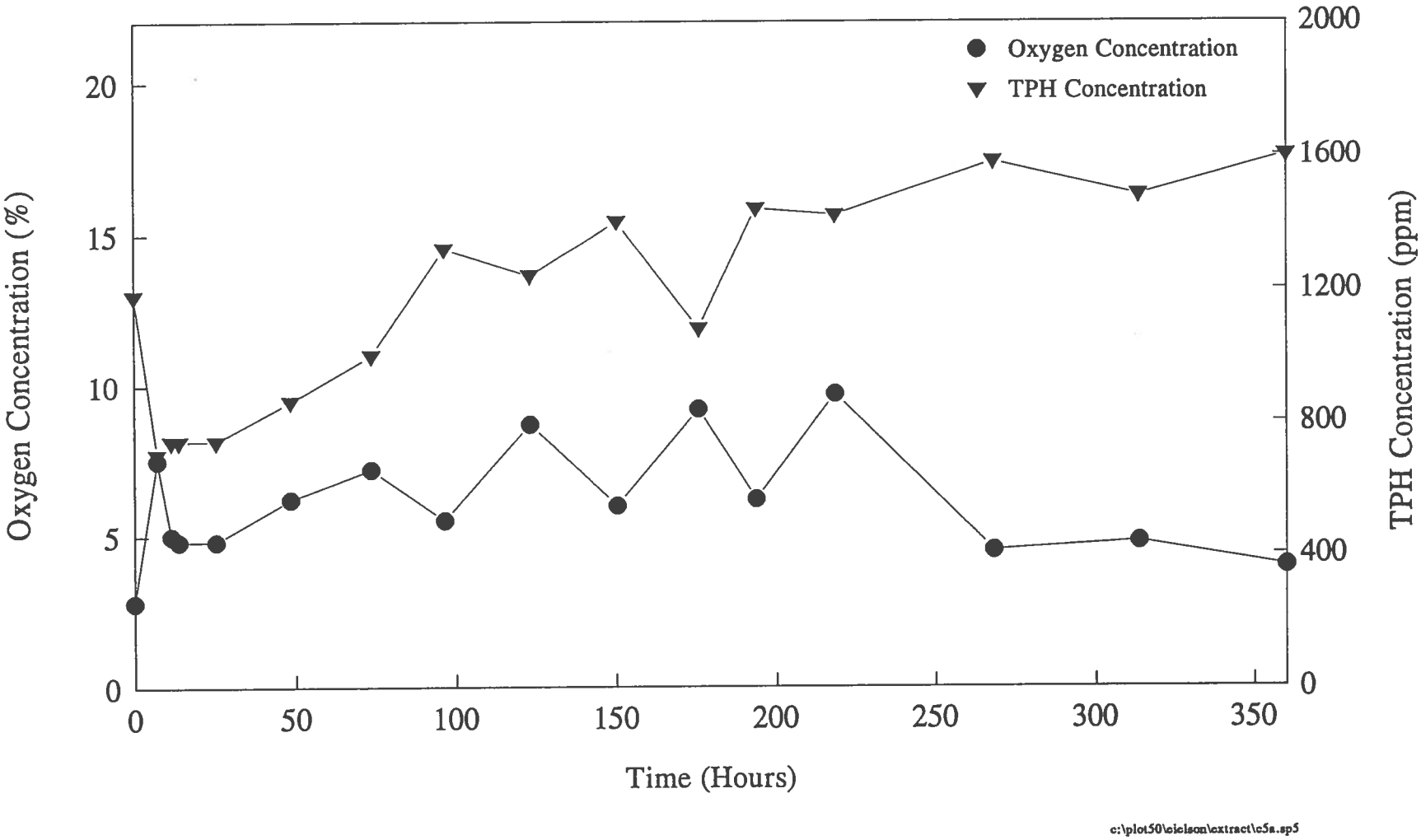


Figure I21. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point C5a

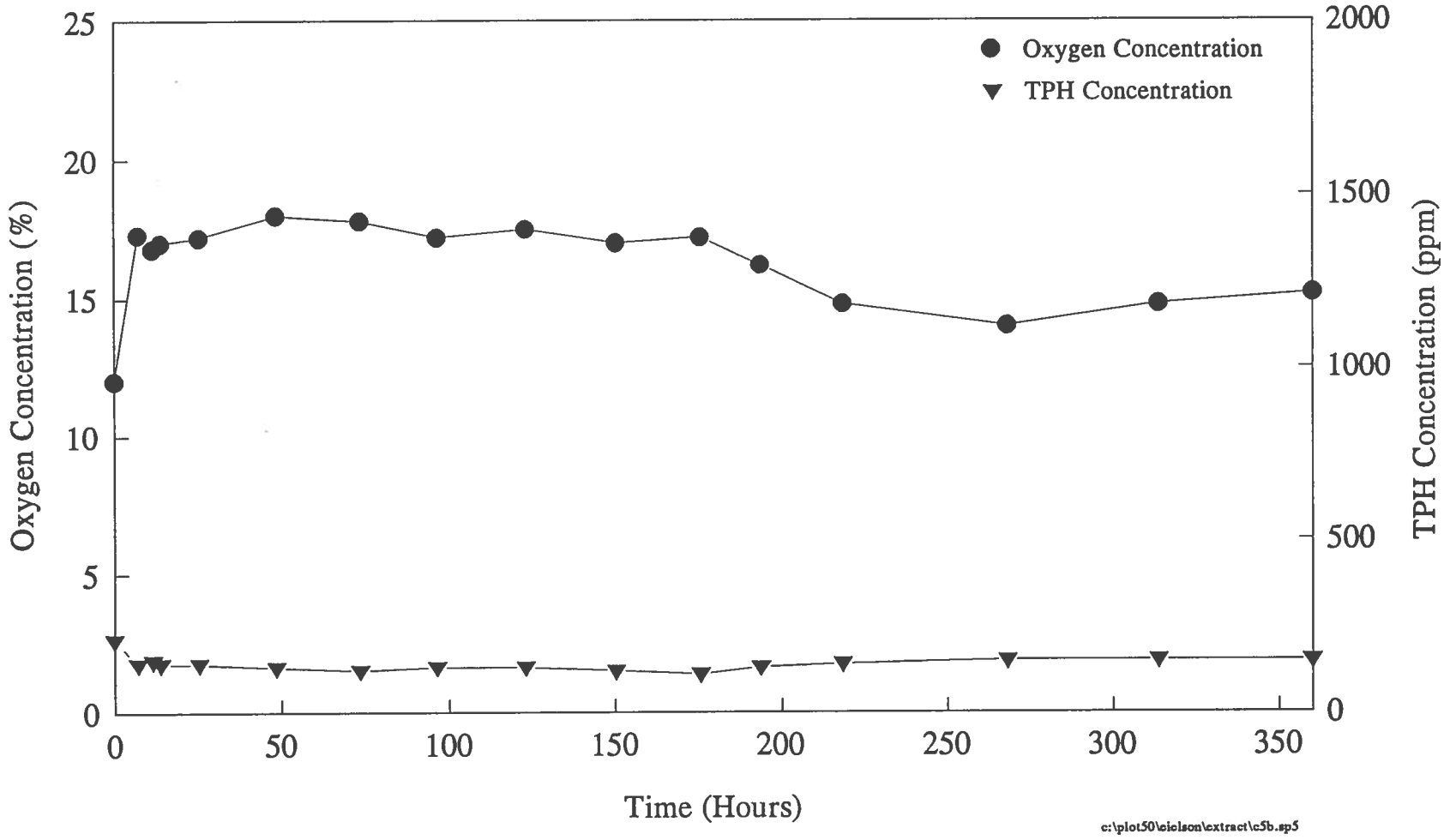


Figure I22. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point C5b

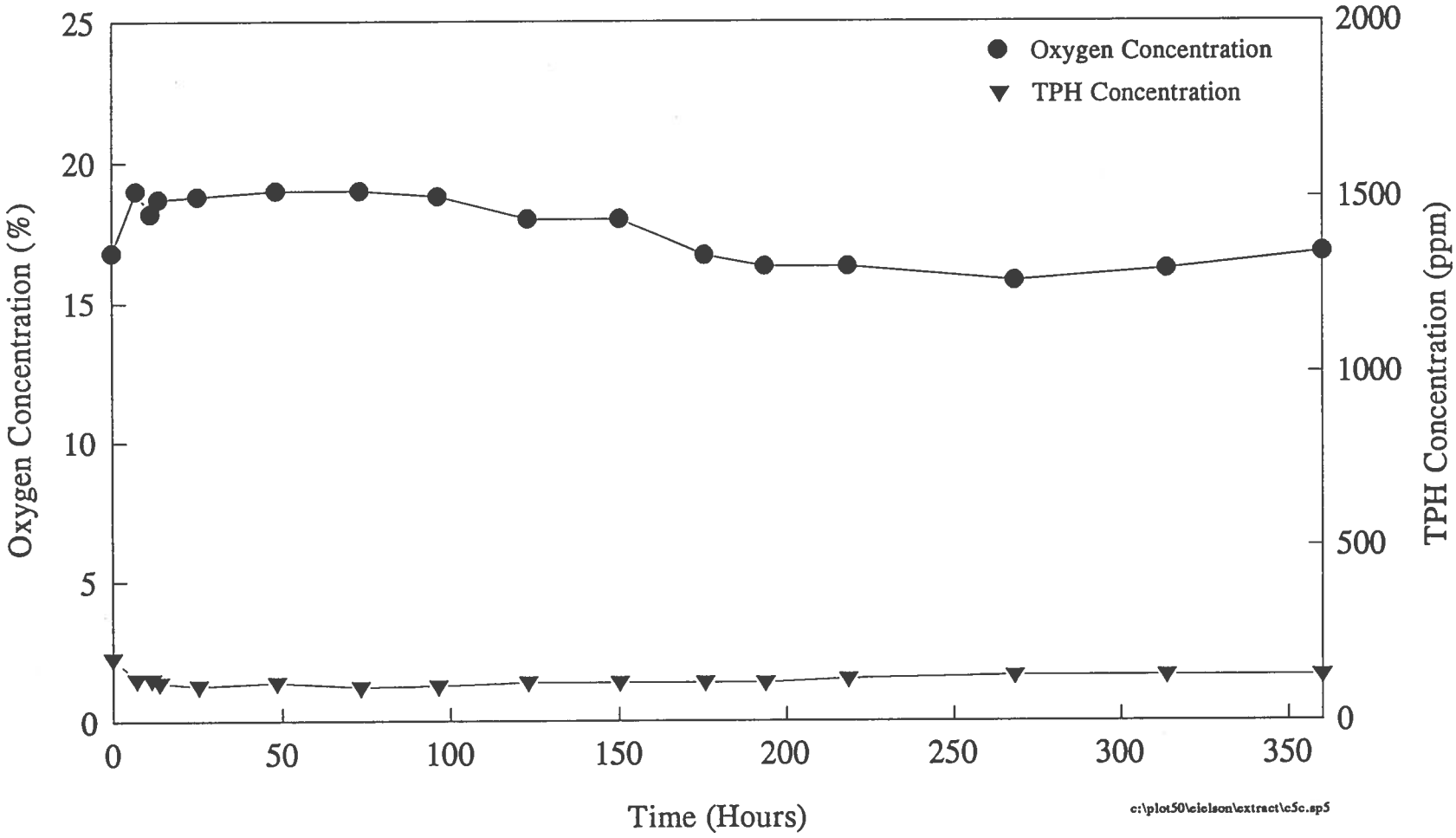


Figure 123. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point C5c

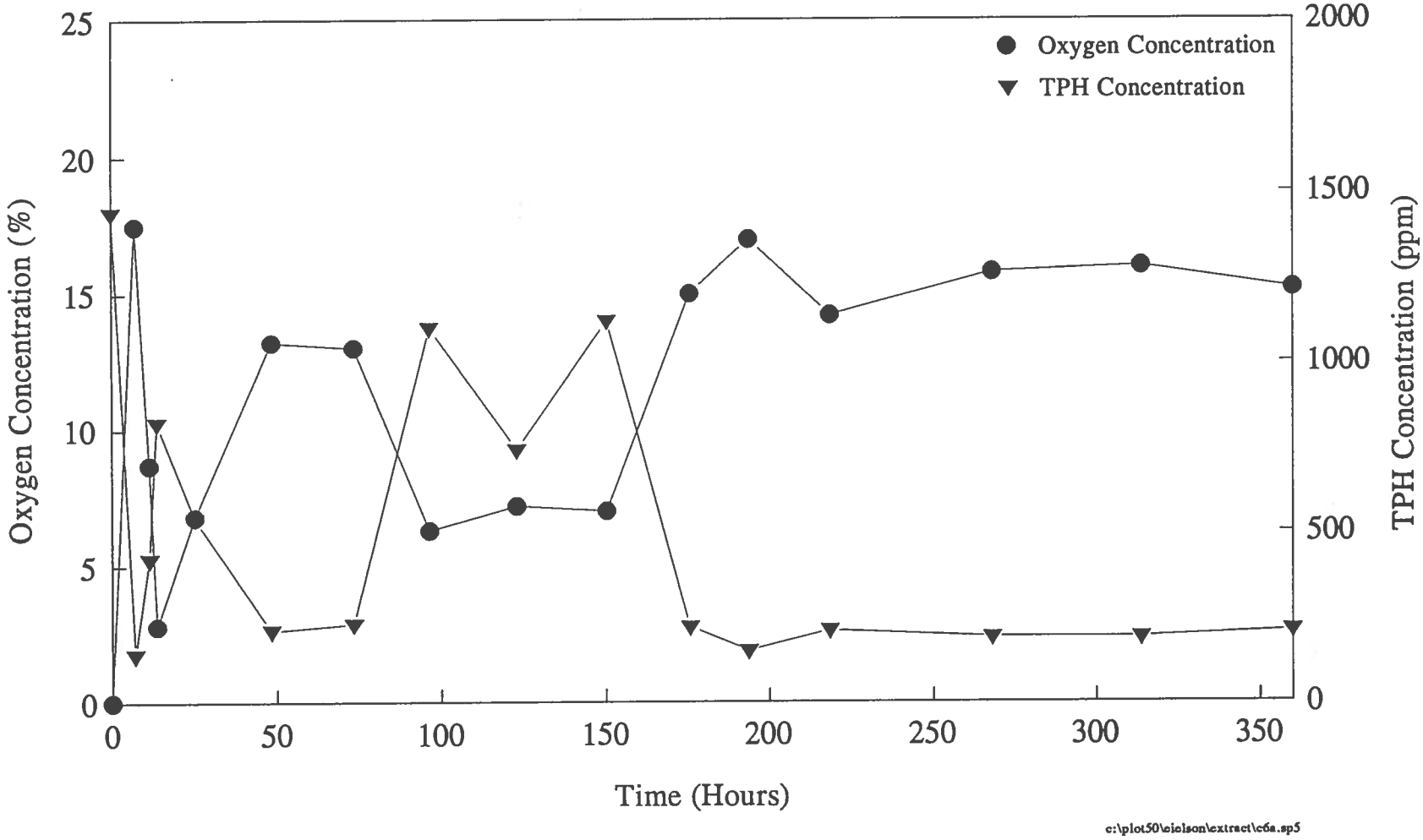


Figure I24. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point C6a

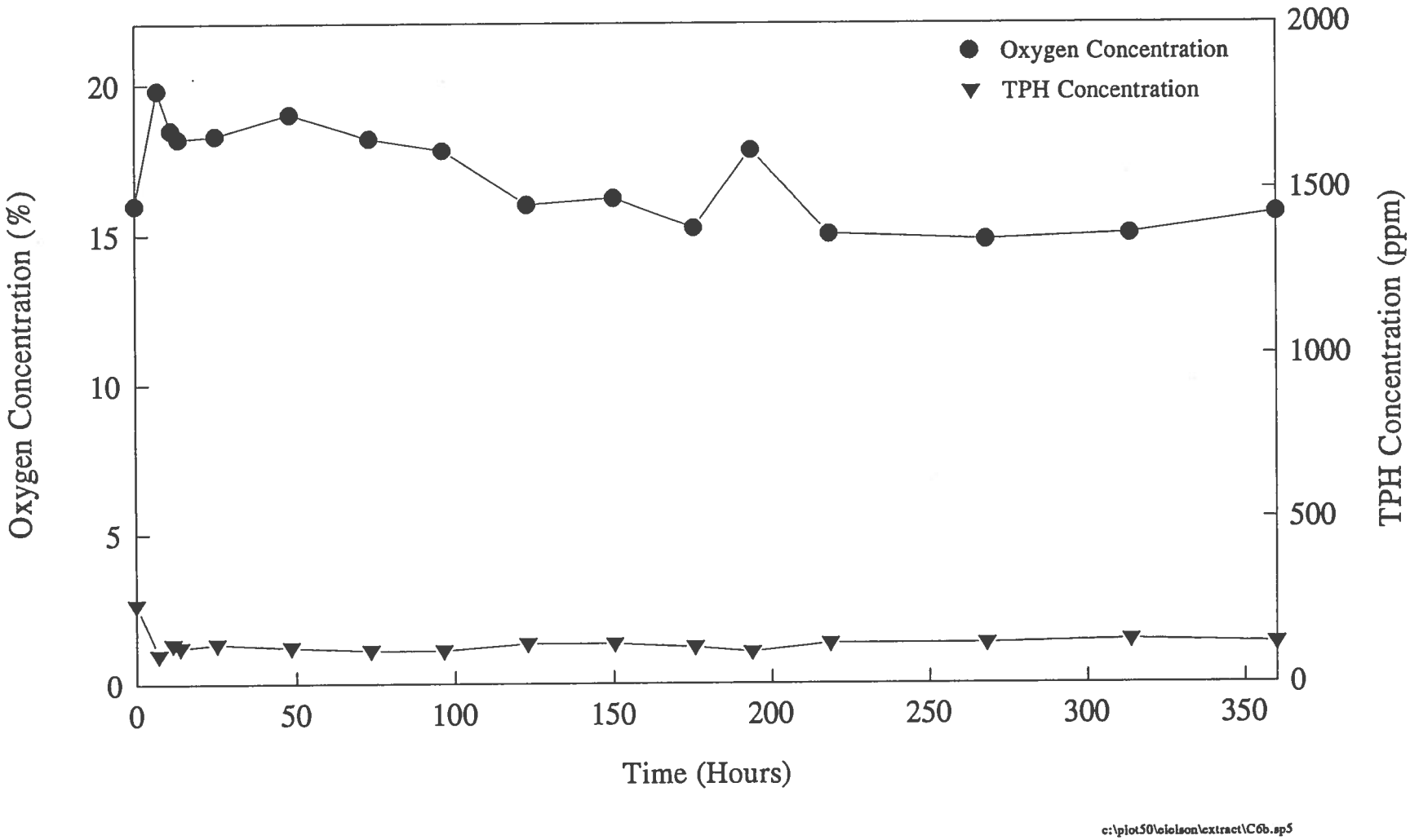


Figure I25. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point C6b

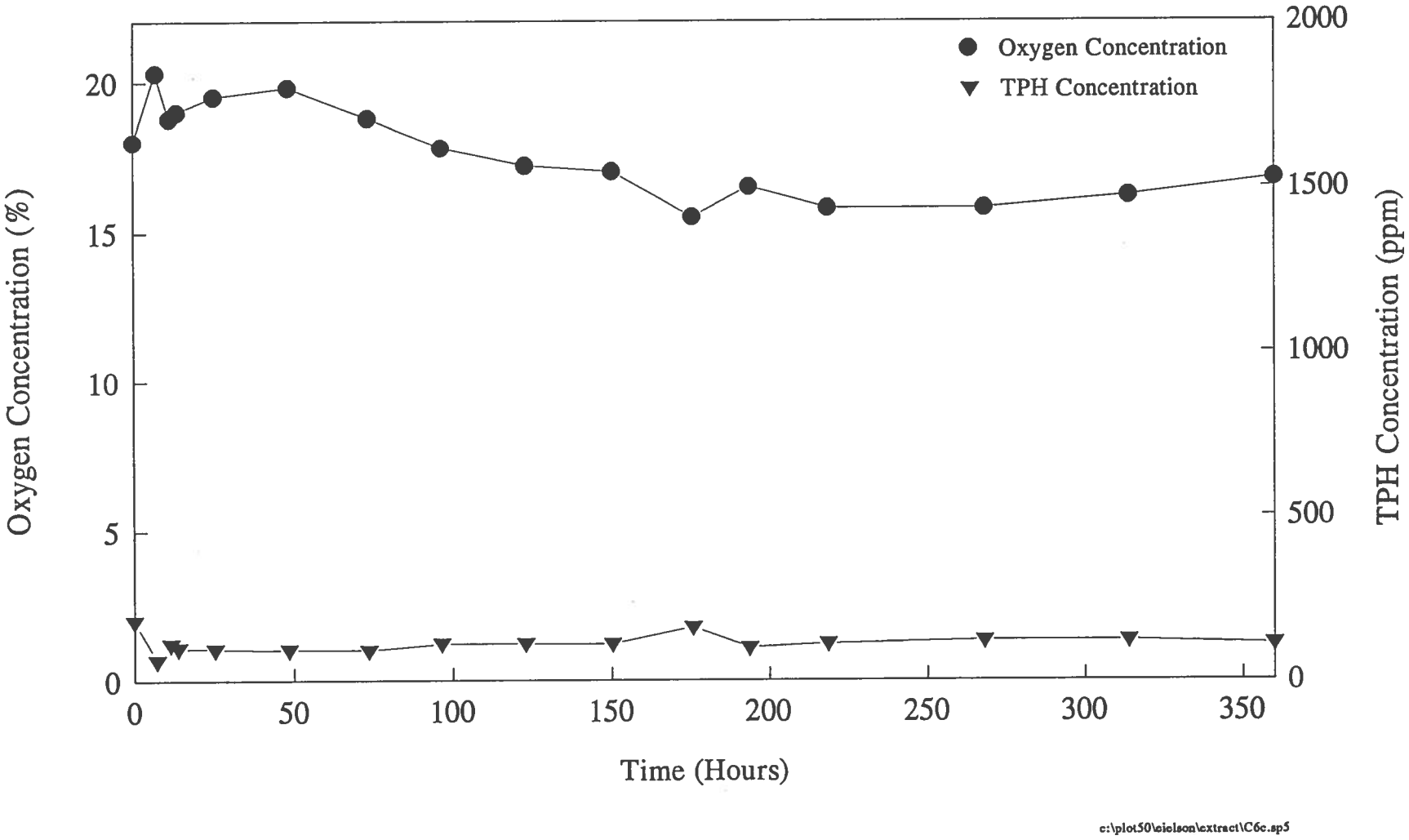


Figure I26. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point C6c

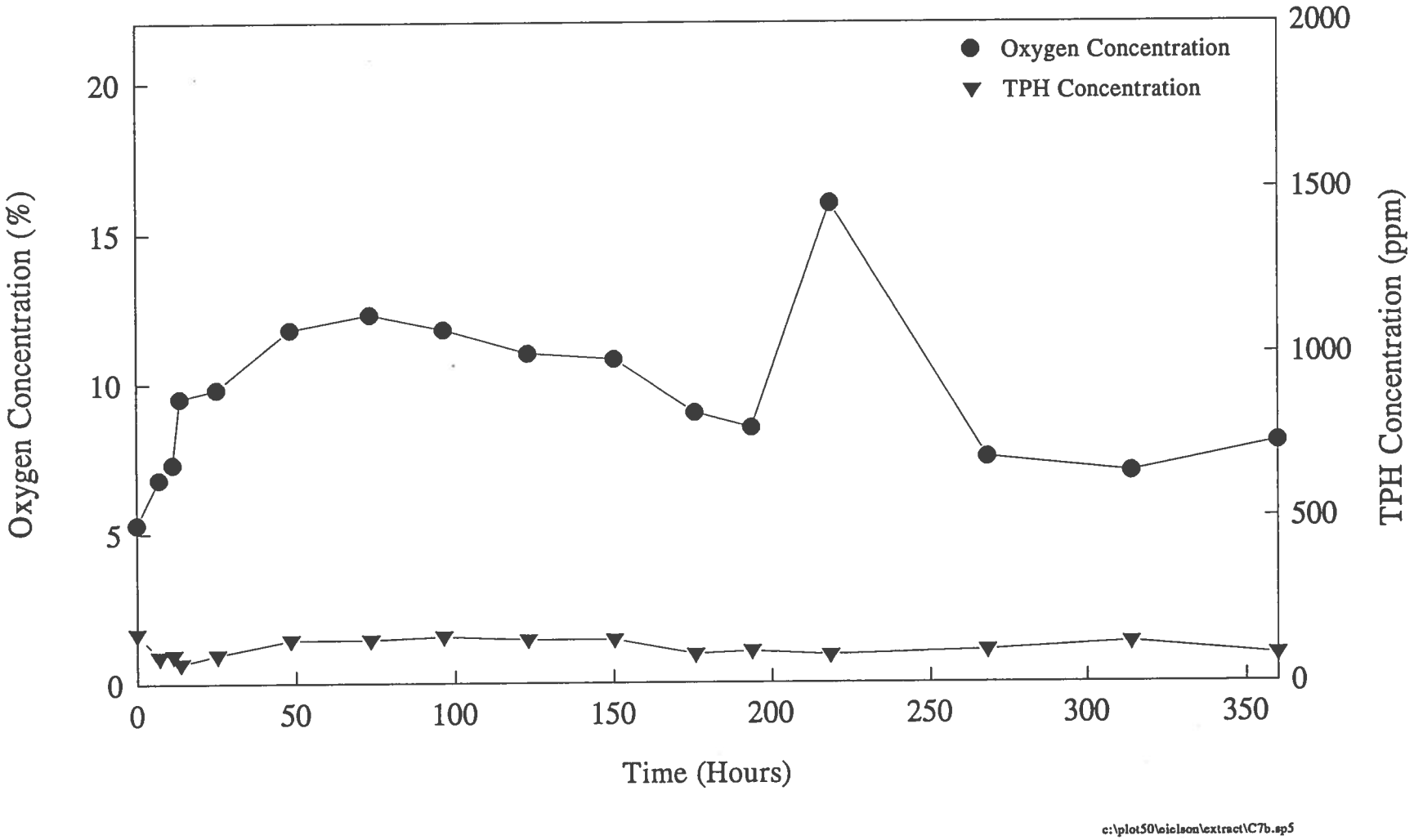


Figure I27. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point C7b

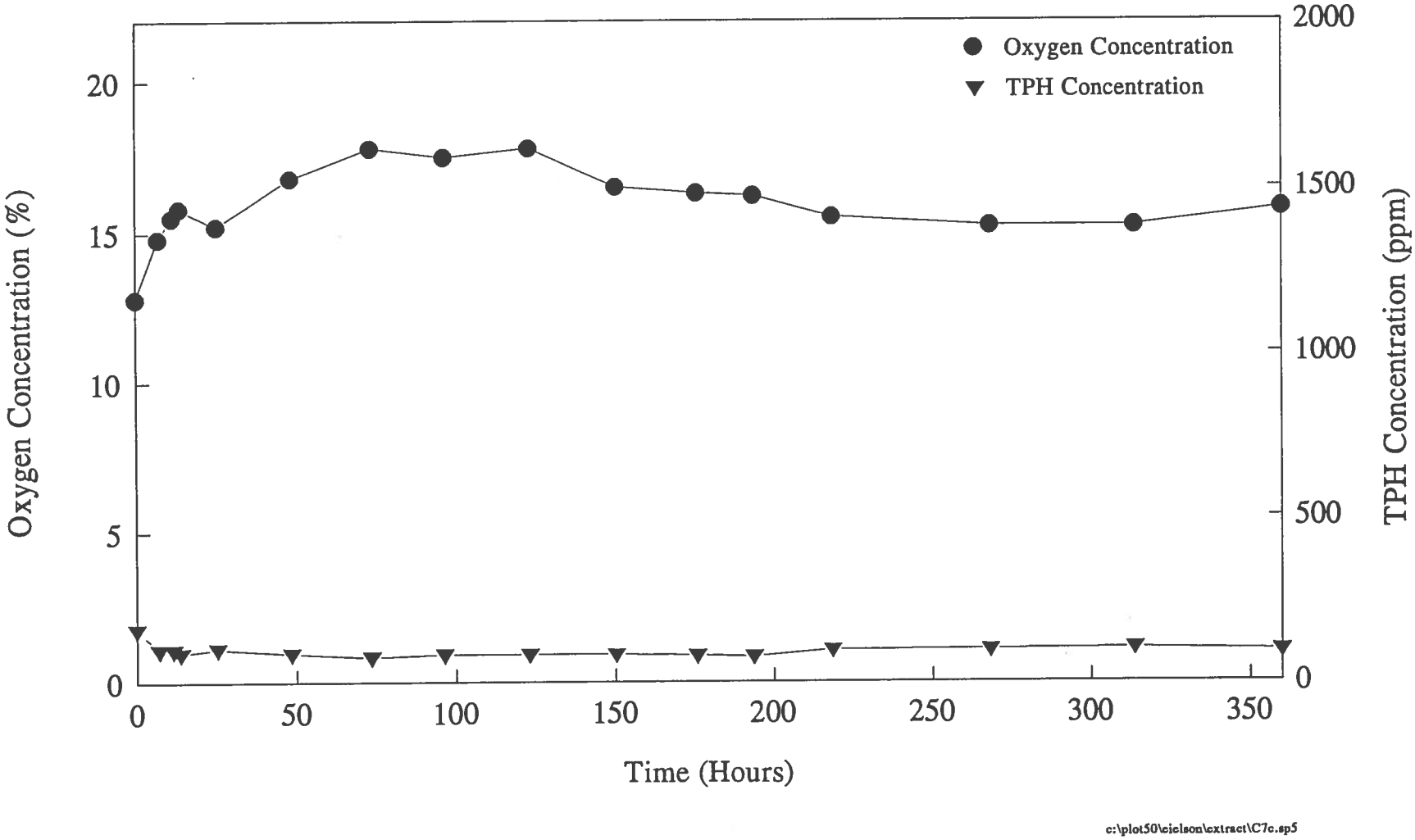


Figure I28. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point C7c

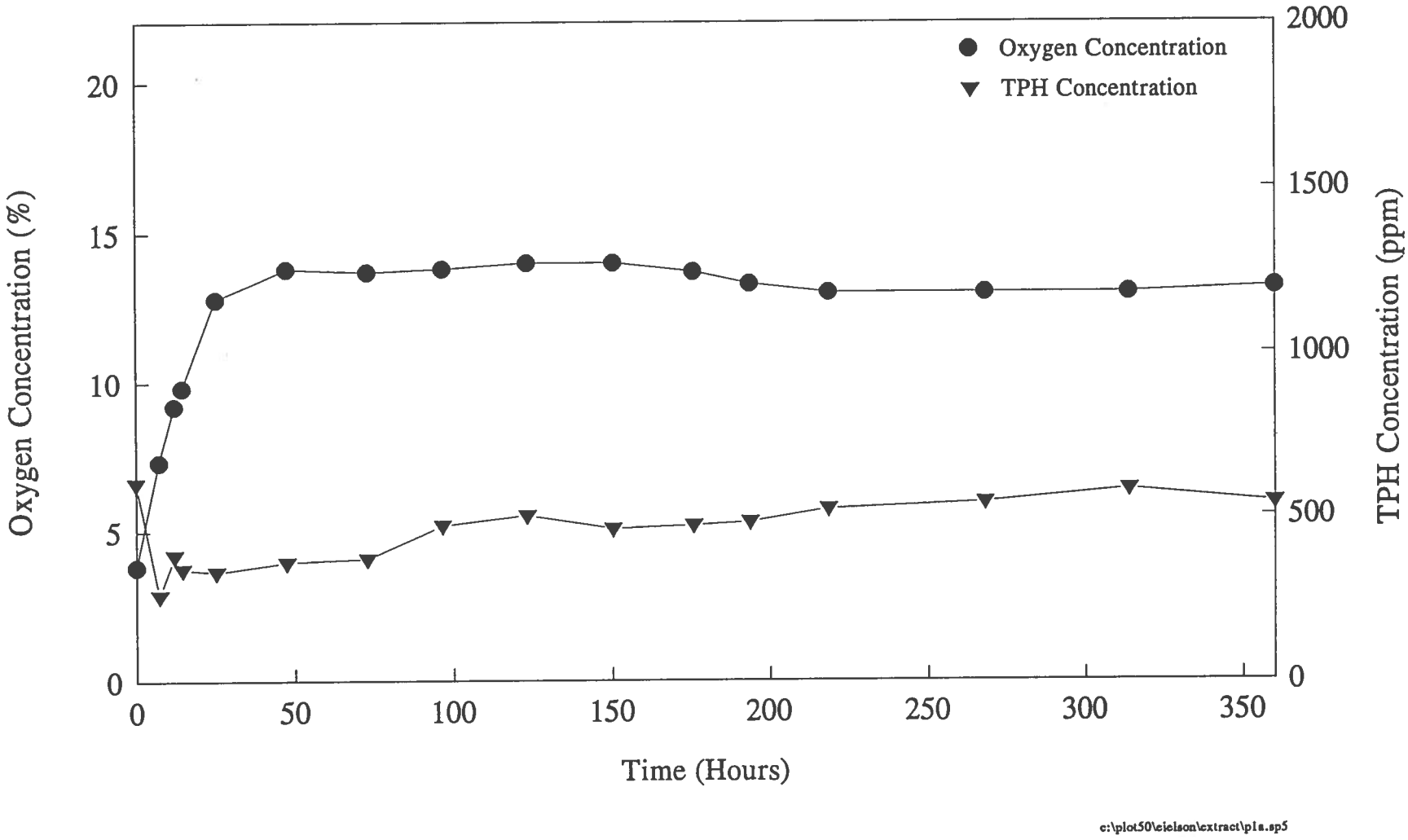


Figure 129. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P1a

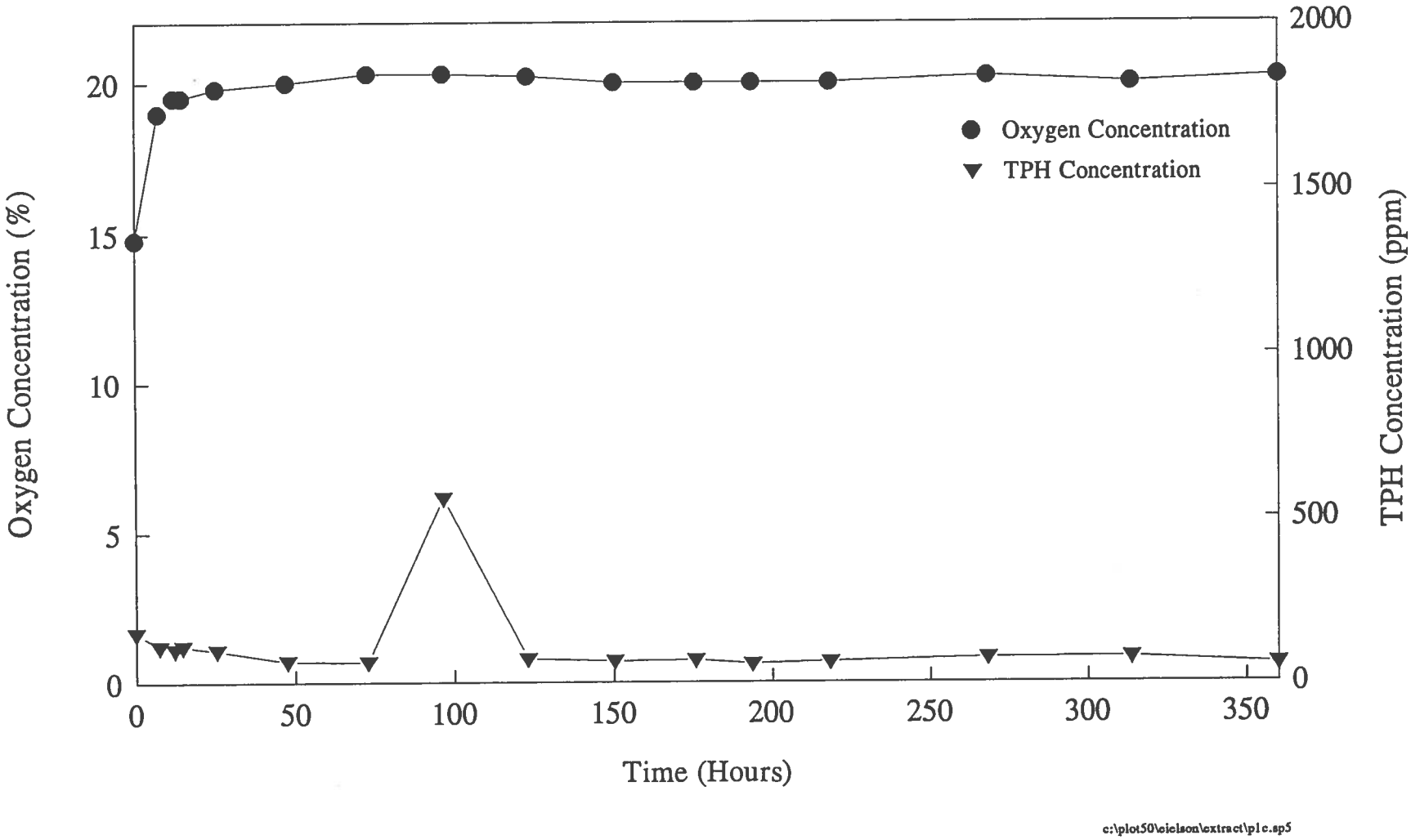


Figure I30. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P1c

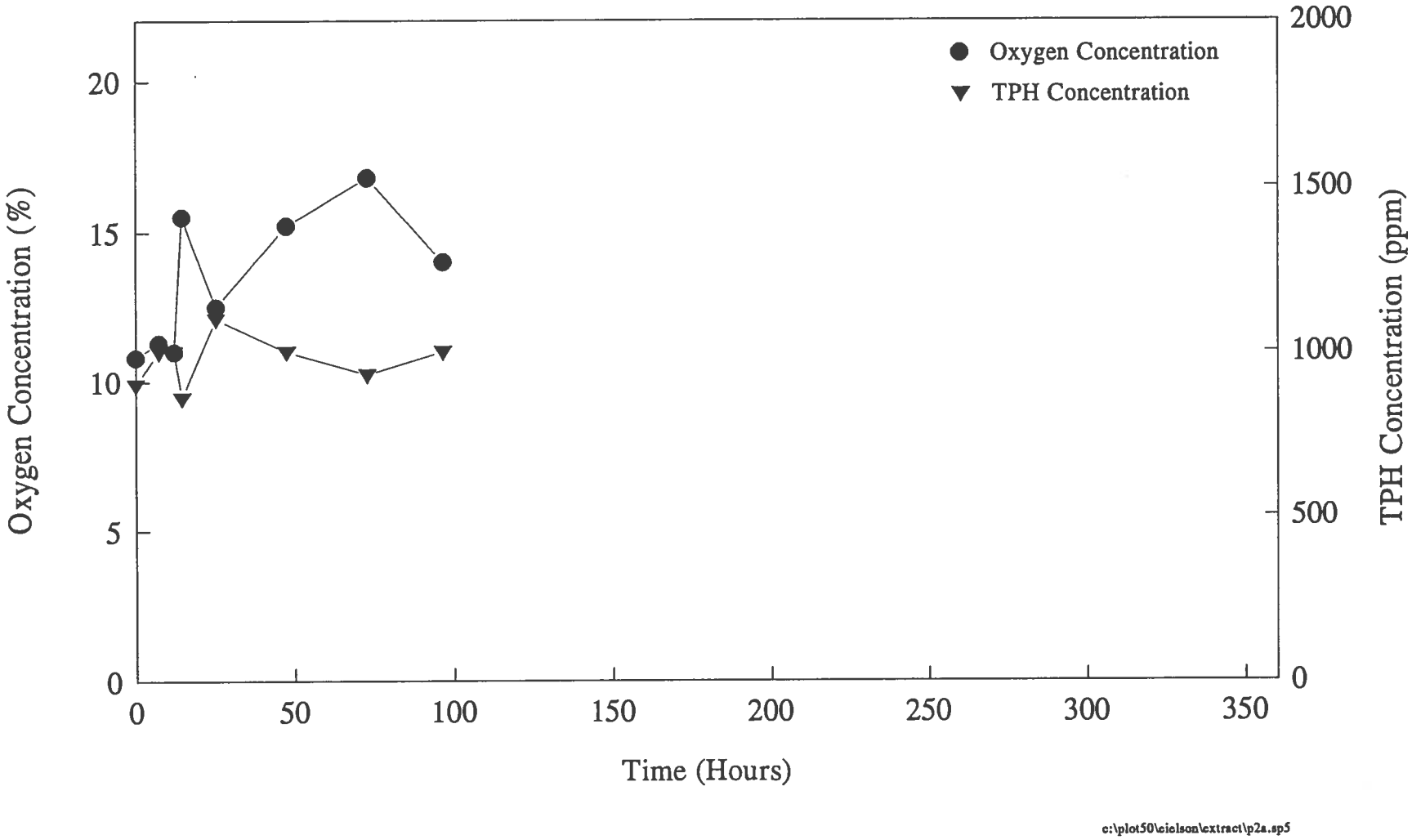


Figure I31. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P2a

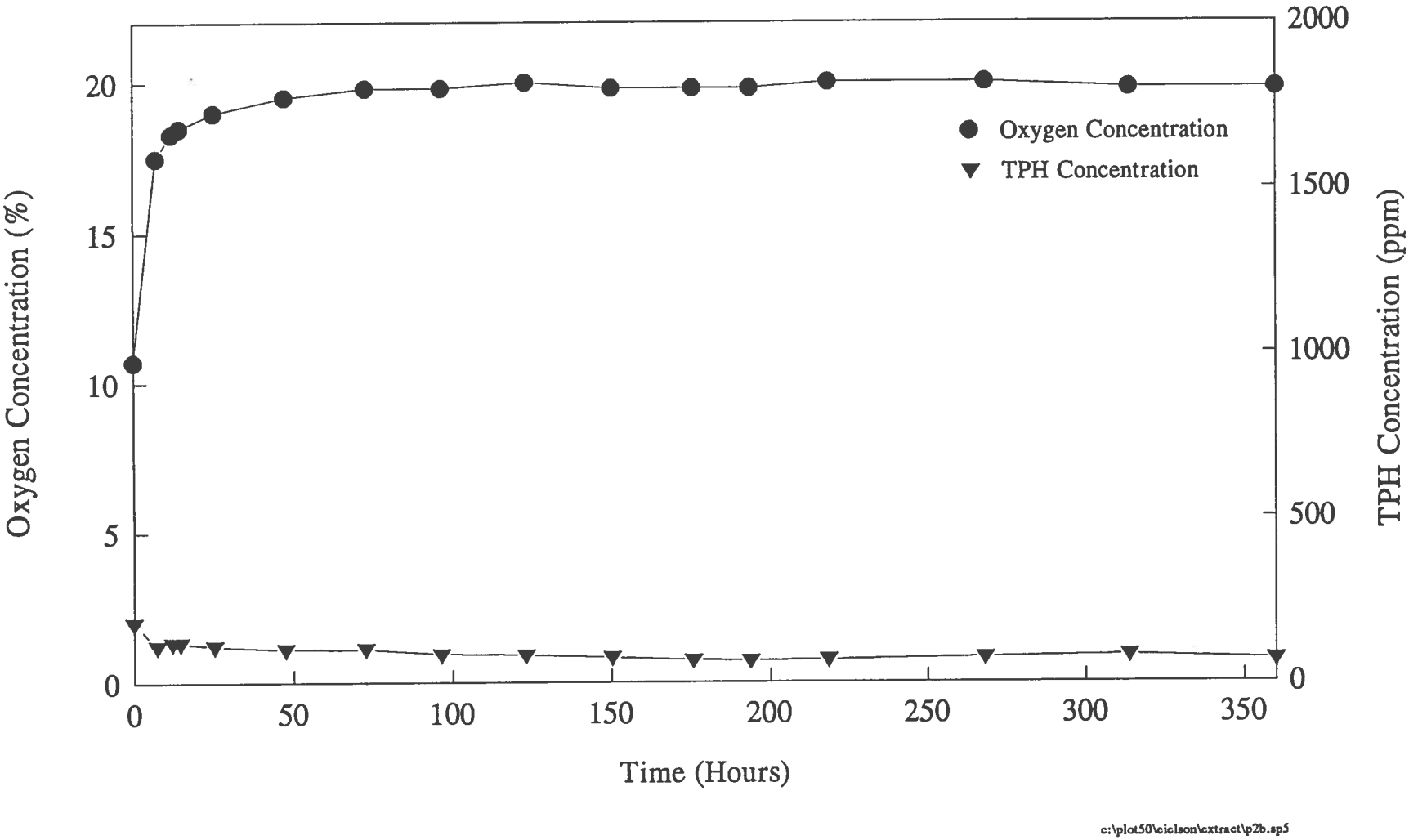


Figure I32. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P2b

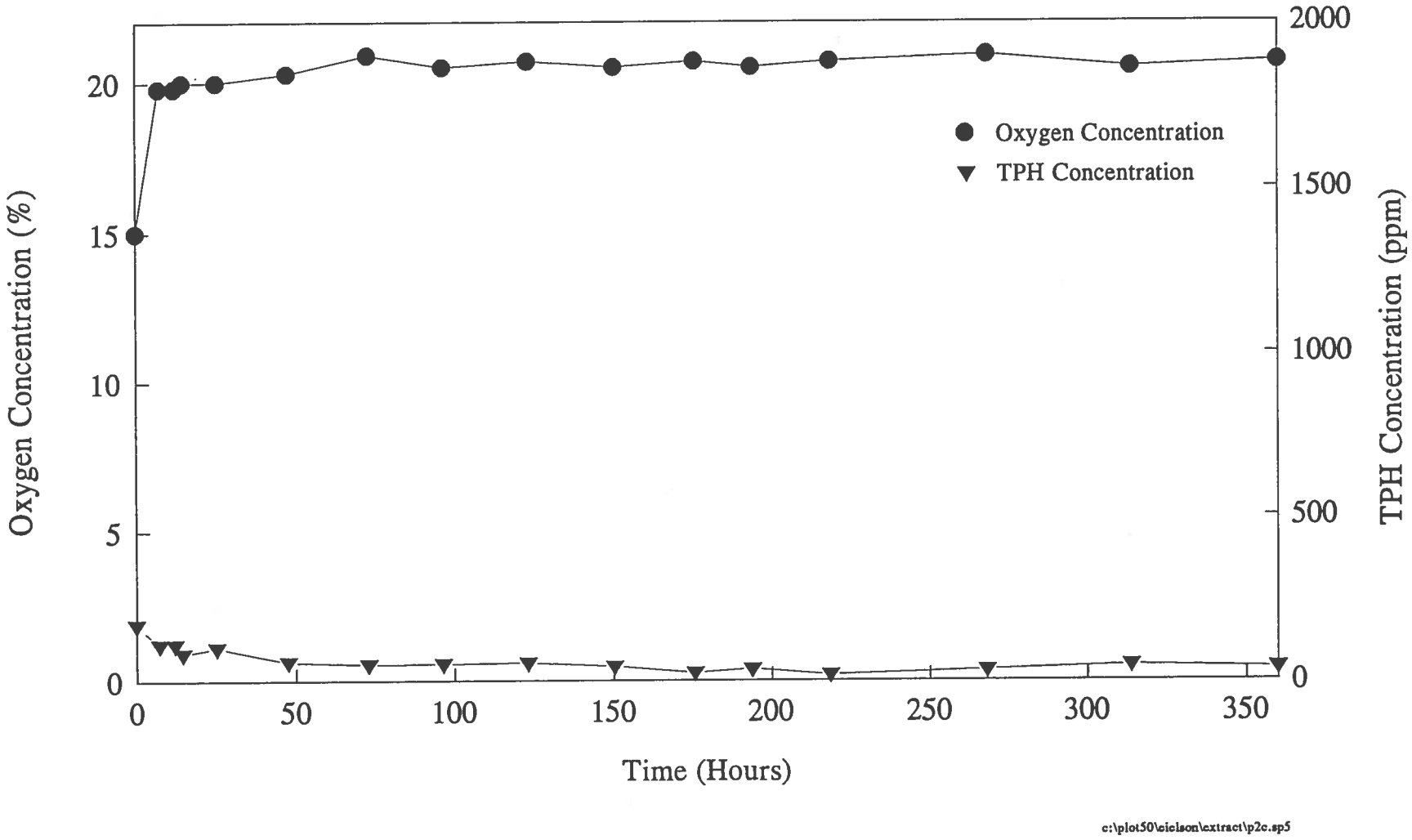


Figure I33. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P2c

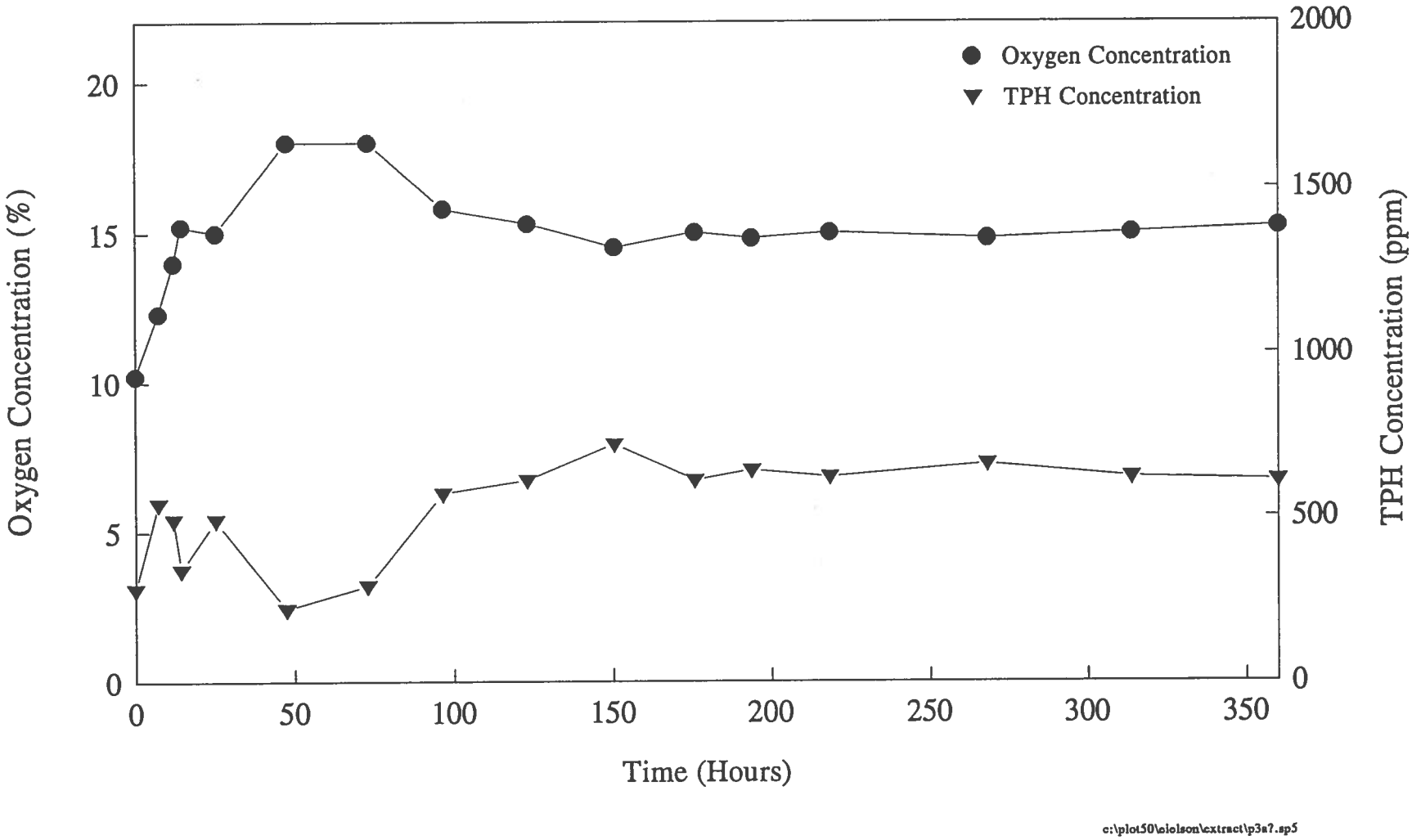


Figure I34. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P3a

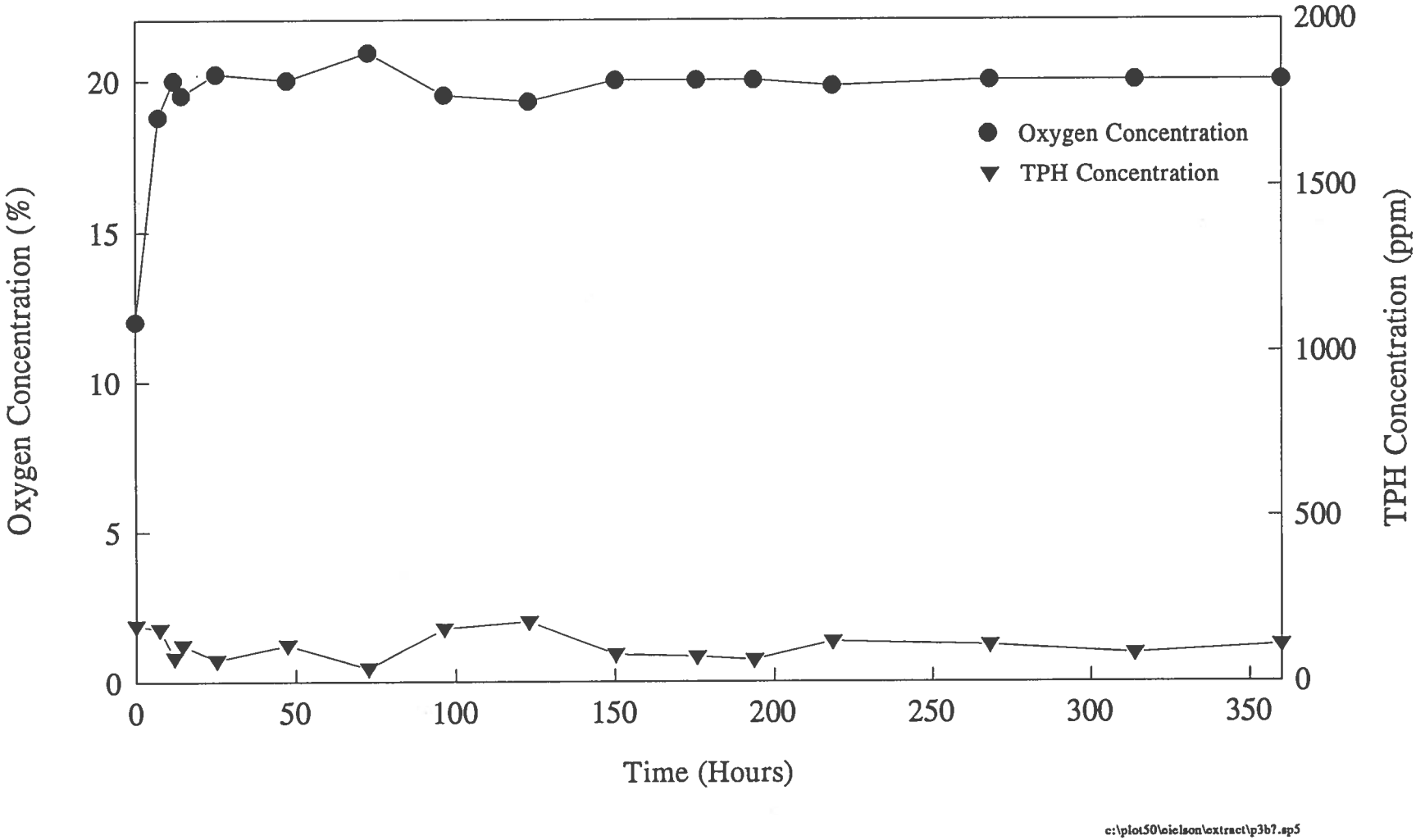


Figure I35. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P3b

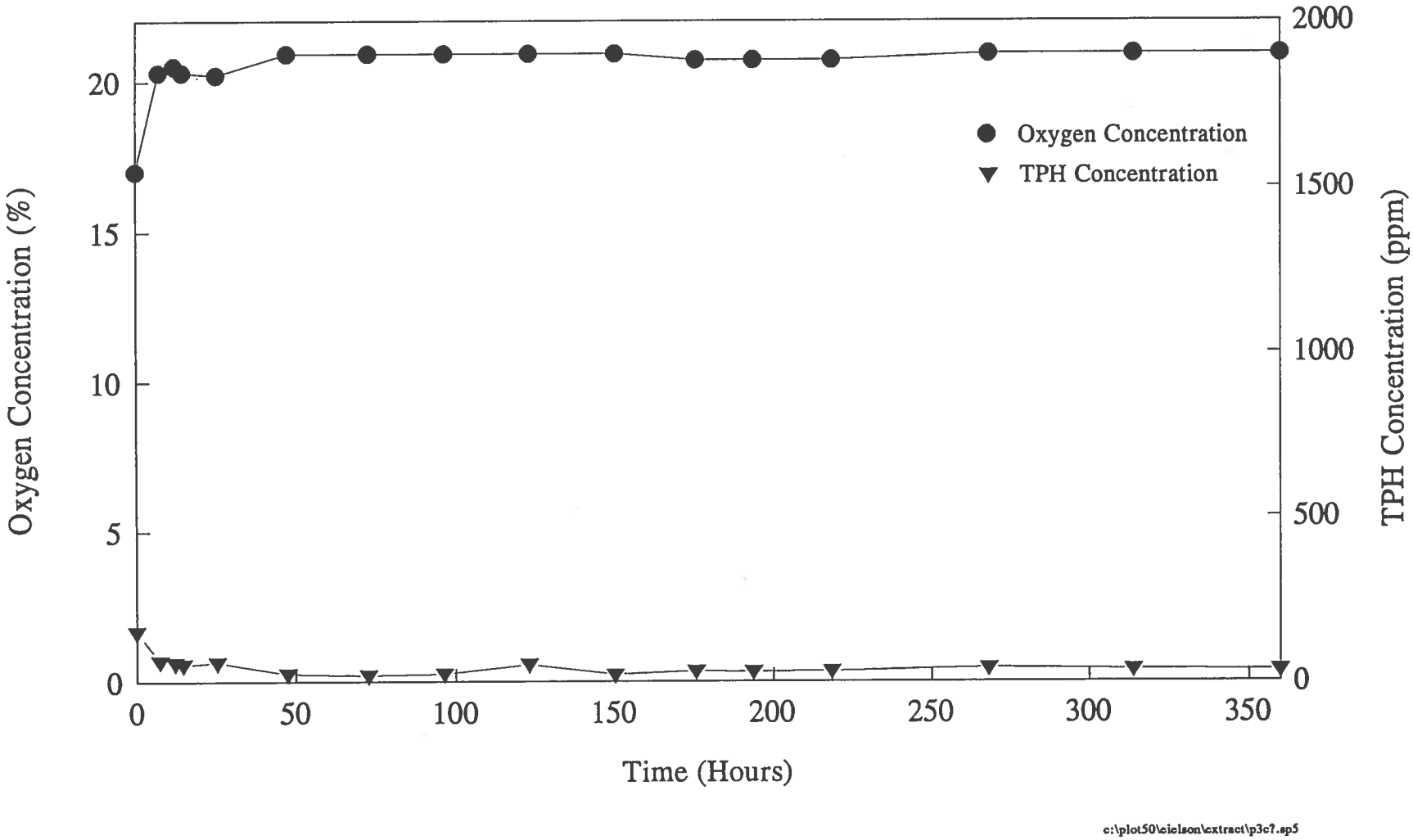


Figure I36. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P3c

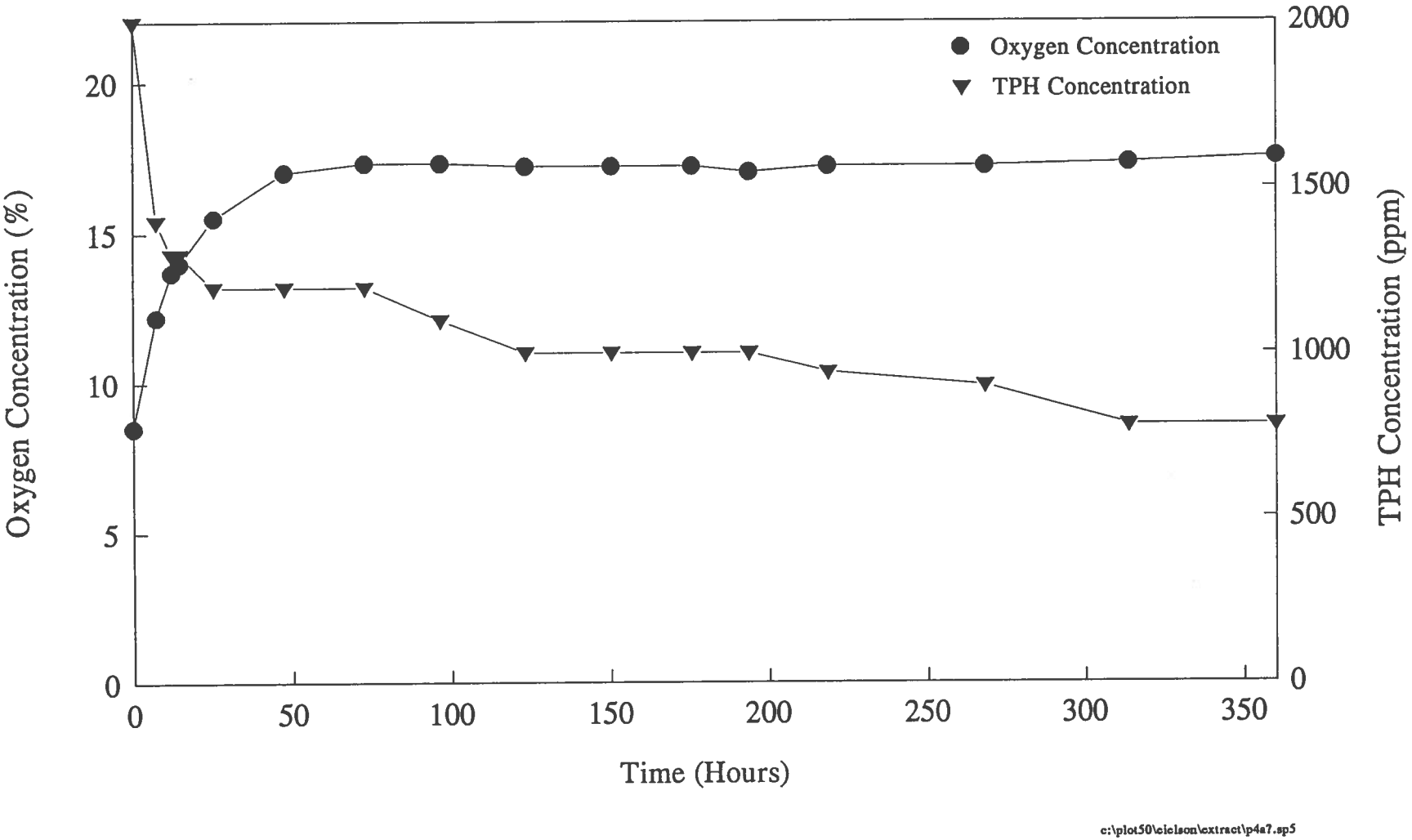


Figure I37. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P4a

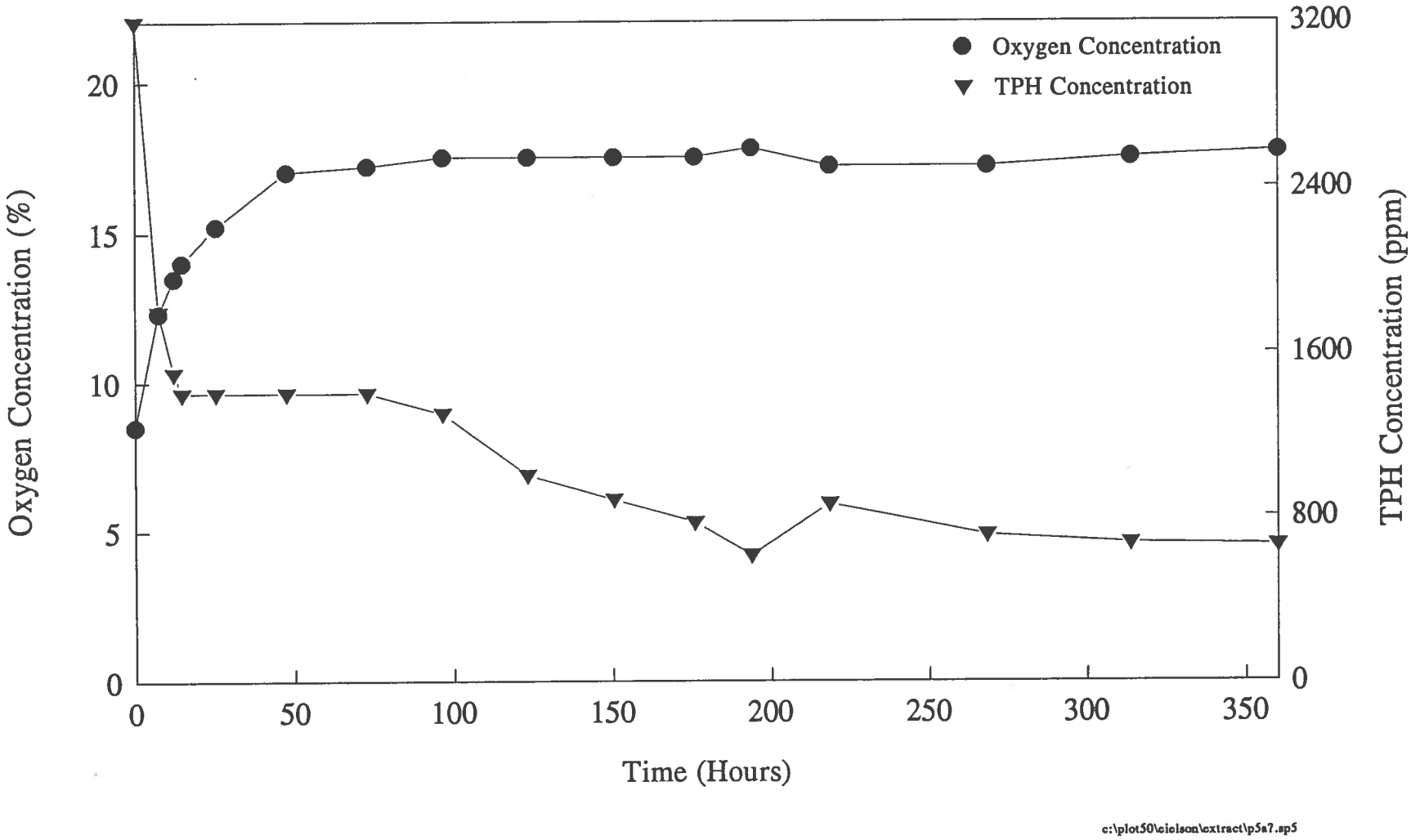


Figure I38. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P5a

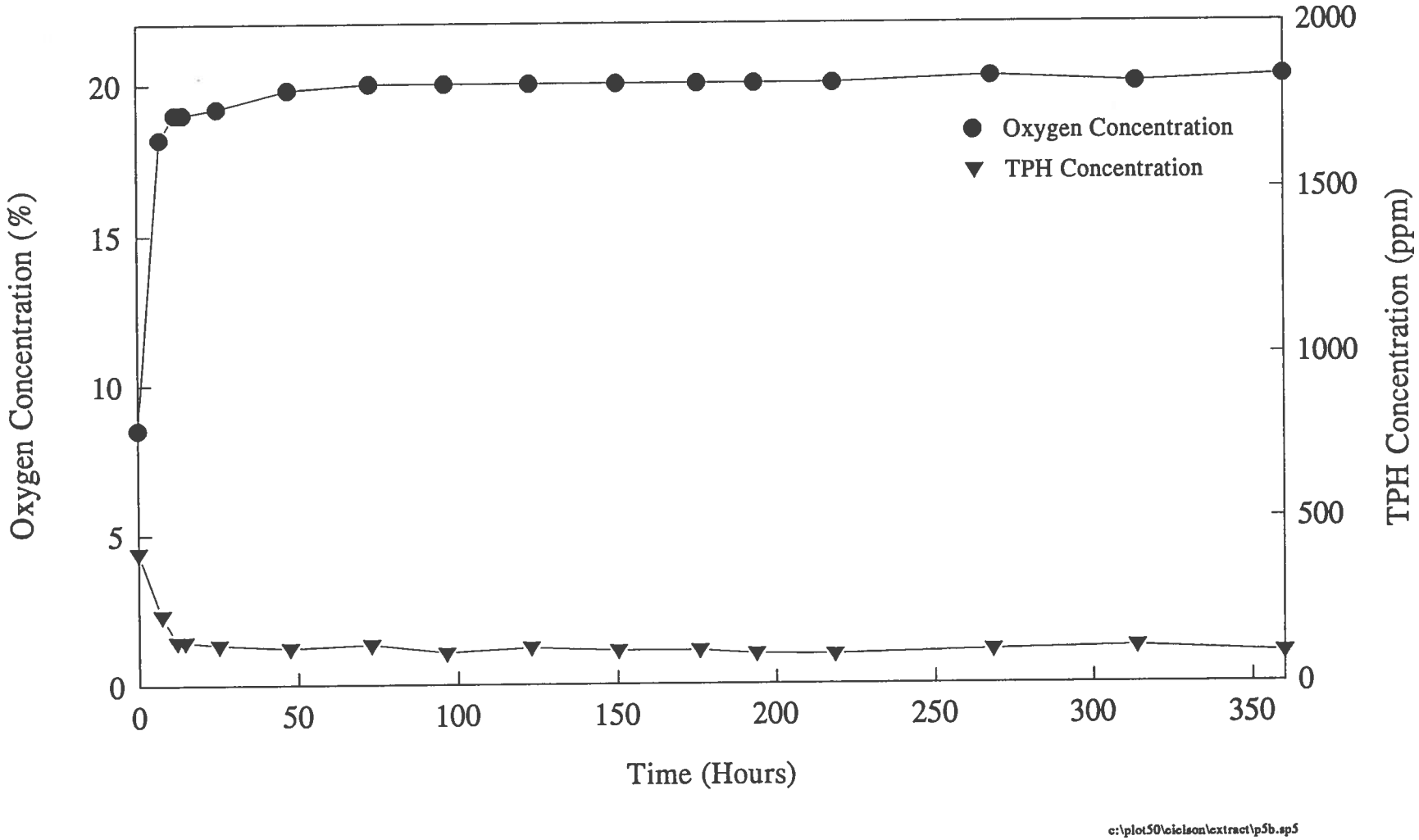


Figure I39. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P5b

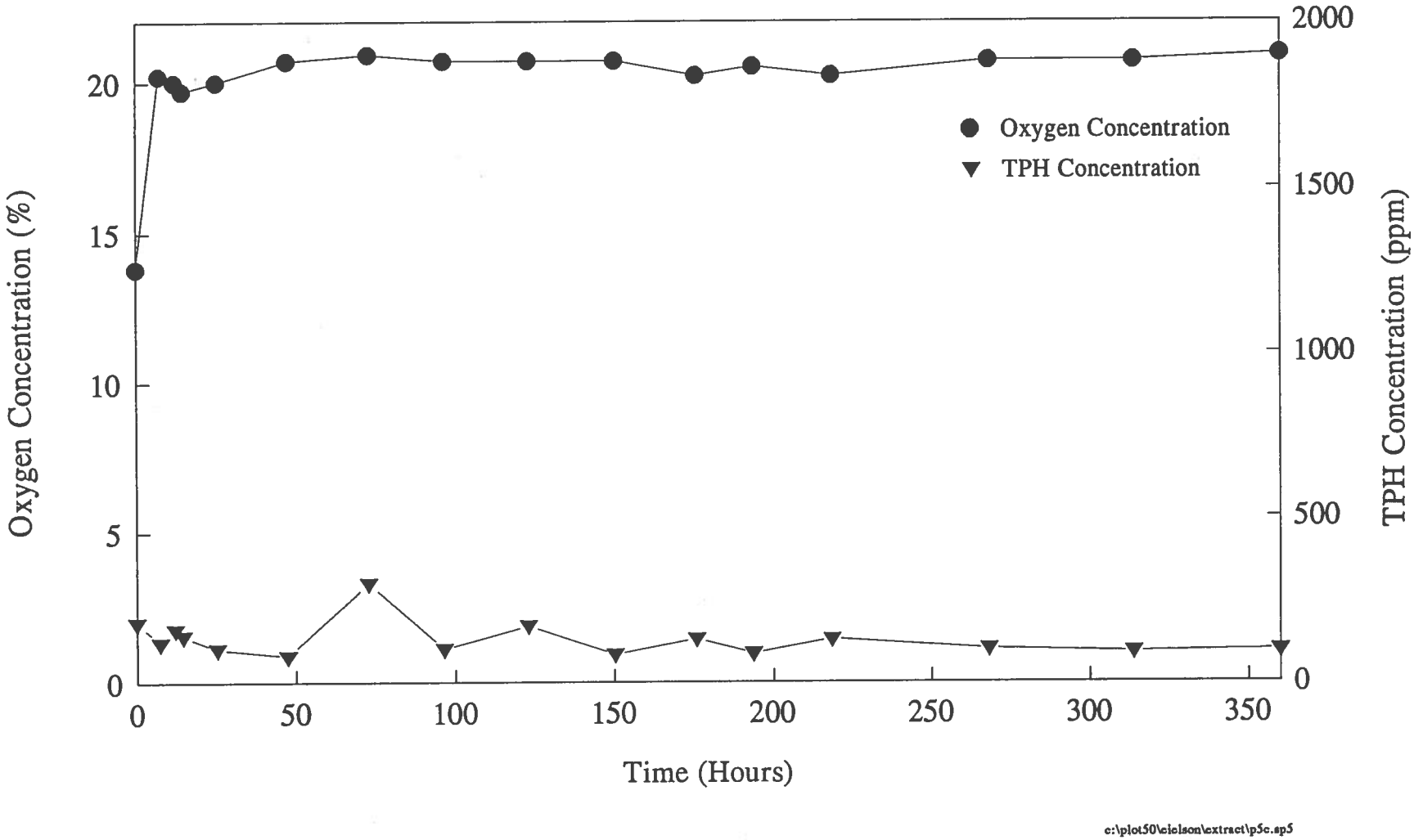


Figure I40. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P5c

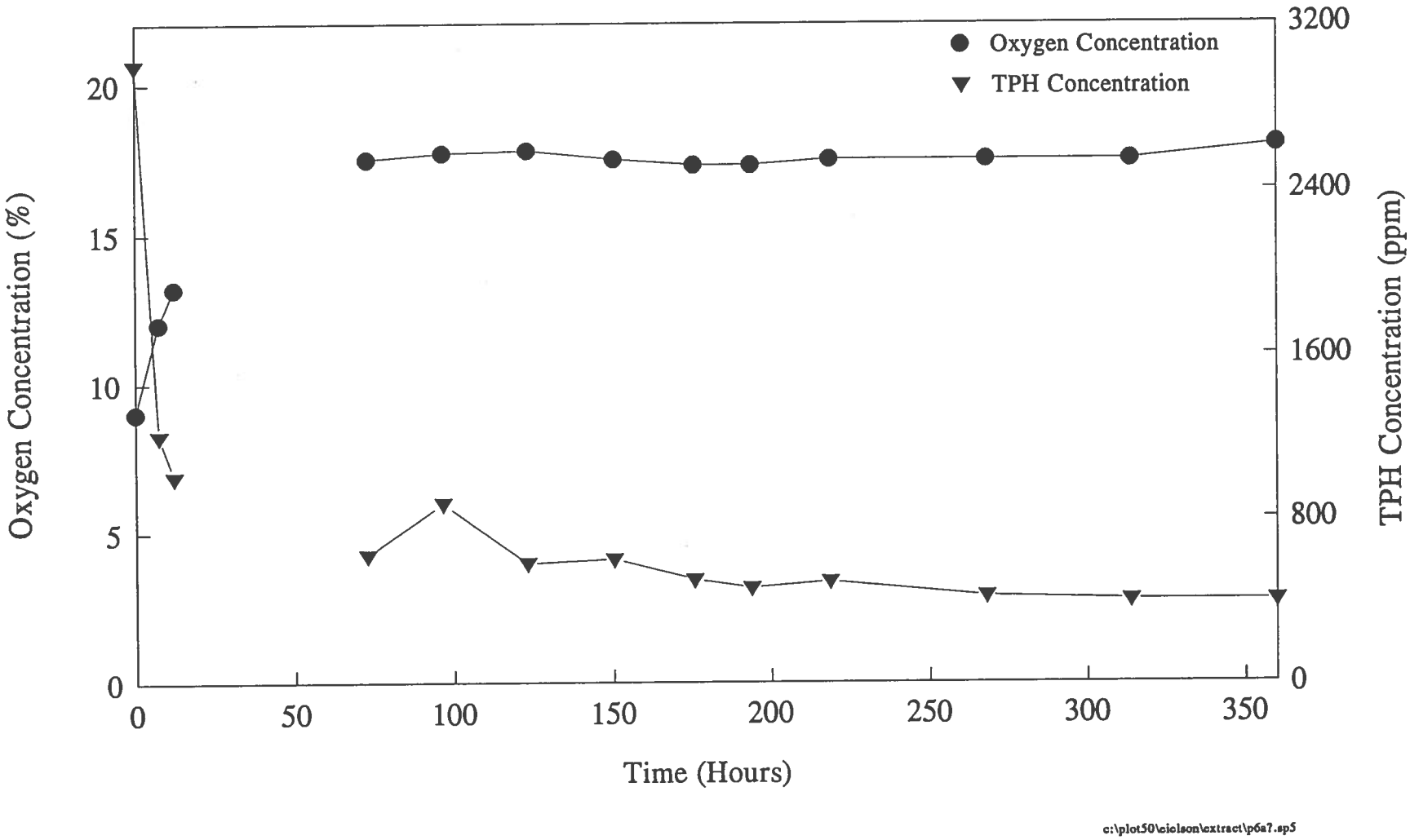


Figure I41. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P6a

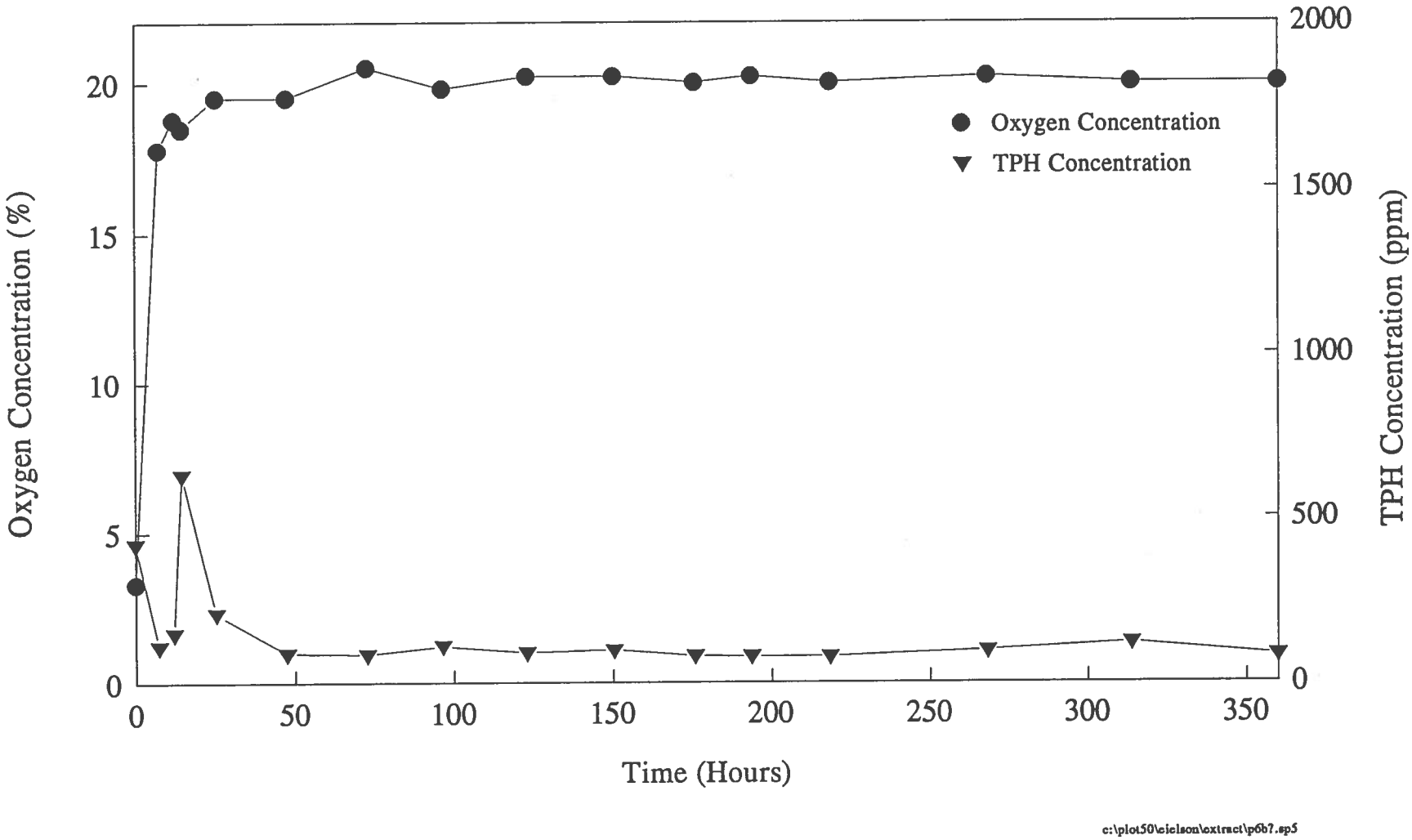


Figure I42. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P6b

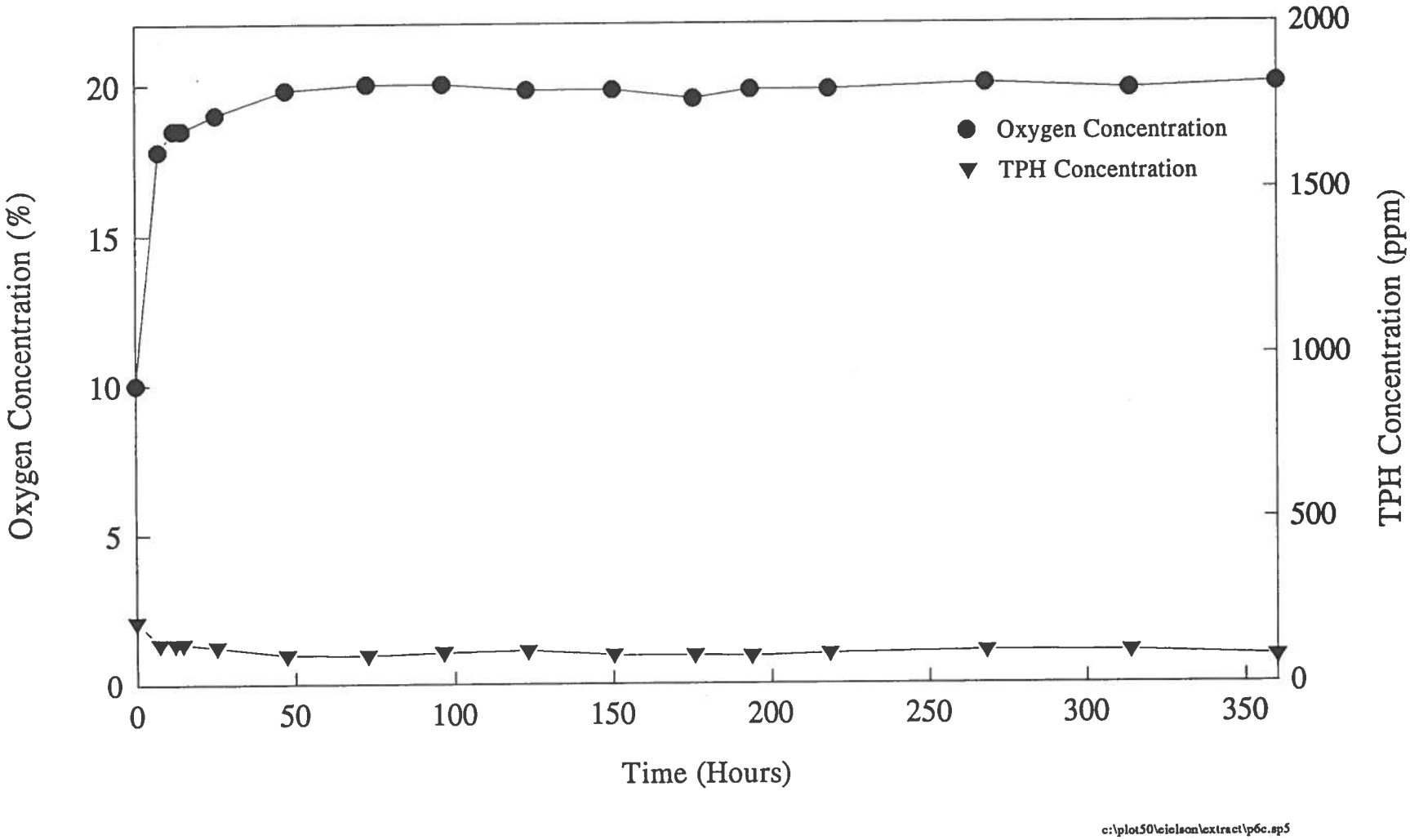


Figure I43. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P6c

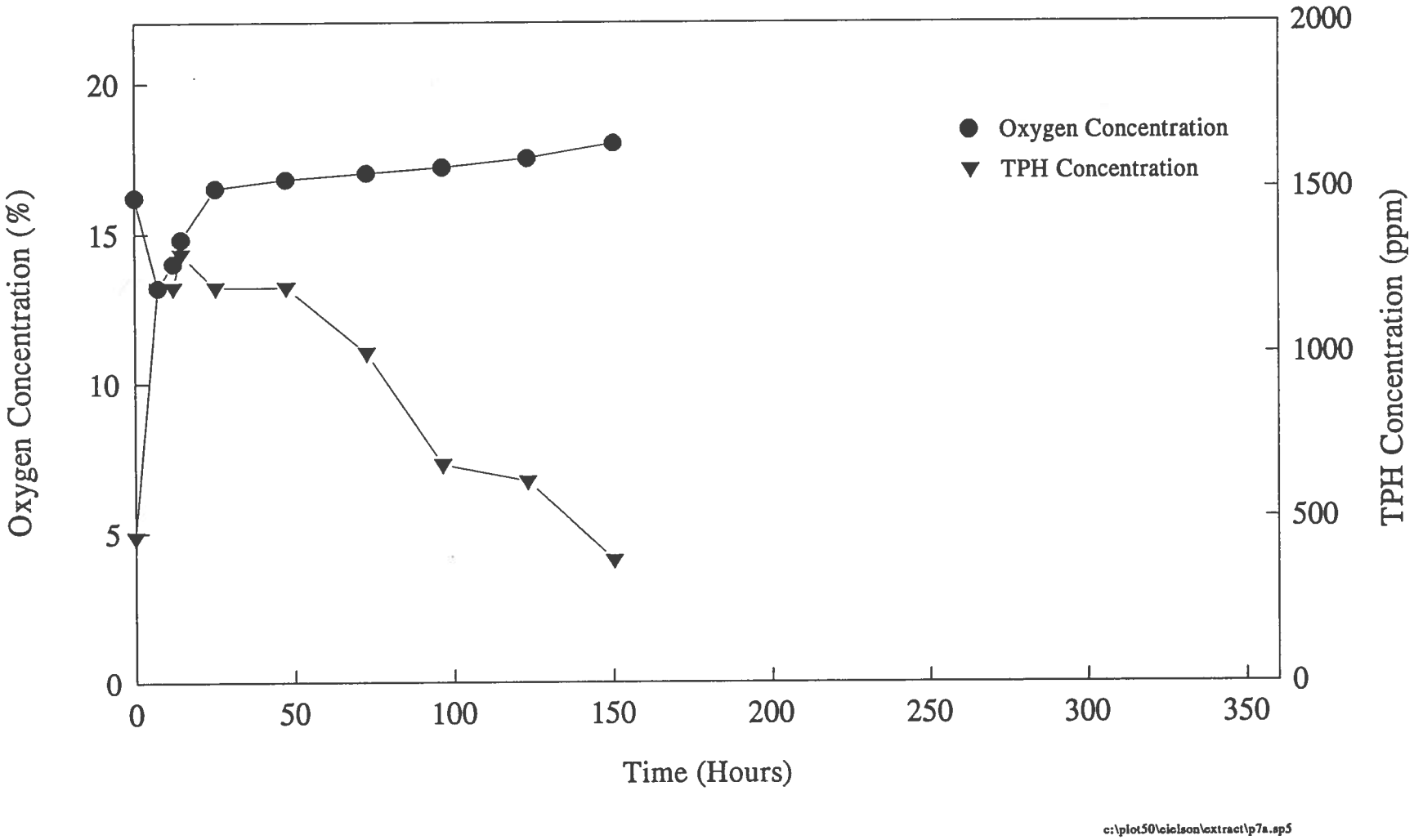


Figure I44. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P7a

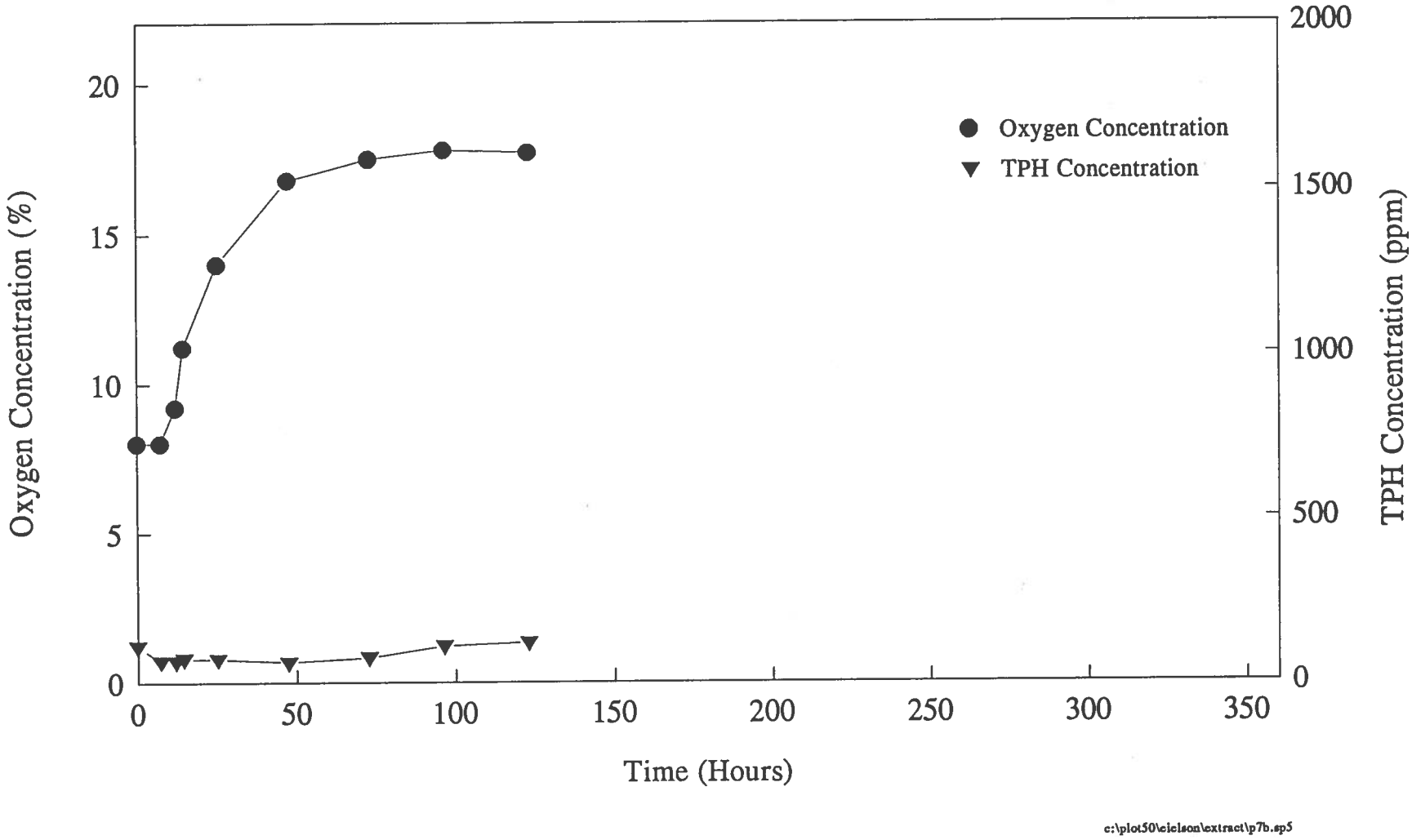


Figure I45. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P7b

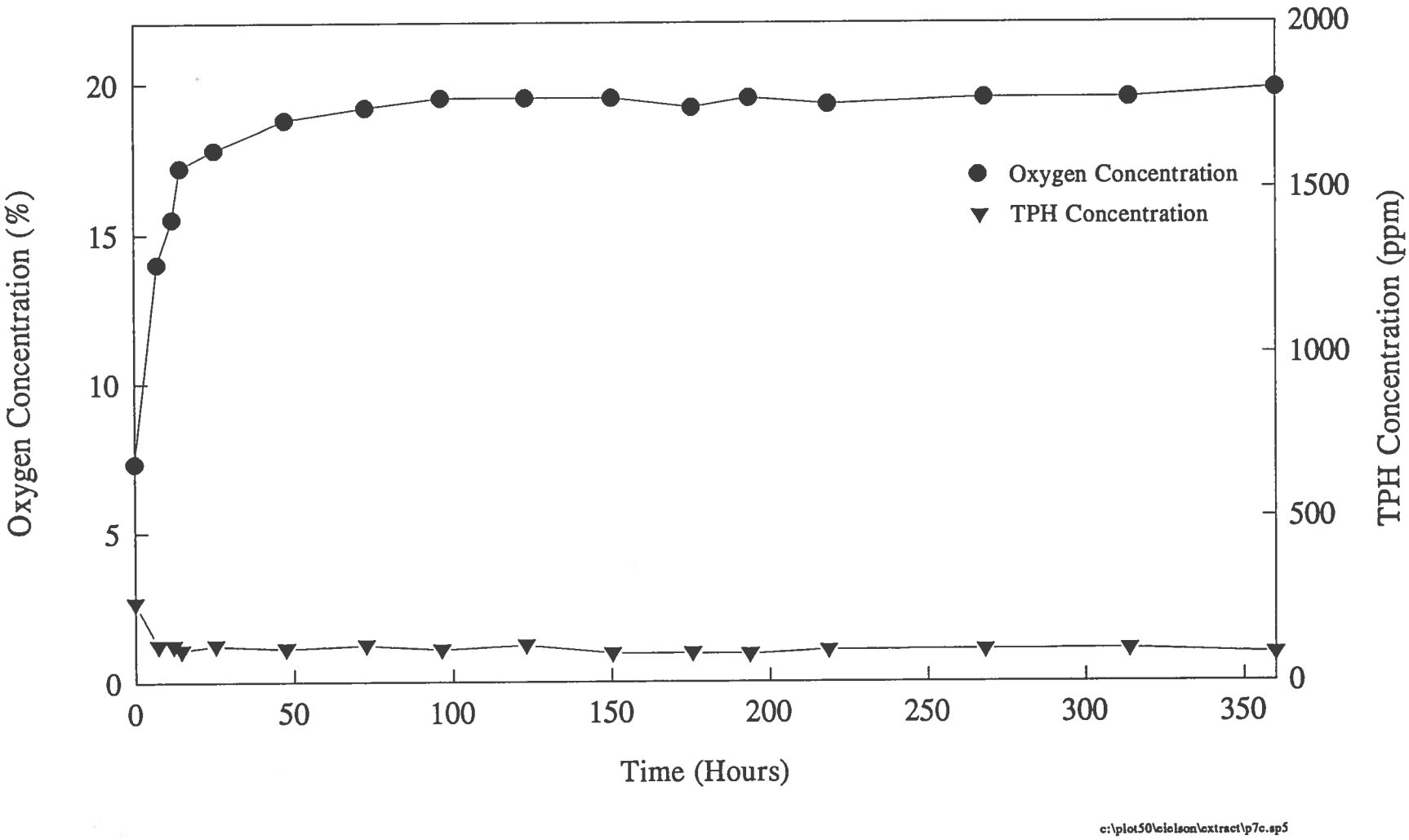


Figure I46. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P7c

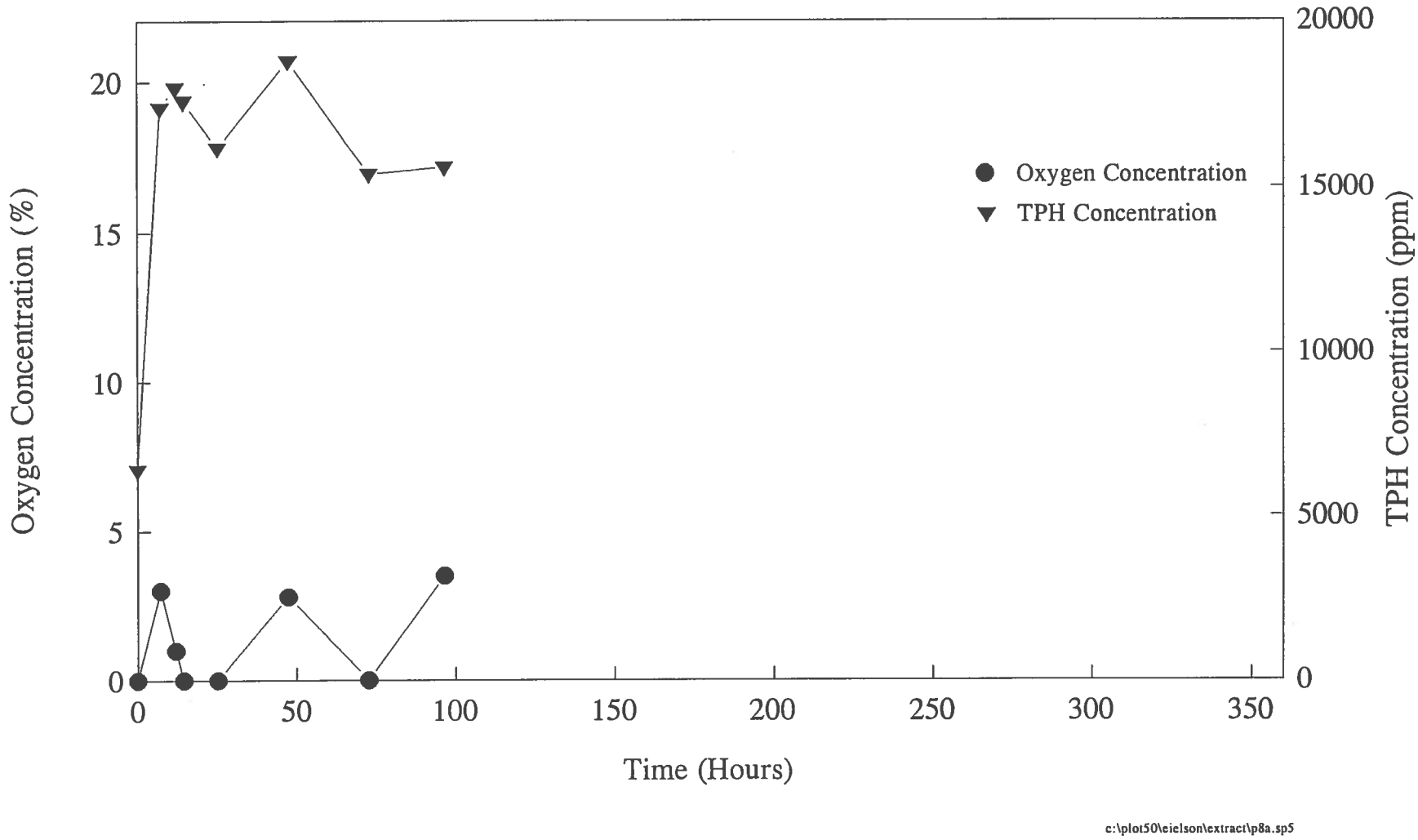


Figure I47. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P8a

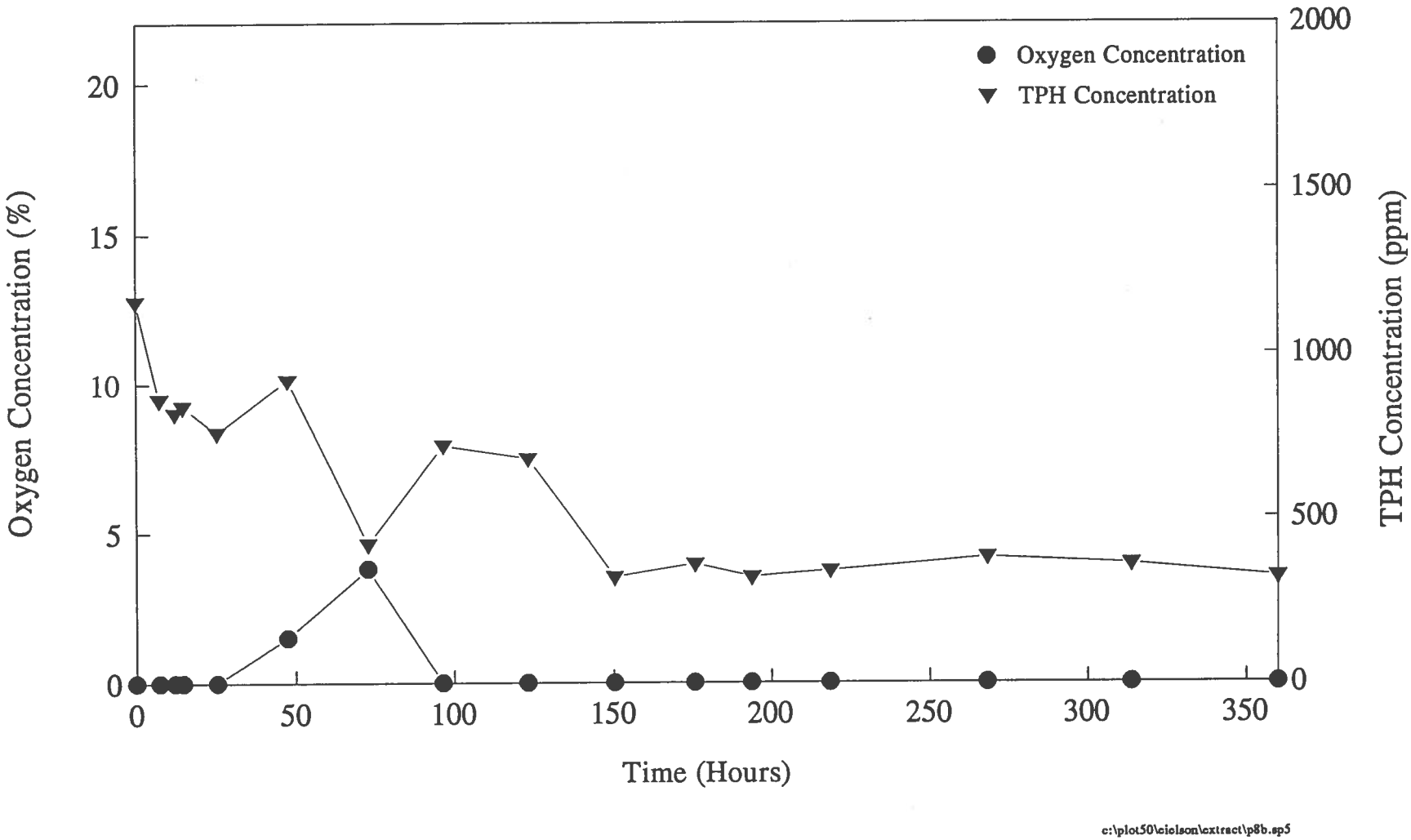


Figure I48. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P8b

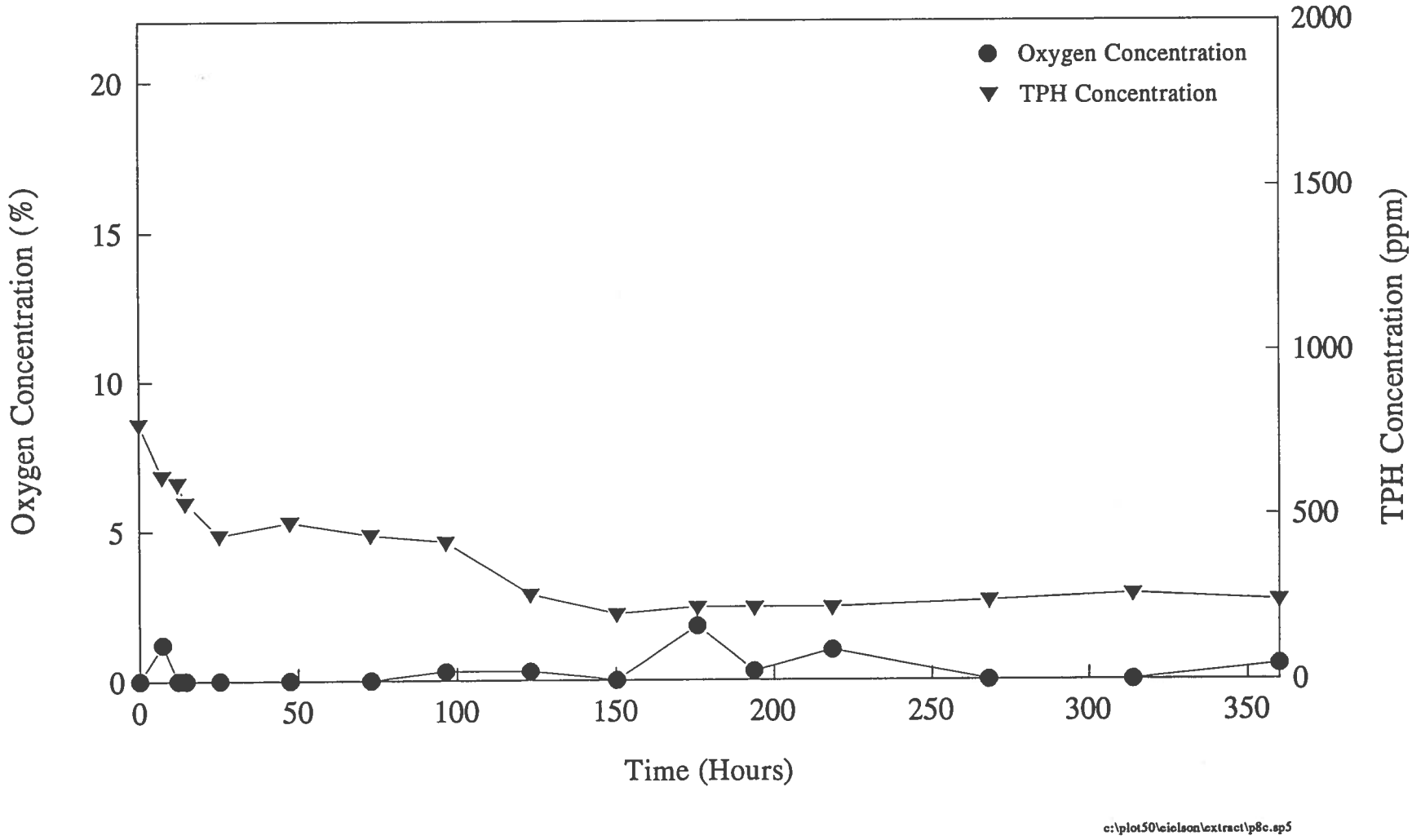


Figure I49. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point P8c

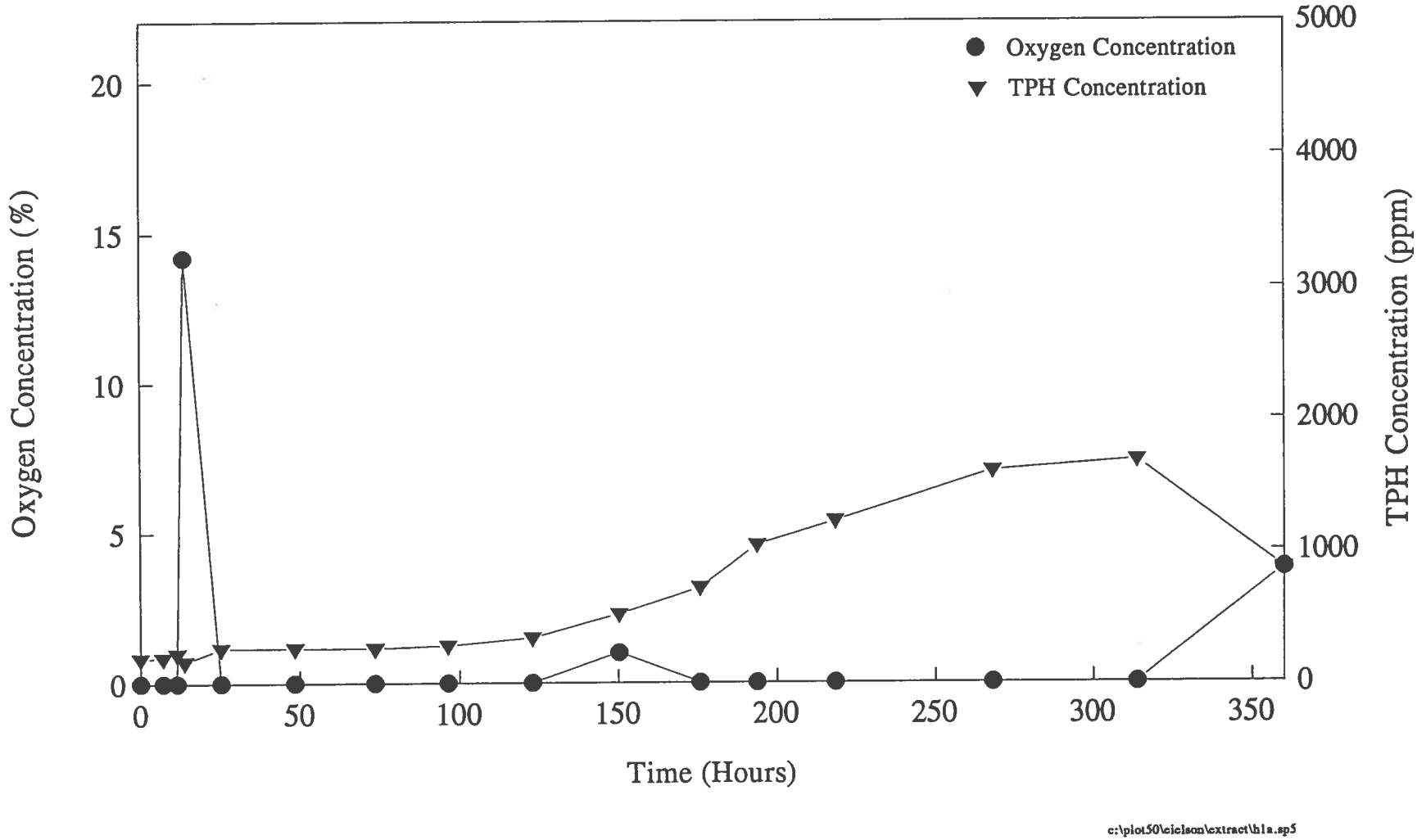


Figure I50. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point H1a

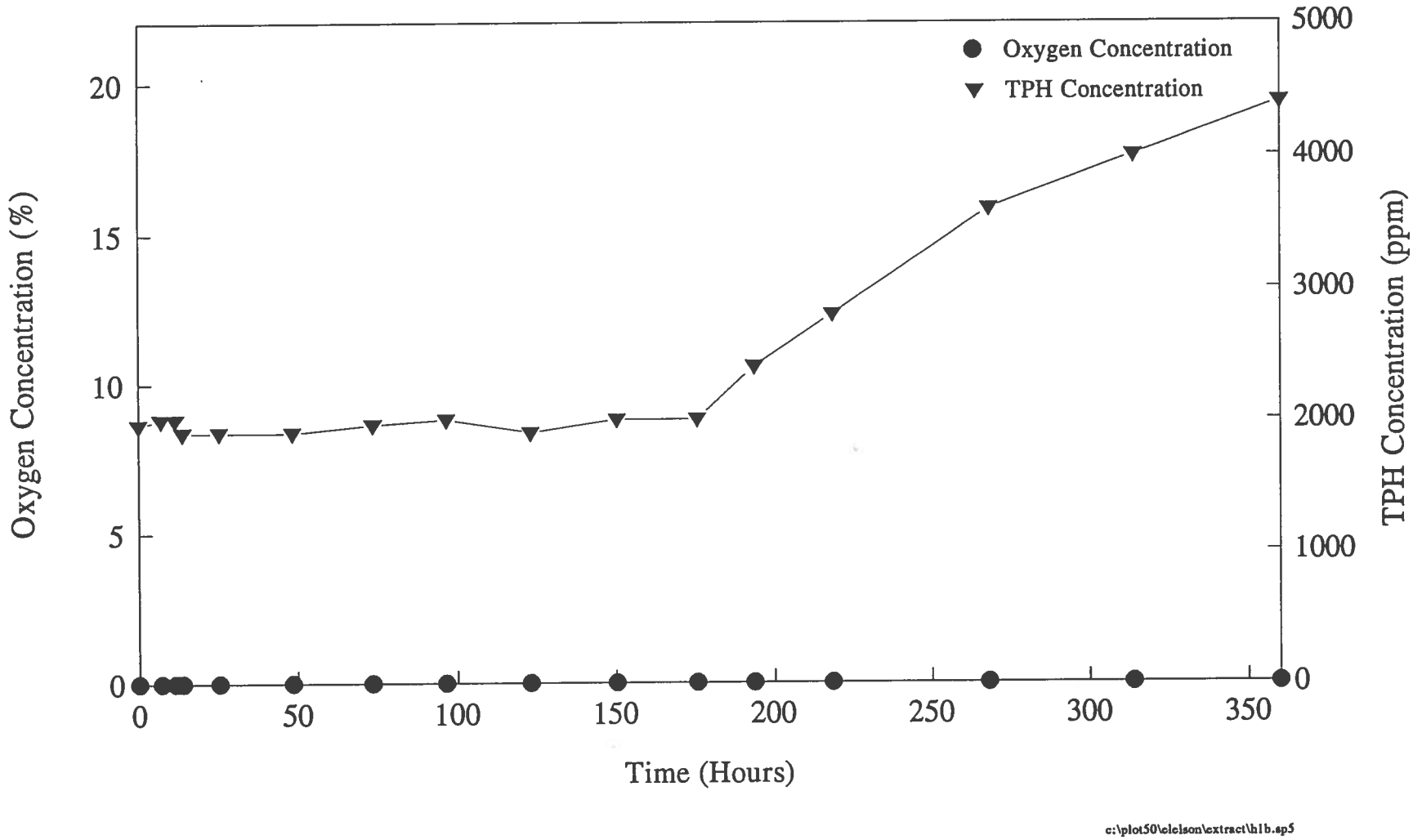


Figure I51. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point H1b

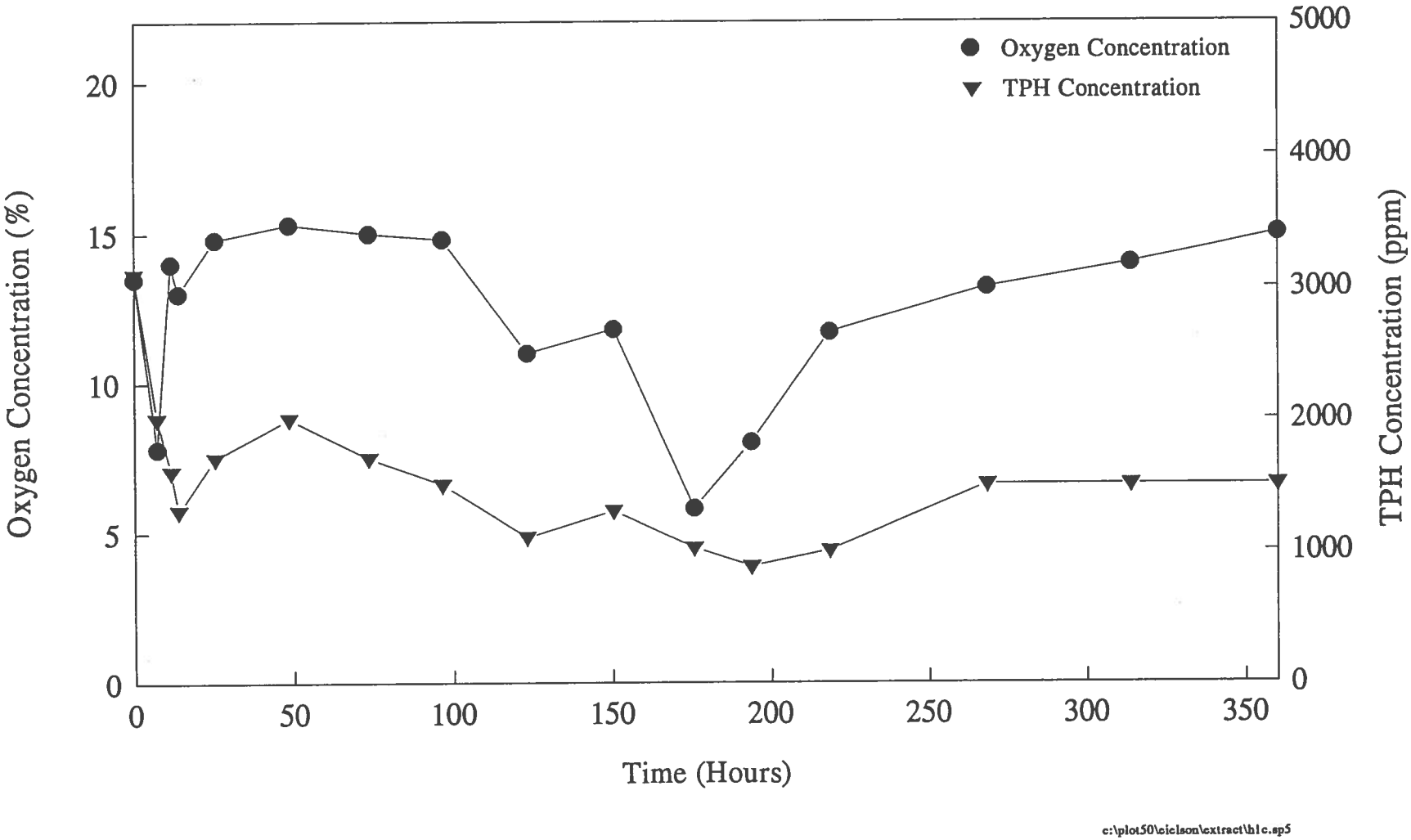


Figure I52. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point H1c

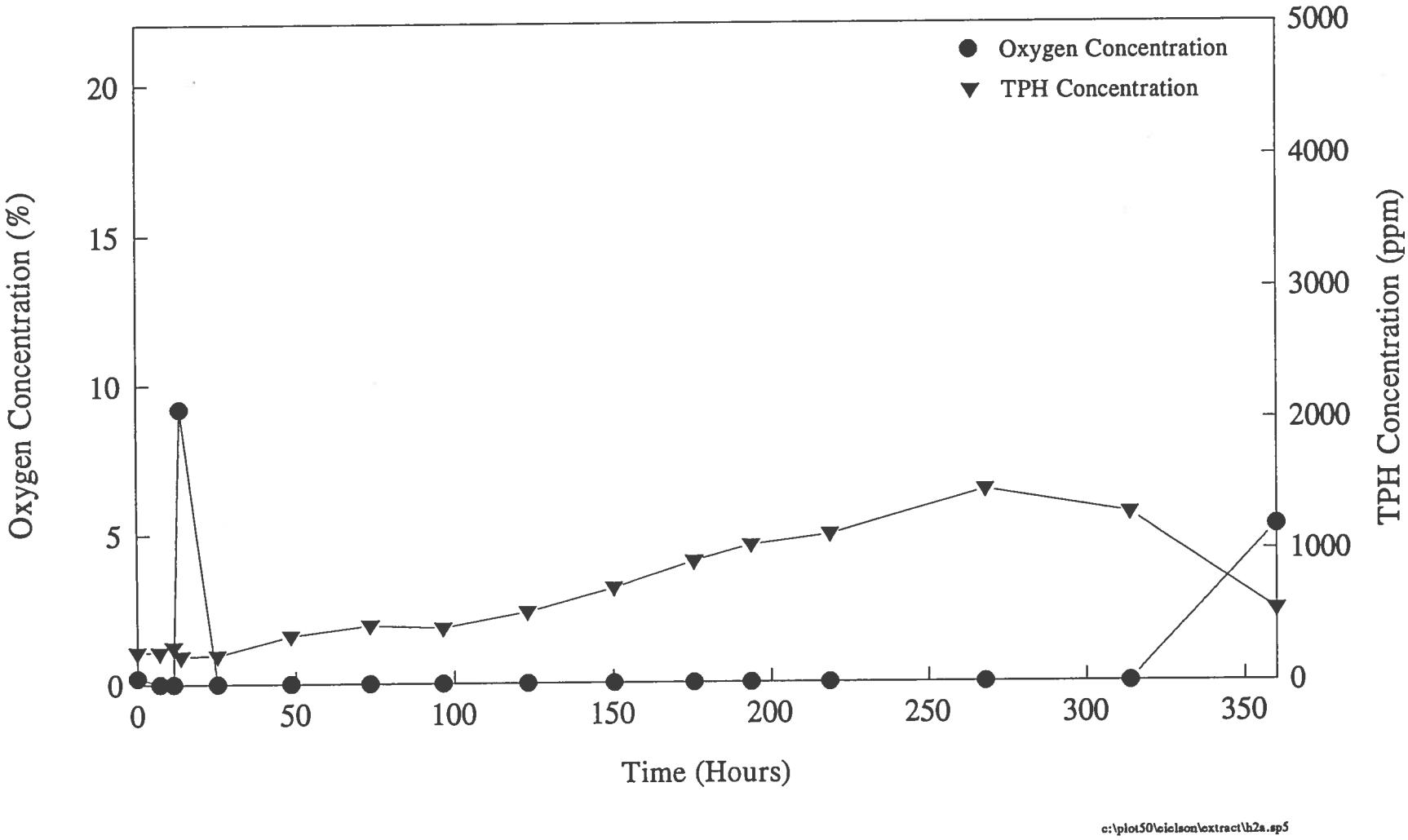


Figure I53. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point H2a

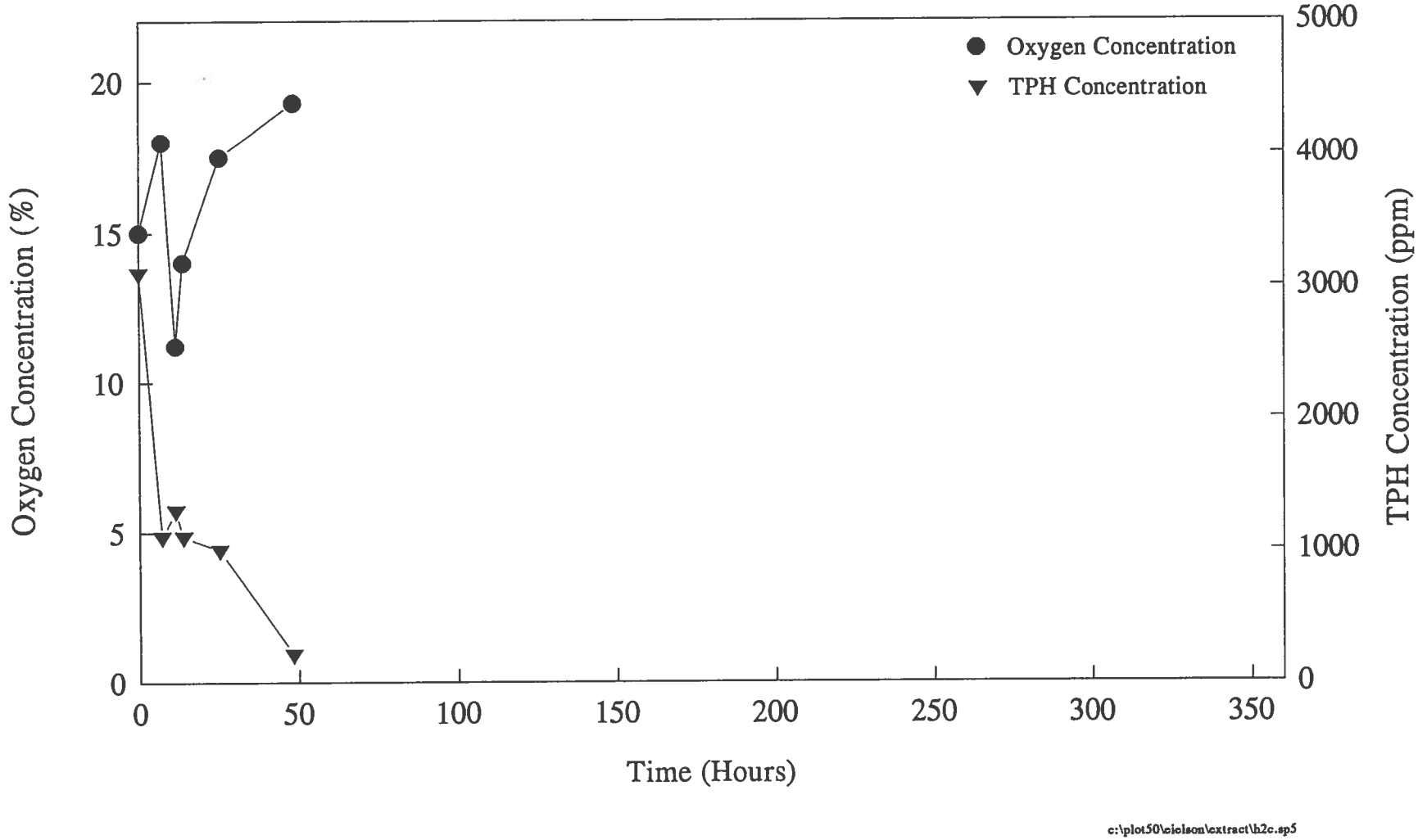


Figure I54. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point H2c

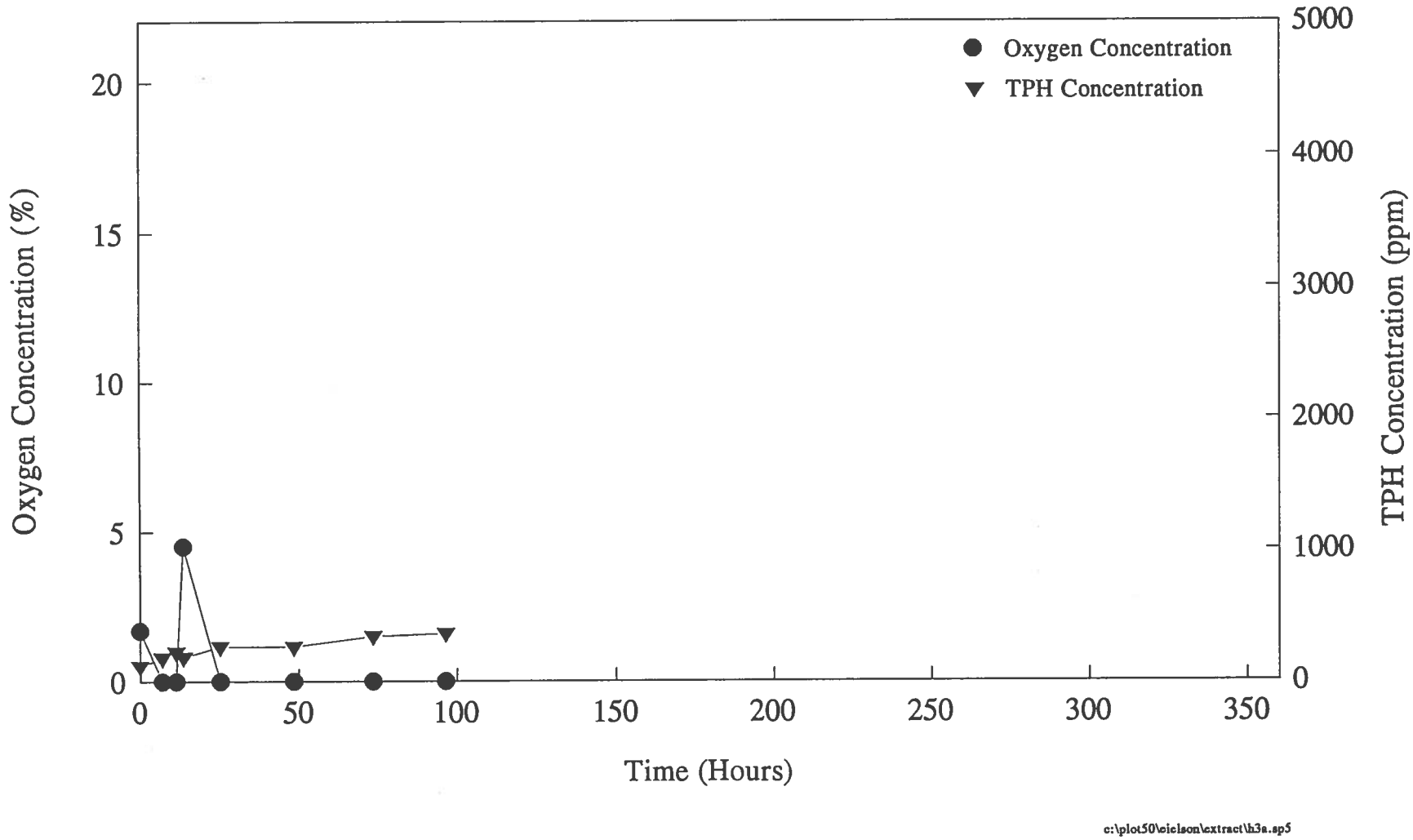


Figure I55. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point H3a

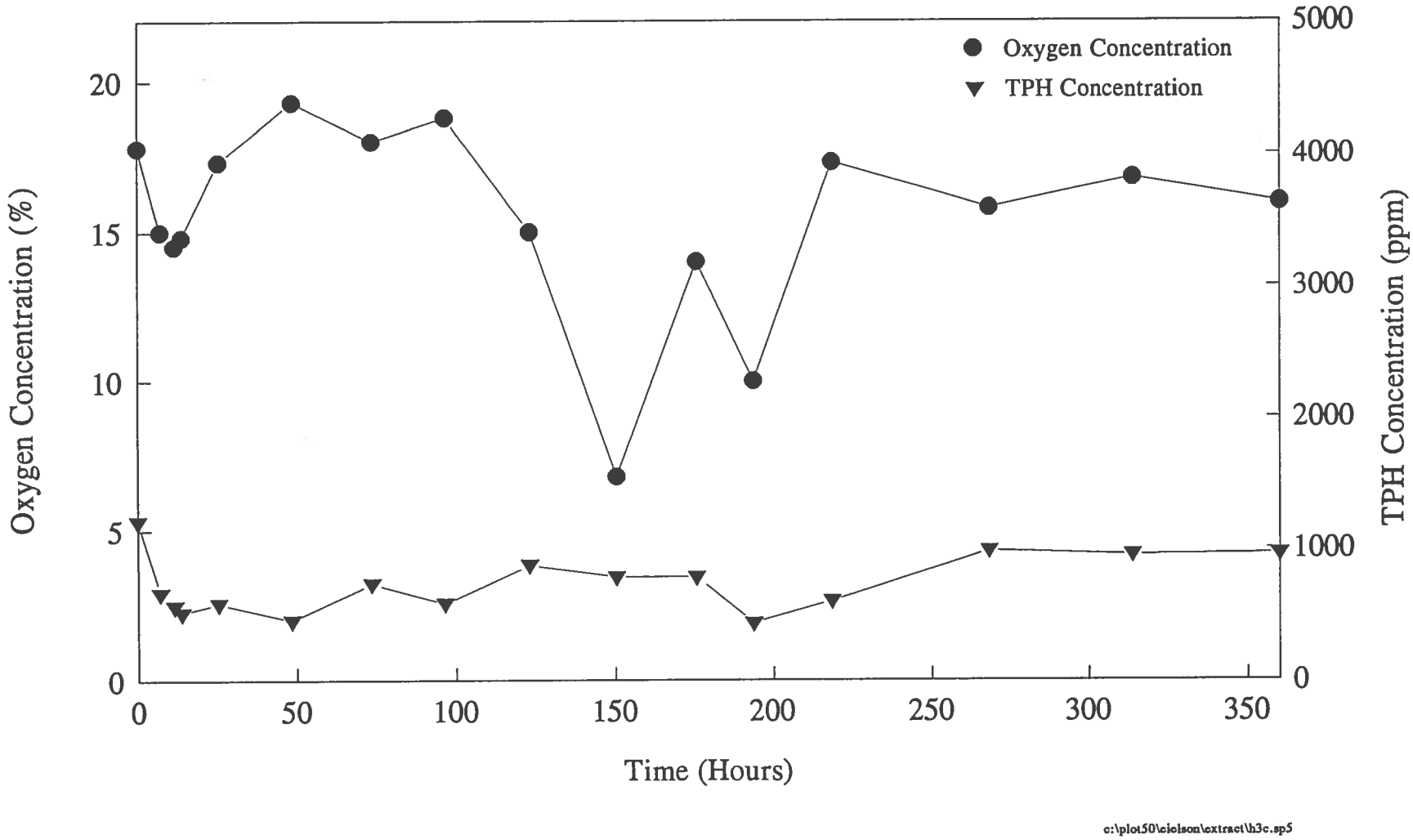


Figure I56. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point H3c

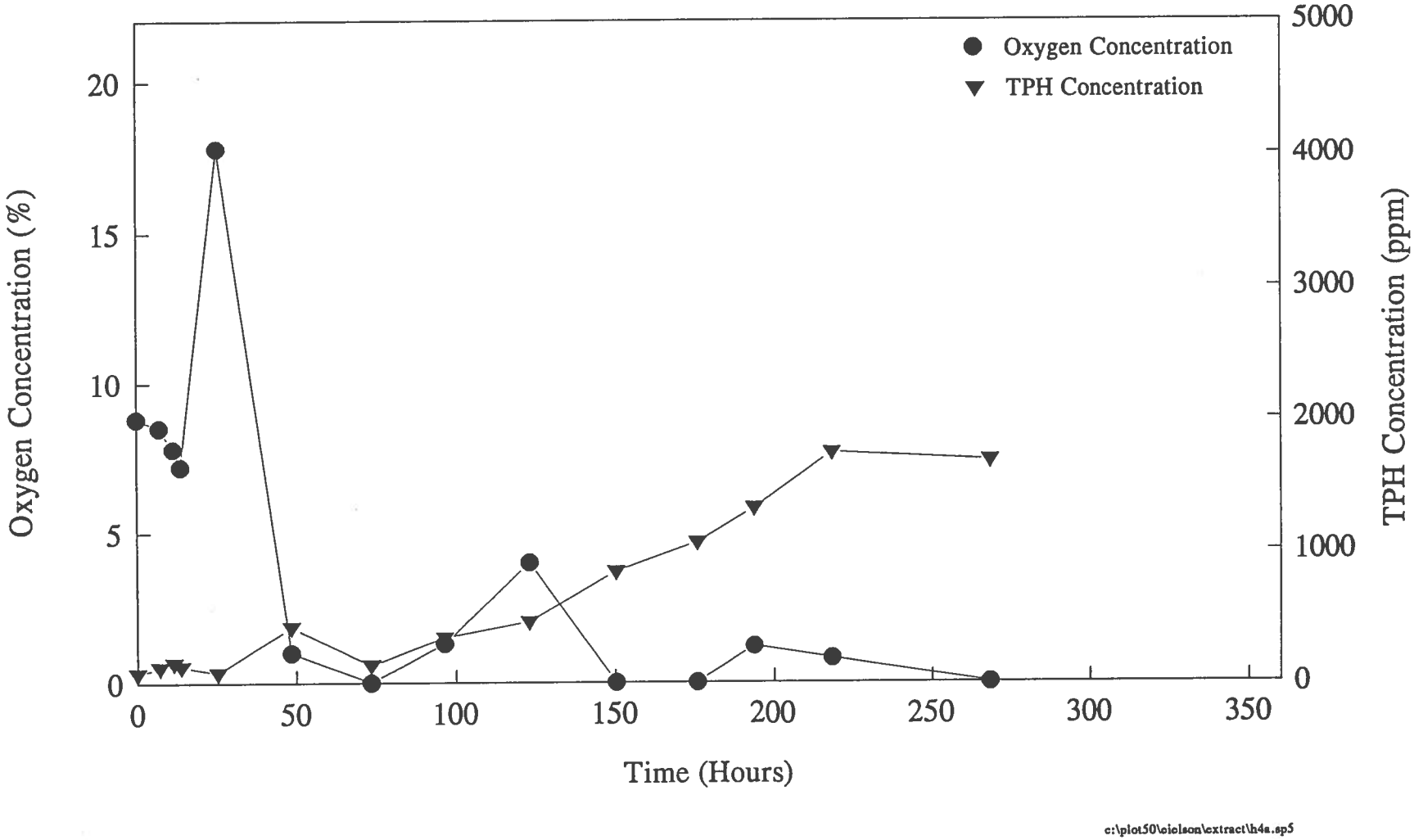


Figure I57. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point H4a

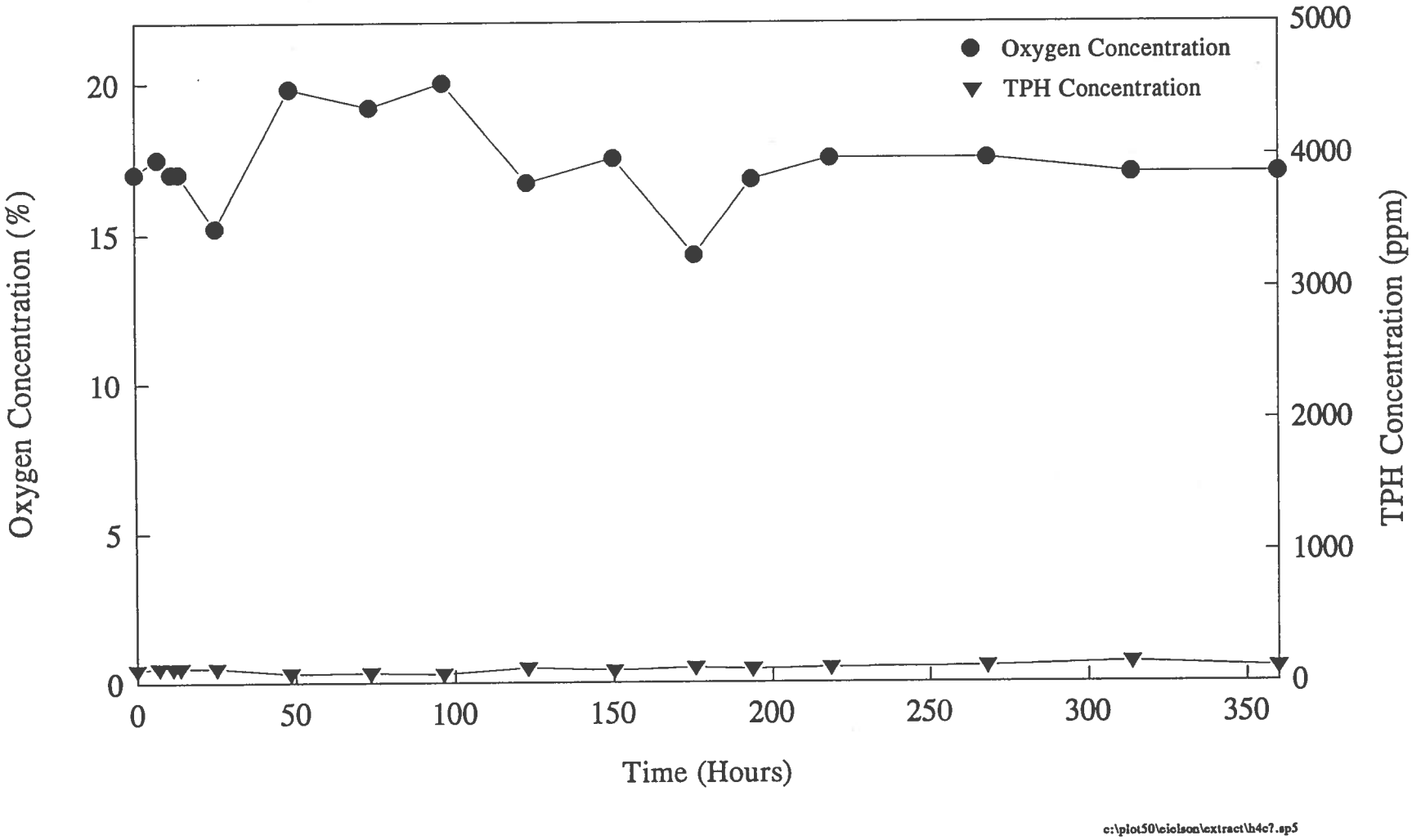


Figure I 58. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point H4c

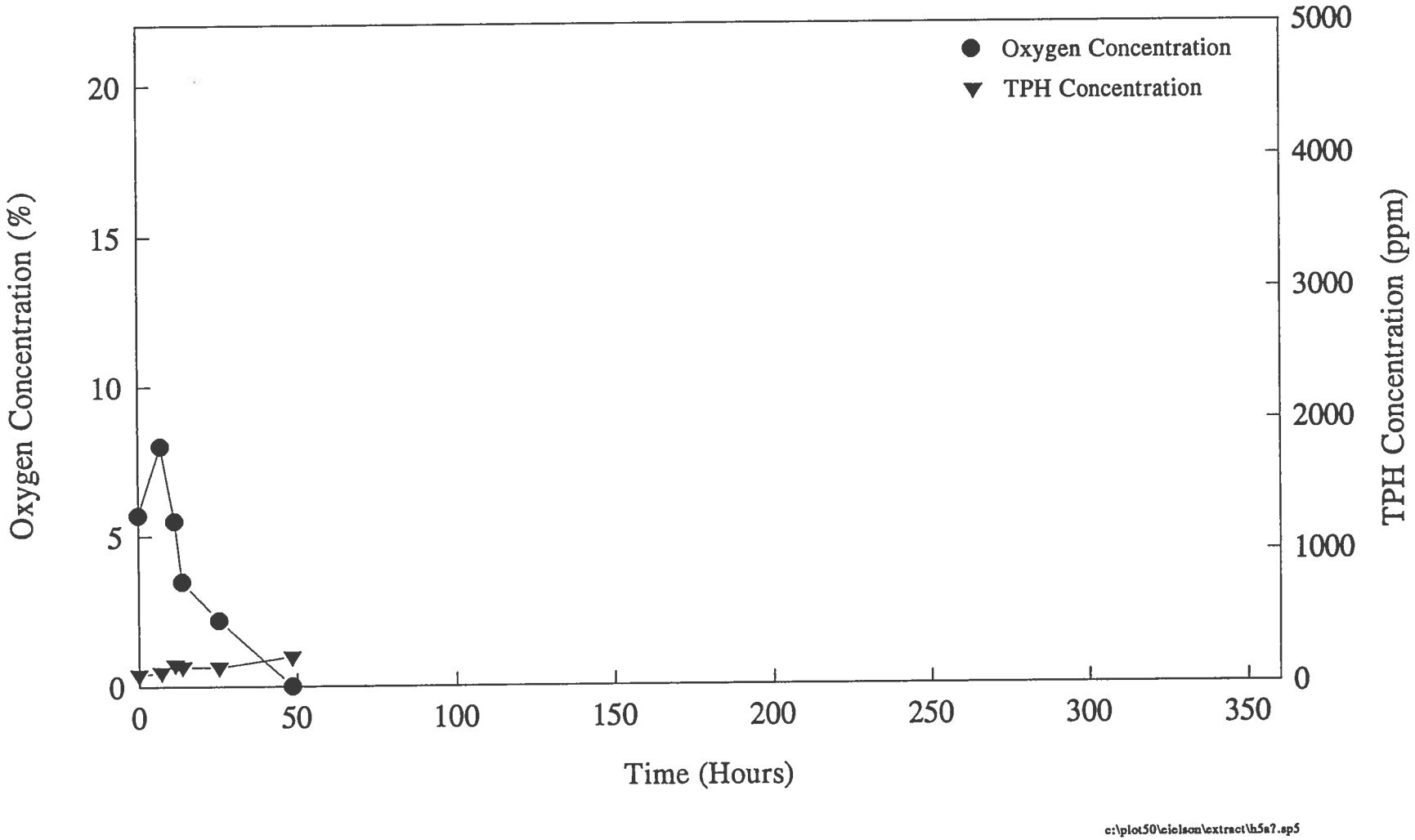


Figure I59. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point H5a

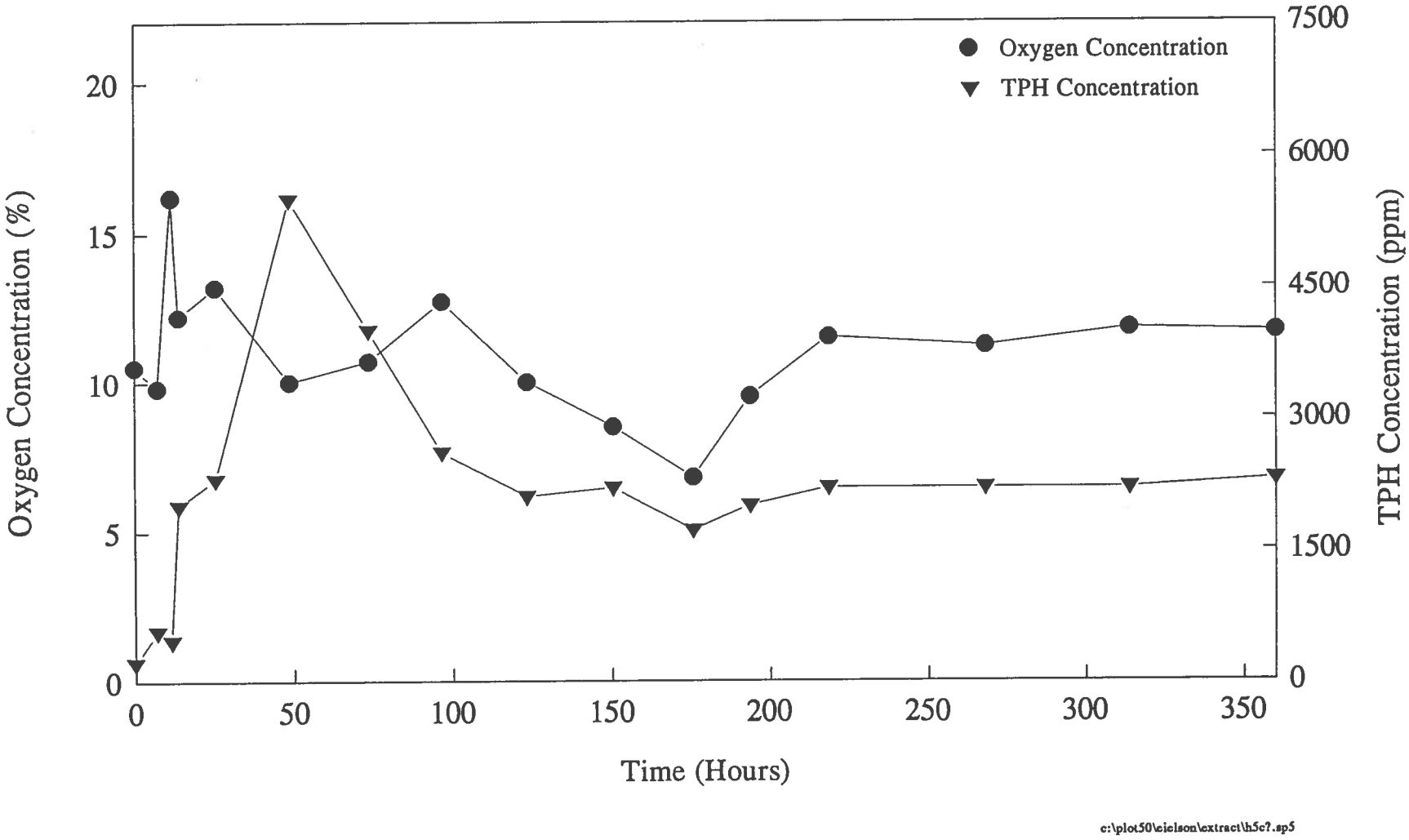


Figure I60. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point H5c

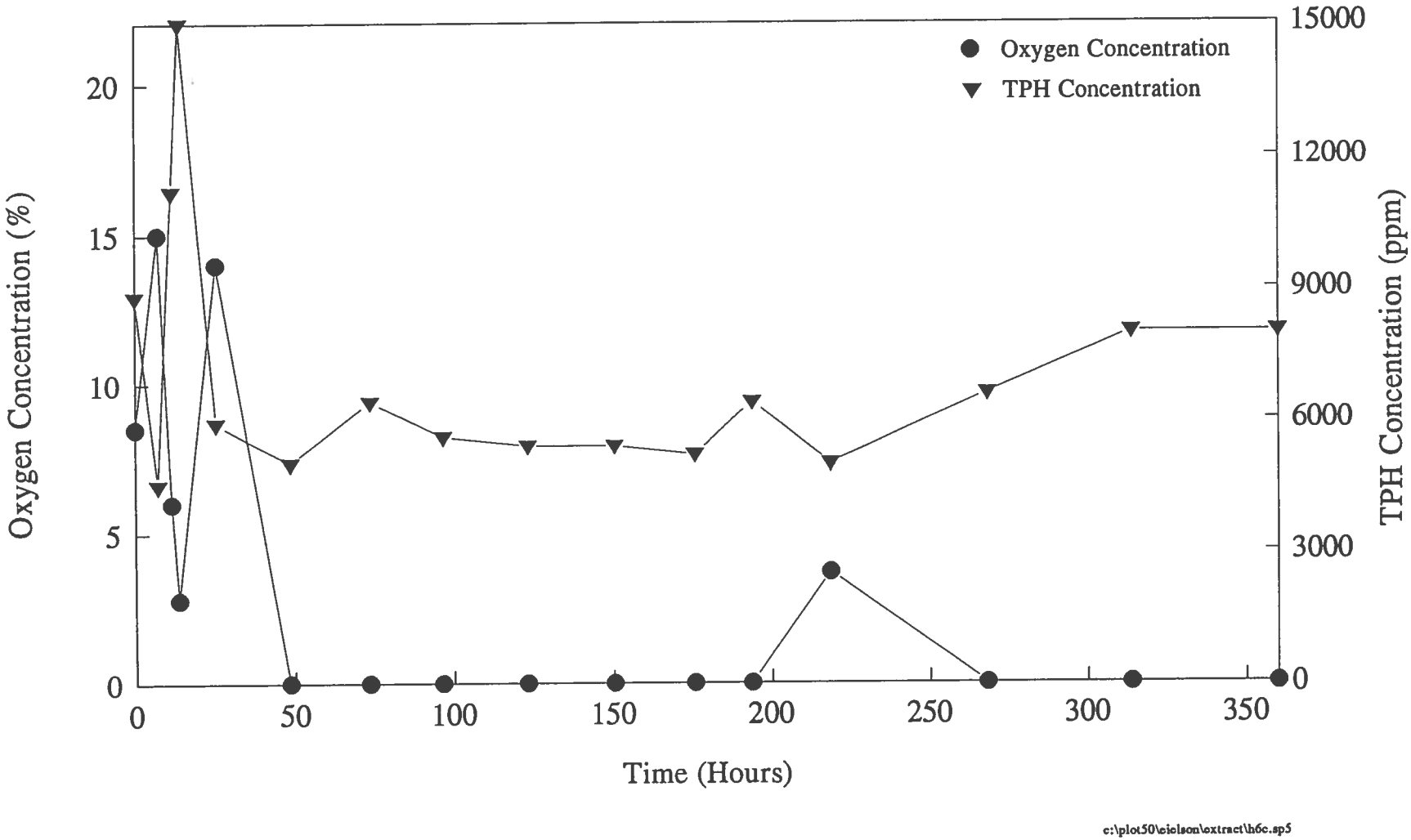


Figure I61. Soil Gas Oxygen and TPH Concentrations During the Extraction Test at Monitoring Point H6c

APPENDIX J

EXTRACTION WITH REINJECTION TEST DATA

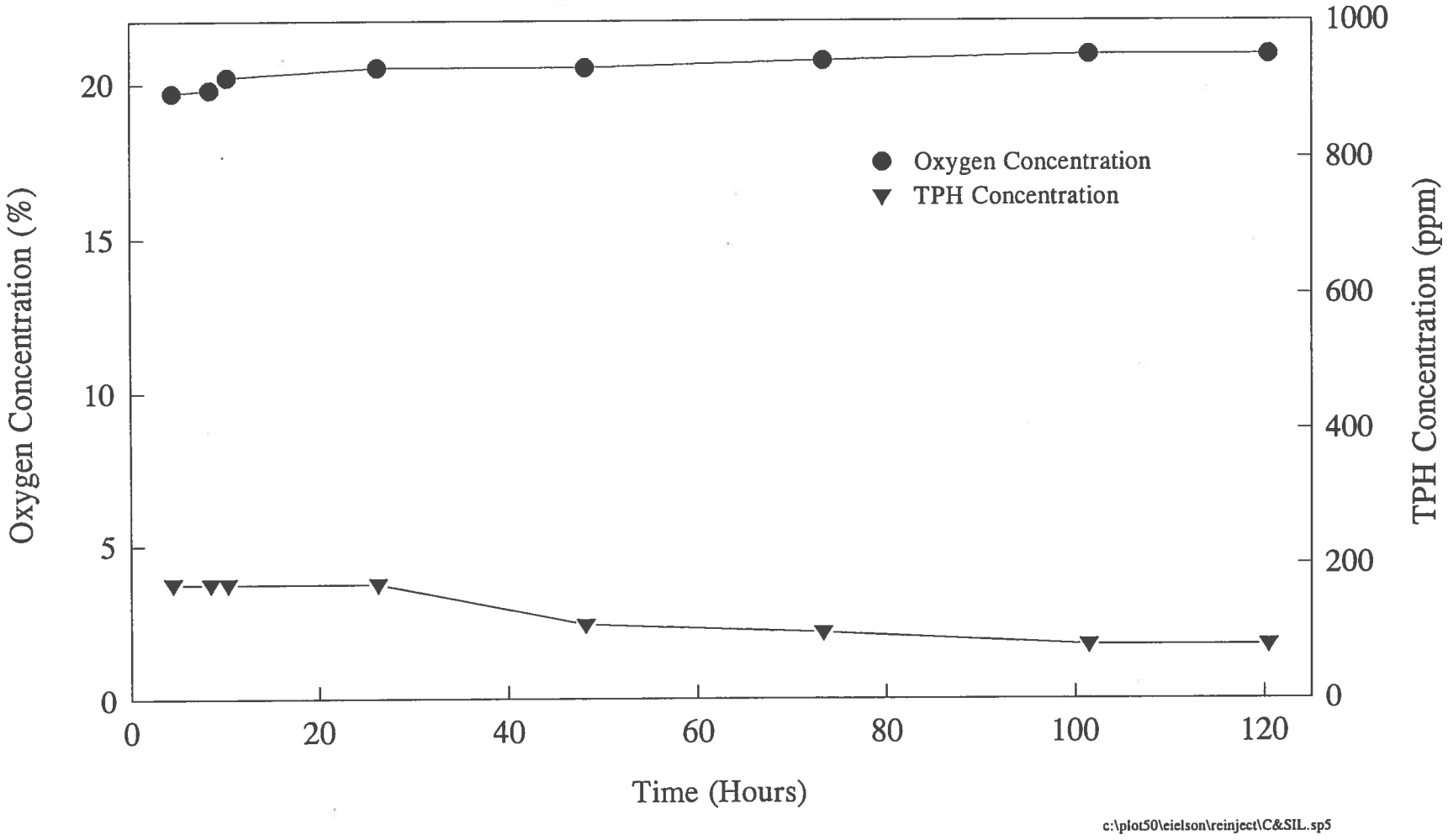


Figure J1. Soil Gas Oxygen and TPH Concentrations From All Test Plots During the Extraction with Reinjection Test

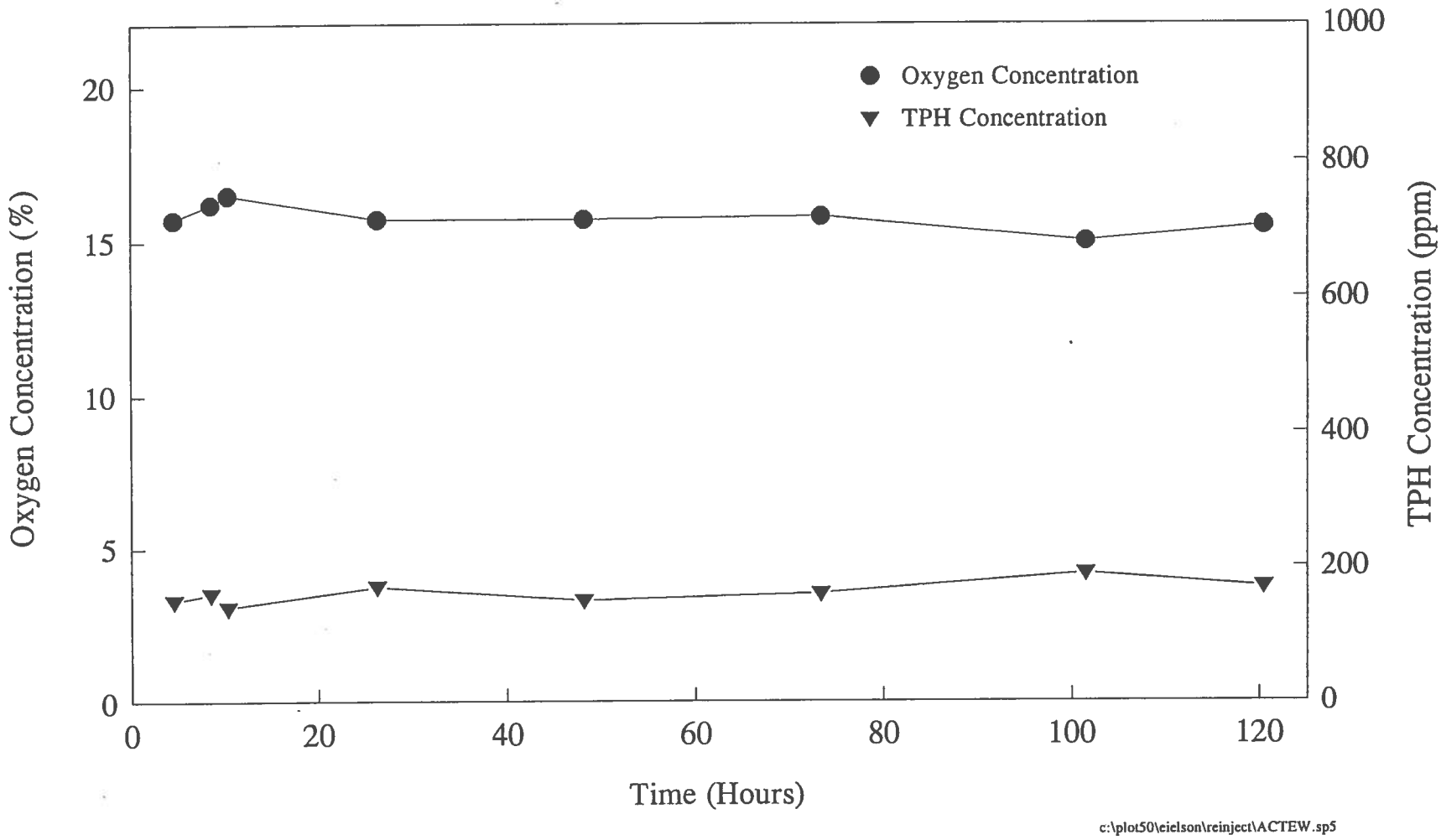


Figure J2. Soil Gas Oxygen and TPH Concentrations From the Active Warming Test Plot During the Extraction with Reinjection Test

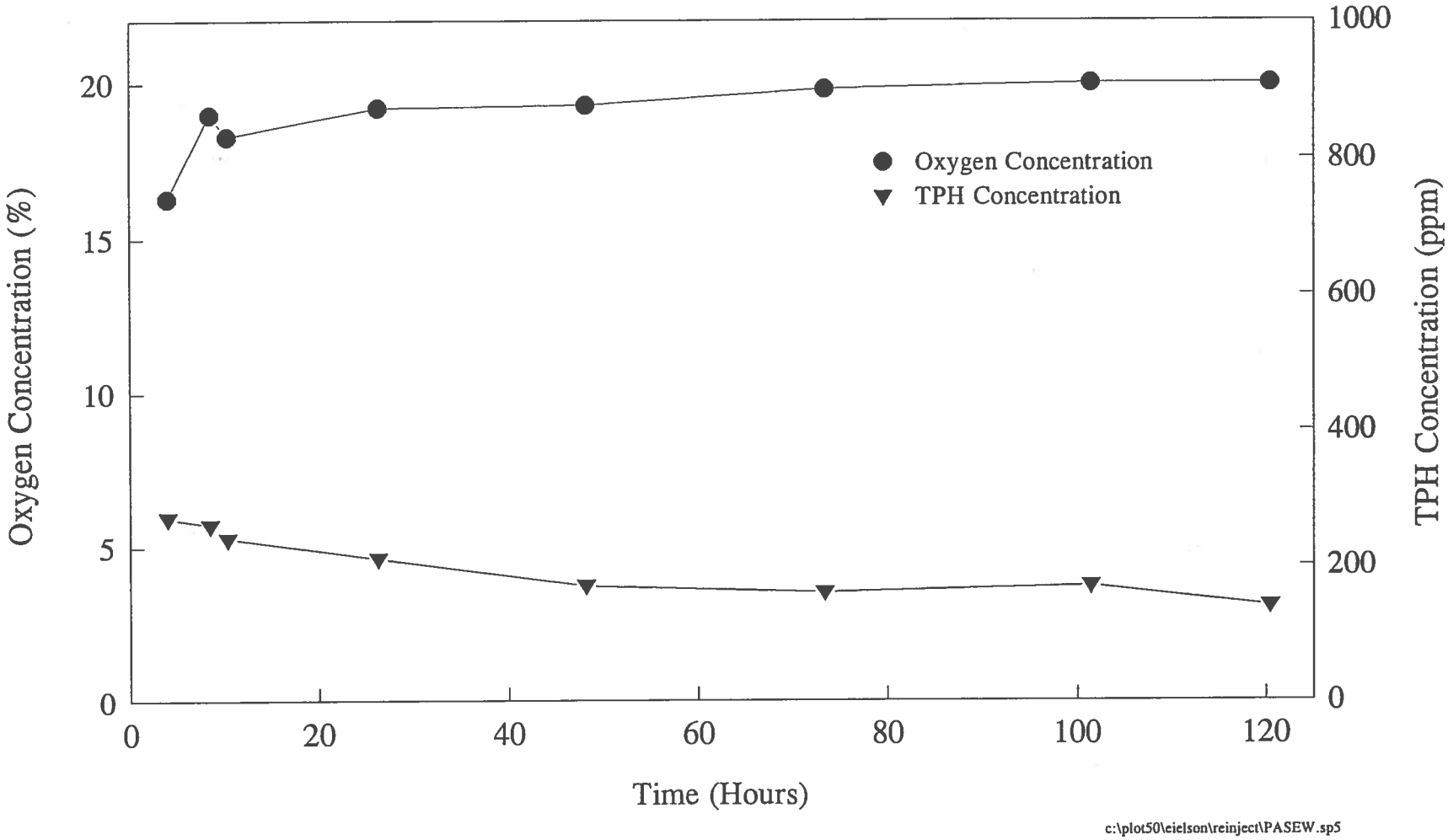


Figure J3. Soil Gas Oxygen and TPH Concentrations From the Passive Warming Test Plot During the Extraction with Reinjection Test

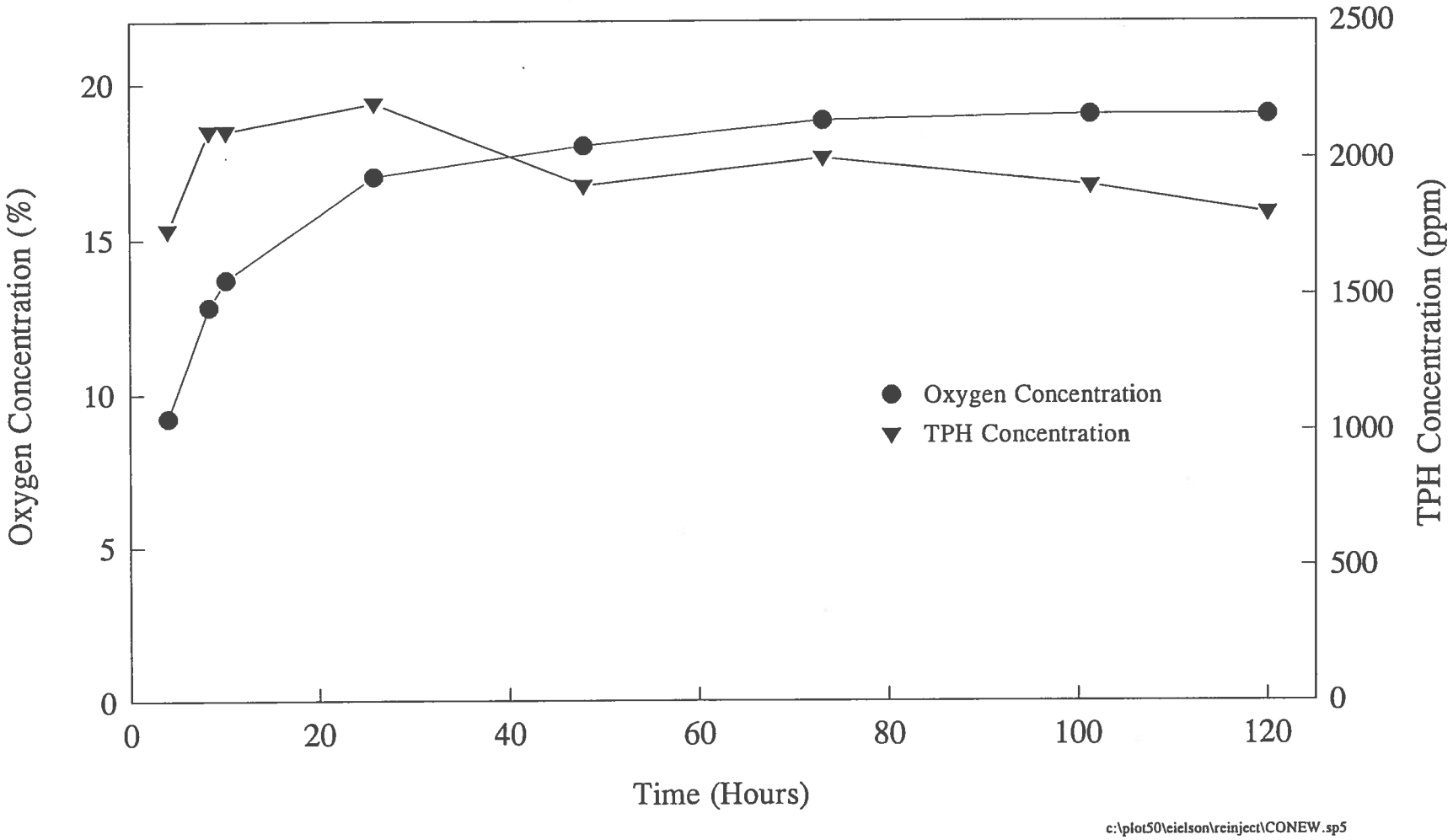


Figure J4. Soil Gas Oxygen and TPH Concentrations From the Control Test Plot During the Extraction with Reinjection Test

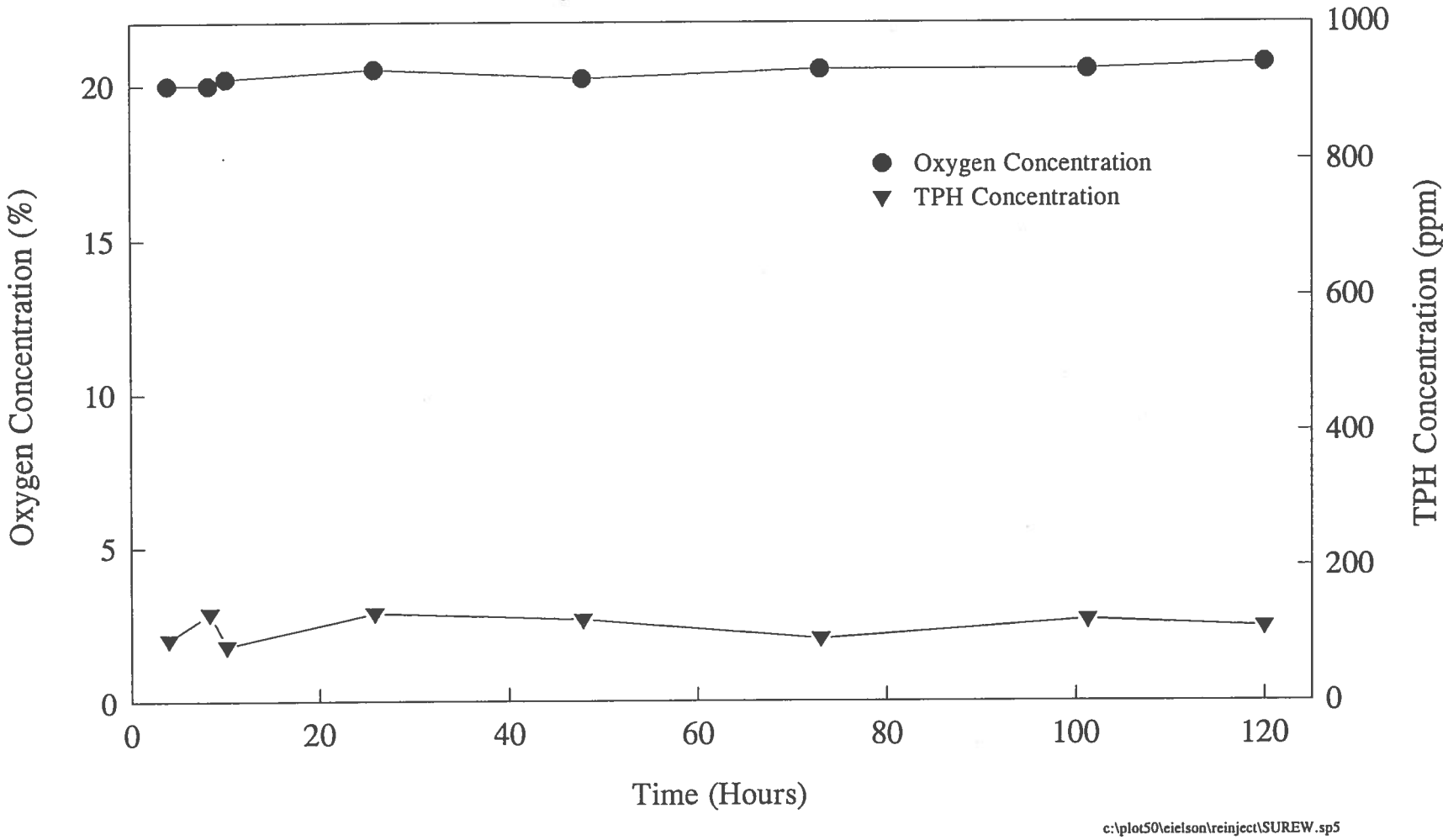


Figure J5. Soil Gas Oxygen and TPH Concentrations From the Surface Warming Test Plot During the Extraction with Reinjection Test

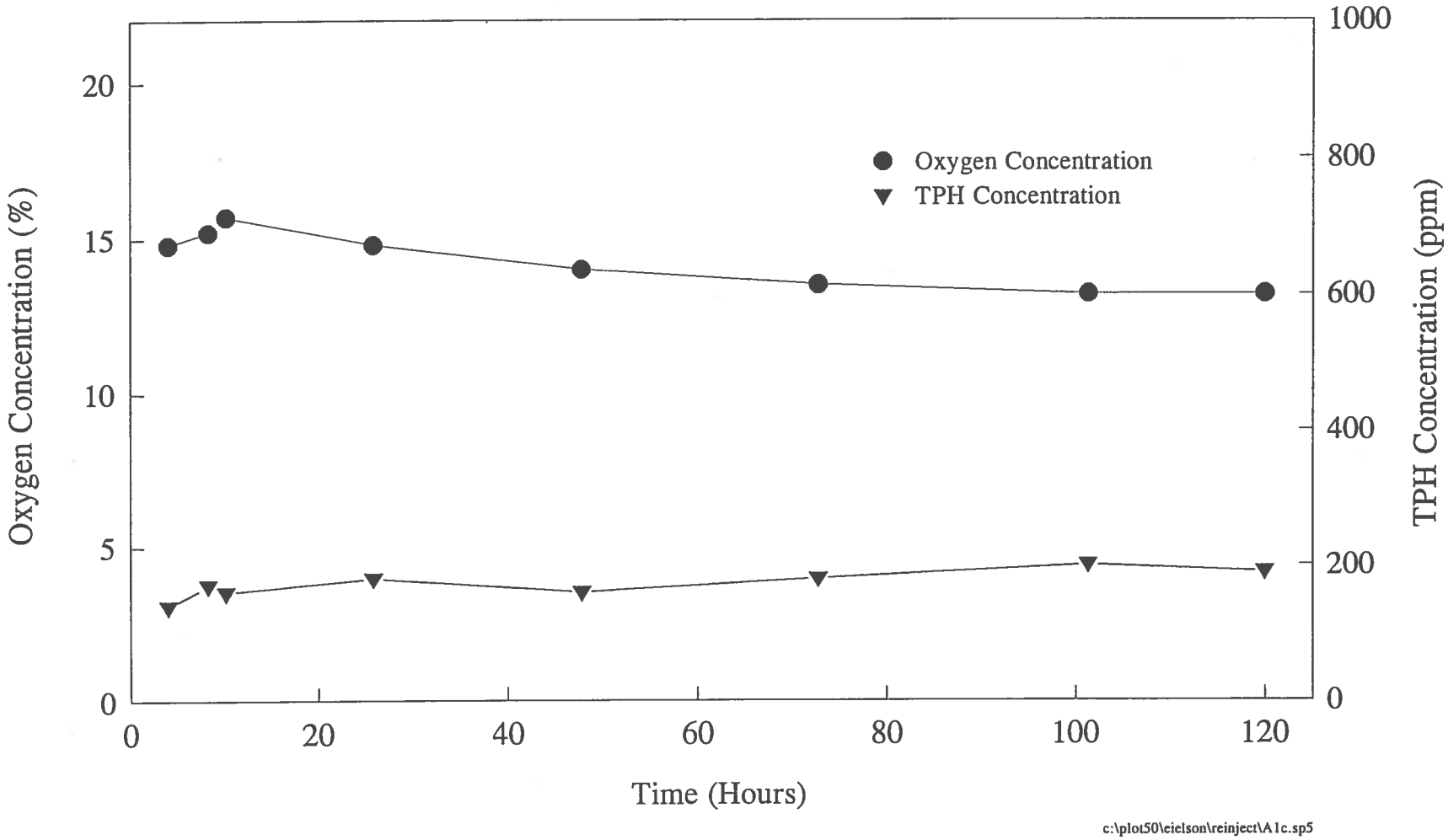


Figure J6. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point A1c

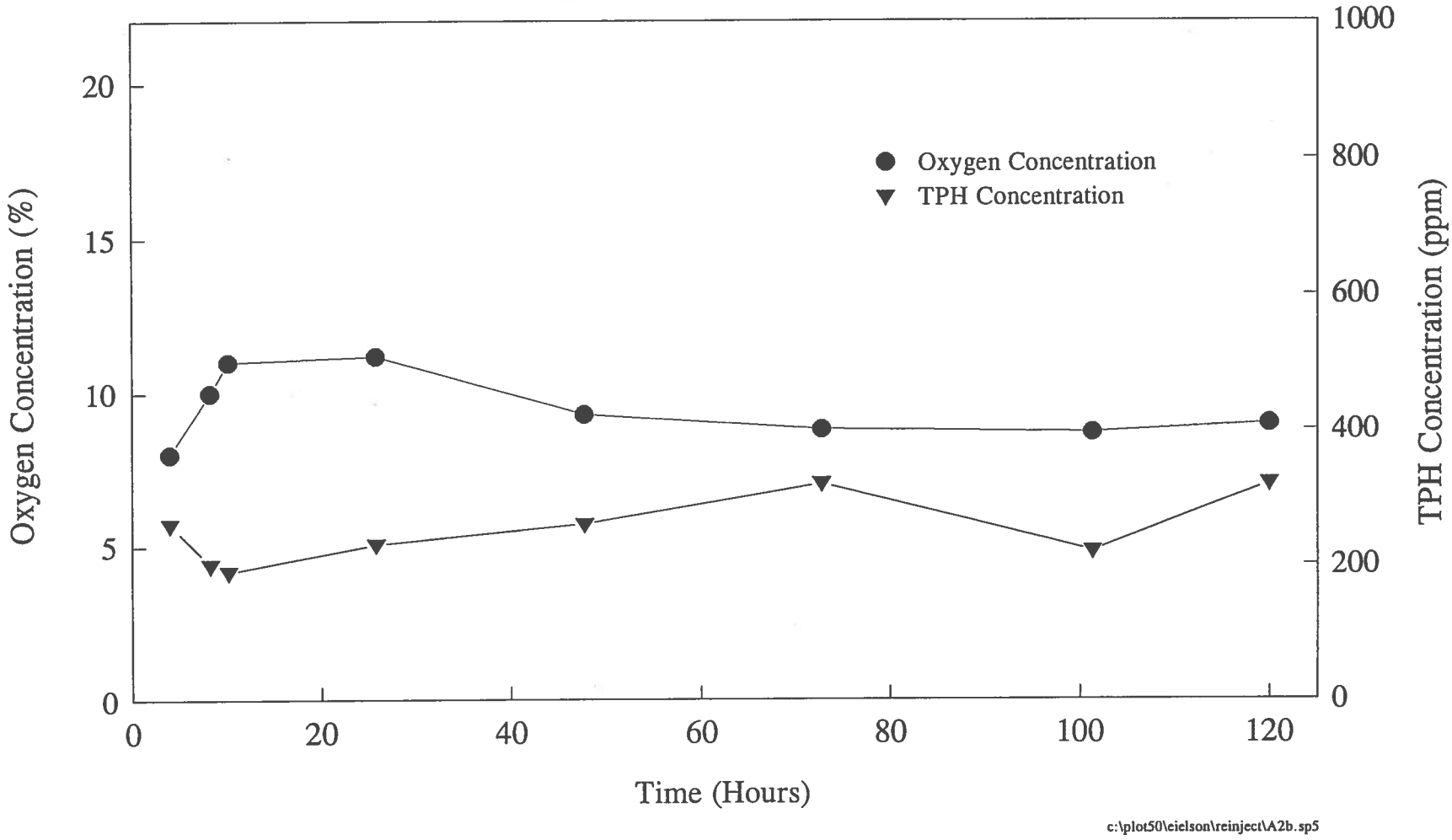


Figure J7. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point A2b

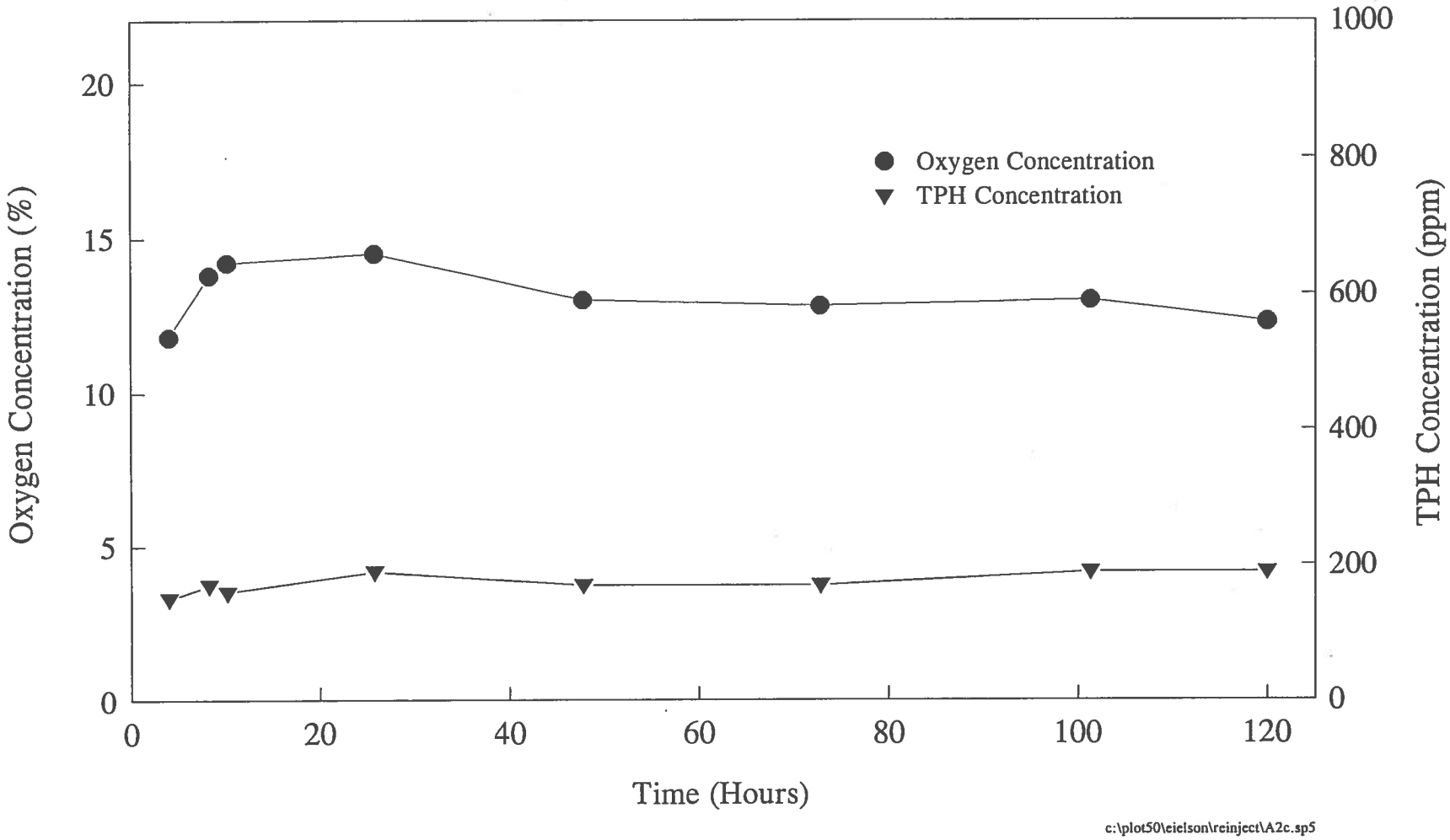


Figure J8. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point A2c

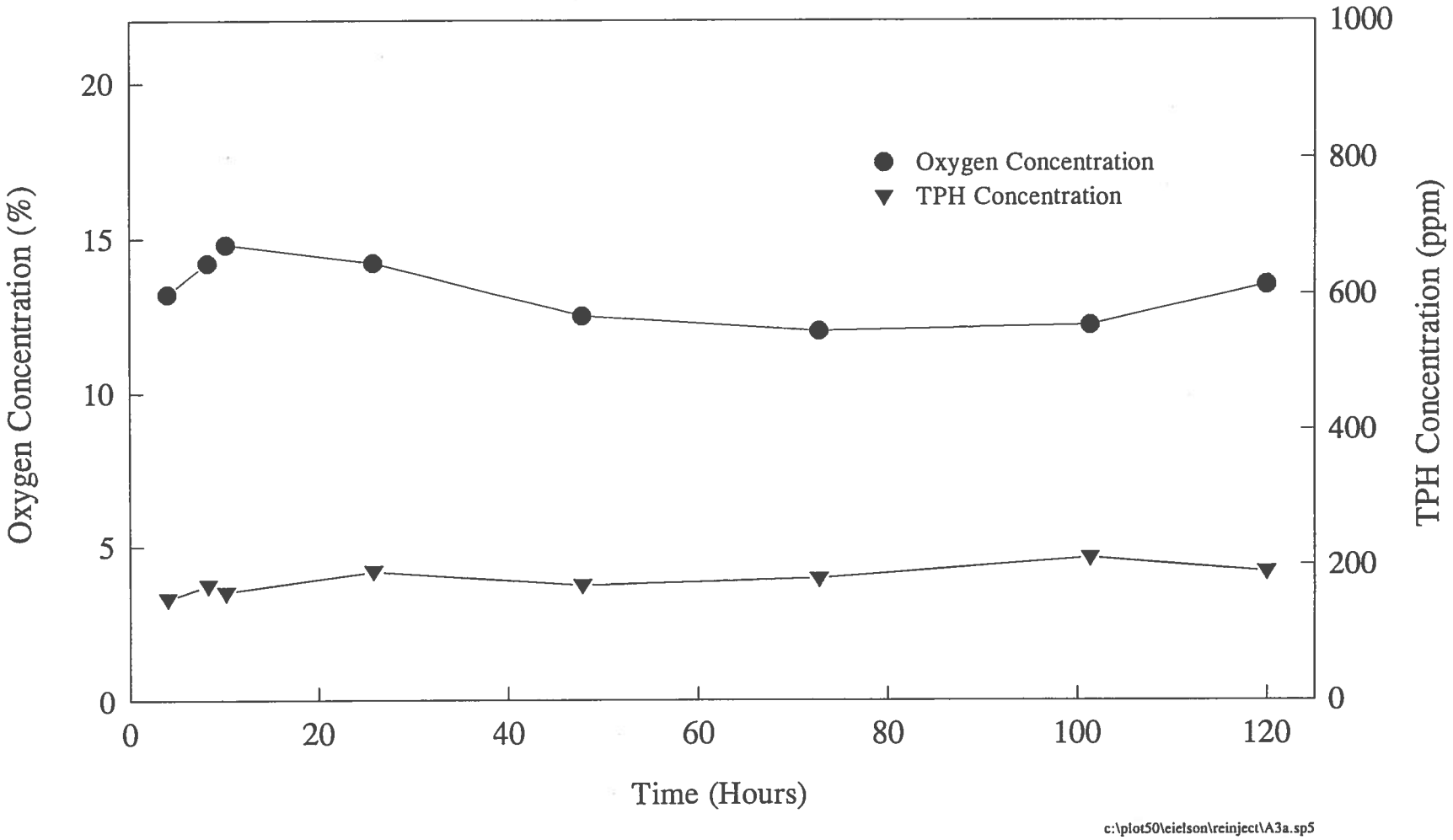


Figure J9. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point A3a

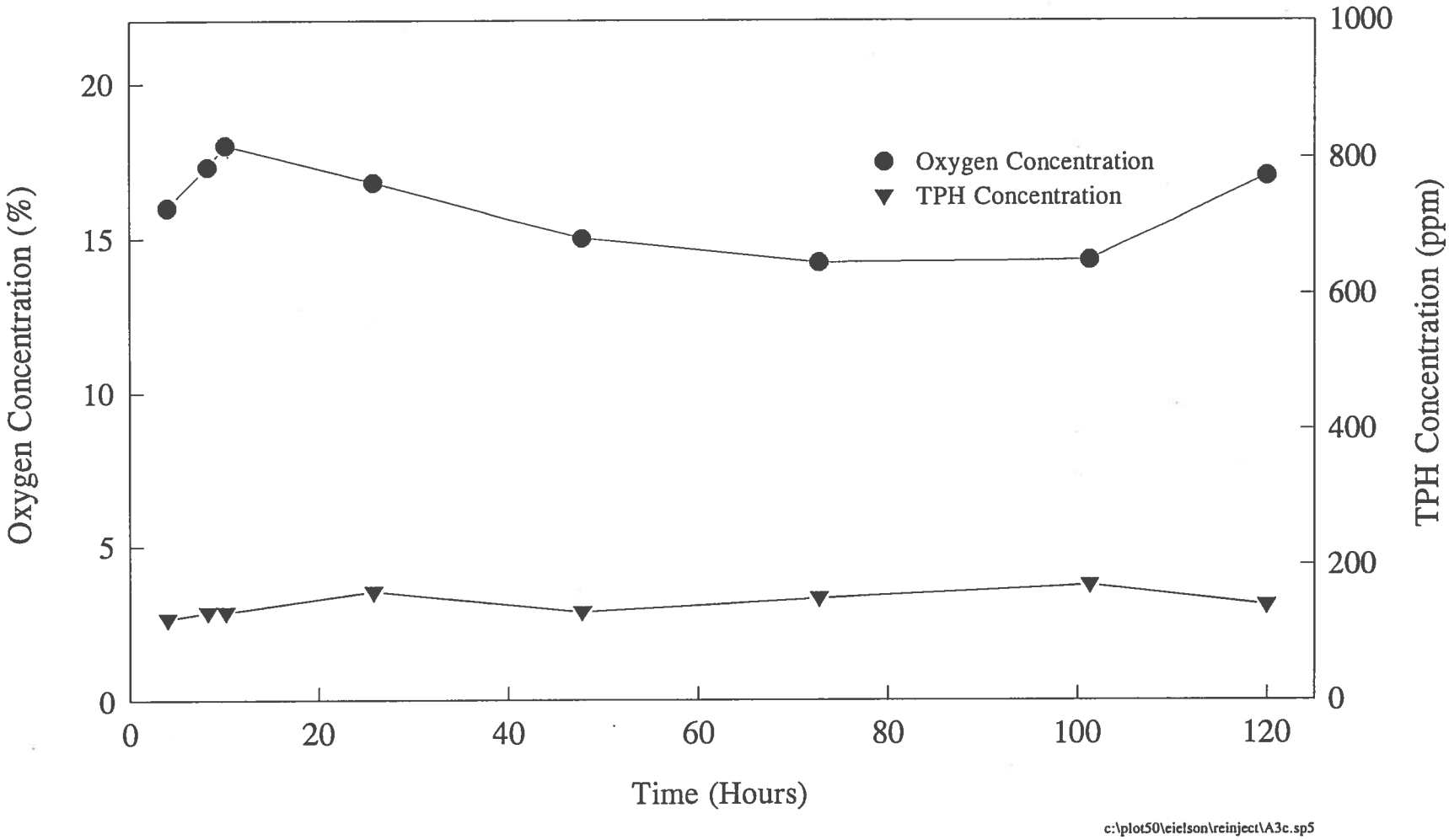


Figure J10. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point A3c

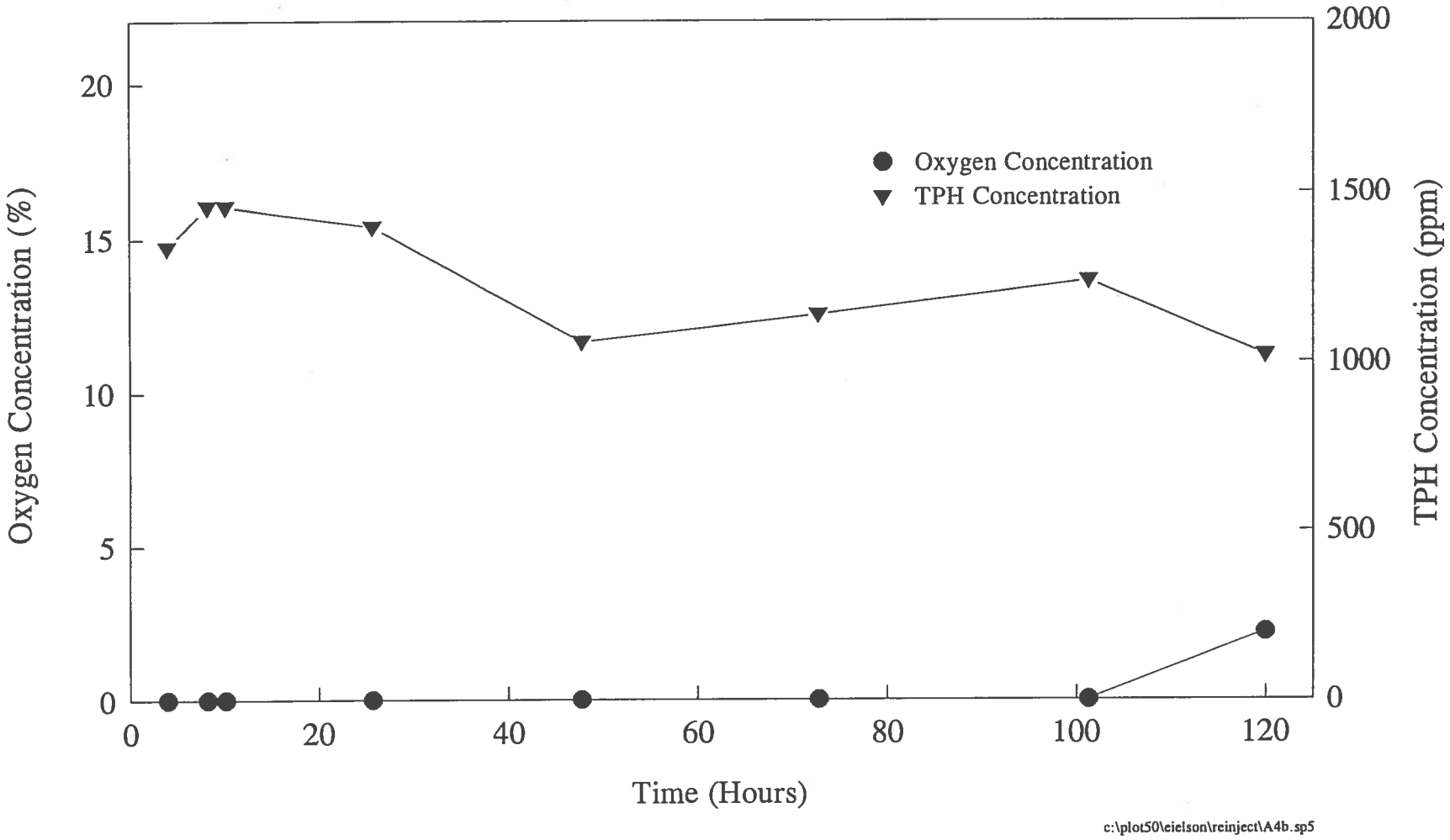


Figure J11. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point A4b

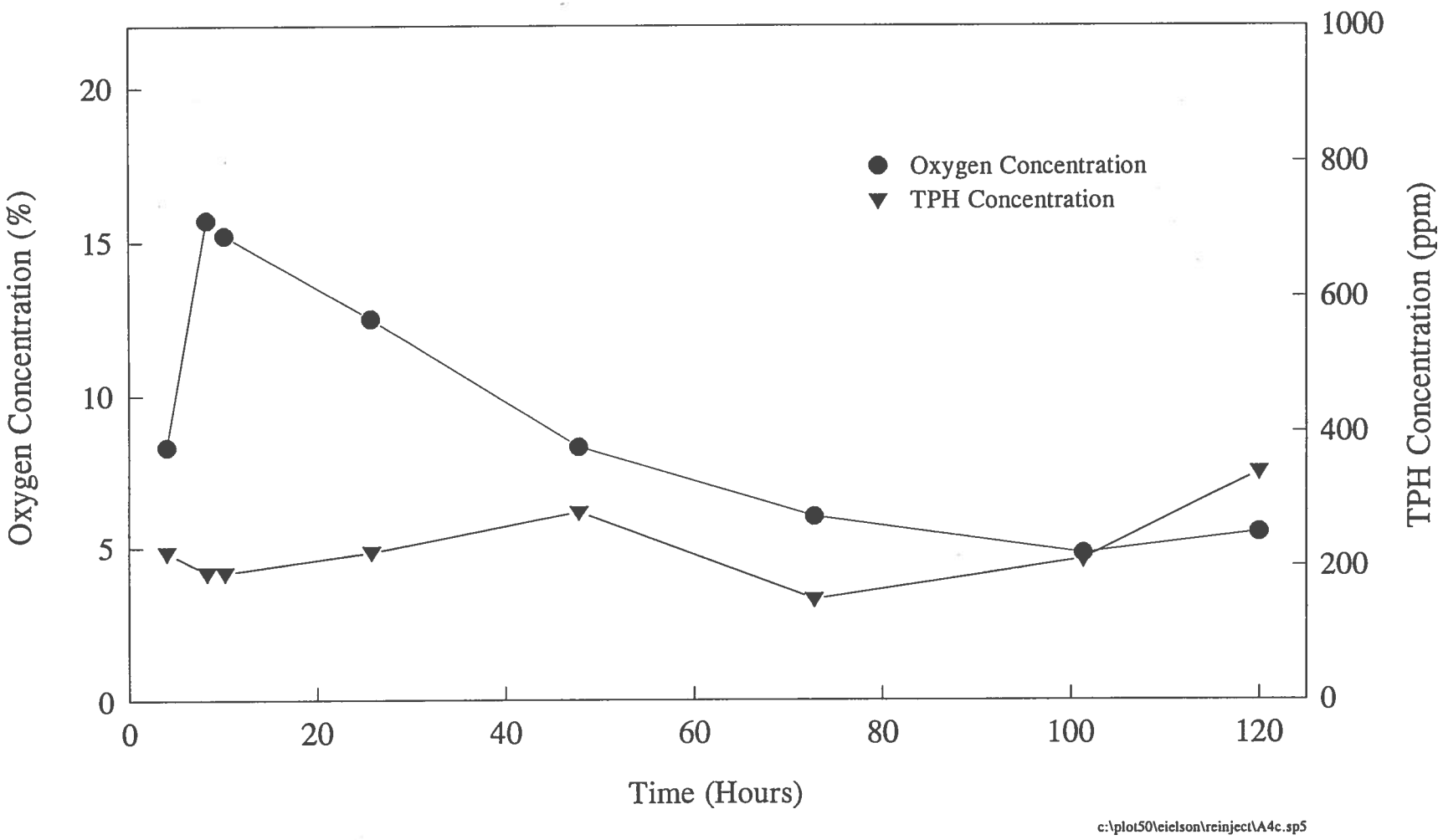


Figure J12. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point A4c

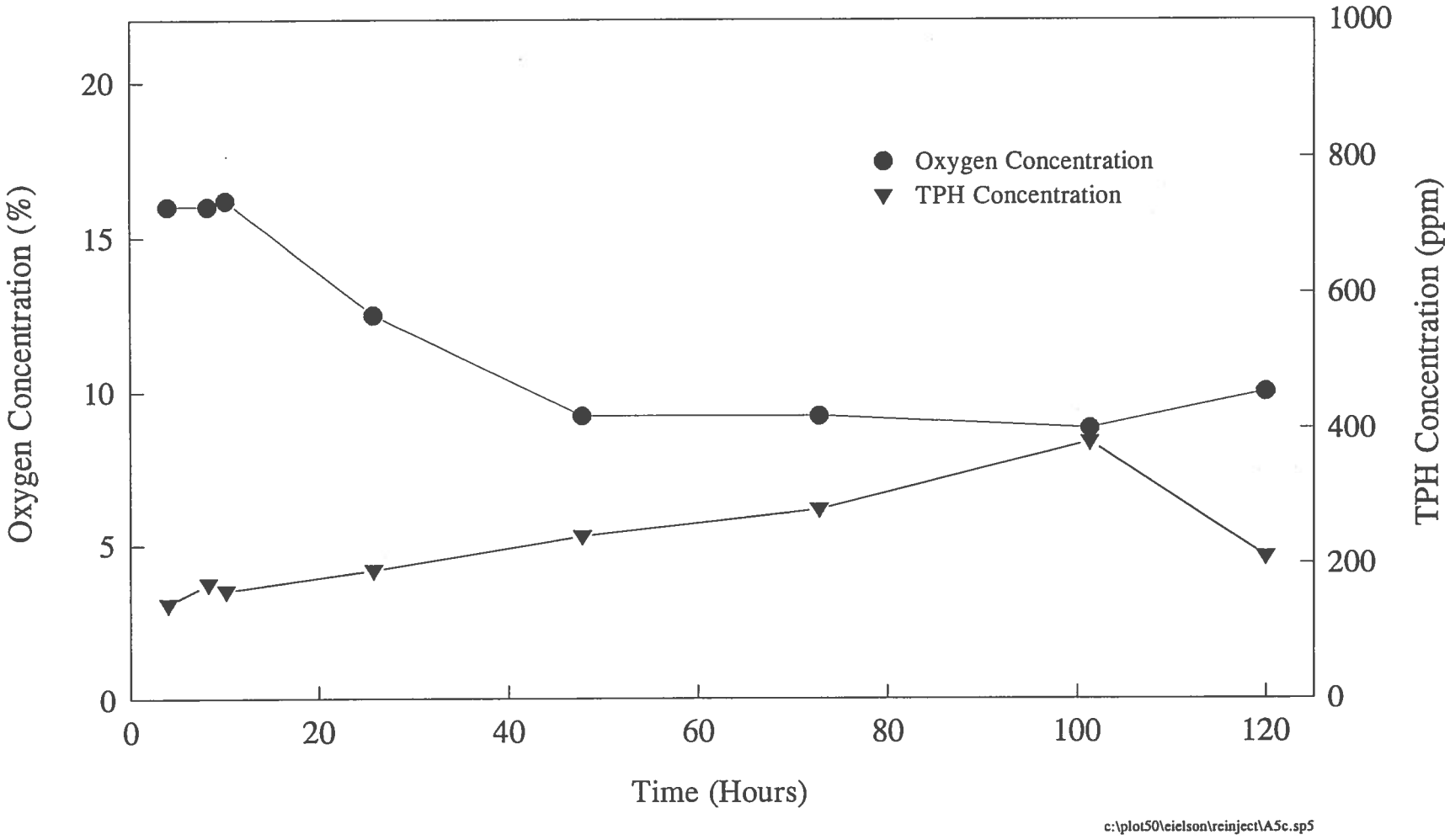


Figure J13. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point A5c

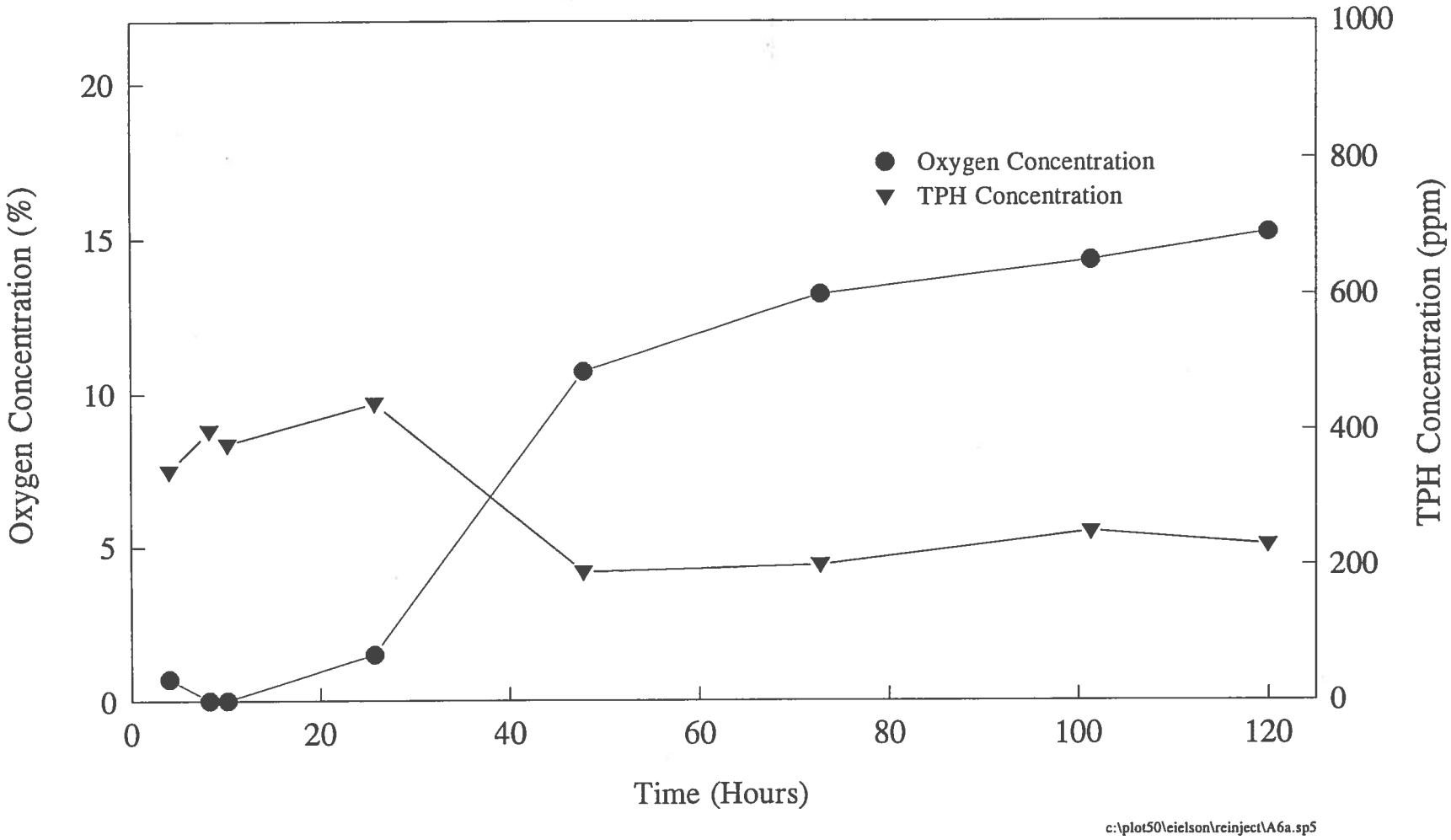


Figure J14. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point A6a

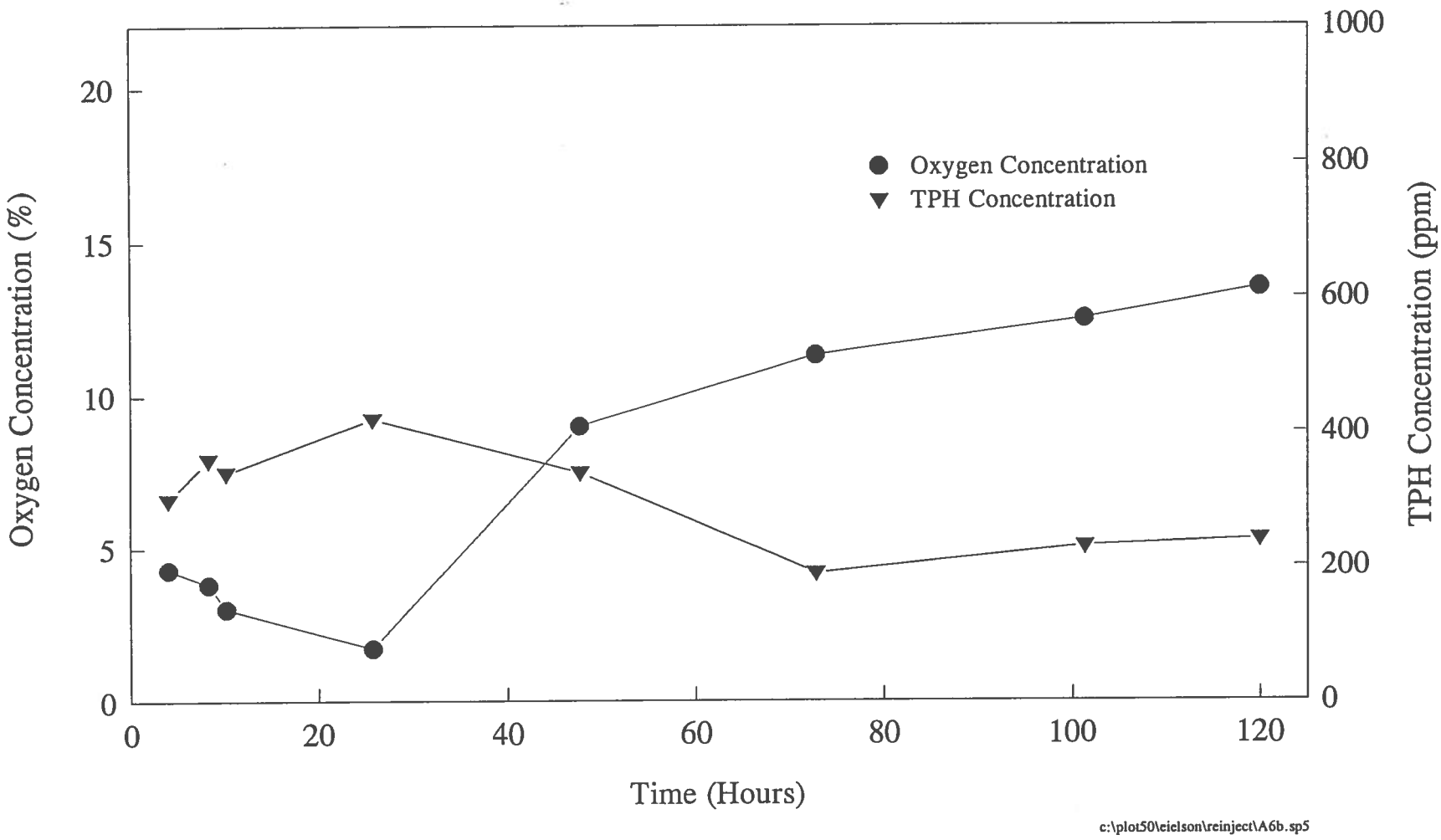


Figure J15. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point A6b

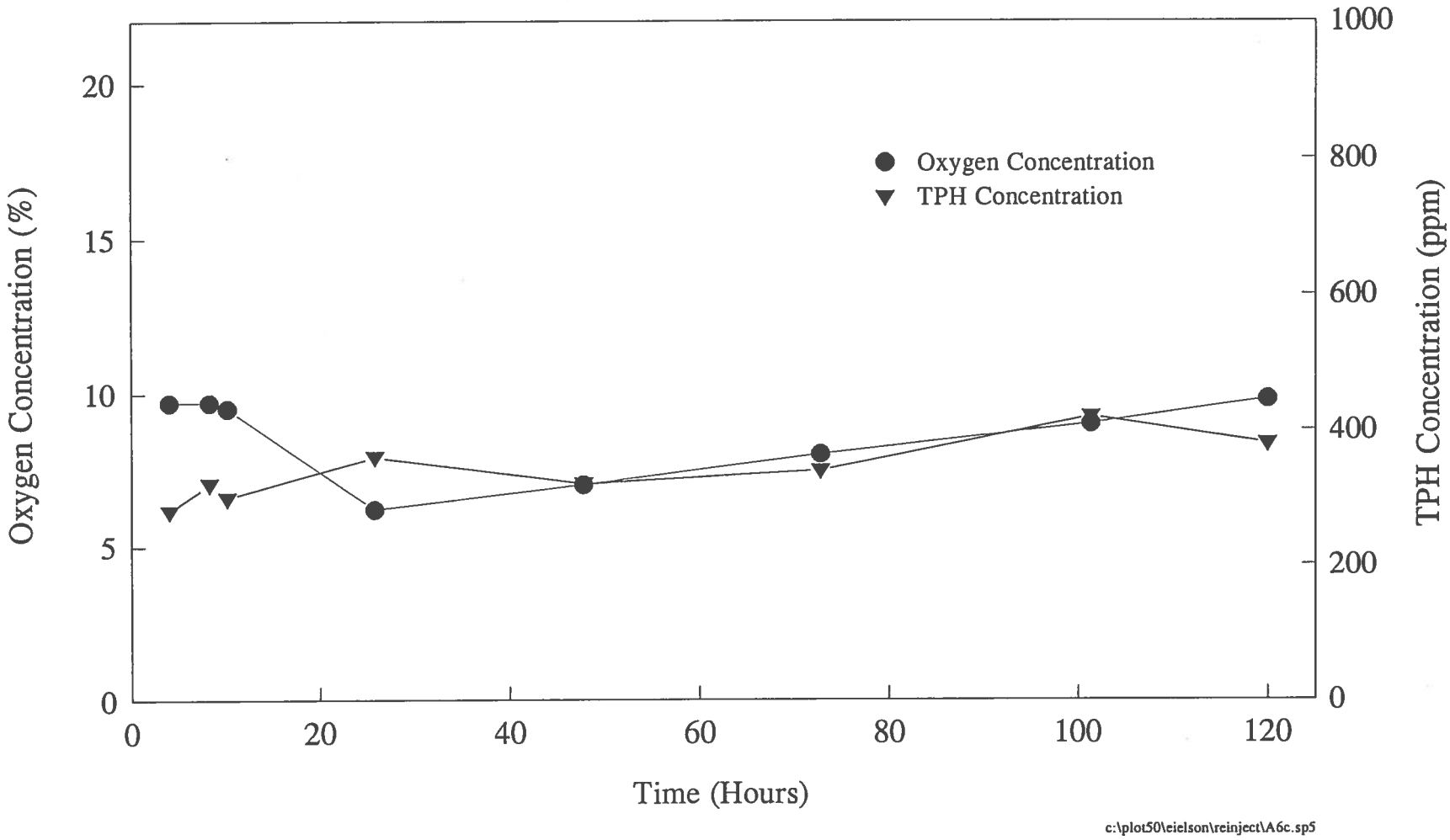


Figure J16. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point A6c

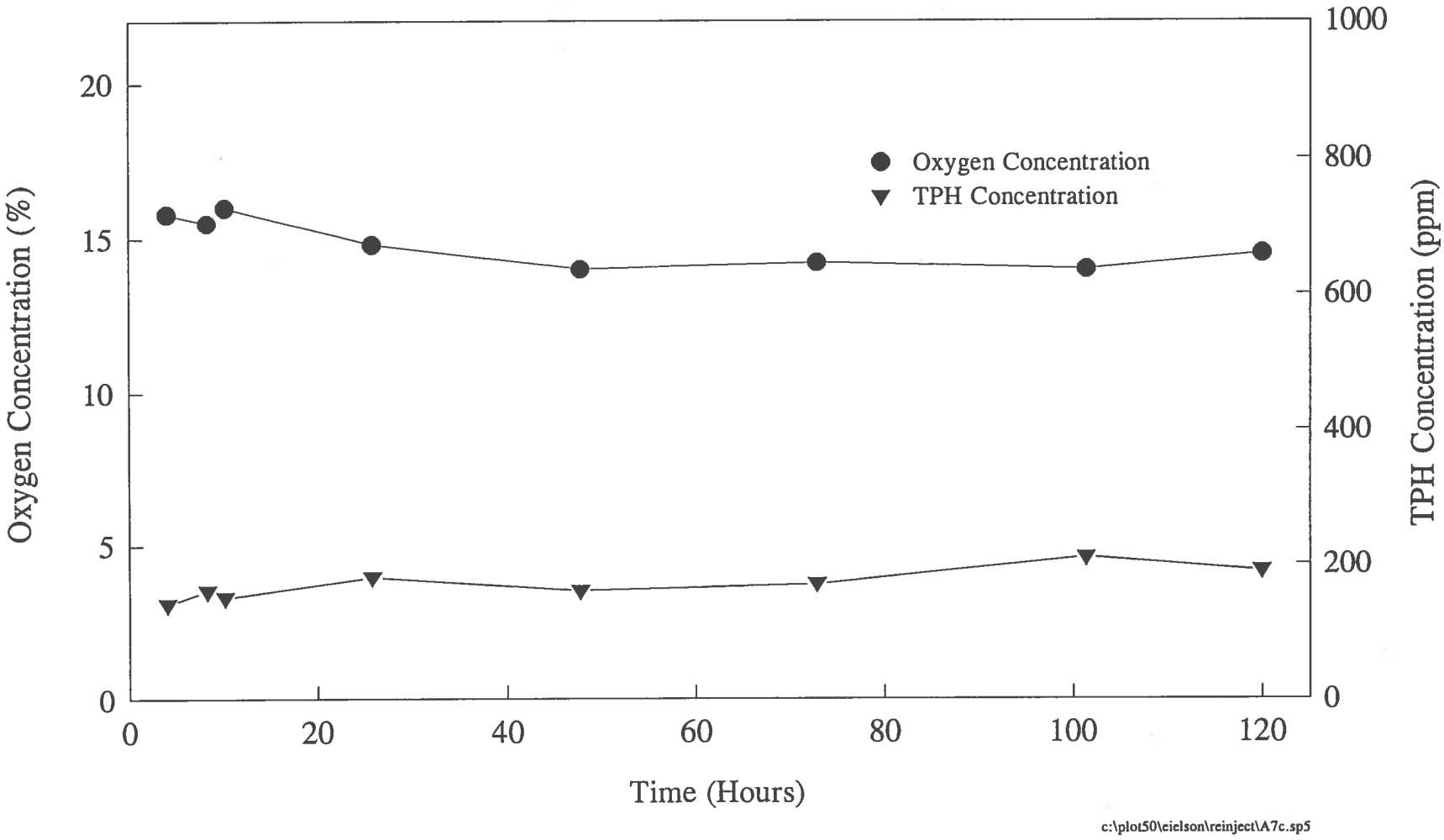


Figure J17. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point A7c

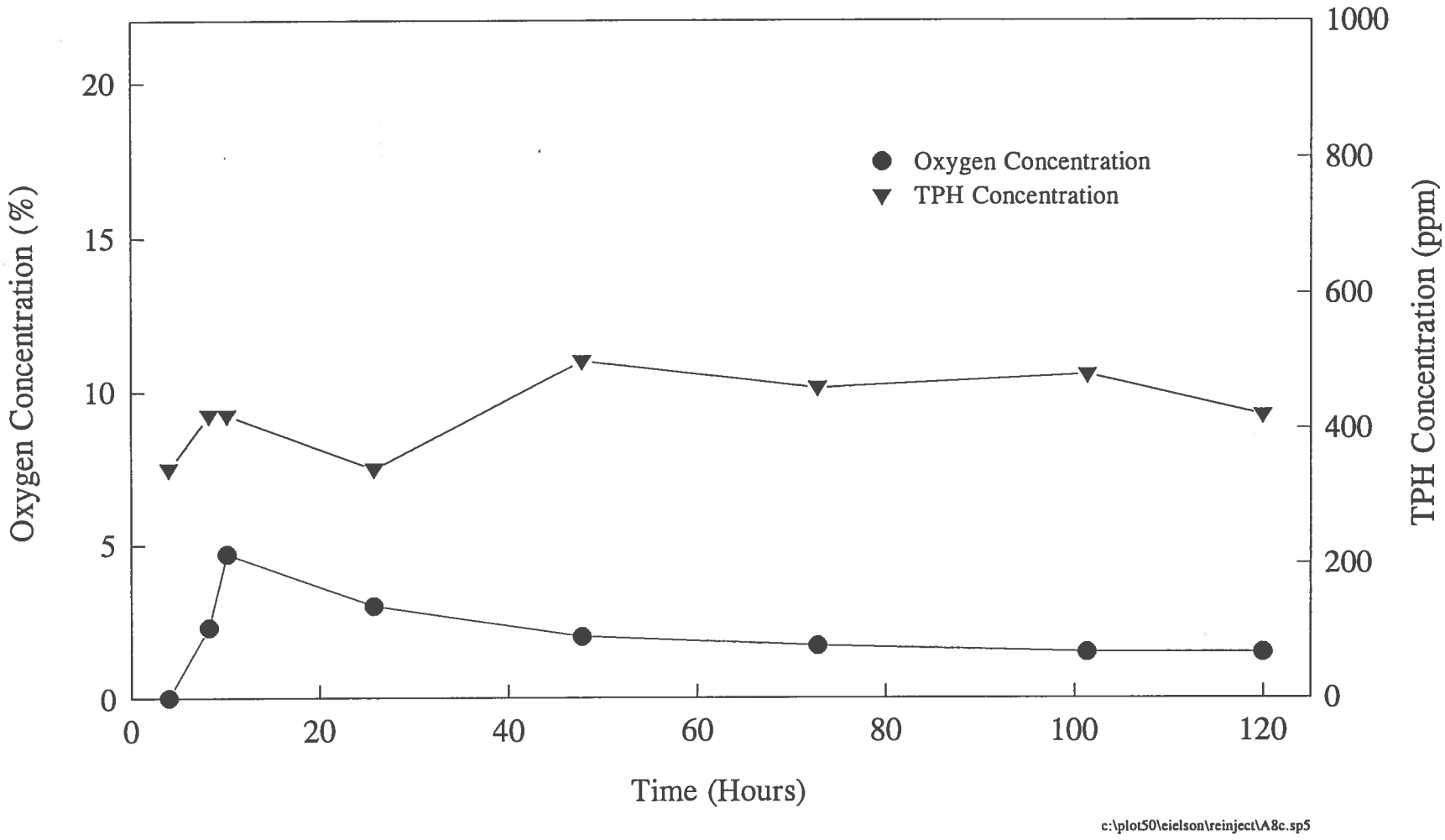


Figure J18. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point A8c

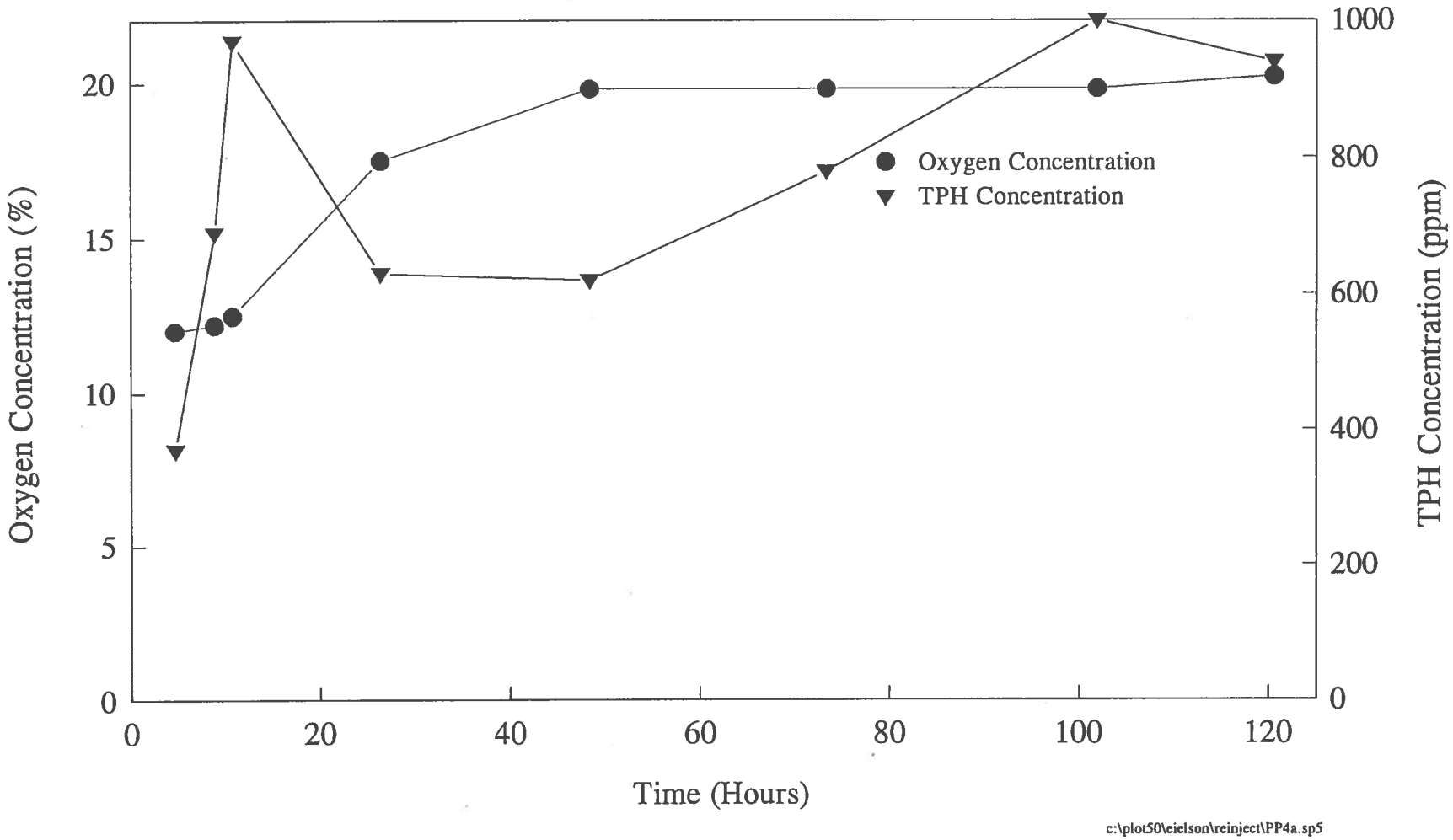


Figure J19. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point PP4a

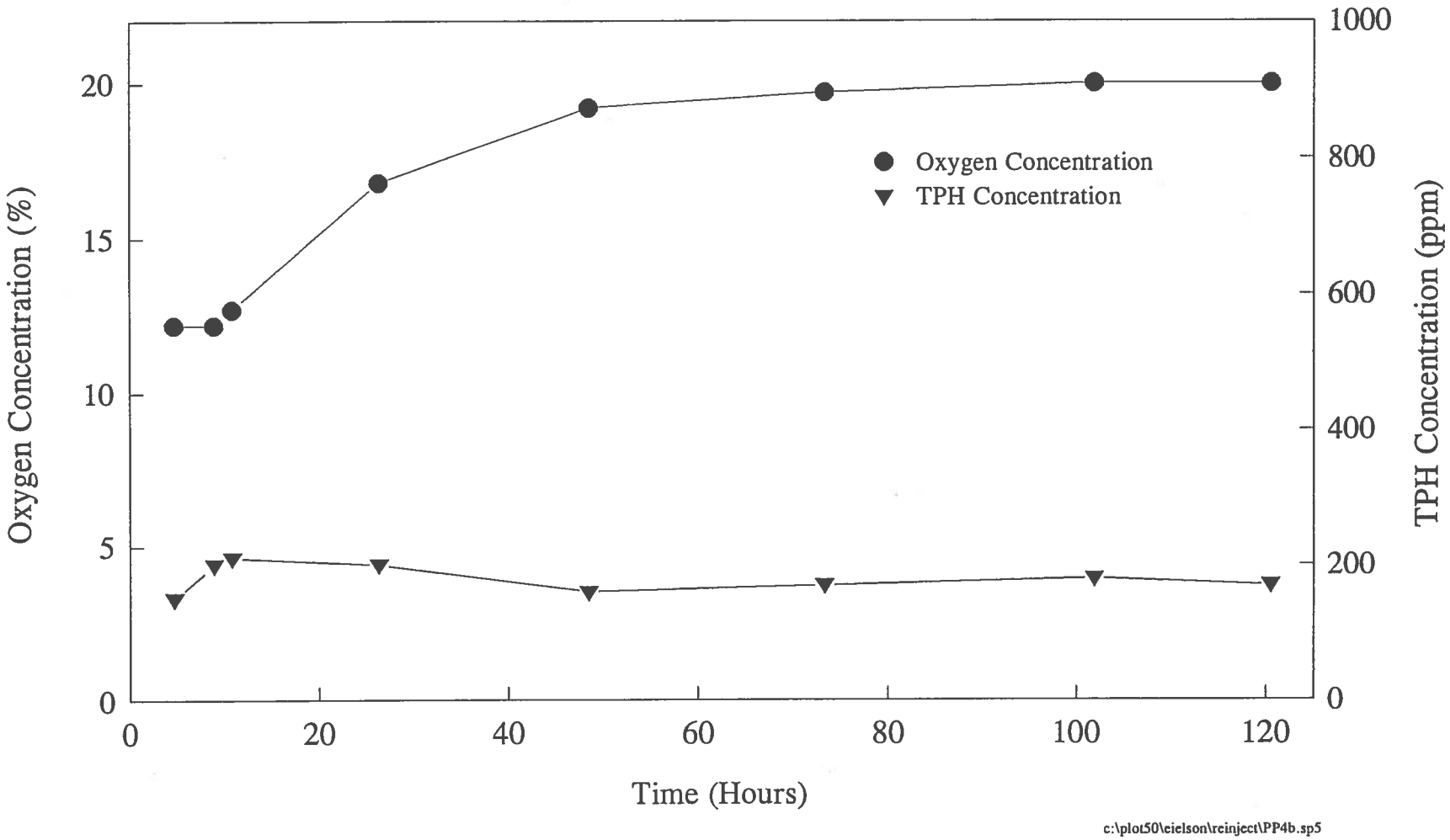


Figure J20. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point PP4b

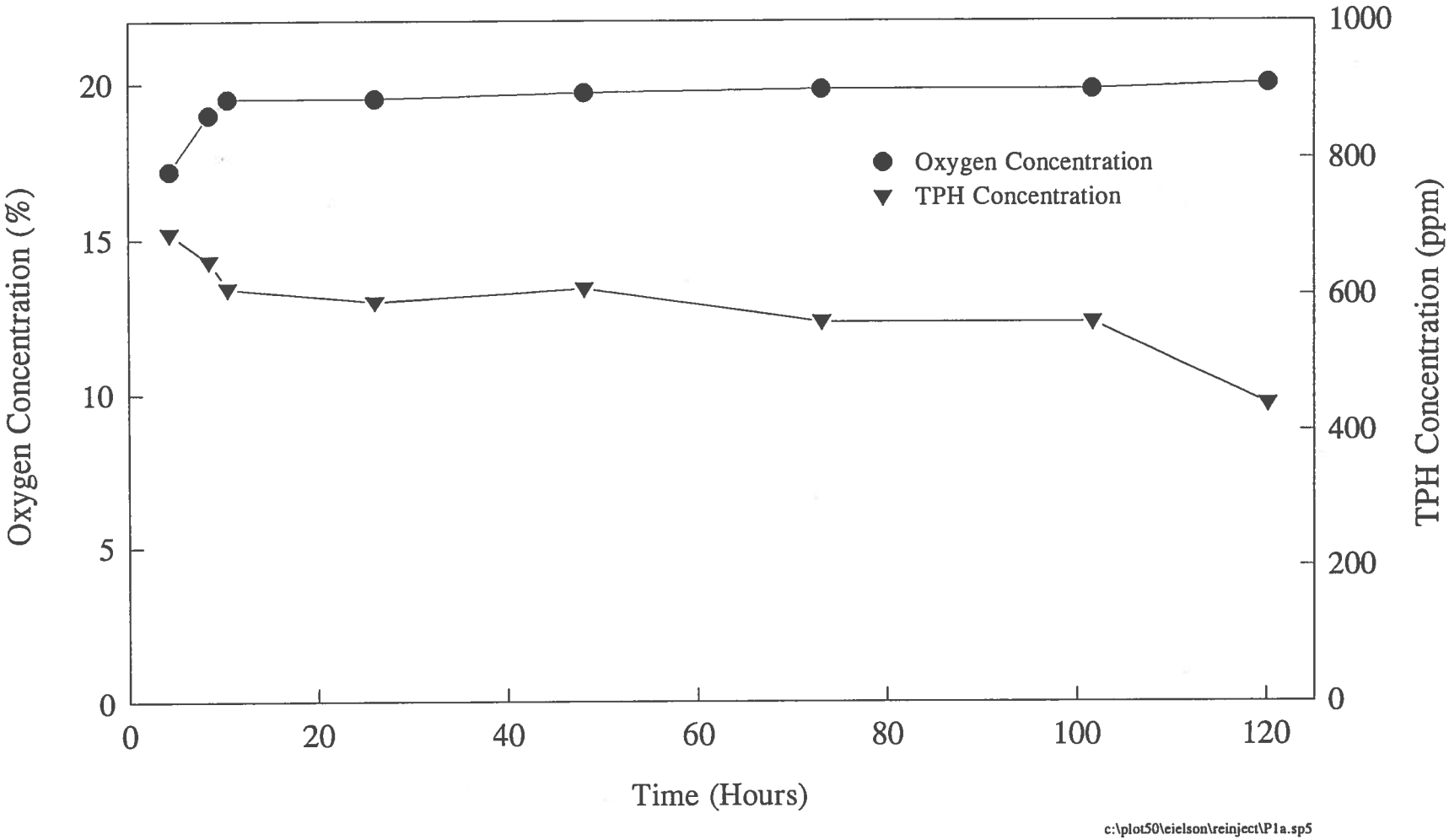


Figure J21. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P1a

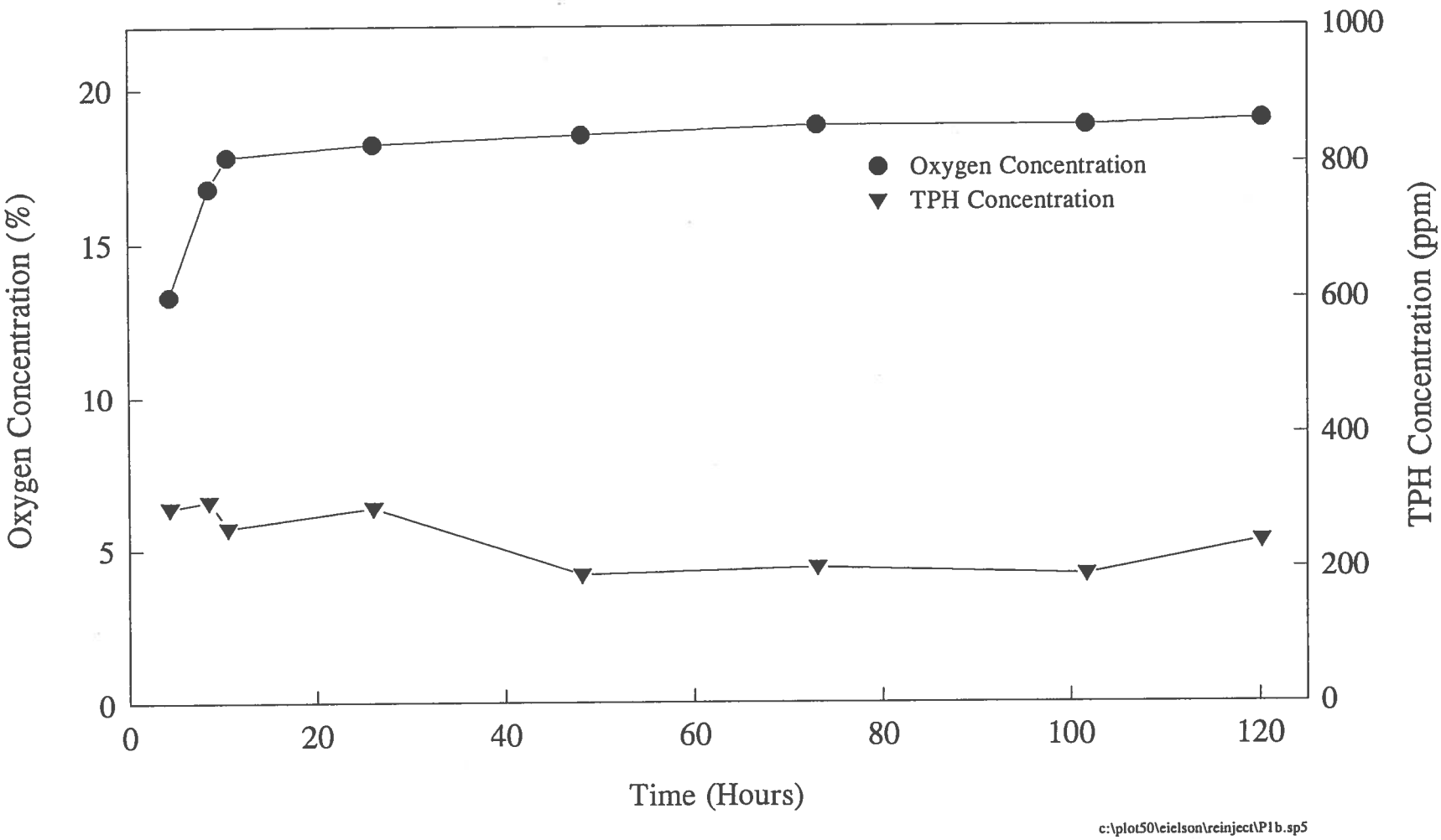


Figure J22. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P1b

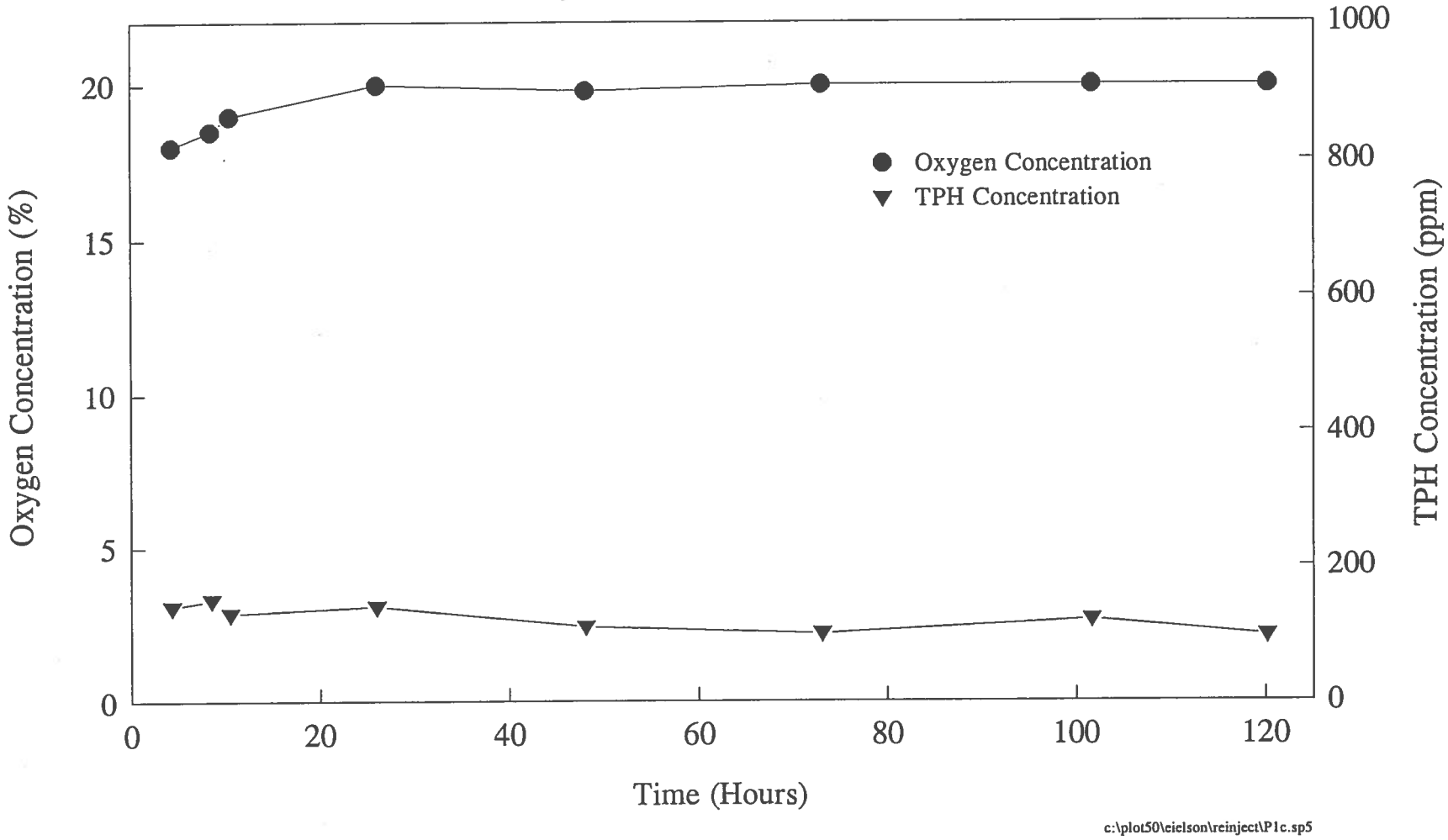


Figure J23. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P1c

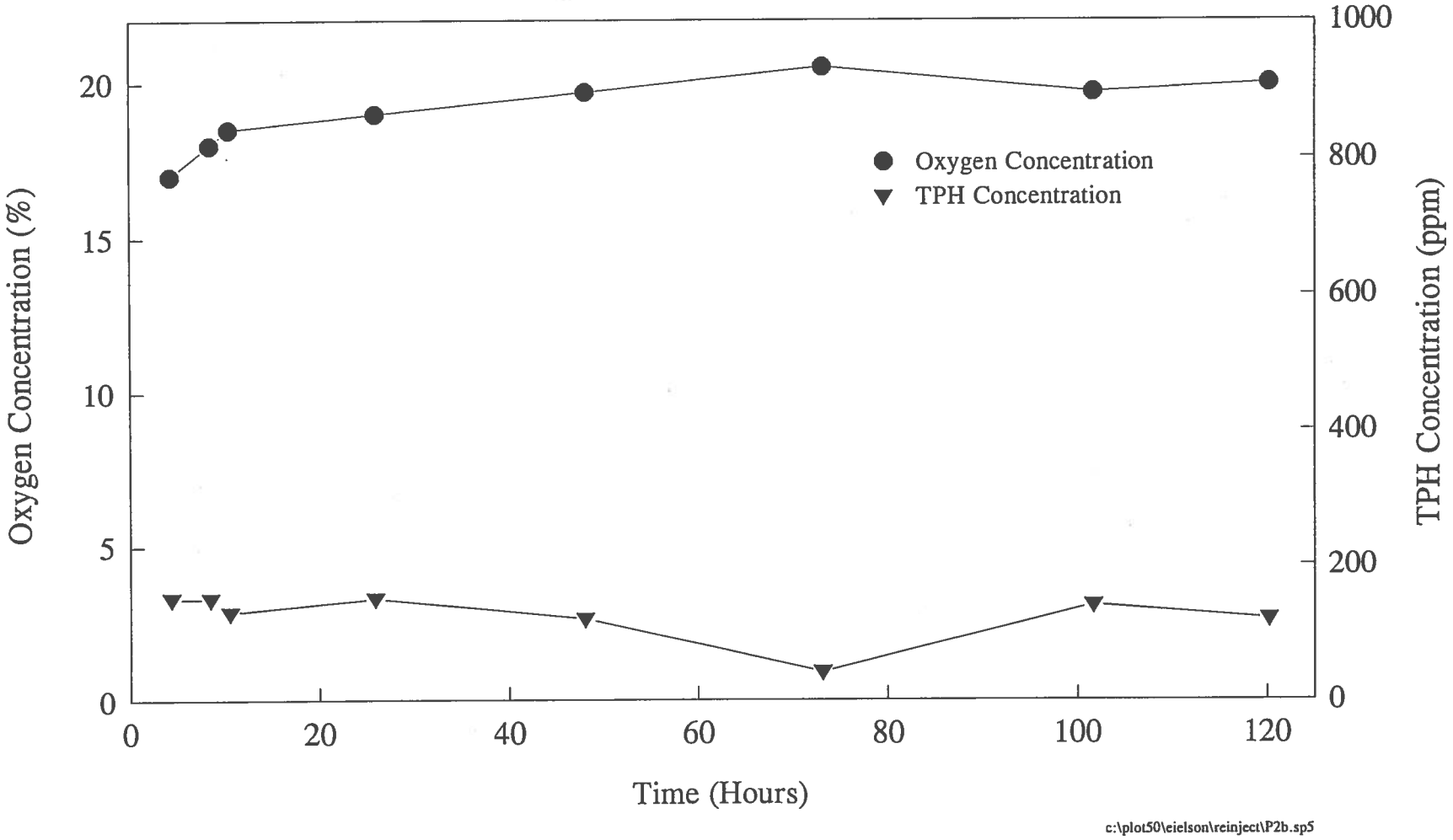


Figure J24. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P2b

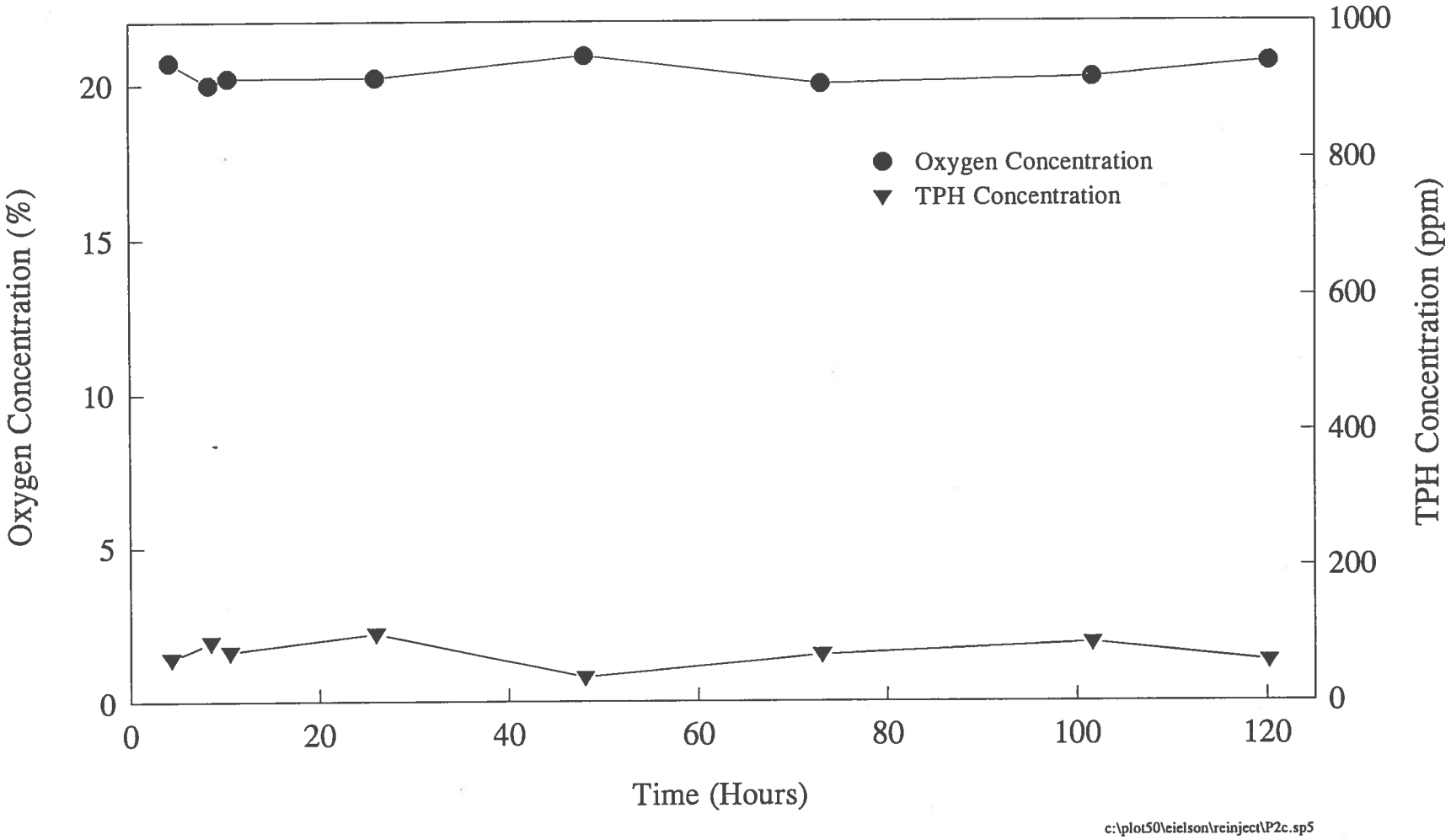


Figure J25. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P2c

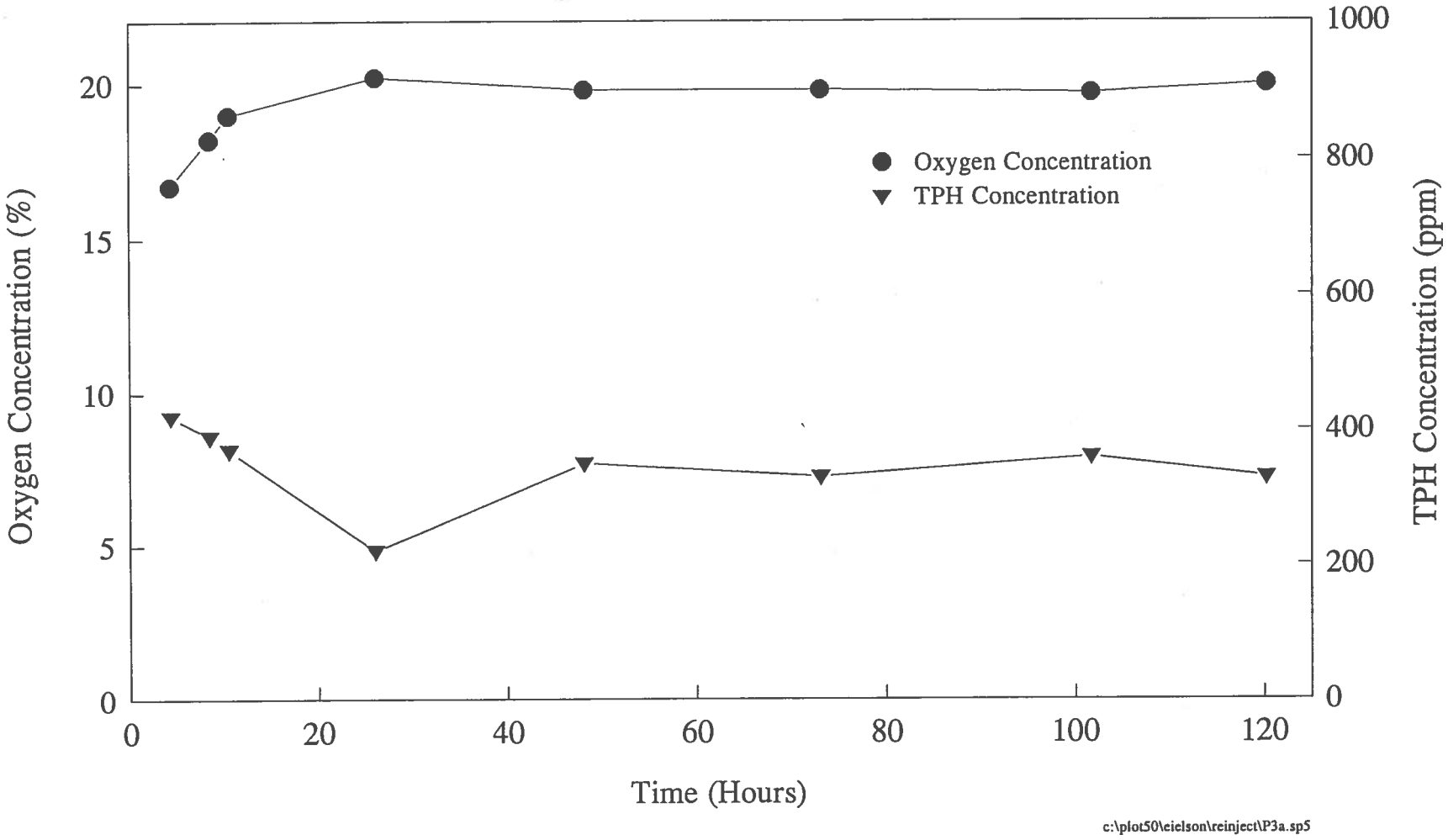


Figure J26. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P3a

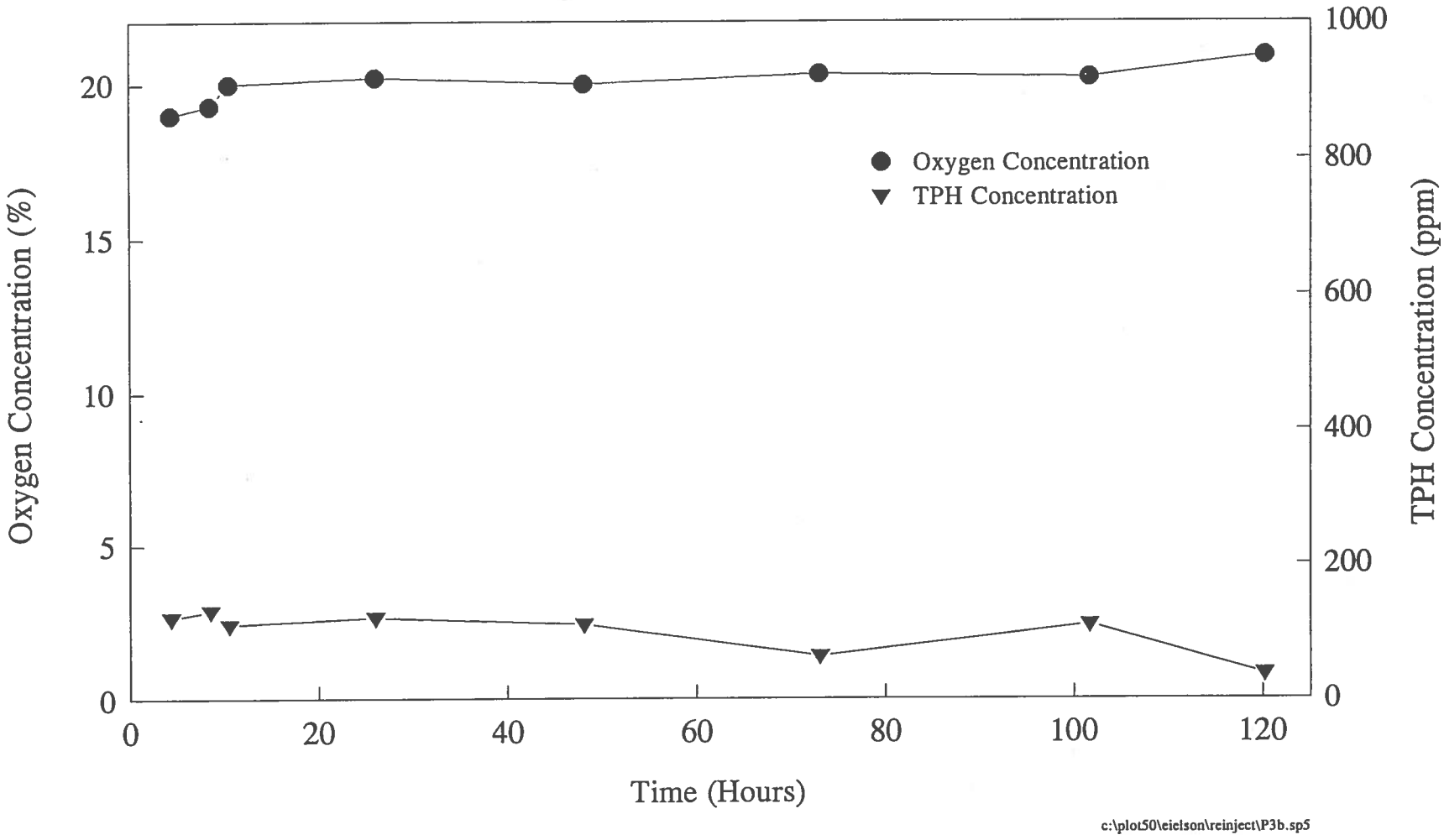


Figure J27. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P3b

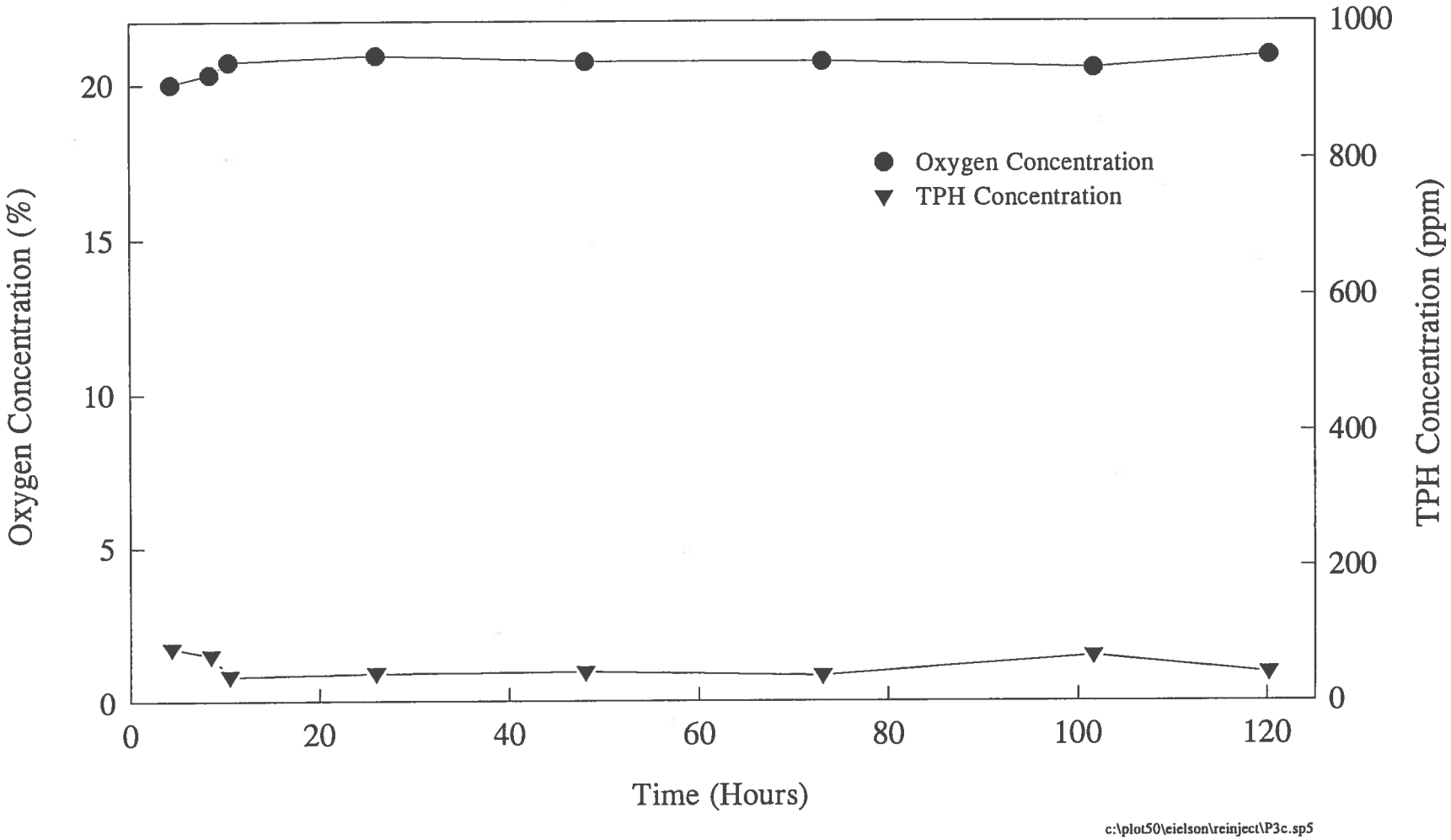


Figure J28. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P3c

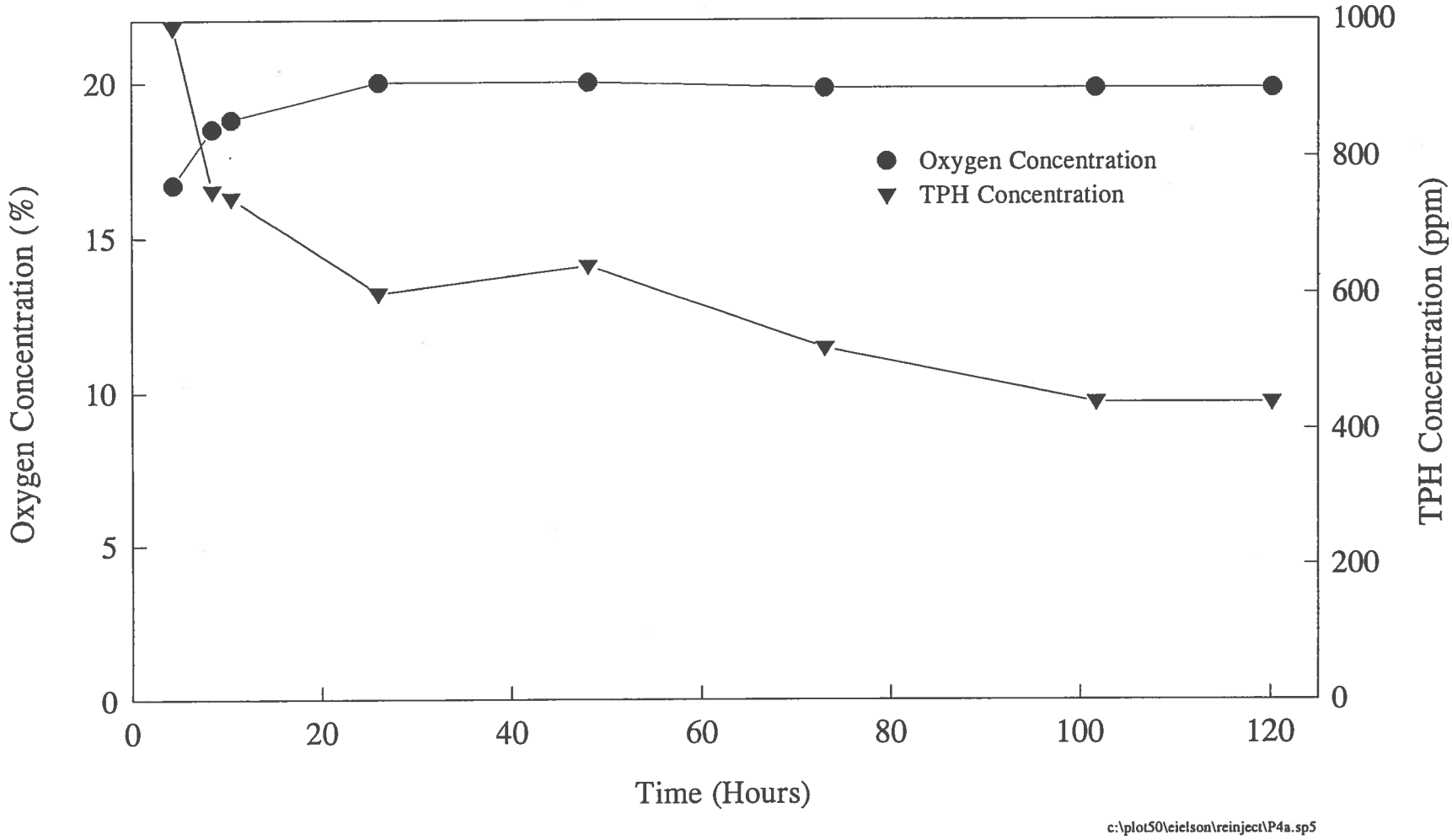


Figure J29. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P4a

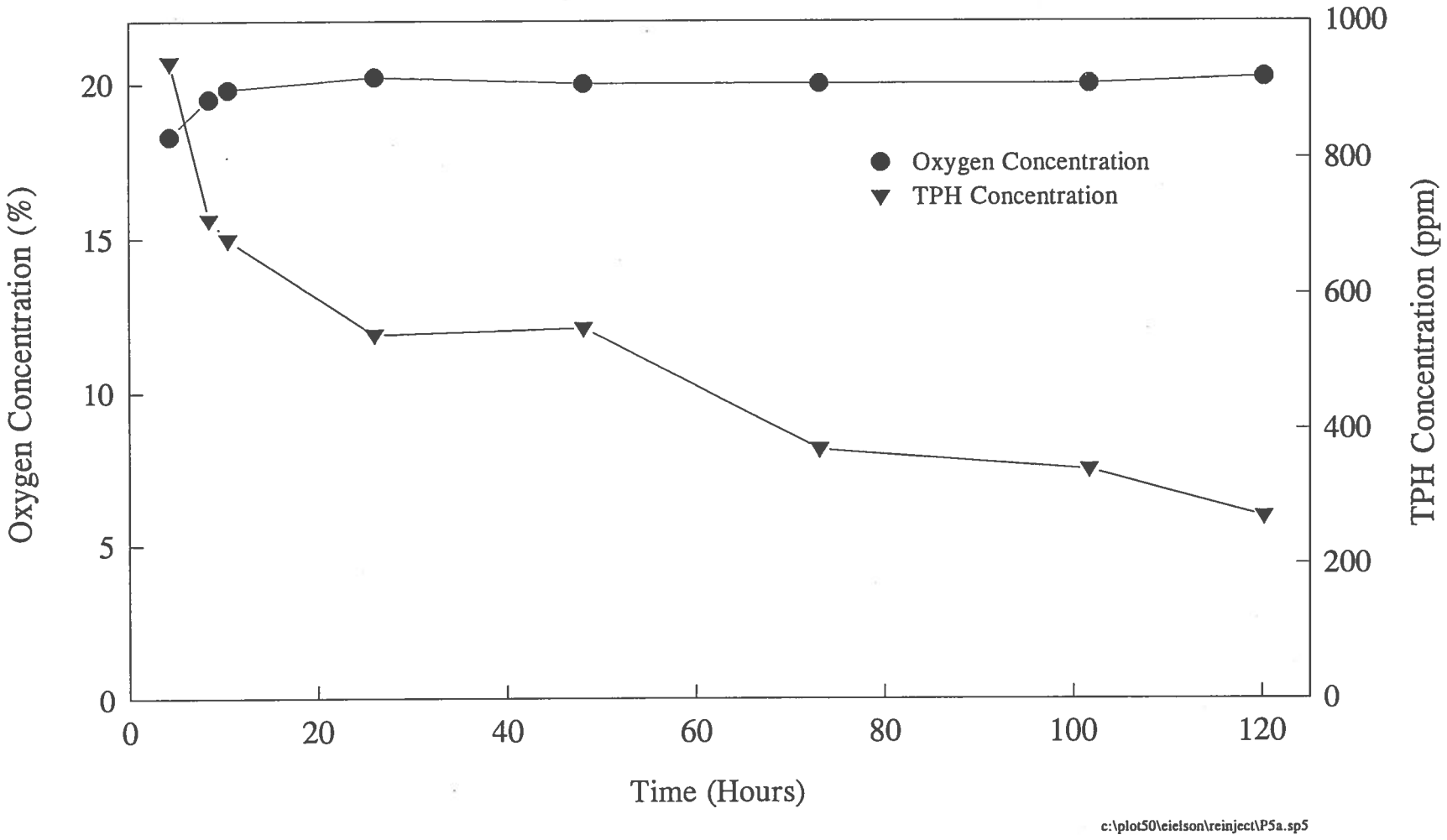


Figure J30. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P5a

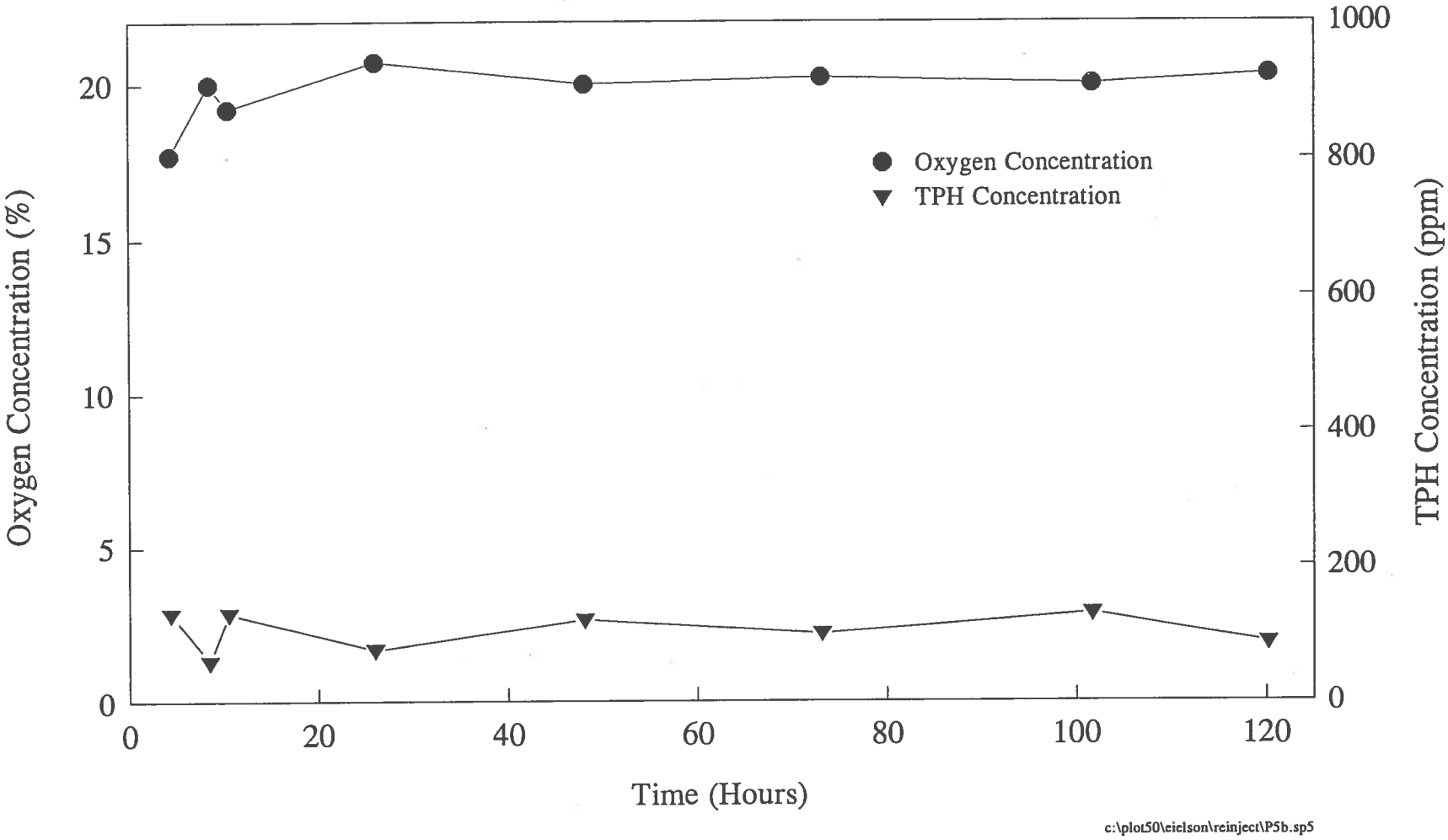


Figure J31. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P5b

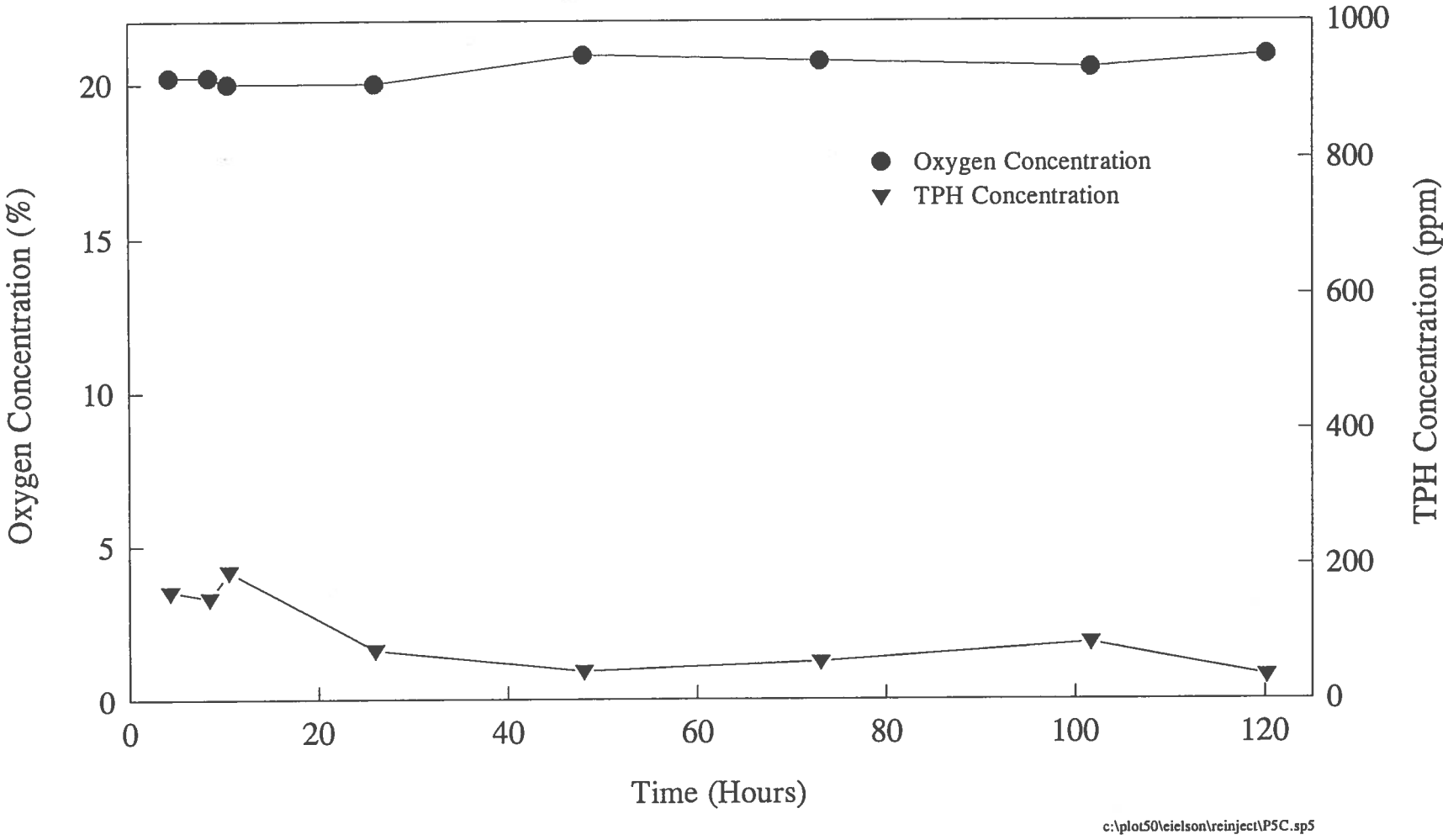


Figure J32. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P5c

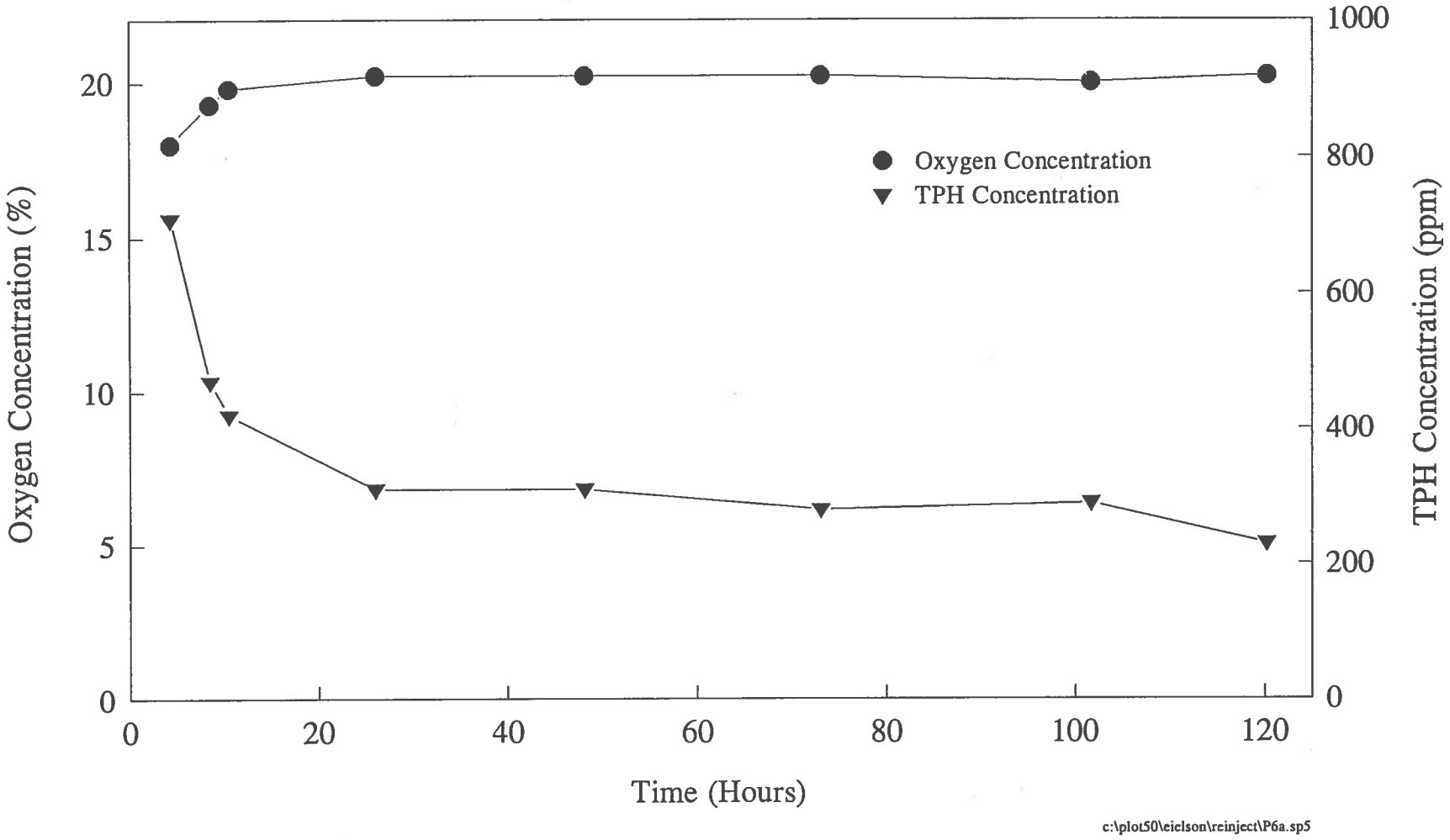


Figure J33. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P6a

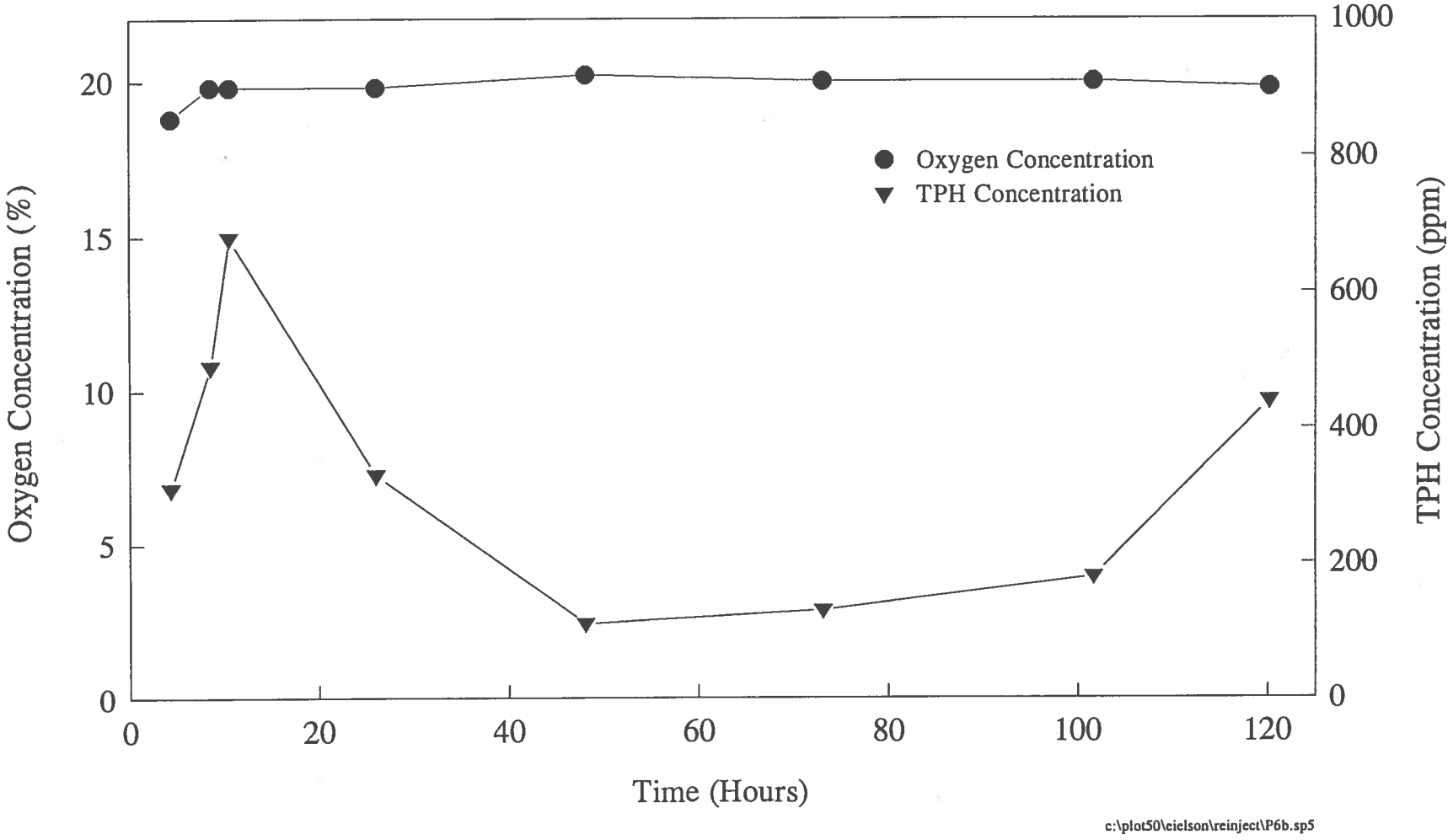


Figure J34. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P6b

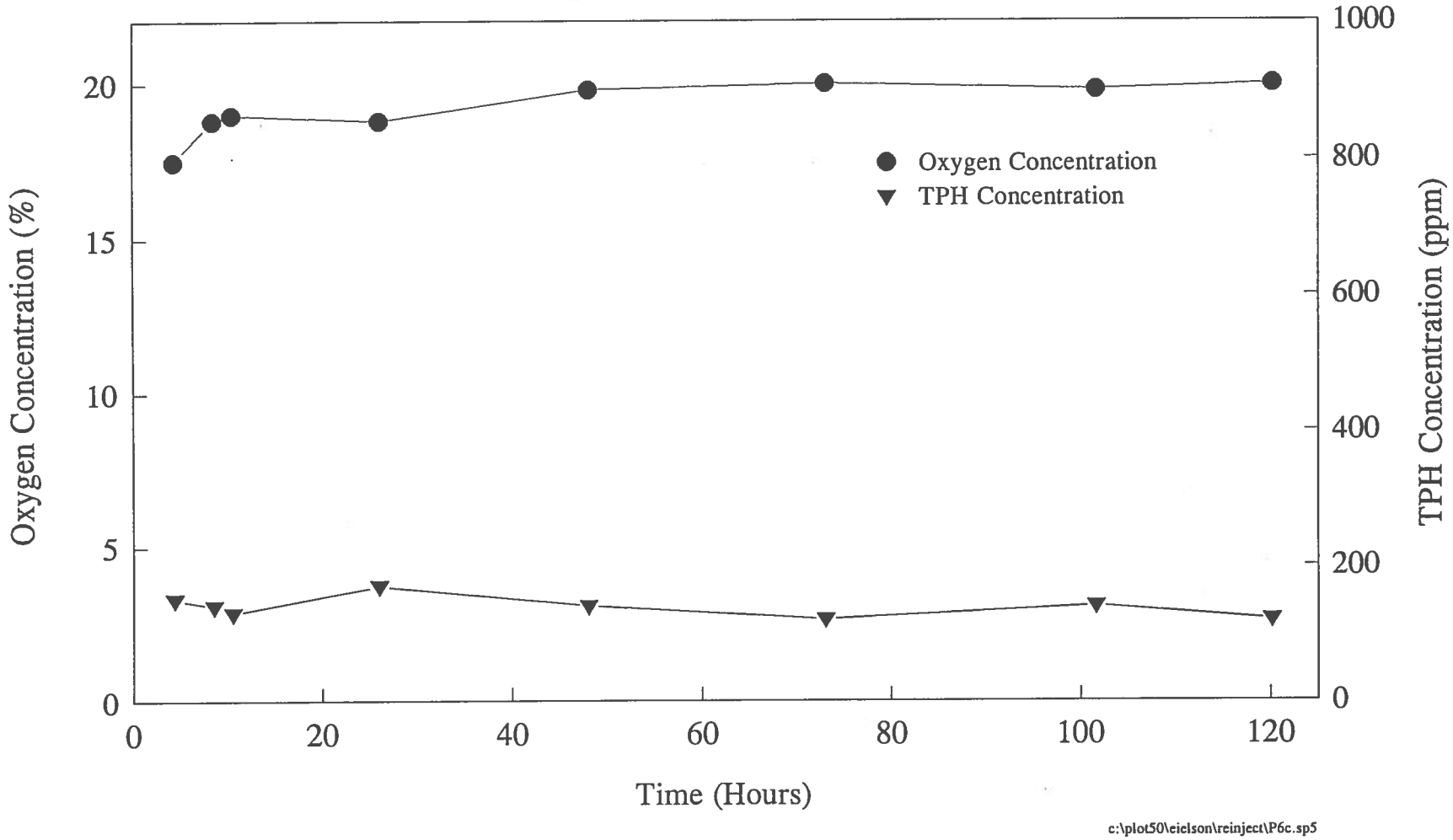


Figure J35. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P6c

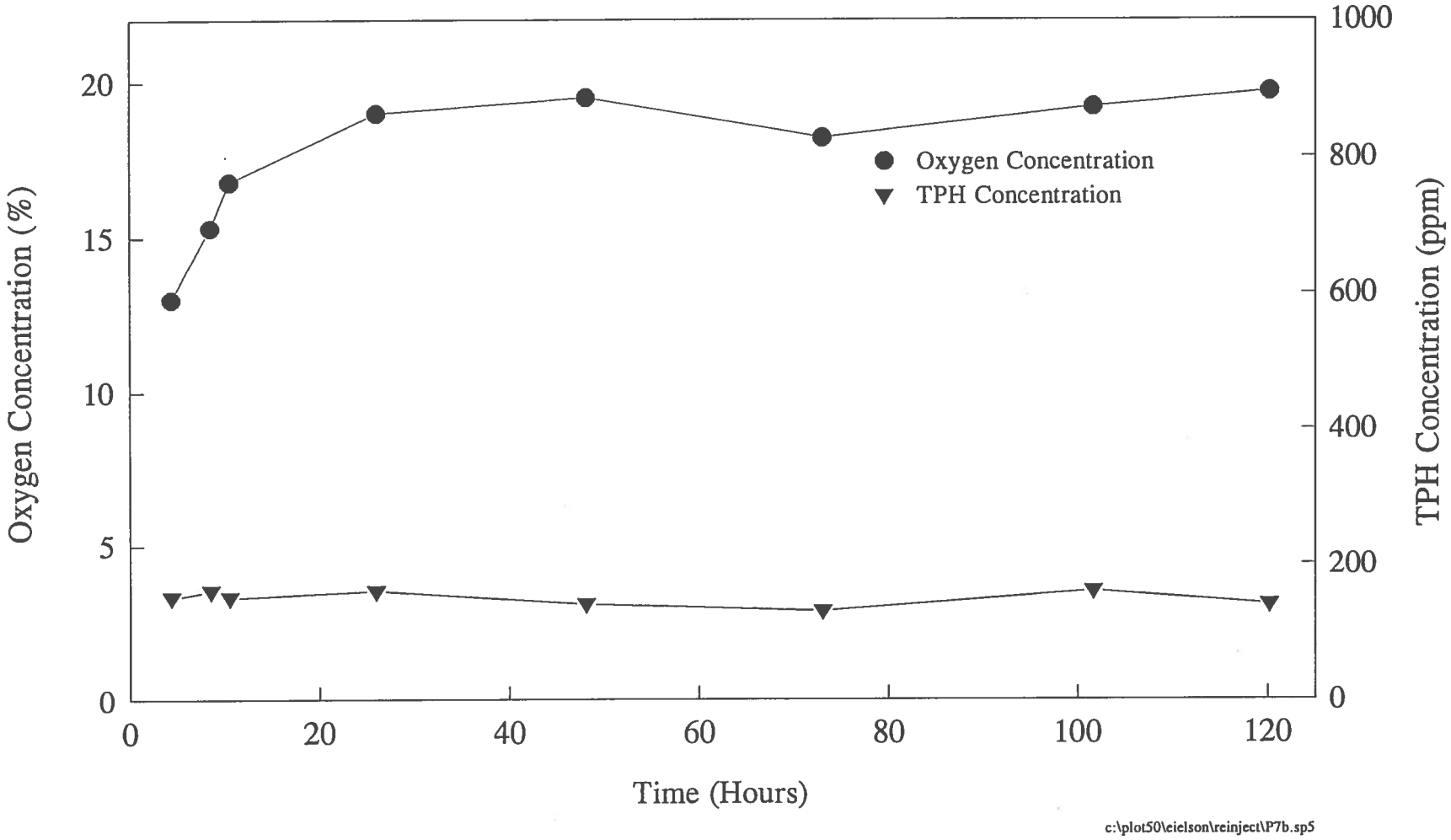


Figure J36. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P7b

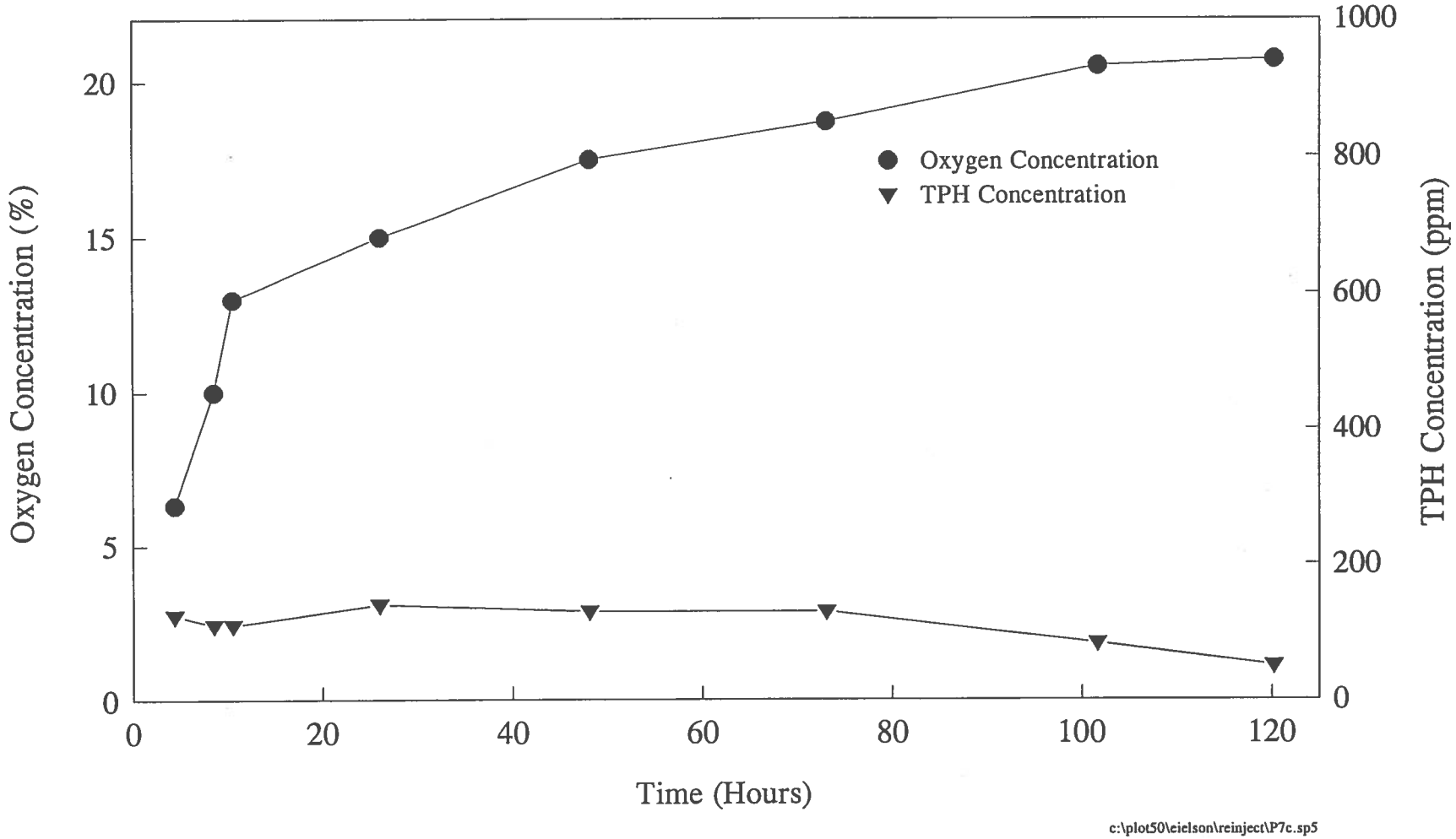


Figure J37. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P7c

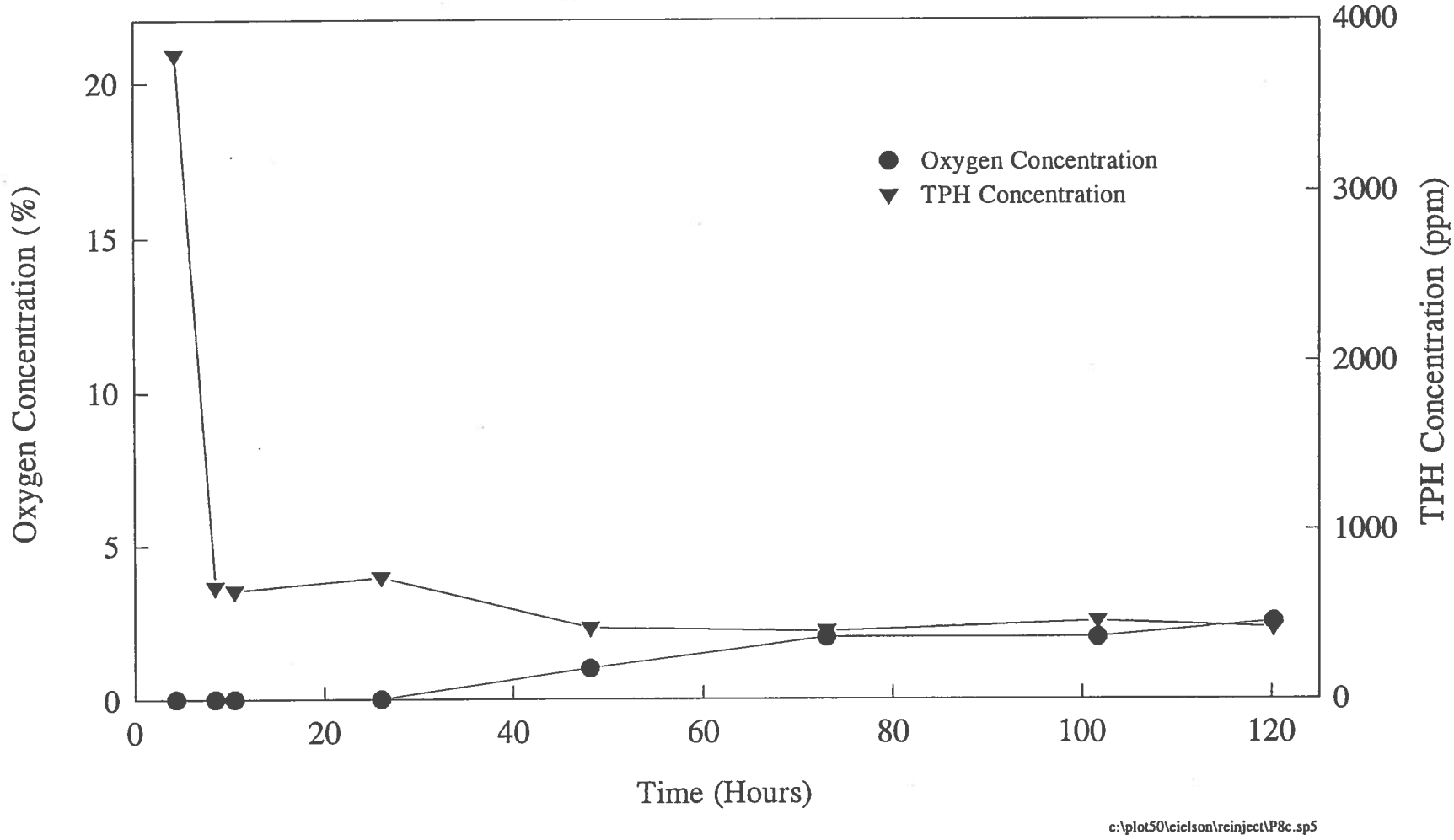


Figure J38. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point P8c

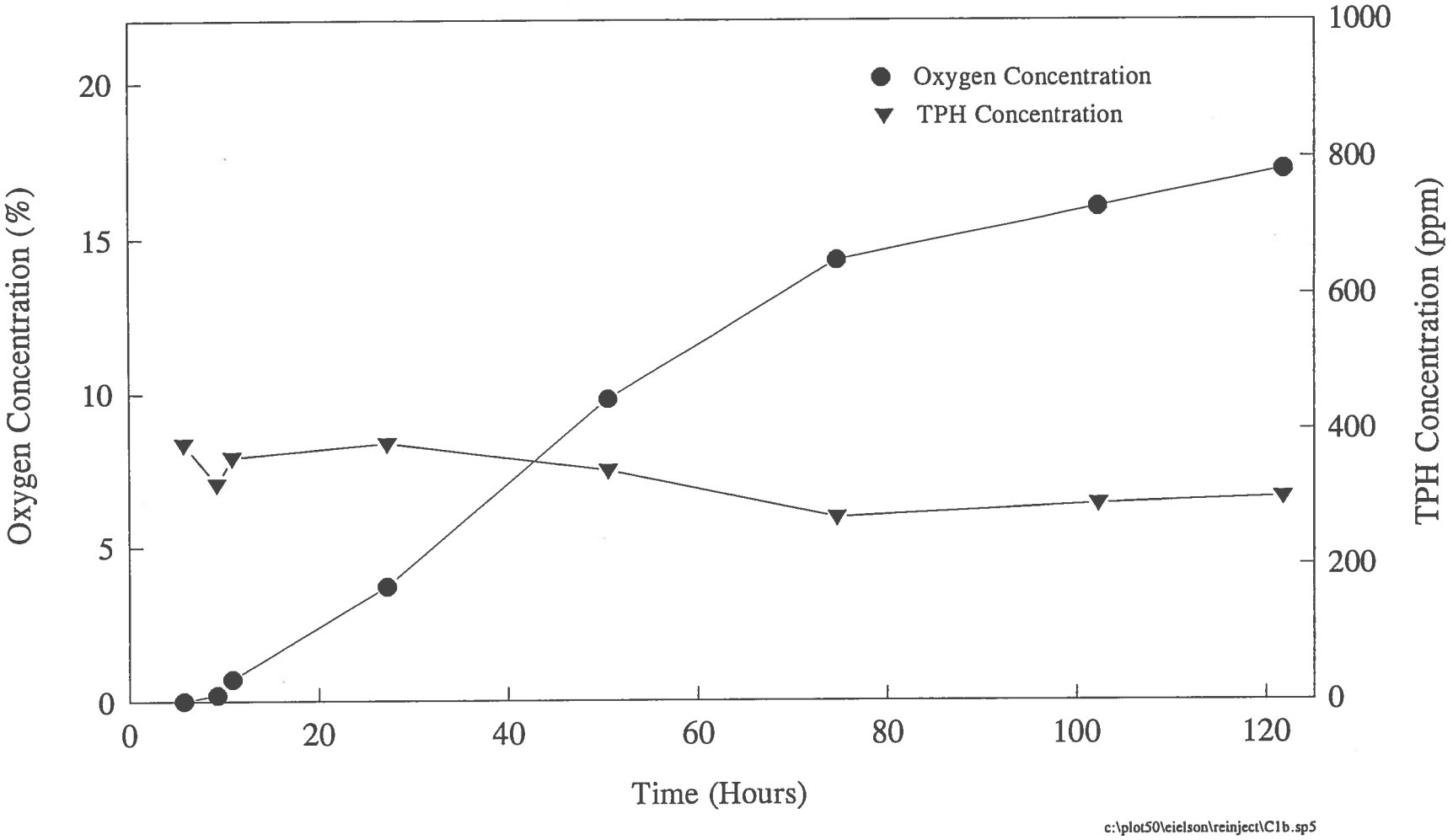


Figure J39. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point C1b

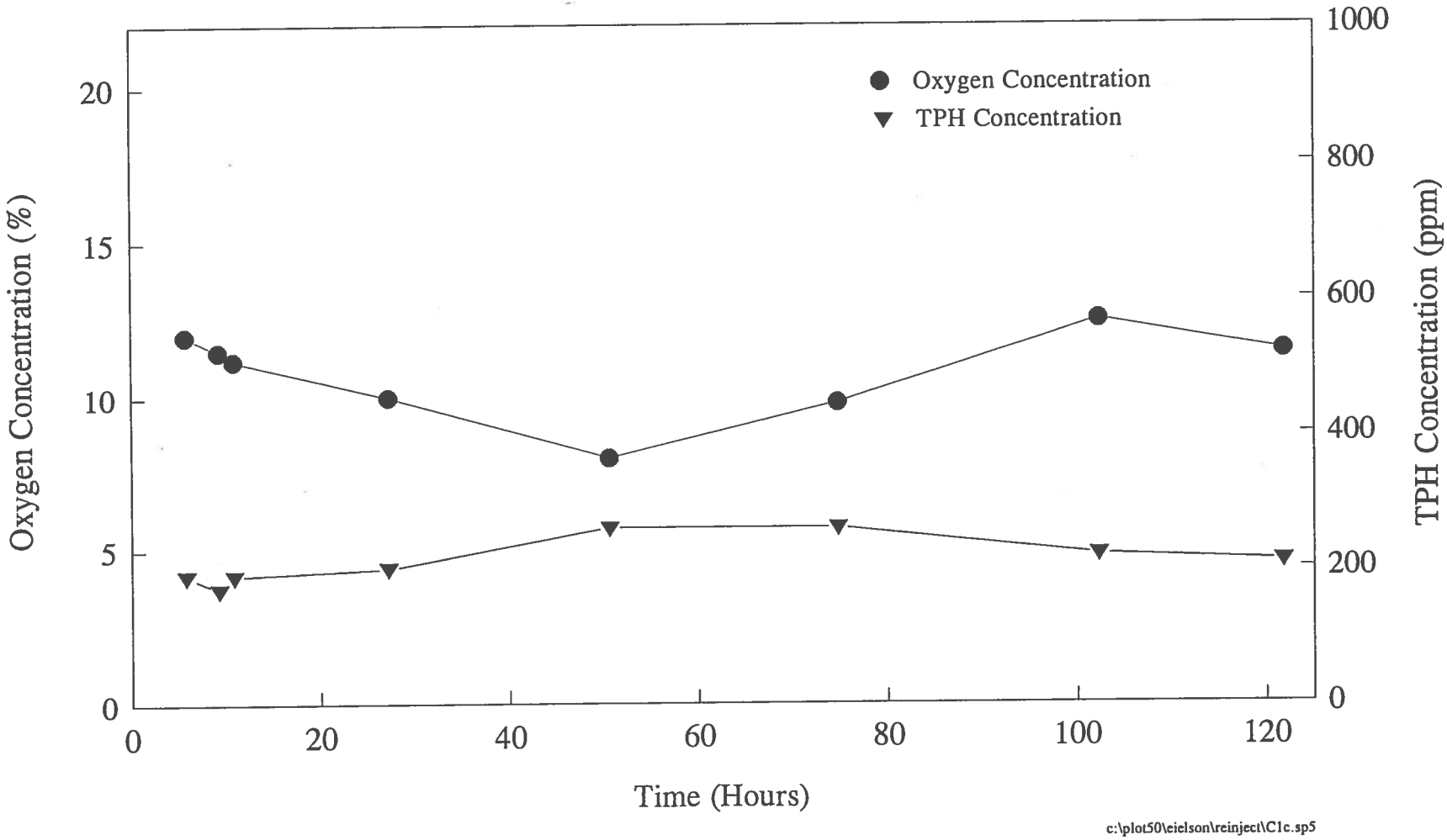


Figure J40. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point C1c

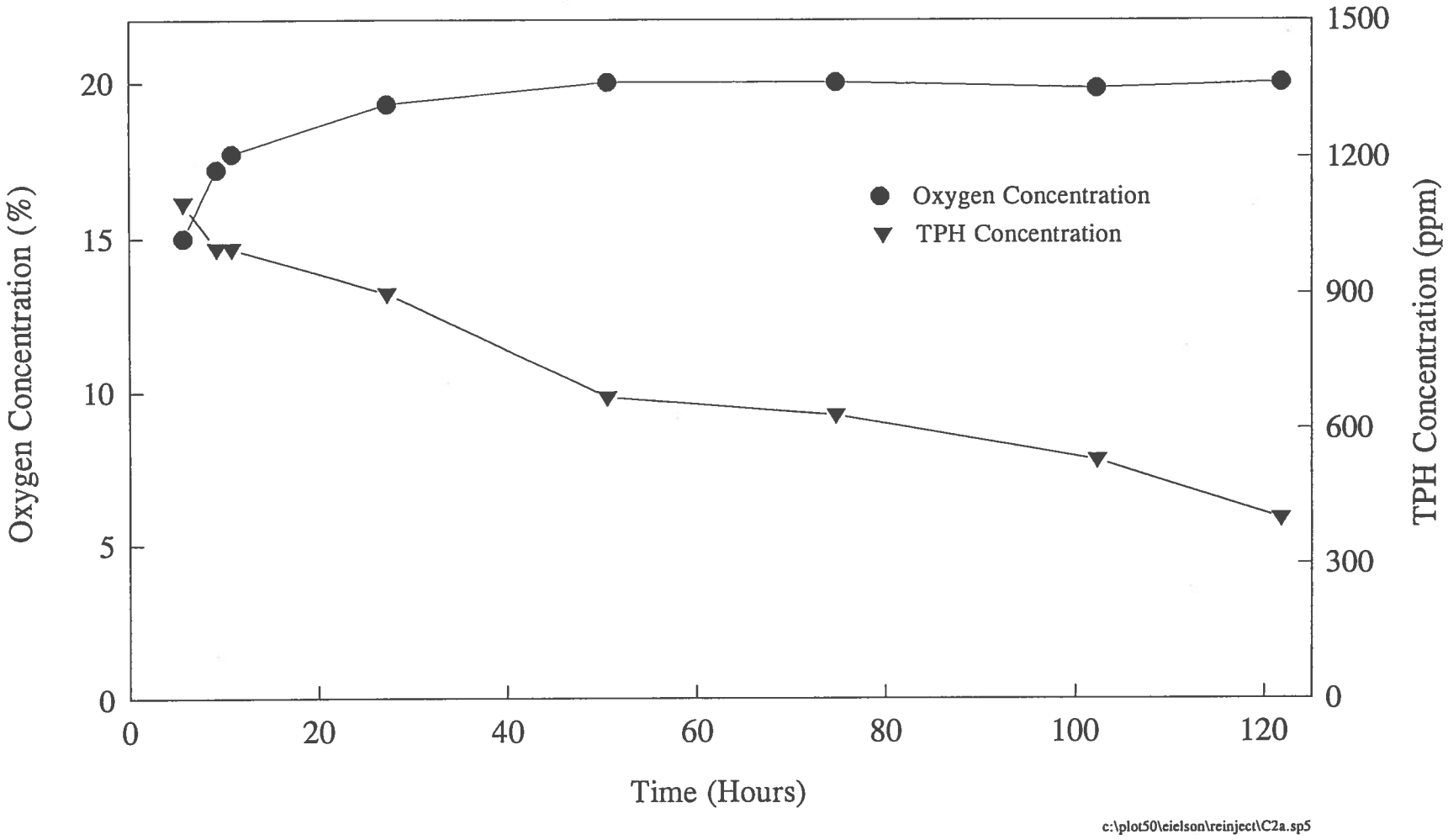


Figure J41. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point C2a

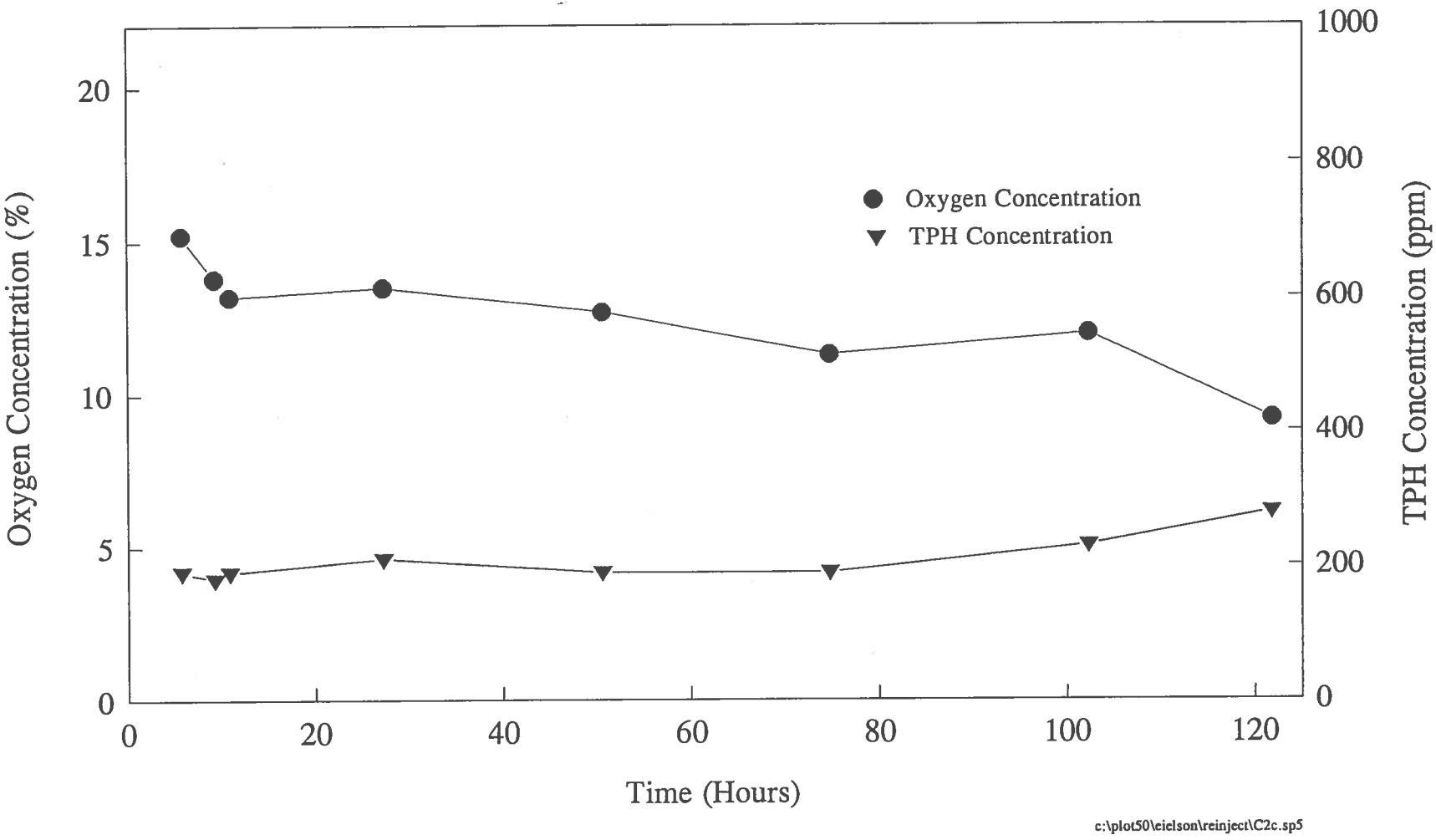


Figure J42. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point C2c

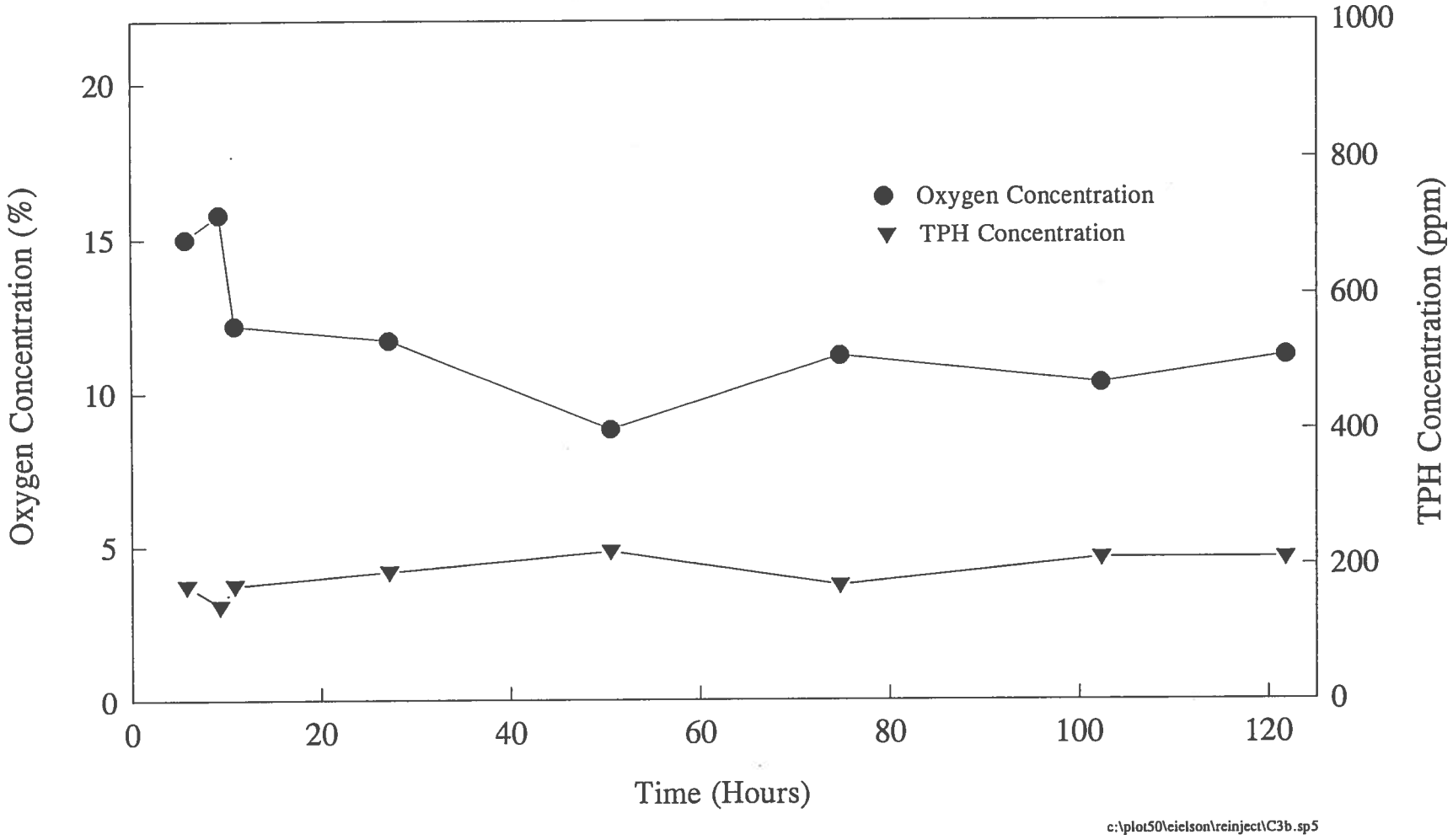


Figure J43. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point C3b

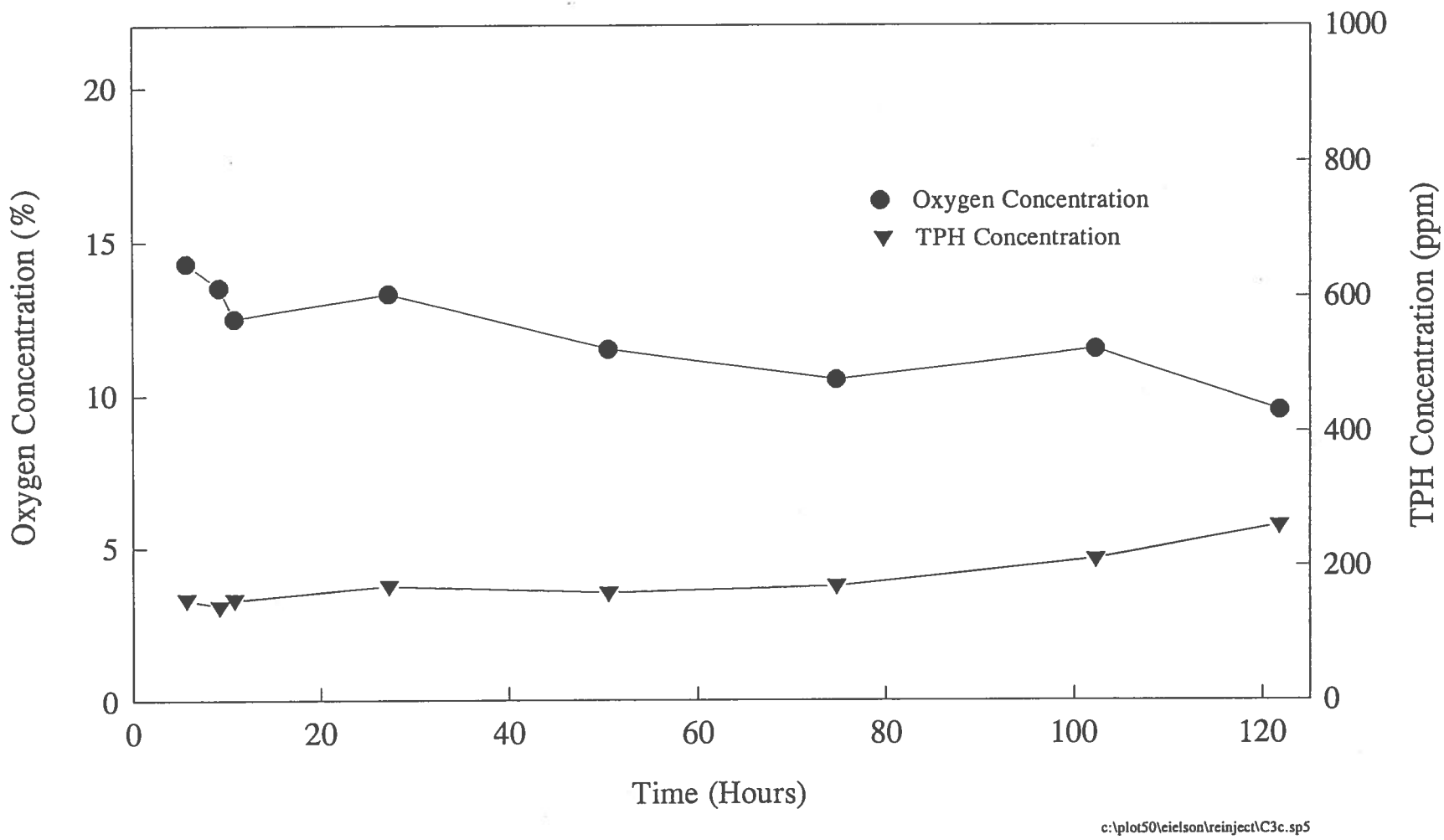


Figure J44. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point C3c

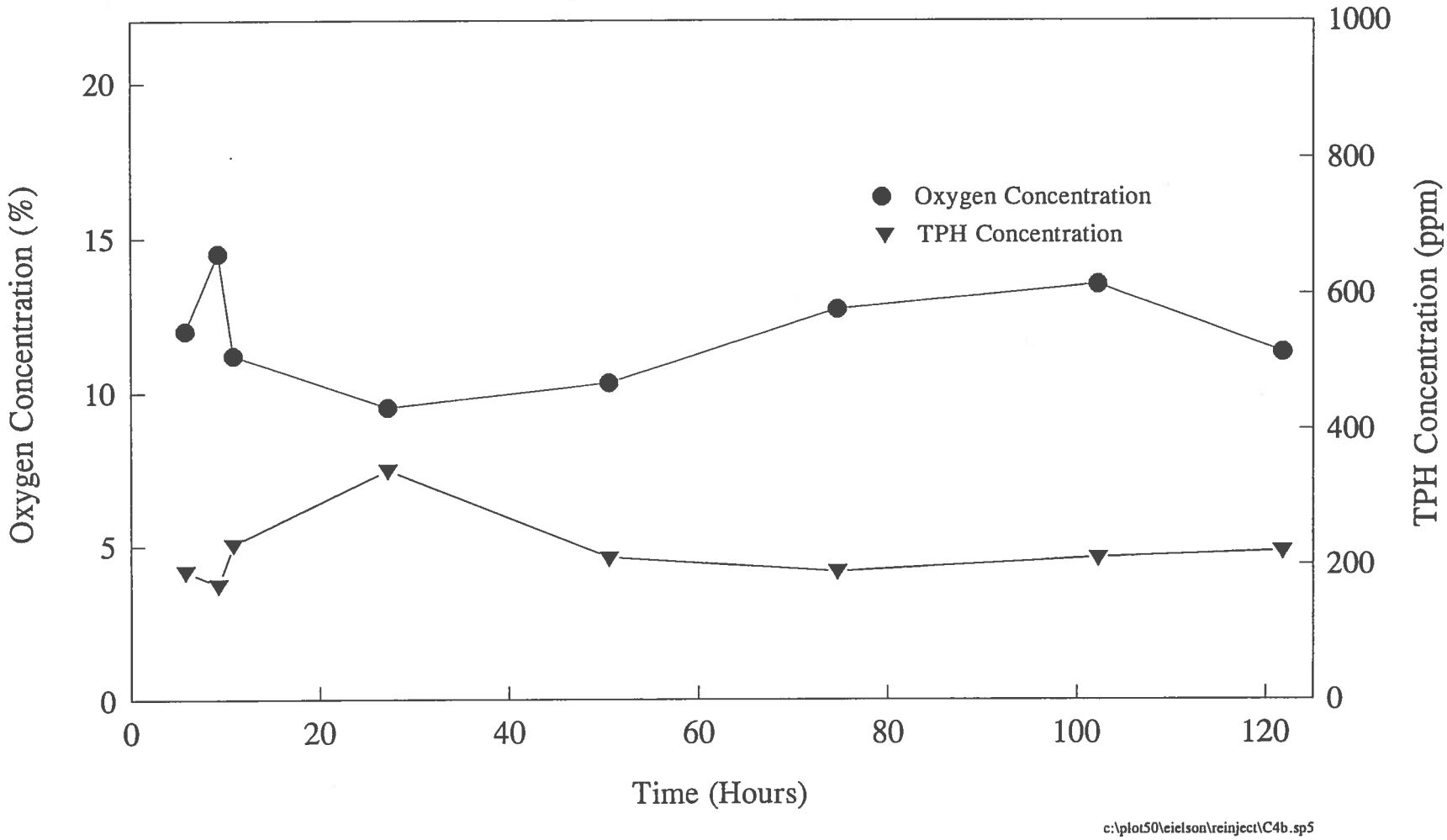


Figure J45. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point C4b

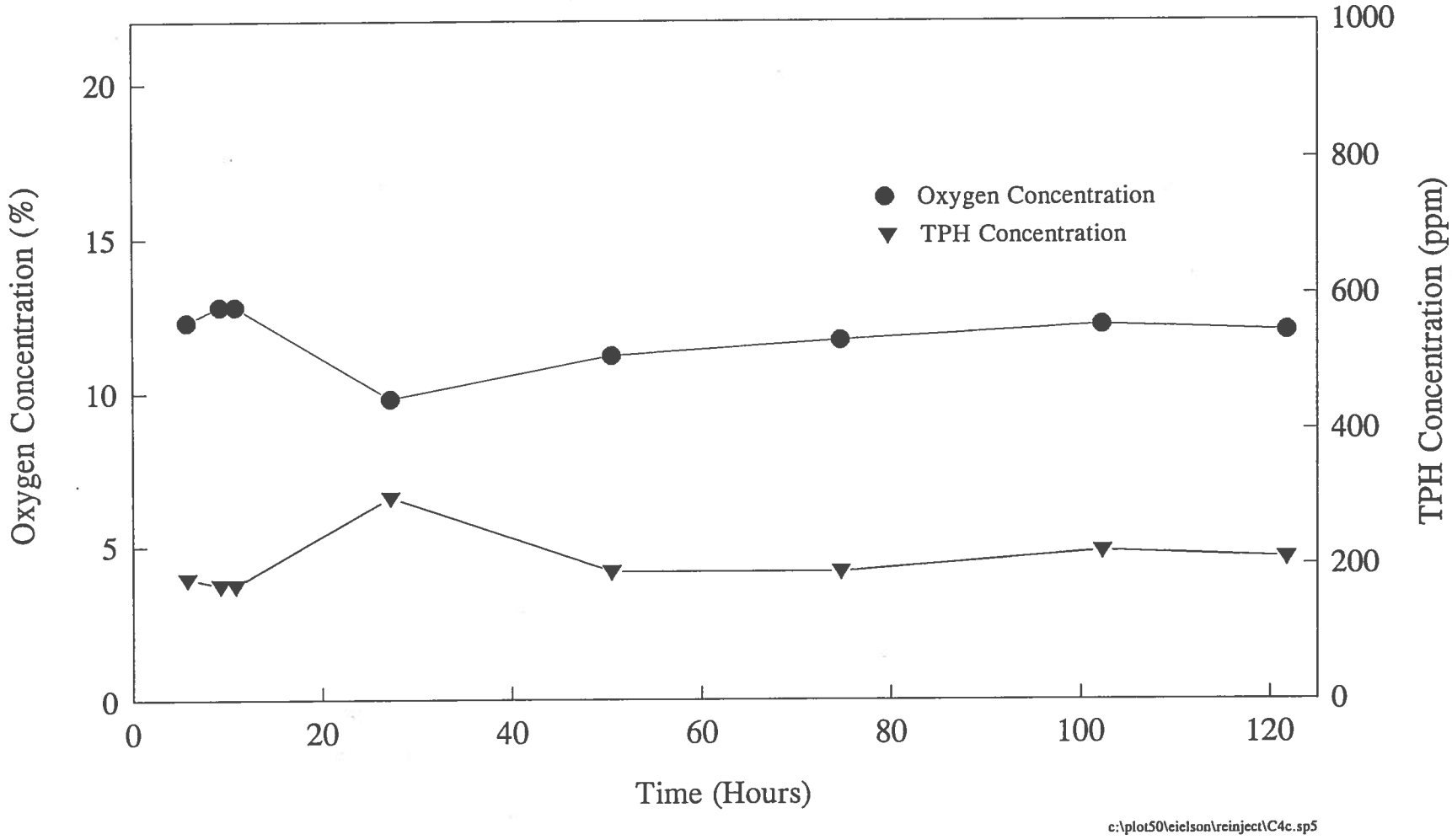


Figure J46. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point C4c

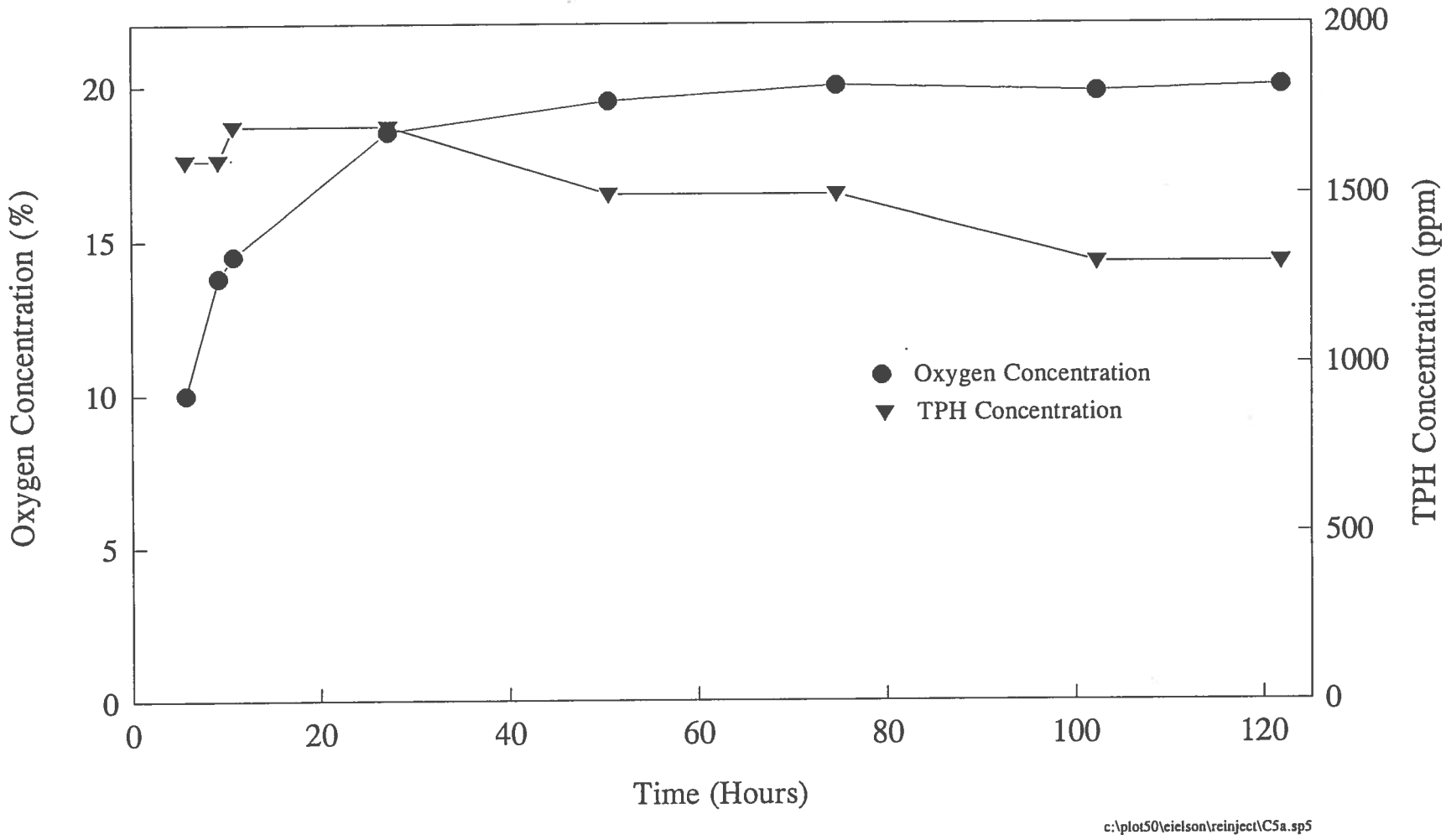


Figure J47. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point C5a

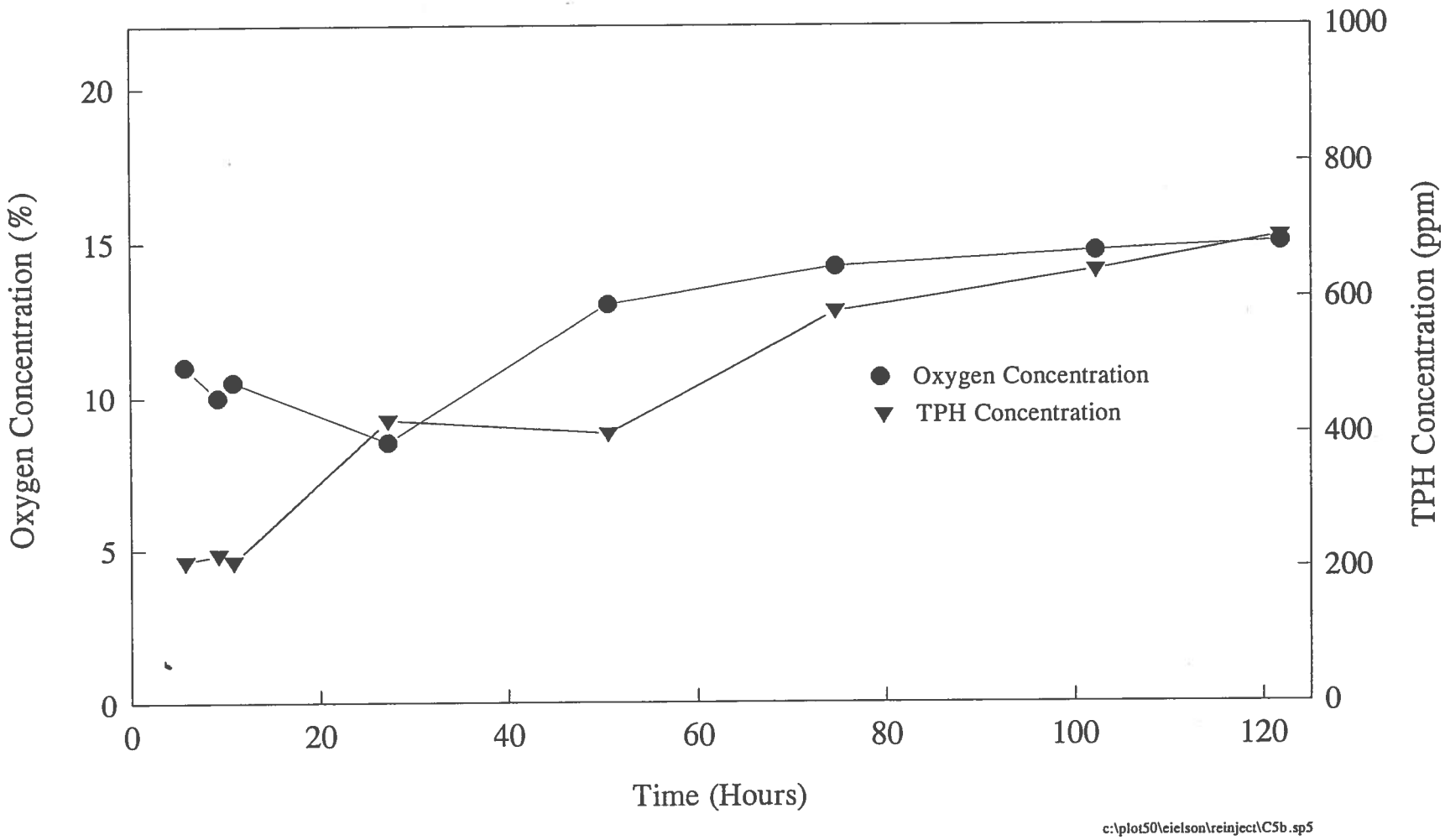


Figure J48. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point C5b

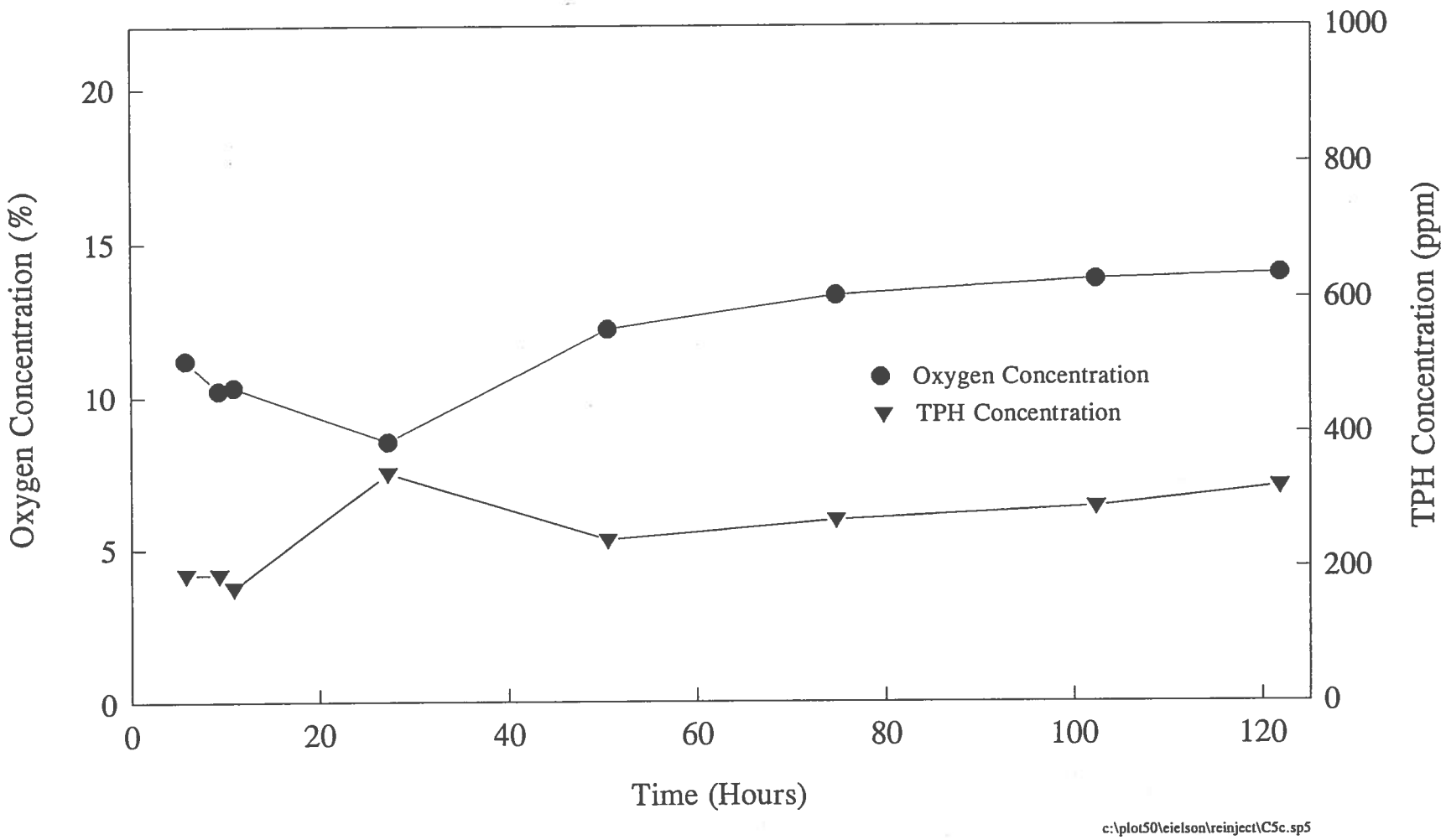


Figure J49. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point C5c

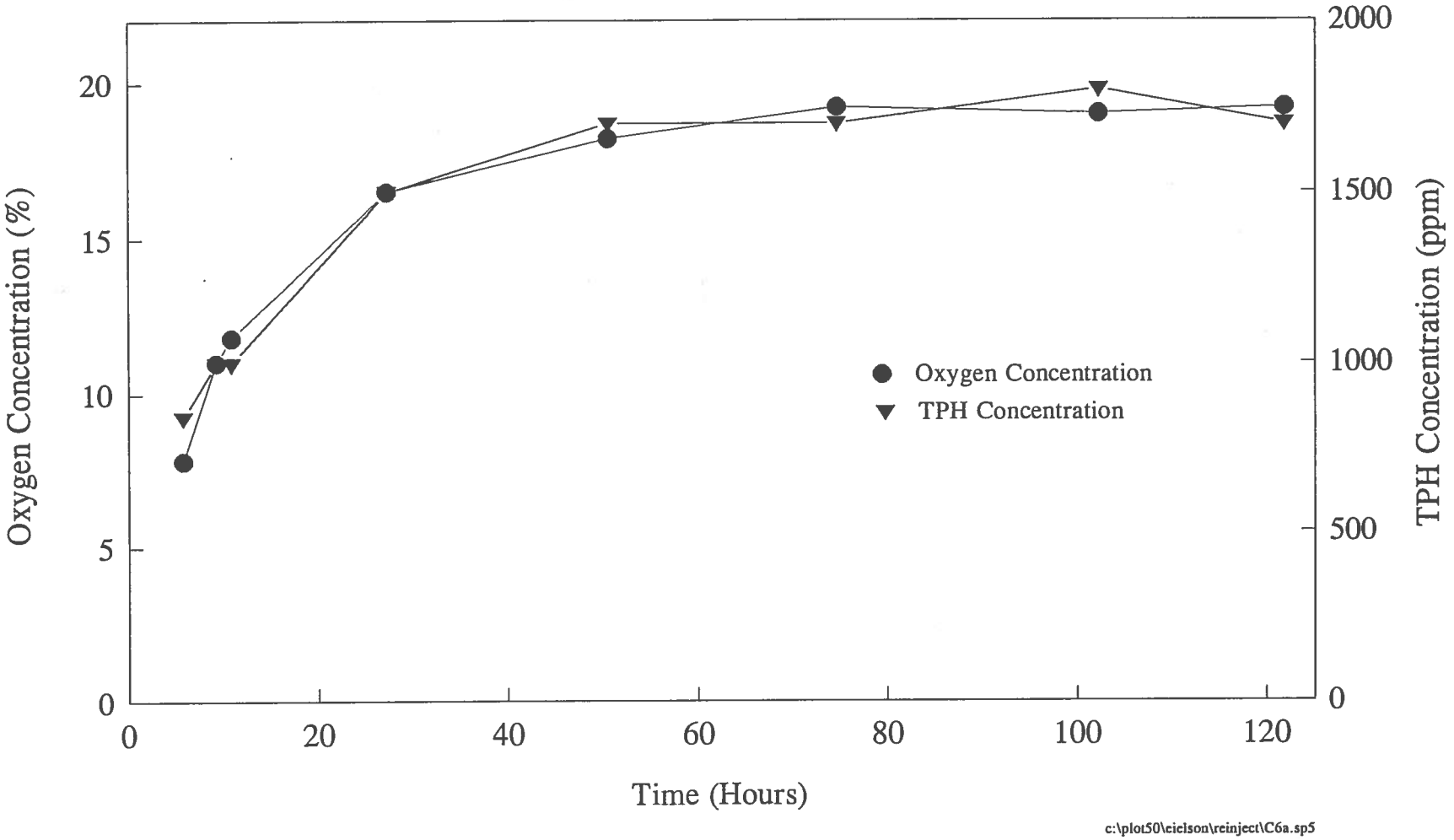


Figure J50. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point C6a

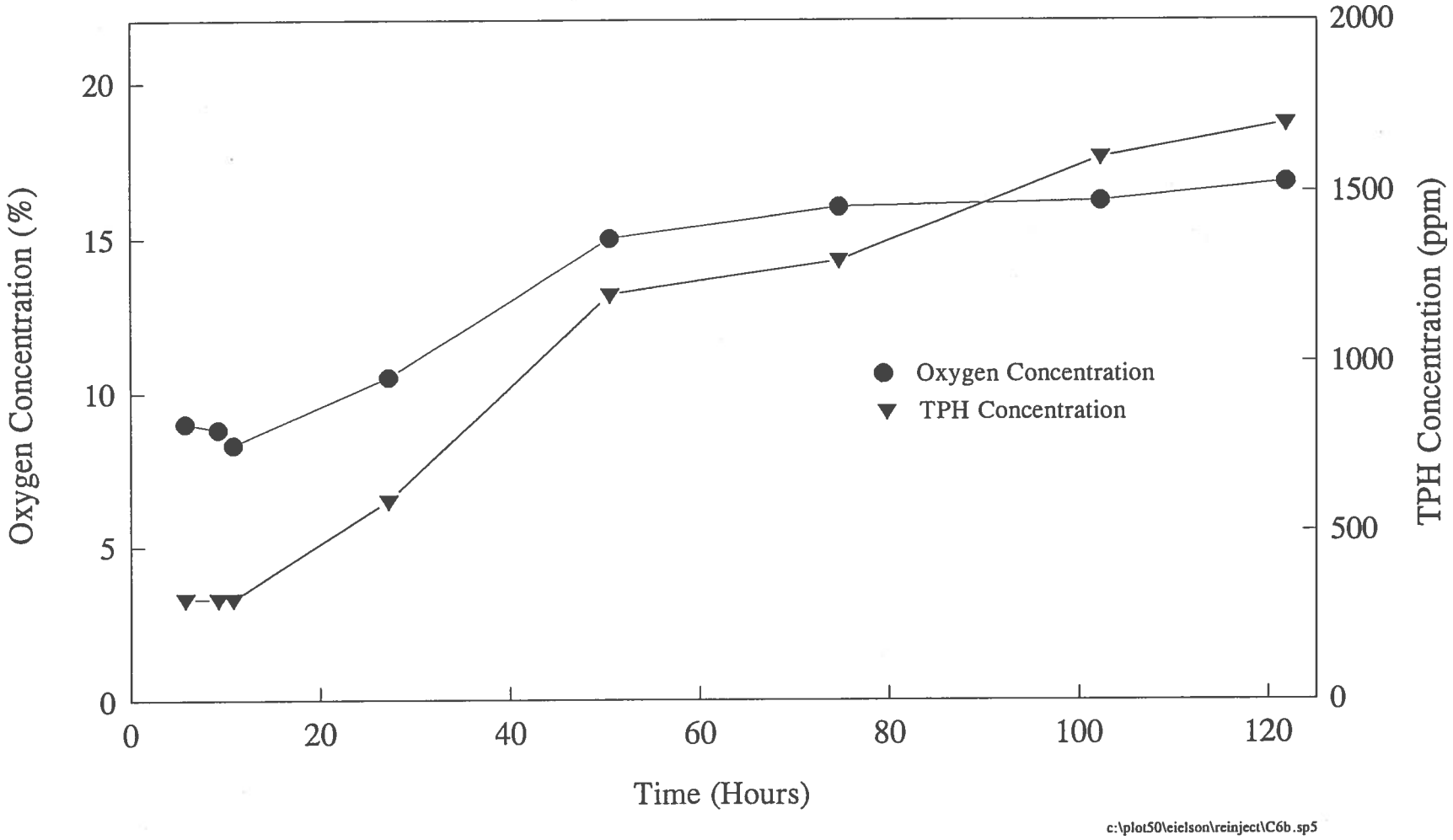


Figure J51. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point C6b

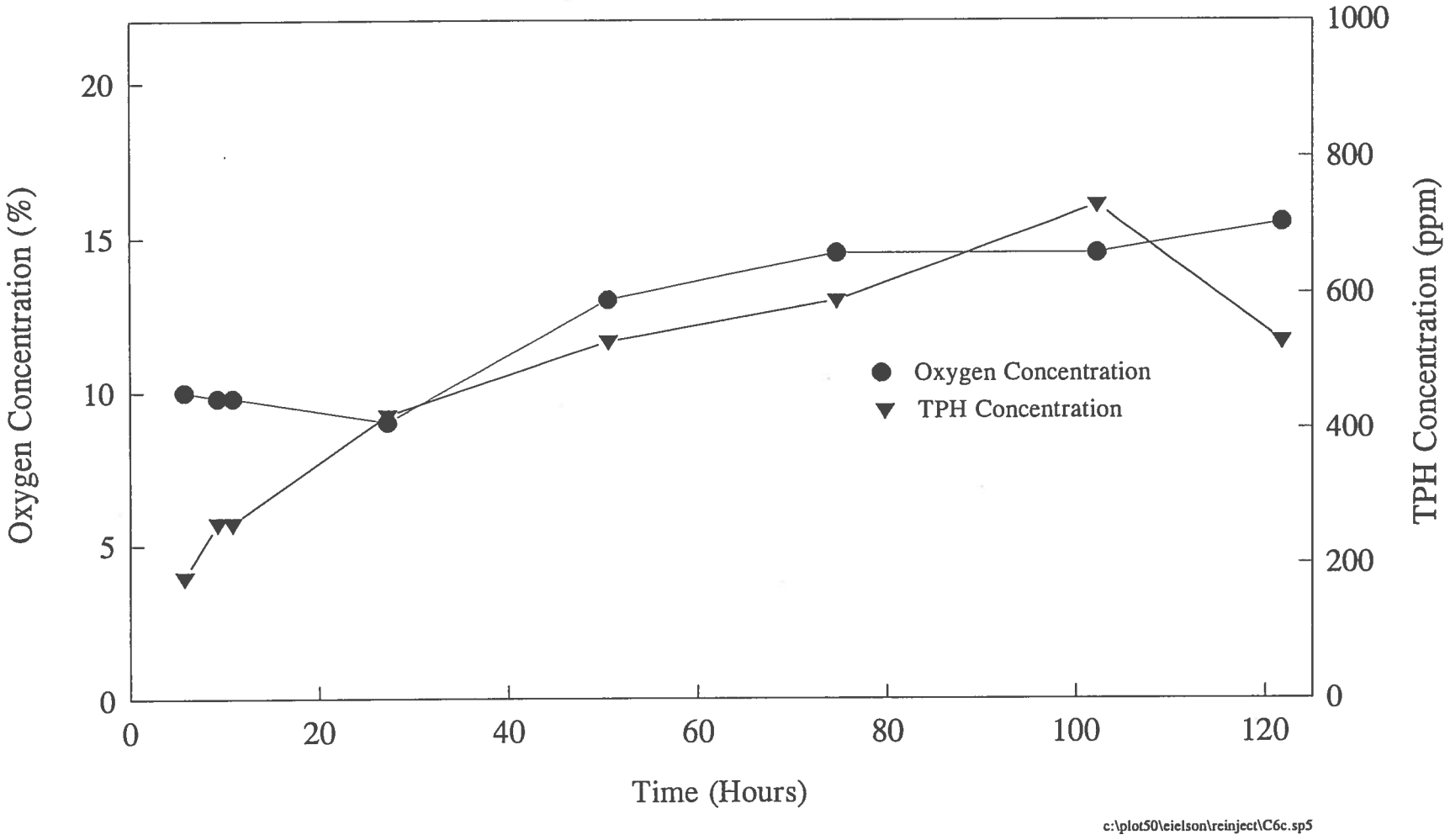


Figure J52. Soil Gas Oxygen and TPH Concentrations During the Extraction Test with Reinjection at Monitoring Point C6c

APPENDIX K

LABORATORY ANALYSES OF QUARTERLY SOIL GAS SAMPLES

Table K1. Distribution of Contaminants in Soil Gas Samples Collected in August, 1991

Compound	Concentration (ppm)									
	A1A	P2A	P3A	P4A	P5A	P6A	ATM2'	ATM4'	ATM6'	Bkgd
Total Hydrocarbon: C-5 to C-15	29750	11503	890	1567	30782	<0.080	46	<0.080	<0.080	<0.080
Total Hydrocarbon: C-6	30000	11599	898	1580	31039	<0.080	48	<0.080	<0.080	<0.080
Benzene	402	678	104	32	808	<0.005	7.02	<0.005	<0.005	<0.005
2,4-Dimethylpentane	2055	1441	93	159	2906	<0.007	7.19	<0.007	<0.007	<0.007
Ethylbenzene	18.48	6.01	<0.004	<0.004	18	<0.004	<0.004	<0.004	<0.004	<0.004
n-Heptane	1335	526	53	83	1665	<0.005	6.14	<0.005	<0.005	<0.005
n-Hexane	3718	<0.005	165	276	3078	<0.005	10.4	<0.005	<0.005	<0.005
2-Methylpentane	2830	2060	111	181	3684	<0.007	<0.007	<0.007	<0.007	<0.007
n-Octane	406	67	11	21	464	<0.004	<0.004	<0.004	<0.004	<0.004
n-Pentadecane	<0.004	0.23	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Toluenes	227	296	0.39	35	778	<0.003	2.2	<0.003	<0.003	<0.003
p-Xylenes	60	<0.003	<0.003	<0.003	45	<0.003	<0.003	<0.003	<0.003	<0.003

Table K2. Distribution of Contaminants in Soil Gas Samples Collected in October, 1992

Compound	Concentration (ppm)									
	P7A	P8A	H1A	H3A	B2A	ATM 1	ATM 2	ATM 3	ATM 4	ATM 5
Total Hydrocarbon: C-5 to C-15	278	14124	2626	472	6.80	<0.080	4.09	<0.080	2.06	6.46
Total Hydrocarbon: C-6	282	14312	2661	478	6.88	<0.080	4.15	<0.080	2.09	6.55
Benzene	7.44	1314	75.3	19.4	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
n-Butylbenzene	<0.003	<0.003	1.27	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
n-Decane	5.36	1.28	2.77	2.46	3.81	<0.004	2.31	<0.004	1.08	3.63
2,4-Dimethylpentane	<0.007	133	21.8	4.07	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Ethylbenzene	9.92	35.4	81.4	4.36	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
n-Heptane	14.4	858	170	29.2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
n-Hexane	<0.005	<0.005	89.4	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
2-Methylbutane	<0.007	314	9.81	17.8	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
2-Methylpentane	<0.007	768	30.9	19.6	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
n-Nonane	<0.004	<0.004	3.72	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
n-Octane	28.4	3.22	1.85	16.5	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
n-Propylbenzene	<0.003	<0.003	2.04	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Toluenes	14.2	33.6	115	13.3	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
n-Undecane	0.81	<0.003	2.66	1.00	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
p-Xylenes	<0.003	5.50	17.1	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003

Table K3. Distribution of Contaminants in Soil Gas Samples Collected in 1993

Compound	Concentration (ppm)										
	Date	P3A	P4A	P5A	P6A	B2A	B2B	B2C	C2A	C6A	H3A
Total Hydrocarbon: C-5 to C-15	January	113	1701	1918	1827	NS	NS	NS	NS	NS	NS
	July	32.9	251	697	1237	0.473	10.9	6.71	NS	342	5.65
	December	3.48	29.2	169	127	NS	0.187	<0.080	33.7	NS	5.46
Total Hydrocarbon: C-6	January	98.9	1497	1688	1894	NS	NS	NS	NS	NS	6.55
	July	34.5	264	734	1302	0.473	11.5	7.07	NS	360	5.96
	December	4.12	34.8	201	152	NS	0.223	<0.080	40.4	NS	6.49
Benzene	January	4.15	97.1	124	131	NS	NS	NS	NS	NS	NS
	July	8.14	61.1	174	254	<0.005	0.952	1.14	NS	20.7	<0.005
	December	0.363	2.55	15.5	11.0	NS	<0.005	<0.005	1.97	NS	0.645
n-Butylbenzene	January	<0.003	<0.003	<0.003	1.98	NS	NS	NS	NS	NS	NS
	July	<0.003	<0.003	1.59	0.429	<0.003	<0.003	<0.003	NS	2.97	<0.003
	December	<0.003	<0.003	<0.003	<0.003	NS	<0.003	<0.003	<0.003	NS	<0.003
n-Decane	January	0.37	2.19	1.92	4.23	NS	NS	NS	NS	NS	NS
	July	0.928	0.624	1.74	0.860	<0.004	0.405	<0.004	NS	2.85	<0.004
	December	0.025	<0.004	<0.004	<0.004	NS	<0.004	<0.004	0.049	NS	<0.004
2,4-Dimethylpentane	January	7.20	103	134	140	NS	NS	NS	NS	NS	NS
	July	8.29	77.4	220	550	<0.007	<0.007	0.743	NS	<0.007	<0.007
	December	<0.007	2.28	<0.007	9.53	NS	<0.007	<0.007	0.958	NS	0.311
n-Dodecane	January	<0.003	<0.003	<0.003	<0.003	NS	NS	NS	NS	NS	NS
	July	3.45	1.55	<0.003	<0.003	<0.003	<0.003	<0.003	NS	<0.003	<0.003
	December	<0.003	<0.003	<0.003	<0.003	NS	<0.003	<0.003	<0.003	NS	<0.003
Ethylbenzene	January	1.50	13.7	12.9	17.9	NS	NS	NS	NS	NS	<0.004
	July	<0.004	4.57	9.45	10.8	<0.004	0.791	0.384	NS	12.7	<0.004
	December	<0.004	0.068	0.723	<0.004	NS	<0.004	<0.004	<0.004	NS	<0.004

Table K3. Distribution of Contaminants in Soil Gas Samples Collected in 1993 (Continued)

Compound	Concentration (ppm)									
	Date	P3A	P4A	P5A	P6A	B2A	B2B	B2C	C2A	C6A	H3A
n-Heptane	January	8.86	113	139	149	NS	NS	NS	NS	NS	NS
	July	1.87	40.5	149	628	<0.005	3.62	4.05	NS	97.7	<0.005
	December	0.187	0.407	4.77	3.71	NS	<0.005	<0.005	0.201	NS	0.503
n-Hexane	January	6.64	102	137	144	NS	NS	NS	NS	NS	NS
	July	2.67	63.0	203	336	<0.005	0.501	<0.005	NS	22.9	<0.005
	December	<0.005	1.50	<0.005	8.52	NS	<0.005	<0.005	0.262	NS	0.061
2-Methylbutane	January	8.70	26.7	17.7	36.6	NS	NS	NS	NS	NS	NS
	July	2.40	5.75	14.1	<0.007	1.96	<0.007	1.83	NS	6.25	<0.007
	December	0.10	0.965	<0.007	2.10	NS	<0.007	<0.007	0.632	NS	1.10
2-Methylpentane	January	3.58	57.1	78.5	79.4	NS	NS	NS	NS	NS	NS
	July	8.08	54.6	148	1097	<0.007	0.418	<0.007	NS	8.58	<0.007
	December	<0.007	2.70	11.9	9.34	NS	<0.007	<0.007	0.334	NS	0.109
Naphthalene	January	<0.004	<0.004	<0.004	<0.004	NS	NS	NS	NS	NS	NS
	July	<0.004	<0.004	1.74	<0.004	<0.004	<0.004	<0.004	NS	<0.004	<0.004
	December	<0.004	<0.004	<0.004	<0.004	NS	<0.004	<0.004	<0.004	NS	<0.004
n-Nonane	January	0.69	13.3	10.8	18.9	NS	NS	NS	NS	NS	NS
	July	<0.004	0.524	4.72	5.39	<0.004	0.337	<0.004	NS	3.35	<0.004
	December	<0.004	<0.004	<0.004	<0.004	NS	<0.004	<0.004	<0.004	NS	<0.004
n-Octane	January	7.73	145	151	162	NS	NS	NS	NS	NS	NS
	July	3.38	38.5	114	193	<0.004	<0.004	<0.004	NS	3.36	<0.004
	December	<0.004	0.714	5.23	3.04	NS	<0.004	<0.004	0.693	NS	<0.004
n-Pentane	January	2.86	13.2	13.5	17.7	NS	NS	NS	NS	NS	NS
	July	0.665	6.82	25.5	<0.008	<0.008	<0.008	<0.008	NS	<0.008	<0.008
	December	<0.008	0.399	<0.008	1.06	NS	<0.008	<0.008	<0.008	NS	<0.008

Table K3. Distribution of Contaminants in Soil Gas Samples Collected in 1993 (Continued)

Compound	Concentration (ppm)									
	Date	P3A	P4A	P5A	P6A	B2A	B2B	B2C	C2A	C6A	H3A
n-Propylbenzene	January	<0.003	<0.003	0.94	<0.003	NS	NS	NS	NS	NS	NS
	July	<0.003	<0.003	2.26	<0.003	<0.003	0.359	0.639	NS	8.41	<0.003
	December	<0.003	<0.003	<0.003	1.90	NS	<0.003	<0.003	0.198	NS	<0.003
n-Tetradecane	January	<0.001	<0.001	<0.001	<0.001	NS	NS	NS	NS	NS	NS
	July	0.702	0.436	0.351	<0.001	0.290	<0.001	<0.001	NS	<0.001	<0.001
	December	<0.001	<0.001	<0.001	<0.001	NS	<0.001	<0.001	<0.001	NS	<0.001
Toluenes	January	4.31	20.0	25.6	32.3	NS	NS	NS	NS	NS	NS
	July	1.59	12.9	90.6	175	<0.003	2.92	1.77	NS	99.5	<0.003
	December	<0.003	0.729	6.25	2.01	NS	<0.003	<0.003	0.755	NS	<0.003
n-Tridecane	January	<0.004	<0.004	<0.004	<0.004	NS	NS	NS	NS	NS	NS
	July	3.87	2.27	1.55	<0.004	<0.004	<0.004	<0.004	NS	<0.004	<0.004
	December	<0.004	<0.004	<0.004	<0.004	NS	<0.004	<0.004	<0.004	NS	<0.004
n-Undecane	January	0.08	<0.003	0.43	0.91	NS	NS	NS	NS	NS	NS
	July	2.46	0.952	3.19	0.845	<0.003	<0.003	<0.003	NS	1.52	<0.003
	December	<0.003	<0.003	<0.003	<0.003	NS	<0.003	<0.003	<0.003	NS	<0.003
p-Xylenes	January	0.09	10.8	9.09	12.8	NS	NS	NS	NS	NS	NS
	July	<0.003	10.6	8.55	7.69	<0.003	1.06	<0.003	NS	9.97	<0.003
	December	<0.003	<0.003	0.249	<0.003	NS	<0.003	<0.003	0.075	NS	<0.003

NS: Not Sampled

Table K4. Distribution of Contaminants in Soil Gas Samples Collected in 1994

Compound	Concentration (ppm)											
	Date	P2B	P3B	P5B	P6B	P8B	B2B	B2C	C2A	C4B	C6B	H1B
Total Hydrocarbon: C-5 to C-15	March	6.30	4.96	4.37	NS	3.15	0.279	<0.080	2.23	NS	NS	278
	May	0.446	0.919	2.62	NS	16.5	<0.080	0.473	NS	NS	148	1989
	July	3.31	NS	0.613	0.696	1.17	0.287	0.279	NS	0.808	NS	1203
Total Hydrocarbon: C-6	March	5.93	4.68	4.12	NS	2.98	0.273	<0.080	2.12	NS	NS	262
	May	0.446	0.919	2.65	NS	16.5	<0.080	0.473	NS	NS	150	2016
	July	3.59	NS	0.668	0.724	1.25	0.293	0.279	NS	0.863	NS	1270
Benzene	March	<0.005	<0.005	<0.005	NS	<0.005	<0.005	<0.005	<0.005	NS	NS	0.614
	May	<0.005	<0.005	<0.005	NS	0.697	<0.005	<0.005	NS	NS<0.	169	215
	July	<0.005	NS	<0.005	<0.005	<0.005	<0.005	<0.005	NS	005	NS	13.12
n-Butylbenzene	March	<0.003	<0.003	<0.003	NS	<0.003	<0.003	<0.003	<0.003	NS	NS	<0.003
	May	<0.003	<0.003	0.320	NS	1.22	<0.003	<0.003	NS	NS	<0.003	<0.003
	July	<0.003	NS	0.088	<0.003	<0.003	<0.003	<0.003	NS	<0.003	NS	<0.003
n-Decane	March	0.506	0.574	0.405	NS	0.337	0.116	<0.004	<0.004	NS	NS	<0.004
	May	<0.004	<0.004	<0.004	NS	<0.004	<0.004	<0.004	NS	NS	<0.004	<0.004
	July	0.067	NS	0.040	<0.004	<0.004	0.062	<0.004	NS	0.025	NS	<0.004
2,4-Dimethylpentane	March	<0.007	<0.007	<0.007	NS	<0.007	<0.007	<0.007	0.192	NS	NS	<0.007
	May	<0.007	<0.007	<0.007	NS	<0.007	<0.007	<0.007	NS	NS	<0.007	<0.007
	July	<0.007	NS	<0.007	<0.007	<0.007	<0.007	<0.007	NS	0.012	NS	516
n-Dodecane	March	<0.003	<0.003	<0.003	NS	<0.003	<0.003	<0.003	<0.003	NS	NS	<0.003
	May	<0.003	<0.003	<0.003	NS	0.225	<0.003	<0.003	NS	NS	<0.003	<0.003
	July	<0.003	NS	<0.003	<0.003	<0.003	<0.003	<0.003	NS	0.030	NS	<0.003
Ethylbenzene	March	<0.004	<0.004	<0.004	NS	<0.004	<0.004	<0.004	<0.004	NS	NS	<0.004
	May	<0.004	<0.004	<0.004	NS	0.565	<0.004	<0.004	NS	NS	26.9	0.125
	July	<0.004	NS	<0.004	0.079	<0.004	<0.004	<0.004	NS	<0.004	NS	0.746

Table K4. Distribution of Contaminants in Soil Gas Samples Collected in 1994 (Continued)

Compound	Concentration (ppm)											
	Date	P2B	P3B	P5B	P6B	P8B	B2B	B2C	C2A	C4B	C6B	H1B
n-Heptane	March	<0.005	<0.005	<0.005	NS	<0.005	<0.005	<0.005	<0.005	NS	NS	0.141
	May	<0.005	<0.005	<0.005	NS	0.335	<0.005	<0.005	NS	NS	<0.005	<0.005
	July	<0.005	NS	0.055	<0.005	<0.005	<0.005	<0.005	NS	<0.005	NS	26.1
n-Hexane	March	<0.005	<0.005	<0.005	NS	<0.005	<0.005	<0.005	<0.005	NS	NS	<0.005
	May	<0.005	<0.005	<0.005	NS	<0.005	<0.005	<0.005	NS	NS	<0.005	<0.005
	July	<0.005	NS	<0.005	<0.005	<0.005	<0.005	<0.005	NS	<0.005	NS	13.3
2-Methylbutane	March	<0.007	<0.007	<0.007	NS	<0.007	<0.007	<0.007	<0.007	NS	NS	<0.007
	May	<0.007	<0.007	<0.007	NS	<0.007	<0.007	<0.007	NS	NS	<0.007	<0.007
	July	<0.007	NS	<0.007	<0.007	<0.007	<0.007	<0.007	NS	<0.007	NS	190
2-Methylpentane	March	<0.007	<0.007	<0.007	NS	<0.007	<0.007	<0.007	<0.007	NS	NS	0.103
	May	<0.007	<0.007	<0.007	NS	<0.007	<0.007	<0.007	NS	NS	<0.007	<0.007
	July	<0.007	NS	<0.007	<0.007	<0.007	<0.007	<0.007	NS	<0.007	NS	100
Naphthalene	March	<0.004	<0.004	<0.004	NS	<0.004	<0.004	<0.004	<0.004	NS	NS	<0.004
	May	<0.004	<0.004	<0.004	NS	0.487	<0.004	<0.004	NS	NS	<0.004	<0.004
	July	<0.004	NS	<0.004	<0.004	<0.004	<0.004	<0.004	NS	<0.004	NS	<0.004
n-Nonane	March	1.22	1.20	0.805	NS	0.618	<0.004	<0.004	<0.004	NS	NS	<0.004
	May	<0.004	<0.004	<0.004	NS	0.393	<0.004	<0.004	NS	NS	<0.004	<0.004
	July	0.037	NS	0.064	<0.004	<0.004	0.033	<0.004	NS	0.028	NS	<0.004
n-Octane	March	0.273	0.160	0.134	NS	0.050	<0.004	<0.004	<0.004	NS	NS	<0.004
	May	<0.004	<0.004	<0.004	NS	0.231	<0.004	<0.004	NS	NS	15.4	<0.004
	July	<0.004	NS	<0.004	0.071	<0.004	<0.004	<0.004	NS	<0.004	NS	<0.004
n-Pentane	March	<0.008	<0.008	<0.008	NS	<0.008	<0.008	<0.008	<0.008	NS	NS	<0.008
	May	<0.008	<0.008	<0.008	NS	<0.008	<0.008	<0.008	NS	NS	<0.008	1.58
	July	<0.008	NS	<0.008	<0.008	<0.008	<0.008	<0.008	NS	<0.008	NS	4.03

Table K4. Distribution of Contaminants in Soil Gas Samples Collected in 1994 (Continued)

Compound	Concentration (ppm)											
	Date	P2B	P3B	P5B	P6B	P8B	B2B	B2C	C2A	C4B	C6B	H1B
n-Propylbenzene	March	<0.003	<0.003	0.419	NS	<0.003	<0.003	<0.003	<0.003	NS	NS	<0.003
	May	<0.003	<0.003	<0.003	NS	0.319	<0.003	<0.003	NS	NS	<0.003	<0.003
	July	<0.003	NS	<0.003	<0.003	<0.003	<0.003	<0.003	NS	0.034	NS	0.052
n-Tetradecane	March	<0.001	<0.001	<0.001	NS	<0.001	<0.001	<0.001	<0.001	NS	NS	<0.001
	May	<0.001	<0.001	<0.001	NS	<0.001	<0.001	<0.001	NS	NS	<0.001	<0.001
	July	<0.001	NS	<0.001	<0.001	<0.001	<0.001	<0.001	NS	0.047	NS	<0.001
Toluenes	March	<0.003	<0.003	<0.003	NS	<0.003	<0.003	<0.003	<0.003	NS	NS	0.073
	May	<0.003	0.391	<0.003	NS	0.573	<0.003	<0.003	NS	NS	15.1	<0.003
	July	<0.003	NS	0.052	<0.003	<0.003	<0.003	0.112	NS	<0.003	NS	0.391
n-Tridecane	March	<0.004	<0.004	<0.004	NS	<0.004	<0.004	<0.004	<0.004	NS	NS	<0.004
	May	<0.004	<0.004	<0.004	NS	<0.004	<0.004	<0.004	NS	NS	<0.004	<0.004
	July	<0.004	NS	<0.004	<0.004	<0.004	<0.004	<0.004	NS	<0.004	NS	<0.004
1,2,4-Trimethylbenzene	March	<0.003	<0.003	<0.003	NS	<0.003	<0.003	<0.003	<0.003	NS	NS	<0.003
	May	<0.003	<0.003	<0.003	NS	0.839	<0.003	<0.003	NS	NS	<0.003	<0.003
	July	<0.003	NS	<0.003	<0.003	<0.003	<0.003	<0.003	NS	0.026	NS	<0.003
1,3,5-Trimethylbenzene	March	<0.003	<0.003	<0.003	NS	<0.003	<0.003	<0.003	<0.003	NS	NS	<0.003
	May	<0.003	<0.003	0.164	NS	1.44	<0.003	<0.003	NS	NS	<0.003	<0.003
	July	0.026	NS	<0.003	<0.003	<0.003	0.028	<0.003	NS	0.034	NS	<0.003
n-Undecane	March	<0.003	<0.003	<0.003	NS	<0.003	<0.003	<0.003	<0.003	NS	NS	<0.003
	May	0.230	0.230	0.215	NS	2.43	<0.003	<0.003	NS	NS	<0.003	<0.003
	July	0.111	NS	0.077	<0.003	<0.003	0.032	0.060	NS	<0.003	NS	<0.003
p-Xylenes	March	0.814	0.102	<0.003	NS	1.15	<0.003	<0.003	<0.003	NS	NS	<0.003
	May	<0.003	<0.003	<0.003	NS	0.316	<0.003	<0.003	NS	NS	<0.003	<0.003
	July	<0.003	NS	<0.003	<0.003	<0.003	<0.003	<0.003	NS	<0.003	NS	0.059

NS: Not Sampled

APPENDIX L

WEEKLY SOIL GAS SAMPLING DATA

Table L1. Eielson AFB Weekly Soil Gas Data: Active Warming Plot

Year	Date	Temp (°C)	A1A			A1B			A1C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/18	NS	1	12	10000	7	13	8000	12	10	200
	9/28	NS	3	NS	NS	8	11	2000	9.5	7.5	740
	10/20	2.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/26	2.7	14.1	2.8	9800	18	2.6	3000	17	3	640
	11/2	-1.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/23	-19.0	5.5	9	9800	5.2	15.5	1000	8.9	11.9	100
	11/30	-16.0	NS	NS	NS	9.9	11.1	2200	10	7.5	1250
	12/24	-19.4	NS	NS	NS	7.4	14.1	900	14	8.2	370
	12/29	-23.3	NS	NS	NS	8.6	13.9	1000	14	9.3	380
1992	1/5	-19.4	NS	NS	NS	7.9	13.1	1000	14	8.4	220
	1/11	-18.9	6.1	8.2	10000	9.5	12.1	1200	12.9	9.1	380
	1/18	-6.0	NS	NS	NS	7.5	12.4	1200	13	9.3	400
	1/25	-18.0	NS	NS	NS	8.7	12.6	990	13.5	9.1	340
	2/15	ND	NS	NS	NS	5.9	14.1	NS	12.3	9.5	NA
	2/22	-28.0	NS	NS	NS	4	14	2600	16.5	6.8	NA
	3/2	-23.0	NS	NS	NS	3	14	1800	NS	NS	NS
	3/8	-28.0	NS	NS	NS	2.3	13.7	2300	NS	NS	NS
	3/28	0.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/4	-17.2	NS	NS	NS	2.9	12.9	3200	NS	NS	NS
	4/24	3.0	NS	NS	NS	1.9	12.2	NS	NS	NS	NS
	5/3	-5.0	NS	NS	NS	8.1	13	10000	NS	NS	NS
	5/17	2.2	20.9	0.05	330	NS	NS	NS	NS	NS	NS
	5/22	18.8	NS	NS	NS	NS	NS	NS	11.5	10.3	390
	5/31	16.6	NS	NS	NS	NS	NS	NS	13.2	9.9	530
	6/7	20.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/28	28.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/5	25.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/11	15.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/22	ND	NS	NS	NS	14	5	NS	8	5	NS
	8/26	18.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/30	19.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	9/2	16.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/3	0.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/7	2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/14	-2.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/22	-8.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/28	-2.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/21	-8.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/29	-8.6	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/5	-20.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/19	-13.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/23	-35.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
1993	1/30	-25.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/6	-19.4	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table L1. Eielson AFB Weekly Soil Gas Data: Active Warming Plot (Continued)

Year	Date	Temp (°C)	A1A			A1B			A1C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	2/10	-22.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/20	-12.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/8	-7.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/12	-7.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/20	-6.2	NS	NS	NS	NS	NS	NS	NS	NS	SN
	4/7	3.3	NS	NS	NS	NS	NS	NS	17	3.8	14
	4/10	7.2	NS	NS	NS	18.5	2.9	150	17.5	3.5	140
	4/20	7.8	NS	NS	NS	13.5	3.3	150	16.2	1.8	110
	5/6	12.8	NS	NS	NS	20.2	0.9	75	NS	NS	NS
	6/6	13.3	NS	NS	NS	NA	1.7	87	NS	NS	NS
	6/22	18.3	NS	NS	NS	17.8	4.5	110	16.3	4.9	110
	6/27	20.0	NS	NS	NS	17.3	5	110	15	5.7	100
	7/3	16.9	NS	NS	NS	16	6.5	120	12.2	7.8	120
	7/22	ND	NS	NS	NS	13.3	8.3	100	9	9.8	196
	8/22	8.4	NS	NS	NS	NS	NS	NS	15	5.3	110
	8/29	12.2	NS	NS	NS	NS	NS	NS	14.2	5.8	190
	9/30	3.7	NS	NS	NS	14	9	270	17	4.5	220
	10/7	13.0	NS	NS	NS	15	8	250	17.2	4.2	210
	10/11	2.6	NS	NS	NS	15	8.2	280	17	4.5	230
	10/14	5.4	NS	NS	NS	15	7.7	250	17.2	4.3	200
	12/21	-10.6	NS	NS	NS	0.3	7.7	540	17.5	2.8	200
1994	1/26	-14.6	NS	NS	NS	2.5	7	280	19	2.5	190
	2/6	-16.0	NS	NS	NS	3.3	7	320	19	2.4	240
	2/13	-29.8	NS	NS	NS	3.2	6.8	390	19.2	2.2	270
	3/10	-10.5	NS	NS	NS	3.2	6.4	310	19.7	1.6	180
	3/17	-18.6	NS	NS	NS	NS	NS	NS	20	1.8	280
	3/24	6.8	NS	NS	NS	NS	NS	NS	20.5	1.2	270
	4/9	-4.9	NS	NS	NS	NS	NS	NS	19	1.5	310
	4/16	-12.4	NS	NS	NS	NS	NS	NS	17.8	3	600
	5/3	10.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/8	13.5	NS	NS	NS	NS	NS	NS	11.7	2	210
	6/6	15.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/23	NS	NS	NS	NS	17.3	5.1	190	16	5.2	190
	7/2	17.7	NS	NS	NS	18.8	3.7	170	18.2	4.8	210

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L1. Eielson AFB Weekly Soil Gas Data: Active Warming Plot (Continued)

Year	Date	Temp (°C)	A2A			A2B			A2C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/18	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	9/28	NS	16.8	5	5400	19	1.65	600	15	5	520
	10/20	2.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/26	2.7	18	2.4	3400	21	0.9	400	20	2.2	380
	11/2	-1.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/23	-19.0	8.1	10.9	10000	15.3	7.4	910	11	11.1	370
	11/30	-16.0	7.4	10.6	10000	10.1	3.1	3200	11.3	9.6	960
	12/24	-19.4	NS	NS	NS	20.9	0	0	20.9	0	0
	12/29	-23.3	NS	NS	NS	18	4.9	1400	14	9.9	560
1992	1/5	-19.4	NS	NS	NS	18.1	4	1600	14.4	9	900
	1/11	-18.9	NS	NS	NS	19	3.9	360	15	9	370
	1/18	-6.0	NS	NS	NS	16.5	5.5	1300	13.3	9.3	1200
	1/25	-18.0	NS	NS	NS	18.4	2.49	320	15	9	360
	2/15	ND	NS	NS	NS	15.9	4.9	NS	14	9.8	NS
	2/22	-28.0	NS	NS	NS	14.9	8.1	400	NS	NS	NS
	3/2	-23.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/8	-28.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/28	0.0	NS	NS	NS	13	13	590	NS	NS	NS
	4/4	-17.2	NS	NS	NS	14	12.2	360	NS	NS	NS
	4/24	3.0	NS	NS	NS	3.1	14.3	6500	NS	NS	NS
	5/3	-5.0	NS	NS	NS	16.9	8	10000	NS	NS	NS
	5/17	2.2	NS	NS	NS	20	0.95	1000	NS	NS	NS
	5/22	18.8	NS	NS	NS	20.2	1.4	940	NS	NS	NS
	5/31	16.6	NS	NS	NS	20.1	0.8	900	NS	NS	NS
	6/7	20.0	NS	NS	NS	20	2.1	910	NS	NS	NS
	6/28	28.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/5	25.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/11	15.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/22	ND	NS	NS	NS	18	2.43	NS	NS	NS	NS
	8/26	18.3	NS	NS	NS	18.2	2.35	NS	NS	NS	NS
	8/30	19.7	NS	NS	NS	18.3	2.4	NS	NS	NS	NS
	9/2	16.7	NS	NS	NS	18.6	2.2	3400	NS	NS	NS
	10/3	0.0	NS	NS	NS	2.5	9	2200	NS	NS	NS
	10/7	2.2	NS	NS	NS	1	11.2	7200	NS	NS	NS
	10/14	-2.8	NS	NS	NS	4	11.8	11400	NS	NS	NS
	10/22	-8.3	NS	NS	NS	2	11.2	11200	NS	NS	NS
	10/28	-2.8	NS	NS	NS	2.5	11.2	13000	NS	NS	NS
	11/21	-8.9	NS	NS	NS	19.5	1.8	4200	NS	NS	NS
	11/29	-8.6	NS	NS	NS	19.8	1.5	3000	NS	NS	NS
	12/5	-20.0	NS	NS	NS	20	1.3	1100	NS	NS	NS
	12/19	-13.3	NS	NS	NS	20	1.2	310	NS	NS	NS
	12/23	-35.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
1993	1/30	-25.0	NS	NS	NS	20	1.2	100	19.2	2.3	150
	2/6	-19.4	NS	NS	NS	20.2	0.8	92	20	1.6	110

Table L1. Eielson AFB Weekly Soil Gas Data: Active Warming Plot (Continued)

Year	Date	Temp (°C)	A2A			A2B			A2C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	2/10	-22.8	NS	NS	NS	20	1	110	19.8	1.2	120
	2/20	-12.8	NS	NS	NS	20	0.8	94	19.5	1.7	120
	3/8	-7.2	NS	NS	NS	20.3	0.8	110	NS	NS	NS
	3/12	-7.8	NS	NS	NS	20.2	0.6	97	20	0.9	110
	3/20	-6.2	NS	NS	NS	20.2	0.8	110	19.8	6.6	120
	4/7	3.3	NS	NS	NS	20.3	0.5	86	20	0.9	100
	4/10	7.2	NS	NS	NS	20.2	0.4	83	20	0.7	100
	4/20	7.8	NS	NS	NS	20.2	0.8	96	19.5	1	100
	5/6	12.8	NS	NS	NS	20.8	0.1	37	20.3	0.5	50
	6/6	13.3	NS	NS	NS	NS	0.3	43	NS	0.8	58
	6/22	18.3	NS	NS	NS	20	1.2	68	19.5	1.8	77
	6/27	20.0	NS	NS	NS	20	1.2	77	19.2	2	92
	7/3	16.9	NS	NS	NS	19.2	2.3	89	NS	NS	NS
	7/22	ND	NS	NS	NS	19	2.7	72	NS	NS	NS
	8/22	8.4	NS	NS	NS	3.2	8	196	10	6	110
	8/29	12.2	NS	NS	NS	3.2	7.8	340	9	4.6	300
	9/30	3.7	NS	NS	NS	19.8	1.8	150	19.2	2.8	180
	10/7	13.0	NS	NS	NS	1.6	20	150	19.5	2.3	170
	10/11	2.6	NS	NS	NS	19.8	1.7	160	19.3	2.4	190
	10/14	5.4	NS	NS	NS	20	1.6	130	19.5	2.2	150
	12/21	-10.6	NS	NS	NS	3.8	4.7	360	7.5	3.8	280
1994	1/26	-14.6	NS	NS	NS	1.3	5.6	190	NS	NS	NS
	2/6	-16.0	NS	NS	NS	1	5.8	260	NS	NS	NS
	2/13	-29.8	NS	NS	NS	2.3	5.5	290	NS	NS	NS
	3/10	-10.5	NS	NS	NS	18.8	1	150	20.9	0.05	17
	3/17	-18.6	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/24	6.8	NS	NS	NS	NS	NS	NS	20.9	0.05	70
	4/9	-4.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/16	-12.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/3	10.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/8	13.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/6	15.7	NS	NS	NS	NS	NS	NS	16.2	2.7	140
	6/23	NS	NS	NS	NS	14	4.2	190	15.5	3.7	170
	7/2	17.7	NS	NS	NS	14.3	6	230	NS	NS	NS

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L1. Eielson AFB Weekly Soil Gas Data: Active Warming Plot (Continued)

Year	Date	Temp (°C)	A3A			A3B			A3C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/18	NS	1	11	5000	9	11	410	11	9	400
	9/28	NS	20	0.25	440	16	4.5	240	17.4	3.6	440
	10/20	2.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/26	2.7	20.5	0.8	250	20	2.6	320	17.1	3.7	330
	11/2	-1.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/23	-19.0	19.3	1	440	15.2	4.4	450	14.4	7.8	370
	11/30	-16.0	16.8	5.9	640	16.8	6	430	14.4	8.4	395
	12/24	-19.4	20	0.62	220	17.6	5.8	330	18.1	5	300
	12/29	-23.3	20.5	1.2	210	17.9	5.9	350	16.9	7.1	360
1992	1/5	-19.4	20	0.7	65	17.9	5.7	180	16.9	7.2	220
	1/11	-18.9	20	1.1	420	17	3.9	440	16.6	7	320
	1/18	-6.0	NS	NS	NS	NS	NS	NS	16.5	6.5	420
	1/25	-18.0	20.2	0.59	220	17.5	6	360	21.5	2.8	320
	2/15	ND	NS	NS	NS	16.9	6.5	NS	15.4	8.1	NS
	2/22	-28.0	20	1.95	480	NS	NS	NS	NS	NS	NS
	3/2	-23.0	19.4	5	490	NS	NS	NS	NS	NS	NS
	3/8	-28.0	18.1	5.1	560	NS	NS	NS	NS	NS	NS
	3/28	0.0	18.4	6.1	530	NS	NS	NS	NS	NS	NS
	4/4	-17.2	18.1	6.1	330	NS	NS	NS	NS	NS	NS
	4/24	3.0	6.2	12.2	6000	NS	NS	NS	NS	NS	NS
	5/3	-5.0	18.5	4.9	10000	NS	NS	NS	NS	NS	NS
	5/17	2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/22	18.8	0.21	20.8	900	NS	NS	NS	NS	NS	NS
	5/31	16.6	20.6	0.3	900	NS	NS	NS	NS	NS	NS
	6/7	20.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/28	28.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/5	25.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/11	15.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/22	ND	19.6	0.7	NS	NS	NS	NS	NS	NS	NS
	8/26	18.3	20	0.83	NS	NS	NS	NS	NS	NS	NS
	8/30	19.7	20	0.8	NS	NS	NS	NS	NS	NS	NS
	9/2	16.7	20.5	0.55	1000	NS	NS	NS	NS	NS	NS
	10/3	0.0	1.5	9.6	1540	NS	NS	NS	NS	NS	NS
	10/7	2.2	4.5	10.8	12000	NS	NS	NS	NS	NS	NS
	10/14	-2.8	8.6	10.3	14400	NS	NS	NS	NS	NS	NS
	10/22	-8.3	6.5	9.3	14000	NS	NS	NS	NS	NS	NS
	10/28	-2.8	8.6	8	18000	NS	NS	NS	NS	NS	NS
	11/21	-8.9	20.2	0.7	2500	NS	NS	NS	NS	NS	NS
	11/29	-8.6	20.5	0.6	1200	NS	NS	NS	NS	NS	NS
	12/5	-20.0	20.5	0.5	340	NS	NS	NS	NS	NS	NS
	12/19	-13.3	20.8	0.5	130	NS	NS	NS	NS	NS	NS
	12/23	-35.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
1993	1/30	-25.0	20.5	0.1	110	NS	NS	NS	NS	NS	NS
	2/6	-19.4	20.9	0.1	96	NS	NS	NS	NS	NS	NS

Table L1. Eielson AFB Weekly Soil Gas Data: Active Warming Plot (Continued)

Year	Date	Temp (°C)	A3A			A3B			A3C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	2/10	-22.8	20.5	0.3	100	NS	NS	NS	NS	NS	NS
	2/20	-12.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/8	-7.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/12	-7.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/20	-6.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/7	3.3	20.9	0.5	72	NS	NS	NS	20.7	0.2	100
	4/10	7.2	20.7	0.05	62	NS	NS	NS	20.5	0.2	75
	4/20	7.8	20.5	0.2	68	NS	NS	NS	20.6	0.3	69
	5/6	12.8	20.8	0.05	30	NS	NS	NS	20.8	0.1	36
	6/6	13.3	NA	0.1	30	NS	NS	NS	NA	0.2	36
	6/22	18.3	20.7	0.05	43	NS	NS	NS	20.5	1	38
	6/27	20.0	20.7	0.2	51	NS	NS	NS	20.5	0.5	55
	7/3	16.9	20.2	0.8	54	NS	NS	NS	20	1.2	62
	7/22	ND	20.2	0.6	40	NS	NS	NS	20	1.3	55
	8/22	8.4	NS	NS	NS	NS	NS	NS	14.3	3.3	91
	8/29	12.2	2.3	5.8	300	NS	NS	NS	11	3.7	160
	9/30	3.7	20.5	0.3	68	NS	NS	NS	20.3	1	97
	10/7	13.0	20.9	0.2	71	NS	NS	NS	20.7	0.7	98
	10/11	2.6	20.6	3	73	NS	NS	NS	20.5	8	110
	10/14	5.4	20.7	0.2	48	NS	NS	NS	20.5	0.7	74
	12/21	-10.6	NS	NS	NS	NS	NS	NS	13.5	1.4	130
1994	1/26	-14.6	17.7	1.2	86	20.9	0.05	22	19.5	0.6	43
	2/6	-16.0	20.9	0.05	42	NS	NS	NS	NS	NS	NS
	2/13	-29.8	20.9	0.05	5	NS	NS	NS	NS	NS	NS
	3/10	-10.5	9.3	3.8	200	NS	NS	NS	20.7	0.1	37
	3/17	-18.6	20.8	0.05	82	NS	NS	NS	NS	NS	NS
	3/24	6.8	20.9	0.05	87	20.9	0.05	93	20.7	0.1	120
	4/9	-4.9	20.9	0.05	38	NS	NS	NS	20	1	150
	4/16	-12.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/3	10.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/8	13.5	NS	NS	NS	NS	NS	NS	18.8	1.5	180
	6/6	15.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/23	NS	NS	NS	NS	15.8	2.5	140	NS	NS	NS
	7/2	17.7	NS	NS	NS	15.5	3	170	NS	NS	NS

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L1. Eielson AFB Weekly Soil Gas Data: Active Warming Plot (Continued)

Year	Date	Temp (°C)	A4A			A4B			A4C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/18	NS	NS	NS	NS	0	12	6400	9	9	700
	9/28	NS	7.5	3.5	3800	6.8	8.1	20000	4	9	1080
	10/20	2.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/26	2.7	19	1.4	3300	11.5	8	8000	13	7	1200
	11/2	-1.3	NS	NS	NS	2.1	16	3800	2	16	1720
	11/23	-19.0	NS	NS	NS	1.1	16	1500	20.9	0	320
	11/30	-16.0	NS	NS	NS	3	14.5	9200	4.8	14.1	10000
	12/24	-19.4	NS	NS	NS	3.1	14.1	5800	10.9	10.7	610
	12/29	-23.3	NS	NS	NS	2.9	14.6	5300	10.8	11.3	380
1992	1/5	-19.4	NS	NS	NS	3.8	14.2	6900	10	11.2	480
	1/11	-18.9	NS	NS	NS	4.6	13.8	10000	9.2	11.4	1900
	1/18	-6.0	NS	NS	NS	16.5	13.5	6800	8.2	11.5	380
	1/25	-18.0	NS	NS	NS	4.3	14.1	8200	8.9	12.2	2200
	2/15	ND	NS	NS	NS	5.5	13.8	NA	8	12.1	NA
	2/22	-28.0	NS	NS	NS	3.5	13.6	10000	NS	NS	NS
	3/2	-23.0	NS	NS	NS	2.9	11.8	NA	12	11	NS
	3/8	-28.0	NS	NS	NS	NS	NS	NS	11.2	10.3	400
	3/28	0.0	NS	NS	NS	1.5	9.1	2100	6.1	13	570
	4/4	-17.2	NS	NS	NS	NS	NS	NS	6.5	13	320
	4/24	3.0	NS	NS	NS	2	10.1	4900	9.3	11.5	700
	5/3	-5.0	NS	NS	NS	15.5	7.5	7400	9.6	10.9	6500
	5/17	2.2	NS	NS	NS	18	1.8	1300	13.5	9.8	1000
	5/22	18.8	NS	NS	NS	18.6	2.7	1000	13	9.8	620
	5/31	16.6	NS	NS	NS	NS	NS	NS	11.7	10.9	530
	6/7	20.0	NS	NS	NS	NS	NS	NS	10	12.5	340
	6/28	28.9	NS	NS	NS	NS	NS	NS	4.8	14.7	210
	7/5	25.5	NS	NS	NS	NS	NS	NS	6	15.3	220
	7/11	15.5	NS	NS	NS	NS	NS	NS	5.3	14.8	210
	8/22	ND	NS	NS	NS	NS	NS	NS	1.6	5	NA
	8/26	18.3	NS	NS	NS	NS	NS	NS	3.3	5	NA
	8/30	19.7	NS	NS	NS	NS	NS	NS	1.2	5	NA
	9/2	16.7	NS	NS	NS	NS	NS	NS	2	5	480
	10/3	0.0	NS	NS	NS	NS	NS	NS	7	12.5	130
	10/7	2.2	NS	NS	NS	NS	NS	NS	10	11.8	620
	10/14	-2.8	NS	NS	NS	NS	NS	NS	9.5	10.5	620
	10/22	-8.3	NS	NS	NS	NS	NS	NS	5.5	8.8	640
	10/28	-2.8	NS	NS	NS	0	7	19600	NS	NS	NS
	11/21	-8.9	NS	NS	NS	NS	NS	NS	7.3	9.3	10000
	11/29	-8.6	NS	NS	NS	15	4.9	14400	9.5	7.8	16000
	12/5	-20.0	NS	NS	NS	16.2	4.7	6600	11.5	7.2	13400
	12/19	-13.3	NS	NS	NS	16	4.2	11800	12.5	6.3	13000
	12/23	-35.9	NS	NS	NS	16.5	4.2	7000	13	6.3	8600
1993	1/30	-25.0	NS	NS	NS	12.8	6.7	1300	11	8	300
	2/6	-19.4	NS	NS	NS	16.8	3.8	2000	13.8	7.2	260

Table L1. Eielson AFB Weekly Soil Gas Data: Active Warming Plot (Continued)

Year	Date	Temp (°C)	A4A			A4B			A4C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	2/10	-22.8	NS	NS	NS	13	5	2000	12	6.8	270
	2/20	-12.8	NS	NS	NS	12	6.2	1900	11.6	7	240
	3/8	-7.2	NS	NS	NS	11.2	7	900	11.2	7.2	160
	3/12	-7.8	NS	NS	NS	12.5	6	650	11.3	7.3	170
	3/20	-6.2	NS	NS	NS	12.5	6.2	480	11.5	7.5	160
	4/7	3.3	NS	NS	NS	16.2	4.2	250	13	70	150
	4/10	7.2	NS	NS	NS	17.5	3.7	260	13.8	6.8	150
	4/20	7.8	NS	NS	NS	2.5	4.8	300	6	5.2	260
	5/6	12.8	NS	NS	NS	8	6.8	280	10.2	7.8	130
	6/6	13.3	NS	NS	NS	NA	5	190	NA	5	92
	6/22	18.3	NS	NS	NS	0	13	1000	9.2	10.5	240
	6/27	20.0	NS	NS	NS	0	13	1020	8	10.2	300
	7/3	16.9	NS	NS	NS	0	13.5	1420	7.8	11.8	280
	7/22	ND	NS	NS	NS	2.3	12.8	260	4	13.3	200
	8/22	8.4	NS	NS	NS	0	13.8	1680	15.5	5	140
	8/29	12.2	NS	NS	NS	0	13.3	1440	15.8	5.2	210
	9/30	3.7	NS	NS	NS	0	13	740	17	5	230
	10/7	13.0	NS	NS	NS	0	12.5	1380	16.2	5.5	270
	10/11	2.6	NS	NS	NS	0	12.8	1440	17	5.5	280
	10/14	5.4	NS	NS	NS	0	12.7	1380	17.2	5.3	240
	12/21	-10.6	NS	NS	NS	0	11.2	1160	14.8	5	290
1994	1/26	-14.6	20.9	0.05	0	0	11.3	710	18	4	270
	2/6	-16.0	NS	NS	NS	0	12	810	18	4	320
	2/13	-29.8	NS	NS	NS	0.2	12	850	18.5	3.8	350
	3/10	-10.5	NS	NS	NS	0.2	12	1100	18.6	3	330
	3/17	-18.6	NS	NS	NS	0	12.8	1000	17.3	4.2	400
	3/24	6.8	20.9	0.05	91	0	12.2	1000	17.6	3.7	420
	4/9	-4.9	NS	NS	NS	0	12.2	970	15.8	4.5	700
	4/16	-12.4	NS	NS	NS	1.5	12.8	810	14.8	5.8	530
	5/3	10.5	NS	NS	NS	0	12.5	1000	NS	NS	NS
	5/8	13.5	NS	NS	NS	0	12.8	1000	14.8	2	290
	6/6	15.7	NS	NS	NS	18.3	3.8	310	20	1.7	110
	6/23	NS	NS	NS	NS	12.3	6.2	360	16.5	3.7	190
	7/2	17.7	NS	NS	NS	12.5	7.8	370	18.2	4	210

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L1. Eielson AFB Weekly Soil Gas Data: Active Warming Plot (Continued)

Year	Date	Temp (°C)	A5A			A5B			A5C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/18	NS	8	10	10000	15	5	800	11	8	420
	9/28	NS	16.2	5	1600	14	2.4	1900	5.8	8.7	700
	10/20	2.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/26	2.7	15	5.8	6000	17	2.4	1200	12.5	6.9	840
	11/2	-1.3	20.9	0.1	8000	20.9	0.1	3200	20.9	0	1400
	11/23	-19.0	NS	NS	NS	2.3	13.8	4100	3.9	15	360
	11/30	-16.0	NS	NS	NS	3	10.4	2200	6.9	13.1	435
	12/24	-19.4	NS	NS	NS	8	9.4	2100	11	10.5	360
	12/29	-23.3	NS	NS	NS	7.6	10.1	1800	11.9	10	310
1992	1/5	-19.4	NS	NS	NS	20.4	0.25	130	12.3	9.6	390
	1/11	-18.9	NS	NS	NS	NS	NS	NS	10.1	10.9	420
	1/18	-6.0	NS	NS	NS	NS	NS	NS	11.2	9.8	400
	1/25	-18.0	NS	NS	NS	8	10.9	1200	12.4	9.4	360
	2/15	ND	NS	NS	NS	5.5	11.9	NA	9.3	10.9	NA
	2/22	-28.0	NS	NS	NS	NS	NS	NS	12.6	8.8	360
	3/2	-23.0	NS	NS	NS	NS	NS	NS	15	9.4	430
	3/8	-28.0	NS	NS	NS	NS	NS	NS	12.9	9.3	400
	3/28	0.0	NS	NS	NS	NS	NS	NS	10	10.6	360
	4/4	-17.2	NS	NS	NS	NS	NS	NS	11.3	10	310
	4/24	3.0	NS	NS	NS	NS	NS	NS	11.9	9.6	450
	5/3	-5.0	NS	NS	NS	NS	NS	NS	16.8	6.1	1300
	5/17	2.2	NS	NS	NS	NS	NS	NS	18.8	2.3	460
	5/22	18.8	NS	NS	NS	NS	NS	NS	18	2.4	300
	5/31	16.6	NS	NS	NS	NS	NS	NS	16.8	5.8	490
	6/7	20.0	NS	NS	NS	NS	NS	NS	15.6	7.9	310
	6/28	28.9	NS	NS	NS	NS	NS	NS	9.1	10.9	220
	7/5	25.5	NS	NS	NS	NS	NS	NS	11.6	10.9	250
	7/11	15.5	NS	NS	NS	NS	NS	NS	10.8	10.4	240
	8/22	ND	NS	NS	NS	NS	NS	NS	6.5	5	NA
	8/26	18.3	NS	NS	NS	NS	NS	NS	8.5	5	NA
	8/30	19.7	NS	NS	NS	NS	NS	NS	6	5	NA
	9/2	16.7	NS	NS	NS	NS	NS	NS	8.3	5	320
	10/3	0.0	NS	NS	NS	NS	NS	NS	9	10.6	130
	10/7	2.2	NS	NS	NS	NS	NS	NS	11.2	10	170
	10/14	-2.8	NS	NS	NS	NS	NS	NS	11.2	8.5	190
	10/22	-8.3	NS	NS	NS	NS	NS	NS	7.2	7.2	400
	10/28	-2.8	NS	NS	NS	NS	NS	NS	8.5	7.2	460
	11/21	-8.9	NS	NS	NS	NS	NS	NS	14	5.5	10800
	11/29	-8.6	NS	NS	NS	NS	NS	NS	16	4	10000
	12/5	-20.0	NS	NS	NS	NS	NS	NS	16.5	3.9	6400
	12/19	-13.3	NS	NS	NS	NS	NS	NS	17.2	3.3	4800
	12/23	-35.9	NS	NS	NS	NS	NS	NS	17.2	3.3	3100
1993	1/30	-25.0	NS	NS	NS	NS	NS	NS	16.5	3.4	200
	2/6	-19.4	NS	NS	NS	NS	NS	NS	17.8	3.5	210

Table L1. Eielson AFB Weekly Soil Gas Data: Active Warming Plot (Continued)

Year	Date	Temp (°C)	A5A			A5B			A5C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	2/10	-22.8	NS	NS	NS	NS	NS	NS	17.5	3.2	240
	2/20	-12.8	NS	NS	NS	NS	NS	NS	17.5	2.8	180
	3/8	-7.2	NS	NS	NS	NS	NS	NS	16.7	3.7	150
	3/12	-7.8	NS	NS	NS	NS	NS	NS	17.2	3.3	160
	3/20	-6.2	NS	NS	NS	NS	NS	NS	17	3.7	140
	4/7	3.3	NS	NS	NS	NS	NS	NS	16.2	4.5	150
	4/10	7.2	NS	NS	NS	NS	NS	NS	10.2	5	200
	4/20	7.8	NS	NS	NS	NS	NS	NS	13.2	3.6	260
	5/6	12.8	NS	NS	NS	NS	NS	NS	15.2	4.5	110
	6/6	13.3	NS	NS	NS	NS	NS	NS	NS	5	94
	6/22	18.3	NS	NS	NS	NS	NS	NS	12.5	8.7	110
	6/27	20.0	NS	NS	NS	NS	NS	NS	12.5	8.3	120
	7/3	16.9	NS	NS	NS	NS	NS	NS	11	9.2	120
	7/22	ND	NS	NS	NS	NS	NS	NS	10	10	96
	8/22	8.4	NS	NS	NS	NS	NS	NS	15.8	4.8	120
	8/29	12.2	NS	NS	NS	NS	NS	NS	16	5.3	190
	9/30	3.7	NS	NS	NS	NS	NS	NS	17	4.8	230
	10/7	13.0	NS	NS	NS	NS	NS	NS	17.2	5	230
	10/11	2.6	NS	NS	NS	NS	NS	NS	17.8	4.5	240
	10/14	5.4	NS	NS	NS	NS	NS	NS	17.5	4.7	220
	12/21	-10.6	NS	NS	NS	NS	NS	NS	16.8	3.8	230
1994	1/26	-14.6	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/6	-16.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/13	-29.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/10	-10.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/17	-18.6	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/24	6.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/9	-4.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/16	-12.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/3	10.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/8	13.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/6	15.7	NS	NS	NS	NS	NS	NS	18.7	3.2	150
	6/23	NS	NS	NS	NS	14.5	5.5	200	15	5	190
	7/2	17.7	NS	NS	NS	15.3	7	220	16.2	6.3	230

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L1. Eielson AFB Weekly Soil Gas Data: Active Warming Plot (Continued)

Year	Date	Temp (°C)	A6A			A6B			A6C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/18	NS	0	12	4000	2.5	11	450	6	9	400
	9/28	NS	12	6.2	990	8.4	7	13600	4.4	8.5	4800
	10/20	2.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/26	2.7	6.1	9.5	5500	7.9	9.5	2200	6.1	9.9	1200
	11/2	-1.3	1.5	10	2800	2	15.9	600	1	16.5	1600
	11/23	-19.0	1.1	15.9	1300	1.9	16	3600	20.9	0	120
	11/30	-16.0	1.1	15	1200	1.8	15	2100	4	15	610
	12/24	-19.4	1.3	15	900	4	14.2	470	6.4	13.9	370
	12/29	-23.3	6.8	12.9	NS	4	14.2	450	8.3	13.1	390
1992	1/5	-19.4	7.6	12	980	7.8	12.2	450	10.2	11.1	410
	1/11	-18.9	4.4	13.9	1000	3	14.3	460	7	13	400
	1/18	-6.0	5.3	12.8	540	3.3	13.8	440	7.1	13.4	360
	1/25	-18.0	5.2	13.5	460	4.5	14.4	380	6.9	13.5	360
	2/15	ND	3.5	14.9	NA	2.9	14.3	NA	6	14	NA
	2/22	-28.0	4.5	13.6	540	8.3	12.2	NA	5.4	12.9	380
	3/2	-23.0	4.3	14	590	3.5	14.1	450	5.2	13.3	400
	3/8	-28.0	10.2	11.2	530	8.5	12.5	490	8	13.1	400
	3/28	0.0	5	12.9	420	3.8	13.5	310	3.6	13.2	380
	4/4	-17.2	10.9	10.3	340	6.6	12.7	330	6.3	12.8	310
	4/24	3.0	1.9	11	1100	7.9	10.9	900	2.4	10.9	3600
	5/3	-5.0	20.3	0.55	800	20.4	0.71	420	NS	NS	NS
	5/17	2.2	20.5	0.45	1500	20.4	0.62	820	20	0.99	450
	5/22	18.8	20.1	0.55	1100	20	0.7	650	19.6	1.2	460
	5/31	16.6	NS	NS	NS	19.8	1.1	430	19.1	1.7	440
	6/7	20.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/28	28.9	19.2	1.85	160	NS	NS	NS	NS	NS	NS
	7/5	25.5	17.9	4.5	900	NS	NS	NS	NS	NS	NS
	7/11	15.5	17.2	5.1	930	NS	NS	NS	NS	NS	NS
	8/22	ND	13.5	5	NA	12	5	NA	9	5	NA
	8/26	18.3	15	4.5	NA	13.5	5	NA	10	5	NA
	8/30	19.7	15.2	4.4	NA	14.2	5	NA	9.3	5	NA
	9/2	16.7	16	3.7	9000	15.5	4.4	8000	11.5	5	4300
	10/3	0.0	9	10.6	260	1.6	12.2	400	6	10.5	280
	10/7	2.2	1.8	10.5	1660	1.5	11.8	1060	4	12	300
	10/14	-2.8	0.5	10.8	1480	1.5	11.2	440	4.8	11.3	260
	10/22	-8.3	0	10	660	1	10	380	3.5	9.5	320
	10/28	-2.8	1	9.3	1000	3	8.6	400	4.6	8.5	320
	11/21	-8.9	17.5	3	13600	17.5	3.2	12800	17	3.5	8600
	11/29	-8.6	18.8	2	8200	19	1.9	8400	18	2.7	11400
	12/5	-20.0	19.3	1.7	7200	19.2	1.9	8000	8.2	2.6	6700
	12/19	-13.3	19.5	1.6	6000	19.3	1.8	6600	18.8	2.2	6300
	12/23	-35.9	19.8	1.3	2700	19.5	1.5	2600	19	2	2500
1993	1/30	-25.0	16.8	6.8	1600	15.5	4.8	930	13.2	6	410
	2/6	-19.4	18.5	2.3	1900	18	3.2	1500	16.5	4.3	1000

Table L1. Eielson AFB Weekly Soil Gas Data: Active Warming Plot (Continued)

Year	Date	Temp (°C)	A6A			A6B			A6C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	2/10	-22.8	18	2.3	1600	17.2	2.8	1500	16.2	3.6	1000
	2/20	-12.8	17.6	2.9	1500	17	3.5	1100	15.5	4.2	710
	3/8	-7.2	16	4.2	620	15.5	5	420	14	5.5	220
	3/12	-7.8	17.2	3.2	930	16.8	3.9	600	15.5	4.8	290
	3/20	-6.2	17	3.3	900	16.5	3.9	580	15.5	4.8	280
	4/7	3.3	9	5.3	360	9	5	360	11.5	5.5	210
	4/10	7.2	3.2	7.8	3400	3.8	8	2400	2	8.8	1940
	4/20	7.8	0.5	7.2	1820	3	7.6	340	4.5	8.5	320
	5/6	12.8	14.5	3.8	280	2.2	9	260	4	10.5	260
	6/6	13.3	NA	5	94	NA	5	89	NA	5	80
	6/22	18.3	8.8	10	220	6.8	11.8	220	5.5	13	220
	6/27	20.0	7.8	9.5	260	6.2	11.2	240	5.2	12.2	240
	7/3	16.9	7.2	9.8	260	5.3	11.2	220	4.3	12.8	240
	7/22	ND	0	14.5	200	0.3	14.3	200	0.8	14.3	200
	8/22	8.4	3	12.8	240	7.5	11.5	220	11.3	9.8	110
	8/29	12.2	1.8	12.8	420	6	11.3	400	10.5	9.5	220
	9/30	3.7	3.5	11.8	250	7.2	10.8	240	11.8	8.8	260
	10/7	13.0	4	11.3	500	7.8	10.2	480	12.2	8.5	270
	10/11	2.6	4.3	11.5	540	7.3	10.3	500	12.8	8.7	290
	10/14	5.4	4.6	11.5	460	9	10	440	13.2	8.7	250
	12/21	-10.6	4.2	9.8	520	6.2	9.2	500	7.5	8.8	500
1994	1/26	-14.6	1.4	11	300	15.2	8.3	320	18.2	4.5	260
	2/6	-16.0	3.4	11.4	350	11.5	11.7	380	17.4	6.6	330
	2/13	-29.8	5.8	11.2	390	15.8	8.3	410	19	4	330
	3/10	-10.5	0	12.8	370	18.2	5.7	330	20	2	210
	3/17	-18.6	4.5	11.3	520	14.5	9.4	460	17.6	5.8	400
	3/24	6.8	0	11.5	490	18	4.5	390	19.8	2	280
	4/9	-4.9	0	11.2	400	12.3	8.4	480	14.7	6.2	460
	4/16	-12.4	6	12.4	350	10.7	9.8	390	14.3	7.3	380
	5/3	10.5	0	12.2	320	7.4	9.7	270	12.4	5.8	300
	5/8	13.5	10.3	9.7	390	15.7	6.7	330	17.5	3	250
	6/6	15.7	11.7	10.8	250	14.8	7.3	210	15	7.2	210
	6/23	NS	9	9.6	190	15.2	6.2	200	9.3	9.7	190
	7/2	17.7	6.2	10	220	9.2	9.7	210	10.2	9.8	250

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L1. Eielson AFB Weekly Soil Gas Data: Active Warming Plot (Continued)

Year	Date	Temp (°C)	A7A			A7B			A7C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/18	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	9/28	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/20	2.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/26	2.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/2	-1.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/23	-19.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/30	-16.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/24	-19.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/29	-23.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
1992	1/5	-19.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/11	-18.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/18	-6.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/25	-18.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/15	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/22	-28.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/2	-23.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/8	-28.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/28	0.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/4	-17.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/24	3.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/3	-5.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/17	2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/22	18.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/31	16.6	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/7	20.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/28	28.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/5	25.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/11	15.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/22	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/26	18.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/30	19.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	9/2	16.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/3	0.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/7	2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/14	-2.8	11.8	9.2	14400	0	7.5	5000	3	9	4400
	10/22	-8.3	12.3	6.8	12000	2	4.6	9200	6	6.5	1260
	10/28	-2.8	. 12	6.8	18800	3	3.3	12400	5.3	5.8	1020
	11/21	-8.9	20	0.9	17200	NS	NS	NS	9	7.2	1020
	11/29	-8.6	20.2	0.8	1600	NS	NS	NS	11	6.2	440
	12/5	-20.0	20.5	0.7	4500	NS	NS	NS	12.2	5.5	430
	12/19	-13.3	20.8	0.6	2400	NS	NS	NS	13.2	5.8	400
	12/23	-35.9	20.5	0.6	730	NS	NS	NS	13.2	6	170
1993	1/30	-25.0	NS	NS	NS	NS	NS	NS	8	5.5	300
	2/6	-19.4	NS	NS	NS	NS	NS	NS	10.5	4.5	180

Table L1. Eielson AFB Weekly Soil Gas Data: Active Warming Plot (Continued)

Year	Date	Temp (°C)	A7A			A7B			A7C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	2/10	-22.8	NS	NS	NS	NS	NS	NS	13.8	4.7	200
	2/20	-12.8	NS	NS	NS	NS	NS	NS	13.8	5.8	190
	3/8	-7.2	NS	NS	NS	NS	NS	NS	15	4.5	150
	3/12	-7.8	12.8	5.2	600	0	2.2	6000	15.2	4.5	190
	3/20	-6.2	NS	NS	NS	NS	NS	NS	14	6	170
	4/7	3.3	12.3	5.5	330	0	2.8	2400	13.2	3.8	150
	4/10	7.2	13.2	5.1	260	NS	NS	NS	15	3.8	140
	4/20	7.8	11.8	3.8	390	NS	NS	NS	15.5	3.3	130
	5/6	12.8	18.8	2.1	120	NS	NS	NS	13.5	4	120
	6/6	13.3	NS	1.1	74	NS	NS	NS	NA	4.2	94
	6/22	18.3	18	3.6	130	NS	NS	NS	10.5	8.6	110
	6/27	20.0	17.8	3.2	120	NS	NS	NS	7.5	8.2	240
	7/3	16.9	16	4.5	120	NS	NS	NS	4.7	11.5	240
	7/22	ND	18.8	2.8	90	NS	NS	NS	7.8	10.8	200
	8/22	8.4	NS	NS	NS	NS	NS	NS	15.5	5.5	110
	8/29	12.2	NS	NS	NS	1.5	5.2	800	15.8	5.7	190
	9/30	3.7	NS	NS	NS	5.8	4.2	220	17.2	4.2	210
	10/7	13.0	NS	NS	NS	NS	NS	NS	17.8	4.2	210
	10/11	2.6	NS	NS	NS	NS	NS	NS	18	4	230
	10/14	5.4	NS	NS	NS	NS	NS	NS	18.2	3.7	190
	12/21	-10.6	NS	NS	NS	4.3	3.8	340	16	4	230
1994	1/26	-14.6	NS	NS	NS	18	2.3	200	18.3	2	170
	2/6	-16.0	NS	NS	NS	16.8	3	270	18	2.6	240
	2/13	-29.8	NS	NS	NS	17.8	2.6	300	18.6	2	270
	3/10	-10.5	NS	NS	NS	19	1.8	210	19.3	1.3	1700
	3/17	-18.6	NS	NS	NS	19	2.8	290	19.5	2	240
	3/24	6.8	20.9	0.05	41	18.6	2.2	290	18.7	2.1	280
	4/9	-4.9	NS	NS	NS	20.2	0.8	140	20.2	0.6	130
	4/16	-12.4	NS	NS	NS	20.6	0.8	110	20.6	0.6	100
	5/3	10.5	NS	NS	NS	16	1.7	180	17	1.6	180
	5/8	13.5	NS	NS	NS	17.3	1.8	210	18.2	1.5	220
	6/6	15.7	NS	NS	NS	NS	NS	NS	17	4	170
	6/23	NS	NS	NS	NS	NS	NS	NS	14.5	5.3	180
	7/2	17.7	NS	NS	NS	NS	NS	NS	17	5.6	220

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L1. Eielson AFB Weekly Soil Gas Data: Active Warming Plot (Continued)

Year	Date	Temp (°C)	A8A			A8B			A8C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/18	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	9/28	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/20	2.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/26	2.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/2	-1.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/23	-19.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/30	-16.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/24	-19.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/29	-23.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
1992	1/5	-19.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/11	-18.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/18	-6.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/25	-18.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/15	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/22	-28.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/2	-23.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/8	-28.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/28	0.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/4	-17.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/24	3.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/3	-5.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/17	2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/22	18.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/31	16.6	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/7	20.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/28	28.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/5	25.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/11	15.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/22	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/26	18.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/30	19.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	9/2	16.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/3	0.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/7	2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/14	-2.8	18.3	5	9600	0.5	5	4200	0.6	5.2	2600
	10/22	-8.3	18.5	3.5	4600	NS	NS	NS	1	4.3	2200
	10/28	-2.8	19	2.8	4400	NS	NS	NS	NS	NS	NS
	11/21	-8.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/29	-8.6	NS	NS	NS	NS	NS	NS	7.5	3.2	2400
	12/5	-20.0	NS	NS	NS	NS	NS	NS	0	4.5	2000
	12/19	-13.3	NS	NS	NS	NS	NS	NS	0	4	1460
	12/23	-35.9	NS	NS	NS	NS	NS	NS	0	4.8	1080
1993	1/30	-25.0	20.2	0.5	180	NS	NS	NS	0.5	5.8	2200
	2/6	-19.4	20.5	0.2	100	NS	NS	NS	0.5	5.8	1460

Table L1. Eielson AFB Weekly Soil Gas Data: Active Warming Plot (Continued)

Year	Date	Temp (°C)	A8A			A8B			A8C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	2/10	-22.8	20.3	0.7	150	NS	NS	NS	0	6.8	780
	2/20	-12.8	20.2	0.8	150	NS	NS	NS	NS	NS	NS
	3/8	-7.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/12	-7.8	NS	NS	NS	NS	NS	NS	2.7	8	380
	3/20	-6.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/7	3.3	20.2	0.05	100	NS	NS	NS	2.8	8.2	340
	4/10	7.2	20	0.5	120	NS	NS	NS	3.8	7.8	600
	4/20	7.8	20.2	0.7	95	NS	NS	NS	0.5	6	2000
	5/6	12.8	20	0.8	65	NS	NS	NS	12.2	5.2	130
	6/6	13.3	NA	0.2	38	NS	NS	NS	NS	5	100
	6/22	18.3	20.2	1.2	74	NS	NS	NS	2.2	10.8	220
	6/27	20.0	20.3	1.3	74	NS	NS	NS	0	10	260
	7/3	16.9	20	1.5	76	NS	NS	NS	0	11.2	260
	7/22	ND	20	0.5	39	NS	NS	NS	0	12	360
	8/22	8.4	NS	NS	NS	NS	NS	NS	0	9	260
	8/29	12.2	NS	NS	NS	NS	NS	NS	0	9.7	460
	9/30	3.7	NS	NS	NS	NS	NS	NS	0	8.3	230
	10/7	13.0	NS	NS	NS	NS	NS	NS	0	8.3	440
	10/11	2.6	NS	NS	NS	NS	NS	NS	0	8.5	520
	10/14	5.4	NS	NS	NS	NS	NS	NS	0	8.2	420
	12/21	-10.6	NS	NS	NS	NS	NS	NS	0.5	6	420
1994	1/26	-14.6	20.9	0.05	0	20.9	0.05	0	11.5	5	330
	2/6	-16.0	NS	NS	NS	NS	NS	NS	10.2	5.7	400
	2/13	-29.8	NS	NS	NS	NS	NS	NS	15.2	3.8	370
	3/10	-10.5	20.9	0.05	17	20.9	0.05	3	12.2	2.8	900
	3/17	-18.6	NS	NS	NS	NS	NS	NS	8.7	3.4	430
	3/24	6.8	20.9	0.05	55	20.9	0.05	89	11.5	2.7	560
	4/9	-4.9	NS	NS	NS	NS	NS	NS	12.8	3.8	370
	4/16	-12.4	NS	NS	NS	NS	NS	NS	13.7	4	320
	5/3	10.5	NS	NS	NS	NS	NS	NS	19	2	180
	5/8	13.5	NS	NS	NS	NS	NS	NS	19	2	210
	6/6	15.7	NS	NS	NS	NS	NS	NS	6.7	6.2	150
	6/23	NS	20.3	0.7	63	NS	NS	NS	18	4.5	170
	7/2	17.7	NS	NS	NS	NS	NS	NS	19	2.8	170

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L2. Eielson AFB Weekly Soil Gas Data: Passive Warming Plot

Year	Date	Temp (°C)	P1A			P1B			P1C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/17	ND	1.0	13.0	8000	0.5	13.5	5000	14.0	7.0	2000
	9/28	ND	20.9	0.0	480	20.9	0.0	300	20.9	0.1	180
	10/20	-1.1	21.5	0.3	520	21.5	0.4	1000	21.1	0.8	1000
	10/26	2.7	21.0	0.3	1200	21.0	0.4	900	21.0	0.5	900
	11/2	-1.3	20.9	0.0	880	20.9	0.1	1400	20.6	0.4	1800
	11/23	-19.0	20.8	0.0	1900	20.7	0.1	1500	20.3	0.4	2700
	11/30	-16.0	20.9	1.0	1300	20.9	1.0	1250	20.9	1.0	980
	12/24	-19.4	20.9	0.1	1200	20.9	0.1	900	20.7	0.4	1300
	12/29	-23.3	20.9	0.0	250	20.9	0.1	500	20.9	0.3	660
1992	1/5	-21.1	20.9	0.1	730	20.9	0.1	760	20.6	0.3	1000
	1/11	-23.3	20.9	0.1	1100	20.5	0.35	720	20.6	0.4	1800
	1/25	-18.0	20.9	0.1	560	20.9	0.1	760	20.9	0.33	900
	2/15	ND	20.8	0.08	NA	20.4	0.2	NA	20.3	0.41	NA
	2/22	-28.0	20.9	0.05	999	20.9	0.1	910	20.9	0.3	970
	3/2	-23.0	21	0.1	1300	20.9	0.18	1200	20.8	0.46	1100
	3/9	-2.2	20.9	0.19	1100	20.8	0.24	1100	20.5	0.5	1100
	3/28	0.0	20.9	0.15	1300	20.8	0.26	1200	20.4	0.49	1100
	4/4	-17.2	20.8	0.11	1100	20.8	0.2	900	20.4	0.45	800
	5/3	-5.0	20.9	0.25	2700	20.9	0.14	830	20.9	0.35	1300
	5/17	2.2	20.9	0.1	310	20.9	0.1	260	20.9	0.2	260
	5/22	18.8	20.9	0.05	180	20.8	0.09	190	20.7	0.15	170
	5/31	16.6	NS	NS	NS	20.5	0.29	430	20.2	0.4	150
	6/7	20.0	NS	NS	NS	20.7	0.53	210	20.6	0.65	190
	6/28	28.9	NS	NS	NS	20.3	0.9	500	20.0	1.6	410
	7/5	25.5	NS	NS	NS	20.8	0.42	570	20.2	1.2	400
	7/11	15.5	20.2	0.5	1300	20.7	0.4	660	20.0	0.99	380
	8/22	ND	19.5	1	NA	20	0.6	NA	19.3	1.2	NA
	8/26	18.3	20.3	0.6	NA	20.5	0.33	NA	20	1.05	NA
	8/30	19.7	20.5	0.5	NA	20.5	0.3	NA	20	0.9	NA
	9/2	16.7	20.5	0.5	3000	20.6	0.26	470	20	0.85	800
	10/3	ND	1	4.7	960	1.3	4	220	12	4.5	110
	10/7	2.2	20.9	2	1200	20.9	1.8	1000	20.5	3.2	720
	10/14	-2.8	20.8	1.6	1100	20.8	1.6	510	20.2	3.6	350
	10/22	-8.3	20.9	0.6	1000	20.9	0.5	440	20.3	1.5	320
	10/28	-2.8	20.5	0.5	1800	20.9	0.3	520	20.3	0.9	500
	11/21	-8.9	20	0.7	1800	20.2	0.3	610	20	0.9	670
	11/29	-8.6	20.9	0.05	96	20.6	0.1	380	20.3	0.6	350
	12/5	-20.0	20.6	0.05	530	20.9	0.1	270	20.6	0.4	170
	12/19	-13.3	20.9	0.05	1100	20.9	0.05	430	20.6	0.3	500
	12/23	-36.0	20.5	0.1	1000	20.9	0.05	410	20.5	0.2	300
1993	1/30	-25.0	20.7	0.05	150	20.7	0.05	57	20.5	0.2	81
	2/6	-19.4	20.8	0.05	170	20.8	0.05	80	20.5	0.3	94
	2/10	-22.8	20.8	0.05	740	20.9	0.05	68	20.7	0.1	100
	2/20	-12.8	20.9	0.05	900	20.9	0.05	65	20.5	0.1	70

Table L2. Eielson AFB Weekly Soil Gas Data: Passive Warming Plot (Continued)

Year	Date	Temp (°C)	P1A			P1B			P1C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	3/8	-7.2	20.9	0.05	270	20.9	0.05	68	20.7	0.1	76
	3/12	-7.8	20.5	0.05	420	20.7	0.05	94	20.5	0.05	100
	3/20	-6.2	20.5	0.05	340	20.9	0.05	52	20.5	0.1	72
	4/7	3.3	20.7	0.05	100	20.7	0.05	72	20.5	0.1	82
	4/10	7.2	20.7	0.05	100	20.7	0.05	84	20.3	0.2	86
	4/20	7.8	20.7	0.05	100	20.5	0.05	100	20.2	0.1	76
	5/6	12.8	NS	NS	NS	20.2	0.2	54	20	0.4	55
	6/6	13.3	NA	0.05	60	NA	0.1	54	NA	0.4	52
	6/22	18.3	20.7	0.05	84	20.7	0.05	51	20.2	1	60
	6/27	20.0	20.9	0.05	72	20.9	0.05	50	20.5	0.7	65
	7/3	16.9	20.5	0.1	76	20.5	0.2	38	19	1.1	71
	7/22	ND	20.3	0.05	320	20.3	0.3	100	20	1.2	56
	8/22	8.4	2.2	7.8	500	NS	NS	NS	10.5	1.8	68
	8/29	12.2	0	8.5	540	0	7	300	8.7	3.2	154
	9/30	3.7	20.7	0.2	64	20.5	0.5	88	20.2	1.1	120
	10/7	13.0	20.9	0.3	110	20.9	0.5	78	20.7	1	97
	10/11	2.5	20.5	0.2	120	20.3	0.2	89	20.2	0.8	120
	10/14	5.4	20.9	0.1	61	20.7	0.2	51	20.5	0.7	73
	12/21	-10.6	20.9	0.05	71	20.7	0.2	50	20.3	0.7	81
1994	1/26	-14.6	20.9	0.05	7	20	1.2	120	20	1.2	110
	2/6	-16.0	20.9	0.05	44	20.2	1	120	20.3	1.2	120
	2/13	-29.8	20.9	0.05	52	20	1.2	200	20.2	0.8	160
	3/10	-10.5	20.9	0.05	38	20.7	0.3	130	20.6	1	180
	3/17	-18.6	20.9	0.05	270	20.8	0.6	84	20.7	1	150
	3/24	6.8	20.8	0.05	110	20.5	0.5	180	20.8	0.8	200
	4/9	-4.9	20.9	0.05	66	20.6	0.2	110	20.5	0.7	150
	4/16	-12.4	20.9	0.05	8	20.9	0.2	45	20.9	0.6	80
	5/3	10.5	NS	NS	NS	20	1.2	140	20	1.2	140
	5/8	13.5	NS	NS	NS	20	1.4	190	19.8	1.2	180
	6/6	16.7	20.8	0.1	60	20.5	0.4	63	20	1.1	82
	6/23	18.3	20.5	0.4	64	19.7	1.8	120	NSC	NSC	NSC
	7/2	17.7	20.7	0.1	78	20	1.2	120	19	2.5	160

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L2. Eielson AFB Weekly Soil Gas Data: Passive Warming Plot (Continued)

Year	Date	Temp (°C)	P2A			P2B			P2C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/17	ND	1.0	12.0	8500	1.0	14.0	600	13.5	7.5	300
	9/28	ND	20.9	0.0	900	20.7	0.1	330	20.8	0.1	330
	10/20	-1.1	21.5	0.4	4200	21.3	0.7	1800	21.5	0.3	1400
	10/26	2.7	21.0	0.3	4400	21.0	0.6	2400	21.0	0.3	1000
	11/2	-1.3	20.9	0.1	5000	20.9	0.3	3400	20.7	0.3	2700
	11/23	-19.0	20.7	0.1	8300	20.4	0.3	4000	20.4	0.3	3500
	11/30	-16.0	20.9	1.0	5600	20.9	1.0	3000	20.9	1.0	2900
	12/24	-19.4	20.9	0.0	2200	20.9	0.2	1300	20.9	0.1	1000
	12/29	-23.3	20.9	0.0	0	20.9	0.0	0	20.8	0.2	760
1992	1/5	-21.1	20.9	0.1	2600	20.7	0.2	1200	20.8	0.3	1100
	1/11	-23.3	20.9	0.1	2000	20.9	0.15	1200	20.9	0.1	1000
	1/25	-18.0	20.9	0.1	1300	20.9	0.15	940	20.9	0.15	780
	2/15	ND	20.8	0.05	NA	20.7	0.2	NA	20.8	0.2	NA
	2/22	-28.0	20.9	0.05	2000	20.9	0.1	890	NS	NS	NS
	3/2	-23.0	20.9	0.1	1700	20.9	0.25	950	20.9	0.25	615
	3/9	-2.2	20.9	0.1	1700	20.9	0.2	590	20.8	0.26	580
	3/28	0.0	20.9	0.08	1600	NS	NS	NS	NS	NS	NS
	4/4	-17.2	20.9	0.07	1300	NS	NS	NS	NS	NS	NS
	5/3	-5.0	NS	NS	NS	20	0.41	2400	20.9	0.29	1400
	5/17	2.2	NS	NS	NS	20.9	0.11	270	20.9	0.12	290
	5/22	18.8	NS	NS	NS	20.8	0.11	160	20.8	0.11	170
	5/31	16.6	NS	NS	NS	20.6	0.2	120	20.5	0.29	130
	6/7	20.0	NS	NS	NS	20.9	0.31	190	20.7	0.38	160
	6/28	28.9	NS	NS	NS	20.3	1.0	720	20.1	1.2	530
	7/5	25.5	NS	NS	NS	20.6	0.75	550	20.4	0.97	470
	7/11	15.5	NS	NS	NS	20.3	0.75	510	20.2	0.85	310
	8/22	ND	NS	NS	NS	19.3	1.15	NA	19	1.4	NA
	8/26	18.3	NS	NS	NS	19.8	1.1	NA	19.5	1.2	NA
	8/30	19.7	20	0.73	NA	20	0.92	NA	19.6	1.1	NA
	9/2	16.7	20.2	0.75	3000	20	0.85	1400	20	1	1100
	10/3	ND	2	6	2800	3	6	280	5	8	148
	10/7	2.2	20.9	2.5	2500	20.2	3.5	520	20.5	3.8	380
	10/14	-2.8	20.5	2.3	2200	20	3	540	20	3	250
	10/22	-8.3	20.6	0.8	1400	20.3	1.5	500	20.3	1.5	270
	10/28	-2.8	20.8	0.5	1000	20	0.9	640	20	1	390
	11/21	-8.9	20.5	0.5	1000	20	0.8	570	20	0.9	480
	11/29	-8.6	20.9	0.05	440	20.3	0.6	380	20.3	0.7	350
	12/5	-20.0	20.9	0.05	260	20.5	0.5	240	20.9	0.5	1400
	12/19	-13.3	20.9	0.05	430	20.7	0.4	500	20.3	0.5	600
	12/23	-36.0	NS	NS	NS	20.5	0.3	350	NS	NS	NS
1993	1/30	-25.0	NS	NS	NS	20.3	0.2	96	NS	NS	NS
	2/6	-19.4	NS	NS	NS	20.5	0.3	110	NS	NS	NS
	2/10	-22.8	NS	NS	NS	20	0.6	180	NS	NS	NS
	2/20	-12.8	NS	NS	NS	20.2	0.6	150	NS	NS	NS

Table L2. Eielson AFB Weekly Soil Gas Data: Passive Warming Plot (Continued)

Year	Date	Temp (°C)	P2A			P2B			P2C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	3/8	-7.2	NS	NS	NS	20.3	0.7	150	NS	NS	NS
	3/12	-7.8	20.5	0.05	3100	20	0.3	200	20.5	0.1	1700
	3/20	-6.2	20.5	0.1	2100	20.2	0.7	150	NS	NS	NS
	4/7	3.3	20.9	0.05	1200	20.5	0.2	110	20.7	0.1	700
	4/10	7.2	20.7	0.05	880	20.3	0.2	110	20.7	0.05	720
	4/20	7.8	20.7	0.05	810	20	0.3	110	20.1	0.2	90
	5/6	12.8	NS	NS	NS	19.2	0.9	85	19.8	0.5	78
	6/6	13.3	NA	0.05	110	NA	0.4	60	NA	0.6	57
	6/22	18.3	19	0.05	86	20	1.3	80	20	1.3	75
	6/27	20.0	20.9	0.05	60	20.2	1.2	78	20.2	1.2	79
	7/3	16.9	20.7	0.4	32	19.8	1.5	72	20	1.8	70
	7/22	ND	20.5	0.2	120	19.2	2.7	92	19.2	2.2	67
	8/22	8.4	NS	NS	NS	5.2	4.8	160	10.2	1.8	43
	8/29	12.2	1.2	5.8	1040	0	6.3	320	7	2	132
	9/30	3.7	20.9	0.05	57	20.2	1.1	120	20	1.2	120
	10/7	13.0	20.9	0.1	68	20.5	1.2	130	20.5	1.2	120
	10/11	2.5	20.6	0.05	78	20	1	140	20	1	140
	10/14	5.4	20.9	0.05	40	20.2	1	91	20.2	1	88
	12/21	-10.6	NS	NS	NS	20.5	0.8	71	20.5	0.8	73
1994	1/26	-14.6	20.9	0.05	0	20.3	0.7	68	20.3	0.8	71
	2/6	-16.0	NS	NS	NS	20.6	0.6	78	20.5	0.7	90
	2/13	-29.8	NS	NS	NS	20.5	0.2	94	20.6	0.2	91
	3/10	-10.5	20.9	0.05	31	20.2	1.1	190	20.5	1	160
	3/17	-18.6	NS	NS	NS	20.2	1	190	20.5	1	150
	3/24	6.8	20.8	0.05	110	20.2	1	200	20.2	1	210
	4/9	-4.9	NS	NS	NS	20.3	0.8	140	20.4	1	160
	4/16	-12.4	NS	NS	NS	20.6	0.7	100	20.7	0.9	120
	5/3	10.5	NS	NS	NS	19.3	1.7	150	19.8	1	130
	5/8	13.5	NS	NS	NS	19.8	1.8	200	19.8	1.2	160
	6/6	16.7	20.8	0.2	60	20	1.4	96	20	1.3	93
	6/23	18.3	20.9	0.05	68	19.2	2.5	140	19.2	2.2	130
	7/2	17.7	20.8	0.1	80	18.8	3	170	18.8	3	160

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L2. Eielson AFB Weekly Soil Gas Data: Passive Warming Plot (Continued)

Year	Date	Temp (°C)	P3A			P3B			P3C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/17	ND	0.0	13.0	8000	2.0	12.5	2200	10.3	8.9	1200
	9/28	ND	20.9	0.0	1000	20.9	0.0	32	20.9	0.0	250
	10/20	-1.1	21.5	0.3	480	21.5	0.3	74	21.5	0.4	420
	10/26	2.7	21.0	0.3	400	21.0	0.3	160	21.0	0.3	540
	11/2	-1.3	20.9	0.0	1400	20.9	0.0	400	20.9	0.0	920
	11/23	-19.0	20.9	0.1	1200	20.9	0.0	90	20.9	0.1	730
	11/30	-16.0	20.9	1.0	810	20.9	1.0	62	20.9	1.0	47
	12/24	-19.4	20.9	0.0	110	20.9	0.0	50	20.9	0.0	130
	12/29	-23.3	20.9	0.0	130	20.9	0.0	0	20.9	0.0	100
1992	1/5	-21.1	20.9	0.0	210	20.9	0.0	80	20.9	0.0	200
	1/11	-23.3	20.9	0.1	280	20.9	0.1	60	20.9	0.1	300
	1/25	-18.0	20.9	0.1	2200	20.9	0.1	20	20.9	0.1	180
	2/15	ND	20.9	0	NA	20.9	0	NA	20.9	0.02	NA
	2/22	-28.0	20.9	0.05	570	20.9	0.05	100	20.9	0.05	100
	3/2	-23.0	20.9	0.0	780	20.9	0.0	30	NS	NS	NS
	3/9	-2.2	20.9	0.05	100	20.9	0.05	30	20.9	0.1	40
	3/28	0.0	20.9	0	130	20.9	0.05	60	20.9	0.09	100
	4/4	-17.2	20.9	0.01	120	20.9	0	100	20.9	0.01	130
	5/3	-5.0	20.9	0.08	710	20.9	0.09	500	20.9	0.15	540
	5/17	2.2	20.9	0.05	180	20.9	0.03	150	20.9	0.05	160
	5/22	18.8	20.9	0.01	120	20.9	0	100	20.9	0.03	110
	5/31	16.6	NS	NS	NS	20.8	0.09	100	20.7	0.12	100
	6/7	20.0	NS	NS	NS	20.9	0.1	130	20.6	0.69	170
	6/28	28.9	20.7	0.5	400	20.8	0.2	140	20.6	0.5	640
	7/5	25.5	20.9	0.26	490	20.9	0.18	150	20.9	0.31	140
	7/11	15.5	20.9	0.23	450	20.9	0.1	50	20.9	0.26	90
	8/22	ND	20	0.35	NA	20	0.15	NA	20	4	NA
	8/26	18.3	20.5	0.35	NA	20.5	0.16	NA	20.5	0.36	NA
	8/30	19.7	20.5	0.33	NA	20.6	0.15	NA	20.5	0.35	NA
	9/2	16.7	20.5	0.3	1000	20.8	0.15	180	20.6	0.3	200
	10/3	ND	1	7.2	340	1.5	7.3	192	11.5	2.2	66
	10/7	2.2	20.5	1.5	490	20.9	0.8	43	20.5	3.7	110
	10/14	-2.8	20.8	1.6	460	20.8	1	76	20.8	1.6	92
	10/22	-8.3	20.9	0.5	800	20.9	0.3	65	20.9	0.5	82
	10/28	-2.8	20.9	0.3	600	20.9	0.05	140	20.6	0.3	110
	11/21	-8.9	20.5	0.1	470	20.9	0.1	300	20.5	0.2	290
	11/29	-8.6	20.9	0.05	310	20.9	0.05	280	20.5	0.1	260
	12/5	-20.0	20.9	0.05	190	20.9	0.05	190	20.9	0.1	210
	12/19	-13.3	20.9	0.05	360	20.9	0.05	340	20.9	0.1	500
	12/23	-36.0	20.9	0.05	160	NS	NS	NS	20.9	0.1	330
1993	1/30	-25.0	20.7	0.05	67	NS	NS	NS	20.7	0.05	110
	2/6	-19.4	20.9	0.05	93	NS	NS	NS	20.7	0.1	120
	2/10	-22.8	20.5	0.1	530	NS	NS	NS	20.3	0.1	370
	2/20	-12.8	0.05	20.9	310	NS	NS	NS	20.3	0.3	250

Table L2. Eielson AFB Weekly Soil Gas Data: Passive Warming Plot (Continued)

Year	Date	Temp (°C)	P3A			P3B			P3C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	3/8	-7.2	20.9	0.05	63	NS	NS	NS	20.5	0.5	260
	3/12	-7.8	20.7	0.05	420	NS	NS	NS	20.7	0.2	180
	3/20	-6.2	20.9	0.05	94	NS	NS	NS	20.7	0.5	210
	4/7	3.3	20.9	0.05	74	NS	NS	NS	20.7	0.05	82
	4/10	7.2	20.9	0.05	73	NS	NS	NS	20.7	0.05	88
	4/20	7.8	19	0.05	110	19.3	0.05	77	19.5	0.05	42
	5/6	12.8	NS	NS	NS	19.5	1	210	19.5	0.7	72
	6/6	13.3	NA	0.05	36	A	0.05	68	NA	0.2	34
	6/22	18.3	20.9	0.05	46	20.9	0.05	67	20.7	0.6	52
	6/27	20.0	20.9	0.05	45	20.9	0.05	54	20.9	0.3	54
	7/3	16.9	0.5	27	15	20.7	0.4	39	20.5	0.9	42
	7/22	ND	20.5	0.2	110	7	5.5	120	20.2	1	40
	8/22	8.4	5.7	6.5	260	7	5.5	172	10	0.3	18
	8/29	12.2	0	8	400	0	8	340	8.5	1.3	104
	9/30	3.7	20.9	0.05	39	20.7	0.05	46	20.7	0.2	53
	10/7	13.0	20.9	0.05	73	20.9	0.05	68	20.9	0.2	75
	10/11	2.5	20.7	0.05	80	20.7	0.05	72	20.7	0.1	90
	10/14	5.4	20.9	0.05	41	20.9	0.05	41	20.7	0.1	73
	12/21	-10.6	20.9	0.05	13	20.9	0.05	11	20.9	23	0.1
1994	1/26	-14.6	20.9	0.05	0	20.9	0.05	0	20.9	0.2	4
	2/6	-16.0	20.9	0.05	25	20.9	0.05	20	20.8	0.2	32
	2/13	-29.8	20.9	0.05	26	20.9	0.05	38	20.8	0.05	46
	3/10	-10.5	20.9	0.05	130	20.6	0.3	120	20.7	0.2	87
	3/17	-18.6	20	1.2	190	20	1.3	210	20.6	0.7	120
	3/24	6.8	20.4	0.05	100	20	1.4	240	20.2	0.7	190
	4/9	-4.9	19.6	1.4	200	20.2	1	170	20.5	0.8	140
	4/16	-12.4	20.7	0.4	67	20.6	0.5	75	20.6	0.7	94
	5/3	10.5	19	2.8	190	19.5	2.7	150	19	1	120
	5/8	13.5	20.7	0.4	130	20.9	0.3	110	20.5	0.8	140
	6/6	16.7	20.8	0.1	45	20.8	0.1	42	20.5	0.5	55
	6/23	18.3	20.9	0.2	51	20.8	0.1	50	20.6	0.5	64
	7/2	17.7	20.8	0.1	55	20.8	0.2	53	20.2	1.2	110

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L2. Eielson AFB Weekly Soil Gas Data: Passive Warming Plot (Continued)

Year	Date	Temp (°C)	P4A			P4B			P4C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/17	ND	0.0	13.0	16000	0.0	13.6	480	5.0	15.0	300
	9/28	ND	20.7	0.0	37	20.7	0.0	34	20.7	0.0	54
	10/20	-1.1	21.5	0.3	74	21.5	0.3	60	21.5	0.4	82
	10/26	2.7	21.0	0.3	90	21.0	0.3	60	21.0	0.3	86
	11/2	-1.3	20.9	0.0	110	20.9	0.0	120	20.9	0.0	70
	11/23	-19.0	20.9	0.1	14	20.9	0.1	19	20.9	0.1	49
	11/30	-16.0	20.9	1.0	0	20.9	1.0	0	20.9	1.0	0
	12/24	-19.4	20.9	0.0	20	20.9	0.0	10	20.9	0.0	20
	12/29	-23.3	20.9	0.0	0	20.9	0.0	0	20.9	0.0	0
1992	1/5	-21.1	20.9	0.0	0	20.9	0.0	0	20.9	0.0	0
	1/11	-23.3	20.9	0.1	80	20.9	0.1	110	20.9	0.2	180
	1/25	-18.0	20.9	0.1	1	20.9	0.1	1	20.9	0.1	30
	2/15	ND	20.9	0	NA	20.9	0	NA	20.9	0.05	NA
	2/22	-28.0	20.9	0.05	100	20.9	0.05	10	20.9	0.05	100
	3/2	-23.0	20.9	0.0	40	NS	NS	NS	20.9	0.0	60
	3/9	-2.2	20.9	0.1	20	20.9	0.05	0	20.9	0.15	43
	3/28	0.0	20.9	0.05	110	20.9	0.05	100	20.9	0.11	130
	4/4	-17.2	20.9	0.04	110	20.9	0.02	50	20.9	0.09	120
	5/3	-5.0	20.9	0.14	1600	20.9	0.06	100	20.9	0.1	130
	5/17	2.2	20.9	0.04	NA	20.9	0.04	150	20.9	0.05	140
	5/22	18.8	NS	NS	NS	20.9	0.01	100	20.9	0.05	110
	5/31	16.6	NS	NS	NS	20.8	0.04	90	20.7	0.1	100
	6/7	20.0	NS	NS	NS	20.9	0.12	120	20.9	0.2	120
	6/28	28.9	20.7	0.4	490	20.7	0.2	90	NS	NS	NS
	7/5	25.5	20.9	0.26	210	20.9	0.12	40	NS	NS	NS
	7/11	15.5	20.9	0.1	50	20.9	0.19	30	NS	NS	NS
	8/22	ND	20.5	0.1	NA	20.3	0.2	NA	20	0.35	NA
	8/26	18.3	20.6	0.1200	NA	20.5	0.2500	NA	20.5	0.4	NA
	8/30	19.7	20.5	0.15	NA	20.5	0.23	NA	20.5	0.4	NA
	9/2	16.7	20.9	0.12	100	20.8	0.22	110	20.5	0.48	130
	10/3	ND	1	7	540	1	7	200	7	2.3	64
	10/7	2.2	20.7	1	680	20.7	0.8	70	20.3	1.5	72
	10/14	-2.8	20.8	1.3	280	20.8	1.3	59	20.8	1.5	70
	10/22	-8.3	20.9	0.3	300	20.9	0.5	67	20.9	0.6	68
	10/28	-2.8	20.9	0.05	500	20.9	0.3	67	20.5	0.5	40
	11/21	-8.9	20.8	0.1	480	20.5	0.1	130	20.5	0.2	110
	11/29	-8.6	20	0.9	2600	20.3	0.5	660	20.3	0.4	440
	12/5	-20.0	20.2	0.8	2400	20.5	0.5	610	20.5	0.5	300
	12/19	-13.3	20.2	0.7	2800	20.8	0.4	700	20.8	0.4	520
	12/23	-36.0	20.3	0.7	1200	20.5	0.3	630	20.7	0.3	390
1993	1/30	-25.0	20.5	0.1	1000	20.7	0.1	180	20.5	0.2	110
	2/6	-19.4	20.5	0.5	1900	20.9	0.1	310	20.6	0.2	120
	2/10	-22.8	20.5	0.3	1000	20	0.8	300	19.8	0.7	120
	2/20	-12.8	20.3	0.4	1000	19.8	1	290	19.5	1.2	170

Table L2. Eielson AFB Weekly Soil Gas Data: Passive Warming Plot (Continued)

Year	Date	Temp (°C)	P4A			P4B			P4C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	3/8	-7.2	20.5	0.3	860	NS	NS	NS	20	1.5	270
	3/12	-7.8	20.5	0.1	420	NS	NS	NS	19.5	1.1	140
	3/20	-6.2	20.5	0.3	470	NS	NS	NS	19.8	1.3	130
	4/7	3.3	20.7	0.05	240	NS	NS	NS	20.7	0.1	85
	4/10	7.2	20.7	0.05	190	NS	NS	NS	20.5	0.1	86
	4/20	7.8	16.2	1	110	17.8	1	100	18.8	0.1	57
	5/6	12.8	NS	NS	NS	NS	NS	NS	19.5	1.2	86
	6/6	13.3	NA	0.2	40	NS	NS	NS	NS	0.4	45
	6/22	18.3	20.9	0.8	44	NS	NS	NS	20.2	1	62
	6/27	20.0	20.9	0.2	51	NS	NS	NS	20.3	1	72
	7/3	16.9	20.7	0.8	41	NS	NS	NS	20	1.5	65
	7/22	ND	20.2	0.9	650	NS	NS	NS	NS	NS	NS
	8/22	8.4	7	6.8	900	NS	NS	NS	NS	NS	NS
	8/29	12.2	0	8.3	1060	NS	NS	NS	NS	NS	NS
	9/30	3.7	20.7	0.3	57	NS	NS	NS	NS	NS	NS
	10/7	13.0	20.9	0.3	78	NS	NS	NS	NS	NS	NS
	10/11	2.5	20.5	0.2	85	NS	NS	NS	NS	NS	NS
	10/14	5.4	20.9	0.1	52	NS	NS	NS	NS	NS	NS
	12/21	-10.6	20.9	0.2	100	NS	NS	NS	NS	NS	NS
1994	1/26	-14.6	20.7	0.4	65	NS	NS	NS	NS	NS	NS
	2/6	-16.0	20.8	0.2	48	NS	NS	NS	NS	NS	NS
	2/13	-29.8	20.8	0.1	93	NS	NS	NS	NS	NS	NS
	3/10	-10.5	19.3	2	250	20.3	0.8	150	20.9	0.05	24
	3/17	-18.6	18.2	3.4	310	20	1.4	190	NS	NS	NS
	3/24	6.8	18.3	3	310	20.9	0.05	140	20.9	0.05	110
	4/9	-4.9	18	3.5	300	NS	NS	NS	NS	NS	NS
	4/16	-12.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/3	10.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/8	13.5	19.2	2.4	230	20.3	1	170	NS	NS	NS
	6/6	16.7	20.3	1	86	20.7	0.3	56	NS	NS	NS
	6/23	18.3	20.3	1.8	120	20.7	0.5	63	NS	NS	NS
	7/2	17.7	19	3.6	180	20.2	1	110	NS	NS	NS

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L2. Eielson AFB Weekly Soil Gas Data: Passive Warming Plot (Continued)

Year	Date	Temp (°C)	P5A			P5B			P5C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/17	ND	0.0	12.5	20000	0.0	13.5	1200	15.0	7.5	300
	9/28	ND	20.7	0.0	49	20.7	0.0	32	20.7	0.0	42
	10/20	-1.1	21.5	0.4	1000	21.5	0.4	1100	21.3	0.7	120
	10/26	2.7	21.0	0.4	1400	21.0	0.4	900	21.0	0.5	110
	11/2	-1.3	20.9	0.1	2800	20.9	0.0	120	20.7	0.3	140
	11/23	-19.0	20.4	0.2	3100	20.5	0.1	2500	20.5	0.4	420
	11/30	-16.0	20.9	1.0	2000	20.9	1.0	42	20.9	1.0	76
	12/24	-19.4	20.9	0.0	350	20.9	0.1	96	20.9	0.2	100
	12/29	-23.3	20.9	0.0	120	20.9	0.1	10	20.9	0.3	100
1992	1/5	-21.1	20.9	0.0	610	20.9	0.0	40	20.7	0.2	61
	1/11	-23.3	20.9	0.1	1200	20.9	0.1	130	20.9	0.25	170
	1/25	-18.0	20.9	0.2	160	20.9	0.12	20	20.9	0.35	66
	2/15	ND	20.8	0.1	NA	20.8	0.07	NA	20.7	0.25	NA
	2/22	-28.0	20.9	0.05	1000	20.9	0.05	60	20.8	0.2	88
	3/2	-23.0	20.9	0.1	1000	20.9	0.07	50	NS	NS	NS
	3/9	-2.2	20.8	0.23	730	20.9	0.13	80	20.9	0.25	100
	3/28	0.0	20.9	0.2	990	20.9	0.15	200	20.7	0.43	220
	4/4	-17.2	20.9	0.15	810	20.9	0.1	180	20.8	0.26	230
	5/3	-5.0	20.6	0.49	7900	20.9	0.1	310	20.9	0.2	110
	5/17	2.2	20.9	0.04	140	20.9	0.01	150	20.9	0.2	160
	5/22	18.8	NS	NS	NS	20.9	0.02	110	20.8	0.08	110
	5/31	16.6	NS	NS	NS	20.9	0.1	110	20.8	0.18	100
	6/7	20.0	NS	NS	NS	20.9	0.2	140	20.8	0.35	150
	6/28	28.9	NS	NS	NS	20.6	0.4	110	20.3	0.8	90
	7/5	25.5	20.9	0.35	460	20.9	0.46	90	20.8	0.7	100
	7/11	15.5	20.9	0.22	360	20.8	0.33	40	20.4	0.63	80
	8/22	ND	20	0.25	NA	19.5	0.46	NA	19.5	0.76	NA
	8/26	18.3	20.5	0.16	NA	20.2	0.5	NA	20	0.7	NA
	8/30	19.7	20.5	0.15	NA	20.3	0.5	NA	20	0.65	NA
	9/2	16.7	20.8	0.15	130	20.5	0.45	130	20.3	0.6	130
	10/3	ND	1.2	7	1720	0	7.5	220	6.5	2.5	82
	10/7	2.2	20.5	1.2	1000	20.2	1.7	110	20	2.5	87
	10/14	-2.8	20.8	1.3	470	20.6	2.3	94	20.5	2.3	89
	10/22	-8.3	20.9	0.5	450	20.5	0.9	93	20.5	0.9	80
	10/28	-2.8	20.9	0.3	780	20.3	36	79	20.5	0.6	60
	11/21	-8.9	20.5	0.2	840	20.3	0.5	160	20.3	0.5	120
	11/29	-8.6	20.5	0.6	1800	20.2	0.7	480	20	0.8	450
	12/5	-20.0	20.6	0.8	1600	20.3	0.7	340	20.2	0.8	210
	12/19	-13.3	20	1	4100	20.5	0.6	770	20.3	0.8	520
	12/23	-36.0	20	0.8	1800	20.5	0.5	540	20.2	0.8	380
1993	1/30	-25.0	20.7	0.05	920	20.3	0.3	110	20.5	0.7	100
	2/6	-19.4	20.5	0.1	1400	20.3	0.5	160	20.2	0.7	110
	2/10	-22.8	20.5	0.2	1900	19.2	1.8	370	19.3	1.2	190
	2/20	-12.8	20.5	0.1	1300	19	1.8	310	19	1.8	160

Table L2. Eielson AFB Weekly Soil Gas Data: Passive Warming Plot (Continued)

Year	Date	Temp (°C)	P5A			P5B			P5C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	3/8	-7.2	20.9	0.05	550	19.2	2.2	240	19.2	2.2	150
	3/12	-7.8	20.9	0.05	660	19.6	1.3	180	19.3	1.8	150
	3/20	-6.2	20.9	0.05	420	19.5	1.5	150	19.5	2	130
	4/7	3.3	20.9	0.05	290	20.9	0.2	180	20.5	0.5	82
	4/10	7.2	20.9	0.05	200	20.5	0.1	81	20.3	0.5	85
	4/20	7.8	17	0.3	100	20	0.8	95	19.5	0.5	73
	5/6	12.8	NS	NS	NS	20.5	0.2	47	20	1	78
	6/6	13.3	NA	1.4	NA	NA	0.3	40	NA	0.8	56
	6/22	18.3	20.9	1	50	20.3	1	60	20	1.7	77
	6/27	20.0	20.9	0.5	59	20.5	1	70	20	1.7	170
	7/3	16.9	0.7	53	11	20	1.3	61	19.5	2.3	100
	7/22	ND	20.5	0.4	960	19.2	2.2	130	18.5	3.3	90
	8/22	8.4	8.3	6.2	2000	1.2	7.5	260	7.7	1.2	132
	8/29	12.2	0	8.5	2000	0	8.2	360	5.8	2	220
	9/30	3.7	20.9	0.3	64	20.3	0.7	76	20.3	1	90
	10/7	13.0	20.9	0.2	76	20.7	0.7	86	20.7	0.8	96
	10/11	2.5	20.7	0.1	80	20.3	0.6	110	20.2	1	110
	10/14	5.4	20.7	0.1	53	20.5	0.4	65	20.5	0.5	87
	12/21	-10.6	20.9	0.2	210	20.8	0.3	46	20.7	0.6	61
1994	1/26	-14.6	20.7	0.4	94	20.5	0.6	49	20.2	0.8	78
	2/6	-16.0	20.8	0.2	60	20.5	0.3	67	20.3	0.8	110
	2/13	-29.8	20.8	0.1	110	20.3	0.5	130	20.2	0.7	150
	3/10	-10.5	16.5	4	330	20.3	1.1	190	20.2	1.8	220
	3/17	-18.6	NS	NS	NS	20.4	1	170	20.2	1.8	230
	3/24	6.8	20.9	0.05	110	20.2	0.8	210	20	1.3	250
	4/9	-4.9	NS	NS	NS	20.3	0.7	150	20	1.4	210
	4/16	-12.4	NS	NS	NS	20.5	0.7	100	20.2	1.2	160
	5/3	10.5	NS	NS	NS	20.2	1	110	18.3	1.3	140
	5/8	13.5	18.2	3.3	270	20	1	180	18.2	1.3	190
	6/6	16.7	20.7	0.8	72	20.2	0.8	73	20	1.2	91
	6/23	18.3	19.3	2.5	140	20.2	1.2	90	20	1.5	110
	7/2	17.7	18	4	190	19.5	2.6	160	18.8	3.4	180

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L2. Eielson AFB Weekly Soil Gas Data: Passive Warming Plot (Continued)

Year	Date	Temp (°C)	P6A			P6B			P6C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/17	ND	1.5	12.0	8800	1.0	13.8	1200	13.0	10.5	300
	9/28	ND	20.9	0.0	3400	20.5	0.0	220	20.5	0.0	100
	10/20	-1.1	21.3	0.5	5400	21.5	0.8	680	21.3	1.0	400
	10/26	2.7	21.0	0.3	4000	21.0	0.4	1800	21.0	0.4	440
	11/2	-1.3	20.9	0.1	6800	20.9	0.0	1000	20.1	0.5	340
	11/23	-19.0	20.8	0.2	5700	20.1	0.5	830	20.1	0.7	780
	11/30	-16.0	20.9	1.0	5200	20.9	1.0	330	20.9	1.0	160
	12/24	-19.4	20.9	0.1	3500	20.8	0.4	330	20.1	0.4	380
	12/29	-23.3	20.9	0.0	1200	20.9	0.1	100	20.8	0.3	130
1992	1/5	-21.1	20.9	0.1	2100	20.7	0.2	310	20.2	0.4	140
	1/11	-23.3	20.9	0.1	2000	20.7	0.25	240	20.5	0.5	190
	1/25	-18.0	20.9	0.1	1400	20.9	0.1	440	20.9	0.25	130
	2/15	ND	20.8	0.08	NA	20.6	0.3	NA	20.2	0.39	NA
	2/22	-28.0	20.9	0.05	1400	20.5	0.25	480	20.3	0.3	200
	3/2	-23.0	20.9	0.09	1300	20.9	0.2	280	20.5	0.45	240
	3/9	-2.2	20.9	0.13	1100	20.8	0.31	260	20.6	0.49	200
	3/28	0.0	20.9	0.13	1000	20.6	0.5	180	20.4	0.55	190
	4/4	-17.2	20.9	0.09	840	20.6	0.33	190	20.4	0.39	180
	5/3	-5.0	20.5	0.6	7600	20.9	0.29	620	20.8	0.63	520
	5/17	2.2	NS	NS	NS	20.9	0.16	170	20.9	0.2	160
	5/22	18.8	NS	NS	NS	20.7	0.18	130	20.6	0.23	120
	5/31	16.6	NS	NS	NS	20.7	0.29	130	20.5	0.4	130
	6/7	20.0	NS	NS	NS	NS	NS	NS	20.4	0.8	180
	6/28	28.9	NS	NS	NS	NS	NS	NS	19.8	1.8	130
	7/5	25.5	NS	NS	NS	NS	NS	NS	19.7	2.19	150
	7/11	15.5	20.8	0.39	800	NS	NS	NS	19.6	1.6	120
	8/22	ND	19.5	0.6	NA	18.5	1.8	NA	18.3	2.45	NA
	8/26	18.3	20.2	0.5	NA	19.3	1.6	NA	19.3	1.8	NA
	8/30	19.7	20.3	0.4	NA	19.3	1.6	NA	19.3	1.6	NA
	9/2	16.7	20.5	0.35	560	19.3	1.65	500	19.5	1.45	270
	10/3	ND	3	7.2	2400	3.5	5.5	280	4	3.3	114
	10/7	2.2	20	1.7	1700	18.5	4.8	190	19	3.8	120
	10/14	-2.8	20.8	1.8	980	18.8	5	170	19.8	4	130
	10/22	-8.3	20.8	0.7	94	20.8	0.7	1000	19.5	1.2	140
	10/28	-2.8	20.3	0.6	1500	19.3	2	170	19.8	1.6	110
	11/21	-8.9	0.5	1300	NA	19	2	240	19.5	1.5	160
	11/29	-8.6	20.5	0.7	3000	NS	NS	NS	19.5	1.3	220
	12/5	-20.0	20.8	0.3	2500	NS	NS	NS	19.8	1.5	180
	12/19	-13.3	20.5	0.8	4800	NS	NS	NS	19.5	1.6	460
	12/23	-36.0	20	0.5	3600	NS	NS	NS	19.8	1.5	230
1993	1/30	-25.0	20.9	0.05	1000	NS	NS	NS	20	1.6	140
	2/6	-19.4	20.9	0.1	1000	NS	NS	NS	20	1.2	630
	2/10	-22.8	20.9	0.05	1100	NS	NS	NS	20	1.2	170
	2/20	-12.8	20.78	0.05	780	NS	NS	NS	20	1.2	104

Table L2. Eielson AFB Weekly Soil Gas Data: Passive Warming Plot (Continued)

Year	Date	Temp (°C)	P6A			P6B			P6C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	3/8	-7.2	20.9	0.05	230	NS	NS	NS	20	1.3	120
	3/12	-7.8	20.9	0.05	230	NS	NS	NS	20	1.2	130
	3/20	-6.2	20.9	0.05	190	NS	NS	NS	20	1.3	110
	4/7	3.3	20.9	0.05	270	NS	NS	NS	20	1	110
	4/10	7.2	20.9	0.05	220	19.2	1.9	180	20	1	110
	4/20	7.8	NS	NS	NS	19.2	1.6	110	19.5	0.9	90
	5/6	12.8	NS	NS	NS	20.2	0.8	78	20.5	0.8	71
	6/6	13.3	NS	NS	NS	NS	3.6	150	NS	2.2	84
	6/22	18.3	20.7	0.6	62	15	7.8	160	17.8	5.2	110
	6/27	20.0	20.5	0.2	66	15	6.8	180	17.5	4.2	120
	7/3	16.9	0.7	120	20	13.8	8.7	180	16.7	6	120
	7/22	ND	0.5	750	19	10.2	11.2	150	13.8	8.3	110
	8/22	8.4	8.7	5.2	1760	0.1	7.8	260	3.7	2.4	128
	8/29	12.2	1.7	7.2	2000	0	8	400	0	3.2	220
	9/30	3.7	20.9	0.2	70	18.2	4.2	220	18.8	3.8	200
	10/7	13.0	20.9	0.2	80	19	3	200	19.8	2.3	170
	10/11	2.5	20.7	0.2	70	17.8	4.7	260	18.5	3.4	210
	10/14	5.4	20.9	0.05	51	19.3	2.4	160	19.8	2.2	150
	12/21	-10.6	20.9	0.1	120	19	2.8	210	20	2	160
1994	1/26	-14.6	20.8	0.1	22	20.2	0.8	73	19.2	2.6	190
	2/6	-16.0	20.9	0.05	33	NS	NS	NS	19.8	2.4	210
	2/13	-29.8	20.8	0.05	55	NS	NS	NS	19.7	2.2	270
	3/10	-10.5	18.2	1.2	190	20.5	1	150	20.5	1.8	240
	3/17	-18.6	NS	NS	NS	NS	NS	NS	20.3	1.8	220
	3/24	6.8	20.9	0.05	89	20.9	0.05	86	20.2	1.1	210
	4/9	-4.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/16	-12.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/3	10.5	NS	NS	NS	20	1	130	13.6	2.2	180
	5/8	13.5	17.8	2.3	250	19.4	1.7	210	14.2	3	250
	6/6	16.7	20.7	0.5	70	18	4.8	190	18	4.6	170
	6/23	18.3	18.5	2.7	150	17.7	4.4	180	17.2	4.1	170
	7/2	17.7	NS	NS	NS	16.5	6	220	16	6	210

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L2. Eielson AFB Weekly Soil Gas Data: Passive Warming Plot (Continued)

Year	Date	Temp (°C)	P7A			P7B			P7C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/17	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	9/28	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/20	-1.1	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/26	2.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/2	-1.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/23	-19.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/30	-16.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/24	-19.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/29	-23.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
1992	1/5	-21.1	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/11	-23.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/25	-18.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/15	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/22	-28.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/2	-23.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/9	-2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/28	0.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/4	-17.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/3	-5.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/17	2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/22	18.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/31	16.6	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/7	20.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/28	28.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/5	25.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/11	15.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/22	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/26	18.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/30	19.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	9/2	16.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/3	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/7	2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/14	-2.8	20.6	0.05	290	NS	NS	NS	NS	NS	NS
	10/22	-8.3	20.8	1.3	420	20.8	1.3	600	20.8	1.5	630
	10/28	-2.8	20.9	0.3	700	20.9	0.3	1000	20.8	0.6	700
	11/21	-8.9	20.8	0.05	840	20.8	0.05	980	20.8	0.05	820
	11/29	-8.6	20.8	0.05	150	20.8	0.05	420	20.5	0.05	400
	12/5	-20.0	20.9	0.05	140	20.9	0.05	210	20.9	0.05	190
	12/19	-13.3	20.9	0.05	58	20.9	0.05	70	20.9	0.05	110
	12/23	-36.0	20.9	0.05	140	20.9	0.05	140	20.9	0.05	130
1993	1/30	-25.0	20.9	0.05	0	20.9	0.05	0	20.9	0.05	5
	2/6	-19.4	20.9	0.05	45	20.9	0.05	41	20.9	0.05	43
	2/10	-22.8	20.9	0.05	34	20.9	0.05	36	20.9	0.05	45
	2/20	-12.8	20.9	0.05	45	20.9	0.05	49	20.9	0.05	56

Table L2. Eielson AFB Weekly Soil Gas Data: Passive Warming Plot (Continued)

Year	Date	Temp (°C)	P7A			P7B			P7C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	3/8	-7.2	20.9	0.05	41	20.9	0.05	38	20.9	0.05	53
	3/12	-7.8	20.9	0.05	43	20.9	0.05	52	20.9	0.05	74
	3/20	-6.2	20.9	0.05	62	20.9	0.05	65	20.9	0.05	68
	4/7	3.3	20.9	0.05	28	20.9	0.05	27	20.9	0.05	41
	4/10	7.2	20.9	0.05	46	20.9	0.05	47	20.7	0.05	54
	4/20	7.8	20.9	0.05	41	20.9	0.05	48	20.9	0.05	58
	5/6	12.8	20.7	0.05	210	20.7	0.05	95	20.5	0.05	100
	6/6	13.3	NS	NS	NS	20.9	0.05	35	20.9	0.05	42
	6/22	18.3	NA	0.5	30	NS	0.2	28	NS	0.6	48
	6/27	20.0	20.9	0.3	42	20.9	0.5	48	19.8	1.6	75
	7/3	16.9	20.9	0.05	45	20.9	0.05	52	20	0.8	82
	7/22	ND	20.8	0.3	20	20.7	0.6	27	19.7	1.8	73
	8/22	8.4	20.6	0.2	566	20.5	0.4	28	19.3	1.8	57
	8/29	12.2	NS	NS	NS	NS	NS	NS	12.7	2.2	84
	9/30	3.7	20.9	0.05	70	20.9	0.1	61	20.5	0.8	94
	10/7	13.0	20.9	0.1	87	20.9	0.1	79	20.7	0.7	98
	10/11	2.5	20.7	0.05	84	20.5	0.1	0.72	20.2	0.6	110
	10/14	5.4	20.9	0.05	40	20.9	0.05	46	20.5	0.4	67
	12/21	-10.6	20.9	0.05	0	20.9	0.05	9	20.8	0.3	35
1994	1/26	-14.6	20.9	0.05	0	20.9	0.05	0	20.7	0.2	11
	2/6	-16.0	NS	NS	NS	20.9	0.05	16	20.7	0.2	60
	2/13	-29.8	NS	NS	NS	20.9	0.05	36	20.9	0.2	67
	3/10	-10.5	20.9	0.05	36	20.9	0.05	25	20.9	0.1	73
	3/17	-18.6	NS	NS	NS	20.9	0.05	15	20.9	0.1	30
	3/24	6.8	20.3	0.05	130	20.9	0.05	140	20.9	0.05	150
	4/9	-4.9	NS	NS	NS	NS	NS	NS	20.9	0.05	95
	4/16	-12.4	NS	NS	NS	NS	NS	NS	20.9	0.05	35
	5/3	10.5	NS	NS	NS	20.9	0.05	52	20.8	0.1	58
	5/8	13.5	NS	NS	NS	20.8	0.05	130	20.6	0.05	140
	6/6	16.7	20.9	0.05	51	20.7	0.2	50	20	0.8	76
	6/23	18.3	NS	NS	NS	20.7	0.1	60	20	1	91
	7/2	17.7	NS	NS	NS	20.3	0.1	73	19.8	1.1	120

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L2. Eielson AFB Weekly Soil Gas Data: Passive Warming Plot (Continued)

Year	Date	Temp (°C)	P8A			P8B			P8C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/17	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	9/28	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/20	-1.1	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/26	2.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/2	-1.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/23	-19.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/30	-16.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/24	-19.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/29	-23.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
1992	1/5	-21.1	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/11	-23.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/25	-18.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/15	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/22	-28.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/2	-23.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/9	-2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/28	0.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/4	-17.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/3	-5.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/17	2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/22	18.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/31	16.6	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/7	20.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/28	28.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/5	25.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/11	15.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/22	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/26	18.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/30	19.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	9/2	16.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/3	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/7	2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/14	-2.8	NS	NS	NS	4	9.8	380	15	5	190
	10/22	-8.3	NS	NS	NS	4	9.3	320	14.5	4	180
	10/28	-2.8	NS	NS	NS	16.5	1.8	270	10.3	5.5	160
	11/21	-8.9	NS	NS	NS	6.2	9	500	6.5	8.5	380
	11/29	-8.6	NS	NS	NS	6.5	9.2	600	6	9.2	400
	12/5	-20.0	NS	NS	NS	10.2	8	630	10	7.9	270
	12/19	-13.3	NS	NS	NS	15.8	4.9	1200	16.8	4.2	840
	12/23	-36.0	NS	NS	NS	15.2	5.3	1200	11.5	9	830
1993	1/30	-25.0	NS	NS	NS	13.5	7	1000	17.5	4.5	330
	2/6	-19.4	NS	NS	NS	15.2	6.5	1100	17.2	5	1100
	2/10	-22.8	NS	NS	NS	13.8	6.5	1000	15.5	5.2	820
	2/20	-12.8	NS	NS	NS	11.8	6.8	900	13.5	5.7	760

Table L2. Eielson AFB Weekly Soil Gas Data: Passive Warming Plot (Continued)

Year	Date	Temp (°C)	P8A			P8B			P8C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	3/8	-7.2	NS	NS	NS	14.5	3.5	610	11.5	6	360
	3/12	-7.8	NS	NS	NS	11.2	7	630	15.2	4.2	340
	3/20	-6.2	NS	NS	NS	12	7	790	14	5.8	570
	4/7	3.3	NS	NS	NS	17.5	4.8	360	NS	NS	NS
	4/10	7.2	NS	NS	NS	18	4.3	300	NS	NS	NS
	4/20	7.8	NS	NS	NS	15	4.5	180	NS	NS	NS
	5/6	12.8	NS	NS	NS	9.5	6.3	240	3.5	6.8	260
	6/6	13.3	NS	NS	NS	NS	5+	110	NA	5	110
	6/22	18.3	NS	NS	NS	0	15.5	280	0	17.5	260
	6/27	20.0	NS	NS	NS	0	14	260	0	16	260
	7/3	16.9	0	10.8	37000	0	17	760	0	19.2	500
	7/22	ND	4.9	11.5	37000	0	17	900	0	19.2	520
	8/22	8.4	NS	NS	NS	0	18	360	0	15.7	260
	8/29	12.2	0	11.8	15000	0	17.3	1080	0	15.2	740
	9/30	3.7	NS	NS	NS	1.3	15.5	270	0	14.2	260
	10/7	13.0	NS	NS	NS	1.5	15.2	270	0.7	14.5	270
	10/11	2.5	NS	NS	NS	0.3	15.5	290	0	14.3	280
	10/14	5.4	NS	NS	NS	7.5	15	220	0	14.2	240
	12/21	-10.6	NS	NS	NS	5.7	13	270	7.3	12.3	270
1994	1/26	-14.6	20.9	0.05	0	6.3	11.5	290	6	12.5	300
	2/6	-16.0	NS	NS	NS	10.2	12	350	8.8	13.2	320
	2/13	-29.8	NS	NS	NS	12.5	11.6	430	11.4	12	430
	3/10	-10.5	20.9	0.05	61	11.3	12.8	420	9	13	400
	3/17	-18.6	NS	NS	NS	11.6	12.7	440	8.8	14	410
	3/24	6.8	20.9	0.05	140	15.6	8.4	390	15.8	8.2	390
	4/9	-4.9	NS	NS	NS	14	11.8	390	NS	NS	NS
	4/16	-12.4	NS	NS	NS	15.7	10.8	350	NS	NS	NS
	5/3	10.5	NS	NS	NS	10.2	11.2	290	7.3	10.7	250
	5/8	13.5	NS	NS	NS	5.5	12.7	310	0.2	13	320
	6/6	16.7	NS	NS	NS	0	17	230	0	19.2	230
	6/23	18.3	NS	NS	NS	0	18	230	0	18.2	230
	7/2	17.7	NS	NS	NS	0	18.5	250	0	18.8	260

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L3. Eielson AFB Weekly Soil Gas Data: Surface Warming Plot

Year	Date	Temp (°C)	H1A			H1B			H1C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1992	10/3	ND	0.05	3	20000	11	2.5	10000	13	1.7	10000
	10/7	2.2	20.6	0.7	6200	20.8	0.7	6200	20.8	0.7	6800
	10/10	ND	20.6	0.05	2200	NS	NS	NS	NS	NS	NS
	10/14	-2.8	20.8	1.3	2000	20.8	1.3	2000	20.8	1.5	1300
	10/22	-8.3	20.9	0.3	1500	20.9	0.3	1400	20.9	0.3	1000
	10/28	-2.8	20.9	0.05	2200	19.2	0.8	5600	20.5	0.5	2000
	11/21	-8.9	20.3	0.1	2000	13.5	5.5	16000	13.5	5.5	16000
	11/29	-8.6	20.6	0.2	1200	13.2	6	16000	14	5	13200
	12/5	-20.0	20.9	0.1	860	14	5.9	10600	15.5	4.7	9800
	12/19	-13.3	20.9	0.1	1000	13.2	6.8	15200	6.8	9.2	11800
	12/23	-36.0	20.9	0.1	770	13.8	6.5	11200	3.9	10.8	9400
1993	1/30	-25.0	20.9	0.05	200	13.5	6.8	7800	10	7.8	6300
	2/6	-19.4	20.8	0.1	170	13.5	6.3	11200	9	8.2	6200
	2/10	-22.8	20.9	0.05	170	14	6	10000	6	10	4800
	2/20	-12.8	20.9	0.05	190	13.2	6.2	10000	10.8	7.6	5000
	3/8	-7.2	NS	NS	NS	13.2	7.2	7400	13.2	6.7	3200
	3/12	-7.8	NS	NS	NS	14.5	6	7000	5	11.2	4400
	3/20	-6.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/7	3.3	20.5	0.4	310	10	11.8	8600	NS	NS	NS
	4/10	7.2	20.5	0.3	210	20	3.8	8100	NS	NS	NS
	4/20	7.8	20.9	0.05	350	7.8	10	6800	NS	NS	NS
	5/6	12.8	20.8	0.05	90	18.8	2.8	3900	3	7.3	3600
	6/6	13.3	NS	0.05	56	NS	2.5	1700	NS	5+	4000
	6/22	18.3	20.9	0.05	50	17.8	3.8	960	8	12.2	4000
	6/27	20.0	20.9	0.2	48	18.2	4.2	680	1.2	16	6400
	7/3	16.9	20.6	0.7	34	17.5	5	530	2.3	15.8	8000
	7/22	ND	20.7	0.05	16	4.2	17.3	220	3.5	14.5	11600
	8/22	8.4	0	7.3	1400	0	13	6200	14	8	2000
	8/29	12.2	0	3	2200	0	14.2	8400	13.5	9	4600
	9/30	3.8	20.7	0.3	84	17	6.2	260	13.3	8.2	1000
	10/7	13.0	20.7	0.1	92	16.2	6.3	270	13.2	8	490
	10/11	2.5	20.7	0.2	76	16.5	6.3	280	12.7	8.8	460
	10/14	5.4	20.9	0.2	55	16.7	6	230	11.5	9.5	380
	12/21	-10.6	20.9	0.2	81	17	5.8	310	12.2	8.8	350
1994	1/26	-11.4	NS	NS	NS	18.5	3.7	290	14	7.2	370
	2/6	-16.0	20.8	0.1	70	18	4.7	310	17.5	4.8	370
	2/13	-29.8	20.7	0.05	37	18.5	3.8	330	18.3	3.4	400
	3/10	-10.5	20.9	0.05	62	3.2	7	1000	18.5	3	340
	3/17	-18.6	NS	NS	NS	2.8	8	1300	18.2	3.8	420
	3/24	6.8	NS	NS	NS	8.8	5.8	1100	18.2	3.5	370
	4/9	-4.9	NS	NS	NS	15.5	0.7	7300	NS	NS	NS
	4/16	-12.4	NS	NS	NS	4	10.2	4900	NS	NS	NS
	5/3	10.5	NS	NS	NS	NS	NS	NS	16.6	1.8	190
	5/8	13.5	NS	NS	NS	0	9.7	6800	16	2.4	290
	6/6	16.7	NS	NS	NS	0	11.7	8200	14.4	7.3	250
	6/23	18.3	NS	NS	NS	0	12	8600	13	8.5	280
	7/2	17.7	NS	NS	NS	0	12.2	2700	14.5	8.3	270

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L3. Eielson AFB Weekly Soil Gas Data: Surface Warming Plot (Continued)

Year	Date	Temp (°C)	H2A			H2B			H2C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1992	10/3	ND	0	6.5	20000	2	4	17200	10.2	3.5	8100
	10/7	2.2	20.5	1	4400	19.5	2.5	6800	11	7.5	7000
	10/10	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/14	-2.8	20.8	1.3	1000	20	3	1600	14	8.6	4600
	10/22	-8.3	20.9	0.3	820	20.3	1.2	980	14.2	6.2	4300
	10/28	-2.8	20.9	0.05	960	19.5	1.5	1100	13.8	6.3	6400
	11/21	-8.9	20.2	0.1	850	11.5	6.2	6800	11.5	7.8	6200
	11/29	-8.6	20.6	4.1	710	12	7	2500	NS	NS	NS
	12/5	-20.0	20.9	0.1	350	NS	NS	NS	NS	NS	NS
	12/19	-13.3	20.8	0.05	530	10	8.5	2600	16.2	4.8	2800
	12/23	-36.0	20.5	0.05	320	11	8.2	2200	16	5.2	3100
1993	1/30	-25.0	20.9	0.05	140	2	10.5	4400	16	4.8	3300
	2/6	-19.4	20.9	0.05	190	NS	NS	NS	10	8.2	7000
	2/10	-22.8	20.9	0.05	230	NS	NS	NS	15	4.8	4000
	2/20	-12.8	20.5	0.05	180	NS	NS	NS	7.5	10.2	8600
	3/8	-7.2	NS	NS	NS	NS	NS	NS	14	6	4000
	3/12	-7.8	NS	NS	NS	NS	NS	NS	16	5	3500
	3/20	-6.2	NS	NS	NS	1.5	14	11800	17	4.3	2900
	4/7	3.3	20.5	0.05	280	NS	NS	NS	NS	NS	NS
	4/10	7.2	20.5	0.05	250	NS	NS	NS	NS	NS	NS
	4/20	7.8	20.7	0.05	190	NS	NS	NS	NS	NS	NS
	5/6	12.8	20.7	0.05	120	NS	NS	NS	8.8	6.3	1500
	6/6	13.3	NS	0.05	150	NS	NS	NS	NS	3.2	2000
	6/22	18.3	20.9	0.05	62	NS	NS	NS	14.8	6.5	2400
	6/27	20.0	20.9	0.1	110	NS	NS	NS	12.2	9	4200
	7/3	16.9	20.5	0.2	100	NS	NS	NS	11.2	9.8	4600
	7/22	ND	20.5	0.05	110	NS	NS	NS	13	8.7	4600
	8/22	8.4	0	7	900	NS	NS	NS	NS	NS	NS
	8/29	12.2	0	8.2	2000	NS	NS	NS	9.7	9.3	3600
	9/30	3.8	20.7	0.1	77	18.8	3.2	9800	12.2	6.3	1600
	10/7	13.0	20.7	0.05	78	NS	NS	NS	13.7	6.5	2200
	10/11	2.5	20.7	0.05	81	NS	NS	NS	14	6.5	1100
	10/14	5.4	20.7	0.05	50	NS	NS	NS	14.2	5.8	250
	12/21	-10.6	20.9	0.1	54	16.3	5.3	NA	13.8	8	840
1994	1/26	-11.4	20.9	0.05	60	20.9	0.05	30	15.7	6	580
	2/6	-16.0	20.9	0.05	64	NS	NS	NS	17.8	4.7	590
	2/13	-29.8	20.9	0.05	14	NS	NS	NS	18.8	2.8	590
	3/10	-10.5	20.9	0.05	48	20.9	0.05	54	18.5	3	570
	3/17	-18.6	NS	NS	NS	NS	NS	NS	18	4	620
	3/24	6.8	NS	NS	NS	20.7	0.05	750	18.3	3.2	730
	4/9	-4.9	NS	NS	NS	20.6	0.05	600	NS	NS	NS
	4/16	-12.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/3	10.5	NS	NS	NS	NS	NS	NS	15.8	3.7	1300
	5/8	13.5	NS	NS	NS	NS	NS	NS	16.2	3.8	900
	6/6	16.7	19.2	3	1300	17.8	3.3	4600	15	6.3	270
	6/23	18.3	NS	NS	NS	NS	NS	NS	16.5	4.5	550
	7/2	17.7	NS	NS	NS	NS	NS	NS	18.3	4	380

NS: Not Sampled
NA: Not Analyzed
ND: No Data

Table L3. Eielson AFB Weekly Soil Gas Data: Surface Warming Plot (Continued)

Year	Date	Temp (°C)	H3A			H3B			H3C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1992	10/3	ND	0	7	20000	2	3.5	19800	20	0.05	1700
	10/7	2.2	20.5	0.7	1000	1	9	16600	9	4.8	11600
	10/10	ND	20.6	0.05	NES	NS	NS	NS	NS	NS	NS
	10/14	-2.8	20.8	1.3	390	0	10.3	13600	3.5	6.2	6200
	10/22	-8.3	20.9	0.2	320	3	7	7200	5	5	8800
	10/28	-2.8	20.9	0.05	360	1.5	8.2	6000	4	5.3	12000
	11/21	-8.9	20.2	0.05	410	3	11	1200	17	0.05	3500
	11/29	-8.6	20.5	0.05	280	4.5	11.2	1420	0	10.2	14400
	12/5	-20.0	20.9	0.05	99	10.5	8	660	3.5	9.2	8600
	12/19	-13.3	20.9	0.05	310	10.2	9.2	1000	0	12.2	16000
	12/23	-36.0	20.9	0.05	140	NS	NS	NS	1.2	12.2	9800
1993	1/30	-25.0	NS	NS	NS	12.2	8.2	780	20.9	0.05	5400
	2/6	-19.4	NS	NS	NS	15.3	5.5	440	1	13	16400
	2/10	-22.8	NS	NS	NS	14.2	6.2	370	20.9	0.05	4300
	2/20	-12.8	NS	NS	NS	14.5	6.5	700	0.5	15.8	19000
	3/8	-7.2	NS	NS	NS	13.2	8.3	390	0.5	17	18800
	3/12	-7.8	NS	NS	NS	13.5	7.5	1000	1	16	16000
	3/20	-6.2	20.5	0.05	230	15	6.2	350	0	16.2	41000
	4/7	3.3	20.7	0.05	140	NS	NS	NS	0	16.5	20000
	4/10	7.2	20.7	0.05	115	NS	NS	NS	0.5	16	12600
	4/20	7.8	20.9	0.05	100	NS	NS	NS	0.5	15	9400
	5/6	12.8	20.5	0.05	110	16.2	5.8	330	2.2	14	6400
	6/6	13.3	NS	0.05	90	NS	4	460	NS	5+	6800
	6/22	18.3	20.9	0.05	76	16.5	6.8	1000	4	14	8000
	6/27	20.0	20.9	0.1	83	17.8	5.3	290	6.8	13	6800
	7/3	16.9	20.2	0.6	130	16.8	6.7	430	9.2	12	6200
	7/22	ND	20.2	0.05	140	16.8	5	1000	8.5	11.5	7000
	8/22	8.4	NS	NS	NS	NS	NS	NS	15.2	7.2	1500
	8/29	12.2	NS	NS	NS	NS	NS	NS	12.3	9.7	2400
	9/30	3.8	20.7	0.05	87	18.7	4.2	1100	9.2	9	1600
	10/7	13.0	20.7	0.1	87	15	8.2	1600	15.2	6.7	2400
	10/11	2.5	20.7	0.05	87	NS	NS	NS	8.2	11	1600
	10/14	5.4	20.9	0.05	45	NS	NS	NS	5.5	11.8	1600
	12/21	-10.6	NS	NS	NS	20.9	0.1	130	12.5	8.3	310
1994	1/26	-11.4	20.9	0.05	30	20.2	1.2	120	11.2	8.5	960
	2/6	-16.0	20.8	0.1	63	17.8	4.8	500	13.2	7.6	760
	2/13	-29.8	NS	NS	NS	NS	NS	NS	17.3	4	720
	3/10	-10.5	20.9	0.05	70	20.9	0.05	52	16.3	4.5	460
	3/17	-18.6	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/24	6.8	NS	NS	NS	17	2.3	1100	16.3	4.6	450
	4/9	-4.9	NS	NS	NS	18.8	1.8	1300	14.5	6	470
	4/16	-12.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/3	10.5	NS	NS	NS	NS	NS	NS	10.5	7.8	430
	5/8	13.5	NS	NS	NS	12.5	8	5800	16.8	4.4	470
	6/6	16.7	19.6	2.2	730	11	19.2	9000	13.3	7.4	670
	6/23	18.3	NS	NS	NS	14.2	7.8	8100	13	7.8	640
	7/2	17.7	NS	NS	NS	13	9	4400	14	7.5	900

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L3. Eielson AFB Weekly Soil Gas Data: Surface Warming Plot (Continued)

Year	Date	Temp (°C)	H4A			H4B			H4C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1992	10/3	ND	5	2	6200	NS	NS	NS	NS	NS	NS
	10/7	2.2	20.5	1	6200	NS	NS	NS	NS	NS	NS
	10/10	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/14	-2.8	20.7	1.3	2200	20.2	2	2000	20	2.3	2200
	10/22	-8.3	20.9	0.3	1320	20.5	0.8	540	20.3	0.8	640
	10/28	-2.8	20.5	0.05	900	19.8	0.9	740	19	1.2	630
	11/21	-8.9	20	0.05	480	17.3	2.8	340	17	3	210
	11/29	-8.6	20	0.1	480	17.5	3	430	NS	NS	NS
	12/5	-20.0	20.5	0.1	240	19	2	250	16.8	3.5	190
	12/19	-13.3	20.5	0.1	580	17.5	3.2	310	15.5	4.8	260
	12/23	-36.0	NS	NS	NS	17	3	210	15	5.2	180
1993	1/30	-25.0	NS	NS	NS	9.2	6.2	420	16	4.3	190
	2/6	-19.4	NS	NS	NS	8.5	5.8	660	14.8	5	250
	2/10	-22.8	NS	NS	NS	8	6.3	560	15.2	4.8	190
	2/20	-12.8	NS	NS	NS	5	7	900	14.2	5.7	320
	3/8	-7.2	NS	NS	NS	3.5	8	800	15.5	5	290
	3/12	-7.8	20.3	0.5	300	7.3	8	260	15.2	5	230
	3/20	-6.2	20.5	0.05	350	6	8.8	680	15	6	290
	4/7	3.3	NS	NS	NS	6.2	8.9	920	10.3	6.2	280
	4/10	7.2	NS	NS	NS	8.2	6	880	14	4.8	190
	4/20	7.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/6	12.8	NS	NS	NS	NS	NS	NS	13.2	5.3	210
	6/6	13.3	NS	NS	NS	NS	NS	NS	NS	3	250
	6/22	18.3	NS	NS	NS	NS	NS	NS	15	7.3	220
	6/27	20.0	NS	NS	NS	NS	NS	NS	14.5	8.3	220
	7/3	16.9	NS	NS	NS	NS	NS	NS	17	6.2	160
	7/22	ND	20.2	0.05	130	0	13	19800	14	8	430
	8/22	8.4	NS	NS	NS	NS	NS	NS	19.2	1.3	83
	8/29	12.2	NS	NS	NS	0	13.3	3100	15.5	6.8	310
	9/30	3.8	20.5	0.6	130	4.8	9.3	7900	17	4.3	280
	10/7	13.0	20.5	0.3	120	0	11	3200	17	4.8	360
	10/11	2.5	20.5	0.3	130	0.7	11	3300	17.8	4.2	260
	10/14	5.4	20.7	0.1	75	17.8	4	200	18.8	2.8	170
	12/21	-10.6	20.9	0.1	130	13	5.2	5400	20.9	0.1	190
1994	1/26	-11.4	20.9	0.05	38	11.5	5	5600	20.9	0.05	210
	2/6	-16.0	20.7	0.2	130	NS	NS	NS	19	2.8	270
	2/13	-29.8	20.7	0.05	76	NS	NS	NS	18.8	2.8	320
	3/10	-10.5	20.9	0.05	68	18.5	1.5	4000	19	2.2	320
	3/17	-18.6	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/24	6.8	20.8	0.05	95	20.2	0.2	1000	19.5	1.8	320
	4/9	-4.9	NS	NS	NS	18.5	1.6	3100	NS	NS	NS
	4/16	-12.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/3	10.5	NS	NS	NS	NS	NS	NS	19.8	1.2	150
	5/8	13.5	11.3	3.3	1400	9	5.5	5100	19	1.7	310
	6/6	16.7	NS	NS	NS	17.8	2.8	4600	19.2	2	310
	6/23	18.3	NS	NS	NS	17	3.2	6300	18	2.2	250
	7/2	17.7	NS	NS	NS	15	4.7	10000	18.3	3.5	400

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L3. Eielson AFB Weekly Soil Gas Data: Surface Warming Plot (Continued)

Year	Date	Temp (°C)	H5A			H5B			H5C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1992	10/3	ND	18.5	4	2600	10.5	1.5	9000	8.5	8.8	4600
	10/7	2.2	NS	NS	NS	3.7	6.5	3000	9.5	6	2400
	10/10	ND	19.5	0.9	14000	3.2	7.2	3400	6.5	7.5	2600
	10/14	-2.8	NS	NS	NS	6.5	7.5	1880	4.5	11	2000
	10/22	-8.3	NS	NS	NS	5.5	8.8	2000	2.6	12	2000
	10/28	-2.8	NS	NS	NS	12	6	1800	6.2	9.2	1560
	11/21	-8.9	NS	NS	NS	11.5	6.8	2800	5.2	10.8	1640
	11/29	-8.6	NS	NS	NS	14	6	1700	7	9.8	1480
	12/5	-20.0	NS	NS	NS	9.5	8	510	2.5	13	1160
	12/19	-13.3	NS	NS	NS	10	7.2	670	3.5	12.2	1100
	12/23	-36.0	NS	NS	NS	8	8.2	550	6	12	1560
1993	1/30	-25.0	NS	NS	NS	6.3	9.2	1340	0.5	15	1240
	2/6	-19.4	NS	NS	NS	6.7	12	2600	20.9	1	1300
	2/10	-22.8	19	1.5	800	7	9.2	880	4	14	1600
	2/20	-12.8	20	0.8	560	6.8	9.3	880	2	15.2	1280
	3/8	-7.2	18	2.5	2500	5.7	13	1400	0	15.5	3400
	3/12	-7.8	18	3.2	3100	1.8	14.8	450	1.2	15	270
	3/20	-6.2	20.3	0.4	1000	3.2	15.5	3000	1.5	11.2	450
	4/7	3.3	20.5	0.05	94	5.8	15	1200	2	13	1480
	4/10	7.2	NA	0.05	100	NA	5	270	NA	5	2800
	4/20	7.8	20.9	0.05	70	10.2	11.2	170	0.5	16	3600
	5/6	12.8	20.9	0.2	88	10.7	11	160	2.2	15.8	3000
	6/6	13.3	20.5	0.5	47	10.2	11.5	140	2.2	16.2	3000
	6/22	18.3	20.2	0.05	160	11.2	10	170	1.5	15.8	3400
	6/27	20.0	NS	NS	NS	NS	NS	NS	8.3	11.5	4000
	7/3	16.9	NS	NS	NS	NS	NS	NS	8.2	12	1520
	7/22	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/22	8.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/29	12.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	9/30	3.8	19.5	1.8	210	12.5	12.2	560	10	10.2	1500
	10/7	13.0	19.2	2.2	280	3	17	400	11.7	9.8	1500
	10/11	2.5	19.5	1.8	200	NS	NS	NS	12.5	9.2	1700
	10/14	5.4	20	1.2	120	NS	NS	NS	9.2	10.8	460
	12/21	-10.6	20.9	0.05	110	20.9	0.1	84	8	11.5	370
1994	1/26	-11.4	20.9	0.05	50	20.9	0.05	42	12	8.8	400
	2/6	-16.0	18.8	1.4	220	10.8	12.2	400	13	8.8	680
	2/13	-29.8	NS	NS	NS	17.5	4.5	360	13.5	8	640
	3/10	-10.5	20.9	0.05	75	13	6.7	1300	13.8	7.8	620
	3/17	-18.6	20.8	0.05	110	NS	NS	NS	14.2	8.2	690
	3/24	6.8	NS	NS	NS	18	2.8	970	13.8	7.8	600
	4/9	-4.9	NS	NS	NS	13.5	8	5200	NS	NS	NS
	4/16	-12.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/3	10.5	NS	NS	NS	14.2	8	1200	15.3	5.4	600
	5/8	13.5	NS	NS	NS	10.2	10.5	5700	11.8	8	530
	6/6	16.7	NS	NS	NS	13	10	4100	11.8	9.2	850
	6/23	18.3	NS	NS	NS	9.7	12.5	6300	12.6	8	830
	7/2	17.7	NS	NS	NS	14.2	9.2	9900	13.2	9.2	810

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L3. Eielson AFB Weekly Soil Gas Data: Surface Warming Plot (Continued)

Year	Date	Temp (°C)	H6A			H6B			H6C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1992	10/3	ND	16	7.3	38000	2.5	10.5	17800	18.3	3.3	3100
	10/7	2.2	19.5	2.2	10400	8	5.5	12000	16.8	2.5	4700
	10/10	ND	19	1.6	18400	2	7.2	19200	16	2.5	6400
	10/14	-2.8	NS	NS	NS	2.5	8.2	16000	9.2	5.5	9400
	10/22	-8.3	NS	NS	NS	0.5	10.2	43000	13.5	4.8	1500
	10/28	-2.8	NS	NS	NS	1	9.2	39000	15.8	4	1100
	11/21	-8.9	NS	NS	NS	0	10	48000	18	2.5	610
	11/29	-8.6	NS	NS	NS	0	10.5	27000	17.8	3.8	460
	12/5	-20.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/19	-13.3	NS	NS	NS	0	10.8	36000	14.8	5.8	580
	12/23	-36.0	NS	NS	NS	0	11.2	32000	17.3	4.5	510
1993	1/30	-25.0	NS	NS	NS	0	10.5	30000	NS	NS	NS
	2/6	-19.4	NS	NS	NS	0	11.5	43000	12.8	6	440
	2/10	-22.8	15.8	3.2	7000	0.5	10.3	33000	16.5	6.8	420
	2/20	-12.8	16	2.8	25000	1	11	34000	13	7.8	4400
	3/8	-7.2	10.2	8.2	22000	0	12	46000	NS	NS	NS
	3/12	-7.8	12.2	8	29000	0	12.2	62000	NS	NS	NS
	3/20	-6.2	19.2	2.8	7400	0.5	7.3	45000	NS	NS	NS
	4/7	3.3	20.2	0.2	110	1.2	13	5800	NS	NS	NS
	4/10	7.2	NA	0.2	120	NA	5	3900	NS	NS	NS
	4/20	7.8	0.5	100	14	16.2	0	7200	NS	NS	NS
	5/6	12.8	20.9	0.5	110	0	16	4200	NS	NS	NS
	6/6	13.3	20.2	0.8	84	0	16.5	2400	NS	NS	NS
	6/22	18.3	20	0.2	110	0	16.2	0	NS	NS	NS
	6/27	20.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/3	16.9	NS	NS	NS	0	16.2	53000	NS	NS	NS
	7/22	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/22	8.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/29	12.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	9/30	3.8	18.5	4.5	320	5.8	12.5	4100	10.7	7.8	5800
	10/7	13.0	17.8	5.8	340	0	15.5	5100	NS	NS	NS
	10/11	2.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/14	5.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/21	-10.6	20.9	0.1	80	8.2	10.8	2500	20.9	0.2	200
1994	1/26	-11.4	20.9	0.05	0	16.8	4	2100	20.9	0.05	48
	2/6	-16.0	19	2.5	270	4.8	13	1500	8.2	7	5000
	2/13	-29.8	NS	NS	NS	NS	NS	NS	9.8	6.2	590
	3/10	-10.5	20.9	0.05	88	8.2	9.8	4700	18.8	1.8	280
	3/17	-18.6	NS	NS	NS	NS	NS	NS	20.9	0.05	60
	3/24	6.8	20.2	0.1	250	13.3	6.8	9200	19	1.6	300
	4/9	-4.9	NS	NS	NS	7	10.2	9400	18.8	1.4	490
	4/16	-12.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/3	10.5	12.5	6	4600	7.2	6.2	3300	NS	NS	NS
	5/8	13.5	5.5	9.8	6100	1.2	8	4300	3.4	7.5	1000
	6/6	16.7	16	5.2	8000	3.8	7.8	2200	12.2	6.8	1700
	6/23	18.3	10.6	8.8	5000	4.5	9	4200	8.7	9.2	370
	7/2	17.7	NS	NS	NS	4	9	5400	16	5.2	1300

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L4. Eielson AFB Weekly Soil Gas Data: Control Plot

Year	Date	Temp (°C)	C1A			C1B			C1C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/17	ND	0.5	10.0	8000	1.0	11.0	4800	NS	NS	NS
	9/28	ND	16.5	3.4	32000	12.8	5.2	32000	11.0	6.9	26000
	10/20	-1.1	16.5	3.8	10000	10.0	5.2	10000	15.5	3.4	4200
	10/26	2.7	17.0	3.1	10000	13.5	4.3	10000	10.1	4.7	8600
	11/2	-1.3	17.3	2.6	10000	10.1	9.9	10000	6.3	11.6	9700
	11/23	-19.0	18.0	1.8	10000	1.8	4.9	10000	9.5	11.1	10000
	11/30	-16.0	15.9	2.4	10000	20.5	0.5	240	20.3	0.5	120
	12/24	-19.4	17.9	5.0	10000	12.5	8.9	10000	15.6	6.7	4800
	12/29	-23.3	19.1	1.9	10000	13.9	8.5	10000	12.1	9.8	7200
1992	1/5	-23.3	19.0	2.3	7200	15.1	7.4	7300	14.1	8.4	6300
	1/11	-22.0	20.1	1.8	14000	14.6	8.1	16200	7.4	13	10600
	1/18	-6.0	18.9	1.5	14000	14.9	4.4	14000	11	10	8400
	1/25	-18.0	19.3	1.3	8900	15	4.1	11200	14.5	11	6800
	2/15	ND	16.8	3.2	NA	6.9	10.8	NA	9.9	11.8	NA
	2/22	-28.0	16.8	3.1	10000	9.9	9.1	10000	9	11.5	7400
	3/2	-20.0	17.0	2.4	10000	9.1	9.5	10000	8.2	12.1	8500
	3/9	0.0	16.3	7.2	10000	11.9	10.9	10000	10.7	14.2	6900
	3/29	-3.0	15.2	6.2	10000	7.3	10.2	10000	11.5	10.8	NA
	4/4	-2.0	15.5	3.6	10000	11.5	9	10000	14.5	8.8	5000
	5/3	-5.0	NS	NS	NS	19.1	2.5	10000	NS	NS	NS
	5/17	2.2	NS	NS	NS	16.6	4.9	3700	NS	NS	NS
	5/22	18.8	NS	NS	NS	15.1	8.1	7500	15.5	8	6800
	5/31	16.6	NS	NS	NS	11.8	8.4	7200	20.6	0.21	430
	6/7	20.0	NS	NS	NS	4.1	9.5	7700	20.9	0.3	330
	6/28	28.9	NS	NS	NS	1.9	12.6	3200	13.9	9.6	2700
	7/5	25.5	NS	NS	NS	2.9	14.6	4400	14.2	11.1	1800
	7/11	15.5	NS	NS	NS	1.9	16.0	2200	13.9	11.6	1200
	8/22	ND	20	0.05	NA	19.3	0.6	NA	18	2.7	NA
	8/26	18.3	NS	NS	NS	20	0.7	NA	18	2.7	NA
	8/30	19.7	20.6	0.2	NA	20	0.65	NA	18.5	2.3	NA
	9/2	16.7	20.8	0.4	2700	20	0.7	4600	18.7	2.2	2900
	10/3	ND	1	6.3	3400	0	5	2000	16	3	760
	10/7	2.2	20.2	1.5	4800	19	3.3	4800	16.8	5	1700
	10/14	-2.8	20.8	1.8	4600	20	3	2700	18.2	5.8	2200
	10/22	-8.3	20.9	0.6	4000	19.5	1.75	3300	17.5	3.5	2100
	10/28	-2.8	20.5	0.5	5000	19	1.5	5000	17.5	3.2	2600
	11/21	-8.9	20.5	0.3	5000	19.5	1.3	3300	18	3.3	2200
	11/29	-8.6	20.5	0.3	4900	19.5	1.2	3000	18	3.2	2400
	12/5	-20.0	20.9	0.3	1700	20	0.9	1200	18.2	3	1800
	12/19	-13.3	20.8	0.3	4700	19.5	1.2	2700	19.2	2.2	2200
	12/23	-36.0	20.8	0.3	2200	19.5	1.2	2000	20	2	2400
1993	1/30	-25.0	20.9	0.1	1800	20	1	1500	19	2.7	2000
	2/6	-19.4	20.9	0.1	1900	20	1.2	2100	19.5	2.3	1700
	2/10	-22.8	20.9	0.05	3800	20.2	0.8	1700	19.3	2.2	1500

Table L4. Eielson AFB Weekly Soil Gas Data: Control Plot (Continued)

Year	Date	Temp (°C)	C1A			C1B			C1C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	2/20	-12.8	20.3	0.1	4300	19.2	1	2200	18.2	2.3	1900
	3/8	-7.2	20.8	0.1	1300	19.8	1.2	2000	18.2	2.5	1700
	3/12	-7.8	20.9	0.05	1400	19.8	0.8	1900	19	2.3	1800
	3/20	-6.2	20.7	0.1	1400	19.8	1	1800	19	2.8	1900
	4/7	3.3	NS	NS	NS	20.2	0.7	130	20.2	1.3	820
	4/10	7.2	20.9	0.05	1400	20.5	0.7	3000	19.8	1.8	100
	4/20	7.8	NS	NS	NS	20	0.7	2000	19.8	0.9	2100
	5/6	12.8	20.9	0.05	1000	20.7	0.2	1100	20.9	0.05	100
	6/6	13.3	NS	NS	NS	NS	0.3	900	NS	1	510
	6/22	18.3	NS	NS	NS	20.2	0.8	730	19.8	1.8	330
	6/27	20.0	NS	NS	NS	20.7	1.2	650	20	2	280
	7/3	16.9	NS	NS	NS	20	1.2	650	19	2.5	250
	7/22	ND	NS	NS	NS	19.8	1.2	640	19	2.7	180
	8/22	8.4	NS	NS	NS	4.8	7.5	200	15	3.5	89
	8/29	12.2	NS	NS	NS	0	8	340	13.5	4.3	340
	9/30	3.8	NS	NS	NS	20.7	0.5	150	20.3	1.1	130
	10/7	12.2	NS	NS	NS	20.5	0.5	130	20.3	1	130
	10/11	12.2	NS	NS	NS	20.6	0.5	130	20.5	1	130
	10/14	12.2	NS	NS	NS	20.7	0.2	97	20.5	0.8	86
	12/21	12.2	NS	NS	NS	17.7	2.7	260	15.7	1.8	200
1994	1/26	-14.6	NF	NF	NF	17.5	1.7	190	19	1.8	210
	2/6	-16.0	NS	NS	NS	10	3.3	310	17.5	2.2	230
	2/13	-29.8	NS	NS	NS	11.3	4.7	380	17.7	2.2	270
	3/10	-10.5	NS	NS	NS	2	7.2	350	16	2.8	320
	3/17	-18.6	NS	NS	NS	NS	NS	NS	16.8	2.8	320
	3/24	6.8	20.9	0.05	88	20.2	0.1	180	18	1.6	260
	4/9	-4.9	NS	NS	NS	20.2	2.2	410	20.5	1.4	310
	4/16	-12.4	NS	NS	NS	19.3	1.2	250	20.7	0.7	170
	5/3	10.5	11	2.8	250	8.5	3.8	150	19.7	0.5	72
	5/8	13.5	3.2	3.3	210	NS	NS	NS	20.7	0.05	120
	6/6	16.7	NS	NS	NS	0.2	4.2	120	20.2	0.8	51
	6/23	18.3	NS	NS	NS	0	7.7	190	11.5	5.4	210
	7/2	17.7	NS	NS	NS	0	9	210	12.8	7.6	230

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L4. Eielson AFB Weekly Soil Gas Data: Control Plot (Continued)

Year	Date	Temp (°C)	C2A			C2B			C2C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/17	ND	1.0	10.0	8800	1.0	10.0	6800	NS	NS	NS
	9/28	ND	19.5	1.5	24500	17.0	2.5	16800	18.8	2.3	3800
	10/20	-1.1	21.0	0.8	8000	21.8	0.1	940	17.9	2.5	1600
	10/26	2.7	20.9	0.7	8600	20.1	1.3	5100	18.5	2.0	1800
	11/2	-1.3	19.9	0.7	8300	18.0	1.9	6800	15.5	2.9	2400
	11/23	-19.0	20.0	0.7	6200	15.9	3.2	5700	6.5	12.0	5800
	11/30	-16.0	19.6	0.5	7300	19.4	0.6	3500	18.5	1.2	1200
	12/24	-19.4	20.2	0.4	4300	20.9	0.0	150	16.4	4.5	3300
	12/29	-23.3	20.8	0.3	2600	20.7	0.3	1900	19.8	1.0	1100
1992	1/5	-23.3	20.0	0.2	1300	17.0	2.8	4500	16.0	6.6	4200
	1/11	-22.0	20.9	0.41	2100	16.4	5.5	6400	8.5	12.1	8600
	1/18	-6.0	20.5	0.2	2000	NS	NS	NS	NS	NS	NS
	1/25	-18.0	20.9	0.1	1400	NS	NS	NS	13.2	9.4	4900
	2/15	ND	13	10	NA	NS	NS	NS	20	0.7	NA
	2/22	-28.0	19.5	0.92	6100	NS	NS	NS	12	9.1	4700
	3/2	-20.0	20.1	0.7	5500	NS	NS	NS	11.5	9.9	5500
	3/9	0.0	19.2	2.6	5600	NS	NS	NS	14	10.9	4400
	3/29	-3.0	19.2	1.3	ND	NS	NS	NS	NS	NS	NS
	4/4	-2.0	NS	NS	NS	15	8.5	3100	NS	NS	NS
	5/3	-5.0	20.9	0.1	6900	NS	NS	NS	NS	NS	NS
	5/17	2.2	15.8	8.2	10000	NS	NS	NS	NS	NS	NS
	5/22	18.8	15	7.9	10000	NS	NS	NS	NS	NS	NS
	5/31	16.6	NS	NS	NS	NS	NS	NS	20.7	0.13	220
	6/7	20.0	NS	NS	NS	NS	NS	NS	20.9	0.08	370
	6/28	28.9	NS	NS	NS	NS	NS	NS	14.7	8.1	810
	7/5	25.5	7.1	11.2	10000	NS	NS	NS	13.9	11.1	490
	7/11	15.5	16.2	8.2	10000	NS	NS	NS	15.0	10.8	440
	8/22	ND	20	0.05	NA	NS	NS	NS	19.3	0.9	NA
	8/26	18.3	20.5	0.16	NA	NS	NS	NS	20	0.85	NA
	8/30	19.7	20.5	0.15	NA	NS	NS	NS	20	0.8	NA
	9/2	16.7	20.8	0.4	1800	NS	NS	NS	20	0.8	690
	10/3	ND	0	6.3	2200	NS	NS	NS	18	1.5	120
	10/7	2.2	20.5	1.3	3400	NS	NS	NS	19.5	2.5	2200
	10/14	-2.8	20.8	1.6	3000	NS	NS	NS	20	3	2400
	10/22	-8.3	20.9	0.6	2200	NS	NS	NS	20	1.5	2200
	10/28	-2.8	20.5	0.5	3200	NS	NS	NS	20.2	0.6	3000
	11/21	-8.9	20.2	0.5	2600	NS	NS	NS	20	0.9	2600
	11/29	-8.6	20.5	0.5	2600	NS	NS	NS	20.2	0.8	2500
	12/5	-20.0	20.8	0.5	1100	NS	NS	NS	20.5	0.8	1600
	12/19	-13.3	20.8	0.5	1900	NS	NS	NS	20.5	0.6	2300
	12/23	-36.0	20.3	0.5	1300	NS	NS	NS	20.3	0.5	1800
1993	1/30	-25.0	20.7	0.2	1100	NS	NS	NS	20.5	0.7	1600
	2/6	-19.4	20.7	0.3	1300	NS	NS	NS	20.5	0.6	2000
	2/10	-22.8	20.5	0.1	1100	NS	NS	NS	20.5	0.5	1900

Table L4. Eielson AFB Weekly Soil Gas Data: Control Plot (Continued)

Year	Date	Temp (°C)	C2A			C2B			C2C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	2/20	-12.8	20.2	0.2	1200	NS	NS	NS	19.8	0.7	2200
	3/8	-7.2	20.7	0.1	1000	NS	NS	NS	20	1	2000
	3/12	-7.8	20.7	0.05	1000	NS	NS	NS	20	0.8	2000
	3/20	-6.2	20.5	0.1	1000	NS	NS	NS	20	0.9	2300
	4/7	3.3	20.7	0.1	950	NS	NS	NS	20.2	0.7	1100
	4/10	7.2	20.7	0.05	430	NS	NS	NS	20.2	0.8	1800
	4/20	7.8	20.9	0.1	930	NS	NS	NS	20.7	0.4	1100
	5/6	12.8	20.9	0.05	98	NS	NS	NS	20.9	0.05	80
	6/6	13.3	NS	0.1	520	NS	NS	NS	NS	0.8	910
	6/22	18.3	20.7	0.5	670	NS	NS	NS	20	1.5	580
	6/27	20.0	20.9	0.5	670	NS	NS	NS	20.2	1.3	520
	7/3	16.9	20.2	0.8	630	NS	NS	NS	19.8	1.5	420
	7/22	ND	20.2	0.4	630	NS	NS	NS	19.5	1.7	450
	8/22	8.4	0	8.8	1000	NS	NS	NS	15.5	2.7	120
	8/29	12.2	0	9.5	1080	NS	NS	NS	14.8	3.8	170
	9/30	3.8	20.7	0.1	130	NS	NS	NS	20.5	0.7	140
	10/7	12.2	20.9	0.1	82	NS	NS	NS	20.7	0.6	120
	10/11	12.2	20.9	0.1	80	NS	NS	NS	20.7	0.5	120
	10/14	12.2	20.9	0.1	86	NS	NS	NS	20.5	0.4	87
	12/21	12.2	20.2	2.4	300	NS	NS	NS	19	2.5	340
1994	1/26	-14.6	16.5	1	200	NS	NS	NS	19.3	1.2	180
	2/6	-16.0	5	5.2	300	NS	NS	NS	14.5	2.2	280
	2/13	-29.8	6.4	9	410	NS	NS	NS	15.5	3.5	370
	3/10	-10.5	0	9	480	NS	NS	NS	16.5	2.8	360
	3/17	-18.6	0	9.3	500	NS	NS	NS	17.5	2.8	300
	3/24	6.8	0.6	8.5	470	20.7	0.05	160	19	1	250
	4/9	-4.9	20.9	0.1	120	NS	NS	NS	20.8	0.5	160
	4/16	-12.4	20.9	0.05	63	NS	NS	NS	20.9	0.05	69
	5/3	10.5	NS	NS	NS	NS	NS	NS	20.9	0.05	50
	5/8	13.5	NS	NS	NS	NS	NS	NS	20.9	0.05	100
	6/6	16.7	NS	NS	NS	NS	NS	NS	20.3	0.7	53
	6/23	18.3	17.2	3.5	200	5.2	7	190	17.8	3	170
	7/2	17.7	9.6	5.8	160	0	8.8	210	17.2	4.2	190

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L4. Eielson AFB Weekly Soil Gas Data: Control Plot (Continued)

Year	Date	Temp (°C)	C3A			C3B			C3C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/17	ND	1.0	10.0	3000	5.0	10.2	1600	18.0	5.0	140
	9/28	ND	20.9	0.2	850	15.8	3.8	1200	18.7	1.9	1650
	10/20	-1.1	21.8	0.2	500	18.5	2.8	620	19.5	1.6	980
	10/26	2.7	21.5	0.2	120	19.5	1.8	860	19.5	1.4	300
	11/2	-1.3	20.9	0.0	310	16.1	3.4	900	20.9	0.0	200
	11/23	-19.0	20.9	0.0	290	14.0	4.8	1100	12.0	4.7	3500
	11/30	-16.0	9.9	6.0	10000	16.5	2.4	5600	19.9	0.4	440
	12/24	-19.4	20.9	0.0	0	13.1	8.1	420	17.5	2.2	1200
	12/29	-23.3	20.9	0.0	0	17.2	2.8	340	18.0	2.2	1800
1992	1/5	-23.3	20.9	0.0	19	12.5	9.9	640	18.6	3.9	2100
	1/11	-22.0	20.9	0.1	120	11	11	1200	NS	NS	NS
	1/18	-6.0	20.6	0.1	100	14.5	8	840	NS	NS	NS
	1/25	-18.0	20.9	0.1	30	15.5	4.8	560	8.5	14	260
	2/15	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/22	-28.0	20.9	0	120	NS	NS	NS	NS	NS	NS
	3/2	-20.0	20.9	0	90	NS	NS	NS	NS	NS	NS
	3/9	0.0	20.9	0.1	180	18.6	3	660	17.9	7	3000
	3/29	-3.0	20.9	0.1	160	NS	NS	NS	NS	NS	NS
	4/4	-2.0	20.9	0.1	36	NS	NS	NS	NS	NS	NS
	5/3	-5.0	20.9	0.02	500	NS	NS	NS	NS	NS	NS
	5/17	2.2	15	8.9	10000	NS	NS	NS	NS	NS	NS
	5/22	18.8	14.3	8.4	10000	NS	NS	NS	NS	NS	NS
	5/31	16.6	NS	NS	NS	NS	NS	NS	20.8	0.09	180
	6/7	20.0	NS	NS	NS	2.0	11.1	1000	20.7	0.14	190
	6/28	28.9	NS	NS	NS	1.1	13.8	1600	11.8	10.0	290
	7/5	25.5	NS	NS	NS	3.6	15.5	4000	12.3	12.0	380
	7/11	15.5	NS	NS	NS	4.1	15.8	4300	13.8	11.7	900
	8/22	ND	20	0.05	NA	19.6	0.16	NA	19.5	0.45	NA
	8/26	18.3	20.5	0.05	NA	20.5	0.25	NA	20.3	0.45	NA
	8/30	19.7	20.6	0.06	NA	20.5	0.25	NA	20.2	0.42	NA
	9/2	16.7	20.9	0.1	110	20.8	0.26	340	20.5	0.45	520
	10/3	ND	4.5	4	380	9.2	2.5	96	17.5	1.5	64
	10/7	2.2	20.5	1.3	3700	20	2	3500	20.2	1.8	2800
	10/14	-2.8	20.8	1.5	2000	20.6	2	2600	20.8	2.2	2400
	10/22	-8.3	NS	NS	NS	NS	NS	NS	20.5	0.9	1700
	10/28	-2.8	NS	NS	NS	NS	NS	NS	20.3	0.6	2800
	11/21	-8.9	NS	NS	NS	NS	NS	NS	20	0.7	2300
	11/29	-8.6	NS	NS	NS	NS	NS	NS	20.5	0.7	2500
	12/5	-20.0	NS	NS	NS	NS	NS	NS	20.8	0.6	1500
	12/19	-13.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/23	-36.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
1993	1/30	-25.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/6	-19.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/10	-22.8	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table L4. Eielson AFB Weekly Soil Gas Data: Control Plot (Continued)

Year	Date	Temp (°C)	C3A			C3B			C3C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	2/20	-12.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/8	-7.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/12	-7.8	NS	NS	NS	20.5	0.3	1000	19.2	2	1600
	3/20	-6.2	NS	NS	NS	20	0.8	1300	19.2	1.9	1800
	4/7	3.3	NS	NS	NS	18.8	3.2	2800	20	1.7	2400
	4/10	7.2	NS	NS	NS	19	3.2	2800	20	1	2100
	4/20	7.8	NS	NS	NS	19	2.2	3500	20.7	0.7	2200
	5/6	12.8	20.9	0.05	200	20.7	0.3	250	19	0.2	380
	6/6	13.3	NS	0.1	1000	NS	0.1	1000	NS	0.3	2100
	6/22	18.3	20.6	0.4	1400	20.7	0.2	1000	20.5	0.7	1400
	6/27	20.0	NS	NS	NS	20.9	0.4	1000	20.7	0.9	1200
	7/3	16.9	20.2	0.5	1200	20.2	0.6	1000	20	1.2	1000
	7/22	ND	NS	NS	NS	20.2	0.6	1000	20	1	960
	8/22	8.4	NS	NS	NS	5	4.2	196	15.5	2.3	87
	8/29	12.2	NS	NS	NS	6.3	6	280	14	4	160
	9/30	3.8	NS	NS	NS	20.7	0.2	150	20.7	0.3	140
	10/7	12.2	NS	NS	NS	20.9	0.2	140	20.7	0.4	130
	10/11	12.2	NS	NS	NS	20.9	0.2	130	20.7	0.3	120
	10/14	12.2	NS	NS	NS	20.9	0.05	86	20.7	0.1	80
	12/21	12.2	NS	NS	NS	20.3	2.3	440	19	3	300
1994	1/26	-14.6	NS	NS	NS	16.3	2	250	17.5	3.8	310
	2/6	-16.0	NS	NS	NS	8.6	4.2	220	16.4	3.6	300
	2/13	-29.8	NS	NS	NS	10.7	4.2	350	16.3	4	350
	3/10	-10.5	NS	NS	NS	12.8	4.7	400	15	4	380
	3/17	-18.6	NS	NS	NS	NS	NS	NS	15.8	3.8	380
	3/24	6.8	NS	NS	NS	17.3	2.1	280	15.5	3.5	350
	4/9	-4.9	NS	NS	NS	NS	NS	NS	20.8	0.5	140
	4/16	-12.4	NS	NS	NS	NS	NS	NS	20.9	0.05	60
	5/3	10.5	NS	NS	NS	13	3.2	220	17.5	1.8	170
	5/8	13.5	NS	NS	NS	11.2	3	260	20.5	0.05	88
	6/6	16.7	20.8	0.5	70	3.2	6.3	150	17.7	2.7	140
	6/23	18.3	20.7	0.7	72	7.3	8.3	190	15.2	5.2	210
	7/2	17.7	20.5	1.1	83	2	10	210	13.8	7	220

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L4. Eielson AFB Weekly Soil Gas Data: Control Plot (Continued)

Year	Date	Temp (°C)	C4A			C4B			C4C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/17	ND	0.5	9.5	2600	12.0	9.0	4800	18.5	3.0	1800
	9/28	ND	20.2	0.2	20	8.7	7.3	1000	16.5	4.8	1800
	10/20	-1.1	21.8	0.3	210	14.9	4.4	470	18.1	3.2	140
	10/26	2.7	21.5	0.2	90	17.0	2.2	300	18.5	2.0	700
	11/2	-1.3	20.9	0.0	210	6.1	13.8	720	15.5	6.6	720
	11/23	-19.0	20.9	0.1	290	4.5	14.2	690	9.9	9.0	1900
	11/30	-16.0	7.5	11.1	10000	16.5	3.0	350	19.6	0.6	460
	12/24	-19.4	20.9	0.0	0	11.3	9.0	370	17.8	3.1	1000
	12/29	-23.3	20.9	0.0	0	16.4	3.8	340	20.0	0.7	450
1992	1/5	-23.3	20.9	0.0	30	10.9	10.1	460	15.9	6.7	2000
	1/11	-22.0	20.9	0.1	88	6	15.1	1200	NS	NS	NS
	1/18	-6.0	20.9	0.1	115	12.2	8.9	750	14.3	8.1	2400
	1/25	-18.0	16	4.1	220	10.1	12	720	NS	NS	NS
	2/15	ND	20.9	0	NA	16.1	3.15	NA	NS	NS	NS
	2/22	-28.0	20.9	0	6	NS	NS	NS	NS	NS	NS
	3/2	-20.0	20.9	0	90	NS	NS	NS	19	2.8	1900
	3/9	0.0	20.9	0	90	NS	NS	NS	19	2	1200
	3/29	-3.0	20.9	0.1	ND	NS	NS	NS	18	2.2	1300
	4/4	-2.0	20.9	0.1	130	NS	NS	NS	18.1	2.1	1100
	5/3	-5.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/17	2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/22	18.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/31	16.6	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/7	20.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/28	28.9	NS	NS	NS	2.3	13.2	3800	12.6	10.1	240
	7/5	25.5	NS	NS	NS	5.9	13.8	2300	12.5	12.2	270
	7/11	15.5	NS	NS	NS	3.4	15.8	2900	13.0	12.7	240
	8/22	ND	NS	NS	NS	19.3	0.75	NA	19.3	0.95	NA
	8/26	18.3	NS	NS	NS	20	0.65	NA	20	0.9	NA
	8/30	19.7	NS	NS	NS	20	0.75	NA	20	0.85	NA
	9/2	16.7	NS	NS	NS	20	0.85	580	20.2	0.82	280
	10/3	ND	NS	NS	NS	6.5	5.5	164	17	2	77
	10/7	2.2	NS	NS	NS	18.5	3.8	2300	19.3	2.5	2100
	10/14	-2.8	NS	NS	NS	20	3	2000	20	3	1900
	10/22	-8.3	NS	NS	NS	NS	NS	NS	19.8	1.5	1400
	10/28	-2.8	NS	NS	NS	NS	NS	NS	19.8	1.2	2100
	11/21	-8.9	NS	NS	NS	NS	NS	NS	19.5	1.8	1300
	11/29	-8.6	NS	NS	NS	NS	NS	NS	19.8	2	1000
	12/5	-20.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/19	-13.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/23	-36.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
1993	1/30	-25.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/6	-19.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/10	-22.8	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table L4. Eielson AFB Weekly Soil Gas Data: Control Plot (Continued)

Year	Date	Temp (°C)	C4A			C4B			C4C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	2/20	-12.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/8	-7.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/12	-7.8	NS	NS	NS	20	1	980	NS	NS	NS
	3/20	-6.2	NS	NS	NS	14.3	2.8	1000	NS	NS	NS
	4/7	3.3	NS	NS	NS	18	3.8	1100	NS	NS	NS
	4/10	7.2	NS	NS	NS	18.8	3	1600	NS	NS	NS
	4/20	7.8	NS	NS	NS	15	3.2	2200	NS	NS	NS
	5/6	12.8	NS	NS	NS	20.3	0.9	170	17	1.3	1100
	6/6	13.3	NS	NS	NS	NS	0.2	1300	NS	0.9	1900
	6/22	18.3	NS	NS	NS	20.7	0.6	1100	20	1.7	1300
	6/27	20.0	NS	NS	NS	20.9	0.8	1000	19.8	2.2	1200
	7/3	16.9	NS	NS	NS	20.2	1.1	1000	19	2.8	1000
	7/22	ND	NS	NS	NS	20	1	1000	18.5	2.8	800
	8/22	8.4	NS	NS	NS	6.3	6.8	220	13.8	4.8	220
	8/29	12.2	NS	NS	NS	5.3	7.5	300	12.2	6	360
	9/30	3.8	NS	NS	NS	20.7	0.5	160	20.3	0.8	150
	10/7	12.2	NS	NS	NS	20.5	0.7	150	20.5	1	140
	10/11	12.2	NS	NS	NS	20.5	0.5	150	20.5	0.8	140
	10/14	12.2	NS	NS	NS	20.7	0.2	110	20.5	0.5	92
	12/21	12.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
1994	1/26	-14.6	NS	NS	NS	NS	NS	NS	12.8	3.7	300
	2/6	-16.0	NS	NS	NS	NS	NS	NS	8.7	4.5	230
	2/13	-29.8	NS	NS	NS	NS	NS	NS	10.5	4	360
	3/10	-10.5	NS	NS	NS	NS	NS	NS	16.8	2.4	360
	3/17	-18.6	NS	NS	NS	NS	NS	NS	17.8	2.2	350
	3/24	6.8	20.9	0.05	130	20.7	0.05	170	20.2	0.5	210
	4/9	-4.9	NS	NS	NS	NS	NS	NS	18.7	1.8	350
	4/16	-12.4	NS	NS	NS	NS	NS	NS	19	1.7	270
	5/3	10.5	NS	NS	NS	17	0.8	190	19.2	0.2	83
	5/8	13.5	NS	NS	NS	NS	NS	NS	17	0.5	170
	6/6	16.7	NS	NS	NS	4	6.2	150	20.3	0.7	46
	6/23	18.3	NS	NS	NS	1	9.2	210	8.2	8.4	180
	7/2	17.7	NS	NS	NS	0	10.7	210	8	9.7	190

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L4. Eielson AFB Weekly Soil Gas Data: Control Plot (Continued)

Year	Date	Temp (°C)	C5A			C5B			C5C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/17	ND	0.5	9.5	25600	20.5	0.0	500	6.0	15.0	200
	9/28	ND	20.5	0.3	750	13.5	6.9	4000	5.0	2900.0	0
	10/20	-1.1	21.3	0.5	280	16.0	4.6	2400	17.5	3.8	2000
	10/26	2.7	21.0	0.4	200	16.0	3.6	1200	16.5	3.2	1600
	11/2	-1.3	20.6	0.2	400	21.0	0.0	440	12.2	4.7	1900
	11/23	-19.0	20.8	0.2	1000	2.5	13.0	1600	5.9	10.9	1600
	11/30	-16.0	20.4	0.5	3600	20.5	1.6	1900	15.5	3.0	1000
	12/24	-19.4	20.9	0.0	40	6.0	12.2	3700	11.0	8.9	2800
	12/29	-23.3	20.9	0.0	0	18.1	2.2	1000	13.4	9.0	2600
1992	1/5	-23.3	20.8	0.2	220	9.1	11.8	4200	12.1	9.1	3300
	1/11	-22.0	20.9	0.1	220	13.9	10	3600	14	9.6	3800
	1/18	-6.0	20.6	0.1	50	11.9	9.5	3400	12.4	9	3200
	1/25	-18.0	NS	NS	NS	11.5	10	3200	14	8	2600
	2/15	ND	NS	NS	NS	NS	NS	NS	14.4	8.2	NA
	2/22	-28.0	NS	NS	NS	12.6	8.6	3200	16.5	5.9	2400
	3/2	-20.0	NS	NS	NS	NS	NS	NS	17.1	3.6	3000
	3/9	0.0	NS	NS	NS	14.2	9.3	3600	16.5	7.2	4300
	3/29	-3.0	NS	NS	NS	15.2	6.9	4000	17.5	4.7	2500
	4/4	-2.0	NS	NS	NS	14.8	4.1	4100	17.1	2.7	2800
	5/3	-5.0	NS	NS	NS	NS	NS	NS	20.2	1.1	7100
	5/17	2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/22	18.8	NS	NS	NS	15.9	6.2	3400	16.5	5.8	3000
	5/31	16.6	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/7	20.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/28	28.9	NS	NS	NS	NS	NS	NS	7.0	12.8	400
	7/5	25.5	NS	NS	NS	NS	NS	NS	7.1	15.3	350
	7/11	15.5	NS	NS	NS	NS	NS	NS	8.0	15.8	220
	8/22	ND	NS	NS	NS	17	4	NS	18.3	2.35	NA
	8/26	18.3	NS	NS	NS	18	3.4	NS	19	2.1	NA
	8/30	19.7	NS	NS	NS	18	3.1	NS	19	1.8	NA
	9/2	16.7	NS	NS	NS	18.2	3	620	19.5	1.7	1000
	10/3	ND	NS	NS	NS	9	5.5	280	15	3.5	160
	10/7	2.2	NS	NS	NS	17.8	5.5	1800	18	4.6	2500
	10/14	-2.8	NS	NS	NS	18.2	6.3	1500	19	5	2400
	10/22	-8.3	NS	NS	NS	17	3.6	1000	17.5	2.2	3200
	10/28	-2.8	NS	NS	NS	17.5	3.2	1700	17.8	3	4000
	11/21	-8.9	NS	NS	NS	18.2	3.3	1000	18.3	3.3	2500
	11/29	-8.6	NS	NS	NS	18	3.5	1200	18.8	3	1900
	12/5	-20.0	NS	NS	NS	18.5	3.2	1000	19	2.8	1500
	12/19	-13.3	NS	NS	NS	18	2.6	1100	NO	SAMPLE	
	12/23	-36.0	NS	NS	NS	17.2	2.8	960	NO	SAMPLE	
1993	1/30	-25.0	NS	NS	NS	17.5	3.5	1400	NO	SAMPLE	
	2/6	-19.4	NS	NS	NS	16.2	4.2	1500	NO	SAMPLE	
	2/10	-22.8	NS	NS	NS	16.8	4	1400	NO	SAMPLE	

Table L4. Eielson AFB Weekly Soil Gas Data: Control Plot (Continued)

Year	Date	Temp (°C)	C5A			C5B			C5C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	2/20	-12.8	NS	NS	NS	17	3.5	1500	NS	NS	NS
	3/8	-7.2	NS	NS	NS	17	4.2	1000	NS	NS	NS
	3/12	-7.8	NS	NS	NS	17.8	4.2	1000	NS	NS	NS
	3/20	-6.2	NS	NS	NS	17	4.2	1100	NS	NS	NS
	4/7	3.3	20.7	0.05	100	18.5	3.5	1400	NS	NS	NS
	4/10	7.2	20.2	0.4	1100	19	3	1600	NS	NS	NS
	4/20	7.8	20	0.7	1300	17	3.2	1600	NS	NS	NS
	5/6	12.8	NS	NS	NS	NS	NS	NS	18.5	1.2	2300
	6/6	13.3	NS	NS	NS	NA	0.6	1500	NA	1.7	1000
	6/22	18.3	NS	NS	NS	20.2	1.3	1200	19.3	2.5	850
	6/27	20.0	NS	NS	NS	20.2	1.5	1000	19.2	2.8	540
	7/3	16.9	NS	NS	NS	19.5	2.2	1000	18.7	3.8	340
	7/22	ND	19.2	1.8	1400	19	2.3	960	18.5	3.2	290
	8/22	8.4	0	9.3	1360	11.7	7	140	13.3	5.8	120
	8/29	12.2	1.7	8.8	1060	8.2	7.8	360	11	7	380
	9/30	3.8	20.9	0.1	150	20.3	1	170	20.2	1.2	220
	10/7	12.2	20.8	0.2	110	20.5	0.8	140	20.3	1.2	190
	10/11	12.2	20.7	0.2	130	20.5	0.8	150	20.2	1	190
	10/14	12.2	20.9	0.05	97	20.5	0.4	120	20.3	0.7	140
	12/21	12.2	NS	NS	NS	NS	NS	NS	17.5	1.6	160
1994	1/26	-14.6	19.3	1	190	19.3	1.8	270	20.3	0.7	140
	2/6	-16.0	10.5	2.2	300	19.8	1.7	300	NS	NS	NS
	2/13	-29.8	13.2	4.2	390	20	0.8	250	NS	NS	NS
	3/10	-10.5	9.8	3.8	300	19.8	8	300	19.6	0.8	200
	3/17	-18.6	11.3	3.3	410	19.5	0.8	250	19.5	0.8	180
	3/24	6.8	18.2	1.2	240	20.7	0.1	160	20.2	0.2	150
	4/9	-4.9	NS	NS	NS	NS	NS	NS	20.8	0.6	150
	4/16	-12.4	NS	NS	NS	NS	NS	NS	20.8	0.1	77
	5/3	10.5	NS	NS	NS	NS	NS	NS	15	1.2	170
	5/8	13.5	NS	NS	NS	NS	NS	NS	15.4	1	190
	6/6	16.7	NS	NS	NS	9.7	5.2	130	20	1.2	72
	6/23	18.3	15.2	4.8	290	11.5	6	250	12.7	6.4	230
	7/2	17.7	7	8	210	7	8.8	190	13.5	7.4	230

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L4. Eielson AFB Weekly Soil Gas Data: Control Plot (Continued)

Year	Date	Temp (°C)	C6A			C6B			C6C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/17	ND	0.5	9.5	25600	10.0	10.0	240	15.0	6.0	200
	9/28	ND	19.5	0.6	6200	16.5	4.0	7200	16.9	4.8	5700
	10/20	-1.1	20.9	1.2	NA	16.9	NA	4000	16.0	3.8	4000
	10/26	2.7	21.0	0.6	4400	16.0	3.4	3600	15.5	3.5	3800
	11/2	-1.3	20.5	0.3	5400	11.0	4.8	3700	15.2	3.0	4300
	11/23	-19.0	20.1	0.6	4300	4.0	11.9	2200	4.1	11.9	2100
	11/30	-16.0	20.0	0.4	4400	3.6	11.5	3200	8.9	10.9	720
	12/24	-19.4	20.3	0.4	2400	7.4	10.6	4700	20.9	0.0	20
	12/29	-23.3	20.9	0.1	480	18.7	1.9	1400	18.6	2.0	1300
1992	1/5	-23.3	20.5	0.3	1600	9.4	10.9	4700	9.9	10.8	4900
	1/11	-22.0	20.5	0.35	2800	12.5	10	5600	14.1	8.8	5600
	1/18	-6.0	NS	NS	NS	7	11.9	5000	10	10.1	4700
	1/25	-18.0	20.5	0.2	1400	11	10.5	NA	11	9.5	3900
	2/15	ND	20.4	0.39	NA	11.4	9.8	NA	13	8.9	NA
	2/22	-28.0	20.4	0.3	1100	12.1	9	4900	11.8	9.1	4400
	3/2	-20.0	20.8	0.32	1700	14.1	8.1	6700	13.9	8.5	5500
	3/9	0.0	20.6	0.29	1200	9.2	13.8	6800	11.6	11.9	4800
	3/29	-3.0	20.5	0.4	1100	9.2	8.8	5700	13	8.5	5300
	4/4	-2.0	20.5	0.35	1100	11.5	5	5600	13.2	4.85	5400
	5/3	-5.0	20.9	0.1	3400	20	1.6	8700	20	1.7	9400
	5/17	2.2	NS	NS	NS	16.9	6	3800	16.8	6.1	3700
	5/22	18.8	NS	NS	NS	NS	NS	NS	16.4	5.9	3100
	5/31	16.6	NS	NS	NS	17.8	3	1300	19	1.8	800
	6/7	20.0	NS	NS	NS	11.7	8	2100	10.4	7.5	1900
	6/28	28.9	NS	NS	NS	1.1	13.1	2100	4.5	14.1	600
	7/5	25.5	NS	NS	NS	2.0	16.1	3800	6.9	15.8	400
	7/11	15.5	NS	NS	NS	4.2	16.6	1400	9.4	14.8	290
	8/22	ND	20	0.1	NA	19.5	0.4	NA	18.5	1.85	NA
	8/26	18.3	20.5	0.25	NA	20.3	0.4	NA	19	1.5	NA
	8/30	19.7	20.5	0.3	NA	20.2	0.4	NA	19.2	1.3	NA
	9/2	16.7	20.6	0.26	1400	20.5	0.45	2000	19.5	1.3	2500
	10/3	ND	1	5	860	14.5	4	760	14.2	3.5	660
	10/7	2.2	20.5	1.5	1200	19.8	3.5	5200	18.8	4.3	3600
	10/14	-2.8	20.7	2	1300	20.5	2.6	2800	19.5	4	3200
	10/22	-8.3	20.8	0.7	1300	19	2	1900	18	2.5	2400
	10/28	-2.8	20.5	0.5	1600	18.8	2	2400	17.5	3	3800
	11/21	-8.9	20	0.7	1500	17.5	3.8	4000	17.5	4	4100
	11/29	-8.6	20.2	0.6	1500	19.2	1.9	2000	19	2.6	2100
	12/5	-20.0	20.5	0.6	1100	20	1.2	2000	19.5	1.9	2500
	12/19	-13.3	20.2	0.8	1300	19.5	1.3	1200	19.5	1.5	1600
	12/23	-36.0	20.2	0.8	1300	19.2	1.5	1000	19.2	1.5	1100
1993	1/30	-25.0	20	1.5	2900	20.5	0.5	1700	NS	NS	NS
	2/6	-19.4	20.5	0.5	1700	19.8	1.6	3700	NS	NS	NS
	2/10	-22.8	20.5	0.3	1700	19.8	1.3	3100	NS	NS	NS

Table L4. Eielson AFB Weekly Soil Gas Data: Control Plot (Continued)

Year	Date	Temp (°C)	C6A			C6B			C6C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	2/20	-12.8	20	0.5	1700	19.5	1.2	2300	NS	NS	NS
	3/8	-7.2	20.5	0.2	1500	19.8	1.2	3100	NS	NS	NS
	3/12	-7.8	20.5	0.1	1500	20	0.9	3000	20	0.9	9000
	3/20	-6.2	20.5	0.2	1600	20	1	3400	19.8	1	7500
	4/7	3.3	20.5	0.1	1400	20.9	0.05	3700	NS	NS	NS
	4/10	7.2	20.5	0.1	1400	20.5	0.3	3800	NS	NS	NS
	4/20	7.8	20.3	0.6	1700	18.5	1.4	4200	NS	NS	NS
	5/6	12.8	20.5	0.3	2900	20.5	0.3	2800	20.3	0.5	1700
	6/6	13.3	NA	0.6	1000	NA	0.3	520	NA	0.5	530
	6/22	18.3	20.5	0.7	1700	20.6	0.8	540	19.8	1.6	440
	6/27	20.0	20.2	1.5	2100	20.7	1	490	20.2	1.3	320
	7/3	16.9	19.7	2	2100	20	1.6	610	19.2	2.7	310
	7/22	ND	20	0.8	1400	19.8	1.3	780	19.2	2.2	340
	8/22	8.4	0	9.5	940	12.8	6.8	130	13.7	6	110
	8/29	12.2	0	9.5	840	9.5	7.5	300	11	7	190
	9/30	3.8	20.7	0.5	160	20.5	0.7	530	20.2	0.8	840
	10/7	12.2	20.7	0.2	120	20.5	0.4	440	20.5	0.5	760
	10/11	12.2	20.3	0.5	150	20.5	0.5	360	20.3	0.7	560
	10/14	12.2	20.5	0.3	100	20.3	0.4	240	20.2	0.7	410
	12/21	12.2	NS	NS	NS	16	3	240	16.8	2.7	240
1994	1/26	-14.6	NS	NS	NS	18	3.2	290	18.2	2.8	280
	2/6	-16.0	NS	NS	NS	15.8	3.8	290	16	3.5	290
	2/13	-29.8	NS	NS	NS	15	3.8	330	15.8	3.2	320
	3/10	-10.5	20.6	0.05	140	9	5.7	290	11.5	4.6	360
	3/17	-18.6	NS	NS	NS	8.6	6.3	330	10.8	5.2	420
	3/24	6.8	20.6	0.1	150	8.8	5.6	310	13.8	3.5	350
	4/9	-4.9	NS	NS	NS	20.9	0.2	110	20.8	0.4	150
	4/16	-12.4	NS	NS	NS	20.9	0.05	51	20.8	0.1	67
	5/3	10.5	16.8	1.7	420	12	2.4	480	NS	NS	NS
	5/8	13.5	NS	NS	NS	10.5	2	410	20.2	0.05	120
	6/6	16.7	NS	NS	NS	14.2	3.8	160	20.7	0.4	43
	6/23	18.3	15.2	5	340	15.2	4.8	260	13	6	230
	7/2	17.7	NS	NS	NS	8	9	190	12.7	7.3	210

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L4. Eielson AFB Weekly Soil Gas Data: Control Plot (Continued)

Year	Date	Temp (°C)	C7A			C7B			C7C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/17	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	9/28	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/20	-1.1	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/26	2.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/2	-1.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/23	-19.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/30	-16.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/24	-19.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/29	-23.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
1992	1/5	-23.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/11	-22.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/18	-6.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/25	-18.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/15	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/22	-28.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/2	-20.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/9	0.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/29	-3.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/4	-2.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/3	-5.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/17	2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/22	18.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/31	16.6	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/7	20.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/28	28.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/5	25.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/11	15.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/22	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/26	18.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/30	19.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	9/2	16.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/3	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/7	2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/14	-2.8	20.8	1.5	3500	20.8	13.3	900	20.8	1.3	1200
	10/22	-8.3	20.9	0.3	3000	20.9	0.2	480	20.9	0.2	1000
	10/28	-2.8	NS	NS	NS	20.9	0.05	460	20.9	0.05	1100
	11/21	-8.9	NS	NS	NS	20.5	0.05	360	20.5	0.05	700
	11/29	-8.6	NS	NS	NS	20.9	0.05	230	20.9	0.05	530
	12/5	-20.0	NS	NS	NS	20.9	0.05	110	20.9	0.05	270
	12/19	-13.3	NS	NS	NS	20.9	0.05	150	20.9	0.05	310
	12/23	-36.0	NS	NS	NS	20.9	0.05	56	20.9	0.1	170
1993	1/30	-25.0	NS	NS	NS	20.9	0.05	140	20.9	0.05	210
	2/6	-19.4	NS	NS	NS	20.9	0.05	120	20.9	0.05	240
	2/10	-22.8	NS	NS	NS	20.9	0.05	160	20.9	0.05	210

Table L4. Eielson AFB Weekly Soil Gas Data: Control Plot (Continued)

Year	Date	Temp (°C)	C7A			C7B			C7C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	2/20	-12.8	NS	NS	NS	20.9	0.05	120	20.5	0.05	290
	3/8	-7.2	NS	NS	NS	20.9	0.05	150	20.9	0.05	160
	3/12	-7.8	NS	NS	NS	20.9	0.05	210	20.9	0.05	200
	3/20	-6.2	NS	NS	NS	20.9	0.05	200	20.9	0.05	480
	4/7	3.3	NS	NS	NS	20.5	0.05	190	NS	NS	NS
	4/10	7.2	NS	NS	NS	20.9	0.05	110	NS	NS	NS
	4/20	7.8	NS	NS	NS	19.2	0.05	270	NS	NS	NS
	5/6	12.8	NS	NS	NS	20.6	0.2	170	NS	NS	NS
	6/6	13.3	NA	0.05	100	NA	0.1	64	NA	0.3	78
	6/22	18.3	20.9	0.05	150	20.9	0.05	71	20.7	0.2	92
	6/27	20.0	20.9	0.3	110	20.9	0.4	65	20.9	0.8	82
	7/3	16.9	20.7	0.8	82	20.6	1	52	20	1.8	85
	7/22	ND	20.7	0.05	72	20.5	0.05	31	20	1	46
	8/22	8.4	NS	NS	NS	0.1	7	240	12.5	3.8	100
	8/29	12.2	NS	NS	NS	0	7.2	280	12.8	3.7	150
	9/30	3.8	20.7	0.05	82	20.7	0.1	76	20.5	0.5	100
	10/7	12.2	20.9	0.05	87	20.9	0.05	63	20.7	0.2	91
	10/11	12.2	20.9	0.05	110	20.9	0.05	67	20.7	0.4	110
	10/14	12.2	20.9	0.05	72	20.7	0.05	56	20.7	0.2	75
	12/21	12.2	NS	NS	NS	20.9	0.8	130	19.3	0.7	110
1994	1/26	-14.6	NS	NS	NS	20	0.5	120	20.3	0.6	110
	2/6	-16.0	NS	NS	NS	15.5	0.8	140	20.7	0.5	110
	2/13	-29.8	NS	NS	NS	9.6	0.6	92	20.6	0.2	83
	3/10	-10.5	20.9	0.05	68	0	2	170	20	0.4	140
	3/17	-18.6	NS	NS	NS	0	2.2	200	20	0.5	160
	3/24	6.8	20.9	0.05	93	2.2	2	180	15.8	0.4	170
	4/9	-4.9	NS	NS	NS	20.5	1.1	240	20.6	0.7	180
	4/16	-12.4	NS	NS	NS	20.5	0.9	170	20.5	0.7	150
	5/3	10.5	NS	NS	NS	14.2	2.3	210	14.3	1	150
	5/8	13.5	NS	NS	NS	10.7	2.3	260	15.4	0.7	190
	6/6	16.7	NS	NS	NS	1.8	3.7	120	16.5	1.3	87
	6/23	18.3	NS	NS	NS	3.5	5.2	210	11	3.6	190
	7/2	17.7	NS	NS	NS	4.5	6.5	180	10.5	4.7	190

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L4. Eielson AFB Weekly Soil Gas Data: Control Plot (Continued)

Year	Date	Temp (°C)	C8A			C8B			C8C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	8/17	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	9/28	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/20	-1.1	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/26	2.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/2	-1.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/23	-19.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/30	-16.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/24	-19.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/29	-23.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
1992	1/5	-23.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/11	-22.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/18	-6.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/25	-18.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/15	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/22	-28.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/2	-20.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/9	0.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/29	-3.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/4	-2.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/3	-5.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/17	2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/22	18.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/31	16.6	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/7	20.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/28	28.9	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/5	25.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/11	15.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/22	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/26	18.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/30	19.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	9/2	16.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/3	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/7	2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/14	-2.8	20.8	1.3	2300	20.6	1.5	3500	20.8	1.3	3600
	10/22	-8.3	20.9	0.3	2200	20.9	0.5	3000	20.6	0.6	3200
	10/28	-2.8	20.8	0.05	3800	20.6	0.05	4400	20.3	0.5	4600
	11/21	-8.9	20.5	0.1	2000	20.5	0.1	3000	20	0.8	3500
	11/29	-8.6	20.9	0.1	1600	20.5	1	3400	19.5	1.8	4300
	12/5	-20.0	20.9	0.1	1000	20.9	0.1	1600	20	1.3	2100
	12/19	-13.3	20.9	0.05	850	20.9	0.05	3000	20.5	0.3	3300
	12/23	-36.0	20.9	0.1	690	20.7	0.1	1000	20.5	0.2	1100
1993	1/30	-25.0	NS	NS	NS	20.9	0.05	1000	20.7	0.1	1000
	2/6	-19.4	NS	NS	NS	20.8	0.1	2000	20.8	0.1	2100
	2/10	-22.8	NS	NS	NS	20.9	0.05	1400	20.9	0.05	1500

Table L4. Eielson AFB Weekly Soil Gas Data: Control Plot (Continued)

Year	Date	Temp (°C)	C8A			C8B			C8C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
	2/20	-12.8	NS	NS	NS	20.6	0.05	2300	20.6	0.05	2000
	3/8	-7.2	NS	NS	NS	20.7	0.1	2300	20.5	0.1	1700
	3/12	-7.8	NS	NS	NS	20.9	0.05	2300	20.5	0.1	1600
	3/20	-6.2	NS	NS	NS	20.5	0.1	2300	20.5	0.1	1900
	4/7	3.3	NS	NS	NS	20.7	0.1	3400	20.3	0.4	1500
	4/10	7.2	NS	NS	NS	20.7	0.1	1800	20.5	0.3	1200
	4/20	7.8	NS	NS	NS	20	0.05	1400	19.5	0.3	1000
	5/6	12.8	NS	NS	NS	20.8	0.1	1100	20.9	0.4	1100
	6/6	13.3	NA	0.05	380	NS	NS	NS	NA	0.7	920
	6/22	18.3	20.9	0.05	270	NS	NS	NS	NS	NS	NS
	6/27	20.0	20.9	0.2	190	NS	NS	NS	NS	NS	NS
	7/3	16.9	20.7	0.8	180	NS	NS	NS	NS	NS	NS
	7/22	ND	20.7	0.05	250	NS	NS	NS	NS	NS	NS
	8/22	8.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
	8/29	12.2	NS	NS	NS	NS	NS	NS	NS	NS	NS
	9/30	3.8	20.7	0.05	98	NS	NS	NS	NS	NS	NS
	10/7	12.2	20.7	0.05	97	NS	NS	NS	NS	NS	NS
	10/11	12.2	20.7	0.05	120	NS	NS	NS	NS	NS	NS
	10/14	12.2	20.9	0.05	92	NS	NS	NS	NS	NS	NS
	12/21	12.2	20.9	0.5	130	NS	NS	NS	NS	NS	NS
1994	1/26	-14.6	NS	NS	NS	NS	NS	NS	19.8	1.2	180
	2/6	-16.0	NS	NS	NS	NS	NS	NS	18.2	1.5	210
	2/13	-29.8	NS	NS	NS	NS	NS	NS	18.4	1.1	210
	3/10	-10.5	20.9	0.05	85	10.2	1.2	310	17.8	1.1	230
	3/17	-18.6	NS	NS	NS	6.7	2	240	17.8	2.2	250
	3/24	6.8	20.9	0.05	85	13	1.1	320	18.2	0.8	210
	4/9	-4.9	NS	NS	NS	20.7	0.9	420	19.7	3	350
	4/16	-12.4	NS	NS	NS	NS	NS	NS	19.8	2.7	280
	5/3	10.5	NS	NS	NS	NS	NS	NS	18	1	190
	5/8	13.5	NS	NS	NS	NS	NS	NS	16.7	1	310
	6/6	16.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/23	18.3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/2	17.7	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS: Not Sampled

NA: Not Analyzed

ND: No Data

Table L5. Eielson AFB Weekly Soil Gas Data: Background Area

Year	Date	Temp (°C)	B1A			B2A			B2B			B2C		
			% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC	% O_2	% CO_2	ppm HC
1991	11/27	-12	21	0	410	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/24	-19	21	0	0	NS	NS	NS	NS	NS	NS	NS	NS	NS
1992	1/5	-23	21	0	0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/15	ND	21	0	NA	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/28	29	21	0	13	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/5	26	21	0	31	NS	NS	NS	NS	NS	NS	NS	NS	NS
	7/11	16	21	0	18	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/10	ND	NS	NS	NS	21	0	52	21	0	40	21	0	44
	10/14	-3	21	1	210	21	1	150	21	1	83	NS	NS	NS
	10/22	-8	21	0	200	21	0	180	21	0	92	21	0	84
	10/28	-3	21	0	240	21	0	240	21	0	130	21	0	180
	11/21	-9	20	0	50	21	0	15	21	0	25	21	0	15
	11/29	-9	21	0	110	21	0	110	21	0	98	21	0	90
	12/5	-20	NS	NS	NS	21	0	28	21	0	10	21	0	5
	12/19	-13	NS	NS	NS	21	0	70	21	0	83	21	0	88
	12/23	-36	NS	NS	NS	21	0	0	21	0	0	21	0	0
1993	1/30	-25	NS	NS	NS	21	0	20	21	0	13	21	0	15
	2/6	-19	NS	NS	NS	21	0	110	21	0	85	21	0	83
	2/10	-23	NS	NS	NS	21	0	46	21	0	42	21	0	40
	2/20	-13	NS	NS	NS	21	0	69	21	0	73	21	0	100
	3/8	-7	NS	NS	NS	21	0	64	21	0	56	21	0	69
	3/12	-8	NS	NS	NS	21	0	82	21	0	87	21	0	88
	3/20	-6	NS	NS	NS	21	0	83	21	0	81	21	0	130
	4/7	3	NS	NS	NS	21	0	78	21	0	88	21	0	97
	4/10	7	NS	NS	NS	21	0	54	21	0	59	21	0	64
	4/20	8	NS	NS	NS	NS	NS	NS	21	0	47	21	0	53
	5/6	13	NS	NS	NS	NS	NS	NS	21	0	42	21	0	42
	6/6	13	NS	NS	NS	NS	NS	NS	NA	0	36	21	0	27
	6/22	18	NS	NS	NS	21	0	43	21	0	48	21	0	48
	6/27	20	NS	NS	NS	21	0	54	21	0	36	21	0	37
	7/3	17	NS	NS	NS	20	0	46	20	0	42	21	0	31
	7/22	ND	NS	NS	NS	20	0	29	20	0	23	20	0	26
	8/22	ND	NS	NS	NS	20	0	23	20	0	28	20	1	37
	8/29	12	NS	NS	NS	20	0	48	20	0	46	20	1	63
	9/30	4	NS	NS	NS	20	1	110	20	1	88	20	1	98
	10/7	13	NS	NS	NS	21	0	68	21	0	70	21	0	70
	10/11	3	NS	NS	NS	21	0	54	21	0	70	21	0	73
	10/14	5	NS	NS	NS	21	0	20	21	0	37	21	0	38
	12/21	-11	NS	NS	NS	NS	NS	NS	21	0	68	21	0	76
1994	1/26	-11	NS	NS	NS	NS	NS	NS	21	0	25	21	0	42
	2/6	-16	NS	NS	NS	NS	NS	NS	21	0	35	21	0	42
	2/13	-30	NS	NS	NS	NS	NS	NS	21	0	11	21	0	13
	3/10	-11	NS	NS	NS	NS	NS	NS	21	0	110	21	0	120
	3/17	-19	NS	NS	NS	NS	NS	NS	21	0	43	21	0	45
	3/24	7	NS	NS	NS	21	0	130	21	0	130	21	0	140
	4/9	-5	NS	NS	NS	NS	NS	NS	21	0	120	21	0	120
	4/16	-12	NS	NS	NS	NS	NS	NS	21	0	43	21	0	44
	5/3	11	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NF
	5/8	14	NS	NS	NS	NS	NS	NS	21	0	120	21	0	120
	6/6	17	NS	NS	NS	21	0	38	21	0	42	21	0	39
	6/23	18	NS	NS	NS	21	0	20	21	0	21	21	0	22
	7/2	18	NS	NS	NS	21	0	11	21	0	10	21	0	12

NS: Not Sampled
NA: Not Analyzed
ND: No Data

APPENDIX M

SOIL TEMPERATURE DATA

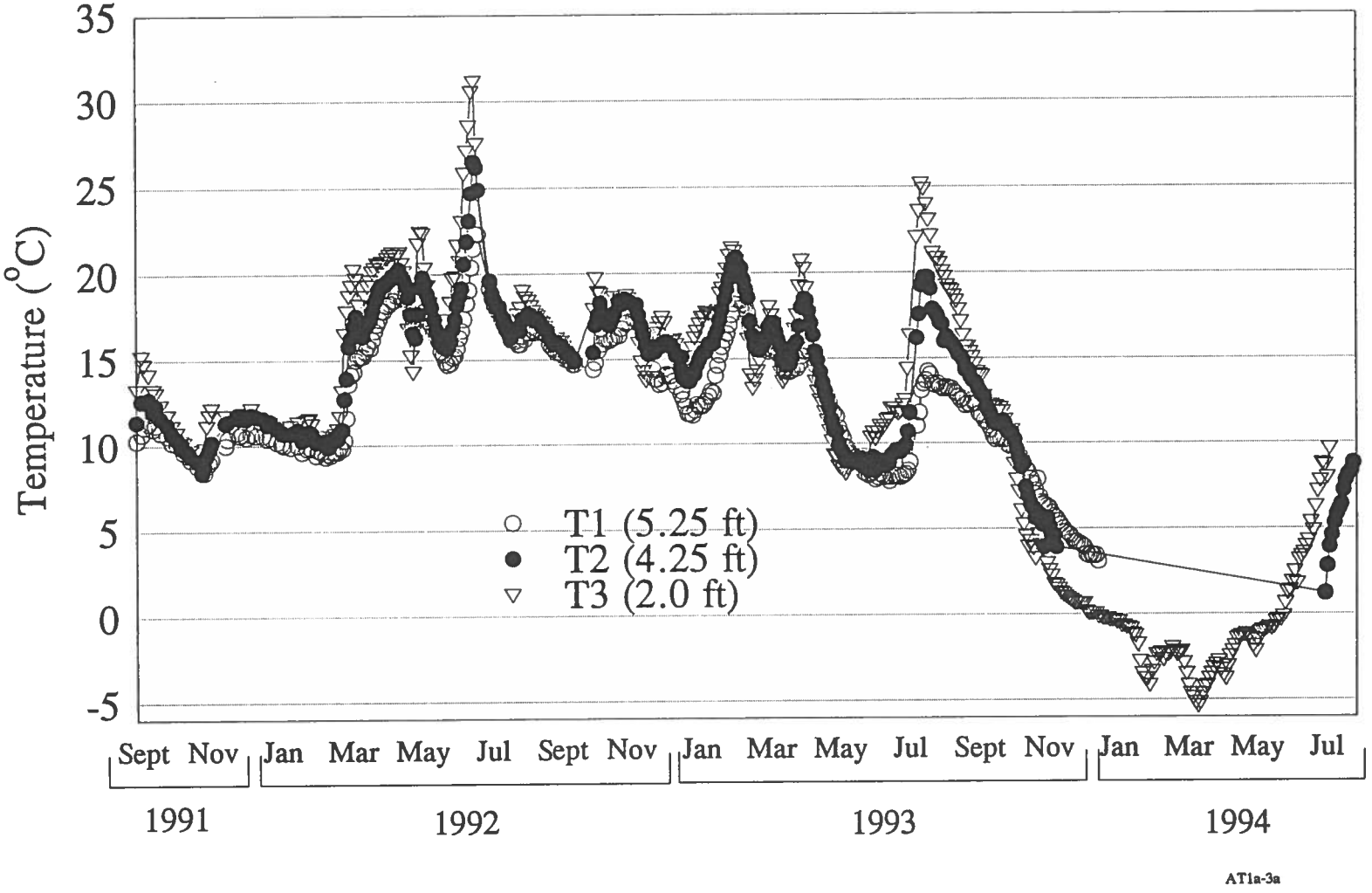


Figure M1. Soil Temperature in Active Warming Test Plot: Thermocouples 1a-3a

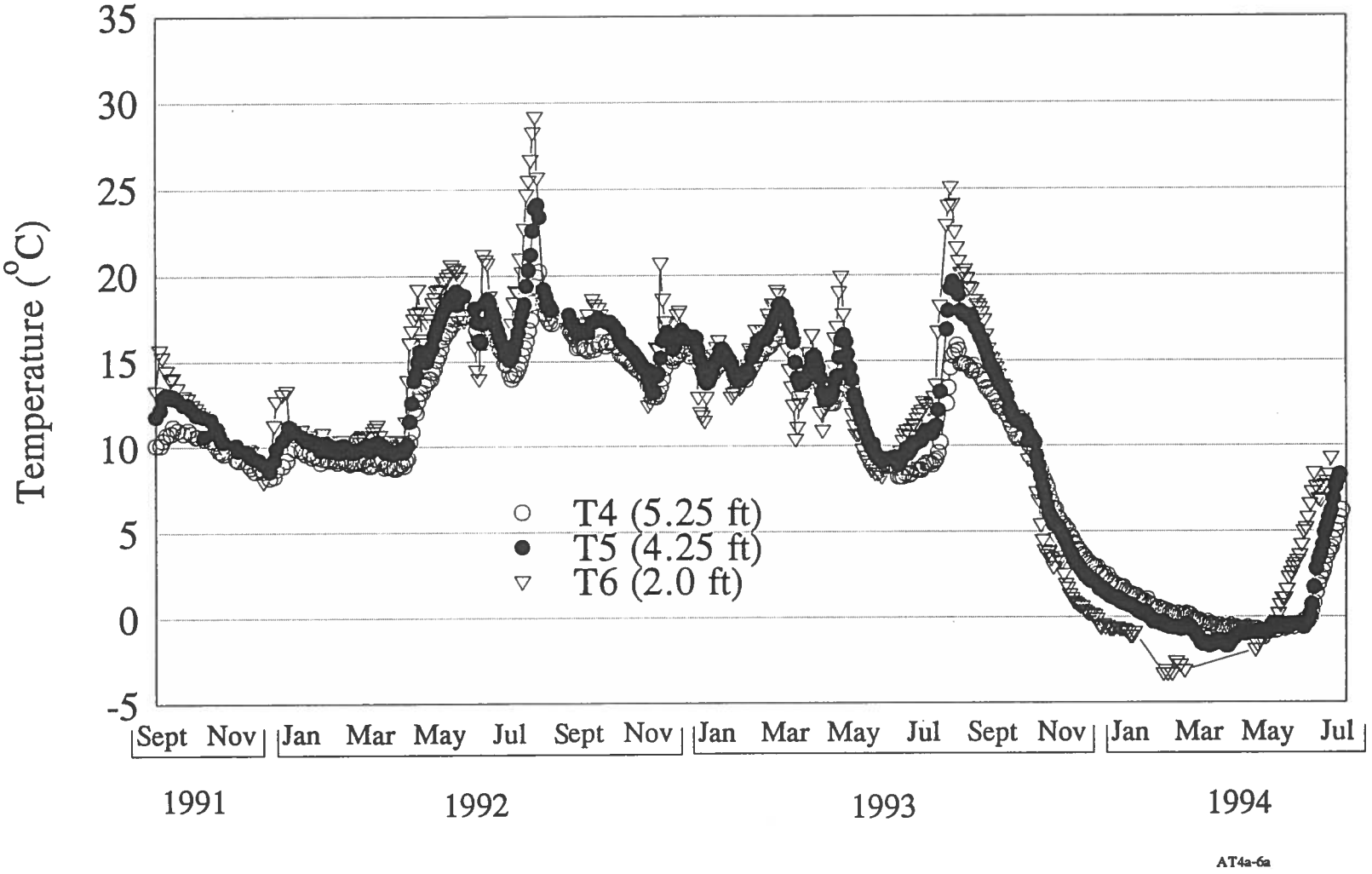


Figure M2. Soil Temperature in Active Warming Test Plot: Thermocouples 4a-6a

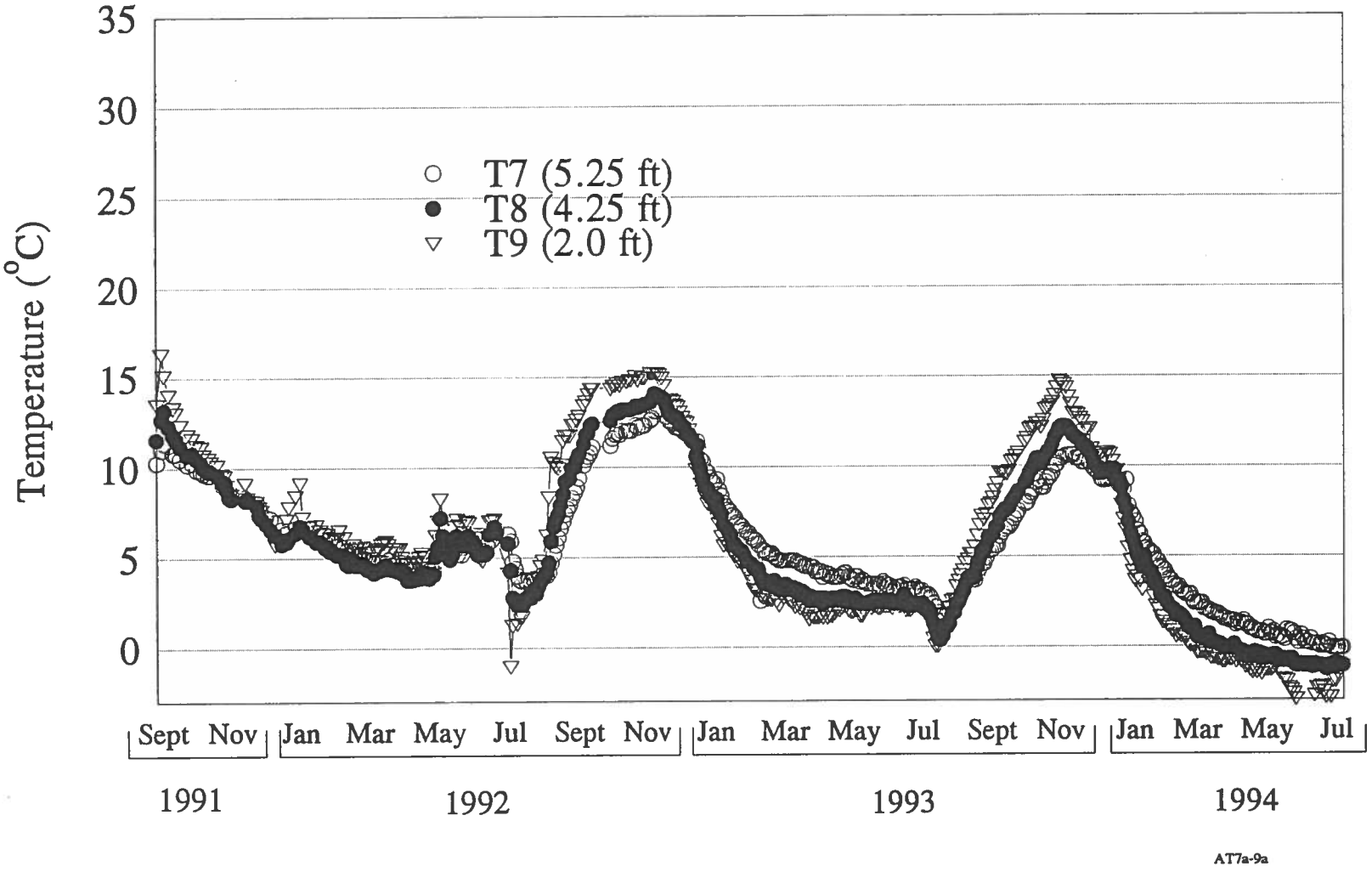


Figure M3. Soil Temperature on Border of Active Warming Test Plot: Thermocouples 7a-9a

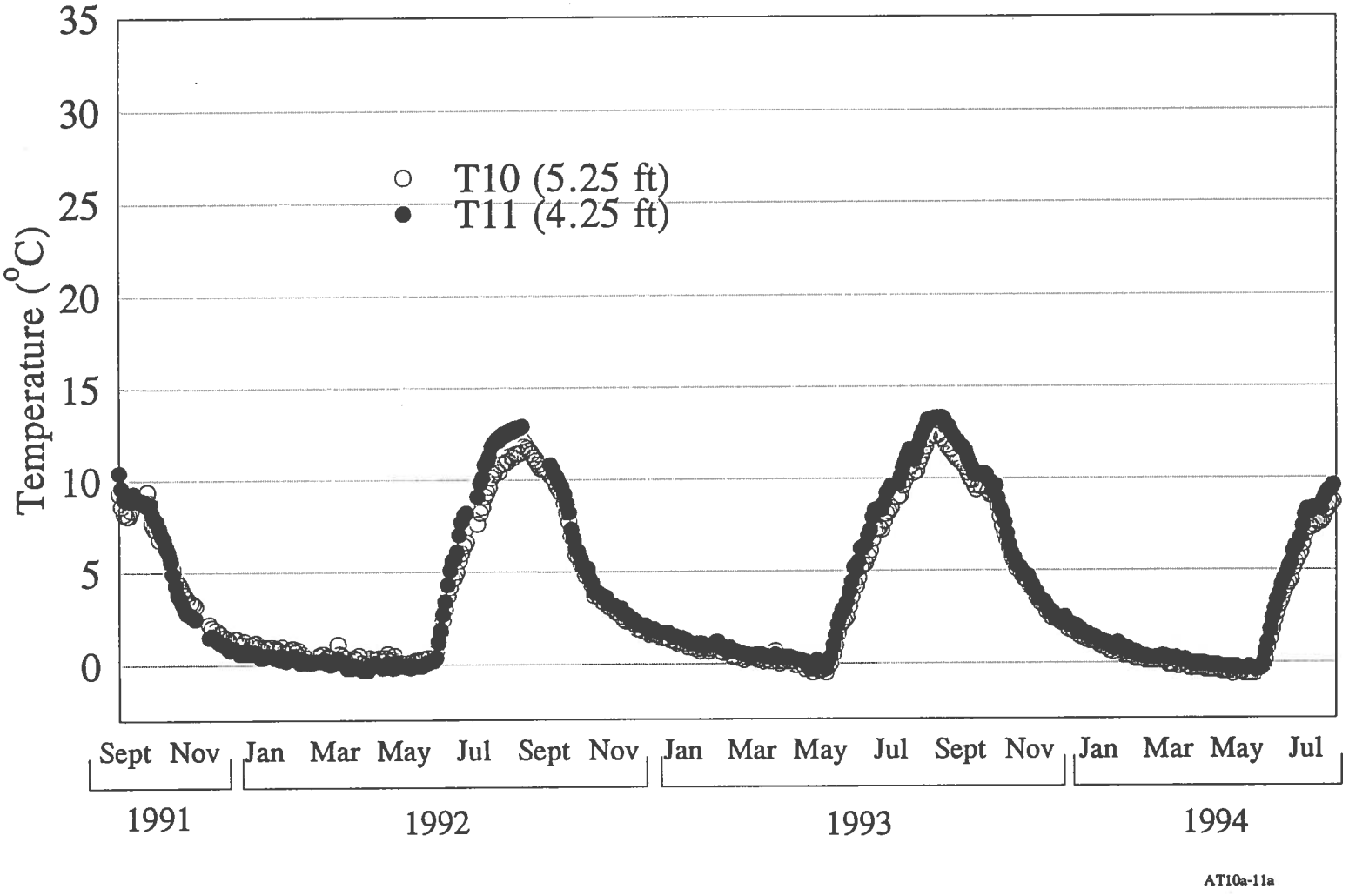


Figure M4. Soil Temperature Ca. 18' From Active Warming Test Plot: Thermocouples 10a and 11a

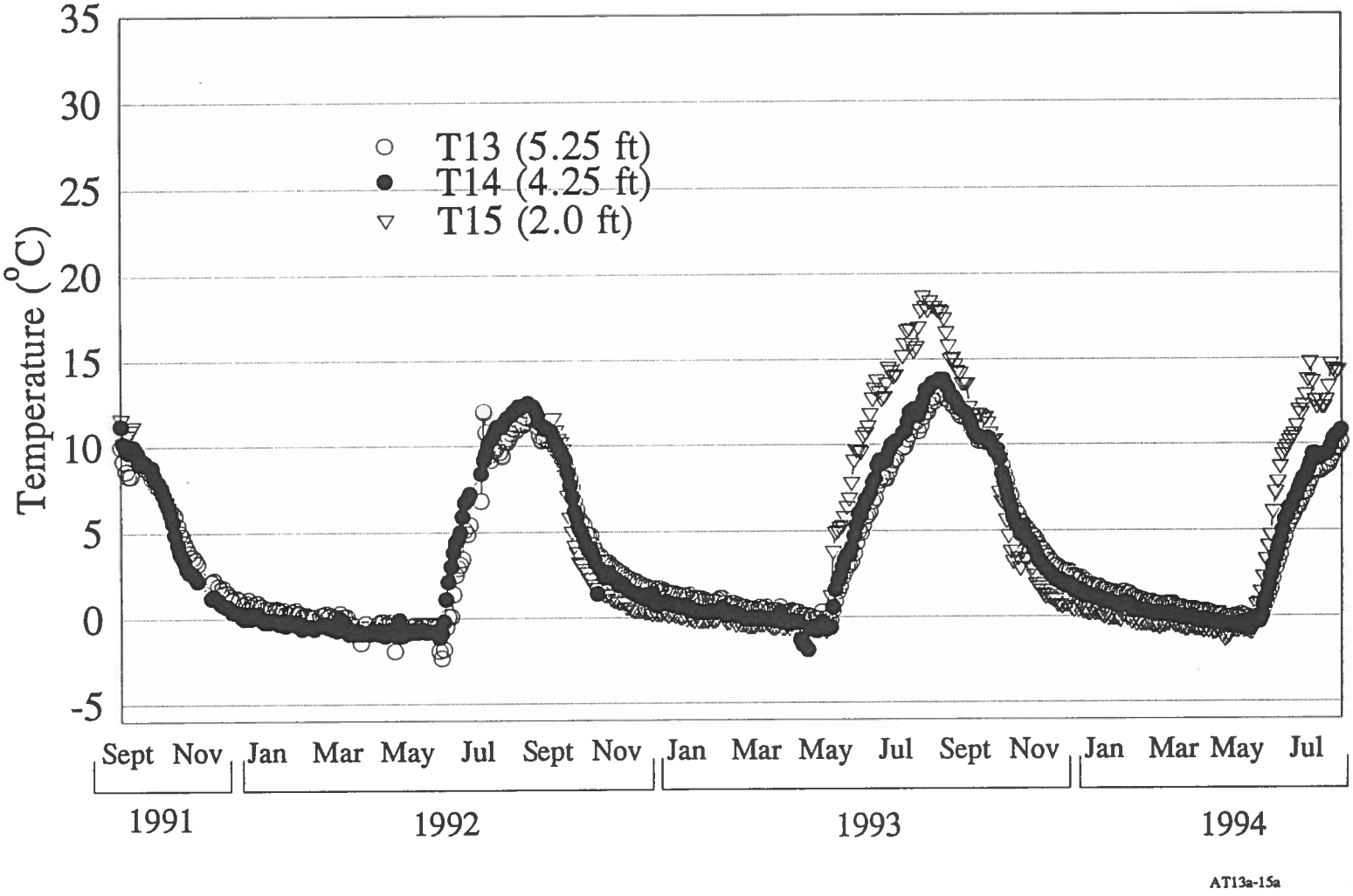


Figure M5. Soil Temperature Ca. 39' From Active Warming Test Plot: Thermocouples 13a-15a

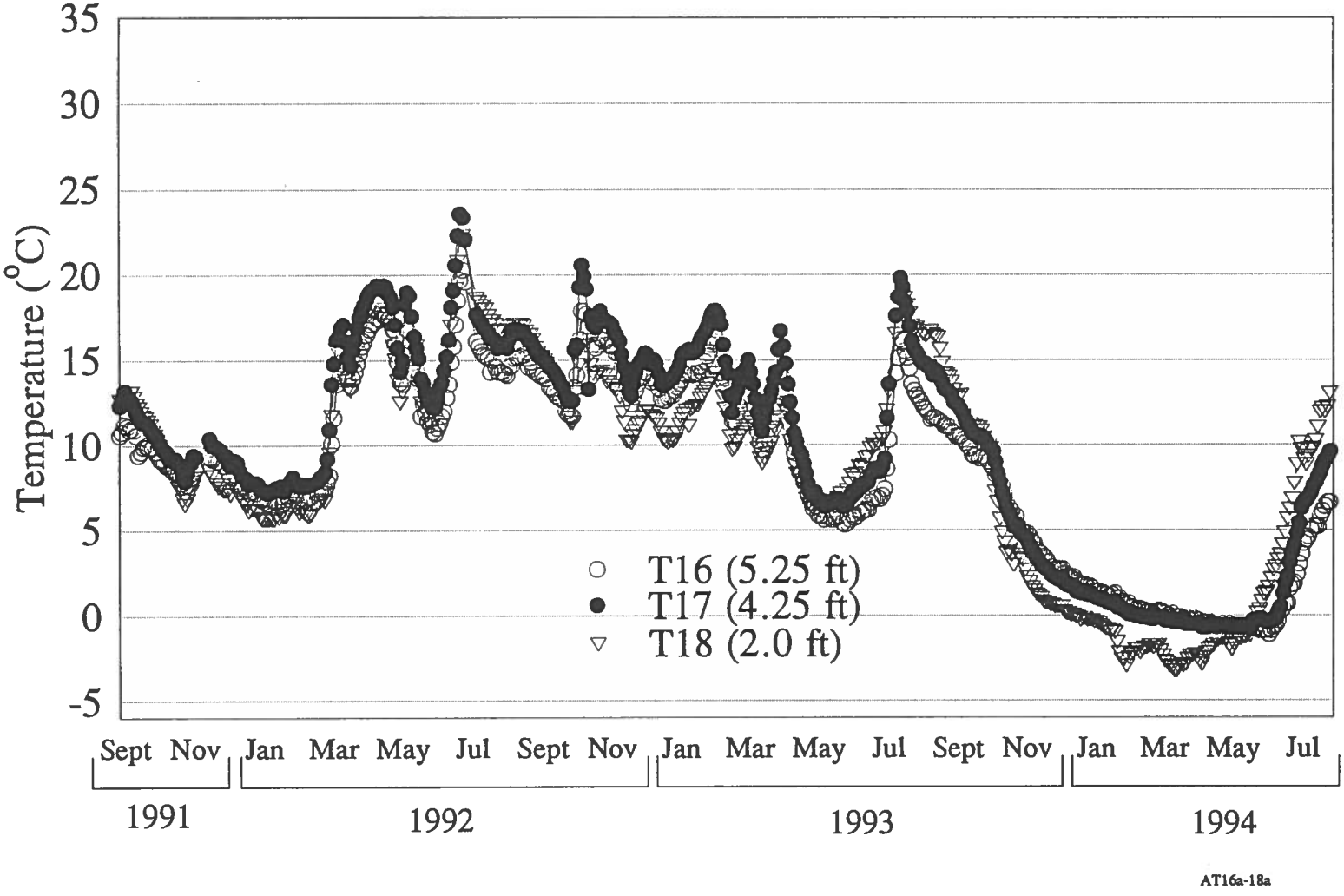


Figure M6. Soil Temperature on Border of Active Warming Test Plot: Thermocouples 16a-18a

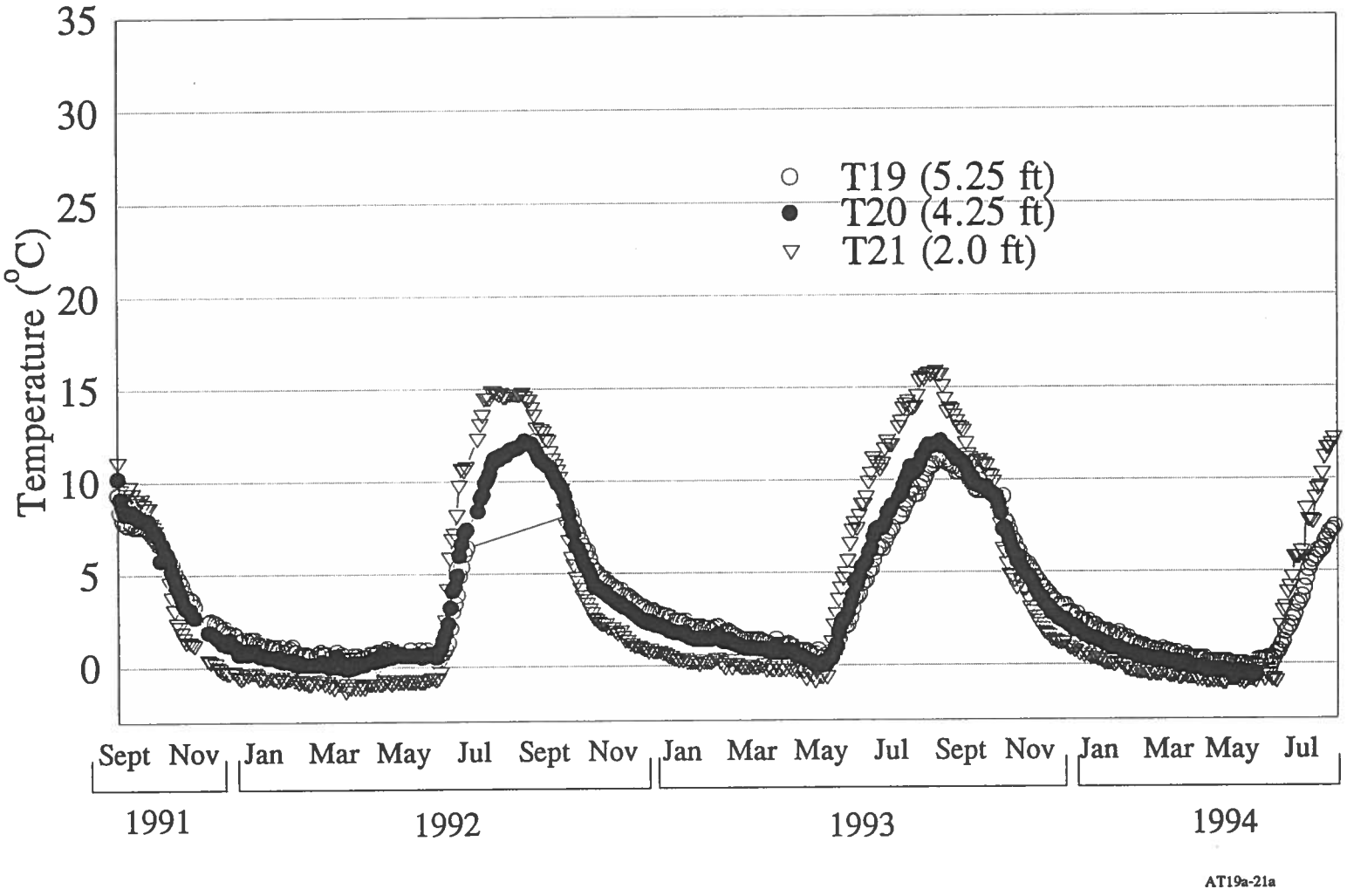


Figure M7. Soil Temperature Ca. 7' From Active Warming Test Plot: Thermocouples 19a-21a

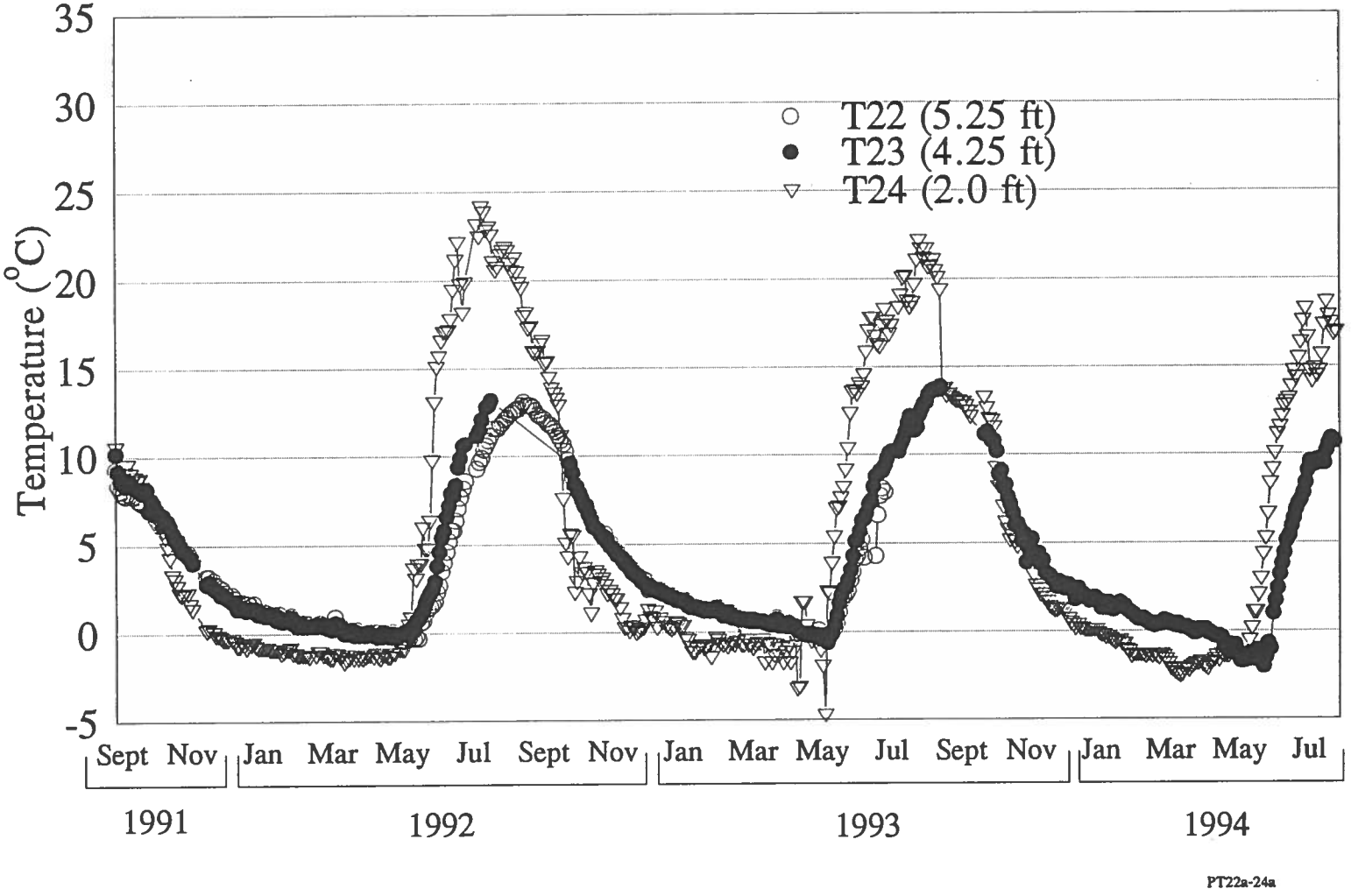


Figure M8. Soil Temperature in Border of Passive Warming Test Plot: Thermocouples 22a-24a

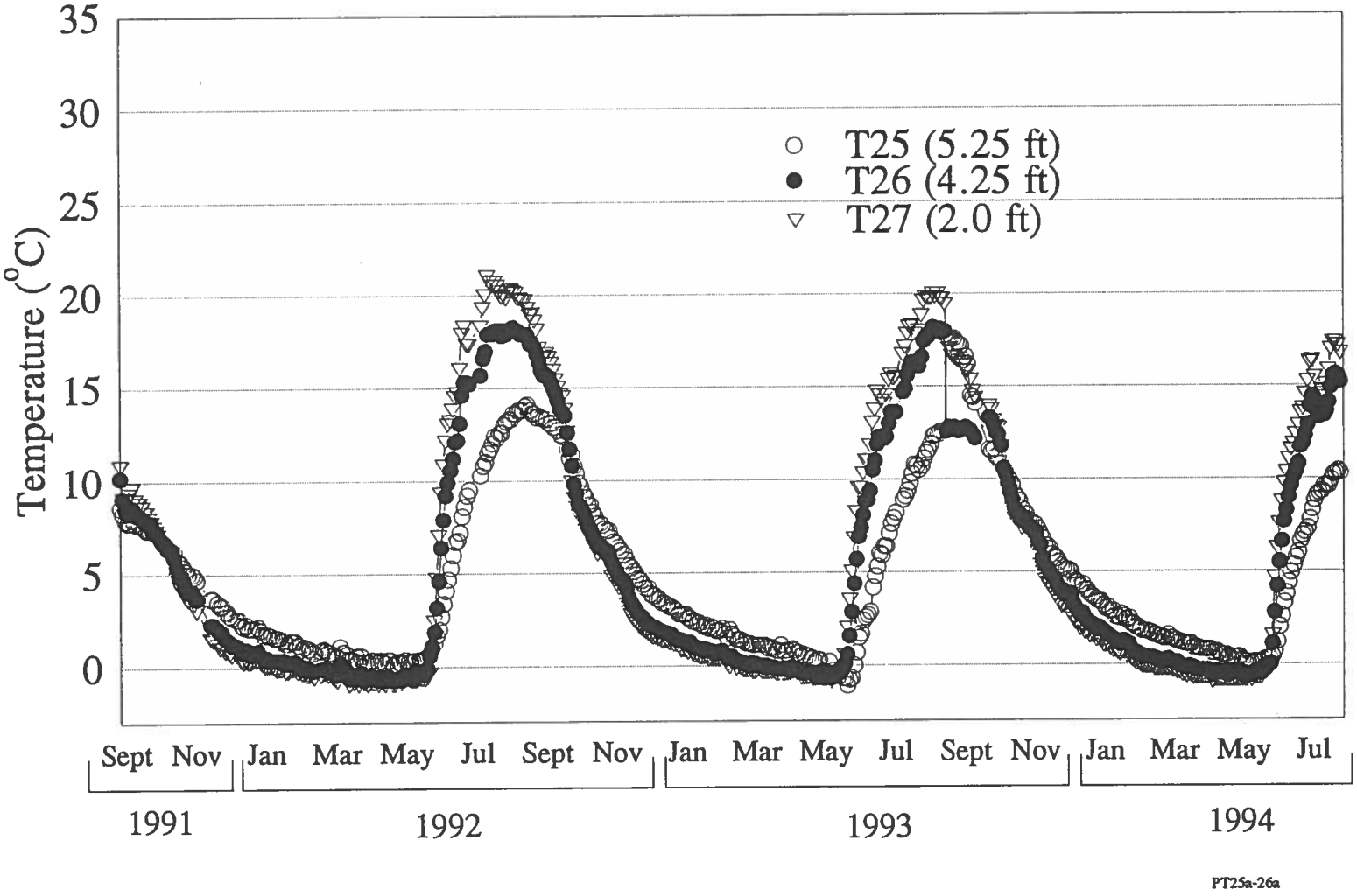


Figure M9. Soil Temperature in Passive Warming Test Plot: Thermocouples 25a-26a

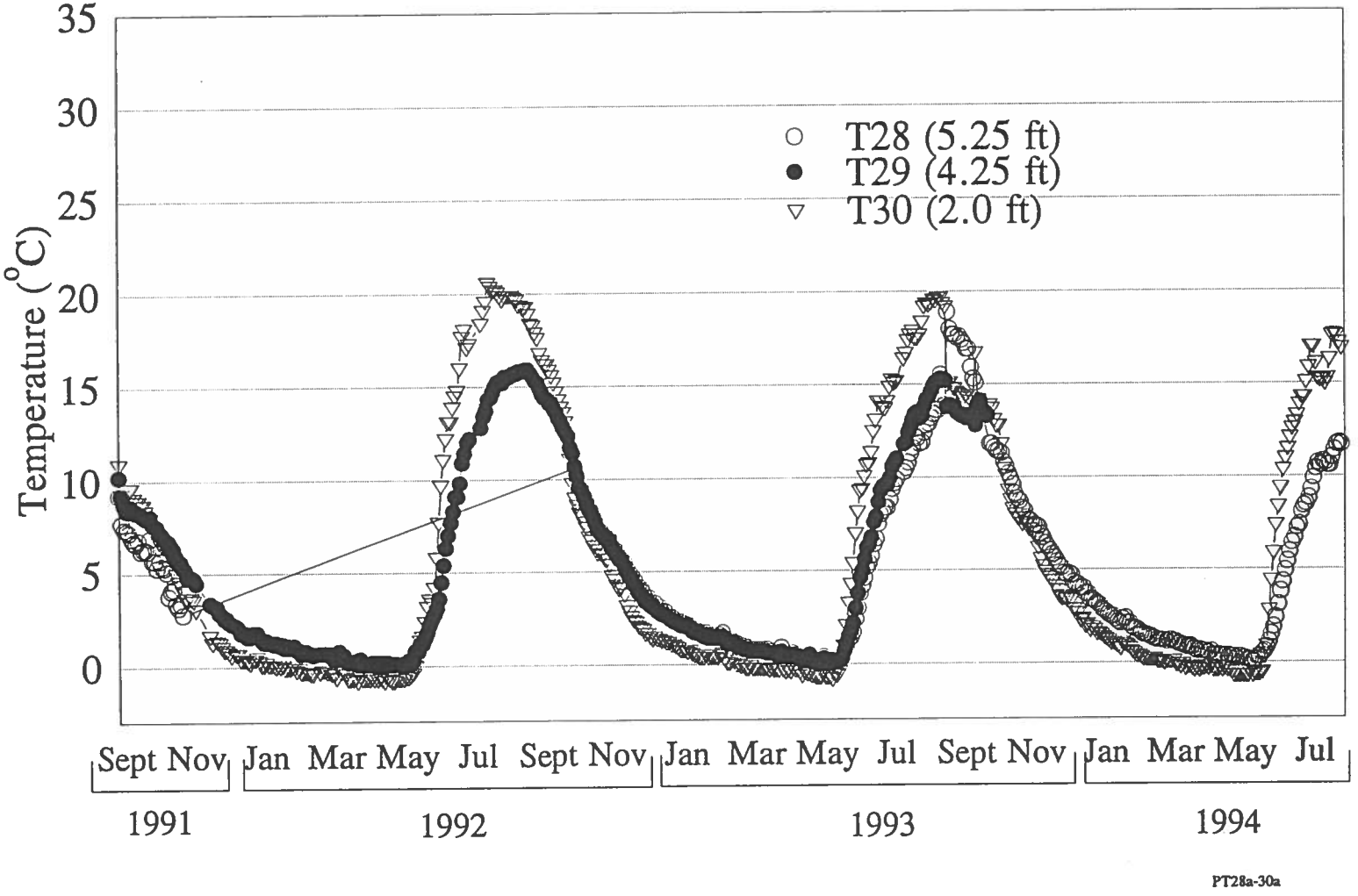


Figure M10. Soil Temperature in Passive Warming Test Plot: Thermocouples 28a-30a

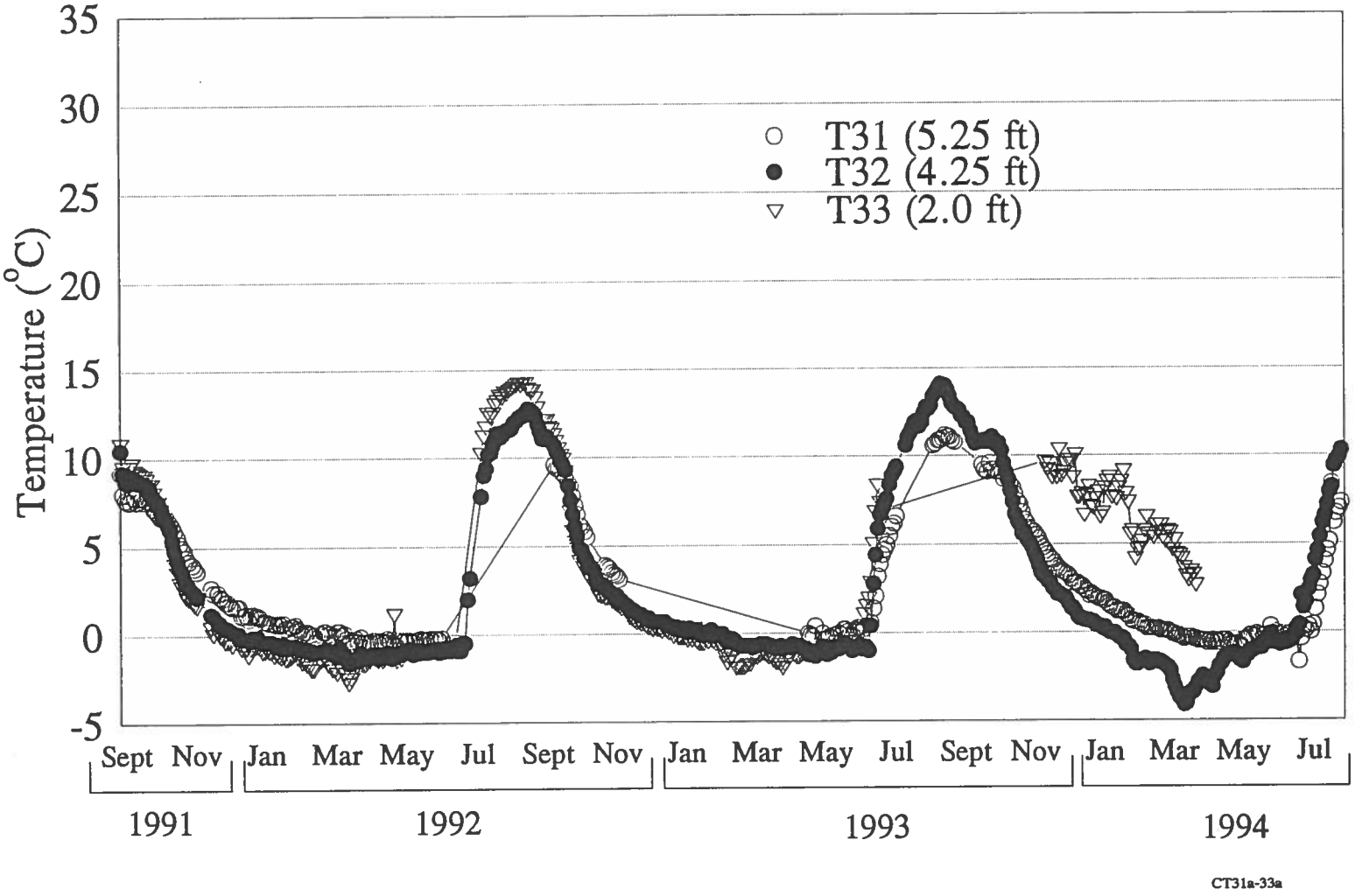


Figure M11. Soil Temperature in Control Test Plot: Thermocouples 31a-33a

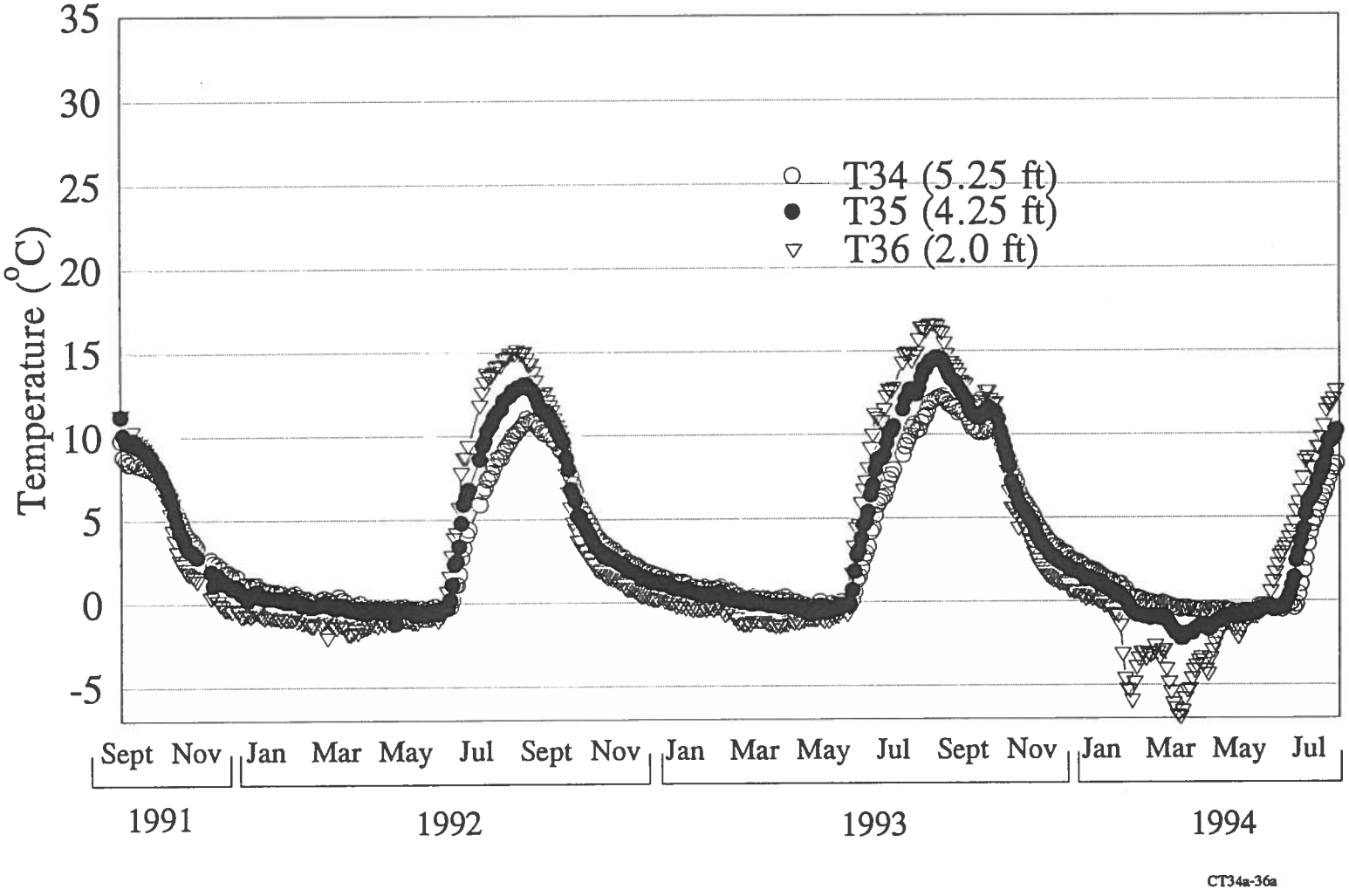


Figure M12. Soil Temperature in Control Test Plot: Thermocouples 34a-36a

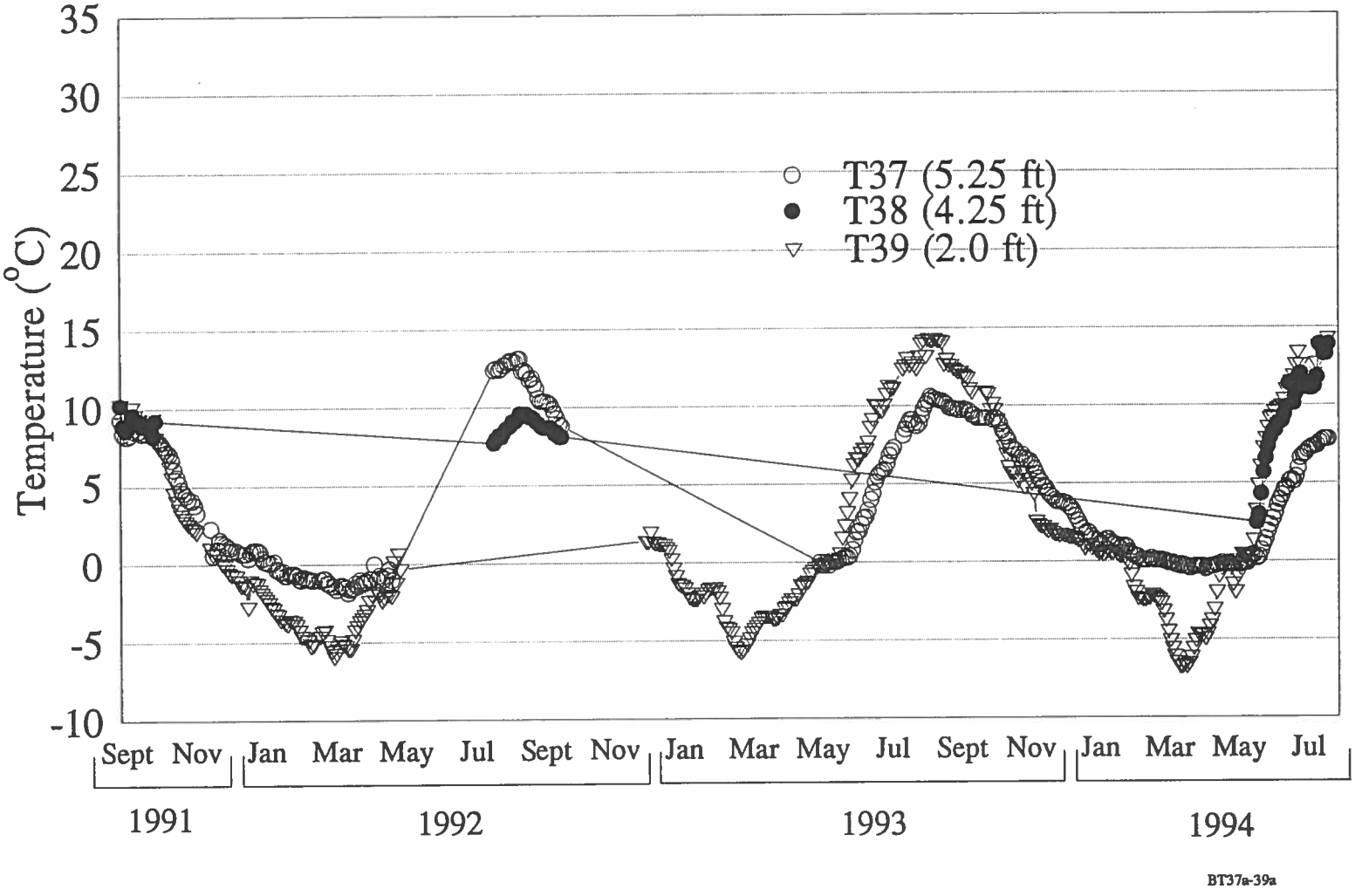


Figure M13. Soil Temperature in Background Area: Thermocouples 37a-39a

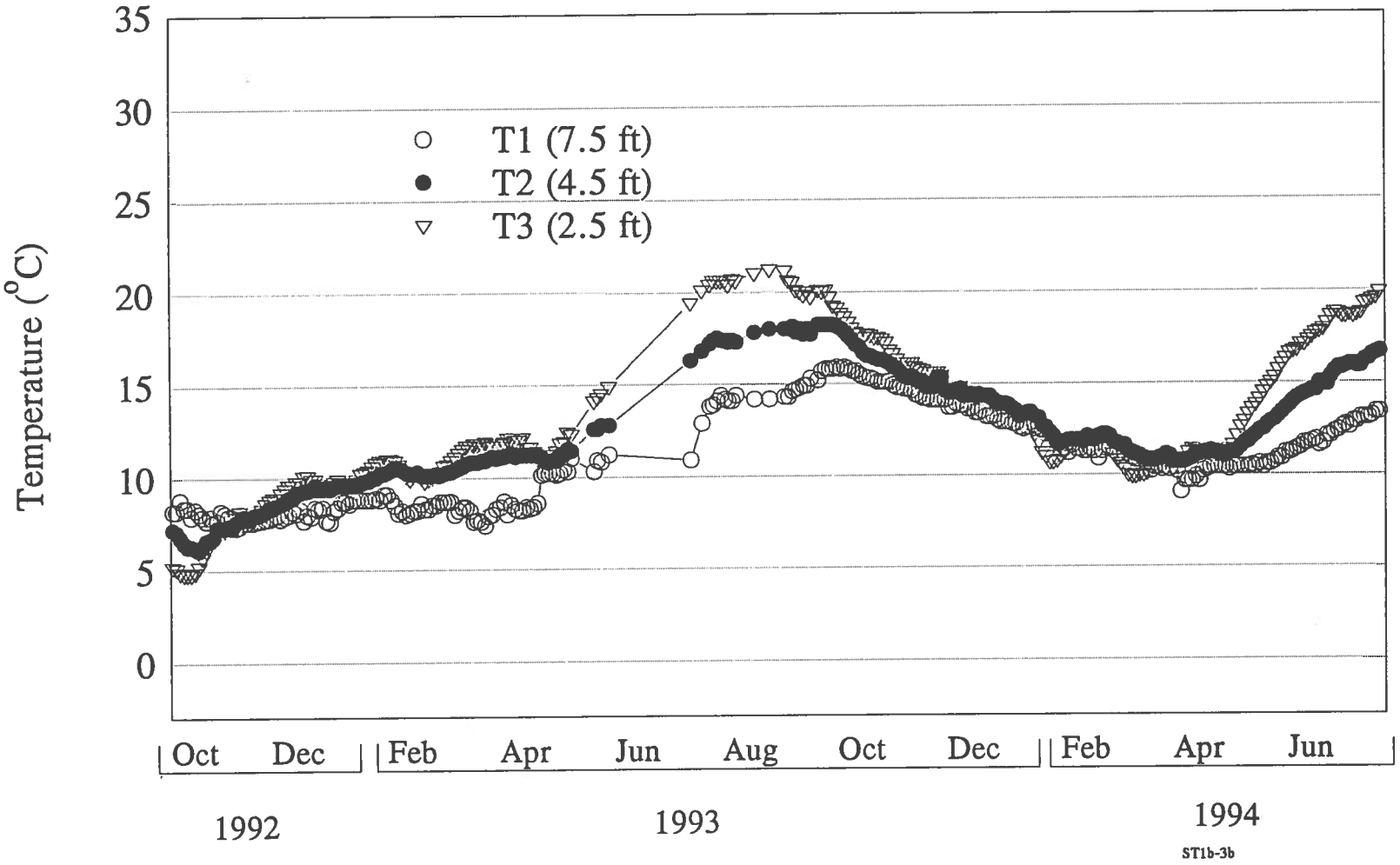


Figure M14. Soil Temperature in Surface Warming Test Plot: Thermocouples 1b-3b

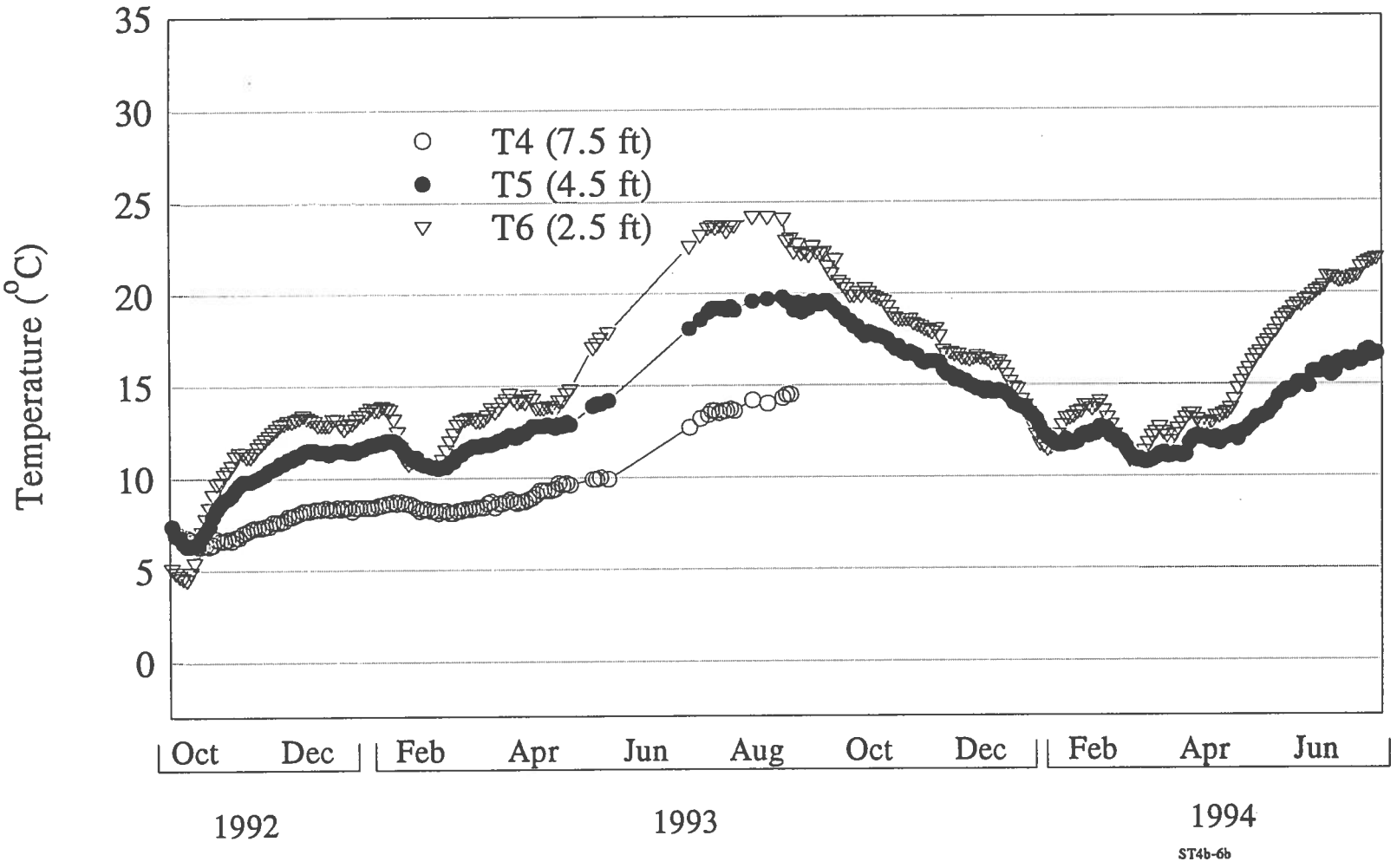


Figure M15. Soil Temperature in Surface Warming Test Plot: Thermocouples 4b-6b

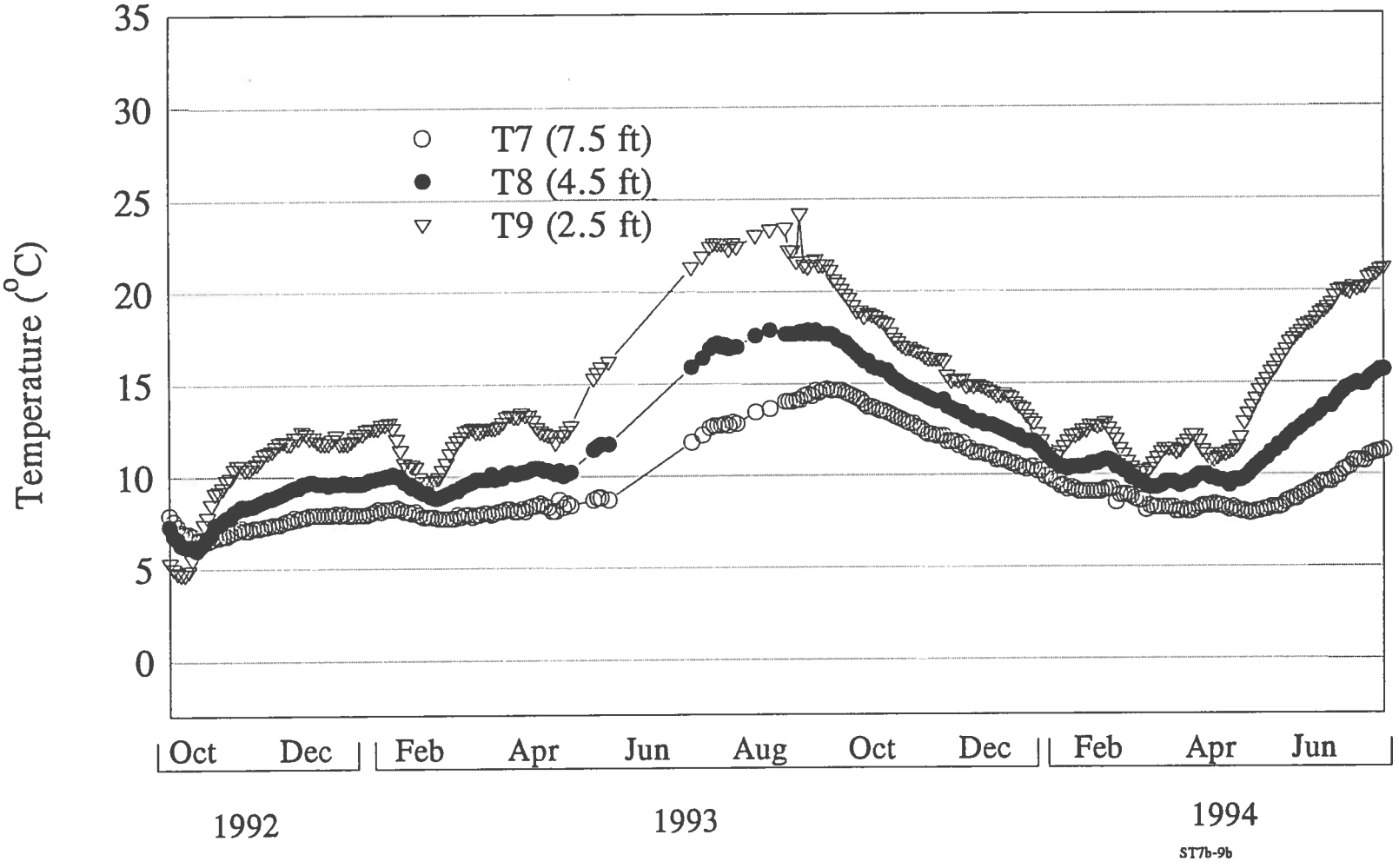


Figure M16. Soil Temperature in Surface Warming Test Plot: Thermocouples 7b-9b

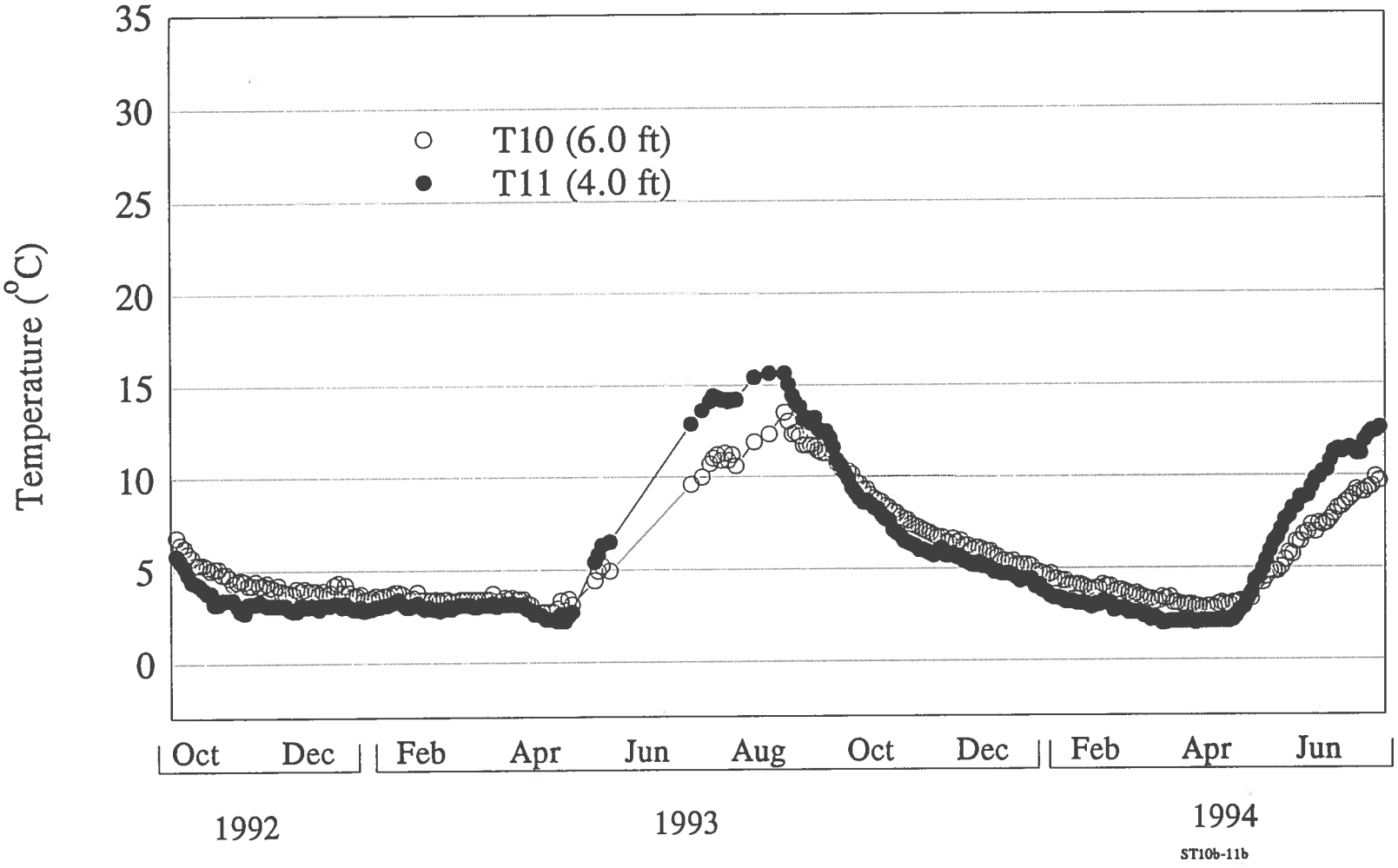


Figure M17. Soil Temperature Near Border of Surface Warming Test Plot: Thermocouples 10b-11b

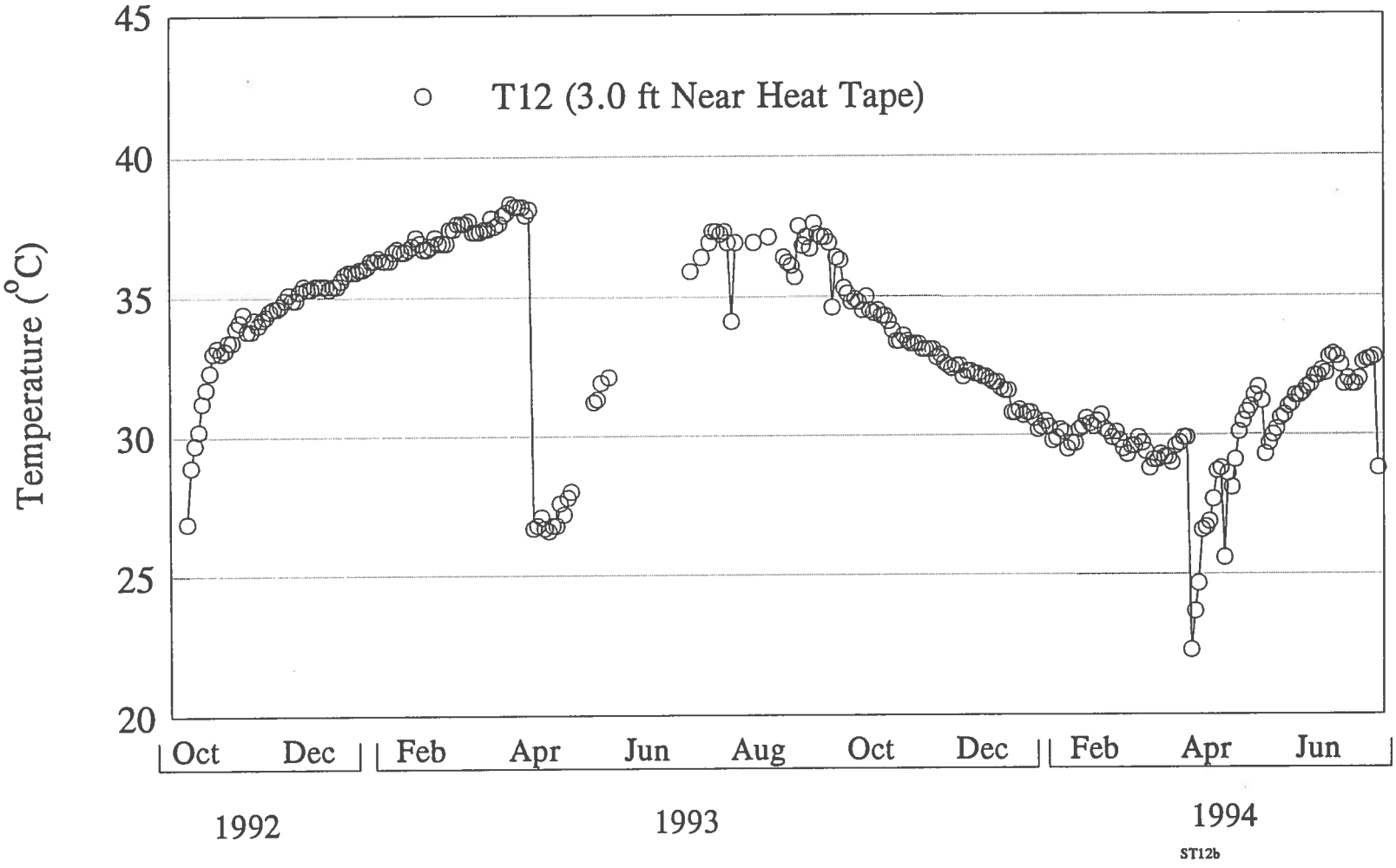


Figure M18. Soil Temperature Near Heat Tape in Surface Warming Test Plot: Thermocouple 12b

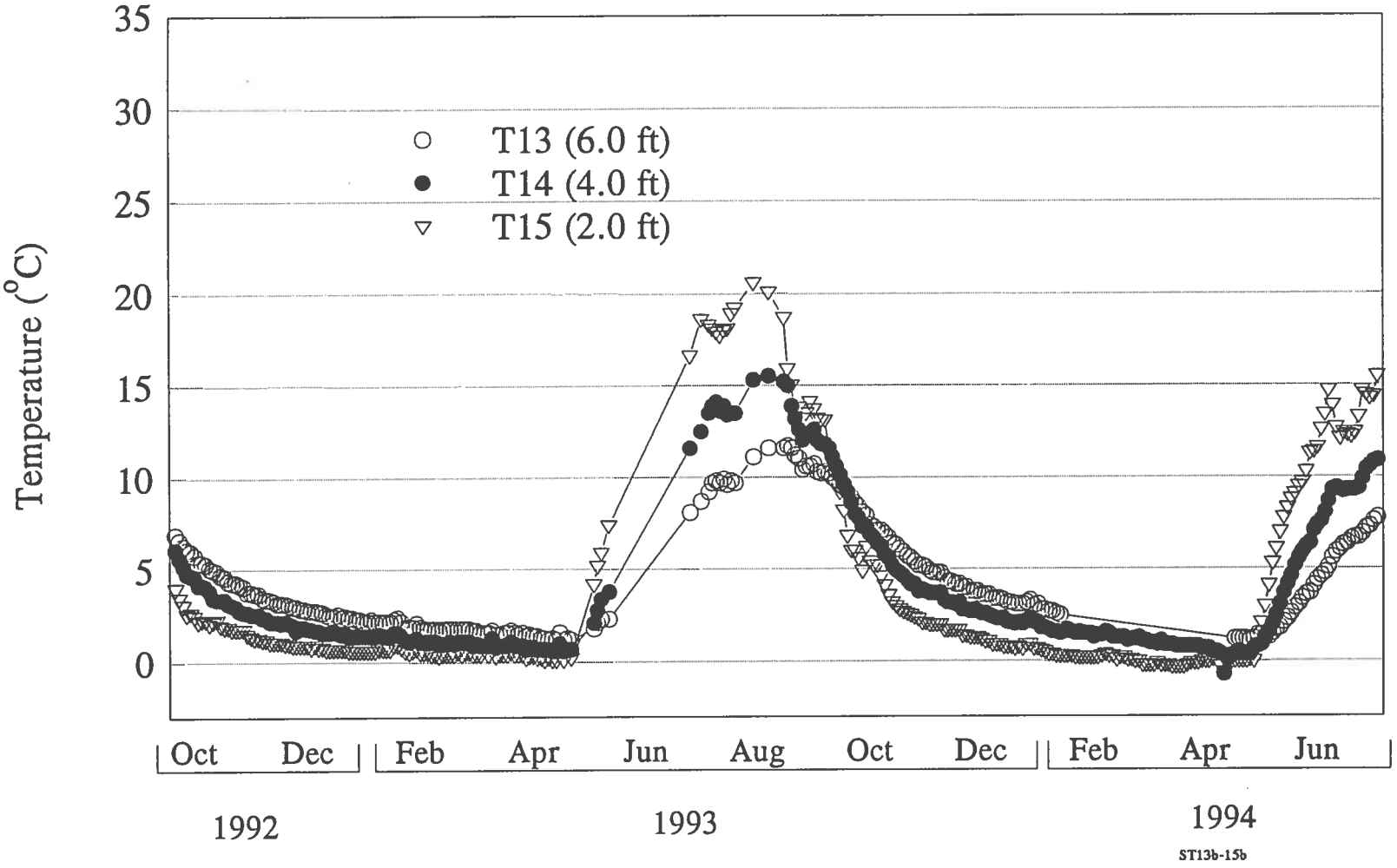


Figure M19. Temperature 15' Outside Border of Surface Warming Test Plot: Thermocouple 13b-15b

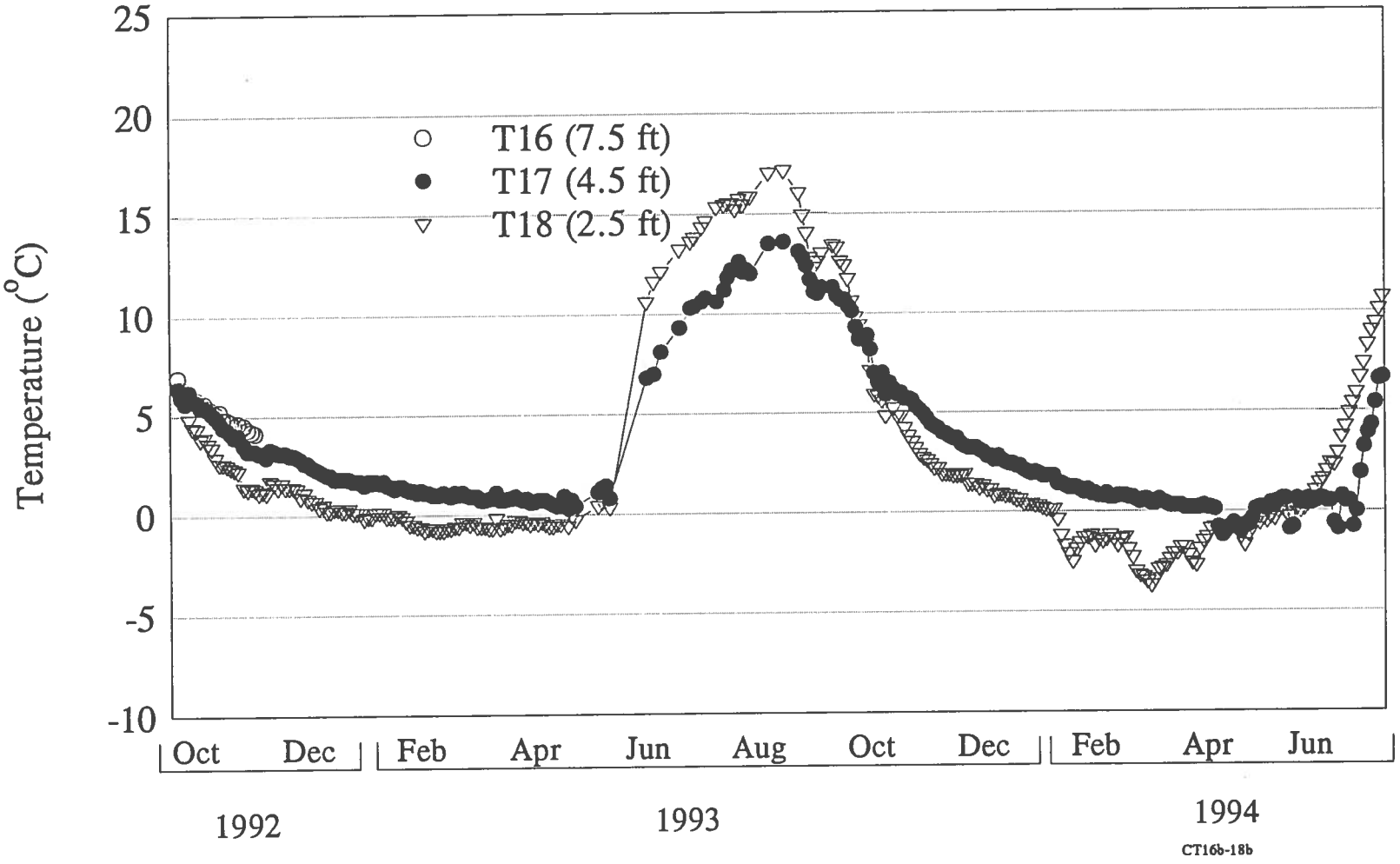


Figure M20. Soil Temperature in Control Test Plot: Thermocouples 16b-18b

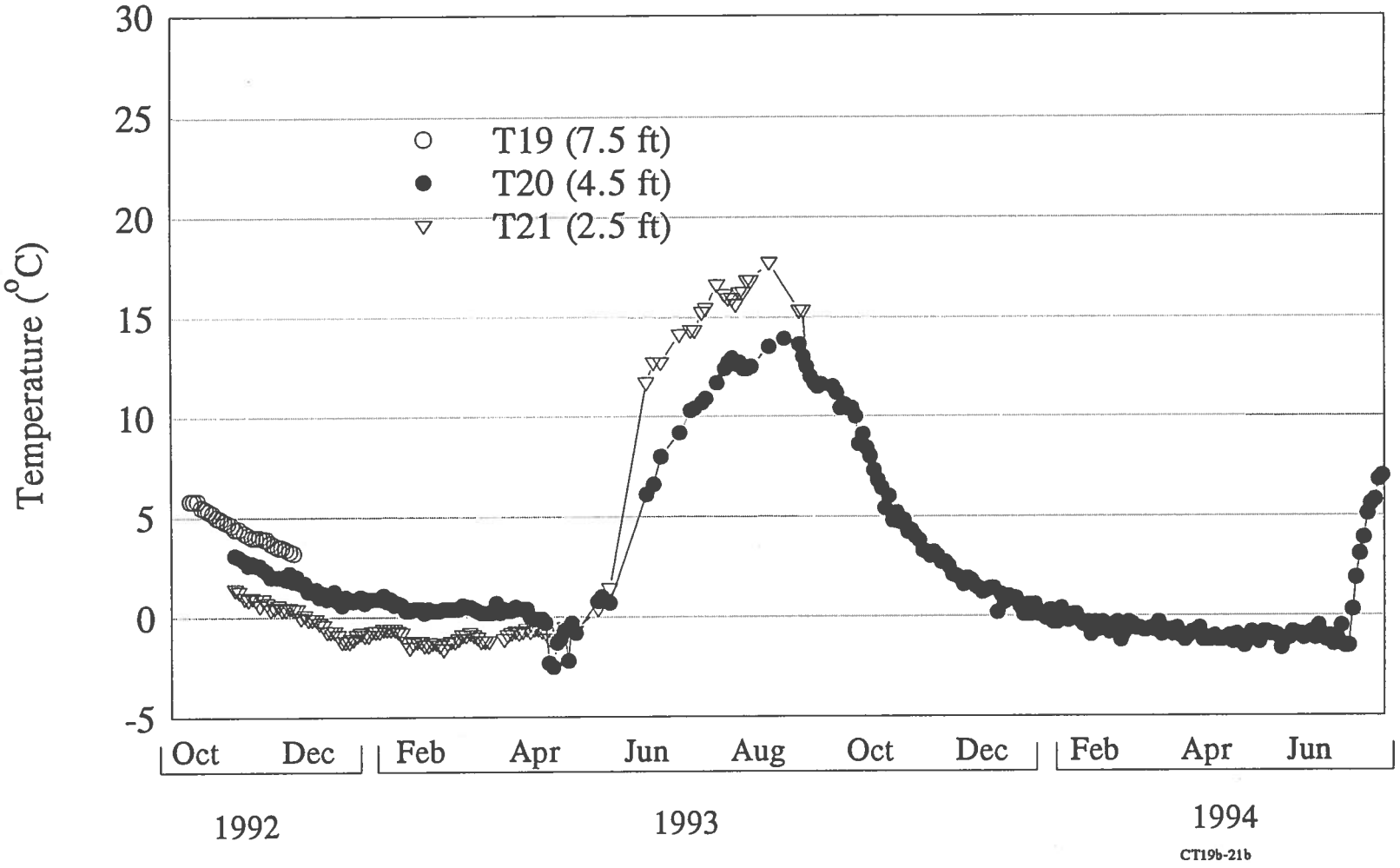


Figure M21. Soil Temperature in Control Test Plot: Thermocouples 19b-21b

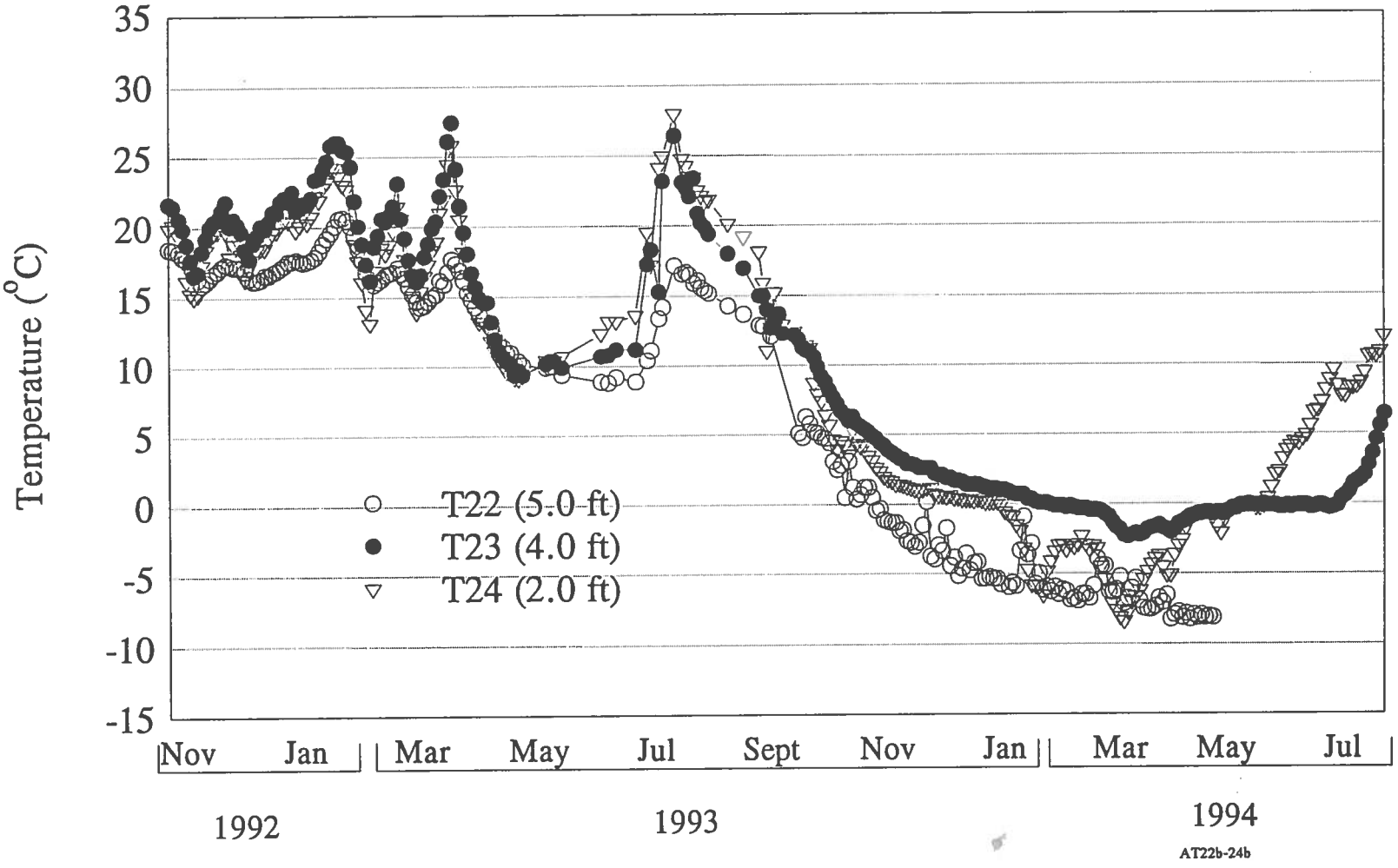


Figure M22. Soil Temperature in Active Warming Test Plot: Thermocouples 22b-24b

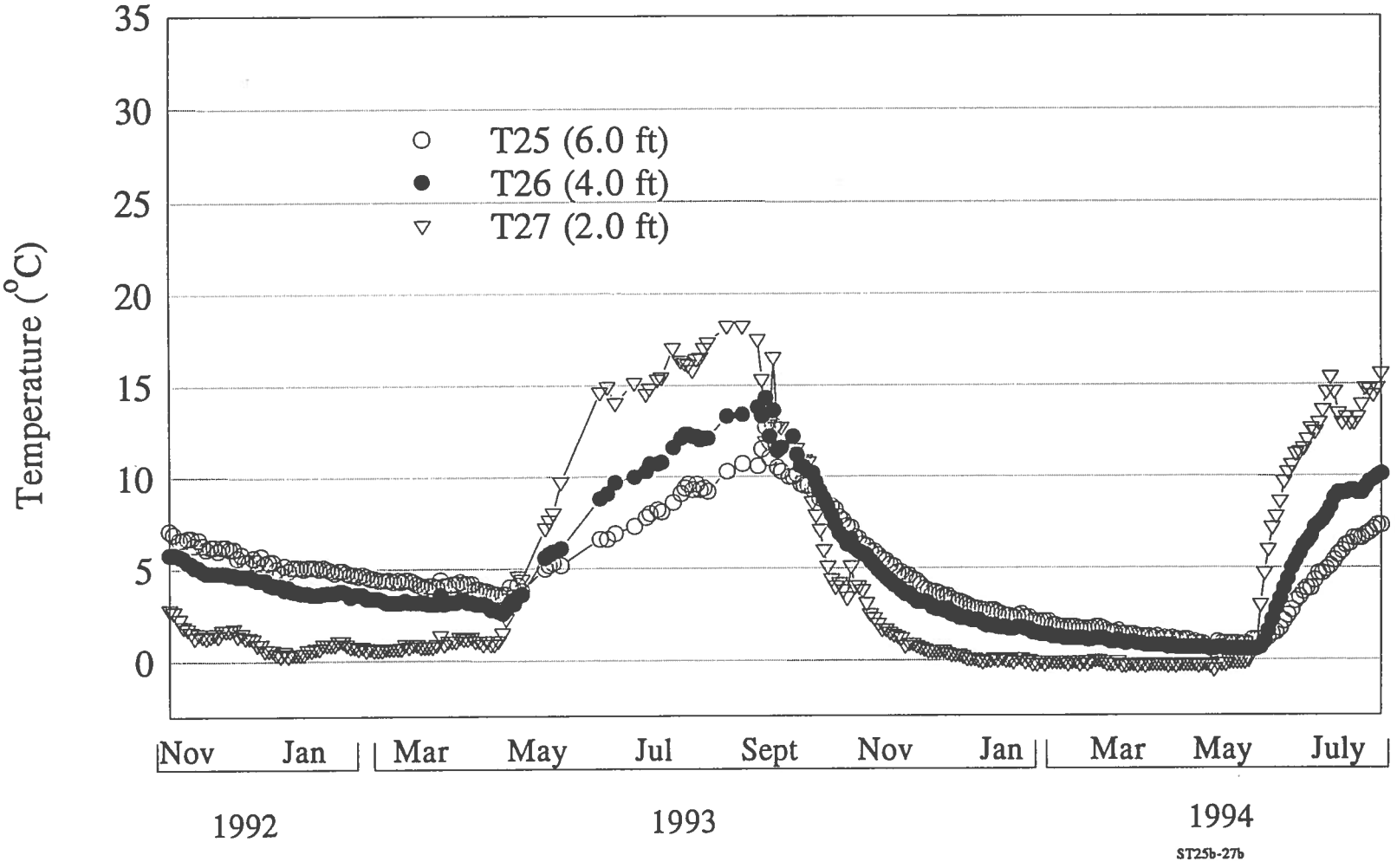


Figure M23. Soil Temperature on Border of Active Warming Test Plot: Thermocouples 25b-27b

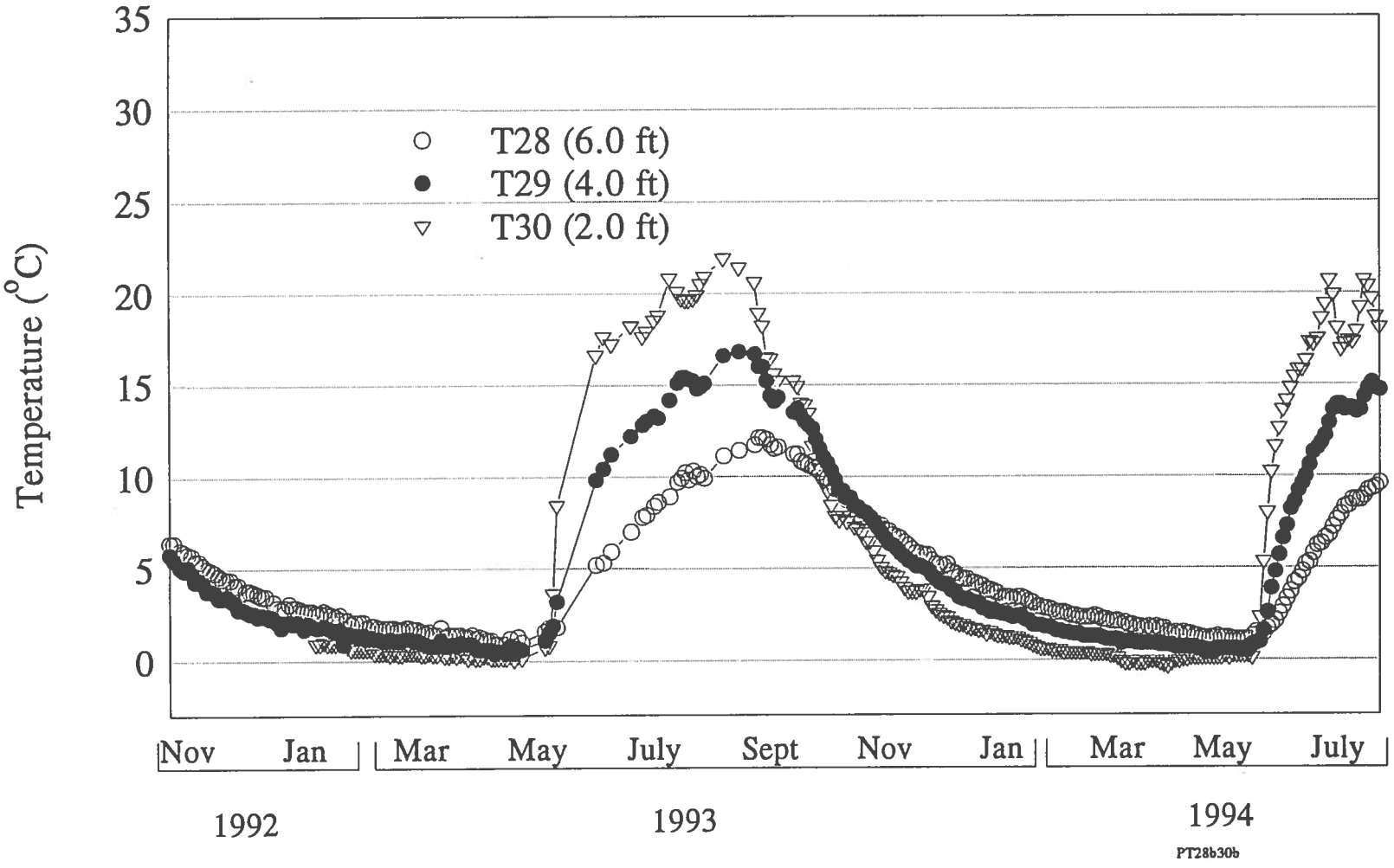


Figure M24. Soil Temperature in Passive Warming Test Plot: Thermocouples 28b-30b

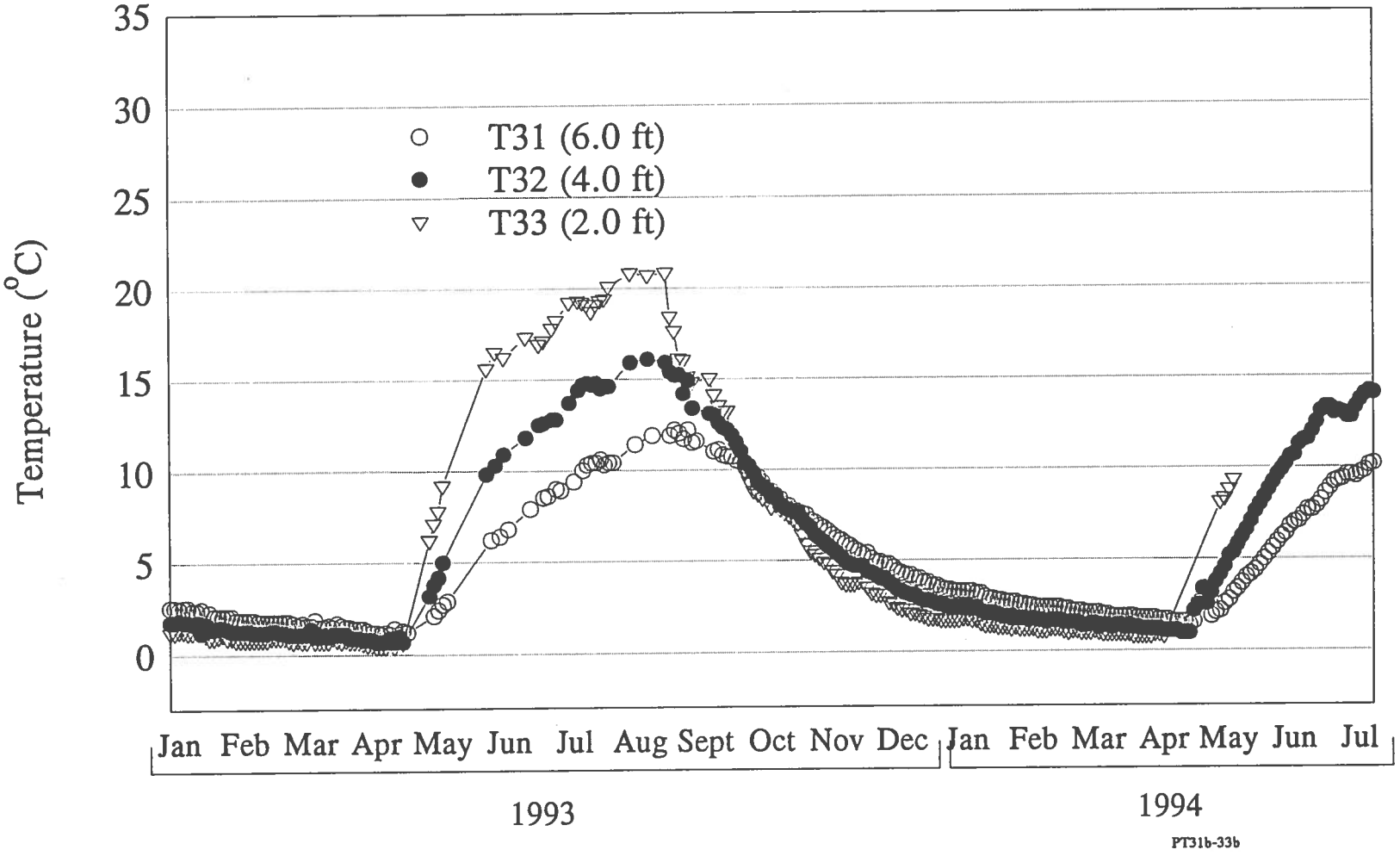


Figure M25. Soil Temperature in Passive Warming Test Plot: Thermocouples 31b-33b

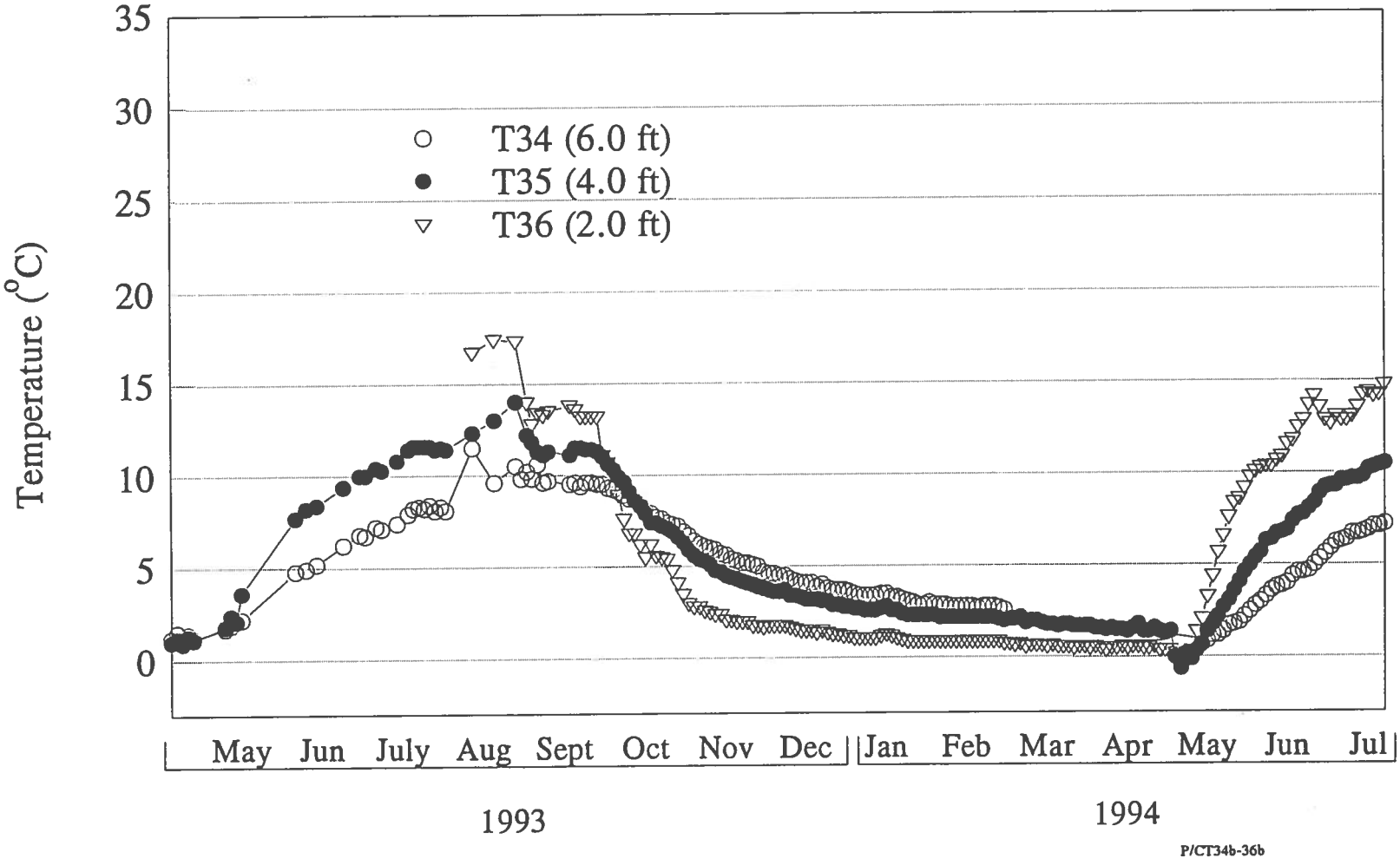


Figure M26. Soil Temperatures between the Passive Warming and the Control Test Plots: Thermocouples 34b-36b

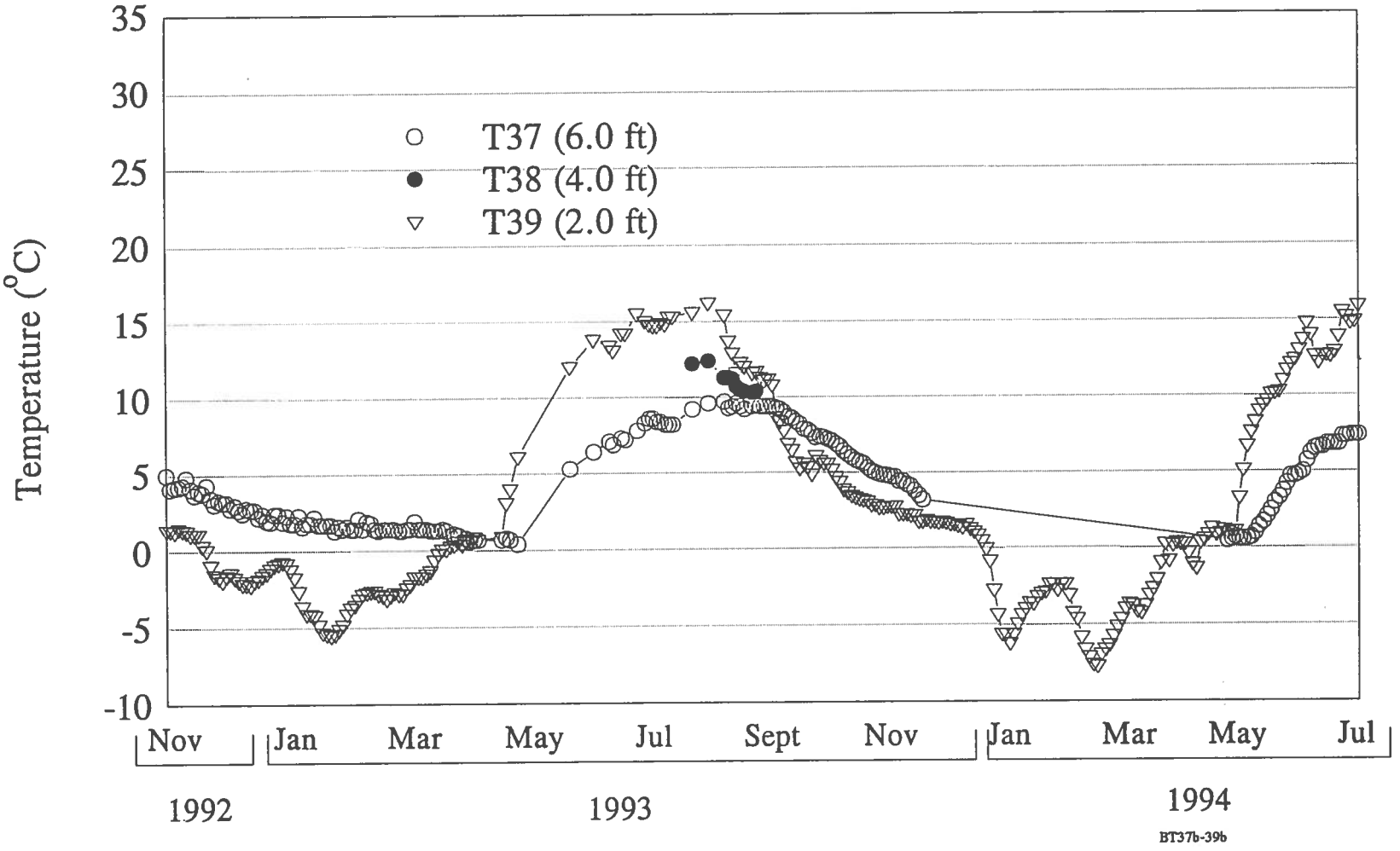


Figure M27. Soil Temperature in Background Area: Thermocouples 37b-39b

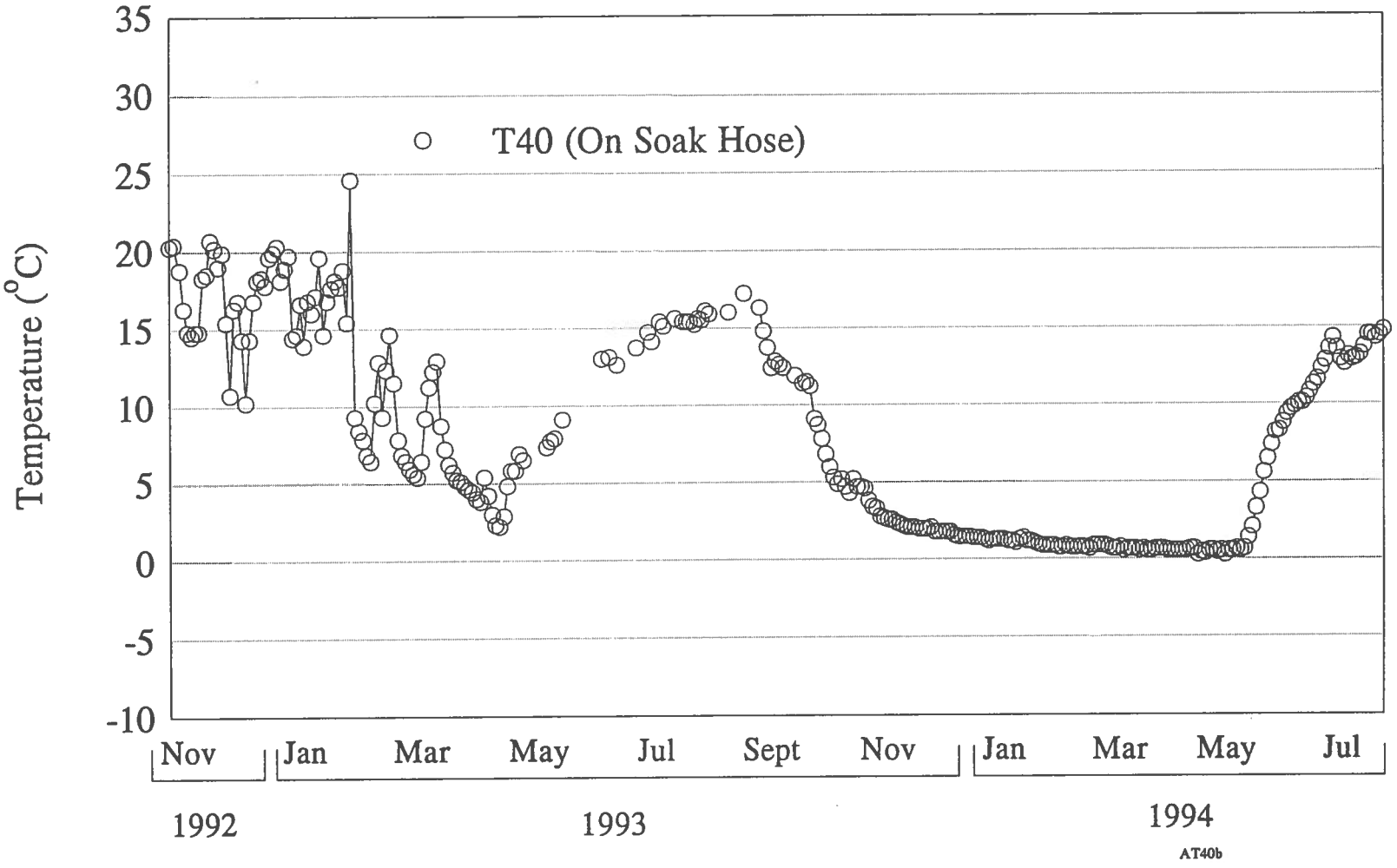


Figure M28. Temperature on Soak Hose on Perimeter of Active Warming test Plot: Thermocouple 40b

APPENDIX N

DATA FROM IN SITU RESPIRATION TESTS

Table N1. In Situ Respiration Test in the Active Warming Test Plot: October 1 to 7, 1991

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)									
		0	4	9	14	25	33	49	70	96	146
A1a	O_2	3	NS	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS
A1b	O_2	8.0	6.2	1.8	NS	NS	NS	NS	NS	NS	NS
	CO_2	11	12	11	NS	NS	NS	NS	NS	NS	NS
A1c	O_2	9.5	8.8	8.5	9.0	9.8	9.5	13	14	14	13
	CO_2	7.5	11	9.2	8.8	8.9	8.7	7.3	7.8	7.2	6.9
A2a	O_2	17	16	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	5	6.5	NS	NS	NS	NS	NS	NS	NS	NS
A2b	O_2	19	15	11	7.3	21	4.5	9.0	4.4	7.2	6.8
	CO_2	1.7	3.1	2.0	3.9	0.1	4.9	5.8	6.5	11	6.9
A2c	O_2	15	14	12	9.0	8.2	7.5	9.9	7.9	8.1	NS
	CO_2	5.0	5.9	5.8	6.1	5.9	6.3	6.1	7.6	11	NS
A3a	O_2	20	17	15	NS	10	12	13	11	13	9.8
	CO_2	0.3	1.5	1.7	NS	2.1	2.8	3.4	3.9	4.1	4.8
A3b	O_2	16	18	16	NS	13	12	16	13	13	12
	CO_2	4.5	4	4.5	NS	4.6	4.4	3.1	4.5	4.9	4.2
A3c	O_2	17	17	16	NS	14	13	13	13	13	12
	CO_2	3.6	5	4.4	NS	4.7	4.6	5.5	4.9	7.5	4.8

NS - Not sampled due to an oxygen concentration less than 5% or poor flow.

Table N1. In Situ Respiration Test in the Active Warming Test Plot: October 1 to 7, 1991 (continued)

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)									
		0	4	9	14	25	33	49	70	96	146
A4a	O_2	7.5	19	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	3.5	1.1	NS	NS	NS	NS	NS	NS	NS	NS
A4b	O_2	6.8	3.6	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	8.1	14	NS	NS	NS	NS	NS	NS	NS	NS
A4c	O_2	4.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	9.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
A5a	O_2	16	17	17	21	NS	NS	NS	NS	NS	NS
	CO_2	5.0	4.8	4.1	0.3	NS	NS	NS	NS	NS	NS
A5b	O_2	14	9.1	8.0	8.0	5.9	3.9	7.9	8.4	17	NS
	CO_2	2.4	7.5	7.2	7.0	8.8	8.3	8.5	9.1	3.0	NS
A5c	O_2	5.8	7.3	9.5	9.8	11	11	16	13	12	10
	CO_2	8.7	13	9.9	8.3	9.9	9.1	6.0	8.1	10	7.4
A6a	O_2	12	11	10	8.0	6.9	4.5	3.1	2.2	NS	NS
	CO_2	6.2	7.8	6.6	7.0	8.2	7.5	8.8	9	NS	NS
A6b	O_2	8.4	7.6	7.0	6.0	4.5	NS	NS	NS	NS	NS
	CO_2	7.0	9.5	8.3	6.8	9.6	NS	NS	NS	NS	NS
A6c	O_2	4.4	NS	NS	4.0	3.8	NS	NS	NS	NS	NS
	CO_2	8.5	NS	NS	9.2	12	NS	NS	NS	NS	NS

NS - Not sampled due to an oxygen concentration less than 5% or poor flow.

Table N2. In Situ Respiration Test in the Passive Warming Test Plot: October 1 to 7, 1991

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)									
		0	4	9	14	25	33	49	70	96	146
P1a	O_2	20.9	20.2	20.2	19.8	19.3	18.5	17.5	16	15	13.9
	CO_2	0	0.1	0.1	0.4	0.2	0.3	0.2	0.5	0.4	0.2
P1b	O_2	20.9	20.5	20.5	20	19.5	18.8	18	16.7	15.8	15.5
	CO_2	0	0.1	0.1	0.4	0.2	0.2	0.2	0.5	0.3	0
P1c	O_2	20.9	20	20	20	19.5	18.9	18.4	17.8	17.4	16.5
	CO_2	0.1	0.4	0.5	0.8	0.6	0.6	0.7	0.7	0.7	0.5
P2a	O_2	20.9	20.6	20.7	21.3	20.1	19.5	19.2	18.9	18.5	16.9
	CO_2	0	0.1	0.1	0.4	0.3	0.4	0.4	0.6	0.4	0.3
P2b	O_2	20.7	20	20	19.5	19.2	18.5	17.8	17	17	14.7
	CO_2	0.1	0.3	0.4	0.9	0.5	0.5	0.6	0.9	0.7	0.7
P2c	O_2	20.8	20.2	20.3	20	19.7	19	18.6	18	18	18.8
	CO_2	0.1	0.3	0.3	0.7	0.4	0.5	0.5	0.7	0.5	0
P3a	O_2	20.9	20.5	20.6	20	20	20.3	18.8	17.9	17.2	17.5
	CO_2	0	0.1	0	0.4	0.1	0.1	0.2	0.4	0.1	0.1
P3b	O_2	20.9	20.7	20.6	20.3	20	19.3	18.9	18.1	17.5	16
	CO_2	0	0	0	0.3	0	0.1	0.1	0.3	0.1	0.2
P3c	O_2	20.9	20.5	20.5	20.4	20.2	19.5	19.4	19.1	18.8	18.5
	CO_2	0	0.1	0.1	0.4	0.1	0.2	0.2	0.4	0.1	0.2

NS - Not sampled due to an oxygen concentration less than 5% or poor flow.

Table N2. In Situ Respiration Test in the Passive Warming Test Plot: October 1 to 7, 1991 (continued)

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)									
		0	4	9	14	25	33	49	70	96	146
P4a	O_2	20.7	20.8	20.8	20.2	20	19.2	18.7	17.5	16.9	15
	CO_2	0	0.1	0	0.4	0	0.1	0.1	0.3	0	0.1
P4b	O_2	20.7	20.6	20.5	20	19.7	18.8	18	16.8	15.8	13.5
	CO_2	0	0.1	0	0.3	0.1	0.2	0.2	0.4	0.1	0.2
P4c	O_2	20.7	20.2	20.3	20.1	19.5	18.8	18.1	17.1	16.4	15
	CO_2	0	0.2	0.1	0.4	0.2	0.3	0.4	0.5	0.2	0.3
P5a	O_2	20.7	20.7	20.7	20.1	20.1	19.5	19	18	17	15.2
	CO_2	0	0.1	0.1	0.5	0.1	0.2	0.2	0.4	0.1	0.2
P5b	O_2	20.7	20.5	20.3	20	19.2	18.3	17.5	16.7	15	12.5
	CO_2	0	0.2	0.1	0.4	0.2	0.2	0.3	0.9	0.3	0.4
P5c	O_2	20.7	20.1	20	19.9	19.3	18.4	17.9	16	16	14.1
	CO_2	0	0.4	0.4	0.6	0.4	0.5	0.5	0.6	0.5	0.6
P6a	O_2	20.9	20.5	20.4	19.2	20	19.3	18.9	18.2	17.2	15.8
	CO_2	0	0.3	0.2	0.7	0.2	0.3	0.4	0.7	0.3	0.6
P6b	O_2	20.5	20	19.6	19	18.1	17	15.6	14	12.4	10.2
	CO_2	0	0.4	0.4	0.8	0.4	0.6	0.6	1.0	0.6	0.6
P6c	O_2	20.5	20	19.7	19.3	19.7	17.8	17	15.8	14.6	12.8
	CO_2	0	0.8	0.7	1.1	0.8	0.9	0.7	1.3	0.8	1.0

NS - Not sampled due to an oxygen concentration less than 5% or poor flow.

Table N3. In Situ Respiration Test in the Control Test Plot: October 1 to 7, 1991

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)									
		0	4	9	14	25	33	49	70	96	146
C1a	O_2	16.5	15.8	15.0	14.0	12.9	11.9	9.5	7.1	6.1	2.5
	CO_2	3.4	3.2	3.2	4.7	3.5	3.8	4.1	4.8	4.5	6.8
C1b	O_2	12.8	11.8	11.0	11.5	10.5	9.5	6.9	5.4	5.5	2.2
	CO_2	5.2	4.9	5.2	6.2	5.6	5.7	6.6	7.4	14.1	6.9
C1c	O_2	11.0	12.0	12.8	13.8	13.9	14.0	13.5	13.5	14.1	12.8
	CO_2	6.9	7.8	6.8	7.8	6.9	6.6	7.3	8.1	6.5	6.6
C2a	O_2	19.5	18.4	18.3	18.0	17.5	17.1	16.0	14.4	13.0	9.1
	CO_2	1.5	1.3	1.3	2.2	1.5	1.7	1.7	2.5	2.3	3.9
C2b	O_2	17.0	13.2	13.4	12.5	17.4	13.2	11.1	11.3	13.6	9.0
	CO_2	2.5	5.8	4.7	6.4	2.3	4.7	6.2	6.2	3.9	5.5
C2c	O_2	18.8	14.5	17.8	NS	NS	NS	NS	NS	17.9	17.2
	CO_2	2.3	3.2	2.3	NS	NS	NS	NS	NS	2.3	3.8
C3a	O_2	20.9	20.2	20.0	20.2	20.0	19.6	19.0	18.6	17.9	15.0
	CO_2	0.2	0.2	0.1	0.5	0.2	0.4	0.4	0.9	0.6	2.2
C3b	O_2	15.8	16.1	15.3	14.0	15.0	14.2	14.4	14.2	15.0	14.0
	CO_2	3.8	3.8	4.3	5.0	4.4	4.7	4.5	4.6	3.4	4.4
C3c	O_2	18.7	19.0	18.8	19.0	18.6	18.3	18.5	18.0	18.0	18.5
	CO_2	1.9	1.9	1.8	2.5	1.8	1.9	1.7	2.3	1.9	1.8

NS - Not sampled due to an oxygen concentration less than 5% or poor flow.

Table N3. In Situ Respiration Test in the Control Test Plot: October 1 to 7, 1991 (continued)

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)									
		0	4	9	14	25	33	49	70	96	146
C4a	O_2	20.2	20.3	20.0	20.0	19.0	18.7	17.4	16.1	15.1	11.0
	CO_2	0.2	0.2	0.1	0.5	0.2	0.3	0.4	0.9	0.6	1.2
C4b	O_2	8.7	10.5	9.2	7.8	8.5	7.6	6.1	5.0	4.3	6.0
	CO_2	7.3	9.1	7.5	8.5	8.0	8.4	9.8	10.5	ND	ND
C4c	O_2	16.5	17.3	17.6	19.0	18.0	17.7	17.8	17.6	18.1	18.0
	CO_2	4.8	5.0	4.1	5.0	3.6	3.8	4.3	4.9	7.4	2.9
C5a	O_2	20.5	19.9	20.3	18.6	17.4	16.6	14.8	12.9	10.3	6.1
	CO_2	0.3	0.4	0.4	0.9	0.4	0.7	1.0	1.6	1.7	2.5
C5b	O_2	13.5	14.0	14.5	14.6	15.0	14.5	15.1	15.0	14.8	15.2
	CO_2	6.9	7.8	6.4	7.8	6.2	6.6	5.9	7.1	15.0	5.0
C5c	O_2	15.9	16.1	16.5	18.0	17.0	16.8	16.9	16.5	17.1	17.0
	CO_2	5.0	5.6	4.8	4.7	4.8	4.7	4.9	6.6	10.1	3.6
C6a	O_2	19.5	19.3	18.6	17.8	16.0	14.8	12.5	9.9	7.6	3.9
	CO_2	0.6	0.8	0.8	1.7	1.2	1.4	1.8	2.8	2.4	3.2
C6b	O_2	16.5	15.5	16.5	16.5	16.5	15.8	15.5	16.0	15.9	16.2
	CO_2	4.0	5.5	4.4	4.9	4.3	4.6	4.7	6.1	4.1	4.0
C6c	O_2	16.9	16.3	16.9	17.0	17.0	16.4	16.3	17.3	16.5	17.1
	CO_2	4.8	5.2	4.4	5.8	4.1	4.3	4.2	3.7	3.8	3.4

NS - Not sampled due to an oxygen concentration less than 5% or poor flow.

Table N4. In Situ Respiration Test in the Perimeter Soil Gas Monitoring Points: October 1 to 7, 1991

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)									
		0	4	9	14	25	33	49	70	96	146
PP1a	O_2	NS	NS	7.0	NS	NS	NS	NS	NS	NS	NS
	CO_2	NS	NS	5.2	NS	NS	NS	NS	NS	NS	NS
PP1b	O_2	20.9	1.0	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	0.3	9.1	NS	NS	NS	NS	NS	NS	NS	NS
PP1c	O_2	19.6	4.0	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	1.5	9.0	NS	NS	NS	NS	NS	NS	NS	NS
PP2a	O_2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
PP2b	O_2	17.4	0.8	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	3.1	10.5	NS	NS	NS	NS	NS	NS	NS	NS
PP2c	O_2	19.2	7.5	11.0	11.0	11.0	11.1	13.5	12.0	14.5	11.1
	CO_2	1.9	9.0	7.8	8.2	8.0	8.2	7.8	8.2	15.9	8.6
PP3a	O_2	20.9	15.1	20.5	NS	NS	NS	NS	NS	NS	NS
	CO_2	0	4.2	0.2	NS	NS	NS	NS	NS	NS	NS
PP3b	O_2	20.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	0.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
PP3c	O_2	18.2	6.5	7.4	8.5	NS	NS	NS	NS	NS	NS
	CO_2	3.1	10.5	10.0	10.0	NS	NS	NS	NS	NS	NS
PP4a	O_2	20.9	20.9	20.6	20.7	20.8	20.5	19.9	19.0	18.6	17.5
	CO_2	0	0	0.2	0.5	0.1	0.1	0.6	0.1	0.1	0.1

Table N4. In Situ Respiration Test in the Perimeter Soil Gas Monitoring Points: October 1 to 7, 1991 (continued)

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)									
		0	4	9	14	25	33	49	70	96	146
PP4b	O_2	20.9	20.9	19.8	19.9	19.5	18.7	18.3	17.6	17.6	16.2
	CO_2	0	0	0.2	0.2	0.1	0.1	0.7	0.1	0.2	0.2
PP5a	O_2	19.8	20.9	20.0	20.5	19.8	19.5	19.7	18.7	18.0	16.8
	CO_2	0.6	0.5	0.4	0.4	1.0	0.6	1.7	0.7	0.6	0.9
PP5b	O_2	18.2	14.0	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	2.7	8.8	NS	NS	NS	NS	NS	NS	NS	NS
PP5c	O_2	14.0	13.0	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	7.8	8.7	NS	NS	NS	NS	NS	NS	NS	NS
PP6a	O_2	11.0	18.3	18.0	18.0	17.6	16.8	15.8	15.0	13.9	11.6
	CO_2	8.4	3.2	3.1	4.3	2.9	3.2	4.9	4.0	4.2	6.5
PP6b	O_2	18.5	19.0	18.8	18.8	18.0	17.5	17.8	15.5	14.1	12.1
	CO_2	2.5	2.2	2.2	2.7	2.4	2.6	3.5	3.4	3.7	6.2
PP6c	O_2	13.5	12.2	12.0	12.8	12.0	12.0	12.6	11.7	11.3	11.0
	CO_2	7.5	8.3	8.0	8.8	8.4	8.2	8.3	8.0	ND	9.0
PP7a	O_2	16.0	15.2	14.5	14.4	13.5	12.0	11.8	8.7	7.1	7.1
	CO_2	2.6	2.7	2.8	2.7	2.5	3.0	3.9	2.8	7.2	2.1
PP7b	O_2	12.0	20.0	2.8	NS	NS	NS	NS	NS	NS	NS
	CO_2	4.6	0.6	7.4	NS	NS	NS	NS	NS	NS	NS
PP7c	O_2	13.2	13.5	13.5	14.9	14.5	14.0	15.2	14.2	15.0	20.5
	CO_2	7.5	8.2	7.4	7.3	7.8	7.5	7.8	7.0	18.5	0

Table N4. In Situ Respiration Test in the Perimeter Soil Gas Monitoring Points: October 1 to 7, 1991 (continued)

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)									
		0	4	9	14	25	33	49	70	96	146
PP8a	O_2	15.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	2.6	NS	NS	NS	NS	NS	NS	NS	NS	NS
PP8b	O_2	12.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	6.5	NS	NS	NS	NS	NS	NS	NS	NS	NS
PP8c	O_2	10.0	10.2	11.0	13.3	11.1	11.0	11.6	11.3	12.0	14.0
	CO_2	8.0	8.2	7.6	7.0	8.0	7.9	7.9	7.2	20.0	7.0
PP9a	O_2	1.5	0.5	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	7.9	8.5	NS	NS	NS	NS	NS	NS	NS	NS
PP9b	O_2	15.8	16.0	16.5	17.2	17.0	16.5	17.0	16.8	17.2	18.2
	CO_2	6.1	7.0	6.7	5.6	6.5	6.0	6.3	6.3	12.0	4.3
PP10a	O_2	11.8	12.0	12.0	12.8	12.2	12.0	12.2	12.7	13.1	15.8
	CO_2	7.0	7.5	6.9	7.7	7.3	7.0	8.0	7.1	17.8	4.6
PP10b	O_2	12.1	12.3	12.2	12.7	12.6	12.3	12.7	13.0	14.2	13.8
	CO_2	7.0	7.2	6.8	7.5	7.2	7.0	7.9	7.0	14.5	7.3

NS - Not sampled due to an oxygen concentration less than 5% or poor flow.

Table N5. In Situ Respiration Test in the Passive Warming Test Plot: November 10 to 14, 1991

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)				
		0	3	24	48	96
P4a	O_2	20.9	18.6	19.9	19.0	ND
	CO_2	0	0	0.02	0	ND
P4b	O_2	20.9	18.9	19.5	18.6	ND
	CO_2	0	0	0.05	0.05	ND
P4c	O_2	20.9	20.4	19.9	19.0	ND
	CO_2	0	0	0.1	0.09	ND
P6a	O_2	20.9	20.9	19.2	18.7	ND
	CO_2	0.1	0	0.22	0.28	ND
P6b	O_2	20.9	20.9	19.5	17.8	ND
	CO_2	0	0	0.26	0.47	ND
P6c	O_2	20.1	19.2	19.9	18.8	ND
	CO_2	0.5	0.4	0.4	0.6	ND

NS - Not sampled due to an oxygen concentration less than 5% or poor flow.
ND - No data.

Table N6. In Situ Respiration Test in the Control Plot: November 10 to 14, 1991

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)				
		0	3	24	48	96
C1a	O_2	17.3	18.3	14.5	14.0	ND
	CO_2	0	1.39	2.5	5.0	ND
C1b	O_2	10.1	12.9	6.5	7.4	4.9
	CO_2	13.8	3.99	6.9	9.2	9.8
C1c	O_2	6.3	5.6	4.5	3.9	ND
	CO_2	6.6	12.8	8.5	13.1	ND
C6a	O_2	20.5	19.7	18.0	16.2	ND
	CO_2	0.3	0.49	0.69	0.9	ND
C6b	O_2	11.0	6.0	8.5	5.0	ND
	CO_2	4.8	9.7	5.1	9.5	ND
C6c	O_2	15.2	8.1	6.1	9.1	5.0
	CO_2	3.0	9.2	6.5	9.0	10.1

NS - Not sampled due to an oxygen concentration less than 5% or poor flow.
ND - No data.

Table N7. In Situ Respiration Test in the Perimeter Soil Gas Monitoring Points: November 10 to 14, 1991

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time				
		0	3	24	48	96
PP1a	O_2	ND	20.9	20.5	20.9	NS
	CO_2	ND	0	0.5	0	NS
PP1b	O_2	ND	20.9	20.9	6.9	20.9
	CO_2	ND	0	0.01	11.9	0.1
PP1c	O_2	ND	13.0	20.5	4.6	NS
	CO_2	ND	3.29	0.1	11.5	NS

NS - Not sampled due to an oxygen concentration less than 5% or poor flow.
ND - No data.

Table N8. In Situ Respiration Test in Test Plots: December 7 to 14, 1991

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)						
		0	4	8	22	47	98	169
A1b	O_2	5.9	5.6	4.7	NS	NS	NS	NS
	CO_2	14.0	13.4	13.5	NS	NS	NS	NS
A6c	O_2	5.1	5.4	NS	2.2	NS	NS	NS
	CO_2	15.0	14.0	NS	13.9	NS	NS	NS
P4a	O_2	20.9	20.9	20.0	20.2	18.8	17.1	15.5
	CO_2	<0.1	<0.1	0.13	<0.1	0.03	0.1	<0.1
P4b	O_2	20.7	20.5	20.0	19.6	18.2	17.2	14.2
	CO_2	<0.1	<0.1	<0.1	<0.1	0.04	0.2	0.2
P4c	O_2	20.7	20.5	20.0	20.6	19.1	18.6	16.9
	CO_2	0.01	<0.1	<0.1	<0.1	0.05	0.22	0.12
P6a	O_2	20.4	20.1	20.5	19.5	18.9	17.1	15.0
	CO_2	0.10	0.16	0.12	0.15	0.11	0.55	0.60
P6b	O_2	20.1	20.1	19.8	19.4	18.0	17.0	NS
	CO_2	0.30	0.30	0.30	0.40	0.35	0.69	NS
P6c	O_2	20.1	20.1	19.8	19.8	18.8	17.4	16.9
	CO_2	0.45	0.42	0.48	0.48	0.49	1.0	0.55
C1a	O_2	16.2	NS	16.3	15.6	13.2	12.1	8.8
	CO_2	2.6	NS	2.4	2.8	5.7	6.1	7.9
C1b	O_2	12.0	10.0	9.0	NS	6.8	7.2	NS
	CO_2	4.7	9.9	12.0	NS	9.8	9.8	NS

Table N8. In Situ Respiration Test in Test Plots: December 7 to 14, 1991

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)						
		0	4	8	22	47	98	169
C6a	O_2	20.0	16.9	20.0	18.5	16.8	14.2	11.3
	CO_2	0.81	4.8	4.5	0.51	0.71	1.9	0.22
C6b	O_2	12.0	9.9	9.8	8.1	7.7	9.8	8.9
	CO_2	8.4	8.5	12.0	10.1	11.9	10.0	10.3

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N9. In Situ Respiration Test in Active Warming Test Plot: January 28 to 30, 1992

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)			
		0	5	31	54
A1b	O_2	8.9	6.0	NS	1.0
	O_2	12.6	13.2	NS	14.1
A1c	O_2	13.5	12.8	12.5	12.0
	CO_2	9.1	9.2	9.0	9.3
A2b	O_2	18.4	15.2	9.4	4.8
	CO_2	2.5	8.6	7.5	8.0
A2c	O_2	15.0	13.2	10.5	10.0
	CO_2	9.0	9.4	9.9	9.9
A3b	O_2	17.5	17.0	13.8	12.5
	CO_2	6.0	5.4	6.0	6.5
A3c	O_2	21.5	16.2	14.0	13.8
	CO_2	2.8	6.7	7.0	7.1
A4b	O_2	4.3	2.5	1.5	1.0
	CO_2	14.1	14.2	14.8	14.8
A4c	O_2	8.9	7.0	8.5	8.0
	CO_2	12.2	12.0	12.0	12.1
A5b	O_2	8.0	6.0	6.0	6.0
	CO_2	10.9	12.0	12.1	12.5
A5c	O_2	12.1	10.0	9.5	9.3
	CO_2	9.4	10.8	10.5	10.1

Table N9. In Situ Respiration Test in Active Warming Test Plot: January 28 to 30, 1992

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)			
		0	5	31	54
A6a	O_2	5.2	4.0	3.8	3.0
	CO_2	13.5	13.2	13.0	13.0

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N10. In Situ Respiration Test in Passive Warming Test Plot: January 28 to February 8, 1992

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)					
		0	6	30	53	104	292
P1a	O_2	20.9	20.5	19.8	19.1	17.6	13.6
	CO_2	<0.1	<0.1	1.0	1.1	0.45	1.0
P1b	O_2	20.9	20.8	20.0	19.5	18.7	14.3
	CO_2	<0.1	<0.1	0.3	0.9	0.16	0.3
P1c	O_2	20.9	20.5	19.9	19.5	18.8	15.8
	CO_2	0.33	0.80	1.0	1.1	0.42	0.44
P2a	O_2	20.9	20.8	20.0	19.6	18.1	NS
	CO_2	<0.1	<0.1	0.90	0.50	0.49	NS
P2b	O_2	20.9	20.7	20.0	19.5	18.1	14.8
	CO_2	0.15	0.10	1.0	0.90	0.31	0.40
P2c	O_2	20.9	20.8	20.1	19.9	19.0	16.0
	CO_2	0.15	0.15	1.1	0.90	0.29	0.28
P3a	O_2	20.9	20.8	19.9	19.1	18.8	13.3
	CO_2	<0.1	<0.1	0.10	0.10	0.09	0.40
P3b	O_2	20.9	20.8	19.9	19.1	18.1	13.9
	CO_2	<0.1	<0.1	0.10	0.10	0.09	0.30
P3c	O_2	20.9	20.9	20.2	19.9	18.4	16.6
	CO_2	<0.1	<0.1	0.10	0.10	0.08	0.08

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N10. In Situ Respiration Test in Passive Warming Test Plot: January 28 to February 8, 1992 (continued)

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)					
		0	6	30	53	104	292
P4a	O_2	20.9	20.9	20.0	19.2	18.0	13.7
	CO_2	<0.1	<0.1	0.10	0.10	0.10	0.20
P4b	O_2	20.9	20.8	19.6	18.4	17.2	11.9
	CO_2	<0.1	<0.1	0.10	0.10	0.19	0.50
P4c	O_2	20.9	20.9	20.0	19.5	18.9	15.1
	CO_2	<0.1	<0.1	0.20	0.10	0.12	0.17
P5a	O_2	20.9	20.5	20.1	19.5	18.1	13.6
	CO_2	0.20	0.20	0.50	0.60	0.30	0.50
P5b	O_2	20.9	20.7	19.7	18.6	17.2	13.0
	CO_2	0.12	0.10	0.60	0.50	0.29	0.60
P5c	O_2	20.9	20.7	20.1	19.7	18.9	14.2
	CO_2	0.35	0.20	0.50	0.60	0.26	0.28
P6a	O_2	20.9	20.6	19.9	19.1	17.9	13.9
	CO_2	0.10	0.20	0.50	0.40	0.30	0.60
P6b	O_2	20.9	20.9	19.5	NS	17.8	13.1
	CO_2	<0.1	0.10	0.15	NS	0.31	0.40
P6c	O_2	20.9	20.8	20.0	18.7	18.6	14.5
	CO_2	0.25	0.20	0.25	1.8	0.42	0.39

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N11. In Situ Respiration Test in the Control Test Plot: January 28 to February 8, 1992

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)					
		0	7	29	51	104	293
C1a	O_2	19.3	19.0	17.5	15.9	14.5	8.0
	CO_2	1.3	2.5	3.0	3.5	2.2	3.2
C1b	O_2	15.0	13.7	12.0	10.2	9.5	2.2
	CO_2	4.1	7.6	7.5	8.7	8.8	10.3
C2a	O_2	20.9	20.5	19.5	18.0	17.0	12.1
	CO_2	<0.1	0.4	0.50	1.0	0.7	2.7
C3a	O_2	20.9	20.9	20.5	19.0	19.3	16.4
	CO_2	<0.1	0.10	<0.1	0.20	0.20	0.50
C3b	O_2	15.5	14.5	10.8	9.5	NS	NS
	CO_2	4.8	8.0	10.1	10.9	NS	NS
C4a	O_2	NS	20.8	20.5	18.9	18.3	11.8
	CO_2	NS	0.10	0.20	0.30	0.20	2.0
C4b	O_2	10.1	8.0	6.2	5.3	NS	NS
	CO_2	12.0	10.8	12.2	12.0	NS	NS
C5c	O_2	14.0	13.0	13.0	11.4	NS	NS
	CO_2	8.0	8.9	9.2	9.3	NS	NS
C6a	O_2	20.5	20.2	18.8	17.8	15.5	9.8
	CO_2	0.20	0.80	0.80	1.1	0.90	1.8

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N12. In Situ Respiration Test: March 17 to 23, 1992

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)				
		0	3	19	49	137
A2b	O_2	14.9	10.4	9.2	1.4	1.4
	CO_2	13.0	10.8	11.5	13.9	16.1
A3a	O_2	18.6	17.6	12.2	6.1	4.8
	CO_2	6.1	6.4	8.4	10.0	13.9
A5c	O_2	9.0	8.8	7.8	6.5	NS
	CO_2	11.0	12.0	11.6	11.9	NS
A6a	O_2	7.8	8.6	5.6	4.2	1.9
	CO_2	13.1	13.0	13.8	12.9	14.6
P4b	O_2	20.9	20.9	20.3	18.5	16.5
	CO_2	<0.10	<0.10	<0.10	0.09	0.22
P4c	O_2	20.9	20.9	20.1	19.5	18.1
	CO_2	<0.10	<0.10	<0.10	0.12	0.22
P6a	O_2	20.9	20.9	20.0	19.4	17.1
	CO_2	<0.1	0.50	0.15	0.18	3.2
P6b	O_2	20.9	20.9	19.9	18.8	16.2
	CO_2	0.25	0.35	0.34	0.50	4.2
P6c	O_2	20.8	20.9	20.1	19.8	18.0
	CO_2	0.41	<0.1	0.43	0.41	4.2
C1b	O_2	8.8	8.8	7.1	7.1	4.0
	CO_2	11.8	11.8	11.0	10.9	18.3

Table N12. In Situ Respiration Test: March 17 to 23, 1992

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)				
		0	3	19	49	137
C2a	O_2	20.8	19.6	18.5	17.1	15.9
	CO_2	0.85	1.0	0.99	1.3	1.7
C6a	O_2	20.9	20.5	18.4	18.0	14.8
	CO_2	0.30	0.40	3.5	0.60	0.99
C6b	O_2	13.0	12.8	11.4	10.1	10.0
	CO_2	10.0	9.7	9.4	10.8	11.4
C6c	O_2	13.1	12.8	12.4	10.1	NS
	CO_2	9.9	9.5	8.8	10.0	NS

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N13. In Situ Respiration Test: April 18 to 23, 1992

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)							
		0	3	6	21	30	47	70	120
A3a	O_2	17.9	10.0	9.0	4.0	NS	NS	NS	NS
	CO_2	7.0	7.0	6.9	10.0	NS	NS	NS	NS
A4c	O_2	9.9	5.0	6.0	3.3	1.5	NS	NS	NS
	CO_2	11.8	9.4	9.1	12.6	12.7	NS	NS	NS
A5c	O_2	14.0	10.0	NS	8.2	8.0	6.1	3.7	NS
	CO_2	8.9	8.0	7.0	9.0	8.8	10.0	10.0	NS
A6a	O_2	NS	17.2	16.4	11.4	9.8	6.5	1.0	NS
	CO_2	NS	3.8	3.6	6.2	6.5	8.0	9.3	NS
A6b	O_2	NS	16.5	15.8	11.0	9.7	6.4	2.0	NS
	CO_2	NS	4.5	4.1	7.1	7.4	9.0	9.5	NS
A6c	O_2	NS	15.0	14.2	10.9	9.5	7.9	4.8	NS
	CO_2	NS	7.5	7.3	10.5	11.0	12.9	12.0	NS
P4b	O_2	20.9	20.8	20.3	19.8	19.3	18.8	17.7	16.1
	CO_2	<0.10	0.01	0.10	0.10	0.10	0.18	0.18	0.30
P4c	O_2	20.9	20.5	20.2	20.0	19.0	19.5	18.8	18.1
	CO_2	<0.10	0.15	0.15	0.13	0.13	0.20	0.20	0.20

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N13. In Situ Respiration Test: April 18 to 23, 1992 (continued)

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)							
		0	3	6	21	30	47	70	120
P5a	O_2	20.9	20.2	20.2	20.0	20.0	19.6	18.8	17.4
	CO_2	0.16	0.19	0.18	0.11	0.12	0.20	0.20	0.32
P6a	O_2	20.9	20.2	20.2	20.0	19.0	19.5	18.9	17.4
	CO_2	<0.10	0.20	0.20	0.17	0.17	0.24	0.24	0.35
P6b	O_2	20.5	20.1	20.0	20.0	19.6	19.0	NS	NS
	CO_2	0.26	0.45	0.42	0.35	0.38	0.45	NS	NS
P6c	O_2	20.3	NS	20.0	20.0	20.0	19.2	19.0	18.5
	CO_2	0.38	NS	0.50	0.58	0.58	0.72	0.70	0.56
C1b	O_2	10.3	6.3	6.3	5.0	4.9	4.4	NS	NS
	CO_2	8.0	8.5	8.2	11.0	11.1	12.5	NS	NS
C2a	O_2	19.2	19.2	18.3	18.0	17.0	16.2	15.3	14.0
	CO_2	1.2	0.90	1.2	1.4	2.2	2.4	1.9	4.0
C6a	O_2	NS	19.0	19.3	18.5	18.0	17.3	15.6	14.9
	CO_2	NS	0.38	0.45	0.36	0.50	0.55	0.60	1.0

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N14. In Situ Respiration Test: June 13 to 20, 1992

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)					
		0	3	27	50	101	169
A4c	O_2	10.0	6.0	7.5	5.7	4.6	7.9
	CO_2	12.5	14.8	13.9	14.8	15.1	13.9
A5c	O_2	15.6	8.8	8.0	7.8	8.6	8.9
	CO_2	7.9	11.7	11.4	12.1	12.1	11.8
P3c	O_2	20.6	19.4	12.4	8.9	6.5	6.0
	CO_2	0.69	0.14	0.31	0.55	1.0	2.4
P4b	O_2	20.9	19.8	14.1	10.7	4.0	0.9
	CO_2	0.12	0.10	0.46	0.70	1.7	2.4
P4c	O_2	20.9	18.6	10.5	7.6	4.2	2.9
	CO_2	0.20	0.25	0.70	1.1	2.1	3.6
P5b	O_2	20.9	19.8	15.1	11.7	5.0	1.4
	CO_2	0.20	0.20	0.55	0.80	2.0	2.6
P6c	O_2	20.4	17.9	7.6	4.1	NS	0.8
	CO_2	0.80	1.05	1.6	1.9	NS	3.7
C1c	O_2	20.9	19.0	18.2	17.3	16.6	15.6
	CO_2	0.30	1.8	2.5	2.9	5.3	7.0

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N15. In Situ Respiration Test: August 9 to 19, 1992

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)												
		0	4	7	9	11	22	36	45	57	69	81	93	117
A2b	O_2	16.0	13.0	12.0	10.0	5.0	2.1	2.0	0.75	—	—	—	—	—
	CO_2	3.0	3.5	4.0	4.0	4.0	4.0	4.2	4.5	—	—	—	—	—
A3a	O_2	17.0	15.0	14.0	12.0	7.0	3.8	3.0	—	—	—	—	—	—
	CO_2	1.8	2.0	2.0	3.0	3.1	3.0	4.0	—	—	—	—	—	—
A6a	O_2	16.0	15.0	9.0	13.5	10.5	7.5	5.0	3.0	0.5	—	—	—	—
	CO_2	4.5	4.5	8.0	4.8	5.0	4.8	6.1	5.3	6.1	—	—	—	—
A6b	O_2	14.0	12.0	8.0	11.0	8.0	6.0	4.5	3.2	1.8	—	—	—	—
	CO_2	5.1	6.0	5.5	6.0	6.1	6.0	7.1	6.3	6.9	—	—	—	—
P1a	O_2	20.0	19.5	19.0	19.0	17.5	16.0	15.0	14.0	12.0	11.5	10.5	5.0	4.5
	CO_2	0.6	1.0	0.75	1.5	1.0	1.0	1.6	0.05	1.1	0.5	1.2	1.0	1.1
P1b	O_2	20.0	20.0	19.5	19.0	18.0	16.0	15.0	13.0	12.8	11.0	10.0	5.0	3.0
	CO_2	0.6	0.75	0.5	1.0	0.8	0.5	1.1	0.5	0.8	0.8	1.1	1.0	1.3
P1c	O_2	18.0	17.0	17.0	16.0	13.0	11.0	10.0	9.5	9.5	9.0	7.5	5.0	4.0
	CO_2	1.6	1.6	1.5	2.0	1.8	1.8	2.5	2.0	4.5	3.0	3.0	3.2	3.5
P2b	O_2	19.0	18.0	18.0	17.0	14.2	12.0	11.0	9.5	8.8	6.5	6.0	1.8	—
	CO_2	1.7	1.75	1.5	2.1	2.5	2.2	2.8	2.5	3.2	3.5	3.5	3.2	—
P2c	O_2	18.0	17.5	17.0	17.0	14.5	13.0	12.1	10.5	9.0	8.0	5.0	3.5	—
	CO_2	2.0	1.6	1.5	2.0	2.0	1.5	1.4	1.1	2.5	2.5	2.4	2.6	—
P3a	O_2	20.0	17.0	19.0	18.2	16.0	13.5	11.2	10.0	8.8	7.5	6.0	2.0	—
	CO_2	0.7	0.6	0.5	0.9	1.0	1.0	0.8	0.2	1.8	2.1	2.5	2.5	—
P3b	O_2	19.5	18.0	18.0	17.8	14.0	12.0	10.0	8.5	8.0	6.2	5.2	1.5	—

Table N15. In Situ Respiration Test: August 9 to 19, 1992

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)												
		0	4	7	9	11	22	36	45	57	69	81	93	117
	CO_2	0.5	0.5	0.5	1.0	1.1	1.2	1.3	0.9	2.5	3.0	3.2	3.4	—
P3c	O_2	19.5	18.5	18.1	18.0	15.5	14.2	13.0	12.5	11.5	10.7	—	5.5	—
	CO_2	0.7	0.6	1.5	1.0	0.8	0.5	1.0	0.05	1.0	1.2	—	1.7	—

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N15. In Situ Respiration Test: August 9 to 19, 1992 (continued)

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)												
		0	4	7	9	11	22	36	45	57	69	81	93	117
P4a	O_2	20.2	20.0	19.5	19.0	17.0	16.2	14.9	14.0	13.0	15.5	12.5	10.7	7.0
	CO_2	0.2	0.3	0.05	0.5	0.8	0.6	1.3	0.5	1.0	0.05	0.7	0.7	1.1
P4b	O_2	19.5	17.5	17.2	16.0	13.0	13.5	7.0	6.0	5.0	5.0	4.0	—	—
	CO_2	0.5	1.0	0.6	1.5	1.9	0.8	3.1	2.6	3.2	2.5	4.0	—	—
P5a	O_2	20.2	20.0	20.0	20.0	19.0	18.0	17.5	17.6	16.8	16.5	15.0	12.5	9.5
	CO_2	0.5	0.5	0.05	1.5	1.0	0.5	1.0	0.2	0.7	0.05	0.7	0.9	1.0
P5b	O_2	18.5	17.0	16.5	15.5	11.0	8.8	6.5	6.0	4.0	3.5	3.0	—	—
	CO_2	1.5	0.75	1.5	2.0	3.0	3.0	4.1	3.5	4.0	4.5	4.2	—	—
P5c	O_2	19.0	18.5	18.2	18.0	15.5	13.0	11.2	10.5	8.8	7.5	7.0	2.5	—
	CO_2	1.2	1.5	1.1	1.3	1.5	1.5	2.0	1.2	1.7	2.0	1.7	1.9	—
P6b	O_2	18.0	17.0	17.5	15.5	15.5	13.0	12.5	12.0	12.5	12.0	6.0	2.5	—
	CO_2	2.5	2.5	2.2	2.7	3.0	2.5	3.1	2.3	2.5	2.8	3.0	2.8	—
P6c	O_2	18.0	17.0	16.0	15.5	13.0	11.0	8.5	6.0	4.5	4.5	2.5	—	—
	CO_2	2.5	2.5	2.2	2.7	3.0	2.2	3.0	2.0	3.0	3.0	3.0	—	—
C1b	O_2	18.5	18.0	17.0	14.0	12.5	9.5	8.0	5.0	2.8	2.0	—	—	—
	CO_2	1.3	1.8	1.3	1.8	2.5	2.0	2.8	2.3	3.0	2.8	—	—	—
C1c	O_2	18.0	18.0	18.0	17.5	16.0	15.0	15.0	15.0	15.0	—	16.0	14.5	14.5
	CO_2	3.2	3.5	2.9	3.0	4.0	3.2	3.9	3.0	5.7	—	3.1	2.8	3.0
C2a	O_2	20.0	20.0	20.0	20.0	20.0	18.0	17.0	16.5	15.4	15.0	14.0	11.0	8.2
	CO_2	0.3	0.5	0.05	0.2	1.0	0.5	0.7	0.05	0.6	0.05	0.5	0.8	1.1
C2c	O_2	19.5	19.0	19.5	19.0	17.5	16.0	16.1	17.0	16.2	16.0	16.2	16.2	16.0

Table N15. In Situ Respiration Test: August 9 to 19, 1992 (continued)

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)												
		0	4	7	9	11	22	36	45	57	69	81	93	117
	CO_2	1.5	1.8	1.1	1.5	2.0	1.9	2.0	0.8	1.7	2.2	2.0	1.8	1.9
C3b	O_2	18.0	17.0	16.5	15.5	11.8	8.5	6.0	4.0	—	—	—	—	—
	CO_2	0.75	1.0	0.9	1.1	1.1	1.0	1.8	1.2	—	—	—	—	—
C3c	O_2	20.0	19.5	19.2	19.0	17.0	16.0	15.8	16.0	16.0	16.0	16.0	15.0	14.5
	CO_2	1.0	1.0	0.7	1.1	0.6	1.2	1.8	1.2	1.5	2.0	1.5	1.6	1.9

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N15. In Situ Respiration Test: August 9 to 19, 1992 (continued)

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)												
		0	4	7	9	11	22	36	45	57	69	81	93	117
C4b	O_2	16.0	16.0	16.0	15.0	10.0	8.5	7.5	3.3	—	—	—	—	—
	CO_2	2.0	3.5	2.0	2.8	2.0	2.5	3.5	2.8	—	—	—	—	—
C4c	O_2	19.0	19.0	19.0	19.0	17.0	16.0	15.5	15.6	15.0	15.0	14.8	13.5	13.6
	CO_2	1.6	1.6	1.2	1.7	1.5	2.0	2.5	1.0	2.5	1.5	2.5	2.8	2.8
C5c	O_2	18.0	18.0	18.0	17.8	16.0	14.5	14.0	14.0	13.0	13.0	13.0	11.0	—
	CO_2	2.3	2.0	2.2	2.8	3.2	3.0	4.0	2.2	2.2	3.8	2.2	3.5	—
C6b	O_2	20.0	19.0	18.7	18.0	16.0	14.0	12.5	11.3	10.5	9.5	8.8	7.0	5.5
	CO_2	1.0	1.2	1.0	1.5	2.0	1.5	2.5	2.0	2.8	1.9	3.1	3.0	4.0
C6c	O_2	20.0	18.0	17.5	17.5	16.0	14.8	14.0	13.5	13.5	12.5	13.0	11.2	11.0
	CO_2	1.2	2.3	3.0	2.5	2.5	2.6	3.5	2.8	3.2	2.5	3.8	3.4	3.5

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N16. In Situ Respiration Test: October 30 to November 12, 1992

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)									
		0	2.62	6.62	9.37	26.20	49.45	97.70	147	194	244
A7a	9.O	9.0	9.0	8.0	0.5	0	—	—	—	—	—
	CO_2	7.3	7.2	6.8	16.3	15.5	—	—	—	—	—
P1a	O_2	20.0	20.2	19.8	18.6	17.6	15.0	11.5	9.5	8.2	—
	CO_2	0.5	0.6	0.6	0.5	0.5	0.7	0.8	1.0	1.2	1.3
P1b	O_2	20.2	20.3	20.3	19.3	18.3	16.3	14.0	12.5	10.8	8.8
	CO_2	0.3	0.5	0.5	0.3	0.4	0.7	0.8	0.9	1.2	1.2
P1c	O_2	19.8	19.6	19.5	19.0	19.3	18.0	16.8	16.5	15.5	15.0
	CO_2	0.8	0.9	0.9	0.8	0.8	1.0	1.0	1.2	1.3	1.2
P2a	O_2	20.2	20.3	20.0	19.0	18.0	16.2	13.2	11.3	11.3	7.5
	CO_2	0.3	0.5	0.5	0.5	0.5	0.8	0.9	1.2	1.3	1.6
P2b	O_2	20.0	19.8	19.8	18.8	17.5	15.0	12.2	10.8	8.8	8.0
	CO_2	0.9	1.0	1.0	1.2	1.3	1.8	2.0	2.2	2.3	2.5
P2c	O_2	20.0	20.3	19.8	19.3	18.8	18.0	16.5	16.0	15.0	14.8
	CO_2	0.9	0.7	0.9	0.8	0.9	1.0	1.0	1.0	1.0	1.0
P3a	O_2	20.3	20.3	20.0	18.3	16.8	13.2	10.3	9.0	6.8	6.0
	CO_2	0.1	0.2	0.3	0.3	0.5	1.0	1.5	2.0	2.6	3.0
P3b	O_2	20.3	20.2	20.0	18.2	16.5	12.8	10.0	8.8	6.0	—
	CO_2	0.1	0.1	0.1	0.2	0.5	1.2	1.8	2.5	3.2	—
P3c	O_2	20.3	20.3	20.0	19.5	19.5	18.5	17.0	16.3	14.0	—
	CO_2	0.2	0.2	0.3	0.3	0.2	0.3	0.3	0.5	0.6	—

Table N16. In Situ Respiration Test: October 30 to November 12, 1992

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)									
		0	2.62	6.62	9.37	26.20	49.45	97.70	147	194	244
P4a	O_2	20.3	20.2	20.0	18.8	17.2	14.0	11.0	9.2	6.2	4.2
	CO_2	0.1	0.2	0.3	0.5	0.6	1.0	1.3	1.8	2.2	2.8
P4b	O_2	20.0	19.5	19.3	16.6	13.6	9.0	5.5	4.5	3.2	2.5
	CO_2	0.2	0.5	0.5	0.8	1.3	2.5	3.3	4.0	4.5	5.2
P4c	O_2	20.3	20.3	20.0	19.5	19.3	17.5	16.3	15.0	13.8	—
	CO_2	0.2	0.3	0.3	0.3	0.2	0.6	0.5	0.7	0.8	—

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N16. In Situ Respiration Test: October 30 to November 12, 1992 (continued)

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)									
		0	2.62	6.62	9.37	26.20	49.95	97.70	147	194	244
P5a	O_2	20.3	20.0	20.0	19.2	18.0	15.8	13.0	11.0	8.8	6.2
	CO_2	0.2	0.3	0.3	0.5	0.7	0.9	1.0	1.3	1.8	2.0
P5b	O_2	20.0	20.3	19.0	16.8	14.5	10.3	7.0	5.8	4.0	4.0
	CO_2	0.7	0.9	0.9	1.2	1.8	2.8	3.6	4.2	4.5	5.0
P5c	O_2	20.2	20.0	20.0	19.5	19.2	17.3	15.5	14.5	13.0	12.5
	CO_2	0.6	0.6	0.7	0.7	0.7	0.9	1.0	1.0	1.2	1.2
P6a	O_2	20.0	20.0	20.0	19.0	18.2	16.0	13.8	12.2	10.0	9.0
	CO_2	0.5	0.5	0.6	0.7	0.8	1.0	1.2	1.5	1.8	2.0
P6b	O_2	18.8	19.0	18.5	17.0	16.5	11.5	9.6	9.0	5.2	—
	CO_2	2.2	1.8	2.0	2.3	2.2	3.2	3.2	3.5	3.8	—
P6c	O_2	19.5	19.5	19.5	19.0	18.8	17.2	15.0	14.3	12.8	12.0
	CO_2	1.5	1.5	1.5	1.5	1.5	1.6	1.7	1.6	1.8	1.8
P7a	O_2	20.0	20.3	20.5	20.5	20.8	18.5	18.5	19.5	14.0	—
	CO_2	0.2	0.1	0.1	0.1	0.05	0.5	0.3	0.3	1.5	—
P7b	O_2	20.5	20.5	20.5	20.9	20.9	20.0	19.8	20.3	17.0	—
	CO_2	0.1	0.1	0.1	0.05	0.05	0.1	0.1	0.2	0.3	—
P7c	O_2	20.9	20.8	20.8	20.9	20.9	20.6	20.2	20.5	19.8	—
	CO_2	0.05	0.05	0.05	0.05	0.05	0.1	0.1	0.2	0.3	—

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N16. In Situ Respiration Test: October 30 to November 12, 1992 (continued)

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)									
		0	4.53	7.36	10.2	27.8	51.4	98	147	194	244
C1a	O_2	20.2	20.0	19.5	19.0	18.0	14.8	10.8	9.0	5.5	5.0
	CO_2	0.6	0.8	0.8	0.9	0.8	1.5	1.8	2.0	2.6	2.8
C1b	O_2	19.0	18.0	17.8	16.5	15.0	11.0	8.0	6.2	4.0	2.0
	CO_2	1.3	1.8	1.8	2.0	2.2	2.8	3.0	3.2	3.5	3.8
C1c	O_2	18.0	17.6	17.5	17.5	17.0	14.8	12.8	12.5	11.5	9.2
	CO_2	2.8	3.3	2.3	3.8	4.2	5.0	4.6	4.6	3.6	4.3
C2a	O_2	20.0	20.0	19.6	19.0	18.0	14.8	11.6	9.0	6.0	3.5
	CO_2	0.6	0.7	0.7	0.8	0.8	1.3	1.5	2.0	2.5	2.8
C2c	O_2	20.0	19.8	19.5	19.0	18.5	16.8	14.3	14.0	11.2	—
	CO_2	0.6	0.9	0.9	1.2	1.5	2.2	2.5	2.5	3.0	—
C3c	O_2	20.2	20.0	19.6	19.8	19.0	17.5	15.3	14.3	12.5	12.0
	CO_2	0.6	0.7	0.7	0.7	0.8	1.3	1.7	1.8	2.2	2.2
C4c	O_2	19.5	19.2	19.0	19.0	18.5	16.2	13.2	12.8	9.5	9.0
	CO_2	1.3	1.3	1.3	1.6	2.2	3.2	3.5	3.5	4.0	3.8
C5b	O_2	17.0	17.0	16.8	16.2	15.0	12.0	10.0	8.5	7.0	5.5
	CO_2	3.3	3.3	3.3	3.3	3.5	3..8	3.8	4.0	4.2	4.5
C5c	O_2	18.0	18.0	17.5	18.0	17.2	15.5	12.3	10.8	9.2	8.5
	CO_2	3.0	3.0	3.2	2.8	3.5	4.0	4.0	4.3	4.5	4.5
C6a	O_2	20.0	20.0	19.5	19.0	17.5	15.0	11.5	8.6	6.0	3.0
	CO_2	0.8	0.7	0.8	0.8	1.0	1.7	2.0	2.5	3.0	3.5

Table N16. In Situ Respiration Test: October 30 to November 12, 1992 (continued)

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)									
		0	4.53	7.36	10.2	27.8	51.4	98	147	194	244
C6b	O_2	18.0	18.3	18.0	17.8	16.8	14.5	12.2	11.0	9.3	8.5
	CO_2	2.3	2.2	2.3	2.3	2.5	3.2	3.3	3.8	4.0	4.2
C6c	O_2	17.5	17.5	17.5	17.5	16.8	15.0	13.2	12.0	10.0	9.5
	CO_2	3.0	2.8	2.9	2.9	3.2	3.6	3.6	3.8	4.0	4.2
C7b	O_2	20.3	20.3	20.3	20.8	20.9	17.0	18.3	—	12.0	—
	CO_2	0.05	0.1	0.1	0.1	0.1	0.5	0.5	—	0.8	—
C8a	O_2	20.5	20.0	20.0	19.8	19.8	16.5	14.3	12.8	9.8	—
	CO_2	0.1	0.1	0.2	0.2	0.3	0.5	0.6	0.8	1.0	—
C8b	O_2	20.5	20.2	20.0	20.	19.3	16.8	14.5	12.8	10.5	9.5
	CO_2	0.1	0.1	0.2	0.1	0.1	0.5	0.5	0.8	1.0	1.0

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N16. In Situ Respiration Test: October 30 to November 12, 1992 (continued)

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)									
		0	4.53	7.36	10.2	27.8	51.4	98	147	194	244
C2a	O_2	20.0	20.0	19.6	19.0	18.0	14.8	11.6	9.0	6.0	3.5
	CO_2	0.6	0.7	0.7	0.8	0.8	1.3	1.5	2.0	2.5	2.8
C2c	O_2	20.0	19.8	19.5	19.0	18.5	16.8	14.3	14.0	11.2	—
	CO_2	0.6	0.9	0.9	1.2	1.5	2.2	2.5	2.5	3.0	—
C3c	O_2	20.2	20.0	19.6	19.8	19.0	17.5	15.3	14.3	12.5	12.0
	CO_2	0.6	0.7	0.7	0.7	0.8	1.3	1.7	1.8	2.2	2.2
C4c	O_2	19.5	19.2	19.0	19.0	18.5	16.2	13.2	12.8	9.5	9.0
	CO_2	1.3	1.3	1.3	1.6	2.2	3.2	3.5	3.5	4.0	3.8
C5b	O_2	17.0	17.0	16.8	16.2	15.0	12.0	10.0	8.5	7.0	5.5
	CO_2	3.3	3.3	3.3	3.3	3.5	3..8	3.8	4.0	4.2	4.5
C5c	O_2	18.0	18.0	17.5	18.0	17.2	15.5	12.3	10.8	9.2	8.5
	CO_2	3.0	3.0	3.2	2.8	3.5	4.0	4.0	4.3	4.5	4.5
C6a	O_2	20.0	20.0	19.5	19.0	17.5	15.0	11.5	8.6	6.0	3.0
	CO_2	0.8	0.7	0.8	0.8	1.0	1.7	2.0	2.5	3.0	3.5
C6b	O_2	18.0	18.3	18.0	17.8	16.8	14.5	12.2	11.0	9.3	8.5
	CO_2	2.3	2.2	2.3	2.3	2.5	3.2	3.3	3.8	4.0	4.2
C6c	O_2	17.5	17.5	17.5	17.5	16.8	15.0	13.2	12.0	10.0	9.5
	CO_2	3.0	2.8	2.9	2.9	3.2	3.6	3.6	3.8	4.0	4.2
C7b	O_2	20.3	20.3	20.3	20.8	20.9	17.0	18.3	—	12.0	—
	CO_2	0.05	0.1	0.1	0.1	0.1	0.5	0.5	—	0.8	—

Table N16. In Situ Respiration Test: October 30 to November 12, 1992 (continued)

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)									
		0	4.53	7.36	10.2	27.8	51.4	98	147	194	244
C8a	O_2	20.5	20.0	20.0	19.8	19.8	16.5	14.3	12.8	9.8	—
	CO_2	0.1	0.1	0.2	0.2	0.3	0.5	0.6	0.8	1.0	—
C8b	O_2	20.5	20.2	20.0	20.	19.3	16.8	14.5	12.8	10.5	9.5
	CO_2	0.1	0.1	0.2	0.1	0.1	0.5	0.5	0.8	1.0	1.0

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N16. In Situ Respiration Test: October 30 to November 12, 1992 (continued)

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)										
		0	4.78	7.70	10.6	28.2	32.0	52.7	57.1	99.4	148	195
S1a	O_2	19.8	19.0	18.0	13.8	13.0	7.0	7.3	0	0	—	—
	CO_2	0.2	0.3	0.5	0.8	1.0	1.6	1.6	2.8	3.0	—	—
S1b	O_2	18.0	15.0	13.6	9.8	6.2	7.2	6.5	1.5	1.0	—	—
	CO_2	1.3	1.3	1.5	2.2	2.8	2.5	2.8	4.0	4.8	—	—
S1c	O_2	18.8	18.2	17.5	16.2	17.2	15.0	—	11.8	10.8	8.5	5.3
	CO_2	0.8	0.8	0.8	1.3	1.2	1.8	—	2.8	3.3	4.0	4.8
S2a	O_2	19.8	19.2	18.5	16.5	15.5	12.5	11.2	0.5	0	—	—
	CO_2	0.1	0.2	0.3	0.5	0.6	0.8	0.8	2.0	2.5	—	—
S2b	O_2	18.5	15.0	14.0	12.5	13.0	10.8	11.3	4.5	1.8	—	—
	CO_2	1.9	3.6	4.8	4.5	5.0	5.5	6.3	8.0	8.2	—	—
S3a	O_2	20.0	19.3	19.0	18.2	18.2	17.6	18.5	3.5	—	—	—
	CO_2	0.05	0.1	0.1	0.1	0.2	0.4	0.5	1.3	—	—	—
S4a	O_2	19.5	18.8	18.3	17.0	15.6	13.0	13.6	13.0	3.0	—	—
	CO_2	0.2	0.3	0.5	0.5	0.6	0.7	0.7	1.3	1.8	—	—
S4b	O_2	19.0	17.3	16.0	15.0	14.0	12.5	-	11.0	10.0	10.5	8.0
	CO_2	1.0	1.2	1.3	1.2	1.5	1.6	-	2.0	2.3	2.3	3.2
S4c	O_2	17.5	17.0	16.5	16.0	16.2	15.0	-	14.2	13.2	-	-
	CO_2	1.5	1.6	2.2	2.0	2.2	2.3	-	3.0	3.5	-	-
S5c	O_2	7.0	8.2	7.5	5.5	4.2	2.5	-	1.6	-	-	-
	CO_2	8.0	8.2	8.0	15.8	17.0	9.3	-	10.0	-	-	-
S6a	O_2	18.2	17.3	16.3	12.5	13.0	8.2	-	-	-	-	-

Table N16. In Situ Respiration Test: October 30 to November 12, 1992 (continued)

Sample		Concentration of Oxygen and Carbon Dioxide (%) over Time (Hours)										
		0	4.78	7.70	10.6	28.2	32.0	52.7	57.1	99.4	148	195
	CO_2	1.6	2.2	2.3	3.2	3.2	3.7	-	-	-	-	-

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N17. In Situ Respiration Test: January 13 through 24, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0	2.2	5.9	31	56	73	94	137	258
A2b	O_2	20.5	18	16	7.6	0	0	NS	NS	NS
	CO_2	1.5	1.8	1.8	2.8	3.5	3.8	NS	NS	NS
A4b	O_2	17	17	17	11	3.2	0	NS	NS	NS
	CO_2	3.8	3.8	3.8	4.2	5	5.8	NS	NS	NS
A4c	O_2	10.2	10.6	11.8	11.8	9	8	7.80	9.8	12.7
	CO_2	7.2	7.3	7.2	7	7	7.2	7.50	7.2	6.5
A5c	O_2	16.5	17.2	17.8	17.5	14.2	15.2	15	15	18
	CO_2	3.5	3.5	2.5	3	3.6	3.3	3.7	3.5	2.2
A6a	O_2	19.5	19	18.8	16.3	12.8	10.5	6.5	1	NS
	CO_2	1.6	1.7	2.5	2	2.3	2.6	3	8.8	NS
A6b	O_2	19.5	18.5	18	14.5	10.5	9	6.5	2.2	NS
	CO_2	1.8	2	2	2.5	2.9	3.2	3.3	3.8	NS
A6c	O_2	18.5	17.3	16	12.3	13	11	6.3	4.5	NS
	CO_2	2.3	2.6	2.8	3.6	3	3.7	4.5	5	NS
A7a	O_2	19.8	17.8	16	NS	NS	NS	NS	NS	NS
	CO_2	2	3	3.8	NS	NS	NS	NS	NS	NS
A7c	O_2	11	11.5	13.5	15	12.5	12.5	10.5	9.8	NS
	CO_2	6.2	6	5.5	5	5.2	5.2	5.8	5.8	NS
A8c	O_2	0	0.5	0.1	6	0	4	NS	NS	NS
	CO_2	5.8	6	16.2	5.2	6.3	6.3	NS	NS	NS

Table N18. In Situ Respiration Test: January 13 through 24, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0	2.42	5.5	31.17	56	73.17	106.17	148.92	269.83
P1a	O_2	20.9	20.5	20.3	19	17.5	16.5	15.5	13	9.5
	CO_2	0.05	0.05	0.05	0.05	0.1	0.1	0.3	0.3	0.5
P1b	O_2	20.9	20.7	20.5	19.5	18.8	18	18	15.8	12.5
	CO_2	0.05	0.05	0.05	0.05	0.05	0.1	0.2	1	0.2
P1c	O_2	20.9	20.5	20	19.2	18.5	18	17.2	16	14.5
	CO_2	0.1	0.1	0.2	0.2	0.2	0.3	0.5	3	0.5
P2b	O_2	20.9	20.3	20.2	19	18	17	15.5	13.8	11
	CO_2	0.2	0.2	0.3	0.3	0.6	0.7	0.8	0.8	1
P3a	O_2	20.9	20.9	20.5	19	17.2	16.5	15	11.3	7.2
	CO_2	0.05	0.05	0.05	0.05	0.1	0.2	0.4	0.5	1.6
P3c	O_2	20.9	20.5	20	19.3	18.2	17.2	16.2	16	14
	CO_2	0.05	0.05	0.1	0.05	0.1	0.3	0.2	0.1	0.2
P4a	O_2	20.9	20.5	20	18.6	17.2	16.2	14.2	11.2	7.5
	CO_2	0.2	0.1	0.1	0.3	0.5	0.7	0.9	1.2	2
P4b	O_2	20.9	20.5	20	17.2	14.5	13.2	13.5	14.2	9
	CO_2	0.1	0.1	0.2	0.6	1	1.3	1.5	1.3	3
P4c	O_2	20.9	20.2	20	18.2	16.8	16	15	14.2	12
	CO_2	0.2	0.1	0.2	0.3	0.5	0.6	0.7	0.7	1
P5a	O_2	20.9	20.5	20.2	19	17.5	17	16	13	8.5
	CO_2	0.1	0.1	0.1	0.3	0.6	0.8	0.9	1.2	1.8

Table N18. In Situ Respiration Test: January 13 through 24, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0	2.42	5.5	31.17	56	73.17	106.17	148.92	269.83
P5b	O_2	20.9	20	19.5	17	14.8	13	11.5	9.5	7.5
	CO_2	0.5	0.3	0.6	0.9	1.2	1.9	2.3	3	3.9
P5c	O_2	20.5	20	20	18.6	17.2	16.5	15.5	13.5	11.2
	CO_2	0.7	0.06	0.7	0.7	0.8	1	1	1	1.2
P6a	O_2	20.9	20.5	20.2	18.8	18	17.2	16	13.8	9
	CO_2	0.05	0.05	0.1	1.3	0.3	0.5	0.7	0.8	1.2

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N18. In Situ Respiration Test: January 13 through 24, 1993 (continued)

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0	2.42	5.5	31.17	56	73.17	106.17	148.92	269.83
P6c	O_2	20.2	19.8	19.5	18.8	17.8	17	15.8	14.5	11
	CO_2	1.3	1.2	1.3	1.3	1.5	1.5	1.8	1.6	1.8
P7a	O_2	20.9	20.9	20.7	20.5	20.5	19.5	19	19.5	15.5
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.05	0.1
P7b	O_2	20.9	20.9	20.7	20.3	20.2	20	19	19	17
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
P7c	O_2	20.9	20.9	20.7	20	20	19.5	19	20	19.2
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.1	0.2
P8b	O_2	13.2	13.3	12.5	12.5	11.2	11.5	9	8	8.5
	CO_2	7.2	6.8	7.2	7	7.3	6.8	7.5	7.8	7.5
P8c	O_2	13.5	13.5	14.5	14	13.2	11.5	10.5	10.6	15
	CO_2	7.3	7.2	7	7	7	7.2	7	7.2	4.8

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N19. In Situ Respiration Test: January 13 through 24, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0	4.5	7.83	33.17	59	75.17	107.17	150.25	271.5
S1a	O_2	20.8	20	19.2	16	10.5	5.3	1	NS	NS
	CO_2	0.05	0.1	0.5	0.8	1.2	2	2.2	NS	NS
S1b	O_2	13.5	11	8	1.5	0	4.5	0	NS	NS
	CO_2	6.5	6.3	7.2	7.8	8.2	7.3	9.2	NS	NS
S1c	O_2	13	8.5	13	10.5	8	10	14	4.8	NS
	CO_2	7	9.5	7.8	8.5	9.5	8.5	5.8	10.5	NS
S2a	O_2	20.9	20	19	13.2	9	3.5	NS	NS	NS
	CO_2	0.05	0.1	0.2	0.8	1.2	1.8	NS	NS	NS
S2b	O_2	3.5	3.5	NS	3	1.5	2.8	NS	NS	NS
	CO_2	13.5	7.8	NS	18.5	12	11	NS	NS	NS
S2c	O_2	16	13.5	17	15.5	15	13.3	12.5	5.8	NS
	CO_2	5	7	4.2	5.5	6	7	7	12	NS
S3a	O_2	20.9	20	19.3	NS	NS	NS	NS	NS	NS
	CO_2	0.05	0.05	0.1	NS	NS	NS	NS	NS	NS
S3b	O_2	NS	NS	NS	NS	0	0	NS	NS	NS
	CO_2	NS	NS	NS	NS	10	9.3	NS	NS	NS
S3c	O_2	0	20.5	5.2	0.5	1.5	1	NS	NS	NS
	CO_2	14	0.5	13	14	14.5	13.5	NS	NS	NS
S4a	O_2	20.9	19.8	19.2	17	14	NS	NS	NS	NS
	CO_2	0.05	0.05	0.1	0.2	0.5	NS	NS	NS	NS

Table N19. In Situ Respiration Test: January 13 through 24, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0	4.5	7.83	33.17	59	75.17	107.17	150.25	271.5
S4b	O_2	17.2	15.3	16.3	14	13	13.5	11.5	11.5	9.8
	CO_2	3.2	3.8	3.8	4	4.8	4.3	5.2	5.2	6
S4c	O_2	15.5	14.5	17	16.5	16.5	15.8	16.2	16.2	17.3
	CO_2	5.2	5.5	4.5	4.5	4.5	4.9	4.2	4.5	4
S5a	O_2	20	19	NS	NS	NS	NS	NS	NS	NS
	CO_2	0.8	0.8	NS	NS	NS	NS	NS	NS	NS

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N19. In Situ Respiration Test: January 13 through 24, 1993 (continued)

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0	4.5	7.83	33.17	59	75.17	107.17	150.25	271.5
S5b	O_2	12.3	10.5	7.5	2.5	0	1	NS	NS	NS
	CO_2	6.2	6.8	7.8	8.8	7.8	7.3	NS	NS	NS
S5c	O_2	4.5	3.5	9	7.2	5	3	NS	NS	NS
	CO_2	11.5	12	10.8	11.5	12.5	13.5	NS	NS	NS
S6a	O_2	18.5	15.5	NS	NS	NS	NS	NS	NS	NS
	CO_2	2.2	2.8	NS	NS	NS	NS	NS	NS	NS
S6b	O_2	0	1	0	0	0	1	NS	NS	NS
	CO_2	14	11.5	12.8	12.8	12.2	11.5	NS	NS	NS
S6c	O_2	18.5	19.5	20	20	19.8	19.5	18.5	17.5	17.5
	CO_2	3.5	1.5	1.8	0.7	1	2.5	3	4	4

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N20. In Situ Respiration Test: January 13 through 24, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0	4.17	7.5	32.92	58.67	86.83	106.92	151	272.17
C1a	O_2	20.5	20.5	20	20	18	17.2	15.5	15	9.8
	CO_2	0.2	0.3	0.5	0.6	0.7	0.9	1	1	1.8
C1b	O_2	19.8	19.2	18.8	17.5	15.8	14.8	13.2	11	7.2
	CO_2	1.2	1.2	1.2	1.5	1.7	1.9	2	2.2	2.8
C1c	O_2	18.5	18	18.5	18.5	18.5	18	17.2	18.2	18
	CO_2	2.3	2.8	2.7	2.6	2.5	2.8	2.8	2.2	2.2
C2a	O_2	20.5	20.2	20	19.2	18.5	17.8	16.2	3.6	NS
	CO_2	0.4	0.5	0.5	0.6	0.6	0.8	0.9	7	NS
C2c	O_2	20.5	20.5	20	20	20	19.5	18.8	19	NS
	CO_2	0.6	0.6	0.6	0.6	0.6	0.7	0.8	7	NS
C5b	O_2	17.8	17.5	17.5	16.8	15.6	14.6	12.5	12.6	9.5
	CO_2	3.5	3.5	3.5	2.5	3.5	3.8	3.8	3.5	4
C6a	O_2	20.5	20	20	19	18	17	15.5	13.5	9.2
	CO_2	0.7	0.7	0.8	0.8	0.9	1.2	1.3	1.7	2.5
C6b	O_2	19.5	19.2	19	18.5	18.2	16.5	15	16.2	12.5
	CO_2	1.3	1.5	1.5	1.5	1.3	2	2.3	2	5
C6c	O_2	19.5	19.2	19	NS	NS	NS	NS	NS	NS
	CO_2	1.5	1.3	1.6	NS	NS	NS	NS	NS	NS
C7b	O_2	20.9	20.5	20.2	20	19.8	19	17	20.2	16
	CO_2	0.05	0.05	0.05	0.05	0.1	0.1	0.2	0.2	0.5
C7c	O_2	20.9	20.9	20.5	20.7	20.7	19.2	18.8	20.7	20.5

Table N20. In Situ Respiration Test: January 13 through 24, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0	4.17	7.5	32.92	58.67	86.83	106.92	151	272.17
	CO_2	0.05	0.05	0..05	0.05	0.05	0.1	0.2	0.1	0.1
C8a	O_2	20.9	20.5	20.2	19.5	19	NS	NS	NS	NS
	CO_2	0.05	0.05	0.05	0.1	0.1	NS	NS	NS	NS
C8b	O_2	20.9	20.9	20.2	19.8	19.5	18.5	17.2	17	14
	CO_2	0.1	0.05	0.05	0.1	0.1	1	0.3	0.3	0.5
C8c	O_2	20.9	20.9	20.5	20.2	20.3	20	19.3	20.5	20.5
	CO_2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N21. In Situ Respiration Test: January 13 through 24, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0	2.17	5.92	30.83	55.67	72.83	93.83	136.50	257.67
B2a	O_2	20.9	20.9	20.7	20.5	20.5	20.7	20.7	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
B2b	O_2	20.9	20.9	20.7	20.5	20.9	20.7	20.7	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
B2c	O_2	20.9	20.9	20.7	20.5	20.5	20.9	20.9	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N22. In Situ Respiration Test in the Active Warming Test Plot: February 24 through March 3, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		0.00	2.00	4.00	45.67	70.5	118	165	189
A2b	O_2	19.2	18.5	17.8	11.2	1.7	0.5	0	0
	CO_2	0.8	1.0	1.0	1.3	1.9	2.2	2.6	2.6
A2c	O_2	19.5	19.0	18.2	14.8	8.5	6.0	4.8	4.3
	CO_2	1.5	1.6	1.8	2.2	2.6	2.8	3.0	3.0
A4b	O_2	16.0	16.2	15.4	11.2	1.3	0	0	0
	CO_2	4.7	4.8	4.8	4.9	6.5	7.3	8.2	8.2
A4c	O_2	14.0	14.2	14.0	13.0	11.1	11.0	12.2	11.0
	CO_2	6.8	6.8	6.8	6.6	6.5	6.2	6.0	6.2
A5c	O_2	17.3	17.2	17.2	16.2	14.9	15.0	15.3	15.0
	CO_2	3.2	3.5	3.4	3.2	3.5	3.6	3.5	3.5
A6a	O_2	18.0	18.0	18.0	16.3	12.0	9.5	6.5	5.2
	CO_2	2.7	2.8	2.8	3.0	3.5	3.8	4.2	4.2
A6b	O_2	17.2	17.5	17.0	15.3	12.0	10.3	8.3	7.3
	CO_2	3.3	3.3	3.4	3.7	4.0	4.2	6.5	4.8
A6c	O_2	16.0	15.8	15.5	15.0	12.8	12.0	12.0	11.5
	CO_2	4.3	4.8	4.8	4.8	5.2	5.2	5.3	5.3
A7c	O_2	10.0	10.5	11.0	11.0	10.2	10.8	11.5	12.0
	CO_2	5.7	5.8	5.8	5.3	5.2	5.0	4.7	4.2
A8a	O_2	18.0	NS	NS	NS	NS	NS	NS	NS
	CO_2	0.9	NS	NS	NS	NS	NS	NS	NS

Table N23. In Situ Respiration Test in the Passive Warming Test Plot: February 24 through March 3, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		0.00	2.00	4.00	45.67	70.5	118	165	189
P4a	O_2	20.2	20.0	20.2	19.0	16.3	15.0	14.3	13.5
	CO_2	0.4	0.5	0.5	0.6	0.9	1.0	1.3	1.5
P4b	O_2	20.2	20.0	20.0	19.5	17.7	16.3	15.0	14.3
	CO_2	0.7	0.7	0.8	0.8	0.8	0.9	1.0	1.0
P4c	O_2	19.5	19.2	19.5	18.8	17.0	16.2	15.2	14.7
	CO_2	1.3	1.5	1.5	1.5	1.6	1.7	1.7	1.7
P5a	O_2	20.5	20.2	20.0	19.3	17.3	16.3	16.0	15.0
	CO_2	0.3	0.3	0.4	0.4	0.7	0.8	0.9	1.0
P5b	O_2	19.2	19.0	18.8	17.2	13.5	12.0	10.8	9.8
	CO_2	2.0	2.2	2.3	2.6	3.2	3.5	3.9	4.0
P5c	O_2	19.2	19.2	19.2	19.0	17.5	16.5	15.8	15.0
	CO_2	2.0	2.0	2.2	1.9	2.0	2.0	1.9	1.9

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N24. In Situ Respiration Test in the Control Test Plot: February 24 through March 3, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		0.00	1.67	3.67	45.3	70.2	118	165	189
C1a	O_2	20.2	20.2	20.0	19.5	17.5	16.2	15.2	14.0
	CO_2	0.4	0.2	0.6	0.7	0.8	0.9	0.9	1.0
C1b	O_2	19.2	19.0	19.2	18.0	15.5	14.2	12.3	11.5
	CO_2	1.2	1.3	1.3	1.6	2.0	2.1	2.2	2.2
C1c	O_2	18.0	18.5	19.0	18.8	19.0	13.8	19.0	19.0
	CO_2	2.8	2.6	2.4	2.3	2.2	2.3	2.3	2.0
C6a	O_2	20.2	20.0	20.2	19.2	17.2	16.2	14.8	13.8
	CO_2	0.6	0.5	0.6	0.8	0.9	0.9	1.1	1.2
C6b	O_2	19.2	19.5	19.2	18.7	17.0	16.2	15.2	14.2
	CO_2	1.3	1.3	1.5	1.8	2.2	2.3	2.6	2.7
C5b	O_2	17.0	17.8	18.0	17.0	15.2	14.2	13.3	12.5
	CO_2	3.8	3.7	3.8	3.8	4.0	4.0	4.2	4.0

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N25. In Situ Respiration Test in the Surface Warming Test Plot: February 24 through March 3, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		0.00	2.00	4.00	45.67	70.50	118	165	189
S1a	O_2	20.9	19.8	18.8	NS	NS	NS	NS	NS
	CO_2	0.05	0.4	0.7	NS	NS	NS	NS	NS
S1b	O_2	11.3	9.7	8.8	1.5	0	0	0	0
	CO_2	6.8	7.0	7.0	7.8	8.5	8.8	9.2	9.2
S1c	O_2	20.0	15.7	16.2	9.2	9.0	13.2	13.0	9.0
	CO_2	0.7	7.2	5.3	9.0	8.7	6.7	6.7	9.2
S2a	O_2	20.0	19.2	NS	NS	NS	NS	NS	NS
	CO_2	0.05	0.4	NS	NS	NS	NS	NS	NS
S2c	O_2	6.5	15.0	16.5	16.2	8.0	13.7	10.2	12.5
	CO_2	11.3	5.8	4.8	4.8	10.3	6.6	8.8	7.2
S3b	O_2	14.0	11.0	8.3	3.3	0	0	0	0
	CO_2	6.2	6.8	8.0	8.5	8.3	8.8	10.5	10.7

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N26. In Situ Respiration Test in the Background Area: February 24 through March 3, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		0.00	2.00	4.00	45.67	70.50	118	165	189
B2a	O_2	20.7	20.7	20.9	20.9	20.7	20.7	20.7	20.5
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
B2b	O_2	20.7	20.7	20..9	20.9	20.9	20.7	20.7	20.5
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
B2c	O_2	20.9	20.7	20.9	20.9	20.7	20.7	20.7	20.5
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N27. In Situ Respiration Test in the Active Warming Test Plot: March 24 through March 31, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0.00	2.00	22.08	50.0	71.5	90.9	127	139	166
A2b	O_2	19.2	18.5	11.7	5.5	2.0	1.2	1.5	1.5	0.5
	CO_2	0.7	0.8	1.0	1.6	1.7	2.0	2.0	2.2	2.5
A2c	O_2	19.2	18.7	15.8	12.2	9.2	6.8	6.2	6.3	4.3
	CO_2	1.4	1.7	1.9	2.2	3.2	1.7	2.8	2.7	3.2
A4b	O_2	16.0	16.0	11.7	6.0	2.0	0	0	1	0
	CO_2	4.5	4.4	5.0	5.8	6.7	7.3	8.0	8.0	8.8
A4c	O_2	14.0	15.0	15.0	15.3	14.0	13.0	13.0	12.8	11.8
	CO_2	7.0	6.5	6.5	6.0	5.9	6.0	5.8	5.8	6.0
A5c	O_2	18.0	18.0	18.3	18.0	17.0	16.3	16.3	15.7	15.8
	CO_2	3.1	3.3	3.2	2.9	3.0	3.2	3.1	3.2	3.5
A6a	O_2	17.8	17.8	16.8	14.8	13.0	11.8	10.2	8.5	8.0
	CO_2	2.5	2.7	2.8	3.2	3.3	3.7	3.8	4.0	4.2
A6b	O_2	17.0	17.0	15.8	15.0	13.5	12.5	11.5	10.5	9.3
	CO_2	3.2	3.3	3.7	3.8	4.0	4.2	4.3	4.3	4.8
A6c	O_2	15.8	15.8	15.5	15.0	15.2	14.0	13.7	13.3	12.7
	CO_2	4.8	4.8	5.0	5.0	5.0	5.2	5.3	5.2	5.5
A7c	O_2	11.0	12.5	12.0	12.5	12.0	12.0	12.2	12.2	12.0
	CO_2	5.8	5.3	5.3	5.0	4.8	4.7	4.5	4.2	3.8

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N28. In Situ Respiration Test in the Passive Warming Test Plot: March 24 through March 31, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0.00	2.00	22.0	49.9	71.4	90.8	115	139	166
P2b	O_2	20.2	20.2	19.5	18.5	17.5	16.7	15.8	15.0	14.0
	CO_2	0.2	0.2	0.3	0.5	0.6	0.6	0.7	0.7	0.8
P4a	O_2	20.2	20.2	19.2	17.8	16.7	15.5	14.5	13.5	12.3
	CO_2	0.05	0.05	0.05	0.2	0.3	0.5	0.6	0.7	0.9
P4c	O_2	20.2	20.2	19.5	18.8	18.2	17.0	16.5	16.3	15.2
	CO_2	0.2	0.2	0.3	0.5	0.6	0.7	0.8	0.7	0.8
P5a	O_2	20.5	20.5	19.5	18.5	17.8	17.0	16.3	15.5	14.5
	CO_2	0.05	0.05	0.05	0.1	0.2	0.3	0.5	0.5	0.7
P5b	O_2	20.0	20.0	18.0	16.0	14.0	13.2	12.0	11.0	9.5
	CO_2	0.3	0.5	0.8	1.2	1.7	2.0	2.3	2.7	3.2
P5c	O_2	20.2	20.0	19.5	19.0	18.2	17.5	17.0	16.2	15.5
	CO_2	0.8	0.9	0.9	1.0	1.1	1.2	1.2	1.2	1.5

Table N29. In Situ Respiration Test in the Control Test Plot: March 24 through March 31, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0.00	2.00	22.08	49.83	71.33	90.75	115	139	166
C1a	O_2	20.2	20.2	19.7	18.5	17.8	17.0	16.0	15.5	14.5
	CO_2	0.1	0.1	0.3	0.5	0.5	0.6	0.7	0.8	0.9
C1b	O_2	19.5	19.5	18.7	17.5	16.5	15.8	15.0	14.0	12.8
	CO_2	0.9	0.9	1.1	1.2	1.5	1.7	1.7	1.8	2.0
C1c	O_2	19.2	19.5	19.7	19.5	19.5	19.2	19.3	19.5	19.2
	CO_2	2.0	2.0	1.8	2.0	2.0	2.0	1.9	1.8	2.0
C5b	O_2	16.8	17.8	17.0	16.0	15.5	15.3	15.0	14.5	13.2
	CO_2	4.0	3.8	3.8	3.8	3.8	3.7	3.6	3.5	3.8
C6a	O_2	20.3	20.3	19.5	18.5	17.8	17.0	16.5	16.5	14.5
	CO_2	0.1	0.1	0.2	0.5	3.6	0.6	0.7	0.8	1.0
C6b	O_2	20.0	20.0	19.3	18.7	18.0	17.5	17.0	16.5	15.7
	CO_2	0.9	0.9	1.2	1.4	1.7	1.8	1.9	2.0	2.2

Table N30. In Situ Respiration Test in the Surface Warming Test Plot: March 24 through March 31, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0.00	1.83	22.08	49.7	71.2	90.6	115	139	166
S2c	O_2	15.8	15.2	12.8	11.7	8.7	9.5	11.2	6.0	9.2
	CO_2	5.1	5.9	4.2	8.0	10.2	9.5	8.2	9.0	9.0
S3b	O_2	14.0	12.0	5.0	1.0	0.5	1.0	0.5	0.5	0.5
	CO_2	7.0	6.3	7.2	7.8	8.0	8.0	9.5	8.8	9.7
S4a	O_2	20.2	20.0	NS	NS	NS	NS	NS	NS	NS
	CO_2	0.05	0.05	NS	NS	NS	NS	NS	NS	NS
S4b	O_2	7.8	11.2	12.0	16.5	11.5	11.8	11.2	11.2	10.0
	CO_2	8.5	8.0	8.0	8.0	7.8	7.6	7.8	7.7	7.8
S4c	O_2	15.3	16.2	15.5	15.0	15.5	16.0	15.0	14.3	14.8
	CO_2	5.2	5.0	5.3	5.3	5.0	5.2	5.2	5.3	5.2
S5b	O_2	7.0	10.0	6.0	1.0	0	0	0	0	0
	CO_2	10.8	8.2	9.2	9.3	9.2	9.5	9.2	9.8	6.0

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N31. In Situ Respiration Test in the Background Area: March 24 through March 31, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0.00	1.83	22.08	49.7	71.2	90.6	115	139	166
B2a	O_2	20.7	20.7	20.7	20.5	20.5	20.7	20.5	20.7	20.7
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
B2b	O_2	20.7	20.7	20.7	20.7	20.5	20.7	20.5	20.7	20.7
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
B2c	O_2	20.7	20.7	20.7	20.7	20.5	20.7	20.5	20.7	20.7
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Table N32. In Situ Respiration Test in the Active Warming Test Plot: May 7 through May 13, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)									
		0	2.00	4.00	6.25	25.75	54.00	77.75	104.25	127.00	150.92
A2b	O_2	20.8	20.0	19.5	18.8	15.0	10.2	7.5	5.0	5.0	NS
	CO_2	0.1	0.1	0.1	0.1	0.3	0.4	0.6	0.8	0.8	NS
A2c	O_2	20.0	20.0	19.5	NS	NS	NS	NS	NS	NS	NS
	CO_2	0.4	0.4	19.5	NS	NS	NS	NS	NS	NS	NS
A3c	O_2	20.8	20.5	20.0	20.0	18.8	17.7	17.2	16.0	15.0	14.0
	CO_2	0.1	0.05	0.05	0.05	0.1	0.05	0.1	0.2	0.3	0.3
A4c	O_2	10.2	11.0	12.0	12.3	12.5	12.8	12.8	12.2	13.0	12.5
	CO_2	7.8	7.3	7.2	7.0	7.2	7.0	7.0	7.2	7.0	6.8
A5c	O_2	15.2	15.5	16.2	16.5	16.0	16.2	15.3	15.2	15.8	15.0
	CO_2	4.5	4.2	4.2	4.0	4.2	4.0	4.5	4.6	4.2	4.5
A6b	O_2	7.2	7.2	8.2	10.2	7.5	6.5	5.0	7.5	5.8	3.7
	CO_2	7.2	7.2	8.8	7.3	8.2	8.2	9.2	8.0	8.0	9.0
A6c	O_2	4.0	5.0	8.7	12.0	7.8	7.2	7.7	6.5	7.0	6.7
	CO_2	10.5	10.2	9.8	7.0	10.2	10.0	9.8	10.2	10.0	10.2
A7a	O_2	2.3	2.3	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	18.0	18.0	NS	NS	NS	NS	NS	NS	NS	NS
A7c	O_2	13.5	13.5	14.3	14.8	8.0	15.0	15.0	14.5	15.2	14.8
	CO_2	4.0	3.8	3.8	3.3	5.5	3.8	4.0	4.0	3.8	3.9
A8c	O_2	12.2	13.0	10.0	10.5	8.0	7.0	4.5	3.8	4.7	NS
	CO_2	5.2	4.7	5.2	4.9	5.5	5.0	5.8	6.2	6.2	NS

Table N33. In Situ Respiration Test in the Passive Warming Test Plot: May 7 through May 13, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)									
		0	2.25	4.05	6.50	26.0	54.25	77.92	104.42	127.17	151.09
P1b	O_2	20.2	20.2	20.2	20.0	19.0	17.8	16.3	15.0	14.5	13.0
	CO_2	0.2	0.1	0.05	0.1	0.1	0.05	0.2	0.3	0.1	0.2
P1c	O_2	20.0	19.7	19.2	19.0	17.0	15.3	15.0	13.5	13.8	12.5
	CO_2	0.4	0.2	0.2	0.2	0.6	0.5	0.8	1.0	0.9	1.2
P2b	O_2	19.2	18.8	18.7	18.5	17.2	15.2	14.0	12.3	12.0	10.7
	CO_2	0.9	0.8	0.9	0.9	1.2	1.1	1.3	1.4	1.6	1.7
P2c	O_2	19.8	19.0	18.2	17.8	16.5	15.0	14.5	13.2	13.0	12.0
	CO_2	0.5	0.6	0.7	0.7	0.8	0.7	0.9	1.1	1.2	1.4
P3b	O_2	19.0	19.0	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	1.0	1.0	NS	NS	NS	NS	NS	NS	NS	NS
P3c	O_2	19.5	19.0	18.5	18.2	17.0	15.5	14.5	13.7	13.7	12.5
	CO_2	1.2	0.7	0.6	0.7	0.8	0.8	1.1	1.2	1.2	1.5
P4c	O_2	20.5	19.0	18.0	17.1	15.8	13.5	12.2	11.0	10.8	10.0
	CO_2	0.2	1.0	1.0	1.0	1.2	1.3	1.9	2.2	2.2	2.3
P5b	O_2	20.0	20.3	19.7	19.5	16.2	11.8	9.7	7.8	6.8	5.5
	CO_2	1.0	1.0	0.4	0.3	0.8	1.1	1.7	2.2	2.2	2.3
P5c	O_2	20.2	19.2	18.7	18.2	15.5	14.5	12.5	12.0	10.8	8.8
	CO_2	0.8	1.1	1.2	1.2	1.5	1.2	1.6	1.8	1.8	2.1
P6b	O_2	20.5	19.5	19.0	18.5	15.0	12.5	11.5	10.2	9.5	8.5
	CO_2	0.5	0.7	0.7	0.8	1.3	1.5	1.9	2.0	2.1	2.1
P6c	O_2	20.9	20.2	19.8	19.2	18.0	13.0	11.3	10.2	9.2	7.5
	CO_2	0.05	0.7	0.8	0.8	0.9	1.3	1.5	1.6	1.7	1.8
P7b	O_2	20.9	20.9	20.8	20.5	20.5	19.2	18.2	17.2	16.8	15.0
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Table N33. In Situ Respiration Test in the Passive Warming Test Plot: May 7 through May 13, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)									
		0	2.25	4.05	6.50	26.0	54.25	77.92	104.42	127.17	151.09
P1b	O_2	20.2	20.2	20.2	20.0	19.0	17.8	16.3	15.0	14.5	13.0
P7c	O_2	20.9	20.8	20.5	20.2	20.0	18.5	17.2	16.2	15.5	14.0
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
P8b	O_2	9.5	9.0	8.2	7.7	8.0	6.3	6.5	4.3	4.5	NS
	CO_2	6.3	6.5	7.0	7.2	7.2	7.2	7.2	8.2	8.5	NS
P8c	O_2	3.5	5.5	6.2	7.0	6.2	5.0	4.2	3.5	3.2	NS
	CO_2	6.8	7.0	7.3	7.2	7.8	8.0	8.5	9.2	10.2	NS

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N34. In Situ Respiration Test in the Control Test Plot: May 7 through May 13, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)									
		0	2.75	5.25	7.25	27.0	55.08	79.00	105.50	128.25	151.75
C1a	O_2	20.9	20.7	20.9	20.2	19.5	NS	NS	NS	NS	NS
	CO_2	0.05	0.05	0.05	0.05	0.1	NS	NS	NS	NS	NS
C1b	O_2	20.7	20.7	20.3	20.2	19.2	19.0	17.0	15.3	14.5	12.3
	CO_2	0.2	0.05	0.05	0.05	0.2	0.1	0.4	0.5	0.4	0.4
C1c	O_2	20.9	20.9	20.7	20.8	20.9	20.5	20.5	20.8	20.5	20.2
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.05	0.05	0.05
C2a	O_2	20.9	20.9	20.5	NS	NS	NS	NS	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS	NS	NS	NS	NS
C2c	O_2	20.9	20.9	20.8	20.8	20.9	20.5	20.5	20.8	20.5	20.2
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
C3a	O_2	20.9	20.9	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	0.05	0.05	NS	NS	NS	NS	NS	NS	NS	NS
C3b	O_2	20.7	20.5	19.7	19.5	19.5	13.7	15.3	11.8	11.2	10.2
	CO_2	0.3	0.1	0.1	0.1	0.2	0.4	0.3	0.5	0.5	0.5
C3c	O_2	19.5	20.2	20.0	20.0	20.3	20.0	20.0	20.0	19.8	19.8
	CO_2	0.7	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
C4b	O_2	20.3	20.2	19.5	19.2	17.0	14.8	13.2	12.2	10.8	NS
	CO_2	0.9	0.5	0.6	0.7	1.0	1.0	1.4	1.5	1.7	NS
C4c	O_2	17.0	18.8	19.0	19.2	18.0	18.2	17.8	18.8	18.3	18.8
	CO_2	1.3	0.9	0.8	0.7	1.0	0.8	1.1	0.8	0.8	0.8
C5c	O_2	18.8	18.8	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	0.9	0.9	NS	NS	NS	NS	NS	NS	NS	NS
C6a	O_2	19.0	19.0	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	0.0	0.6	NS	NS	NS	NS	NS	NS	NS	NS
C6b	O_2	20.5	20.7	20.3	20.2	20.0	18.7	17.8	16.2	15.0	13.2
	CO_2	0.3	0.1	0.1	0.1	0.4	0.4	0.7	0.7	0.7	0.7

Table N34. In Situ Respiration Test in the Control Test Plot: May 7 through May 13, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)									
		0	2.75	5.25	7.25	27.0	55.08	79.00	105.50	128.25	151.75
C1a	O_2	20.9	20.7	20.9	20.2	19.5	NS	NS	NS	NS	NS
C6c	O_2	20.3	20.5	20.0	20.0	19.2	18.0	18.0	17.5	17.0	16.8
	CO_2	0.5	0.1	0.2	0.1	0.4	0.2	0.5	0.7	0.6	0.8
C7b	O_2	20.6	20.7	20.2	20.0	20.0	18.2	16.5	15.2	14.0	13.0
	CO_2	0.20	0.05	0.05	0.1	0.2	0.2	0.6	0.6	0.7	0.8
C8b	O_2	NS	20.7	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	NS	0.05	NS	NS	NS	NS	NS	NS	NS	NS
C8c	O_2	20.9	20.7	20.5	20.2	20.0	18.8	17.2	15.2	13.7	12.8
	CO_2	0.4	0.1	0.1	0.5	0.1	0.1	0.1	0.1	0.1	0.05

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N35. In Situ Respiration Test in the Surface Warming Test Plot: May 7 through May 13, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)									
		0	3.00	5.50	7.50	27.25	55.25	79.25	105.67	128.42	151.92
S1a	O_2	20.5	20.5	20.0	19.5	17.6	NS	NS	NS	NS	NS
	CO_2	0.05	0.05	0.05	0.05	0.3	NS	NS	NS	NS	NS
S1b	O_2	18.8	17.2	15.8	14.5	9.5	4.2	2.0	2.5	4.2	NS
	CO_2	2.8	2.7	2.8	3.2	4.0	4.5	5.3	5.8	5.8	NS
S1c	O_2	3.0	8.0	14.0	16.5	15.5	11.3	12.2	11.5	13.2	14.0
	CO_2	7.3	6.7	4.3	2.3	3.4	5.3	5.2	6.0	4.2	4.2
S2c	O_2	8.8	16.0	12.5	13.5	11.7	10.2	10.2	11.0	13.2	9.2
	CO_2	6.3	3.3	5.8	5.5	7.2	7.0	7.3	7.2	5.2	8.3
S3b	O_2	15.2	15.2	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	6.4	6.4	NS	NS	NS	NS	NS	NS	NS	NS
S3c	O_2	14.0	16.0	12.7	16.3	10.2	8.7	14.5	16.0	13.5	14.0
	CO_2	2.2	4.0	7.2	4.5	7.3	8.2	5.2	4.5	5.8	6.0
S4c	O_2	13.2	14.8	18.0	18.5	17.8	17.8	17.8	16.3	15.3	17.0
	CO_2	5.3	4.2	2.3	2.3	3.2	2.8	2.5	4.0	3.1	3.5
S5b	O_2	6.0	6.0	8.5	NS	NS	NS	NS	NS	NS	NS
	CO_2	13.5	13.5	11.2	NS	NS	NS	NS	NS	NS	NS
S5c	O_2	2.0	4.7	8.2	11.2	5.8	10.8	11.5	5.5	5.8	8.2
	CO_2	13.0	12.2	10.3	9.2	11.7	7.3	8.2	12.2	12.2	10.5
S6a	O_2	19.8	19.8	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	0.4	0.4	NS	NS	NS	NS	NS	NS	NS	NS

Table N35. In Situ Respiration Test in the Surface Warming Test Plot: May 7 through May 13, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)									
		0	3.00	5.50	7.50	27.25	55.25	79.25	105.67	128.42	151.92
S1a	O_2	20.5	20.5	20.0	19.5	17.6	NS	NS	NS	NS	NS
S6b	O_2	2.0	2.0	2.5	NS	NS	NS	NS	NS	NS	NS
	CO_2	13.0	13.0	12.8	NS	NS	NS	NS	NS	NS	NS

Table N36. In Situ Respiration Test in the Background Area: May 7 through May 13, 1993

Monitoring Point	Measurement	2.00	4.00	6.25	25.75	54.0	77.25	104	127
B2b	O_2	20.9	20.9	NS	NS	NS	NS	NS	NS
	CO_2	0.05	0.05	NS	NS	NS	NS	NS	NS

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N37. In Situ Respiration Test in the Active Warming Test Plot: July 7 through July 11, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)										
		0	2.00	4.00	6.00	8.00	21.50	30.25	47.00	57.25	73.42	92.75
A1b	O_2	16.2	15.5	14.8	14.0	13.2	8.0	4.5	0	0	0	0
	CO_2	6.3	6.5	6.8	6.8	7.0	7.5	7.5	7.8	8.0	8.8	9.3
A1c	O_2	9.2	10.0	10.2	10.5	10.5	9.2	8.5	7.3	7.0	6.2	5.7
	CO_2	9.0	9.0	9.0	9.0	9.2	9.5	9.2	9.5	9.8	10.5	9.8
A2b	O_2	19.5	18.2	17.3	16.8	16.0	11.0	8.5	4.2	2.8	1.2	0.5
	CO_2	1.9	2.0	2.2	2.2	2.5	3.0	3.0	3.0	3.8	4.5	4.0
A3a	O_2	20.5	19.5	18.8	18.2	18.0	13.8	12.0	8.0	6.5	4.0	1.7
	CO_2	0.5	0.4	0.7	0.7	0.8	1.4	1.3	1.3	2.0	2.7	2.3
A3c	O_2	20.0	19.8	19.8	19.5	19.5	18.0	17.0	15.2	14.5	13.0	11.8
	CO_2	1.2	1.2	1.2	1.2	1.2	1.5	1.3	1.2	1.6	2.2	1.6
A4b	O_2	0	0	0	0	0	0	0	0	0	0	0
	CO_2	14.2	14.0	14.0	14.3	14.7	14.7	14.3	14.0	14.3	15.0	14.2
A4c	O_2	8.7	9.0	9.5	9.8	10.0	9.5	8.8	8.8	8.5	8.7	7.5
	CO_2	11.8	11.3	11.3	11.0	11.3	11.3	11.2	11.0	11.7	12.0	11.3
A5c	O_2	11.5	12.8	13.2	14.2	14.8	13.2	12.5	12.7	12.8	13.0	12.0
	CO_2	9.0	8.3	8.5	8.0	8.2	8.2	8.3	7.8	8.2	8.5	8.2
A6a	O_2	1.0	1.0	1.0	1.0	0.8	1.0	1.0	0.5	0	0	0
	CO_2	12.2	12.0	12.2	12.0	12.5	12.8	12.2	12.2	12.8	13.2	12.5
A6b	O_2	2.2	2.5	2.2	2.2	2.2	2.3	2.2	2.2	1.7	1.2	1.0
	CO_2	12.2	12.0	12.2	12.2	12.5	13.0	12.7	12.2	12.8	13.5	12.8
A6c	O_2	3.6	3.5	3.8	4.3	4.5	4.7	4.5	4.3	4.2	4.3	4.0
	CO_2	13.3	13.0	13.2	13.0	13.3	14.8	13.2	13.0	13.2	14.0	13.2
A7a	O_2	17.0	12.8	13.2	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	5.8	6.7	6.3	NS	NS	NS	NS	NS	NS	NS	NS

Table N37. In Situ Respiration Test in the Active Warming Test Plot: July 7 through July 11, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)										
		0	2.00	4.00	6.00	8.00	21.50	30.25	47.00	57.25	73.42	92.75
A7c	O_2	6.0	7.0	8.3	9.5	10.0	9.2	9.2	8.5	9.0	9.0	8.8
	CO_2	14.0	10.5	10.2	10.0	10.2	12.0	10.0	9.8	10.0	10.5	9.7
A8a	O_2	20.0	19.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	1.0	0.8	NS	NS	NS	NS	NS	NS	NS	NS	NS
A8c	O_2	0.5	2.5	2.8	3.2	3.2	0	0	0	0	0	0
	CO_2	12.2	10.2	11.0	11.0	11.0	13.0	10.5	11.0	11.2	12.2	11.5

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N38. In Situ Respiration Test in the Passive Warming Test Plot: July 7 through July 11, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)										
		0.00	2.00	4.00	6.00	8.00	21.50	30.25	47.00	57.25	73.42	92.75
P2b	O_2	19.8	19.0	18.7	18.2	18.0	15.8	14.5	12.0	10.8	9.0	6.3
	CO_2	1.5	1.6	1.8	1.8	2.2	3.8	2.8	3.2	3.7	4.0	4.2
P4a	O_2	20.5	20.2	20.0	19.8	19.8	18.2	17.0	15.2	14.0	14.5	10.8
	CO_2	0.05	0.1	0.4	0.4	0.6	1.8	1.2	1.2	1.5	1.8	2.0
P4c	O_2	20.0	19.0	18.2	18.0	17.8	14.8	13.5	11.5	10.7	9.3	8.0
	CO_2	0.8	1.0	1.2	1.2	1.3	2.6	1.8	2.0	2.3	3.0	3.0
P5a	O_2	20.7	20.2	20.2	20.0	20.0	19.0	18.5	17.3	17.2	16.3	15.0
	CO_2	0.1	0.2	0.3	0.5	0.5	1.6	1.0	1.0	1.2	1.6	1.4
P5b	O_2	19.8	19.0	18.2	17.5	17.0	12.0	9.7	6.2	4.5	2.8	1.5
	CO_2	1.2	1.3	1.8	2.0	2.2	4.5	4.2	5.2	6.0	7.2	7.3
P5c	O_2	19.5	18.8	18.2	17.8	17.5	14.2	13.0	10.2	9.0	7.8	6.7
	CO_2	1.8	1.8	1.8	2.0	2.2	3.2	2.5	2.7	3.0	3.7	3.8

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N39. In Situ Respiration Test in the Control Test Plot: July 7 through July 11, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)										
		0.00	2.00	4.00	6.00	8.00	21.50	30.25	47.50	57.25	73.42	92.75
C1b	O_2	20.0	19.5	19.2	18.8	18.7	15.8	14.0	11.2	10.0	8.0	6.0
	CO_2	1.0	1.0	1.0	1.2	1.2	2.3	1.7	1.8	2.0	2.5	2.3
C1c	O_2	19.3	19.0	19.0	18.8	19.0	17.8	17.5	17.0	17.0	17.8	16.8
	CO_2	2.2	1.8	2.0	2.2	2.2	3.2	2.5	2.2	2.8	2.5	2.8
C2a	O_2	20.3	20.0	20.0	20.0	20.0	18.3	17.5	15.2	14.2	13.0	11.2
	CO_2	0.5	0.4	0.5	0.7	0.7	1.8	1.0	1.0	1.3	1.5	1.7
C5b	O_2	19.5	19.0	18.8	18.2	18.0	15.3	14.0	12.0	11.2	10.7	9.8
	CO_2	1.8	1.8	1.8	2.0	2.0	4.3	2.6	2.7	3.0	3.2	3.5
C6a	O_2	19.8	19.5	19.8	19.5	19.5	17.8	17.0	15.0	14.2	12.8	10.8
	CO_2	1.7	1.2	1.2	1.3	1.5	2.5	1.8	1.8	2.0	2.2	2.4
C6b	O_2	20.0	19.5	19.0	18.8	18.8	16.2	15.3	13.5	13.0	12.5	11.8
	CO_2	1.2	1.2	1.2	1.3	1.5	3.0	2.0	2.3	2.8	3.0	3.2

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N40. In Situ Respiration Test in the Surface Warming Test Plot: July 7 through July 11, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)										
		0.00	2.00	4.00	6.00	8.00	21.50	30.05	47.50	57.25	73.42	92.75
S2c	O_2	12.0	10.2	15.0	13.2	13.2	13.2	12.8	10.2	13.0	12.2	12.0
	CO_2	8.8	9.8	7.0	8.5	8.8	9.3	8.8	9.2	8.8	9.0	9.2
S3b	O_2	17.0	15.3	14.2	11.8	10.8	4.2	1.5	0	0	0	0
	CO_2	5.5	6.5	6.2	6.8	6.7	8.8	7.8	8.2	9.0	8.2	8.2
S4c	O_2	13.5	14.5	17.5	17.2	17.7	17.0	15.5	15.5	15.8	16.5	14.2
	CO_2	8.8	8.2	5.3	5.8	5.8	6.8	7.2	6.2	7.0	6.0	7.8
S5a	O_2	20.6	20.2	20.0	19.8	19.8	17.8	16.8	14.2	14.0	11.8	10.0
	CO_2	0.4	0.1	0.1	0.2	0.2	1.2	0.5	0.4	1.0	0.7	0.7
S5b	O_2	10.5	10.2	11.0	10.8	14.0	6.2	2.5	0.1	0	0	1.2
	CO_2	11.0	11.5	10.2	9.7	8.8	12.2	11.0	10.5	11.0	12.2	11.5
S5c	O_2	4.0	9.5	9.3	9.0	8.5	10.5	6.8	5.3	9.0	9.0	5.7
	CO_2	14.8	12.3	12.2	12.8	13.0	13.0	13.2	13.5	12.7	12.0	13.5

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N41. In Situ Respiration Test in the Background Area: July 7 through July 11, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)										
		0.00	2.00	4.00	6.00	8.00	21.50	30.25	47.00	57.25	73.42	92.75
B2a	O_2	20.7	20.5	20.9	20.9	20.9	20.5	20.5	20.3	20.5	20.2	20.2
	CO_2	0.05	0.05	0.05	0.05	0.05	0.1	0.05	0.05	0.05	0.05	0.05
B2b	O_2	20.9	20.7	20.9	20.9	20.9	20.5	20.3	20.2	20.5	20.2	20.2
	CO_2	0.05	0.05	0.05	0.05	0.05	0.1	0.05	0.05	0.05	0.1	0
B2c	O_2	20.9	20.7	20.9	20.9	20.9	20.2	20.2	20.0	20.2	20.0	20.2
	CO_2	0.05	0.05	0.05	0.05	0.05	0.1	0.05	0.05	0.05	0.1	0

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N42. In Situ Respiration Test in the Active Warming Test Plot: July 24 through July 28, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		0.00	2.00	5.00	7.42	27.08	35.75	53.33	77.25
A1b	O_2	11.0	NS	NS	NS	NS	NS	NS	NS
	CO_2	8.8	NS	NS	NS	NS	NS	NS	NS
A1c	O_2	11.3	12.0	13.0	10.0	11.5	11.2	11.2	11.8
	CO_2	9.2	9.2	9.0	9.5	9.2	9.2	9.2	9.0
A2b	O_2	17.7	15.8	15.2	9.0	6.5	3.0	NS	NS
	CO_2	3.0	3.2	3.0	3.7	3.8	4.0	NS	NS
A3a	O_2	19.2	18.5	18.0	12.8	10.5	7.0	2.0	NS
	CO_2	0.8	1.0	1.0	1.2	1.4	1.7	2.2	NS
A3c	O_2	19.8	19.5	20.0	17.3	17.2	16.0	13.3	12.0
	CO_2	1.3	1.3	0.8	1.3	1.3	1.2	1.7	2.0
A4b	O_2	2.5	NS	NS	NS	NS	NS	NS	NS
	CO_2	13.0	NS	NS	NS	NS	NS	NS	NS
A4c	O_2	12.2	12.2	13.0	13.0	11.8	12.8	12.5	NS
	CO_2	10.8	11.0	10.5	10.2	11.0	10.5	10.5	NS
A5c	O_2	13.2	13.5	13.5	14.3	13.3	14.5	14.3	NS
	CO_2	9.2	8.8	9.2	8.3	9.0	8.5	8.3	NS
A6a	O_2	3.0	NS	NS	NS	NS	NS	NS	NS
	CO_2	14.0	NS	NS	NS	NS	NS	NS	NS
A6b	O_2	2.8	NS	NS	NS	NS	NS	NS	NS
	CO_2	14.0	NS	NS	NS	NS	NS	NS	NS
A6c	O_2	1.2	NS	NS	NS	NS	NS	NS	NS
	CO_2	14.0	NS	NS	NS	NS	NS	NS	NS
A7a	O_2	19.2	19.0	18.0	15.2	11.8	10.0	7.0	NS
	CO_2	1.7	1.7	2.2	2.7	3.0	4.0	4.7	NS

Table N42. In Situ Respiration Test in the Active Warming Test Plot: July 24 through July 28, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		0.00	2.00	5.00	7.42	27.08	35.75	53.33	77.25
A1b	O_2	11.0	NS	NS	NS	NS	NS	NS	NS
A7c	O_2	12.0	13.8	14.2	13.0	13.2	14.0	14.7	NS
	CO_2	9.5	8.5	8.3	8.8	8.7	8.3	8.5	NS
A8a	O_2	20.2	20.2	20.0	NS	17.8	16.8	15.3	NS
	CO_2	0.2	0.2	0.2	NS	0.5	0.7	0.8	NS
A8c	O_2	0	NS	NS	NS	NS	NS	NS	NS
	CO_2	11.8	NS	NS	NS	NS	NS	NS	NS

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N43. In Situ Respiration Test in the Passive Warming Test Plot: July 24 through July 28, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0	2.42	5.75	7.83	27.33	35.92	53.50	77.50	102.33
P1a	O_2	20.3	20.2	19.0	19.0	14.5	12.5	9.8	7.0	5.0
	CO_2	0.05	0.1	0.3	0.05	0.2	0.2	0.5	0.7	2.4
P1b	O_2	20.3	20.0	19.2	18.8	16.0	14.2	11.8	9.2	6.3
	CO_2	0.3	0.2	0.8	0.4	0.8	1.0	1.3	1.8	2.7
P1c	O_2	20.0	19.0	18.0	17.8	16.8	14.0	12.8	11.7	9.8
	CO_2	1.2	1.2	1.8	1.3	1.2	2.0	2.5	2.8	3.8
P2a	O_2	20.5	20.7	20.3	20.2	19.2	18.2	16.5	14.2	14.2
	CO_2	0.2	0.05	0.1	0.05	0.05	0.1	0.3	0.2	0.2
P2b	O_2	18.7	18.7	18.0	17.2	13.8	12.0	10.5	6.2	3.2
	CO_2	2.7	2.7	2.8	2.8	3.8	4.2	4.5	5.0	5.8
P2c	O_2	19.2	18.8	18.0	17.8	15.0	14.0	12.3	9.8	8.0
	CO_2	2.2	2.2	2.5	2.2	2.5	2.8	3.0	4.2	4.0
P3a	O_2	20.5	20.2	19.8	19.2	16.2	14.8	12.0	8.5	5.7
	CO_2	0.2	0.1	0.5	0.2	1.0	1.0	1.8	2.2	3.5
P3b	O_2	20.5	20.0	19.2	18.8	14.3	12.5	8.3	5.5	2.7
	CO_2	0.2	0.2	0.5	0.5	1.3	1.7	2.8	4.0	5.3
P3c	O_2	20.2	19.5	18.8	18.5	15.8	14.8	13.0	10.8	9.7
	CO_2	1.0	1.0	1.0	1.0	1.0	1.2	1.6	1.7	2.2
P4a	O_2	20.2	20.0	19.8	19.2	16.5	15.2	12.8	10.0	6.3
	CO_2	0.9	0.2	0.7	0.8	1.2	1.7	2.3	2.5	3.5
P5a	O_2	20.5	20.0	19.8	19.5	17.8	17.2	15.8	13.8	11.5
	CO_2	0.4	0.3	0.7	0.7	1.0	1.0	1.5	1.5	2.0

Table N43. In Situ Respiration Test in the Passive Warming Test Plot: July 24 through July 28, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0	2.42	5.75	7.83	27.33	35.92	53.50	77.50	102.33
P5b	O_2	19.2	18.0	16.5	16.0	9.5	7.5	5.5	2.8	NS
	CO_2	2.2	3.0	4.0	3.8	5.8	6.5	7.7	8.2	NS
P5c	O_2	18.5	18.3	16.2	15.7	12.3	10.2	8.0	4.8	NS
	CO_2	3.3	2.5	3.8	4.2	4.2	4.5	5.5	5.8	NS
P6a	O_2	20.2	20.2	19.8	19.5	17.5	16.2	15.0	12.8	11.3
	CO_2	0.5	0.2	0.5	0.5	0.8	1.0	1.2	1.2	1.8

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N43. In Situ Respiration Test in the Passive Warming Test Plot: July 24 through July 28, 1993 (continued)

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0	2.42	5.75	7.83	27.33	35.92	53.50	77.50	102.33
P6b	O_2	10.2	9.8	8.7	10.5	4.3	3.0	2.5	NS	NS
	CO_2	11.2	11.0	11.2	10.0	11.5	11.8	11.8	NS	NS
P6c	O_2	13.8	13.2	12.8	12.2	8.8	7.5	5.3	0.5	NS
	CO_2	8.3	8.3	8.2	8.2	8.2	8.2	8.7	8.8	NS
P7a	O_2	20.6	20.2	NS	19.2	17.2	16.8	15.8	14.0	12.0
	CO_2	0.2	0.1	NS	0.7	1.0	1.0	1.6	1.8	4.2
P7b	O_2	20.5	20.5	20.2	20.0	18.8	18.0	17.0	15.0	13.0
	CO_2	0.4	0.1	0.1	0.3	0.2	0.4	0.5	0.2	0.5
P7c	O_2	19.3	19.8	19.5	19.2	17.0	16.5	15.0	12.3	10.0
	CO_2	1.8	1.3	1.2	1.2	1.5	1.7	1.8	1.7	1.8
P8a	O_2	4.9	10.0	12.0	15.5	9.3	11.2	1.2	NS	NS
	CO_2	1.5	8.8	8.8	5.2	6.2	8.3	9.0	NS	NS
P8b	O_2	1.0	1.0	NS	NS	NS	NS	NS	NS	NS
	CO_2	17.8	17.8	NS	NS	NS	NS	NS	NS	NS
P8c	O_2	0	0	NS	NS	NS	NS	NS	NS	NS
	CO_2	19.2	19.2	NS	NS	NS	NS	NS	NS	NS

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N44. In Situ Respiration Test in the Control Test Plot: July 24 through July 28, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0	3.67	6.17	8.50	28.25	36.83	55.17	78.83	102.67
C1b	O_2	19.8	19.0	18.8	18.0	14.0	13.2	11.5	7.5	5.0
	CO_2	1.2	1.2	1.2	1.6	1.8	2.2	2.3	2.7	3.0
C1c	O_2	19.0	18.8	19.0	18.8	18.2	18.2	18.0	17.2	17.0
	CO_2	2.7	2.2	2.2	2.3	2.2	2.8	3.0	2.8	2.8
C2a	O_2	20.2	19.8	20.0	NS	17.5	16.8	14.8	12.3	9.7
	CO_2	0.4	0.5	0.5	NS	1.0	1.3	1.3	1.7	2.0
C2c	O_2	19.5	19.0	19.2	19.0	18.5	18.2	18.2	18.0	18.0
	CO_2	1.7	1.3	1.3	1.7	1.7	2.2	2.2	2.2	2.2
C3b	O_2	20.2	19.0	18.2	17.5	12.5	11.8	10.5	8.5	8.0
	CO_2	0.6	0.3	0.5	0.8	0.8	1.2	1.2	1.2	2.0
C3c	O_2	20.0	19.0	19.0	18.8	18.0	18.2	17.5	16.8	17.0
	CO_2	1.0	0.8	1.2	1.2	1.5	2.0	2.5	2.7	2.8
C4b	O_2	20.0	18.3	18.0	17.0	13.2	NS	8.5	6.7	6.5
	CO_2	1.0	0.8	1.0	1.2	1.2	NS	2.2	2.3	3.2
C4c	O_2	18.5	17.8	18.0	17.8	16.8	16.8	16.5	15.2	15.8
	CO_2	2.8	2.7	2.8	3.2	3.3	4.0	4.0	4.3	4.3
C5a	O_2	19.2	19.0	19.8	19.8	17.8	16.8	14.8	12.2	10.7
	CO_2	1.5	1.4	1.2	1.2	1.0	1.3	1.8	2.0	1.8
C5b	O_2	19.0	18.0	18.0	17.3	14.8	14.0	12.8	11.2	11.0
	CO_2	2.3	2.3	2.3	2.8	3.0	3.8	4.0	4.0	4.5
C5c	O_2	18.5	19.0	18.2	18.0	17.0	16.8	16.2	15.0	15.2
	CO_2	3.2	3.2	3.2	3.5	3.5	4.2	4.3	4.2	4.4

Table N44. In Situ Respiration Test in the Control Test Plot: July 24 through July 28, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0	3.67	6.17	8.50	28.25	36.83	55.17	78.83	102.67
C1b	O_2	19.8	19.0	18.8	18.0	14.0	13.2	11.5	7.5	5.0
C6a	O_2	20.0	18.0	19.8	19.2	16.8	16.2	14.8	11.8	12.8
	CO_2	0.8	1.2	1.0	1.2	1.5	1.8	1.8	1.8	2.7
C6b	O_2	19.8	18.8	19.0	18.8	17.0	16.8	16.0	16.5	13.8
	CO_2	1.3	1.4	1.7	1.8	2.2	2.8	3.0	2.7	4.8
C6c	O_2	19.2	18.8	19.5	19.0	18.2	18.2	18.0	16.2	16.0
	CO_2	2.2	1.8	1.8	2.0	2.2	2.8	3.0	3.0	3.5

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N44. In Situ Respiration Test in the Control Test Plot: July 24 through July 28, 1993 (continued)

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0	3.67	6.17	8.50	28.25	36.83	55.17	78.83	102.67
C7a	O_2	20.0	20.0	NS	NS	NS	NS	NS	NS	NS
	CO_2	0.05	0.05	NS	NS	NS	NS	NS	NS	NS
C7b	O_2	20.5	20.0	20.3	19.8	18.2	17.8	16.2	15.2	12.2
	CO_2	0.05	0.05	0.1	0.4	0.5	1.0	1.2	0.8	1.0
C7c	O_2	20.0	19.5	20.0	19.2	18.0	17.7	16.5	14.5	14.2
	CO_2	1.0	1.0	1.0	1.2	1.5	2.0	2.0	2.0	2.0
C8a	O_2	20.7	19.3	19.8	19.0	17.8	17.0	15.0	13.3	11.2
	CO_2	0.05	0.05	0.1	0.4	0.5	1.2	1.7	1.4	1.5

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N45. In Situ Respiration Test in the Surface Warming Test Plot: July 24 through July 28, 1993

Monitoring Point	Measurement	0.00	4.00	6.75	9.00	28.50	37.00	55.3	79.08
S1a	O_2	20.0	20.0	19.5	16.8	15.7	17.0	16.5	5.8
	CO_2	0.05	0.05	0.5	0.3	0.8	0.8	0.6	1.2
S1b	O_2	14.8	15.5	12.0	3.0	0	0	NS	NS
	CO_2	4.8	3.6	5.5	6.5	7.5	7.3	NS	NS
S1c	O_2	5.0	14.5	13.5	14.0	10.0	5.2	4.2	NS
	CO_2	14.0	8.5	10.0	9.0	12.0	13.5	14.0	NS
S2A	O_2	20.0	20.0	19.3	16.8	15.0	13.2	13.0	3.2
	CO_2	0.05	0.2	0.2	0.4	0.8	0.8	0.8	1.6
S2c	O_2	15.0	19.0	18.5	14.2	9.2	NS	10.3	15.3
	CO_2	6.8	3.8	4.0	7.8	11.5	NS	9.5	6.2
S3a	O_2	20.0	20.2	20.0	17.8	16.0	14.0	10.5	4.2
	CO_2	0.05	0.1	0.2	0.1	0.6	0.4	0.5	1.2
S3b	O_2	14.8	NS	NS	NS	NS	NS	NS	NS
	CO_2	5.5	NS	NS	NS	NS	NS	NS	NS
S3c	O_2	11.5	19.3	15.0	14.0	13.7	13.8	8.5	16.8
	CO_2	9.7	3.2	7.8	7.8	8.5	8.2	11.0	5.0
S4a	O_2	20.0	20.2	20.0	18.2	18.2	17.0	16.0	12.2
	CO_2	0.05	0.2	0.2	0.1	0.5	0.2	0.1	0.2
S4b	O_2	16.2	19.0	20.5	20.7	NS	NS	NS	NS
	CO_2	0.05	3.2	0.2	0.05	NS	NS	NS	NS
S4c	O_2	14.2	16.2	18.0	17.5	16.2	15.5	14.8	17.0
	CO_2	7.8	7.8	5.0	4.8	7.0	6.7	7.3	4.8
S5a	O_2	19.2	20.0	20.0	19.0	16.8	14.8	15.8	15.3
	CO_2	0.05	0.3	0.2	0.05	0.7	0.5	0.5	0.2
S5b	O_2	9.0	13.5	15.0	17.0	1.8	0.1	NS	NS
	CO_2	10.8	8.5	6.8	3.3	11.0	11.5	NS	NS

Table N45. In Situ Respiration Test in the Surface Warming Test Plot: July 24 through July 28, 1993

Monitoring Point	Measurement	0.00	4.00	6.75	9.00	28.50	37.00	55.3	79.08
S1a	O_2	20.0	20.0	19.5	16.8	15.7	17.0	16.5	5.8
S5c	O_2	5.3	7.7	7.2	6.8	5.2	8.0	5.0	11.3
	CO_2	14.0	13.8	13.2	13.2	14.2	12.8	13.5	10.5
S6a	O_2	19.0	19.0	19.0	16.2	15.0	12.0	8.8	14.8
	CO_2	0.2	1.0	0.8	0.5	1.0	1.2	1.2	0.4
S6b	O_2	4.2	NS	NS	NS	NS	NS	NS	NS
	CO_2	11.2	NS	NS	NS	NS	NS	NS	NS

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N46. In Situ Respiration Test in the Background Area: July 24 through July 28, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	3.17	11.17	29.50	53.33	77.67
B2c	O_2	20.7	20.9	20.9	20.9	20.2	20.0
	CO_2	0.05	0.05	0.1	0.1	0.05	0.05

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N47. In Situ Respiration Test in the Active Warming Test Plot: October 20 through October 26, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)									
		0	0.25	3.00	6.00	25.58	49.75	72.42	96.17	130.58	149.08
A1b	O_2	15.0	11.2	11.0	11.2	8.3	5.5	4.0	2.0	NS	NS
	CO_2	7.7	7.8	7.8	7.5	8.0	8.2	8.0	8.2	NS	NS
A1c	O_2	17.2	17.2	17.3	17.7	17.8	18.0	17.8	18.0	18.0	18.0
	CO_2	4.3	3.8	4.0	3.8	3.8	3.7	3.8	3.8	3.8	3.8
A2b	O_2	20.0	17.0	16.8	16.7	14.5	12.7	19.0	22.0	12.0	13.0
	CO_2	1.6	2.8	1.8	1.8	2.0	2.0	2.2	2.3	2.3	2.7
A3a	O_2	20.7	19.2	18.8	18.6	16.5	14.5	13.0	12.2	NS	NS
	CO_2	0.2	0.5	0.5	0.7	0.8	0.8	1.0	1.0	NS	NS
A3c	O_2	20.5	19.8	19.7	19.7	19.2	19.0	18.5	18.2	18.0	17.8
	CO_2	0.7	0.6	0.7	0.7	0.7	0.6	0.7	0.7	0.7	0.8
A4b	O_2	0.0	0	0	NS	NS	NS	NS	NS	NS	NS
	CO_2	12.2	12.2	12.5	NS	NS	NS	NS	NS	NS	NS
A4c	O_2	17.2	17.3	17.2	17.7	17.8	18.0	18.2	18.5	NS	18.0
	CO_2	5.3	4.6	4.8	4.8	4.7	4.3	4.0	4.0	NS	4.6
A5c	O_2	17.5	18.0	18.0	18.3	18.2	18.3	18.5	18.8	18.7	18.5
	CO_2	4.7	4.0	4.0	3.8	4.0	3.8	3.8	3.3	3.5	3.8
A6a	O_2	5.2	5.2	4.8	NS	NS	NS	NS	NS	NS	NS
	CO_2	11.0	11.0	11.2	NS	NS	NS	NS	NS	NS	NS
A6b	O_2	9.0	9.3	8.8	9.0	9.2	9.6	9.8	10.2	10.0	10.3
	CO_2	10.0	9.8	9.8	9.8	10.0	9.7	9.6	9.5	9.3	9.3
A6c	O_2	13.2	13.5	13.3	13.8	13.8	14.7	14.5	14.8	14.6	14.8
	CO_2	8.7	8.0	8.2	8.0	8.0	7.4	7.7	7.7	7.5	7.5

Table N47. In Situ Respiration Test in the Active Warming Test Plot: October 20 through October 26, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)									
		0	0.25	3.00	6.00	25.58	49.75	72.42	96.17	130.58	149.08
A7c	O_2	18.2	18.3	18.5	18.7	18.7	18.8	18.8	19.0	18.7	18.7
	CO_2	3.7	4.3	3.5	3.3	4.2	3.0	3.0	3.0	3.0	3.2
A8c	O_2	0.0	0	2.8	NS	NS	NS	NS	NS	NS	NS
	CO_2	8.2	8.2	8.0	NS	NS	NS	NS	NS	NS	NS

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N48. In Situ Respiration Test in the Passive Warming Test Plot: October 20 through October 26, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)									
		0	0.58	3.25	6.25	25.75	49.92	72.58	96.33	118.75	149.25
P2b	O_2	20.2	16.0	15.8	15.5	14.3	12.7	11.2	10.2	8.8	7.8
	CO_2	1.0	1.3	1.7	1.6	1.8	1.8	2.0	2.2	2.2	2.7
P3c	O_2	20.7	18.8	19.7	18.7	18.0	17.5	17.2	16.8	16.0	15.8
	CO_2	0.1	0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
P4a	O_2	20.9	18.7	18.2	17.8	16.0	13.5	10.7	13.8	8.5	7.0
	CO_2	0.1	0.8	1.0	1.0	1.5	1.8	2.2	2.0	2.5	3.0
P5a	O_2	20.7	19.0	19.0	18.8	17.2	16.0	14.3	14.2	12.5	11.2
	CO_2	0.1	0.8	1.0	1.0	1.4	1.7	2.0	2.0	2.3	2.8
P5b	O_2	20.5	14.8	14.3	14.7	11.2	10.5	10.2	6.5	4.5	3.8
	CO_2	0.4	2.2	2.3	2.3	3.2	3.7	4.0	4.8	5.5	5.8
P5c	O_2	20.5	16.2	16.5	16.5	15.8	15.3	14.8	14.7	14.0	14.0
	CO_2	0.4	0.7	0.8	0.8	1.0	0.8	1.0	1.0	1.0	1.0

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N49. In Situ Respiration Test in the Control Test Plot: October 20 through October 26, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)									
		0	0.67	3.42	6.42	25.92	50.08	72.75	96.42	118.92	149.33
C1b	O_2	20.7	20.5	20.2	20.0	18.8	17.8	16.2	15.5	14.2	14.0
	CO_2	0.2	0.1	0.3	0.3	0.4	0.4	0.6	0.6	0.7	0.8
C1c	O_2	20.5	20.3	20.2	20.2	19.8	19.3	19.0	19.0	18.3	18.0
	CO_2	0.6	0.5	0.7	0.6	0.7	0.8	0.8	0.8	0.8	1.0
C2a	O_2	20.9	20.7	20.5	20.2	19.2	18.0	16.8	16.2	15.0	13.8
	CO_2	0.1	0.05	0.05	0.1	0.2	0.1	0.4	0.5	0.7	0.8
C5a	O_2	20.9	20.7	20.5	20.3	19.3	20.2	17.8	18.0	17.2	16.0
	CO_2	0.5	0.05	0.05	0.1	0.4	0.3	0.3	0.4	0.4	0.7
C5b	O_2	20.5	20.5	20.2	20.0	19.0	18.2	17.5	17.0	16.4	16.0
	CO_2	0.4	0.5	0.5	0.6	0.7	0.8	0.8	0.8	0.8	1.0
C6c	O_2	20.2	20.3	20.2	20.0	19.2	18.7	18.0	17.8	17.2	16.5
	CO_2	0.7	0.2	0.3	0.4	0.5	0.6	0.6	0.6	0.7	0.8

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N50. In Situ Respiration Test in the Surface Warming Test Plot: October 20 through October 26, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)									
		0	0.83	3.50	6.58	26.08	50.17	72.92	96.58	119.08	149.42
S1b	O_2	16.7	16.0	14.2	12.3	11.8	4.2	0	0	NS	NS
	CO_2	6.0	6.2	6.2	6.8	7.0	7.6	8.0	8.3	NS	NS
S3c	O_2	5.5	8.5	15.5	15.8	14.5	10.3	12.8	12.0	17.2	11.0
	CO_2	11.8	10.5	6.2	6.5	6.5	8.8	7.8	8.3	4.3	8.5
S4c	O_2	18.8	18.0	18.2	18.3	18.0	17.2	17.8	18.0	18.0	18.3
	CO_2	2.8	3.2	3.6	3.6	4.0	4.7	3.8	3.8	3.7	3.2
S5a	O_2	19.2	19.2	NS	NS	NS	NS	NS	NS	NS	NS
	CO_2	1.4	1.4	NS	NS	NS	NS	NS	NS	NS	NS
S5b	O_2	3.8	3.8	9.8	10.2	NS	NS	NS	NS	NS	NS
	CO_2	15.0	15.0	12.0	12.2	NS	NS	NS	NS	NS	NS
S5c	O_2	9.2	9.2	10.3	11.8	8.3	8.3	8.8	8.5	8.7	9.7
	CO_2	10.8	10.6	10.5	9.7	11.0	10.7	10.0	10.8	10.8	10.2

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N51. In Situ Respiration Test in the Background Area: October 20 through October 26, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)									
		0	1.00	3.58	6.75	26.85	50.25	73.08	96.08	118.42	148.92
B2b	O_2	20.9	20.9	20.9	20.9	20.5	20.2	NS	NS	NS	NS
	CO_2	0.05	0.05	0.1	0.1	0.05	0.05	NS	NS	NS	NS
B2c	O_2	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N52. In Situ Respiration Test in the Active Warming Test Plot: November 16 through November 21, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		0.16	4.0	6.66	26.16	48.83	73.41	97.16	119.16
A1b	O_2	0	0	NS	NS	NS	NS	NS	NS
	CO_2	8.3	8.3	NS	NS	NS	NS	NS	NS
A1c	O_2	17.0	17.0	17.2	17.5	17.3	17.5	18.0	18.0
	CO_2	3.2	3.0	3.0	3.0	3.0	3.2	3.0	3.0
A2b	O_2	5.8	6.2	6.2	6.0	6.5	5.5	6.3	6.0
	CO_2	3.8	3.2	3.9	3.8	3.5	4.0	4.7	4.8
A2c	O_2	9.7	10.0	10.0	10.3	10.8	11.0	11.6	11.2
	CO_2	3.0	2.7	3.2	3.0	3.0	3.0	3.0	3.0
A3c	O_2	14.5	15.0	15.0	15.8	16.0	16.0	16.0	16.0
	CO_2	1.0	0.8	1.2	1.0	0.9	1.2	1.0	1.2
A4b	O_2	0	0	NS	NS	NS	NS	NS	NS
	CO_2	11.8	11.5	NS	NS	NS	NS	NS	NS
A4c	O_2	15.2	15.5	15.6	15.6	15.5	15.7	15.8	15.8
	CO_2	4.7	4.3	4.8	4.6	5.0	5.7	5.8	5.6
A5c	O_2	16.8	16.2	16.8	16.6	16.7	17.0	17.3	17.3
	CO_2	4.0	4.0	4.2	4.0	4.2	4.4	4.2	4.2
A6a	O_2	5.2	5.5	5.0	5.8	6.5	6.5	7.0	6.5
	CO_2	10.2	9.8	10.5	10.0	9.7	10.2	10.0	10.0
A6b	O_2	9.0	9.0	8.8	9.5	10.0	10.2	10.8	10.2
	CO_2	9.0	8.3	9.0	8.7	8.4	8.8	8.5	8.8
A6c	O_2	12.0	12.0	12.2	12.0	12.7	12.7	12.8	12.5
	CO_2	7.8	7.0	7.7	7.3	7.0	8.8	7.8	8.0
A7b	O_2	0	2	NS	NS	NS	NS	NS	NS

Table N52. In Situ Respiration Test in the Active Warming Test Plot: November 16 through November 21, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		0.16	4.0	6.66	26.16	48.83	73.41	97.16	119.16
A1b	O_2	0	0	NS	NS	NS	NS	NS	NS
	CO_2	4.3	4.3	NS	NS	NS	NS	NS	NS
A7c	O_2	16.8	17.0	17.0	17.3	17.3	17.3	18.0	18.0
	CO_2	3.3	2.8	3.2	2.8	3.0	3.8	3.4	3.2
A8c	O_2	0	0	NS	NS	NS	NS	NS	NS
	CO_2	7.0	6.4	NS	NS	NS	NS	NS	NS

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N53. In Situ Respiration Test in the Passive Warming Test Plot: November 16 through November 21, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		0.5	4.25	6.91	26.5	50.16	73.66	97.41	121.33
P1a	O_2	20.9	20.2	20.7	16.2	13.8	11.2	10.5	9.2
	CO_2	0.05	0.05	0.1	0.05	0.1	0.1	0.4	0.8
P1b	O_2	20.7	20.2	20.0	18.7	17.0	15.5	14.8	13.3
	CO_2	0.3	0.1	0.5	0.2	0.6	1.0	0.9	1.2
P1c	O_2	20.3	20.0	20.0	19.8	19.5	19.0	19.2	19.0
	CO_2	0.8	0.8	0.9	0.7	0.8	1.0	0.8	0.8
P2a	O_2	20.9	20.7	20.5	18.8	18.7	NS	NS	NS
	CO_2	0.05	0.05	0.05	0.05	0.05	NS	NS	NS
P2b	O_2	20.2	20.0	19.8	18.8	17.3	15.8	15.0	13.7
	CO_2	1.0	1.0	1.2	1.2	1.2	1.8	1.5	1.8
P2c	O_2	20.2	20.0	20.0	20.0	19.5	19.0	19.0	18.5
	CO_2	1.0	0.9	1.0	0.9	0.8	1.2	0.8	1.0
P3a	O_2	20.9	20.3	20.2	19.2	14.0	15.8	14.3	13.0
	CO_2	0.05	0.05	0.05	0.05	0.1	0.4	0.4	0.7
P3b	O_2	20.9	20.3	20.2	19.2	19.0	15.8	14.7	13.0
	CO_2	0.05	0.05	0.05	0.2	0.05	0.5	0.1	0.7
P3c	O_2	20.8	20.5	20.3	20.2	19.8	19.3	19.0	18.2
	CO_2	0.1	0.1	0.2	0.1	0.05	0.2	0.05	0.2
P4a	O_2	20.8	20.2	20.0	19.0	17.4	15.5	14.5	13.2
	CO_2	0.2	0.1	0.3	0.3	0.7	1.2	1.3	1.4
P5c	O_2	20.3	20.0	20.0	19.2	18.6	18.0	17.8	17.5
	CO_2	0.8	0.8	0.8	0.7	0.8	1.0	0.8	1.0

Table N53. In Situ Respiration Test in the Passive Warming Test Plot: November 16 through November 21, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		0.5	4.25	6.91	26.5	50.16	73.66	97.41	121.33
P6a	O_2	20.8	20.2	20.2	18.8	18.0	17.0	16.8	15.8
	CO_2	0.1	0.1	0.1	0.1	0.4	0.8	0.5	0.8
P6b	O_2	17.8	15.5	15.8	13.0	10.2	9.8	11.5	8.5
	CO_2	4.0	5.2	4.8	5.0	6.5	7.0	5.8	6.8
P6c	O_2	20.8	19.0	19.0	18.8	18.0	17.4	17.2	17.0
	CO_2	0.05	3.0	3.0	2.5	2.6	2.8	2.5	2.6

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N53. In Situ Respiration Test in the Passive Warming Test Plot: November 16 through November 21, 1993 (continued)

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		0.5	4.25	6.91	26.5	50.16	73.66	97.41	121.33
P7b	O_2	20.9	20.6	20.6	20.0	19.0	18.0	17.3	16.8
	CO_2	0.05	0.1	0.1	0.1	0.05	0.2	0.05	0.05
P7c	O_2	20.5	20.3	20.5	20.2	19.8	17.0	18.8	18.2
	CO_2	0.4	0.4	0.4	0.2	0.2	0.5	0.2	0.3
P8b	O_2	2.5	5.5	8.7	3.3	1.7	NS	NS	NS
	CO_2	13.5	13.0	11.5	12.8	13.0	NS	NS	NS
P8c	O_2	3.7	5.2	6.2	5.6	6.0	6.7	7.8	7.6
	CO_2	13.3	13.2	12.8	12.8	12.8	13.0	12.2	12.2

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N54. In Situ Respiration Test in the Control Test Plot: November 16 through November 21, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		2.66	5.33	7.92	28.66	51.42	74.66	98.66	120.33
C1b	O_2	20.0	19.8	20.0	19.0	18.0	17.3	16.8	16.0
	CO_2	1.3	0.2	0.5	0.4	0.4	0.8	0.8	0.8
C1c	O_2	20.2	20.0	20.0	19.5	18.8	18.3	18.0	17.8
	CO_2	0.1	0.1	0.4	0.2	0.2	0.7	0.5	0.7
C2a	O_2	20.5	20.2	20.2	19.4	18.2	17.3	17.0	15.5
	CO_2	0.1	0.1	0.4	0.2	0.4	0.8	0.7	0.8
C2c	O_2	20.2	20.0	20.0	19.8	19.0	18.8	18.3	17.8
	CO_2	0.1	0.05	0.3	0.1	0.3	0.5	0.5	0.6
C3b	O_2	20.7	20.0	20.0	19.0	18.2	18.0	18.0	17.0
	CO_2	0.1	0.05	0.3	0.05	0.1	0.2	0.1	0.2
C3c	O_2	20.5	20.2	20.2	20.0	19.2	19.2	19.0	18.8
	CO_2	0.1	0.05	0.4	0.1	0.2	0.3	0.4	0.4
C4c	O_2	20.2	20.0	20.0	20.0	19.2	19.0	19.0	18.3
	CO_2	0.4	0.4	0.6	0.3	0.5	0.8	0.8	0.8
C5c	O_2	20.0	19.8	20.0	19.5	19.0	18.5	18.0	17.5
	CO_2	0.7	0.8	1.0	0.8	0.9	1.0	1.0	1.2
C6b	O_2	19.8	19.8	19.7	19.7	18.5	18.5	17.8	17.0
	CO_2	0.8	0.7	1.0	0.8	0.7	0.8	0.8	1.0
C6c	O_2	20.0	19.8	20.20	19.3	18.8	18.3	18.0	17.3
	CO_2	0.6	0.7	0.8	0.7	0.7	0.9	0.8	1.0
C7b	O_2	20.8	20.3	20.7	20.0	19.5	18.8	18.3	17.8
	CO_2	0.1	0.1	0.2	0.1	0.1	0.3	0.2	0.3

Table N54. In Situ Respiration Test in the Control Test Plot: November 16 through November 21, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		2.66	5.33	7.92	28.66	51.42	74.66	98.66	120.33
C7c	O_2	20.5	20.2	20.5	20.2	20.0	20.0	19.6	19.3
	CO_2	0.4	0.3	0.5	0.3	0.3	0.7	0.5	0.6
C8a	O_2	20.5	20.2	20.2	19.5	18.7	18.0	17.5	16.3
	CO_2	0.1	0.1	0.2	0.2	0.2	0.8	1.0	0.9

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N55. In Situ Respiration Test in the Surface Warming Test Plot: November 16 through November 21, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		3.00	5.66	8.16	28.83	51.66	74.91	98.91	120.5
S1a	O_2	20.0	19.7	19.3	18.0	15.5	12.2	9.0	5.0
	CO_2	0.3	0.4	0.8	0.8	1.0	1.5	1.7	1.9
S1b	O_2	14.8	12.8	12.0	6.3	1.6	NS	NS	NS
	CO_2	7.0	7.3	7.5	7.8	8.0	NS	NS	NS
S1c	O_2	10.3	15.2	16.5	16.8	16.8	14.3	15.0	15.5
	CO_2	9.7	7.3	7.5	6.0	5.3	8.0	7.2	6.7
S2a	O_2	20.2	19.8	19.3	17.0	13.2	9.3	7.0	4.0
	CO_2	0.1	0.4	0.6	0.7	1.0	1.8	1.8	2.2
S2c	O_2	11.8	15.2	14.8	15.0	16.0	12.0	12.5	15.5
	CO_2	8.5	6.5	7.2	6.8	5.5	9.0	8.4	6.0
S3a	O_2	20.2	NS	NS	NS	NS	NS	NS	NS
	CO_2	0.2	NS	NS	NS	NS	NS	NS	NS
S3b	O_2	14.0	12.7	NS	NS	NS	NS	NS	NS
	CO_2	7.8	8.0	NS	NS	NS	NS	NS	NS
S3c	O_2	13.2	12.7	17.2	15.2	16.8	10.0	17.8	16.2
	CO_2	8.0	8.3	5.0	6.0	4.5	9.5	4.0	5.0
S4a	O_2	20.0	19.3	NS	NS	NS	NS	NS	NS
	CO_2	0.4	0.4	NS	NS	NS	NS	NS	NS
S6a	O_2	18.3	NS	NS	NS	NS	NS	NS	NS
	CO_2	3.2	NS	NS	NS	NS	NS	NS	NS
S6b	O_2	0	0	NS	NS	NS	NS	NS	NS
	CO_2	14.5	14.7	NS	NS	NS	NS	NS	NS

Table N55. In Situ Respiration Test in the Surface Warming Test Plot: November 16 through November 21, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		3.00	5.66	8.16	28.83	51.66	74.91	98.91	120.5
S1a	O_2	20.0	19.7	19.3	18.0	15.5	12.2	9.0	5.0

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N56. In Situ Respiration Test in the Active Warming Test Plot: December 21 through December 28, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0	24.5	68.5	120.00	168.00
A1b	O_2	0.3	0	NS	NS	NS
	CO_2	7.7	7.7	NS	NS	NS
A1c	O_2	17.5	17.2	17.5	17.5	18.0
	CO_2	2.8	2.8	3.0	3.0	2.8
A2b	O_2	3.8	4.7	3.7	NS	NS
	CO_2	4.7	4.5	5.0	NS	NS
A2c	O_2	7.5	8.0	6.8	9.2	8.2
	CO_2	3.8	3.7	4.7	3.7	4.7
A3c	O_2	13.5	13.8	14.0	16.2	14.0
	CO_2	1.4	1.4	1.8	1.2	1.6
A4b	O_2	0	0	NS	NS	NS
	CO_2	11.2	11.2	NS	NS	NS
A4c	O_2	14.8	14.5	15.3	16.0	16.5
	CO_2	5.0	5.0	5.3	4.7	4.3
A5c	O_2	16.8	16.3	17.5	18.0	18.5
	CO_2	3.8	4.0	3.8	3.2	3.0
A6a	O_2	4.2	4.3	4.5	4.2	4.7
	CO_2	9.8	9.8	10.2	10.0	9.5
A6b	O_2	6.2	6.2	6.2	7.2	7.5
	CO_2	9.2	9.2	9.6	9.2	9.0
A6c	O_2	7.5	7.2	7.0	12.5	10.5
	CO_2	8.8	9.0	9.3	6.5	7.3

Table N56. In Situ Respiration Test in the Active Warming Test Plot: December 21 through December 28, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0	24.5	68.5	120.00	168.00
A1b	O_2	0.3	0	NS	NS	NS
A7c	O_2	16.0	16.0	16.3	17.0	17.5
	CO_2	4.0	4.0	4.2	4.0	3.4
A8c	O_2	0.5	1.8	1.2	NS	NS
	CO_2	6.0	5.8	6.8	NS	NS

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N57. In Situ Respiration Test in the Passive Warming Test Plot: December 21 through 28, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0.00	24.50	68.50	120.00	168.00
P2b	O_2	20.5	19.5	17.3	15.0	13.2
	CO_2	0.8	0.8	1.2	1.4	1.4
P3c	O_2	20.9	20.3	19.5	18.5	17.8
	CO_2	0.1	0.05	0.2	0.2	0.1
P4a	O_2	20.9	19.7	17.2	14.3	12.8
	CO_2	0.2	0.2	0.9	1.2	1.3
P5a	O_2	20.9	19.3	17.3	15.2	13.2
	CO_2	0.2	0.3	1.0	1.4	1.5
P5b	O_2	20.8	18.3	14.8	11.7	9.8
	CO_2	0.3	0.7	1.7	2.7	3.0
P5c	O_2	20.7	20.0	18.8	17.7	17.0
	CO_2	0.6	0.5	0.9	1.0	0.8

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N58. In Situ Respiration Test in the Control Test Plot: December 21 through December 28, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0.00	23.50	67.50	118.00	166.00
C1b	O_2	17.7	15.2	13.2	11.5	10.8
	CO_2	2.7	2.3	2.8	2.8	2.8
C1c	O_2	15.7	15.8	15.3	18.0	18.2
	CO_2	1.8	1.7	2.0	1.0	1.0
C2a	O_2	20.2	19.0	17.2	15.0	13.4
	CO_2	2.4	2.7	3.5	2.7	3.7
C5c	O_2	17.5	17.0	19.5	19.2	19.3
	CO_2	1.6	1.8	0.8	0.8	0.7
C6b	O_2	16.0	15.8	15.0	14.2	13.8
	CO_2	3.0	2.8	3.2	3.2	3.4
C6c	O_2	16.8	16.2	18.2	17.2	16.8
	CO_2	2.7	2.7	1.7	2.2	2.0

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N59. In Situ Respiration Test in the Surface Warming Test Plot: December 21 through 28, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0.00	23.00	67.00	118.50	166.50
S1b	O_2	17.0	12.2	8.2	7.8	8.0
	CO_2	5.8	5.5	5.2	5.8	5.2
S3c	O_2	12.5	12.0	13.2	14.3	12.6
	CO_2	8.3	8.0	7.5	6.5	7.5
S4b	O_2	13	6.2	15.8	19.8	20.9
	CO_2	5.2	8.2	3.6	1.0	0.05
S5a	O_2	20.9	20.9	20.9	20.8	20.9
	CO_2	0.05	0.05	0.05	0.1	0.05
S5b	O_2	20.9	20.9	20.9	20.8	20.9
	CO_2	0.1	0.05	0.1	0.1	0.05
S5c	O_2	8.0	9.5	12.8	13.3	12.6
	CO_2	11.5	10.2	8.5	8.0	8.3

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N60. In Situ Respiration Test in the Background Area: December 21 through December 28, 1993

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0.00	23.50	67.50	118.00	166.00
B2b	O_2	20.9	20.9	20.9	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05
B2c	O_2	20.9	20.9	20.9	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N61. In Situ Respiration Test: January 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	23.017	46.583	74.783	118.3	166.25
B2A	O_2	20.9	20.9	20.9	20.9	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05
B2B	O_2	20.9	20.9	20.9	20.9	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05
B2C	O_2	20.9	20.9	20.9	20.9	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N62. In Situ Respiration Test: January 8 through January 15, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	18.5	41.58	70.28	113.83	161.58
A1A	O_2	NS	NS	NS	NS	NS	NS
	CO_2	NS	NS	NS	NS	NS	NS
A1B	O_2	2.0	NS	NS	NS	NS	NS
	CO_2	7.3	NS	NS	NS	NS	NS
A1C	O_2	2.3	2.3	2.2	2.2	2.2	2.0
	CO_2	18.2	18.7	18.8	19.0	19.2	19.3
A2A	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS
A2B	O_2	3.2	NS	NS	NS	NS	NS
	CO_2	4.9	NS	NS	NS	NS	NS
A2C	O_2	18.8	14.8	17.0	19.3	20.0	20.3
	CO_2	0.8	2.2	1.3	0.4	0.4	0.2
A3A	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS
A3B	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS
A3C	O_2	20.5	19.8	19.7	20.7	20.0	19.5
	CO_2	0.05	0.5	0.5	0.1	0.4	0.3
A4A	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS

Table N62. In Situ Respiration Test: January 8 through January 15, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	18.5	41.58	70.28	113.83	161.58
A4B	O_2	14.0	0	1.3	NS	NS	NS
	CO_2	0.2	11.6	10.7	NS	NS	NS
A4C	O_2	18.3	18.8	18.8	19.0	19.0	19.2
	CO_2	2.7	2.5	2.4	2.4	3.0	2.3
A5A	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS
A5B	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS
A6A	O_2	3.8	NS	NS	NS	NS	NS
	CO_2	10.0	NS	NS	NS	NS	NS
A6B	O_2	5.6	NS	NS	NS	NS	NS
	CO_2	10.0	NS	NS	NS	NS	NS
A6C	O_2	20.0	18.5	16.8	19.7	18.0	19.2
	CO_2	1.0	2.8	4.2	1.7	3.4	2.0
A7A	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS
A7B	O_2	18.8	19.3	13.5	18.5	15.8	20.0
	CO_2	0.5	0.8	2.2	1.0	2.0	1.2
A7C	O_2	20.0	20.0	20.0	20.0	20.2	20.0
	CO_2	1.2	1.4	1.2	1.2	1.3	1.3

Table N62. In Situ Respiration Test: January 8 through January 15, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	18.5	41.58	70.28	113.83	161.58
A8A	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS
A8B	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS
A8C	O_2	16.0	14.8	11.4	13.8	14.2	16.7
	CO_2	2.2	3.2	4.3	3.7	3.7	2.5

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N63. In Situ Respiration Test: January 8 through January 15, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	18.58	42.08	70.5	114.08	161.83
P1A	O_2	20.7	18.2	16.2	14.0	12.8	9.7
	CO_2	0.1	0.3	0.4	1.8	1.3	1.7
P1B	O_2	20.0	18.8	17.8	16.8	15.0	13.3
	CO_2	1.0	1.2	1.2	1.5	1.8	2.0
P1C	O_2	20.0	19.8	19.3	19.5	19.0	18.3
	CO_2	1.0	1.0	1.0	1.0	1.2	1.0
P2A	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS
P2B	O_2	20.0	19.2	18.2	17.3	15.8	14.0
	CO_2	1.0	1.3	1.2	1.5	1.7	1.8
P2C	O_2	20.0	19.8	19.4	19.3	18.7	18.0
	CO_2	0.8	1.0	0.8	1.0	1.0	0.8
P3A	O_2	20.9	19.8	18.3	17.3	15.2	13.0
	CO_2	0.05	0.1	0.1	0.4	0.6	0.8
P3B	O_2	20.8	19.8	18.3	17.3	15.2	13.5
	CO_2	0.05	0.1	0.1	0.2	0.4	0.4
P3C	O_2	20.8	20.0	20.8	19.3	18.8	18.0
	CO_2	0.05	0.3	0.1	0.2	0.2	0.2
P4A	O_2	20.2	19.0	18.0	17.0	15.0	13.2
	CO_2	0.5	1.0	0.8	1.3	1.7	1.8

Table N63. In Situ Respiration Test: January 8 through January 15, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	18.58	42.08	70.5	114.08	161.83
P4B	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS
P4C	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS
P5A	O_2	20.5	19.5	18.3	17.3	15.5	14.0
	CO_2	0.6	1.0	1.0	1.6	2.0	2.2
P5B	O_2	20.2	18.8	17.0	18.5	12.5	10.5
	CO_2	0.7	1.2	1.3	1.0	2.8	3.3
P5C	O_2	20.0	19.5	18.8	18.0	17.0	16.0
	CO_2	0.8	1.0	0.8	1.0	1.0	1.0
P6A	O_2	20.7	19.5	18.0	17.0	15.8	14.8
	CO_2	0.1	0.8	1.2	1.8	2.2	2.6
P6B	O_2	20.9	16.7	16.3	15.0	13.2	12.3
	CO_2	0.05	3.8	4.6	4.4	5.0	5.2
P6C	O_2	19.0	19.0	18.5	18.0	17.0	16.2
	CO_2	2.2	2.2	2.0	2.4	2.2	2.0
P7A	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS
P7B	O_2	20.9	20.5	20.0	19.0	18.0	17.0
	CO_2	0.05	0.05	0.05	0.1	0.05	0.1

Table N63. In Situ Respiration Test: January 8 through January 15, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	18.58	42.08	70.5	114.08	161.83
P7C	O_2	20.3	20.3	20.0	19.8	19.0	18.2
	CO_2	0.1	0.3	0.1	0.5	0.2	0.2
P8A	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS
P8B	O_2	7.2	6.0	5.7	6.0	4.5	4.0
	CO_2	11.2	12.2	12.0	12.3	12.2	12.2
P8C	O_2	11.0	10.2	9.5	9.5	7.0	6.0
	CO_2	10.0	11.7	11.5	12.0	12.7	13.0

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N64. In Situ Respiration Test: January 8 through January 15, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	19	42.52	70.75	114.25	162.22
PP1C	O_2	3.2	NS	NS	NS	NS	NS
	CO_2	10.0	NS	NS	NS	NS	NS
PP2C	O_2	4.8	NS	NS	NS	NS	NS
	CO_2	11.8	NS	NS	NS	NS	NS
PP3A	O_2	19.0	20.8	20.8	20.9	20.9	20.8
	CO_2	2.3	0.05	0.05	0.1	0.05	0.05
PP3C	O_2	17.0	16.8	15.2	14.3	13.8	12.5
	CO_2	7.2	6.5	7.0	7.8	7.0	7.3
PP4B	O_2	20.9	20.8	20.3	20.3	20.0	19.8
	CO_2	0.05	0.1	0.1	0.2	0.05	0.05
PP7A	O_2	13.8	2.8	1.2	1.8	0.5	1.0
	CO_2	10.0	7.5	7.0	7.8	7.8	7.8
PP7B	O_2	20.9	20.9	20.9	20.8	20.9	20.8
	CO_2	0.05	0.05	0.05	0.1	0.05	0.05
PP7C	O_2	0.2	NS	NS	NS	NS	NS
	CO_2	8.2	NS	NS	NS	NS	NS

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N65. In Situ Respiration Test: January 8 through January 15, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	20.58	44.58	72.92	115.35	164.17
C1B	O_2	20.2	19.6	18.8	18.5	17.0	16.5
	CO_2	1.8	1.5	2.0	2.0	2.2	2.2
C1C	O_2	20.0	20.0	20.0	20.0	19.8	19.8
	CO_2	1.4	1.0	1.2	1.2	1.2	1.2
C2A	O_2	20.9	20.0	19.3	18.5	18.3	15.8
	CO_2	0.8	0.8	1.0	1.2	1.0	1.4
C2C	O_2	20.3	20.5	20.6	20.5	20.5	20.3
	CO_2	1.0	0.3	0.7	0.8	0.6	0.7
C3B	O_2	20.9	20.0	19.0	19.0	18.0	17.2
	CO_2	0.5	0.2	0.7	0.8	0.8	1.2
C3C	O_2	20.2	19.2	18.0	18.5	18.0	18.0
	CO_2	1.5	1.6	2.2	2.2	2.2	2.4
C4B	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.1	NS	NS	NS
C4C	O_2	20.9	20.9	17.8	17.0	15.5	14.2
	CO_2	0.05	0.05	1.6	1.8	1.8	2.2
C5A	O_2	20.8	20.8	20.2	20.2	19.8	19.0
	CO_2	0.6	0.2	0.7	0.7	0.5	0.8
C5B	O_2	20.7	20.3	20.0	20.0	19.5	19.3
	CO_2	0.7	0.8	1.2	1.3	1.5	1.4

Table N65. In Situ Respiration Test: January 8 through January 15, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	20.58	44.58	72.92	115.35	164.17
C5C	O_2	20.0	19.8	20.0	20.0	20.0	20.2
	CO_2	1.5	1.6	1.4	1.2	1.0	0.6
C6A	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS
C6B	O_2	19.0	18.5	19.0	18.2	17.4	16.7
	CO_2	3.0	3.3	2.8	3.5	3.7	4.0
C6C	O_2	19.3	19.8	19.7	19.0	18.5	18.0
	CO_2	2.5	1.6	2.0	2.4	2.7	2.8
C7B	O_2	20.9	20.2	20.0	19.5	18.7	17.5
	CO_2	0.2	0.4	0.4	0.6	0.5	0.6
C7C	O_2	20.6	20.2	20.8	20.7	20.6	20.2
	CO_2	0.7	0.7	0.5	0.7	0.4	0.6
C8B	O_2	20.9	20.9	20.9	20.9	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05
C8C	O_2	20.0	20.0	20.0	20.0	20.0	19.8
	CO_2	1.0	0.7	0.8	0.8	0.8	0.7

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N66. In Situ Respiration Test: January 8 through January 15, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	21.22	45.05	73.22	115.58	164.50
S1A	O_2	20.9	19.8	20.9	20.9	20.9	20.9
	CO_2	0.05	0.2	0.05	0.05	0.05	0.05
S1B	O_2	18.2	14.8	10.7	10.7	6.3	6.2
	CO_2	4.3	4.2	5.0	4.6	5.3	5.7
S1C	O_2	15.8	17.2	16.7	16.3	16.8	16.7
	CO_2	5.8	4.5	5.2	5.7	4.7	5.0
S2A	O_2	20.9	18.5	20.9	20.9	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05
S2B	O_2	17.3	20.9	20.9	20.9	20.9	20.9
	CO_2	4.0	0.05	0.05	0.05	0.05	0.05
S2C	O_2	19.0	18.5	19.5	19.0	17.2	18.3
	CO_2	3.0	3.5	2.2	3.0	4.2	3.0
S3C	O_2	17.0	15.2	16.5	11.5	14.2	13.2
	CO_2	4.5	5.8	4.7	8.0	6.0	6.5
S4B	O_2	20.9	9.0	10.5	19.5	16.8	19.0
	CO_2	0.05	7.0	6.3	1.3	2.8	1.4
S4C	O_2	14.2	20.9	20.9	20.9	20.9	20.9
	CO_2	4.7	0.05	0.05	0.05	0.05	0.05
S5A	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS

Table N66. In Situ Respiration Test: January 8 through January 15, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	21.22	45.05	73.22	115.58	164.50
S1A	O_2	20.9	19.8	20.9	20.9	20.9	20.9
S5B	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS
S5C	O_2	12.3	12.6	12.5	13.5	13.2	14.7
	CO_2	8.7	8.3	8.0	7.8	7.4	6.7
S6A	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS
S6B	O_2	9.2	8.7	10.5	20.9	20.9	20.9
	CO_2	9.8	10.2	9.2	0.05	0.05	0.05
S6C	O_2	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N67. In Situ Respiration Test: February 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	7.50	19.92	48.17	74.00	113.75
B2B	O_2	20.9	20.9	20.9	20.9	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05
B2C	O_2	20.9	20.9	20.9	20.9	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N68. In Situ Respiration Test: February 19 through February 24, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	7.00	19.50	47.67	73.67	113.33
A1B	O_2	3.8	6.4	4.5	3.8	3.0	3.3
	CO_2	6.7	5.8	6.5	7.0	6.8	6.8
A1C	O_2	19.8	19.8	20.0	19.8	20.0	19.8
	CO_2	1.8	1.8	1.8	1.8	1.5	1.6
A2B	O_2	8.5	5.0	4.2	4.3	4.5	4.2
	CO_2	1.2	5.0	5.7	6.0	5.7	6.0
A3A	O_2	20.8	20.9	20.9	20.9	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05
A4B	O_2	0.0	0.8	0.0	0.0	0.0	0.0
	CO_2	12.3	11.8	12.2	12.2	12.0	12.2
A4C	O_2	18.8	18.8	19.0	19.0	19.3	19.2
	CO_2	3.2	3.0	3.0	2.8	2.5	2.7
A6A	O_2	5.2	4.7	4.2	3.2	2.8	2.0
	CO_2	11.7	11.7	12.2	12.3	12.3	12.7
A6B	O_2	15.3	18.2	18.2	17.8	17.2	17.2
	CO_2	9.4	4.2	4.5	4.7	5.4	5.5
A6C	O_2	19.0	20.2	20.6	20.0	20.0	20.0
	CO_2	4.8	1.3	1.3	1.4	1.7	1.8
A7B	O_2	19.0	19.0	19.5	19.3	19.5	19.2
	CO_2	2.0	1.8	1.8	1.8	1.6	1.8

Table N68. In Situ Respiration Test: February 19 through February 24, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	7.00	19.50	47.67	73.67	113.33
A1B	O_2	3.8	6.4	4.5	3.8	3.0	3.3
A7C	O_2	19.5	19.5	19.8	19.8	20.0	20.0
	CO_2	1.6	1.5	1.5	1.3	1.2	1.2
A8C	O_2	15.5	18.2	18.6	19.0	19.0	19.2
	CO_2	3.8	2.2	2.3	1.8	1.8	1.8

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N69. In Situ Respiration Test: February 19 through February 24, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	7.00	19.50	47.67	73.67	113.33
P2B	O_2	20.5	20.2	20.0	18.5	17.8	15.8
	CO_2	0.5	0.5	0.7	0.8	0.8	1.1
P3C	O_2	20.8	20.8	20.8	20.0	19.5	18.2
	CO_2	0.1	0.1	0.1	0.2	0.05	0.2
P4A	O_2	20.7	20.3	20.0	18.4	17.3	15.5
	CO_2	0.5	0.5	0.7	1.0	1.0	1.5
P5A	O_2	20.7	20.5	20.2	19.0	18.2	16.8
	CO_2	0.5	0.4	0.8	1.2	1.2	1.8
P5B	O_2	20.3	19.8	19.0	16.7	15.2	13.0
	CO_2	1.0	0.8	1.3	1.8	2.0	2.8
P5C	O_2	20.2	20.0	19.8	18.8	18.2	17.0
	CO_2	1.2	1.0	1.2	1.3	1.2	1.7

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N70. In Situ Respiration Test: February 19 through February 24, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	7.58	20.08	48.25	74.08	113.83
C1B	O_2	10.3	11.3	12.5	9.0	9.0	8.2
	CO_2	5.2	4.7	4.4	5.6	5.4	5.8
C1C	O_2	18.3	19.0	19.0	18.8	19.0	18.7
	CO_2	2.0	1.6	1.8	1.7	1.6	1.8
C2A	O_2	3.2	3.0	2.2	1.3	0.8	0.2
	CO_2	9.0	9.0	9.0	9.0	8.8	8.8
C5A	O_2	11.0	15.8	14.0	13.3	11.7	10.4
	CO_2	4.4	2.4	3.0	3.2	3.7	4.2
C5B	O_2	19.6	20.2	20.2	20.0	20.2	20.0
	CO_2	1.2	0.7	0.4	0.4	0.4	0.7
C6C	O_2	14.6	15.7	15.2	14.8	14.8	14.2
	CO_2	3.7	3.2	3.2	3.4	3.5	4.0

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N71. In Situ Respiration Test: February 19 through February 24, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	7.75	20.25	48.33	74.25	114.00
S1A	O_2	NS	NS	NS	NS	NS	NS
	CO_2	NS	NS	NS	NS	NS	NS
S1B	O_2	13.6	9.8	7.2	4.2	3.4	3.0
	CO_2	4.2	5.8	6.0	6.2	6.3	7.2
S1C	O_2	18.0	19.6	19.0	18.8	19.2	18.8
	CO_2	3.8	2.3	3.0	3.0	2.7	3.2
S2A	O_2	20.3	NS	NS	NS	NS	NS
	CO_2	0.02	NS	NS	NS	NS	NS
S2C	O_2	17.8	19.0	19.3	19.2	19.8	19.0
	CO_2	3.8	3.0	2.5	2.4	2.0	2.8
S3C	O_2	17.2	17.6	19.0	18.5	19.0	18.3
	CO_2	4.0	4.5	2.7	2.8	2.2	3.0
S4A	O_2	20.7	20.8	20.9	20.9	20.9	20.8
	CO_2	0.05	0.05	0.05	0.05	0.05	0.1
S4C	O_2	19.2	19.8	19.8	19.8	19.5	19.4
	CO_2	2.0	1.8	1.8	1.8	1.8	1.8
S5B	O_2	20.0	16.3	15.6	13.7	14.2	9.5
	CO_2	1.0	4.0	5.2	6.0	6.6	8.0
S5C	O_2	13.8	16.0	15.0	13.7	15.5	15.7
	CO_2	7.8	6.3	7.2	7.8	6.2	6.4

Table N71. In Situ Respiration Test: February 19 through February 24, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	7.75	20.25	48.33	74.25	114.00
S1A	O_2	NS	NS	NS	NS	NS	NS
S6C	O_2	17.4	17.5	19.4	20.0	19.7	18.8
	CO_2	2.8	4.2	2.8	1.4	2.4	3.2

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N72. In Situ Respiration Test: March 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		0.00	6.58	25.33	41.75	70.37	92.83	113.58	142.00
B2A	O_2	20.9	20.9	20.9	NS	NS	NS	NS	NS
	CO_2	0.05	0.05	0.05	NS	NS	NS	NS	NS
B2B	O_2	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
B2C	O_2	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N73. In Situ Respiration Test: March 24 through March 30, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		0.00	6.16	24.83	41.16	58.08	80.58	101.33	118.16
A1C	O_2	20.5	20.3	20.2	20.5	20.3	20.2	NS	NS
	CO_2	1.2	1.4	1.5	1.4	1.5	1.8	NS	NS
A2C	O_2	20.9	NS	NS	NS	NS	NS	NS	NS
	CO_2	0.05	NS	NS	NS	NS	NS	NS	NS
A3A	O_2	20.9	20.9	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	0.05	0.05	NS	NS	NS
A3B	O_2	20.9	20.9	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	0.05	0.05	NS	NS	NS
A3C	O_2	20.7	20.7	20.7	20.8	20.7	NS	NS	NS
	CO_2	0.1	0.2	0.4	0.3	0.3	NS	NS	NS
A4A	O_2	20.9	20.9	20.9	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.05	0.05	0.05	NS	NS	NS
A4B	O_2	0.0	0.1	0.0	0.0	NS	NS	NS	NS
	CO_2	12.2	12.3	12.5	13.0	NS	NS	NS	NS
A4C	O_2	17.6	18.0	18.0	18.2	18.4	18.3	NS	NS
	CO_2	3.7	3.8	4.0	3.8	3.7	4.2	NS	NS
A6A	O_2	0.0	0.0	0.0	0.0	NS	NS	NS	NS
	CO_2	11.5	11.8	12.2	12.2	NS	NS	NS	NS
A6B	O_2	18.0	16.6	15.5	15.7	15.2	15.3	15.0	15.2
	CO_2	4.5	5.5	6.2	6.2	6.5	7.0	6.6	6.8

Table N73. In Situ Respiration Test: March 24 through March 30, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		0.00	6.16	24.83	41.16	58.08	80.58	101.33	118.16
A6C	O_2	19.8	19.0	18.8	19.0	18.8	18.8	18.2	18.2
	CO_2	2.0	3.1	3.7	3.8	3.8	4.0	4.2	4.2
A7A	O_2	20.9	NS	NS	NS	NS	NS	NS	NS
	CO_2	0.05	NS	NS	NS	NS	NS	NS	NS
A7B	O_2	18.6	18.3	18.2	18.5	19.0	18.8	NS	NS
	CO_2	2.2	2.7	3.0	2.8	2.3	2.5	NS	NS
A7C	O_2	18.7	18.8	18.5	19.3	19.2	19.2	NS	NS
	CO_2	2.1	2.2	2.4	2.0	1.8	2.0	NS	NS
A8A	O_2	20.9	20.9	20.8	20.9	20.9	NS	NS	NS
	CO_2	0.05	0.05	0.1	0.05	0.05	NS	NS	NS
A8B	O_2	20.9	NS	NS	NS	NS	NS	NS	NS
	CO_2	0.05	NS	NS	NS	NS	NS	NS	NS
A8C	O_2	11.5	13.5	15.0	17.0	16.8	17.5	NS	NS
	CO_2	2.7	2.5	2.8	2.5	2.4	2.7	NS	NS

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N74. In Situ Respiration Test: March 24 through March 30, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		0.00	6.41	25.08	41.42	70.25	92.67	113.33	141.83
P2B	O_2	20.2	20.0	19.2	18.5	17.0	16.0	15.0	13.7
	CO_2	1.0	1.1	1.3	1.4	1.4	1.6	1.6	1.8
P3C	O_2	20.2	20.2	20.0	19.8	18.8	18.0	17.2	16.2
	CO_2	0.7	1.0	1.0	1.0	0.8	1.0	0.8	1.0
P5A	O_2	20.9	NS	15.0	20.9	20.9	20.9	NS	NS
	CO_2	0.05	NS	5.0	0.05	0.05	0.05	NS	NS
P5B	O_2	20.2	19.8	18.0	16.8	14.7	13.0	11.8	10.2
	CO_2	0.8	1.3	1.8	2.2	2.4	3.0	3.2	3.8
P5C	O_2	20.0	20.0	19.0	18.8	17.2	16.2	15.3	14.2
	CO_2	1.3	1.8	2.1	2.1	2.0	2.2	2.2	2.4
P6C	O_2	20.2	20.2	19.7	19.5	18.3	17.8	17.3	16.7
	CO_2	1.1	1.7	2.0	2.0	2.0	2.0	1.8	2.0
P8B	O_2	15.6	11.6	11.0	10.2	8.5	7.7	7.0	6.0
	CO_2	8.4	12.6	12.8	13.0	13.0	13.0	13.0	13.0
P8C	O_2	15.8	17.0	17.3	13.5	10.8	9.7	10.2	8.8
	CO_2	8.2	7.8	10.0	11.0	12.0	12.0	11.0	11.8

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N75. In Situ Respiration Test: March 24 through March 30, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0.00	1.58	9.1	27.83	44.25	72.92	95.33	113	152.5
C1B	O_2	20.2	0.5	2.4	1.2	0.8	1.0	NS	NS	NS
	CO_2	0.1	8.0	7.6	8.0	8.0	7.8	NS	NS	NS
C1C	O_2	16.8	18	16.4	16.7	17.0	17.0	17.0	NS	NS
	CO_2	1.6	3.2	3.5	3.2	3.2	3.0	NS	NS	NS
C2A	O_2	0.6	0.0	0.0	0.0	0.0	NS	NS	NS	NS
	CO_2	8.5	9.5	9.8	9.7	9.5	NS	NS	NS	NS
C3B	O_2	12.8	17.3	20.2	18	16	15.2	15.3	16	16.5
	CO_2	2.1	0.3	2.0	3.8	4.8	4.8	5.0	5.2	NS
C5A	O_2	18.2	16.0	17.0	20.9	19.8	18.0	20.9	20.9	NS
	CO_2	1.2	2.0	1.7	0.05	0.6	1.2	0.05	0.05	NS
C5B	O_2	19.5	20.7	19.3	19.3	19.3	19.8	19.2	NS	NS
	CO_2	0.1	1.0	1.1	1.0	1.0	1.1	NS	NS	NS
C6C	O_2	10.8	13.8	9.5	9.5	9.7	9.8	9.8	10	9.8
	CO_2	3.5	5.7	6.0	5.8	6.0	6.0	5.5	6.0	NS

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N76. In Situ Respiration Test: March 24 through March 30, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)							
		0.00	6.83	25.58	42.08	70.58	93.08	114.58	142.08
S1B	O_2	8.8	1.0	0.0	0.4	0.1	NS	NS	NS
	CO_2	5.8	8.8	9.2	9.2	9.5	NS	NS	NS
S1C	O_2	18.2	18.0	18.3	19.4	18.4	18.5	NS	NS
	CO_2	3.5	4.2	4.0	3.0	3.7	3.5	NS	NS
S2C	O_2	18.3	18.0	17.3	19.7	17.6	18.2	NS	NS
	CO_2	3.2	4.2	5.0	2.7	4.3	3.7	NS	NS
S3B	O_2	17.0	15.2	9.2	20.9	15.8	9.0	10.7	11.0
	CO_2	2.3	3.0	7.0	0.05	2.7	7.0	6.2	6.8
S4B	O_2	20.2	14.2	14.7	NS	20.9	15.5	15.5	17.5
	CO_2	0.2	4.2	4.2	NS	0.05	3.8	3.2	2.5
S4C	O_2	19.5	19.0	19.7	20.7	19.8	20.0	NS	NS
	CO_2	1.8	3.0	2.2	1.1	1.4	1.7	NS	NS
S5B	O_2	18.0	20.8	9.2	20.9	20.9	12.2	20.9	11.8
	CO_2	2.8	0.1	9.2	0.05	0.05	8.0	0.05	8.2
S6B	O_2	13.3	6.5	8.7	20.9	20.9	5.0	15.2	6.0
	CO_2	6.8	11.0	10.4	0.05	0.05	12.0	5.5	11.8

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N77. In Situ Respiration Test: April 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0.00	21.93	48.52	76.18	99.85	123.10	145.52	167.68	191.60
B2B	O_2	20.9	20.9	20.9	20.9	20.8	20.8	20.8	20.8	20.7
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
B2C	O_2	20.9	20.9	20.9	20.9	20.9	20.8	20.8	20.8	20.7
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N78. In Situ Respiration Test: April 16 through April 24, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0.00	22.75	49.58	77.25	101.25	124.08	146.67	167.67	193.50
A1C	O_2	17.8	18.0	18.0	18.0	17.8	17.7	17.3	17.3	17.0
	CO_2	3.0	2.4	2.5	2.5	2.7	2.4	2.2	2.5	3.0
A4B	O_2	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	CO_2	12.8	13.0	13.2	13.2	13.2	13.2	13.2	13.2	13.0
A4C	O_2	14.8	15.2	15.0	14.7	13.8	13.8	13.2	12.8	12.2
	CO_2	5.8	5.3	5.8	6.2	6.7	6.5	6.3	6.0	5.8
A6A	O_2	6.0	5.7	5.0	4.2	3.5	2.7	2.0	1.0	0.0
	CO_2	12.4	12.3	12.3	12.3	12.3	12.3	12.4	12.0	12.0
A6B	O_2	10.7	14.0	14.0	13.8	12.8	12.5	11.8	11.2	9.8
	CO_2	9.8	8.0	8.2	8.2	8.3	8.3	8.5	8.4	8.6
A6C	O_2	14.3	16.3	16.3	16.2	15.8	15.2	14.8	13.8	12.3
	CO_2	7.3	5.8	6.0	6.0	6.0	6.0	6.3	6.5	7.2
A7B	O_2	20.6	20.2	20.0	20.2	20.0	19.8	19.4	18.3	15.6
	CO_2	0.8	0.7	0.8	0.8	0.8	1.0	1.1	1.1	1.7
A7C	O_2	20.6	20.3	20.2	20.0	20.0	19.8	19.0	18.2	16.5
	CO_2	0.6	0.6	0.8	0.8	0.8	1.0	1.1	1.1	1.5
A8C	O_2	13.7	16.0	17.3	17.8	17.7	17.5	17.5	17.8	19.0
	CO_2	4.0	3.5	3.2	3.0	3.0	3.0	3.0	2.8	2.2

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N79. In Situ Respiration Test: April 16 through April 24, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0.00	22.50	49.25	76.92	100.92	123.75	146.33	168.33	193.17
P1A	O_2	20.9	17.7	15.3	12.5	12.0	12.6	14.5	20.9	20.9
	CO_2	0.05	0.1	0.1	0.2	0.4	0.4	0.6	0.05	0.05
P1B	O_2	20.9	19.2	17.2	16.0	15.2	14.8	14.2	13.8	12.8
	CO_2	0.2	0.3	0.6	0.8	0.8	1.0	1.2	1.2	1.8
P1C	O_2	20.9	20.2	19.7	19.2	18.8	18.2	17.3	16.8	16.2
	CO_2	0.6	0.6	0.8	0.8	0.8	0.8	1.0	0.8	0.8
P2B	O_2	20.6	19.5	18.2	17.0	16.0	14.8	13.8	13.5	12.5
	CO_2	0.7	0.8	1.0	1.2	1.2	1.3	1.7	1.5	1.8
P2C	O_2	20.7	20.0	19.6	19.0	18.3	17.3	13.6	16.0	15.2
	CO_2	0.9	0.8	1.0	1.0	1.0	1.0	1.8	1.1	1.1
P3A	O_2	20.7	19.0	17.2	15.7	13.8	12.8	12.5	12.0	11.8
	CO_2	0.4	0.7	1.1	1.5	1.6	1.8	2.2	2.5	3.0
P3B	O_2	20.6	19.3	18.0	16.5	15.0	14.0	13.2	12.8	12.2
	CO_2	0.5	0.5	0.8	1.2	1.2	1.4	2.0	2.0	2.3
P3C	O_2	20.6	20.0	19.3	18.8	17.8	17.0	16.0	15.8	14.8
	CO_2	0.7	0.8	0.8	0.9	0.9	1.0	1.1	1.0	1.0
P5B	O_2	20.5	18.4	16.2	14.3	13.2	12.0	10.5	10.7	10.3
	CO_2	0.7	1.1	1.7	2.2	2.2	2.7	3.5	3.6	4.0
P5C	O_2	20.2	19.3	18.3	17.5	16.5	15.8	15.2	15.0	14.3
	CO_2	1.2	1.4	1.6	1.8	1.8	2.0	2.2	2.1	2.1

Table N79. In Situ Respiration Test: April 16 through April 24, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0.00	22.50	49.25	76.92	100.92	123.75	146.33	168.33	193.17
P7C	O_2	20.9	20.2	20.0	19.8	19.2	18.8	18.0	18.0	17.8
	CO_2	0.05	0.1	0.2	0.3	0.2	0.2	0.5	0.3	0.2
P8B	O_2	15.7	14.8	13.8	12.8	11.8	10.8	10.7	10.3	8.2
	CO_2	10.8	11.0	11.2	11.5	11.3	11.7	11.8	11.0	11.5

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N80. In Situ Respiration Test: April 16 through April 24, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0.00	22.00	48.50	76.20	99.83	123.08	145.50	167.67	192.58
C1B	O_2	19.3	20.0	20.0	19.7	19.2	18.8	18.3	18.2	17.2
	CO_2	1.2	1.5	1.8	2.0	1.8	2.1	2.2	2.2	2.2
C1C	O_2	20.7	20.2	20.2	19.8	19.2	18.7	18.3	18.3	17.5
	CO_2	0.7	0.7	1.0	1.1	1.2	1.5	1.7	1.5	1.7
C2A	O_2	20.9	20.0	19.2	18.3	17.3	16.2	15.0	13.8	14.2
	CO_2	0.05	0.1	0.3	0.5	0.7	1.0	1.2	1.3	1.2
C2C	O_2	20.9	20.6	20.5	20.2	19.8	19.0	18.5	18.0	17.5
	CO_2	0.05	0.05	0.2	0.3	0.4	0.6	0.7	0.6	0.6
C3C	O_2	20.9	20.3	20.2	20.0	19.5	18.8	18.2	17.7	16.5
	CO_2	0.05	0.1	0.2	0.4	0.4	0.7	0.8	0.8	0.8
C4C	O_2	19.0	20.2	20.4	20.3	20.0	19.4	19.0	19.0	18.2
	CO_2	1.7	1.0	0.8	0.8	0.8	0.8	0.8	0.6	0.6
C5C	O_2	20.8	20.6	20.5	20.2	19.8	19.0	18.4	18.0	17.3
	CO_2	0.1	0.1	0.2	0.2	0.3	0.5	0.6	0.4	0.5
C6B	O_2	20.9	20.0	20.0	19.5	18.5	16.2	15.2	13.8	12.2
	CO_2	0.05	0.3	0.5	0.7	1.0	1.8	2.2	2.3	2.5
C6C	O_2	20.8	20.0	20.0	19.6	18.5	16.6	15.5	14.0	12.2
	CO_2	0.1	0.2	0.5	0.7	1.0	1.6	2.0	2.0	2.2
C7B	O_2	0.9	1.0	1.2	1.3	1.3	1.5	1.7	1.6	1.8
	CO_2	20.5	19.8	19.0	18.2	17.6	17.0	16.2	15.5	14.5

Table N80. In Situ Respiration Test: April 16 through April 24, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)								
		0.00	22.00	48.50	76.20	99.83	123.08	145.50	167.67	192.58
C7C	O_2	20.5	20.2	20.3	20.0	19.0	18.8	18.3	18.5	17.2
	CO_2	0.7	0.6	0.8	0.8	1.2	1.3	1.4	1.2	1.2
C8C	O_2	19.8	19.8	19.7	19.3	18.8	18.5	18.2	18.3	17.8
	CO_2	2.7	2.5	2.5	2.5	2.7	3.0	3.0	2.8	2.8

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N81. In Situ Respiration Test: April 16 through April 19, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)			
		0.00	21.42	48.08	75.67
S1B	O_2	4.0	2.0	2.0	7.0
	CO_2	10.2	10.8	10.8	9.5

Table N82. In Situ Respiration Test: May 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0.00	29.08	51.28	71.62	92.83
B2B	O_2	20.9	20.9	20.9	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05
B2C	O_2	20.9	20.9	20.9	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.05

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N83. In Situ Respiration Test: May 8 through May 12, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0.00	30.00	52.25	72.67	93.67
A1C	O_2	11.7	11.8	11.8	NS	NS
	CO_2	2.0	2.2	2.2	NS	NS
A3C	O_2	18.8	17.2	16.2	15.3	15.3
	CO_2	1.5	2.2	2.0	2.4	2.2
A4B	O_2	0.0	0.0	0.0	0.0	0.0
	CO_2	12.8	13.0	13.0	13.0	13.0
A4C	O_2	14.8	NS	NS	NS	NS
	CO_2	2.0	NS	NS	NS	NS
A6A	O_2	10.3	8.2	9.8	5.2	6.7
	CO_2	9.7	9.8	9.0	10.2	10.0
A6B	O_2	15.7	13.8	14.0	14.7	13.8
	CO_2	6.7	9.2	8.7	8.2	8.2
A6C	O_2	17.5	16.8	16.7	16.0	16.3
	CO_2	3.0	4.0	4.2	4.2	4.2
A7B	O_2	17.3	17.4	17.2	17.5	17.5
	CO_2	1.8	2.2	2.2	2.0	2.4
A7C	O_2	18.2	18.2	18.3	17.8	18.2
	CO_2	1.5	1.8	2.0	2.2	2.2
A8C	O_2	19.0	17.7	NS	NS	NS
	CO_2	2.0	3.8	NS	NS	NS

Table N84. In Situ Respiration Test: May 8 through May 12, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0.00	30.25	52.50	72.83	93.83
P2B	O_2	19.8	18.2	17.0	16.0	15.0
	CO_2	1.8	2.2	2.3	2.5	2.8
P3A	O_2	20.7	18.4	17.5	16.2	15.8
	CO_2	0.4	2.2	1.7	2.0	2.2
P3B	O_2	20.9	19.0	17.8	16.8	16.0
	CO_2	0.3	0.9	1.2	1.4	1.7
P3C	O_2	20.5	18.5	17.5	17.0	16.8
	CO_2	0.8	1.0	1.0	1.0	1.0
P5A	O_2	18.2	15.3	13.0	NS	NS
	CO_2	3.3	5.2	5.4	NS	NS
P5B	O_2	20.0	17.2	15.2	13.6	11.7
	CO_2	1.0	2.0	2.3	2.7	3.2
P5C	O_2	18.2	15.8	14.8	13.5	13.0
	CO_2	1.3	1.7	1.8	2.0	2.2
P8B	O_2	5.5	4.0	2.6	1.3	0.6
	CO_2	12.7	13.0	13.5	14.0	14.2

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N85. In Situ Respiration Test: May 8 through May 12, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0.00	29.05	51.25	71.55	92.97
C1A	O_2	3.2	1.8	0.8	0.3	0.0
	CO_2	3.3	3.7	3.8	4.0	4.2
C1C	O_2	20.7	20.8	20.9	20.9	20.9
	CO_2	0.05	0.05	0.05	0.05	0.1
C3B	O_2	11.2	14.2	16.8	17.3	NS
	CO_2	3.0	3.0	2.2	1.8	NS
C3C	O_2	20.5	20.8	20.9	20.6	20.7
	CO_2	0.05	0.05	0.05	0.1	0.2
C6B	O_2	10.5	11.2	10.8	10.3	9.5
	CO_2	2.0	2.3	2.3	2.4	2.7
C6C	O_2	20.2	20.6	20.7	20.2	20.5
	CO_2	0.05	0.05	0.1	0.2	0.2
C7B	O_2	10.7	13.8	15.8	13.7	17.5
	CO_2	2.3	2.5	2.3	2.5	2.0

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N86. In Situ Respiration Test: May 8 through 12, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0.00	28.83	51.00	71.33	92.75
S1B	O_2	0.0	0.0	0.0	1.0	0.0
	CO_2	9.7	9.8	10.0	9.8	10.0
S1C	O_2	16.0	15.8	16.3	16.4	16.7
	CO_2	2.4	3.5	3.2	3.2	3.3
S2C	O_2	16.2	16.2	15.3	16.2	16.4
	CO_2	3.8	4.8	5.4	4.8	4.8
S3B	O_2	12.5	NS	NS	NS	NS
	CO_2	8.0	NS	NS	NS	NS
S3C	O_2	16.8	15.5	15.0	16.2	17.0
	CO_2	4.4	7.0	7.7	6.3	5.6
S4A	O_2	11.3	NS	NS	NS	NS
	CO_2	3.3	NS	NS	NS	NS
S4B	O_2	9.0	NS	NS	NS	NS
	CO_2	5.5	NS	NS	NS	NS
S4C	O_2	19.0	19.0	19.2	19.3	19.0
	CO_2	1.7	2.2	2.2	2.0	2.4
S5B	O_2	10.2	6.0	6.2	7.8	4.0
	CO_2	10.5	13.2	13.2	12.2	14.0
S5C	O_2	11.8	11.2	14.2	13.0	15.0
	CO_2	8.0	8.8	7.2	8.0	7.0

Table N86. In Situ Respiration Test: May 8 through 12, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0.00	28.83	51.00	71.33	92.75
S6A	O_2	5.5	NS	NS	NS	NS
	CO_2	9.8	NS	NS	NS	NS
S6B	O_2	1.2	0.0	1.0	0.8	0.4
	CO_2	8.0	8.4	8.7	9.0	9.2
S6C	O_2	3.4	0.2	4.5	0.9	0.2
	CO_2	7.5	10.8	10.3	12.0	12.7

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N87. In Situ Respiration Test: June 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	13.47	36.83	66.42	90.00	112.08
B2A	O_2	20.9	20.9	20.9	20.7	20.6	20.7
	CO_2	0.05	0.05	0.05	0.05	0.1	0.1
B2B	O_2	20.9	20.9	20.9	20.7	20.6	20.5
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05
B2C	O_2	20.9	20.9	20.9	20.6	20.5	20.5
	CO_2	0.05	0.05	0.05	0.05	0.05	0.05

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N88. In Situ Respiration Test: June 6 through June 11, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	13.17	36.58	66.17	89.83	111.83
A2C	O_2	16.2	16.3	17.0	16.7	16.8	16.8
	CO_2	2.7	2.6	2.2	2.6	2.8	2.8
A4B	O_2	18.3	18.8	18.8	NS	NS	NS
	CO_2	3.8	3.0	2.7	NS	NS	NS
A4C	O_2	20.0	20.0	20.0	19.8	19.8	20.0
	CO_2	1.7	1.5	1.4	1.8	2.0	2.0
A5C	O_2	18.7	18.5	18.5	18.8	18.5	18.5
	CO_2	3.2	2.6	3.2	3.8	3.7	3.8
A6A	O_2	11.7	12.2	12.0	10.8	10.2	10.0
	CO_2	10.8	10.2	9.2	8.8	9.0	8.8
A6B	O_2	14.8	14.2	13.7	13.2	13.6	13.0
	CO_2	7.3	8.0	8.3	8.5	8.3	8.2
A6C	O_2	15.0	15.0	14.8	14.2	14.0	14.2
	CO_2	7.2	7.5	7.5	7.8	8.2	8.0
A7C	O_2	17.0	17.2	17.8	17.7	17.5	17.3
	CO_2	4.0	4.0	3.8	4.0	4.5	4.5
A8C	O_2	6.7	6.0	4.5	3.2	2.8	2.6
	CO_2	6.2	6.2	5.8	6.2	6.8	6.5

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N89. In Situ Respiration Test: June 6 through June 11, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	13.33	36.75	66.33	89.92	112.00
P2B	O_2	20.0	18.8	16.3	13.2	11.0	8.8
	CO_2	1.4	1.8	2.0	2.5	3.0	3.4
P3A	O_2	20.8	19.5	17.2	14.8	12.7	11.0
	CO_2	0.1	0.5	0.6	0.1	1.5	1.8
P3B	O_2	20.8	19.4	17.1	14.2	12.0	10.0
	CO_2	0.1	0.4	0.3	0.7	1.2	1.7
P3C	O_2	20.5	19.0	16.8	15.0	13.8	12.7
	CO_2	0.5	0.8	0.6	0.8	1.1	1.3
P5A	O_2	20.7	19.5	17.7	15.8	14.8	13.6
	CO_2	0.8	1.8	2.4	3.3	4.2	4.5
P5B	O_2	20.2	17.8	13.5	9.0	6.2	4.0
	CO_2	0.8	1.7	2.2	3.2	4.4	5.2
P5C	O_2	20.0	17.3	14.2	10.8	8.8	7.0
	CO_2	1.2	1.8	1.8	2.2	2.8	3.2
P8B	O_2	0.0	0.0	0.0	0.0	NS	NS
	CO_2	17.0	17.2	17.0	17.0	NS	NS

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N90. In Situ Respiration Test: June 6 through June 11, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	13.58	36.92	66.50	90.17	112.25
C1C	O_2	20.2	20.0	19.8	19.3	19.5	19.2
	CO_2	0.8	1.0	0.8	0.9	1.2	1.5
C3A	O_2	20.8	20.0	18.8	17.2	16.4	15.3
	CO_2	0.5	0.8	0.8	1.1	1.7	2.0
C3B	O_2	3.2	3.2	2.3	1.8	1.7	1.5
	CO_2	6.3	6.8	6.4	6.4	7.0	7.0
C3C	O_2	17.7	18.0	17.2	16.5	16.2	16.2
	CO_2	2.7	3.0	3.0	3.0	3.8	4.0
C5B	O_2	9.7	9.3	9.0	8.7	8.3	8.2
	CO_2	5.2	5.4	5.2	5.3	6.0	6.0
C5C	O_2	20.0	20.0	19.5	19.0	19.0	18.8
	CO_2	1.2	1.2	1.2	1.3	2.0	2.0
C6B	O_2	14.2	13.2	13.0	12.8	12.8	12.7
	CO_2	3.8	4.3	4.2	4.2	4.7	4.8
C6C	O_2	20.7	20.6	20.3	20.0	20.0	19.2
	CO_2	0.4	0.7	0.4	0.4	1.0	1.3
C7C	O_2	16.5	17.3	16.7	16.2	16.5	16.2
	CO_2	1.3	1.5	1.4	1.3	1.8	2.0

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N91. In Situ Respiration Test: June 6 through June 11, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	13.75	37.08	66.67	90.25	112.33
S1B	O_2	0.0	0.0	0.0	0.0	NS	NS
	CO_2	11.7	11.8	11.4	11.2	NS	NS
S1C	O_2	14.4	12.8	15.5	15.7	NS	NS
	CO_2	7.3	9.0	6.4	6.0	NS	NS
S3B	O_2	11.0	3.3	3.2	3.8	2.7	3.2
	CO_2	19.2	13.0	13.0	12.0	13.3	13.0
S3C	O_2	13.3	12.8	13.8	13.7	14.0	15.8
	CO_2	7.4	9.2	8.0	7.3	8.0	6.2
S5B	O_2	13.0	5.2	5.5	6.2	3.0	3.8
	CO_2	10.0	5.0	14.6	13.2	16.0	14.8
S5C	O_2	11.8	10.7	11.8	10.7	11.7	12.5
	CO_2	9.2	10.7	8.8	9.5	9.8	9.0
S6A	O_2	16.0	4.7	10.8	16.0	NS	NS
	CO_2	5.2	11.5	8.4	4.8	NS	NS
S6B	O_2	3.8	0.7	0.2	1.8	NS	NS
	CO_2	7.8	9.8	9.8	9.0	NS	NS
S6C	O_2	12.2	3.2	9.5	10.2	NS	NS
	CO_2	6.8	12.5	9.8	9.0	NS	NS

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N92. In Situ Respiration Test: July 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0:00	15:17	31:92	86:08	151:50
B2A	O_2	20.9	NS	NS	NS	NS
	CO_2	0.05	NS	NS	NS	NS
B2B	O_2	20.9	20.9	20.9	20.9	20.3
	CO_2	0.05	0.05	0.05	0.05	0.05
B2C	O_2	20.9	20.9	20.8	20.8	20.2
	CO_2	0.05	0.05	0.05	0.05	0.05

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N93. In Situ Respiration Test: July 2 through July 9, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0.00	17.83	34.92	88.83	153.92
A1B	O_2	18.8	17.5	16.8	14.5	14.7
	CO_2	3.7	4.0	4.1	4.4	4.5
A1C	O_2	18.2	18.0	18.3	18.0	18.2
	CO_2	4.8	4.5	4.5	4.2	4.2
A2B	O_2	14.3	11.0	10.4	5.8	4.0
	CO_2	6.0	5.5	5.3	6.1	6.4
A3B	O_2	15.5	15.5	15.7	15.0	14.7
	CO_2	3.0	3.0	3.0	3.2	3.3
A4B	O_2	12.5	13.4	13.8	13.0	13.4
	CO_2	7.8	7.5	7.0	7.5	7.5
A4C	O_2	18.2	19.0	19.3	19.0	19.5
	CO_2	4.0	3.2	2.8	3.0	2.7
A5B	O_2	15.3	15.3	15.8	14.3	15.0
	CO_2	7.0	7.0	7.2	7.3	7.3
A5C	O_2	16.2	17.0	17.0	15.8	16.8
	CO_2	6.3	6.2	6.1	6.4	6.5
A6A	O_2	6.2	6.5	6.3	5.3	4.6
	CO_2	10.0	9.8	10.2	10.8	11.5
A6B	O_2	9.2	10.0	10.1	9.3	9.7
	CO_2	9.7	10.0	10.2	10.5	10.8

Table N93. In Situ Respiration Test: July 2 through July 9, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0.00	17.83	34.92	88.83	153.92
A6C	O_2	10.2	11.2	11.3	10.5	11.0
	CO_2	9.8	9.6	10.0	10.2	10.4
A7C	O_2	17.0	17.2	17.2	17.7	17.0
	CO_2	5.6	5.2	5.8	5.2	5.8
A8C	O_2	19.0	15.8	11.0	3.0	0.0
	CO_2	2.8	3.2	4.1	5.0	6.5

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N94. In Situ Respiration Test: July 2 through July 9, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	18.00	35.08	69.67	89.00	154.17
P1A	O_2	20.7	16.2	10.3	3.2	1.0	0.0
	CO_2	0.1	0.2	0.8	1.1	1.4	2.7
P1B	O_2	20.0	17.0	13.8	8.8	7.3	1.7
	CO_2	1.2	1.5	2.1	3.0	3.3	5.0
P1C	O_2	19.0	14.8	12.8	11.3	11.2	10.8
	CO_2	2.5	3.2	4.0	4.7	5.0	6.0
P2A	O_2	20.8	20.0	19.2	17.3	15.7	10.7
	CO_2	0.1	0.2	0.5	0.6	1.0	1.1
P2B	O_2	18.8	16.8	14.7	10.2	8.0	2.2
	CO_2	3.0	3.8	4.2	4.8	5.2	6.2
P2C	O_2	18.8	16.0	14.0	11.5	11.0	9.2
	CO_2	3.0	3.5	4.0	4.2	4.8	5.4
P3A	O_2	20.8	18.2	16.0	11.0	9.8	2.2
	CO_2	0.1	0.7	1.0	1.6	2.1	4.0
P3B	O_2	20.8	18.2	16.0	10.8	9.3	2.2
	CO_2	0.2	0.6	1.0	1.7	2.2	4.3
P3C	O_2	20.2	17.0	15.2	12.5	11.8	9.8
	CO_2	1.2	1.6	2.0	2.2	2.7	3.8
P4A	O_2	19.0	15.0	11.7	5.6	3.0	0.0
	CO_2	3.6	4.3	5.2	6.7	7.6	8.8

Table N94. In Situ Respiration Test: July 2 through July 9, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)					
		0.00	18.00	35.08	69.67	89.00	154.17
P4B	O_2	20.2	16.5	13.2	6.7	4.2	0.0
	CO_2	1.0	2.2	3.2	5.0	6.0	8.0
P5A	O_2	18.0	11.2	8.0	1.5	3.0	2.0
	CO_2	4.0	6.8	7.7	9.6	9.9	10.2
P5B	O_2	19.5	14.8	11.2	5.0	2.8	0.0
	CO_2	2.6	4.2	5.0	6.7	7.8	8.8
P5C	O_2	18.8	14.0	11.0	6.5	6.0	5.6
	CO_2	3.4	4.6	4.8	5.2	5.7	6.5
P6B	O_2	16.5	7.2	4.5	0.2	0.5	0.0
	CO_2	6.0	9.8	10.8	12.0	11.2	11.5
P6C	O_2	16.0	12.3	8.5	3.3	2.2	2.6
	CO_2	6.0	7.0	7.5	8.2	8.3	8.3
P7B	O_2	20.3	19.0	17.0	13.0	10.8	5.8
	CO_2	0.1	0.3	0.3	0.4	0.6	0.8
P7C	O_2	19.8	18.7	15.8	11.5	9.6	6.3
	CO_2	1.1	1.2	1.12	1.5	1.7	2.0
P8B	O_2	0.0	0.0	NS	NS	NS	NS
	CO_2	18.5	18.3	NS	NS	NS	NS
P8C	O_2	0.0	0.0	NS	NS	NS	NS
	CO_2	18.5	18.3	NS	NS	NS	NS

Table N95. In Situ Respiration Test: July 2 through July 9, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0.00	19.42	36.17	90.33	155.75
C1B	O_2	0.0	0.0	NS	NS	NS
	CO_2	9.0	9.0	NS	NS	NS
C1C	O_2	12.8	13.5	13.0	13.2	13.5
	CO_2	7.6	7.3	7.8	8.0	8.2
C2A	O_2	9.6	7.8	6.5	2.7	0.3
	CO_2	5.8	5.8	6.0	7.0	7.7
C2B	O_2	0.0	0.0	NS	NS	NS
	CO_2	8.8	9.0	NS	NS	NS
C2C	O_2	17.2	17.8	17.7	18.0	17.8
	CO_2	4.2	4.0	4.2	4.0	4.2
C3A	O_2	20.5	17.8	14.5	9.8	9.0
	CO_2	1.1	1.2	2.0	2.8	3.0
C3B	O_2	2.0	4.0	4.0	3.8	2.8
	CO_2	10.0	10.0	10.7	10.5	11.3
C3C	O_2	13.8	15.0	14.5	14.2	14.2
	CO_2	7.0	6.5	7.0	7.0	7.6
C4B	O_2	0.0	1.6	2.0	1.2	1.0
	CO_2	10.7	10.8	11.0	11.2	11.8
C4C	O_2	8.0	9.2	9.2	9.0	9.3
	CO_2	9.7	9.8	10.0	9.8	10.2

Table N95. In Situ Respiration Test: July 2 through July 9, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0.00	19.42	36.17	90.33	155.75
C5A	O_2	7.0	6.8	7.2	5.7	4.0
	CO_2	8.0	8.0	8.4	8.8	9.3
C5B	O_2	7.0	7.3	8.0	8.2	8.2
	CO_2	8.8	8.8	9.2	9.5	9.8
C5C	O_2	13.5	14.2	14.2	15.0	15.8
	CO_2	7.4	7.0	7.2	7.0	6.8
C6B	O_2	8.0	9.2	9.5	10.2	11.0
	CO_2	9.0	9.0	9.5	9.8	10.0
C6C	O_2	12.7	12.6	13.0	14.0	14.8
	CO_2	7.3	7.5	7.8	7.8	7.8
C7B	O_2	4.5	0.0	NS	NS	NS
	CO_2	6.5	7.0	NS	NS	NS
C7C	O_2	10.5	13.2	12.8	12.5	13.2
	CO_2	4.7	4.2	4.8	5.0	5.2

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N96. In Situ Respiration Test: July 2 through July 9, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0.00	19.67	36.33	90.50	155.92
S1B	O_2	0.0	0.0	NS	NS	NS
	CO_2	12.2	12.0	NS	NS	NS
S1C	O_2	14.5	15.2	14.7	16.0	13.7
	CO_2	8.3	7.5	8.0	7.2	8.8
S2C	O_2	18.3	15.3	16.6	15.0	15.0
	CO_2	4.0	6.7	5.3	7.0	7.0
S3B	O_2	13.0	13.6	11.2	1.2	1.6
	CO_2	9.0	7.8	9.5	14.2	14.0
S3C	O_2	14.0	14.5	16.3	11.8	12.2
	CO_2	7.5	7.5	6.7	9.2	8.8
S4B	O_2	15.0	18.3	17.8	9.7	NS
	CO_2	4.7	2.0	3.0	8.0	NS
S4C	O_2	18.3	18.0	18.7	18.2	17.2
	CO_2	3.5	3.5	2.8	3.8	4.7
S5B	O_2	14.2	13.2	12.0	9.8	7.0
	CO_2	9.2	9.2	10.3	12.7	14.0
S5C	O_2	13.2	11.3	14.0	12.2	10.8
	CO_2	9.2	10.0	8.2	9.5	10.2
S6B	O_2	4.0	6.6	7.6	6.7	1.3
	CO_2	9.0	8.0	8.0	9.0	10.5

Table N96. In Situ Respiration Test: July 2 through July 9, 1994

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)				
		0.00	19.67	36.33	90.50	155.92
S6C	O_2	16.0	12.5	13.8	6.2	9.0
	CO_2	5.2	8.0	7.7	12.0	11.0

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.

Table N97. In Situ Respiration Test: January 27 through February 1, 1995

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)						
		0	26.38	27	49.33	73.92	97.33	120.73
A1b	O_2	20	20.8	20.7	19.5	19	18.5	18.5
	CO_2							
A2a	O_2	20.8	20.8	20.8	20.5	17	17	
	CO_2							
A2b	O_2	20.5	20.7	20.8	18.6	18		
	CO_2							
P2a	O_2	14.8	20.8	20.6	11	10	9	9
	CO_2							
P2b	O_2	15	20.8	20.6	10.5	9.9	8.5	8.3
	CO_2							
P2c	O_2	20.9	20.8	20				
	CO_2							
S5a	O_2	18.5	20.8	20.7				
	CO_2							
S5c	O_2	20	17.3		17.5	17.5	17	17.1
	CO_2							
C5a	O_2	20.7	19	18.4	18	16.9	16	
	CO_2							
C5b	O_2	20.8	17.16.1	16.5	15.9	16		
	CO_2							

Table N97. In Situ Respiration Test: January 27 through February 1, 1995

Monitoring Point	Measurement	Soil Gas Concentrations Over Time (Hours)						
C5c	O_2	20.8	18.1	17.9	17	15	15.5	
	CO_2							

NS - Not sampled due to an oxygen concentration less than 5%, poor gas flow, or high soil moisture content.