Title

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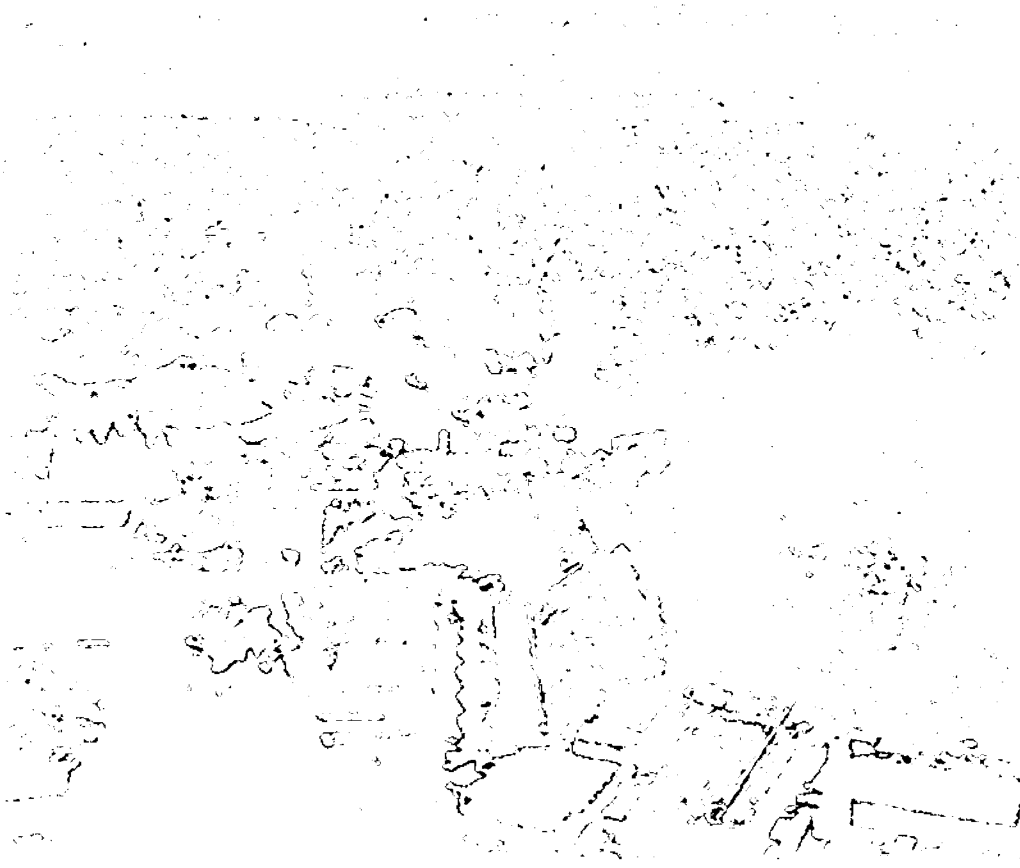

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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EXECUTIVE SUMMARY

Over the last two and one half years, Lawrence Berkeley National Laboratory (LBNL) has been collecting data from the Vadose Zone Monitoring System (VZMS) at site S-7 in Investigation Cluster 34 (IC 34) at McClellan AFB. In addition to the monitoring effort, we have developed numerical models and carried out enhanced data analysis to interpret the data and make quantitative predictions of flow and transport. The primary goal of this project is to characterize volatile organic chemical (VOC) transport through the vadose zone at this site. A secondary goal of the project is to validate prior modeling by comparison of VZMS data and model analysis to prior modeling results. Motivation for the project arose from the practical need to use modeling for assessing risk and designing remediation approaches at the many lightly contaminated sites at McClellan AFB. For model results to be defensible, they must to be based on site data and have credible predictive capability. Thus there is a need for detailed vadose zone data and enhanced data analysis from at least one site to develop and validate vadose zone flow and transport models. The idea is that once such models are validated at one site, they can be used credibly at other sites where less extensive site characterization data are available.

Site S-7 was selected for the VZMS project as a representative lightly contaminated site at McClellan AFB. Site S-7 is the former location of water cooling ponds and the Industrial Wastewater Treatment Plant No. 3 (IWTP 3). A prior remedial investigation concluded that the former IWTP 3 was one of the primary source areas of contamination in IC 34. Site S-7 has relatively low levels of VOC contamination, and has been the focus of prior modeling efforts, the results of which could be compared against detailed data collection and modeling associated with the present VZMS project.

We installed vadose zone instrumentation at site S-7 consisting of two deep sensor strings (VZMS-A and VZMS-B), one shallow sensor string (VZMS-C), two neutron probe access wells (NP-1 and NP-2), and a groundwater well (Well-1). VZMS is an integration of technologies for assessing soil hydraulic potential, moisture content, liquid- and gas-phase pressure, and temperature of the formation, as well as the concentrations of contaminants in both liquid and gas phases. Thirteen levels of instrument clusters span the 110 ft of vadose zone in VZMS-A and -B. Each level in VZMS-A and -B is instrumented to measure hydraulic potential with tensiometers, soil solution sampling with suction lysimeters, soil gas sampling and gas pressure measurements with a soil gas sampling port, and temperature with thermistors. VZMS-C contains seven levels of instruments spread over its 25-foot length. Each level contains a tensiometer, lysimeter, and two psychrometers. Relative measurements of soil moisture content are made using a downhole neutron probe in NP-1 and -2.

Standard hollow-stem drilling, coring, and sampling methods were used during the installation of VZMS-A and -B. Two vertical borings were drilled to 115 ft using a 10-in OD hollow-stem auger. The boreholes were then reamed with a 12-in OD auger. Installation of 13 levels of instruments occurred in these two boreholes through the 12-in OD auger. VZMS-C was drilled using 8.25-in OD hollow-stem augers, with instrument installation in the open borehole. Continuous core was collected in VZMS-A and –B, and split-spoon sampling representative of the various lithologic units of notable thickness was done for VZMS-C. Sediments at site S-7 consist generally of interlayered silts and sands, with occasional layers of coarse sand. Moisture content of sediment samples ranged in value from 6.0 to 41.4%, with porosity from 36.1 up to 59.9%. Total organic carbon in samples ranged from non-detectable to 350 mg/kg.

Most of the observed temperature fluctuations occur in the top 30 ft. Diurnal changes in air temperature do not result in quantifiable changes in formation temperature, even at the shallowest thermister depth of 6 ft. However, seasonal temperature variations cause reversals of the temperature gradient in the formation down to depths of 18 ft.

Gas-phase pressure was measured using the gas sampling probes. These were allowed to equilibrate with the subsurface environment and pressure was measured using dedicated pressure transducers. Overall, gas-phase pressures throughout the column are very close to atmospheric pressure, but display lag and dampening with depth relative to diurnal and seasonal atmospheric pressure changes.

Liquid-phase pressure was measured using tensiometers. Because of the relatively high air-entry pressure of the stainless steel porous cups used in VZMS-A and -B, those tensiometers were unable to measure the relatively low matric potentials in most of the formation, except immediately above the water table. Tensiometers in VZMS-C use ceramic porous cups, with a 1-bar air-entry pressure, allowing for the collection of reliable matric potential data. Although longer-term tensiometer data are needed to confirm the trends, it appears that downward displacement of the liquid phase is occurring, though this is largely limited to the top 10-15 ft of the vadose zone.

Tensiometer measurements are corroborated by the moisture content measurements made with the neutron probe. Overall volumetric moisture content in the formation remained fairly stable throughout most of the formation over the period of monitoring. Some moisture movement occurred in the top 15 ft of the formation, with seasonal wetting and drying above 5 ft and slight wetting below that depth. More significant wetting occurred around the depths of 12 to 14 ft. These trends, together with matric potential data, are suggestive of the redistribution of infiltrated rainwater. However, the redistribution is vertically limited, with nearly no increases below 15 ft. This does not mean that water and associated liquid-phase contaminants do not move downward throughout the profile, but rather that the flux of water is both small and approximately steady-state.

The gas phase was sampled every one to two months. TCE, cis-1,2-DCE, and Freon 123a are the major contaminants in the system. TCE and cis-1,2-DCE concentrations were consistently highest at 6 ft, the shallowest monitored depth in VZMS-A and -B. Monitoring data reveal an overall increase of both compounds at 6, 11, and 18 ft with time. At depths of 105 and 109 ft, increases in TCE and Freon 123a, but not cis-1,2-DCE, concentrations were observed. There are two apparent sources of contamination. Sediments in the top 15 to 20 ft are contaminated with TCE and cis-1,2-DCE, with total VOC concentrations between 100 and 250 ppmv. The formation immediately above the groundwater table contains gas-phase TCE concentrations up to 6 ppmv, but much lower cis-1,2-DCE levels (generally less than 1 ppmv). In addition, the area at and immediately above the groundwater is contaminated with Freon 123a, with the highest concentrations, up to 20 ppmv, found at 105 and 109 ft. Freon 123a is not detected above 74 ft. TCE and cis-1,2-DCE concentrations between 30 and 90 ft are generally at or below 1 ppmv and 0.5 ppmv, respectively.

The liquid-phase was sampled using suction lysimeters. The deepest pore-water samples, particularly in VZMS-A, are representative of groundwater VOC concentrations, and fluctuate around a mean of 50 ppb. This groundwater TCE plume is likely from a source other than the near-surface TCE contamination. The presence of two distinct plumes is supported by non-detectable to very low cis-1,2-DCE concentrations in groundwater. The peak of TCE concentrations occurs at a depth of 7 ft, with lower concentrations both above and below this depth. This suggests that the center of the TCE plume has migrated a few ft below ground surface, or that the original spill occurred below the present grade. The location of this peak is 4 ft below the older concrete pad at 3 ft.

In June of 1999, constant mass-flux air-permeability tests were conducted at site S-7. Tests were conducted using the VZMS-A and -B soil gas monitoring probes as injection and observation locations. Both low-flow single-hole tests and high-flow cross-hole tests were conducted. The cross-hole tests indicate an effective permeability that is an order of magnitude greater ($k \sim 10^{-11}$–10^{-12} m^2) than the single-borehole estimates ($k \sim 10^{-12}$–10^{-13} m^2). For use in characterization for remediation approaches such as vapor extraction, the cross-hole test results are more representative of site S-7 effective air permeability than the single-hole tests.

Enhanced data analysis of a variety of VZMS data was carried out. Broadly, the enhanced data analysis for VZMS data involves developing a conceptual model for the site, implementing the conceptual model into a numerical simulator, iteratively updating the conceptual model, and carrying out numerical simulation studies. We used the numerical simulator T2VOC for multiphase (gas, aqueous, NAPL) and multicomponent (air, water, VOC) flow and transport modeling along with the inverse modeling code ITOUGH2. The results of enhanced data analysis can be compared to prior modeling results obtained with other numerical models for model intercomparison and validation.

A spatially averaged, one-dimensional layered site S-7 representative model was developed using data collected over the course of the project including lithologic logs, particle size analyses, laboratory-measured values of porosity, absolute permeability, and van Genuchten capillary pressure function parameters. Good qualitative agreement between the moisture content as measured by neutron probe and simulated for the T2VOC conceptual model using 100 mm yr^{-1} percolation rate provides significant validation of the conceptual model.

Focusing on thermal effects, we used an analytical solution to investigate heat flow. By varying the unknown parameters, we obtained a match to the long-term features of the subsurface temperatures as measured by the VZMS. The analysis suggests that subsurface heat transfer in the vadose zone at site S-7 is conduction-dominated, and the thermal diffusivity is well approximated by a constant value. It is also of interest to note that the groundwater temperature measure by the VZMS is slightly cooler than the average measured vadose zone temperature, suggesting that the largely-paved McClellan AFB site acts as a heat island compared to the surrounding land under which the groundwater flows. Because temperature changes are relatively small in the subsurface, the overall effect of seasonal subsurface temperature variations on TCE transport is expected to be small.

The T2VOC layered conceptual model was used to simulate gas-phase pressure variation in the vadose zone. The objective is to match the dampening of the gas pressure signal with depth by varying uncertain properties of the system such as permeability and liquid saturation. A good match between VZMS data and the model can be attained by using a percolation rate of 10 mm yr^{-1}.

In order to model VOC contaminant flow and transport, we assumed the presence of a source term consisting of several kg of TCE present as NAPL at a depth of approximately 3 ft 30 years before present. We also assumed that groundwater at the water table is contaminated by dissolved TCE at a constant concentration of 50 ppb (the value presently observed in the groundwater). In the model, TCE is transported by liquid and gas phase advection, gas-phase gravity flow and diffusion, and flow of NAPL, if present, as a separate phase. Equilibrium adsorption of TCE onto solid grains is also modeled.

Numerical simulations using the simple layered conceptual model show that the sharp concentration gradient at shallow depths and moderate concentration gradient above the water table observed with the VZMS only develop when the percolation rate is small (<10 mm yr^{-1}), or when VOC transport is controlled by gas-phase diffusion. These modeling results suggest that at this site, percolation may be lower than the accepted infiltration rate for McClellan AFB (2×10^{-9} m s^{-1} = 63 mm yr^{-1}).

We extended our model analyses to consider three different conceptual models: (1) layered single-continuum model; (2) dual-continuum model; and (3) anisotropic model. The layered single-continuum model assumes a single porous medium composed of layers of sediments. The dual-continuum model considers the subsurface to be composed of two interacting continua, one consisting of preferential flow paths (PFPs) and the other of isolated sediment blocks (ISBs). The anisotropic model involves plume migration downward and laterally at the same time, with the VZMS boreholes intersecting only the top portion of the plume.

Various simulation scenarios using the above conceptual models have been carried out. The thirty-year VOC concentration profile for the 100-mm yr^{-1} single-continuum case does not match the profile measured by the VZMS. In particular, the maximum concentration is not near the surface, but spread out over a range of depths well below it, presumably a result of aqueous phase advection of TCE. The VOC profile for the 10-mm yr^{-1} case agrees better with the observed data, with the maximum concentration near the surface and a sharp concentration gradient below it. In order for NAPL to still be present in the system after thirty years of plume evolution, a slow-release, isolated source is required. In a two-year period, simulation results show the gas-phase TCE plume would be advected less than 2 ft.

A high percolation rate (100 mm yr^{-1}) could be consistent with the observed VOC concentration profile if we hypothesize either a dual-continuum model, in which most of the infiltration travels through isolated preferential flow paths (PFPs) that bypass isolated sediment blocks (ISBs), or an anisotropic medium in which the VOC plume travels diagonally downward and away from the VZMS boreholes. Comparing flow and transport in the PFPs and the ISBs shows that the PFPs may not account for 99 % of the aqueous flux of TCE despite carrying 99% of the percolation. This is because the concentration in the PFPs decreases relatively quickly as TCE in the small volume PFPs is flushed out by infiltrating water.

A single best conceptual model for site S-7 cannot be definitively determined. In general, it is difficult to reconcile all of the VZMS observations using simple conceptualizations of VOC flow and transport. In particular, the VapourT results for site S-7 using initial conditions from well SS7SB08 and percolation rate of 2×10^{-9} m s^{-1} are not consistent with the site S-7 VZMS data.

Our analysis and monitoring suggest that downward migration of VOCs at site S-7 is contributing minor amounts of VOCs to the groundwater table regardless of which conceptual model is chosen. The fact that the bulk of the mass of contaminant has remained in the top 15 ft decades after contaminant release supports this conclusion.

1 INTRODUCTION

Over the last two and one half years, Lawrence Berkeley National Laboratory (LBNL) has been collecting data from the Vadose Zone Monitoring System (VZMS) (LBNL, 1996) at site S-7 in IC 34 at McClellan AFB. The VZMS, as installed at site S-7, collects vadose zone data on soil-gas pressure, gas chemistry, water chemistry, and temperature in two boreholes over 100 ft (30 m) in depth. Hydraulic potential is collected in a third borehole 25 ft (7.6 m) in depth, and moisture content data are collected in separate boreholes using a neutron probe to depths of approximately 100 ft (30 m). All of the VZMS boreholes are within a radius of approximately 15 ft (4.6 m). Closely coupled with this monitoring and data collection effort are data interpretation and enhanced data analysis by numerical simulation. The primary goal of the project is to characterize volatile organic chemical (VOC) transport through the alluvial sediments in the vadose zone at this site. A secondary goal of the project is to validate prior modeling by comparison of VZMS data and enhanced data analysis to prior modeling results at the site.

Our work over the course of the project is documented in numerous quarterly, semi-annual, and annual reports. The purpose of this final report is to summarize our work over the entire project and to present new results not shown in prior reports. Our goal is to be comprehensive while keeping the length of the report reasonable. To this end, we make frequent reference to prior reports. In addition to summarizing the motivation for the work, the site S-7 characteristics, the instrument development and installation, and the sampling procedures and results, we present results from a new air-permeability test conducted in summer 1999, as well as new enhanced data analysis results using the numerical simulator T2VOC (Falta et al., 1995). We conclude with a set of recommendations based on our understanding of site S-7 gained over the course of the project.

1.1. MOTIVATION

By virtue of their high degree of contamination, only a fraction of the more than 250 contaminated sites at McClellan AFB have been characterized sufficiently to design and implement efficient and site-specific remedial actions. The remaining majority of confirmed sites likely poses much smaller risks due to lower contaminant concentrations and smaller total masses of contaminants. Nevertheless, it is necessary to determine whether these more enigmatic sites contribute to the degradation of the groundwater in the aquifer 100 ft below. Such a determination will help prioritize remedial actions and may suggest promising remediation strategies for the majority of confirmed sites. The problem is how to determine whether lightly contaminated sites are contributing contaminants, and VOCs in particular, to the underlying aquifer.

Our approach involved detailed instrumentation and monitoring of two boreholes in the vadose zone to investigate the transport of water and contaminants. The collective instruments in several boreholes are referred to as the Vadose Zone Monitoring System, or VZMS. The instrumented boreholes span the entire vadose zone (approximately 100 ft, or 30 m) and partially penetrate the saturated zone. Closely coupled to the monitoring effort were data analysis and enhanced data analysis by numerical simulation.

The VZMS provides detailed characterization data for the site and can be used directly to assist in designing an effective remediation strategy. However, given the large number of contaminated sites at McClellan AFB, it would be impractical to collect detailed VZMS data at more than a handful of sites. Thus, the majority of sites must rely on modeling studies to assist in characterization and remediation design. Although great improvements in modeling capabilities have been made over the last 10 years, modeling results alone are typically not sufficient to design effective remediation strategies or to satisfy regulatory requirements. For model results to be defensible, they need to be based on actual site data and have credible predictive capability. Thus there is a need for detailed data from the vadose zone and enhanced data analysis to develop and validate vadose zone flow and transport models. In addition, the enhanced data analysis can be used for sensitivity analyses to determine which properties most strongly control important aspects of system behavior, such as the downward flux of contaminants, and thereby guide site characterization efforts. With the two-fold objectives of (1) collecting detailed vadose zone data over time, and (2) carrying out modeling studies using VZMS data as constraints, we undertook the VZMS project in conjunction with McClellan AFB. The investment made in the VZMS project may lead to future cost savings at other sites by enabling defensible risk analysis and remediation design through modeling, as well as by allowing more focused site characterization studies to be performed.

1.2 SITE SELECTION

Because the initial stage of this project was carried out under subcontract to Radian Corporation, the group involved in selecting a site for the VZMS was led by Radian. The S-7 site was selected because it had low levels of VOC contamination from a near-surface source, and because it had been the subject of prior modeling analysis (Jacobs Engineering, 1998), the results of which could be evaluated and compared against the detailed data to be collected with the VZMS. Wells near this site showed that groundwater was contaminated with VOCs, but it was not known whether VOCs from site S-7 caused the contamination in the aquifer, or if VOCs migrated under site S-7 from other areas. In general, site S-7 is representative of the lightly-contaminated sites at McClellan AFB in that it contains paved and unpaved surfaces, is near other potential sources of contaminants, has ongoing industrial activity nearby, and is underlain by the fluvial and alluvial silts and sands common to sites at McClellan AFB.

1.3 SITE HISTORY

Site S-7 is the former location of water cooling ponds and the Industrial Wastewater Treatment Plant No. 3 (IWTP 3) (Jacobs Engineering, 1998). The water cooling ponds operated from 1940 to 1956, while IWTP 3 was used from 1956 to 1981. All of the IWTP 3 structures were removed in 1981. At the time of operation, the IWTP 3 consisted of a free oil separator, an oil sump, a clarifying tank, an air-saturation tank, a flotation tank, holding tanks, a bleed-off tank, two sand filters, and an underground holding tank. Piping between tanks was below grade. The area was paved after decommissioning of the IWTP 3 in 1981, and has been used as a storage facility for generator and plumbing supplies since that time. A map of the site is shown in Fig. 1.1.

1.4 PRIOR S-7 INVESTIGATIONS

Site S-7 has been the subject of environmental studies since the mid-1980's. McLaren Environmental carried out shallow auger profile borings and soil sample borings in 1986 (Jacobs Engineering, 1998). They found a host of VOCs and grease and oil at a depth of 9.5 ft (2.9 m). Jacobs Engineering carried out phase 1 and 2 remedial investigations for Investigation Cluster 34 (IC 34), of which site S-7 is a part, from 1992 to 1996 (Jacobs Engineering, 1998). Soil, soil gas, and water samples were collected in shallow and deep borings. The remedial investigation concluded that the former IWTP 3 was one of the primary source areas of contamination in IC 34. Cis-1,2-DCE and TCE were found in soil gas with concentrations decreasing with depth indicative of a shallow source (Jacobs Engineering, 1998). Soil samples from site S-7 show contamination limited to depths less than 20 ft (6.1 m). The most widespread groundwater contaminant under IC 34 is TCE. Groundwater contamination is migrating toward the southwest. A summary of prior work at site S-7 can be found in Jacobs Engineering (1998).

Prior sampling of soil gas at site S-7 was done using one-time sampling techniques. The present VZMS uses *in situ* soil gas samplers and suction lysimeters to collect soil gas and water samples. These instruments were used to monitor contaminant concentrations over time. The VZMS allows the collection of more representative samples, and it allows monitoring of changes in concentration over time, which provides information about flow directions and rates.

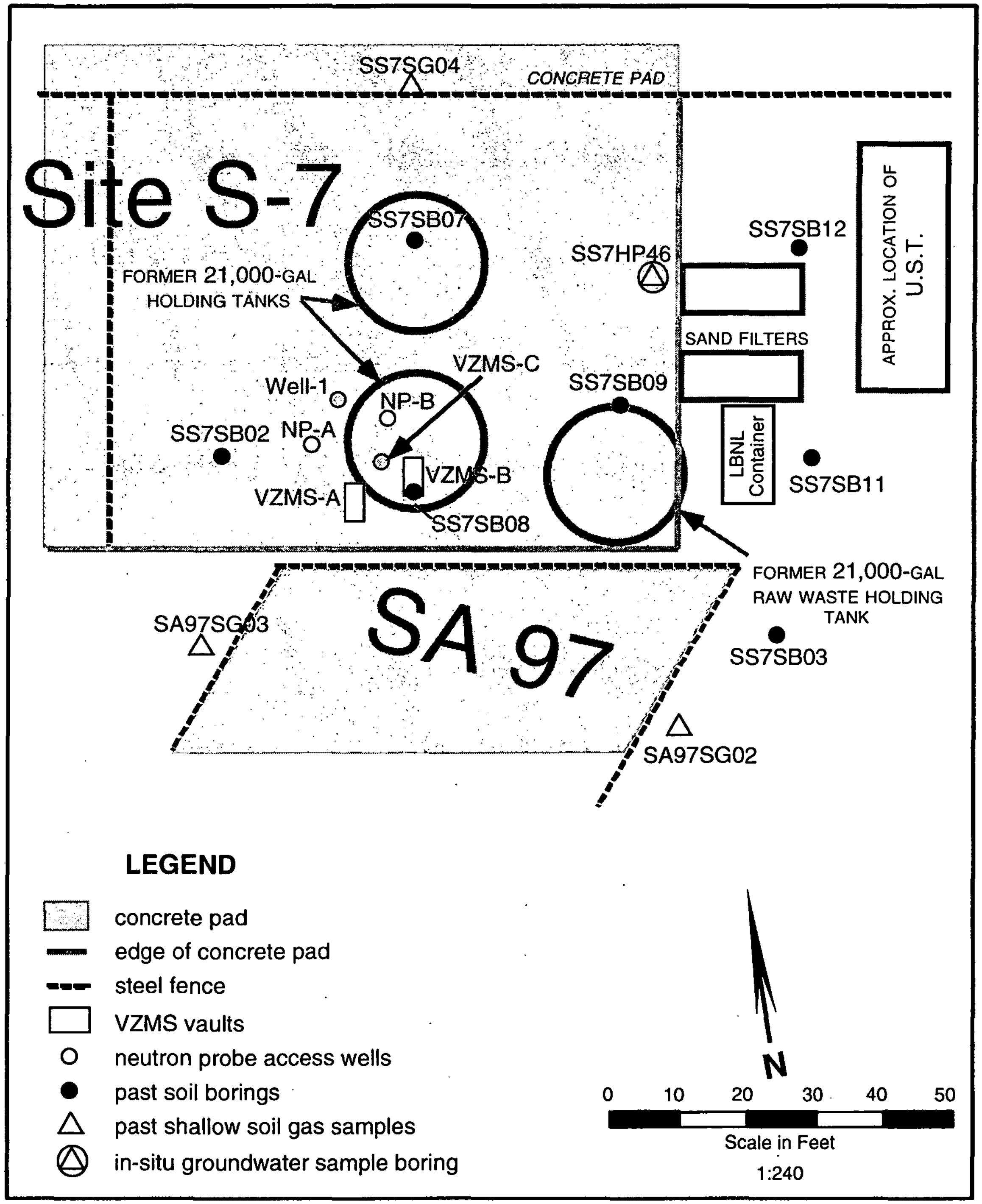


Figure 1.1. Location of VZMS installations relative to existing and former structures at site S-7, including locations of previously drilled boreholes and soil-gas sampling points.

2 INSTRUMENTATION

Vadose zone instrumentation at site S-7 consists of two deep sensor strings (VZMS-A and VZMS-B), one shallow sensor string (VZMS-C), and two neutron probe access wells (NP-1 and NP-2). In addition, a groundwater well (Well-1) was installed near the VZMS nests as shown in Fig. 1.1. The specifications of each of these installation types are shown in Table 2.1. VZMS-A, VZMS-B, NP-1, and NP-2 drilling and installation took place between 12/13/95 and 12/21/95. Drilling services were provided by Water Development Inc. and geologic logging and soil-gas sample collection were carried out by Radian International. VZMS-C and Well-1 were drilled and instrumented between 4/20/98 and 4/22/98. Drilling was performed by Water Development Inc., with geologic logging by Jacobs Engineering Group Inc. Continuous core samples were collected from VZMS-A and VZMS-B. Samples from these cores were subsequently analyzed for moisture content, particle-size distribution, organic carbon, bulk density, saturated conductivity, and the moisture characteristic curve.

Table 2.1. Specifications of vadose zone insrumentation boreholes and Well-1.

Wells	**Purpose**	**Date completed**	**Total depth (ft)**	**Drilled OD (in)**	**Final ID (in)**	**# of levels**	**Types of instruments**
VZMS-A	Measurement of gas-phase and liquid-phase pressure, temperature; gas and water sampling	12/21/95	115	12	N/A	13	Gas probes; soil water samplers; tensiometers; thermistors
VZMS-B	Same as above	12/21/95	115	12	N/A	13	Same as above
VZMS-C	Measurement of liquid-phase pressure; water sampling	4/22/98	23	8.25	N/A	7	Soil water samplers; tensiometers; psychrometers;
NP-A, NP-B	Access boreholes for neutron probe	12/21/95	100	4	2	N/A	None
Well-1	Measurement of water table; potential groundwater sampling	4/20/98	119	10	4	N/A	None

2.1 MONITORING AND SAMPLING TOOL DESIGN

2.1.1 The Vadose Zone Monitoring System

The Vadose Zone Monitoring System (VZMS), as installed in VZMS-A and -B, is an array of instruments used to monitor the unsaturated zone. The array has been developed to allow its emplacement down a borehole to form a monitoring nest consisting of several sets of instruments arranged vertically along the borehole. VZMS is an integration of technologies for assessing soil hydraulic potential, moisture content, liquid- and gas-phase pressure, and temperature of the formation, as well as the concentrations of contaminants in both liquid and gas phases. Instruments are placed in clusters (Fig. 2.1) and installed at the desired depth as illustrated in Fig. 2.2. The cluster includes a stainless-steel, spring-loaded mechanism which, when released during installation, pushes the instruments against the borehole wall to establish contact between the sensor and the formation. Those instruments which rely on the exchange of fluids between the formation and the sensor have backfill sacks, which are described in a subsequent section. Stainless steel construction was used for all parts which might be in contact with contaminated gas or water.

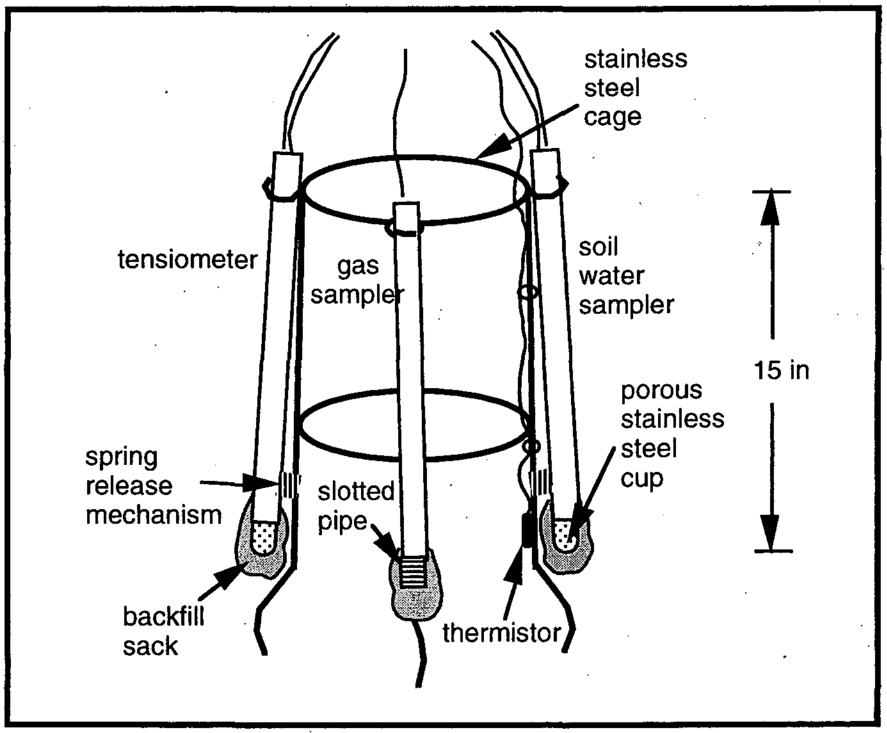


Figure 2.1. Schematic drawing of a single level of a VZMS cluster.

Each level in VZMS-A and -B is instrumented to provide the following types of measurements:

- Hydraulic potential measurements (tensiometer)
- Soil solution sampling (suction lysimeter)
- Soil gas sampling and gas pressure measurements (soil gas sampling port)
- Temperature measurements (thermistors)

Each level of instrumentation is backfilled with sand and then separated from underlying and overlying levels with a layer of bentonite. Neutron logging for moisture content measurement is performed in separate, smaller diameter boreholes. The description of individual instruments follows.

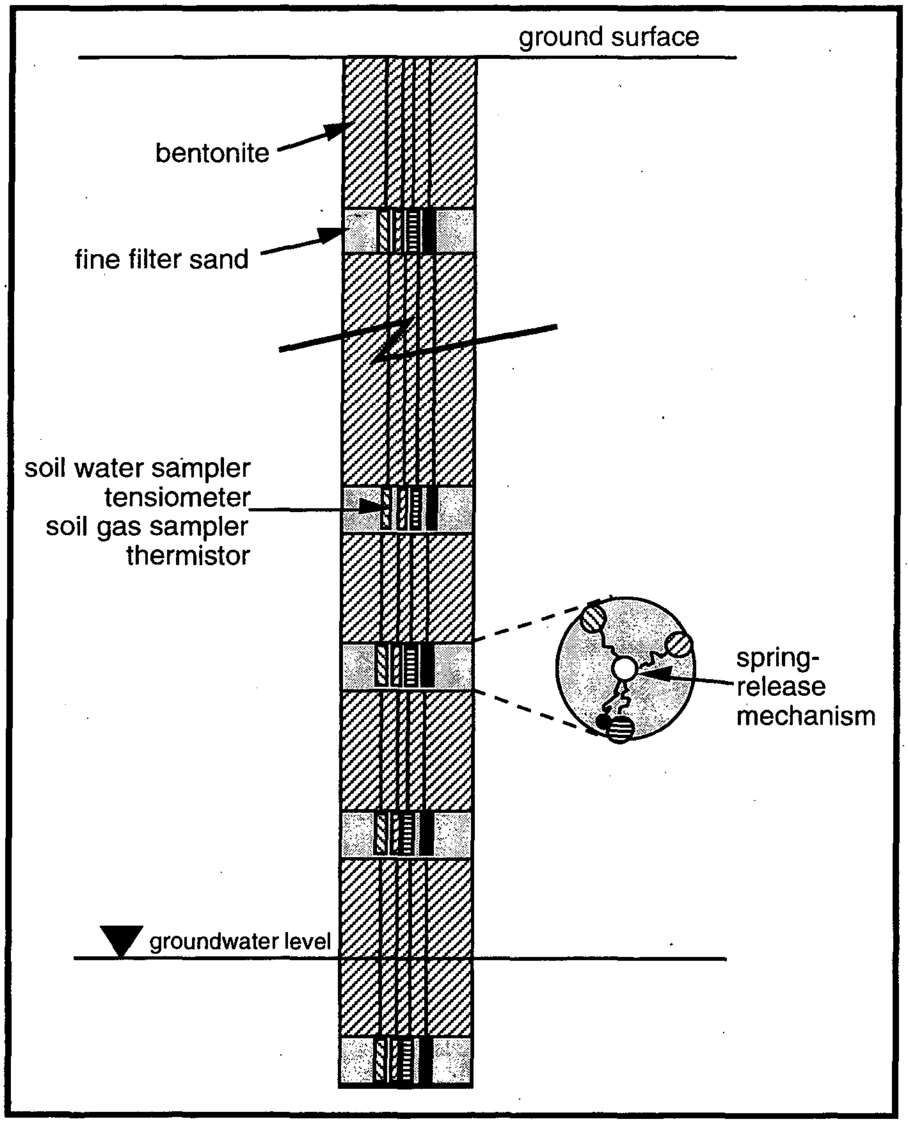


Figure 2.2. Vertical profile schematic illustrating VZMS cluster layout in a borehole.

2.1.2 Instrument Design and Application: VZMS-A and VZMS-B

The instruments used in VZMS-A and VZMS-B were custom-made at LBNL. Among the goals of this design were the collection of representative samples for chemical analysis, miniaturization of instruments to fit in a relatively narrow borehole, and integration to allow easy deployment.

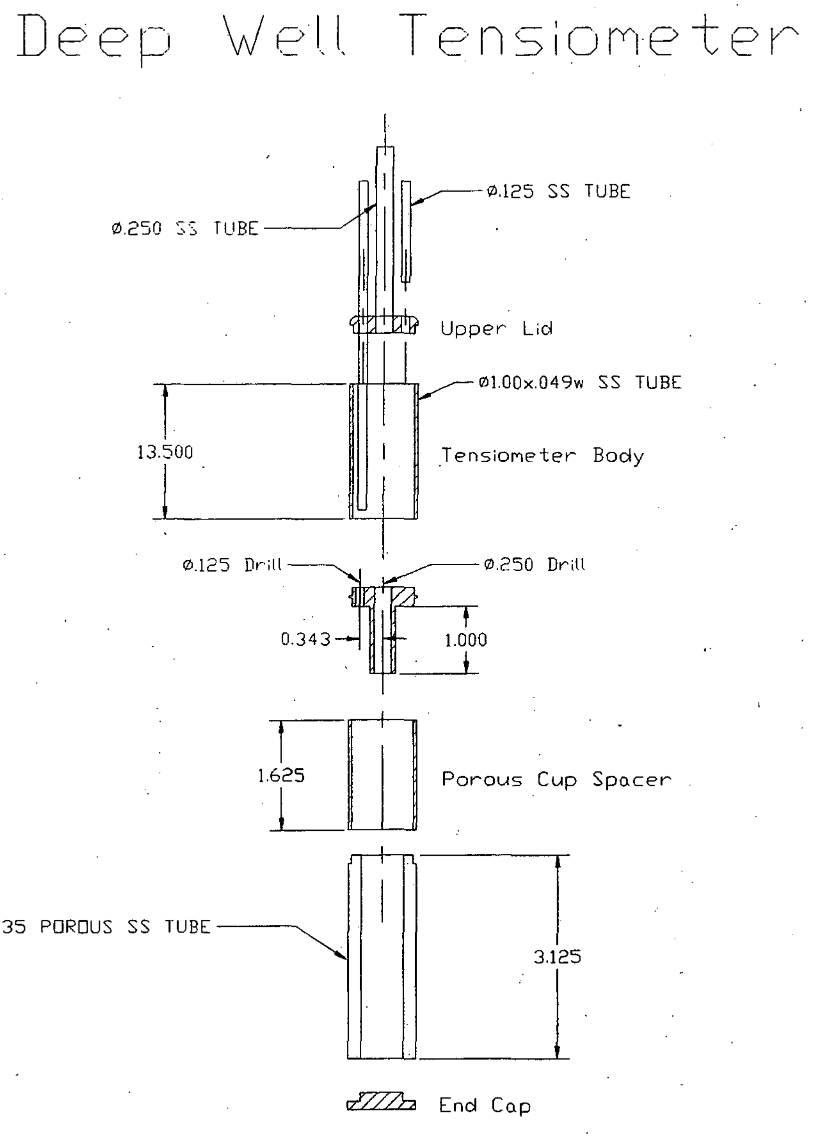
2.1.2.1 Tensiometer

The tensiometer provides a means of measuring soil water pressures that may be either negative (unsaturated zone) or positive (saturated zone). Conventional tensiometers with water filled tubes can not be used at depths significantly greater than 20 ft. The disadvantage of conventional tensiometers is that the water level in the water-filled tube of the tensiometer is uncontrollable, which may increase its response time and disturb the equilibrium of the "soil-tensiometer" system. We have installed a new design of the air-pocket tensiometer in which a porous tip is connected to a two-cell transducer with a constant water level above the porous tip (Faybishenko, 1996). This type of tensiometer has been used for monitoring water movement in the vadose zone at many field sites in the former Soviet Union (Faybishenko, 1986), and has been tested and used to monitor hydraulic pressure in fractured unsaturated-saturated basalt at the Box Canyon site of the Idaho National Engineering Laboratory. For this project, all parts of the tensiometer were custom made in order to fit the tensiometer into a borehole monitoring cluster.

The tensiometer consists of three parts: (1) a porous tip of cylindrical shape, (2) a two-cell transducer, and (3) a module consisting of three air-filled tubes that provide a means for measurements and maintenance. The porous tip was fabricated from a stainless steel porous tube [distributed by *Soil Measurement Systems*, Tucson, Arizona] and has an air-entry pressure of approximately -250 to -300 mbar. The fabrication layout of the tensiometer is shown in Fig. 2.3.

The porous tip is filled with water and connected through a coupling to the two-cell transducer. The transducer, an essential component of the tensiometer, is designed to maintain an essentially constant water level above the porous tip. This is accomplished by constructing the transducer with a lower and upper cell. These cells are separated by a concentric ring-plate with an opening at the center. A short tube located in the lower cell is fixed to the opening in the plate and provides a means of controlling water level in the lower cell. Such a design creates a confined air pocket in the top portion of the lower cell. The upper cell serves as a reservoir to recharge the lower cell with water as needed.

The connecting tubes provide a means of measuring pressure and replenishing water to the transducer as needed. One of the tubes connects the top point of the upper cell and allows measurement of the air pressure in the upper cell. The second tube is terminated 1-2 cm beneath the top of the upper cell and is used to add or withdraw water from the tensiometer. The third tube connects to the top point of the lower cell, providing access to and measurement of the air pressure in lower cell. The tubes at the top of the lower and upper cells are connected to pressure transducers and a computerized data acquisition system. To accelerate the process of equilibrating the tensiometer with the soil, an initial vacuum can be applied to the tensiometer. The direction in which the pressure is trending is then observed in the field and the vacuum can be modified accordingly. During installation, the porous tip of the tensiometer was enclosed in a bag filled with silica sand, called a backfill sack. Tensiometer readings were collected electronically on a 4-hour interval by the data acquisition system. The readings, in voltage, were converted to pressure using the calibrations for each individual pressure transducer.

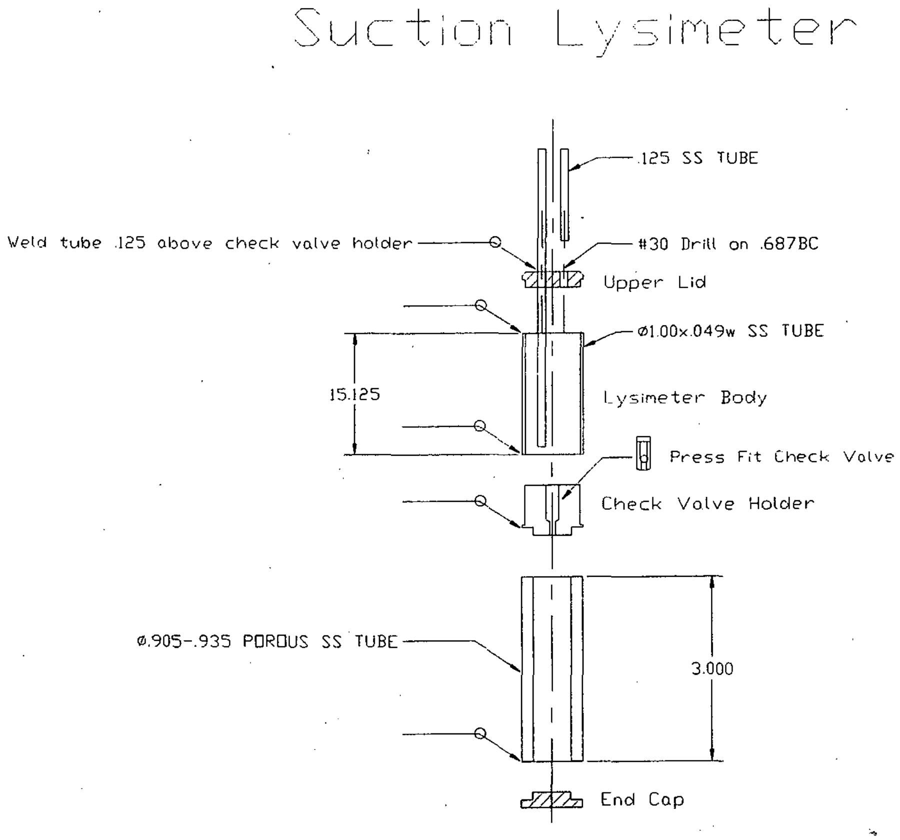


All material: Type 304SS. Use only water soluble cutting fluids.

Figure 2.3. Tensiometer fabrication layout.

2.1.2.2 Suction Lysimeter

The suction lysimeter is a two chamber design used for sampling at depths greater than 7-8 m. The fabrication layout of the suction lysimeter design is shown in Fig. 2.4. The stainless steel porous cup was constructed of the same material as used in the tensiometer design. Two 0.125-in tubes connect the lysimeter to the surface. One tube is used for the introduction of a purge gas and the other line allows the sample collected to be transported to the surface. A miniature check valve separates the lower chamber from the upper chamber. A 0.5-μm porous stainless steel cylinder permits the collection of the sample, which is drawn by vacuum through the check valve into the upper chamber.



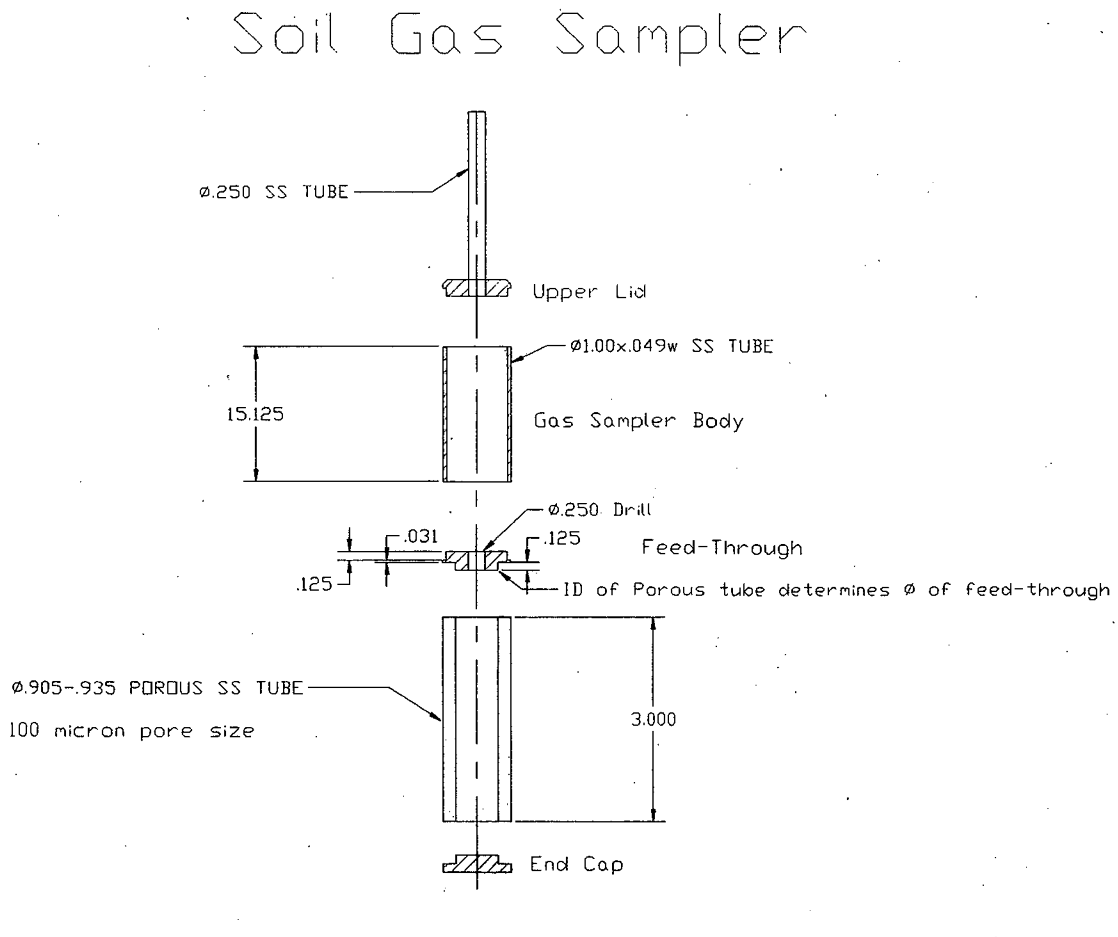
All material: Type 304SS. Use only water soluble cutting fluids. Perform lower lysimeter body weld prior to installing check valve.

Figure 2.4. Suction lysimeter fabrication layout.

The porous end of the suction lysimeter was enclosed in a nylon backfill sack. To withdraw a water sample from the soils into the suction lysimeter, a vacuum is applied to the tube connected to the top of the upper chamber. In order to bring the water sample to the surface, nitrogen or argon gas is used to pressurize the upper chamber, forcing the water sample up through the second tube that connects the bottom of the upper chamber to ground surface. The check valve closes, preventing liquid from being forced back into the lower chamber. The samples were routed into a 4-, 6-, or 44-mL vial, depending on the volume of the sample. The samples were generally not acid-preserved as the analysis was performed within 1-4 days of sampling. Samples were stored at 4°C prior to analysis, which was performed by the Environmental Measurements Laboratory (EML) of LBNL, using EPA Method 8260. Field blanks and duplicates were included in each sample set.

2.1.2.3 Soil Gas Probe

The soil gas probe, shown in Fig. 2.5, consists of a 7.62-cm long, 100-µm porous metal cylinder with welded top and bottom flanges. A 0.25-in diameter stainless steel tube extends out from the top flange and is connected using Swagelok® compression fittings to a 0.25-in teflon tube that goes up to the ground surface. A Swagelok® plug with a silicon septum stopper is used to seal the Teflon line. The probe is used for both gas-phase pressure measurements and gas sampling. The gas phase pressure is measured electronically using a dedicated pressure transducer, connected to the data acquisition system.



All material: Type 304SS. Use only water soluble cutting fluids.

Figure 2.5. Soil gas probe fabrication layout.

In order to purge the gas collected in the gas probe, gas is pumped out using a vacuum pump (approximate flow rate = 500 mL min^{-1}) integral to a photoionization detector (PID). As the gas is drawn through the PID, continuous measurements of total VOCs are made until the reading stabilizes (usually in 1-2 minutes). At that point, the PID is disconnected and a gas sample is withdrawn through a TENAX absorbent tube, using a vacuum pump, at approximately 60 mL min^{-1}, for 1.5 min. The sample volume is precisely accounted for. The absorbent tube is sealed with brass Swagelok™ compression fittings lined with Teflon gaskets. This sampling method does not require refrigeration and the sample holding time is 45 days. VOCs were analyzed by the EML using EPA Method TO14. Field blanks and duplicates were included in the analysis.

2.1.2.4 Thermistor

Thermistors are thermally sensitive resistors that exhibit a change in electrical resistance with a change in temperature. The thermistors used in this system (NTC-DC95, Thermometrics) are ceramic semiconductors with a negative temperature coefficient of resistance, i.e. resistance readings decrease with increasing temperature. These bead-shaped thermistors have Pt-alloy lead wires, directly centered into a ceramic body. The standard resistance for the thermochip at 25°C is 10,000 Ω. The unit is accurate to within ±1°C within the range 0°C to 70°C when using the standard resistance ratio curve. Due to the high resistance of the thermochip, the resistance measurement can be taken in a two-wire configuration with less than 0.05% error due to leadwire length. Each thermistor was soldered onto a 100-ft-long Belden #8451 twisted and shielded 22AWG instrumentation cable. To protect the thermistor from mechanical stress, each bead was housed in a stainless-steel shield. To prevent moisture from seeping into the lead wires, each wire was shrink-wrapped and then insulated with epoxy.

Calibration of each thermistor was done in the laboratory, using the procedure recommended by the manufacturer. The Steinhart and Hart equation was used:

$$\frac{1}{T} = a + b(\ln R) + c(\ln R)^3 \qquad (2.1)$$

where R is resistance in ohms and a, b, and c are coefficients derived from measurement. For this set of thermistors, the average values for a, b, and c are $1.1\text{x}10^{-3}$, $2.35\text{x}10^{-4}$, and $9.56\text{x}10^{-8}$, respectively, where T is in units of °C.

Thermistor readings were collected electronically on a 4-hour interval by the data acquisition system. The readings, in voltage, were converted to temperature using the calibrations curve.

2.1.2 Instrument Design and Application: VZMS-C

Three types of instruments were installed in VZMS-C: tensiometers, psychrometers, and pressure-vacuum lysimeters. The tensiometers and lysimeters were purchased from Soilmoisture Equipment Corp., while the psychrometers were obtained from Wescor, Inc..

Each tensiometer consists of a 7/8-in OD acrylic body with a 1-bar air-entry pressure porous ceramic cup at the bottom and a rubber septum on the above-ground end of the tube. The tensiometer is installed in such a way that the porous cup is at the desired monitoring depth. Once filled with water, the pressure inside the tensiometer will equilibrate with the pressure in the formation via the exchange of water through the porous cup. A pressure transducer connected to a needle is used to measure the pressure inside the tensiometer via the septum stopper. Tensiometers can be used in the practical range of 0 to -800 mbar matric potential.

Each psychrometer consists of a thermocouple embedded in a porous stainless steel screen and connected to an insulated lead wire. The thermocouple-screen assembly is approximately 1/4-in in diameter, and approximately 0.5-in long. The thermocouple is installed at the desired measurement depth and the other end of the cable extends to the ground surface. The psychrometer measures the relative humidity of the formation which is then converted to a matric potential. The measurement is done by inducing condensation of a bead of water onto an "evaporating" surface. The rate at which this water evaporates from the junction can be correlated with the formation humidity. In theory, psychrometers can be used in the matric potential range of -1 to -80 bar, but ones for field application are only effective at matric potentials lower than -2 bar. All psychrometers were calibrated in the laboratory prior to installation.

Pressure-vacuum lysimeters consist of a 1.9-in OD, 12-in long PVC body with a 1-bar air-entry pressure, high-conductivity porous ceramic cup at the bottom, and two polyethylene tubes leading to the surface. One of the tubes reaches the bottom of the porous cup, while the other just barely enters the PVC body. The former is used to apply vacuum and the latter to apply pressure during sampling. The lysimeter works via the application of a vacuum which then draws formation water in via the ceramic cup. Pressure-vacuum lysimeters can be installed at any depth, but are limited to the same range of matric potential as the tensiometers.

Due to the use of distilled water during the installation, the lysimeters were used to extract water from the backfill until an equilibrium with the surrounding formation was reached. The system was assumed to be at equilibrium when the volume extracted during a set amount of time was consistently the same and when pH and electrical conductivity of the extracted water stabilized. Psychrometers are just out of range, giving results which qualitatively indicate matric potentials near -1 bar. This agrees with the fact that most of the tensiometers are within their operating range of 0 to -800 mbar.

Vacuum is applied to the lysimeters to draw formation water into the ceramic cup. Pressure is applied through the air line to bring the sample to the surface. The sample is placed in 44 ml vials. The samples were generally not acid-preserved as the analysis was performed within 1-4 days of sampling. Samples were stored at 4°C prior to analysis, which was performed by the EML, using EPA Method 8260. Field blanks and duplicates were included in each sample set.

2.1.3 Instrument Design and Application: Neutron Probe (NP)

Relative measurements of soil moisture content are made using a downhole neutron probe. Neutron probe measurements are based on the principle of neutron thermalization during collisions with hydrogen atoms. "Fast" neutrons are emitted by the probe into the formation. A detector in the probe counts the "slow" neutrons produced by these collisions. The number of "slow" neutrons is proportional to the moisture content of the surrounding medium. In conjunction with tensiometer data, neutron probe measurements help define movement of water in the subsurface. The neutron source required for a measurement with an effective radius of 15 cm is of sufficiently low strength that it poses an insignificant health hazard when properly used. The probe used in this system (CPN 503DR Hydroprobe) consists of a 50 mCi Am-Be neutron source which emits 1.1×10^5 neutrons per second and a He detector of thermal neutrons. When high energy neutrons are emitted into the rock or sediment formation, they are “slowed down” or “thermalized” when they collide with hydrogen nuclei. The slow or thermal neutrons are detected and their count is proportional to the hydrogen concentration in the formation. Since water is by far the main source of hydrogen in this setting, the count is proportional to the moisture content. Although many calibrations exist for converting counts to moisture content, conversion is always highly formation- and well-completion-specific. Therefore, the counts, or ratio of counts to some standard count, are most reliably used for the determination of relative moisture content changes.

The NP-1 and NP-2 boreholes were completed using 2-in PVC casing which was cement-grouted in place. During measurement, the neutron probe was lowered through the casing. Readings were taken at selected depth intervals, usually on the order of 1 to 2 ft. Neutron probe readings were calibrated to moisture content data collected from core samples from VZMS-A and VZMS-B.

2.2 DRILLING OPERATIONS

2.2.1 VZMS-A, VZMS-B, NP-1, NP-2

Standard hollow-stem drilling, coring and sampling methods were used during the installation. Two vertical borings were drilled to 115 ft using an 10-in OD hollow-stem auger. The boreholes were then reamed with a 12-in OD auger. Installation of nested instruments occurred in these two boreholes, through the 12-in OD auger. Continuous samples were taken using a Modified California split-spoon sampler and described in the field by field geologists from Radian and LBNL. Each borehole was drilled to approximately 2 ft below the water table. Out of concern for borehole collapse, the auger stem was gradually raised as the instruments were installed through the auger stem.

Soil samples not slated for physical or TOC analyses were placed in wax-impregnated cardboard core-boxes, labeled, and described by the method in ASTM D 2487-90. Selected soil samples for TOC analysis and physical parameter determination were sent to BSK & Assoc. laboratory. Samples were capped and sealed to preserve moisture content. Soil gas samples were collected in canisters at approximately 10-ft depth intervals and were submitted for TO-14 analysis (Air Toxics Ltd.).

Two additional vertical 4-in borings were drilled using a solid-stem auger for the purpose of neutron probe access pipe installation. These were drilled to the water table. The neutron probe borings were not sampled because a larger boring would have been required and in turn would have resulted in a larger annulus of backfill and a reduced effective radius of penetration into the formation for neutron logging.

2.2.2 VZMS-C, Well-1

VZMS-C was drilled using 8.25-in OD hollow-stem augers. Since the geology of the area had been well characterized by the nearby boreholes, split-spoon samples were collected every 5 ft. These samples were subsequently used for the determination of physical properties. After the augers were removed from the borehole, no seepage was observed. Based on the apparent stability of the borehole, the decision was made that it was not necessary to install the instruments through the auger, and all instruments were installed in the open borehole over the course of 2 hours.

Well-1 was drilled and installed on 4/20/98. The well was constructed of Schedule 40 PVC, with a stainless-steel screened interval between 98 and 118 ft. Groundwater was encountered at 112 ft bgs.

2.3 INSTRUMENT INSTALLATION PROCEDURES

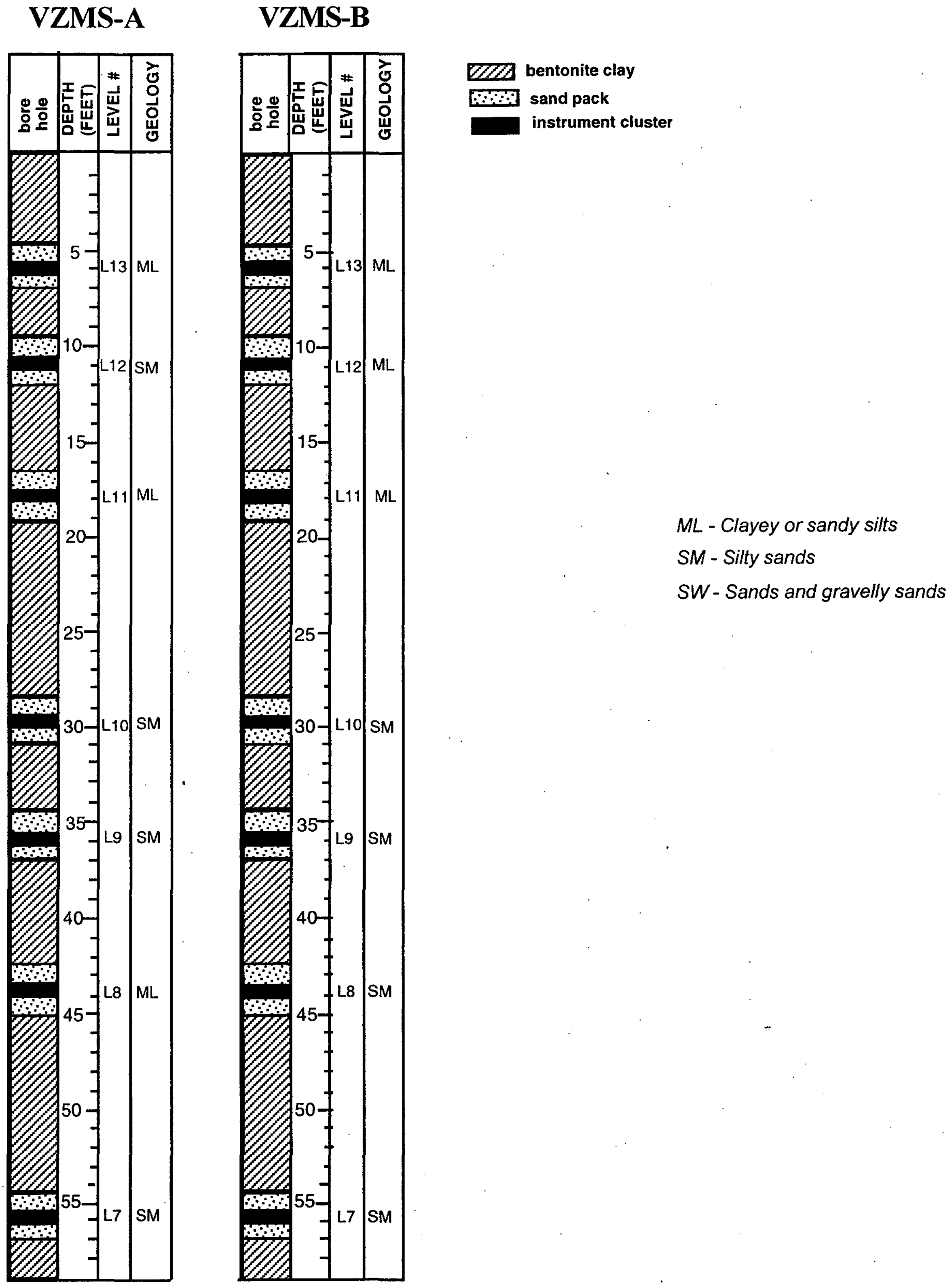
Geologic information from sampled cores and soil-gas analysis results were used in the selection of depth intervals at which instruments were installed. The primary criterion was to capture data from all or most of the lithologic units of notable thickness. Another criterion was to ensure that each cluster was placed entirely within a single lithologic unit.

Although the lithologic sequences in the three boreholes differ in detail, in general they consist of interlayered silts and sands, with occasional layers of coarse sand, especially toward the bottom of the profile (Appendix A). These layers are generally 5 to 10 ft thick. Core recovery was high, approximately 90 to 100% in most cases and provided an almost continuous record. No samples were taken below 100 ft, but the cuttings indicated sandy sediment.

The most significant feature of the sequence was the predominance of sandy silt in the top 30 ft of borehole VZMS-A and the top 20 ft of VZMS-B and -C. Sands dominate both A and B profiles below 60 ft, with a coarse sand layer in both boreholes between 61 and 66 ft, again around 72 ft, and once more below 93-95 ft. Little moisture was observed, with most samples characterized as dry to damp. An exception was encountered in VZMS-C, with the observation of water seepage out of the road base gravel underlying the buried concrete slab, at a depth of approximately 3 ft.

2.3.1 Instrument Installation: VZMS-A and VZMS-B

A schematic construction log of the VZMS-A and -B instrumentation is shown in Fig. 2.6. The instruments were labeled L1 through L13, with L1 being the deepest level. The geologic logs can be found in Appendix A. Instruments installed at a single depth were arranged in clusters prior to installation. The spring-release mechanism (described in Section 2.1.1) which was used

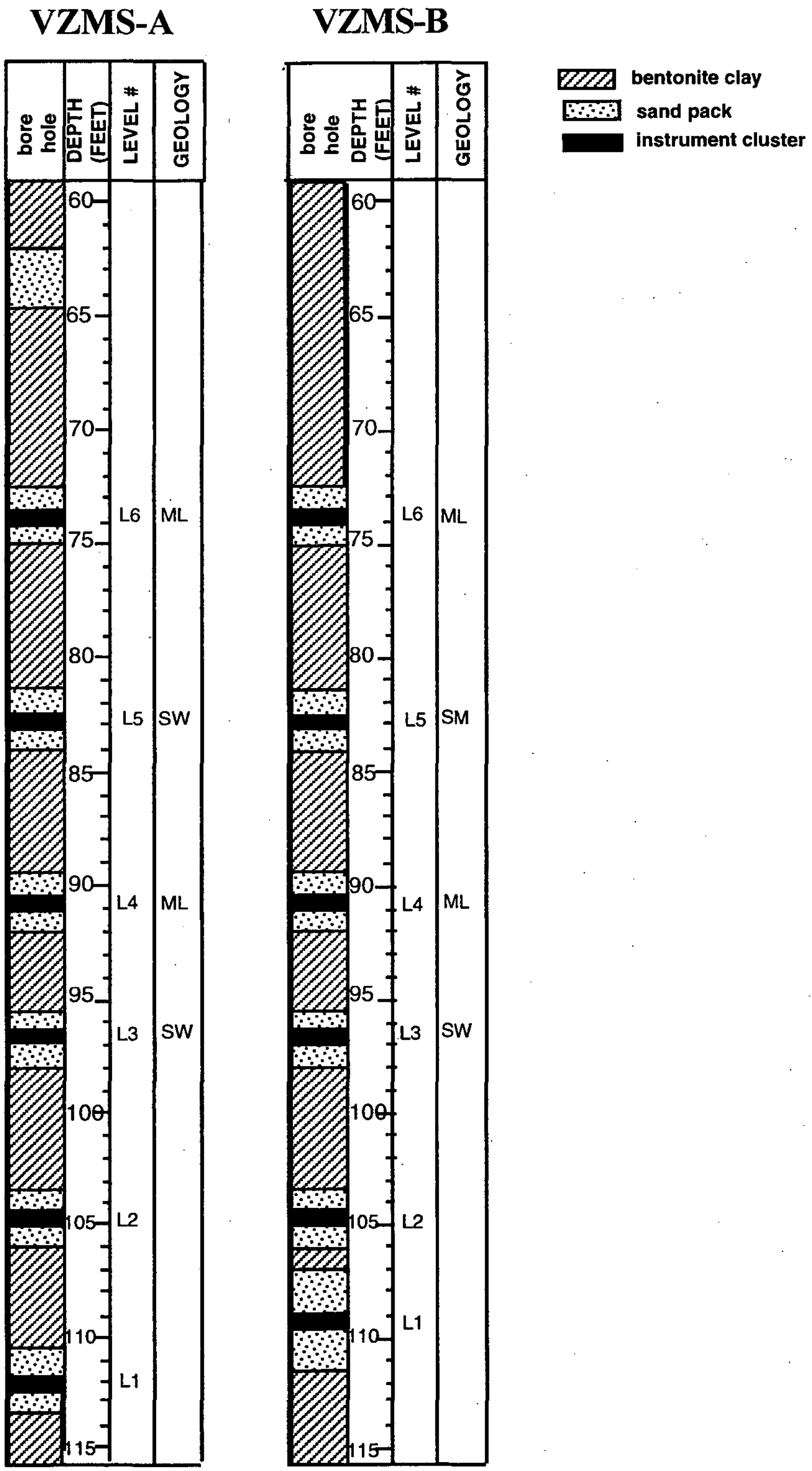


ML - Clayey or sandy silts

SM - Silty sands

SW - Sands and gravelly sands

Figure 2.6. VZMS-A and -B instrumentation log.



ML - Clayey or sandy silts

SM - Silty sands

SW - Sands and gravelly sands

Figure 2.6. continued.

to press instruments against the borehole wall was set up in the "closed" position and hooked up to a nylon string which was later used to release the springs. Each instrumentation level was underlain by at least 1 ft of bentonite which was poured through an auger and was saturated with water. Care was taken to introduce only enough water to saturate the bentonite without excessively wetting the borehole. On top of the bentonite, a 0.5 ft layer of fine sand was set. Subsequently the instrument cluster was lowered down the borehole, after which the springs were released. More fine sand was poured to cover all sensors, approximately a 1 ft thickness. All intervals between instrument clusters were backfilled with coarse bentonite and saturated with water. After the top-most level of instrumentation was installed, a cement grout slurry was poured to a depth of 2 ft below land surface. A flush-mounted, water-tight utility vault was installed.

Tube bundles from the nested instruments are terminated below the ground surface in Christy boxes covered with steel plates. Fig. 2.7 shows the dimensions of the Christy boxes. Four-inch PVC conduit connects to a side access port of the Christy box and comes through the concrete pad. Cables are routed above ground, via the PVC conduit, to a data acquisition system in a nearby shipping container.

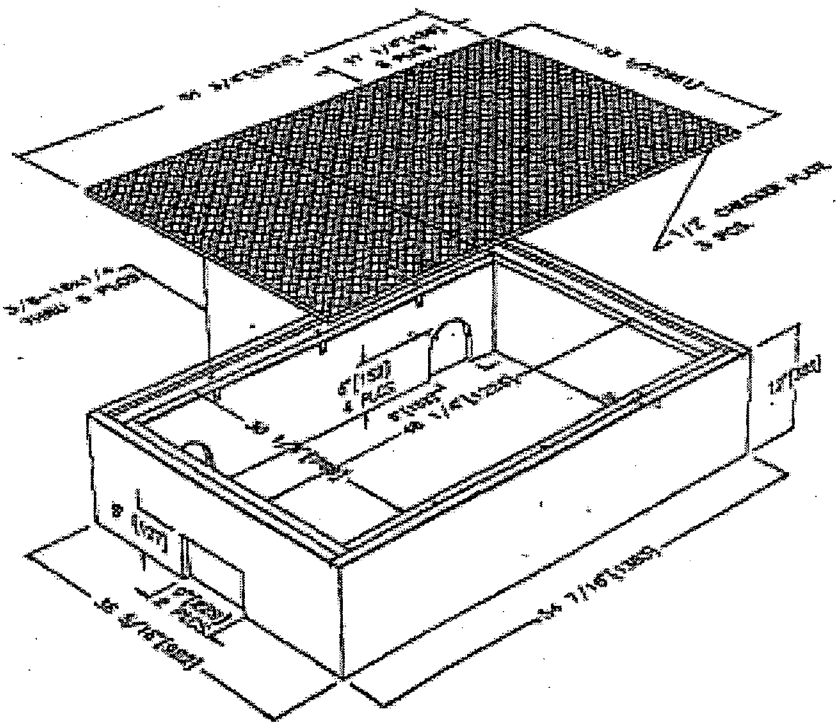
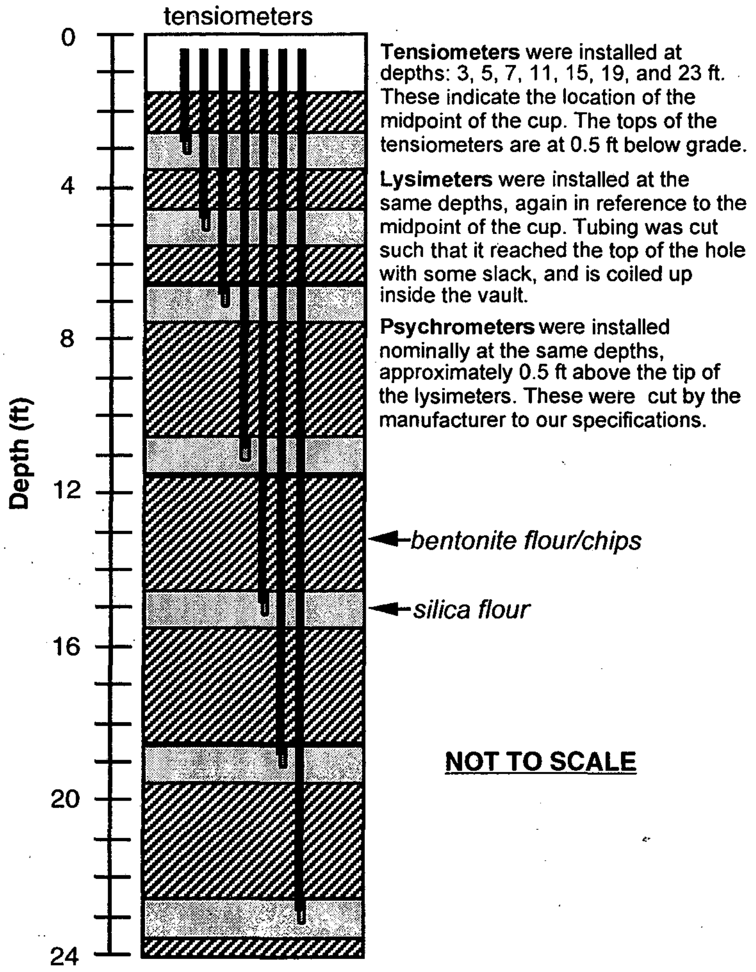


Figure 2.7. Surface completion of VZMS-A and -B.

2.3.2 Instrument Installation: VZMS-C

Seven levels of instruments were installed (Fig. 2.8), at 3, 5, 7, 11, 15, 19, and 23 ft in the shallower VZMS-C borehole. Each level consisted of one tensiometer, one lysimeter, and two psychrometers, each strapped to the opposite side of the lysimeter body approximately 10 cm above the porous cup. Each level is underlain by 6 inches of saturated bentonite powder. Before any instruments were installed, 4 inches of silica flour were poured into the borehole via a tremmie pipe. Then, the instruments were lowered into the borehole and placed as close to the borehole wall and as far from each other as possible. Another 8 in of silica flour was added to cover the instruments. Approximately 25% equivalent volume of distilled water was added to wet the silica flour in order to establish hydraulic contact with the formation. Subsequently, 6 inches of bentonite powder was tremmied down the hole, followed by 6 inches of bentonite chips, through which 1.5 gal of distilled water was poured. Bentonite chips were added until the next desired level was reached and the procedure was repeated.



Tensiometers were installed at depths: 3, 5, 7, 11, 15, 19, and 23 ft. These indicate the location of the midpoint of the cup. The tops of the tensiometers are at 0.5 ft below grade.

Lysimeters were installed at the same depths, again in reference to the midpoint of the cup. Tubing was cut such that it reached the top of the hole with some slack, and is coiled up inside the vault.

Psychrometers were installed nominally at the same depths, approximately 0.5 ft above the tip of the lysimeters. These were cut by the manufacturer to our specifications.

Figure 2.8. Schematic drawing of the distribution of instrumentation in VZMS-C. For the sake of clarity, only tensiometers are shown.

Following the instrumentation of the shallowest level, approximately 1.5 ft of concrete was poured onto the saturated bentonite and an 8-inch vault was built, flush with ground surface. All of the leads and tubing extend into this vault.

2.4 LABORATORY TESTING OF FIELD SOIL SAMPLES

Twenty-two soil samples taken from VZMS-A and VZMS-B were submitted to BSK & Assoc. laboratory for TOC analysis and physical parameter determination. Soil samples were tested to determine bulk (wet) density, moisture content, specific gravity, porosity and total organic carbon. Moisture content of soil samples ranged in value from 6.0 to 41.4%. Bulk density of samples ranged from 1.38 to 1.94 g/cc. Porosity measurements ranged from 36.1 up to 59.9%. Total organic carbon in samples ranged from non-detectable to 350 mg/kg. Another subset of soil samples, from VZMS-A, -B, and -C was submitted to D.B. Stephens and Assoc. for determination of moisture characteristic curves and saturated conductivity. The full report can be found in Appendix B.

Table 2.2. Results of Particle Size Analyses for VZMS-A and VZMS-B.

Depth	Class	SIEVE	(%)		PSA	(%)	
(ft.)		>2000 μm	425-2000 μm	75-425 μm	sand	silt	clay
VZMS-A							
06.0	ML	00.0	11.0	13.2	33.8	60.0	06.3
09.5	SP	00.3	01.3	86.1	76.5	17.4	06.1
17.5	SM	00.0	00.3	31.7	50.7	44.6	04.7
22.0	SM	00.0	00.0	27.9	56.2	41.1	02.7
28.5	SM	00.0	00.2	58.0	68.7	28.2	03.1
34.0	SM	00.0	03.5	40.3	49.2	43.0	07.8
44.0	ML	00.0	00.0	14.5	22.5	67.0	10.4
50.0	ML	00.0	03.7	18.4	35.0	56.8	08.3
52.0	SM	00.2	00.2	73.6	70.4	27.3	02.3
57.5	SM	00.0	13.8	58.2	73.0	21.6	05.4
62.0	SP	00.0	25.4	64.8	77.5	18.7	03.7
68.0	SM	00.0	06.1	24.0	49.8	44.9	05.3
71.0	SP	00.0	33.2	64.4	95.7	02.7	01.7
79.0	ML	00.0	01.7	09.6	39.6	53.7	06.7
83.0	SP	00.0	23.7	73.9	97.7	00.7	01.7
86.0	SM	00.0	00.9	08.2	59.9	27.2	12.8
88.5	SW	00.0	00.3	94.6	100.0	00.0	00.5
92.0	ML	00.0	00.6	00.6	34.9	58.2	06.9
96.0	SP	00.0	30.6	67.7	97.2	00.8	02.0
99.0	ML	00.0	00.0	00.0	31.5	59.2	09.2
VZMS-B							
07.0	SP	00.0	00.3	38.2	83.0	12.5	04.5
13.5	SP	00.2	62.3	34.1	87.2	08.3	04.5
18.5	SM	00.0	00.4	37.6	58.6	36.2	05.2
22.0	SM	00.0	00.3	26.4	52.9	43.8	03.3
28.5	SM	00.3	00.3	19.8	51.0	47.1	01.9
33.5	SM	00.0	00.4	39.7	65.9	32.5	01.6
38.5	SM	00.0	00.3	39.0	67.6	30.9	01.5
43.5	SP	00.0	13.5	67.8	87.0	10.9	02.0
52.0	SP	00.0	00.2	70.5	83.2	15.5	01.3
58.5	SP	00.7	13.5	49.9	82.7	14.5	02.8
63.0	SP	00.0	27.8	58.4	93.3	04.8	01.9
67.0	ML	00.0	01.3	17.6	43.6	55.5	00.9
73.0	SP	00.0	17.0	76.9	98.6	00.0	01.8
76.0	SP	00.0	17.1	78.0	95.5	03.3	01.2
79.5	SM	00.0	00.3	11.5	53.3	45.3	01.4
86.0	SM	00.0	00.2	27.5	51.6	40.6	07.9
93.0	ML	00.0	00.0	00.6	36.0	60.4	03.7
98.5	SP	00.0	21.2	78.9	99.0	00.4	00.6

Particle size analyses were performed on soil samples taken from VZMS-A and VZMS-B. Results are provided in Table 2.2. In VZMS-A, the percentages of sand, silt and clay for the samples taken from the field ranged from 22.5 to 100%, 0 to 67% and 1.7 to 12.8%, respectively. In VZMS-B, similar ranges of 36 to 99%, 0 to 60.4 % and 0.6 to 7.9 % described the sand, silt and clay content, respectively.

3 MONITORING RESULTS

Vadose zone monitoring at site S-7 took place from March 1997 through June 1999. Data include formation temperature and pressure measurements, soil-water and soil-gas analysis, and moisture content measurements. These data are summarized in the following sections. Analytical reports for previously unreported data comprise Appendix C.

3.1 TEMPERATURE

Formation temperature was measured using in-situ thermistors. The data were collected electronically in real time and the measured resistance was converted to temperature in °C using calibrations generated in the laboratory prior to installation. Most of the observed fluctuations in formation temperature occur in the top 30 ft (Fig. 3.1).

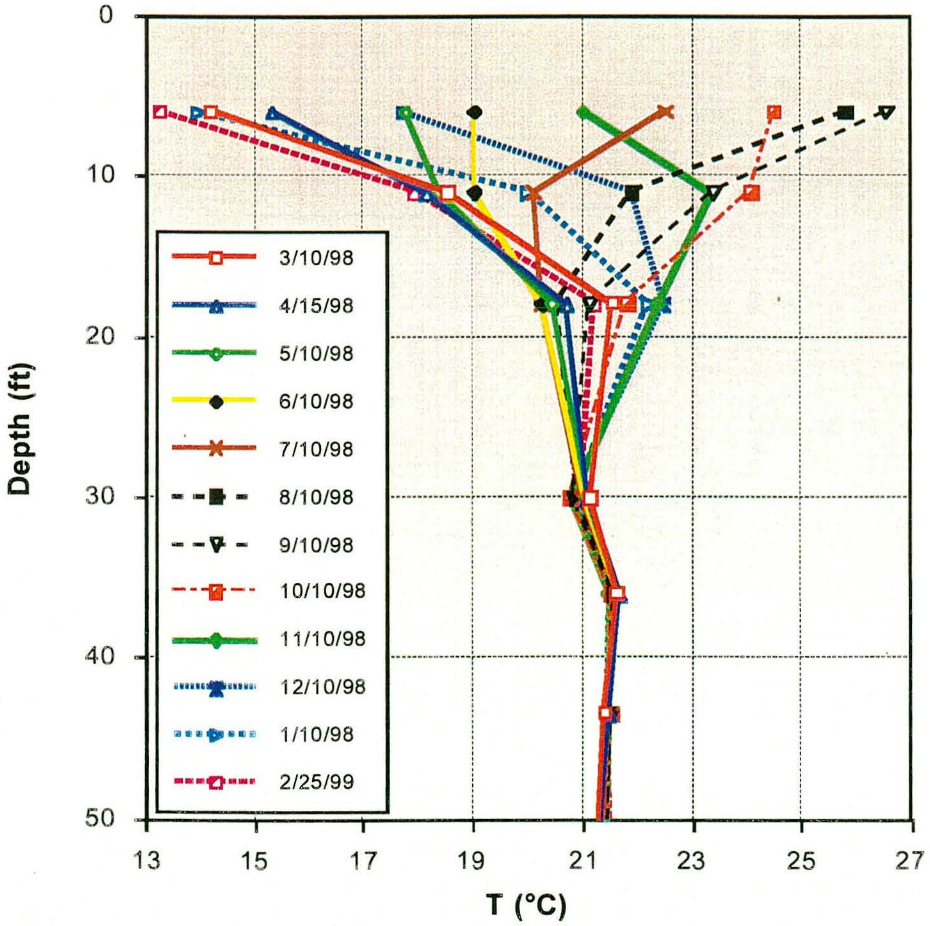


Figure 3.1. Monthly formation temperature fluctuations in VZMS-A, from 3/98-2/99.

As expected, the magnitude of air temperature changes is rapidly dampened with depth, due to the very high heat capacity of the formation (Hillel, 1980). Diurnal changes in air temperature do not result in quantifiable changes in formation temperature, not even at the shallowest depth of 6 ft.

The continuous record of mean daily temperature measured at 6-, 11-, 18-, and 30-ft depths in VZMS-A is shown in Fig. 3.2, beginning in May 1997 through June 1999. Temperature patterns from VZMS-B (not shown) are nearly identical. Temperature fluctuations are dampened rapidly with depth; temperature at 6 ft varies from as high as 27°C in August, to as low as 14°C in March, while temperature at 18 ft varies by only ±1.5°C from a mean of 21.5°C. At 30 ft, net changes are on the order of a fraction of a degree. This graph also illustrates a time lag in the temperature cycle at each depth, with peak temperatures at 6 ft and at 18 ft occurring in August and December, respectively. Such lags, and those at un-instrumented shallower depths, which cannot be documented, result in reversals of the temperature gradient, which could contribute to the movement of VOCs in the top 20 ft of the profile. On average, seasonal temperatures decreased slightly from 1997 to 1998 and again in 1999.

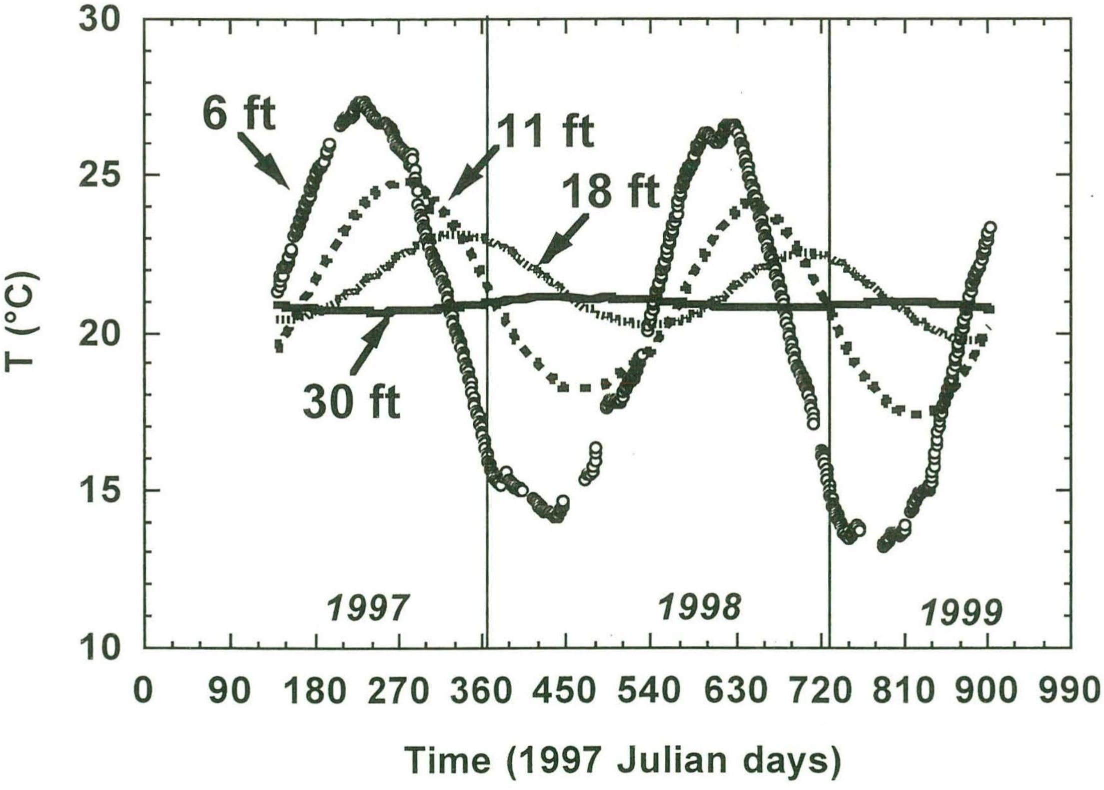


Figure 3.2. Daily formation temperature at depths of 6 ft, 11 ft, 18 ft, and 30 ft in VZMS-A.

3.2 PRESSURE

3.2.1 Gas-Phase Pressure

Gas-phase pressure was measured using the same gas probes as used for gas sampling. These were allowed to equilibrate with the subsurface environment and the pressure was measured using dedicated pressure transducers. Overall, gas-phase pressures are very close to atmospheric pressure, but display a slight lag and dampening relative to diurnal atmospheric pressure fluctuations. Both effects are to be expected given that the gas samplers are measuring pressure at depth. Gas-phase pressure measured at the depth of 112 ft (SG-A-1) in VZMS-A deviates from the common trend, though remains within 10 cm of atmospheric pressure. This can be explained by the fact that this sampler is very near the groundwater table and likely in the capillary fringe, which would impair the communication via the gas-phase. Note that uncertainty due to calibration error causes downhole pressure to range both lower and higher than atmospheric pressure. The main purpose of gas-phase pressure monitoring is to observe changes rather than measure absolute values.

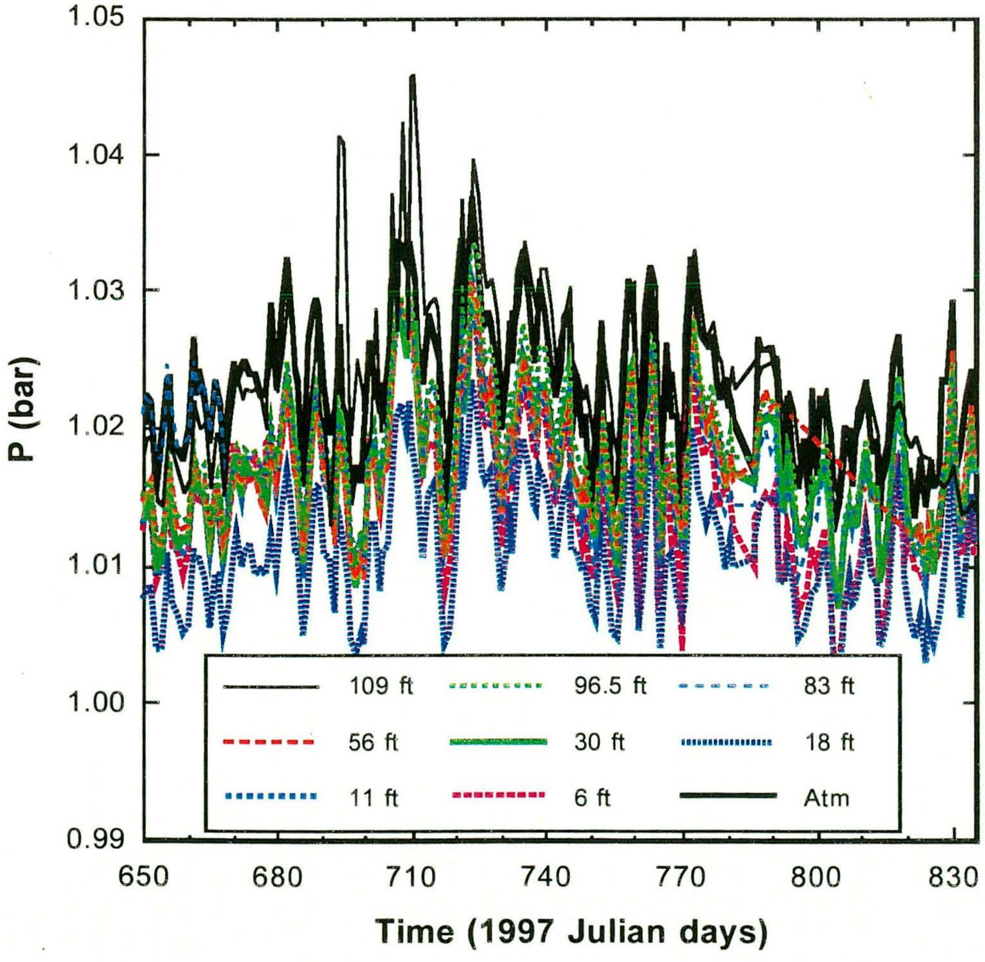


Figure 3.3. Daily atmospheric and formation pressure at selected depths in VZMS-B.

Atmospheric and formation gas-phase pressure from selected depths are shown in Fig. 3.3 for the period 10/12/98–4/10/99. There is a range of approximately 10 cm between the highest and lowest readings, which is indicative of the uncertainty resulting from calibration error. The lag between atmospheric pressure fluctuations and formation gas-phase pressure changes is shown in Fig 3.4. A lag of 6 to 13 hours between atmospheric pressure and formation pressure can be estimated.

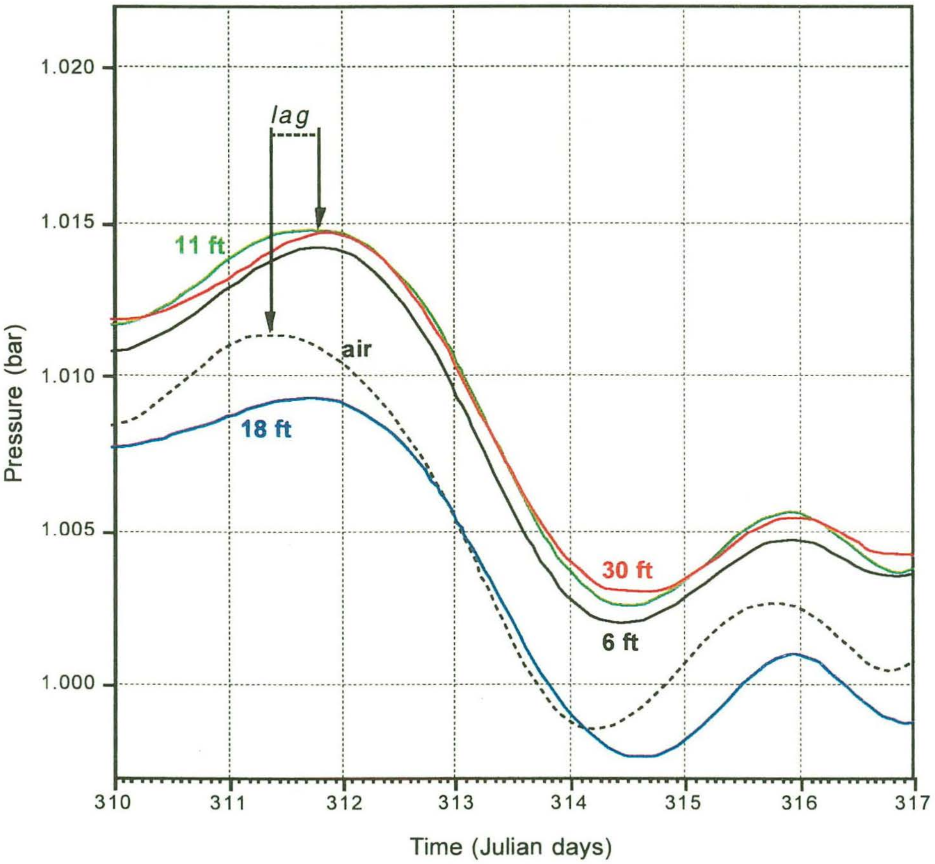


Figure 3.4. Average daily formation and air pressure in VZMS-B, from 11/6/97 to 11/13/97, interpolated and smoothed.

3.2.2 Liquid-Phase Pressure

Liquid-phase pressure was measured using tensiometers. Because of the relatively high air-entry pressure of the stainless steel porous cups used in VZMS-A and -B, those tensiometers were unable to measure the relatively low matric potentials in most of the formation, except immediately above the water table. Tensiometers in VZMS-C use ceramic porous cups, with a 1-bar air-entry pressure, allowing for the collection of reliable matric potential data. Tensiometers below the depth of 15 ft cannot equilibrate with the formation due to continuous, but slow water loss, suggesting that the matric potential of the formation is very close to the air-entry pressure of the cup, namely 1 bar. Also, if the matric potential were more negative than -0.5 bar, the large column of water in a tensiometer below 20 ft would result in a total gage pressure exceeding -1 bar. Profiles of matric potential in the top 15 ft are shown in Fig. 3.5. Note that the tensiometer at 11 ft failed in December 1998, for reasons unknown. The matric potential at 3 and 5 ft was in the range of -125 mbar to +50 mbar. This indicates that this region is moist and occasionally water-saturated. The matric potential at 7 ft was lower, generally between -175 and -100 mbar. At 11 ft, the matric potential increased to between -100 and -25 mbar. There was a large decrease in matric potential at 15 ft, with values ranging from -325 to -200 mbar. This explains the failure of stainless steel tensiometers in VZMS-A and -B to attain hydraulic equilibrium with the formation. Overall, this profile shows the drying of the formation with depth.

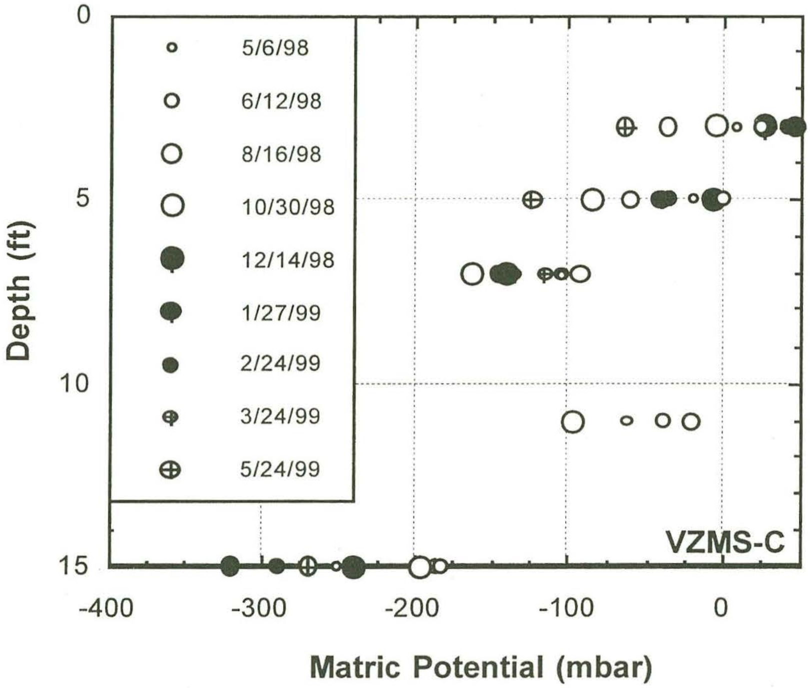


Figure 3.5. Matric potential measured using tensiometers in VZMS-C, 5/98-5/99.

The same data set is presented in terms of hydraulic head in Fig. 3.6. The profile emphasizes the downward water flow in this system. However, the actual rates of this flow remain to be determined. In Fig. 3.7, data from 3, 5, 7, and 15 ft are shown as a function of time. Seasonal fluctuations in moisture content are apparent, with increases in moisture at 3 and 5 ft during times corresponding to wet winter periods, with subsequent drying in the summer. It appears that during most of the winter, the formation at 3 ft is saturated. This agrees with the visual observation of free water at 3 ft during the installation of VZMS-C. At 5 ft, the formation also appears saturated on a few occasions. On the other hand, at 7 ft and particularly at 15 ft there appears to be a lag, with relatively wetter conditions in the summer and drying during the winter. Changes at 7 ft are rather subtle. Although longer-term data are needed to confirm these trends, it appears that liquid phase downward displacement is occurring, though is largely limited to the top 5 - 10 ft.

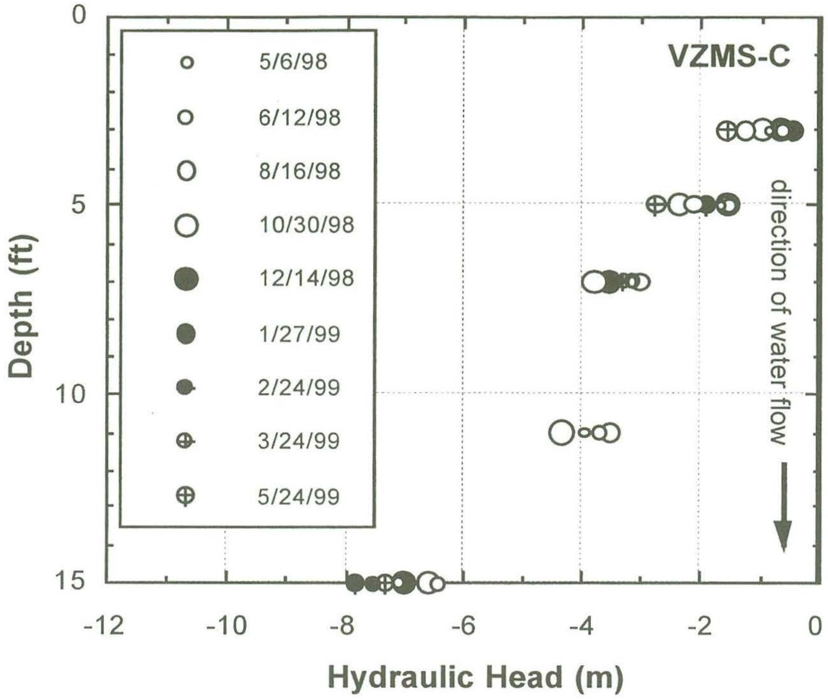


Figure 3.6. Hydraulic head measured using tensiometers in VZMS-C, 5/98-5/99.

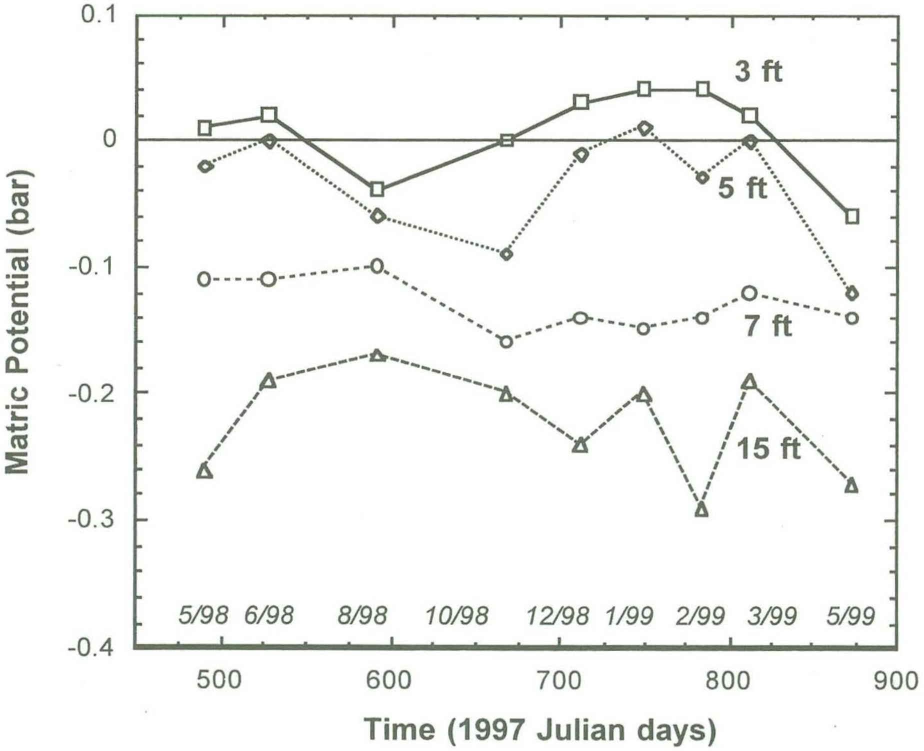


Figure 3.7. Matric potential at 3, 5, 7, and 15 ft as a function of time. Positive matric potentials signify saturated conditions.

3.3 MOISTURE CONTENT

Moisture content was measured by neutron logging via access wells NP-1 and NP-2. Due to the presence of casing and backfill material, as well as the spatial variability of geologic properties of the medium, this information is largely qualitative, although relative percentage change in moisture content at any one point can be quantified. Therefore, this tool is best used to measure changes in the moisture distribution, whether due to evaporation or rainfall infiltration. In conjunction with moisture content data from cores, a calibration of neutron counts to moisture content was made (LBNL, 1998a).

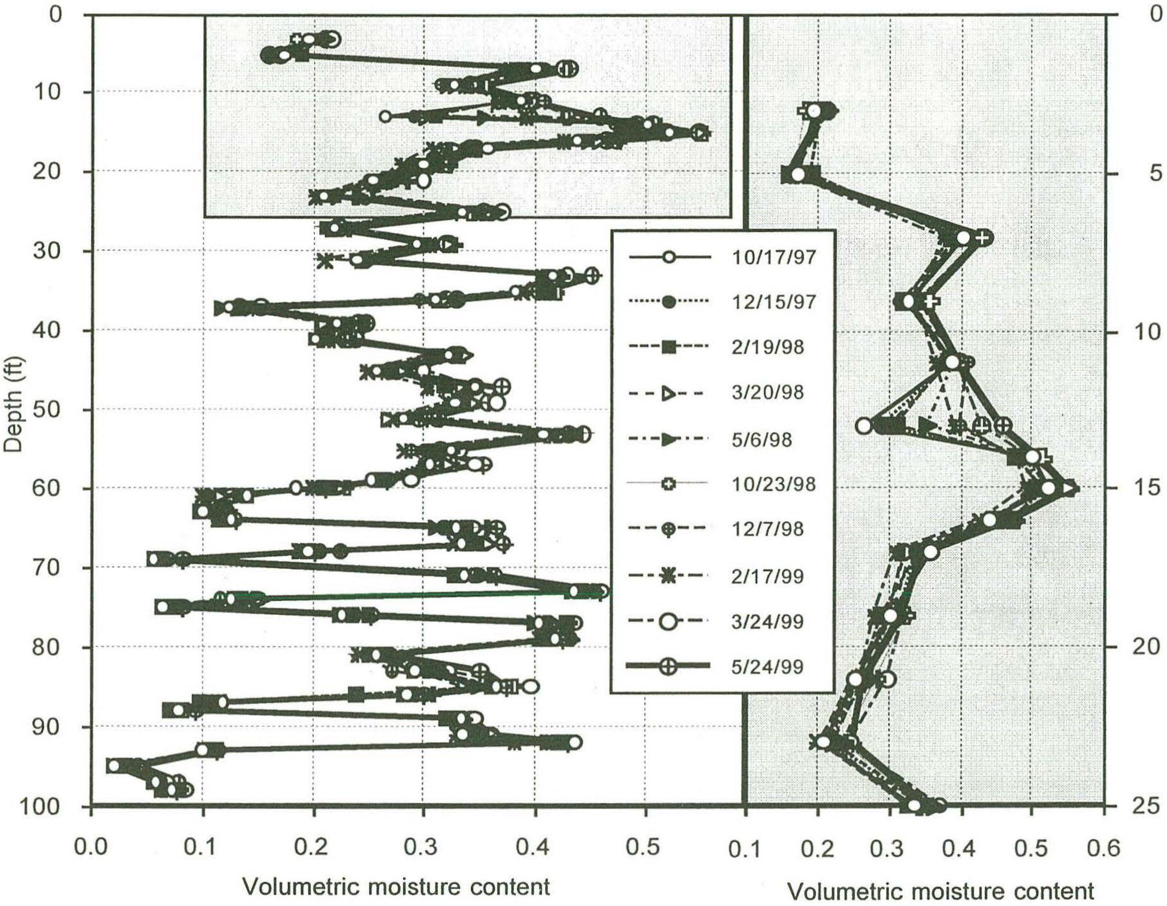


Figure 3.8. Volumetric moisture content based on neutron counts measured in Well NP-B over the period 10/97 to 5/99.

Neutron logging was performed at the site on 10/23/98 using a CPN 503DR Hydroprobe consisting of a 50 mCi Am-Be neutron source and a He detector of thermal neutrons. Due to a slight bend in the access pipe in NP-A, only the top 25 ft of the borehole can be logged. Well NP-B was logged to a depth of 98 ft. Results are shown in Fig. 3.8. As seen from these results, the overall volumetric moisture content in the formation remained stable throughout most of the formation. Some moisture movement occurred in the top 15 ft of the formation, with seasonal wetting and drying above 5 ft and slight wetting below that depth. More significant wetting occurred around the depths of 12 to 14 ft.

These trends, together with matric potential data, are suggestive of the redistribution of infiltrated rainwater. Conversely, the redistribution is vertically limited, with nearly no increases below 15 ft. This does not mean that water and associated liquid-phase contaminants do not move vertically in the profile, but rather that the flux of water is both small and approximately steady-state.

3.4 GAS-PHASE CONTAMINANTS

The gas phase was sampled every one to two months. Seventeen complete sets of gas samples were collected on the following dates: 4/4/97, 5/8/97, 7/22/97, 8/26/97, 10/23/97, 12/15/97, 1/21/98, 2/19/98, 3/20/98, 5/1/98, 6/19/98, 8/13/98, 10/30/98, 12/14/98, 1/27/99, 3/31/99, and 5/24/99. The analysis of the 4/4/97 samples from VZMS-A was out of control due to problems with sample dilution. Results from 7/22/97 need to be interpreted with caution, since unlike all other data sets, they do not quantitatively agree with concentrations in pore-water samples, as compared using Henry's Law (LBNL, 1998a). The 12/14/99 data from VZMS-A did not pass QC, and will not be considered. A failure of a part of the sampling pump resulted in artificially low concentrations during the 1/27/99 and 3/31/99 collections. Therefore, VZMS-A and -B data from 4/4/97, 1/27/99, and 3/31/99, and VZMS-A data from 12/14/99 will not be considered.

TCE, cis-1,2-DCE, and Freon 123a have been identified as the major contaminants in the system (LBNL, 1997b). There are two apparent sources of contamination. Sediments in the top 15 to 20 ft are contaminated with TCE and cis-1,2-DCE, with total VOC concentrations between 100 and 250 ppmv. The formation immediately above the groundwater table contains gas-phase TCE concentrations up to 6 ppmv, but much lower cis-1,2-DCE levels (generally less than 1 ppmv). In addition, the area at and immediately above the groundwater is contaminated with Freon 123a, with the highest concentrations, up to 20 ppmv, found at 105 and 109 ft. Freon123a is not detected above 74 ft. TCE and cis-1,2-DCE concentrations between 30 and 90 ft are generally at or below 1 ppmv and 0.5 ppmv, respectively. This distribution of VOCs suggests that a surface or near-surface source of TCE and cis-1,2-DCE is responsible for the shallow contamination, whereas a second source, likely the groundwater, is responsible for the deeper contamination, immediately above the water table. Liquid-phase VOC data, presented in a subsequent section, confirms the presence of contamination in groundwater.

Profiles of TCE gas-phase concentrations (10/97-5/99) in VZMS-A and VZMS-B are shown in Figs. 3.9 and 3.10, respectively. In the lower frame of each graph, the top 25 ft of the formation is highlighted to show temporal changes in the most contaminated part of the profile. In both profiles, the concentrations were consistently highest at 6 ft, the shallowest monitored depth. Temporal changes in the TCE and cis-1,2-DCE concentrations in the top 30 ft are shown

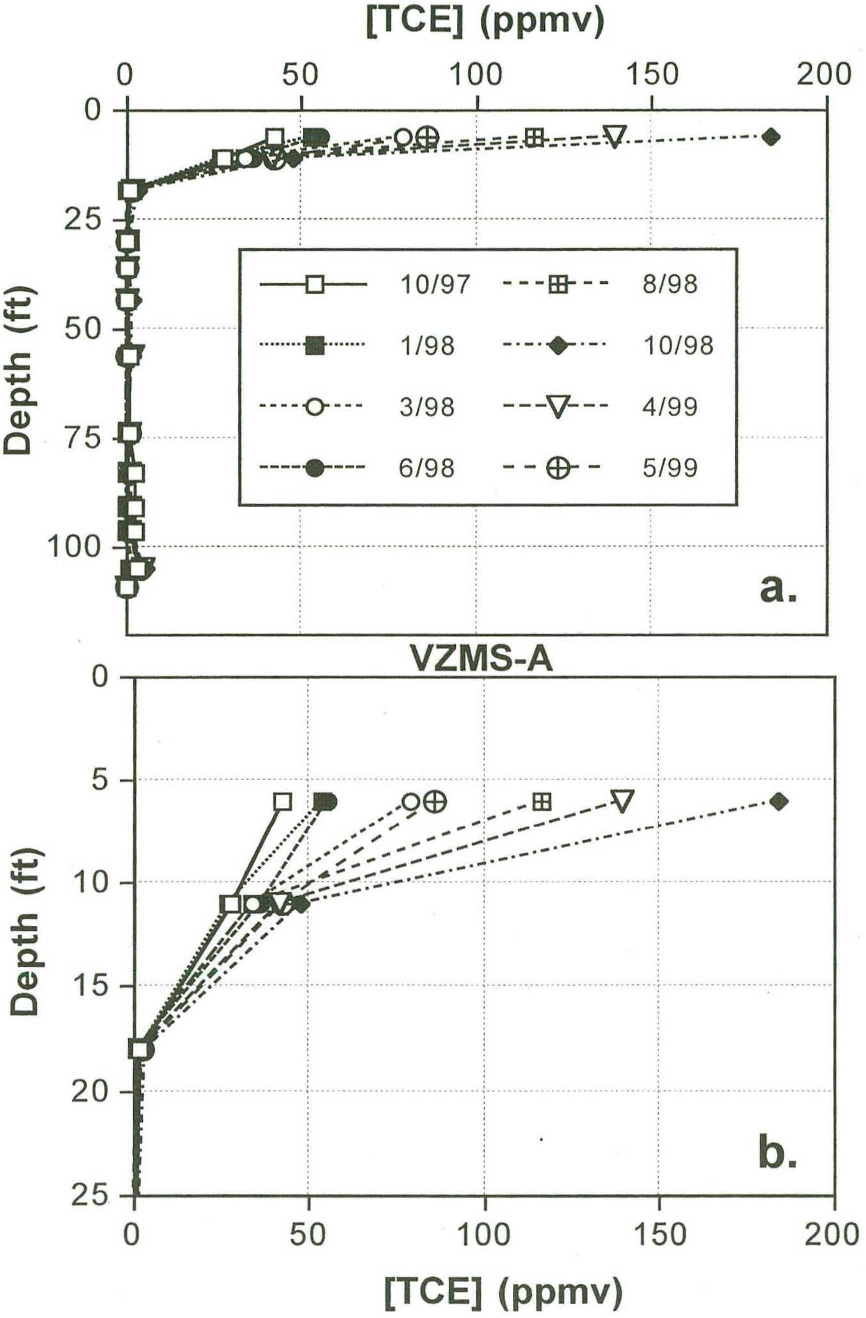


Figure 3.9. Gas-phase TCE concentrations in VZMS-A over the period 10/97 to 5/99.

in Figs. 3.11 and 3.12, respectively. The overall trend is one of net increase of both compounds at 6, 11, and 18 ft. At 30 ft, there are small temporal fluctuations, but no net change, except for a small increase in cis-1,2-DCE in VZMS-B. The most prominent changes in TCE are observed at 6 ft, where an initial steady increase over the first 10 months of monitoring is followed by a decrease in May of 1998. Concentrations then continue to increase until October 1998, and then decline through May of 1999. Given that monitoring was conducted over only a 24-month period, it is difficult to assign long-term trends to the data. However, TCE concentrations were lowest in May of each year (1997, 1998, and 1999). TCE levels at 11 ft also increased substantially and with less prominent temporal fluctuations. The TCE concentration in both VZMS-A and VZMS-B at 11 ft increased from less than 5 ppmv to approximately 40 ppmv during the 24-month period.

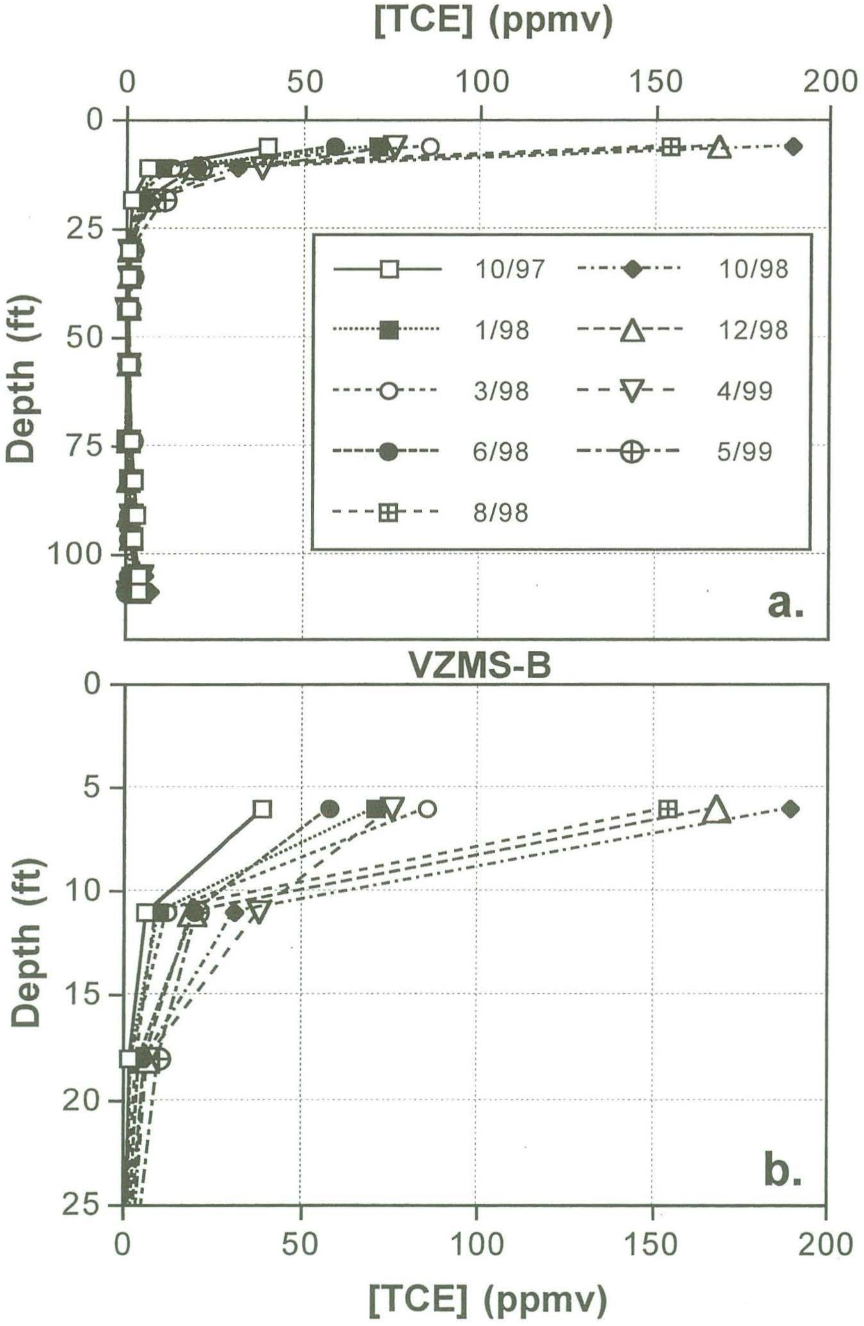


Figure 3.10. Gas-phase TCE concentrations in VZMS-B over the period 10/97 to 5/99.

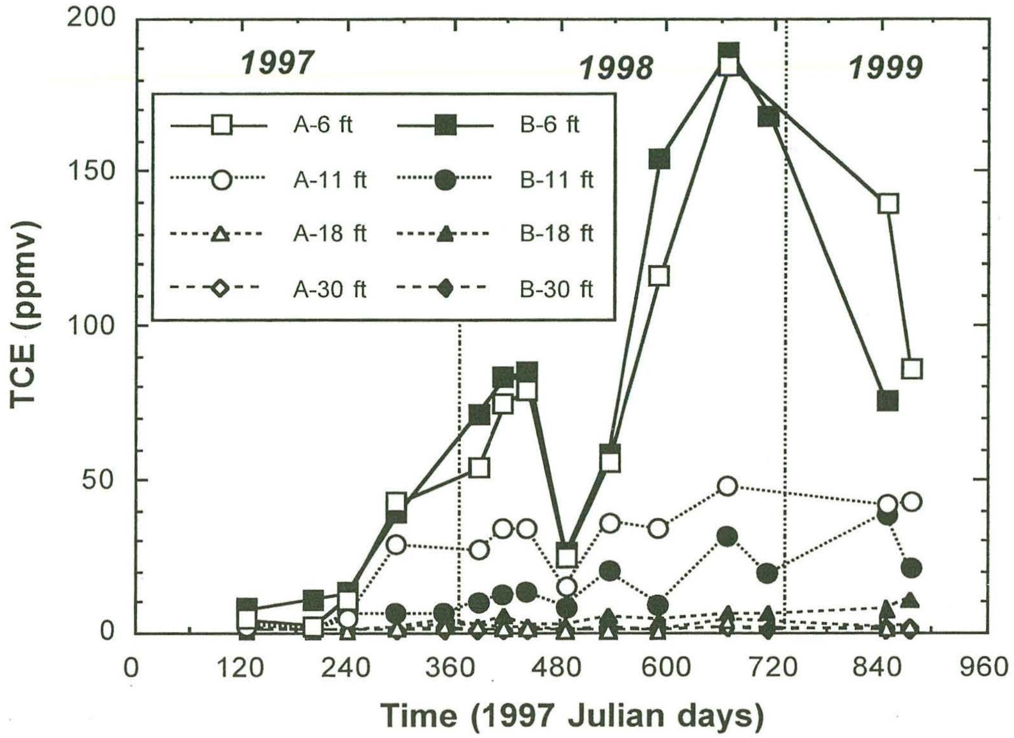


Figure 3.11. Gas-phase TCE concentrations in the top 30 ft in VZMS-A, and -B over the period 5/97 to 5/99.

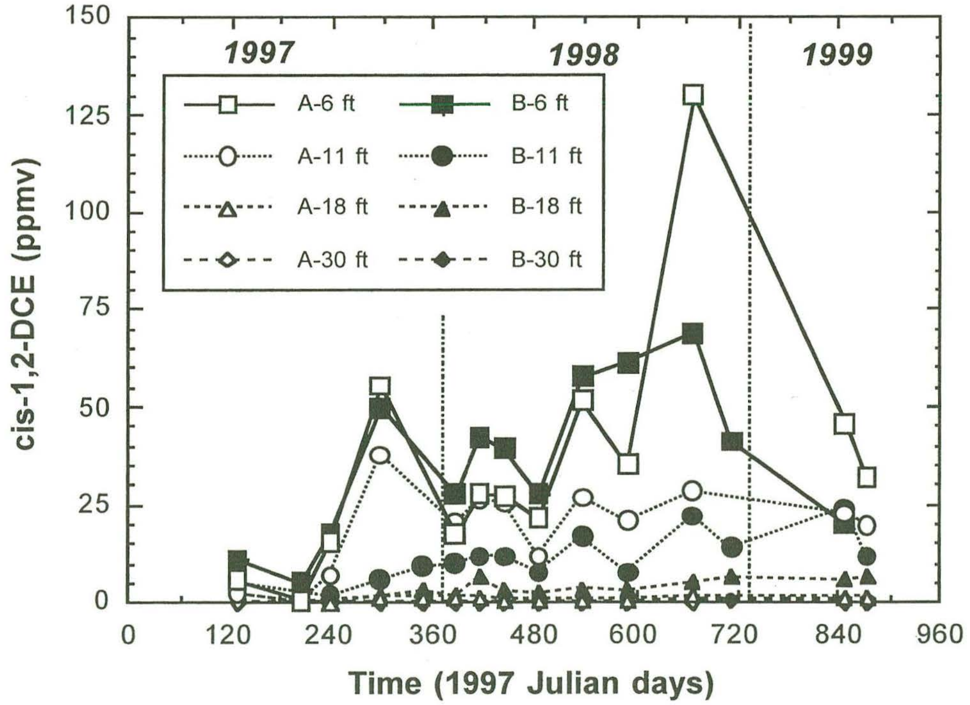


Figure 3.12. Gas-phase cis-1,2-DCE concentrations in the top 30 ft in VZMS-A, and -B over the period 5/97 to 5/99.

Trends in cis-1,2-DCE concentrations are also show a general increase, though the net increases are smaller, are subject to much greater temporal fluctuations, and do not always coincide with TCE trends. In particular, cis-1,2-DCE at the 6 ft depth varies substantially between October 1997 and mid-1998, when a more consistent increase is observed. The concentration in VZMS-A increased to a high of 130 ppmv in October 1998, while the concentration at the same depth in VZMS-B increased to only 70 ppmv. Subsequently, a decrease was observed in cis-1,2-DCE levels at 6 ft in both nests through May of 1999. Furthermore, the concentration in VZMS-B at 6 ft decreased to just slightly below the level found at 11 ft. At 11 ft in VZMS-A, cis-1,2-DCE increased primarily during mid-1997, with only moderate fluctuations through May of 1999. The trend at 11 ft in VZMS-B was one of a more steady increase, with a net change from around 5 ppmv to around 10 to 20 ppmv. Cis-1,2-DCE levels at 18 ft were not consistent. In VZMS-A, cis-1,2-DCE remained between 0.5 and 1.5 ppmv, while in VZMS-B they increased from around 2 ppmv to 6 ppmv over the 24-month period.

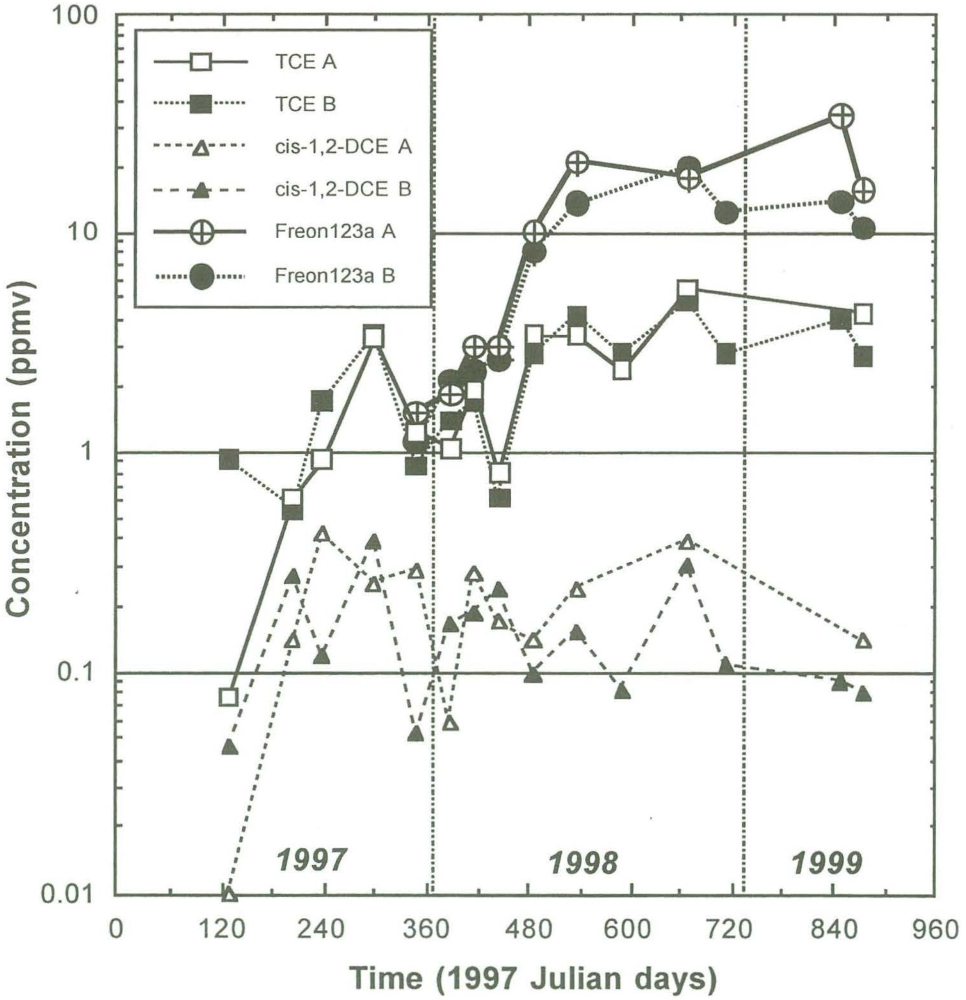


Figure 3.13. VOC concentrations at the 105-ft depth in both VZMS-A and -B, over the period 5/97 to 5/99. Note that Freon123a was not definitively identified and quantified until 12/97.

At depths of 105 and 109 ft, increases in TCE and Freon 123a, but not cis-1,2-DCE, concentrations were observed. A comparison of the three compounds at 105 ft is shown in Fig. 3.13. At depths above 105 ft, the TCE and Freon 123a concentrations fluctuated but no consistent trend was established. Freon 123a increases at 105 ft were particularly substantial, with a 10-fold increase between 12/97 and 5/99, though most of that increase occurred between 12/97 and 6/98. Due to its proximity to the water table, the formation at 109 ft was occasionally too wet to obtain a representative gas sample; these data are not presented.

3.5 LIQUID-PHASE CONTAMINANTS

The liquid-phase was sampled using two types of suction lysimeters. In VZMS-A and -B, pore water was sampled using two-chamber, stainless steel, lysimeters designed for use at depths greater than 7-8 m. In VZMS-C, PVC-body, ceramic-cup pressure-vacuum lysimeters were used. Pore water samples were extracted from VZMS-A and -B on 4/2/97, 5/7/97, 7/17/97, 10/23/97, 12/15/97, 1/21/98, 2/19/98, 3/20/98, 5/1/98, 6/19/98, 8/13/98, 10/30/98, 12/14/98, 1/27/99, 2/24/99, 3/31/99. Samples from VZMS-C were collected on 6/19/98, 8/13/98, 10/30/98, 12/14/98, 1/27/99, 2/24/99, 3/31/99, and 5/24/99. Due to the relative dryness of the formation, extracting water from levels deeper than 30 ft was largely impossible, except from levels close to the water table.

Although several compounds have been found to occur in the aqueous phase (LBNL, 1997a), TCE, cis-1,2-DCE, and Freon 123a are by far the dominant contaminants and only their distributions are presented in this report. All of the TCE data are shown in Figs. 3.14 and 3.15, for VZMS-A and VZMS-B, respectively. Due to one outlying point in VZMS-B, the concentration scale in Fig. 3.15 is different from Fig. 3.14. Also, Fig. 3.15 includes data from the 6-ft sampler, whereas the shallowest data in VZMS-A are from 11 ft. Overall, the TCE distribution in A and B is very similar and in qualitative agreement with gas-phase data (see Figs. 3.9 and 3.10). In previous work (LBNL, 1998a), quantitative agreement between gas-phase and liquid-phase data via the Henry's Law constant was demonstrated on the basis of selected data sets. High TCE concentrations in the top 11 ft of the sediment profile, low to non-detectable values between 25 and 90 ft and moderate values below 100 ft are found in both the liquid and gas phases. However, the peak in liquid-phase TCE and cis-1,2-DCE (Figs. 3.16 and 3.17) appears to occur at 11 ft, with lower concentrations at 6 ft (Fig. 3.15). This is in contrast with gas-phase data, which consistently show highest concentrations at the 6-ft depth.

The deepest pore-water samples, particularly in VZMS-A, are representative of groundwater concentrations, and fluctuate around a mean of 50 ppb. This groundwater TCE plume is likely from a source other than the near-surface TCE contamination. The presence of two distinct plumes is supported by non-detectable to very low cis-1,2-DCE concentrations in groundwater (Fig. 3.16).

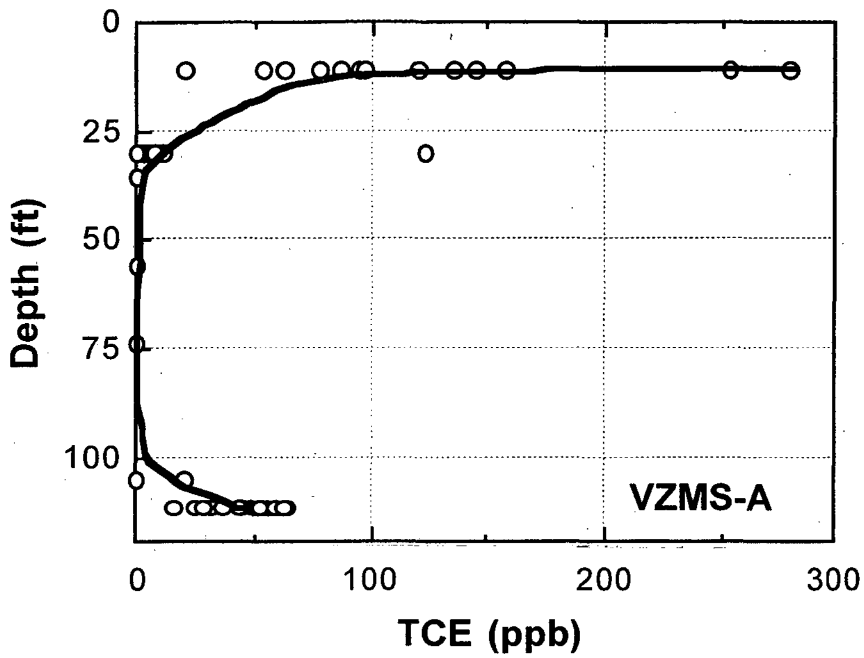


Figure 3.14. Liquid-phase TCE concentrations in VZMS-A, sampled over the period 4/97 to 3/99.

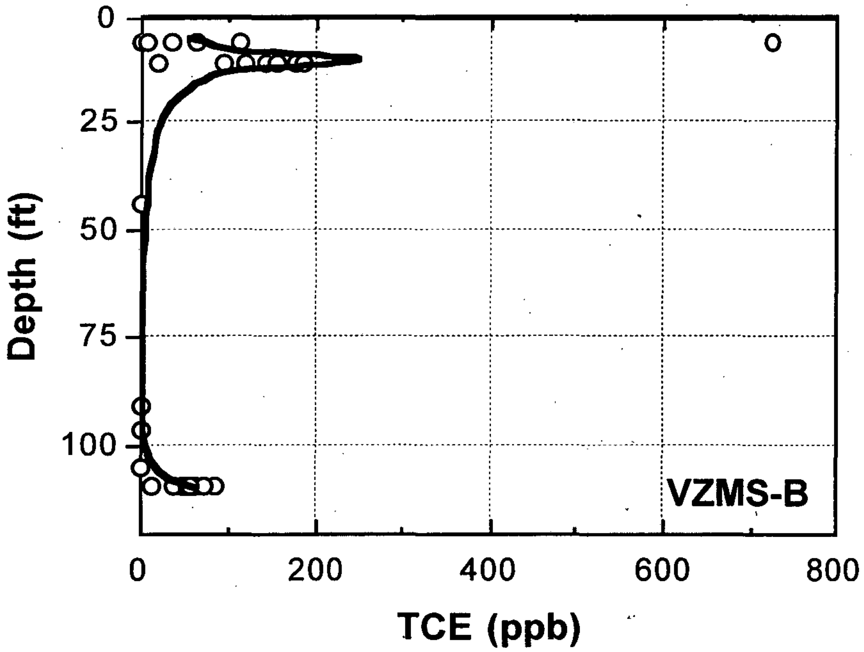


Figure 3.15. Liquid-phase TCE concentrations in VZMS-B, sampled from 4/97 to 3/99.

Temporal changes in TCE concentrations in the top 30 ft are shown in Fig. 3.18. The time trends in the liquid phase are in good qualitative agreement with the gas phase (Fig. 3.11) until the middle of 1998. Subsequently, gas-phase TCE concentrations increase, whereas liquid-phase concentrations largely remain unchanged. The reason for this difference is unclear, though perhaps some of it may be a function of the much greater spatial density of gas-phase data, compared with liquid-phase data. It is possible that a more complete liquid-phase data set would explain this discrepancy.

Data from the lysimeter nest VZMS-C are shown in Figs. 3.19-22. This nest is located approximately 5 ft from VZMS-A and -B (See Fig. 1.1). TCE concentrations (Fig. 3.19) are somewhat higher than in VZMS-A and -B (see Figs. 3.14 and 3.15), suggesting that this location may be more proximate to the center of the contaminated area. The peak of TCE concentrations occurs at a depth of 7 ft, with lower concentrations both above and below this depth. This suggests that the center of the TCE plume has migrated a few feet below ground surface, or that the original spill occurred below grade. The location of this peak is 4 ft below the older concrete pad at 3 ft. Concentrations drop off significantly below 11 ft. While large temporal fluctuations are observed at the 3, 5, 7, and 11 ft depths, concentrations at 15, 19, and 23 ft are much more stable. A similar distribution is seen in cis-1,2-DCE (Fig. 3.20), except that the peak at 7 ft is more pronounced and the concentrations at 3 and 5 ft are relatively lower than those of TCE. Temporal changes in TCE and cis-1,2-DCE concentrations in the VZMS-C nest are shown in Figs. 3.21 and 3.22, respectively. Since data were collected over a one-year period, it is difficult to determine seasonal effects. However, it appears that seasonal infiltration affects TCE concentrations at the 3-, 5-, and 7-ft depths. A large, but gradual increase was observed at 11 ft, which may also be due to TCE transport by infiltrating rainwater. The TCE concentrations at 15-23 ft showed a small gradual increase.

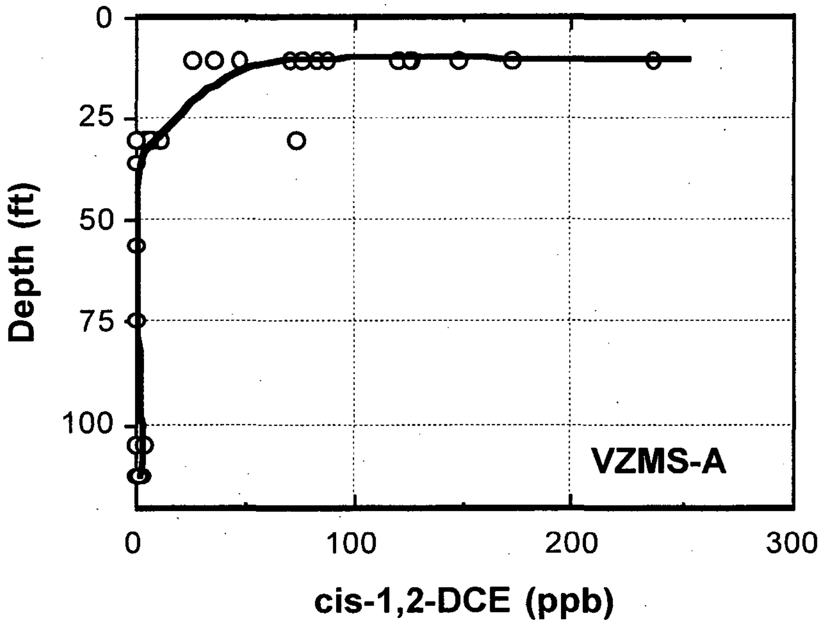


Figure 3.16. Liquid-phase cis-1,2-DCE concentrations in VZMS-A, sampled from 4/97 to 3/99.

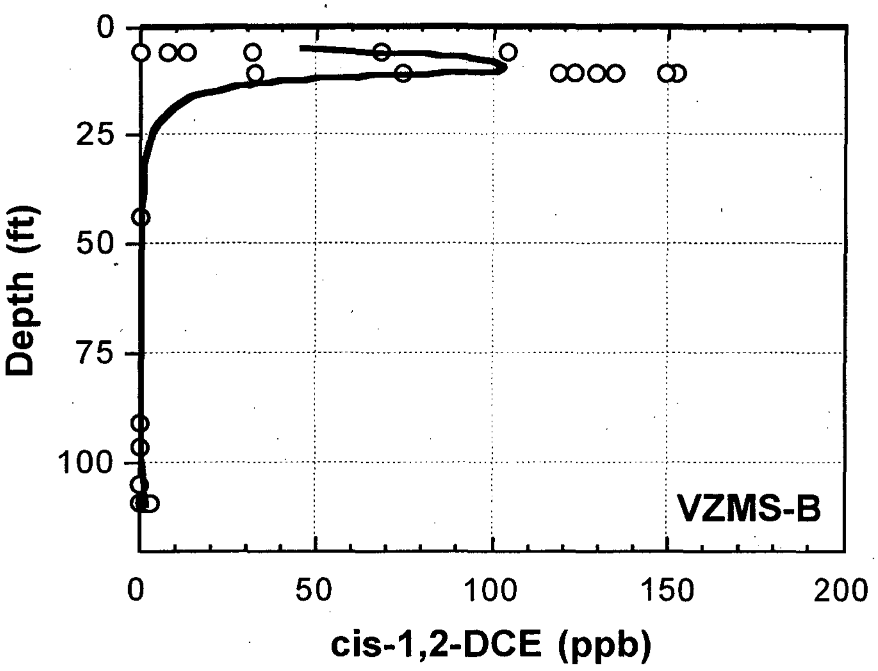


Figure 3.17. Liquid-phase cis-1,2-DCE concentrations in VZMS-B, sampled from 4/97 to 3/99.

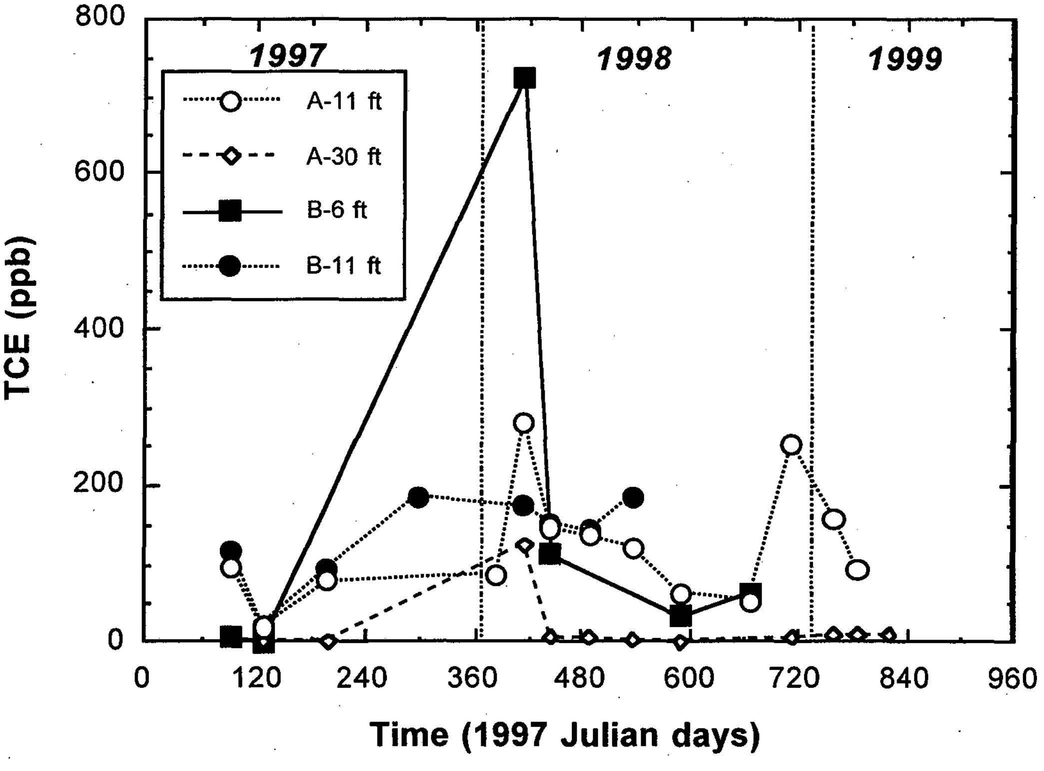


Figure 3.18. Liquid-phase TCE concentrations in the top 30 ft in VZMS-A, and -B over the period 5/97 to 5/99.

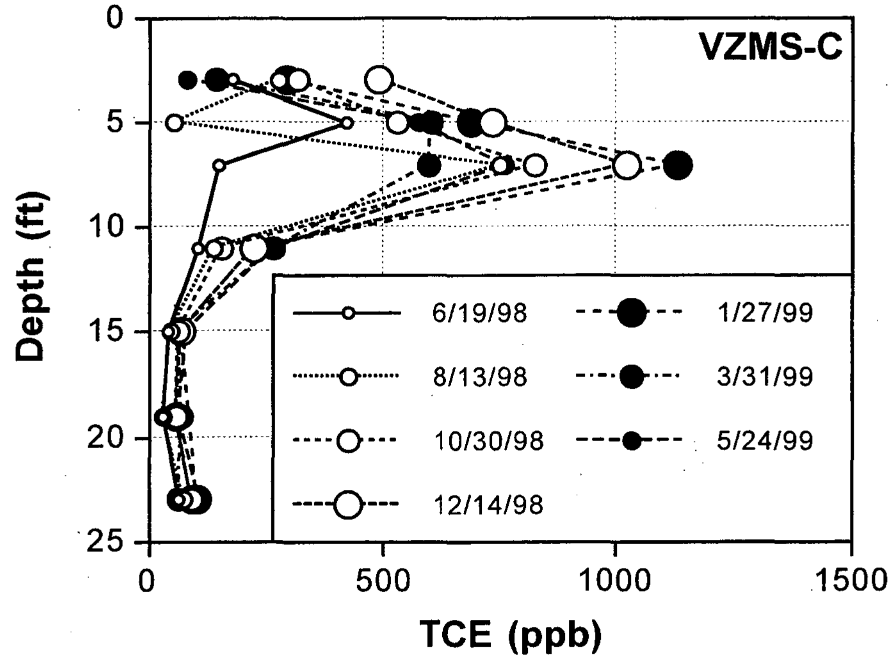


Figure 3.19. TCE concentrations in the liquid-phase in VZMS-C from 6/98 to 5/99.

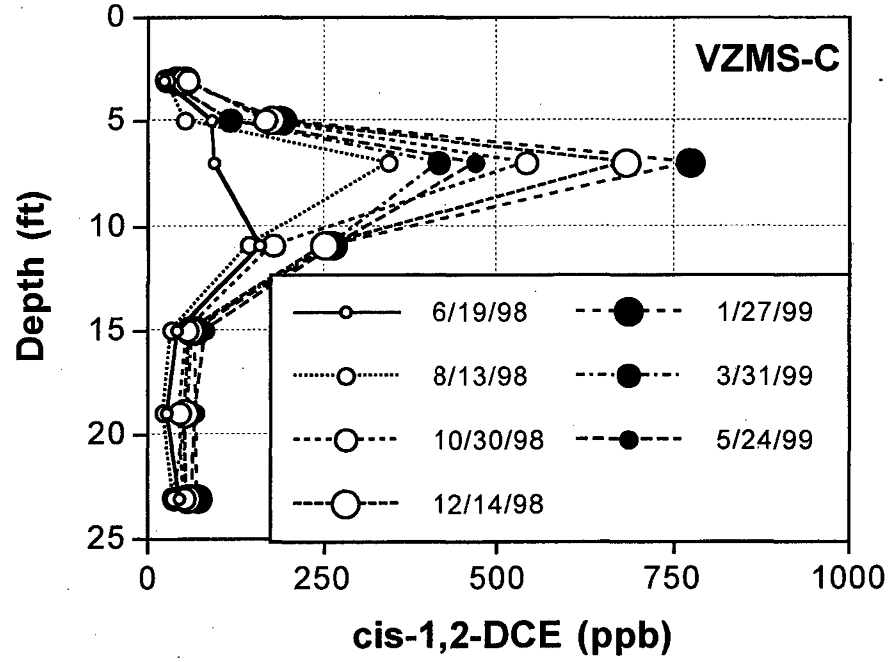


Figure 3.20. Cis-1,2-DCE concentrations in the liquid-phase in VZMS-C from 6/98 to 5/99.

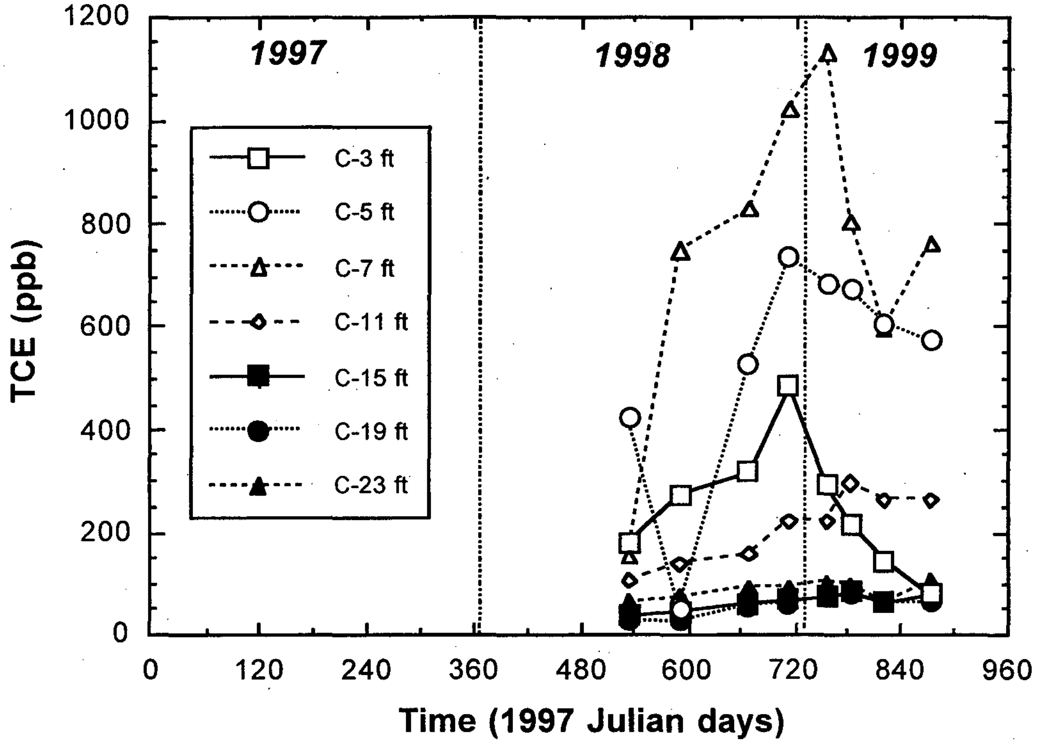


Figure 3.21. Liquid-phase TCE concentration in VZMS-C from 6/98 to 5/99.

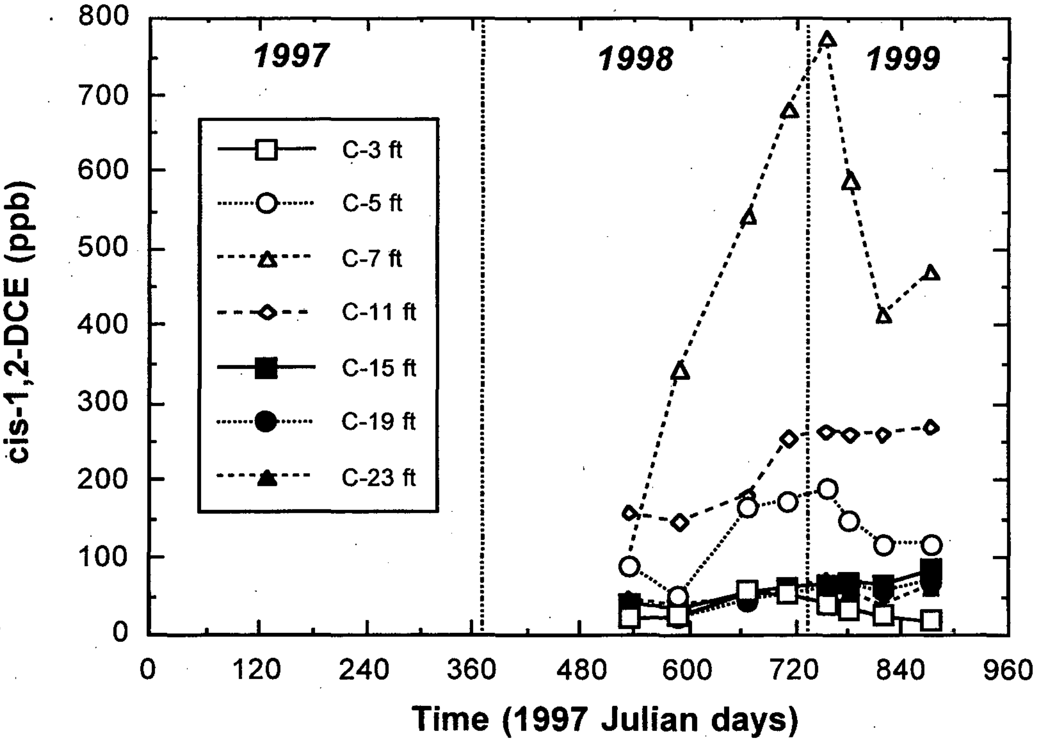


Figure 3.22. Liquid-phase cis-1,2-DCE concentration in VZMS-C from 6/98 to 5/99.

All of the VZMS-A, -B, and -C liquid-phase TCE data are plotted together in Fig. 3.23. The distribution is consistent and shows that there is a sharp concentration gradient, with an order of magnitude decrease in concentration below the depth of 11 ft and another decline below 25 ft. This sharp gradient is in agreement with the gradient in gas-phase TCE (Figs. 3.9 and 3.10).

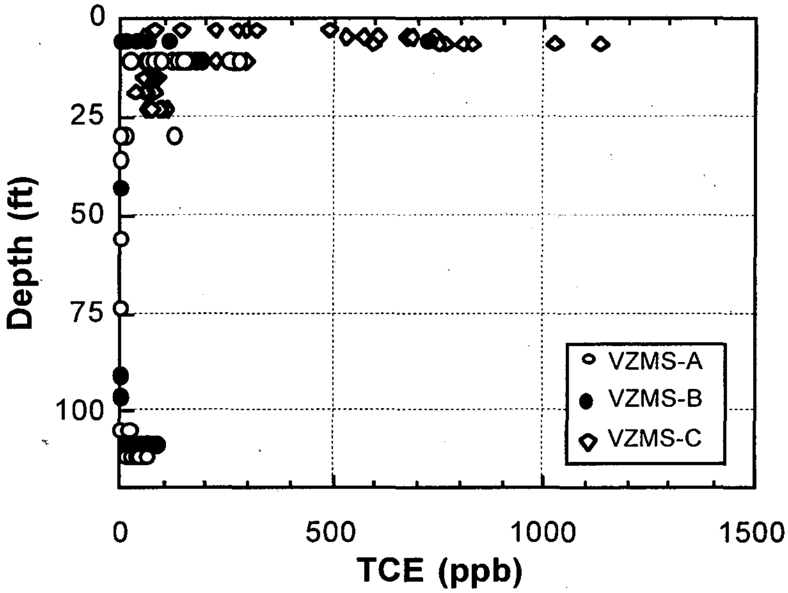


Figure 3.23. Liquid-phase TCE concentrations in VZMS-A, -B, and -C, sampled from 4/97 to 5/99.

Table 3.1. Freon 123a concentrations in pore water samples collected from specified depths.

Date	Freon 123a at 112 ft, VZMS-A (ppb)	Freon 123a at 109 ft, VZMS-B (ppb)
5/7/97	51	80
7/22/97	76	51
10/23/97	101	65
1/21/98	75	58
2/19/98	91	65
3/20/98	27	60
5/1/98	66	63
6/19/98	52	48
8/13/98	45	41
10/30/98	47	38
12/14/98	48	43
1/27/99	40	46
2/24/99	35	47
3/31/99	30	46

Freon 123a concentrations are shown in Table 3.1. Freon 123a has only been detected in pore water at depths of 112 ft and 109 ft in VZMS-A and -B, respectively. Samples were not always available from the next shallowest depth, 105 ft in each well, but it never contained Freon 123a above the quantification limit of 5 ppb. Freon 123a concentrations appear to be fairly stable in both wells, with a range of 40 to 100 ppb. There were no long-term changes in Freon 123a in the groundwater (as characterized by the 112-ft depth in VZMS-A). Increases in gas-phase Freon 123a (Fig. 3.13) suggest that the liquid and gas phases are not in equilibrium.

4 AIR-PERMEABILITY TESTING

In June of 1999, constant mass-flux air-permeability tests were conducted at site S-7. Tests were conducted using the VZMS soil gas monitoring probes as injection and observation locations (see Section 2.1.2.3 for details on soil gas probe construction). Although the gas probes were not originally designed for conducting permeability testing, the 0.25-in Teflon access tube connected to the 100-µm sintered porous metal sampling port allowed for a large enough injection flow rate for cross borehole responses to be measured using the surface-based Kavlico™ pressure transducers. Two distinct sets of tests were conducted: (1) low-flow single-hole tests were used to estimate local permeability at the injection point; and (2) high-flow cross-hole tests were used to estimate permeability between gas probes in the VZMS-A and –B boreholes 7.8 ft (2.4 m) apart. The acquired data sets provide field-scale estimates for the relative air-permeability of the formation underlying site S-7. The results are useful both in developing realistic predictive models as well as in the design and estimation of the effectiveness of vapor extraction remediation systems.

4.1 TEST DESIGN

Because the tests were conducted at low pressures, usually less than 0.5 atm injection pressure, they do not significantly mobilize water. The permeability that is measured is the relative permeability of the kinematically connected gas-filled pore space. At locations where liquid saturation is large, such as at the deepest gas probe locations, the relative air permeability will be small. Since the air-permeability tests influence a large three-dimensional volume of the formation (at least several meters for the high flow test), they tend to average out small scale heterogeneities with the air flowing preferentially through parts of the formation with higher relative permeability.

A schematic diagram of the test equipment is shown in Fig. 4.1. A portable air compressor was used to supply filtered air to a Sierra Instruments™, Model 840 Mass Flow Controller (MFC). A Hewlett-Packard™ power supply applied a set point voltage to the MFC. The flow rate output of the MFC was recorded by the same data acquisition system used to record the pressure transducer outputs. The controlled air stream from the MFC was connected to the gas sampling port and was carried to the test interval through the 0.25-in access tube. The low-flow tests were performed with injection flow rates of 1 standard liter per minute (SLPM) and 2 SLPM. The high-flow tests used injection rates that ranged from 60 SLPM at the shallowest depths to 30 SLPM for the deepest zones. The flow rate was decreased to limit the injection pressures to below the full-scale range of the pressure transducers, 30 psia.

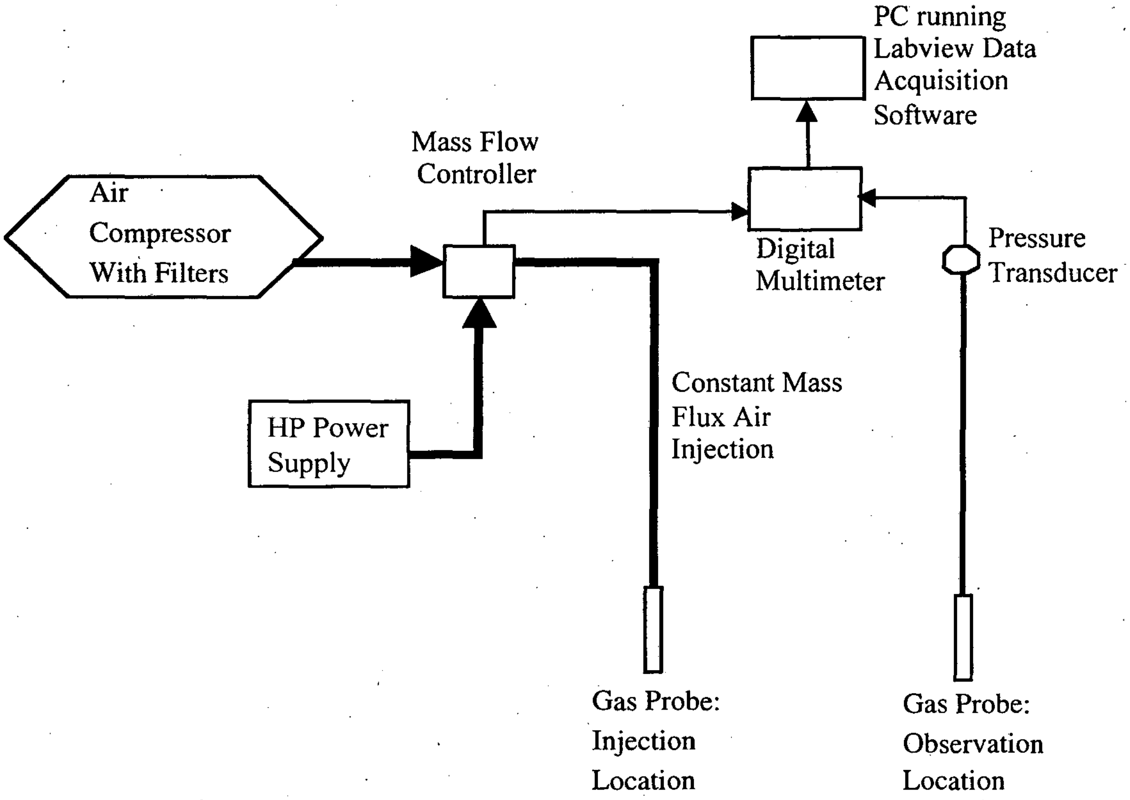


Figure 4.1. Schematic of equipment used for conducting constant mass flux air-permeability tests at site S-7.

4.2 TEST RESULTS AND INTERPRETATION

Figure 4.2 shows a set of pressure transients recorded during injection into VZMS-B-12, located at a depth of 11.2 ft (3.4 m). The pressure responses reach a steady-state value fairly quickly and do not decrease with time. This indicates that mobilization of water is insignificant. To interpret the data and obtain an estimate for relative gas permeability, k_{rg}, a steady-state model for spherical flow which relates permeability to the ratio between gas injection flow rate, Q, and the steady-state increase in pressure at the observation location has been applied.

$$k_{rg} = \frac{Q \mu P_i}{2 \pi r (P_r^2 - P_i^2)} \tag{4.1}$$

In Equation 4.1, P_r is the steady state pressure measured during injection and P_i is the initial pressure, both measured at the observation location. The distance between the injection and observation points is r and μ is gas viscosity. In this section, when we discuss permeability, we refer to the *gas phase relative permeability* of the formation.

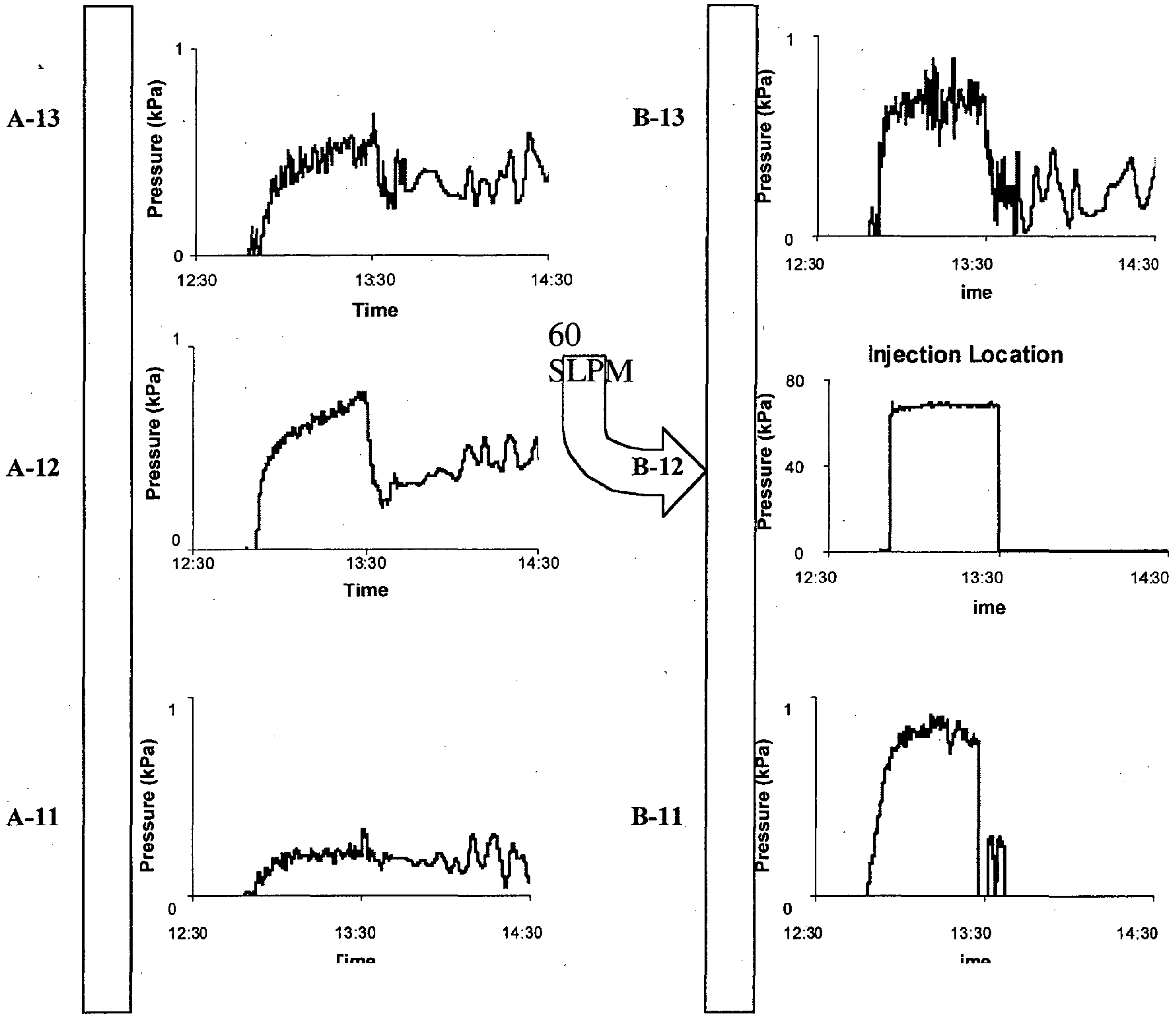


Figure 4.2. Constant 60 SLPM air injection test in VZMS-B-12 showing pressure transients recorded at 6 locations. Note the time scale is hrs:mins and ordinate on the B-12 pressure graph ranges from 0 to 80 kPa while the ordinate for the observation locations are from 0 to 1 kPa.

Table 4.1 shows permeability estimates for the high-flow tests which had observable pressure responses. Because of the weak signal at the observation borehole and a significant sensor noise level, there are many tests that had no quantifiable cross-hole response. Observing a null cross-hole response may indicate that the formation permeability is larger than what the equipment can measure, since with a large permeability the cross-hole pressure response will be small. It can also indicate that due to low permeability existing at the observation point and higher permeability elsewhere in the formation there is no pressure buildup at the observation point. Since neither of these two conditions can be determined definitively by the tests conducted, null cross-hole responses are not reported. The cross-hole pressure transients for the high-flow tests usually had the greatest magnitude when the observation point was at the same depth as the injection location. When a pressure transient is recorded above or below the injection location, but within the same borehole, this was considered a cross-depth response. Cross-depth responses are shown in Table 4.2. Below 44 ft (13.4 m) no cross-depth responses were obtained. This could be due to the more pronounced horizontal layering in the lithology, as is suggested by the particle size analyses (Table 2.2). Below the 44 ft depth there exist layers with a very large percentage of sand and a low percentage of silt, alternating with layers with high silt and a reduced sand fraction. This alternating lithology is more pronounced in VZMS-A. More heterogeneity in the vertical direction would tend to create a more horizontal flow field, limiting pressure buildup above or below the zone of injection.

Table 4.1. Crosshole air-permeability tests

VZMS-A Injections

Instrument Location	Depth (m)	Q (SLPM)	dP (kPa)	k (m^2)	Comments
13	1.8	40	0.35	1.13E-12	B-13 Response
12	3.4	40	0.42	9.45E-13	B-12 Response
11	5.5	40	0.26	1.53E-12	B-11 Response
10	9.1	40	0.08	4.97E-12	B-10 Response
9	11	40	0.04	9.95E-12	B-9 Response
8	13.4	40	0.15	2.65E-12	B-8 Response
7	17.1	40	0.06	6.63E-12	B-7 Response
6	22.6	30	0.05	5.97E-12	B-6 Response
5	25.3	30	0.04	4.96E-12	B-6 Response r=3.61

VZMS-B Injections *

Instrument Location	Depth (m)	Q (SLPM)	dP (kPa)	k (m^2)	Comments
13	1.8	60	0.7	8.50E-13	A-13 Response
12	3.4	60	0.5	1.19E-12	A-12 Response
11	5.5	40	0.25	1.59E-12	A-11 Response

* No crosshole responses noted at zones below VZMS A-11.

Table 4.2. Cross-depth air permeability tests.

Cross-depth responses within VZMS-A						
Injection Location	**Injection Depth (m)**	**Observed Depth (m)**	**Distance (m)**	**Q (SLPM)**	**dP (kPa)**	**k (m^2)**
13	1.8	3.4	1.6	40	0.5	1.19E-12
13	1.8	5.5	3.7	40	0.08	3.22E-12
12	3.4	1.8	1.6	40	0.34	1.75E-12
12	3.4	5.5	2.1	40	0.18	2.52E-12
11	5.5	9.1	3.6	40	0.12	2.21E-12
11	5.5	11	5.5	40	0.05	3.47E-12

All injection depths below 5.5 m have no discernable crosshole responses.

Cross-depth responses within VZMS-B						
Injection Location	**Injection Depth (m)**	**Observed Depth (m)**	**Distance (m)**	**Q (SLPM)**	**dP (kPa)**	**k (m^2)**
13	1.8	3.4	1.6	60	0.7	1.27E-12
12	3.4	1.8	1.6	60	0.32	2.79E-12
12	3.4	5.5	2.1	60	1	6.79E-13
11	5.5	3.4	2.1	40	0.3	1.51E-12
10	9.1	13.4	4.3	40	0.08	2.77E-12

The single-hole low-flow test analysis also relies upon Equation 4.1 and assumes spherical flow. Unlike the high flow tests, where Q represents the flow rate into the injection location and the pressure increase is observed at a location remote from the injection point, the single-hole tests use pressure measurements taken within the injection zone. The pressure measured at the surface represents the pressure that exists on the sandface of the augured borehole. This measured pressure fails to take into account the head losses due to the significant length of tubing required to reach the injection location.

To correct for the dynamic head losses within the 0.25 in Teflon tube which runs the length L between the pressure transducer and the injection location, the laminar flow head loss equation

$$h_{f,lam} = \frac{128\mu LQ}{\pi\rho g d^4} \tag{4.2}$$

is used (White, 1986). To verify that laminar flow exists at the injection rates used, 1 and 2 SLPM, the Reynolds number was computed. The Reynolds number represents the ratio between inertial forces and viscous forces and is found to be Re_d=250 and Re_d=500, respectively, for the two different flow rates. Since this is far below the transition from laminar to turbulent flow,

Re_d=2300, flow in the smooth Teflon tube is considered laminar and it is appropriate to use Equation 4.2.

Unlike the cross-hole tests, where the radius, r, is taken as the distance between the injection location and the observation point, r for the single borehole test is assumed to represent a hypothetical spherical source, where the injected gas enters the formation. In actuality, the gas probe is surrounded by sand in a cylindrically shaped volume that has a diameter of 12 in, the size of the augered borehole, and a length of 24 in. Since the sand packed volume is sealed with bentonite, the ends of the cylinder are not considered permeable. The sand backfill for the VZMS clusters has a grain size of approximately 1 mm which has a permeability two to three orders of magnitude greater than what is expected for site S-7 lithology. For the purposes of using the spherical source solution, Equation 4.1, we have assumed an equivalent spherical radius of 8.5 in, based upon an equivalent surface area to the cylindrical source.

Table 4.3 shows permeability estimates based on the application of Equation 4.1 to analyze the low-flow test data for both VZMS-A and -B. Figure 4.3 compares permeability as a function of depth for both the single-hole and cross-hole tests. The cross-hole tests indicate a permeability that is about an order of magnitude greater than the single-borehole estimates. Both the low-flow single-hole and high-flow cross-hole tests can be affected by formation heterogeneity. The presence of areas of significantly higher or lower permeability near the testing region may act as boundary conditions that will cause errors in the application of Equation 4.1, which assumes a homogeneous isotropic formation. It is assumed that the single borehole tests are dominated by conditions local to the injection point. A series of local measurements will yield a distribution of values for permeability, which for many formations is believed to follow a normal distribution (de Marsily, 1986). Larger scale tests will have a permeability that ranges between the harmonic mean and arithmetic mean of the local permeabilities if a statistically significant number of single-hole tests are performed.

Table 4.3. Low-flow single-hole air-permeability tests conducted at 1 SLPM.

Calculation Of Permeability using 1 SLPM Test (Assume r=21.6 cm)

Location	**Corrected dp (kPa)**	**k (m^2)**	**Location**	**Corrected dp (kPa)**	**k (m^2)**
A13	0.25	4.416E-13	B13	No Data	No Data
A12	0.18	6.136E-13	B12	0.15	7.364E-13
A11	0.44	2.507E-13	B11	0.28	3.943E-13
A10	0.26	4.246E-13	B10	0.22	5.019E-13
A9	0.94	1.171E-13	B9	0.33	3.344E-13
A8	0.28	3.943E-13	B8	0.17	6.497E-13
A7	0.29	3.807E-13	B7	0.18	6.136E-13
A6	0.82	1.343E-13	B6	0.24	4.601E-13
A5	0.41	2.691E-13	B5	0.21	5.259E-13
A4	0.39	2.829E-13	B4	0.22	5.019E-13
A3	0.26	4.246E-13	B3	0.24	4.601E-13
A2	No Data	No Data	B2	0.37	2.982E-13
A1	7.13	1.498E-14	B1	2.16	5.064E-14

The arithmetic mean permeability for the cross-hole tests conducted at site S-7 is 3.5×10^{-12} m^2. The harmonic mean permeability is 1.9×10^{-12} m^2. The cross-depth permeabilities which were obtained using responses at depths down to 44 ft have an arithmetic mean of 2.1×10^{-12} m^2 and a harmonic mean of 1.7×10^{-12} m^2. The single borehole permeability values were much lower with an arithmetic mean of 3.9×10^{-13} m^2 and a harmonic mean of 1.6×10^{-13} m^2.

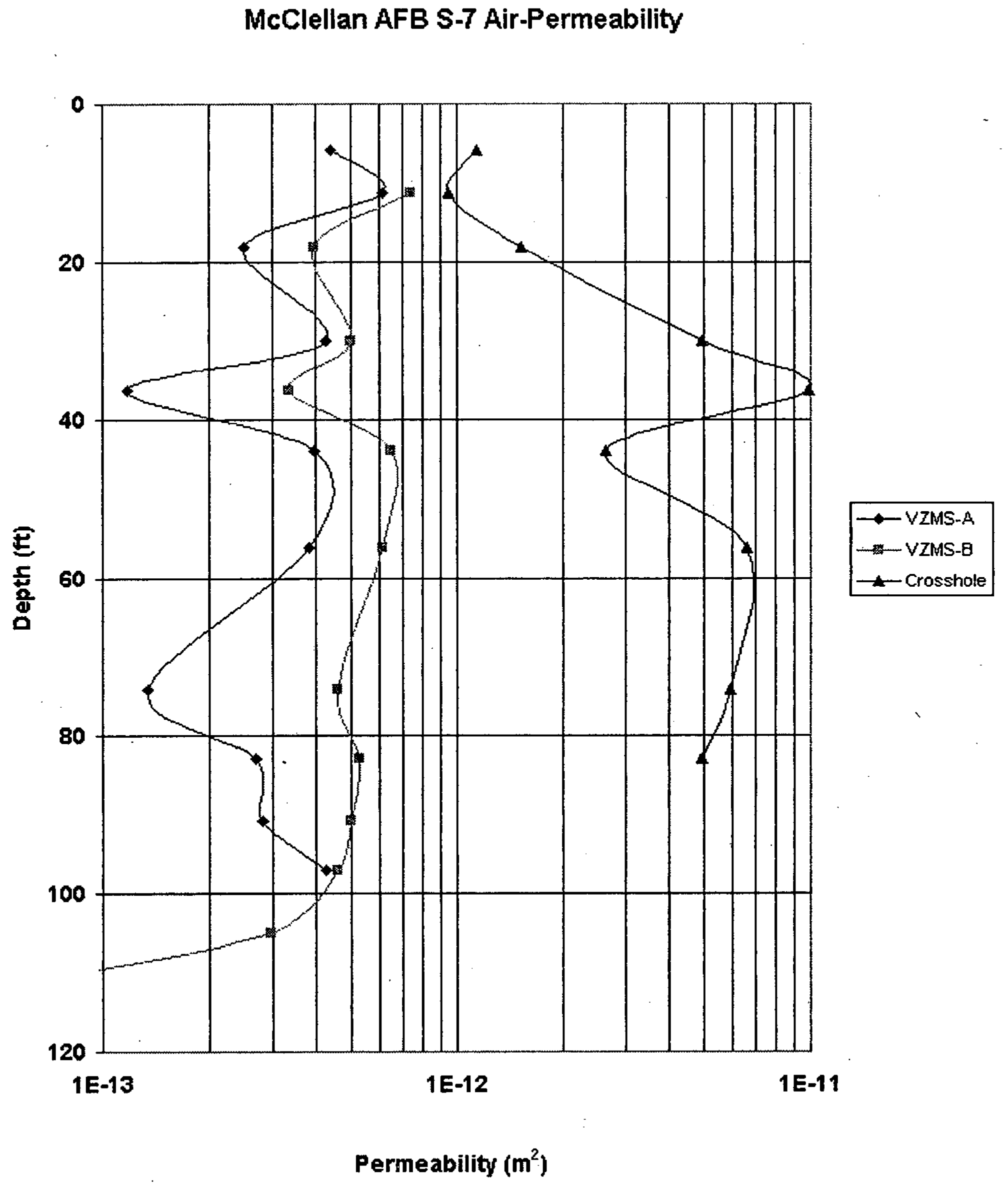


Figure 4.3. Air-permeability as a function of depth, as estimated from single-hole and cross-hole constant mass flux injection tests.

Contrary to expectation, the cross-hole tests do not have air-permeability values within the range of the harmonic and arithmetic means for the single-hole tests. One possible reason for the discrepancy in air-permeability values between the single-hole and cross-hole tests at site S-7 is potential error in the radius, *r*, assumed when Equation 4.1 is used to analyze the single-borehole tests. In the cross-hole test the values for *r* are know to reasonable accuracy, with the error being less than the diameter of the 12-in boring over a total injection-observation separation of 8 ft or more. For the single-hole tests we assume the radius at which the measured pressure occurs is on a sphere with equivalent surface area to the borehole sandface. The radius value assumes that there is negligible resistance in the sintered metal porous gas probe and in the sand backfill. If there exists significant resistance to flow due to the combination of backfill and the gas probe porous cup, then the measured pressure would represent the pressure at a smaller (possibly much smaller) radius sphere than assumed, leading to an erroneously small estimate for permeability.

4.3 CONCLUSIONS

It is believed that estimating the permeability using the data obtained with the cross-hole tests may be less subject to errors than the single-hole tests since no assumption is necessary about the radius *r* used in Equation 4.1 for analyzing the cross-hole test. Since when modeling contaminant transport or designing vapor extraction remediation systems we are motivated by field-scale processes, it is more appropriate to use the permeability values obtained through cross-hole tests for characterizing site S-7.

5 MODEL ANALYSIS

In this section, we discuss our modeling and data analysis for the VZMS at site S-7. Although some of the work presented here has been discussed in greater detail in earlier reports (LBNL 1998a, d, g), we also present new analyses. Work reported on in prior reports will be summarized; new work will be indicated by the absence of references to prior reports. In short, this section presents the methodology and application of enhanced data analysis that we have used to interpret 2.5 years of VZMS data. This methodology has led to the current understanding of the vadose zone at site S-7.

5.1 ENHANCED DATA ANALYSIS

Prior to presenting modeling analysis carried out for the VZMS at site S-7, we provide here a brief overview of the methodology. Broadly, the enhanced data analysis for VZMS data involves developing a conceptual model for the site, implementing the conceptual model into a numerical simulator, carrying out numerical simulation studies, and then iteratively updating the conceptual model. This iterative methodology is shown schematically in Fig. 5.1. The process starts with the collection of site data, for example from borehole drilling and well monitoring along with the broader knowledge developed over time at a site. Interpretations of these data provide the information necessary to develop an initial conceptual model. Next, the conceptual model is implemented into a numerical model, in this case the three-dimensional multiphase (gas, aqueous, NAPL) and multicomponent (air, water, VOC) integral finite difference simulator T2VOC (Falta et al., 1995; 1992a; 1992b). The processes and methods used in T2VOC were described in an appendix of an earlier report (LBNL, 1998d). The numerical model T2VOC requires the conceptual model to be defined by a computational domain with boundary and initial conditions, as well as physical properties such as porosity and permeability. Once implemented into T2VOC, we refer to the conceptual model as the T2VOC conceptual model. The T2VOC simulator can then be applied to carry out forward simulations to make predictions of moisture migration, pressure response, or the transport of VOCs, for example. One way of using these predictions is to compare them to the VZMS data that are collected over time. When deviations between observed and calculated results arise, the T2VOC conceptual model properties or boundary conditions can be adjusted to improve the predictions.

In the enhanced data analysis for the VZMS, we employ the inverse modeling code ITOUGH2 (Finsterle, 1997) which can automatically adjust property values until differences between observed and calculated values are minimized. The methods used in ITOUGH2 were described in an appendix in an earlier report (LBNL, 1998d). As shown in Fig. 5.1, the simulation predictions can be used alone for remediation design or risk analysis, or compared with observations from the VZMS. The iterative updating based on agreement between predictions and VZMS data results in a T2VOC conceptual model that is based on all relevant data. We emphasize that the T2VOC conceptual model is an averaged model that is based on information from many sources and will generally not exactly match data from every source in every respect.

The resulting T2VOC conceptual model is used in the enhanced data analysis to quantify interpretations, test hypotheses, and perform uncertainty and sensitivity analyses. Specifically, we can perform numerical experiments to quantify and test the causes of trends observed in the data. Similarly, we can perform sensitivity analyses to determine which properties of the system most strongly influence system behavior. This information can lead to more efficient site characterization that is focused on obtaining values of the most important properties of the system. Simulation results from the T2VOC conceptual model can also be used to predict ranges of possible contaminant fluxes given the inherent uncertainty in the many subsurface property values. Finally, the results of our enhanced data analysis can be compared to prior or new modeling results obtained with other, possibly simpler, numerical models. Credibility will be given to these simpler models if they produce results consistent with VZMS data and T2VOC simulation results.

As discussed above, the bulk of enhanced data analysis is numerical simulation studies, which comprise the whole set of T2VOC forward calculations as well as the ITOUGH2 inverse, sensitivity, and uncertainty calculations. As we will show in the applications below, there is a tight coupling between VZMS data and the enhanced data analysis.

5.2 CONCEPTUAL MODEL DEVELOPMENT

5.2.1 Hydrostratigraphy

The subsurface at site S-7 consists of a thick section of dry to moist alluvial and fluvial sediments variably contaminated by VOCs. The sediments consist of interbedded, poorly-graded sand and silt layers with thin and sparse gravel and clay layers. The water table is located at a depth of approximately 110 ft. Hydrostratigraphic site-specific data include lithologic logs collected during drilling, physical parameter and particle size analysis of split-spoon samples, moisture retention, porosity, and permeability measured from core samples, as well as neutron probe measurements of sediment moisture content at depth (LBNL, 1996). Because the data collected at site S-7 come from several different boreholes, we developed a spatially averaged model that is representative of the site in an average sense. This representative model must be broadly consistent with each borehole, but may not necessarily coincide with any one borehole in particular. The objective is to develop a conceptual model that is representative of the site S-7 subsurface in general, so that data collected at all of the various VZMS boreholes can be used as constraints on the representative model. Recognizing that the primary interest at site S-7 is on vertical VOC transport, we chose to develop a one-dimensional (1-D) model that is a plausible spatial average of the area encompassed by VZMS boreholes.

The spatially averaged, one-dimensional site S-7 representative model has been developed using data collected over the course of the project including lithologic logs, particle size analyses, laboratory-measured values of porosity, absolute permeability, and van Genuchten capillary pressure function parameters, and matric potential data from VZMS-C tensiometers. The development of the site S-7 representative model began with the development of a spatially averaged lithologic log. By visually comparing the four lithologic logs (VZMS-A, B, C and Well 1), we observed the general spatial trends and the salient features representing the overall sequence of sediment types. We collected samples of nine distinct sediment types during drilling of VZMS-C. These samples were analyzed by Daniel B. Stephens and Associates (DBS&A) for permeability and van Genuchten capillary pressure function parameters. In the selection of this number of samples, it was thought that all relevant sediment types present in the subsurface at site S-7 would be characterized. Correspondingly, nine sediment types, one for each analyzed sample, were defined and then distributed throughout the spatially averaged, site S-7 representative model. Figure 5.2 illustrates the resulting site S-7 representative model with the lithologic log shown on the left-hand side and the hydrogeologic parameters measured by DBS&A on the right-hand side. Hydrogeologic parameters include absolute permeability, and van Genuchten capillary pressure curve parameters of air entry pressure $1/\alpha$, n, and residual liquid saturation S_r. Because no site data existed for the layers of concrete, an additional sediment type with low permeability was prescribed for the T2VOC simulations. Development of this conceptual model is described in more detail in an earlier report (LBNL, 1998g).

5.2.2 T2VOC Conceptual Model Validation

The site S-7 representative model must be implemented into a T2VOC conceptual model for enhanced data analysis. Because we assume that the predominant direction of flow and transport is vertical, a one-dimensional vertical model domain is used for many of our simulations. We define the physical domain as a one-dimensional sediment column bounded above by atmospheric pressure and below by the water table. The 110 ft column is discretized into over 200 six-inch gridblocks (0.152 m). The atmospheric pressure boundary is variable through time and mimics the atmospheric pressure data recorded from on-site pressure transducers.

A steady-state moisture profile within the column was created by saturating the T2VOC conceptual model and allowing the liquid phase to redistribute itself by gravity and capillary forces. We present in Fig. 5.3 comparisons of neutron probe data from NP-B of moisture content with simulations for three different percolation rates. Very good agreement is observed for all three percolation rates in the lower part of the section, while in the upper part the higher percolation rates appear to match the data better. It is important to note that the T2VOC conceptual model is intended to be an abstraction of the actual system and is based on data from several boreholes. Therefore, we do not require the T2VOC conceptual model to exactly match data from any one source. Furthermore, in the depositional setting of the S-7 subsurface, differences in sediment type can occur over short distances in the vertical and horizontal directions. Nevertheless, the good qualitative agreement between the moisture content as measured by neutron probe in NP-B and simulated for the T2VOC conceptual model provides significant validation of the conceptual model. Steady-state moisture profiles are used as initial conditions for many of the subsequent applications presented in this section. With confidence in the hydrostratigraphic description of the subsurface at site S-7, the T2VOC conceptual model can be used to model system behavior as observed by the VZMS.

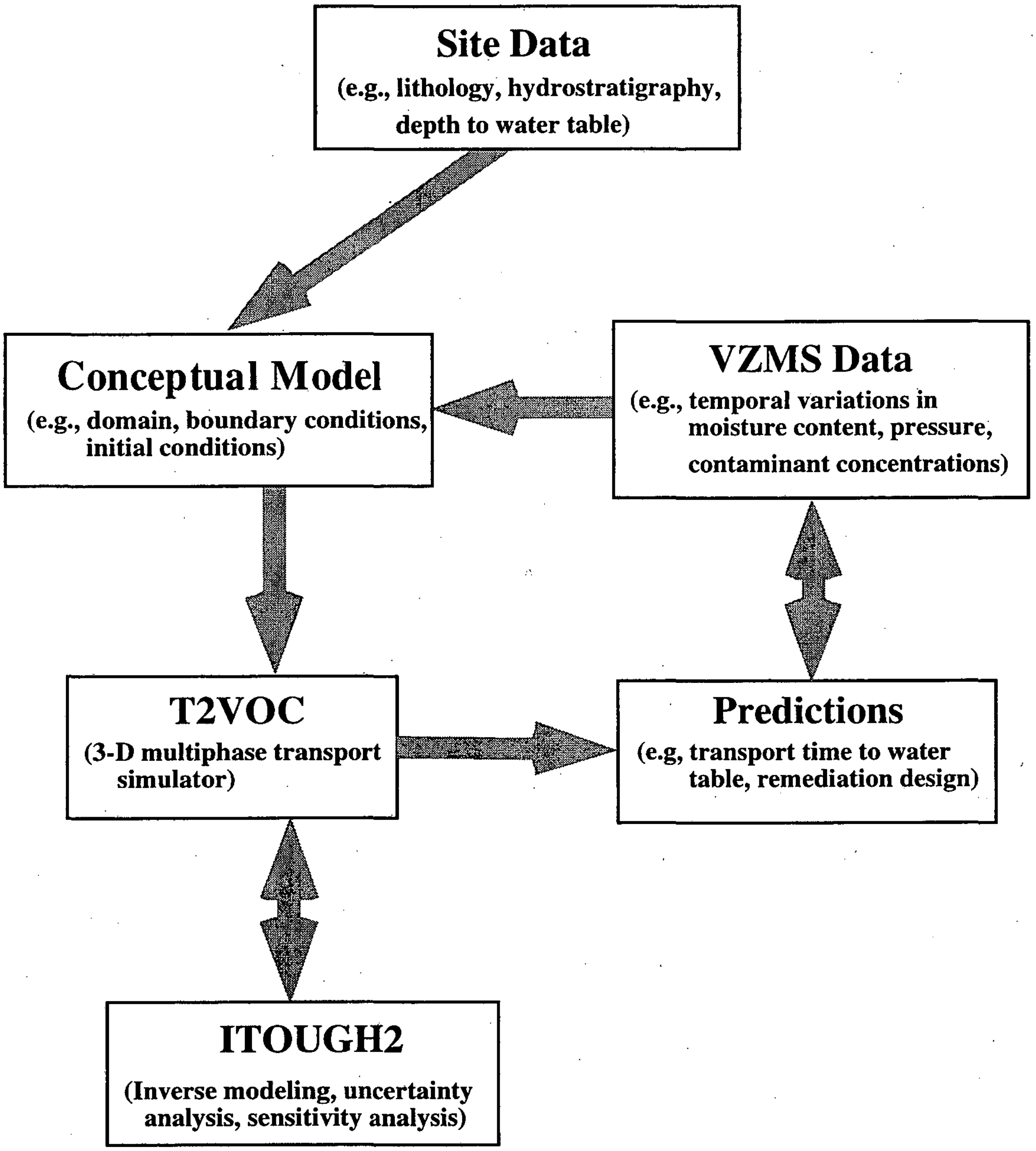
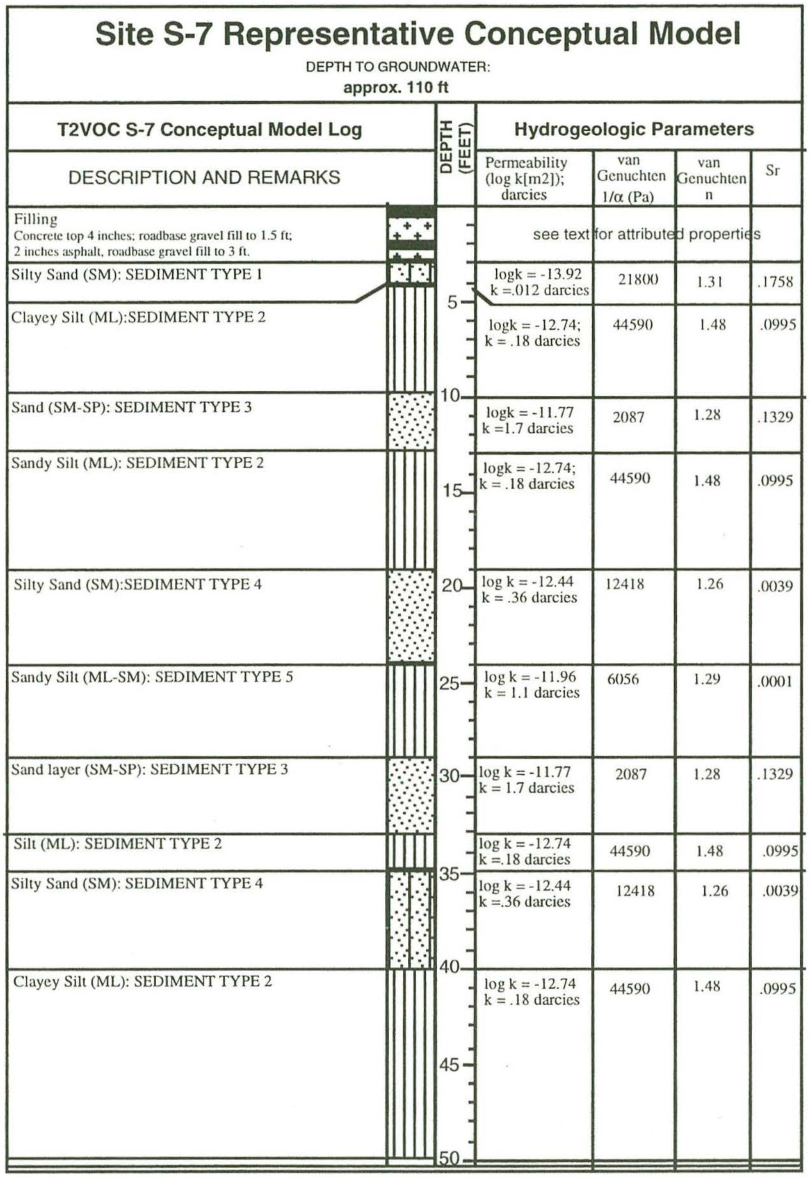


Figure 5.1. Schematic of the enhanced data analysis iterative loop.

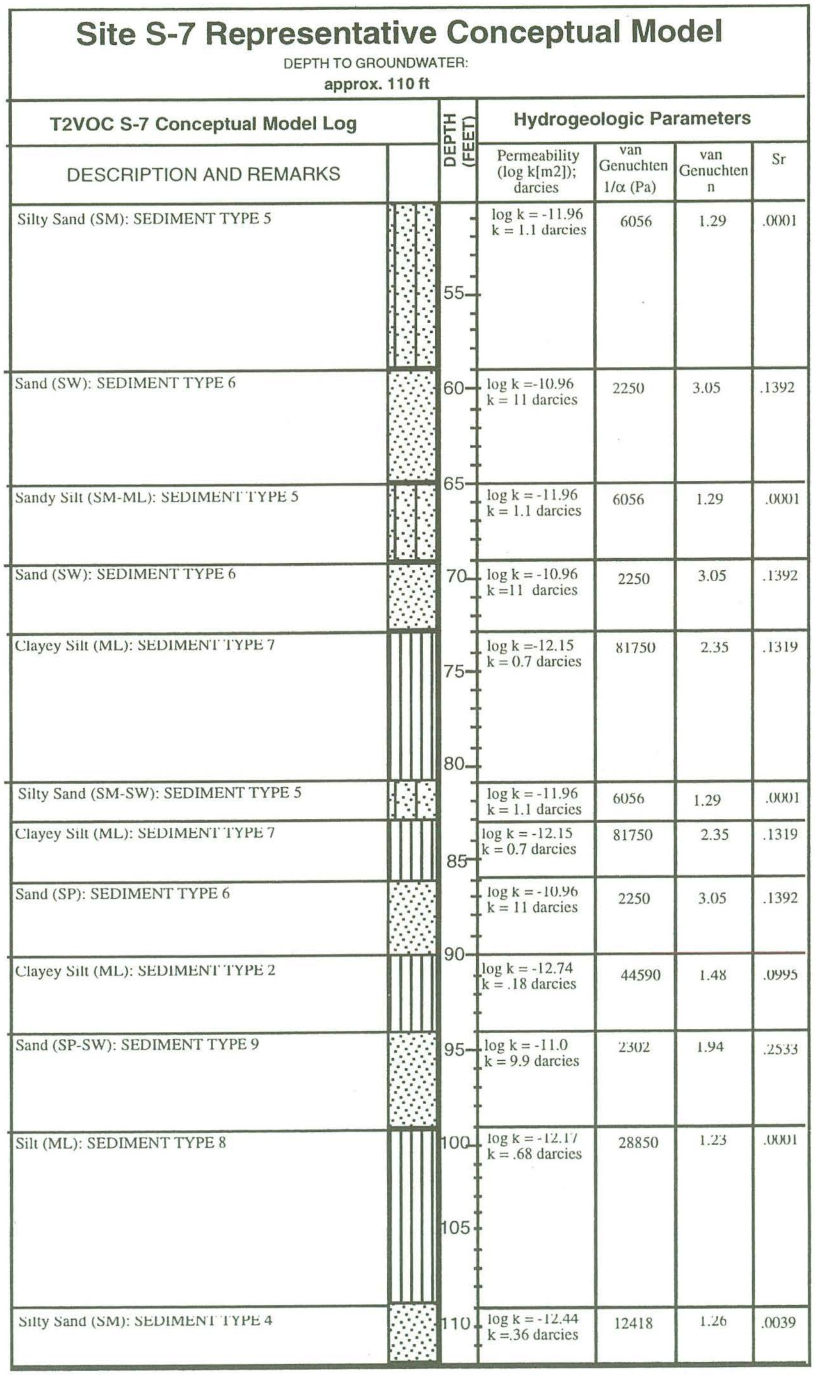


Site S-7 Representative Conceptual Model

DEPTH TO GROUNDWATER:
approx. 110 ft

T2VOC S-7 Conceptual Model Log	Hydrogeologic Parameters			
DESCRIPTION AND REMARKS	Permeability (log k[m2]); darcies	van Genuchten 1/α (Pa)	van Genuchten n	Sr
Filling Concrete top 4 inches; roadbase gravel fill to 1.5 ft; 2 inches asphalt, roadbase gravel fill to 3 ft.	see text for attributed properties			
Silty Sand (SM): SEDIMENT TYPE 1	logk = -13.92 k =.012 darcies	21800	1.31	.1758
Clayey Silt (ML):SEDIMENT TYPE 2	logk = -12.74; k = .18 darcies	44590	1.48	.0995
Sand (SM-SP): SEDIMENT TYPE 3	logk = -11.77 k =1.7 darcies	2087	1.28	.1329
Sandy Silt (ML): SEDIMENT TYPE 2	logk = -12.74; k = .18 darcies	44590	1.48	.0995
Silty Sand (SM):SEDIMENT TYPE 4	log k = -12.44 k = .36 darcies	12418	1.26	.0039
Sandy Silt (ML-SM): SEDIMENT TYPE 5	log k = -11.96 k = 1.1 darcies	6056	1.29	.0001
Sand layer (SM-SP): SEDIMENT TYPE 3	log k = -11.77 k = 1.7 darcies	2087	1.28	.1329
Silt (ML): SEDIMENT TYPE 2	log k = -12.74 k =.18 darcies	44590	1.48	.0995
Silty Sand (SM): SEDIMENT TYPE 4	log k = -12.44 k =.36 darcies	12418	1.26	.0039
Clayey Silt (ML): SEDIMENT TYPE 2	log k = -12.74 k = .18 darcies	44590	1.48	.0995

Figure 5.2. Site S-7 representative lithologic log.



Site S-7 Representative Conceptual Model

DEPTH TO GROUNDWATER:
approx. 110 ft

T2VOC S-7 Conceptual Model Log	Hydrogeologic Parameters			
DESCRIPTION AND REMARKS	Permeability (log k[m2]); darcies	van Genuchten 1/α (Pa)	van Genuchten n	Sr
Silty Sand (SM): SEDIMENT TYPE 5	log k = -11.96 k = 1.1 darcies	6056	1.29	.0001
Sand (SW): SEDIMENT TYPE 6	log k =-10.96 k = 11 darcies	2250	3.05	.1392
Sandy Silt (SM-ML): SEDIMENT TYPE 5	log k = -11.96 k = 1.1 darcies	6056	1.29	.0001
Sand (SW): SEDIMENT TYPE 6	log k = -10.96 k =11 darcies	2250	3.05	.1392
Clayey Silt (ML): SEDIMENT TYPE 7	log k =-12.15 k = 0.7 darcies	81750	2.35	.1319
Silty Sand (SM-SW): SEDIMENT TYPE 5	log k = -11.96 k = 1.1 darcies	6056	1.29	.0001
Clayey Silt (ML): SEDIMENT TYPE 7	log k = -12.15 k = 0.7 darcies	81750	2.35	.1319
Sand (SP): SEDIMENT TYPE 6	log k = -10.96 k = 11 darcies	2250	3.05	.1392
Clayey Silt (ML): SEDIMENT TYPE 2	log k = -12.74 k = .18 darcies	44590	1.48	.0995
Sand (SP-SW): SEDIMENT TYPE 9	log k = -11.0 k = 9.9 darcies	2302	1.94	.2533
Silt (ML): SEDIMENT TYPE 8	log k = -12.17 k = .68 darcies	28850	1.23	.0001
Silty Sand (SM): SEDIMENT TYPE 4	log k = -12.44 k =.36 darcies	12418	1.26	.0039

Figure 5.2 continued. Site S-7 representative lithologic log.

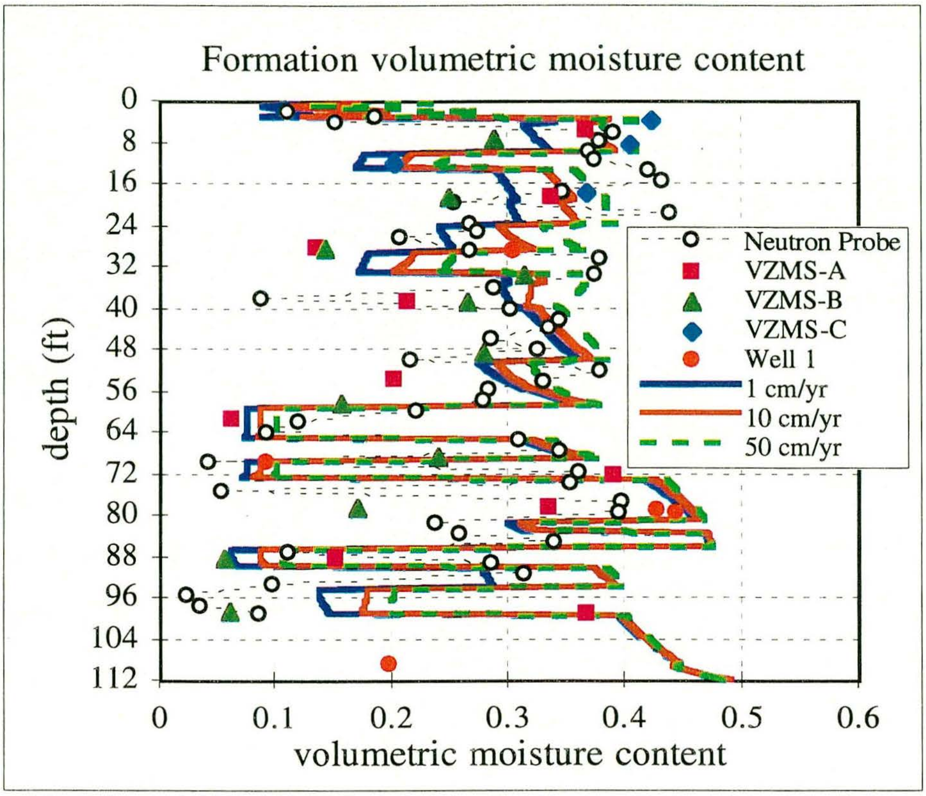


Figure 5.3. Observed formation volumetric moisture content and simulated 1-D moisture profiles using percolation rates of 1, 10 and 50 cm yr^{-1}.

5.3 NUMERICAL MODELING

The numerical modeling studies start with the T2VOC conceptual model described above. Before we use the model to simulate the transport of VOC, we analyze transient temperature and gas pressure data collected from the VZMS boreholes. By matching the responses to surface temperature and atmospheric pressure changes at various depths in the VZMS wells, we infer average properties over the scale of the borehole monitoring locations (typically 10s of feet), rather than on the scale of core samples (typically a few inches). Because the contamination problems at McClellan AFB generally occur at the larger scale, it is desirable to incorporate these larger-scale properties into the T2VOC conceptual model. Additionally, comparing properties at different scales provides valuable insights into the heterogeneity structure of the subsurface.

5.3.1 Temperature Modeling

5.3.1.1 Observed Temperature Variation

The VZMS has been collecting continuous temperature data from 13 levels in two boreholes at site S-7 for two years. In this section, these data are used along with enhanced data analysis and McClellan AFB air-temperature data to examine heat transfer processes in the

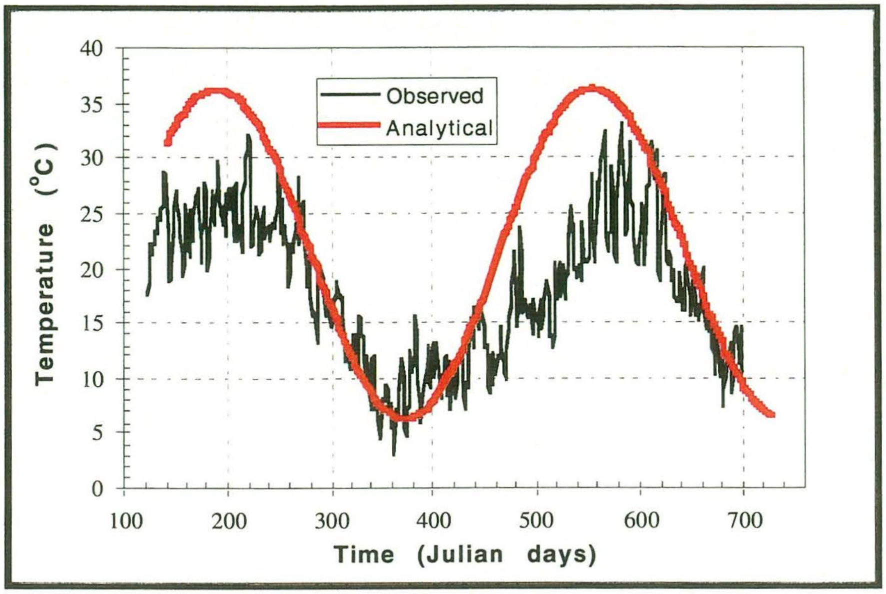


Figure 5.4. Comparison of observed air temperature with sinusoidal ground surface temperature obtained by fitting analytical solution to subsurface temperatures, as shown in Fig. 5.5.

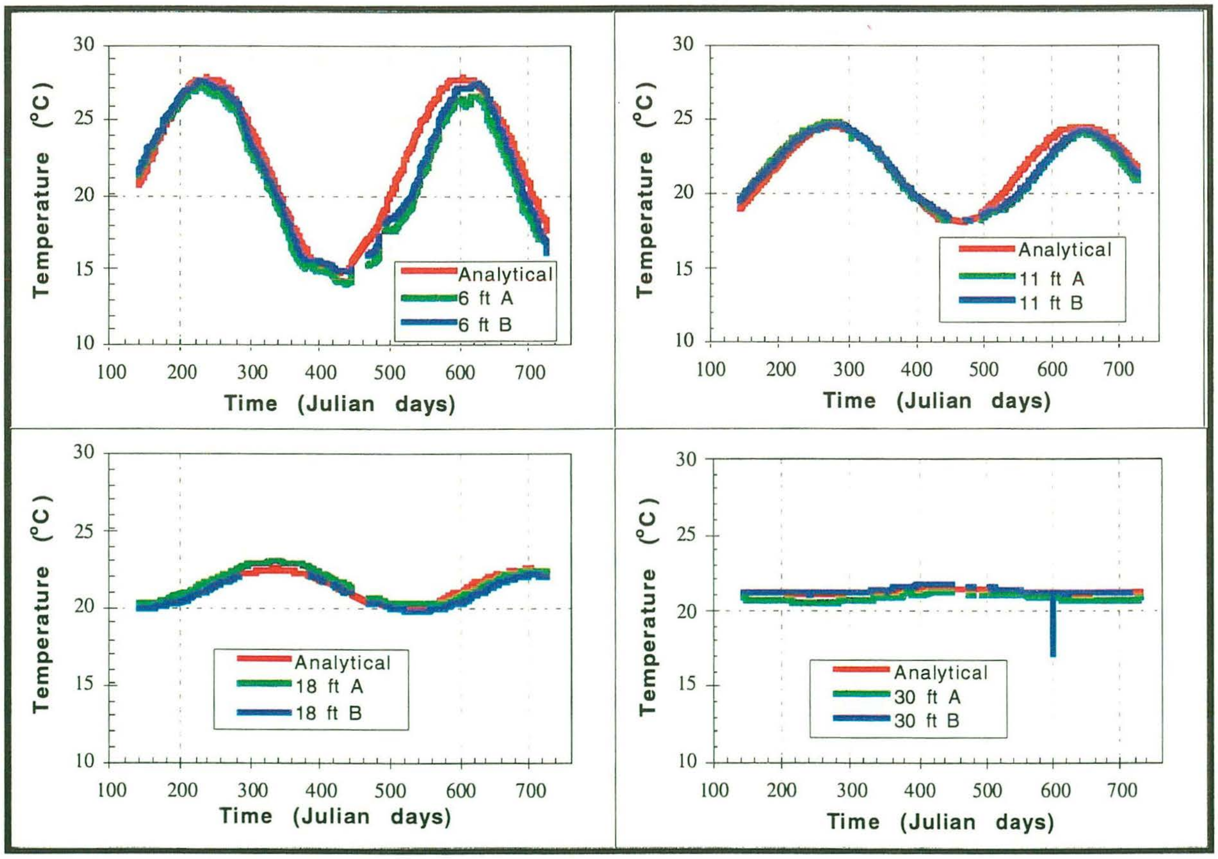


Figure 5.5. Comparison of observed subsurface temperatures with analytical solution for conductive heat transfer.

vadose zone at S-7. Further details of this analysis may be found in LBNL (1999b). Figure 5.4 shows the daily average air temperature measured at McClellan AFB from May 1997 through December 1998 (NOAA, 1999), which illustrates the combination of short-term temperature fluctuations and gradual seasonal variation typical of mid-latitude climates. Figure 5.5 shows the temperatures measured in VZMS-A and VZMS-B at depths of 6, 11, 18, and 30 ft for the same time period. Note that strong temperature variations are present at a depth of 6 ft, and that they become smaller and smoother as depth increases, until at 30 ft the temperature is nearly constant.

5.3.1.2 Analytical Solution for Conductive Heat Transport

We can model the subsurface temperature variation in space and time by considering one-dimensional conductive heat transfer from a specified temperature boundary condition at the ground surface. If we assume a homogeneous medium (thermal conductivity λ and heat capacity C uniform) and a sinusoidally varying surface temperature, then the analytical solution to describe the subsurface temperature distribution $T(z,t)$ is given by (Hillel, 1980):

$$T(z,t) = T_0 + T_1 \exp(-z/D)\cos\left[\omega(t - t_0) - z/D\right], \qquad (5.1)$$

where

$$D = \left(\frac{2\lambda}{\omega C}\right)^{1/2} \qquad (5.2)$$

and $\omega = 2\pi/\tau$, τ is the period of the temperature variation, T_0 is the average surface temperature, T_1 is the amplitude of the surface temperature variation, and t_0 is a phase constant used to identify the time at which surface temperature is a maximum.

Equation (5.1) shows a dampening of the surface signal with depth through the exponential term and a phase lag that also depends on depth. Both processes are controlled by the parameter D, which depends directly on thermal conductivity λ and inversely on ω, the frequency of the temperature variation, and C, the formation heat capacity. Thus for longer period temperature variations, surface temperature variations will propagate farther into the subsurface. This effect is apparent in the field data in that the seasonal temperature variation is observed all the way down to depths of 30 ft, whereas the short-term variations (with periods of a few days to a week) are barely visible at a depth of 6 ft (Fig. 5.5). Hence, we first consider just the seasonal temperature variation, and take τ = 365 days in Equation (5.2). We vary the unknown parameters T_0, T_1, D, and t_0 by hand to obtain a reasonable match to the long-term features of the subsurface temperatures shown in Fig. 5.5. Using the parameters $T_0 = 21.3°C$, $T_1 = 15°C$, $t_0 = 190$ days (July 9, 1997), and $D = 2.2$ m yields a very good match, suggesting that subsurface heat transfer in the vadose zone at site S-7 is in fact conduction-dominated, and the thermal diffusivity, λ/C is well approximated by a constant value. A comparably good match is obtained for $T_0 = 21.3°C$, $T_1 = 13°C$, $t_0 = 200$ days (July 19, 1997), and $D = 2.4$ m, providing an idea of the range of uncertainty of the inferred parameter values. Table 5.1 summarizes the parameters used in the temperature modeling.

Table 5.1. Summary of parameters used in temperature modeling.

Parameter	Value	Source
Average surface temperature, T_0	21.3 °C	Inferred by fitting $T(z,t)$ data
Amplitude of surface temperature variation, T_1	13 – 15 °C	Inferred by fitting $T(z,t)$ data
Time of maximum surface temperature, t_0	July 9 – July 19	Inferred by fitting $T(z,t)$ data
Dampening parameter for seasonal temperature variations, D	2.2 – 2.4 m	Inferred by fitting $T(z,t)$ data
Volumetric heat capacity, C	2.1 MJ m^{-3} $°C^{-1}$	Representative site S-7 model
Thermal conductivity, λ	1–1.2 W m^{-1} $°C^{-1}$	Calculated from Equation (5.2)
Dampening parameter for daily temperature variations, D_d	0.12 – 0.13 m	Calculated from Equation (5.2), substituting a period of 1 day for a period of 365 days
Penetration depth for seasonal temperature variations	10 – 11 m	Depth for which $\exp(-z/D) = 0.01$
Penetration depth for daily temperature variations	0.5 – 0.6 m	Depth for which $\exp(-z/D_d) = 0.01$

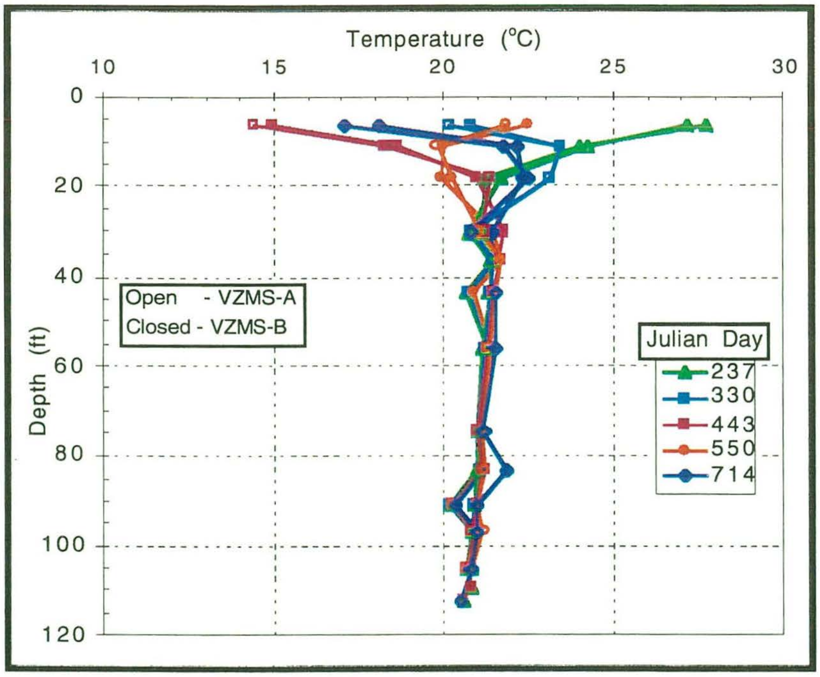


Figure 5.6. Temperature versus depth profiles for several times. (Open symbols show VZMS-A, closed symbols VZMS-B).

Figure 5.4 compares the daily average air temperature observed at McClellan AFB with a sinusoidal surface temperature using the values of T_0, T_1, and t_0, obtained from matching the subsurface temperatures. It is clear that although the long-term variation of the daily average air temperature does have a sinusoidal form, the surface temperature significantly exceeds the daily average air temperature during the summer months. This is consistent with everyday experience for non-vegetated places in warm climates and illustrates the value of using subsurface temperatures to estimate average surface temperature, a quantity not easily measured in the field.

Figure 5.6 shows temperature versus depth profiles for several times. Note the seasonal reversal of temperature gradient near the ground surface, which implies a reversal in the direction of heat flow. It is also of interest to note that the groundwater temperature (20.5°C) is slightly cooler than the average vadose zone temperature (T_0 = 21.3°C), suggesting that the largely-paved McClellan AFB site acts as a "heat island," compared to the surrounding land under which the groundwater flows.

5.3.1.3 Potential Temperature Effects on VOC Transport

The highest expected temperatures at McClellan AFB (a seasonal maximum surface temperature of 36°C, with an estimated daily maximum surface temperature of 46°C) are well below the boiling point of TCE (~87°C). However, if NAPL is present, its volatility will change within this range of observed temperatures leading to higher gas-phase and aqueous-phase concentrations of TCE as temperature increases. If NAPL is not present, temperature increases will cause TCE to partition more strongly into the gas phase relative to the aqueous phase, leading to higher gas-phase concentrations. Because gas-phase TCE is more mobile than aqueous-phase TCE, and both phases are more mobile than NAPL in the vadose zone, temperature can affect the transport of TCE. However, over the course of a year, subsurface temperatures spend just as much time below the average temperature as above it, so the enhanced transport of TCE accompanying higher temperatures during part of the year is balanced by diminished transport occurring at lower than average temperatures during other parts of the year. Therefore, the overall effect of seasonal subsurface temperature variations on TCE transport due to variation in volatility is expected to be small.

Another potential temperature effect is through buoyancy flow. In the gas-phase, for a given temperature and pressure, soil gas containing high concentrations of TCE is denser than ambient air and thus will tend to sink (Falta et al., 1989). During fall and winter, when reversals in temperature gradients make the surface cooler than the shallow subsurface (e.g., Fig. 5.6) thermal buoyancy can cause upward flow of soil gas from the shallow vadose zone. If this soil gas is contaminated with TCE at low levels (~100 ppmv) and there is a 2 °C temperature difference between air at the ground surface and the shallow vadose zone, thermal effects on buoyancy will dominate over composition effects and upward flow of contaminated soil gas will occur. Combined with gas-phase diffusion, which always drives TCE from regions of high to low concentration, these processes lead to outgassing of shallow subsurface VOC contamination.

5.3.2 Gas Pressure Modeling

5.3.2.1 Observed Gas Pressure Variation

Figure 5.7 shows the atmospheric pressure variation along with the observed gas pressure responses in Well VZMS-B for a two-week period. The pressures at the top four depths have been shifted to account for the calibration offset, as described in LBNL (1998b). For pressures at greater depths, where no calibration offset is available, the curves were shifted to place the observations at the first time on a gas-static profile. The main thing we want to try to match with the model is not the absolute values of pressure, but the way the pressure signal is dampened as depth increases. Note that there is a greater dampening with depth of short-term variations than long-term variations, but that overall, there is not much dampening of the atmospheric signal.

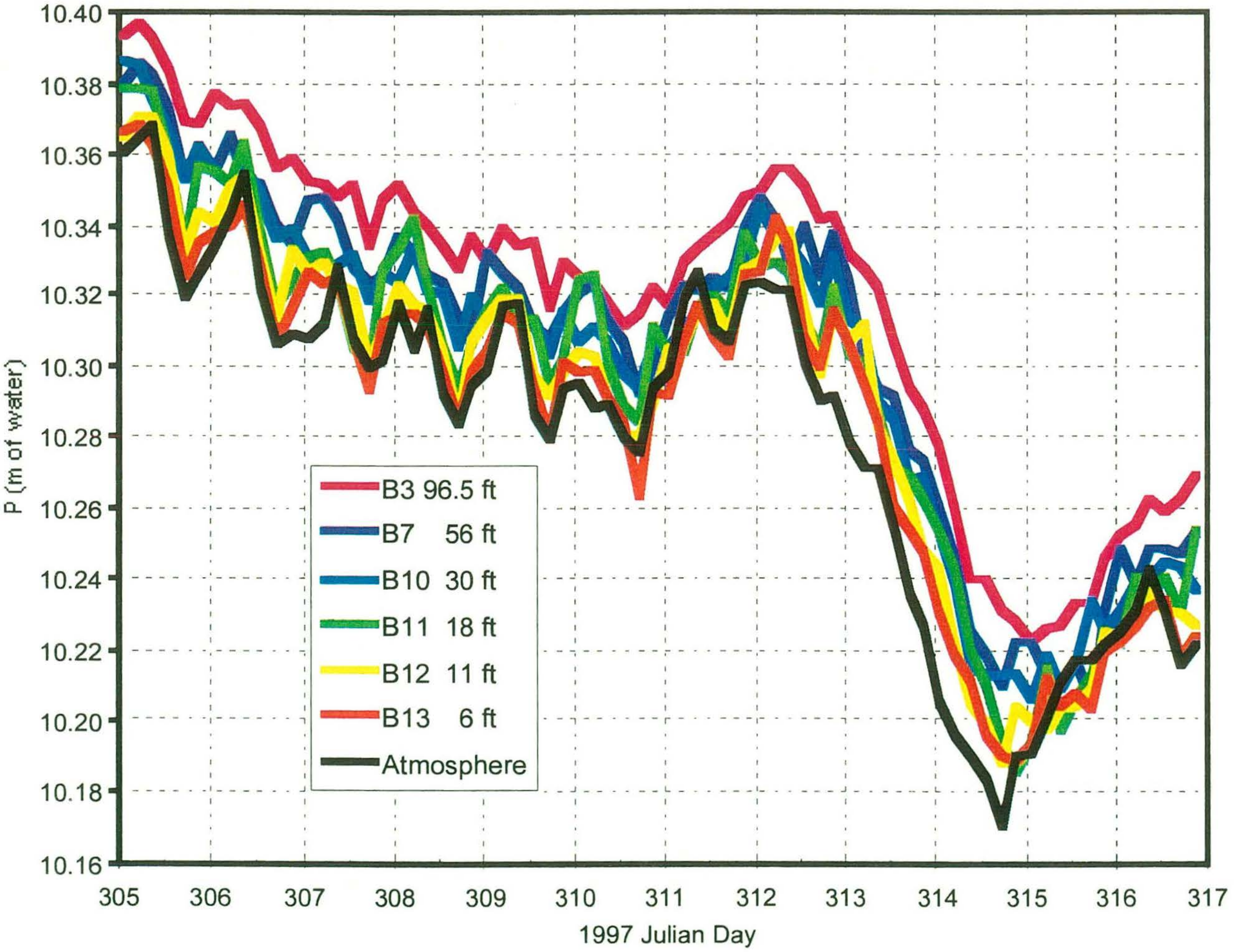


Figure 5.7. Atmospheric pressure and pressure measured at selected depths in Well VZMS-B for November 1 – November 13, 1997.

5.3.2.2 Numerical Model

Figure 5.8 shows the pressure response for the original site S-7 representative model, when the atmospheric pressure signal is applied as a boundary condition at the top of the model. The pressure response is too small (i.e., too strongly dampened) at all depths, but especially at 96 ft.

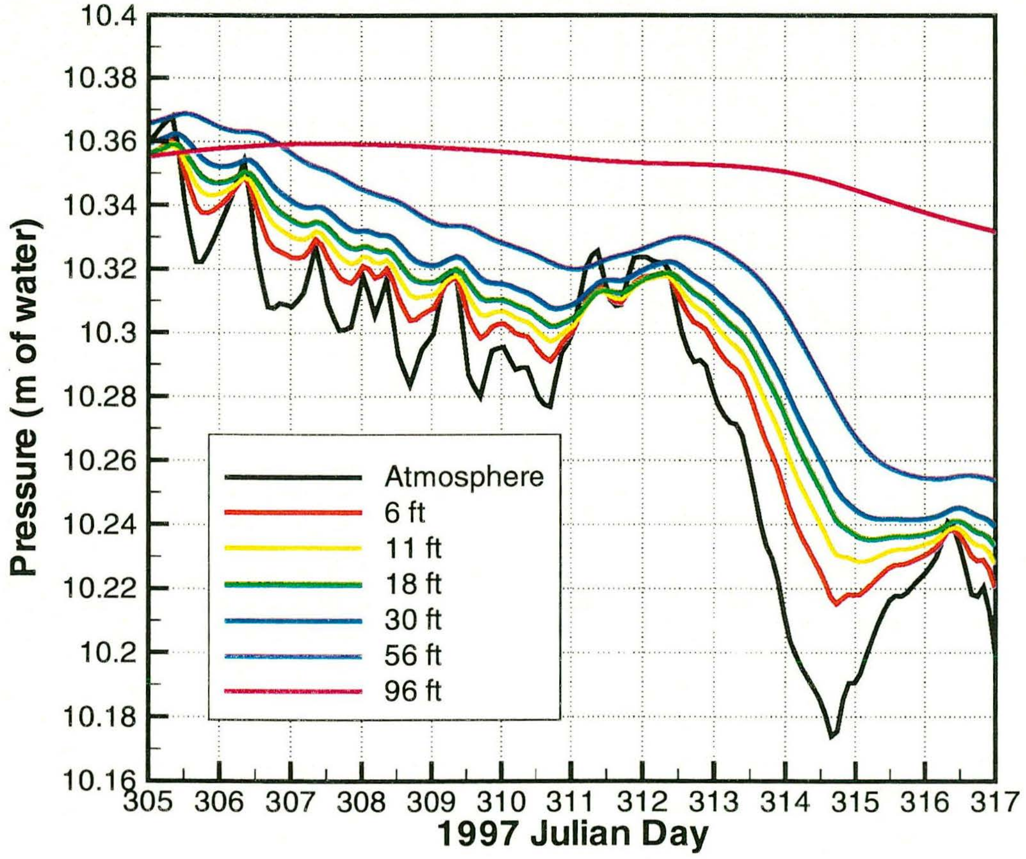


Figure 5.8. Modeled pressure response for the original site S-7 representative model for November 1 – November 13, 1997.

5.3.2.3 Model Modifications

The permeability of the concrete just below the ground surface is less well constrained than the underlying sediment permeabilities, so it was the first model parameter modified in the attempt to improve the match to the observed data. Although increasing concrete permeability does increase the subsurface pressure response somewhat, the effect is relatively small. Thus, properties of the sediments themselves were also varied by trial and error, until the match to the observed data improved significantly. Ultimately, the hydrostratigraphic model was modified in three ways:

1. Decrease percolation rate from 100 mm yr^{-1} to 10 mm yr^{-1}. This produces a drier saturation profile (see Fig. 5.3), hence greater gas-phase permeability, and less dampening of the

atmospheric signal. This modification increases the modeled pressure response, but not enough.

2. Increase permeabilities to a minimum of 1 Darcy (the average value observed during the interference air-permeability tests, see Section 4). Permeabilities greater than 1 Darcy were not altered. This modification does not significantly alter the saturation profile, except in the upper 3 ft of the model, where the permeability is increased significantly (the concrete layer and uppermost sediment layer). Elsewhere in the profile, the permeability increase is less than a factor of five. This modification greatly increases the modeled pressure response, except at a depth of 96 ft.

3. Alter the van Genuchten α parameter of Sediment Type 7, which occurs at 73-86 ft, to decrease the liquid saturation, and thus provide a higher gas-permeability. This increases the pressure response at 96 ft significantly. Sediment Type 7 had by far the smallest α value and produced by far the wettest spot in the saturation profile. The new lower saturation is still consistent with neutron probe moisture measurements.

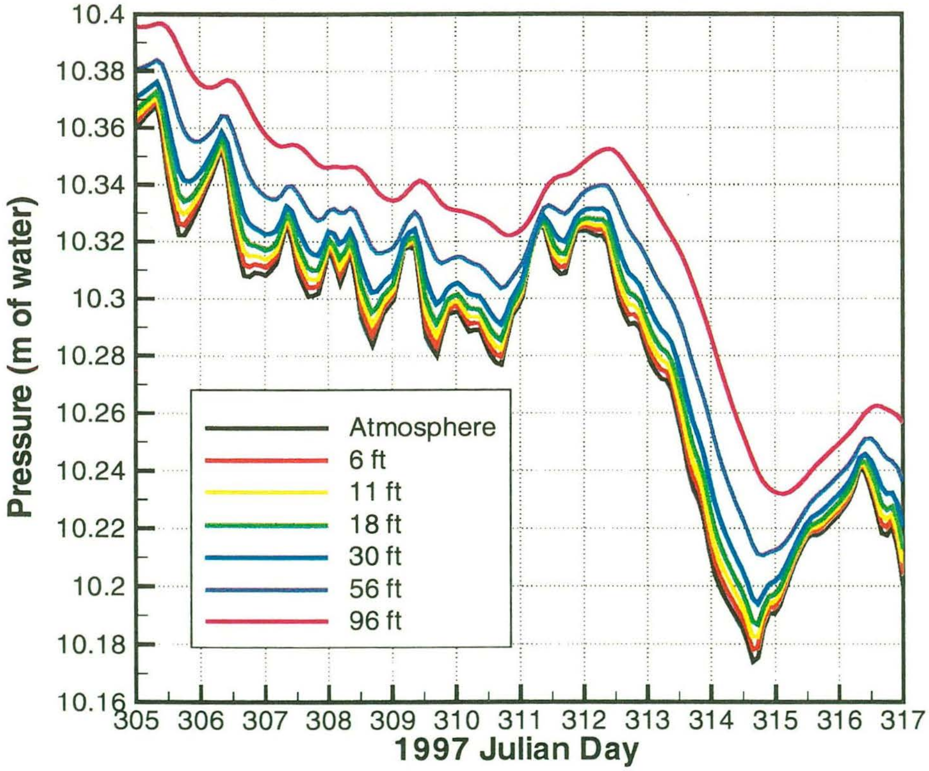


Figure 5.9. Modeled pressure response for the modified site S-7 representative model for November 1 – November 13, 1997.

Figure 5.9 shows the model results including all these changes. The match to the observed data is much improved. These results suggest that a lower percolation rate of 10 mm yr^{-1} may be more appropriate than the 100 mm yr^{-1} previously assumed. However, we cannot definitively say that percolation is 10 mm yr^{-1} rather than 100 mm yr^{-1}, because increasing permeability beyond 1 Darcy would probably improve the match with a 100-mm yr^{-1} percolation rate. Because the air-permeability tests produced an average permeability near 1 Darcy, the combination of this permeability and a percolation rate of 10 mm yr^{-1} is supported by the data.

The fact that we altered the permeability and moisture retention properties of several layers in the model does not mean we believe the core-sample analyses were incorrect, just that the core-sample parameters cannot be extrapolated to form continuous layers. Although there are undoubtedly isolated occurrences of Sediment Type 7 with small α values causing near-saturated conditions, the large pressure response at 96 ft provides good evidence that there is not a continuous high-saturation layer, isolating greater depths from atmospheric pressure variations. Similarly, there may be low-permeability sediments or intact concrete in the shallow subsurface, but they do not form a continuous barrier to gas-phase flow either. Table 5.2 summarizes the changes made from the original T2VOC conceptual model shown in Fig. 5.2.

Table 5.2. Summary of changes made to T2VOC conceptual model in order to match VZMS borehole observations.

Sediment Type	Property	Original Value	Modified Value	Reason for Change
All	Thermal conductivity (W m^{-1} °C^{-1})	2.85	1.0	Match subsurface temperature variations
Concrete, 1, 2, 4, 7, 8	Permeability (darcies)	Various (see Fig. 5.2)	1	Match subsurface gas pressure variations
7 (73-81 ft)	van Genuchten 1/α (Pa)	81,750	51,857	Match subsurface gas pressure variations
7 (83-86 ft)	van Genuchten 1/α (Pa)	81,750	24,194	Match subsurface gas pressure variations
8	van Genuchten 1/α (Pa)	28,850	20,214	Match gas-phase VOC concentrations above water table
1S*	Permeability (darcies)	-	0.012	Match gas-phase VOC concentrations near surface
1S*	van Genuchten 1/α (Pa)	-	212,227	Match gas-phase VOC concentrations near surface

*NAPL source, not a continuous layer in the model

5.3.3 VOC Transport Modeling

5.3.3.1 Observed Gas-Phase VOC Concentrations

Data on VOC concentrations from the VZMS wells collected over the last two years can be used to constrain conceptual models of VOC transport in the vadose zone at site S-7. Figure

5.10 shows gas-phase concentrations of TCE, cis-1,2-DCE, and Freon 123a as a function of

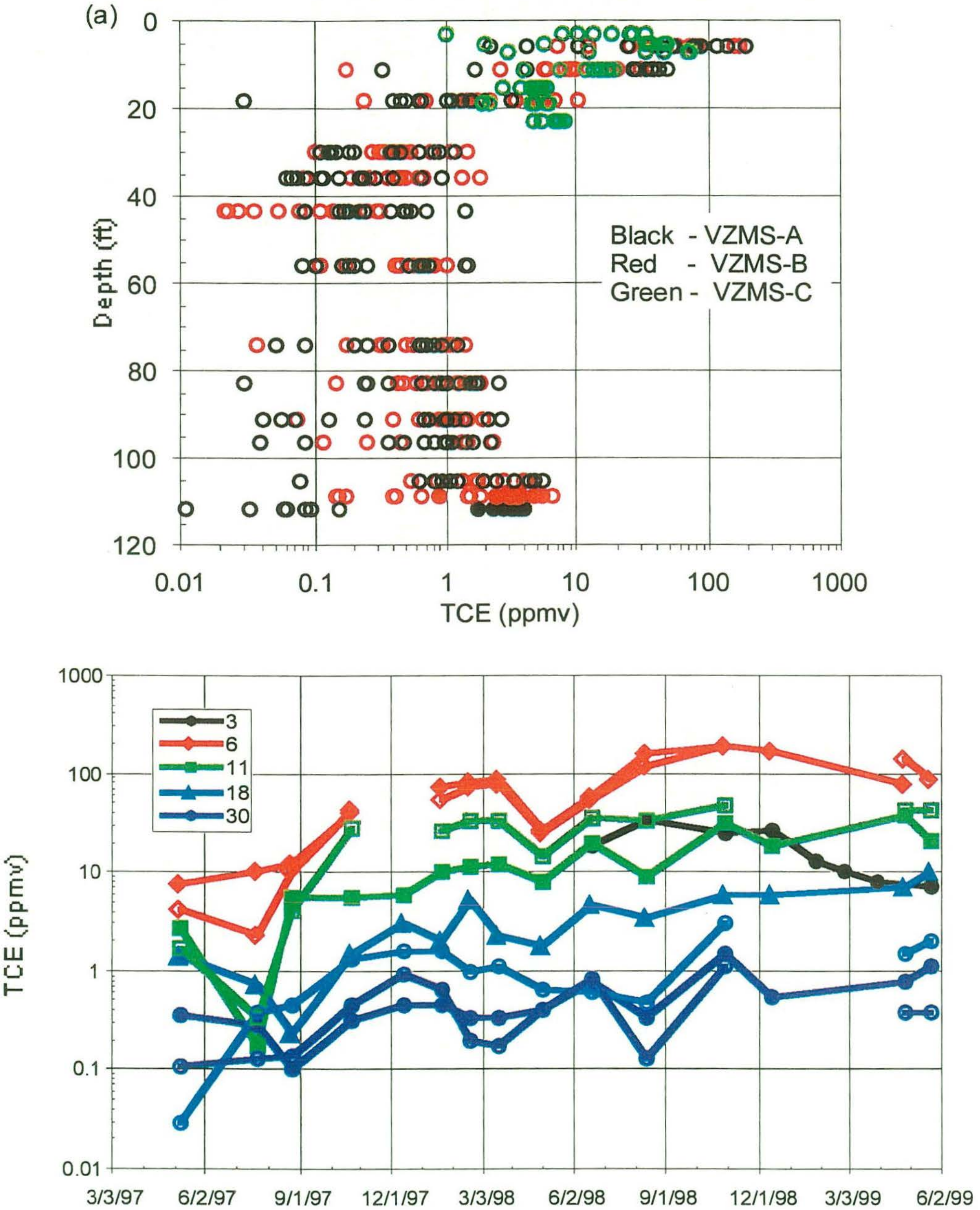


Figure 5.10. (a) TCE, (b) cis-1,2-DCE, and (c) Freon 123a concentration as a function of depth for all monitoring times and as a function of time for selected depths. The open symbols for VZMS-A and VZMS-B represent gas-phase concentrations; the closed symbols for VZMS-A and VZMS-B and the VZMS-C data represent liquid-phase measurements converted to gas-phase concentrations using Henry's law.

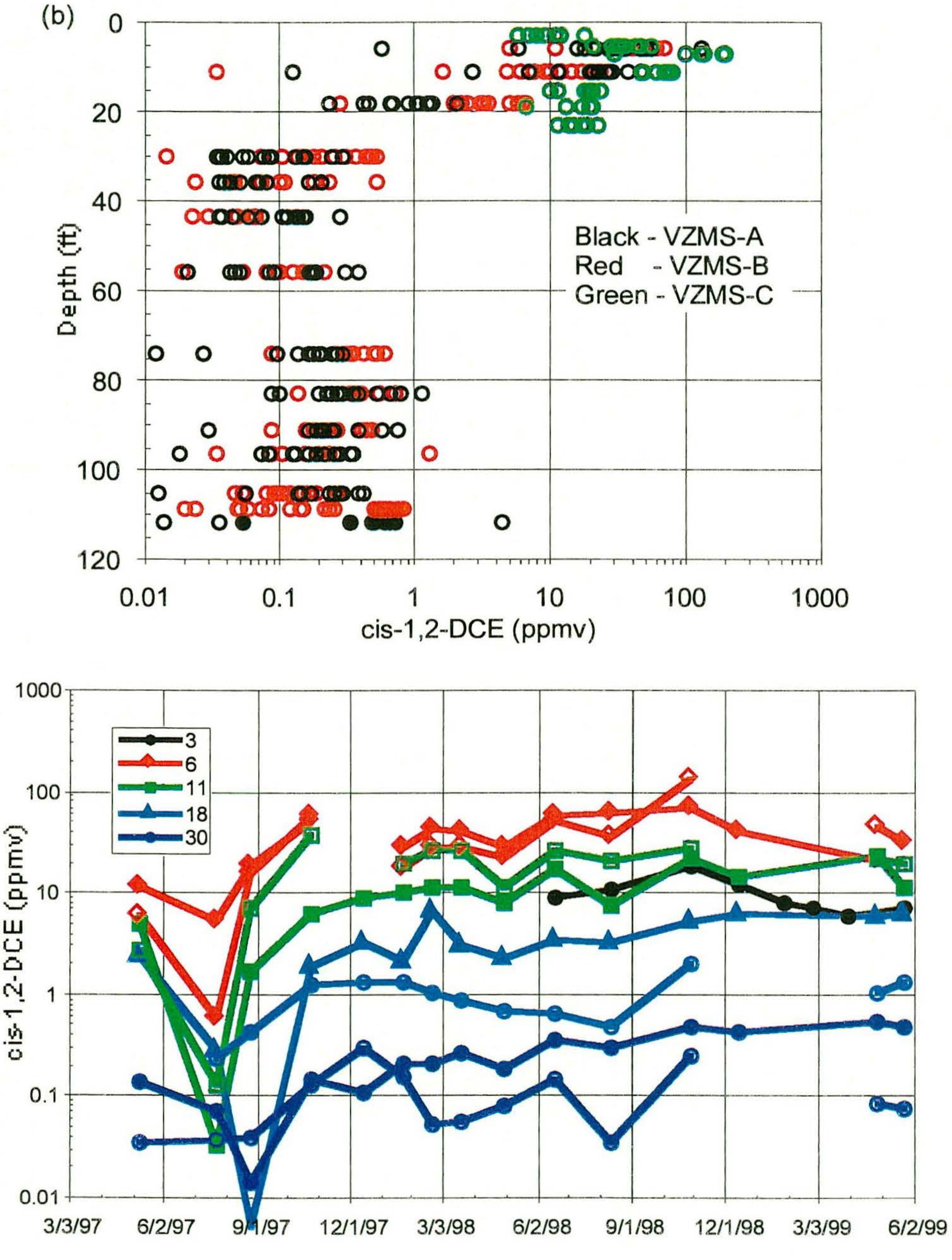


Figure 5.10. continued.

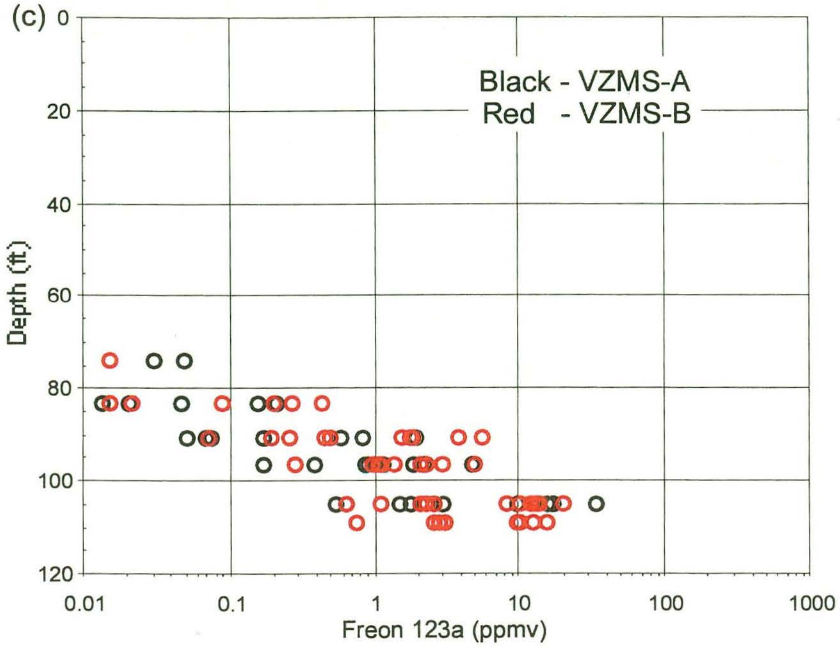


Figure 5.10. continued.

depth for all monitoring times and as a function of time for selected monitoring depths. Generally, we find that gas-phase and aqueous-phase VOC concentrations are in equilibrium according to Henry's law (LBNL, 1998a); data from Well VZMS-C and the water-table level of Wells VZMS-A and VZMS-B represent liquid-phase measurements that have been converted to gas-phase concentrations. The maximum concentrations shown in these figures are several of orders of magnitude smaller than would be found in a gas phase that is in equilibrium with bulk NAPL. Note that TCE and cis-1,2-DCE show similar profiles at depths less than 80 ft, whereas TCE and Freon 123a show similar profiles just above the water table. This is consistent with the notion that there is a shallow source of TCE and cis-1,2-DCE and a groundwater source of TCE and Freon 123a. We focus on the TCE concentrations as constraints on VOC transport models.

There are several noteworthy features in the TCE spatial distribution (Figure 5.10a), including (1) a sharp concentration gradient near the surface (concentration decreases from about 100 ppmv to less than 1 ppmv over about 25 ft), (2) a zone of low concentrations (depths from 30 to 70 ft), and (3) a gradual concentration increase toward the water table (depths from 70 to 112 ft). Note that all VZMS wells show very similar concentration profiles, demonstrating the reliability of our sample collection methods and suggesting local lateral continuity of the lithologic features controlling transport. However, data reported by Jacobs Engineering (1998) from a one-time soil-gas sampling event for the nearby well SS7SB08 (Fig. 1.1) show markedly different concentration profiles, with cis-1,2-DCE concentrations at 50-100 ppmv at depths of 30-40 ft, suggesting that vadose zone contamination may be strongly heterogeneous. The fluvial geologic setting underlying McClellan AFB would be expected to show strong hydrologic heterogeneity, with the expression of buried stream channels providing high-permeability pathways, and flood-plain and overbank deposits potentially providing low-permeability barriers to flow. There are inherent limitations in developing a model based on data from one-dimensional vertical boreholes for an intrinsically three-dimensional flow and transport problem. The challenges involved in conceptual model development will be further discussed below.

Another important feature of Fig. 5.10a is the temporal variability in measurements. While most measurements at each depth fall within a band of width slightly less than an order of magnitude in concentration, the variability is at least an order of magnitude when one includes all the data points. Although there does seem to be a systematic increase in concentration with time in the upper 25 ft (Fig. 5.10a), suggesting that the TCE plume is moving downward, there is also a great deal of scatter around this trend. This scatter may be due to the method of sampling, rather than actual large, short-term changes in TCE concentration. Each gas sample requires extraction of a relatively large volume of gas (~1 liter). For typical porosity ($\phi = 0.47$) and liquid saturation ($S_l = 0.7$) values, this corresponds to a subsurface volume of about 7 liters. As the moisture distribution surrounding the extraction point changes over time, gas from different regions may be pulled into different samples, providing highly variable TCE concentrations, although the movement of TCE itself is limited.

5.3.3.2 Assumptions Regarding VOC Source and Evolution

The historical record of activities at site S-7 is not sufficiently detailed to establish how VOCs were introduced into the vadose zone nor the chronology of the contamination. Therefore, to try to explain what is observed in the subsurface today, we have to make a number of assumptions about the contamination history. In our calculations, we assume that a source term consisting of several kg of TCE is present as NAPL at a depth of about 3 ft, 30 years before present, and that groundwater is contaminated by dissolved TCE at a constant concentration of 50 ppb (the value presently observed in the groundwater). Then we model the evolution of the system to the present day. TCE may be lost from the vadose zone to the atmosphere and lost or gained via exchange with the underlying groundwater. Water percolation occurs at a constant rate between 10 and 100 mm yr^{-1}, values inferred from modeling present-day moisture distributions (LBNL, 1998c). TCE is transported by liquid and gas phase advection, gas-phase gravity flow and diffusion, and flow of the NAPL as a separate phase, and may also be adsorbed on sediments. We assume equilibrium partitioning of TCE between phases. More details on the physical processes modeled in T2VOC are provided elsewhere (LBNL, 1998b; Falta et al., 1995).

The maximum observed gas-phase TCE concentrations (~100 ppmv) provide several constraints on the nature of the NAPL source. The source must be somewhat isolated from any monitoring location or else the observed concentrations would be much higher (~10^5 ppmv for a gas phase in equilibrium with bulk NAPL). The source must also be somewhat isolated from the ground surface or else it would evaporate and be lost to the atmosphere in less than the thirty-year observation period, resulting in much lower observed concentrations. We achieve this partial isolation by locating the source in a region with high liquid saturation and low permeability. Thus, we have low gas-phase diffusion and low liquid-phase advection away from the source. We do not assume a continuous layer in the model with these properties, as that would contradict gas pressure observations. The properties used for the NAPL source location are given in Table 5.2.

The linear nature of the Freon 123a profile (on a log scale) suggests gas-phase diffusion up from the water table controls transport. However, at the water table itself and at the base of the capillary fringe, where liquid saturation is very high, gas-phase diffusion is negligible. Freon 123a apparently moves up far enough into the capillary fringe for gas-phase diffusion to become significant. It turns out that the water table level typically varies several feet each year at McClellan AFB (Radian, 1992), providing a good opportunity for VOC-contaminated water to encounter a sufficiently high gas saturation to enable gas-phase diffusion. Rather than attempting to model a moving water table explicitly, we assign the constant Freon 123a concentration a few feet above the water table. To produce strong enough diffusion to match the VOC concentration profiles shown in Fig. 5.10, we slightly modified the moisture-retention properties of Sediment Type 8, located just above the water table, to decrease the liquid saturation in the capillary fringe (see Table 5.2).

A significant feature that is not included in the present model is an overall decrease in water-table level, which is estimated to be about 30 ft over the last 30 years (Radian, 1992). If the groundwater were contaminated throughout this time, we would expect to see an extensive, nearly constant VOC concentration profile above the present water table. The moderate, nearly constant TCE levels between depths of 80 and 100 ft (Fig. 5.10a) are consistent with this effect, but the upwardly decreasing Freon 123a profile (Fig. 5.10c) is not.

5.3.3.3 Conceptual Models for Subsurface Flow and Transport

Numerical simulations (described below) indicate that the existence of the sharp concentration gradient at shallow depths and the moderate concentration gradient above the water table shown in Fig. 5.10 only develop when the percolation rate is small (<10 mm yr^{-1}), and VOC transport is controlled by gas-phase diffusion and gravity flow, along with retardation due to adsorption onto sediments. With a larger percolation rate, the shallow high concentrations would extend farther downward and the moderate concentrations at the water table would not extend as far upward, as liquid-phase advection followed by equilibration between liquid- and gas-phase VOC would become an important transport mechanism. However, the moisture content data (Fig. 5.3) indicate that while percolation rates of both 10 mm yr^{-1} and 100 mm yr^{-1} appear plausible, the higher percolation rate seems to match the observed data better. Furthermore, the generally accepted percolation rate for McClellan AFB is also relatively high at 63 mm yr^{-1} (Jacobs Engineering, 1998). We have investigated three alternative hypothetical conceptual models for VOC flow and transport to try to reconcile these findings. These conceptual models are shown schematically in Fig. 5.11 and discussed in more detail below. It is possible that greater retardation would allow the higher percolation-rate model to produce the observed concentration gradients, but retardation is controlled by the fraction of organic carbon (FOC), a quantity that has been measured in core samples at site S-7, and we do not feel justified arbitrarily increasing it.

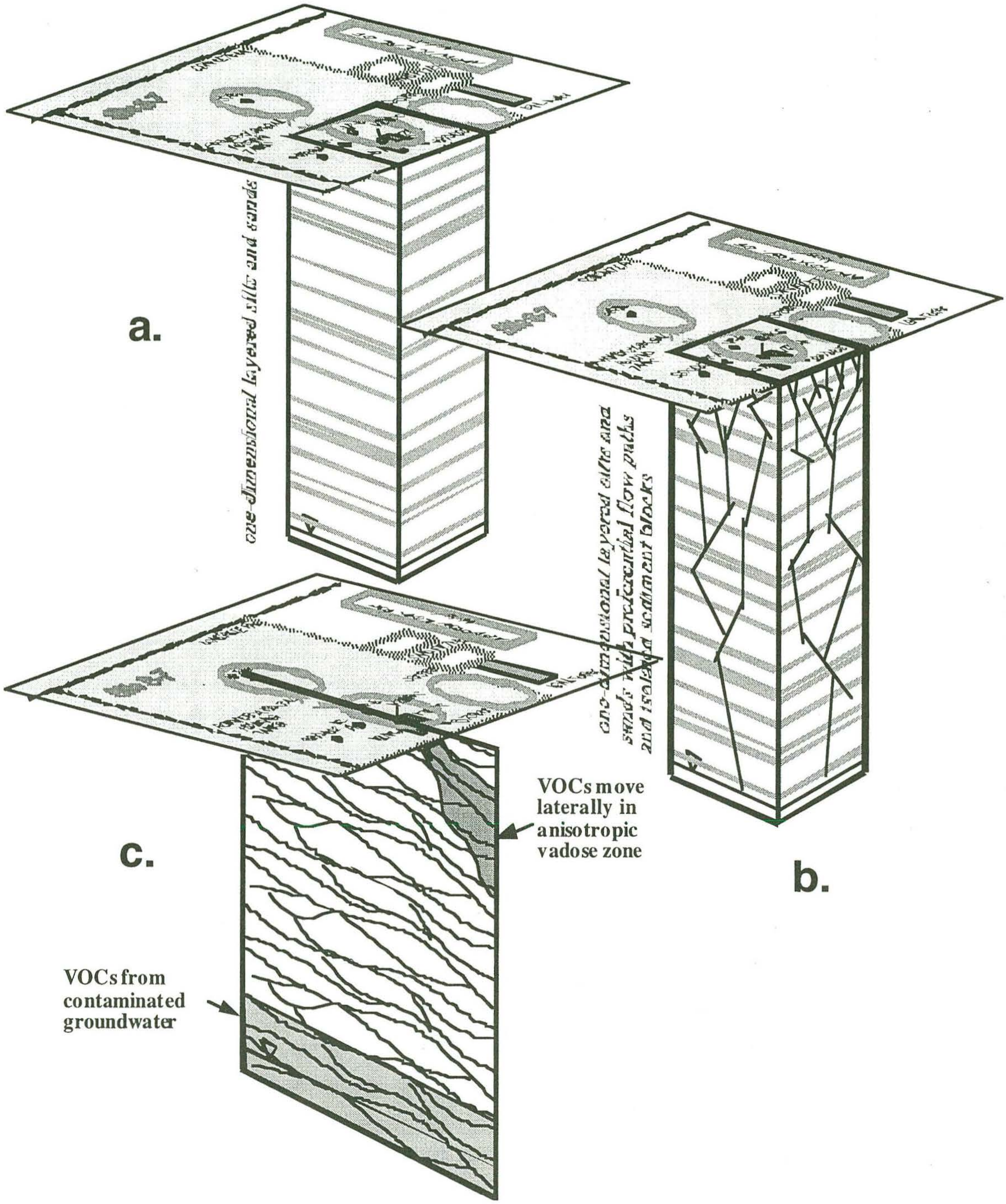


Figure 5.11. Conceptual models for subsurface flow and transport beneath site S-7. (a) Layered single-continuum model; (b) Layered dual-continuum model with preferential flow paths (PFPs) and isolated sediment blocks (ISBs); (c) Anisotropic single-continuum model.

Layered Single-Continuum Model

The layered single-continuum model (Fig. 5.11a) is the site S-7 representative model based on the lithologies observed in the VZMS boreholes, developed from previous studies matching moisture content/percolation rate and laboratory core-sample analysis (LBNL, 1998c), modified as described above to match temperature and gas pressure data. The model contains continuous layers, except for the NAPL source, which is localized in both vertical and lateral extent. This model is the simplest of the three conceptual models, and the only one that can be directly developed from the essentially one-dimensional information provided by the vertical VZMS wells. However, it requires a low percolation rate (~10 mm yr^{-1}) to produce VOC concentration profiles consistent with the observed ones, and does not allow explicit incorporation of the low permeability values determined from core-sample analysis.

Dual-Continuum Model

The dual-continuum model (Fig. 5.11b) considers the subsurface to be composed of two interacting continua, one consisting of preferential flow paths (PFPs) and the other of isolated sediment blocks (ISBs). The preferential flow paths are sparse, so they are rarely intersected by boreholes. However, the bulk of the liquid infiltration into the subsurface occurs through them, and they provide the network of flow paths whose permeability controls the subsurface gas-pressure response to barometric pressure variations and the response to air-permeability tests. The isolated sediment blocks comprise the bulk of the medium, so moisture contents measured with neutron probes, matric potentials measured with tensiometers, and core-sample analyses are all likely to be representative of the ISB continuum. Use of a dual-continuum model enables us to use a higher percolation rate (~100 mm yr^{-1}) and to incorporate both the higher permeabilities (~1 darcy) inferred from the air-permeability tests and gas-pressure response to atmospheric pressure, and the lower permeabilities (as low as 0.012 darcies) obtained from core-sample analysis in a single model.

As a limiting case, we assume that the intrinsic permeability of the ISBs is about 100 times smaller than that of the PFPs, that is, they are characterized by the lowest permeability values obtained from the core-sample analysis. We also assume that the characteristic curves (relative permeability and capillary pressure functions) of the two continua are the same. The latter assumption is made due to lack of data on characteristic curves for hypothetical PFPs. With these two assumptions, the percolation rate through the ISBs can be 100 times smaller than that through the PFPs while maintaining the same moisture distribution.

We hypothesize that originally the NAPL source was introduced into the subsurface via the PFPs, but that near the surface (near the NAPL source), the sediment blocks became contaminated as well. Because the PFPs carry nearly all of the infiltrating liquid through the subsurface, VOC there will show an advective depth profile whereas VOC in the sediment blocks will be transported primarily by diffusion. Because in this conceptual model the PFPs are sparse, we would not tend to sample them in the VZMS wells, hence we would only observe the diffusive VOC profile illustrated by the shallow portion of Fig. 5.10a. For this model to work, we would have to assume that at depth the sediment blocks are slow to take up VOC from the neighboring PFPs. Either there has not been a long enough time to transfer significant VOC from PFPs to the sediment blocks, or there is not enough effective area of contact to allow significant interaction between PFPs and sediment blocks. This would account for the low concentrations observed in the middle depths of Fig. 5.10a. The increase in concentration above the water table represents diffusive transport from the water table, which occurs in both PFPs and ISBs.

This dual-continuum model introduces a great deal more complexity to the system relative to the single-continuum model, none of which can be directly supported by field observations. We introduce it for three reasons. First, it enables us to incorporate the range of permeability values inferred from small-scale core-sample measurements and larger-scale pressure measurements. Second, the simpler single-continuum model requires a relatively low percolation rate (10 mm yr^{-1}) to model the observed VOC concentration data whereas the dual-continuum model can accommodate a much larger percolation rate. Finally, the last decade of research has shown that, with a few exceptions (e.g., Weirenga, 1991; Hills et al., 1991), preferential flow is pervasive in the vadose zone (Kung, 1990a,b; Ghodrati and Jury, 1990; 1992; Li and Ghodrati, 1994; Flury et al., 1994, 1995; McCord et al., 1997).

A key unknown parameter of the dual-continuum model is the strength of the interaction between the PFPs and the sediment blocks. If this interaction is strong, the two continua will essentially be in equilibrium, and show the same advective concentration profile, a feature not observed in the VZMS data. Hence, we must justify why the interaction between the two continua is limited. Merely decreasing the permeability of the ISBs does not work, because the interaction can be accomplished by gas-phase diffusion, which does not depend on permeability. Increasing the liquid saturation of the ISBs would decrease diffusion, but it would be inconsistent with the notion that the neutron probe mainly measures the ISB moisture content, so it is not a variable we are free to modify. From a geometric point of view, we expect that the interaction area between PFPs and sediment blocks will decrease with depth, as multiple PFPs coalesce to form fewer, larger PFPs (e.g., Kung, 1990a,b). Interaction area may also be temporally limited. Despite our modeling assumption of a steady percolation rate, percolation at McClellan AFB may be episodic, with the bulk of the infiltration occurring during and after intense winter storms. If preferential flow paths are only water-filled for a small percentage of the time, then they are only likely to advect VOC-contaminated water an even smaller percentage of the time (with clean water being flushed through the system behind it). Hence, through the effects of both spatial and temporal isolation, the opportunity for PFPs to transfer VOC to the sediment blocks may be limited.

Another possible means to decrease transport of VOC from PFPs to sediment blocks is to simply make the PFPs such a small volume faction of the medium that whatever VOC they contain makes a negligible contribution to the surrounding sediment block. The limiting factor in this approach is that if the volume fraction of the PFP continuum decreases too much, the permeability required for individual flow paths would have to become unreasonably large and the transit time from the surface to the water table would become unreasonably small. Thus, there are heuristic constraints on how we divide the system into PFPs and ISBs.

Anisotropic single continuum

This conceptual model (Fig. 5.11c) assumes the plume is migrating by liquid advection downward and laterally at the same time, and the VZMS holes are intersecting only the top portions of the plume. This migration pattern could arise from fluvial deposits and permeability differences leading to an anisotropic medium. Recharge is flowing through the entire column intersected by the VZMS holes, but below the top 25 ft or so, it is clean water that originated at the surface beyond the lateral extent of the TCE plume that intersects the VZMS-A and B wells. The low TCE concentrations arise by diffusive transport from the main plume itself, which is some distance away. The increase in concentration near the water table cannot be caused simply by diffusion up from the water table if downward percolation is large (~100 mm yr^{-1}). It could arise from a shallower water table in the past, or it could also be due to a change of direction of the vadose zone plume that brings it closer to the monitoring location under site S-7.

This anisotropic flow conceptual model is not amenable to a one-dimensional column model or an axisymmetric (r,z) model. For a rigorous analysis, it requires a fully three-dimensional model, which cannot be developed in sufficient detail using the limited subsurface lithologic data available at this time. However, a qualitative estimate of the effect of anisotropic flow can be obtained with an axisymmetric (r,z) model, by locating observation points off the $r = 0$ axis.

5.3.3.4 Thirty-Year History Simulations (1969-1999)

We ran several simulations of the thirty-year evolution of TCE at site S-7 to test the different conceptual models described above. Each uses a single-continuum, axisymmetric model, but by varying the percolation rate and monitoring locations, we can approximately model the ISB component of a dual-continuum model and the anisotropic flow case as well. The numerical grid used for the simulations is shown in Fig. 5.12. It represents an axisymmetric (r,z) model in which layer properties are taken from the site S-7 representative model shown in Fig. 5.2, along with the modifications necessary to match subsurface temperature and gas pressure data, summarized in Table 5.2. The vertical grid spacing is coarser than that used for the one-dimensional site S-7 representative model (a total of 79 layers rather than 225) but the grid is fine enough to resolve all the layering shown in Fig. 5.2. The NAPL source occupies a grid block at a depth of about 3 ft with a radial extent of 2 ft, which has properties specially chosen to isolate the NAPL source from the monitoring locations and the ground surface (see Table 5.2). The radial grid spacing is fine just beyond the NAPL source, where concentration gradients are expected to be high, medium at distances for which significant concentration changes are expected (out to about 60 ft), and steadily becomes coarser beyond that, to represent a laterally infinite medium.

The top boundary of the model is the atmosphere, which is modeled as a constant-pressure, constant-temperature boundary containing no mobile liquid water. The lower boundary of the model is the water table, which is modeled as a water-saturated, constant-pressure, constant-temperature boundary. Water percolation is specified as a constant mass source in the uppermost layer of the model below the atmosphere, with a strength equivalent to the desired percolation rate: either 100 mm yr^{-1} or 10 mm yr^{-1}. For comparison to the percolation rate used in VapourT modeling ($v = 2.0 \times 10^{-9}$ m s^{-1}) (Jacobs Engineering, 1998), 100 mm yr^{-1} corresponds to a percolation rate of 3.2×10^{-9} m s^{-1}. The initial saturation distribution for the thirty-year simulation is the steady-state flow field arising from a balance of capillary and gravity forces for the specified percolation rate (Fig. 5.3).

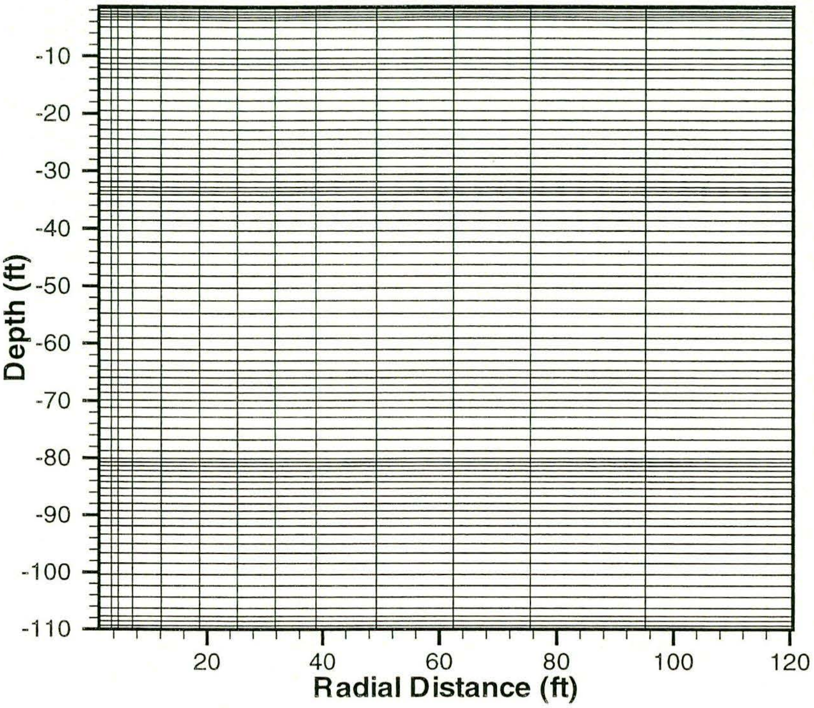


Figure 5.12. Central portion of the axisymmetric (r,z) grid used for the thirty-year simulations. The grid extends out to about 220 ft, with steadily increasing grid spacing.

Figures 5.13 and 5.14 show the results of the 100-mm yr^{-1} and 10-mm yr^{-1} percolation rate cases, respectively, by displaying gas-phase TCE concentration profiles for the innermost column of the model at a series of times during the thirty-year simulation. The liquid saturation profile is also shown; it does not change in time as it represents equilibrium between gravity flow of infiltrating water and capillary forces. Note that the thirty-year concentration profile for the 100-mm yr^{-1} case differs greatly from the observed profile shown in Fig. 5.10a. In particular, the maximum concentration is not near the surface, but spread out over a range of depths well below it, presumably a result of liquid-phase advection of TCE dissolved in the aqueous phase that subsequently partitions into the gas-phase. A simulation using the properties of the original hydrostratigraphic model (not shown) produces a concentration distribution that is nearly indistinguishable from Figure 5.13. Hypothesizing a large amount of organic carbon in the sediments around the NAPL source (simulation not shown) produces slightly lower TCE concentrations due to increased adsorption, but does not change the shape of the concentration profile. The concentration profile for the 10-mm yr^{-1} case (Figure 5.14) agrees much better with the observed data, with the maximum concentration near the surface and a sharp concentration gradient below it. Both cases reproduce the gradual concentration increase above the water table, but it is somewhat dampened by advection in the 100-mm yr^{-1} case.

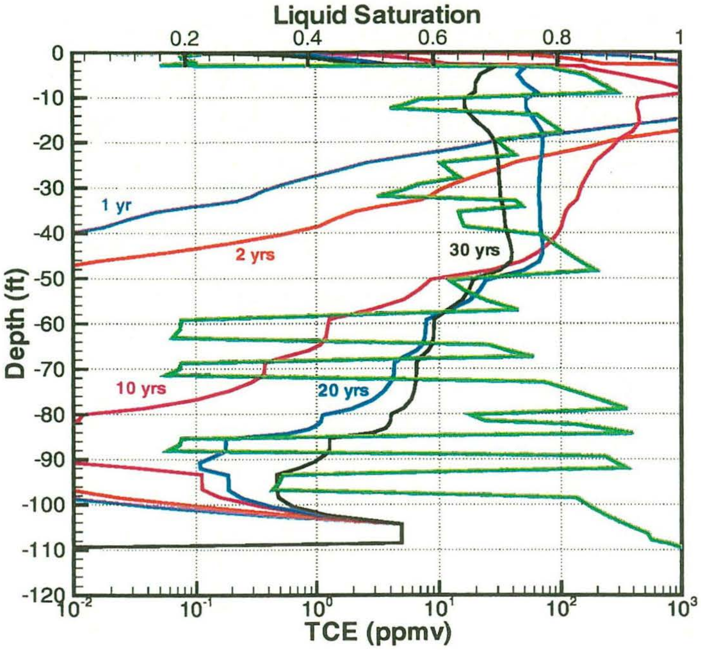


Figure 5.13. Simulated liquid saturation profile (green) and gas-phase TCE concentration profiles at the innermost column of the (r,z) model for the thirty-year history simulation; 100-mm yr^{-1} percolation rate.

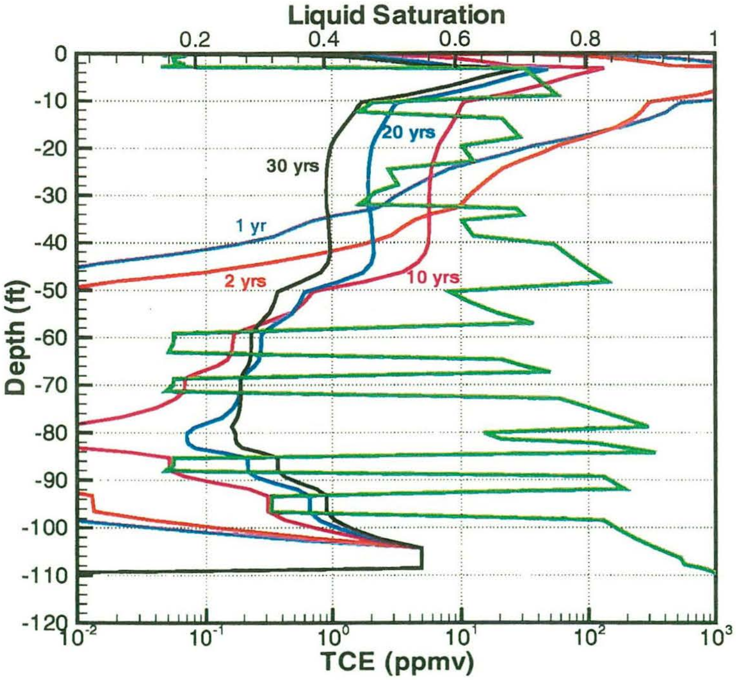


Figure 5.14. Simulated liquid saturation profile (green) and gas-phase TCE concentration profiles at the innermost column of the (r,z) model for the thirty-year history simulation; 10-mm yr^{-1} percolation rate.

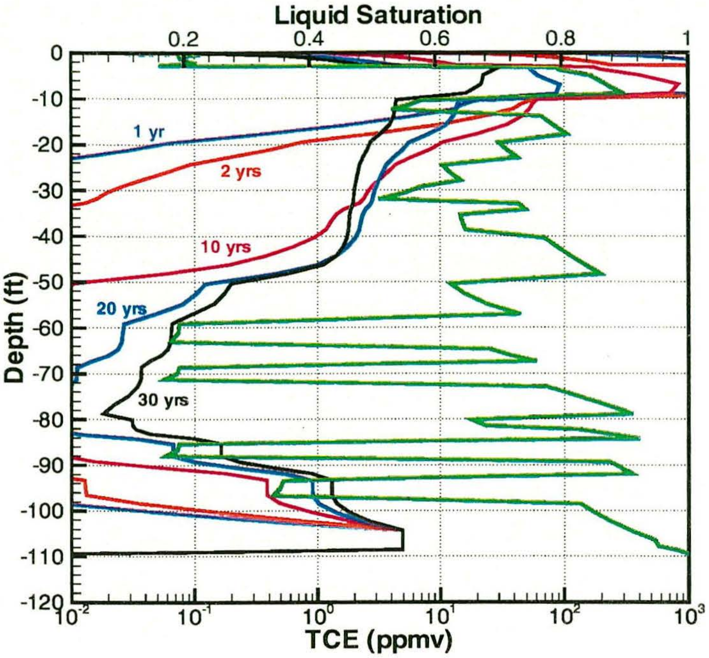


Figure 5.15. Simulated liquid saturation profile (green) and gas-phase TCE concentration profiles at the innermost column of the (r,z) model for the thirty-year history simulation; 1 mm yr^{-1} percolation rate with hundred-fold decrease in permeability to represent ISBs for an overall 100-mm yr^{-1} percolation rate.

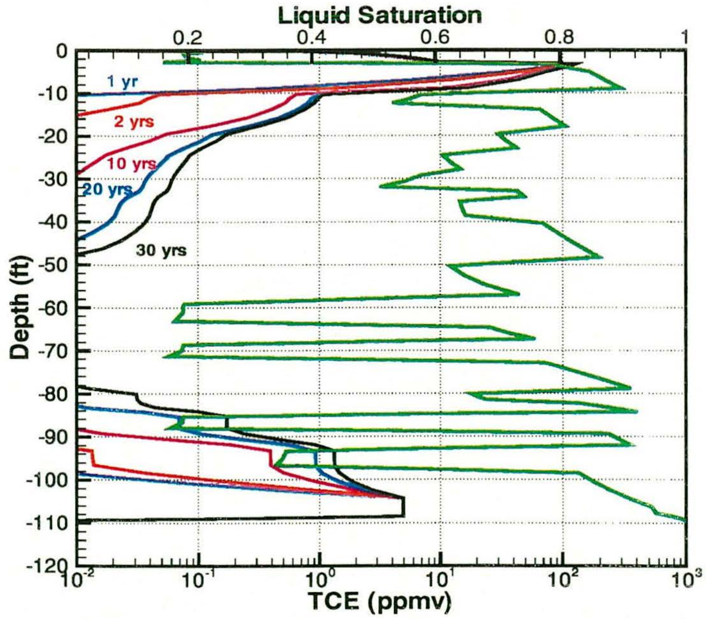


Figure 5.16. Simulated liquid saturation profile (green) and gas-phase TCE concentration profiles at the innermost column of the (r,z) model for the thirty-year history simulation; diffusion-only model with liquid saturation profile for a 100-mm yr^{-1} percolation rate.

We can approximate the response in the ISBs of a dual-continuum model by decreasing the percolation rate and the permeability by the same amount, while maintaining all other parameters at their original values. The results of such a simulation using a percolation rate of 1 mm yr^{-1} are shown in Fig. 5.15. They are generally similar to the 10-mm yr^{-1} case, suggesting that once percolation is as small as 10 mm yr^{-1}, making it even smaller has little effect. The most noticeable difference between the ISB case and the 10-mm yr^{-1} case arises from the liquid saturation distributions. Because the ISB case uses the wetter saturation distribution of the 100-mm yr^{-1} case, gas-phase diffusion is smaller. This is especially noticeable for the concentration profiles at one and two years.

Another way to approximate the ISB part of a dual-continuum model is to assume that there is no liquid water percolation at all, by making water in the subsurface immobile. Figure 5.16 shows the results of this simulation. As in Figs. 5.13–5.15, the liquid saturation does not change in time, however in this case it is because no water movement occurs. Hence, the TCE transport occurs solely by gas-phase gravity flow and diffusion. Note the significant differences in the TCE concentration profiles in Figs. 5.15 and 5.16. Despite the fact that percolation is only 1 mm yr^{-1} in the former case, allowing water to be mobile enhances the spread of TCE, and produces a concentration profile more consistent with the observed data.

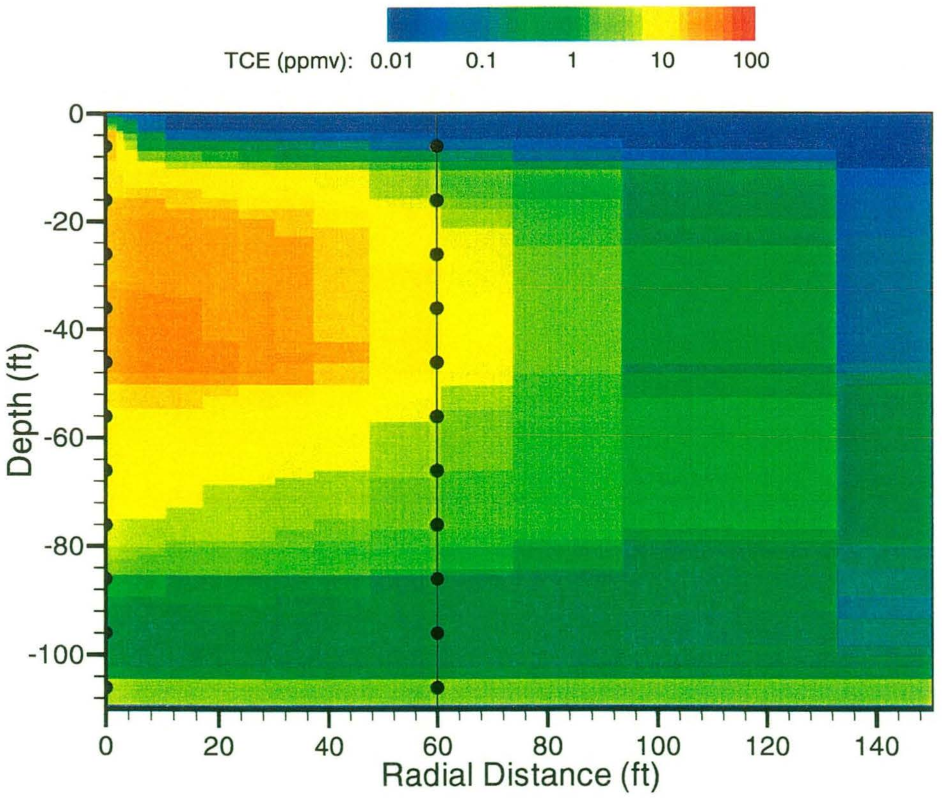


Figure 5.17. Thirty-year gas-phase TCE concentration distribution for a 100 mm yr^{-1} percolation rate. Hypothetical monitoring locations at $r = 0$ and $r > 0$ are shown.

Figure 5.17 shows a contour plot of gas-phase TCE concentration in the (r,z) plane after 30 years for the 100-mm yr^{-1} case with vertical percolation. Plotting the concentration profile along the line $r = 0$ yields the concentration profile shown in Fig. 5.13. This profile is what would be measured along a vertical borehole coincident with the center of a TCE plume. For an anisotropic medium with a plume moving diagonally away from our monitoring borehole, we can combine shallow observations from the $r = 0$ profile with deep observations from the $r > 0$ profile to get a sense of what would be seen in the field. As illustrated in Figure 5.17, if a plume moved 60 ft laterally as it moved 40 ft vertically, peak concentrations would go unmonitored and the resulting profile would look more like the low-percolation rate cases.

In summary, the thirty-year simulations have indicated that vertical percolation at 100 mm yr^{-1} does not produce concentration profiles consistent with the observed data. Lower percolation rates of 1 or 10 mm yr^{-1} match the observations better. The 10 mm yr^{-1} percolation rate is consistent with a simple single-continuum model, whereas the 1 mm yr^{-1} rate is associated with the ISBs of a dual-continuum model. A dual-continuum model can also assume no percolation at all through the ISBs, but the resulting concentration profile does not resemble the observed data so well. Finally, if the 100 mm yr^{-1} percolation moves diagonally through the subsurface, due to medium anisotropy, it may be possible to produce a concentration profile with the characteristics of the observed data.

5.3.3.5 Two-Year Simulations (1997-1999)

The two years of data collected by the VZMS at site S-7 have been used to further test the first two conceptual models. T2VOC simulations start in the spring of 1997 by applying the observed VZMS-A and -B gas-phase TCE concentrations as initial conditions, and simulate TCE evolution until the spring of 1999. This sort of simulation has far fewer uncertainties than does a thirty-year simulation, because we have a much better idea of the initial conditions. Furthermore, for a short-term simulation of a mature plume such as this, we can use a one-dimensional column model, because radial dilution will not be a major factor in plume evolution. (The anisotropic conceptual model requires a more elaborate multi-dimensional numerical model, which has not been constructed). The top and bottom boundary conditions are the same as for the (r,z) model.

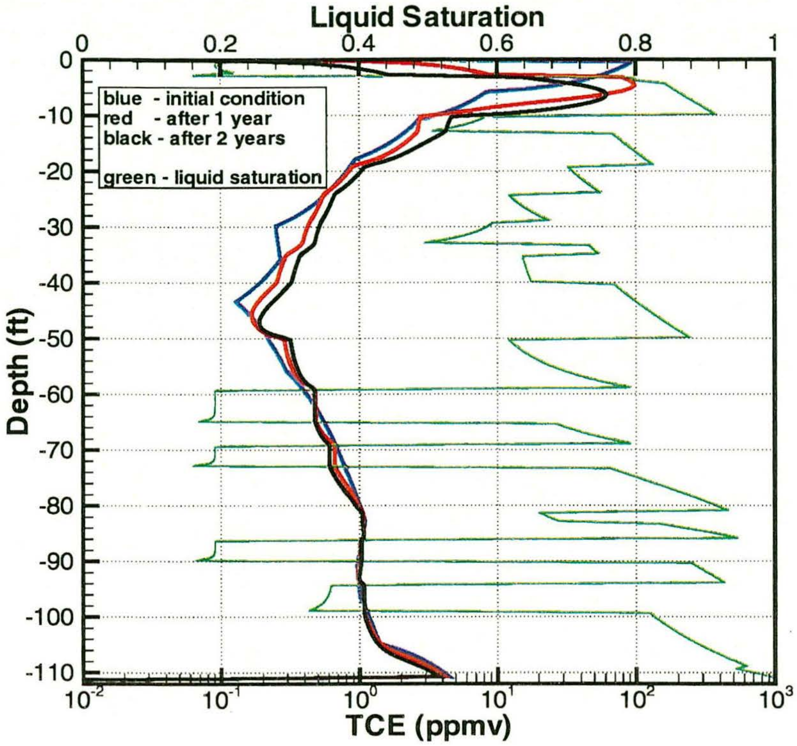
Our first two-year simulation used the single-continuum model with a percolation rate of 100 mm yr^{-1} and assumed that the observed gas-phase TCE concentrations represent equilibrium between gas-phase and aqueous-phase TCE, and that there is no NAPL present. To assign grid block initial conditions, we linearly interpolated between observed TCE concentrations, and extrapolated the shallow concentration gradient to the ground surface. Simulation results showed that TCE concentration at a depth of 3 ft decreased rapidly, due to losses to the atmosphere, and that concentration at 6 ft increased just slightly before decreasing. At depths greater than 6 ft, both observed and model concentrations increased gradually with time (see LBNL, 1999b; Figs. 4.1 and 4.2). Apparently, even when we start with rather high concentrations near the surface, losses to the atmosphere preclude a significant concentration increase at depths of 3-6 ft.

We tried to improve the model by making various changes to the ground surface boundary condition (LBNL, 1999b), but none of these features helped the model match the shallow concentration data. Therefore, we hypothesize that either some NAPL remains in the system, gradually volatilizing to replace gas-phase TCE that is lost to the atmosphere, or that TCE-contaminated water flows through the gravel layer between the two concrete layers in the shallowest 3 ft of the system and acts to replenish the TCE source. The need for NAPL or a continuing TCE source to be present is consistent with the thirty-year simulation results, which show that as soon as NAPL disappears, the sharp shallow concentration gradient vanishes as well. As in the thirty-year simulations, if NAPL is present, it must be a small amount, somewhat isolated from any monitoring location, otherwise the observed TCE gas-phase concentrations would be much higher. It is probably located between the monitoring locations at depths of 3 and 6 ft, because of the reversal in the concentration-depth profile between 3 and 6 ft and the complementary concentration-time trends at these two depths (Fig. 5.10a). Constraints on the VOC-contaminated lateral water flow possibility are minimal, and thus we focus on testing the NAPL hypothesis.

To test the NAPL hypothesis, we added a small grid block containing about 10 g of TCE with a NAPL saturation of 0.7 at a depth of 3 ft, and reran the two-year simulation. Figure 5.18a shows the resulting TCE concentration-depth profiles, and Fig. 5.18b shows the corresponding concentration transients for several depths. The model now shows a gradual increase in TCE concentration at all depths below 3 ft, corresponding to a small downward movement of the TCE plume. This downward movement results from a combination of advection and diffusion. We can estimate the advection contribution by converting the percolation rate of 100 mm yr^{-1} to a pore velocity by dividing by average porosity (0.47) and liquid saturation (0.7). This yields a pore velocity of 0.3 m yr^{-1} and a corresponding water travel time from the ground surface to the water table of 112 years for the single-continuum model. Hence in a two-year simulation period, the TCE plume would be advected less than 2 ft. Given the spacing and variability in the observed TCE data, the single-continuum model with a large percolation rate of 100 mm yr^{-1} is consistent with the observed data, for this short time period.

We repeated the two-year simulation with a small NAPL source for the single-continuum model with a small percolation rate of 10 mm yr^{-1}; results are shown in Fig. 5.19. The biggest difference from the 100-mm yr^{-1} case is the noticeably larger contribution of gas-phase diffusion, arising from the lower liquid saturation values. The lower saturation around the NAPL source also means the concentration at 6 ft increases more quickly for the 10-mm yr^{-1} case. When compared to the observed data (Fig. 5.10a), the 100-mm yr^{-1} case matches the 6-ft concentrations better, but the 10-mm yr^{-1} case matches the deeper concentrations better.

We repeated the two-year simulation with a small NAPL source for two versions of the dual-continuum model. T2VOC contains an automated grid-generator called MINC (Multiple Interacting Continua) that converts a single-continuum grid into a dual-continuum grid (Pruess, 1991). The user specifies the volume fraction of each continuum, several geometric parameters that control the interaction between continua (including the characteristic length scale and geometric structure of PFPs), and the material properties of each continuum. In the first case, we assume that the PFPs make up 5% of the subsurface volume, but in the second case only 0.2%.



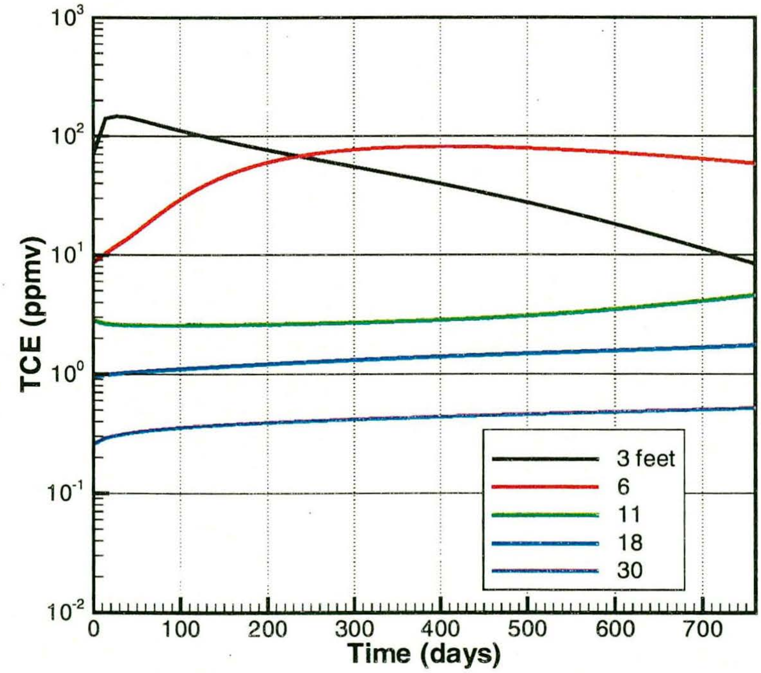


Figure 5.18. Gas-phase TCE concentrations for 1997-1999 simulation with a 1-D single-continuum model and a percolation rate of 100 mm yr^{-1}. (a) concentration versus depth profiles; (b) concentration transients at selected depths.

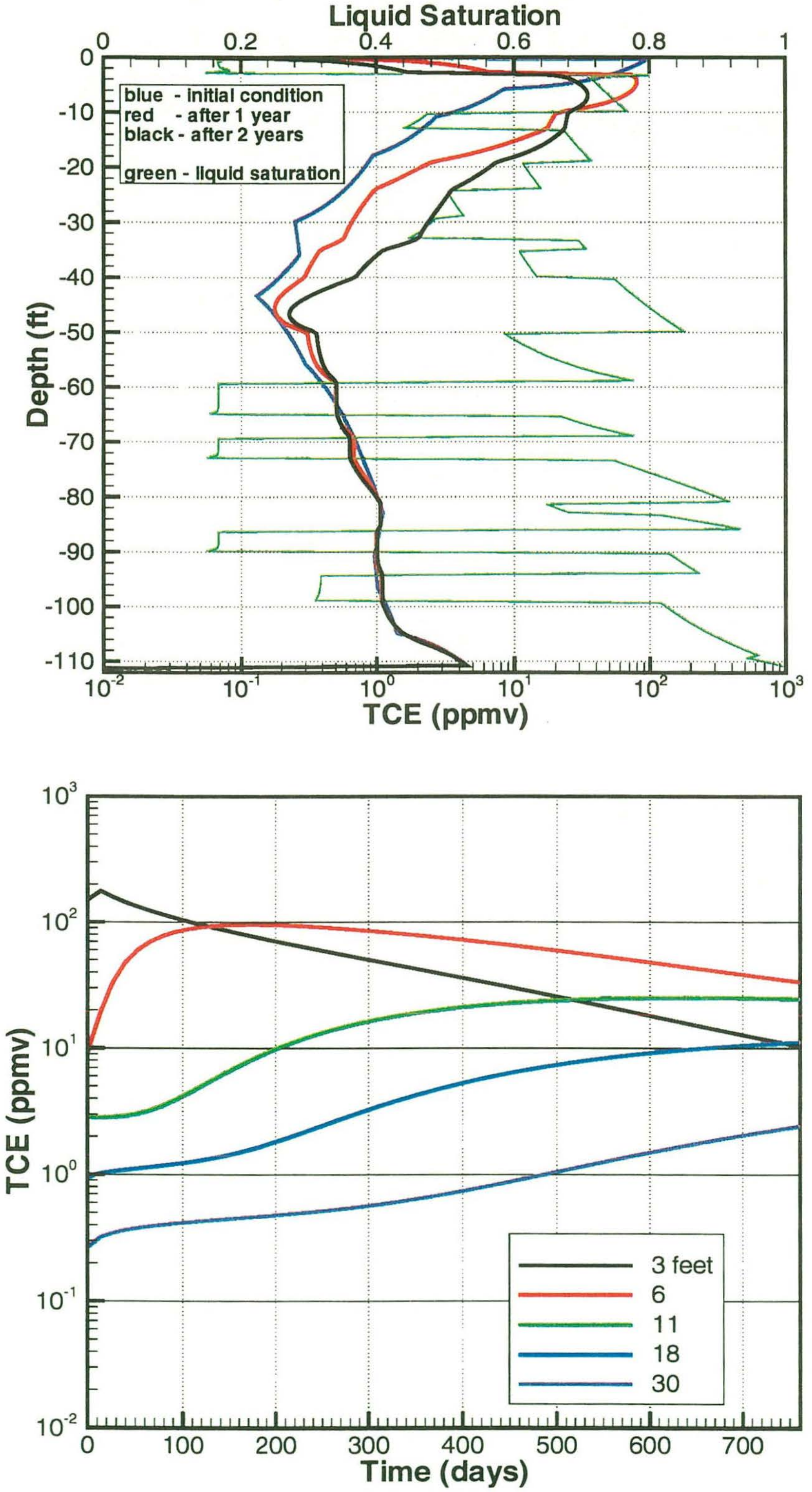
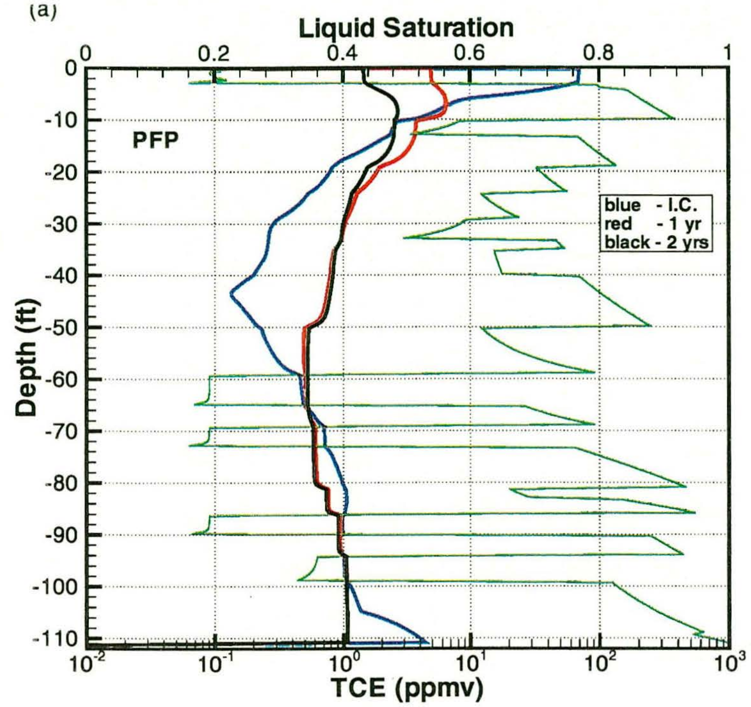


Figure 5.19. Gas-phase TCE concentrations for 1997-1999 simulation with a 1-D single-continuum model and a percolation rate of 10 mm yr^{-1}. (a) concentration versus depth profiles; (b) concentration transients at selected depths.



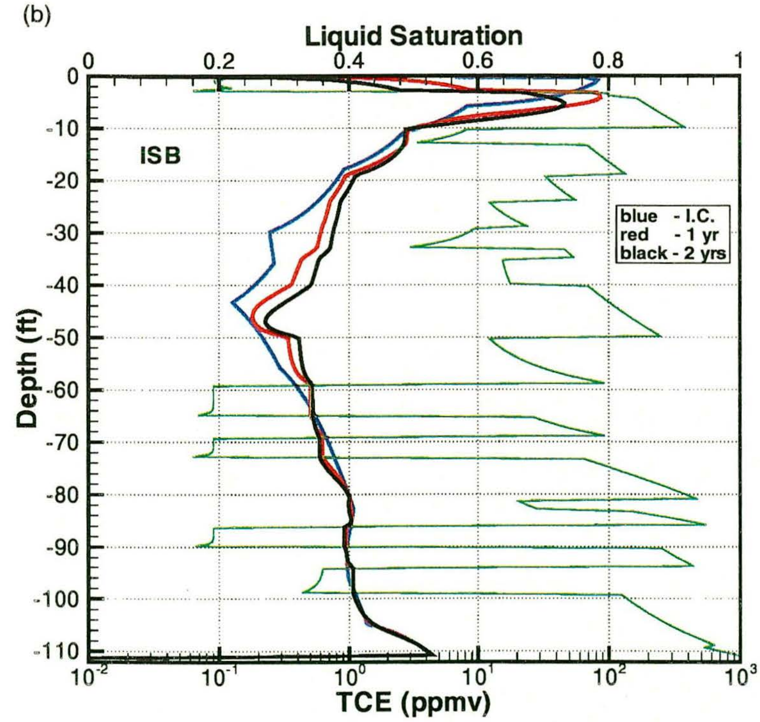


Figure 5.20. Gas-phase TCE concentration versus depth profiles for 1997-1999 simulation with a 1-D dual-continuum model and a percolation rate of 100 mm yr^{-1}. (a) PFPs; (b) ISBs.

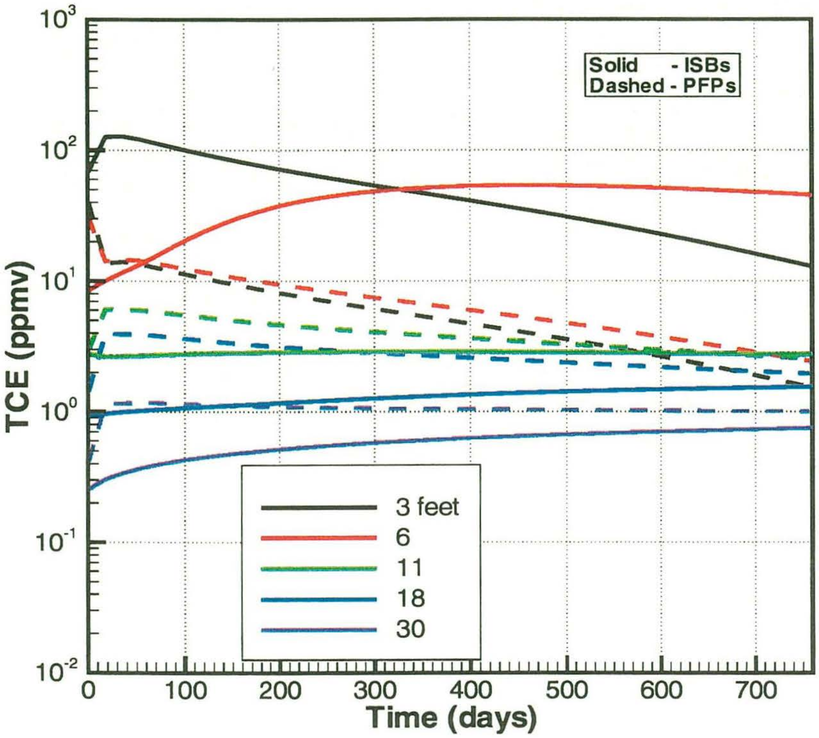


Figure 5.21. Gas-phase TCE concentration transients for 1997-1999 simulation with a 1-D dual-continuum model and a percolation rate of 100 mm yr^{-1}.

These percentages are not based on hard data, but are intended to represent a range of possible configurations. In the first case, the water travel time from the surface to the water table is 6 years, whereas in the second case it is only 3 months. In both cases, we assume typical PFP spacing is 2 m, and the PFPs have a ribbon-like structure (as opposed to a planer structure that might be used to represent a fractured medium). As mentioned above, material properties for the two continua are identical, with the exception that the intrinsic permeability of the ISBs is 100 times lower than that of the PFPs, resulting in initial conditions for the two-year simulation consisting of identical moisture distributions in the two continua, with 100 times less percolation in the ISBs.

For the 5% PFP case, there is a strong interaction between PFPs and ISBs, and both show similar concentration profiles that do not differ greatly from those of the single-continuum model. For the 0.2% case, the situation is noticeably different, as illustrated in Fig. 5.20, which shows the concentration-depth profiles for the two continua. For the PFPs there is a significant advective contribution, whereas for the ISBs the concentration profile is diffusion controlled. The ISB concentration profile affects the PFP profile, increasing shallow concentrations, but because the PFP volume fraction is so small, it does not significantly affect the ISB profile. Recall that for our present conceptual model, the ISB concentrations are the ones to be compared to field data. Fig. 5.21 shows the concentration transients. Those representing the ISBs are reasonably consistent with the observed data.

Our preliminary conclusion from the two-year simulations is that we cannot eliminate either of the first two conceptual models from further consideration. The single-continuum model actually matches the concentration transients a little bit better, but this may not be attributable to the strength of advection. Instead, subtle differences in the details of the liquid saturation profile between the model and the actual system cause differences in gas-phase diffusion that lead to a good match.

5.3.3.6 Thirty-Year Future Simulations (1999-2029)

We took each of the *(r,z)* models described in the thirty-year history simulation section and continued running them for another thirty years. That is, the final conditions of the thirty-year history simulations became the initial conditions for the thirty-year future simulations. Figures 5.22 and 5.23 show the predicted concentration profiles for a series of times for the 100-mm yr^{-1} and 10-mm yr^{-1} cases, respectively. The 1-mm yr^{-1} case and diffusion-only case look generally similar to the 10-mm yr^{-1} case. For all cases, concentration is changing very slowly, with the primary losses occurring to the atmosphere via gas-phase diffusion. There is very little NAPL left for all the cases in which liquid is mobile, but liquid saturation around the source is high, so it is slow to disappear. This is a direct consequence of the way the model was set up, locating the NAPL in a high-saturation, low-permeability zone. But recall that this set up was not chosen arbitrarily – it was required to match the present-day concentration observations. Apparently, if NAPL is to last for thirty years, it is not about to disappear all of a sudden thereafter.

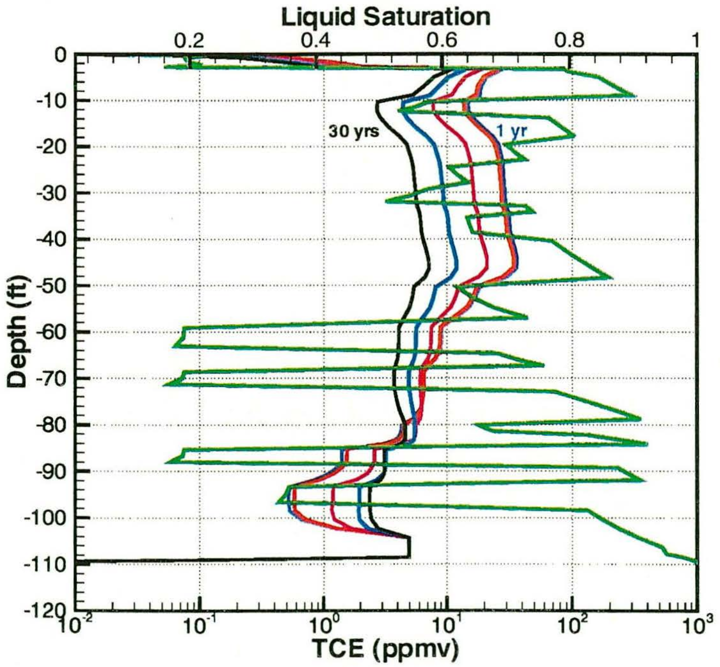


Figure 5.22. Simulated liquid saturation profile (green) and gas-phase TCE concentration profiles at the innermost column of the (r,z) model for the thirty-year future simulation; 100-mm yr^{-1} percolation rate.

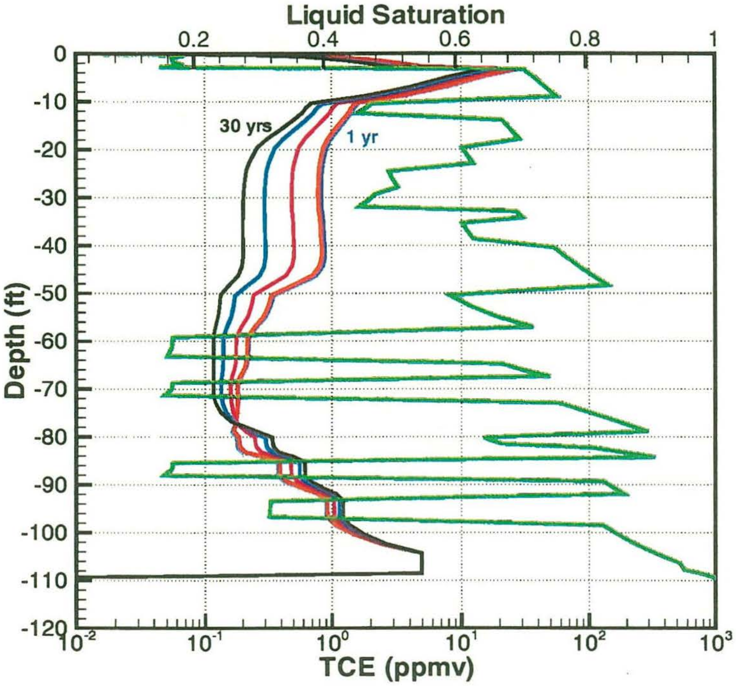


Figure 5.23. Simulated liquid saturation profile (green) and gas-phase TCE concentration profiles at the innermost column of the (r,z) model for the thirty-year future simulation; 10-mm yr^{-1} *percolation rate.*

5.4 CONSTRAINTS, SENSITIVITIES, AND INTERPRETATIONS PROVIDED BY NUMERICAL MODELING

Although all of the model results must be viewed as preliminary, given the great simplicity of the models, we can make the following general observations about the VOC contamination at site S-7, based on analysis of the observed data and comparison with model results.

5.4.1 Constraints on NAPL Source from VOC Concentration Profiles

In order for NAPL to still be present in the system after thirty years of plume evolution, a slow-release, isolated source is required. Once NAPL disappears, it is not possible to maintain the sharp concentration gradients observed in the upper 30 ft of the vadose zone. We have used a low-permeability sediment with strong moisture retention to isolate the NAPL. High liquid saturation means minimal gas-phase diffusion and gas-phase advection; low permeability means low liquid advection. Note that such a sediment cannot form a continuous layer as that would contradict the gas pressure observations. Based on the spatial and temporal variation of TCE concentration in the upper 30 ft (Fig. 5.10a), we believe the source location is between depths of 3 and 6 ft. It is also possible that there is a continuous non-NAPL source consisting of dissolved

TCE in sub-grade flow. This scenario has not been modeled, but it appears to at least qualitatively meet the requirements of the shallow VOC concentration profile.

There also appears to be a source of dissolved TCE and Freon 123a in the groundwater. Because no Freon 123a is observed at shallow depths at site S-7, its presence in the groundwater suggests an upgradient source of contamination. The TCE profile immediately above the groundwater table is similar to that of Freon 123a. Furthermore, TCE concentrations are higher just above the water table than at overlying depths. Therefore, there is likely an off-site source of TCE.

5.4.2 Constraints on Percolation Rate from VOC Concentration Profiles

A high percolation rate (100 mm yr^{-1}) is inconsistent with the observed VOC concentration profile, unless we hypothesize either a dual-continuum model, in which most of the percolation travels through isolated PFPs (which we do not monitor) or an anisotropic medium in which the VOC plume travels diagonally away from our monitoring boreholes. Conversely, we can say that the concentration profiles are best matched with a low percolation rate, but we cannot distinguish whether that low percolation occurs uniformly through a single-continuum, or we are just sampling the ISBs of a dual-continuum. The diagonal flow concept improves the shallow concentration profile, but does not address the concentration increase just above the water table. However, because we have not quantitatively addressed the issue of a declining water table, we can not definitively eliminate a high percolation rate on this basis.

5.4.3 Sensitivity to Temporally Varying Surface Conditions

In previous sensitivity studies (LBNL, 1999b) we examined the effects of different surface boundary conditions, in order to incorporate more realism into the models. We included temporal variations in the surface temperature, atmospheric pressure, and percolation rate applied to the model. These simulations used the single-continuum model with a 100-mm yr^{-1} average percolation rate, and they have since been repeated using the dual-continuum model. Surface temperature variations produce modest concentration changes at depths of 3 and 6 ft, but do not change the overall transport of VOCs. Atmospheric pressure changes and a monthly variable percolation rate produce concentration changes only at the shallowest monitoring location (3 ft), and again do not affect the overall transport of VOCs significantly. However, viewing the precipitation record suggests that a shorter interval than monthly may be necessary to fully capture the transient nature of infiltration at McClellan AFB. For a dual-continuum model with limited interaction between PFPs and ISBs, such short-term transient behavior could have significant effects as PFPs are rapidly flushed out by infiltrating water.

5.4.4 Predicted VOC Flux

Table 5.3 shows the mass fluxes of TCE in the aqueous and gas phases for the single-continuum and dual-continuum models during the two-year simulations (i.e., at the present day). Because the present models are so simple, the estimates of VOC flux should be considered very rough; they are better used for making comparisons between models than quoting absolute values.

In all cases, the maximum aqueous and downward gas fluxes occur shallow in the vadose zone, at and just below the TCE concentration maximum. For the single-continuum models and the ISBs of the dual-continuum model, the fluxes of TCE dissolved in the aqueous phase are proportional to the percolation rate, because the liquid-phase flow occurs by advection with nearly the same concentration profiles. The flux of TCE in the soil gas is slightly larger for the lower percolation rate because of the increased gas-phase diffusion that accompanies lower liquid saturations. Because the ISBs have the same liquid saturation distribution as the single-continuum model with a percolation rate of 100 mm yr^{-1}, the gas fluxes for the two cases are the same.

Table 5.3. TCE fluxes in kg m^{-2} yr^{-1} calculated by T2VOC during the two-year simulations.

	Maximum Aqueous Flux	Aqueous Flux at Water Table	Gas Flux to Atmosphere	Maximum Downward Gas Flux
Single-Continuum Models				
q = 100 mm yr^{-1}	1 x 10^{-4}	6 x 10^{-6}	5 x 10^{-4}	1 x 10^{-4}
q = 10 mm yr^{-1}	1 x 10^{-5}	6 x 10^{-7}	6 x 10^{-4}	2 x 10^{-4}
Dual-Continuum Model q=100 mm yr^{-1}				
PFPs (q = 99 mm yr^{-1})	3 x 10^{-6}	2 x 10^{-6}	3 x 10^{-5}	1 x 10^{-6}
ISBs (q = 1 mm yr^{-1})	1 x 10^{-6}	6 x 10^{-8}	5 x 10^{-4}	1 x 10^{-4}
Total	4 x 10^{-6}	2 x 10^{-6}	6 x 10^{-4}	1 x 10^{-4}

Comparing the PFPs and the ISBs shows that the PFPs may not account for 99 percent of the aqueous flux of TCE, despite carrying 99% of the percolation. This is because the concentration in the PFPs may decrease relatively quickly as the small volume PFPs are flushed out by infiltrating water. In fact, the relatively large contribution of the PFPs to the aqueous flux of TCE shown in Table 5.3 may be an artifact of the assignment of identical initial concentration profiles in the PFPs and the ISBs. In reality, if communication between the PFPs and ISBs is limited, concentrations in the PFPs may be significantly lower than those in the ISBs for all but the early stage of plume evolution. Hence, the aqueous flux of TCE for the various conceptual models differ significantly, indicating that further investigation into the best conceptual model for the McClellan site is warranted.

5.4.5 Limitations and Caveats

As already noted above, the present models represent gross simplifications of nature, and rely on poorly known initial conditions. As such, their predictions must always be viewed cautiously. Just because a particular set of parameters produces a match to some observed data set, this does not guarantee that these parameters accurately describe the subsurface. By combining information from multiple data sets, we make plausible model predictions, but the problem remains inherently poorly posed.

One process not explicitly accounted for in our modeling is water table fluctuation. The water table is known to have declined about 30 ft over the last 30 years. If the groundwater were contaminated when it was shallow, its decline would probably leave a smeared out zone of relatively constant contamination, such as is seen in the middle depths of the TCE profiles. Such a zone is not seen in the Freon 123a data, suggesting it may be a more recent addition to the site. With the present model using a fixed water table, one of the arguments against a high percolation rate is the gradual concentration increase above the water table seen in the TCE and Freon 123a data, which is interpreted as a diffusive transfer from the groundwater. However, it is possible that a declining water table coupled with a high percolation rate could produce the same signature.

5.4.6 Interpretation of Modeling Studies

Because we have not been able to choose a single conceptual model that we feel best describes VOC flow and transport at site S-7, it remains to examine the different features of the candidate conceptual models, and relate them to the various observed data sets.

During the course of these studies, one of our preliminary findings was to eliminate a single-continuum model with vertical percolation, because the hypothesized percolation rate of 100 mm yr^{-1} was inconsistent with the VOC concentration profiles observed in the VZMS wells. This led to the introduction of the more complicated dual-continuum and diagonal flow models. However, if we allow a lower percolation rate, on the order of 10 mm yr^{-1} or less, the simple single-continuum model is consistent with the VOC concentration profiles. While a simpler model is generally preferable to a complicated one, especially when many parameters of the complicated model are unknown or unknowable, we are reluctant to abandon all aspects of the dual-continuum model, for the following reasons.

Subsurface heterogeneity leading to preferential flow is widely accepted as the general condition for vadose zone studies, and VOC concentration patterns at McClellan AFB beyond site S-7 show strong variability. Even within site S-7, we see that permeability values required to explain the gas pressure response to barometric pressure changes differ from core-sample analyses. Furthermore, we must conjecture very different conditions for the NAPL source location (high liquid saturation, low permeability), than are indicated by the gas pressure responses to barometric pressure and air-permeability tests (Section 4).

Thus we hypothesize that although the subsurface is actually heterogeneous, we can treat it locally at the site S-7 scale by considering a single-continuum model with special consideration of the NAPL source, and a low percolation rate. Nearby wells that show VOC concentrations spread over greater depths may be exhibiting the effects of a higher percolation rate. With its combination of paved and unpaved (and imperfectly paved) areas, it is reasonable to expect percolation rate to be spatially variable. This scenario is really not so different from the dual-continuum model with preferential flow paths and isolated sediment blocks, except that here we consider that the PFPs may not arise based on just the geology along the flow path, but also based on where surface infiltration is large.

5.5 VAPOURT MODEL VALIDATION

Model analyses of cis-1,2-DCE transport using VapourT (Mendoza and Frind, 1990a,b; Mendoza, 1992) have been carried out by Jacobs Engineering (Jacobs Engineering, 1998) for site S-7. In this section, we summarize our comparison of prior VapourT model analyses with VZMS data and our own modeling analyses. Because VZMS data represent conditions in particular boreholes at S-7, whereas VapourT predictions are generalized for the S-7 site as a whole, the discussion and evaluation of VapourT predictions is based on a combination of VZMS data and more generalized enhanced data analysis results. A more complete discussion of this comparsion can be found in LBNL (1999b).

VapourT models VOC transport by diffusion, dispersion, and advection in gas and aqueous phases, density-driven gas-phase flow, as well as VOC gas-aqueous phase partitioning including adsorption. Procedures for VapourT modeling at McClellan AFB are set out formally in Jacobs (1998 Engineering, App. B). These procedures involve the identification of the center of mass of the VOC, delineation of a vertical profile of VOC concentrations through the vadose zone, and the specification of a constant percolation rate, chosen as 2.0×10^{-9} m s^{-1} for site S-7. Because of the sparseness of VOC contaminant concentration data, as well as its heterogeneity in both the horizontal and vertical directions, interpolation and extrapolation procedures for defining the initial VOC contaminant distribution based on limited concentration data are defined (Jacobs Engineering, 1998, pp. B19–B25).

Using lithologic data from several boreholes in S-7, and contaminant concentration data from borehole SS7SB08 (see Fig. 1.1), a layered geologic model and an initial profile of cis-1,2-DCE were established by Jacobs Engineering (1998). VapourT predictions using the constant 2.0×10^{-9} m s^{-1} percolation rate lead to downward VOC advection at rates that would bring significant concentrations of VOC to a depth of 12 m (40 ft) after 30 years. VapourT model results predicted leachate concentrations would increase within 70 to 75 years for a two-dimensional radial model grid, while the atmospheric losses would decrease in the next 100 years.

As shown in Figs. 5.10a and 5.10b and discussed in Section 5.3.3.1, TCE and cis-1,2-DCE profiles from the VZMS show consistently high concentrations in the shallow vadose zone, and very low concentrations at depths greater than 20 ft. VapourT predictions using the constant 2.0×10^{-9} m s^{-1} percolation rate lead to downward VOC advection to a depth of 12 m (40 ft) after 30 years, a feature not observed in VZMS data. Our T2VOC simulations for a simple single continuum conceptualization discussed in Section 5.3.3 are similar to the VapourT simulations, and show VOC profiles that are not consistent with VZMS data. In addition, the VapourT predictions are based on initial conditions from borehole SS7SB08 which shows high cis-1,2-DCE contamination at a depth of 8 m (Jacobs Engineering, 1998; Fig. 3.1), a feature not observed in the nearby VZMS wells.

In summary, model predictions that use simple conceptualizations of VOC transport cannot be substantiated by comparison to VZMS data. In particular, the VapourT results for site S-7 using initial conditions from well SS7SB08 as presented by Jacobs Engineering (1998) are not consistent with the site S-7 VZMS data. However, as our discussion in Section 5.4 emphasizes, matching VZMS VOC concentration data with numerical simulation results may require detailed consideration of preferential flow paths through multiple interacting continuum approaches, and two- and three-dimensional aspects of the underlying hydrostratigraphic layers, in particular heterogeneity in permeability and porosity including discrete flow paths. We have endeavored to use the VZMS data to constrain and develop conceptualizations consistent with these data. But the VZMS data represent conditions in the immediate vicinity of the boreholes and may not be representative of site S-7 in general. Without further data from site S-7, we conclude only that VOC data from VZMS-A and -B do not substantiate the generalized VapourT predictions of Jacobs Engineering (1998) that are based on the cis-1,2-DCE concentrations in SS7SB08.

6 CONCLUSIONS AND RECOMMENDATIONS

Vadose zone monitoring and modeling have provided a great deal of insight into the current and future VOC distribution at site S-7. The long-term prediction of VOC distribution is often challenging because of the spatial heterogeneity of both the hydrogeologic characteristics and the VOC plume. In practice, the estimated travel time for VOCs through the vadose zone depends on the conceptual model chosen. For the single-continuum model with 100 mm yr^{-1} percolation rate, the travel time for water is approximately 100 years, with even longer travel times for the smaller percolation rates that we feel are appropriate. However, in the dual-continuum model, travel times for dissolved VOCs can be significantly shorter. One must keep in mind, however, that small travel time does not necessarily correlate with large VOC flux. Preferential flow paths occupy a small fraction of the formation, and VOC transport to these preferential flow paths may be limited by low permeability and high liquid saturation of the sediment blocks. Assuming a 100 m^2 area, the maximum downward aqueous- and gas-phase flow of TCE for the single-continuum model occurs at a depth of approximately 15 ft and is 0.02 kg yr^{-1}. The upward gas flow of TCE out of the system may be 2.5 times this value. Therefore, our analysis and monitoring suggest that downward migration of VOCs at site S-7 is contributing minor amounts of VOCs to the groundwater table regardless of which conceptual model is chosen.

Although previous data, specifically soil-gas samples from SS7SB08, have shown elevated VOC concentrations at a depth of 40 ft, more weight must be given to the VZMS sampling results, for several reasons. First, the SS7SB08 soil gas data are based on a one-time sampling event, whereas the VZMS data were collected over two and a half years. Second, the VZMS data are from three closely-spaced boreholes with multiple-depth sampling ports. Finally, data from all other boreholes in the site S-7 vicinity are in much closer agreement with the VZMS data than SS7SB08 data with respect to VOC distribution. Thus, if we exclude SS7SB08 data from consideration, we may conclude that the bulk of the mass of contaminant has remained in the top 15 ft decades after contaminant release.

In addition to the broad summary stated above, our work has led us to the following conclusions:

- Deep regions of the vadose zone below site S-7 are relatively dry, with matric potentials in the -200 to -325 mbar range. At depths shallower than 5 ft, the formation at site S-7 becomes fully saturated at times.
- The moisture distribution is relatively constant over time. The apparent downward flow of water is effectively slow in terms of its effect on VOC transport and moisture redistribution.
- TCE, cis-1,2-DCE, and Freon 123a are the primary contaminants present in the S-7 subsurface.
- The distribution of these VOCs suggests two separate sources of contamination, one associated with spills of TCE and cis-1,2-DCE on the surface at site S-7 and another associated with the groundwater, suggesting an off-site source of TCE and Freon 123a.

- The sharp VOC gradient in the top 30 ft of the formation indicates that the bulk of the contaminant mass resides near the surface.
- The peak in VOC concentrations is at approximately 7 ft.
- Air-permeability testing shows that effective air permeability is on the order of 10^{-11} to 10^{-12} m^2. The scale dependence of air permeability shows the potential for faster flow on a scale of a few meters.
- In order for the numerical model to reproduce the shallow VOC concentration profiles observed in the VZMS wells, there needs to be a source of TCE and cis-1,2-DCE between 3-6 ft below the ground surface.
- In order for the numerical model to reproduce the VOC concentration profiles just above the water table, there needs to be a source of TCE and Freon 123a in the groundwater, which are transferred upward by gas-phase diffusion.
- The percolation rate at site S-7 appears to be smaller than the 2. x 10^{-9} m s^{-1} (63 mm yr^{-1}) currently used for McClellan AFB modeling. A percolation rate of 10 mm yr^{-1} produces a reasonable match to the observed concentration profiles. The apparent low percolation rate may be interpreted in two ways. The subsurface may act like a layered single-continuum, in which percolation is locally small at site S-7 (perhaps due to surface features). Alternatively, the system may behave like a dual-continuum model containing isolated preferential flow paths that carry much of the infiltration in periodic events and isolated sediment blocks that contain minimal percolation but that contain most of the VOC.
- Based on modeling results, the largest loss of VOC occurs via gas-phase diffusion upward to the ground surface. A smaller amount is advected downward toward the water table along with percolation.
- There is a variety of circumstantial evidence supporting the idea of preferential flow. This includes the following: core-scale permeability measurements that are smaller than field-scale values; inferred existence of a NAPL source that is located in a high-saturation, low-permeability zone; VZMS wells that show different concentration profiles than a nearby well; and apparent percolation past the VZMS wells that is lower than expected. If preferential flow dominates in the vadose zone at site S-7, present-day downward movement of VOC is quite slow, and the primary loss mechanism is to the atmosphere.
- Prior VapourT results for site S-7 using initial conditions from well SS7SB08 and percolation rate of 2 x 10^{-9} m s^{-1} are not consistent with the site S-7 VZMS data.

Based on these findings, we have arrived at a set of recommendations.

- Continue monitoring VOC concentrations and moisture distribution at site S-7. Concentration and moisture redistribution occur slowly therefore requiring an extended period of time to see more than just a snapshot of VOC evolution. A dynamic data set provides far greater constraints on conceptual and mathematical models than does a static data set, meaning that a model calibrated to dynamic data can be used to predict future behavior with greater confidence.

- Additional monitoring or sampling should be undertaken at S-7 to further resolve the apparent heterogeneity in the three-dimensional distribution of VOCs. In particular, VZMS-A, -B, and -C all show small contamination at depths below 25 ft, whereas prior sampling in a nearby well (SS7SB08) showed high VOC concentrations down to a depth of 40 ft. If VOC contamination is mostly confined to the shallow subsurface, excavation may be a simple way to remove most of the source.
- If vapor extraction is used nearby, the existing VZMS instruments at S-7 should be used to monitor the remediation progress.
- Before site S-7 results are used to develop models for other McClellan AFB sites, similarity between site S-7 and the other sites must be established.
- The effects on infiltration of concrete, asphalt, and underlying road-base are poorly understood. Investigation should be directed at determining what role various road surfaces play in controlling infiltration. Effects of cracks, ponding, concentrated runoff at the perimeter, and large permeability of the roadbase gravel may be important. Test beds could be defined at existing areas at McClellan with coverings in various states of cracking, age, thickness, etc. and these could be instrumented with shallow VZMS clusters to monitor infiltration effects. Sprinkler irrigation tests could be performed to mimic rainfall events.
- Further investigation into the importance of preferential flow at McClellan AFB should be undertaken. The main questions to be answered are whether preferential flow is common, and if so, how much contaminant can potentially be transported downward by this mechanism relative to how much contaminant remains isolated from the preferential flow paths. Controlled infiltration experiments could be carried out using dyes and tracers at an uncontaminated site with detailed monitoring including electrical resistance tomography followed by excavation.
- Research into dual continuum models and their applicability to preferential flow in sediments should continue. Modeling and analysis can be directed at studying the differences between discrete flow path models and dual continuum models

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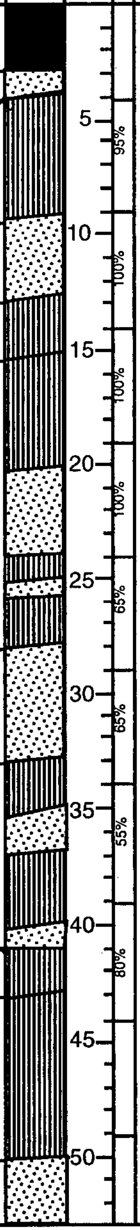
APPENDIX A -- GEOLOGIC LOGS

VZMS-A	SURFACE ELEVATION:	LOGGED BY: **Lisa Gessford**	DATE DRILLED: **12/13/95**	PAGE: **1/2**
DEPTH TO GROUNDWATER: **approx. 110 ft**	DRILLING CONTRACTOR: **Water Development**	BORING EQUIPMENT: **6 5/8" HSA**		DRILL RIG: **CME**

DESCRIPTION AND CLASSIFICATION

DESCRIPTION AND REMARKS	PID readings (ppm)	REMARKS
CONCRETE • fill from 6" to 2.5'		Note: samples named VZMS1 correspond to VZMS-A
SILTY SAND (SM), dark brown, munsell: 3 3/3, mod grading, wet, very fine to mod, subrounded		
CLAYEY SILT (ML), dark grayish brown, munsell: 4 4/2, well graded,wet, very hard		
SILTY SAND (SM), dark grayish brown, munsell: 4 4/2, very fine to fine, subrounded, moist, silt decreasing with depth		VZMS1-SG01N • taken at 0942 • in field: 0 ppm
SANDY SILT (ML), brown, munsell: 10yr 4/3, very fine to fine,dry to damp		
SANDY SILT (ML), with interlayered SILTY SAND (SM), brown, munsell: 5 5/3, dry to damp, mod iron staining • from 21.5 to 24 ft minor iron staining • from 20 to 24 ft SILTY SAND (SM) • from 25 to 26 ft SILTY SAND (SM)		VZMS1-SG02N • in field: 33 ppm
SAND (SM), with traces of silt, dark brown, munsell: 3 3/3, very fine to fine, subrounded, dry, 5 % mica • moderate iron staining • silt lens from 30 to 31 ft		VZMS1-SG03N • taken at 1015 • in field: 0 ppm
SILT (ML), with traces of sand, brown, munsell: 5 5/3, 5-10% mica, interbedded with SILTY SAND (SM) • minor iron staining • no recovery from 34 to 36 ft • sand lens from 36.5 to 37 ft • from 35 to 37 ft SILTY SAND (SM) • from 41 to 42 ft SILTY SAND (SM)		VZMS1-SG04N • taken at 1100 • in field: 0 ppm
CLAYEY SILT (ML), dark yellowish brown, munsell: 4 4/4, less that 5 % mica, dry • abundant iron staining • interbedded hard silt lens 6" thick from 46.5 to 47 ft	0 ppm 0 ppm	
SILTY SAND (SM)		VZMS1-SG05N • taken at 1133 • in field: 0 ppm • OSF



LBNL	EXPLORATORY BORING LOG		
	PROJECT # McClellan VZMS	DATE: 10/17/96	BORING # **VZMS-A**

BORING # **VZMS-A**	SURFACE ELEVATION:	LOGGED BY: **Lisa Gessford**	DATE DRILLED: **12/13/95**	PAGE: **2/2**
DEPTH TO GROUNDWATER: **approx. 110 ft**	DRILLING CONTRACTOR: **Water Development**	BORING EQUIPMENT: **6 5/8" HSA**	DRILL RIG: **CME**	

DESCRIPTION AND CLASSIFICATION

DESCRIPTION AND REMARKS | SOIL TYPE | DEPTH (FEET) | SAMPLE | Penetration Resistance (Blows/ft) | PID readings (ppm) | REMARKS | Well Construction

SILTY SAND (SM) continued

SAND (SW), with traces of silt, very dark gray, munsell: 3 3/1, fine to coarse, subrounded, well graded, 10 % mica

CLAYEY SILT (ML), with traces of sand, brown, munsell: 5 5/3, dry, less than 5 % mica, very hard, abundant iron staining

SAND (ML-SW), with traces of silt, very dark brown, munsell: 3 3/2, very fine to mod, subrounded, less than 5% mica, dry

CLAYEY SILT (ML), brown, munsell: 4 4/3, dry

SAND (SW), very dark gray brown, munsell: 3 3/2, very fine to mod, well graded, subrounded

CLAYEY SILT (ML), with traces of sand, brown, munsell: 5 5/3, dry

SAND (SP), very dark grayish brown, munsell: 3 3/2, very fine to fine, poorly graded, subrounded, less than 5% mica, dry

CLAYEY SILT (ML), with traces of sand, brown, munsell: 5 5/3, dry, very hard

SAND (SW), with traces of silt, very dark gray brown, very fine to coarse, well graded, subrounded, 10 % mica, dry

CLAY (CL), with traces of sand, dry, mod plasticity, minor iron staining

Total drilled depth = 115 ft
- 100 to 115 ft not cored

PID readings (ppm):

0 ppm
0 ppm
0 ppm
0 ppm
0 ppm
0 ppm
0 ppm
0 ppm
0 ppm
0 ppm
0 ppm
0 ppm

REMARKS:

VZMS1-SG06N
- taken at 1157
- in field: 0 ppm

VZMS1-SG07N
- taken at 1405
- in field: 0 ppm

VZMS1-SG08N
- taken at 1440

VZMS1-SG09N
- taken at 1530
- in field: 0 ppm

VZMS1-SG10N
- in field: 0 ppm

Well Construction: see accompanying well construction log

LBNL	EXPLORATORY BORING LOG		
	PROJECT # **McClellan VZMS**	DATE: **10/17/96**	BORING # **VZMS-A**

BORING # **VZMS-B**	SURFACE ELEVATION:	LOGGED BY: **John D Long**	DATE DRILLED: **12/13/95**	PAGE: **1/2**
DEPTH TO GROUNDWATER: **approx. 110 ft**	DRILLING CONTRACTOR: **Water Development**	BORING EQUIPMENT: **6 5/8" HSA**	DRILL RIG: **CME**	

DESCRIPTION AND CLASSIFICATION

DESCRIPTION AND REMARKS

CONCRETE
- fill-gravel from 6" to 2.5 ft

SANDY SILT (SM), brown, 10yr 4/3, wet, indurated, hard

SANDY SILT (SM), 254 5/3, well graded, dry
- changes to silt at 8 ft

SILT (ML), 54 5/2, dry, iron staining at 9 ft

SANDY SILT (ML), well graded, damp

SAND (SP), olive, 54 5/3, fine to coarse, mod graded, 90% quartz, 5% mafic and mica, damp, iron staining in patches
- silty starting at 13 ft

SANDY SILT (ML), dark yellow brown, 10yr 4/4, damp, white carbonate and black rootlets parallel to bedding and vertical, 14 to 18 ft

SILTY SAND (SM), light olive brownm 2.54 5/3, very fine to fine, poorly graded, dry
- iron staining; dark rusting minerals on bedding
- mica prominenent (95% quartz, 5 % mica)
- similar lithology through core

SANDY SILT (ML)

SILTY SAND (SM), light olive borwn, 2.54 5/3, very fine to fine, poorly graded, 95% quartz, 5% mica, damp
- color change at 27 to 28 ft
- parting observed along .5 cm bedding planes, mica (around 29 ft)

SAND (SW-SP), light olive brown, 2.54 5/4, fine to mod, mod graded, subrounded, 90% quartz, 5% mafic, 5-10% mica
- coarse sand, rusty zones for 31 to 33 ft
- return to silty sand for 33 to 34 ft

SILTY SAND (SM), light olive brown, 2.5 5/4, fine to coarse, 5% mica
- coarser sand, lower % silt than overlying sed

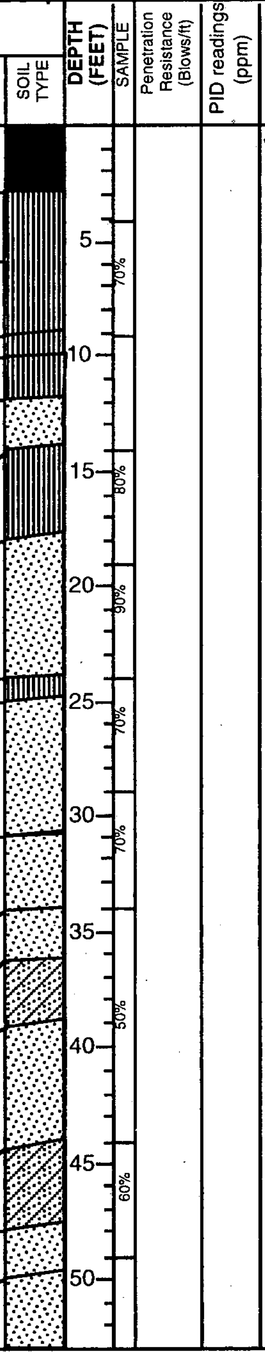
SILTY CLAYEY SAND (SM-SL), very fine to fine, 5% mica

SILTY SAND (SM), light olive brown, 2.54 4/3, very fine to fine, subrounded, dry, indurated
- 43 to 43.5 ft - coarser silty sand
- white carbonate layers at 41 ft
- rusty root holes at 44-45 ft
- trace clay content oscillates in core, clayey silty sand starting at 44 ft

CLAYEY SAND (SC)

SILTY SAND (SM), with traces of clay, yellow brown, 10yr 5/6, very fine to fine, mod graded, subangular, dry

SAND (SW), with traces of silt, dark yellow brown, 10yr 4/4



REMARKS

- start at 1100 hrs
- 3 to 4 ft - only recovery, no samples kept

Note: samples named VZMS2 correspond to VZMS-B

VZMS2-SG01N

VZMS2-SG02
- in field: 53 ppm

VZMS2-SG03N
- taken at 1233
- in field: 5 ppm

VZMS2-SG04N
- in field: 40.9 ppm

VZMS2-SG05N
- in field: 5.6 ppm

Well Construction: see accompanying well construction log

EXPLORATORY BORING LOG

LBNL	PROJECT # **McClellan VZMS**	DATE: **10/21/96**	BORING # **VZMS-B**

BORING # **VZMS-B**	SURFACE ELEVATION:	LOGGED BY: **John D Long**	DATE DRILLED: **12/13/95**	PAGE: **2/2**
DEPTH TO GROUNDWATER: **approx. 110 ft**	DRILLING CONTRACTOR: **Water Development**	BORING EQUIPMENT: **6 5/8" HSA**		DRILL RIG: **CME**

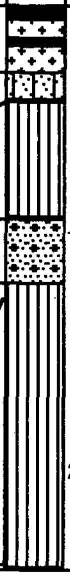
DESCRIPTION AND CLASSIFICATION

DESCRIPTION AND REMARKS	SOIL TYPE	DEPTH (FEET)	SAMPLE	Penetration Resistance (Blows/ft)	PID readings (ppm)	REMARKS	Well Construction
SAND (SW) continued	░		65%				see accompanying well construction log
SANDY SILT (ML), light olive green, 54 6/2, damp, root traces, predominate iron oxidation	▥	55	70%				
SILTY SAND (SM), dark yellow brown, 10yr 4/4, very fine to fine, 1mm holes, well indurated, transition from ML, some crystalline white solids	░						
ILTY SAND (SM), light olive brown, 2.54 5/6, ery fine to mod, mod graded, 95% quartz, 5% mica, oorly indurated, stringers of white crystalline inerals; at 60 ft, changes to SW	░	60	60%			VZMS2-SG06N • taken at 1410 • in field: 6.7 ppm	
SAND (SW), with traces of silt, light olive brown, .54 5/3, very fine to fine, mod graded, subangular, damp, 1-2 mm crystalline solids in sand	░	65					
SANDY SILT (ML), olive gray, 54 4/2, mod graded, 5% mica, moist • also clayey from 69 to 70 ft	▥		70%				
SAND (SW), yellow brown, 10yr 5/4, fine to coarse, well graded, subrounded, 5% mica	░	70	60%			VZMS2-SG07N • in field: 0 ppm	
CLAYEY SILT (ML), light olive brown, 2.54 5/3, damp	▥						
SAND (SW), gray, 54 6/1, fine to coarse, well graded, subrounded, 5% mica, damp, a small 2" wide bed	░	75	60%				
CLAYEY SILT (ML), gray, 54 5/1, dry, indurated • minimal root holes and iron rust noted	▥						
SANDY SILT (ML), olive gray, 54 5/2, very fine to fine	▥	80	100%			VZMS2-SG08N • in field: 0 ppm	
SILTY SAND (SM), olive, 54 5/3, very fine to mod, mod graded, subangular, small cm-wide silt interbeds	░		100%				
SANDY SILT (ML), olive, 54 5/3, damp, indurated silt, no clay	▥	85	100%				
SAND (SP), gray, 54 5/1, very fine to fine, poorly graded, subangular, damp	░		100%				
SANDY SILT (ML), olive gray, 54 5/2, very fine to fine, damp, rootholes, iron rusting and indurated	▥	90	70%			VZMS2-SG09N • taken at 1610 • in field: 0 ppm	
SAND (SP-SW), fine to coarse, mod graded, 5% mafic, 5% mica, damp • color change at 98 ft to rusty orange	░	95	50%				
Total drilled depth = 115 ft • 100 to 115 ft not cored		100				VZMS2-SG10N • in field: 9.8 ppm	

LBNL	EXPLORATORY BORING LOG		
	PROJECT # **McClellan VZMS**	DATE: **10/21/96**	BORING # **VZMS-B**

BORING # **VZMS-C**	SURFACE ELEVATION:	LOGGED BY: **D. Schreiner**	DATE DRILLED: **4/20/98**	PAGE: **1/1**
DEPTH TO GROUNDWATER: **approx. 24 ft**	DRILLING CONTRACTOR: **Water Development**	BORING EQUIPMENT: **HSA**	DRILL RIG: **CME 85**	

DESCRIPTION AND CLASSIFICATION



DESCRIPTION AND REMARKS	SOIL TYPE	DEPTH (FEET)	SAMPLE (%)	Penetration Resistance (Blows/ft)	PID readings (ppm)	REMARKS
• concrete top 4 inches; roadbase gravel fill to 1.5 ft; 2 inches asphalt, roadbase gravel fill to 3 ft.						Notes: 1. Boring terminated at 24 ft. 2. Samples collected by LBNL for potential properties only. 3. Field analysis with PID meter taken in soil samples by CBD/Dolver.
Silty Sand (SM): brown (10YR4/3), fine-grained, poorly graded, weakly cemented, subangular, moist. Sharp contact at 4.2 ft to:			100	16, 25, 31	PID=0	
Silt (ML): light olive brown (2.5Y5/3), moderate plasticity, slow dilatancy, trace fine-grained sand, travc iron staining.		5				
Silt (ML): same as above. Sharp contact at 9 ft.			100	6, 9, 15	PID=0	
Sand (SP): brown (10YR6/3), poorly graded, fine-grained, no cementation, subangular, damp.		10	100	6,11,15	PID=0	
Sand with Silt (SM): brown (10YR4/3), poorly graded, weakly cemented, subangular, damp, root casts up to ? throughout. Sharp contact at 12.6 ft to:						
Silt (ML): light olive brown, low plasticity, slow dilatancy, damp, trace fine-grained sand in shoe.		15				
Sandy Silt (ML): light olive brown, fine-grained sand, slow dilatancy, low to no plasticity, damp.			100	6, 18, 23	PID=0	
		20				
Sandy Silt (ML): same as above.			100	8, 14, 24	PID=0	

LBNL	EXPLORATORY BORING LOG		
	PROJECT # **McClellan VZMS**	DATE: **4/20/98**	BORING # **VZMS-C**

APPENDIX B -- HYDROGEOLOGIC PARAMETERS

Hydraulic Properties of Lawrence Berkeley National Laboratory Soil Samples

Prepared for **Lawrence Berkeley National Laboratory**
Berkeley, California

July 21, 1998

Daniel B. Stephens & Associates, Inc.

6020 Academy NE, Suite 100 • Albuquerque, New Mexico 87109

July 21, 1998

Mr. Peter Zawislanski
Lawrence Berkeley National Laboratory
Earth Sciences Division
Mail Stop 90-1116
Berkeley, CA 94720

Dear Mr. Zawislanski:

Enclosed is the final report for the Lawrence Berkeley National Laboratory samples that we received on May 13, 1998.

All testing results were evaluated subjectively for consistency and reasonableness, and the results appear to be reasonably representative of the material tested. However, DBS&A does not assume any responsibility for interpretations or analyses based on the data enclosed, nor can we guarantee that these data are fully representative of the undisturbed materials at the field site. We recommend that careful evaluation of these laboratory results be made for your particular application.

We are pleased to provide this service to Lawrence Berkeley and look forward to future laboratory testing on other projects. If you have any questions about the enclosed data, please do not hesitate to call.

Sincerely,

DANIEL B. STEPHENS & ASSOCIATES, INC.

Jeff Locke

Jeff Locke
Enclosure

Daniel B. Stephens & Associates, Inc.
6020 Academy NE, Suite 100 505-822-9400
Albuquerque, NM 87109 FAX 505-822-8877

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Table of Contents

List of Appendices

Appendix

Summary

The Hydrologic Testing Laboratory at Daniel B. Stephens & Associates, Inc. (DBS&A) has completed laboratory tests on Lawrence Berkeley National Laboratory soil samples as requested by Peter Zawislanski and summarized in Table 1. Tables 2 through 5 give the results of the specified analyses. Raw laboratory data and graphical plots of data (where appropriate) are contained in the appendices. A detailed description of each method is available upon request.

Overall, the results appear reasonable and internally consistent. However, DBS&A cannot guarantee that these results are representative of the undisturbed materials at the field site, nor can we assume any responsibility for interpretations or analyses based on these data. We recommend that careful evaluation of these laboratory results be made for your particular application.

Table 1. Summary of Tests Performed

Laboratory Sample Number	Initial Soil Properties[1] (ρ_0, θ, ϕ)	Saturated Hydraulic Conductivity[2]		Moisture Characteristics[3]				Unsaturated Hydraulic Conductivity	Particle Size[4]			Effective Porosity	Particle Density	Air Permeability	Atterberg Limits	Proctor Compaction
		CH	FH	HC	PP	TH	RH		DS	WS	H					
VZMS-C 3.5-4	X		X	X	X	X	X	X								
VZMS-C 8.5-9	X	X		X	X	X	X	X								
VZMS-C 12-12.5	X	X		X	X	X		X								
VZMS-C 17.5-18	X	X		X	X	X	X	X								
WELL-1 29-29.5	X	X		X	X	X	X	X								
WELL-1 69.5-70	X	X		X	X	X		X								
WELL-1 79-79.5	X	X		X	X	X	X	X								
WELL-1 79.5-80	X	X		X	X	X	X	X								
WELL-1 109-109.5	X	X		X	X	X		X								

[1] ρ_0 = Initial moisture content, θ = Dry bulk density, ϕ = Calculated porosity

[2] CH = Constant head, FH = falling head

[3] HC = Hanging column, PP = Pressure plate, TH = Thermocouple psychrometer, RH = Relative humidity box

[4] DS = Dry sieve, WS = Wet sieve, H = Hydrometer

Table 2. Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

Sample Number	Initial Moisture Content Gravimetric (%, g/g)	Initial Moisture Content Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
VZMS-C 3.5-4	29.8	42.2	1.41	1.83	46.7
VZMS-C 8.5-9	26.4	40.4	1.53	1.93	42.3
VZMS-C 12-12.5	12.1	20.4	1.68	1.89	36.5
VZMS-C 17.5-18	26.7	36.7	1.38	1.74	48.1
WELL-1 29-29.5	21.6	30.5	1.41	1.71	46.9
WELL-1 69.5-70	6.4	9.3	1.44	1.53	45.6
WELL-1 79-79.5	30.8	42.7	1.38	1.81	47.7
WELL-1 79.5-80	31.3	44.4	1.42	1.86	46.5
WELL-1 109-109.5	14.8	19.8	1.33	1.53	49.7

Table 3. Summary of Saturated Hydraulic Conductivity Tests

Sample Number	K_{sat} (cm/sec)	Method of Analysis Constant Head	 Falling Head
VZMS-C 3.5-4	1.2E-05		X
VZMS-C 8.5-9	1.8E-04	X	
VZMS-C 12-12.5	1.7E-03	X	
VZMS-C 17.5-18	3.6E-04	X	
WELL-1 29-29.5	1.1E-03	X	
WELL-1 69.5-70	1.1E-02	X	
WELL-1 79-79.5	7.0E-04	X	
WELL-1 79.5-80	6.8E-04	X	
WELL-1 109-109.5	9.9E-03	X	

Table 4. Summary of Moisture Characteristics of the Initial Drainage Curve

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
VZMS-C 3.5-4	0	49.3
	23	47.1
	61	44.8
	155	42.5
	510	38.1
	5303	22.2
	35285	16.2
	848426	11.5
VZMS-C 8.5-9	0	50.4
	23	48.9
	53	47.5
	153	44.4
	510	39.6
	3773	20.7
	10708	13.1
	848426	5.8
VZMS-C 12-12.5	0	45.7
	12	44.3
	36	39.4
	73	30.6
	255	25.2
	918	20.3
	4487	15.2
	46401	8.8

Table 4. Summary of Moisture Characteristics of the Initial Drainage Curve (Continued)

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
VZMS-C 17.5-18	0	53.5
	20	50.7
	52	48.7
	149	43.0
	510	37.3
	14583	14.2
	8566	17.7
	848426	6.1
WELL-1 29-29.5	0	50.9
	10	47.7
	41	44.3
	80	38.9
	255	33.7
	6935	11.8
	848426	2.1
WELL-1 69.5-70	0	45.4
	10	43.7
	24	29.8
	65	10.5
	255	9.0
	918	7.6
	27229	3.5
	9280	5.9

Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

	Initial Moisture Content				
Sample Number	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
VZMS-C 3.5-4	29.8	42.2	1.41	1.83	46.7
VZMS-C 8.5-9	26.4	40.4	1.53	1.93	42.3
VZMS-C 12-12.5	12.1	20.4	1.68	1.89	36.5
VZMS-C 17.5-18	26.7	36.7	1.38	1.74	48.1
WELL-1 29-29.5	21.6	30.5	1.41	1.71	46.9
WELL-1 69.5-70	6.4	9.3	1.44	1.53	45.6
WELL-1 79-79.5	30.8	42.7	1.38	1.81	47.7
WELL-1 79.5-80	31.3	44.4	1.42	1.86	46.5
WELL-1 109-109.5	14.8	19.8	1.33	1.53	49.7

Appendix A

Initial Moisture Content, Bulk Density, and Porosity

Table 4. Summary of Moisture Characteristics of the Initial Drainage Curve (Continued)

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
WELL-1 79-79.5	0	53.0
	19	48.9
	50	46.7
	153	44.5
	510	42.5
	10912	7.4
	16827	6.2
	848426	7.2
WELL-1 79.5-80	0	52.7
	21	49.9
	55	48.0
	158	45.9
	510	43.0
	4589	25.2
	848426	8.3
WELL-1 109-109.5	0	51.6
	12	50.9
	27	40.1
	65	24.1
	255	19.7
	918	17.4
	4283	13.0
	38854	8.3

Table 5. Summary of Calculated Unsaturated Hydraulic Properties

	α (cm^{-1})			N (dimensionless)				
	Calculated	95% Confidence Limits		Calculated	95% Confidence Limits		θ_r	θ_s
Sample Number	Value	Lower	Upper	Value	Lower	Upper	(%)	(%)
VZMS-C 3.5-4	0.0045	-0.0001	0.0090	1.3121	1.0916	1.5326	0.0821	0.4773
VZMS-C 8.5-9	0.0022	0.0007	0.0037	1.4758	1.2450	1.7067	0.0421	0.4882
VZMS-C 12-12.5	0.0470	-0.0207	0.1147	1.2794	0.9929	1.5659	0.0485	0.4656
VZMS-C 17.5-18	0.0079	0.0002	0.0156	1.2584	1.0947	1.4220	0.0019	0.5221
WELL-1 29-29.5	0.0162	0.0028	0.0297	1.2939	1.1974	1.3903	0.0000	0.4958
WELL-1 69.5-70	0.0436	0.0297	0.0575	3.0465	1.5027	4.5903	0.0635	0.4553
WELL-1 79-79.5	0.0012	0.0003	0.0022	2.3507	-1.0555	5.7569	0.0629	0.4849
WELL-1 79.5-80	0.0034	-0.0003	0.0072	1.2357	1.1472	1.3241	0.0000	0.5069
WELL-1 109-109.5	0.0426	-0.0060	0.0912	1.9360	0.7862	3.0857	0.1259	0.5315

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name:	Berkeley
Job Number:	8818.01
Sample Number:	VZMS-C 3.5-4
Ring Number:	VZMS-C 3.5-4
Depth:	3.5-4
Test Date:	14-May-98
Field weight of sample* (g):	305.79
Tare weight, ring (g):	48.83
Tare weight, cap/plate/epoxy (g):	113.88
Dry weight of sample (g):	110.19
Sample volume (cm^3):	78.01
Assumed particle density:	2.65

Initial Volumetric Moisture Content (% vol):	42.2
Initial Gravimetric Moisture Content (% g/g):	29.8
Dry bulk density (g/cm^3):	1.41
Wet bulk density (g/cm^3):	1.83
Calculated Porosity (% vol):	46.7
Percent Saturation:	90.3

Comments:

* Weight including tares

Laboratory analysis by: T. Gere
Data entered by: T. Gere
Checked by: J. Locke

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: Berkeley
Job Number: 8818.01
Sample Number: VZMS-C 8.5-9
Ring Number: VZMS-C 8.5-9
Depth: 8.5-9

Test Date: 14-May-98

Field weight of sample* (g): 282.41
Tare weight, ring (g): 41.95
Tare weight, cap/plate/epoxy (g): 113.82

Dry weight of sample (g): 100.16
Sample volume (cm^3): 65.50
Assumed particle density: 2.65

Initial Volumetric Moisture Content (% vol): 40.4
Initial Gravimetric Moisture Content (% g/g): 26.4
Dry bulk density (g/cm^3): 1.53
Wet bulk density (g/cm^3): 1.93
Calculated Porosity (% vol): 42.3
Percent Saturation: 95.6

Comments:

* Weight including tares

Laboratory analysis by: T. Gere
Data entered by: T. Gere
Checked by: J. Locke

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name:	Berkeley
Job Number:	8818.01
Sample Number:	VZMS-C 12-12.5
Ring Number:	VZMS-C 12-12.5
Depth:	12-12.5
Test Date:	14-May-98

Field weight of sample* (g):	397.94
Tare weight, ring (g):	72.23
Tare weight, cap/plate/epoxy (g):	113.80
Dry weight of sample (g):	189.01
Sample volume (cm^3):	112.34
Assumed particle density:	2.65

Initial Volumetric Moisture Content (% vol):	20.4
Initial Gravimetric Moisture Content (% g/g):	12.1
Dry bulk density (g/cm^3):	1.68
Wet bulk density (g/cm^3):	1.89
Calculated Porosity (% vol):	36.5
Percent Saturation:	55.8

Comments:

* Weight including tares

Laboratory analysis by:	T. Gere
Data entered by:	T. Gere
Checked by:	J. Locke

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name:	Berkeley
Job Number:	8818.01
Sample Number:	VZMS-C 17.5-18
Ring Number:	VZMS-C 17.5-18
Depth:	17.5-18
Test Date:	14-May-98
Field weight of sample* (g):	301.59
Tare weight, ring (g):	50.31
Tare weight, cap/plate/epoxy (g):	113.88
Dry weight of sample (g):	108.44
Sample volume (cm^3):	78.86
Assumed particle density:	2.65

Initial Volumetric Moisture Content (% vol):	36.7
Initial Gravimetric Moisture Content (% g/g):	26.7
Dry bulk density (g/cm^3):	1.38
Wet bulk density (g/cm^3):	1.74
Calculated Porosity (% vol):	48.1
Percent Saturation:	76.3

Comments:

* Weight including tares

Laboratory analysis by: T. Gere
Data entered by: T. Gere
Checked by: J. Locke

Daniel B. Stephens & Associates, Inc.

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: Berkeley
Job Number: 8818.01
Sample Number: WELL-1 29-29.5
Ring Number: WELL-1 29-29.5
Depth: 29-29.5

Test Date: 15-May-98

Field weight of sample* (g)*:* 266.07
Tare weight, ring (g)*:* 41.03
Tare weight, cap/plate/epoxy (g)*:* 113.83

Dry weight of sample (g)*:* 91.42
Sample volume (cm^3)*:* 64.95
Assumed particle density: 2.65

Initial Volumetric Moisture Content (% vol)*:* 30.5
Initial Gravimetric Moisture Content (% g/g)*:* 21.6
Dry bulk density (g/cm^3)*:* 1.41
Wet bulk density (g/cm^3)*:* 1.71
Calculated Porosity (% vol)*:* 46.9
Percent Saturation: 65.0

Comments:

* Weight including tares

Laboratory analysis by: T. Gere
Data entered by: T. Gere
Checked by: J. Locke

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: Berkeley
Job Number: 8818.01
Sample Number: WELL-1 69.5-70
Ring Number: WELL-1 69.5-70
Depth: 69.5-70

Test Date: 15-May-98

Field weight of sample* (g)*:* 376.97
Tare weight, ring (g)*:* 76.47
Tare weight, cap/plate/epoxy (g)*:* 113.81

Dry weight of sample (g)*:* 175.40
Sample volume (cm^3)*:* 121.75
Assumed particle density: 2.65

Initial Volumetric Moisture Content (% vol)*:* 9.3

Initial Gravimetric Moisture Content (% g/g)*:* 6.4

Dry bulk density (g/cm^3)*:* 1.44

Wet bulk density (g/cm^3)*:* 1.53

Calculated Porosity (% vol)*:* 45.6

Percent Saturation: 20.3

Comments:

* Weight including tares

Laboratory analysis by: T. Gere
Data entered by: T. Gere
Checked by: J. Locke

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: Berkeley
Job Number: 8818.01
Sample Number: WELL-1 79-79.5
Ring Number: WELL-1 79-79.5
Depth: 79-79.5

Test Date: 15-May-98

Field weight of sample* (g): 279.11
Tare weight, ring (g): 42.62
Tare weight, cap/plate/epoxy (g): 113.84

Dry weight of sample (g): 93.76
Sample volume (cm^3): 67.71
Assumed particle density: 2.65

Initial Volumetric Moisture Content (% vol): 42.7
Initial Gravimetric Moisture Content (% g/g): 30.8
Dry bulk density (g/cm^3): 1.38
Wet bulk density (g/cm^3): 1.81
Calculated Porosity (% vol): 47.7
Percent Saturation: 89.4

Comments:

* Weight including tares

Laboratory analysis by: T. Gere
Data entered by: T. Gere
Checked by: J. Locke

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: Berkeley
Job Number: 8818.01
Sample Number: WELL-1 79.5-80
Ring Number: WELL-1 79.5-80
Depth: 79.5-80

Test Date: 15-May-98

Field weight of sample* (g)*:* 293.70
Tare weight, ring (g)*:* 45.52
Tare weight, cap/plate/epoxy (g)*:* 113.84

Dry weight of sample (g)*:* 102.32
Sample volume (cm^3)*:* 72.19
Assumed particle density: 2.65

Initial Volumetric Moisture Content (% vol)*:* 44.4
Initial Gravimetric Moisture Content (% g/g)*:* 31.3
Dry bulk density (g/cm^3)*:* 1.42
Wet bulk density (g/cm^3)*:* 1.86
Calculated Porosity (% vol)*:* 46.5
Percent Saturation: 95.4

Comments:

* Weight including tares

Laboratory analysis by: T. Gere
Data entered by: T. Gere
Checked by: J. Locke

Daniel B. Stephens & Associates, Inc.

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: Berkeley
Job Number: 8818.01
Sample Number: WELL-1 109-109.5
Ring Number: WELL-1 109-109.5
Depth: 109-109.5

Test Date: 15-May-98

Field weight of sample* (g): 395.74
Tare weight, ring (g): 81.41
Tare weight, cap/plate/epoxy (g): 113.81

Dry weight of sample (g): 174.64
Sample volume (cm^3): 130.95
Assumed particle density: 2.65

Initial Volumetric Moisture Content (% vol): 19.8
Initial Gravimetric Moisture Content (% g/g): 14.8
Dry bulk density (g/cm^3): 1.33
Wet bulk density (g/cm^3): 1.53
Calculated Porosity (% vol): 49.7
Percent Saturation: 39.8

Comments:

* Weight including tares

Laboratory analysis by: T. Gere
Data entered by: T. Gere
Checked by: J. Locke

Appendix B

Saturated Hydraulic Conductivity

Summary of Saturated Hydraulic Conductivity Tests

Sample Number	K_{sat} (cm/sec)	Method of Analysis	
		Constant Head	Falling Head
VZMS-C 3.5-4	1.2E-05		X
VZMS-C 8.5-9	1.8E-04	X	
VZMS-C 12-12.5	1.7E-03	X	
VZMS-C 17.5-18	3.6E-04	X	
WELL-1 29-29.5	1.1E-03	X	
WELL-1 69.5-70	1.1E-02	X	
WELL-1 79-79.5	7.0E-04	X	
WELL-1 79.5-80	6.8E-04	X	
WELL-1 109-109.5	9.9E-03	X	

Saturated Hydraulic Conductivity
Falling Head Method

Job name: Berkeley
Job number: 8818.01
Sample number: VZMS-C 3.5-4
Ring number: VZMS-C 3.5-4
Depth: 3.5-4

Type of water used: TAP
Backpressure (psi)*:* 0.0
Offset (cm)*:* 1.9
Sample length (cm)*:* 4.24
Sample x-sectional area (cm^2)*:* 18.40
Reservoir x-sectional area (cm^2)*:* 0.70

Date	Time	Temp (°C)	Reservoir head (cm)	Corrected head (cm)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:							
01-Jun-98	12:14:21	22.5	34.5	32.6	4504	1.3E-05	1.2E-05
01-Jun-98	13:29:25	22.5	24.6	22.7			
Test # 2:							
01-Jun-98	13:29:25	22.5	24.6	22.7	8943	1.1E-05	1.1E-05
01-Jun-98	15:58:28	22.5	14.1	12.2			
Test # 3:							
02-Jun-98	11:07:26	23.0	56.1	54.2	20308	1.3E-05	1.2E-05
02-Jun-98	16:45:54	23.0	12.5	10.6			

Average Ksat* (cm/sec)*: **1.2E-05**

Intrinsic Permeability* (cm^2)*: **1.2E-10**

Comments:

Laboratory analysis by: T. Gere
Data entered by: T. Gere
Checked by: J. Locke

Saturated Hydraulic Conductivity
Constant Head Method

Job name: Berkeley
Job number: 8818.01
Sample number: VZMS-C 8.5-9
Ring number: VZMS-C 8.5-9
Depth: 8.5-9

Type of water used: TAP
Collection vessel tare (g)*:* 10.70
Sample length (cm)*:* 3.56
Sample diameter (cm)*:* 4.84
Sample x-sectional area (cm^2)*:* 18.40

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
29-May-98	12:32:36	23.0	10.3	51.3	40.6	3831	2.0E-04	1.9E-04
29-May-98	13:36:27							
Test # 2:								
03-Jun-98	10:29:30	23.0	10.2	30.7	20.0	2055	1.8E-04	1.7E-04
03-Jun-98	11:03:45							
Test # 3:								
03-Jun-98	14:31:49	23.0	10.2	46.5	35.8	3693	1.8E-04	1.7E-04
03-Jun-98	15:33:22							

Average Ksat* (cm/sec)*: **1.8E-04**

Intrinsic Permeability* (cm^2)*: **1.8E-09**

Comments:

Laboratory analysis by: T. Gere
Data entered by: T. Gere
Checked by: J. Locke

Saturated Hydraulic Conductivity
Constant Head Method

Job name:	Berkeley	*Type of water used:*	TAP
Job number:	8818.01	*Collection vessel tare* (g):	11.92
Sample number:	VZMS-C 12-12.5	*Sample length* (cm):	6.26
Ring number:	VZMS-C 12-12.5	*Sample diameter* (cm):	4.78
Depth:	12-12.5	*Sample x-sectional area* (cm^2):	17.95

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
26-May-98	10:40:23	23.0	8.1	22.9	11.0	266	1.8E-03	1.7E-03
26-May-98	10:44:49							
Test # 2:								
26-May-98	16:24:56	23.0	8.1	25.7	13.8	323	1.8E-03	1.7E-03
26-May-98	16:30:19							
Test # 3:								
27-May-98	10:23:04	23.0	8.1	28.1	16.1	360	1.9E-03	1.8E-03
27-May-98	10:29:04							

***Average Ksat* (cm/sec): 1.7E-03**

***Intrinsic Permeability* (cm^2): 1.7E-08**

Comments:

Laboratory analysis by: T. Gere
Data entered by: T. Gere
Checked by: J. Locke

Saturated Hydraulic Conductivity
Constant Head Method

Job name:	Berkeley	*Type of water used:*	TAP
Job number:	8818.01	*Collection vessel tare* (g)*:*	10.63
Sample number:	VZMS-C 17.5-18	*Sample length* (cm)*:*	4.34
Ring number:	VZMS-C 17.5-18	*Sample diameter* (cm)*:*	4.81
Depth:	17.5-18	*Sample x-sectional area* (cm^2)*:*	18.17

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
26-May-98	16:25:30	23.0	10.3	18.0	7.4	475	3.6E-04	3.4E-04
26-May-98	16:33:25							
Test # 2:								
27-May-98	10:24:51	23.0	10.3	18.6	8.0	466	4.0E-04	3.7E-04
27-May-98	10:32:37							
Test # 3:								
27-May-98	16:38:08	23.0	10.3	17.8	7.2	423	3.9E-04	3.7E-04
27-May-98	16:45:11							

Average Ksat* (cm/sec)*: **3.6E-04**

Intrinsic Permeability* (cm^2)*: **3.6E-09**

Comments:

Laboratory analysis by: T. Gere
Data entered by: T. Gere
Checked by: J. Locke

Saturated Hydraulic Conductivity
Constant Head Method

Job name:	Berkeley	*Type of water used:*	TAP
Job number:	8818.01	*Collection vessel tare* (g):	10.82
Sample number:	WELL-1 29-29.5	*Sample length* (cm):	3.53
Ring number:	WELL-1 29-29.5	*Sample diameter* (cm):	4.84
Depth:	29-29.5	*Sample x-sectional area* (cm^2):	18.40

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
26-May-98	10:37:56	23.0	9.4	29.0	18.2	323	1.2E-03	1.1E-03
26-May-98	10:43:19							
Test # 2:								
26-May-98	16:23:32	23.0	9.4	28.2	17.4	301	1.2E-03	1.1E-03
26-May-98	16:28:33							
Test # 3:								
27-May-98	16:36:39	23.0	9.4	25.3	14.5	224	1.3E-03	1.2E-03
27-May-98	16:40:23							

***Average Ksat* (cm/sec):** **1.1E-03**

***Intrinsic Permeability* (cm^2):** **1.1E-08**

Comments:

Laboratory analysis by: T. Gere
Data entered by: T. Gere
Checked by: J. Locke

Saturated Hydraulic Conductivity
Constant Head Method

Job name: Berkeley
Job number: 8818.01
Sample number: WELL-1 69.5-70
Ring number: WELL-1 69.5-70
Depth: 69.5-70

Type of water used: TAP
Collection vessel tare (g)*:* 11.82
Sample length (cm)*:* 6.59
Sample diameter (cm)*:* 4.85
Sample x-sectional area (cm^2)*:* 18.47

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
26-May-98	10:37:35	23.0	6.4	28.1	16.2	75	1.2E-02	1.1E-02
26-May-98	10:38:50							
Test # 2:								
26-May-98	16:23:13	23.0	6.4	52.2	40.4	197	1.1E-02	1.1E-02
26-May-98	16:26:30							
Test # 3:								
27-May-98	10:20:37	23.0	6.4	44.6	32.8	166	1.1E-02	1.0E-02
27-May-98	10:23:23							

Average Ksat* (cm/sec)*: **1.1E-02**

Intrinsic Permeability* (cm^2)*: **1.1E-07**

Comments:

Laboratory analysis by: T. Gere
Data entered by: T. Gere
Checked by: J. Locke

Saturated Hydraulic Conductivity
Constant Head Method

Job name: Berkeley
Job number: 8818.01
Sample number: WELL-1 79-79.5
Ring number: WELL-1 79-79.5
Depth: 79-79.5

Type of water used: TAP
Collection vessel tare (g)*:* 11.26
Sample length (cm)*:* 3.68
Sample diameter (cm)*:* 4.84
Sample x-sectional area (cm^2)*:* 18.40

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
22-May-98	12:41:31	23.0	11.2	17.5	6.2	146	7.6E-04	7.1E-04
22-May-98	12:43:57							
Test # 2:								
26-May-98	16:26:02	23.0	11.2	24.3	13.1	299	7.8E-04	7.3E-04
26-May-98	16:31:01							
Test # 3:								
27-May-98	16:38:40	23.0	11.2	24.0	12.7	326	7.0E-04	6.5E-04
27-May-98	16:44:06							

***Average Ksat* (cm/sec):** **7.0E-04**

***Intrinsic Permeability* (cm^2):** **7.0E-09**

Comments:

Laboratory analysis by: T. Gere
Data entered by: T. Gere
Checked by: J. Locke

Saturated Hydraulic Conductivity
Constant Head Method

Job name: Berkeley
Job number: 8818.01
Sample number: WELL-1 79.5-80
Ring number: WELL-1 79.5-80
Depth: 79.5-80

Type of water used: TAP
Collection vessel tare (g)*:* 10.96
Sample length (cm)*:* 3.94
Sample diameter (cm)*:* 4.83
Sample x-sectional area (cm^2)*:* 18.32

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
26-May-98	10:42:04	23.0	11.1	22.3	11.4	298	7.4E-04	6.9E-04
26-May-98	10:47:02							
Test # 2:								
26-May-98	16:27:45	23.0	11.1	22.7	11.8	308	7.4E-04	6.9E-04
26-May-98	16:32:53							
Test # 3:								
27-May-98	10:25:31	23.0	11.1	25.1	14.1	390	7.0E-04	6.6E-04
27-May-98	10:32:01							

Average Ksat* (cm/sec)*: **6.8E-04**

Intrinsic Permeability* (cm^2)*: **6.8E-09**

Comments:

Laboratory analysis by: T. Gere
Data entered by: T. Gere
Checked by: J. Locke

Saturated Hydraulic Conductivity
Constant Head Method

Job name: Berkeley
Job number: 8818.01
Sample number: WELL-1 109-109.5
Ring number: WELL-1 109-109.5
Depth: 109-109.5

Type of water used: TAP
Collection vessel tare (g): 11.93
Sample length (cm): 7.03
Sample diameter (cm): 4.87
Sample x-sectional area (cm^2): 18.63

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
22-May-98	12:42:01	23.0	7.8	18.6	6.6	30	1.1E-02	1.0E-02
22-May-98	12:42:31							
Test # 2:								
26-May-98	10:42:20	23.0	7.8	52.8	40.9	187	1.1E-02	9.9E-03
26-May-98	10:45:27							
Test # 3:								
26-May-98	16:27:59	23.0	7.8	33.4	21.4	98	1.1E-02	9.9E-03
26-May-98	16:29:37							

***Average Ksat* (cm/sec):** **9.9E-03**

***Intrinsic Permeability* (cm^2):** **9.9E-08**

Comments:

Laboratory analysis by: T. Gere
Data entered by: T. Gere
Checked by: J. Locke

Appendix C

Moisture Characteristics

Summary of Moisture Characteristics of the Initial Drainage Curve

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
VZMS-C 3.5-4	0	49.3
	23	47.1
	61	44.8
	155	42.5
	510	38.1
	5303	22.2
	35285	16.2
	848426	11.5
VZMS-C 8.5-9	0	50.4
	23	48.9
	53	47.5
	153	44.4
	510	39.6
	3773	20.7
	10708	13.1
	848426	5.8
VZMS-C 12-12.5	0	45.7
	12	44.3
	36	39.4
	73	30.6
	255	25.2
	918	20.3
	4487	15.2
	46401	8.8

Summary of Moisture Characteristics of the Initial Drainage Curve (Continued)

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
VZMS-C 17.5-18	0	53.5
	20	50.7
	52	48.7
	149	43.0
	510	37.3
	14583	14.2
	8566	17.7
	848426	6.1
WELL-1 29-29.5	0	50.9
	10	47.7
	41	44.3
	80	38.9
	255	33.7
	6935	11.8
	848426	2.1
WELL-1 69.5-70	0	45.4
	10	43.7
	24	29.8
	65	10.5
	255	9.0
	918	7.6
	27229	3.5
	9280	5.9

Summary of Moisture Characteristics of the Initial Drainage Curve (Continued)

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
WELL-1 79-79.5	0	53.0
	19	48.9
	50	46.7
	153	44.5
	510	42.5
	10912	7.4
	16827	6.2
	848426	7.2
WELL-1 79.5-80	0	52.7
	21	49.9
	55	48.0
	158	45.9
	510	43.0
	4589	25.2
	848426	8.3
WELL-1 109-109.5	0	51.6
	12	50.9
	27	40.1
	65	24.1
	255	19.7
	918	17.4
	4283	13.0
	38854	8.3

Moisture Retention Data

Hanging Column/Pressure Plate/Thermocouple

(Main Drainage Curve)

Job Name: Berkeley
Job Number: 8818.01
Sample Number: VZMS-C 3.5-4
Ring Number: VZMS-C 3.5-4
Depth: 3.5-4

Dry wt. of sample (g)*:* 110.19
Tare wt., screen & clamp (g)*:* 23.94
Tare wt., ring (g)*:* 48.83
Tare wt., epoxy (g)*:* 0.00
Sample volume (cm^3)*:* 78.01

Saturated weight at 0 cm tension* (g)*:* 221.39
Volume of water† *in saturated sample* (cm^3)*:* 38.43
Saturated moisture content (% vol)*:* 49.26

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	03-Jun-98 / 10:50	221.39	0.00	49.26
	08-Jun-98 / 12:30	219.73	23.20	47.14
	11-Jun-98 / 08:42	217.88	61.20	44.76
	15-Jun-98 / 10:25	216.11	154.60	42.49
Pressure plate:	18-Jun-98 / 10:10	212.70	509.90	38.12

Dry weight of thermocouple sample* (g)*:* 275.80
Tare weight, jar (g)*:* 165.61
Sample bulk density (g/cm^3)*:* 1.41

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Thermocouple:	25-Jun-98 / 11:00	293.15	5303.0	22.24
	25-Jun-98 / 17:20	288.41	35285.1	16.16

Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: T. Gere/J. Locke
Data entered by: T. Gere
Checked by: J. Locke

Moisture Retention Data
Relative Humidity Box
(Main Drainage Curve)

Job Name: Berkeley
Job Number: 8818.01
Sample Number: VZMS-C 3.5-4
Ring Number: VZMS-C 3.5-4
Depth: 3.5-4

Dry weight of relative humidity box sample* (g): 51.13
Tare weight (g): 40.11
Sample bulk density (g/cm^3): 1.41

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content[†] (% vol)
Relative humidity box:	14-Jul-98 / 08:05	52.03	848426	11.53

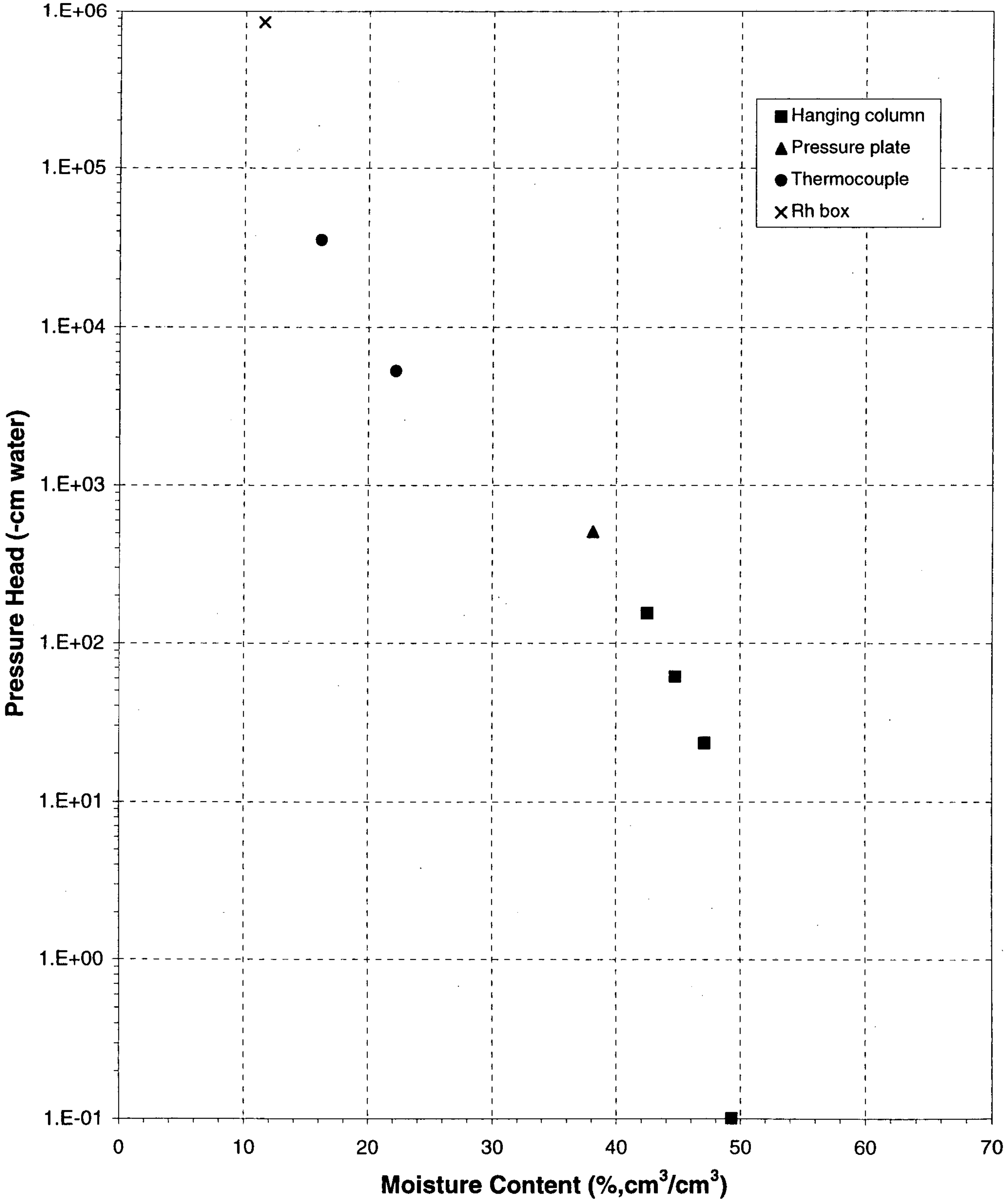
Comments:

* Weight including tares
[†] Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: J. Locke
Data entered by: T. Gere
Checked by: J. Locke

Water Retention Data Points

Sample Number: VZMS-C 3.5-4



Moisture Retention Data

Hanging Column/Pressure Plate/Thermocouple

(Main Drainage Curve)

Job Name:	Berkeley	*Dry wt. of sample* (g):	100.16
Job Number:	8818.01	*Tare wt., screen & clamp* (g):	23.22
Sample Number:	VZMS-C 8.5-9	*Tare wt., ring* (g):	41.95
Ring Number:	VZMS-C 8.5-9	*Tare wt., epoxy* (g):	0.00
Depth:	8.5-9	*Sample volume* (cm^3):	65.50

Saturated weight at 0 cm tension* (g): 198.35

Volume of water† *in saturated sample* (cm^3): 33.02

Saturated moisture content (% vol): 50.41

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	03-Jun-98 / 16:50	198.35	0.00	50.41
	08-Jun-98 / 12:40	197.33	22.80	48.86
	11-Jun-98 / 09:10	196.44	53.30	47.50
	15-Jun-98 / 10:30	194.44	152.70	44.44
Pressure plate:	18-Jun-98 / 10:05	191.25	509.90	39.57

Dry weight of thermocouple sample* (g): 267.83

Tare weight, jar (g): 167.67

Sample bulk density (g/cm^3): 1.53

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Thermocouple:	25-Jun-98 / 11:30	281.42	3773.3	20.75
	25-Jun-98 / 17:15	276.40	10707.9	13.08

Comments:

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: T. Gere/J. Locke
Data entered by: T. Gere
Checked by: J. Locke

Moisture Retention Data

Relative Humidity Box

(Main Drainage Curve)

Job Name: Berkeley
Job Number: 8818.01
Sample Number: VZMS-C 8.5-9
Ring Number: VZMS-C 8.5-9
Depth: 8.5-9

Dry weight of relative humidity box sample* (g): 54.80
Tare weight (g): 39.83
Sample bulk density (g/cm^3): 1.53

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content[T] (% vol)
Relative humidity box:	14-Jul-98 / 08:10	55.37	848426	5.80

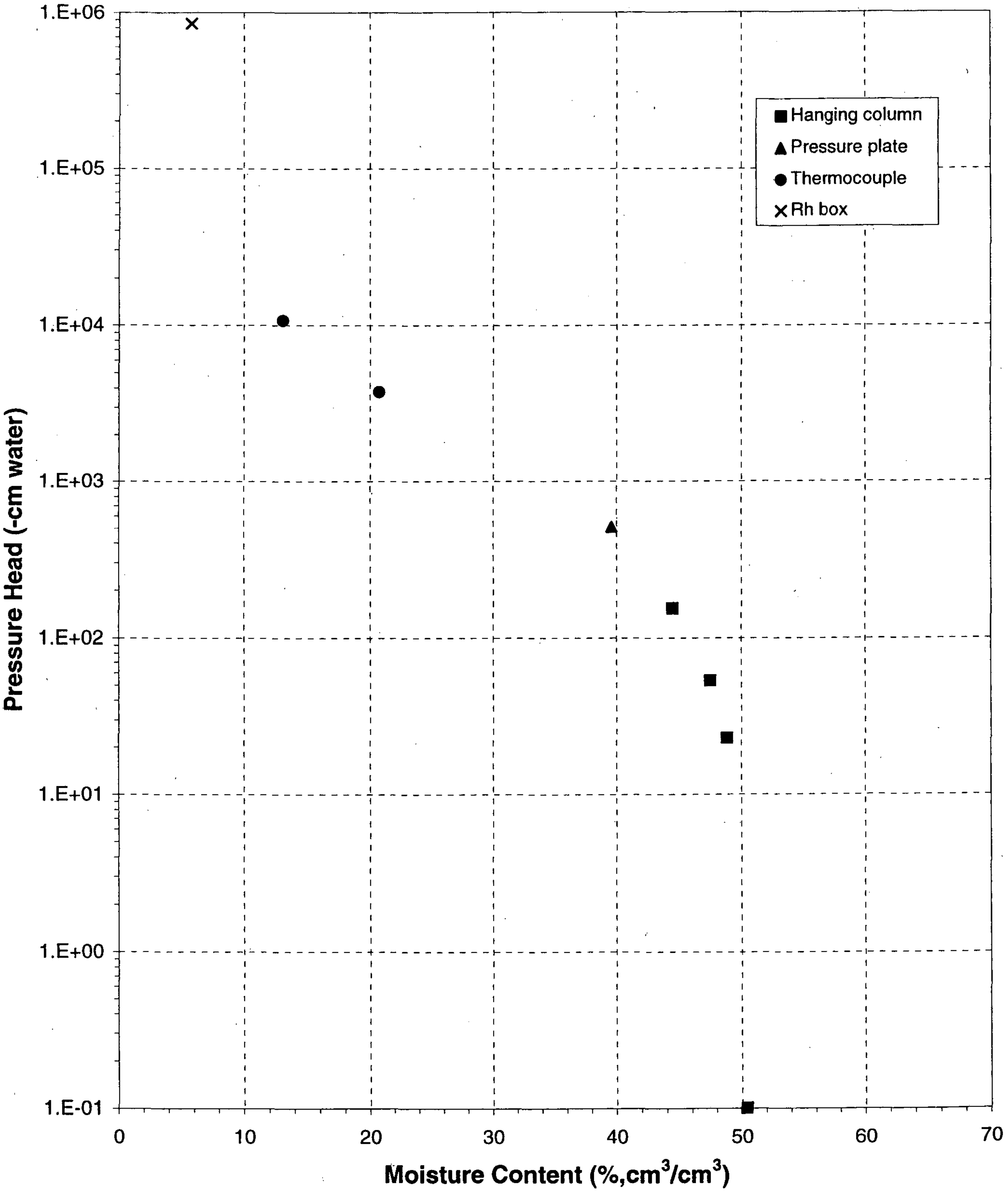
Comments:

* Weight including tares
[†] Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: J. Locke
Data entered by: T. Gere
Checked by: J. Locke

Water Retention Data Points

Sample Number: VZMS-C 8.5-9



Moisture Retention Data

Hanging Column/Pressure Plate/Thermocouple

(Main Drainage Curve)

Job Name:	Berkeley	*Dry wt. of sample* (g):	189.01
Job Number:	8818.01	*Tare wt., screen & clamp* (g):	23.42
Sample Number:	VZMS-C 12-12.5	*Tare wt., ring* (g):	72.23
Ring Number:	VZMS-C 12-12.5	*Tare wt., epoxy* (g):	0.00
Depth:	12-12.5	*Sample volume* (cm^3):	112.34

Saturated weight at 0 cm tension* (g): 336.01
Volume of water[†] *in saturated sample* (cm^3): 51.35
Saturated moisture content (% vol): 45.71

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content[T] (% vol)
Hanging column:	28-May-98 / 16:10	336.01	0.00	45.71
	01-Jun-98 / 11:20	334.42	11.80	44.30
	04-Jun-98 / 11:30	328.97	36.20	39.44
	08-Jun-98 / 12:52	319.00	73.10	30.57
Pressure plate:	11-Jun-98 / 08:15	312.95	254.95	25.18
	15-Jun-98 / 10:00	307.45	917.82	20.29

Dry weight of thermocouple sample* (g): 395.34
Tare weight, jar (g): 206.33
Sample bulk density (g/cm^3): 1.68

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content[T] (% vol)
Thermocouple:	24-Jun-98 / 10:50	412.40	4487.1	15.19
	25-Jun-98 / 11:20	405.26	46400.9	8.83

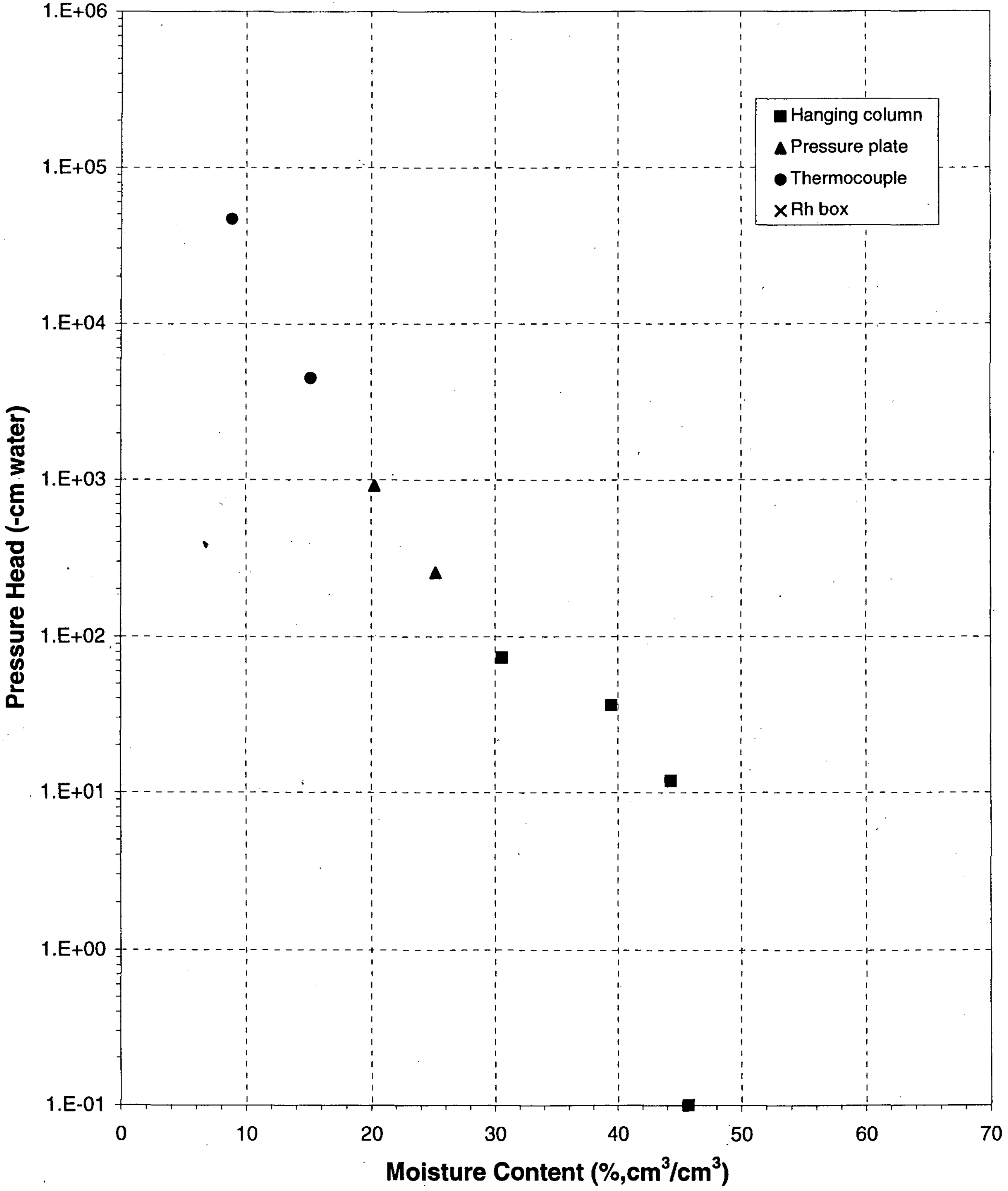
Comments:

* Weight including tares
[†] Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: T. Gere/J. Locke
Data entered by: T. Gere
Checked by: J. Locke

Water Retention Data Points

Sample Number: VZMS-C 12-12.5



Moisture Retention Data

Hanging Column/Pressure Plate/Thermocouple

(Main Drainage Curve)

Job Name:	Berkeley	*Dry wt. of sample* (g):	108.44
Job Number:	8818.01	*Tare wt., screen & clamp* (g):	23.12
Sample Number:	VZMS-C 17.5-18	*Tare wt., ring* (g):	50.31
Ring Number:	VZMS-C 17.5-18	*Tare wt., epoxy* (g):	0.00
Depth:	17.5-18	*Sample volume* (cm^3):	78.86

Saturated weight at 0 cm tension* (g): 224.04
Volume of water[†] *in saturated sample* (cm^3): 42.17
Saturated moisture content (% vol): 53.47

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content[†] (% vol)
Hanging column:	28-May-98 / 14:30	224.04	0.00	53.47
	01-Jun-98 / 11:35	221.83	20.40	50.67
	04-Jun-98 / 11:35	220.24	51.80	48.65
	08-Jun-98 / 13:15	215.75	148.70	42.96
Pressure plate:	11-Jun-98 / 08:40	211.28	509.90	37.29

Dry weight of thermocouple sample* (g): 276.01
Tare weight, jar (g): 167.57
Sample bulk density (g/cm^3): 1.38

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content[†] (% vol)
Thermocouple:	25-Jun-98 / 11:15	287.22	14583.1	14.21
	25-Jun-98 / 17:10	289.93	8566.3	17.65

Comments:

* Weight including tares
[†] Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: T. Gere/J. Locke
Data entered by: T. Gere
Checked by: J. Locke

Moisture Retention Data
Relative Humidity Box
(Main Drainage Curve)

Job Name: Berkeley
Job Number: 8818.01
Sample Number: VZMS-C 17.5-18
Ring Number: VZMS-C 17.5-18
Depth: 17.5-18

Dry weight of relative humidity box sample* (g): 48.55
Tare weight (g): 34.60
Sample bulk density (g/cm^3): 1.38

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content[†] (% vol)
Relative humidity box:	14-Jul-98 / 08:10	49.17	848426	6.08

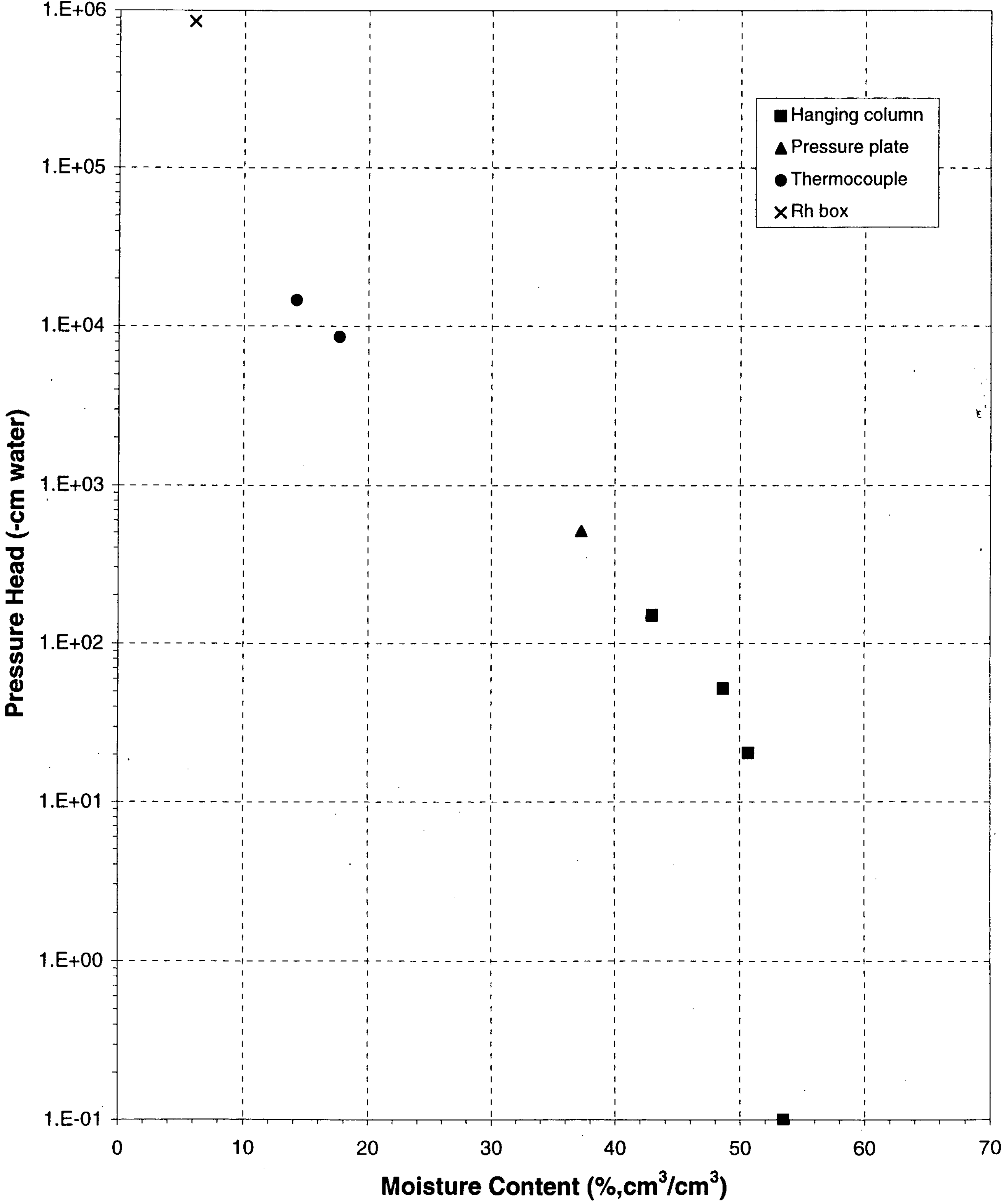
Comments:

* Weight including tares
[†] Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: J. Locke
Data entered by: T. Gere
Checked by: J. Locke

Water Retention Data Points

Sample Number: VZMS-C 17.5-18



Moisture Retention Data

Hanging Column/Pressure Plate/Thermocouple

(Main Drainage Curve)

Job Name:	Berkeley	*Dry wt. of sample* (g):	91.42
Job Number:	8818.01	*Tare wt., screen & clamp* (g):	24.19
Sample Number:	WELL-1 29-29.5	*Tare wt., ring* (g):	41.03
Ring Number:	WELL-1 29-29.5	*Tare wt., epoxy* (g):	0.00
Depth:	29-29.5	*Sample volume* (cm^3):	64.95

Saturated weight at 0 cm tension* (g): 189.72
Volume of water† *in saturated sample* (cm^3): 33.08
Saturated moisture content (% vol): 50.93

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	29-May-98 / 13:00	189.72	0.00	50.93
	01-Jun-98 / 12:00	187.62	10.40	47.70
	04-Jun-98 / 11:40	185.40	41.10	44.28
	08-Jun-98 / 13:05	181.92	80.00	38.92
Pressure plate:	11-Jun-98 / 08:30	178.55	254.95	33.74

Dry weight of thermocouple sample* (g): 265.35
Tare weight, jar (g): 173.93
Sample bulk density (g/cm^3): 1.41

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Thermocouple:	25-Jun-98 / 11:15	273.04	6934.6	11.84

Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: T. Gere/J. Locke
Data entered by: T. Gere
Checked by: J. Locke

Moisture Retention Data

Relative Humidity Box

(Main Drainage Curve)

Job Name: Berkeley
Job Number: 8818.01
Sample Number: WELL-1 29-29.5
Ring Number: WELL-1 29-29.5
Depth: 29-29.5

Dry weight of relative humidity box sample* (g)*:* 62.18
Tare weight (g)*:* 43.53
Sample bulk density (g/cm^3)*:* 1.41

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content^T (% vol)
Relative humidity box:	14-Jul-98 / 08:15	62.46	848426	2.08

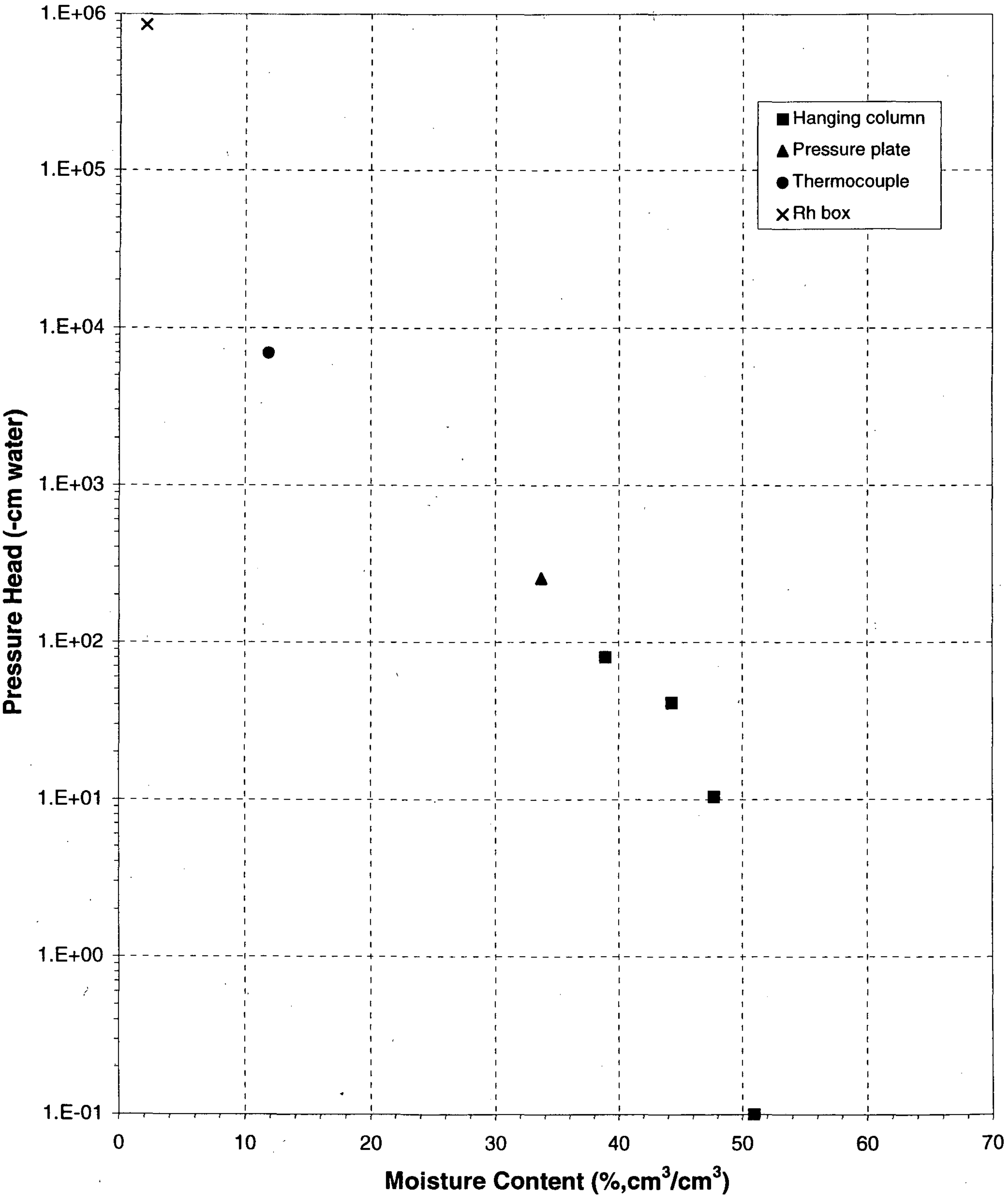
Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: J. Locke
Data entered by: T. Gere
Checked by: J. Locke

Water Retention Data Points

Sample Number: WELL-1 29-29.5



Moisture Retention Data

Hanging Column/Pressure Plate/Thermocouple

(Main Drainage Curve)

Job Name:	Berkeley	*Dry wt. of sample* (g):	175.40
Job Number:	8818.01	*Tare wt., screen & clamp* (g):	23.01
Sample Number:	WELL-1 69.5-70	*Tare wt., ring* (g):	76.47
Ring Number:	WELL-1 69.5-70	*Tare wt., epoxy* (g):	0.00
Depth:	69.5-70	*Sample volume* (cm^3):	121.75

Saturated weight at 0 cm tension* (g): 330.16
Volume of water[†] *in saturated sample* (cm^3): 55.28
Saturated moisture content (% vol): 45.41

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content[T] (% vol)
Hanging column:	28-May-98 / 16:00	330.16	0.00	45.41
	01-Jun-98 / 11:15	328.07	10.20	43.69
	04-Jun-98 / 11:18	311.17	24.40	29.81
	08-Jun-98 / 12:45	287.66	65.40	10.50
Pressure plate:	11-Jun-98 / 08:10	285.88	254.95	9.04
	15-Jun-98 / 10:10	284.08	917.82	7.56

Dry weight of thermocouple sample* (g): 381.92
Tare weight, jar (g): 206.52
Sample bulk density (g/cm^3): 1.44

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content[T] (% vol)
Thermocouple:	24-Jun-98 / 11:10	386.23	27228.7	3.54
	25-Jun-98 / 11:30	389.05	9280.2	5.86

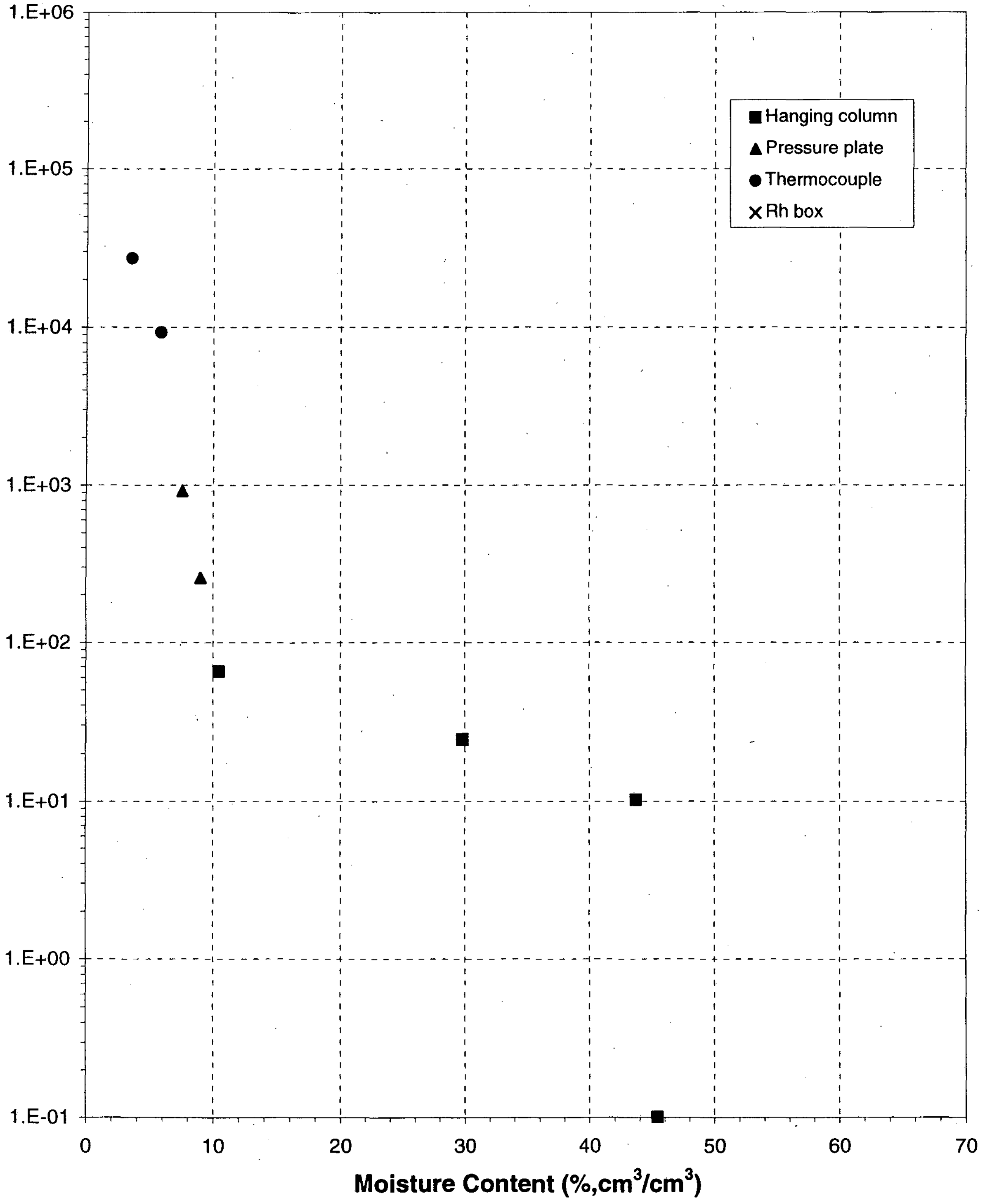
Comments:

* Weight including tares
[†] Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: T. Gere/J. Locke
Data entered by: T. Gere
Checked by: J. Locke

Water Retention Data Points

Sample Number: WELL-1 69.5-70



Moisture Retention Data

Hanging Column/Pressure Plate/Thermocouple

(Main Drainage Curve)

Job Name:	Berkeley	*Dry wt. of sample* (g):	93.76
Job Number:	8818.01	*Tare wt., screen & clamp* (g):	23.30
Sample Number:	WELL-1 79-79.5	*Tare wt., ring* (g):	42.62
Ring Number:	WELL-1 79-79.5	*Tare wt., epoxy* (g):	0.00
Depth:	79-79.5	*Sample volume* (cm^3):	67.71

Saturated weight at 0 cm tension* (g): 195.55
Volume of water† *in saturated sample* (cm^3): 35.87
Saturated moisture content (% vol): 52.98

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	29-May-98 / 13:00	195.55	0.00	52.98
	01-Jun-98 / 12:10	192.77	18.60	48.87
	04-Jun-98 / 11:45	191.32	50.30	46.73
	08-Jun-98 / 13:10	189.82	153.40	44.52
Pressure plate:	11-Jun-98 / 08:40	188.47	509.90	42.52

Dry weight of thermocouple sample* (g): 260.57
Tare weight, jar (g): 16.81
Sample bulk density (g/cm^3): 1.38

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Thermocouple:	25-Jun-98 / 11:30	273.61	10911.9	7.41
	25-Jun-98 / 17:20	271.54	16826.7	6.23

Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: T. Gere/J. Locke
Data entered by: T. Gere
Checked by: J. Locke

Moisture Retention Data

Relative Humidity Box

(Main Drainage Curve)

Job Name: Berkeley
Job Number: 8818.01
Sample Number: WELL-1 79-79.5
Ring Number: WELL-1 79-79.5
Depth: 79-79.5

Dry weight of relative humidity box sample* (g): 62.03
Tare weight (g): 41.63
Sample bulk density (g/cm^3): 1.38

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Relative humidity box:	14-Jul-98 / 08:15	63.08	848426	7.16

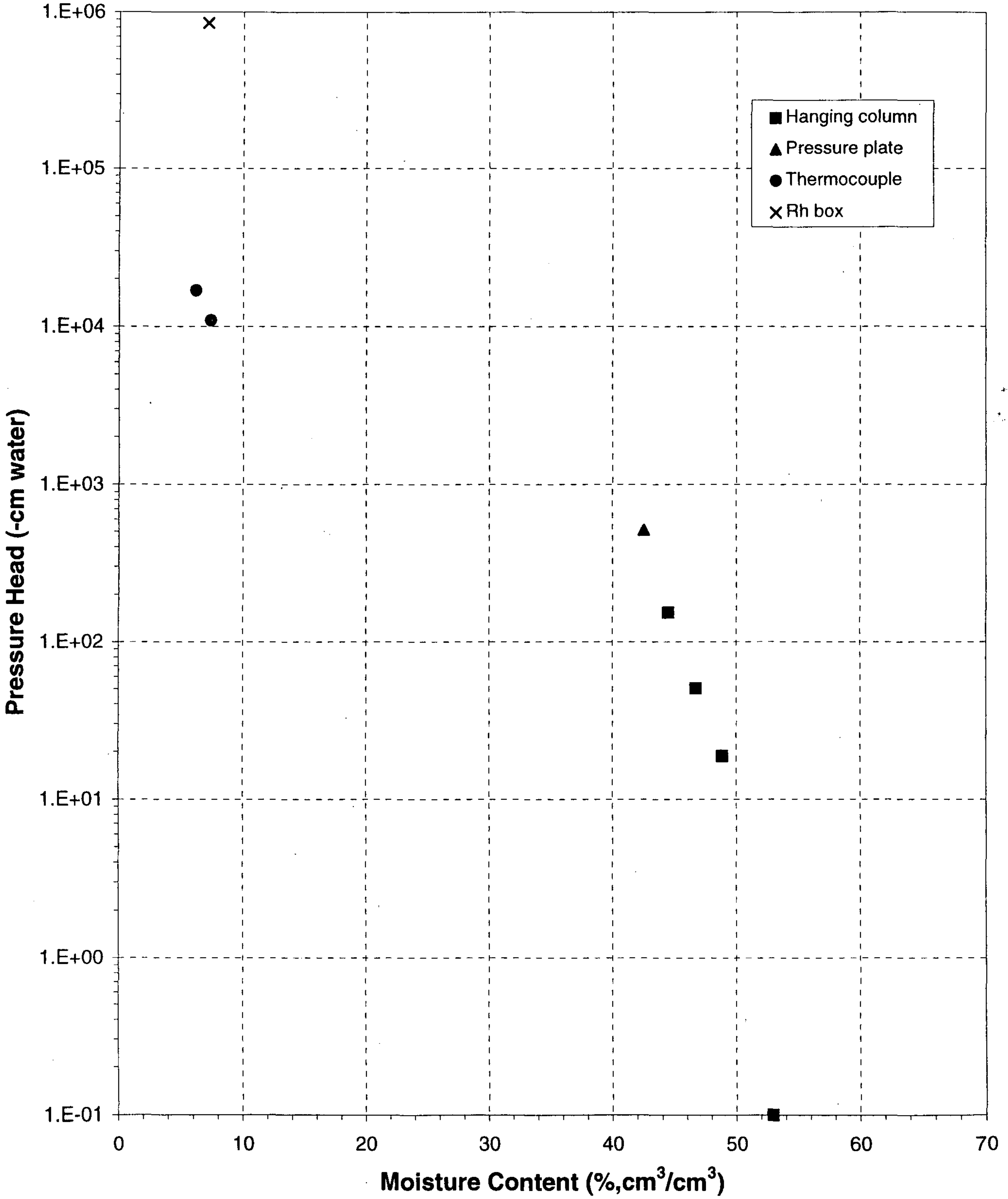
Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: J. Locke
Data entered by: T. Gere
Checked by: J. Locke

Water Retention Data Points

Sample Number: WELL-1 79-79.5



Moisture Retention Data

Hanging Column/Pressure Plate/Thermocouple

(Main Drainage Curve)

Job Name: Berkeley
Job Number: 8818.01
Sample Number: WELL-1 79.5-80
Ring Number: WELL-1 79.5-80
Depth: 79.5-80

Dry wt. of sample (g)*:* 102.32
Tare wt., screen & clamp (g)*:* 23.20
Tare wt., ring (g)*:* 45.52
Tare wt., epoxy (g)*:* 0.00
Sample volume (cm^3)*:* 72.19

Saturated weight at 0 cm tension* (g)*:* 209.09
Volume of water[†] *in saturated sample* (cm^3)*:* 38.05
Saturated moisture content (% vol)*:* 52.71

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content[†] (% vol)
Hanging column:	28-May-98 / 16:45	209.09	0.00	52.71
	01-Jun-98 / 11:35	207.04	20.70	49.87
	08-Jun-98 / 13:00	205.70	54.80	48.01
	11-Jun-98 / 09:30	204.17	157.70	45.89
Pressure plate:	15-Jun-98 / 10:10	202.07	509.90	42.98

Dry weight of thermocouple sample* (g)*:* 272.27
Tare weight, jar (g)*:* 169.95
Sample bulk density (g/cm^3)*:* 1.42

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content[†] (% vol)
Thermocouple:	25-Jun-98 / 11:15	290.45	4589.1	25.18

Comments:

* Weight including tares

[†] Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: T. Gere/J. Locke
Data entered by: T. Gere
Checked by: J. Locke

Moisture Retention Data
Relative Humidity Box
(Main Drainage Curve)

Job Name: Berkeley
Job Number: 8818.01
Sample Number: WELL-1 79.5-80
Ring Number: WELL-1 79.5-80
Depth: 79.5-80

Dry weight of relative humidity box sample* (g)*:* 59.14
Tare weight (g)*:* 42.28
Sample bulk density (g/cm^3)*:* 1.42

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content[†] (% vol)
Relative humidity box:	14-Jul-98 / 08:15	60.13	848426	8.31

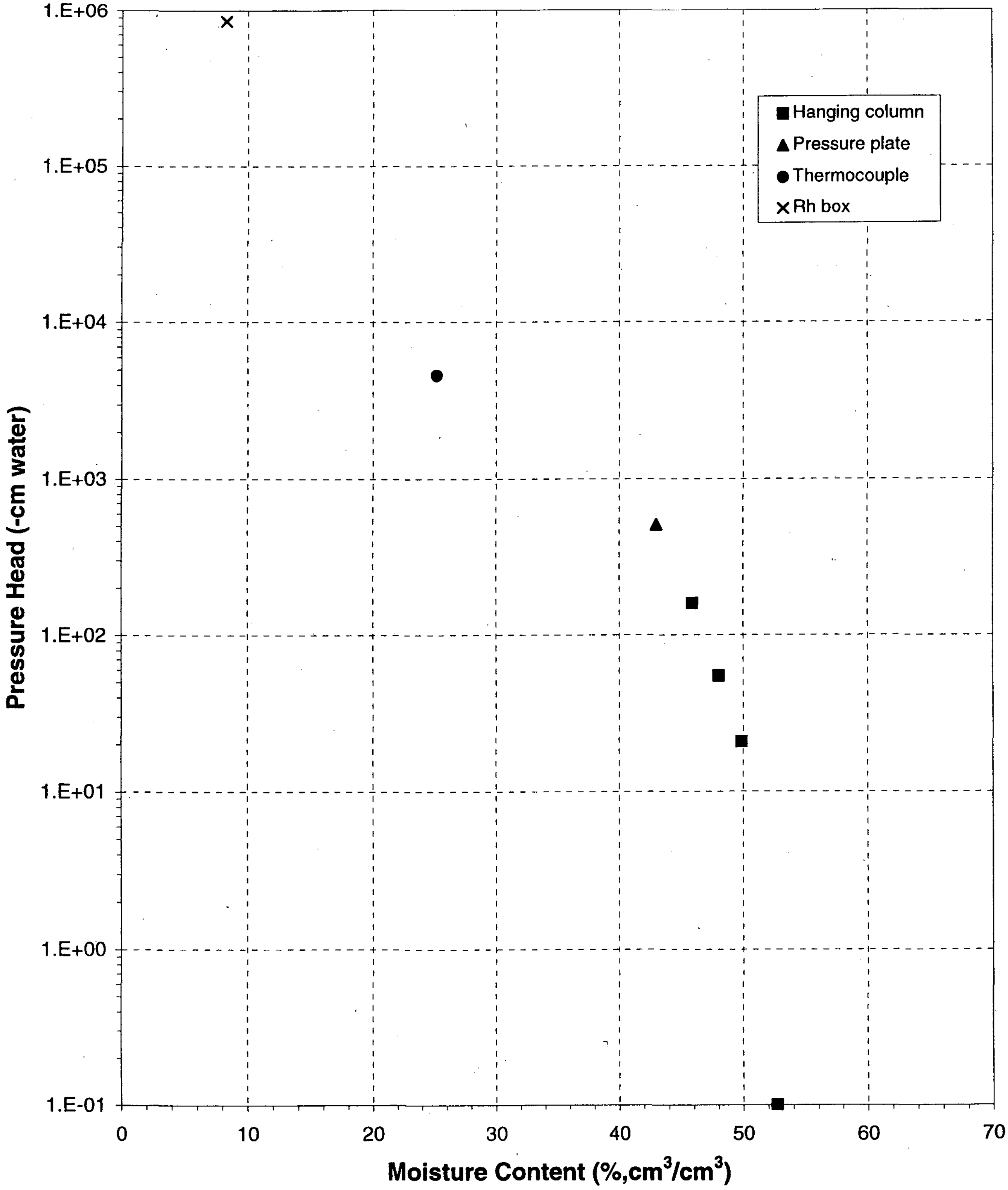
Comments:

* Weight including tares
[†] Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: J. Locke
Data entered by: T. Gere
Checked by: J. Locke

Water Retention Data Points

Sample Number: WELL-1 79.5-80



Moisture Retention Data

Hanging Column/Pressure Plate/Thermocouple

(Main Drainage Curve)

Job Name: Berkeley
Job Number: 8818.01
Sample Number: WELL-1 109-109.5
Ring Number: WELL-1 109-109.5
Depth: 109-109.5

Dry wt. of sample (g): 174.64
Tare wt., screen & clamp (g): 25.63
Tare wt., ring (g): 81.41
Tare wt., epoxy (g): 0.00
Sample volume (cm^3): 130.95

Saturated weight at 0 cm tension* (g): 349.21
Volume of water[†] *in saturated sample* (cm^3): 67.53
Saturated moisture content (% vol): 51.57

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content[†] (% vol)
Hanging column:	28-May-98 / 14:50	349.21	0.00	51.57
	01-Jun-98 / 12:00	348.39	11.50	50.94
	04-Jun-98 / 11:40	334.25	26.80	40.15
	08-Jun-98 / 13:05	313.19	65.20	24.06
Pressure plate:	11-Jun-98 / 08:25	307.43	254.95	19.66
	15-Jun-98 / 09:55	304.42	917.82	17.37

Dry weight of thermocouple sample* (g): 379.12
Tare weight, jar (g): 204.48
Sample bulk density (g/cm^3): 1.33

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content[†] (% vol)
Thermocouple:	24-Jun-98 / 11:00	396.20	4283.2	13.04
	25-Jun-98 / 11:30	390.02	38854.4	8.32

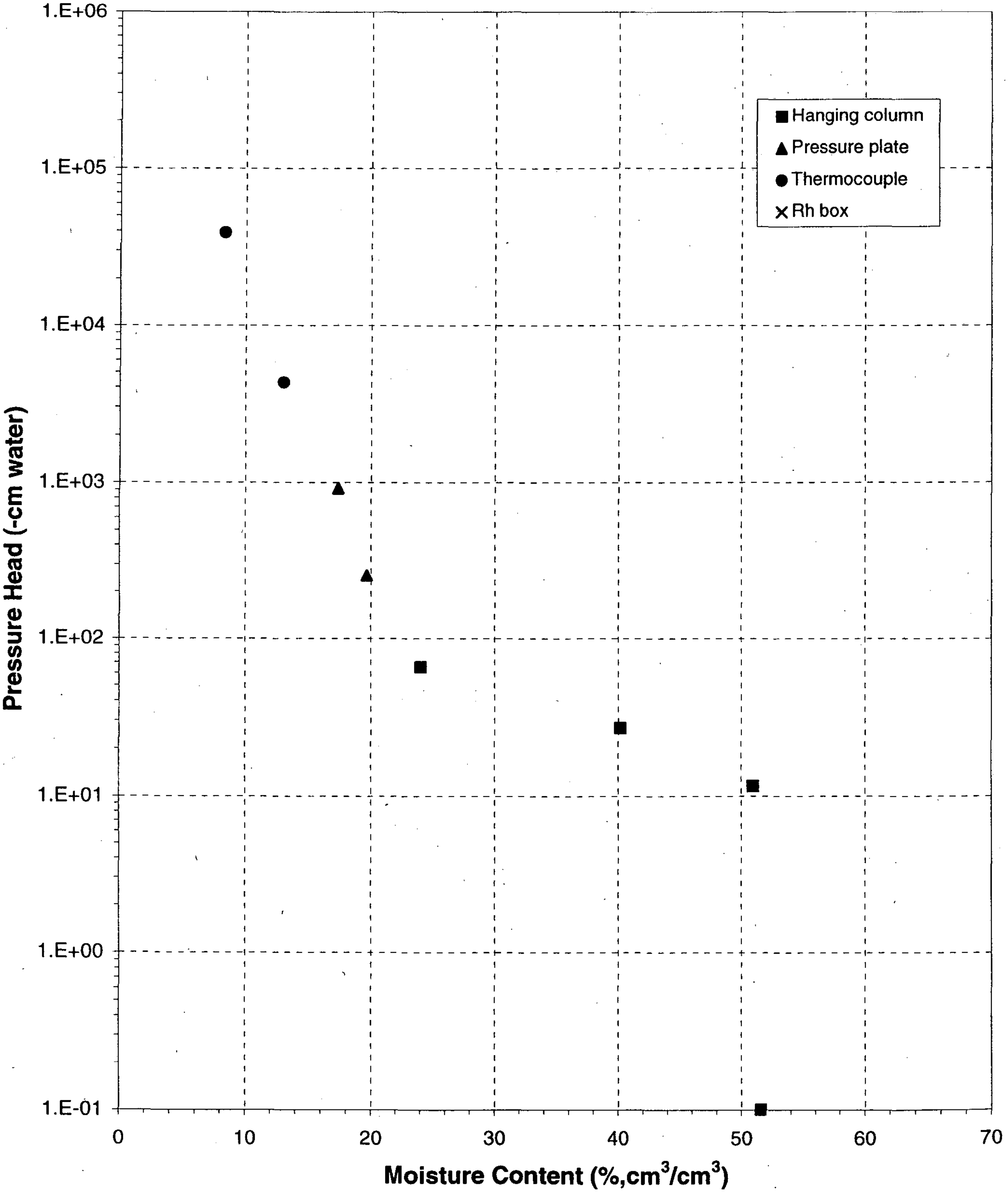
Comments:

* Weight including tares
[†] Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: T. Gere/J. Locke
Data entered by: T. Gere
Checked by: J. Locke

Water Retention Data Points

Sample Number: WELL-1 109-109.5



Appendix D

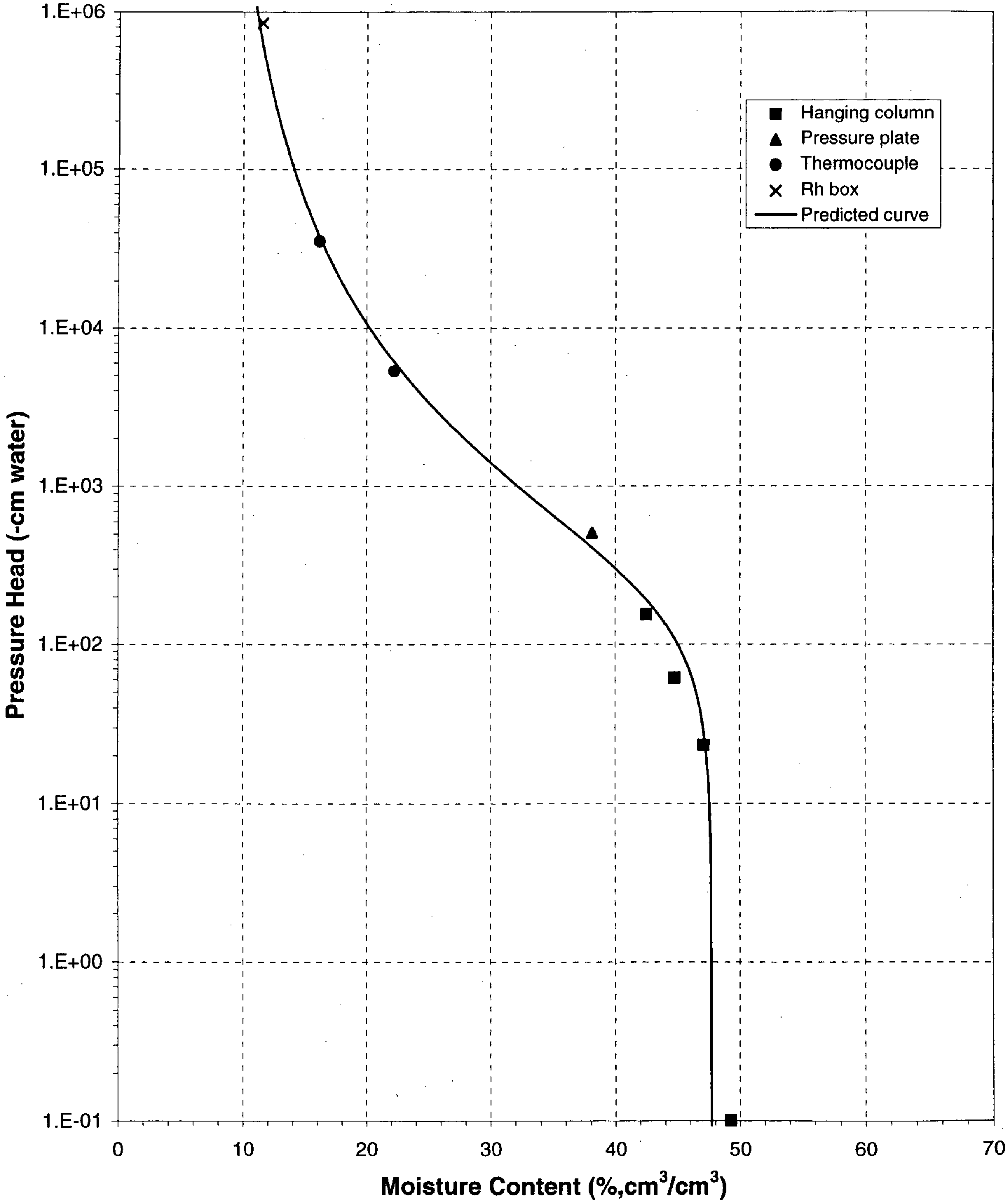
Unsaturated Hydraulic Properties

Summary of Calculated Unsaturated Hydraulic Properties

Sample Number	α (cm^{-1}) Calculated Value	α 95% Confidence Limits Lower	α 95% Confidence Limits Upper	N (dimensionless) Calculated Value	N 95% Confidence Limits Lower	N 95% Confidence Limits Upper	θ_r (%)	θ_s (%)
VZMS-C 3.5-4	0.0045	-0.0001	0.0090	1.3121	1.0916	1.5326	0.0821	0.4773
VZMS-C 8.5-9	0.0022	0.0007	0.0037	1.4758	1.2450	1.7067	0.0421	0.4882
VZMS-C 12-12.5	0.0470	-0.0207	0.1147	1.2794	0.9929	1.5659	0.0485	0.4656
VZMS-C 17.5-18	0.0079	0.0002	0.0156	1.2584	1.0947	1.4220	0.0019	0.5221
WELL-1 29-29.5	0.0162	0.0028	0.0297	1.2939	1.1974	1.3903	0.0000	0.4958
WELL-1 69.5-70	0.0436	0.0297	0.0575	3.0465	1.5027	4.5903	0.0635	0.4553
WELL-1 79-79.5	0.0012	0.0003	0.0022	2.3507	-1.0555	5.7569	0.0629	0.4849
WELL-1 79.5-80	0.0034	-0.0003	0.0072	1.2357	1.1472	1.3241	0.0000	0.5069
WELL-1 109-109.5	0.0426	-0.0060	0.0912	1.9360	0.7862	3.0857	0.1259	0.5315

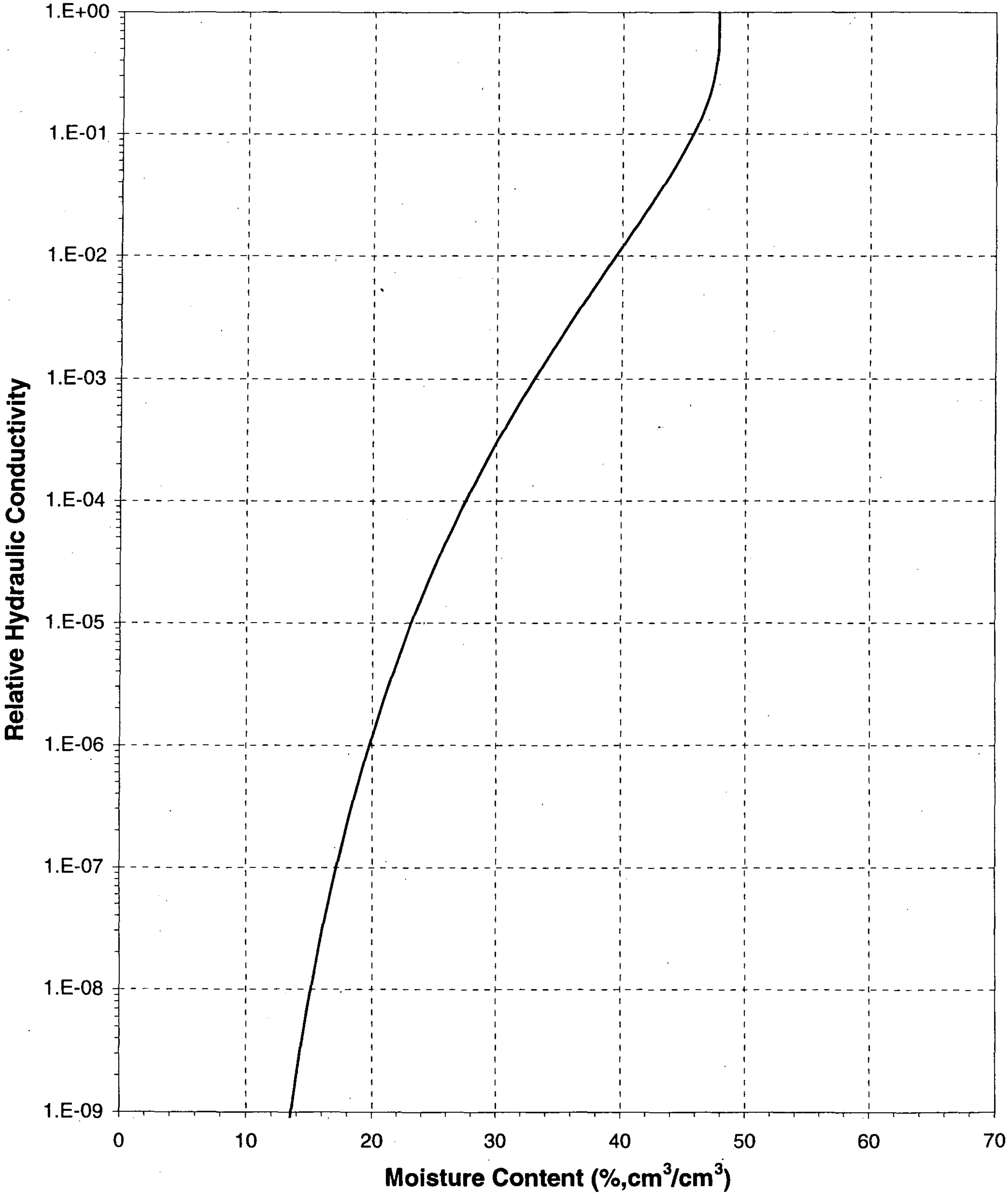
Predicted Water Retention Curve and Data Points

Sample Number: VZMS-C 3.5-4



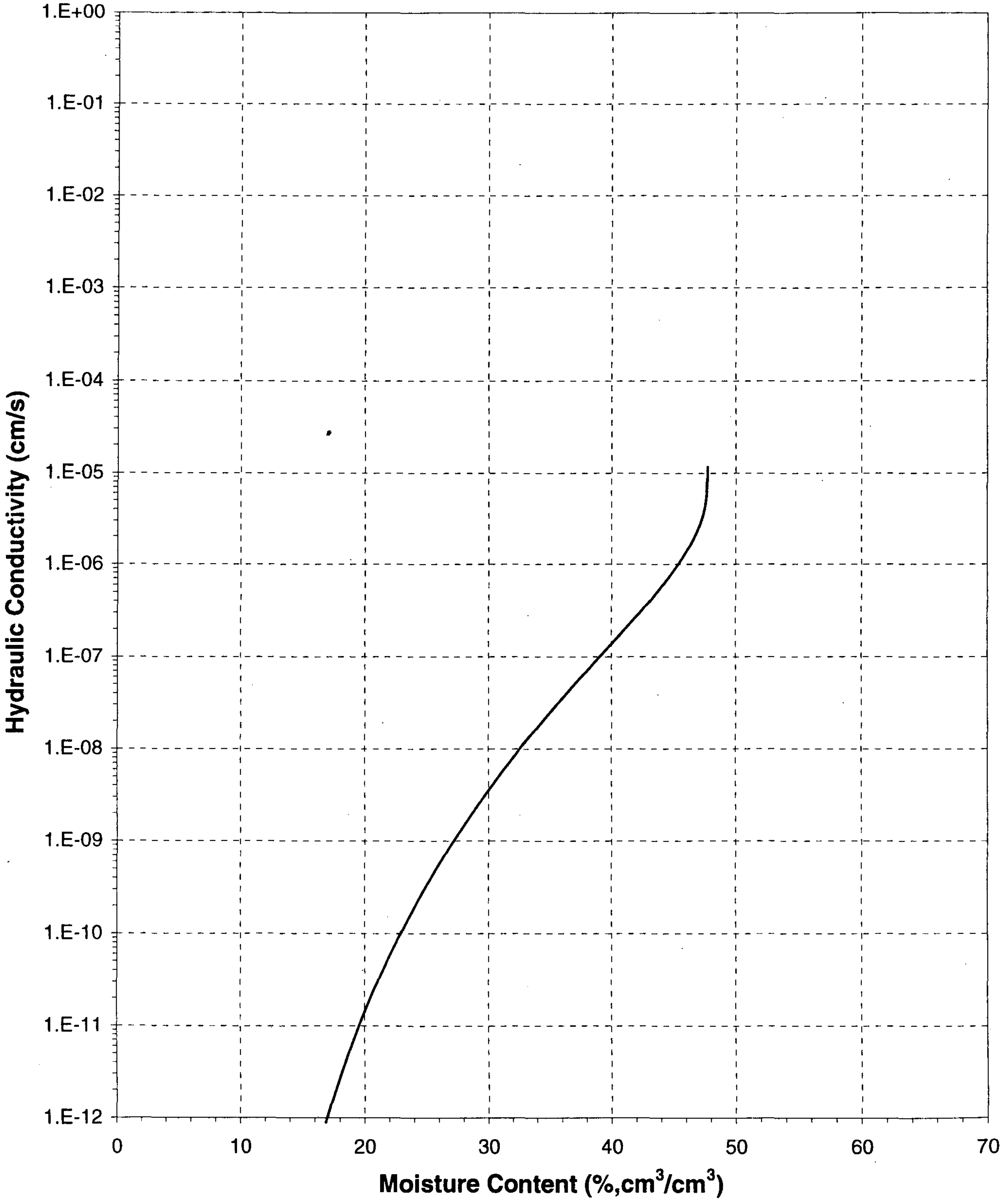
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: VZMS-C 3.5-4



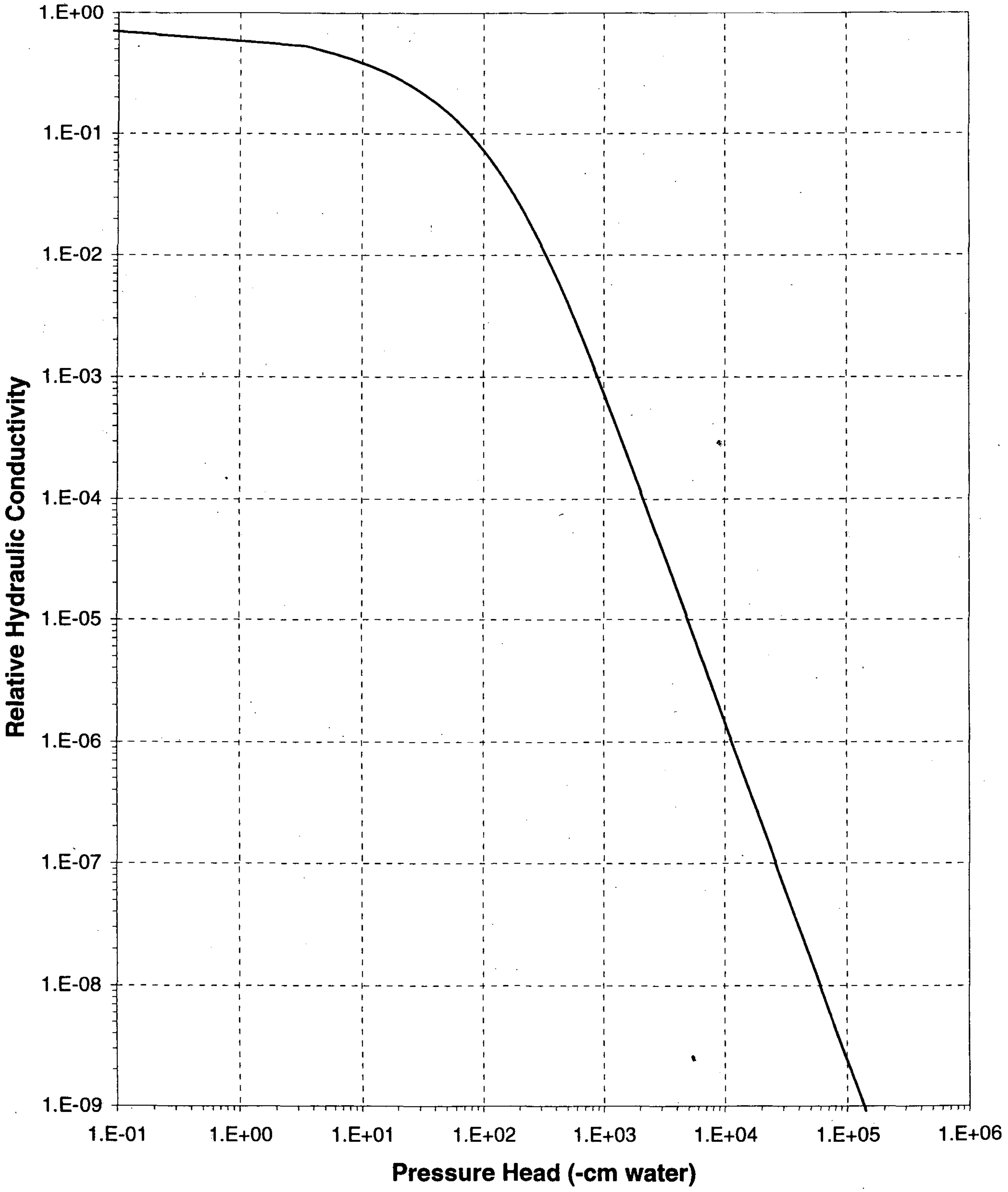
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: VZMS-C 3.5-4



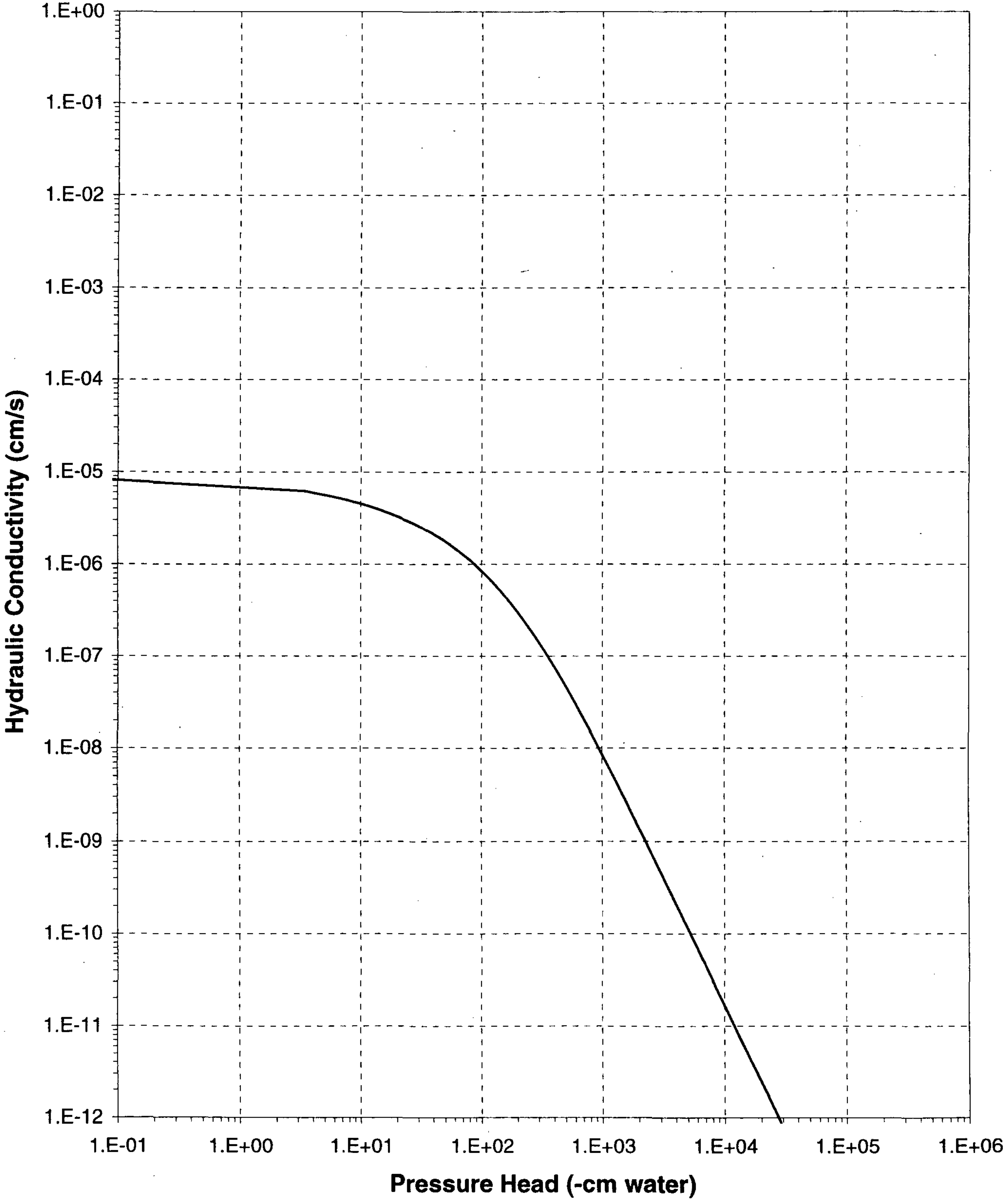
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: VZMS-C 3.5-4



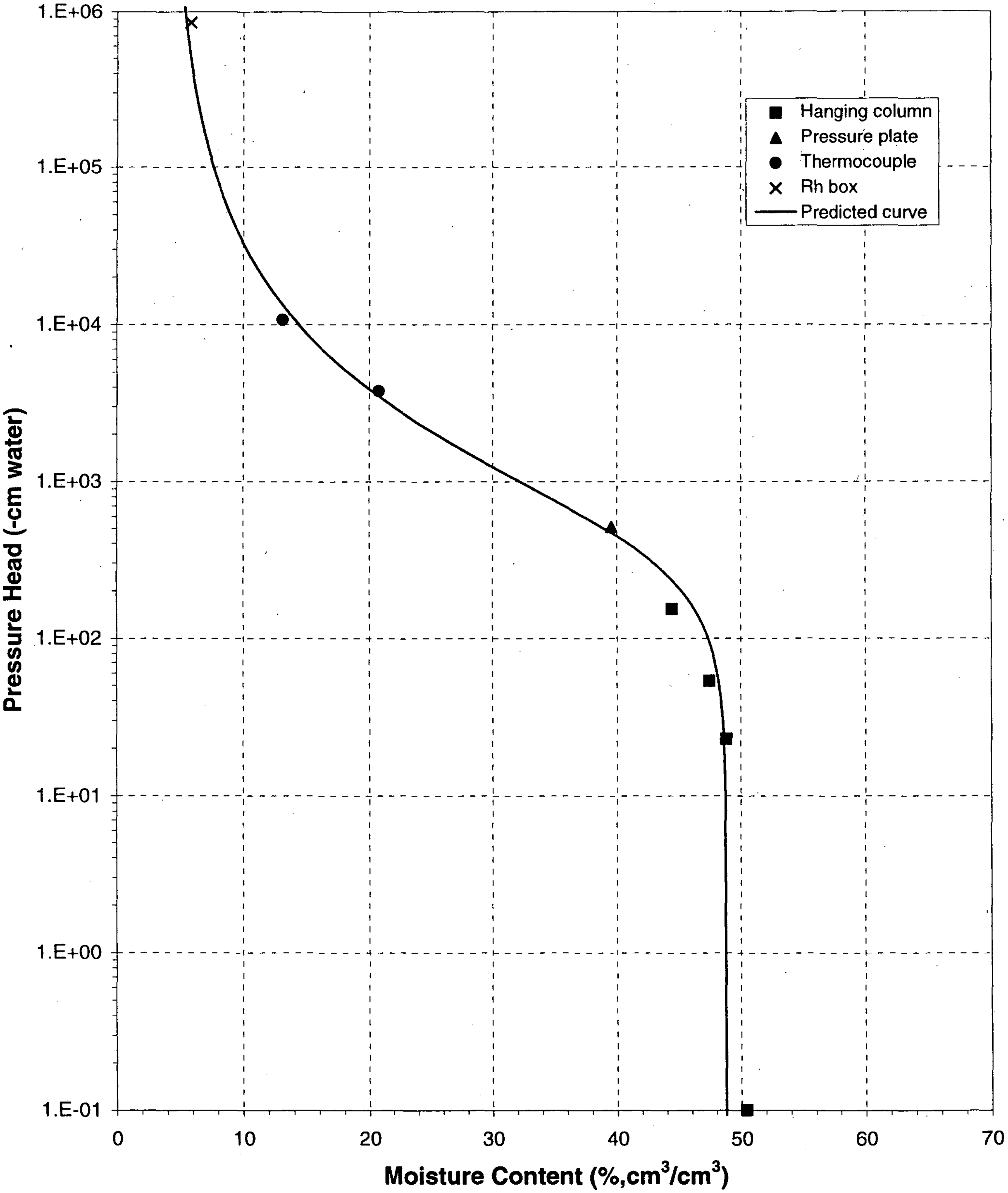
Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: VZMS-C 3.5-4



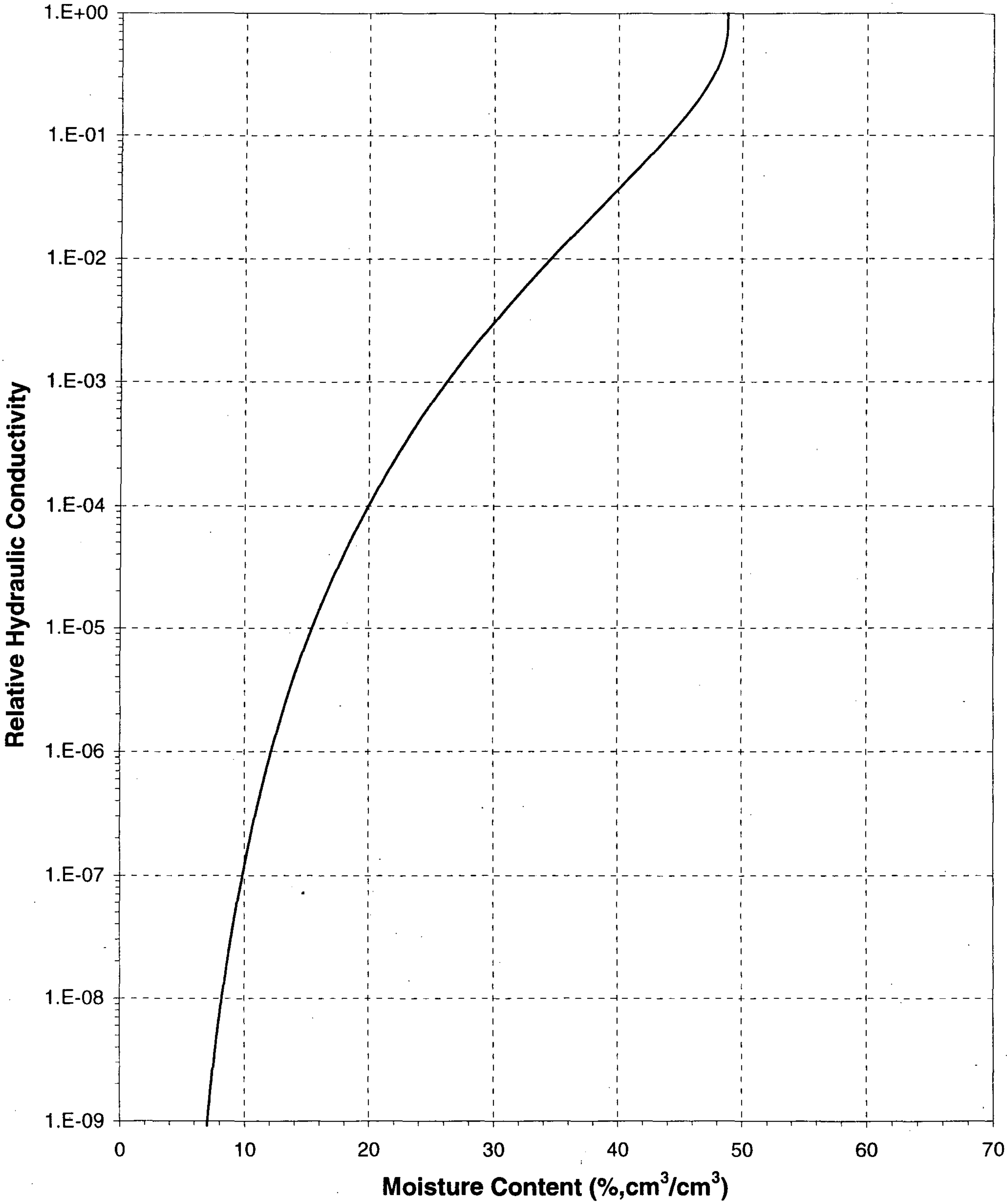
Predicted Water Retention Curve and Data Points

Sample Number: VZMS-C 8.5-9



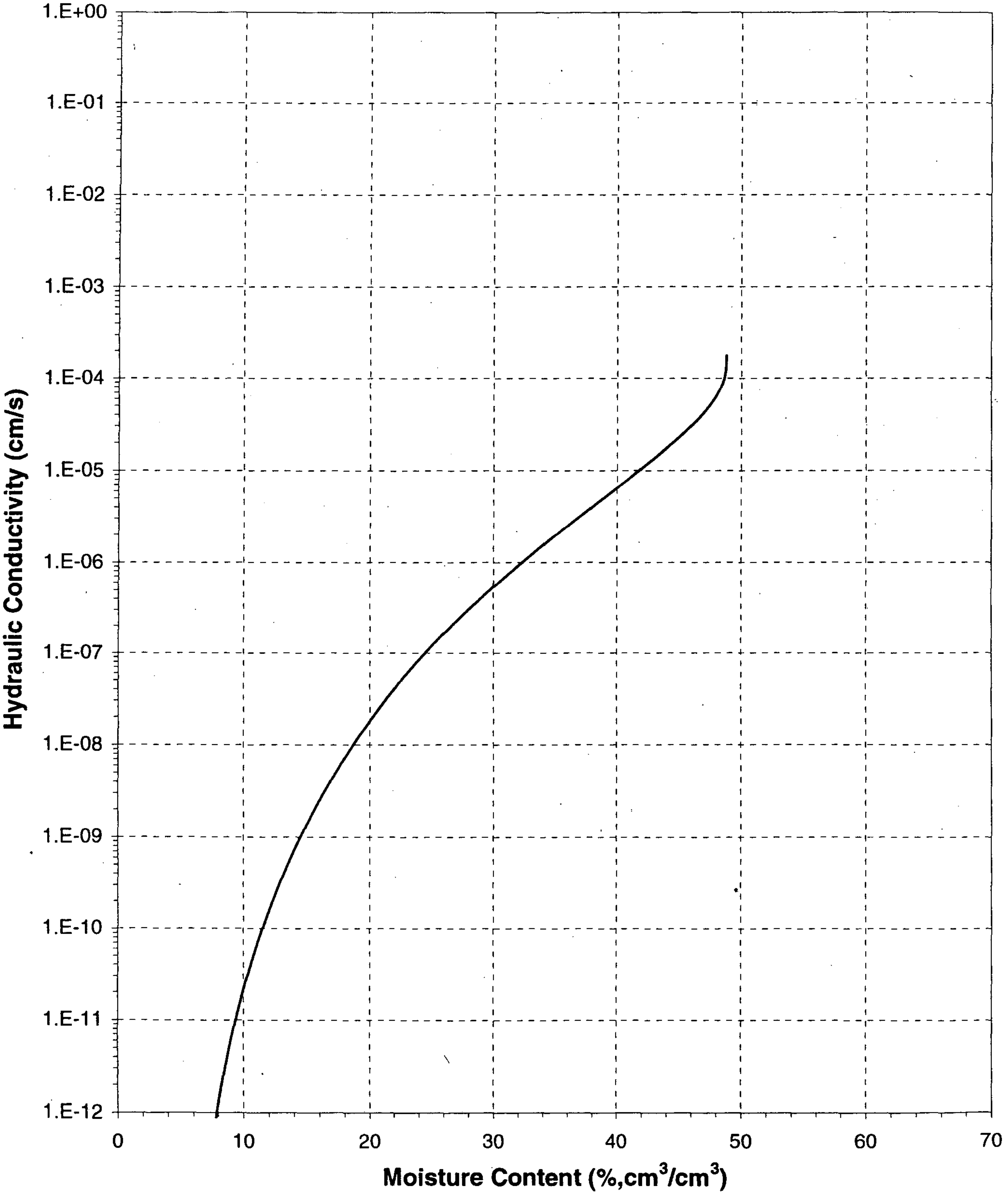
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: VZMS-C 8.5-9



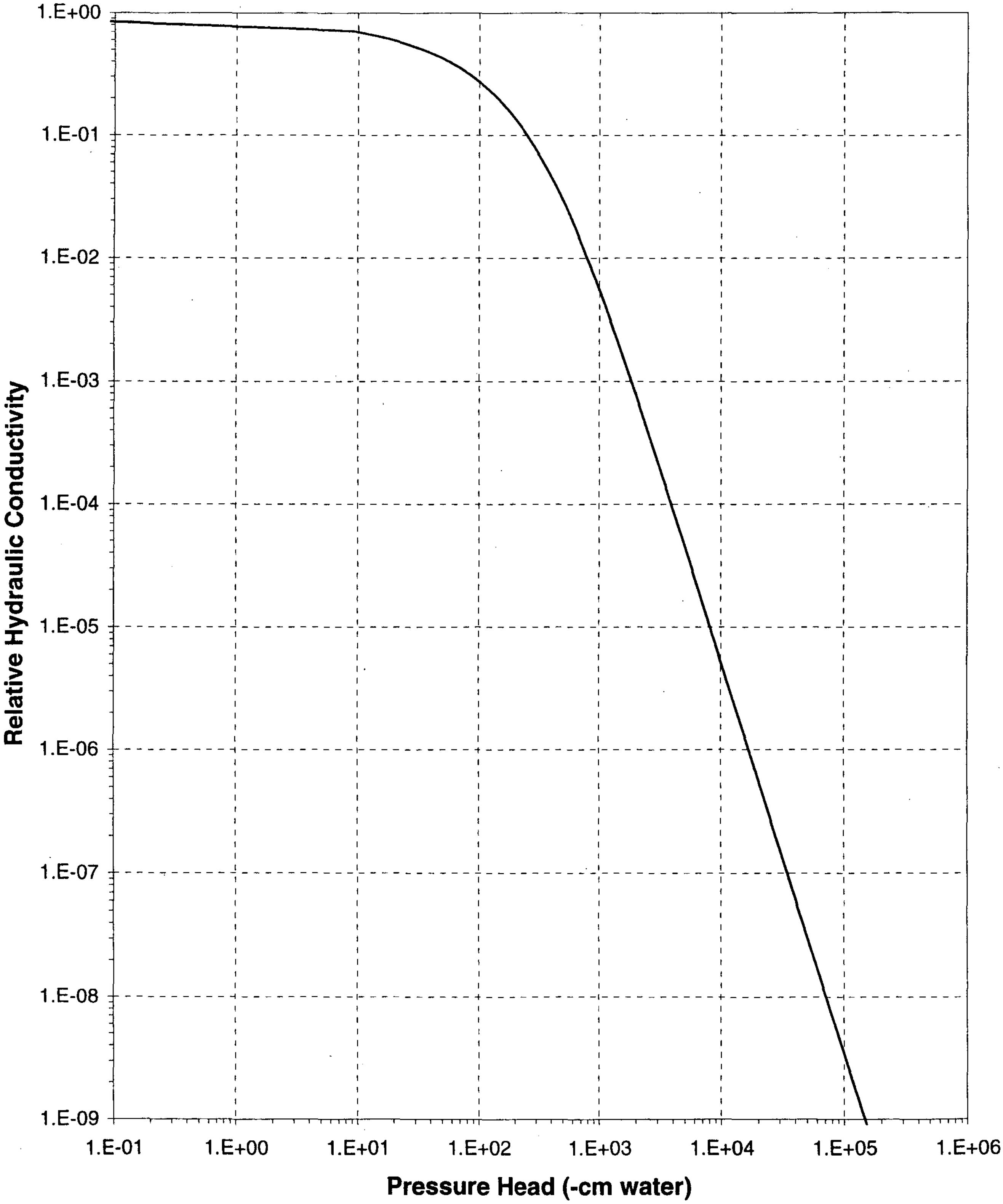
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: VZMS-C 8.5-9



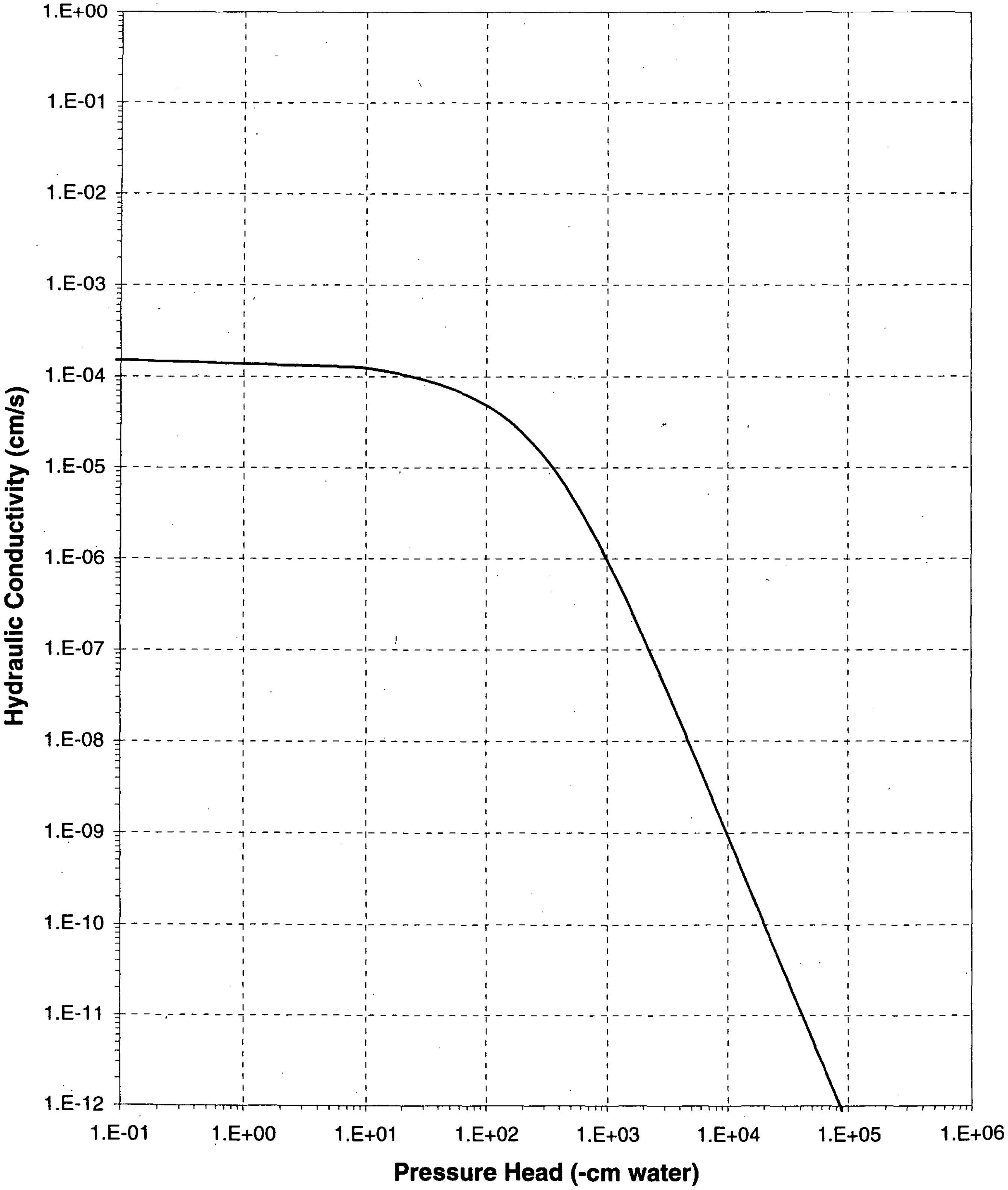
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: VZMS-C 8.5-9



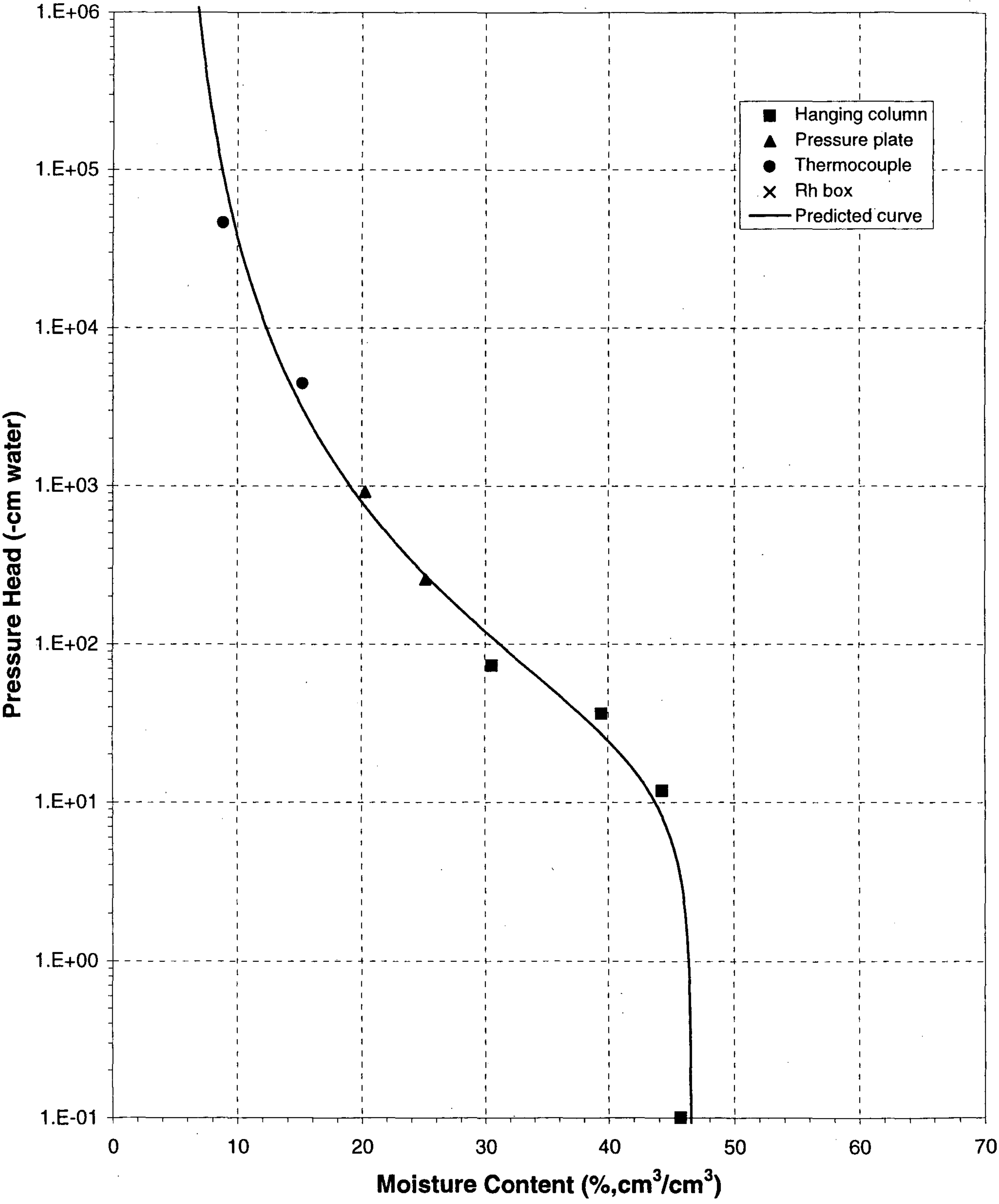
Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: VZMS-C 8.5-9



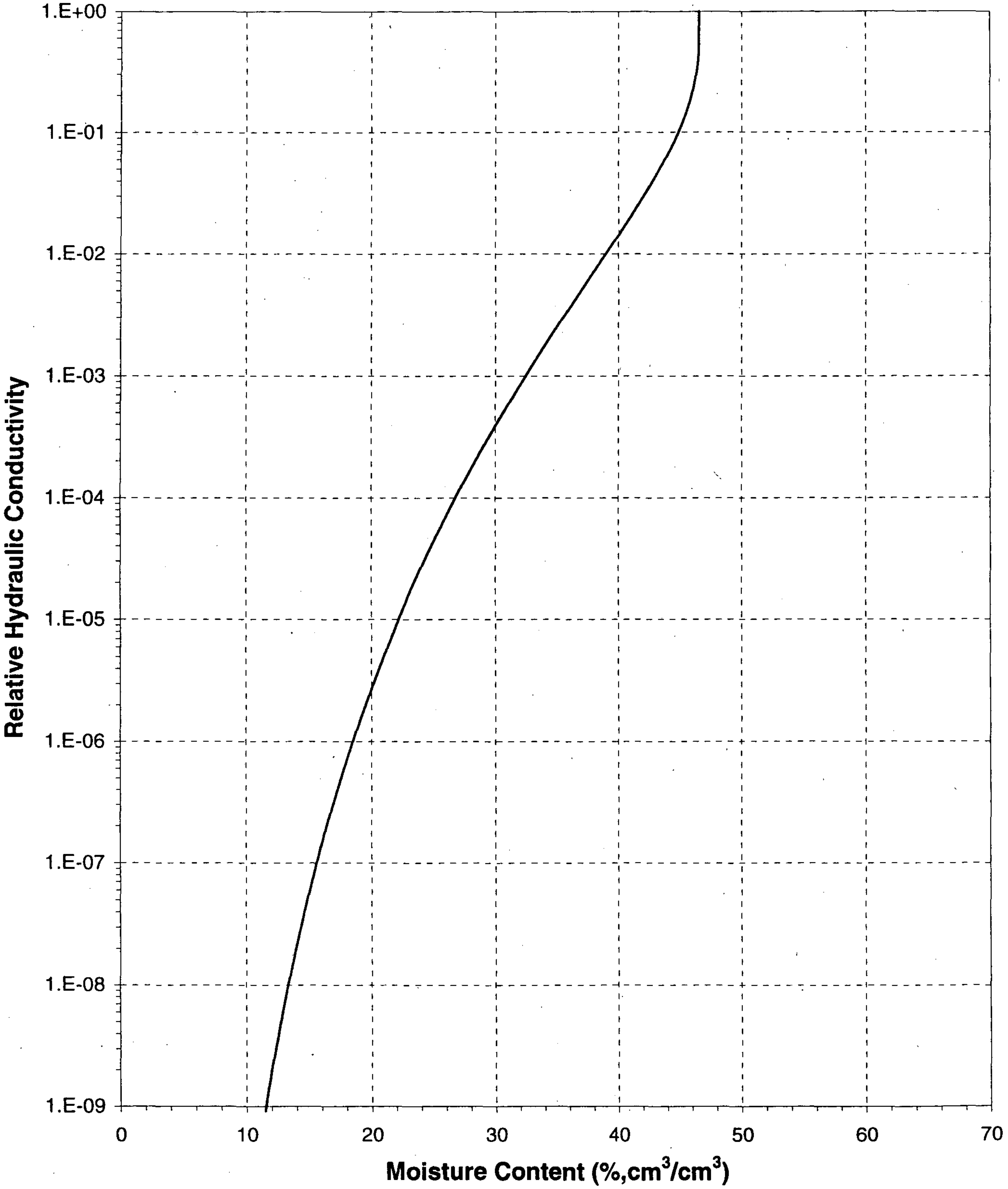
Predicted Water Retention Curve and Data Points

Sample Number: VZMS-C 12-12.5



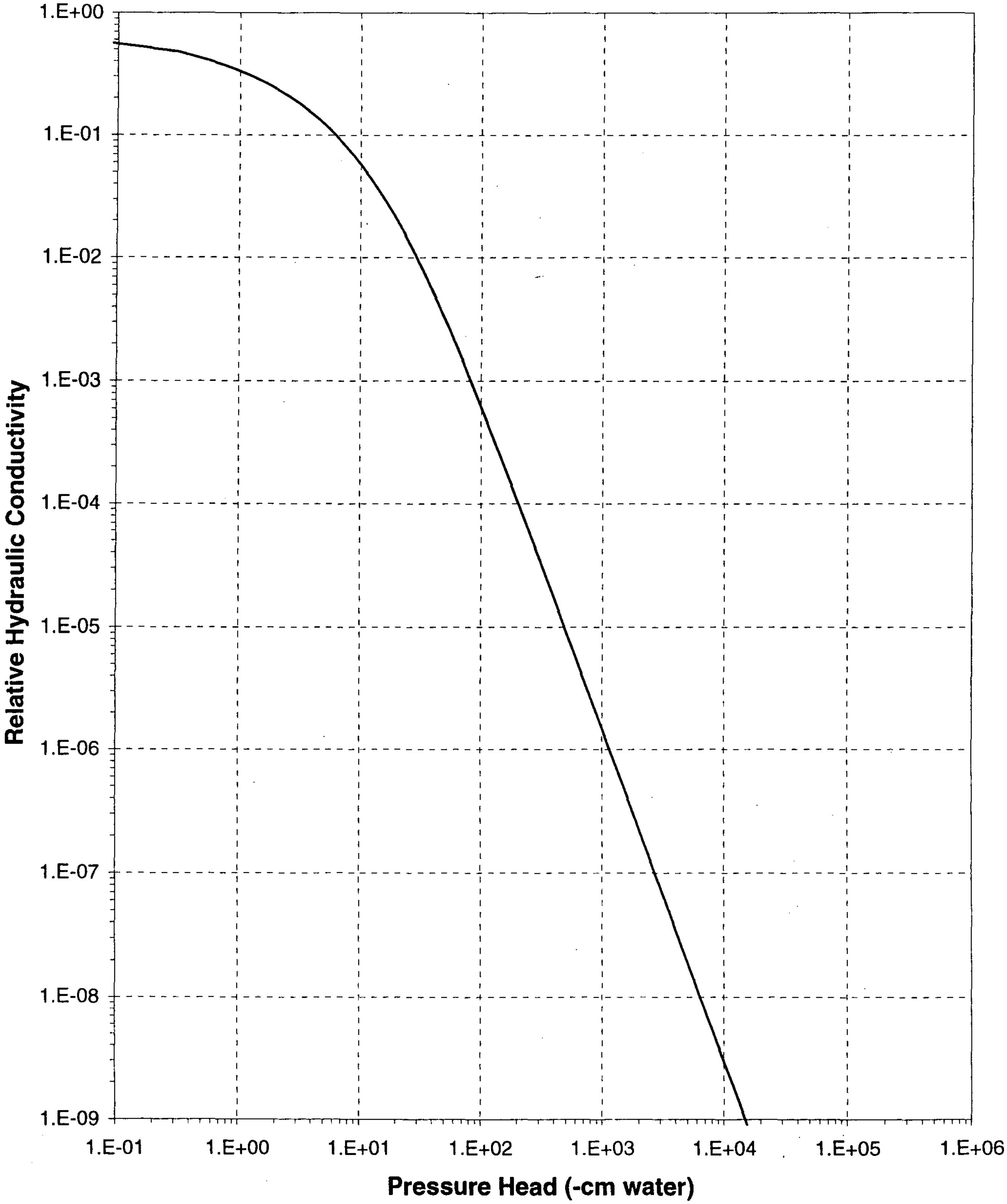
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: VZMS-C 12-12.5



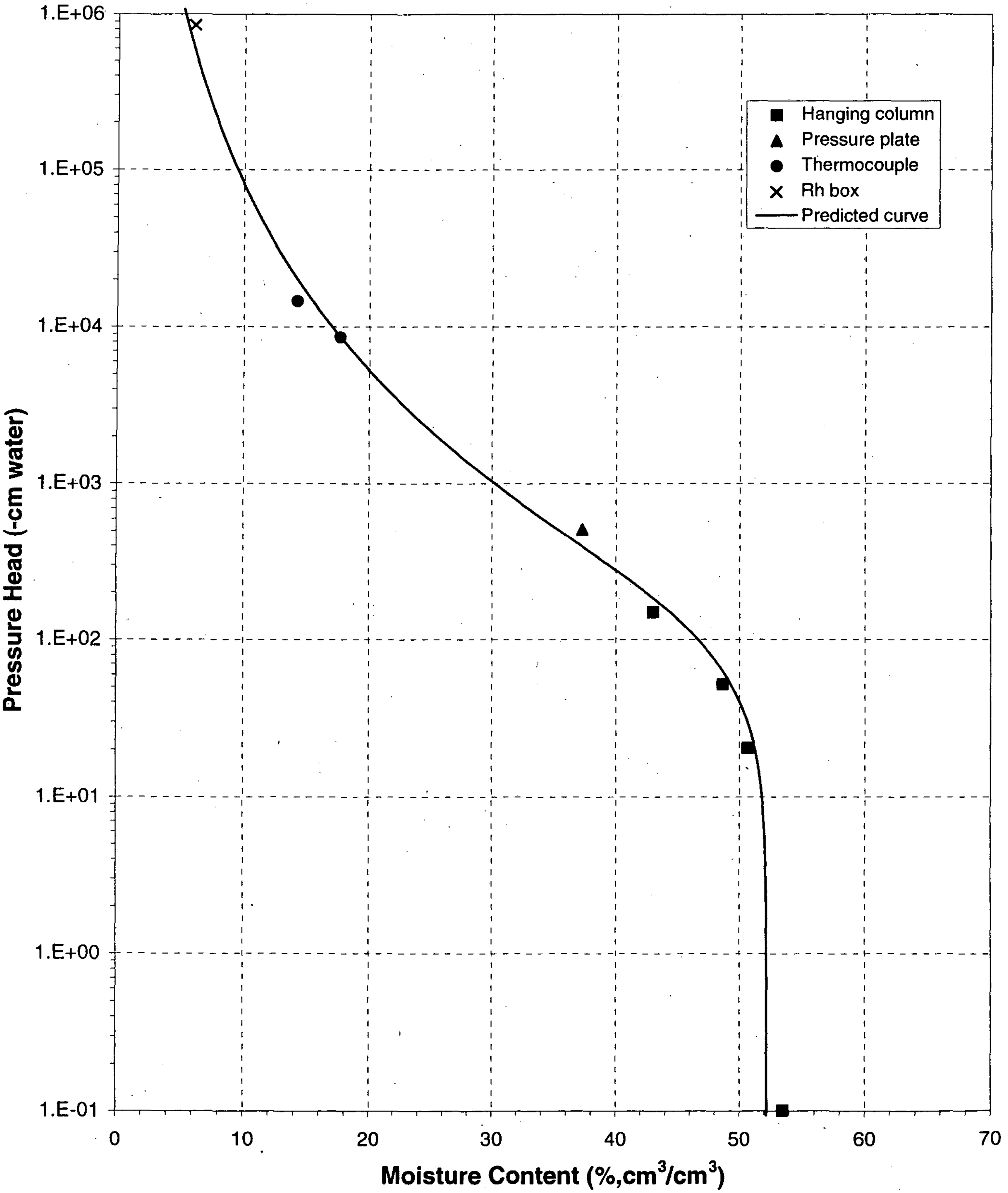
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: VZMS-C 12-12.5



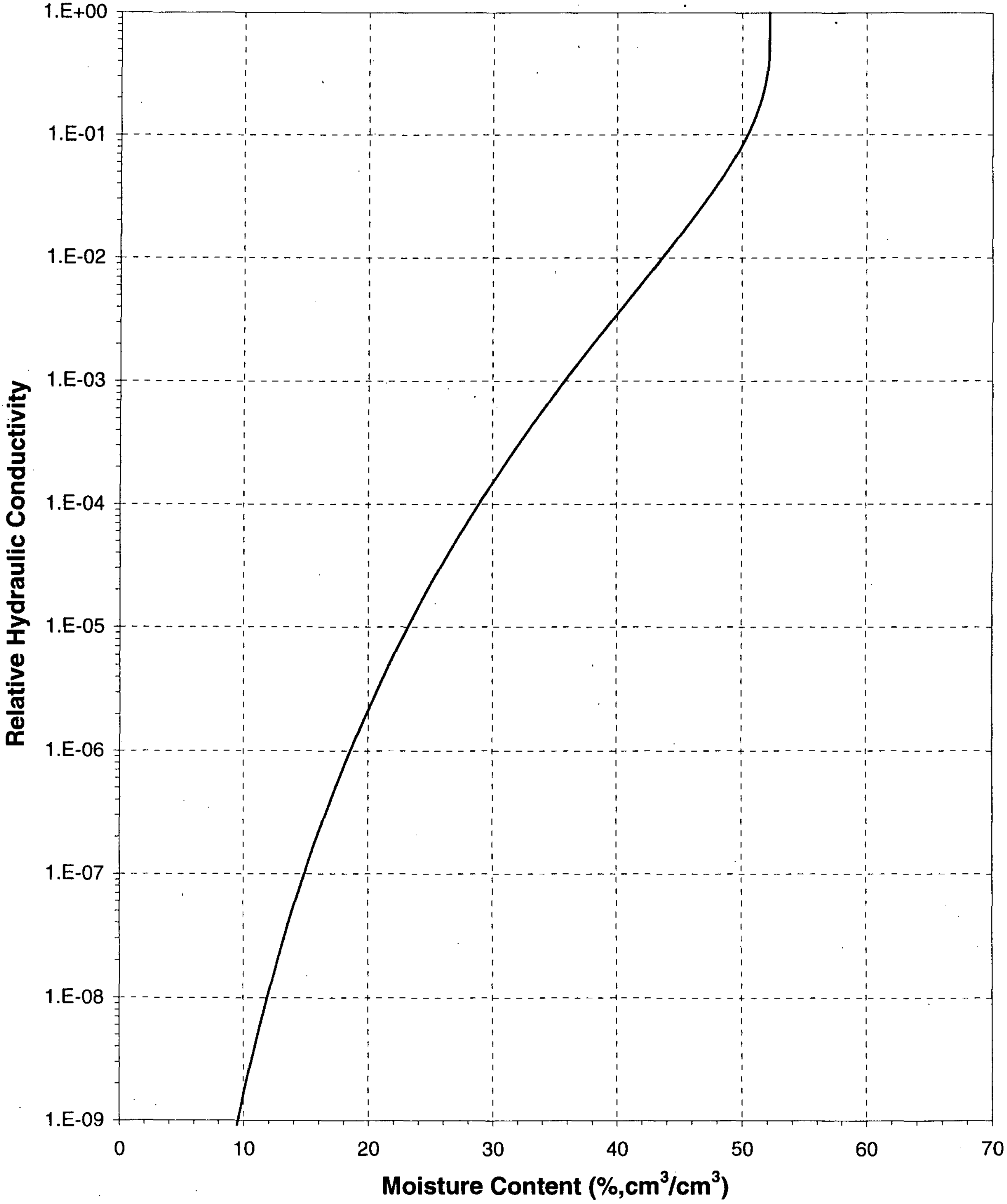
Predicted Water Retention Curve and Data Points

Sample Number: VZMS-C 17.5-18



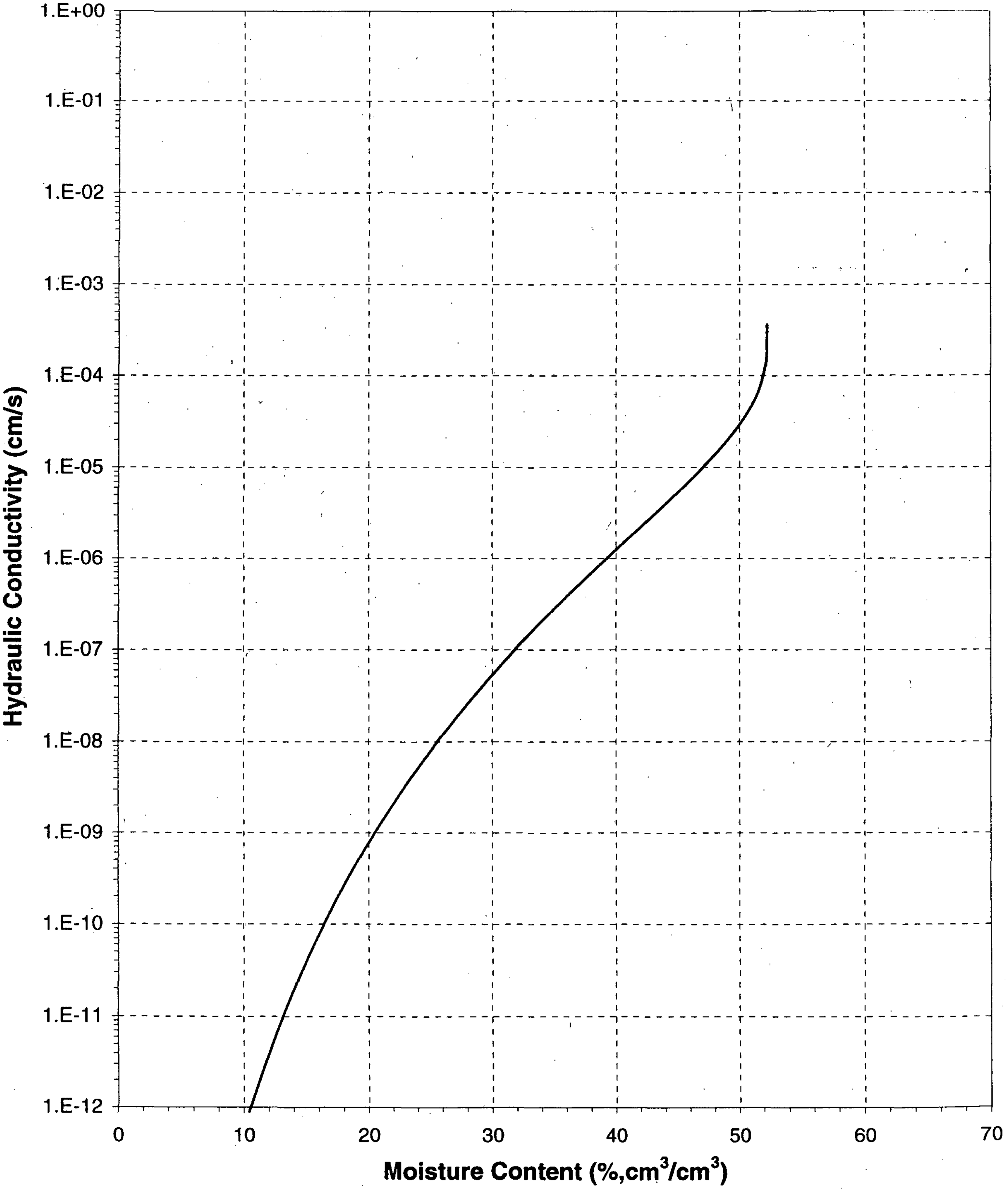
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: VZMS-C 17.5-18



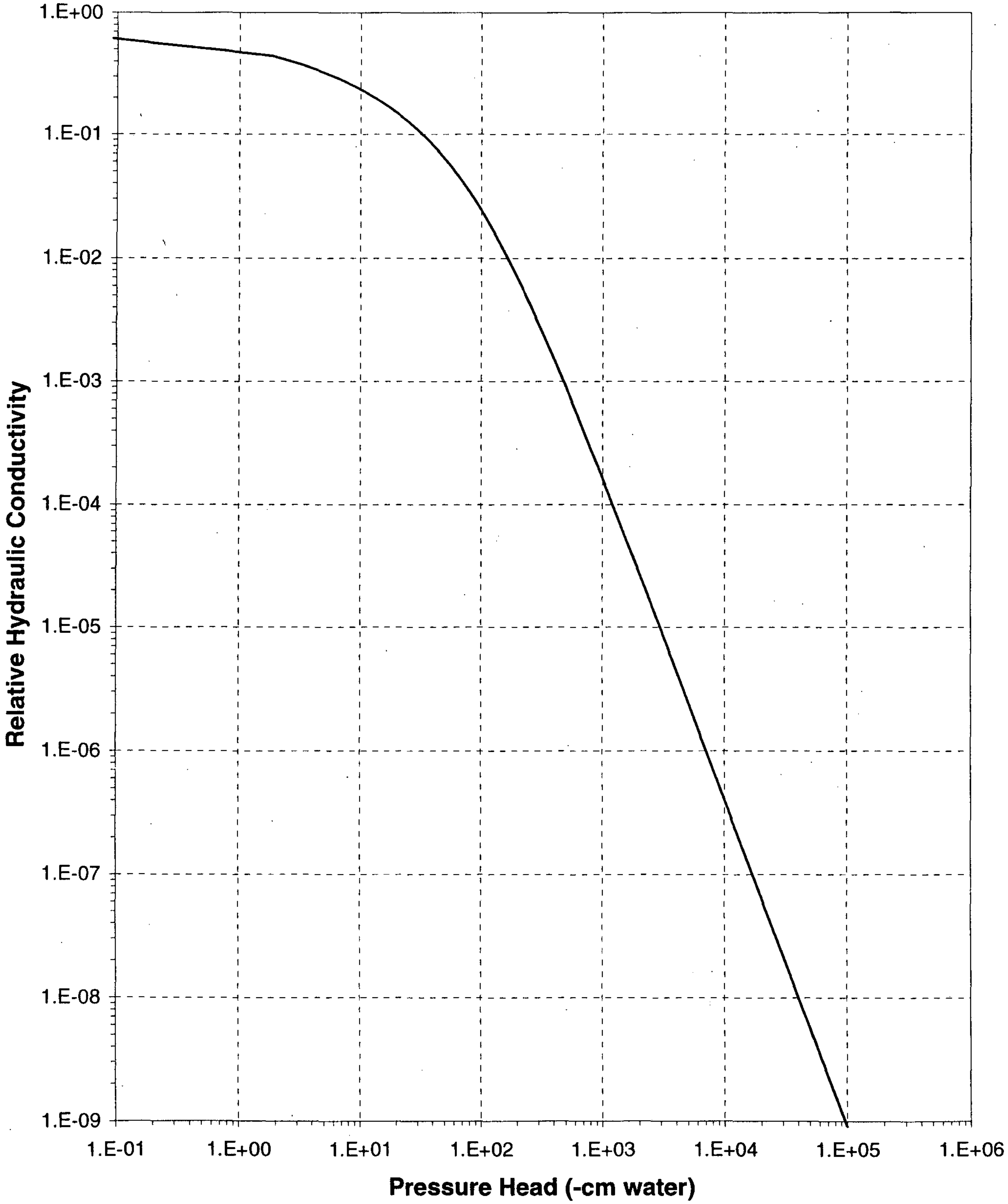
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: VZMS-C 17.5-18



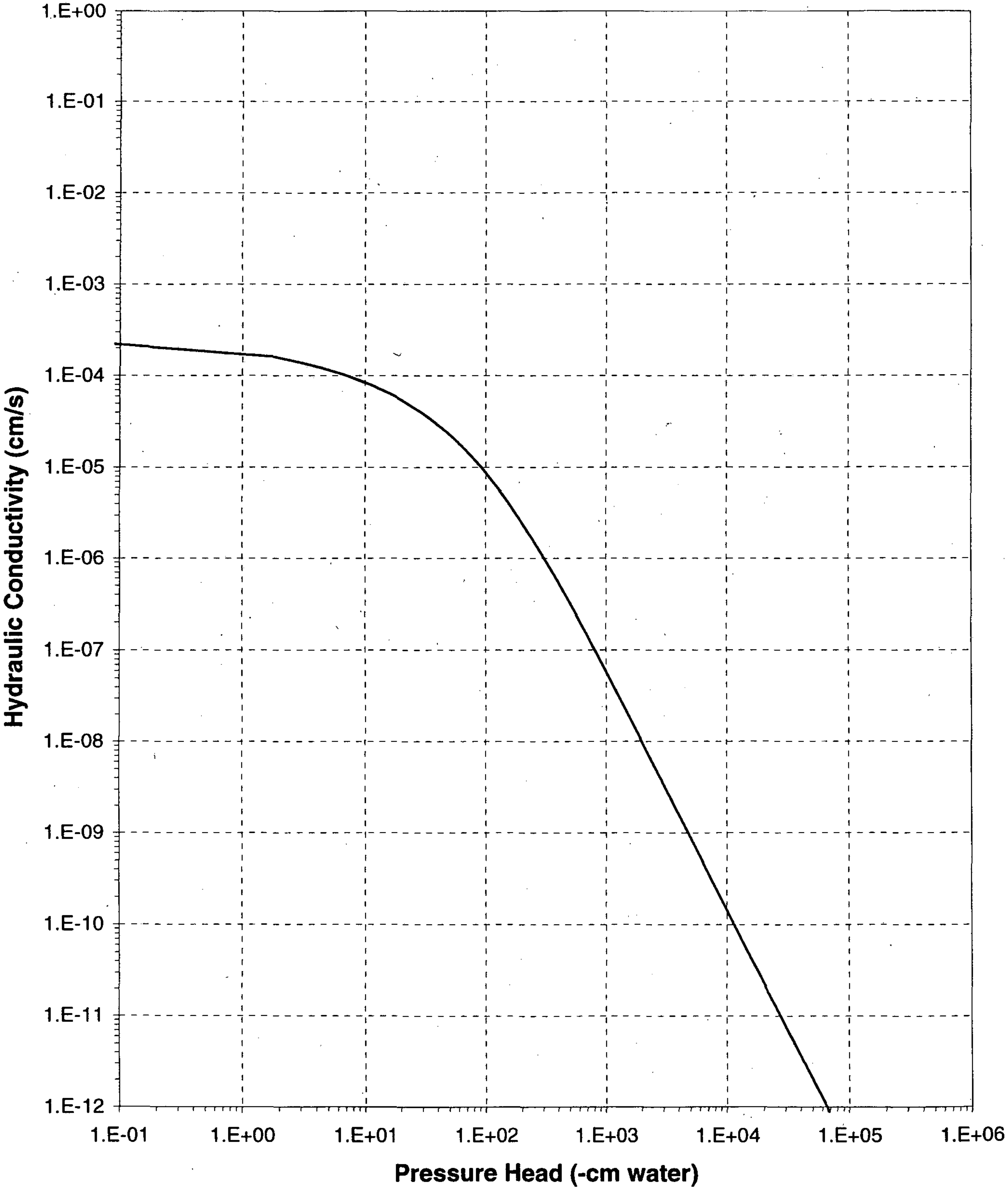
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: VZMS-C 17.5-18



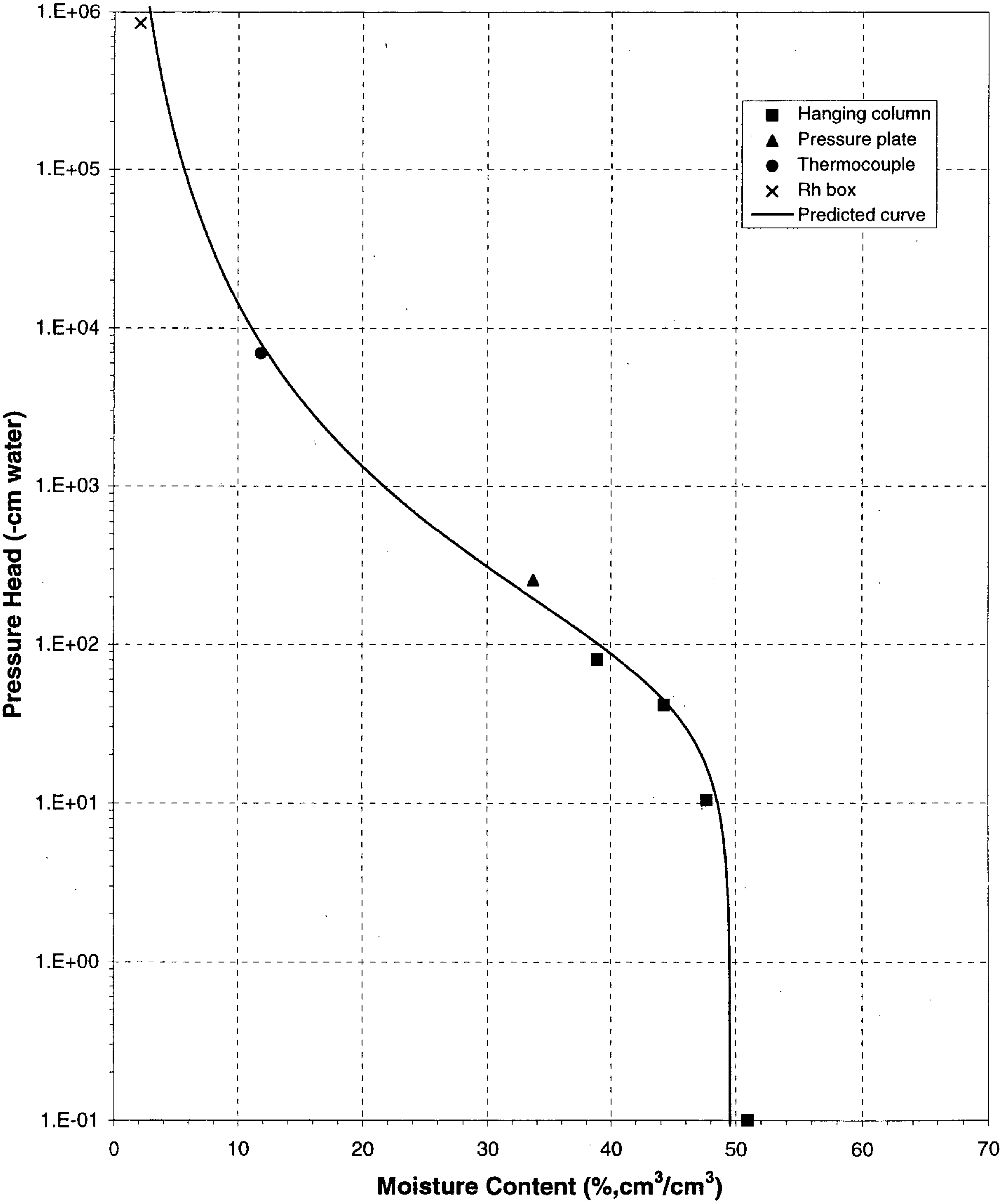
Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: VZMS-C 17.5-18



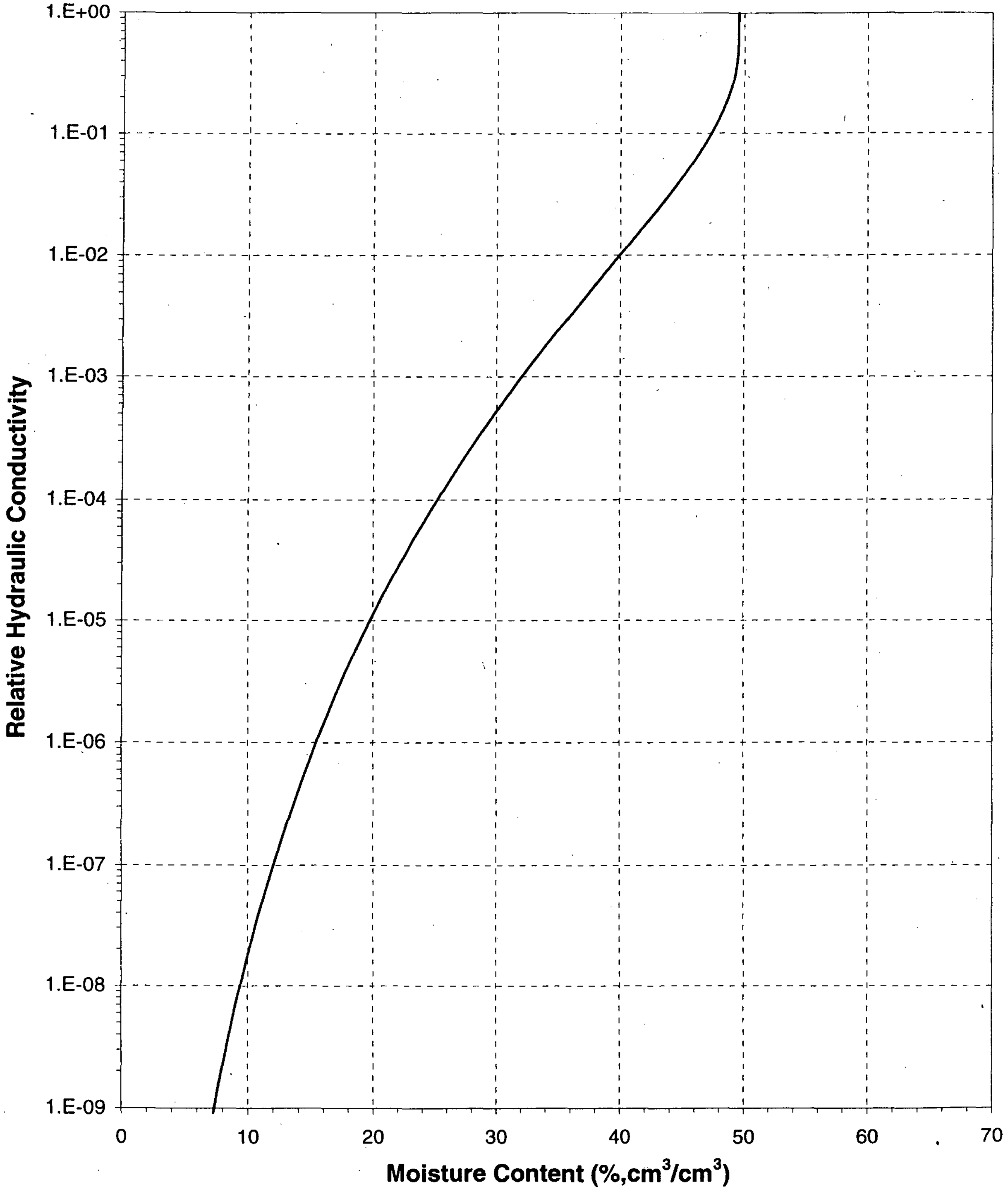
Predicted Water Retention Curve and Data Points

Sample Number: WELL-1 29-29.5



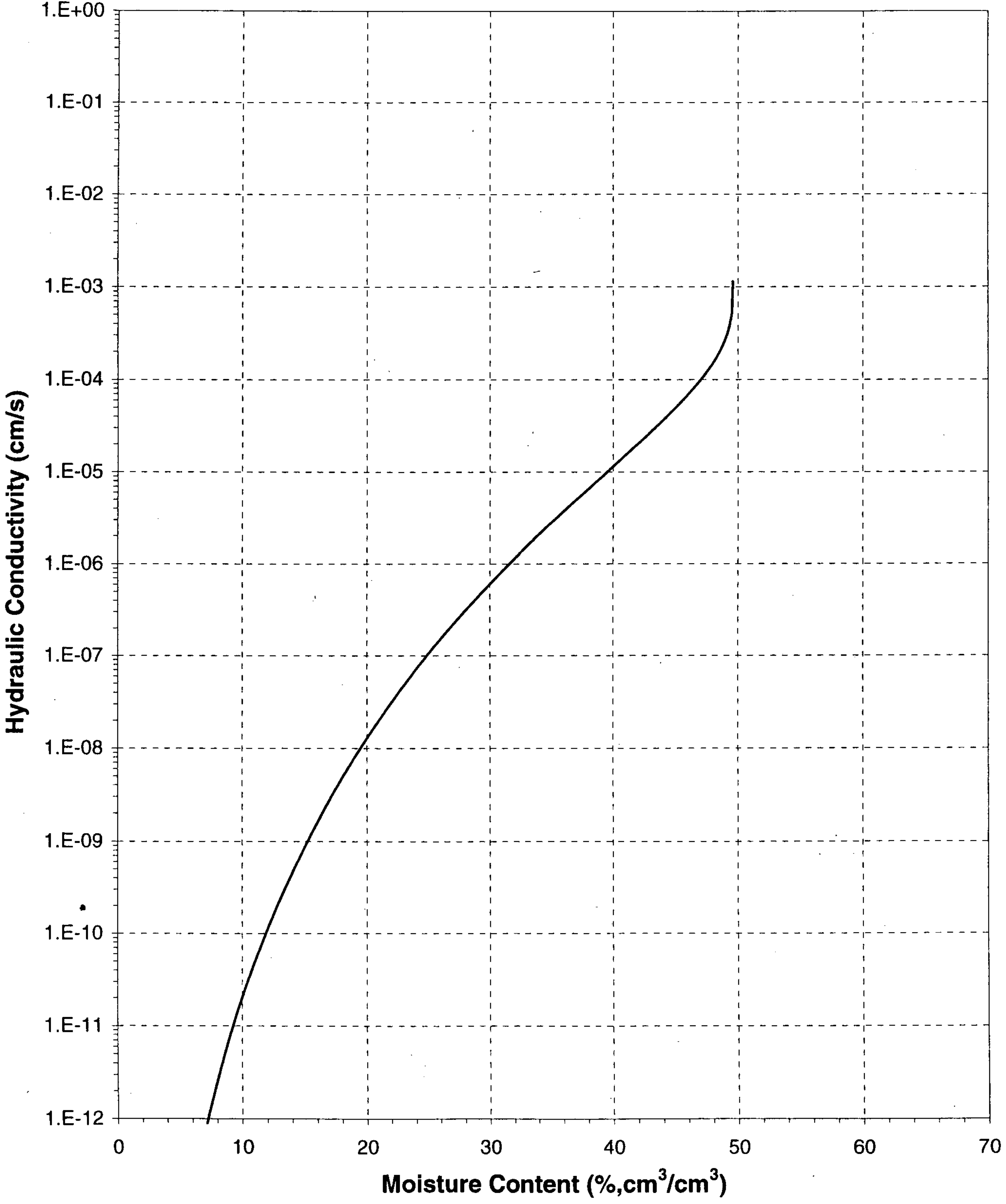
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: WELL-1 29-29.5



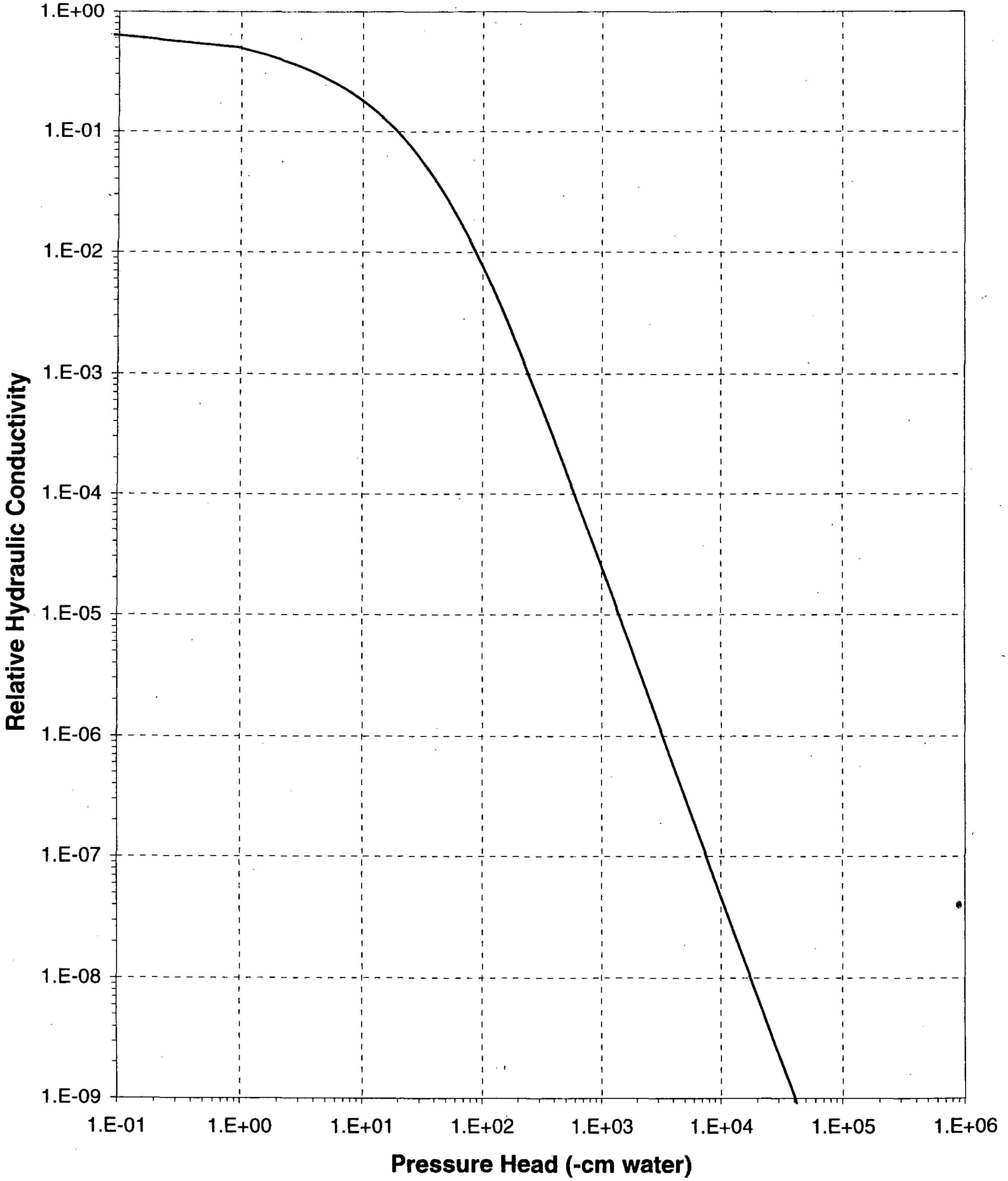
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: WELL-1 29-29.5



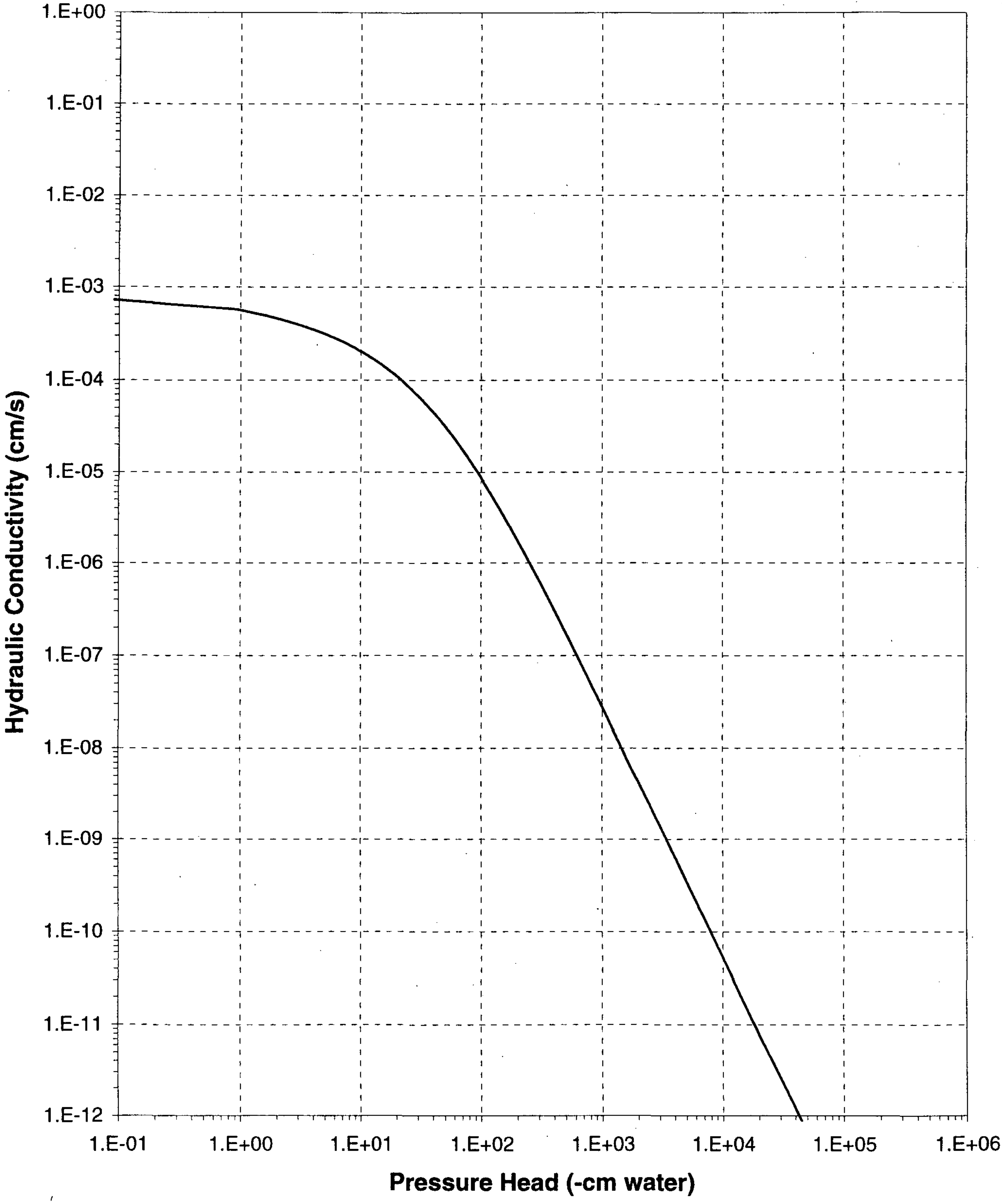
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: WELL-1 29-29.5



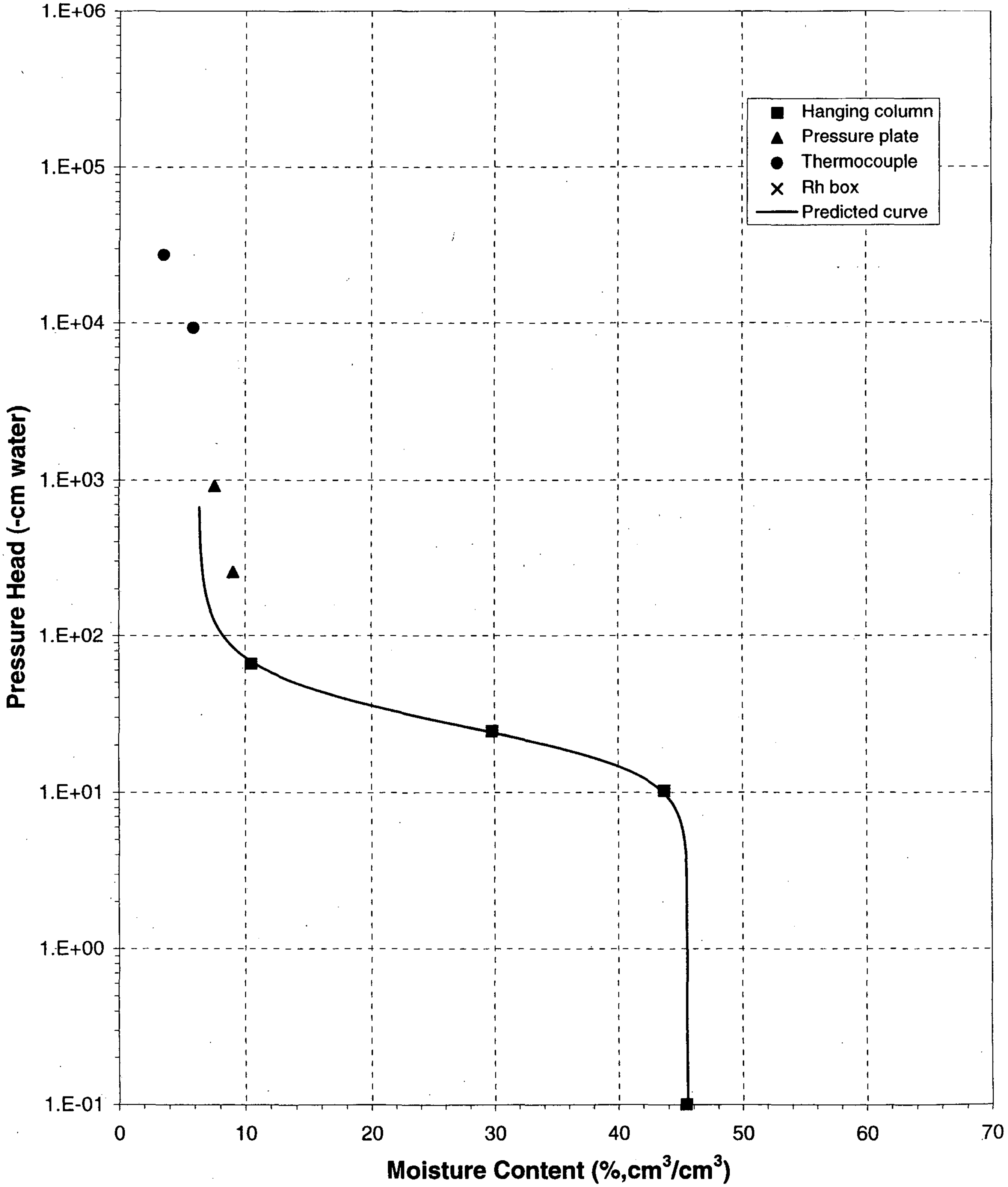
Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: WELL-1 29-29.5



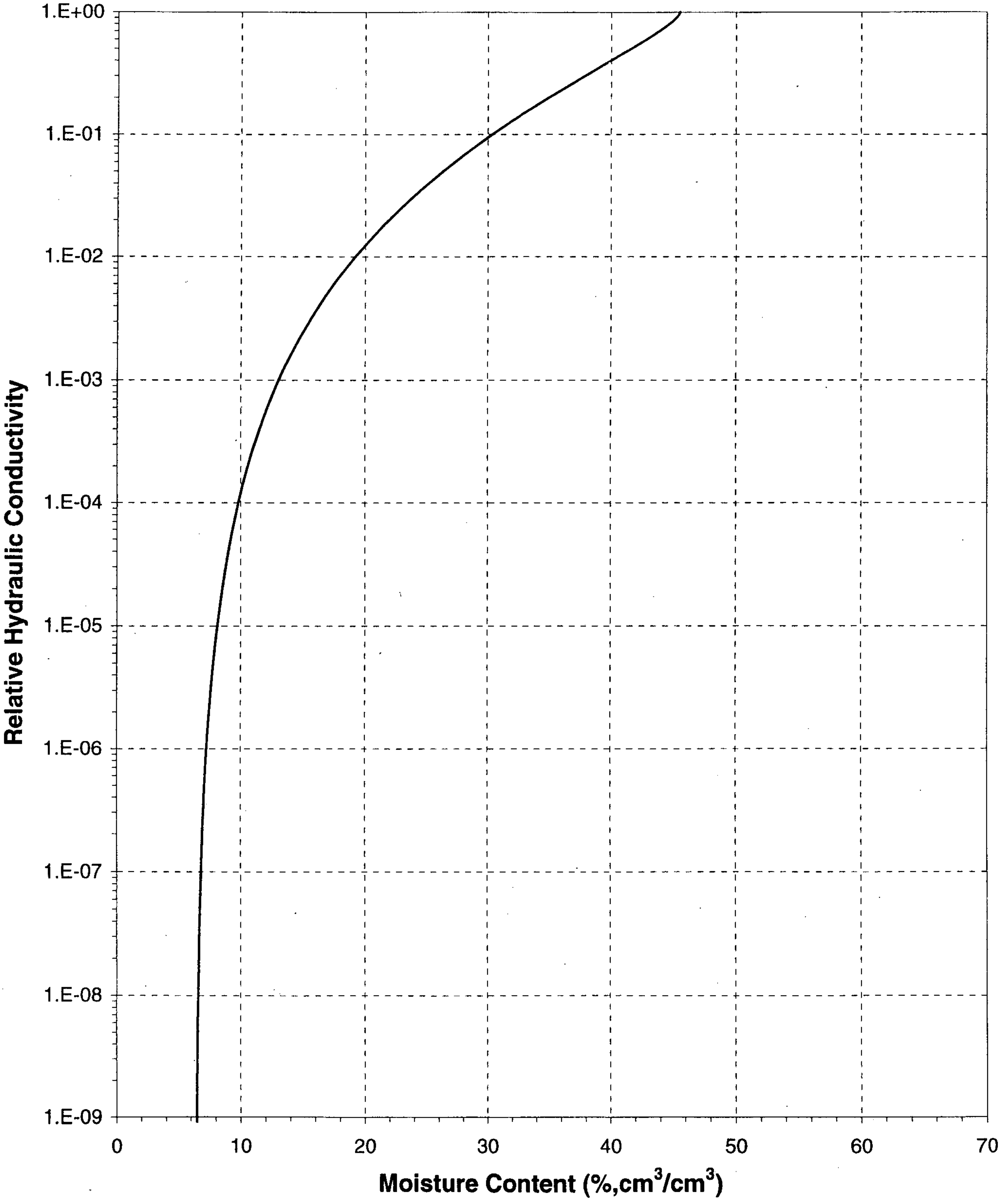
Predicted Water Retention Curve and Data Points

Sample Number: WELL-1 69.5-70



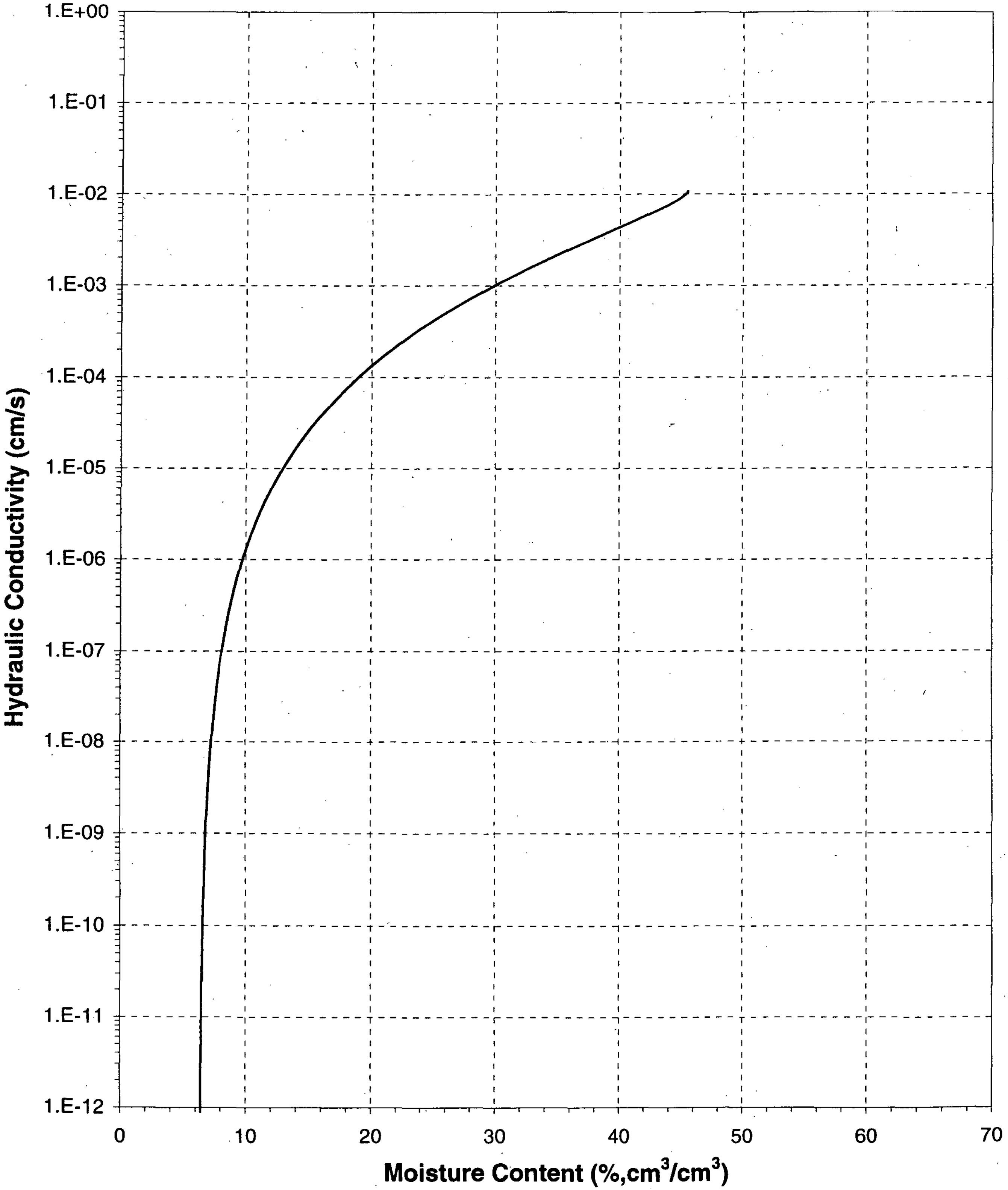
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: WELL-1 69.5-70



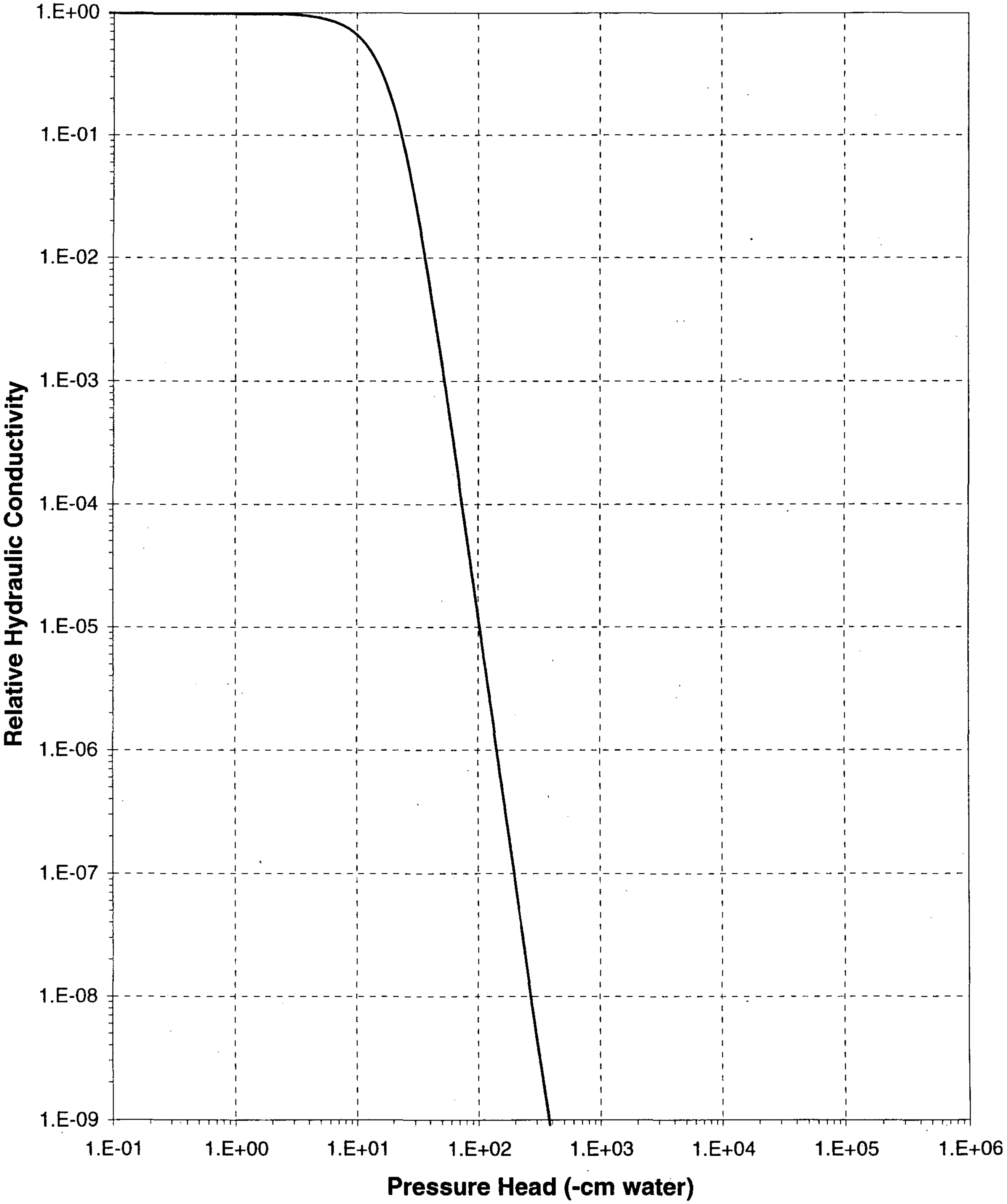
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: WELL-1 69.5-70



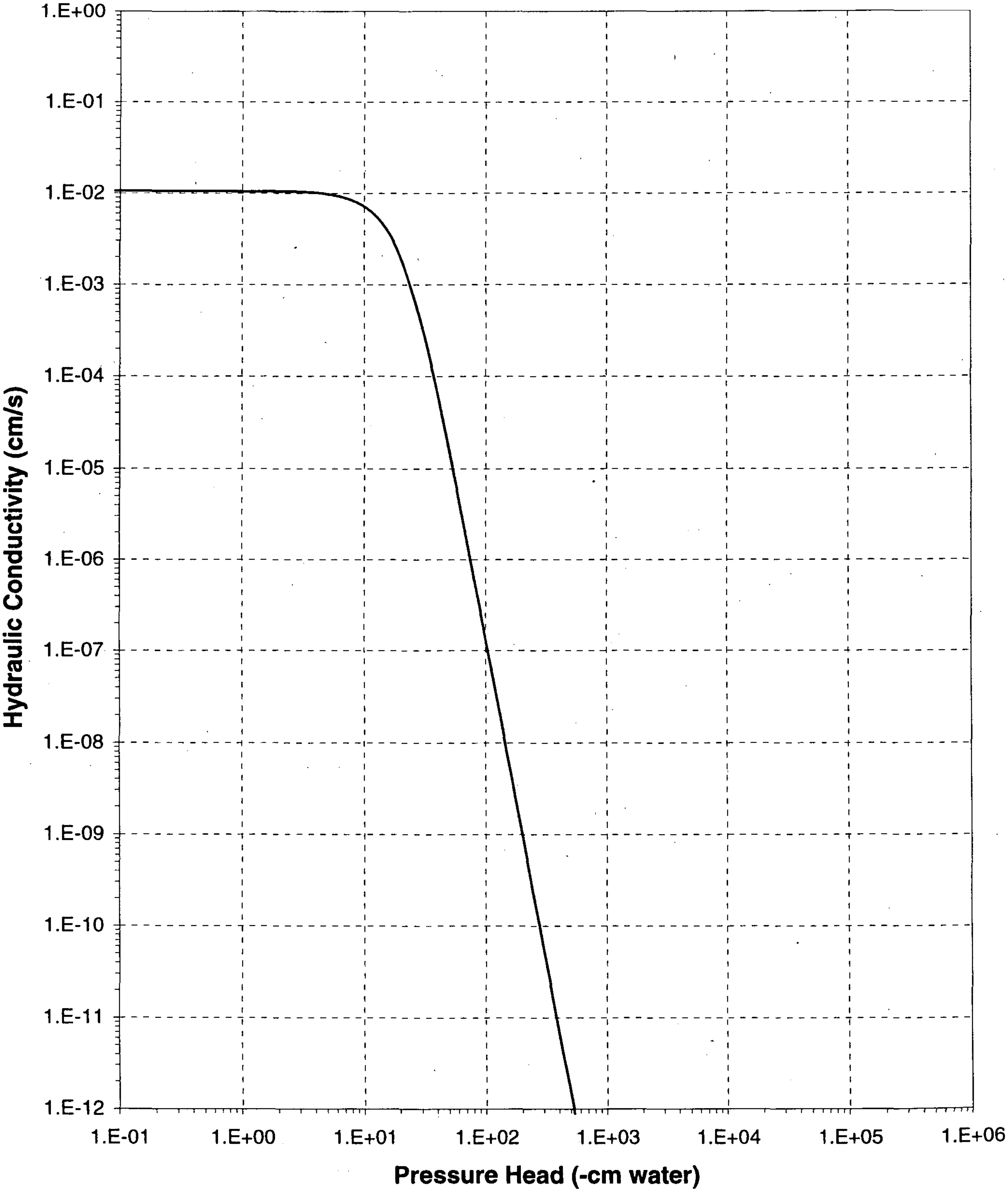
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: WELL-1 69.5-70



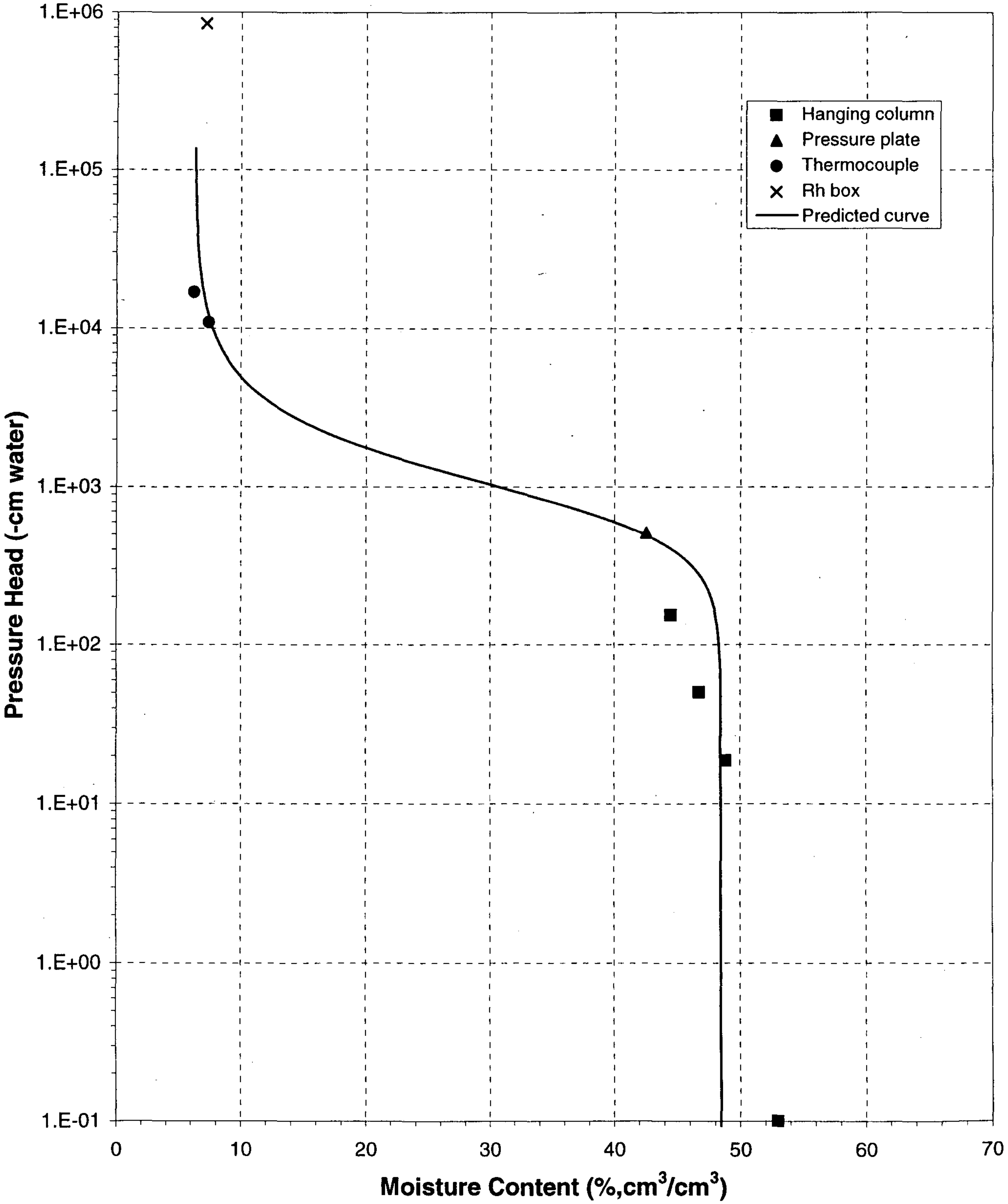
Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: WELL-1 69.5-70



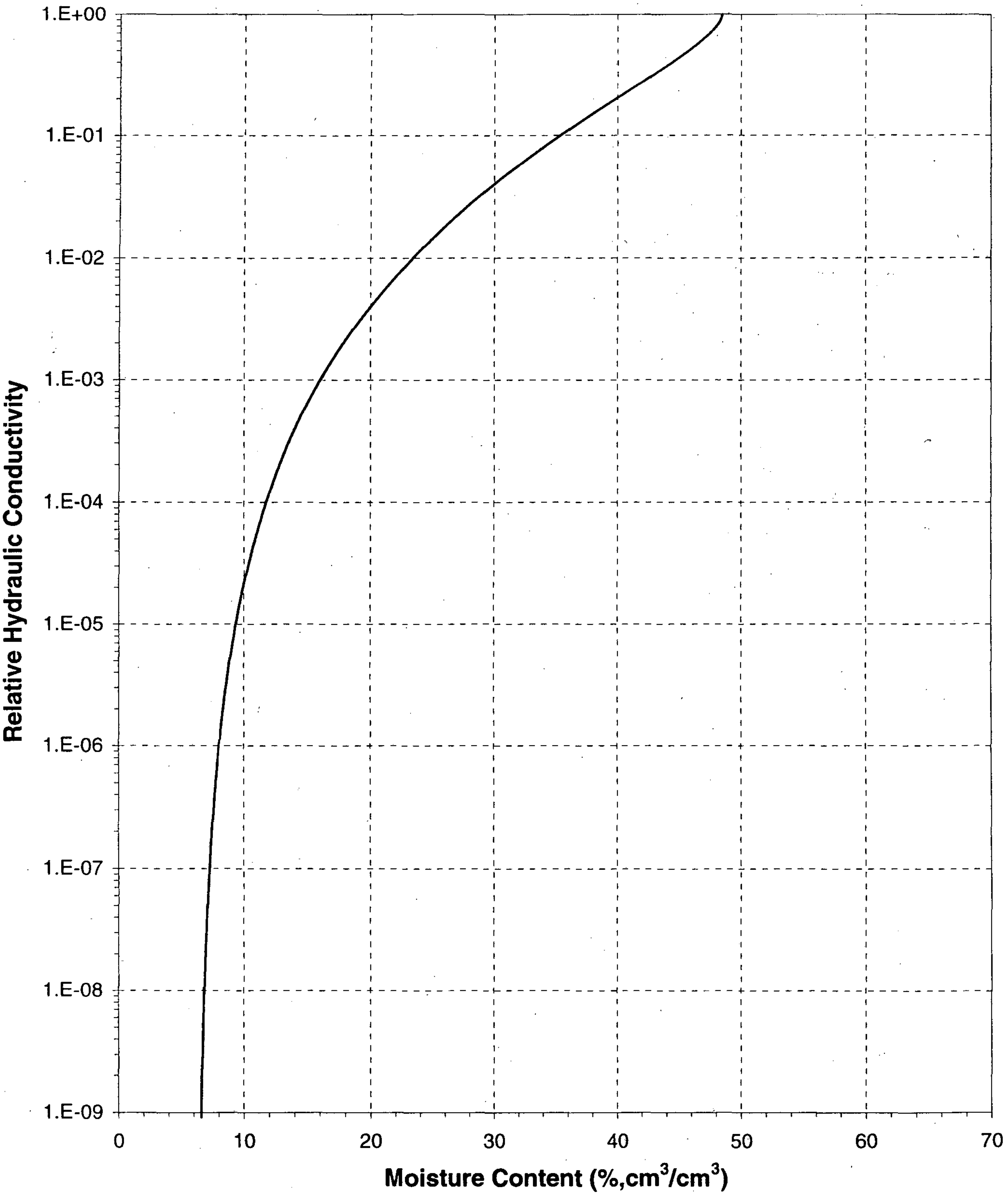
Predicted Water Retention Curve and Data Points

Sample Number: WELL-1 79-79.5



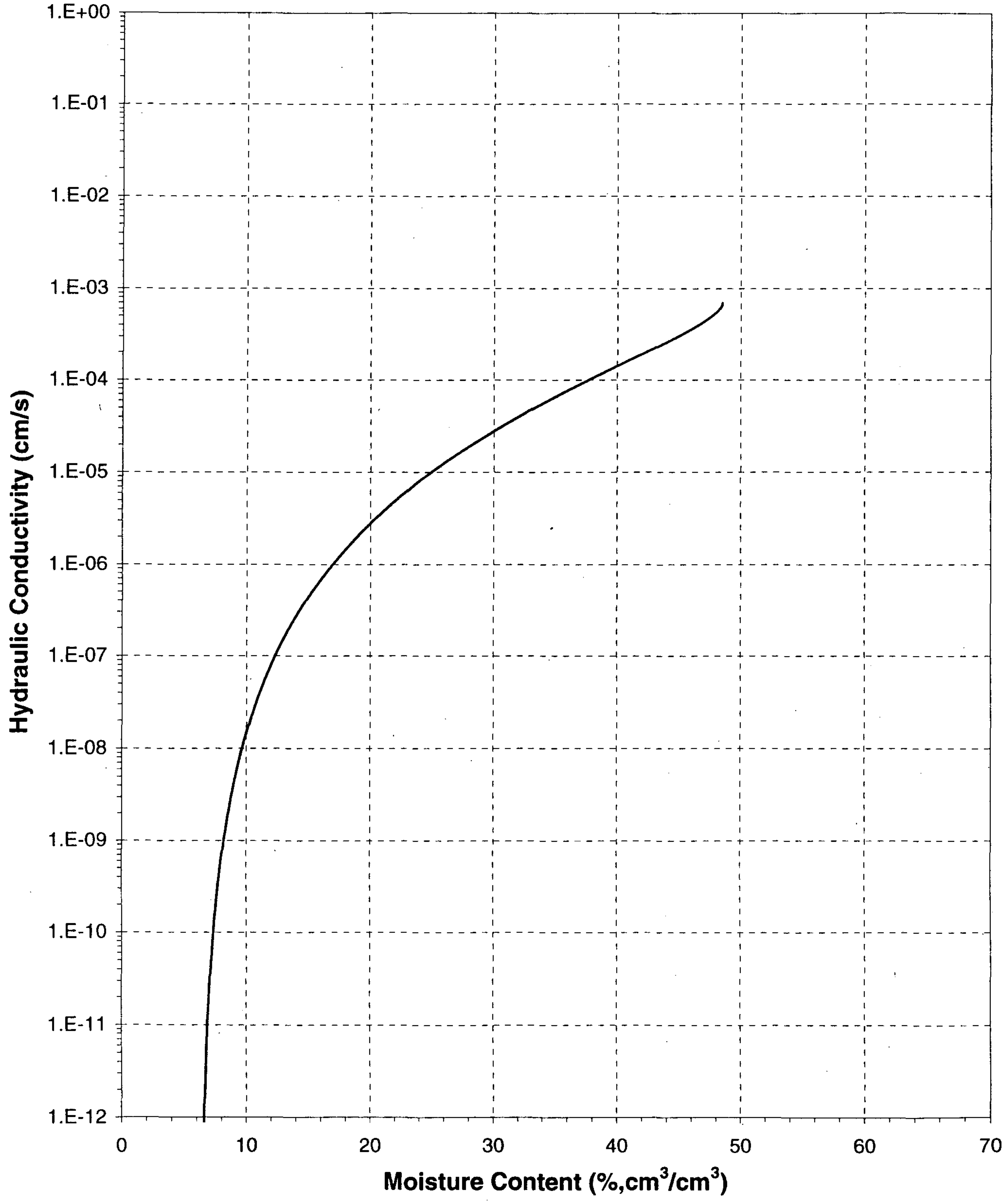
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: WELL-1 79-79.5



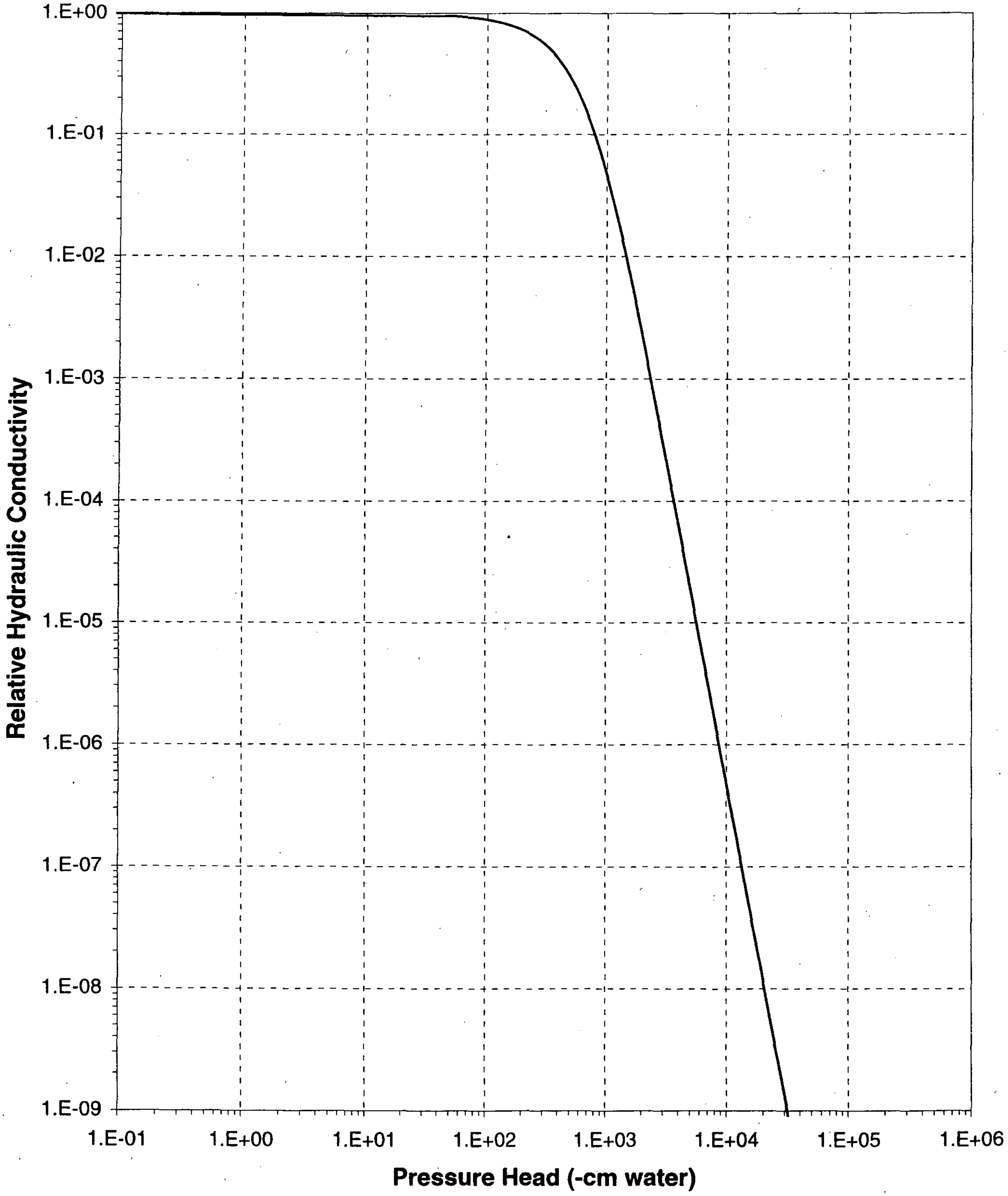
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: WELL-1 79-79.5



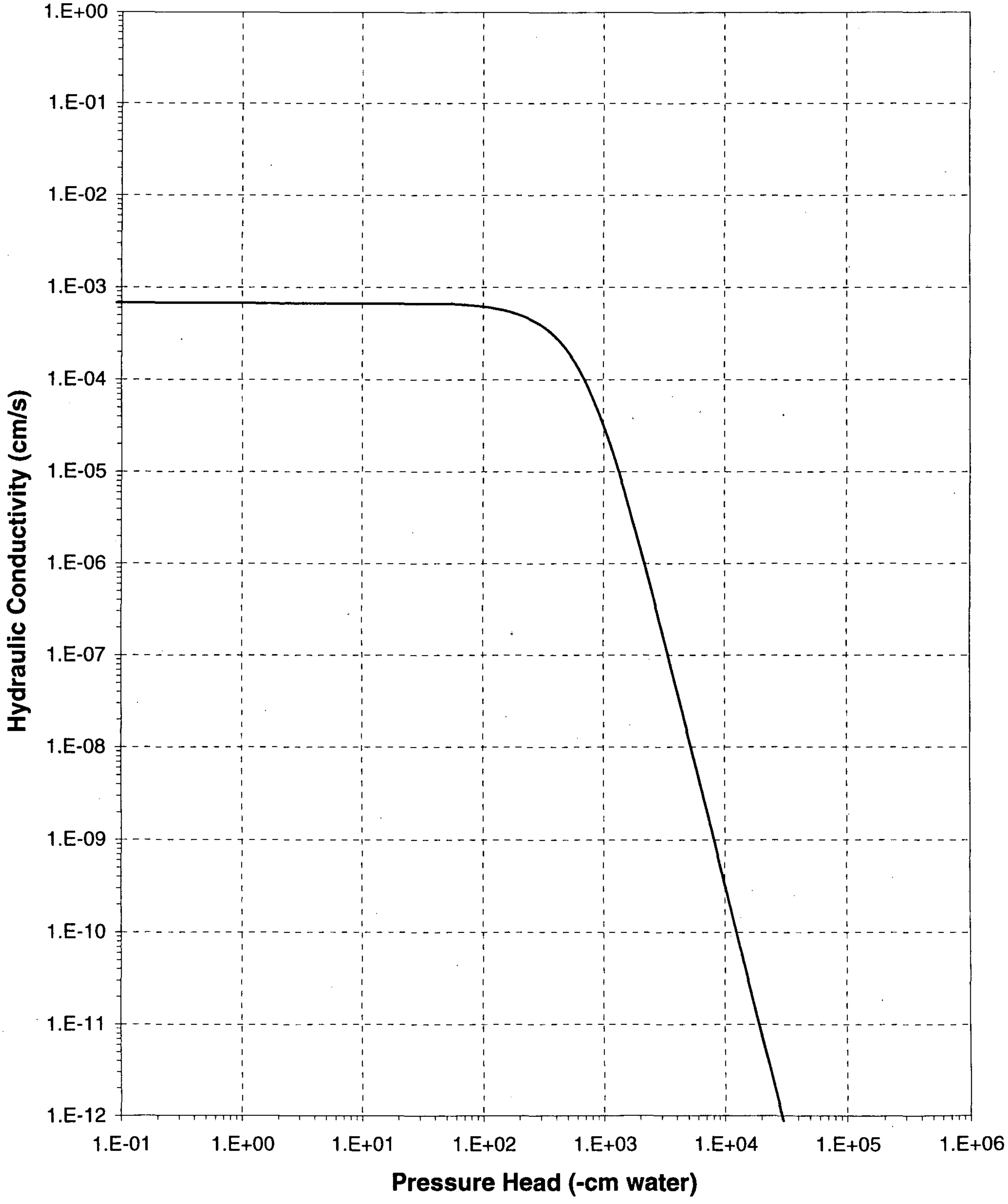
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: WELL-1 79-79.5



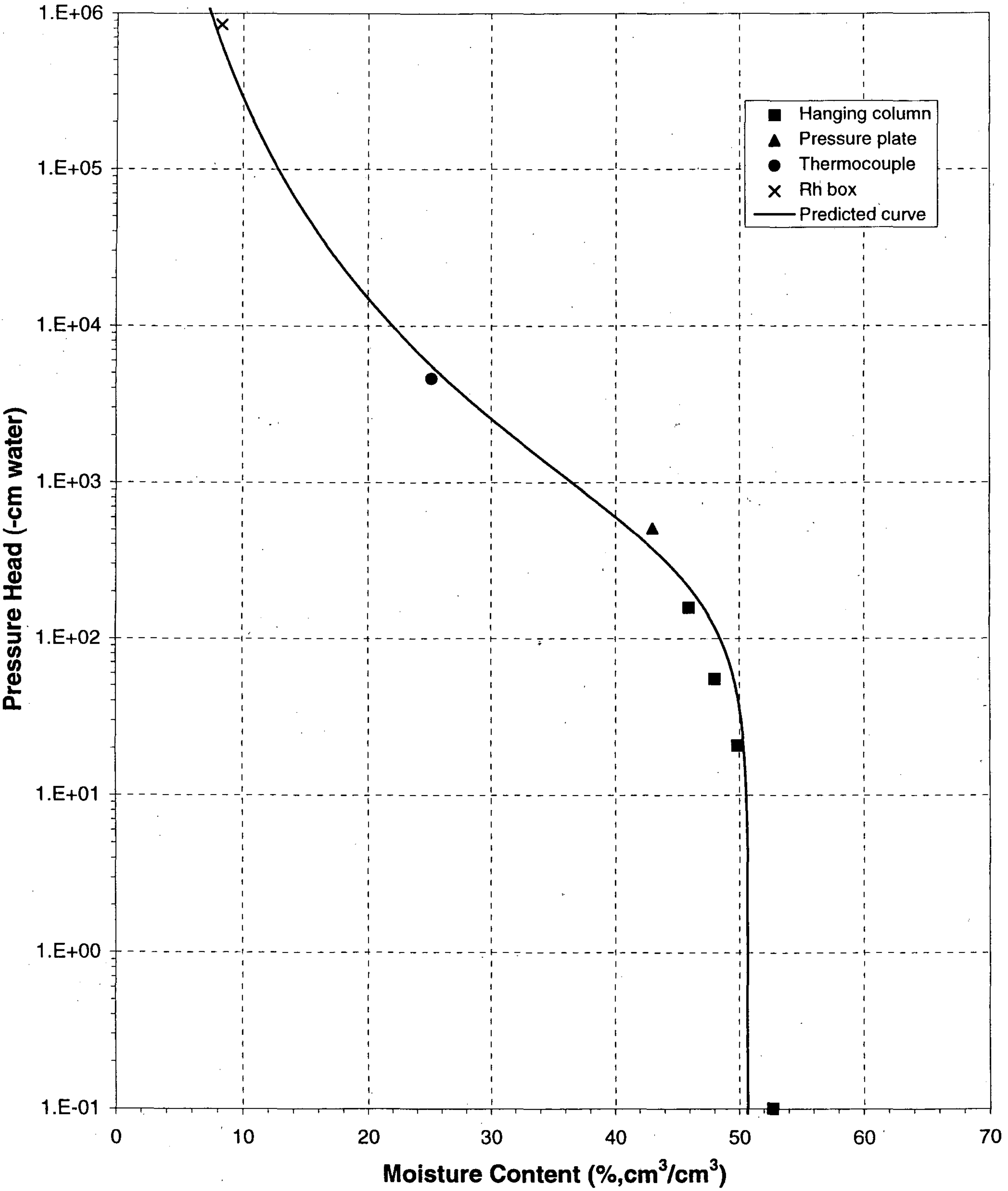
Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: WELL-1 79-79.5



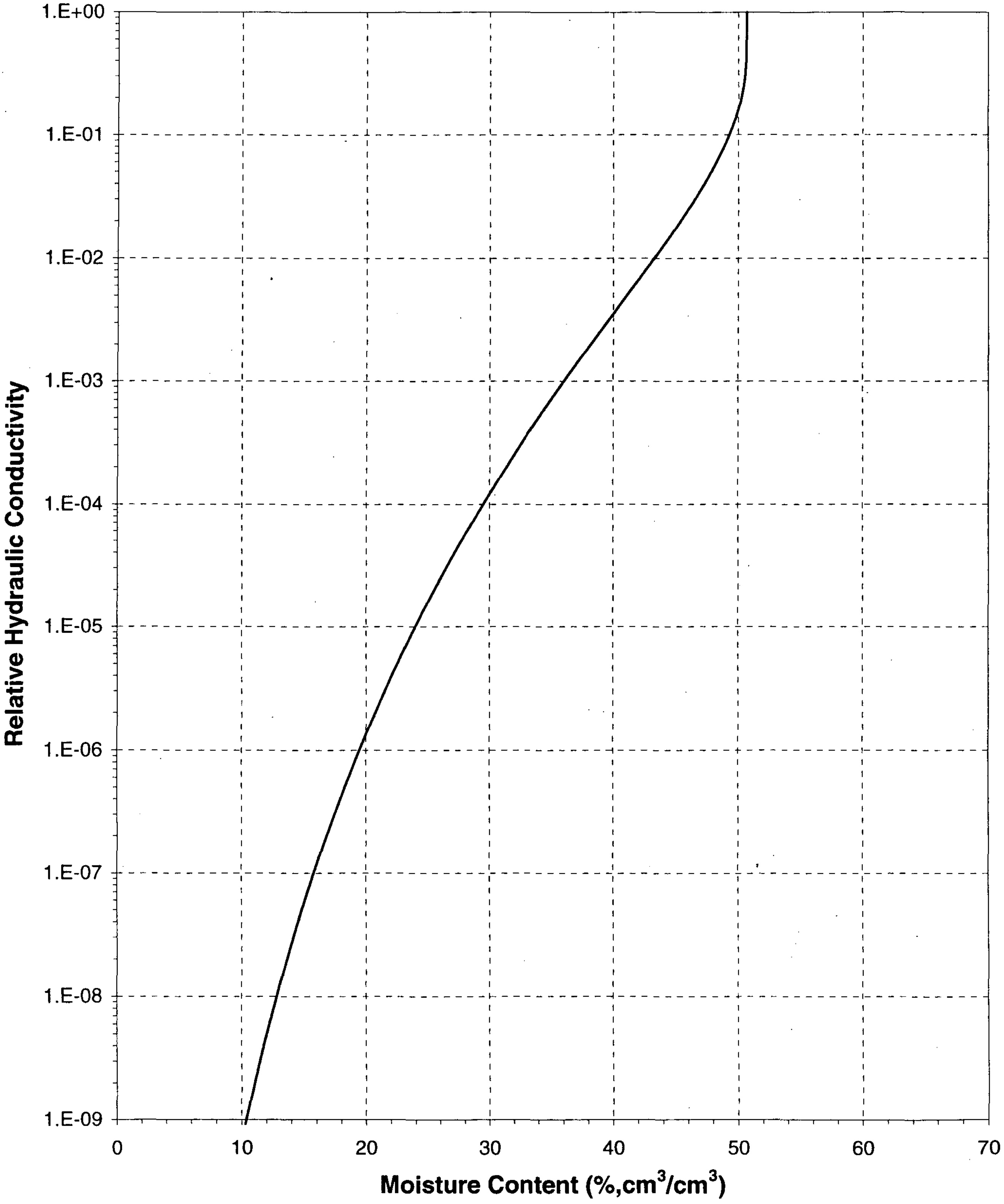
Predicted Water Retention Curve and Data Points

Sample Number: WELL-1 79.5-80



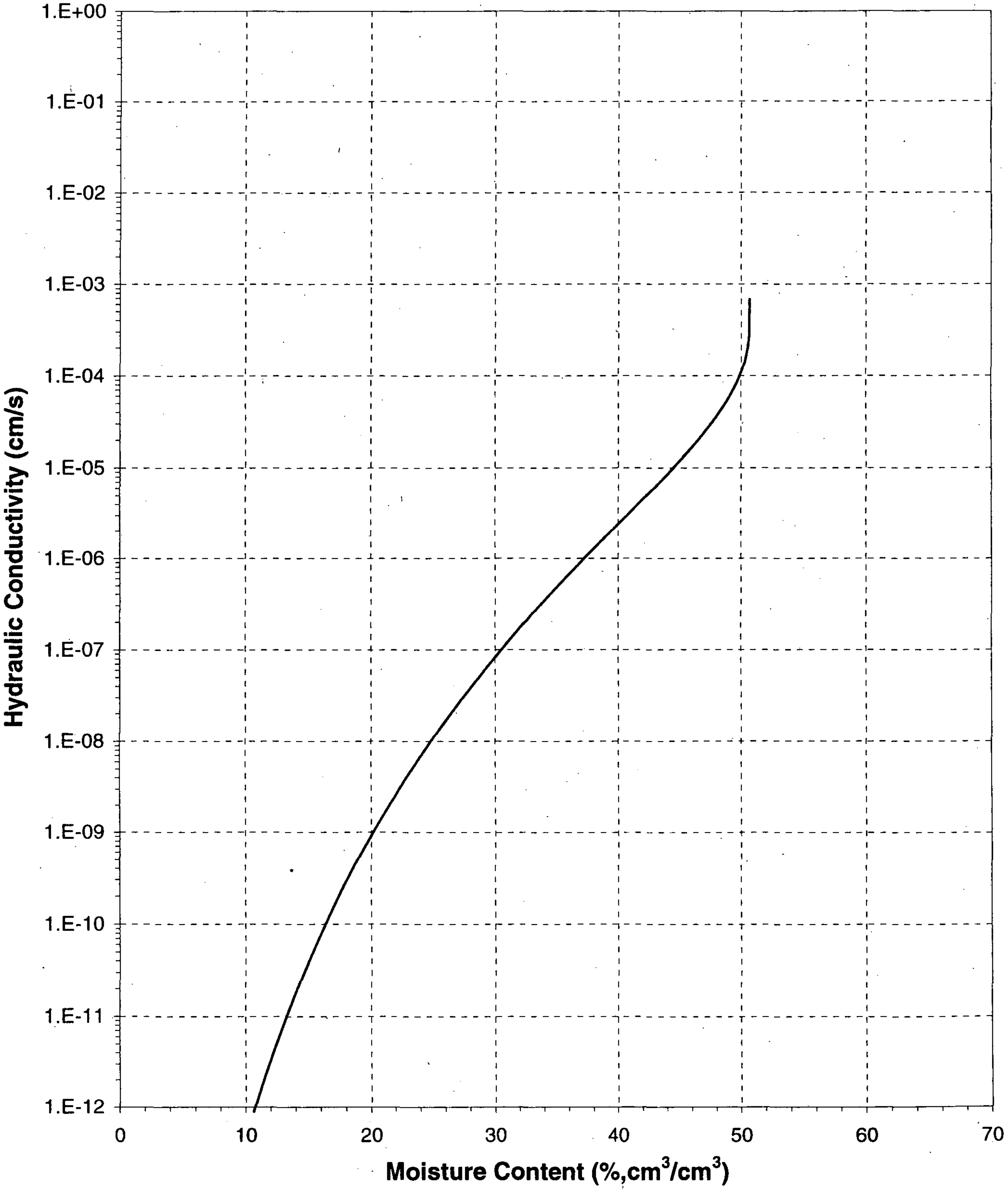
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: WELL-1 79.5-80



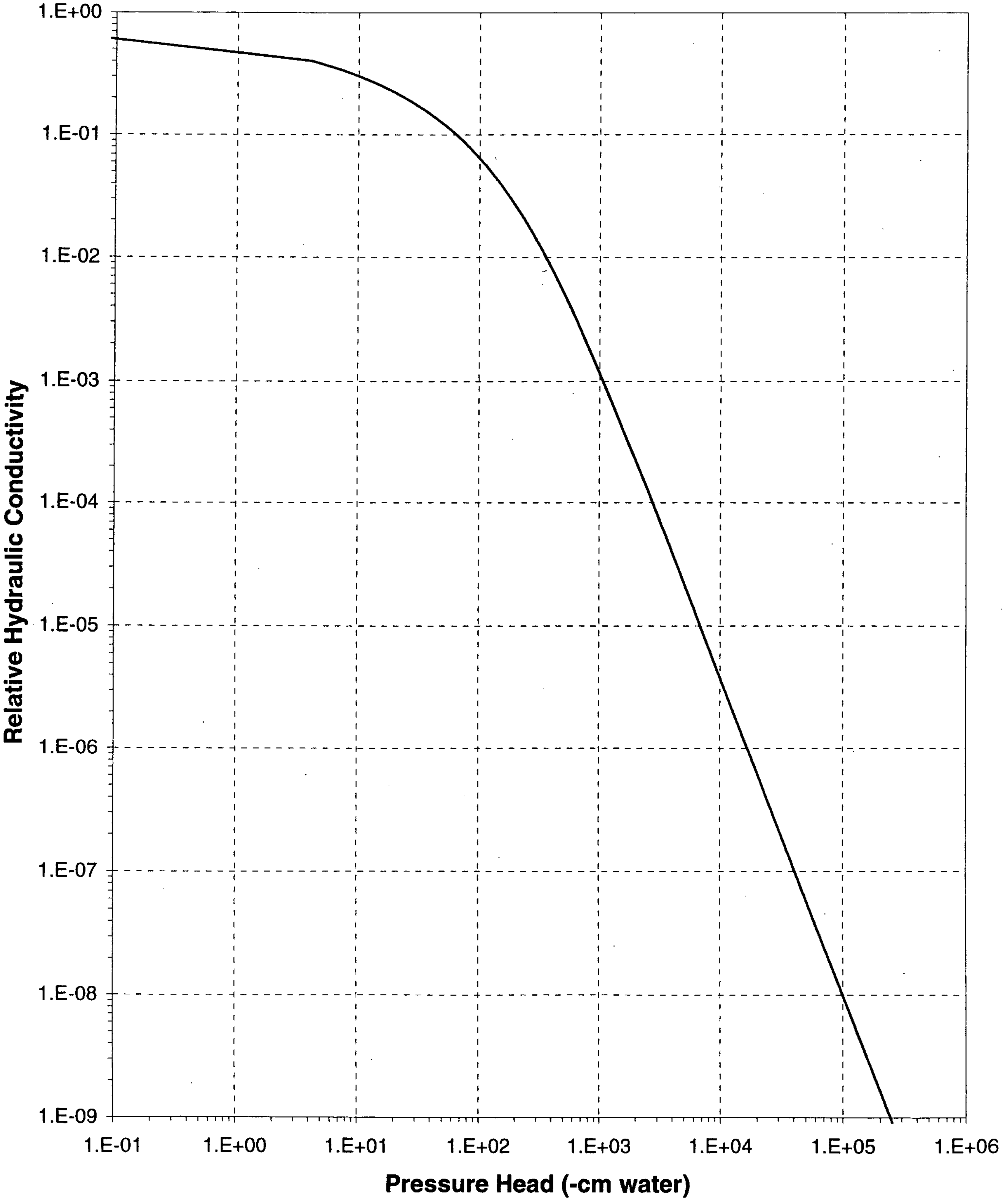
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: WELL-1 79.5-80



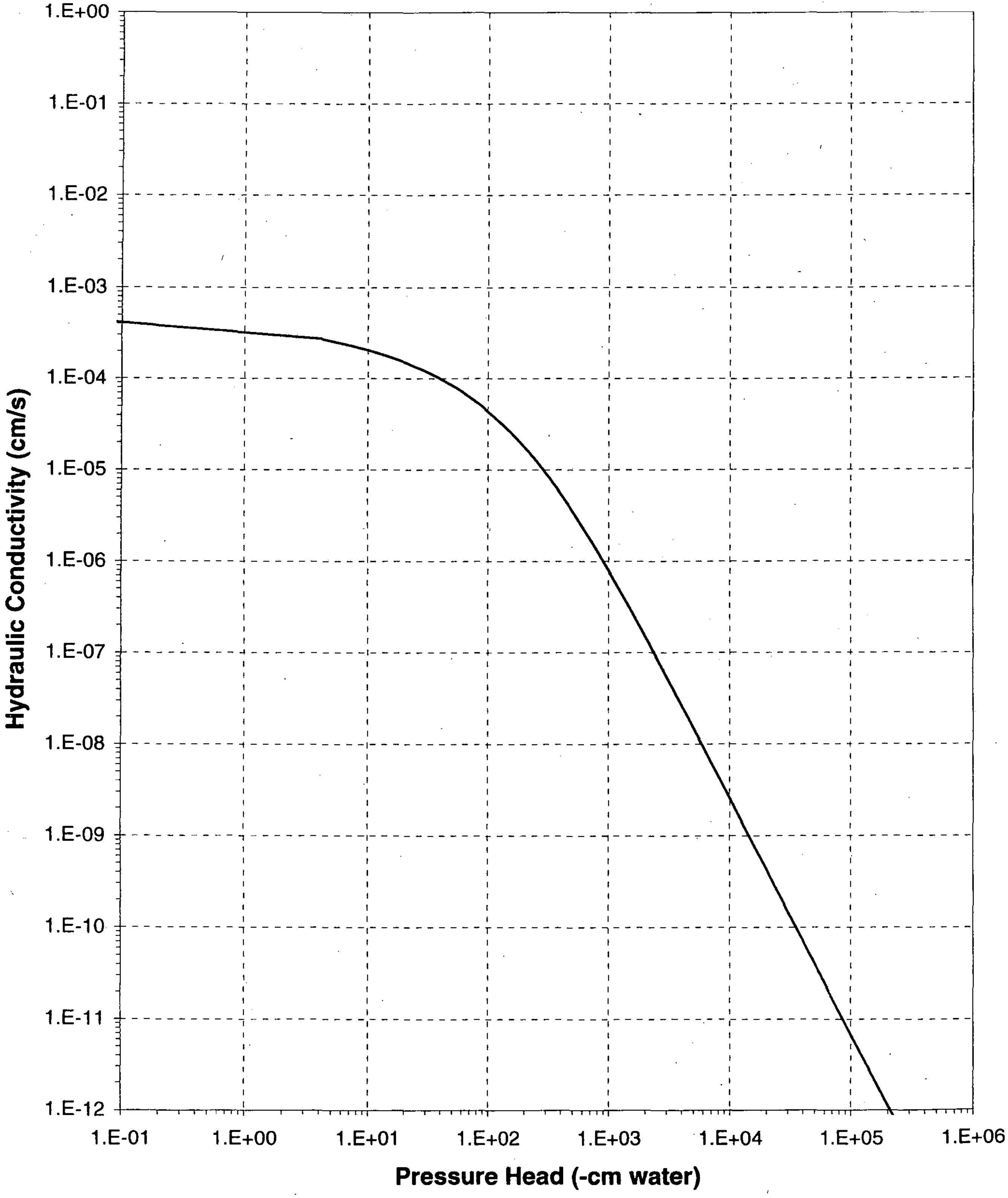
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: WELL-1 79.5-80



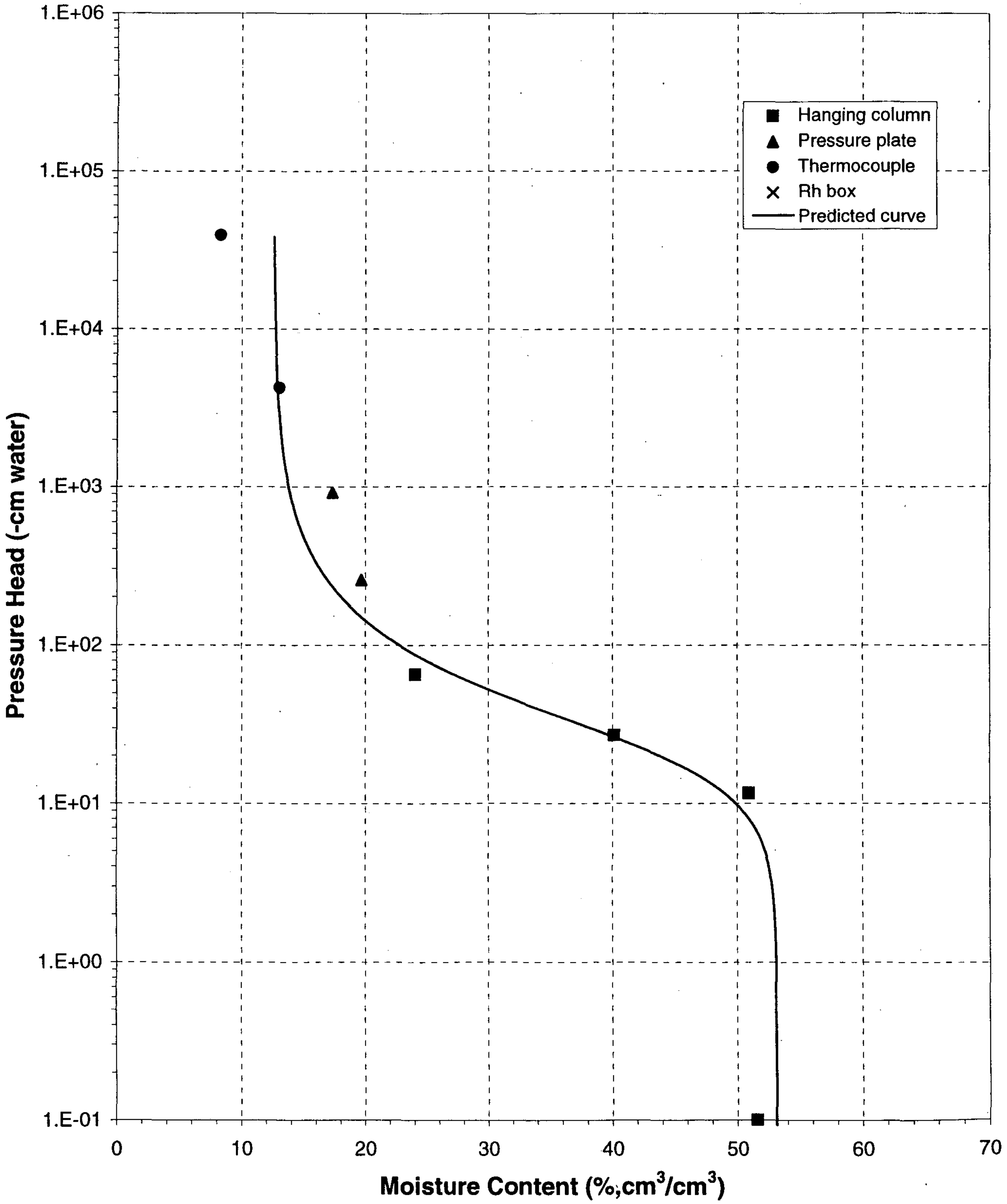
Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: WELL-1 79.5-80



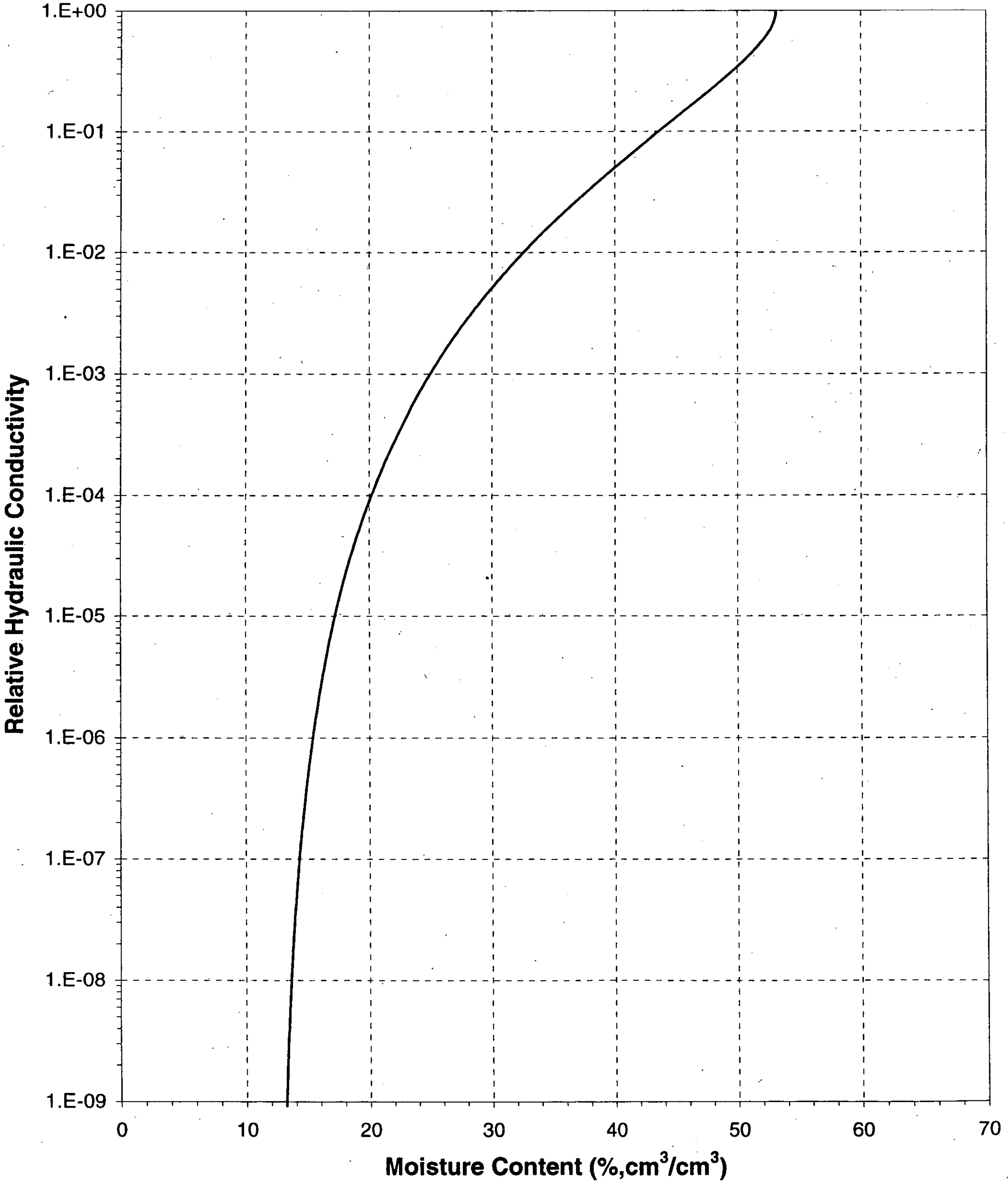
Predicted Water Retention Curve and Data Points

Sample Number: WELL-1 109-109.5



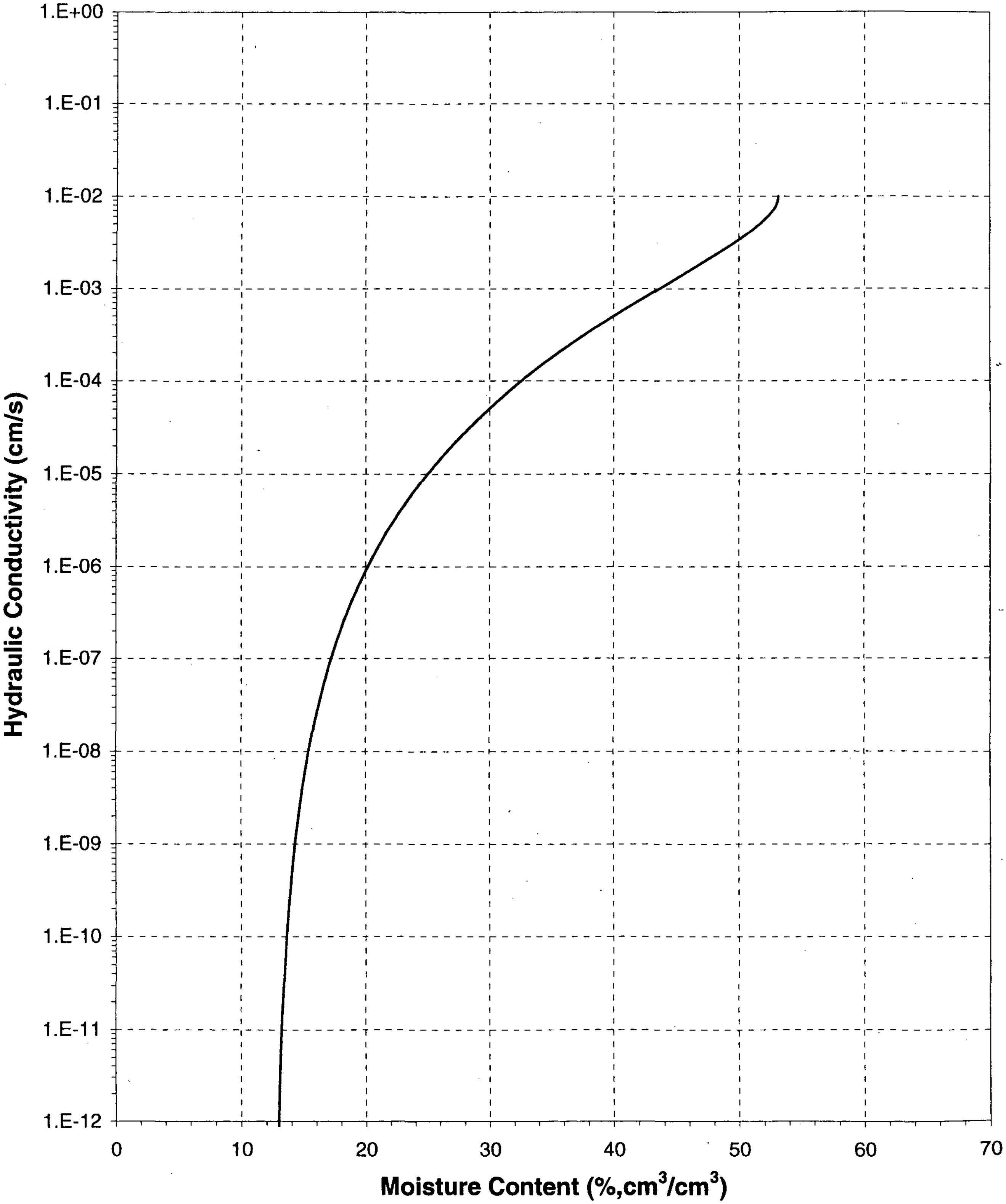
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: WELL-1 109-109.5



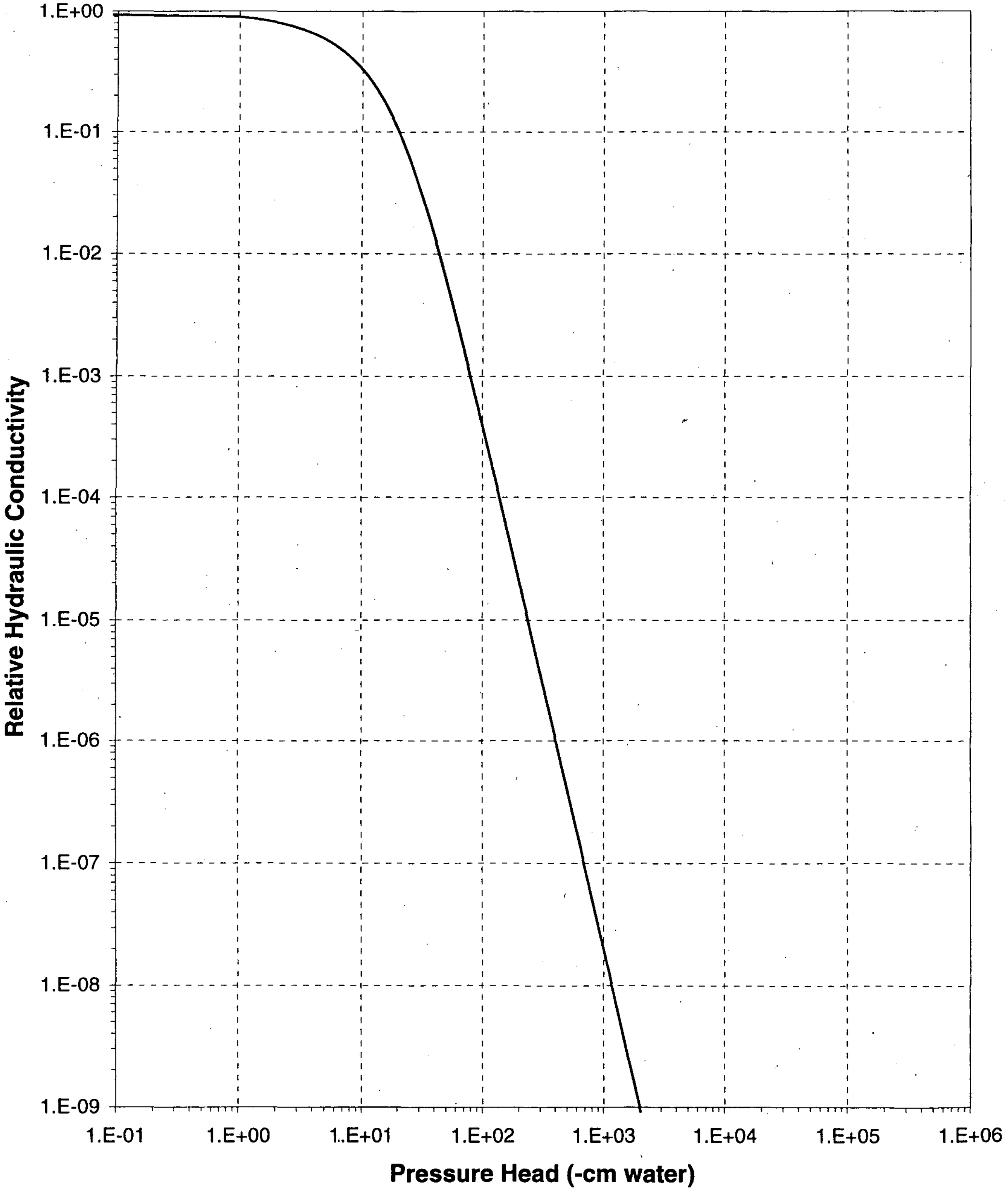
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: WELL-1 109-109.5



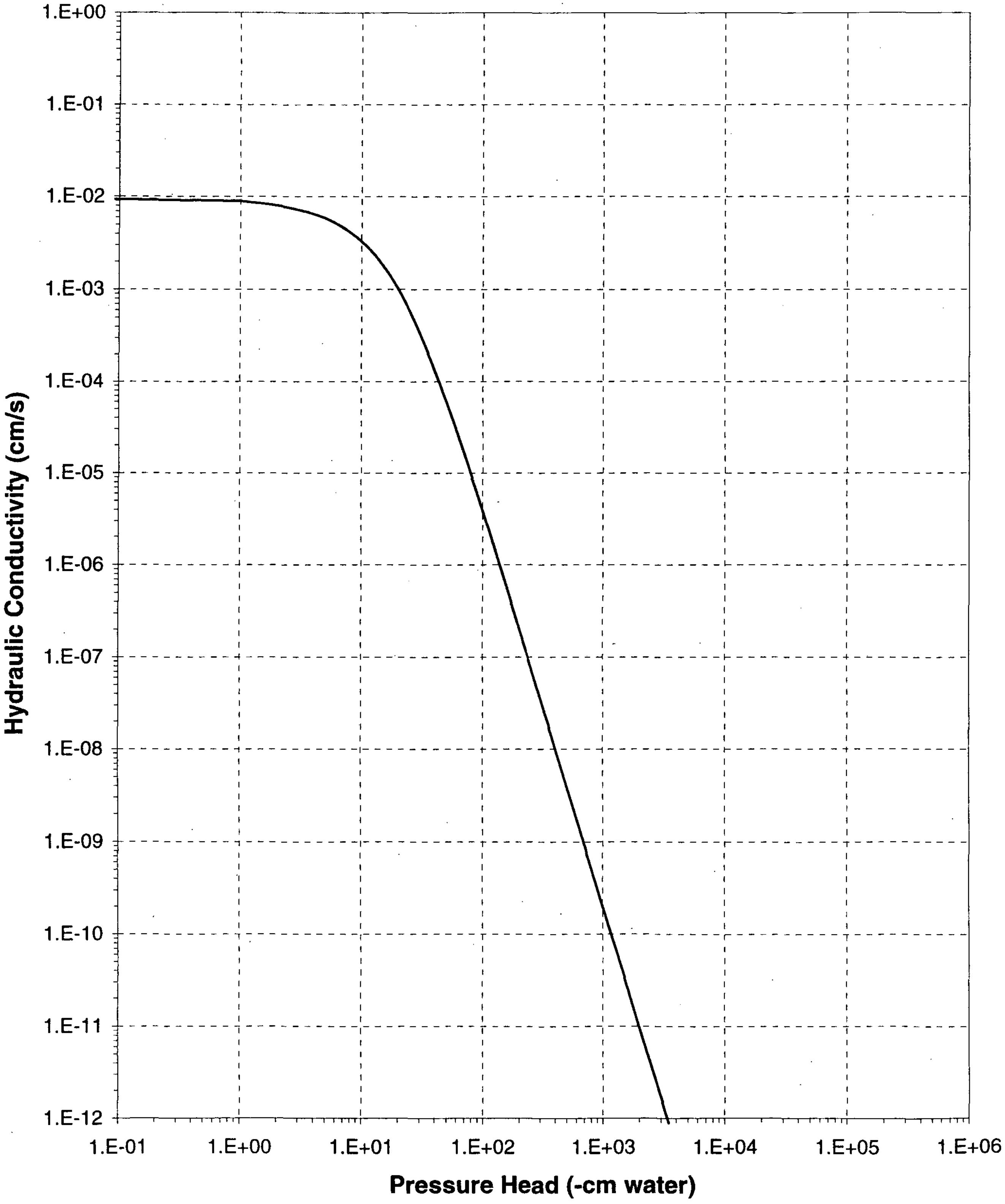
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: WELL-1 109-109.5



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: WELL-1 109-109.5



Appendix E

Laboratory Methods

SUMMARY OF LABORATORY METHODS

Methods	**Reference**
Moisture Content	ASTM D 2216-92
Bulk Density	ASTM D 2937-94/Klute, 1986. Chp. 13, pp. 363-367
Porosity	Klute, 1986. Chp. 18, pp. 444-445
Saturated Hydraulic Conductivity	
Constant Head	ASTM D 2434-68(74)
Falling Head	Klute, 1986. Chp. 28, pp. 700-703
Moisture Retention Characteristics	
Hanging Column	Klute, 1986. Chp. 26, pp. 637-639
Pressure Plate Extractor	ASTM D 2325-68(94)
Thermocouple Psychrometer	Klute, 1986. Chp. 24, pp. 597-618 Operators Manual for the SC-10A Thermocouple Psychrometer Sample Chamber (manufactured by Decagon Devices, Inc., Pullman, WA)
Unsaturated Hydraulic Conductivity (Calculated from Moisture Retention Data)	Van Genuchten, M. 1980. A Closed Form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils. *Soil Sci. Soc. Am. J.* 44:892-898.

* Klute, A. (ed.) 1986. *Methods of Soil Analysis, Part 1*, 2nd ed. American Society of Agronomy. Madison, WI.

APPENDIX C -- ANALYTICAL RESULTS

LBL Environmental Measurements Laboratory
Volatile Organics Analysis Data Sheet

Sample ID:	A1	Laboratory ID:	OW990401
Matrix:	Water	Sample Wt./Vol.:	5.0 ml
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/2/99	Method:	EPA 8260(Purge & Trap)

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
1	Benzene	71-43-2	LT	1.0
2	Bromobenzene	108-86-1	LT	1.0
3	Bromochloromethane	74-97-5	LT	2.0
4	Bromodichloromethane	75-27-4	LT	1.0
5	Bromoform	75-25-2	LT	2.0
6	Bromomethane	74-83-9	LT	4.0
7	n-Butylbenzene	104-51-8	LT	1.0
8	sec-Butylbenzene	135-98-8	LT	1.0
9	ter-Butylbenzene	98-06-6	LT	1.0
10	Carbon Tetrachloride	56-23-5	LT	1.0
11	Chlorobenzene	108-90-7	LT	1.0
12	Chlorodifluoromethane(Freon-22)	75-45-6	LT	30.0
13	Chloroethane	75-00-3	LT	30.0
14	Chloroform	67-66-3	LT	1.0
15	Chloromethane	74-87-3	LT	1.0
16	2-Chlorotoluene	95-49-8	LT	2.0
17	4-Chlorotoluene	106-43-4	LT	2.0
18	Dibromochloromethane	124-48-1	LT	2.0
19	1,2-Dibromo-3-chloropropane	96-12-8	LT	2.0
20	1,2-Dibromoethane	106-93-4	LT	2.0
21	Dibromomethane	74-95-3	LT	1.0
22	1,2-Dichlorobenzene	95-50-1	LT	1.0
23	1,3-Dichlorobenzene	541-73-1	LT	1.0
24	1,4-Dichlorobenzene	106-46-7	LT	1.0
25	Dichlorodifluoromethane(Freon-12)	75-71-8	LT	3.0
26	1,1-Dichloroethane	75-34-3	LT	1.0
27	1,2-Dichloroethane	107-06-2	LT	2.0
28	1,1-Dichloroethene	75-35-4	LT	1.0
29	cis-1,2-Dichloroethene	156-69-9	LT	1.0
30	trans-1,2-Dichloroethene	156-60-5	LT	1.0
31	Dichlorofluoromethane(Freon-21)	75-43-4	LT	3.0
32	1,2-Dichloropropane	78-87-5	LT	1.0
33	1,3-Dichloropropane	142-28-9	LT	1.0
34	2,2-Dichloropropane	594-20-7	LT	1.0

Volatile Organics Analysis Data Sheet (Continued) Laboratory ID: OW990401

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
35	1,1-Dichloropropene	563-58-6	LT	1.0
36	cis-1,3-Dichloropropene	10061-01-5	LT	1.0
37	trans-1,3-Dichloropropene	10061-02-6	LT	1.0
38	1,2-Dichlorotetrafluoroethane(Freon-114)	76-14-2	LT	3.0
39	Dichlorotrifluoroethane(Freon-123)	306-83-2	LT	1.0
40	Dichlorotrifluoroethane(Freon-123A)	354-23-4	30.1	1.0
41	Ethylbenzene	100-41-4	LT	1.0
42	Hexachlorobutadien	87-68-3	LT	3.0
43	Isopropylbenzene	98-82-8	LT	2.0
44	p-Isopropyltoluene	99-87-6	LT	1.0
45	Methylene Chloride	75-09-2	LT	1.0
45	Methyl tert-Butyl Ether	1634-04-4	LT	5.0
46	Naphthalene	91-20-3	LT	2.0
47	n-Propylbenzene	103-65-1	LT	1.0
48	Styrene	100-42-5	LT	1.0
49	1,1,2,2-Tetrachloroethane	79-34-5	LT	1.0
50	1,1,1,2-Tetrachloroethane	79-34-5	LT	2.0
51	Tetrachloroethene	127-18-4	LT	1.0
52	Toluene	108-88-3	LT	1.0
53	1,2,3-Trichlorobenzene	87-61-6	LT	2.0
54	1,2,4-Trichlorobenzene	120-82-1	LT	1.0
55	1,1,1-Trichloroethane	71-55-6	LT	1.0
56	1,1,2-Trichloroethane	79-00-5	LT	1.0
57	Trichloroethene	79-01-6	15.4	1.0
58	Trichlorofluoromethane(Freon-11)	75-69-4	LT	2.0
59	1,2,3-Trichloropropane	96-18-4	LT	1.0
60	1,1,2-Trichlorotrifluoroethane(Freon-113)	76-13-1	LT	1.0
61	1,2,4-Trimethylbenzene	95-63-6	LT	1.0
62	1,3,5-Trimethylbenzene	108-67-8	LT	1.0
63	Vinyl Chloride	75-01-4	LT	1.0
64	Total-Xylene	1330-20-7	LT	2.0

Surrogate Compounds	% Recovery	QC Limits (%)
4-Bromofluorobenzene	98.4	**86-115**
Dibromofluoromethane	103.2	**86-118**
Toluene-d8	98.0	**88-110**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits (based on 5 ml water sample volume)
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99

LBL Environmental Measurements Laboratory
Volatile Organics Analysis Data Sheet

Sample ID:	A6	Laboratory ID:	OW990402
Matrix:	Water	Sample Wt./Vol.:	5.0 ml
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/2/99	Method:	EPA 8260(Purge & Trap)

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
1	Benzene	71-43-2	LT	2.4
2	Bromobenzene	108-86-1	LT	2.4
3	Bromochloromethane	74-97-5	LT	4.8
4	Bromodichloromethane	75-27-4	LT	2.4
5	Bromoform	75-25-2	LT	4.8
6	Bromomethane	74-83-9	LT	9.5
7	n-Butylbenzene	104-51-8	LT	2.4
8	sec-Butylbenzene	135-98-8	LT	2.4
9	ter-Butylbenzene	98-06-6	LT	2.4
10	Carbon Tetrachloride	56-23-5	LT	2.4
11	Chlorobenzene	108-90-7	LT	2.4
12	Chlorodifluoromethane(Freon-22)	75-45-6	LT	71.4
13	Chloroethane	75-00-3	LT	71.4
14	Chloroform	67-66-3	LT	2.4
15	Chloromethane	74-87-3	LT	2.4
16	2-Chlorotoluene	95-49-8	LT	4.8
17	4-Chlorotoluene	106-43-4	LT	4.8
18	Dibromochloromethane	124-48-1	LT	4.8
19	1,2-Dibromo-3-chloropropane	96-12-8	LT	4.8
20	1,2-Dibromoethane	106-93-4	LT	4.8
21	Dibromomethane	74-95-3	LT	2.4
22	1,2-Dichlorobenzene	95-50-1	LT	2.4
23	1,3-Dichlorobenzene	541-73-1	LT	2.4
24	1,4-Dichlorobenzene	106-46-7	LT	2.4
25	Dichlorodifluoromethane(Freon-12)	75-71-8	LT	7.1
26	1,1-Dichloroethane	75-34-3	LT	2.4
27	1,2-Dichloroethane	107-06-2	LT	4.8
28	1,1-Dichloroethene	75-35-4	LT	2.4
29	cis-1,2-Dichloroethene	156-69-9	LT	2.4
30	trans-1,2-Dichloroethene	156-60-5	LT	2.4
31	Dichlorofluoromethane(Freon-21)	75-43-4	LT	7.1
32	1,2-Dichloropropane	78-87-5	LT	2.4
33	1,3-Dichloropropane	142-28-9	LT	2.4
34	2,2-Dichloropropane	594-20-7	LT	2.4

Volatile Organics Analysis Data Sheet (Continued) Laboratory ID: OW990402

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
35	1,1-Dichloropropene	563-58-6	LT	2.4
36	cis-1,3-Dichloropropene	10061-01-5	LT	2.4
37	trans-1,3-Dichloropropene	10061-02-6	LT	2.4
38	1,2-Dichlorotetrafluoroethane(Freon-114)	76-14-2	LT	7.1
39	Dichlorotrifluoroethane(Freon-123)	306-83-2	LT	2.4
40	Dichlorotrifluoroethane(Freon-123A)	354-23-4	LT	2.4
41	Ethylbenzene	100-41-4	LT	2.4
42	Hexachlorobutadien	87-68-3	LT	7.1
43	Isopropylbenzene	98-82-8	LT	4.8
44	p-Isopropyltoluene	99-87-6	LT	2.4
45	Methylene Chloride	75-09-2	LT	2.4
45	Methyl tert-Butyl Ether	1634-04-4	LT	11.9
46	Naphthalene	91-20-3	LT	4.8
47	n-Propylbenzene	103-65-1	LT	2.4
48	Styrene	100-42-5	LT	2.4
49	1,1,2,2-Tetrachloroethane	79-34-5	LT	2.4
50	1,1,1,2-Tetrachloroethane	79-34-5	LT	4.8
51	Tetrachloroethene	127-18-4	LT	2.4
52	Toluene	108-88-3	LT	2.4
53	1,2,3-Trichlorobenzene	87-61-6	LT	4.8
54	1,2,4-Trichlorobenzene	120-82-1	LT	2.4
55	1,1,1-Trichloroethane	71-55-6	LT	2.4
56	1,1,2-Trichloroethane	79-00-5	LT	2.4
57	Trichloroethene	79-01-6	LT	2.4
58	Trichlorofluoromethane(Freon-11)	75-69-4	LT	4.8
59	1,2,3-Trichloropropane	96-18-4	LT	2.4
60	1,1,2-Trichlorotrifluoroethane(Freon-113)	76-13-1	LT	2.4
61	1,2,4-Trimethylbenzene	95-63-6	LT	2.4
62	1,3,5-Trimethylbenzene	108-67-8	LT	2.4
63	Vinyl Chloride	75-01-4	LT	2.4
64	Total-Xylene	1330-20-7	LT	4.8

Surrogate Compounds	% Recovery	QC Limits (%)
4-Bromofluorobenzene	103.0	**86-115**
Dibromofluoromethane	102.6	**86-118**
Toluene-d8	97.0	**88-110**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits (based on 5 ml water sample volume)
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory

Volatile Organics Analysis Data Sheet

Sample ID:	A10	Laboratory ID:	OW990403
Matrix:	Water	Sample Wt./Vol.:	5.0 ml
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/2/99	Method:	EPA 8260(Purge & Trap)

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
1	Benzene	71-43-2	LT	1.4
2	Bromobenzene	108-86-1	LT	1.4
3	Bromochloromethane	74-97-5	LT	2.9
4	Bromodichloromethane	75-27-4	LT	1.4
5	Bromoform	75-25-2	LT	2.9
6	Bromomethane	74-83-9	LT	5.7
7	n-Butylbenzene	104-51-8	LT	1.4
8	sec-Butylbenzene	135-98-8	LT	1.4
9	ter-Butylbenzene	98-06-6	LT	1.4
10	Carbon Tetrachloride	56-23-5	LT	1.4
11	Chlorobenzene	108-90-7	LT	1.4
12	Chlorodifluoromethane(Freon-22)	75-45-6	LT	42.9
13	Chloroethane	75-00-3	LT	42.9
14	Chloroform	67-66-3	LT	1.4
15	Chloromethane	74-87-3	LT	1.4
16	2-Chlorotoluene	95-49-8	LT	2.9
17	4-Chlorotoluene	106-43-4	LT	2.9
18	Dibromochloromethane	124-48-1	LT	2.9
19	1,2-Dibromo-3-chloropropane	96-12-8	LT	2.9
20	1,2-Dibromoethane	106-93-4	LT	2.9
21	Dibromomethane	74-95-3	LT	1.4
22	1,2-Dichlorobenzene	95-50-1	LT	1.4
23	1,3-Dichlorobenzene	541-73-1	LT	1.4
24	1,4-Dichlorobenzene	106-46-7	LT	1.4
25	Dichlorodifluoromethane(Freon-12)	75-71-8	LT	4.3
26	1,1-Dichloroethane	75-34-3	LT	1.4
27	1,2-Dichloroethane	107-06-2	LT	2.9
28	1,1-Dichloroethene	75-35-4	LT	1.4
29	cis-1,2-Dichloroethene	156-69-9	10.4	1.4
30	trans-1,2-Dichloroethene	156-60-5	LT	1.4
31	Dichlorofluoromethane(Freon-21)	75-43-4	LT	4.3
32	1,2-Dichloropropane	78-87-5	LT	1.4
33	1,3-Dichloropropane	142-28-9	LT	1.4
34	2,2-Dichloropropane	594-20-7	LT	1.4

Volatile Organics Analysis Data Sheet (Continued) Laboratory ID: OW990403

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
35	1,1-Dichloropropene	563-58-6	LT	1.4
36	cis-1,3-Dichloropropene	10061-01-5	LT	1.4
37	trans-1,3-Dichloropropene	10061-02-6	LT	1.4
38	1,2-Dichlorotetrafluoroethane(Freon-114)	76-14-2	LT	4.3
39	Dichlorotrifluoroethane(Freon-123)	306-83-2	LT	1.4
40	Dichlorotrifluoroethane(Freon-123A)	354-23-4	LT	1.4
41	Ethylbenzene	100-41-4	LT	1.4
42	Hexachlorobutadien	87-68-3	LT	4.3
43	Isopropylbenzene	98-82-8	LT	2.9
44	p-Isopropyltoluene	99-87-6	LT	1.4
45	Methylene Chloride	75-09-2	LT	1.4
45	Methyl tert-Butyl Ether	1634-04-4	LT	7.1
46	Naphthalene	91-20-3	LT	2.9
47	n-Propylbenzene	103-65-1	LT	1.4
48	Styrene	100-42-5	LT	1.4
49	1,1,2,2-Tetrachloroethane	79-34-5	LT	1.4
50	1,1,1,2-Tetrachloroethane	79-34-5	LT	2.9
51	Tetrachloroethene	127-18-4	LT	1.4
52	Toluene	108-88-3	LT	1.4
53	1,2,3-Trichlorobenzene	87-61-6	LT	2.9
54	1,2,4-Trichlorobenzene	120-82-1	LT	1.4
55	1,1,1-Trichloroethane	71-55-6	LT	1.4
56	1,1,2-Trichloroethane	79-00-5	LT	1.4
57	Trichloroethene	79-01-6	11.2	1.4
58	Trichlorofluoromethane(Freon-11)	75-69-4	LT	2.9
59	1,2,3-Trichloropropane	96-18-4	LT	1.4
60	1,1,2-Trichlorotrifluoroethane(Freon-113)	76-13-1	LT	1.4
61	1,2,4-Trimethylbenzene	95-63-6	LT	1.4
62	1,3,5-Trimethylbenzene	108-67-8	LT	1.4
63	Vinyl Chloride	75-01-4	LT	1.4
64	Total-Xylene	1330-20-7	LT	2.9

Surrogate Compounds	% Recovery	QC Limits (%)
4-Bromofluorobenzene	103.0	**86-115**
Dibromofluoromethane	104.8	**86-118**
Toluene-d8	100.4	**88-110**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits (based on 5 ml water sample volume)
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : ____________ Date: 8/3/99
Reviewer: ____________ Date: 8/3/99.

LBL Environmental Measurements Laboratory
Volatile Organics Analysis Data Sheet

Sample ID:	B1	Laboratory ID:	OW990404
Matrix:	Water	Sample Wt./Vol.:	5.0 ml
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/2/99	Method:	EPA 8260(Purge & Trap)

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
1	Benzene	71-43-2	LT	1.0
2	Bromobenzene	108-86-1	LT	1.0
3	Bromochloromethane	74-97-5	LT	2.0
4	Bromodichloromethane	75-27-4	LT	1.0
5	Bromoform	75-25-2	LT	2.0
6	Bromomethane	74-83-9	LT	4.0
7	n-Butylbenzene	104-51-8	LT	1.0
8	sec-Butylbenzene	135-98-8	LT	1.0
9	ter-Butylbenzene	98-06-6	LT	1.0
10	Carbon Tetrachloride	56-23-5	LT	1.0
11	Chlorobenzene	108-90-7	LT	1.0
12	Chlorodifluoromethane(Freon-22)	75-45-6	LT	30.0
13	Chloroethane	75-00-3	LT	30.0
14	Chloroform	67-66-3	LT	1.0
15	Chloromethane	74-87-3	LT	1.0
16	2-Chlorotoluene	95-49-8	LT	2.0
17	4-Chlorotoluene	106-43-4	LT	2.0
18	Dibromochloromethane	124-48-1	LT	2.0
19	1,2-Dibromo-3-chloropropane	96-12-8	LT	2.0
20	1,2-Dibromoethane	106-93-4	LT	2.0
21	Dibromomethane	74-95-3	LT	1.0
22	1,2-Dichlorobenzene	95-50-1	LT	1.0
23	1,3-Dichlorobenzene	541-73-1	LT	1.0
24	1,4-Dichlorobenzene	106-46-7	LT	1.0
25	Dichlorodifluoromethane(Freon-12)	75-71-8	LT	3.0
26	1,1-Dichloroethane	75-34-3	LT	1.0
27	1,2-Dichloroethane	107-06-2	LT	2.0
28	1,1-Dichloroethene	75-35-4	LT	1.0
29	cis-1,2-Dichloroethene	156-69-9	2.5	1.0
30	trans-1,2-Dichloroethene	156-60-5	LT	1.0
31	Dichlorofluoromethane(Freon-21)	75-43-4	LT	3.0
32	1,2-Dichloropropane	78-87-5	LT	1.0
33	1,3-Dichloropropane	142-28-9	LT	1.0
34	2,2-Dichloropropane	594-20-7	LT	1.0

Volatile Organics Analysis Data Sheet (Continued) Laboratory ID: OW990404

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
35	1,1-Dichloropropene	563-58-6	LT	1.0
36	cis-1,3-Dichloropropene	10061-01-5	LT	1.0
37	trans-1,3-Dichloropropene	10061-02-6	LT	1.0
38	1,2-Dichlorotetrafluoroethane(Freon-114)	76-14-2	LT	3.0
39	Dichlorotrifluoroethane(Freon-123)	306-83-2	LT	1.0
40	Dichlorotrifluoroethane(Freon-123A)	354-23-4	45.9	1.0
41	Ethylbenzene	100-41-4	LT	1.0
42	Hexachlorobutadien	87-68-3	LT	3.0
43	Isopropylbenzene	98-82-8	LT	2.0
44	p-Isopropyltoluene	99-87-6	LT	1.0
45	Methylene Chloride	75-09-2	LT	1.0
45	Methyl tert-Butyl Ether	1634-04-4	LT	5.0
46	Naphthalene	91-20-3	LT	2.0
47	n-Propylbenzene	103-65-1	LT	1.0
48	Styrene	100-42-5	LT	1.0
49	1,1,2,2-Tetrachloroethane	79-34-5	LT	1.0
50	1,1,1,2-Tetrachloroethane	79-34-5	LT	2.0
51	Tetrachloroethene	127-18-4	LT	1.0
52	Toluene	108-88-3	LT	1.0
53	1,2,3-Trichlorobenzene	87-61-6	LT	2.0
54	1,2,4-Trichlorobenzene	120-82-1	LT	1.0
55	1,1,1-Trichloroethane	71-55-6	LT	1.0
56	1,1,2-Trichloroethane	79-00-5	LT	1.0
57	Trichloroethene	79-01-6	57.9	1.0
58	Trichlorofluoromethane(Freon-11)	75-69-4	LT	2.0
59	1,2,3-Trichloropropane	96-18-4	LT	1.0
60	1,1,2-Trichlorotrifluoroethane(Freon-113)	76-13-1	LT	1.0
61	1,2,4-Trimethylbenzene	95-63-6	LT	1.0
62	1,3,5-Trimethylbenzene	108-67-8	LT	1.0
63	Vinyl Chloride	75-01-4	LT	1.0
64	Total-Xylene	1330-20-7	LT	2.0

Surrogate Compounds	% Recovery	QC Limits (%)
4-Bromofluorobenzene	102.4	**86-115**
Dibromofluoromethane	103.8	**86-118**
Toluene-d8	97.8	**88-110**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits (based on 5 ml water sample volume)
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
Volatile Organics Analysis Data Sheet

Sample ID:	B3	Laboratory ID:	OW990405
Matrix:	Water	Sample Wt./Vol.:	5.0 ml
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/2/99	Method:	EPA 8260(Purge & Trap)

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
1	Benzene	71-43-2	LT	10.0
2	Bromobenzene	108-86-1	LT	10.0
3	Bromochloromethane	74-97-5	LT	20.0
4	Bromodichloromethane	75-27-4	LT	10.0
5	Bromoform	75-25-2	LT	20.0
6	Bromomethane	74-83-9	LT	40.0
7	n-Butylbenzene	104-51-8	LT	10.0
8	sec-Butylbenzene	135-98-8	LT	10.0
9	ter-Butylbenzene	98-06-6	LT	10.0
10	Carbon Tetrachloride	56-23-5	LT	10.0
11	Chlorobenzene	108-90-7	LT	10.0
12	Chlorodifluoromethane(Freon-22)	75-45-6	LT	300.0
13	Chloroethane	75-00-3	LT	300.0
14	Chloroform	67-66-3	LT	10.0
15	Chloromethane	74-87-3	LT	10.0
16	2-Chlorotoluene	95-49-8	LT	20.0
17	4-Chlorotoluene	106-43-4	LT	20.0
18	Dibromochloromethane	124-48-1	LT	20.0
19	1,2-Dibromo-3-chloropropane	96-12-8	LT	20.0
20	1,2-Dibromoethane	106-93-4	LT	20.0
21	Dibromomethane	74-95-3	LT	10.0
22	1,2-Dichlorobenzene	95-50-1	LT	10.0
23	1,3-Dichlorobenzene	541-73-1	LT	10.0
24	1,4-Dichlorobenzene	106-46-7	LT	10.0
25	Dichlorodifluoromethane(Freon-12)	75-71-8	LT	30.0
26	1,1-Dichloroethane	75-34-3	LT	10.0
27	1,2-Dichloroethane	107-06-2	LT	20.0
28	1,1-Dichloroethene	75-35-4	LT	10.0
29	cis-1,2-Dichloroethene	156-69-9	LT	10.0
30	trans-1,2-Dichloroethene	156-60-5	LT	10.0
31	Dichlorofluoromethane(Freon-21)	75-43-4	LT	30.0
32	1,2-Dichloropropane	78-87-5	LT	10.0
33	1,3-Dichloropropane	142-28-9	LT	10.0
34	2,2-Dichloropropane	594-20-7	LT	10.0

Volatile Organics Analysis Data Sheet (Continued) Laboratory ID: OW990405

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
35	1,1-Dichloropropene	563-58-6	LT	10.0
36	cis-1,3-Dichloropropene	10061-01-5	LT	10.0
37	trans-1,3-Dichloropropene	10061-02-6	LT	10.0
38	1,2-Dichlorotetrafluoroethane(Freon-114)	76-14-2	LT	30.0
39	Dichlorotrifluoroethane(Freon-123)	306-83-2	LT	10.0
40	Dichlorotrifluoroethane(Freon-123A)	354-23-4	LT	10.0
41	Ethylbenzene	100-41-4	LT	10.0
42	Hexachlorobutadien	87-68-3	LT	30.0
43	Isopropylbenzene	98-82-8	LT	20.0
44	p-Isopropyltoluene	99-87-6	LT	10.0
45	Methylene Chloride	75-09-2	LT	10.0
45	Methyl tert-Butyl Ether	1634-04-4	LT	50.0
46	Naphthalene	91-20-3	LT	20.0
47	n-Propylbenzene	103-65-1	LT	10.0
48	Styrene	100-42-5	LT	10.0
49	1,1,2,2-Tetrachloroethane	79-34-5	LT	10.0
50	1,1,1,2-Tetrachloroethane	79-34-5	LT	20.0
51	Tetrachloroethene	127-18-4	LT	10.0
52	Toluene	108-88-3	LT	10.0
53	1,2,3-Trichlorobenzene	87-61-6	LT	20.0
54	1,2,4-Trichlorobenzene	120-82-1	LT	10.0
55	1,1,1-Trichloroethane	71-55-6	LT	10.0
56	1,1,2-Trichloroethane	79-00-5	LT	10.0
57	Trichloroethene	79-01-6	LT	10.0
58	Trichlorofluoromethane(Freon-11)	75-69-4	LT	20.0
59	1,2,3-Trichloropropane	96-18-4	LT	10.0
60	1,1,2-Trichlorotrifluoroethane(Freon-113)	76-13-1	LT	10.0
61	1,2,4-Trimethylbenzene	95-63-6	LT	10.0
62	1,3,5-Trimethylbenzene	108-67-8	LT	10.0
63	Vinyl Chloride	75-01-4	LT	10.0
64	Total-Xylene	1330-20-7	LT	20.0

Surrogate Compounds	% Recovery	QC Limits (%)
4-Bromofluorobenzene	99.6	**86-115**
Dibromofluoromethane	108.8	**86-118**
Toluene-d8	98.6	**88-110**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits (based on 5 ml water sample volume)
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
Volatile Organics Analysis Data Sheet

Sample ID:	B8	Laboratory ID:	OW990406
Matrix:	Water	Sample Wt./Vol.:	5.0 ml
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/2/99	Method:	EPA 8260(Purge & Trap)

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
1	Benzene	71-43-2	LT	4.2
2	Bromobenzene	108-86-1	LT	4.2
3	Bromochloromethane	74-97-5	LT	8.3
4	Bromodichloromethane	75-27-4	LT	4.2
5	Bromoform	75-25-2	LT	8.3
6	Bromomethane	74-83-9	LT	16.7
7	n-Butylbenzene	104-51-8	LT	4.2
8	sec-Butylbenzene	135-98-8	LT	4.2
9	ter-Butylbenzene	98-06-6	LT	4.2
10	Carbon Tetrachloride	56-23-5	LT	4.2
11	Chlorobenzene	108-90-7	LT	4.2
12	Chlorodifluoromethane(Freon-22)	75-45-6	LT	125.0
13	Chloroethane	75-00-3	LT	125.0
14	Chloroform	67-66-3	LT	4.2
15	Chloromethane	74-87-3	LT	4.2
16	2-Chlorotoluene	95-49-8	LT	8.3
17	4-Chlorotoluene	106-43-4	LT	8.3
18	Dibromochloromethane	124-48-1	LT	8.3
19	1,2-Dibromo-3-chloropropane	96-12-8	LT	8.3
20	1,2-Dibromoethane	106-93-4	LT	8.3
21	Dibromomethane	74-95-3	LT	4.2
22	1,2-Dichlorobenzene	95-50-1	LT	4.2
23	1,3-Dichlorobenzene	541-73-1	LT	4.2
24	1,4-Dichlorobenzene	106-46-7	LT	4.2
25	Dichlorodifluoromethane(Freon-12)	75-71-8	LT	12.5
26	1,1-Dichloroethane	75-34-3	LT	4.2
27	1,2-Dichloroethane	107-06-2	LT	8.3
28	1,1-Dichloroethene	75-35-4	LT	4.2
29	cis-1,2-Dichloroethene	156-69-9	LT	4.2
30	trans-1,2-Dichloroethene	156-60-5	LT	4.2
31	Dichlorofluoromethane(Freon-21)	75-43-4	LT	12.5
32	1,2-Dichloropropane	78-87-5	LT	4.2
33	1,3-Dichloropropane	142-28-9	LT	4.2
34	2,2-Dichloropropane	594-20-7	LT	4.2

Volatile Organics Analysis Data Sheet (Continued) Laboratory ID: OW990406

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
35	1,1-Dichloropropene	563-58-6	LT	4.2
36	cis-1,3-Dichloropropene	10061-01-5	LT	4.2
37	trans-1,3-Dichloropropene	10061-02-6	LT	4.2
38	1,2-Dichlorotetrafluoroethane(Freon-114)	76-14-2	LT	12.5
39	Dichlorotrifluoroethane(Freon-123)	306-83-2	LT	4.2
40	Dichlorotrifluoroethane(Freon-123A)	354-23-4	LT	4.2
41	Ethylbenzene	100-41-4	LT	4.2
42	Hexachlorobutadien	87-68-3	LT	12.5
43	Isopropylbenzene	98-82-8	LT	8.3
44	p-Isopropyltoluene	99-87-6	LT	4.2
45	Methylene Chloride	75-09-2	LT	4.2
45	Methyl tert-Butyl Ether	1634-04-4	LT	20.8
46	Naphthalene	91-20-3	LT	8.3
47	n-Propylbenzene	103-65-1	LT	4.2
48	Styrene	100-42-5	LT	4.2
49	1,1,2,2-Tetrachloroethane	79-34-5	LT	4.2
50	1,1,1,2-Tetrachloroethane	79-34-5	LT	8.3
51	Tetrachloroethene	127-18-4	LT	4.2
52	Toluene	108-88-3	LT	4.2
53	1,2,3-Trichlorobenzene	87-61-6	LT	8.3
54	1,2,4-Trichlorobenzene	120-82-1	LT	4.2
55	1,1,1-Trichloroethane	71-55-6	LT	4.2
56	1,1,2-Trichloroethane	79-00-5	LT	4.2
57	Trichloroethene	79-01-6	LT	4.2
58	Trichlorofluoromethane(Freon-11)	75-69-4	LT	8.3
59	1,2,3-Trichloropropane	96-18-4	LT	4.2
60	1,1,2-Trichlorotrifluoroethane(Freon-113)	76-13-1	LT	4.2
61	1,2,4-Trimethylbenzene	95-63-6	LT	4.2
62	1,3,5-Trimethylbenzene	108-67-8	LT	4.2
63	Vinyl Chloride	75-01-4	LT	4.2
64	Total-Xylene	1330-20-7	LT	8.3

Surrogate Compounds	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101.0	**86-115**
Dibromofluoromethane	103.2	**86-118**
Toluene-d8	98.6	**88-110**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits (based on 5 ml water sample volume)
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst: Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory

Volatile Organics Analysis Data Sheet

Sample ID:	DUP 1	Laboratory ID:	OW990407
Matrix:	Water	Sample Wt./Vol.:	5.0 ml
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/2/99	Method:	EPA 8260(Purge & Trap)

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
1	Benzene	71-43-2	LT	1.0
2	Bromobenzene	108-86-1	LT	1.0
3	Bromochloromethane	74-97-5	LT	2.0
4	Bromodichloromethane	75-27-4	LT	1.0
5	Bromoform	75-25-2	LT	2.0
6	Bromomethane	74-83-9	LT	4.0
7	n-Butylbenzene	104-51-8	LT	1.0
8	sec-Butylbenzene	135-98-8	LT	1.0
9	ter-Butylbenzene	98-06-6	LT	1.0
10	Carbon Tetrachloride	56-23-5	LT	1.0
11	Chlorobenzene	108-90-7	LT	1.0
12	Chlorodifluoromethane(Freon-22)	75-45-6	LT	30.0
13	Chloroethane	75-00-3	LT	30.0
14	Chloroform	67-66-3	LT	1.0
15	Chloromethane	74-87-3	LT	1.0
16	2-Chlorotoluene	95-49-8	LT	2.0
17	4-Chlorotoluene	106-43-4	LT	2.0
18	Dibromochloromethane	124-48-1	LT	2.0
19	1,2-Dibromo-3-chloropropane	96-12-8	LT	2.0
20	1,2-Dibromoethane	106-93-4	LT	2.0
21	Dibromomethane	74-95-3	LT	1.0
22	1,2-Dichlorobenzene	95-50-1	LT	1.0
23	1,3-Dichlorobenzene	541-73-1	LT	1.0
24	1,4-Dichlorobenzene	106-46-7	LT	1.0
25	Dichlorodifluoromethane(Freon-12)	75-71-8	LT	3.0
26	1,1-Dichloroethane	75-34-3	LT	1.0
27	1,2-Dichloroethane	107-06-2	LT	2.0
28	1,1-Dichloroethene	75-35-4	LT	1.0
29	cis-1,2-Dichloroethene	156-69-9	LT	1.0
30	trans-1,2-Dichloroethene	156-60-5	LT	1.0
31	Dichlorofluoromethane(Freon-21)	75-43-4	LT	3.0
32	1,2-Dichloropropane	78-87-5	LT	1.0
33	1,3-Dichloropropane	142-28-9	LT	1.0
34	2,2-Dichloropropane	594-20-7	LT	1.0

Volatile Organics Analysis Data Sheet (Continued) Laboratory ID: OW990407

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
35	1,1-Dichloropropene	563-58-6	LT	1.0
36	cis-1,3-Dichloropropene	10061-01-5	LT	1.0
37	trans-1,3-Dichloropropene	10061-02-6	LT	1.0
38	1,2-Dichlorotetrafluoroethane(Freon-114)	76-14-2	LT	3.0
39	Dichlorotrifluoroethane(Freon-123)	306-83-2	LT	1.0
40	Dichlorotrifluoroethane(Freon-123A)	354-23-4	33.4	1.0
41	Ethylbenzene	100-41-4	LT	1.0
42	Hexachlorobutadien	87-68-3	LT	3.0
43	Isopropylbenzene	98-82-8	LT	2.0
44	p-Isopropyltoluene	99-87-6	LT	1.0
45	Methylene Chloride	75-09-2	LT	1.0
45	Methyl tert-Butyl Ether	1634-04-4	LT	5.0
46	Naphthalene	91-20-3	LT	2.0
47	n-Propylbenzene	103-65-1	LT	1.0
48	Styrene	100-42-5	LT	1.0
49	1,1,2,2-Tetrachloroethane	79-34-5	LT	1.0
50	1,1,1,2-Tetrachloroethane	79-34-5	LT	2.0
51	Tetrachloroethene	127-18-4	LT	1.0
52	Toluene	108-88-3	LT	1.0
53	1,2,3-Trichlorobenzene	87-61-6	LT	2.0
54	1,2,4-Trichlorobenzene	120-82-1	LT	1.0
55	1,1,1-Trichloroethane	71-55-6	LT	1.0
56	1,1,2-Trichloroethane	79-00-5	LT	1.0
57	Trichloroethene	79-01-6	13.5	1.0
58	Trichlorofluoromethane(Freon-11)	75-69-4	LT	2.0
59	1,2,3-Trichloropropane	96-18-4	LT	1.0
60	1,1,2-Trichlorotrifluoroethane(Freon-113)	76-13-1	LT	1.0
61	1,2,4-Trimethylbenzene	95-63-6	LT	1.0
62	1,3,5-Trimethylbenzene	108-67-8	LT	1.0
63	Vinyl Chloride	75-01-4	LT	1.0
64	Total-Xylene	1330-20-7	LT	2.0

Surrogate Compounds	% Recovery	QC Limits (%)
4-Bromofluorobenzene	103.4	**86-115**
Dibromofluoromethane	103.2	**86-118**
Toluene-d8	98.6	**88-110**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits (based on 5 ml water sample volume)
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : ____ Date: 8/3/99
Reviewer: ____ Date: 8/3/99.

LBL Environmental Measurements Laboratory

Volatile Organics Analysis Data Sheet

Sample ID:	DUP 2	Laboratory ID:	OW990408
Matrix:	Water	Sample Wt./Vol.:	5.0 ml
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/2/99	Method:	EPA 8260(Purge & Trap)

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
1	Benzene	71-43-2	LT	1.0
2	Bromobenzene	108-86-1	LT	1.0
3	Bromochloromethane	74-97-5	LT	2.0
4	Bromodichloromethane	75-27-4	LT	1.0
5	Bromoform	75-25-2	LT	2.0
6	Bromomethane	74-83-9	LT	4.0
7	n-Butylbenzene	104-51-8	LT	1.0
8	sec-Butylbenzene	135-98-8	LT	1.0
9	ter-Butylbenzene	98-06-6	LT	1.0
10	Carbon Tetrachloride	56-23-5	LT	1.0
11	Chlorobenzene	108-90-7	LT	1.0
12	Chlorodifluoromethane(Freon-22)	75-45-6	LT	30.0
13	Chloroethane	75-00-3	LT	30.0
14	Chloroform	67-66-3	LT	1.0
15	Chloromethane	74-87-3	LT	1.0
16	2-Chlorotoluene	95-49-8	LT	2.0
17	4-Chlorotoluene	106-43-4	LT	2.0
18	Dibromochloromethane	124-48-1	LT	2.0
19	1,2-Dibromo-3-chloropropane	96-12-8	LT	2.0
20	1,2-Dibromoethane	106-93-4	LT	2.0
21	Dibromomethane	74-95-3	LT	1.0
22	1,2-Dichlorobenzene	95-50-1	LT	1.0
23	1,3-Dichlorobenzene	541-73-1	LT	1.0
24	1,4-Dichlorobenzene	106-46-7	LT	1.0
25	Dichlorodifluoromethane(Freon-12)	75-71-8	LT	3.0
26	1,1-Dichloroethane	75-34-3	LT	1.0
27	1,2-Dichloroethane	107-06-2	LT	2.0
28	1,1-Dichloroethene	75-35-4	LT	1.0
29	cis-1,2-Dichloroethene	156-69-9	1.9	1.0
30	trans-1,2-Dichloroethene	156-60-5	LT	1.0
31	Dichlorofluoromethane(Freon-21)	75-43-4	LT	3.0
32	1,2-Dichloropropane	78-87-5	LT	1.0
33	1,3-Dichloropropane	142-28-9	LT	1.0
34	2,2-Dichloropropane	594-20-7	LT	1.0

Volatile Organics Analysis Data Sheet (Continued) Laboratory ID: OW990408

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
35	1,1-Dichloropropene	563-58-6	LT	1.0
36	cis-1,3-Dichloropropene	10061-01-5	LT	1.0
37	trans-1,3-Dichloropropene	10061-02-6	LT	1.0
38	1,2-Dichlorotetrafluoroethane(Freon-114)	76-14-2	LT	3.0
39	Dichlorotrifluoroethane(Freon-123)	306-83-2	LT	1.0
40	Dichlorotrifluoroethane(Freon-123A)	354-23-4	42.7	1.0
41	Ethylbenzene	100-41-4	LT	1.0
42	Hexachlorobutadien	87-68-3	LT	3.0
43	Isopropylbenzene	98-82-8	LT	2.0
44	p-Isopropyltoluene	99-87-6	LT	1.0
45	Methylene Chloride	75-09-2	LT	1.0
45	Methyl tert-Butyl Ether	1634-04-4	LT	5.0
46	Naphthalene	91-20-3	LT	2.0
47	n-Propylbenzene	103-65-1	LT	1.0
48	Styrene	100-42-5	LT	1.0
49	1,1,2,2-Tetrachloroethane	79-34-5	LT	1.0
50	1,1,1,2-Tetrachloroethane	79-34-5	LT	2.0
51	Tetrachloroethene	127-18-4	LT	1.0
52	Toluene	108-88-3	LT	1.0
53	1,2,3-Trichlorobenzene	87-61-6	LT	2.0
54	1,2,4-Trichlorobenzene	120-82-1	LT	1.0
55	1,1,1-Trichloroethane	71-55-6	LT	1.0
56	1,1,2-Trichloroethane	79-00-5	LT	1.0
57	Trichloroethene	79-01-6	56.5	1.0
58	Trichlorofluoromethane(Freon-11)	75-69-4	LT	2.0
59	1,2,3-Trichloropropane	96-18-4	LT	1.0
60	1,1,2-Trichlorotrifluoroethane(Freon-113)	76-13-1	LT	1.0
61	1,2,4-Trimethylbenzene	95-63-6	LT	1.0
62	1,3,5-Trimethylbenzene	108-67-8	LT	1.0
63	Vinyl Chloride	75-01-4	LT	1.0
64	Total-Xylene	1330-20-7	LT	2.0

Surrogate Compounds	% Recovery	QC Limits (%)
4-Bromofluorobenzene	104.0	**86-115**
Dibromofluoromethane	100.8	**86-118**
Toluene-d8	98.2	**88-110**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits (based on 5 ml water sample volume)
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
Volatile Organics Analysis Data Sheet

Sample ID:	C1	Laboratory ID:	OW990409
Matrix:	Water	Sample Wt./Vol.:	5.0 ml
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/2/99	Method:	EPA 8260(Purge & Trap)

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
1	Benzene	71-43-2	LT	1.2
2	Bromobenzene	108-86-1	LT	1.2
3	Bromochloromethane	74-97-5	LT	2.4
4	Bromodichloromethane	75-27-4	LT	1.2
5	Bromoform	75-25-2	LT	2.4
6	Bromomethane	74-83-9	LT	4.9
7	n-Butylbenzene	104-51-8	LT	1.2
8	sec-Butylbenzene	135-98-8	LT	1.2
9	ter-Butylbenzene	98-06-6	LT	1.2
10	Carbon Tetrachloride	56-23-5	LT	1.2
11	Chlorobenzene	108-90-7	LT	1.2
12	Chlorodifluoromethane(Freon-22)	75-45-6	LT	36.6
13	Chloroethane	75-00-3	LT	36.6
14	Chloroform	67-66-3	LT	1.2
15	Chloromethane	74-87-3	LT	1.2
16	2-Chlorotoluene	95-49-8	LT	2.4
17	4-Chlorotoluene	106-43-4	LT	2.4
18	Dibromochloromethane	124-48-1	LT	2.4
19	1,2-Dibromo-3-chloropropane	96-12-8	LT	2.4
20	1,2-Dibromoethane	106-93-4	LT	2.4
21	Dibromomethane	74-95-3	LT	1.2
22	1,2-Dichlorobenzene	95-50-1	LT	1.2
23	1,3-Dichlorobenzene	541-73-1	LT	1.2
24	1,4-Dichlorobenzene	106-46-7	LT	1.2
25	Dichlorodifluoromethane(Freon-12)	75-71-8	LT	3.7
26	1,1-Dichloroethane	75-34-3	LT	1.2
27	1,2-Dichloroethane	107-06-2	4.6	2.4
28	1,1-Dichloroethene	75-35-4	LT	1.2
29	cis-1,2-Dichloroethene	156-69-9	36.7	1.2
30	trans-1,2-Dichloroethene	156-60-5	LT	1.2
31	Dichlorofluoromethane(Freon-21)	75-43-4	LT	3.7
32	1,2-Dichloropropane	78-87-5	LT	1.2
33	1,3-Dichloropropane	142-28-9	LT	1.2
34	2,2-Dichloropropane	594-20-7	LT	1.2

Volatile Organics Analysis Data Sheet (Continued) Laboratory ID: OW990409

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
35	1,1-Dichloropropene	563-58-6	LT	1.2
36	cis-1,3-Dichloropropene	10061-01-5	LT	1.2
37	trans-1,3-Dichloropropene	10061-02-6	LT	1.2
38	1,2-Dichlorotetrafluoroethane(Freon-114)	76-14-2	LT	3.7
39	Dichlorotrifluoroethane(Freon-123)	306-83-2	LT	1.2
40	Dichlorotrifluoroethane(Freon-123A)	354-23-4	LT	1.2
41	Ethylbenzene	100-41-4	LT	1.2
42	Hexachlorobutadien	87-68-3	LT	3.7
43	Isopropylbenzene	98-82-8	LT	2.4
44	p-Isopropyltoluene	99-87-6	LT	1.2
45	Methylene Chloride	75-09-2	LT	1.2
45	Methyl tert-Butyl Ether	1634-04-4	LT	6.1
46	Naphthalene	91-20-3	LT	2.4
47	n-Propylbenzene	103-65-1	LT	1.2
48	Styrene	100-42-5	LT	1.2
49	1,1,2,2-Tetrachloroethane	79-34-5	LT	1.2
50	1,1,1,2-Tetrachloroethane	79-34-5	LT	2.4
51	Tetrachloroethene	127-18-4	LT	1.2
52	Toluene	108-88-3	LT	1.2
53	1,2,3-Trichlorobenzene	87-61-6	LT	2.4
54	1,2,4-Trichlorobenzene	120-82-1	LT	1.2
55	1,1,1-Trichloroethane	71-55-6	LT	1.2
56	1,1,2-Trichloroethane	79-00-5	LT	1.2
57	Trichloroethene	79-01-6	62.8	1.2
58	Trichlorofluoromethane(Freon-11)	75-69-4	LT	2.4
59	1,2,3-Trichloropropane	96-18-4	LT	1.2
60	1,1,2-Trichlorotrifluoroethane(Freon-113)	76-13-1	LT	1.2
61	1,2,4-Trimethylbenzene	95-63-6	LT	1.2
62	1,3,5-Trimethylbenzene	108-67-8	LT	1.2
63	Vinyl Chloride	75-01-4	LT	1.2
64	Total-Xylene	1330-20-7	LT	2.4

Surrogate Compounds	% Recovery	QC Limits (%)
4-Bromofluorobenzene	103.6	**86-115**
Dibromofluoromethane	103.0	**86-118**
Toluene-d8	99.0	**88-110**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits (based on 5 ml water sample volume)
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : ______________ Date: 8/3/99
Reviewer: ______________ Date: 8/3/99.

LBL Environmental Measurements Laboratory

Volatile Organics Analysis Data Sheet

Sample ID:	C2	Laboratory ID:	OW990410
Matrix:	Water	Sample Wt./Vol.:	5.0 ml
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/2/99	Method:	EPA 8260(Purge & Trap)

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
1	Benzene	71-43-2	LT	1.0
2	Bromobenzene	108-86-1	LT	1.0
3	Bromochloromethane	74-97-5	LT	2.0
4	Bromodichloromethane	75-27-4	LT	1.0
5	Bromoform	75-25-2	LT	2.0
6	Bromomethane	74-83-9	LT	4.0
7	n-Butylbenzene	104-51-8	LT	1.0
8	sec-Butylbenzene	135-98-8	LT	1.0
9	ter-Butylbenzene	98-06-6	LT	1.0
10	Carbon Tetrachloride	56-23-5	LT	1.0
11	Chlorobenzene	108-90-7	LT	1.0
12	Chlorodifluoromethane(Freon-22)	75-45-6	LT	30.0
13	Chloroethane	75-00-3	LT	30.0
14	Chloroform	67-66-3	LT	1.0
15	Chloromethane	74-87-3	LT	1.0
16	2-Chlorotoluene	95-49-8	LT	2.0
17	4-Chlorotoluene	106-43-4	LT	2.0
18	Dibromochloromethane	124-48-1	LT	2.0
19	1,2-Dibromo-3-chloropropane	96-12-8	LT	2.0
20	1,2-Dibromoethane	106-93-4	LT	2.0
21	Dibromomethane	74-95-3	LT	1.0
22	1,2-Dichlorobenzene	95-50-1	LT	1.0
23	1,3-Dichlorobenzene	541-73-1	LT	1.0
24	1,4-Dichlorobenzene	106-46-7	LT	1.0
25	Dichlorodifluoromethane(Freon-12)	75-71-8	LT	3.0
26	1,1-Dichloroethane	75-34-3	LT	1.0
27	1,2-Dichloroethane	107-06-2	7.5	2.0
28	1,1-Dichloroethene	75-35-4	LT	1.0
29	cis-1,2-Dichloroethene	156-69-9	56.6	1.0
30	trans-1,2-Dichloroethene	156-60-5	LT	1.0
31	Dichlorofluoromethane(Freon-21)	75-43-4	LT	3.0
32	1,2-Dichloropropane	78-87-5	LT	1.0
33	1,3-Dichloropropane	142-28-9	LT	1.0
34	2,2-Dichloropropane	594-20-7	LT	1.0

Volatile Organics Analysis Data Sheet (Continued) Laboratory ID: OW990410

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
35	1,1-Dichloropropene	563-58-6	LT	1.0
36	cis-1,3-Dichloropropene	10061-01-5	LT	1.0
37	trans-1,3-Dichloropropene	10061-02-6	LT	1.0
38	1,2-Dichlorotetrafluoroethane(Freon-114)	76-14-2	LT	3.0
39	Dichlorotrifluoroethane(Freon-123)	306-83-2	LT	1.0
40	Dichlorotrifluoroethane(Freon-123A)	354-23-4	LT	1.0
41	Ethylbenzene	100-41-4	LT	1.0
42	Hexachlorobutadien	87-68-3	LT	3.0
43	Isopropylbenzene	98-82-8	LT	2.0
44	p-Isopropyltoluene	99-87-6	LT	1.0
45	Methylene Chloride	75-09-2	LT	1.0
45	Methyl tert-Butyl Ether	1634-04-4	LT	5.0
46	Naphthalene	91-20-3	LT	2.0
47	n-Propylbenzene	103-65-1	LT	1.0
48	Styrene	100-42-5	LT	1.0
49	1,1,2,2-Tetrachloroethane	79-34-5	LT	1.0
50	1,1,1,2-Tetrachloroethane	79-34-5	LT	2.0
51	Tetrachloroethene	127-18-4	LT	1.0
52	Toluene	108-88-3	LT	1.0
53	1,2,3-Trichlorobenzene	87-61-6	LT	2.0
54	1,2,4-Trichlorobenzene	120-82-1	LT	1.0
55	1,1,1-Trichloroethane	71-55-6	LT	1.0
56	1,1,2-Trichloroethane	79-00-5	1.1	1.0
57	Trichloroethene	79-01-6	68.4	1.0
58	Trichlorofluoromethane(Freon-11)	75-69-4	LT	2.0
59	1,2,3-Trichloropropane	96-18-4	LT	1.0
60	1,1,2-Trichlorotrifluoroethane(Freon-113)	76-13-1	LT	1.0
61	1,2,4-Trimethylbenzene	95-63-6	LT	1.0
62	1,3,5-Trimethylbenzene	108-67-8	LT	1.0
63	Vinyl Chloride	75-01-4	LT	1.0
64	Total-Xylene	1330-20-7	LT	2.0

Surrogate Compounds	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100.8	**86-115**
Dibromofluoromethane	101.8	**86-118**
Toluene-d8	96.6	**88-110**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits (based on 5 ml water sample volume)
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
Volatile Organics Analysis Data Sheet

Sample ID:	C3	Laboratory ID:	OW990411
Matrix:	Water	Sample Wt./Vol.:	5.0 ml
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/3/99	Method:	EPA 8260(Purge & Trap)

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
1	Benzene	71-43-2	LT	1.0
2	Bromobenzene	108-86-1	LT	1.0
3	Bromochloromethane	74-97-5	LT	2.0
4	Bromodichloromethane	75-27-4	LT	1.0
5	Bromoform	75-25-2	LT	2.0
6	Bromomethane	74-83-9	LT	4.0
7	n-Butylbenzene	104-51-8	LT	1.0
8	sec-Butylbenzene	135-98-8	LT	1.0
9	ter-Butylbenzene	98-06-6	LT	1.0
10	Carbon Tetrachloride	56-23-5	LT	1.0
11	Chlorobenzene	108-90-7	LT	1.0
12	Chlorodifluoromethane(Freon-22)	75-45-6	LT	30.0
13	Chloroethane	75-00-3	LT	30.0
14	Chloroform	67-66-3	LT	1.0
15	Chloromethane	74-87-3	LT	1.0
16	2-Chlorotoluene	95-49-8	LT	2.0
17	4-Chlorotoluene	106-43-4	LT	2.0
18	Dibromochloromethane	124-48-1	LT	2.0
19	1,2-Dibromo-3-chloropropane	96-12-8	LT	2.0
20	1,2-Dibromoethane	106-93-4	LT	2.0
21	Dibromomethane	74-95-3	LT	1.0
22	1,2-Dichlorobenzene	95-50-1	LT	1.0
23	1,3-Dichlorobenzene	541-73-1	LT	1.0
24	1,4-Dichlorobenzene	106-46-7	LT	1.0
25	Dichlorodifluoromethane(Freon-12)	75-71-8	LT	3.0
26	1,1-Dichloroethane	75-34-3	LT	1.0
27	1,2-Dichloroethane	107-06-2	7.9	2.0
28	1,1-Dichloroethene	75-35-4	LT	1.0
29	cis-1,2-Dichloroethene	156-69-9	64.2	1.0
30	trans-1,2-Dichloroethene	156-60-5	LT	1.0
31	Dichlorofluoromethane(Freon-21)	75-43-4	LT	3.0
32	1,2-Dichloropropane	78-87-5	LT	1.0
33	1,3-Dichloropropane	142-28-9	LT	1.0
34	2,2-Dichloropropane	594-20-7	LT	1.0

Volatile Organics Analysis Data Sheet (Continued) Laboratory ID: OW990411

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
35	1,1-Dichloropropene	563-58-6	LT	1.0
36	cis-1,3-Dichloropropene	10061-01-5	LT	1.0
37	trans-1,3-Dichloropropene	10061-02-6	LT	1.0
38	1,2-Dichlorotetrafluoroethane(Freon-114)	76-14-2	LT	3.0
39	Dichlorotrifluoroethane(Freon-123)	306-83-2	LT	1.0
40	Dichlorotrifluoroethane(Freon-123A)	354-23-4	LT	1.0
41	Ethylbenzene	100-41-4	LT	1.0
42	Hexachlorobutadien	87-68-3	LT	3.0
43	Isopropylbenzene	98-82-8	LT	2.0
44	p-Isopropyltoluene	99-87-6	LT	1.0
45	Methylene Chloride	75-09-2	LT	1.0
45	Methyl tert-Butyl Ether	1634-04-4	LT	5.0
46	Naphthalene	91-20-3	LT	2.0
47	n-Propylbenzene	103-65-1	LT	1.0
48	Styrene	100-42-5	LT	1.0
49	1,1,2,2-Tetrachloroethane	79-34-5	LT	1.0
50	1,1,1,2-Tetrachloroethane	79-34-5	LT	2.0
51	Tetrachloroethene	127-18-4	LT	1.0
52	Toluene	108-88-3	LT	1.0
53	1,2,3-Trichlorobenzene	87-61-6	LT	2.0
54	1,2,4-Trichlorobenzene	120-82-1	LT	1.0
55	1,1,1-Trichloroethane	71-55-6	LT	1.0
56	1,1,2-Trichloroethane	79-00-5	LT	1.0
57	Trichloroethene	79-01-6	64.0	1.0
58	Trichlorofluoromethane(Freon-11)	75-69-4	LT	2.0
59	1,2,3-Trichloropropane	96-18-4	LT	1.0
60	1,1,2-Trichlorotrifluoroethane(Freon-113)	76-13-1	LT	1.0
61	1,2,4-Trimethylbenzene	95-63-6	LT	1.0
62	1,3,5-Trimethylbenzene	108-67-8	LT	1.0
63	Vinyl Chloride	75-01-4	LT	1.0
64	Total-Xylene	1330-20-7	LT	2.0

Surrogate Compounds	% Recovery	QC Limits (%)
4-Bromofluorobenzene	102.8	**86-115**
Dibromofluoromethane	101.9	**86-118**
Toluene-d8	97.9	**88-110**

CAS #: Chemical Abstract Services Registry Number

PQL: Practical Quantitation Limits (based on 5 ml water sample volume)

LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99

Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-4	Laboratory ID:	OA990445
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	4/30/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	42.0	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	269	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	79-00-5	LT	17.41
19	Trichloroethene	79-01-6	1309	17.70
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	1843	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		3463	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL
California D.O.H.S. Cert. # 1704

Analyst: _______________ Date: 8/3/99
Reviewer: _______________ Date: 8/3/99

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-3	Laboratory ID:	OA990444
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	5/3/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	LT	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	107	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	79-00-5	LT	17.41
19	Trichloroethene	79-01-6	1339	17.70
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	2283	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		3729	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : ______ Date: 8/3/99
Reviewer: ______ Date: 8/3/99

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-2	Laboratory ID:	OA990443
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	5/3/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	LT	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	91.1	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	79-00-5	LT	17.41
19	Trichloroethene	79-01-6	3950	17.70
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	13800	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		17841	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	99%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG 1	Laboratory ID:	OA990442
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	5/3/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	LT	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	LT	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	71-55-6	LT	17.41
19	Trichloroethene	79-01-6	172	17.70
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	LT	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		172	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	99%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	Field Blank-1	Laboratory ID:	OA990441
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	4/30/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	LT	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	23.97
11	cis-1,2-Dichloroethene	156-69-9	LT	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	79-00-5	LT	17.41
19	Trichloroethene	79-01-6	LT	17.70
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		0	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Rich Dahlquist Date: 8/3/99
Reviewer: HG Fourtd. Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-13	Laboratory ID:	OA990440
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	5/6/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	3992
2	Benzene	71-43-2	LT	2973
3	Carbon Tetrachloride	56-23-5	LT	1512
4	Chloroform	67-66-3	LT	1948
5	1,2-Dichlorobenzene	95-50-1	LT	1581
6	1,3-Dichlorobenzene	541-73-1	LT	1581
7	1,4-Dichlorobenzene	106-46-7	LT	1581
8	1,1-Dichloroethane	75-34-3	LT	2345
9	1,2-Dichloroethane	107-06-2	LT	2397
10	1,1-Dichloroethene	75-35-4	LT	2397
11	cis-1,2-Dichloroethene	156-69-9	45700	2397
12	trans-1,2-Dichloroethene	156-60-5	LT	2397
13	Ethylbenzene	100-41-4	LT	2191
14	Methylene Chloride	75-09-2	LT	2737
15	Tetrachloroethene	127-18-4	LT	1402
16	Toluene	108-88-3	LT	2523
17	1,1,1-Trichloroethane	71-55-6	LT	1741
18	1,1,2-Trichloroethane	79-00-5	LT	1741
19	Trichloroethene	79-01-6	139000	1770
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	1541
21	1,2,4-Trimethylbenzene	95-63-6	LT	2523
22	Vinyl Chloride	75-01-4	LT	3716
23	Total-Xylene	1330-20-7	LT	2191
24	Total VOC		184700	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	108%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory

TO-14 Analysis Data Sheet

Sample ID:	AG-12-1	Laboratory ID:	OA990439
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	5/5/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	3992
2	Benzene	71-43-2	LT	2973
3	Carbon Tetrachloride	56-23-5	LT	1512
4	Chloroform	67-66-3	LT	1948
5	1,2-Dichlorobenzene	95-50-1	LT	1581
6	1,3-Dichlorobenzene	541-73-1	LT	1581
7	1,4-Dichlorobenzene	106-46-7	LT	1581
8	1,1-Dichloroethane	75-34-3	LT	2345
9	1,2-Dichloroethane	107-06-2	LT	2397
10	1,1-Dichloroethene	75-35-4	LT	2397
11	cis-1,2-Dichloroethene	156-69-9	22400	2397
12	trans-1,2-Dichloroethene	156-60-5	LT	2397
13	Ethylbenzene	100-41-4	LT	2191
14	Methylene Chloride	75-09-2	LT	2737
15	Tetrachloroethene	127-18-4	LT	1402
16	Toluene	108-88-3	LT	2523
17	1,1,1-Trichloroethane	71-55-6	LT	1741
18	1,1,2-Trichloroethane	79-00-5	LT	1741
19	Trichloroethene	79-01-6	41500	1770
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	1541
21	1,2,4-Trimethylbenzene	95-63-6	LT	2523
22	Vinyl Chloride	75-01-4	LT	3716
23	Total-Xylene	1330-20-7	LT	2191
24	Total VOC		63900	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	104%	75-130

** Detector is saturated

CAS #: Chemical Abstract Services Registry Number

PQL: Practical Quantitation Limits

LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99

Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID: AG-11 Laboratory ID: OA990438
Matrix: Gas Cartridge Sample Vol.(L): 0.104
Date Sampled: 4/28/99 Date Received: 4/28/99
Date Analyzed: 5/3/99 Method: TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.9
2	Benzene	71-43-2	LT	29.7
3	Carbon Tetrachloride	56-23-5	LT	15.1
4	Chloroform	67-66-3	LT	19.5
5	1,2-Dichlorobenzene	95-50-1	LT	15.8
6	1,3-Dichlorobenzene	541-73-1	LT	15.8
7	1,4-Dichlorobenzene	106-46-7	LT	15.8
8	1,1-Dichloroethane	75-34-3	LT	23.5
9	1,2-Dichloroethane	107-06-2	LT	24.0
10	1,1-Dichloroethene	75-35-4	LT	24.0
11	cis-1,2-Dichloroethene	156-69-9	1076	24.0
12	trans-1,2-Dichloroethene	156-60-5	LT	24.0
13	Ethylbenzene	100-41-4	LT	21.9
14	Methylene Chloride	75-09-2	LT	27.4
15	Tetrachloroethene	127-18-4	LT	14.0
16	Toluene	108-88-3	LT	25.2
17	1,1,1-Trichloroethane	71-55-6	LT	17.4
18	1,1,2-Trichloroethane	79-00-5	LT	17.4
19	Trichloroethene	79-01-6	1497	17.7
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.4
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.2
22	Vinyl Chloride	75-01-4	LT	37.2
23	Total-Xylene	1330-20-7	LT	21.9
24	Total VOC		2573	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	99%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-10	Laboratory ID:	OA990437
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	4/30/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	LT	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	88.2	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	79-00-5	LT	17.41
19	Trichloroethene	79-01-6	373	17.70
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		461	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL
* Compounds could not be determined because of interferent on detector.
California D.O.H.S. Cert. # 1704

Analyst: ______ Date: 8/3/99
Reviewer: ______ Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-9	Laboratory ID:	OA990436
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	4/30/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	LT	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	42.0	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	79-00-5	LT	17.41
19	Trichloroethene	79-01-6	221	17.70
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		263	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	**75-130**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : ____________ Date: 8/3/99
Reviewer: ____________ Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-8	Laboratory ID:	OA990435
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	4/30/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	LT	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	114	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
14	Tetrachloroethene	127-18-4	LT	14.02
15	Toluene	108-88-3	LT	25.23
16	1,1,1-Trichloroethane	71-55-6	LT	17.41
16	1,1,2-Trichloroethane	79-00-5	LT	17.41
17	Trichloroethene	79-01-6	547	17.70
18	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.41
17	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
18	Vinyl Chloride	75-01-4	LT	37.16
19	Total-Xylene	1330-20-7	LT	21.91
19	Total VOC		661	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-7	Laboratory ID:	OA990434
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	4/30/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	50.4	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	LT	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	393	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	79-00-5	LT	17.41
19	Trichloroethene	79-01-6	1445	17.70
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		1888	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-6	Laboratory ID:	OA990433
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	4/30/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	LT	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	180	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	79-00-5	LT	17.41
19	Trichloroethene	79-01-6	641	17.70
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	30.8	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		851	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-5	Laboratory ID:	OA990432
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	4/30/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	LT	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	59.94
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	349	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	79-00-5	LT	17.41
19	Trichloroethene	79-01-6	1257	17.70
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	156	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		1761	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99

LBL Environmental Measurements Laboratory

TO-14 Analysis Data Sheet

Sample ID:	AG-4	Laboratory ID:	OA990431
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	4/30/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	28.4	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	244	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	79-00-5	LT	17.41
19	Trichloroethene	79-01-6	1182	17.70
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	812	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		2266	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number

PQL: Practical Quantitation Limits

LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99

Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID: AG-3
Laboratory ID: OA990430
Matrix: Gas Cartridge
Sample Vol.(L): 0.104
Date Sampled: 4/28/99
Date Received: 4/28/99
Date Analyzed: 4/29/99
Method: TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	28.6	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	127	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	79-00-5	LT	17.41
19	Trichloroethene	79-01-6	1132	17.70
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	1877	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		3164	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

** Detector is saturated

CAS #: Chemical Abstract Services Registry Number

PQL: Practical Quantitation Limits

LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst :
Date: 8/3/99

Reviewer:
Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-2	Laboratory ID:	OA990429
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	5/14/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	LT	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	175	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	71-55-6	LT	17.41
19	Trichloroethene	79-01-6	4660	17.70
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	34100	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		38935	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	99%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	Dup 1	Laboratory ID:	OA990428
Matrix:	Gas Cartridge	Sample Vol.(L):	0.102
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/4/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	40.51
2	Benzene	71-43-2	39.5	30.17
3	Carbon Tetrachloride	56-23-5	LT	15.34
4	Chloroform	67-66-3	LT	19.77
5	1,2-Dichlorobenzene	95-50-1	LT	16.05
6	1,3-Dichlorobenzene	541-73-1	LT	16.05
7	1,4-Dichlorobenzene	106-46-7	LT	16.05
8	1,1-Dichloroethane	75-34-3	LT	23.80
9	1,2-Dichloroethane	107-06-2	LT	24.33
10	1,1-Dichloroethene	75-35-4	LT	72.98
11	cis-1,2-Dichloroethene	156-69-9	152	24.33
12	trans-1,2-Dichloroethene	156-60-5	LT	24.33
13	Ethylbenzene	100-41-4	LT	22.23
14	Methylene Chloride	75-09-2	LT	27.77
15	Tetrachloroethene	127-18-4	LT	14.23
16	Toluene	108-88-3	LT	25.60
17	1,1,1-Trichloroethane	71-55-6	LT	17.66
18	1,1,2-Trichloroethane	79-00-5	LT	17.66
19	Trichloroethene	79-01-6	862	17.96
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.64
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.60
22	Vinyl Chloride	75-01-4	LT	37.71
23	Total-Xylene	1330-20-7	LT	22.23
24	Total VOC		1053	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	**75-130**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	FB 2	Laboratory ID:	OA990427
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/4/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	LT	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	LT	18.32
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		0	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	Field Blank-1	Laboratory ID:	OA990413
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/4/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	24.81
11	cis-1,2-Dichloroethene	156-69-9	LT	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	LT	18.32
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		0	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-13-3	Laboratory ID:	OA990426
Matrix:	Gas Cartridge	Sample Vol.(L):	0.101
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/8/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	4112
2	Benzene	71-43-2	LT	3062
3	Carbon Tetrachloride	56-23-5	LT	1557
4	Chloroform	67-66-3	LT	2006
5	1,2-Dichlorobenzene	95-50-1	LT	1629
6	1,3-Dichlorobenzene	541-73-1	LT	1629
7	1,4-Dichlorobenzene	106-46-7	LT	1629
8	1,1-Dichloroethane	75-34-3	LT	2415
9	1,2-Dichloroethane	107-06-2	LT	2469
10	1,1-Dichloroethene	75-35-4	LT	2469
11	cis-1,2-Dichloroethene	156-69-9	10150	2469
12	trans-1,2-Dichloroethene	156-60-5	LT	2469
13	Ethylbenzene	100-41-4	LT	2256
14	Methylene Chloride	75-09-2	LT	2819
15	Tetrachloroethene	127-18-4	LT	1444
16	Toluene	108-88-3	LT	2598
17	1,1,1-Trichloroethane	71-55-6	LT	1793
18	1,1,2-Trichloroethane	79-00-5	LT	1793
19	Trichloroethene	79-01-6	27800	1822
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	1587
21	1,2,4-Trimethylbenzene	95-63-6	LT	2598
22	Vinyl Chloride	75-01-4	LT	3827
23	Total-Xylene	1330-20-7	LT	2256
24	Total VOC		37950	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

** Detector is saturated

CAS #: Chemical Abstract Services Registry Number

PQL: Practical Quantitation Limits

LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : _______ Date: 8/3/99

Reviewer: _______ Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID: BG-12-1 Laboratory ID: OA990425
Matrix: Gas Cartridge Sample Vol.(L): 0.101
Date Sampled: 3/31/99 Date Received: 4/1/99
Date Analyzed: 4/8/99 Method: TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	4083
2	Benzene	71-43-2	LT	3040
3	Carbon Tetrachloride	56-23-5	LT	1546
4	Chloroform	67-66-3	LT	1992
5	1,2-Dichlorobenzene	95-50-1	LT	1617
6	1,3-Dichlorobenzene	541-73-1	LT	1617
7	1,4-Dichlorobenzene	106-46-7	LT	1617
8	1,1-Dichloroethane	75-34-3	LT	2398
9	1,2-Dichloroethane	107-06-2	LT	2452
10	1,1-Dichloroethene	75-35-4	LT	2452
11	cis-1,2-Dichloroethene	156-69-9	4320	2452
12	trans-1,2-Dichloroethene	156-60-5	LT	2452
13	Ethylbenzene	100-41-4	LT	2241
14	Methylene Chloride	75-09-2	LT	2799
15	Tetrachloroethene	127-18-4	LT	1434
16	Toluene	108-88-3	LT	2580
17	1,1,1-Trichloroethane	71-55-6	LT	1780
18	1,1,2-Trichloroethane	79-00-5	LT	1780
19	Trichloroethene	79-01-6	7090	1810
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	1576
21	1,2,4-Trimethylbenzene	95-63-6	LT	2580
22	Vinyl Chloride	75-01-4	LT	3801
23	Total-Xylene	1330-20-7	LT	2241
24	Total VOC		11410	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-11	Laboratory ID:	OA990424
Matrix:	Gas Cartridge	Sample Vol.(L):	0.101
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/4/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	408
2	Benzene	71-43-2	LT	304
3	Carbon Tetrachloride	56-23-5	LT	155
4	Chloroform	67-66-3	LT	199
5	1,2-Dichlorobenzene	95-50-1	LT	162
6	1,3-Dichlorobenzene	541-73-1	LT	162
7	1,4-Dichlorobenzene	106-46-7	LT	162
8	1,1-Dichloroethane	75-34-3	LT	240
9	1,2-Dichloroethane	107-06-2	LT	245
10	1,1-Dichloroethene	75-35-4	LT	245
11	cis-1,2-Dichloroethene	156-69-9	412	245
12	trans-1,2-Dichloroethene	156-60-5	LT	245
13	Ethylbenzene	100-41-4	LT	224
14	Methylene Chloride	75-09-2	LT	280
15	Tetrachloroethene	127-18-4	LT	143
16	Toluene	108-88-3	LT	258
17	1,1,1-Trichloroethane	71-55-6	LT	178
18	1,1,2-Trichloroethane	79-00-5	LT	178
19	Trichloroethene	79-01-6	502	181
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	158
21	1,2,4-Trimethylbenzene	95-63-6	LT	258
22	Vinyl Chloride	75-01-4	LT	380
23	Total-Xylene	1330-20-7	LT	224
24	Total VOC		915	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID: BG-10 Laboratory ID: OA990423
Matrix: Gas Cartridge Sample Vol.(L): 0.102
Date Sampled: 3/31/99 Date Received: 4/1/99
Date Analyzed: 4/4/99 Method: TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	40.71
2	Benzene	71-43-2	LT	30.31
3	Carbon Tetrachloride	56-23-5	LT	15.42
4	Chloroform	67-66-3	LT	19.86
5	1,2-Dichlorobenzene	95-50-1	LT	16.12
6	1,3-Dichlorobenzene	541-73-1	LT	16.12
7	1,4-Dichlorobenzene	106-46-7	LT	16.12
8	1,1-Dichloroethane	75-34-3	LT	23.91
9	1,2-Dichloroethane	107-06-2	LT	24.45
10	1,1-Dichloroethene	75-35-4	LT	73.34
11	cis-1,2-Dichloroethene	156-69-9	42.8	24.45
12	trans-1,2-Dichloroethene	156-60-5	LT	24.45
13	Ethylbenzene	100-41-4	LT	22.34
14	Methylene Chloride	75-09-2	LT	27.91
15	Tetrachloroethene	127-18-4	LT	14.30
16	Toluene	108-88-3	LT	25.72
17	1,1,1-Trichloroethane	71-55-6	LT	17.75
18	1,1,2-Trichloroethane	79-00-5	LT	17.75
19	Trichloroethene	79-01-6	132	18.04
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.71
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.72
22	Vinyl Chloride	75-01-4	LT	37.89
23	Total-Xylene	1330-20-7	LT	22.34
24	Total VOC		175	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL
* Compounds could not be determined because of interferent on detector.
California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory

TO-14 Analysis Data Sheet

Sample ID:	BG-9	Laboratory ID:	OA990422
Matrix:	Gas Cartridge	Sample Vol.(L):	0.102
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/4/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	40.55
2	Benzene	71-43-2	LT	30.20
3	Carbon Tetrachloride	56-23-5	LT	15.36
4	Chloroform	67-66-3	LT	19.79
5	1,2-Dichlorobenzene	95-50-1	LT	16.06
6	1,3-Dichlorobenzene	541-73-1	LT	16.06
7	1,4-Dichlorobenzene	106-46-7	LT	16.06
8	1,1-Dichloroethane	75-34-3	LT	23.82
9	1,2-Dichloroethane	107-06-2	LT	24.35
10	1,1-Dichloroethene	75-35-4	LT	73.05
11	cis-1,2-Dichloroethene	156-69-9	78.4	24.35
12	trans-1,2-Dichloroethene	156-60-5	LT	24.35
13	Ethylbenzene	100-41-4	LT	22.25
14	Methylene Chloride	75-09-2	LT	27.80
15	Tetrachloroethene	127-18-4	LT	14.24
16	Toluene	108-88-3	LT	25.62
17	1,1,1-Trichloroethane	71-55-6	LT	17.68
18	1,1,2-Trichloroethane	79-00-5	LT	17.68
19	Trichloroethene	79-01-6	436	17.97
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.65
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.62
22	Vinyl Chloride	75-01-4	LT	37.74
23	Total-Xylene	1330-20-7	LT	22.25
24	Total VOC		514	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-8	Laboratory ID:	OA990421
Matrix:	Gas Cartridge	Sample Vol.(L):	0.102
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/4/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	40.43
2	Benzene	71-43-2	LT	30.11
3	Carbon Tetrachloride	56-23-5	LT	15.31
4	Chloroform	67-66-3	LT	19.73
5	1,2-Dichlorobenzene	95-50-1	LT	16.01
6	1,3-Dichlorobenzene	541-73-1	LT	16.01
7	1,4-Dichlorobenzene	106-46-7	LT	16.01
8	1,1-Dichloroethane	75-34-3	LT	23.75
9	1,2-Dichloroethane	107-06-2	LT	24.28
10	1,1-Dichloroethene	75-35-4	LT	72.84
11	cis-1,2-Dichloroethene	156-69-9	LT	24.28
12	trans-1,2-Dichloroethene	156-60-5	LT	24.28
13	Ethylbenzene	100-41-4	LT	22.19
14	Methylene Chloride	75-09-2	LT	27.72
14	Tetrachloroethene	127-18-4	LT	14.20
15	Toluene	108-88-3	LT	25.55
16	1,1,1-Trichloroethane	71-55-6	LT	17.63
16	1,1,2-Trichloroethane	79-00-5	LT	17.63
17	Trichloroethene	79-01-6	LT	17.92
18	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.61
17	1,2,4-Trimethylbenzene	95-63-6	LT	25.55
18	Vinyl Chloride	75-01-4	LT	37.63
19	Total-Xylene	1330-20-7	LT	22.19
19	Total VOC		0	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	**75-130**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99

LBL Environmental Measurements Laboratory

TO-14 Analysis Data Sheet

Sample ID:	BG-7	Laboratory ID:	OA990420
Matrix:	Gas Cartridge	Sample Vol.(L):	0.103
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/4/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	40.28
2	Benzene	71-43-2	LT	29.99
3	Carbon Tetrachloride	56-23-5	LT	15.25
4	Chloroform	67-66-3	LT	19.65
5	1,2-Dichlorobenzene	95-50-1	LT	15.95
6	1,3-Dichlorobenzene	541-73-1	LT	15.95
7	1,4-Dichlorobenzene	106-46-7	LT	15.95
8	1,1-Dichloroethane	75-34-3	LT	23.66
9	1,2-Dichloroethane	107-06-2	LT	24.19
10	1,1-Dichloroethene	75-35-4	LT	72.56
11	cis-1,2-Dichloroethene	156-69-9	237	24.19
12	trans-1,2-Dichloroethene	156-60-5	LT	24.19
13	Ethylbenzene	100-41-4	LT	22.10
14	Methylene Chloride	75-09-2	LT	27.61
15	Tetrachloroethene	127-18-4	LT	14.15
16	Toluene	108-88-3	LT	25.45
17	1,1,1-Trichloroethane	71-55-6	LT	17.56
18	1,1,2-Trichloroethane	79-00-5	LT	17.56
19	Trichloroethene	79-01-6	1053	17.85
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.54
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.45
22	Vinyl Chloride	75-01-4	LT	37.49
23	Total-Xylene	1330-20-7	LT	22.10
24	Total VOC		1290	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory

TO-14 Analysis Data Sheet

Sample ID:	BG-6	Laboratory ID:	OA990419
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/8/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.62
2	Benzene	71-43-2	LT	29.50
3	Carbon Tetrachloride	56-23-5	LT	15.00
4	Chloroform	67-66-3	NR	19.33
5	1,2-Dichlorobenzene	95-50-1	LT	15.69
6	1,3-Dichlorobenzene	541-73-1	LT	15.69
7	1,4-Dichlorobenzene	106-46-7	LT	15.69
8	1,1-Dichloroethane	75-34-3	NR	23.27
9	1,2-Dichloroethane	107-06-2	NR	23.79
10	1,1-Dichloroethene	75-35-4	LT	71.37
11	cis-1,2-Dichloroethene	156-69-9	37.5	23.79
12	trans-1,2-Dichloroethene	156-60-5	LT	23.79
13	Ethylbenzene	100-41-4	LT	21.74
14	Methylene Chloride	75-09-2	NR	27.16
15	Tetrachloroethene	127-18-4	LT	13.92
16	Toluene	108-88-3	LT	25.03
17	1,1,1-Trichloroethane	71-55-6	LT	17.28
18	1,1,2-Trichloroethane	79-00-5	LT	17.28
19	Trichloroethene	79-01-6	244	17.56
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.29
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.03
22	Vinyl Chloride	75-01-4	LT	36.88
23	Total-Xylene	1330-20-7	LT	21.74
24	Total VOC		282	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL
NR: Hall detector malfunctioned during analysis.
California D.O.H.S. Cert. # 1704

Analyst: Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-5	Laboratory ID:	OA990418
Matrix:	Gas Cartridge	Sample Vol.(L):	0.103
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/13/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	40.00
2	Benzene	71-43-2	43.4	29.79
3	Carbon Tetrachloride	56-23-5	LT	15.15
4	Chloroform	67-66-3	NR	19.52
5	1,2-Dichlorobenzene	95-50-1	LT	15.84
6	1,3-Dichlorobenzene	541-73-1	LT	15.84
7	1,4-Dichlorobenzene	106-46-7	LT	15.84
8	1,1-Dichloroethane	75-34-3	NR	23.50
9	1,2-Dichloroethane	107-06-2	LT	24.02
10	1,1-Dichloroethene	75-35-4	LT	72.06
11	cis-1,2-Dichloroethene	156-69-9	472	24.02
12	trans-1,2-Dichloroethene	156-60-5	LT	24.02
13	Ethylbenzene	100-41-4	LT	21.95
14	Methylene Chloride	75-09-2	LT	27.42
15	Tetrachloroethene	127-18-4	LT	14.05
16	Toluene	108-88-3	LT	25.28
17	1,1,1-Trichloroethane	71-55-6	LT	17.44
18	1,1,2-Trichloroethane	79-00-5	LT	17.44
19	Trichloroethene	79-01-6	1341	17.73
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	NR	15.44
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.28
22	Vinyl Chloride	75-01-4	LT	37.23
23	Total-Xylene	1330-20-7	LT	21.95
24	Total VOC		1856	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL
NR: Hall detector malfunctioned during analysis.
California D.O.H.S. Cert. # 1704

Analyst : ______ Date: 8/3/99
Reviewer: ______ Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID: BG-4
Laboratory ID: OA990417
Matrix: Gas Cartridge
Sample Vol.(L): 0.104
Date Sampled: 3/31/99
Date Received: 4/1/99
Date Analyzed: 4/13/99
Method: TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.89
2	Benzene	71-43-2	LT	29.70
3	Carbon Tetrachloride	56-23-5	LT	15.11
4	Chloroform	67-66-3	NR	19.46
5	1,2-Dichlorobenzene	95-50-1	LT	15.80
6	1,3-Dichlorobenzene	541-73-1	LT	15.80
7	1,4-Dichlorobenzene	106-46-7	LT	15.80
8	1,1-Dichloroethane	75-34-3	NR	23.43
9	1,2-Dichloroethane	107-06-2	LT	23.95
10	1,1-Dichloroethene	75-35-4	LT	71.85
11	cis-1,2-Dichloroethene	156-69-9	237	23.95
12	trans-1,2-Dichloroethene	156-60-5	LT	23.95
13	Ethylbenzene	100-41-4	LT	21.89
14	Methylene Chloride	75-09-2	LT	27.34
15	Tetrachloroethene	127-18-4	LT	14.01
16	Toluene	108-88-3	LT	25.20
17	1,1,1-Trichloroethane	71-55-6	LT	17.39
18	1,1,2-Trichloroethane	79-00-5	LT	17.39
19	Trichloroethene	79-01-6	1163	17.68
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	NR	15.39
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.20
22	Vinyl Chloride	75-01-4	LT	37.13
23	Total-Xylene	1330-20-7	LT	21.89
24	Total VOC		1400	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL
NR: Hall detector malfunctioned during analysis.
California D.O.H.S. Cert. # 1704

Analyst :
Date: 8/3/99
Reviewer:
Date: 8/3/99.

LBL Environmental Measurements Laboratory

TO-14 Analysis Data Sheet

Sample ID:	BG-3	Laboratory ID:	OA990416
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/8/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.73
2	Benzene	71-43-2	LT	29.59
3	Carbon Tetrachloride	56-23-5	LT	15.05
4	Chloroform	67-66-3	LT	19.39
5	1,2-Dichlorobenzene	95-50-1	LT	15.74
6	1,3-Dichlorobenzene	541-73-1	LT	15.74
7	1,4-Dichlorobenzene	106-46-7	LT	15.74
8	1,1-Dichloroethane	75-34-3	LT	23.34
9	1,2-Dichloroethane	107-06-2	LT	23.86
10	1,1-Dichloroethene	75-35-4	LT	71.58
11	cis-1,2-Dichloroethene	156-69-9	143	23.86
12	trans-1,2-Dichloroethene	156-60-5	LT	23.86
13	Ethylbenzene	100-41-4	LT	21.80
14	Methylene Chloride	75-09-2	LT	27.24
15	Tetrachloroethene	127-18-4	LT	13.96
16	Toluene	108-88-3	LT	25.11
17	1,1,1-Trichloroethane	71-55-6	LT	17.33
18	1,1,2-Trichloroethane	79-00-5	LT	17.33
19	Trichloroethene	79-01-6	1050	17.61
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	1830	15.34
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.11
22	Vinyl Chloride	75-01-4	LT	36.98
23	Total-Xylene	1330-20-7	LT	21.80
24	Total VOC		3023	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Rob Dakfeurd Date: 8/3/99
Reviewer: HGfoutfd. Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID: BG-2
Laboratory ID: OA990415
Matrix: Gas Cartridge
Sample Vol.(L): 0.104
Date Sampled: 3/31/99
Date Received: 4/1/99
Date Analyzed: 4/8/99
Method: TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.62
2	Benzene	71-43-2	LT	29.50
3	Carbon Tetrachloride	56-23-5	LT	15.00
4	Chloroform	67-66-3	LT	19.33
5	1,2-Dichlorobenzene	95-50-1	LT	15.69
6	1,3-Dichlorobenzene	541-73-1	LT	15.69
7	1,4-Dichlorobenzene	106-46-7	LT	15.69
8	1,1-Dichloroethane	75-34-3	LT	23.27
9	1,2-Dichloroethane	107-06-2	LT	23.79
10	1,1-Dichloroethene	75-35-4	LT	71.37
11	cis-1,2-Dichloroethene	156-69-9	96.3	23.79
12	trans-1,2-Dichloroethene	156-60-5	LT	23.79
13	Ethylbenzene	100-41-4	LT	21.74
14	Methylene Chloride	75-09-2	LT	27.16
15	Tetrachloroethene	127-18-4	LT	13.92
16	Toluene	108-88-3	LT	25.03
17	1,1,1-Trichloroethane	71-55-6	LT	17.28
18	1,1,2-Trichloroethane	79-00-5	LT	17.28
19	Trichloroethene	79-01-6	1295	17.56
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	4814	15.29
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.03
22	Vinyl Chloride	75-01-4	LT	36.88
23	Total-Xylene	1330-20-7	LT	21.74
24	Total VOC		6205	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	102%	**75-130**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst:
Date: 8/3/99
Reviewer:
Date: 8/3/99.

Volatile Organics Analysis Data Sheet (Continued) Laboratory ID: OW990415

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
35	1,1-Dichloropropene	563-58-6	LT	2.0
36	cis-1,3-Dichloropropene	10061-01-5	LT	2.0
37	trans-1,3-Dichloropropene	10061-02-6	LT	2.0
38	1,2-Dichlorotetrafluoroethane(Freon-114)	76-14-2	LT	6.0
39	Dichlorotrifluoroethane(Freon-123)	306-83-2	LT	2.0
40	Dichlorotrifluoroethane(Freon-123A)	354-23-4	LT	2.0
41	Ethylbenzene	100-41-4	LT	2.0
42	Hexachlorobutadien	87-68-3	LT	6.0
43	Isopropylbenzene	98-82-8	LT	4.0
44	p-Isopropyltoluene	99-87-6	LT	2.0
45	Methylene Chloride	75-09-2	LT	2.0
45	Methyl tert-Butyl Ether	1634-04-4	LT	10.0
46	Naphthalene	91-20-3	LT	4.0
47	n-Propylbenzene	103-65-1	LT	2.0
48	Styrene	100-42-5	LT	2.0
49	1,1,2,2-Tetrachloroethane	79-34-5	LT	2.0
50	1,1,1,2-Tetrachloroethane	79-34-5	LT	4.0
51	Tetrachloroethene	127-18-4	LT	2.0
52	Toluene	108-88-3	LT	2.0
53	1,2,3-Trichlorobenzene	87-61-6	LT	4.0
54	1,2,4-Trichlorobenzene	120-82-1	LT	2.0
55	1,1,1-Trichloroethane	71-55-6	LT	2.0
56	1,1,2-Trichloroethane	79-00-5	LT	2.0
57	Trichloroethene	79-01-6	143	2.0
58	Trichlorofluoromethane(Freon-11)	75-69-4	LT	4.0
59	1,2,3-Trichloropropane	96-18-4	LT	2.0
60	1,1,2-Trichlorotrifluoroethane(Freon-113)	76-13-1	LT	2.0
61	1,2,4-Trimethylbenzene	95-63-6	LT	2.0
62	1,3,5-Trimethylbenzene	108-67-8	LT	2.0
63	Vinyl Chloride	75-01-4	LT	2.0
64	Total-Xylene	1330-20-7	LT	4.0

Surrogate Compounds	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100.4	**86-115**
Dibromofluoromethane	103.0	**86-118**
Toluene-d8	98.8	**88-110**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits (based on 5 ml water sample volume)
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : ____________ Date: 8/3/99
Reviewer: ____________ Date: 8/3/99.

LBL Environmental Measurements Laboratory
Volatile Organics Analysis Data Sheet

Sample ID:	C7	Laboratory ID:	OW990415
Matrix:	Water	Sample Wt./Vol.:	5.0 ml
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/3/99	Method:	EPA 8260(Purge & Trap)

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
1	Benzene	71-43-2	LT	2.0
2	Bromobenzene	108-86-1	LT	2.0
3	Bromochloromethane	74-97-5	LT	4.0
4	Bromodichloromethane	75-27-4	LT	2.0
5	Bromoform	75-25-2	LT	4.0
6	Bromomethane	74-83-9	LT	8.0
7	n-Butylbenzene	104-51-8	LT	2.0
8	sec-Butylbenzene	135-98-8	LT	2.0
9	ter-Butylbenzene	98-06-6	LT	2.0
10	Carbon Tetrachloride	56-23-5	LT	2.0
11	Chlorobenzene	108-90-7	LT	2.0
12	Chlorodifluoromethane(Freon-22)	75-45-6	LT	60.0
13	Chloroethane	75-00-3	LT	60.0
14	Chloroform	67-66-3	LT	2.0
15	Chloromethane	74-87-3	LT	2.0
16	2-Chlorotoluene	95-49-8	LT	4.0
17	4-Chlorotoluene	106-43-4	LT	4.0
18	Dibromochloromethane	124-48-1	LT	4.0
19	1,2-Dibromo-3-chloropropane	96-12-8	LT	4.0
20	1,2-Dibromoethane	106-93-4	LT	4.0
21	Dibromomethane	74-95-3	LT	2.0
22	1,2-Dichlorobenzene	95-50-1	LT	2.0
23	1,3-Dichlorobenzene	541-73-1	LT	2.0
24	1,4-Dichlorobenzene	106-46-7	LT	2.0
25	Dichlorodifluoromethane(Freon-12)	75-71-8	LT	6.0
26	1,1-Dichloroethane	75-34-3	LT	2.0
27	1,2-Dichloroethane	107-06-2	LT	4.0
28	1,1-Dichloroethene	75-35-4	LT	2.0
29	cis-1,2-Dichloroethene	156-69-9	24.5	2.0
30	trans-1,2-Dichloroethene	156-60-5	LT	2.0
31	Dichlorofluoromethane(Freon-21)	75-43-4	LT	6.0
32	1,2-Dichloropropane	78-87-5	LT	2.0
33	1,3-Dichloropropane	142-28-9	LT	2.0
34	2,2-Dichloropropane	594-20-7	LT	2.0

Volatile Organics Analysis Data Sheet (Continued) Laboratory ID: OW990414

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
35	1,1-Dichloropropene	563-58-6	LT	5.0
36	cis-1,3-Dichloropropene	10061-01-5	LT	5.0
37	trans-1,3-Dichloropropene	10061-02-6	LT	5.0
38	1,2-Dichlorotetrafluoroethane(Freon-114)	76-14-2	LT	15.0
39	Dichlorotrifluoroethane(Freon-123)	306-83-2	LT	5.0
40	Dichlorotrifluoroethane(Freon-123A)	354-23-4	LT	5.0
41	Ethylbenzene	100-41-4	LT	5.0
42	Hexachlorobutadien	87-68-3	LT	15.0
43	Isopropylbenzene	98-82-8	LT	10.0
44	p-Isopropyltoluene	99-87-6	LT	5.0
45	Methylene Chloride	75-09-2	LT	5.0
45	Methyl tert-Butyl Ether	1634-04-4	LT	25.0
46	Naphthalene	91-20-3	LT	10.0
47	n-Propylbenzene	103-65-1	LT	5.0
48	Styrene	100-42-5	LT	5.0
49	1,1,2,2-Tetrachloroethane	79-34-5	LT	5.0
50	1,1,1,2-Tetrachloroethane	79-34-5	LT	10.0
51	Tetrachloroethene	127-18-4	LT	5.0
52	Toluene	108-88-3	LT	5.0
53	1,2,3-Trichlorobenzene	87-61-6	LT	10.0
54	1,2,4-Trichlorobenzene	120-82-1	LT	5.0
55	1,1,1-Trichloroethane	71-55-6	LT	5.0
56	1,1,2-Trichloroethane	79-00-5	LT	5.0
57	Trichloroethene	79-01-6	604	5.0
58	Trichlorofluoromethane(Freon-11)	75-69-4	LT	10.0
59	1,2,3-Trichloropropane	96-18-4	LT	5.0
60	1,1,2-Trichlorotrifluoroethane(Freon-113)	76-13-1	LT	5.0
61	1,2,4-Trimethylbenzene	95-63-6	LT	5.0
62	1,3,5-Trimethylbenzene	108-67-8	LT	5.0
63	Vinyl Chloride	75-01-4	LT	5.0
64	Total-Xylene	1330-20-7	LT	10.0

Surrogate Compounds	% Recovery	QC Limits (%)
4-Bromofluorobenzene	98.6	**86-115**
Dibromofluoromethane	105.2	**86-118**
Toluene-d8	103.0	**88-110**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits (based on 5 ml water sample volume)
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99

LBL Environmental Measurements Laboratory
Volatile Organics Analysis Data Sheet

Sample ID:	C6	Laboratory ID:	OW990414
Matrix:	Water	Sample Wt./Vol.:	5.0 ml
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/3/99	Method:	EPA 8260(Purge & Trap)

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
1	Benzene	71-43-2	LT	5.0
2	Bromobenzene	108-86-1	LT	5.0
3	Bromochloromethane	74-97-5	LT	10.0
4	Bromodichloromethane	75-27-4	LT	5.0
5	Bromoform	75-25-2	LT	10.0
6	Bromomethane	74-83-9	LT	20.0
7	n-Butylbenzene	104-51-8	LT	5.0
8	sec-Butylbenzene	135-98-8	LT	5.0
9	ter-Butylbenzene	98-06-6	LT	5.0
10	Carbon Tetrachloride	56-23-5	LT	5.0
11	Chlorobenzene	108-90-7	LT	5.0
12	Chlorodifluoromethane(Freon-22)	75-45-6	LT	150.0
13	Chloroethane	75-00-3	LT	150.0
14	Chloroform	67-66-3	LT	5.0
15	Chloromethane	74-87-3	LT	5.0
16	2-Chlorotoluene	95-49-8	LT	10.0
17	4-Chlorotoluene	106-43-4	LT	10.0
18	Dibromochloromethane	124-48-1	LT	10.0
19	1,2-Dibromo-3-chloropropane	96-12-8	LT	10.0
20	1,2-Dibromoethane	106-93-4	LT	10.0
21	Dibromomethane	74-95-3	LT	5.0
22	1,2-Dichlorobenzene	95-50-1	LT	5.0
23	1,3-Dichlorobenzene	541-73-1	LT	5.0
24	1,4-Dichlorobenzene	106-46-7	LT	5.0
25	Dichlorodifluoromethane(Freon-12)	75-71-8	LT	15.0
26	1,1-Dichloroethane	75-34-3	LT	5.0
27	1,2-Dichloroethane	107-06-2	LT	10.0
28	1,1-Dichloroethene	75-35-4	LT	5.0
29	cis-1,2-Dichloroethene	156-69-9	118	5.0
30	trans-1,2-Dichloroethene	156-60-5	LT	5.0
31	Dichlorofluoromethane(Freon-21)	75-43-4	LT	15.0
32	1,2-Dichloropropane	78-87-5	LT	5.0
33	1,3-Dichloropropane	142-28-9	LT	5.0
34	2,2-Dichloropropane	594-20-7	LT	5.0

Volatile Organics Analysis Data Sheet (Continued) Laboratory ID: OW990413

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
35	1,1-Dichloropropene	563-58-6	LT	10.0
36	cis-1,3-Dichloropropene	10061-01-5	LT	10.0
37	trans-1,3-Dichloropropene	10061-02-6	LT	10.0
38	1,2-Dichlorotetrafluoroethane(Freon-114)	76-14-2	LT	30.0
39	Dichlorotrifluoroethane(Freon-123)	306-83-2	LT	10.0
40	Dichlorotrifluoroethane(Freon-123A)	354-23-4	LT	10.0
41	Ethylbenzene	100-41-4	LT	10.0
42	Hexachlorobutadien	87-68-3	LT	30.0
43	Isopropylbenzene	98-82-8	LT	20.0
44	p-Isopropyltoluene	99-87-6	LT	10.0
45	Methylene Chloride	75-09-2	LT	10.0
45	Methyl tert-Butyl Ether	1634-04-4	LT	50.0
46	Naphthalene	91-20-3	LT	20.0
47	n-Propylbenzene	103-65-1	LT	10.0
48	Styrene	100-42-5	LT	10.0
49	1,1,2,2-Tetrachloroethane	79-34-5	LT	10.0
50	1,1,1,2-Tetrachloroethane	79-34-5	LT	20.0
51	Tetrachloroethene	127-18-4	LT	10.0
52	Toluene	108-88-3	LT	10.0
53	1,2,3-Trichlorobenzene	87-61-6	LT	20.0
54	1,2,4-Trichlorobenzene	120-82-1	LT	10.0
55	1,1,1-Trichloroethane	71-55-6	LT	10.0
56	1,1,2-Trichloroethane	79-00-5	LT	10.0
57	Trichloroethene	79-01-6	595	10.0
58	Trichlorofluoromethane(Freon-11)	75-69-4	LT	20.0
59	1,2,3-Trichloropropane	96-18-4	LT	10.0
60	1,1,2-Trichlorotrifluoroethane(Freon-113)	76-13-1	LT	10.0
61	1,2,4-Trimethylbenzene	95-63-6	LT	10.0
62	1,3,5-Trimethylbenzene	108-67-8	LT	10.0
63	Vinyl Chloride	75-01-4	LT	10.0
64	Total-Xylene	1330-20-7	LT	20.0

Surrogate Compounds	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100.2	**86-115**
Dibromofluoromethane	103.2	**86-118**
Toluene-d8	99.4	**88-110**

CAS #: Chemical Abstract Services Registry Number

PQL: Practical Quantitation Limits (based on 5 ml water sample volume)

LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99

Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
Volatile Organics Analysis Data Sheet

Sample ID:	C5	Laboratory ID:	OW990413
Matrix:	Water	Sample Wt./Vol.:	5.0 ml
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/3/99	Method:	EPA 8260(Purge & Trap)

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
1	Benzene	71-43-2	LT	10.0
2	Bromobenzene	108-86-1	LT	10.0
3	Bromochloromethane	74-97-5	LT	20.0
4	Bromodichloromethane	75-27-4	LT	10.0
5	Bromoform	75-25-2	LT	20.0
6	Bromomethane	74-83-9	LT	40.0
7	n-Butylbenzene	104-51-8	LT	10.0
8	sec-Butylbenzene	135-98-8	LT	10.0
9	ter-Butylbenzene	98-06-6	LT	10.0
10	Carbon Tetrachloride	56-23-5	LT	10.0
11	Chlorobenzene	108-90-7	LT	10.0
12	Chlorodifluoromethane(Freon-22)	75-45-6	LT	300.0
13	Chloroethane	75-00-3	LT	300.0
14	Chloroform	67-66-3	LT	10.0
15	Chloromethane	74-87-3	LT	10.0
16	2-Chlorotoluene	95-49-8	LT	20.0
17	4-Chlorotoluene	106-43-4	LT	20.0
18	Dibromochloromethane	124-48-1	LT	20.0
19	1,2-Dibromo-3-chloropropane	96-12-8	LT	20.0
20	1,2-Dibromoethane	106-93-4	LT	20.0
21	Dibromomethane	74-95-3	LT	10.0
22	1,2-Dichlorobenzene	95-50-1	LT	10.0
23	1,3-Dichlorobenzene	541-73-1	LT	10.0
24	1,4-Dichlorobenzene	106-46-7	LT	10.0
25	Dichlorodifluoromethane(Freon-12)	75-71-8	LT	30.0
26	1,1-Dichloroethane	75-34-3	LT	10.0
27	1,2-Dichloroethane	107-06-2	LT	20.0
28	1,1-Dichloroethene	75-35-4	LT	10.0
29	cis-1,2-Dichloroethene	156-69-9	413	10.0
30	trans-1,2-Dichloroethene	156-60-5	LT	10.0
31	Dichlorofluoromethane(Freon-21)	75-43-4	LT	30.0
32	1,2-Dichloropropane	78-87-5	LT	10.0
33	1,3-Dichloropropane	142-28-9	LT	10.0
34	2,2-Dichloropropane	594-20-7	LT	10.0

Volatile Organics Analysis Data Sheet (Continued) Laboratory ID: OW990412

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
35	1,1-Dichloropropene	563-58-6	LT	5.0
36	cis-1,3-Dichloropropene	10061-01-5	LT	5.0
37	trans-1,3-Dichloropropene	10061-02-6	LT	5.0
38	1,2-Dichlorotetrafluoroethane(Freon-114)	76-14-2	LT	15.0
39	Dichlorotrifluoroethane(Freon-123)	306-83-2	LT	5.0
40	Dichlorotrifluoroethane(Freon-123A)	354-23-4	LT	5.0
41	Ethylbenzene	100-41-4	LT	5.0
42	Hexachlorobutadien	87-68-3	LT	15.0
43	Isopropylbenzene	98-82-8	LT	10.0
44	p-Isopropyltoluene	99-87-6	LT	5.0
45	Methylene Chloride	75-09-2	LT	5.0
45	Methyl tert-Butyl Ether	1634-04-4	LT	25.0
46	Naphthalene	91-20-3	LT	10.0
47	n-Propylbenzene	103-65-1	LT	5.0
48	Styrene	100-42-5	LT	5.0
49	1,1,2,2-Tetrachloroethane	79-34-5	LT	5.0
50	1,1,1,2-Tetrachloroethane	79-34-5	LT	10.0
51	Tetrachloroethene	127-18-4	LT	5.0
52	Toluene	108-88-3	LT	5.0
53	1,2,3-Trichlorobenzene	87-61-6	LT	10.0
54	1,2,4-Trichlorobenzene	120-82-1	LT	5.0
55	1,1,1-Trichloroethane	71-55-6	LT	5.0
56	1,1,2-Trichloroethane	79-00-5	LT	5.0
57	Trichloroethene	79-01-6	264	5.0
58	Trichlorofluoromethane(Freon-11)	75-69-4	LT	10.0
59	1,2,3-Trichloropropane	96-18-4	LT	5.0
60	1,1,2-Trichlorotrifluoroethane(Freon-113)	76-13-1	LT	5.0
61	1,2,4-Trimethylbenzene	95-63-6	LT	5.0
62	1,3,5-Trimethylbenzene	108-67-8	LT	5.0
63	Vinyl Chloride	75-01-4	LT	5.0
64	Total-Xylene	1330-20-7	LT	10.0

Surrogate Compounds	% Recovery	QC Limits (%)
4-Bromofluorobenzene	98.0	**86-115**
Dibromofluoromethane	100.9	**86-118**
Toluene-d8	98.0	**88-110**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits (based on 5 ml water sample volume)
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
Volatile Organics Analysis Data Sheet

Sample ID:	C4	Laboratory ID:	OW990412
Matrix:	Water	Sample Wt./Vol.:	5.0 ml
Date Sampled:	3/31/99	Date Received:	4/1/99
Date Analyzed:	4/3/99	Method:	EPA 8260(Purge & Trap)

	Compound	CAS #	Conc.(ug/L)	PQL(ug/L)
1	Benzene	71-43-2	LT	5.0
2	Bromobenzene	108-86-1	LT	5.0
3	Bromochloromethane	74-97-5	LT	10.0
4	Bromodichloromethane	75-27-4	LT	5.0
5	Bromoform	75-25-2	LT	10.0
6	Bromomethane	74-83-9	LT	20.0
7	n-Butylbenzene	104-51-8	LT	5.0
8	sec-Butylbenzene	135-98-8	LT	5.0
9	ter-Butylbenzene	98-06-6	LT	5.0
10	Carbon Tetrachloride	56-23-5	LT	5.0
11	Chlorobenzene	108-90-7	LT	5.0
12	Chlorodifluoromethane(Freon-22)	75-45-6	LT	150.0
13	Chloroethane	75-00-3	LT	150.0
14	Chloroform	67-66-3	LT	5.0
15	Chloromethane	74-87-3	LT	5.0
16	2-Chlorotoluene	95-49-8	LT	10.0
17	4-Chlorotoluene	106-43-4	LT	10.0
18	Dibromochloromethane	124-48-1	LT	10.0
19	1,2-Dibromo-3-chloropropane	96-12-8	LT	10.0
20	1,2-Dibromoethane	106-93-4	LT	10.0
21	Dibromomethane	74-95-3	LT	5.0
22	1,2-Dichlorobenzene	95-50-1	LT	5.0
23	1,3-Dichlorobenzene	541-73-1	LT	5.0
24	1,4-Dichlorobenzene	106-46-7	LT	5.0
25	Dichlorodifluoromethane(Freon-12)	75-71-8	LT	15.0
26	1,1-Dichloroethane	75-34-3	LT	5.0
27	1,2-Dichloroethane	107-06-2	LT	10.0
28	1,1-Dichloroethene	75-35-4	LT	5.0
29	cis-1,2-Dichloroethene	156-69-9	259	5.0
30	trans-1,2-Dichloroethene	156-60-5	LT	5.0
31	Dichlorofluoromethane(Freon-21)	75-43-4	LT	15.0
32	1,2-Dichloropropane	78-87-5	LT	5.0
33	1,3-Dichloropropane	142-28-9	LT	5.0
34	2,2-Dichloropropane	594-20-7	LT	5.0

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-5	Laboratory ID:	OA990446
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	4/30/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	**Benzene**	**71-43-2**	**30.0**	**29.73**
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	LT	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	527	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	79-00-5	LT	17.41
19	Trichloroethene	79-01-6	1274	17.70
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	199	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		2029	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	**75-130**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL
California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID: BG-6
Laboratory ID: OA990447
Matrix: Gas Cartridge
Sample Vol.(L): 0.104
Date Sampled: 4/28/99
Date Received: 4/28/99
Date Analyzed: 4/30/99
Method: TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.9
2	Benzene	71-43-2	LT	29.7
3	Carbon Tetrachloride	56-23-5	LT	15.1
4	Chloroform	67-66-3	24.1	19.5
5	1,2-Dichlorobenzene	95-50-1	LT	15.8
6	1,3-Dichlorobenzene	541-73-1	LT	15.8
7	1,4-Dichlorobenzene	106-46-7	LT	15.8
8	1,1-Dichloroethane	75-34-3	LT	23.5
9	1,2-Dichloroethane	107-06-2	LT	24.0
10	1,1-Dichloroethene	75-35-4	LT	71.9
11	cis-1,2-Dichloroethene	156-69-9	315	24.0
12	trans-1,2-Dichloroethene	156-60-5	LT	24.0
13	Ethylbenzene	100-41-4	LT	21.9
14	Methylene Chloride	75-09-2	LT	27.4
15	Tetrachloroethene	127-18-4	LT	14.0
16	Toluene	108-88-3	LT	25.2
17	1,1,1-Trichloroethane	71-55-6	LT	17.4
18	1,1,2-Trichloroethane	79-00-5	LT	17.4
19	Trichloroethene	79-01-6	648	17.7
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	15.4	15.4
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.2
22	Vinyl Chloride	75-01-4	LT	37.2
23	Total-Xylene	1330-20-7	LT	21.9
24	Total VOC		1003	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL
NR: Hall detector malfunctioned during analysis.
California D.O.H.S. Cert. # 1704

Analyst:
Date: 8/3/99
Reviewer:
Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-7	Laboratory ID:	OA990448
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	4/30/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	LT	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	124	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	79-00-5	LT	17.41
19	Trichloroethene	79-01-6	821	17.70
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		945	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Rich Dahlquist Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory

TO-14 Analysis Data Sheet

Sample ID:	BG-8	Laboratory ID:	OA990449
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	4/30/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	LT	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	LT	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
14	Tetrachloroethene	127-18-4	LT	14.02
15	Toluene	108-88-3	LT	25.23
16	1,1,1-Trichloroethane	71-55-6	LT	17.41
16	1,1,2-Trichloroethane	79-00-5	LT	17.41
17	Trichloroethene	79-01-6	26.7	17.70
18	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.41
17	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
18	Vinyl Chloride	75-01-4	LT	37.16
19	Total-Xylene	1330-20-7	LT	21.91
19	Total VOC		27	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number

PQL: Practical Quantitation Limits

LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99

Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-9	Laboratory ID:	OA990450
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	4/30/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	30.4	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	LT	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	79.5	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	79-00-5	LT	17.41
19	Trichloroethene	79-01-6	504	17.70
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		613	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	**75-130**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : ____________ Date: 8/3/99
Reviewer: ____________ Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-10	Laboratory ID:	OA990451
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	4/30/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	LT	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	76.5	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	543	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	79-00-5	LT	17.41
19	Trichloroethene	79-01-6	770	17.70
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		1389	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL
* Compounds could not be determined because of interferent on detector.
California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID: BG-11
Laboratory ID: OA990452
Matrix: Gas Cartridge
Sample Vol.(L): 0.104
Date Sampled: 4/28/99
Date Received: 4/28/99
Date Analyzed: 5/4/99
Method: TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	399
2	Benzene	71-43-2	LT	297
3	Carbon Tetrachloride	56-23-5	LT	151
4	Chloroform	67-66-3	LT	195
5	1,2-Dichlorobenzene	95-50-1	LT	158
6	1,3-Dichlorobenzene	541-73-1	LT	158
7	1,4-Dichlorobenzene	106-46-7	LT	158
8	1,1-Dichloroethane	75-34-3	LT	235
9	1,2-Dichloroethane	107-06-2	LT	240
10	1,1-Dichloroethene	75-35-4	LT	240
11	cis-1,2-Dichloroethene	156-69-9	5917	240
12	trans-1,2-Dichloroethene	156-60-5	LT	240
13	Ethylbenzene	100-41-4	LT	219
14	Methylene Chloride	75-09-2	LT	274
15	Tetrachloroethene	127-18-4	LT	140
16	Toluene	108-88-3	LT	252
17	1,1,1-Trichloroethane	71-55-6	LT	174
18	1,1,2-Trichloroethane	79-00-5	LT	174
19	Trichloroethene	79-01-6	6979	177
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	154
21	1,2,4-Trimethylbenzene	95-63-6	LT	252
22	Vinyl Chloride	75-01-4	LT	372
23	Total-Xylene	1330-20-7	LT	219
24	Total VOC		12896	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst :
Date: 8/3/99
Reviewer:
Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-12-1	Laboratory ID:	OA990453
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	5/4/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	3992
2	Benzene	71-43-2	LT	2973
3	Carbon Tetrachloride	56-23-5	LT	1512
4	Chloroform	67-66-3	LT	1948
5	1,2-Dichlorobenzene	95-50-1	LT	1581
6	1,3-Dichlorobenzene	541-73-1	LT	1581
7	1,4-Dichlorobenzene	106-46-7	LT	1581
8	1,1-Dichloroethane	75-34-3	LT	2345
9	1,2-Dichloroethane	107-06-2	LT	2397
10	1,1-Dichloroethene	75-35-4	LT	2397
11	cis-1,2-Dichloroethene	156-69-9	23600	2397
12	trans-1,2-Dichloroethene	156-60-5	LT	2397
13	Ethylbenzene	100-41-4	LT	2191
14	Methylene Chloride	75-09-2	LT	2737
15	Tetrachloroethene	127-18-4	LT	1402
16	Toluene	108-88-3	LT	2523
17	1,1,1-Trichloroethane	71-55-6	LT	1741
18	1,1,2-Trichloroethane	79-00-5	LT	1741
19	Trichloroethene	79-01-6	37700	1770
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	1541
21	1,2,4-Trimethylbenzene	95-63-6	LT	2523
22	Vinyl Chloride	75-01-4	LT	3716
23	Total-Xylene	1330-20-7	LT	2191
24	Total VOC		61300	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	104%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-13-3	Laboratory ID:	OA990454
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	5/6/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	3992
2	Benzene	71-43-2	LT	2973
3	Carbon Tetrachloride	56-23-5	LT	1512
4	Chloroform	67-66-3	LT	1948
5	1,2-Dichlorobenzene	95-50-1	LT	1581
6	1,3-Dichlorobenzene	541-73-1	LT	1581
7	1,4-Dichlorobenzene	106-46-7	LT	1581
8	1,1-Dichloroethane	75-34-3	LT	2345
9	1,2-Dichloroethane	107-06-2	LT	2397
10	1,1-Dichloroethene	75-35-4	LT	2397
11	**cis-1,2-Dichloroethene**	**156-69-9**	**20300**	**2397**
12	trans-1,2-Dichloroethene	156-60-5	LT	2397
13	Ethylbenzene	100-41-4	LT	2191
14	Methylene Chloride	75-09-2	LT	2737
15	Tetrachloroethene	127-18-4	LT	1402
16	Toluene	108-88-3	LT	2523
17	1,1,1-Trichloroethane	71-55-6	LT	1741
18	1,1,2-Trichloroethane	79-00-5	LT	1741
19	Trichloroethene	79-01-6	75100	1770
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	1541
21	1,2,4-Trimethylbenzene	95-63-6	LT	2523
22	Vinyl Chloride	75-01-4	LT	3716
23	Total-Xylene	1330-20-7	LT	2191
24	Total VOC		95400	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

** Detector is saturated

CAS #: Chemical Abstract Services Registry Number

PQL: Practical Quantitation Limits

LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99

Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	DUP-2	Laboratory ID:	OA990455
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	5/1/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	399.25
2	Benzene	71-43-2	LT	297.29
3	Carbon Tetrachloride	56-23-5	LT	151.20
4	Chloroform	67-66-3	LT	194.80
5	1,2-Dichlorobenzene	95-50-1	LT	158.13
6	1,3-Dichlorobenzene	541-73-1	LT	158.13
7	1,4-Dichlorobenzene	106-46-7	LT	158.13
8	1,1-Dichloroethane	75-34-3	LT	234.51
9	1,2-Dichloroethane	107-06-2	LT	239.75
10	1,1-Dichloroethene	75-35-4	LT	239.75
11	cis-1,2-Dichloroethene	156-69-9	2891	239.75
12	trans-1,2-Dichloroethene	156-60-5	LT	239.75
13	Ethylbenzene	100-41-4	LT	219.09
14	Methylene Chloride	75-09-2	LT	273.71
15	Tetrachloroethene	127-18-4	LT	140.23
16	Toluene	108-88-3	LT	252.27
17	1,1,1-Trichloroethane	71-55-6	LT	174.09
18	1,1,2-Trichloroethane	79-00-5	LT	174.09
19	Trichloroethene	79-01-6	1774	176.96
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	154.10
21	1,2,4-Trimethylbenzene	95-63-6	LT	252.27
22	Vinyl Chloride	75-01-4	LT	371.61
23	Total-Xylene	1330-20-7	LT	219.09
24	Total VOC		4666	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	80%	75-130

* Saturated Detector and no duplicate sample for reanalysis.

CAS #: Chemical Abstract Services Registry Number

PQL: Practical Quantitation Limits

LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : ______ Date: 8/3/99

Reviewer: ______ Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	FB 2	Laboratory ID:	OA990455 A
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	4/30/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	LT	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	LT	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	LT	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	79-00-5	LT	17.41
19	Trichloroethene	79-01-6	LT	17.70
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		0	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	Dup 1	Laboratory ID:	OA990456
Matrix:	Gas Cartridge	Sample Vol.(L):	0.104
Date Sampled:	4/28/99	Date Received:	4/28/99
Date Analyzed:	4/30/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	39.92
2	Benzene	71-43-2	LT	29.73
3	Carbon Tetrachloride	56-23-5	LT	15.12
4	Chloroform	67-66-3	42.4	19.48
5	1,2-Dichlorobenzene	95-50-1	LT	15.81
6	1,3-Dichlorobenzene	541-73-1	LT	15.81
7	1,4-Dichlorobenzene	106-46-7	LT	15.81
8	1,1-Dichloroethane	75-34-3	LT	23.45
9	1,2-Dichloroethane	107-06-2	76.1	23.97
10	1,1-Dichloroethene	75-35-4	LT	71.92
11	cis-1,2-Dichloroethene	156-69-9	1941	23.97
12	trans-1,2-Dichloroethene	156-60-5	LT	23.97
13	Ethylbenzene	100-41-4	LT	21.91
14	Methylene Chloride	75-09-2	LT	27.37
15	Tetrachloroethene	127-18-4	LT	14.02
16	Toluene	108-88-3	LT	25.23
17	1,1,1-Trichloroethane	71-55-6	LT	17.41
18	1,1,2-Trichloroethane	79-00-5	LT	17.41
19	Trichloroethene	79-01-6	sat	17.70
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.41
21	1,2,4-Trimethylbenzene	95-63-6	LT	25.23
22	Vinyl Chloride	75-01-4	LT	37.16
23	Total-Xylene	1330-20-7	LT	21.91
24	Total VOC		2060	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-2	Laboratory ID:	OA990501
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/26/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	141	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	71-55-6	LT	18.02
19	Trichloroethene	79-01-6	4250	18.32
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	15500	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		19891	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	96%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID: AG-3
Laboratory ID: OA990502
Matrix: Gas Cartridge
Sample Vol.(L): 0.100
Date Sampled: 5/24/99
Date Received: 5/25/99
Date Analyzed: 5/27/99
Method: TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	72.6	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	797	18.32
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	2203	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		3072	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	99%	75-130

** Detector is saturated
CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst: Date: 8/3/99
Reviewer: Date: 8/3/99

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-4	Laboratory ID:	OA990503
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/27/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	166	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	960	18.32
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	805	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		1932	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-4	Laboratory ID:	OA990503
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/27/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	166	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	960	18.32
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	805	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		1932	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-5	Laboratory ID:	OA990504
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/27/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	62.03
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	200	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	924	18.32
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	47.1	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		1171	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-6	Laboratory ID:	OA990505
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/28/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	202	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	950	18.32
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	49.3	22.68
24	Total VOC		1201	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-7	Laboratory ID:	OA990506
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/28/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	84.5	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	507	18.32
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		592	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-8	Laboratory ID:	OA990507
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/28/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	37.8	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
14	Tetrachloroethene	127-18-4	LT	14.51
15	Toluene	108-88-3	LT	26.11
16	1,1,1-Trichloroethane	71-55-6	LT	18.02
16	1,1,2-Trichloroethane	79-00-5	LT	18.02
17	Trichloroethene	79-01-6	240	18.32
18	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.95
17	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
18	Vinyl Chloride	75-01-4	LT	38.46
19	Total-Xylene	1330-20-7	LT	22.68
19	Total VOC		278	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-9	Laboratory ID:	OA990508
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/28/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	67.7	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	391	18.32
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		459	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-10	Laboratory ID:	OA990509
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/28/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	75.3	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	372	18.32
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		448	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL
* Compounds could not be determined because of interferent on detector.
California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-11	Laboratory ID:	OA990510
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/26/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.3
2	Benzene	71-43-2	LT	30.8
3	Carbon Tetrachloride	56-23-5	LT	15.6
4	Chloroform	67-66-3	LT	20.2
5	1,2-Dichlorobenzene	95-50-1	LT	16.4
6	1,3-Dichlorobenzene	541-73-1	LT	16.4
7	1,4-Dichlorobenzene	106-46-7	LT	16.4
8	1,1-Dichloroethane	75-34-3	LT	24.3
9	1,2-Dichloroethane	107-06-2	LT	24.8
10	1,1-Dichloroethene	75-35-4	LT	24.8
11	cis-1,2-Dichloroethene	156-69-9	1322	24.8
12	trans-1,2-Dichloroethene	156-60-5	LT	24.8
13	Ethylbenzene	100-41-4	LT	22.7
14	Methylene Chloride	75-09-2	LT	28.3
15	Tetrachloroethene	127-18-4	LT	14.5
16	Toluene	108-88-3	LT	26.1
17	1,1,1-Trichloroethane	71-55-6	LT	18.0
18	1,1,2-Trichloroethane	79-00-5	LT	18.0
19	Trichloroethene	79-01-6	1996	18.3
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.9
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.1
22	Vinyl Chloride	75-01-4	LT	38.5
23	Total-Xylene	1330-20-7	LT	22.7
24	Total VOC		3318	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	98%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	AG-12-2	Laboratory ID:	OA990511
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/25/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	4132
2	Benzene	71-43-2	LT	3077
3	Carbon Tetrachloride	56-23-5	LT	1565
4	Chloroform	67-66-3	LT	2016
5	1,2-Dichlorobenzene	95-50-1	LT	1637
6	1,3-Dichlorobenzene	541-73-1	LT	1637
7	1,4-Dichlorobenzene	106-46-7	LT	1637
8	1,1-Dichloroethane	75-34-3	LT	2427
9	1,2-Dichloroethane	107-06-2	LT	2481
10	1,1-Dichloroethene	75-35-4	LT	2481
11	cis-1,2-Dichloroethene	156-69-9	20000	2481
12	trans-1,2-Dichloroethene	156-60-5	LT	2481
13	Ethylbenzene	100-41-4	LT	2268
14	Methylene Chloride	75-09-2	LT	2833
15	Tetrachloroethene	127-18-4	LT	1451
16	Toluene	108-88-3	LT	2611
17	1,1,1-Trichloroethane	71-55-6	LT	1802
18	1,1,2-Trichloroethane	79-00-5	LT	1802
19	Trichloroethene	79-01-6	41980	1832
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	1595
21	1,2,4-Trimethylbenzene	95-63-6	LT	2611
22	Vinyl Chloride	75-01-4	LT	3846
23	Total-Xylene	1330-20-7	LT	2268
24	Total VOC		61980	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

** Detector is saturated

CAS #: Chemical Abstract Services Registry Number

PQL: Practical Quantitation Limits

LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst: Date: 8/3/99

Reviewer: Date: 8/3/99

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID: AG-13
Laboratory ID: OA990512
Matrix: Gas Cartridge
Sample Vol.(L): 0.100
Date Sampled: 5/24/99
Date Received: 5/25/99
Date Analyzed: 5/25/99
Method: TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	4132
2	Benzene	71-43-2	LT	3077
3	Carbon Tetrachloride	56-23-5	LT	1565
4	Chloroform	67-66-3	LT	2016
5	1,2-Dichlorobenzene	95-50-1	LT	1637
6	1,3-Dichlorobenzene	541-73-1	LT	1637
7	1,4-Dichlorobenzene	106-46-7	LT	1637
8	1,1-Dichloroethane	75-34-3	LT	2427
9	1,2-Dichloroethane	107-06-2	LT	2481
10	1,1-Dichloroethene	75-35-4	LT	2481
11	cis-1,2-Dichloroethene	156-69-9	32100	2481
12	trans-1,2-Dichloroethene	156-60-5	LT	2481
13	Ethylbenzene	100-41-4	LT	2268
14	Methylene Chloride	75-09-2	LT	2833
15	Tetrachloroethene	127-18-4	LT	1451
16	Toluene	108-88-3	LT	2611
17	1,1,1-Trichloroethane	71-55-6	LT	1802
18	1,1,2-Trichloroethane	79-00-5	LT	1802
19	Trichloroethene	79-01-6	85820	1832
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	1595
21	1,2,4-Trimethylbenzene	95-63-6	LT	2611
22	Vinyl Chloride	75-01-4	LT	3846
23	Total-Xylene	1330-20-7	LT	2268
24	Total VOC		117920	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	102%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	Field Blank-1	Laboratory ID:	OA990513
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/28/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	24.81
11	cis-1,2-Dichloroethene	156-69-9	LT	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	LT	18.32
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		0	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	DUP-2	Laboratory ID:	OA990527
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/28/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	413.22
2	Benzene	71-43-2	LT	307.69
3	Carbon Tetrachloride	56-23-5	LT	156.49
4	Chloroform	67-66-3	LT	201.61
5	1,2-Dichlorobenzene	95-50-1	LT	163.67
6	1,3-Dichlorobenzene	541-73-1	LT	163.67
7	1,4-Dichlorobenzene	106-46-7	LT	163.67
8	1,1-Dichloroethane	75-34-3	LT	242.72
9	1,2-Dichloroethane	107-06-2	LT	248.14
10	1,1-Dichloroethene	75-35-4	LT	248.14
11	cis-1,2-Dichloroethene	156-69-9	511	248.14
12	trans-1,2-Dichloroethene	156-60-5	LT	248.14
13	Ethylbenzene	100-41-4	LT	226.76
14	Methylene Chloride	75-09-2	LT	283.29
15	Tetrachloroethene	127-18-4	LT	145.14
16	Toluene	108-88-3	LT	261.10
17	1,1,1-Trichloroethane	71-55-6	LT	180.18
18	1,1,2-Trichloroethane	79-00-5	LT	180.18
19	Trichloroethene	79-01-6	1747	183.15
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	159.49
21	1,2,4-Trimethylbenzene	95-63-6	LT	261.10
22	Vinyl Chloride	75-01-4	LT	384.62
23	Total-Xylene	1330-20-7	LT	226.76
24	Total VOC		2258	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

* Saturated Detector and no duplicate sample for reanalysis.

CAS #: Chemical Abstract Services Registry Number

PQL: Practical Quantitation Limits

LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst: Date: 8/3/99

Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID: BG 1 Laboratory ID: OA990514
Matrix: Gas Cartridge Sample Vol.(L): 0.100
Date Sampled: 5/24/99 Date Received: 5/25/99
Date Analyzed: 6/2/99 Method: TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	47.6	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	71-55-6	LT	18.02
19	Trichloroethene	79-01-6	407	18.32
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	LT	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		454	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-2	Laboratory ID:	OA990515
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/26/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	80.5	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	2750	18.32
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	10400	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		13231	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	**75-130**

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst: Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-3	Laboratory ID:	OA990516
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/26/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	87.6	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	1123	18.32
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	2134	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		3344	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	98%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-4	Laboratory ID:	OA990517
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/28/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	180	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	1206	18.32
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	1775	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		3161	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL
California D.O.H.S. Cert. # 1704

Analyst : ____________ Date: 8/3/99
Reviewer: ____________ Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-5	Laboratory ID:	OA990518
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/28/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	48.0	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	339	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	1380	18.32
20	Dichlorotrifluoroethane(Freon-123)	306-83-2	89.0	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		1856	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL
California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99

LBL Environmental Measurements Laboratory

TO-14 Analysis Data Sheet

Sample ID:	BG-6	Laboratory ID:	OA990519
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/28/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.3
2	Benzene	71-43-2	34.1	30.8
3	Carbon Tetrachloride	56-23-5	LT	15.6
4	Chloroform	67-66-3	LT	20.2
5	1,2-Dichlorobenzene	95-50-1	LT	16.4
6	1,3-Dichlorobenzene	541-73-1	LT	16.4
7	1,4-Dichlorobenzene	106-46-7	LT	16.4
8	1,1-Dichloroethane	75-34-3	LT	24.3
9	1,2-Dichloroethane	107-06-2	LT	24.8
10	1,1-Dichloroethene	75-35-4	LT	74.4
11	cis-1,2-Dichloroethene	156-69-9	350	24.8
12	trans-1,2-Dichloroethene	156-60-5	LT	24.8
13	Ethylbenzene	100-41-4	LT	22.7
14	Methylene Chloride	75-09-2	LT	28.3
15	Tetrachloroethene	127-18-4	LT	14.5
16	Toluene	108-88-3	LT	26.1
17	1,1,1-Trichloroethane	71-55-6	LT	18.0
18	1,1,2-Trichloroethane	79-00-5	LT	18.0
19	Trichloroethene	79-01-6	1422	18.3
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.9
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.1
22	Vinyl Chloride	75-01-4	LT	38.5
23	Total-Xylene	1330-20-7	LT	22.7
24	Total VOC		1806	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL
NR: Hall detector malfunctioned during analysis.
California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-7	Laboratory ID:	OA990520
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/28/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	93.5	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	759	18.32
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		853	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-8	Laboratory ID:	OA990521
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/28/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	29.5	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
14	Tetrachloroethene	127-18-4	LT	14.51
15	Toluene	108-88-3	LT	26.11
16	1,1,1-Trichloroethane	71-55-6	LT	18.02
16	1,1,2-Trichloroethane	79-00-5	LT	18.02
17	Trichloroethene	79-01-6	216	18.32
18	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.95
17	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
18	Vinyl Chloride	75-01-4	LT	38.46
19	Total-Xylene	1330-20-7	LT	22.68
19	Total VOC		245	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID: BG-9 Laboratory ID: OA990522
Matrix: Gas Cartridge Sample Vol.(L): 0.100
Date Sampled: 5/24/99 Date Received: 5/25/99
Date Analyzed: 5/28/99 Method: TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	121	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	202	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	1348	18.32
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		1672	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory

TO-14 Analysis Data Sheet

Sample ID:	BG-10	Laboratory ID:	OA990523
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/28/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	41.8	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	46.7	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	474	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	1100	18.32
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		1662	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL
* Compounds could not be determined because of interferent on detector.
California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID: BG-11 Laboratory ID: OA990524
Matrix: Gas Cartridge Sample Vol.(L): 0.100
Date Sampled: 5/24/99 Date Received: 5/25/99
Date Analyzed: 5/26/99 Method: TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	413
2	Benzene	71-43-2	LT	308
3	Carbon Tetrachloride	56-23-5	LT	156
4	Chloroform	67-66-3	LT	202
5	1,2-Dichlorobenzene	95-50-1	LT	164
6	1,3-Dichlorobenzene	541-73-1	LT	164
7	1,4-Dichlorobenzene	106-46-7	LT	164
8	1,1-Dichloroethane	75-34-3	LT	243
9	1,2-Dichloroethane	107-06-2	LT	248
10	1,1-Dichloroethene	75-35-4	LT	248
11	cis-1,2-Dichloroethene	156-69-9	6340	248
12	trans-1,2-Dichloroethene	156-60-5	LT	248
13	Ethylbenzene	100-41-4	LT	227
14	Methylene Chloride	75-09-2	LT	283
15	Tetrachloroethene	127-18-4	LT	145
16	Toluene	108-88-3	LT	261
17	1,1,1-Trichloroethane	71-55-6	LT	180
18	1,1,2-Trichloroethane	79-00-5	LT	180
19	Trichloroethene	79-01-6	10100	183
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	159
21	1,2,4-Trimethylbenzene	95-63-6	LT	261
22	Vinyl Chloride	75-01-4	LT	385
23	Total-Xylene	1330-20-7	LT	227
24	Total VOC		16440	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	98%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-12-1	Laboratory ID:	OA990525
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/25/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	4132
2	Benzene	71-43-2	LT	3077
3	Carbon Tetrachloride	56-23-5	LT	1565
4	Chloroform	67-66-3	LT	2016
5	1,2-Dichlorobenzene	95-50-1	LT	1637
6	1,3-Dichlorobenzene	541-73-1	LT	1637
7	1,4-Dichlorobenzene	106-46-7	LT	1637
8	1,1-Dichloroethane	75-34-3	LT	2427
9	1,2-Dichloroethane	107-06-2	LT	2481
10	1,1-Dichloroethene	75-35-4	LT	2481
11	cis-1,2-Dichloroethene	156-69-9	11600	2481
12	trans-1,2-Dichloroethene	156-60-5	LT	2481
13	Ethylbenzene	100-41-4	LT	2268
14	Methylene Chloride	75-09-2	LT	2833
15	Tetrachloroethene	127-18-4	LT	1451
16	Toluene	108-88-3	LT	2611
17	1,1,1-Trichloroethane	71-55-6	LT	1802
18	1,1,2-Trichloroethane	79-00-5	LT	1802
19	Trichloroethene	79-01-6	20100	1832
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	1595
21	1,2,4-Trimethylbenzene	95-63-6	LT	2611
22	Vinyl Chloride	75-01-4	LT	3846
23	Total-Xylene	1330-20-7	LT	2268
24	Total VOC		31700	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	100%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	BG-13-3	Laboratory ID:	OA990526
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/26/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	4132
2	Benzene	71-43-2	LT	3077
3	Carbon Tetrachloride	56-23-5	LT	1565
4	Chloroform	67-66-3	LT	2016
5	1,2-Dichlorobenzene	95-50-1	LT	1637
6	1,3-Dichlorobenzene	541-73-1	LT	1637
7	1,4-Dichlorobenzene	106-46-7	LT	1637
8	1,1-Dichloroethane	75-34-3	LT	2427
9	1,2-Dichloroethane	107-06-2	LT	2481
10	1,1-Dichloroethene	75-35-4	LT	2481
11	cis-1,2-Dichloroethene	156-69-9	3400	2481
12	trans-1,2-Dichloroethene	156-60-5	LT	2481
13	Ethylbenzene	100-41-4	LT	2268
14	Methylene Chloride	75-09-2	LT	2833
15	Tetrachloroethene	127-18-4	LT	1451
16	Toluene	108-88-3	LT	2611
17	1,1,1-Trichloroethane	71-55-6	LT	1802
18	1,1,2-Trichloroethane	79-00-5	LT	1802
19	Trichloroethene	79-01-6	14400	1832
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	1595
21	1,2,4-Trimethylbenzene	95-63-6	LT	2611
22	Vinyl Chloride	75-01-4	LT	3846
23	Total-Xylene	1330-20-7	LT	2268
24	Total VOC		17800	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	103%	75-130

** Detector is saturated

CAS #: Chemical Abstract Services Registry Number

PQL: Practical Quantitation Limits

LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : ______________ Date: 8/3/99

Reviewer: ______________ Date: 8/3/99.

LBL Environmental Measurements Laboratory
TO-14 Analysis Data Sheet

Sample ID:	Dup 1	Laboratory ID:	OA990527
Matrix:	Gas Cartridge	Sample Vol.(L):	0.100
Date Sampled:	5/24/99	Date Received:	5/25/99
Date Analyzed:	5/28/99	Method:	TO-14

	Compound	CAS #	Conc.(ppbv)	PQL(ppbv)
1	Acetone	67-64-1	LT	41.32
2	Benzene	71-43-2	LT	30.77
3	Carbon Tetrachloride	56-23-5	LT	15.65
4	Chloroform	67-66-3	LT	20.16
5	1,2-Dichlorobenzene	95-50-1	LT	16.37
6	1,3-Dichlorobenzene	541-73-1	LT	16.37
7	1,4-Dichlorobenzene	106-46-7	LT	16.37
8	1,1-Dichloroethane	75-34-3	LT	24.27
9	1,2-Dichloroethane	107-06-2	LT	24.81
10	1,1-Dichloroethene	75-35-4	LT	74.44
11	cis-1,2-Dichloroethene	156-69-9	57.5	24.81
12	trans-1,2-Dichloroethene	156-60-5	LT	24.81
13	Ethylbenzene	100-41-4	LT	22.68
14	Methylene Chloride	75-09-2	LT	28.33
15	Tetrachloroethene	127-18-4	LT	14.51
16	Toluene	108-88-3	LT	26.11
17	1,1,1-Trichloroethane	71-55-6	LT	18.02
18	1,1,2-Trichloroethane	79-00-5	LT	18.02
19	Trichloroethene	79-01-6	317	18.32
20	Dichlorotrifluoroethane (Freon 123)	306-83-2	LT	15.95
21	1,2,4-Trimethylbenzene	95-63-6	LT	26.11
22	Vinyl Chloride	75-01-4	LT	38.46
23	Total-Xylene	1330-20-7	LT	22.68
24	Total VOC		374	

Surrogate Compound	% Recovery	QC Limits (%)
4-Bromofluorobenzene	101%	75-130

CAS #: Chemical Abstract Services Registry Number
PQL: Practical Quantitation Limits
LT: Less than PQL

California D.O.H.S. Cert. # 1704

Analyst : Date: 8/3/99
Reviewer: Date: 8/3/99.

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