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MALCOLM PIRNIE, INC.
ENVIRONMENTAL ENGINEERS, SCIENTISTS & PLANNERS

December 17, 1990

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Bureau of
Construction Services

Mr. Mike Cruden
Bureau of Construction Services
Division of Hazardous Waste Remediation
New York State Department of
 Environmental Conservation
50 Wolf Road
Albany, New York 12233-7010

RE: Columbia Mills Site, Minetto, Oswego County, New York
Site No. 7-38-012
Interim Remedial Measure Program
Test Pit 3 Area Vapor Extraction - Feasibility Report

Dear Mr. Cruden:

Enclosed are two (2) copies of Vapex Environmental Technologies, Inc.'s report documenting the performance of the Vapor Extraction Pilot Study conducted in the Test Pit 3 area at the Columbia Mills site in Minetto, New York. The study was undertaken as part of the Interim Remedial Measure (IRM) Program being conducted at the site. The enclosed report examines the feasibility of utilizing the vapor extraction process on a full scale to alleviate contamination present in the subsurface soils in the area surrounding Test Pit 3.

As part of the study, two pilot tests were performed during September 12 and 13, 1990. A 24-hour pilot test was first run, then a shorter test was run at a higher air flow rate. Dewatering of the area was undertaken by Malcolm Pirnie, Inc. (MPI) in order to depress the shallow water table and increase the depth of unsaturated soils and effectiveness of vapor extraction. Ground water discharge during dewatering operations was conducted in accordance with conditions set forth by the New York State Department of Environmental Conservation (NYSDEC), Region 7.

Based on the results of the pilot scale study and Vapex modeling, it appears that utilizing a full scale vapor extraction system would be an effective method for remediation in this area. Vapex determined that approximately 43.5 pounds of total volatile organic compounds (VOCs) were removed over the duration of the pilot study. The majority of compounds removed were "estimated other VOCs", or non-target VOCs.

Vapex measured soil hydrocarbon vapor concentrations in vapor probes, installed near the former test pit, prior to the initiation of the pilot study. Total VOC concentrations ranged from 2,060 to 5,756 parts per million (ppm). Estimated total VOC concentrations in the soil gas discharge from the vapor recovery well at the beginning of the two pilot tests were 38,835 ppm and 28,135 ppm.

Based on this information, MPI contacted you on December 4, 1990, and requested that the submittal of a report documenting the feasibilities of vapor extraction and excavation be bypassed. Instead, MPI would submit the Vapex report and commence full scale vapor extraction design following NYSDEC review and approval. Because of the high VOC concentrations in the soil gas, excavation of the contaminated soils in the area surrounding Test Pit 3 would not be a feasible method of remediation. Uncontrolled emissions could possibly pose a threat to those in close proximity of the site.

Soil vapor extraction does appear to be a feasible method for alleviating VOC contamination in this area and air emissions would be controlled. As agreed upon in our December 4, 1990 phone conversation, MPI is submitting the Vapex report for NYSDEC review and approval. Upon receipt of process approval from the NYSDEC, MPI will initiate the design of the full scale system under the IRM program.

Feel free to contact us if you have any questions or require additional information.

Very truly yours,

MALCOLM PIRNIE, INC.

Richard W. Klippel

Richard W. Klippel, P.E.
Senior Associate

dd
enclosure
c: David Markell, NYSDEC
Dean Sommer, NYS Dept. of Law
Ronald Tramontano, NYSDOH
Ronald Heerkens, NYSDOH
Dolores Tuohy, NYSDEC
Charlie Branagh, NYSDEC
Les Deming, BS&K
John Metz, Columbia Mills
1069-03-1

PRELIMINARY DESIGN EVALUATION AND FULL SCALE CONCEPTUAL DESIGN OF A SOIL VAPOR EXTRACTION SYSTEM FOR THE TEST PIT 3 AREA AT THE COLUMBIA MILLS SITE, MINETTO, NY

PREPARED FOR:

MALCOLM PIRNIE, INC.
7481 HENRY CLAY BOULEVARD
LIVERPOOL, NY 13088

PREPARED BY:

VAPEX ENVIRONMENTAL TECHNOLOGIES, INC.
480 NEPONSET STREET
CANTON, MA 02021

DECEMBER 1990

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

1.0 INTRODUCTION

This report summarizes the vapor extraction feasibility work performed by Vapex Environmental Technologies, Inc. (*VAPEX*) at the Columbia Mills Site located in Minetto, NY. The site location plan is shown in Figure 1. Work was performed in accordance with *VAPEX's* proposal to Mr. Dave Knutsen of Malcolm Pirnie, Inc. (MPI), dated March 20, 1990.

The results of vadose and saturated zone soil sampling and analytical testing obtained during previous investigations by MPI had identified several volatile organic compounds (VOCs) present in the Test Pit 3 Area, as shown in Figure 2. The objectives of this project were to: 1) develop a preliminary design of a soil vapor extraction system (SVES) and conduct a pilot test in the vicinity of Test Pit 3 (site), 2) perform bench scale treatability tests on site soils to determine achievable cleanup levels for contaminants detected by MPI, 3) based on bench and pilot scale test results, establish design criteria for well spacing, radius of influence, air flow rates, and VOC removal rates for a full scale SVES, and 4) evaluate the overall feasibility (based on conceptual design criteria and technical constraints) of applying vapor extraction technology for the removal of VOC's from subsurface soils at the Columbia Mills site.

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The vadose zone in the vicinity of Test Pit 3 is typically four to five feet thick. MPI headspace screening of soil samples in this area indicated that VOCs were detected on soil samples from approximately 3 feet to 12 feet below grade. These conditions require that ground water be artificially depressed in order to expose enough saturated zone soils to accurately assess the feasibility of SVE technology. Based on MPI drilling logs and soil sampling results, *VAPEX* determined that depressing the ground water table to a depth of approximately 13 feet below grade over a 25 foot by 25 foot area would be sufficient to assess the feasibility of applying SVE to the site soils. MPI subsequently determined the hydraulic performance of the site's underlying aquifer by the performance of a step drawdown pump test. The pump test results indicated that dewatering the site to *VAPEX's* specifications was feasible with the operation of one pumping well.

The project was carried out jointly by MPI and *VAPEX*. MPI was responsible for determining dewatering effectiveness in the Test Pit 3 vicinity and for operating the dewatering system during SVES pilot testing. MPI, in its role as prime contractor for the Columbia Mills Site, was also responsible for the contracting and coordination of all drilling activities associated with the installation of soil vapor extraction wells and vapor probes.

One vapor extraction well and seven soil vapor probes were installed on August 28 and 29, 1990, under the supervision of a *VAPEX* geologist. On September 12 and September 13, 1990, *VAPEX* performed soil vapor extraction field pilot and air permeability tests to generate *in-situ* performance data for use in the feasibility determination and conceptual full scale SVES design. The *in-situ* physical data collected during pilot testing was used to develop values of the relative intrinsic air permeability tensor for the soil strata through which air flow occurs. Following the evaluation of the soil air permeability tensor, applicable air flow models were selected based on site specific conditions. The *in-situ* chemical data (i.e., specific soil gas contaminant concentrations) collected during the conduct of the field pilot test was utilized in conjunction with bench scale test results to determine achievable contaminant removal rates. The pilot test data, airflow modeling, and chemical removal rates were utilized to assess the overall feasibility of applying soil vapor extraction technology at the site and in the conceptual design of an optimal full scale SVES.

The first sections of the report summarize the design, performance, and findings of the field pilot and air permeability tests. The following sections present the results of air flow modelling and chemical data interpretation performed by *VAPEX* as part of the overall feasibility determination. The final sections of the report present conclusions regarding the overall feasibility, conceptual design, and practicality of the application of soil vapor extraction in conjunction with ground water depression to remediate subsurface VOC contamination at the Columbia Mills site.

2.0 PRELIMINARY DESIGN AND PILOT TEST PREPARATION

2.1 Preliminary SVES Design

VAPEX reviewed data provided by MPI including: site plans, boring logs, and soil chemical data in order to develop a preliminary SVES design and a site specific field pilot test approach. The preliminary SVES design called for the installation of one vapor extraction well (VW-1) adjacent to Test Pit 3, a distance of approximately 10 feet from drawdown well RW-1. The location of the vapor extraction well was chosen to limit the potential for short circuiting from RW-1, to satisfy the two-dimensional air flow model assumption of a flat water table surface, and to provide operating conditions representative of full scale SVE conditions.

In addition to the extraction well, the preliminary SVES design called for the installation of vadose zone soil vapor probes. *VAPEX's* vapor probes are used to collect soil gas samples and to obtain vacuum pressure measurements under ambient test conditions. Soil gas samples are analyzed to help establish the nature and extent of vadose zone VOC contamination. Seven soil vapor probes were installed in five borings at the site. Borings were advanced adjacent to the vapor extraction well for the installation of nested vapor probes to obtain data for the evaluation of the vadose zone air flow characteristics in the vicinity of vacuum well VW-1.

2.2 Vapor Extraction Well and Soil Vapor Probe Installation

The soil borings for the installation of the extraction well and vapor probes were advanced under *VAPEX* supervision on August 28 and 29, 1990. Figure 3 presents the locations of the installed vapor extraction wells and probes.

2.2.1 Soil Boring and Sampling Procedures

The vacuum extraction wells and soil vapor probes were installed in borings which were advanced using hollow stem auger drilling techniques. As the borings were advanced, standard split spoon sampling procedures were used to collect subsurface soil samples. The samples were used for visual soil classification and to screen for hydrocarbon content using the jar headspace method.

2.2.2 Geologic Description and Jar Headspace Results

The site is covered by a four inch concrete slab, which is the ruin of a former factory building. This slab is underlain by approximately two to three feet of fill material consisting of sand and fine to medium gravel. Soils below the fill are primarily a soft, very fine to medium sand with traces of fine gravel and silt. Soil color varies from dark brown to olive brown to black with some evidence of mottling and the presence of natural organic matter. The soil was wet at a depth of approximately four feet. A concrete lined trench runs through the site at an estimated depth of three to four feet. The trench is indicated in Figure 3.

Split spoon soil samples from selected borings were screened for total hydrocarbons via the jar headspace method using a Thermo Environmental Model 580B (TE-580B) portable photoionization detector equipped with an 11.8 eV lamp. The detection limit for the TE-580B is 0.1 ppm v/v total ionizable hydrocarbons. The TE-580B response is very sensitive to environmental conditions and is generally utilized to detect the presence and relative concentrations of hydrocarbon contaminants. Soil jar headspace concentrations, which are summarized in Table 1, indicated areas of moderate (90 - 267 ppm v/v) to high (623 - 800 ppm-v/v) hydrocarbon concentrations in soils between 5 feet and 13 feet below grade. Soil samples showing high jar headspace concentrations also appeared to have a slight sheen and exhibited characteristic petroleum hydrocarbon odors.

2.2.3 Vapor Extraction Well Installation

The vapor extraction well was constructed of two inch Schedule 40 PVC well screen (20 slot) and riser. Prior to installing the well, a 2.5 foot bentonite pellet seal was placed in the bottom of the borehole. Five feet of well screen was placed from 5 feet to 10 feet below grade. The annular space between the boring wall and the well was backfilled with a sand pack from the top of the screen to six inches below. A bentonite pellet seal was placed above the sand pack backfill to a depth of one foot below grade. The well was finished to grade with a nine inch diameter flush mounted well cover which was installed such that the borehole was completely sealed at the surface. A typical vacuum extraction well installation detail is presented in Figure 4.

2.2.4 Soil Vapor Probe Installation

A total of seven vapor probes were installed in five borings at the site. A set of two probes were installed in borings VP-1 and VP-2. Borings VP-3, VP-4, and VP-5 each contained one probe. In general, borings were advanced to approximately 6" to 12" below the desired probe depth. Following the addition of a 6" to 12" sand pack, the assembled probe was placed in the borehole and the annular space between the borehole sidewalls and the vapor probe was backfilled with additional sand to one foot above the probe. A one to two foot bentonite pellet seal was placed above the sand pack to minimize the potential for short circuiting of soil gas through the borehole annular space. For boreholes containing a set of nested vapor probes, the installation procedure was repeated for each additional vapor probe. Installation finishing procedures were performed as described for the vacuum well installation. A typical vapor probe is presented in Figure 5. A schematic cross section drawing of the complete vacuum well and vapor probe installation including jar headspace readings is presented in Figure 6. Copies of the boring and installation logs are presented in Appendix A.

3.0 PILOT TEST PERFORMANCE

3.1 Vapor Probe Soil Gas Sampling and Analyses

Prior to the initiation of the pilot test operation, *VAPEX* sampled soil gas from all vapor probes using the 580B. The data obtained from this sampling event, which was used primarily to provide a screening base prior to gas chromatographic analyses of the pilot system discharge, are presented in Table 2. All 580B results are presented in terms of parts per million of total hydrocarbons on a volume per volume basis as benzene (ppm-v/v). 580B screening, which was conducted on September 12, 1990, resulted in the detection of hydrocarbons at all vapor probe locations, with concentrations ranging from 2,060 ppm-v/v at probe VP-5 to 5,756 at probe VP-1S. The 580B data, as stated previously, is not utilized quantitatively, but is used to detect the presence of VOCs in the soil gas and to provide a methodology for selection of locations for soil gas qualification and quantification by gas chromatographic analysis.

3.2 Field Air Permeability Test System and Procedures

VAPEX utilized a rotary vane vacuum pump with a 20 cfm maximum air flow capacity to conduct the field air permeability tests. The pump was located adjacent to the vacuum well and was plumbed to the well using 1-1/2 inch diameter Schedule 40 PVC pipe. The pilot system discharged through two, 200 pound vapor phase carbon cannisters connected in series. A schematic diagram of the pilot system is shown in Figure 7.

Sampling ports were provided at several locations to allow *VAPEX* to periodically monitor system performance by collecting data consisting of: vacuum levels and air flow rates at the well head, vacuum levels at the vapor probes, VOC concentrations in the pump discharge, and VOC concentration in the discharge from the carbon cannisters.

Detailed descriptions of the sampling methods, analytical equipment and protocols are provided in Appendix B.

3.3 Operating Conditions

VAPEX performed the field tests over a 2 day period. The vacuum well was tested at a flow rate of 5 cfm for a 24 hour period on September 12 and September 13 (Test 1), and at a flow rate of 7 cfm for approximately 4.5 hours on September 13, (Test 2).

The 10 foot distance between the vacuum well and the ground water pumping well caused local mounding of the water table beneath the vacuum well when a vacuum was applied. As a result of the vacuum induced mounding of the ground water table during pilot testing, ground water entered the lower screened interval of the vacuum well. Initial pilot test air flow rates were limited due to this mounding and due to the high degree of capillary saturation in the pores within the vicinity of the well screen. As the pilot test progressed, capillary water held in pore spaces adjacent to the vacuum well screen was removed by the vacuum well, thereby increasing the effective air porosity, which permitted higher air flow rates and lower operating vacuums.

Under the equilibrium vacuum dewatering condition, *VAPEX* found that a constant flow rate of 5 cfm was achievable without water accumulation in the vacuum well. At the increased test air flow rate of 7 cfm, periodic bailing of the vacuum extraction well was required during the test to prevent a buildup of water which subsequently resulted in a reduction in the effective screen length and restriction in the air flow into the well. At air flow rates of 7 cfm, ground water mounding reached an equilibrium in the bottom two feet of vacuum well screen. Vacuum pressures at the well and vapor probes were apparently unaffected by the bailing. A chronological description of pilot test activities is provided in Appendix D.

4.0 PILOT TEST RESULTS

4.1 Vacuum Measurement Results

Results of vacuum measurements are presented in Table 3 and are summarized below. During the initial test of VW1 at an air flow rate of 5 cfm, vacuum at the well head was measured at 3.9 inches of mercury and vacuum was detected at all vapor probes except VP-1S, the lack of measurable vacuum at this probe in relation to its distance from the vacuum well indicated it was probably damaged during or after installation. Vapor probe vacuum readings ranged from 11.5 inches of water at VP1-D (at a distance of 3.5 feet from VW1) to 0.16 inches of water at VP-5 (at a distance of 33 feet from VW1).

While operating at a vacuum well air flow rate of 7 cfm, the vacuum pressure at the well head was measured at 5.7 inches of mercury and vacuum was detected at all vapor probes with the exception of VP-1S. Vapor probe vacuum readings ranged from 16 inches of water at VP-1D, to 0.19 inches of water at VP-5. The relatively low well head vacuum at the 5 and 7 cfm air flow rates indicate that higher flow rates may be attained providing soil moisture in the unsaturated zone can be effectively removed from site soils and that ground water elevations can be lowered and maintained.

4.2 Discharge Sampling Results

4.2.1 Analytical Methods

During the conduct of each pilot test, *VAPEX* collected and analyzed soil gas samples from the vacuum well discharge prior to and subsequent to carbon treatment. An HNU Model 321 gas chromatograph, equipped with a photoionization detector (GC/PID) was utilized in the soil gas analyses. Details of the sampling and analytical procedures are presented in Appendix B. Six VOCs were selected as target compounds based on their prominence in soils and ground water previously analyzed at this site. The target compounds were: ethylbenzene, methylene chloride, m-xylene, methyl ethyl ketone, toluene, and benzene. The discharge sample analysis results from each pilot test are presented in Table 4; VOC concentrations are presented in terms of parts-per-million on a volume-per-volume basis (ppm-v/v).

In addition to VOC concentrations reported for target VOCs, "Estimated Other VOCs" were evaluated using an assumption of a direct correlation of the average ppm to chromatogram peak area counts for target compounds and the total area for non-target compounds. Total VOC concentrations were estimated based on an assumption of all known and estimated concentrations. The chromatograms developed in the GC/PID analyses are presented in Appendix C.

4.2.2 Test No. 1

The GC/PID analyses of discharge samples collected during Test 1 (5 cfm) indicate a high, but fluctuating discharge rate. Initial estimated total VOC concentrations were 38,835 ppm-v/v which decreased to 19,858 ppm-v/v after 2.83 hours, then increased to 26,433 ppm-v/v after 9.4 hours, followed by a steady decline to 24,530 after 22.95 hours, just before termination of Test 1. The predominant compounds detected in the discharge were benzene, toluene, and "Estimated Other VOCs", with minor concentrations of m-xylene and ethyl benzene. Benzene concentrations decreased steadily from 6,436 ppm-v/v at the start of the test to 3,885 ppm-v/v followed by an increased to 4,176 ppm-v/v before decreasing to 3,556 ppm-v/v at the end of the test. Toluene concentrations ranged from a high 2,992 ppm-v/v to 1,439 ppm-v/v followed by increases to 2,243 ppm-v/v and a final decrease to 1,841 ppm-v/v at the end of the test. "Estimated Other VOC" concentrations displayed variations similar to those observed for estimated total VOCs. Based on comparison with the bench scale GC/MS analytical results, no methyl ethyl ketone or methylene chloride was detected in soil gas discharge samples from Test 1. It is estimated that approximately 26.6 pounds of "Estimated Other VOCs" (quantified as benzene and adjusted for dilution) and 5.9 pounds of benzene contributed to a total of 36.1 pounds of estimated total VOCs removed from the vadose zone during the 23 hour VW1 test.

The VOC discharge concentrations measured in Test 1 are indicative of the presence of a free phase VOC source or residually saturated soils in the vadose zone within the vicinity of VW-1. The following decrease and subsequent increase of individual and total VOC concentrations indicates that VW-1 was influencing other vadose zone source areas containing free phase or residually saturated soil areas of contamination inside the nearfield of VW-1 and within the periphery of the area of vacuum influence.

Another factor which may have caused fluctuations in the soil gas discharge concentration is the pore water which is retained on freshly dewatered soils by capillary forces. During pilot testing of these soils, pore water is removed from the unsaturated zone which is within the influence of the vacuum well; thereby, increasing both the effective porosity and air flow permeability. These increases permit greater air flow from distant free phase or residually contaminated soils. The presence of a distant vadose zone source(s) and the dynamic condition of gradually increasing air flow permeability as was observed in these soils most likely caused the soil gas discharge concentration fluctuations observed during Test 1.

4.2.3 Test No. 2

The GC/PID analyses of discharge samples collected during Test 2 (7 cfm) indicate that initial estimated total VOC concentrations were 28,136 ppm-v/v which decreased to 17,550 ppm-v/v followed by an increase to 22,910 ppm-v/v. The predominant compounds detected in the discharge were toluene, benzene, and "estimated other VOCs" with minor concentrations of m-xylene and ethylbenzene. All VOC concentrations showed relatively inconsistent discharge rates, similar to those observed in Test 1. The highest concentration in the discharge was "Estimated Other VOCs" with an initial concentration of 19,660 ppm-v/v which decreased to 12,832 ppm-v/v followed by an increase to 16,613 ppm-v/v. Benzene concentrations were the highest target compound, with an initial concentration of 4,938 ppm-v/v, a minimum concentration of 2,376 ppm-v/v and a final concentration of 3,156 ppm-v/v. Toluene concentrations fluctuated from 2,148 ppm-v/v to 1,341 ppm-v/v followed by an increase to 1,907 ppm-v/v. It is estimated that approximately 5.4 pounds of "Estimated Other VOCs" (quantified as benzene and adjusted for dilution) and 1.1 pounds of benzene contributed to a total VOC removal from the vadose zone of 7.4 pounds during the second four hour test.

The VOC concentrations initially measured in Test 2 are indicative of the presence of residually saturated soils in the vadose zone within the immediate vicinity of VW1. The patterns of discharge concentration fluctuation observed during Test 2 are similar to those observed during Test 1 which are indicative of significant vadose zone source(s) and variations in pore water content which effect local soils air flow permeability.

4.2.4 Post Carbon Discharge Sampling Results

Throughout the course of each pilot test, *VAPEX* monitored the discharge from the carbon cannister(s) to evaluate the effectiveness of the carbon for providing control of VOCs discharge to the atmosphere. Periodic screening was performed over the total duration of pilot tests, using the 580B. The 580B results indicate that breakthrough of a low concentration of VOCs did occur at the first cannister, however, 580B analyses of discharge from the second cannister indicate that no breakthrough occurred from this cannister.

5.0 BENCH SCALE VENT TEST

A bench scale vent test was performed on a composite soil sample collected on September 12, 1990 from the boring advanced for the installation of VW1. The sample was collected from auger cuttings displaying high VOC concentrations at a depth of approximately 5 to 10 feet below ground surface. The purpose of the bench scale vent test was to qualify and quantify volatile and semi-volatile contaminants present in the soil sample, to evaluate the effects, if any, of the complex mixture of contaminants on the volatilization of the VOCs, and to demonstrate the level of remediation that may be achieved from the implementation of the proposed full scale SVES.

In general, the bench scale vent test procedures involved the simulation of soil vapor extraction on the soil sample from boring VW1 contained within a laboratory column under an enhanced air-flow condition. Volatile and semi-volatile contaminant concentrations in the soil sample were qualified and quantified by gas chromatography/mass spectrometry (GC/MS) prior to and following the performance of the test, utilizing EPA Methods 8240 and 8270, respectively. The vapor discharge from the column was sampled and analyzed by GC/FID at predetermined time intervals over the duration of the test. The vent test was run for a period of approximately eleven days. Based on compound listings from the EPA test methodology, no target compounds were identified or quantified during the analyses; quantification and qualification by a general GC/MS scan tentatively identified C_7 and C_9 hydrocarbons as the primary VOCs discharged. No chlorinated VOCs were identified in the discharge by the GC/MS analyses. The results of the bench scale are presented in Table 5 and a summary of operating conditions and vent test results is presented in the following tables.

Figure 10 presents a graphical depiction of the venting column discharge concentration (calculated as dimethyl cyclohexane) the representative C_7 to C_9 compound), over the duration of the test. Integration of the area under the curve in Figure 10 gives a more representative estimation of the mass of the VOCs removed during the bench scale vent test and therefore the initial concentrations of VOCs in the soil mass. Details on the laboratory procedures, data sheets, and analytical results are provided in Appendix E.

5.1 Bench Scale Pilot Test Results

SOIL SAMPLE

MASS (g)	AREA (cm^2)	HEIGHT (cm)	PACKING DENSITY (g/cm^3)	TEMP (°C)
2618	45.3	33.0	1.7	20

TEST EVENTS

1. Initial sample analysis - EPA Method 8240 plus EPA Method 8270 for semivolatile organics (a)
2. Soil column preparation (a)
3. Laboratory vent test - per VAPEX specifications (b),(c)
4. Final sample analysis - EPA Method 8240 plus EPA Method 8270 for semivolatile organics (a)

TEST CONDITIONS

AIR FLOW RATE (cm^3/min)	AIR LOADING RATE (cm^3/cm^2-min)	PRESSURE 1 (mm Hg)	PRESSURE 2 (mm Hg)	PRESSURE DIFFERENCE (cm H$_2$0)
100	2.19	752.75	750.0	4.00

temperature of inlet air = 20°C
test duration hours = 266.60 hours
number of sample points = 16

TEST RESULTS

EPA Method 8240, 8270
Soil Total VOC Contaminant Concentration (mg/kg)
Initial = 68.5 Final = 1

Semi and non-volatiles: See Section 4.2.2

Initial total soil contaminant concentration from integration of "Mass Loss Rate" curve (Figure 6) = 35.57 mg/kg

Identified volatile contaminants removed - relative percentage
(C7 to C9) Hydrocarbons: 97.85%

* the contaminants tentatively identified were predominantly C7 to C9 hydrocarbons

(a) Appendix E contains brief descriptions of the column preparation, column testing, and analytical procedures used in performance of the pilot tests.

(b) Appendix E presents the GC/FID data processed over the duration of the pilot tests.

(c) Appendix E presents the total ion chromatograms and ion fragmentation patterns obtained from the GC/MS analyses.

5.2 Discussion of Bench Scale Pilot Test Results

5.2.1 Volatile Contaminants Identification by GC/MS

Two gas Chromatograph/Mass Spectrometry tests were performed on the soil sample using EPA Method 8240. A soil sample was tested prior and subsequent to soil venting. The target compounds incorporated in the EPA Method 8240 search are predominantly VOCs which are low molecular weight chlorinated compounds and simple aromatics; a listing of the target compounds is provided within the laboratory report in Appendix E. The results of the GC/MS scan demonstrated that all target compounds identified by EPA Method 8240 were below the method detection limit. Compounds quantified and qualified were C7 through C9 hydrocarbons representative of weathered gasoline or fuel oil product. Dimethyl cyclohexane was used to quantify the C7 to C9 hydrocarbons as this compound is considered to be representative of the C7 to C9 compound range.

5.2.2 Semivolatile Contaminant Identification by GC/MS

Two soil samples were collected for analyses of semi-volatile compounds by EPA Method 8270. A soil sample was analyzed prior to and after the soil venting activities. No target semi-volatile compounds were qualified or quantified in the GC/MS analyses. A listing of the target compounds within Method 8270 are presented within the laboratory report provided in Appendix E. Further, a GC/MS 40,000 compound library search was not able to generate a sufficient match for compound identification purposes. Appendix E presents the total ion chromatogram generated during the analyses.

From the GC/MS analysis performed on a 5 gram composite soil sample prior to soil venting, the total VOC content was quantified as 68.5 mg/kg as dimethyl cyclohexane.

An advantage of the laboratory vent test is that the plot of contaminant mass loss rate versus time may be integrated to estimate and/or verify the total initial mass of unknown VOCs in the larger soil sample contained in the test column.

The VOC removal achieved during the vent test was calculated from the integration of Figure 10. From the results of the curve integration, the initial concentration of VOCs in the soil was calculated as 35.57 mg/kg. The difference observed in the VOC concentrations using the EPA 8240/8270 and curve integration methods of evaluation indicates the degree of heterogeneity in the distribution of VOCs in the soil sample. Due to the larger soil mass involved, *VAPEX* prefers to utilize the contaminant concentration value obtained from the integration of the mass loss rate versus time curves in evaluating site remediation requirements.

Following eleven days of venting of the soil sample and having observed a significant reduction in the contaminant removal rates, the vent test was terminated. A longitudinal core of soil was removed from the test column. Two 5 gram composite samples of the soil core (one from the top and one from the bottom of the core) were analyzed by EPA Method 8240/8270. The resulting VOC concentration from the GC/MS analyses was approximately 1 mg/kg.

Based on the initial soil contaminant concentrations calculated utilizing EPA 8240 and 8270, a greater than 98 percent reduction of VOCs in the soil sample from VW1 was achieved. Utilizing the initial soil contaminant concentration levels as calculated from the integration of Figure 10, a greater than 97 percent removal of VOCs were achieved.

VAPEX considers that the degree of contaminant removal achieved in the vent test confirms the feasibility of utilizing vapor extraction to remove VOCs from the unsaturated zone soils at the contaminated site. The results of these tests indicate that it is technically feasible to reduce the concentration of VOCs in the soil sample to less than 1 parts per million (by weight).

SVES is not considered an optimal technology to apply for remediation of non-volatile components; subsurface air movement (oxygen induction) during soil vapor extraction activities would be expected to enhance non-volatile compound remediation from the source soils through naturally occurring biodegradation.

6.0 COMPUTER MODELLING OF SUBSURFACE AIR FLOW

VAPEX utilizes proprietary air flow and contaminant transport models to evaluate the air flow characteristics of the vadose zone soils and to simulate vapor extraction system performance. Modeling allows *VAPEX* to determine overall system feasibility, to establish optimal vapor extraction system configurations and operating parameters, and to estimate the time required to remediate the soils to specified target contaminant closure levels.

6.1 Modelling Approach

Physical characteristics of the site such as soil type(s), soil heterogeneity, and anisotropy, surface cover, underground trenches, etc. are required data input to the airflow models utilized in the analysis and evaluation of a specific site.

The physical characteristics of each vacuum well/vapor probe system, the vacuum pressure data, and the air flow rates recorded during the field pilot testing were used as additional input into *VAPEX's* proprietary two-dimensional (2-D), radially symmetric air flow model.

The 2-D model is utilized to determine the permeability tensor of the soil strata through which the air flow occurs. The intrinsic air permeability tensor is the matrix of soil air permeability values along specified areas, e.g., in the x, y, and z direction in a Cartesian coordinate system. Values for the relative horizontal intrinsic permeability and the relative vertical intrinsic permeability are determined for each strata of concern, and the equivalent relative vertical intrinsic permeability is determined for surface and subsurface airflow boundaries that may exist.

The operation of the field pilot/air permeability test at more than one air flow rate allows for both the initial calibration (i.e., parameter evaluation using field data) and verification of the model (i.e., the model is set to simulate the system for the second air flow rate using the parameters established in the calibration mode; a comparison is made between the model predicted pressure distribution, and the actual pressure data measured at the well/probes at the second air flow rate).

Following calibration and verification, *VAPEX's* site specific air flow model is used in the simulation mode to obtain the pressure distributions associated with various system configurations. This allows determination of the expected air flow paths, air flow rates, and the achievable effective radius of influence of the simulated soil vapor extraction system.

6.2 Modelling Results

Based on vacuum measurements at the vapor probes and vacuum well, subsurface air flow pathways in the near influence of vacuum well VW-1 appeared to be predominantly in the radial direction.

The air flow rate, vacuum well/vapor probe vacuum data, and groundwater depths obtained during the 24 hour, 5 cfm pilot test at VW-1 was used as input to calibrate *VAPEX*'s two dimensional radially symmetric air flow model. The horizontal (K_r) and vertical (K_z) relative intrinsic permeabilities for the vacuum influenced soils in the vicinity of Test Pit 3 were calculated to be 8.85×10^{-9} cm^2

and 6.0×10^{-10} cm^2, respectively. Soils displaying intrinsic air permeability values in these ranges are considered to be of moderate to low permeability. Figure 8 presents a comparison of predicted vacuum distribution and the observed vacuum data (observed at vapor probes VP-1, VP-2, and VP-3) during the 24 hour, 5 cfm test (model calibration).

Verification of the air flow model was performed by simulating SVES performance during the four hour (7 cfm) test. A comparison of predicted and observed vacuum distribution, shown in Figure 9, indicates good correlation and supports the modeling approach.

The calibrated/verified airflow model was utilized to simulate full scale SVES performance. The maximum achievable air flow rate for vapor extraction well VW1 is predicted to be in the range of 10 to 15 cfm with a maximum predicted radius of vacuum influence of approximately 30 feet. The predicted radius of vacuum influence is highly dependent of the relative intrinsic permeability of the surface boundary condition (i.e.; the concrete slab foundation). The observed vacuum at vapor probe VP-5 was slightly higher than the model predicted vacuum which may be a result of a local variation in the slab permeability.

The location selected for installation of vapor probe VP-3 was chosen to evaluate whether the Test Pit and/or the foundation of Building 11 effected subsurface air flow paths. Vacuum data collected from vapor probe VP-3 is depicted in Figures 8 and 9 as the field data point 18 feet from the vacuum well. Because the observed vacuum levels correlate fairly well with the model predicted levels, influences on subsurface air flow paths resulting from the Test Pit and the Building 11 foundation appear to be negligible.

VP-4 was installed at a depth of 12 feet adjacent to the pumping well RW-1 in order to determine pressure distribution within the well's zone of depression. During pilot Test 1 and Test 2, the observed vacuum readings within the cone of depression were high relative to within those recorded in other vacuum probes located equidistant from the vacuum well. This indicates that as expected, air flow within the cone of depression was significantly less than which occurs through overlying soils. For modeling purposes, the unsaturated zone was assumed to be a constant thickness of 11 feet throughout the pilot test area, therefore, data obtained from this probe was not used in calibrating the 2-D analytical model.

7.0 VAPOR EXTRACTION DESIGN CRITERIA DISCUSSION

7.1 Extraction Well Air Flow Rate and Configuration

Pilot test and air flow modelling results indicate that the maximum achievable air flow rate from VW-1 is approximately 10 to 15 cfm, which is relatively low. Vacuum system air flow rates can be effectively increased by the use of longer well screen intervals. The verified 2-D model was used to predict well flow rates and vacuum levels for a 10 foot screen interval vacuum well (screened from 4' to 14' below grade) in the vicinity of Test Pit 3. Depth to ground water was assumed to be depressed to a level of 15 feet below grade to allow placement of the vacuum well. Under these conditions, maximum vacuum well flow rates increase to a range of 20 to 25 cfm.

The achievable radius of vacuum influence is generally a function of local soil properties and surface layer permeability and is largely unaffected by vacuum well flow rates. The maximum radius of vacuum influence that can be achieved in the vicinity of Test Pit 3 is approximately 30 feet. Thus, a soil vapor extraction system for the soils in the vicinity of Test Pit 3 would consist of vertical vapor extraction wells spaced at intervals approximately 60 feet on center. The total number of wells will depend on the extent of the proposed remediation area.

maybe 1/2 dis?

The successful operation of a full scale SVES at the site dictates the use of a ground water drawdown system that can achieve dewatering to specifications as outlined in full scale soil vapor extraction system design specifications. If insufficient ground water control is maintained during SVES operation, mounding of groundwater directly under vacuum wells may occur which will negatively impact system performance by restricting air flow paths to the vacuum well. In turn, this will increase vacuum well operating vacuums, reduce well flow rates and hydrocarbon removal rates, and extend the duration of SVES operation. In order to avoid inefficient SVES designs, *VAPEX* recommends that final full scale vacuum well configurations be designed based on field verified ground water drawdown levels which will occur under steady state pumping conditions.

has this been achieved during pump tests?

Regardless of water table elevations, pore water will also migrate into vacuum wells as unsaturated flow occurs from previously saturated soils. The degree of water accumulation will be greatest at the start of vacuum well operation and will decrease as surrounding soils are "dried" by the vacuum wells. A means of withdrawing water from vacuum wells as it accumulates will be necessary for optimum full scale system performance.

7.2 System Performance

MPI has provided *VAPEX* with the anticipated limits of the SVE treatment area and preliminary design specifications for a ground water pumping system which would provide hydraulic control of water levels in the vicinity of Test Pit 3 and areas to the east. The dewatering design specifies the installation of four pumping wells in addition to the existing pumping well. MPI has specified that a full scale SVES be designed to remediate soil extending from grade to a maximum depth of 13 feet below grade.

Based on these conditions, *VAPEX* has made several assumptions regarding the operating conditions of a full scale SVES which incorporated MPI's dewatering design. *VAPEX* anticipates that a total of 9 vacuum wells would be required to ensure adequate vacuum influence over the area delineated by MPI. Each well would produce an individual well air flow of approximately 20 cfm. If all full scale vacuum wells are operated simultaneously, individual vacuum well flow rates may be decreased. It is assumed that the ground water table will be lowered to a depth of 15 feet below grade during full scale SVES operation and that the highest soil gas concentrations will be encountered in the Test Pit 3 area with decreasing concentration gradients to the east, northeast, and southeast.

At an air flow rate of 20 cfm, it is anticipated that the maximum initial VOC removal rate in the vicinity of Test Pit 3 would vary from 116 to 227 pounds of VOCs per day, per well depending upon soil VOC concentrations in the vicinity of each specific extraction well. VOC removal rates would be expected to decrease rapidly following start up. Time to clean up would vary depending upon the initial soil VOC concentration, the specific types of VOCs occurring in soil gas, the soil clean up criteria, and possible discharge restrictions dictated by air controls. Thus, clean up times would likely vary at different locations.

For the purposes of this design discussion, *VAPEX* is assuming that clean up time represents the time required for the vapor extraction system to remove the majority of VOCs from vadose zone soils within its zone of influence. *VAPEX* considers that the removal of the "majority" of VOCs would be consistent with a clean up goal of 1 ppm total VOCs.

VAPEX utilized its proprietary chemical transport model (VaporChem™) to estimate the time required to remediate vadose zone soils in the areas delineated by MPI. Several assumptions were made concerning model input since the degree and extent of vadose zone contamination is as yet undefined. Model input parameters consisted of an individual well air flow rate of 20 cfm, increasing dilution factors, and an original spill volume of 100 gallons within the 30 foot radius of vacuum well influence.

The model results indicate that under the above conditions, it would require approximately four years to remediate contaminated vadose zone soils in the area delineated by MPI to a level of 1 ppm total VOCs. The variables used in this simulation represent a worst case cleanup time estimate.

8.0 CONCLUSIONS

8.1 Site Conditions

Subsurface soils are relatively consistent in description throughout the Test Pit 3 area. The upper soils consist of a gravelly, sand fill which extends to a depth of up to three to four feet. The fill is underlain by a loose fine sand with 0% to 10% silt and coarser sands.

Based on the results of soil borings, soil vapor probe sampling, and pilot test discharge vapor analyses, it is evident that petroleum range VOCs are widely distributed in the vadose and saturated zone soils in the Test Pit 3 area.

Vadose zone total VOC concentrations observed in the Test Pit 3 area ranged from 2,060 ppm at vapor probe VP5 to 5,756 ppm at VP1-S. The highest vapor concentrations were observed in shallow soils (four feet below grade) in the vicinity of VW-1. The primary VOCs were benzene, toluene, and "Estimated Other" VOCs. The estimated total VOC concentrations observed in soil vapor discharge from VW1 indicate that soils within the nearfield of VW1 are residually saturated with petroleum hydrocarbons. The fluctuations in soil gas discharge observed during both Test 1 and 2 suggest that other areas within the periphery of the radius of vacuum influence may contain free phase or residually saturated soils.

Vadose zone soils were found to be of moderate to low permeability. The relative intrinsic horizontal air permeability, K_r, was calculated to be 8.85×10^{-9} cm^2 in the vicinity of Test Pit 3.

8.2 Soil Vapor Extraction Feasibility

Field pilot test and modelling results indicate that soil vapor extraction is a feasible technology for application in the remediation of vadose zone soils at the site. The largest measured zone of influence during pilot testing was 34 feet. Modelling results indicate that the maximum achievable zone of influence is approximately 30 feet. The maximum achievable air flow rate from vacuum extraction well VW-1 is estimated to be 10 to 15 cfm. However, air flow modeling also indicated that drawing ground water levels down to a depth of 15 feet or more below grade and installing extraction wells with 10 foot screen intervals will allow flow rates of 20 to 25 cfm from each well.

Estimated total VOC discharge concentrations at VW1 indicate that soil vapor extraction provides an effective means of removing vadose zone VOCs at Test Pit 3. Approximately 43.5 pounds of total VOCs were removed over the duration of Test No. 1 and No. 2 at VW1.

VOC removal rates of individual vacuum extraction wells vary significantly depending on their proximity to and the degree of a vadose zone VOC source. Under full scale operating conditions, vacuum extraction wells that are located within relatively close proximity to a significant vadose zone VOC source, such as VW1, would be expected to produce initial VOC removal rates of up to 227 pounds per day at an air flow rate of 20 cfm.

9.0 REPORT PREPARATION AND REVIEW

The report presented above was prepared and reviewed by *VAPEX*. The report was prepared by David J. Hazebrouck (Project Manager), Matthew Walsh (Geologist), and Michael C. Marley (Director, Technical Development).

VAPEX ENVIRONMENTAL TECHNOLOGIES, INC.

David J. Hazebrouck

David J. Hazebrouck
Project Manager

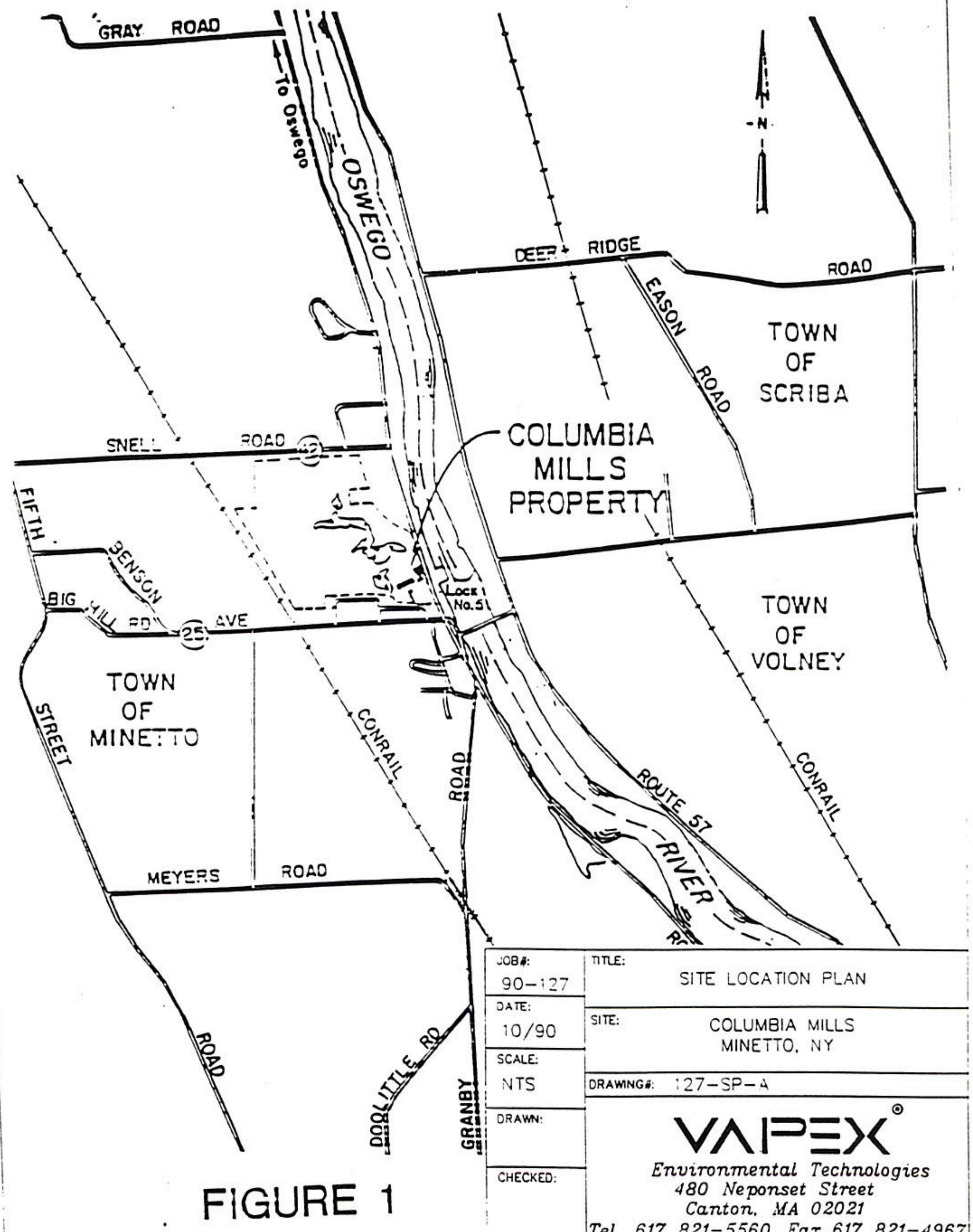
Matthew T Walsh

Matthew T. Walsh
Geologist

Michael C. Marley
Director, Technical Development

FIGURES

SOURCE: SITE PLAN BASED ON MALCOLM PIRNIE PLAN



JOB#: 90-127	TITLE: SITE LOCATION PLAN
DATE: 10/90	SITE: COLUMBIA MILLS MINETTO, NY
SCALE: NTS	DRAWING#: 127-SP-A
DRAWN:	VAPEX® *Environmental Technologies* *480 Neponset Street* *Canton, MA 02021* *Tel. 617 821-5560 Fax 617 821-4967*
CHECKED:	

FIGURE 1

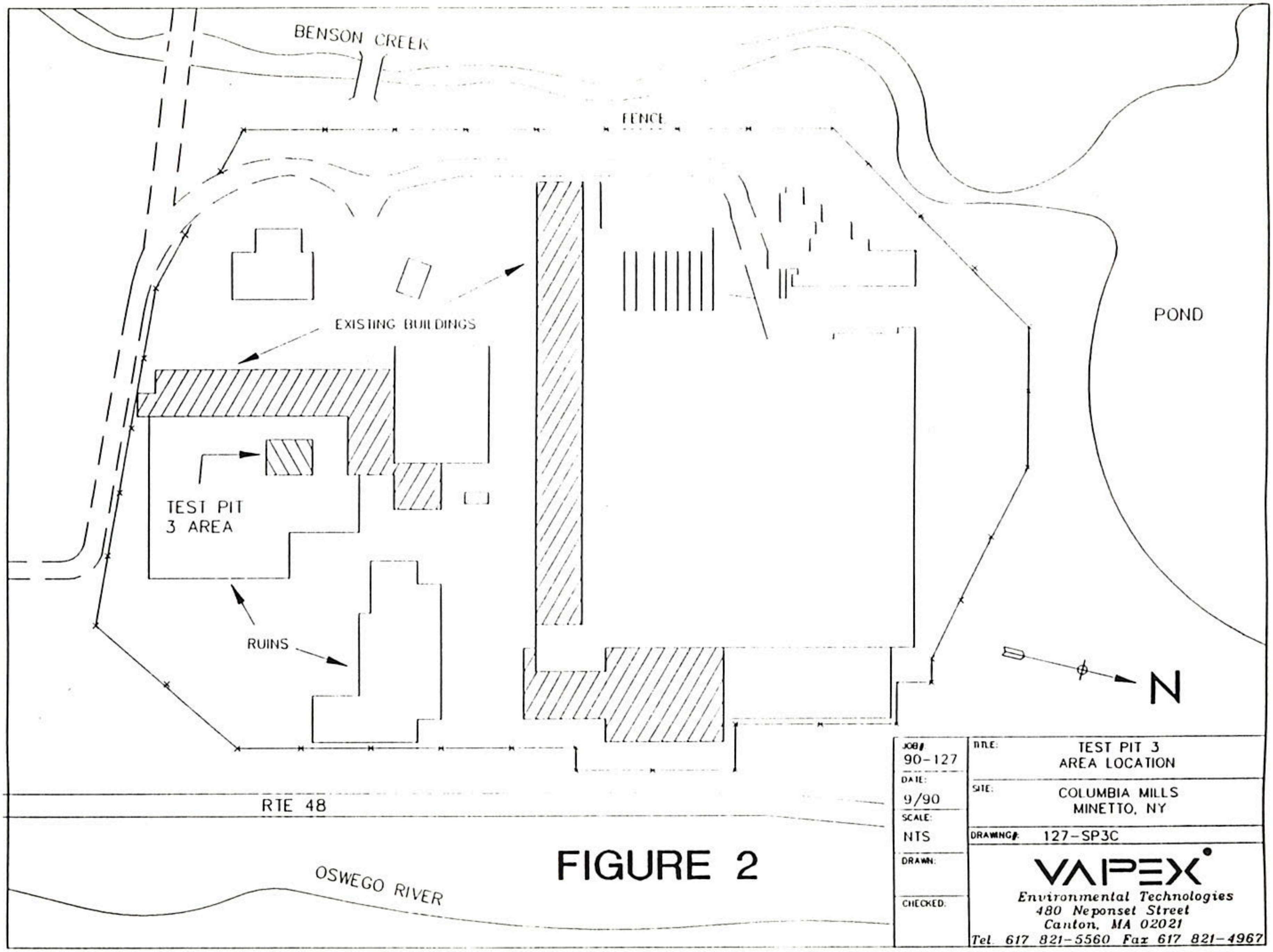


FIGURE 2

JOB# 90-127
DATE: 9/90
SCALE: NTS
DRAWN:
CHECKED:

TITLE: TEST PIT 3
AREA LOCATION

SITE: COLUMBIA MILLS
MINETTO, NY

DRAWING#: 127-SP3C

VAPEX
Environmental Technologies
480 Neponset Street
Canton, MA 02021
Tel. 617 821-5560 Fax 617 821-4967

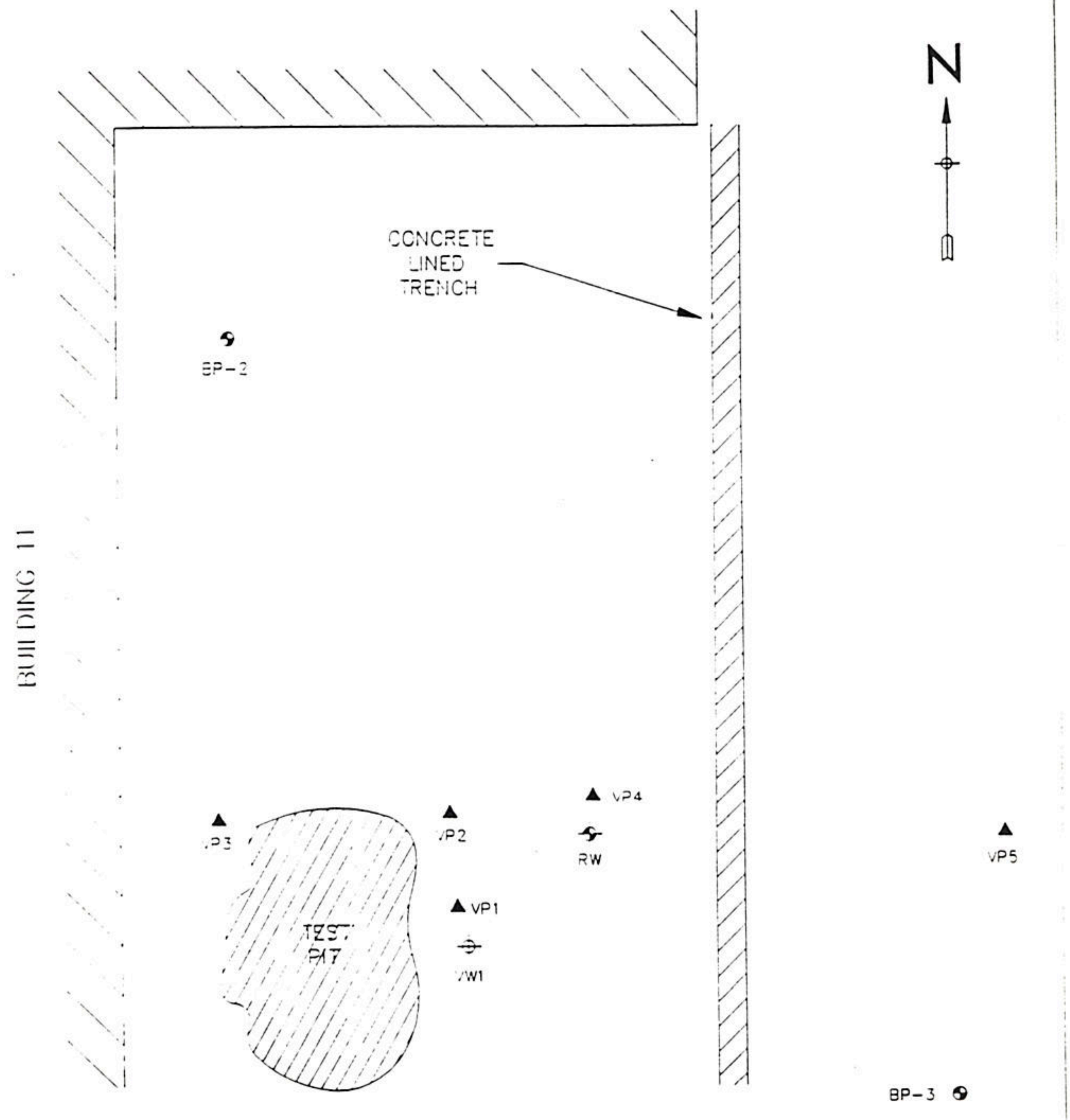


FIGURE 3

LEGEND

▲ – VAPOR PROBE

⌖ – VAPOR EXTRACTION WELL

◍ – RECOVERY WELL

JOB#: 90–127	TITLE: ENLARGED VIEW OF PROBE LOCATIONS
DATE: 10/90	SITE: COLUMBIA MILLS MINETTO, NY
SCALE: NTS	DRAWING#: 127–SP2B
DRAWN:	VAPEX®
CHECKED:	*Environmental Technologies* *480 Neponset Street* *Canton, MA 02021* *Tel. 617 821–5560 Fax 617 821–4967*

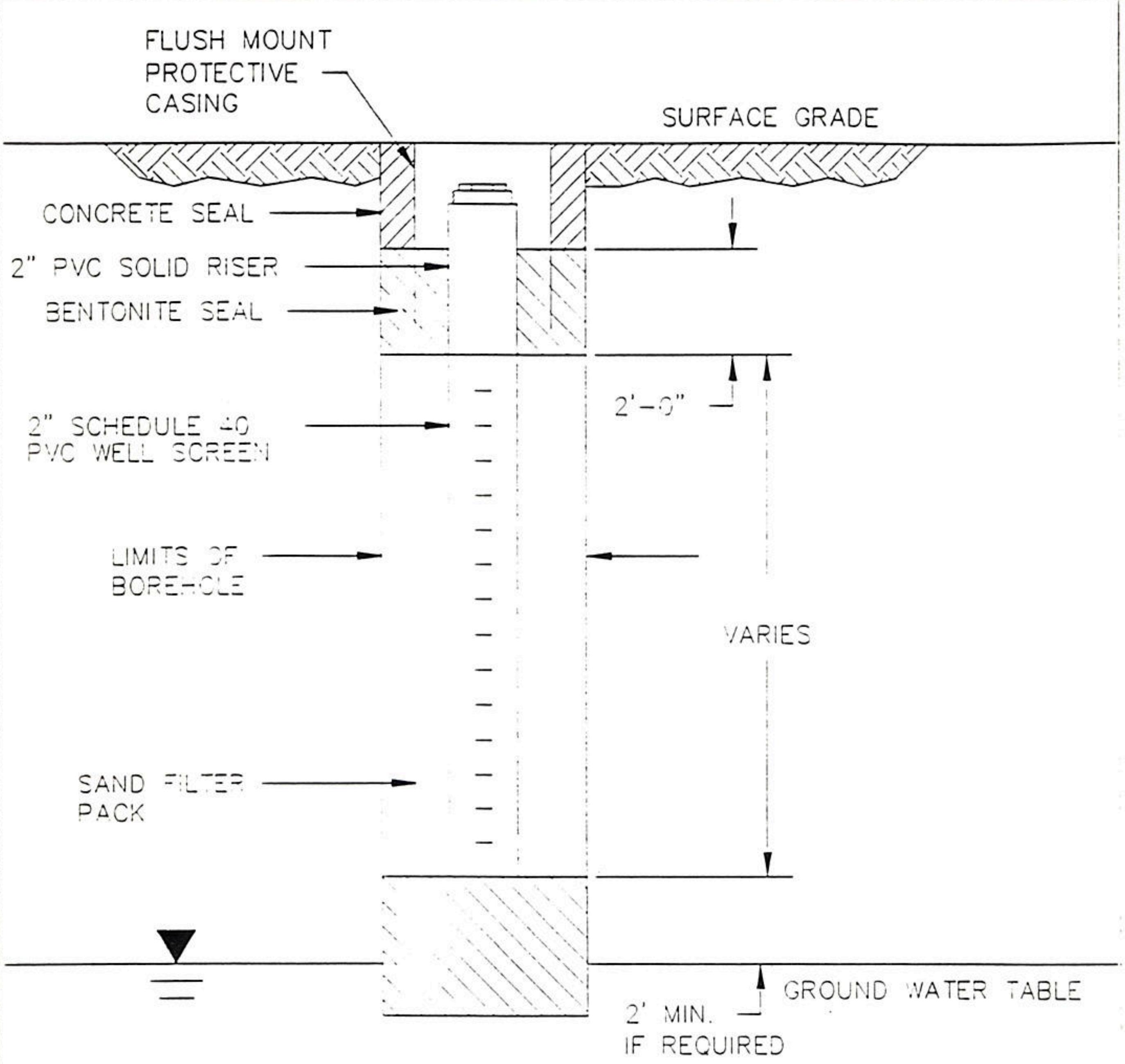


FIGURE 4

KEY

▨ - CONCRETE
▧ - BENTONITE
☐ - SAND

JOB#: 90127	TITLE: TYPICAL EXTRACTION WELL
DATE: 7/90	SITE: COLUMBIA MILLS MINETTO, NY
SCALE: NTS	DRAWING#: 127-VW-A
DRAWN:	VAPEX® *Environmental Technologies* *480 Neponset Street* *Canton, MA 02021* *Tel. 617 821-5560 Fax 617 821-4967*
CHECKED:	

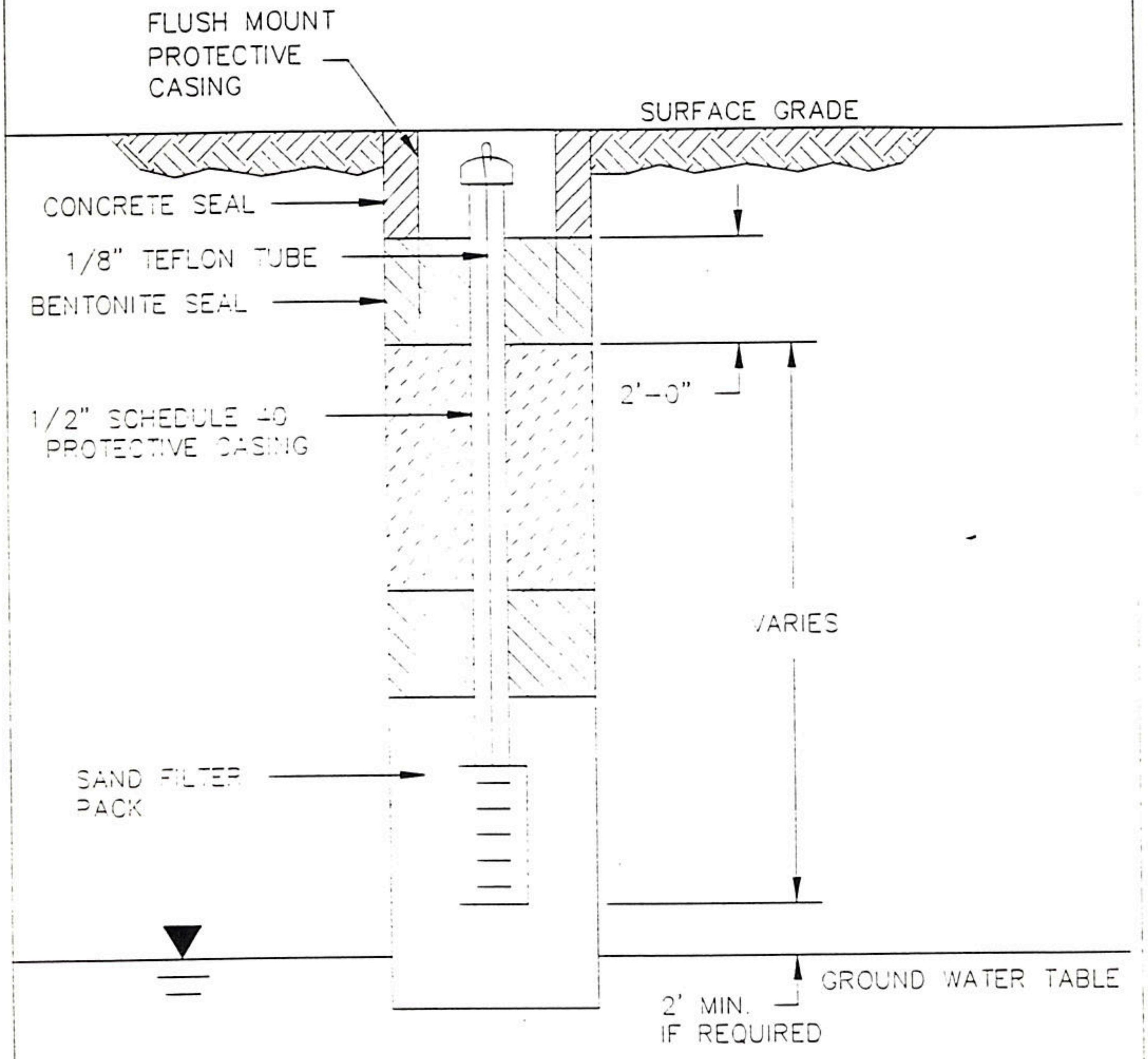


FIGURE 5

KEY

▨ – CONCRETE

▧ – BENTONITE

☐ – SAND

░ – NATIVE MATERIAL

JOB#: 90127	TITLE: TYPICAL VAPOR PROBE
DATE: 7/90	SITE: COLUMBIA MILLS MINETTO, NY
SCALE: NTS	DRAWING#: 127-VP-A
DRAWN:	VAPEX® Environmental Technologies 480 Neponset Street Canton, MA 02021 Tel. 617 821-5560 Fax 617 821-4967
CHECKED:	

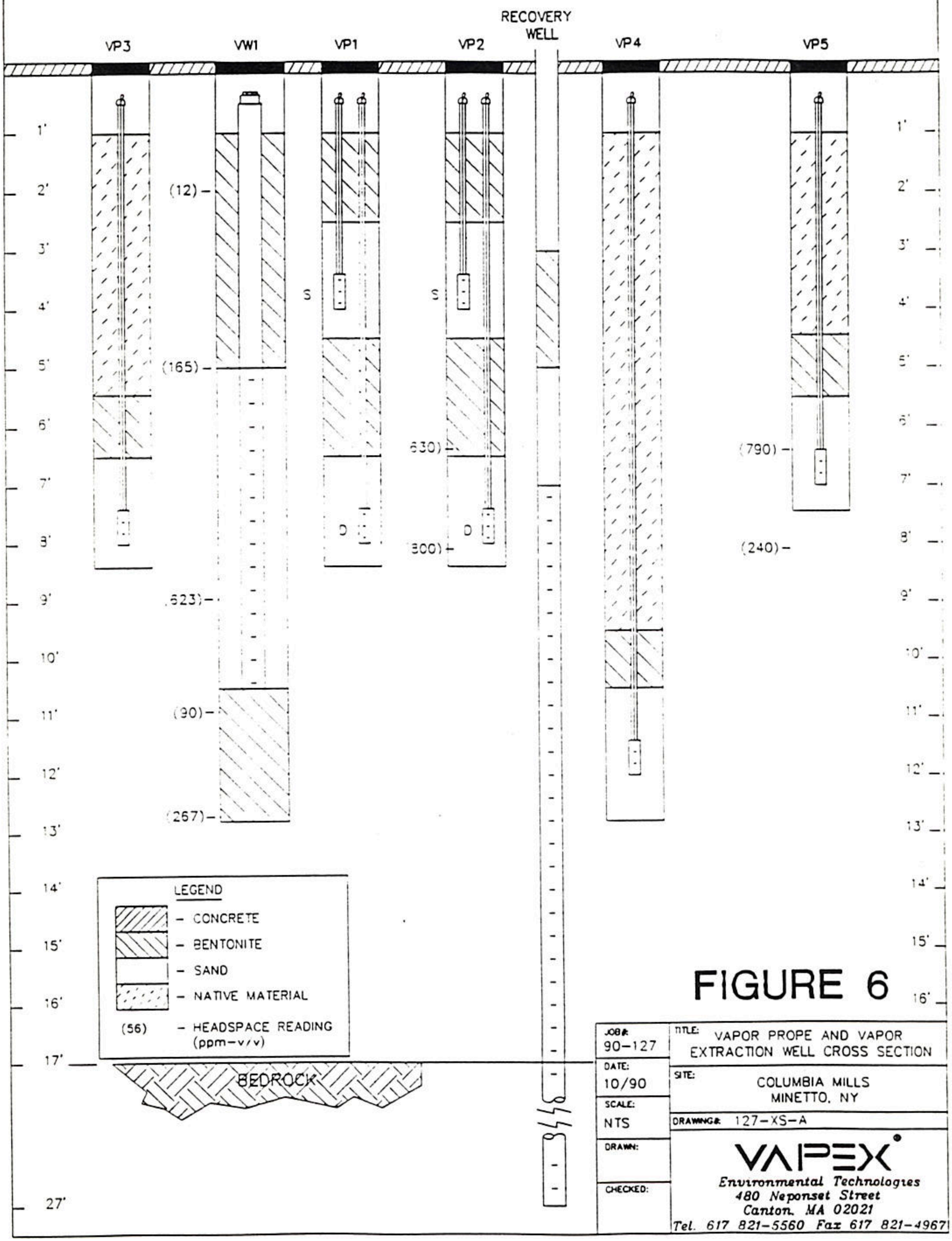


FIGURE 6

JOB #: 90-127
DATE: 10/90
SCALE: NTS
DRAWN:
CHECKED:

TITLE: VAPOR PROPE AND VAPOR EXTRACTION WELL CROSS SECTION

SITE: COLUMBIA MILLS
MINETTO, NY

DRAWING#: 127-XS-A

VAPEX®
Environmental Technologies
480 Neponset Street
Canton, MA 02021
Tel. 617 821-5560 Fax 617 821-4967

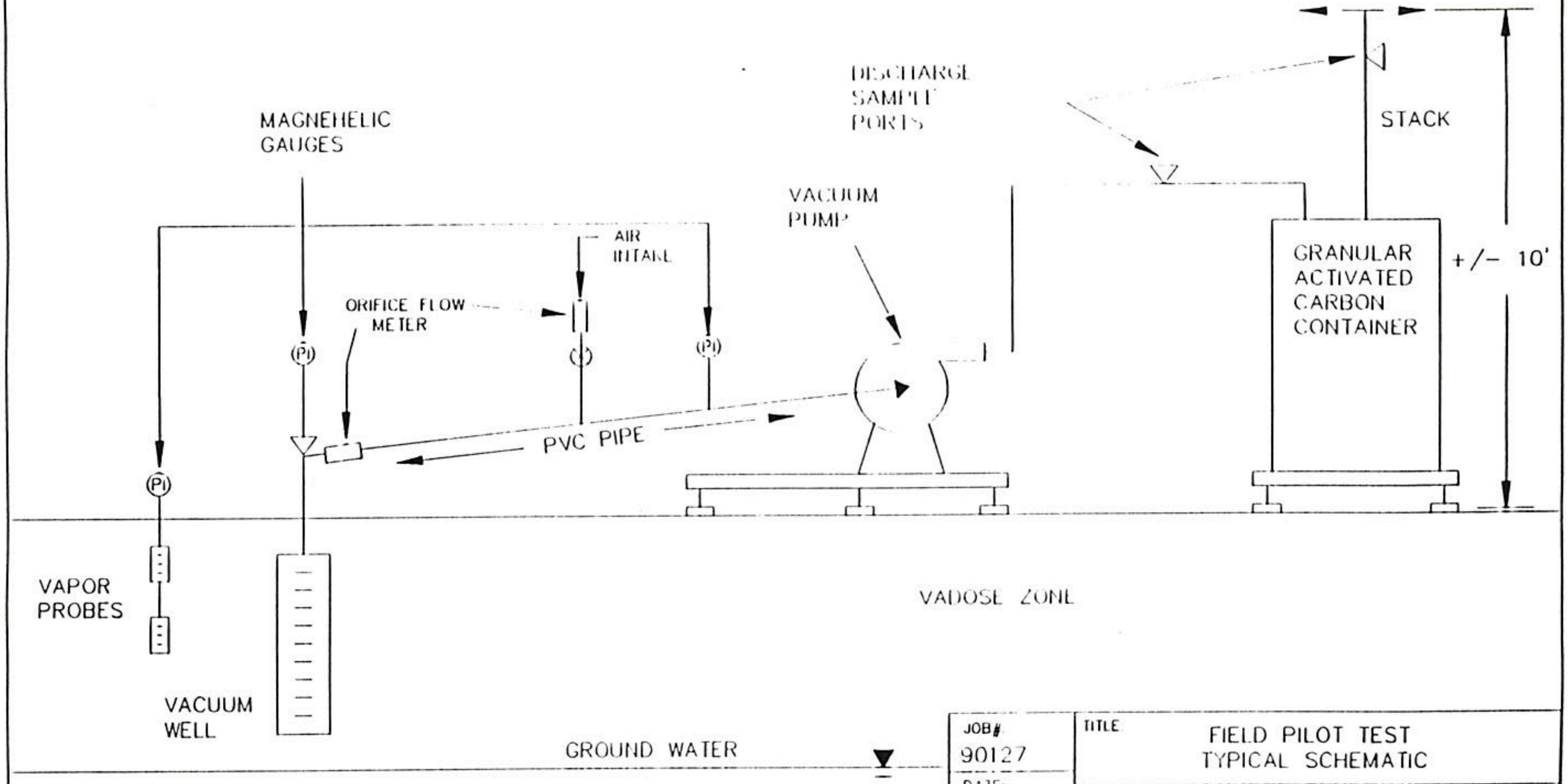


FIGURE 7

JOB#: 90127	TITLE: FIELD PILOT TEST TYPICAL SCHEMATIC
DATE: 7/90	SITE: COLUMBIA MILLS MINETTO, NY
SCALE: NTS	DRAWING#: 127-FP-A
DRAWN:	VAPEX®
CHECKED:	*Environmental Technologies* *180 Neponset Street* *Canton, MA 02021* *Tel 617 821-5560 Fax 617 821-4967*

Figure 8

2-D MODEL CALIBRATION, CO. MILLS

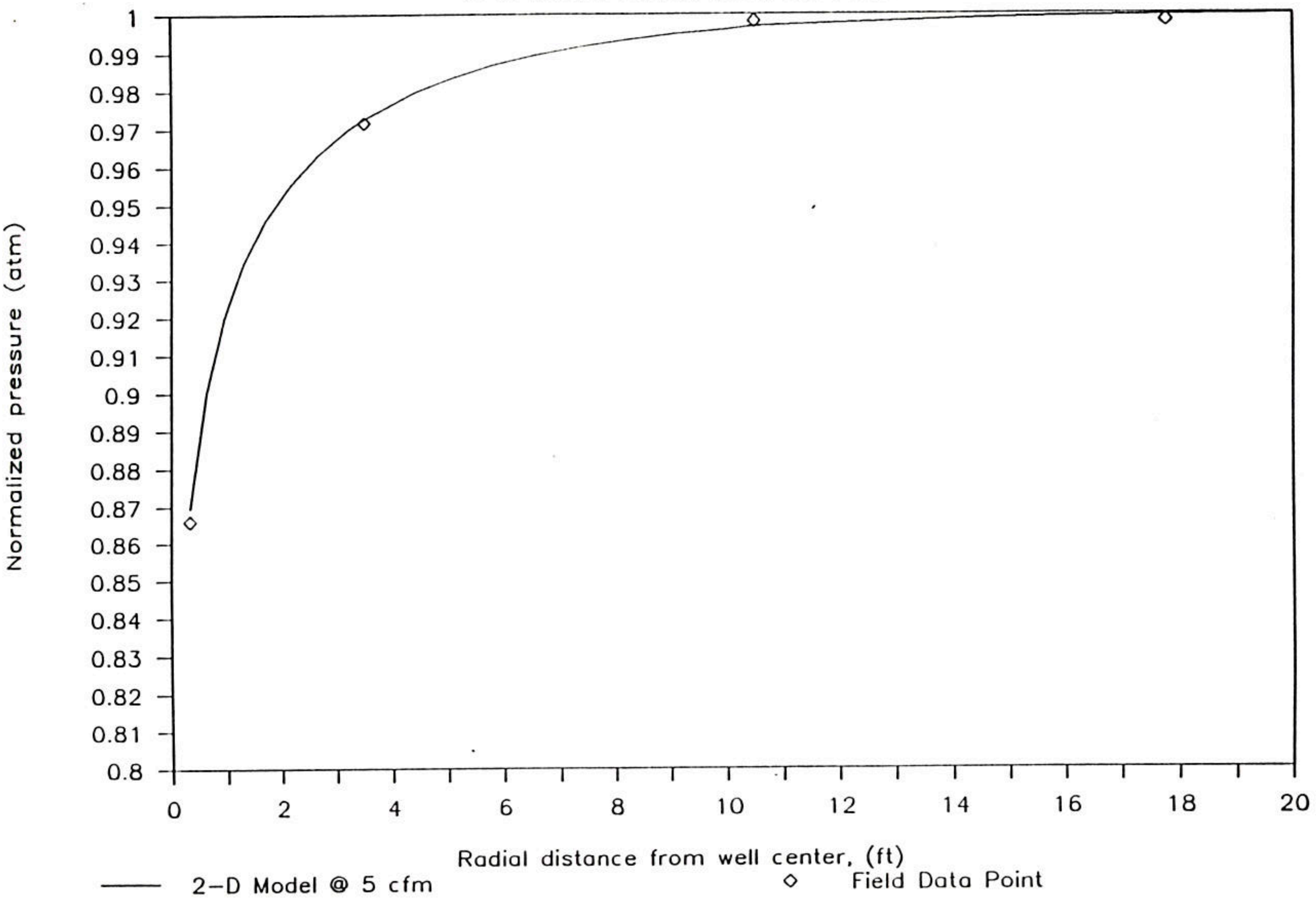


Figure 9

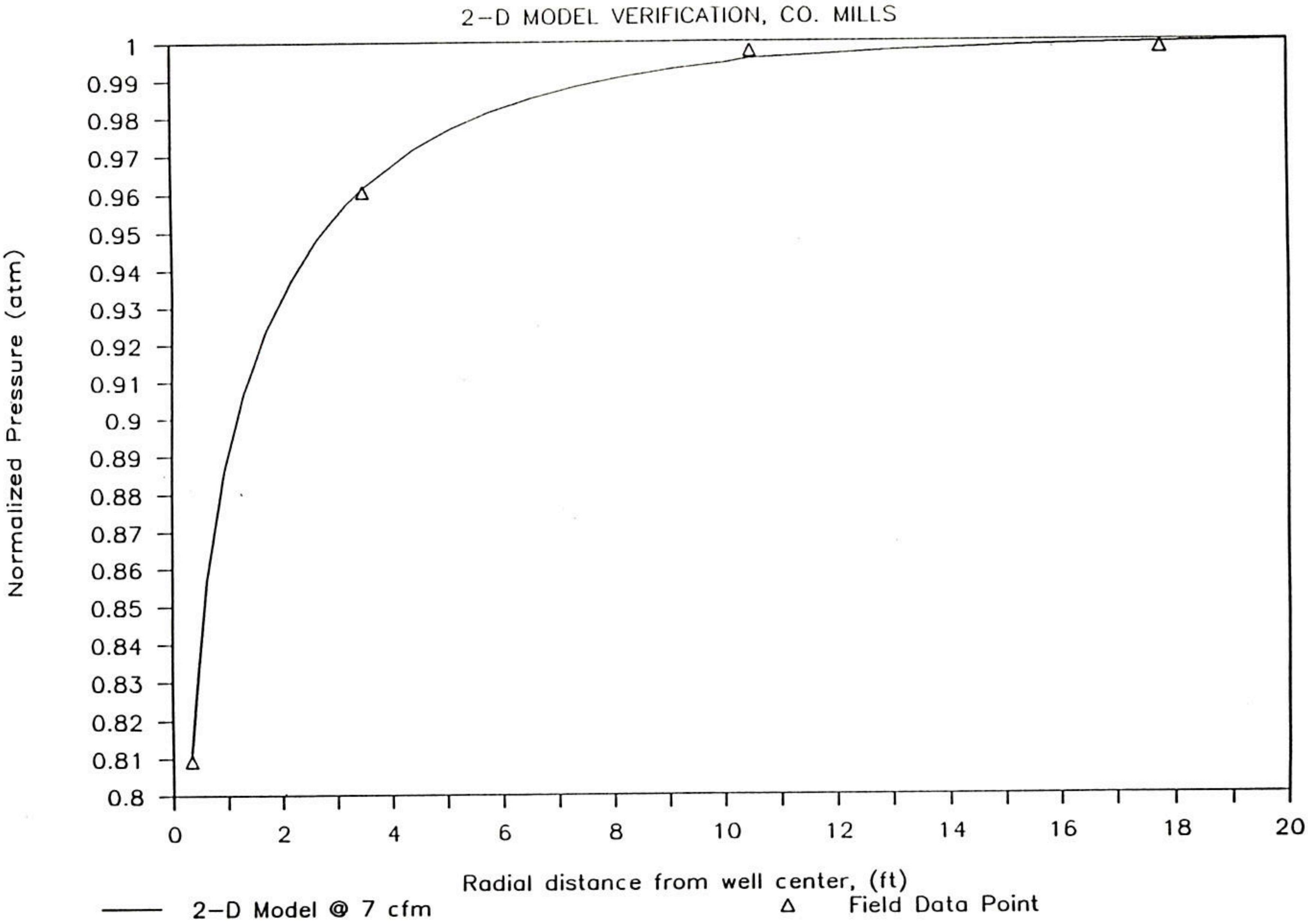
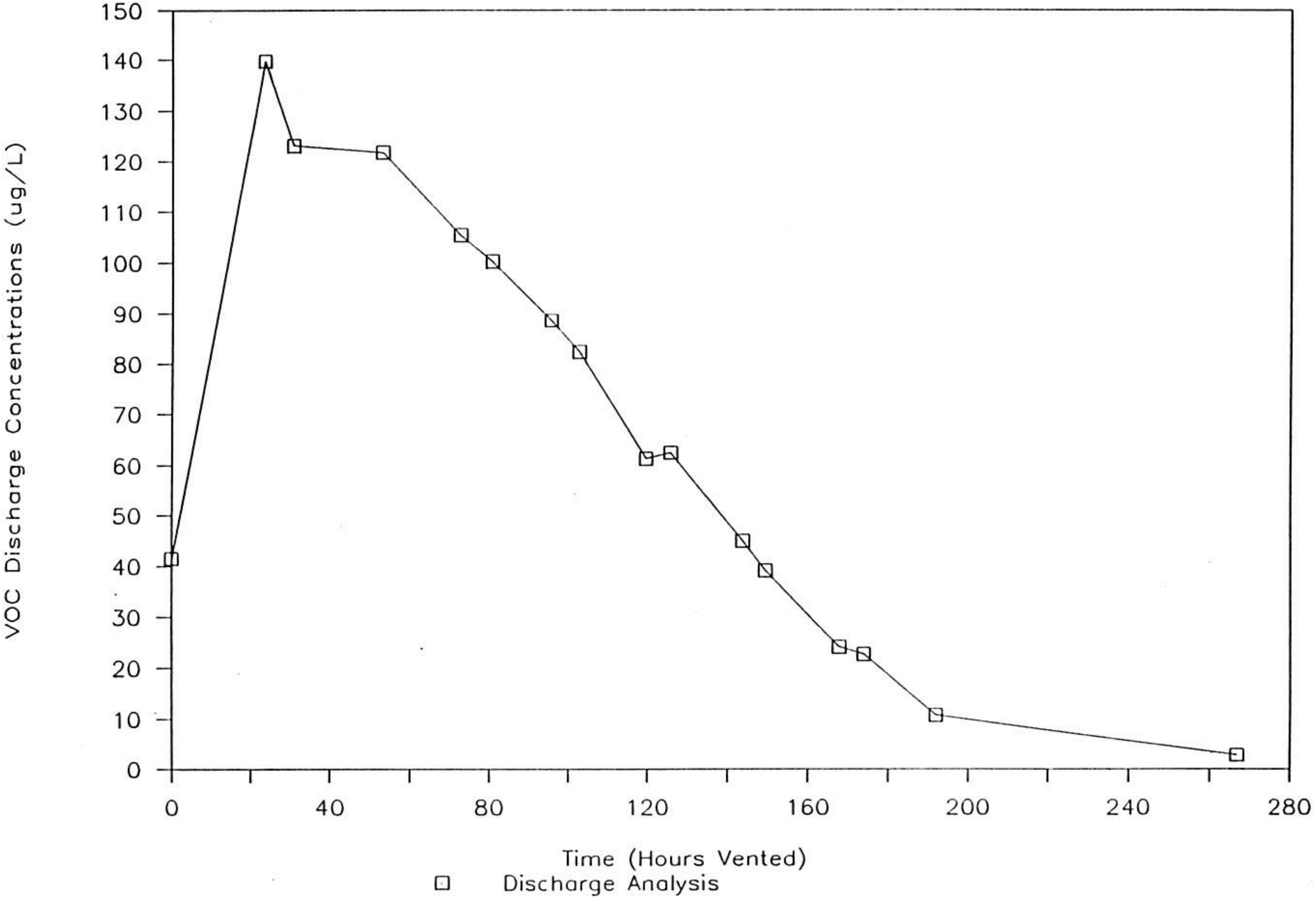

2-D MODEL VERIFICATION, CO. MILLS
Normalized Pressure (atm)
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0.9
0.89
0.88
0.87
0.86
0.85
0.84
0.83
0.82
0.81
0.8
0
2
4
6
8
10
12
14
16
18
20
Radial distance from well center, (ft)
2-D Model @ 7 cfm
Δ Field Data Point

FIGURE 10

Bench Scale Vent Test–Columbia Mills,NY



TABLES

TABLE 1

Soil Sample Jar Headspace Analysis*

Columbia Mills – Minetto, NY
August 28–29, 1990

	Boring Location		
Depth	VW–1	VP–2	VP–5
2'–4'	12	–	–
4'–6'	165	–	–
6'–8'	No Rec.	630**	790**
8'–10'	623	800^	240^
10'–12'	90	–	–
12'–14'	267	–	–

127–T1–C

* Samples analysed using a Thermo Environmental Model 580B portable photoionization detector equipped with an 11.8 eV bulb. The instrument was calibrated to 100 ppm isobutylene prior to analysis.

** Sample taken from 5' to 7' below ground surface.

^ Sample taken from 7' to 9' below ground surface.

TABLE 2

Background Pressure and Soil Hydrocarbon Vapor Measurements at Probes Gas Analysis by PID

Columbia Mills – Minetto, NY
September 12, 1990

Sample	Description	Depth (feet)	Ambient Vacuum Pressure (in. H2O)	Total VOC'S
VP1–S	Shallow	4	ND	5,756
VP1–D	Deep	8	ND	3,276
VP2–S	Shallow	4	ND	4,160
VP2–D	Deep	8	ND	4,160
VP3	Deep	8	ND	3,230
VP4	Deep	12	ND	3,010
VP5	Deep	7	ND	2,060

127–T2–C

* Samples analyzed using a Thermo Electron instruments 580 B OVM equipped with an 11.8 eV Photoionization detector. OVM Calibrated to 1020 ppm benzene standard prior to sampling.

ND Not Detectable

TABLE 3

Vacuum Pressure Measurements During Pilot Test

Columbia Mills – Minetto, NY
September 12,13, 1990

Sample Location	Vacuum* Test 1 5 cfm 24 Hours	Vacuum* Test 2 7 cfm 4 Hours	Radial Distance From Vacuum Well	depth (ft.)
VW1	3.9 Hg	5.7 Hg	-	
VP1-S	ND**	ND**	3.5	4
VP1-D	11.5	16.0	3.5	8
VP2-S	0.70	1.00	10.5	4
VP2-D	0.75	1.05	10.5	8
VP3	0.75	0.82	18	8
VP4	2.40	3.20	15	12
VP5	0.160	0.190	33	7

127-T3-A

*	Vacuum in inches of water using Magnehelic differential pressure gauges unless otherwise stated.
**	No detectable vacuum at VP1-S. Probes probably damaged.
Hg	Vacuum in inches of Mercury.
ND	Not Detected (less than 0.05″ H_2O)

TABLE 4

Soil Gas Discharge GC/PID Analysis

Columbia Mills – Minetto, NY
September 12–13, 1990

Sample	Time	Run Time	MEK	Methylene Chloride	Benzene	Toluene	Ethyl Benzene	M-Xylene	ESTIMATED OTHERS	ESTIMATED TOTAL VOCs
Test1										
EX1	10:40 AM	0.07	ND	ND	6,436	2,922	845	322	28,310	38,835
EX2	11:46 AM	1.17	ND	ND	5,516	2,147	385	160	22,889	31,098
EX3	12:36 PM	2.00	ND	ND	4,227	1,709	441	191	17,217	23,787
EX4	01:26 PM	2.83	ND	ND	3,520	1,493	434	176	14,232	19,858
EX5	02:36 PM	4.00	ND	ND	3,885	1,626	469	192	16,512	22,688
EX6	04:08 PM	5.53	ND	ND	4,160	1,762	419	149	17,347	23,843
EX7	08:00 PM	9.40	ND	ND	4,176	1,791	447	150	19,860	26,433
EX8	11:05 AM	12.48	ND	ND	3,995	1,830	324	100	19,309	25,570
EX9	07:30 AM	20.90	ND	ND	3,842	2,243	352	115	19,868	26,441
EX10	09:33 AM	22.95	ND	ND	3,556	1,841	334	112	18,664	24,530
Test2										
EX11	12:08 PM	0.00	ND	ND	4,938	2,148	1,187	202	19,660	28,135
EX12	01:15 PM	1.12	ND	ND	3,068	1,551	978	164	15,204	20,966
EX13	02:56 PM	2.80	ND	ND	2,376	1,341	855	143	12,832	17,550
EX14	03:56 PM	3.80	ND	ND	3,155	1,907	1,046	185	16,613	22,910

127-T4-B

Samples analyzed using an HNU model 321 Gas Chromatograph equipped with an 11.7 ev photoionization detector (GC/PID).
All results expressed in ppm-v/v.

MEK	Methylethylketone
ESTIMATED OTHERS	Estimated value of summation of all other non-target VOCs. In ppm-v/v as benxene.
Est. Total VOCs	Summation of all target and non-target VOCs in ppm-v/v.
NA	Not analyzed
ND	Not detected or below detection limit

TABLE 5

Bench Scale Test Results

Columbia Mills – Minetto, NY
Composit Soil Sample Collected From VW1

Hours Vented	Minutes Vented	VOCs ug/L	Area ug min/L	Amount (ug)	Cumulative Total (ug)	Flow rate (L/min)
0.00	0.00	41.52	0.00	0.00	0.00	0.1
23.60	1416.00	139.8	128374.56	2939.62	2939.62	0.1
30.95	1857.00	123.16	57982.68	3998.11	6937.72	0.1
53.25	3195.00	121.76	163851.48	17592.02	24529.75	0.1
72.70	4362.00	105.44	132571.20	14291.08	38820.83	0.1
80.65	4839.00	100.24	49054.68	5418.72	44239.55	0.1
95.60	5736.00	88.56	84676.80	9224.75	53464.30	0.1
102.80	6168.00	82.36	36918.72	4078.08	57542.38	0.1
119.62	7177.00	61.28	72466.38	8622.91	66165.29	0.1
125.87	7552.00	62.48	23205.00	2693.25	68858.54	0.1
143.80	8628.00	45	57824.24	6658.29	75516.83	0.1
149.37	8962.00	39.08	14041.36	1794.92	77311.74	0.1
167.73	10064.00	24.12	34823.20	4632.81	81944.55	0.1
173.78	10427.00	22.68	8494.20	1147.08	83091.63	0.1
191.88	11513.00	10.8	18179.64	2541.24	85632.87	0.1
266.60	15996.00	2.84	30574.06	7504.54	93137.41	0.1

127-T5-A

APPENDIX A

DRILLING AND WELL INSTALLATIONS
VAPOR EXTRACTION PROCESS
COLUMBIA MILLS
MINETTO, NEW YORK

parratt
wolff inc

FISHER RD., EAST SYRACUSE, N.Y. 13057
TELEPHONE AREA CODE 315/437-1429
FAX 315/437-1770

August 30, 1990

Malcolm Pirnie, Inc.
7481 Henry Clay Boulevard
Liverpool, New York 13088

Attention: Mr. Mark D. Wilder, CPG

Re: 90242
Drilling and Well Installations
Vapor Extraction Process
Columbia Mills
Minetto, New York

Gentlemen:

Enclosed are driller's field logs for one (1) groundwater monitoring well and five (5) piezometer installations made for you for the above project.

Soil samples from these borings were retained by your representative at the job site.

The borings were made at the locations requested and drilling was done in accordance with ASTM method D-1586 for split barrel sampling in soils. The well and piezometers were installed according to your instructions.

Thank you for this opportunity to work with you.

Very truly yours,

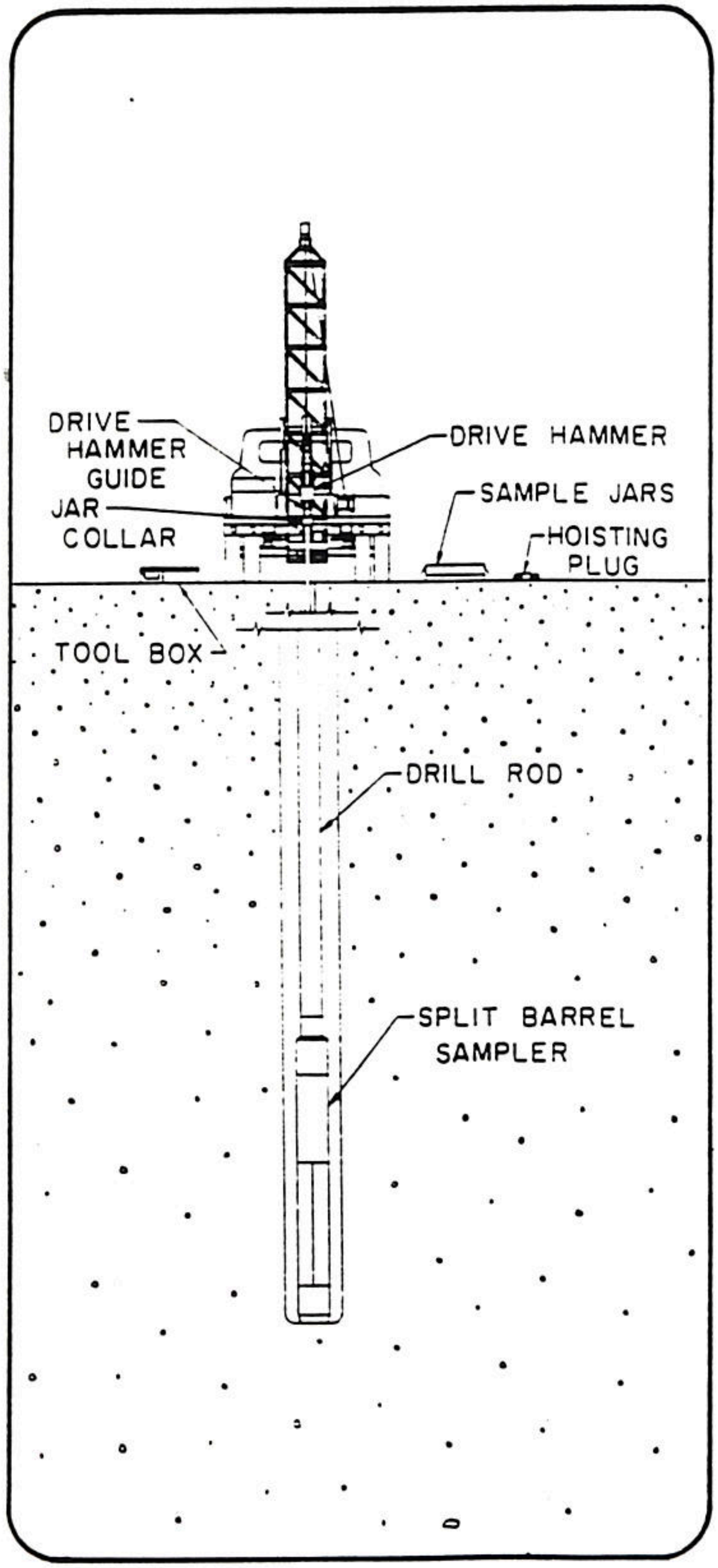
PARRATT - WOLFF, INC.

Steffen Wolff
SW/lc
encs:
cc: w/encls: (1) Vapex Environmental Technologies
480 Neponset Street
Canton, Massachusetts 02021
Attention: Mr. Matthew T. Walsh

(1) Leslie H. Deming, Esq.
Bond, Schoeneck and King
215 Washington Street
Watertown, New York 13601

SOIL SAMPLING-METHODS

parratt
wolff inc
FISHER RD., EAST SYRACUSE, N.Y. 13057
TELEPHONE AREA CODE 315/437-1429



Split barrel sampling

The following excerpts are from "Standard Method for penetration test and split-barrel sampling of soils."[1] (ASTM designation: D-1586-67 AASHO Designation: T-206-70.)

1. Scope

1.1 This method describes a procedure for using a split-barrel sampler to obtain respresentative samples of soil for identification purposes and other laboratory tests, and to obtain a measure of the resistance of the soil to penetration of the sampler.

2. Apparatus

2.1 Drilling Equipment — Any drilling equipment shall be acceptable that provides a reasonably clean hole before insertion of the sampler to ensure that the penetration test is performed on undisturbed soil, and that will permit the driving of the sampler to obtain the sample and penetration record in accordance with the procedure described in 3. Procedure. To avoid "whips" under the blows of the hammer, it is recommended that the drill rod have stiffness equal to or greater than the A-rod. An "A" rod is a hollow drill rod or "steel" having an outside diameter of 1-5/8 in. or 41.2 mm and an inside diameter of 1-1/8 in. or 28.5 mm, through which the rotary motion of drilling is transferred from the drilling motor to the cutting bit. A stiffer drill rod is suggested for holes deeper than 50 ft (15m). The hole shall be limited in diameter to between 2-1/4 and 6 in. (57.2 and 152mm).

2.2 Split-Barrel Sampler — The sampler shall be constructed with the dimensions indicated (in Fig. 1.) The drive shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The coupling head shall have four 1/2-in. (12.7-mm) (minimum diameter) vent ports and shall contain a ball check valve. If sizes other than the 2-in. (50.8-mm) sampler are permitted, the size shall be conspicuously noted on all penetration records.

2.3 Drive Weight Assembly — The assembly shall consist of a 140-lb (63.5-kg) weight, a driving head, and a guide permitting a free fall of 30 in. (0.76 m). Special precautions shall be taken to ensure that the energy of the falling weight is not reduced by friction between the drive weight and the guides.

2.4 Accessory Equipment — Labels, data sheets, sample jars, paraffin, and other necessary supplies should accompany the sampling equipment.

parratt
wolff inc
FISHER RD., EAST SYRACUSE, N.Y. 13057
TELEPHONE AREA CODE 315/437-1429

GENERAL NOTES

1. Soil boring logs, notes and other data shown are the results of personal observations and interpretations made by Parratt-Wolff, Inc.

Exploration records prepared by our drilling foreman in the field form the basis of all logs, and samples of subsurface materials retained by the driller are observed by technical personnel in our laboratory to check field classifications.

2. Explanation of the classifications and terms:

a. Bedrock — Natural solid mineral matter occurring in great thickness and extent in its natural location. It is classified according to geological type and structure (joints, bedding, etc.) and described as solid, weathered, broken or fragmented depending on its condition.

b. Soils — Sediments or other unconsolidated accumulations of particles produced by the physical and chemical disintegration of rocks and which may or may not contain organic matter.

PENETRATION RESISTANCE

COHESIONLESS SOILS

Blows Per Ft.	Relative Density
0 to 4	Very Loose
4 to 10	Loose
10 to 30	Medium Dense
30 to 50	Dense
Over 50	Very Dense

COHESIVE SOILS

Blows Per Ft.	Consistency
0 to 2	Very Soft
2 to 4	Soft
4 to 8	Medium Stiff
8 to 15	Stiff
15 to 30	Very Stiff
Over 30	Hard

Size Component Terms

Boulder		Larger than 8 inches	
Cobble		8 inches to 3 inches	
Gravel	— coarse	3 inches to 1 inch	
	— medium	1 inch to 3/8 inch	
	— fine	3/8 inch to 4.76 mm	
Sand	— coarse	4.76 mm to 2.00 mm	(#10 sieve)
	— medium	2.00 mm to 0.42 mm	(#40 sieve)
	— fine	0.42 mm to 0.074 mm	(#200 sieve)
Silt and Clay		Finer than 0.074 mm	

Proportion By Weight

Major component is shown with all letters capitalized.

Minor component percentage terms of total sample are:

and	35 to 50 percent
some	20 to 35 percent
little	10 to 20 percent
trace	1 to 10 percent

c. Gradation Terms — The terms coarse. medium and fine are used to describe gradation of Sand and Gravel.

d. The terms used to describe the various soil components and proportions are arrived at by visual estimates of the recovered soil samples. Other terms are used when the recovered samples are not truly representative of the natural materials, such as soil containing numerous cobbles and boulders which cannot be sampled, thinly stratified soils, organic soils, and fills.

e. Ground water — The measurement was made during exploration work or immediately after completion, unless otherwise noted. The depth recorded is influenced by exploration methods, soil type and weather conditions during exploration. Where no water was observed it is so indicated. It is anticipated that the ground water will rise during periods of wet weather. In addition, perched ground water above the water levels indicated (or above the bottom of the hole where no ground water is indicated) may be encountered at changes in soil strata or top of rock.

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wolff inc
FISHER RD., EAST SYRACUSE, N.Y. 13057
TELEPHONE AREA CODE 315/437-1429

A BRIEF DESCRIPTION OF THE UNIFIED SOIL SYSTEM

The Unified Classification System is an engineering soil classification that is an outgrowth of the Air-Field classification developed by Casagrande.

The system incorporates the textural characteristics of a soil into the engineering classification. All soils are classified into fifteen groups, each group being designated by two letters. These letters are as follows: G—gravel, S—sand, M—Non plastic or low plasticity fines, C—plastic fines, Pt—peat, humus and swamp soils, O—organic, W—well graded, P—poorly graded, L—low liquid limit, H—high liquid limit.

GW and SW Groups

These groups comprise well graded gravelly and sandy soils which contain less than 5% of non plastic fines passing a #200 sieve. Fines which are present must not noticeably change the strength characteristics of the coarse grain fraction and must not interfere with its free draining characteristics. In areas subject to frost action the material should not contain more than about 3% of soil grains smaller than .02 millimeters in size.

GP and SP Groups

These groups are poorly graded gravels and sands containing less than 5% non plastic fines. They may consist of uniform gravels, uniform sands, or non uniform mixtures of very coarse material and very fine sand with intermediate sizes lacking. Materials of this latter type are sometimes referred to as skip graded, cap graded, or step graded.

GM and SM Groups

In general, these groups include gravels or sands which contain more than 12% of fines having little or no plasticity. The plasticity index and liquid limit of a soil in either of these groups plot below the "A" line on a plasticity chart. Gradation is not important and both low grade and poorly graded materials are included. Some sands and gravels in these groups may have a binder composed of natural cementing agents so proportioned that the mixture shows negligible swelling or shrinkage. Thus, the dry strength is provided by a small amount of soil binder or dry cementation of calcareous materials or iron oxide. A fine fraction of non cemented materials may be composed of silts or rock flour types having little or no plasticity, and the mixture will exhibit no dry strength.

GC and SC Groups

These groups comprise gravelly or sandy soils with more than 12% of fines which exhibit either low or high plasticity. The plasticity index and liquid limit of a soil in either of these groups plot above the "A" line on the plasticity chart. Gradation of these materials is not important. Plasticity of the binder fraction has more influence on the behavior of the soils than does the variation in gradation. A fine fraction is generally composed of clays.

ML and MH Groups

These groups include predominantly silty materials and micaceous or diatomaceous soils. An arbitrary division between the two groups has been established with a liquid limit of 50. Soils in these groups are sandy silts, clayey silts or organic silts with relatively low plasticity. Also included are loessial soils and rock flours. Micaceous and diatomaceous soils generally fall within the MH group, but may extend into the ML group when their liquid limit is less than 50. The same is true for certain types of kaolin clays and some illite clays having relatively low plasticity.

CL and CH Groups

The CL and CH groups embrace clays with low and high liquid limits respectively. They are primarily inorganic clays. Low plasticity clays are classified as CL and are usually lean clays, sandy clays, and silty clays. The medium plasticity and high plasticity clays are classified as CH. These include fat clays, gumbo clays, certain volcanic clays and bentonite.

OL and OH Groups

The soils in these groups are characterized by the presence of organic matter including organic silts and clays. They have a plasticity range that corresponds with the ML and MH groups.

Pt Group

Highly organic soils which are very compressible have undesirable construction characteristics and are classified in one group with the symbol Pt. Peat, humus and swamp soils with a highly organic texture are typical of the group. Particles of leaves, grass, branches of bushes and other fibrous vegetable matter are common components of these soils.

Borderline Classification

Soils in the GW, SW, GP and SP groups are non plastic materials having less than 5% passing the #200 sieve, while GM, SM, GC, and SC soils have more than 12% passing the #200 sieve. When these coarse grain materials contain between 5% and 12% of fines they are classified as borderline, and are designated by the dual symbol such as GW-GM. Similarly coarse grain soils which have less than 5% passing the #200 sieve, but which are not free draining or in which the fine fraction exhibits plasticity are also classed as borderline and are given a dual symbol. Still another type of borderline classification occurs when a liquid limit of a fine grain soil is less than 29 and the plasticity index lies in the range of four to seven. These limits are indicated by the shaded area on the plasticity chart.

Silty and Clayey

In the Unified System, these terms are used to describe soils whose Atterberg limits plot below and above the "A" line on the plasticity chart. The adjectives silty and clayey are used to describe soils whose limits plot close to the "A" line.

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TEST BORING LOG

FISHER ROAD
EAST SYRACUSE, N.Y. 13057

PROJECT	Drilling and Well Installation - Vapor Extraction Process - Columbia Mills	HOLE NO.	VW-1
LOCATION	Minetto, New York	SURF. EL.	
DATE STARTED	8/28/90 DATE COMPLETED 8/28/90	JOB NO.	90242

GROUND WATER DEPTH
WHILE DRILLING 10.0'
BEFORE CASING REMOVED Dry
AFTER CASING REMOVED Installed Well

N — NO. OF BLOWS TO DRIVE SAMPLER 12" W/140# HAMMER FALLING 30" — ASTM D-1586, STANDARD PENETRATION TEST

C — NO. OF BLOWS TO DRIVE CASING 12" W/ # HAMMER FALLING "/OR — % CORE RECOVERY

CASING TYPE - HOLLOW STEM AUGER
DRILLER'S FIELD LOG

SHEET 1 OF 1

DEPTH	SAMPLE DEPTH	SAMPLE NUMBER	C	SAMPLE DRIVE RECORD PER 6"	N	DESCRIPTION OF MATERIAL	STRATA CHANGE DEPTH
						CONCRETE	0.4'
						Brown moist medium dense to loose fine to coarse SAND, some fine to medium gravel	
	2.0'-	1		10/18			
	4.0'			9/8	27		
5.0	4.0'-	2		3/3			
	6.0'			2/3	5		
	6.0'-	3	No	4/3			
	8.0'		Rec	3/2	6		
	8.0'-	4		8/9			
10.0 ▼	10.0'			8/3	17		10.0'
WL	10.0'-	5		5/4		Gray-brown wet loose to medium dense fine to coarse SAND, some silt, trace fine gravel	
	12.0'			1/1	5		
	12.0'-	6		8/9			
	14.0'			4/3	13		
15.0						Bottom of Boring	14.0'
						Note: Installed 2" PVC 20 slot screen 10.0' to 5.0', 2" PVC riser to surface with 9" flush mounted cover.	

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TEST BORING LOG

FISHER ROAD
EAST SYRACUSE, N.Y. 13057

PROJECT Drilling and Well Installation - Vapor Extraction Process - Columbia Mills
LOCATION Minetto, New York
DATE STARTED 8/28/90 DATE COMPLETED 8/29/90

HOLE NO. VP-1
SURF. EL.
JOB NO. 90242
GROUND WATER DEPTH
WHILE DRILLING Dry
BEFORE CASING REMOVED Installed Piezometers
AFTER CASING REMOVED

N — NO. OF BLOWS TO DRIVE SAMPLER 12" W/140# HAMMER FALLING 30" — ASTM D-1586, STANDARD PENETRATION TEST

C — NO. OF BLOWS TO DRIVE CASING 12" W/ # HAMMER FALLING "/OR — % CORE RECOVERY

CASING TYPE - HOLLOW STEM AUGER
DRILLER'S FIELD LOG

SHEET 1 OF 1

DEPTH	SAMPLE DEPTH	SAMPLE NUMBER	C	SAMPLE DRIVE RECORD PER 6"	N	DESCRIPTION OF MATERIAL	STRATA CHANGE DEPTH
						CONCRETE	0.4'
						Brown-gray moist fine to coarse SAND, some to trace fine to medium gravel	
5.0							
						Bottom of Boring	8.0'
10.0						Note: Installed dual piezometers: 2" PVC 20 slot screen 8.0' to 7.2', 0.5" PVC tubing to surface - 2" PVC 20 slot screen 4.0' to 3.2', 0.5" tubing to surface with 9" flush mounted cover.	

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TEST BORING LOG

FISHER ROAD
EAST SYRACUSE, N.Y. 13057

PROJECT Drilling and Well Installation - Vapor Extraction Process - Columbia Mills

LOCATION Minetto, New York

DATE STARTED 8/29/90 DATE COMPLETED 8/29/90

HOLE NO. VP-2

SURF. EL.

JOB NO. 90242

GROUND WATER DEPTH

WHILE DRILLING Dry

BEFORE CASING REMOVED Installed Piezometer:

AFTER CASING REMOVED

N — NO. OF BLOWS TO DRIVE SAMPLER 12" W/140# HAMMER FALLING 30" — ASTM D-1586, STANDARD PENETRATION TEST

C — NO. OF BLOWS TO DRIVE CASING 12" W/ # HAMMER FALLING "/OR — % CORE RECOVERY

CASING TYPE - HOLLOW STEM AUGER

DRILLER'S FIELD LOG

SHEET 1 OF 1

DEPTH	SAMPLE DEPTH	SAMPLE NUMBER	C	SAMPLE DRIVE RECORD PER 6"	N	DESCRIPTION OF MATERIAL	STRATA CHANGE DEPTH
						CONCRETE	0.4'
						Brown moist medium dense fine to coarse SAND, some fine to coarse gravel	
5.0							
	5.0'-	1		4/10			
	7.0'			13/6	23		7.0'
	7.0'-	2		4/4		Brown-gray wet loose fine to coarse SAND and SILT, little fine to medium gravel	
	9.0'			4/6	8		
10.0						Bottom of Boring	9.0'
						Note: Installed dual piezometers: 2" PVC 20 slot screen 8.0' to 7.2', 0.5" PVC tubing to surface - 2" PVC 20 slot screen 4.0' to 3.2', 0.5" tubing to surface with 9" flush mounted cover.	

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TEST BORING LOG

FISHER ROAD
EAST SYRACUSE, N.Y. 13057

PROJECT Drilling and Well Installation - Vapor Extraction Process - Columbia Mills

LOCATION Minetto, New York

DATE STARTED 8/29/90 DATE COMPLETED 8/29/90

HOLE NO. VP-3

SURF. EL.

JOB NO. 90242

GROUND WATER DEPTH

WHILE DRILLING Dry

BEFORE CASING REMOVED Installed Piezometer

AFTER CASING REMOVED

N — NO. OF BLOWS TO DRIVE SAMPLER 12" W/140# HAMMER FALLING 30" — ASTM D-1586, STANDARD PENETRATION TEST

C — NO. OF BLOWS TO DRIVE CASING 12" W/ # HAMMER FALLING "/OR — % CORE RECOVERY

CASING TYPE - HOLLOW STEM AUGER

DRILLER'S FIELD LOG

SHEET 1 OF 1

DEPTH	SAMPLE DEPTH	SAMPLE NUMBER	C	SAMPLE DRIVE RECORD PER 6"	N	DESCRIPTION OF MATERIAL	STRATA CHANGE DEPTH
						CONCRETE	0.4'
5.0						Brown moist fine to coarse SAND and SILT, some to little fine to coarse gravel	
10.0						Bottom of Boring Note: Installed piezometer: 2" PVC 20 slot screen 8.0' to 7.2', 0.5" PVC tubing to surface with 9" flush mounted cover.	8.0'

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FISHER ROAD
EAST SYRACUSE, N.Y. 13057

TEST BORING LOG

PROJECT Drilling and Well Installation - Vapor Extraction Process - Columbia Mills

LOCATION Minetto, New York

DATE STARTED 8/29/90 DATE COMPLETED 8/29/90

HOLE NO. VP-4

SURF. EL.

JOB NO. 90242

GROUND WATER DEPTH
WHILE DRILLING Dry

BEFORE CASING REMOVED Installed Piezometer

AFTER CASING REMOVED

N — NO. OF BLOWS TO DRIVE SAMPLER 12" W/140# HAMMER FALLING 30" — ASTM D-1586, STANDARD PENETRATION TEST

C — NO. OF BLOWS TO DRIVE CASING 12" W/ # HAMMER FALLING "/OR — % CORE RECOVERY

CASING TYPE - HOLLOW STEM AUGER
DRILLER'S FIELD LOG

SHEET 1 OF 1

DEPTH	SAMPLE DEPTH	SAMPLE NUMBER	C	SAMPLE DRIVE RECORD PER 6"	N	DESCRIPTION OF MATERIAL	STRATA CHANGE DEPTH
						CONCRETE	0.4'
						Brown moist to wet fine to coarse SAND and SILT, some to little fine to coarse gravel	
5.0							
10.0							
						Bottom of Boring	13.0'
15.0							
						Note: Installed piezometer: 2" PVC 20 slot screen 12.0' to 11.2', 0.5" PVC tubing to surface with 9" flush mounted cover.	

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TEST BORING LOG

FISHER ROAD
EAST SYRACUSE, N.Y. 13057

PROJECT Drilling and Well Installation - Vapor Extraction Process - Columbia Mills

LOCATION Minetto, New York

DATE STARTED 8/29/90 DATE COMPLETED 8/29/90

HOLE NO. VP-5

SURF. EL.

JOB NO. 90242

GROUND WATER DEPTH
WHILE DRILLING 7.5'

BEFORE CASING REMOVED Installed Piezometer

AFTER CASING REMOVED

N — NO. OF BLOWS TO DRIVE SAMPLER 12" W/140# HAMMER FALLING 30" — ASTM D-1586, STANDARD PENETRATION TEST

C — NO. OF BLOWS TO DRIVE CASING 12" W/ # HAMMER FALLING "/OR — % CORE RECOVERY

CASING TYPE - HOLLOW STEM AUGER

DRILLER'S FIELD LOG

SHEET 1 OF 1

DEPTH	SAMPLE DEPTH	SAMPLE NUMBER	C	SAMPLE DRIVE RECORD PER 6"	N	DESCRIPTION OF MATERIAL	STRATA CHANGE DEPTH
						CONCRETE	0.4'
						Brown dry fine to coarse SAND and fine to coarse GRAVEL	
5.0							5.0'
	5.0'-	1		4/4		Brown moist to wet loose to medium dense fine to coarse SAND and SILT, little fine to medium gravel	
	7.0'			3/3	7		
	7.0'-	2		8/11			
	9.0'			8/6	19		
10.0						Bottom of Boring	9.0'
						Note: Installed piezometer: 2" PVC 20 slot screen 7.0' to 6.2', 0.5" PVC tubing to surface with 9" flush mounted cover.	

APPENDIX B

VAPEX ENVIRONMENTAL TECHNOLOGIES, INC.

STANDARD OPERATING PROCEDURES (SOP)

HNU MODEL 321 GAS CHROMATOGRAPH FIELD SETUP AND OPERATION

VAPEX SOP#: GC-OP

Purpose: To document specific procedures for the operation of the HNU Gas Chromatograph.

Objectives: To outline procedures for setup and operation of the HNU Model 321 Gas Chromatograph and associated equipment. Setup and operation includes:

- Setup of the GC and equipment
- Procedures for establishment of a GC baseline
- The preparation, injection and analysis of a field vapor standard
- The injection and analysis of field samples
- Procedures for shutting down the GC

Required Associated SOPs: *VAPEX* SOP Nos: GC-QAQC-I and GC-QAQC-II.

Definitions:

carrier gas - medium which moves sample through the GC column. This is typically an inert gas such as nitrogen (N2) or helium (H2). Synonym = "mobile phase."

baseline - chart recorder/integrator/computer baseline. This is the established level of chromatograph response and sensitivity which corresponds to levels which are below the detection limit.

sample blank - usually ambient air which is drawn into a Hamilton gas-tight glass syringe and injected into the GC/PID to establish the baseline and determine the existence and quantity of background contamination or column residual (if any). It is also used to establish the extent of baseline drift caused by temperature gradient program.

temperature gradient program - a program by which the temperature of the GC oven is varied with time. The temperature gradient program greatly increases the separation efficiency of the GC column as a result of an increase in molecular/column interactions.

attenuation - the level of GC/PID response/sensitivity which can be adjusted by the user in response to changes in sample concentration.

GC/PID - Gas Chromatograph with Photoionization detector. GC/PID is equipped with 1 ml gas sampling loop, which ensures repetitive sample volume injection.

GC/FID - Gas Chromatograph with Flame ionization detector. GC/PID is equipped with 1 ml gas sampling loop, which ensures repetitive sample volume injection.

Equipment Description: Equipment used in the operation of the HNU Gas Chromatograph are listed below:

1. Hamilton 1 ul and 5 ul syringes
2. Two liter (2L) volumetric static dilution flask
3. HNU Model 321 GC Controller
4. HNU Model 321 Gas Chromatograph:
   Column (Stainless): 1/8" stainless steel packed column, 5 percent SP-1200/1.75 percent Benton 34 on 100/120 Supelcoport (1-2134). *Column (Capillary)*: Supelco SPB-5 30m x 0.75mm ID wide-bore capillary column; 1 micron film.
   Column temp (Stainless Column): 5 min. at 70 ^{o}C, then to 160 ^{o}C @ 5^{o}C/min. *Column temp (Capillary Column)*: 5 min. @ 40 oC, then to 160 oC @ 8oC/min.
   Flow rate (Stainless): N2, 18-22 ml/min; H2 (GC/FID), 30 ml/min; Zero-Air (GC/FID), 300 ml/min. *Flow Rate (Capillary)*: N2, 8-12 ml/min; Make-up gas (N2), 8-12 ml/min,; H2 (GC/FID), same; Zero Air (GC/FID), same.
   Detector: 10.2/11.7 eV photoionization detector (PID) and/or flame ionization detector (FID).
5. Nelson Analytical A/D Interface
6. Toshiba T1200 laptop computer, equipped with P.E. Nelson Model 2100 PC Integrator Chromatography Software, Revision 5.0.
7. Formatted 3.5" floppy diskettes.
8. Extension cord equipped with a voltage surge protector and a Ground Fault Interrupter (GFI).
9. Nitrogen, Hydrogen (GC/FID) and Zero-Air (GC/FID) tanks equipped w/ swagelok fittings and copper tubing for hook-up w/ GC.
10. Hamilton 10 ml syringe ("BLANK" syringe)
11. Equimolar standard solution (Gasoline analysis: benzene, toluene and m-xylene; Halogenated hydrocarbon analysis: 111-TCA, TCE and PCE - typically) of known ppm concentration which is prepared in the field by the GC operator as described below in "Standard Preparation".
12. Supply of sample syringes (10 mL) Hamilton Gastight equipped with Teflon Minivert valves.
13. Heat gun.

Health and Safety: 1) VITON or equivalent gloves will be used when handling chemicals. Work with chemicals must not be conducted in a closed/contained space. 2) Hydrogen is an extremely flammable gas - when starting the FID, always turn the Zero-Air on before the hydrogen; when turning the FID off, always turn the hydrogen off before turning the Zero-Air off.

1.0 PROCEDURE: PHASE I/SET UP

1. Unload all GC equipment.
2. Set up equipment in configuration illustrated below:
3. Make all necessary connections/communication lines between equipment.

4. Connect the Nitrogen (N2) to the GC (if using the GC/FID, also attach the hydrogen and zero-air).
5. Turn on N2. Record N2 tank and regulator psi.
6. After 2-3 min., turn on GC (do not turn on the detector).
7. After GC is on for 2-3 min., turn on the controller.
8. Program #1: Note that all program entries must be followed by an "ENTER" (the "down arrow" on the controller is the "enter").

    i. Enter "**1**" for "Temp only".
    ii. Ambient mode? **YES**
    iii. Inj./Det temp? **95** (11.7eV PID)/**250** (10.2eV PID)
    iv. Oven temp ramp? **No**

Note: a "NO" was programmed so as to bake the GC column for a period of time prior to use (usually 0.5 hr.).

v. Final oven temp? **160** °C
vi. Just hit **enter** for question #'s 10 and 11.
vii. Press "**enter**" again to start the temperature control.
viii. Turn on the **NELSON.**
ix. While the GC warms up, format a 3.5" floppy diskette on the computer and download all appropriate GC Software methods onto the diskette.
x. Continue preparing by establishing an entry in the **GC FIELD NOTEBOOK** and recording all GC operating parameters as shown in the example in Figure 2.
xi. Once the GC warms up to the programmed parameters, allow the GC to stabilize at these settings for 30-60 min.

END PHASE I

2.0 PHASE II/TEMPERATURE RAMP

Program the controller for the following temperature ramp.

1. Press the "UP" arrow on the controller to get back to the start of the program.

2. Program as above in Steps 4i-4iii until the controller prompts for an oven temperature ramp. Enter "**YES**".

Continue the temperature program as follows:

Initial temperature (°C):	**70**
Hold time (**seconds**/units = 5 mins):	**500**
Ramp (°C/min):	**5**
Second temperature (°C):	**160**
Second hold time (**sec.**/ units=10 min.):	**1000**
Second ramp (°C/min):	**ENTER**
Final Temperature (°C):	**160**
#10, #11, #12:	**ENTER**

4. After you start the temperature program, open the cover on the GC to facilitate cooling.

5. When controller lets you know it is ready, hit "enter" to start a run - EXCEPT, press **"STOP"** immediately after this.

Because the GC was allowed to warm up to 160 ^{O}C, the short amount of time you allowed for cooling was not enough. So, because the controller thinks it is ready, it will try to maintain a 70 ^{O}C oven temp while the GC cover is open. Were you to close the lid without further cooling, the temp would immediately jump past 70 ^{O}C.

6. When temp reaches approx. 48 ^{O}C, close the GC cover, and press **"ENTER"** to start the temperature program.

7. Turn on the detector - check to see that it is on (purple glow).

8. If using the GC/FID: turn on the zero-air, then the hydrogen (flowrates are preset). Wait approximately 1 minutes to allow the gases to reach the FID. Ignite the FID by depressing the DETECTOR B switch and holding it down for approximately 1-3 seconds - you should hear a "pop" indicating the flame is lit. *Note: Do not hold down the igniter switch longer than 1-3 seconds - it is possible to burn out the igniter coil.* Check to see that the FID is lit by holding a small, glass vial above the exit port - you should see water vapor condense on the vial. Repeat if necessary.

END PHASE II

3.0 PHASE III/ESTABLISH BASELINE

1. Get into the main menu of the Nelson GC software by typing at the **C:>** prompt:

GC, enter
MENU, enter

2. Get into the GC Polling menu (hit enter = **0** on main menu). Press **F2** to get into method downloading, and load the appropriate preprogrammed data method (*.MET) file which should already be on A:\ (if not, copy it from C:\ to A:\).

Enter an appropriate file name and a description including the attenuation you expect to shoot the sample on: for example "BLANK, atten. = H1". Download to NELSON.

3. Inject three volumes of ambient air through the GC sample loop in both the INJECT (down position) and LOAD (up position) positions with the blank syringe to purge any hydrocarbon vapors remaining in the loop.

4. Simultaneously; **INJECT** the sample, press **ENTER** on the controller to start the run and press **START** on the NELSON to begin data sampling.

Note: If NELSON shows "Under Range" past 1.25 min., hit the "auto zero" on the GC till baseline stabilizes and Nelson remains in "Sampling" mode.

Also, if residuals are detected, let the chromatogram continue to elute for approximately 25 minutes, then:

1. Heat the sample loop with the heat gun while the injector is in the sample position (up).
2. Blow 10 volumes of air through loop with the "blank" syringe.
3. Cool the loop down with the heat gun on "cool" position.
4. Shoot another blank.
5. Press "**STOP**" on controller to end the run and "**STOP**" on NELSON to begin downloading the data into the computer. Open the GC cover to facilitate cooling.
6. When the Controller has cooled, it will print a small menu. At this point, close the GC cover and press **ENTER** on the Controller to start the temperature program.
7. When the GC has reached starting temperature (70 ^{O}C), the Controller will print a "Ready" menu.
8. Repeat steps 2-7 for each consecutive blank injection.

END PHASE III

4.0 PHASE IV/STANDARD ANALYSIS

Once a steady baseline is established, a standard prepared in the field is injected. The standard is usually a equimolar mixture of at least three specified/target compounds which are expected to be detected in the field. The standard is prepared as follows:

Standard Preparation:

i. *A microliter (typically, 1 uL) syringe is rinsed with methanol (MeOH) and allowed to dry.*

ii. *A 2 liter static dilution flask is cleaned/heated with a heat gun (approx. 2-3 minutes) until it is free of any contamination. The flask is allowed to cool. The flask is tested with a Foxboro Century Model 128 Organic Vapor Analyzer (OVA) or an HNU Model HW-101 Portable Ionization Analyzer (PID: 10.2/11.7 eV) to ensure the flask is free of contamination. This step is repeated if necessary.*

iii. *A 3-5 mL vial of liquid/neat benzene is taken from storage *.*

iv. *The microliter syringe (1.0 uL) is introduced into the benzene through the septum of the sample vial. This is done to minimize contact with the benzene and/or vaporization of the chemical into the air.*

v. *While holding the needle of the syringe in the liquid and holding the syringe and vial up into the light, a small amount of liquid is slowly extracted into the syringe. This initial volume is expelled into the liquid and careful attention is paid to notice any small bubbles which may elute (even the tiniest bubble can have a dramatic effect on the resultant concentration of the final standard solution). This procedure is repeated until no bubbles are observed. At this point, a small (pre-calculated) volume is once again extracted up into the syringe. The syringe is carefully, but quickly, taken out of the liquid and vial and introduced into the static dilution flask where the sample is expelled. Note that the use of larger volume syringes (5, 10, 25 uL) would require procedural modifications, such as the incorporation of a volume of head space (air or methanol) prior to the extraction of sample into the syringe to 1) ensure accurate sample measurement, and 2) to provide a mechanism for the removal of all sample from the needle volume. However, the construction of the 1.0 uL syringe coupled with experimental analytical data for standards prepared with the 1.0 uL syringe indicate that consistently accurate standards can be generated without the* *addition of a headspace volume - these results are a function of a perfected analytical technique.*

vi. *The sample is allowed to evaporate off the needle and equilibrate.*

vii. *Steps iii through vi are repeated for trichloroethylene (TCE) and perchloroethylene (PCE) and/or any other chemicals of interest.*

viii. *Since the resultant mixture of standard components will be nonhomogeneous, the flask should be maintained at a constant temperature (70 °F) and agitated prior to use to ensure homogeneous mixing.*

In summary, the composition of the prepared standard sample should be characteristic of the expected field contaminant(s) and is designed to test the response of the detector and column over the effective range characteristic of the expected levels of the contaminant.

1. The GC Temperature Controller, the Nelson and the computer are reset to accept another run.

2. Flush the sample loop with three volumes of ambient air with the blank syringe.

3. Standards for injection are extracted from the two liter volumetric dilution flask via a 5 ml gastight syringe. Care is taken to avoid standard/sample dilution due to needle head space. The valve on the syringe is closed.

4. The syringe is attached to the loop; the syringe valve is opened and a portion of the standard in injected into the loop.

5. Simultaneously: **INJECT** the sample, hit the **ENTER** (down arrow) on the GC Temperature Controller and hit the **START** button on the Nelson Interface to start recording the run.

6. Allow the run to elute until it is certain that no other peaks may elute, then: hit the **STOP** button on the Controller to stop the run and the **STOP** button on the Nelson to begin the downloading process to the computer.

7. Open the cover of the GC to facilitate cooling and reset the GC for the next run as described above in Section 3.0.

Area counts (AC) and retention times (Rt) are calculated for each injection of standard and compared to assure statistical guidelines are met (briefly, both AC and Rt must be within at least 10 percent of known laboratory values for 90 percent confidence). Failure to meet these criteria might be caused by 1) an old and degrading column, 2) a leak in the mobile phase, 3) an unexpected change in carrier gas pressure or 4) non-equilibrated temperature ramp starting conditions. These and other possibilities should be investigated to determine the cause of the Rt discrepancy before continuing. Duplicate and/or replicate injections should be run if necessary.

b. Area Counts (AC) for each peak are compared to expected values by correlation with the computer-resident, programmed external standards. Deviation greater than 10% may indicate error in sample preparation or suggest that the GC/PID may need recalibration. A newly prepared sample may help to determine the cause. *NOTE: The preparation of standards which contain hydrocarbon vapor at very low concentrations is difficult to prepare.*

The comparison of peak Rt may serve as a better evaluation of GC/PID performance at lower concentrations (x<100 ppb).

8. If standard response is within quality assurance performance criteria, then a field sample may be collected and injected as described below. Note that a blank and a standard will be injected 1) after six field samples have been run 2) after a reattenuation has resulted in a change from a less sensitive (high concentration) GC/PID attenuation setting to that of a more sensitive (lower concentration) GC/PID attenuation setting.

* *Liquid/neat chemical standards are kept in 3-5 mL brown, open-faced sample vials equipped with teflon-faced silicon septa. These sample vials are stored in a resealable plastic bag which is stored in a small container of carbon.*

5.0 PHASE V/SAMPLE ANALYSIS:

1. Collect field samples for GC/PID and/or GC/FID analysis as specified in VAPEX SOP No.GC-S.
2. Reset the GC, controller, Nelson and computer for the next sample.
3. Flush the sample loop with three (3) volumes of ambient air with the blank syringe.
4. Attach the sample syringe to the loop, open the syringe valve and inject a portion of the 10 mL syringe sample into the 1 mL sampling loop. *A portion of the sample can be saved for duplicate analysis by closing the valve to ensure that no sample leaks from the syringe.*
5. As described above, simultaneously: **INJECT** the sample, hit the **ENTER** (down arrow) on the GC Temperature Controller and hit the **START** button on the Nelson Interface to start recording the run.
6. Allow the run to elute until it is certain that no other peaks may elute, then: hit the **STOP** button on the Controller to stop the run and the **STOP** button on the Nelson to begin the downloading process to the computer.
7. Open the cover of the GC to facilitate cooling and reset the equipment for the next run.

Note 1: By screening the contaminated area(s) with a total hydrocarbon PID/FID, it is possible to approach the GC sampling round so that sampling locations of similar contamination concentrations can be grouped together. This is advantageous in that it reduces the frequency of GC attenuation adjustments. Furthermore, in regards to column dynamics, sampling strategy assumes that samples are selected in increasing concentration.

Note 2: Sample syringes will be sterilized with heat gun after use and checked with a total organic vapor analyzer (TOVA) for residual contamination before repeated use.

6.0 PHASE VI/BREAKDOWN

After all field analyses have been completed, the equipment must be broken down for transportation back to the lab.

1. Turn off detector (if using the FID, turn off the Hydrogen, then the Zero-Air).
2. Turn off computer.
3. Turn off Nelson.

4. Turn off Controller.
5. With GC cover up, make sure the GC oven temp is below 30 ^{o}C and the injector temperature is below 100 ^{o}C. Then, turn off the GC.
6. Turn off N2 and unhook the N2 line from the GC.

REFERENCES:

1. HNU Model 321 Gas Chromatograph Operator's Manual, Ver. 1.0; HNU Systems, Inc., Newton, Massachusetts.

2. P.E. Nelson 900 Series Intelligent Interface Operator's Manual; Perkin Elmer Nelson Systems, Inc., Cupertino, California.

3. P.E. Nelson PC Integrator User's Manual, Revision 5.0; Perkin Elmer Nelson Systems, Inc., Cupertino, California.

4. The Merck Index, 9th Ed.; Merck & Co., Inc., Rahway, New Jersey.

VAPEX ENVIRONMENTAL TECHNOLOGIES, INC.

STANDARD QA/QC OPERATING PROCEDURES (SOP)

STANDARDIZATION/CALIBRATION OF HNU MODEL 321 GAS CHROMATOGRAPH

VAPEX SOP NO: GC-QAQC-I

Purpose: To document specific procedures for the Standardization/Calibration of an HNU Model 321 Gas Chromatograph equipped with an 11.7 eV photoionization detector (GC/PID).

Objectives: Describe the procedures/techniques used in the calibration of the Gas Chromatograph for chlorinated and non-chlorinated hydrocarbons.

Required Associated SOPs: GC-OP and GC-QAQC-II

Definitions:

1. carrier gas - medium which moves sample through the GC column. This is typically an inert gas such as nitrogen (N2) or helium (H2). Synonym = "mobile phase."

2. baseline - chart recorder/integrator/computer baseline. This is the established level of chromatograph response and sensitivity which corresponds to levels which are below the detection limit.

3. sample blank - usually ambient air which is drawn into a Hamilton gas-tight glass syringe and injected into the GC/PID to establish the baseline and determine the existence and quantity of background contamination or column residual (if any). It is also used to establish the extent of baseline drift caused by temperature gradient program.

4. temperature gradient program - a program by which the temperature of the GC oven is varied with time. The temperature gradient program greatly increases the separation efficiency of the GC column as a result of an increase in molecular/column interactions.

5. attenuation - the level of GC/PID response/sensitivity which can be adjusted by the user in response to changes in sample concentration.

7. VOC's - Volatile Organic Compounds

8. GC/PID - Gas Chromatograph with Photoionization detector. GC/PID is equipped with 1 ml gas sampling loop, which ensures repetitive sample volume injection.

Equipment Description: Equipment used in the standardization/calibration of GC -

1. Hamilton 1 ul and 5 ul syringes
2. Three volumetric (2 liter) static dilution flasks
3. HNU Model 321 GC/PID Controller
4. HNU Model 321 GC/PID: 1/8" stainless steel packed column, 5% SP-1200/1.75% Benton 34 on 100/120 Supelcoport (1-2134). Column temp: 5 min. @ 70 ^{O}C, then to 160 ^{O}C @ 5 ^{O}C/min. Flow rate: 23 ml/min., N2. Det.: Photoionization detector (PID) (11.7 eV).
5. Nelson Model 950 Intelligent Interface
6. Toshiba T1200 laptop computer (280K MS DOS), equipped with P.E. Nelson Model 2100 PC Integrator Chromatography Software, Revision 5.0.
7. Formatted 3.5" floppy diskettes.
8. Extension cord equipped with a voltage surge protector.
9. Nitrogen tank equipped with compression fittings and copper tubing for hook-up w/ GC.
10. Equimolar standard solutions (benzene, TCE and PCE - typically) or selected compounds which are expected to be encountered in the field.) The preparation of these standards can be found in the section entitled "Standard Preparation" in *VAPEX* SOP No. QA/QC-IIIA.
11. Hamilton 5 mL Gastight Syringe equipped with a teflon mininert valve and a removable needle.

Procedure:

1. The Gas Chromatograph is set up in the lab according to the procedure described in *VAPEX* SOP No. GC-OP; Sections 1 through 3.

2. The GC attenuation is set to the target level.

3. Three vapor standards (of known concentration) containing the selected compounds are prepared in static dilution flasks as described in *VAPEX* SOP No. GC-OP Section 3. The three standards are designed to allow calibration the GC over the linear range of the desired attenuation. The constituent concentration levels should reflect the lower, higher and intermediate values detectable within the given attenuation range. The concentrations of each standard is calculated in units of ppm, volume per volume.

4. Three samples of the least concentrated standard are injected and run on the GC as described below:

   i. Because chlorinated solvents are heavier than air, the flask should be agitated to assure that the standard/sample is homogeneous and that a representative sample can be withdrawn. Additionally, the sample flask is kept at room temperature, 70 ^{O}F.

   ii. A small aliquot of sample is withdrawn into the 5 mL Hamilton gastight syringe from the dilution flask (approx. 0.5-1 mL) and expelled into the hood. This is to purge the head volume of the needle with sample so as to prevent sample dilution.

iii. The syringe is once again inserted into the flask and a sample is withdrawn (approx. 1.5-3 mL).

iv. The needle is removed, and the sample is injected into the GC via the 1 mL sample loop.

v. Steps i-v are repeated for three (3) separate injections.

5. Step 4 is repeated for each standard in increasing concentration until all three standards (for a total of nine injections) have been run. Note: a blank may be injected after each standard/mixture to assure that component residuals do not adversely effect peak quantification.

6. Results of each sample analysis are downloaded by the Nelson Intelligent Interface into the computer and stored on the 3.5" floppy diskette.

7. Data analysis is performed as specified in *VAPEX's* Standard Operating Procedure No. GC-QA/QC-II.

References:

1. HNU Model 321 Gas Chromatograph Operator's Manual, Ver. 1.0; HNU Systems, Inc., Newton, Massachusetts.
2. P.E. Nelson 900 Series Intelligent Interface Operator's Manual; Perkin Elmer Nelson Systems, Inc., Cupertino, California.
3. P.E. Nelson PC Integrator User's Manual, Revision 5.0; Perkin Elmer Nelson Systems, Inc., Cupertino, California.
4. The Merck Index, 9th Ed.; Merck & Co., Inc., Rahway, New Jersey.

VAPEX ENVIRONMENTAL TECHNOLOGIES, INC.

STANDARD QA/QC OPERATING PROCEDURES (SOP)

DATA ANALYSIS AND STATISTICAL TREATMENT: AS APPLIED TO THE LABORATORY STANDARDIZATION OF HNU GAS CHROMATOGRAPH AND FIELD GENERATED DATA

VAPEX SOP NO. GC-QAQC-II

Purpose: To document a specific procedure for the analysis and statistical treatment of data generated by HNU Model 321 Gas Chromatograph during the laboratory and/or field standardization/calibration of the instrument.

Objectives: Describe the procedures and statistical methods of analysis used in the treatment of data as generated by the HNU Model 321 Gas Chromatograph. Procedures described here apply to both laboratory standardization and field-generated data. Also included is standard field QA/QC protocol.

Required Associated SOPs: Vapex SOP Nos. GC-OP and GC-QA/QC-I

Definitions:

1. area count (AC) - a measure of the area under a chromatographic peak as calculated by the PC Integrator. Area is directly proportional to molecular concentration.

2. Retention time (Rt) - the time it takes a compound to elute from the column and be detected. Each compound has a characteristic Rt and this Rt is used in identifying each compound.

Equipment Description: Equipment used in the analysis of GC data:

1. Toshiba T1200 laptop computer (280K MS DOS), equipped with P.E. Nelson Model 2100 PC Integrator Chromatography Software, Revision 5.0.
2. Computer data files from field and/or standardization of Gas Chromatograph.

Procedure: Laboratory

1. Consecutive injections of a given concentration are analyzed to assure that peak response parameters for each compound are statistically consistent: Area Counts (AC) and Retention times (Rt) are compared to see that response remains within 95 percent confidence level as defined as plus (+) or minus (-) two standard deviations as determined by a Student's T-test on replicate analyses.

2. The area counts for each calibration level (ppm concentration) within a given GC attenuation are averaged. The retention times for each component (Rt is not a function of the calibration level, but is an intrinsic property characteristic of each component) are averaged.

3. The averaged AC and Rt for each component are entered into the Nelson Chromatographic software along with other chromatographic parameters unique to the particular method being generated.

4. Once requirements in Step 1 are satisfied, the Nelson chromatographic software is used to generate calibration curves from which vapor concentrations from field data is calculated.

5. The linearity of the calibration curve is tested via linear regression. The calibration curve is rejected if the R-squared value is less than 95 percent.

6. Quality control standards are analyzed periodically and accepted if the relative standard deviation of the response factors is less than 10 percent of the anticipated value(s). New calibration curves are prepared when quality control limits are exceeded.

Procedure: Field

1. As described in *VAPEX* GC-OP, blanks are injected and analyzed at the start of each GC field round and no less frequently then every six field samples. Field duplicates are integrated into the sampling protocol - at least two duplicates per sampling round.

2. As described in Step 6 above, standards are injected at the beginning of each sampling round and periodically throughout a single day's operation.

Specific:

Further calibration in the field may be necessary if it is determined that: 1) detected field concentrations are outside the linear range of the established laboratory calibration curve for the given GC attenuation, and 2) will have an adverse effect on peak quantification. In this case, a new set of vapor standards must be prepared for the new expected range. Data analysis and generation of new calibration curve follow before analysis of field samples can resume.

References:

1. P.E. Nelson PC Integrator User's Manual, Revision 5.0; Perkin Elmer Nelson Systems, Inc., Cupertino, California.

2. Young, R., Lee, C., Statistical Methods of Analysis, 3rd. Ed., MacGraw-Hill, Inc., New York.

VAPEX ENVIRONMENTAL TECHNOLOGIES, INC.

STANDARD QA/QC OPERATING PROCEDURES (SOP)

PORTABLE TOTAL ORGANIC VAPOR ANALYZER CALIBRATION

VAPEX SOP NO.: TOVA-QAQC-I

Purpose: To establish an operating procedure for the laboratory and field calibration of the portable total organic vapor analyzers (TOVA) with prepared or pre-prepared standard samples of gaseous volatile organic compounds (VOC's).

Objectives: To outline techniques for the laboratory and field calibration of TOVAs and discuss methods for the assessment of instrument performance

This procedure is applicable to several portable total organic vapor analyzers, including the following:

- Foxboro Century Model 128 Organic Vapor Analyzer (OVA).
- Foxboro Century Model 108 Organic Vapor Analyzer (OVA).
- HNU Model HW-101 Total Organic Vapor Analyzer (PID).

The Foxboro OVAs are equipped with flame ionization detectors (FID). The PID is equipped with an 11.7 eV photoionization detector (PID).

LABORATORY CALIBRATION

NOTE: For procedures to START UP and OPERATE any of the Total instruments, refer to VAPEX SOP NO. ST-CHECK or the appropriate instrument operation manual.

PROCEDURE NO.1: Preparation of Standards from Liquid

Materials:

1. Three to five, 1-2 Liter Teflon or Tedlar gas sampling bags, each equipped with a sampling nozzle and gastight septum.
2. Sampling pump equipped with fresh tygon tubing.
3. 1, 5, 10 and 25 uL Hamilton syringes.
4. A sample of liquid benzene (FID) or perchloroethylene (PCE).
5. A 500 mL Hamilton gastight syringe.
6. Tygon tubing for attachment from bag to instrument.
7. TOVA
8. Computer with Lotus 123.

Procedure:

1. Line up all the Teflon/Tedlar bags on a clean table with the septa and nozzles closest to you. (Each Teflon bag is dedicated to one sample gas concentration level.)

2. Use the positive pressure from the sampling pump to fill each bag with clean air (test the quality of the air from the pump with an instrument to verify that the air is free of residual contamination). Use the vacuum side of the pump to flush the air out of the bag. Repeat this procedure a minimum of three times for each bag or until exhaust gas sampled and analyzed from the bag with a TOVA indicates no residual contamination.
3. Establish the number of calibration points (concentration) you expect to have (at least three, five to six is recommended). Target calibration concentration levels to test the instrument response over the range of the instrument and/or the range of each attenuation on the instrument.
4. For the first bag, calculate the number of microliters of liquid sample necessary to make up the desired vapor concentration.
5. Use the pump to pull a vacuum on the bag to completely empty the bag of any residual air - close the nozzle.
6. Fill the 500 mL Hamilton syringe with 500 mL of zero grade or contaminant-free ambient air.
7. Hook up the charged 500 mL syringe to the bag.
8. Open the bag nozzle and expel the 500 mL of air into the bag. With the syringe still hooked up to the bag, close the bag nozzle (Note: As a requirement for step 9, the idea is to fill the bag with volume sufficient to allow space for the insertion of the microliter syringe. The syringe must not accidently puncture the the other side of the bag).
9. Carefully extract the required liquid (standard) aliquot into the microliter syringe (for information on the techniques used for sampling of liquid samples with Hamilton microliter syringes, see VAPEX SOP No. GC-OP, Section 3: Sample Preparation); carefully and quickly insert the needle into the bag thru the septa and inject the sample.
10. Allow the sample to equilibrate for a period of 5-10 minutes.
11. While the bag equilibrates, turn on the TOVA and allow it to warm up.
12. Add another 500 mL (or the residual volume necessary for the final desired concentration) of air to the bag as described above.
13. Let the bag equilibrate for another 5 minutes.
14. Hook up the bag directly to the TOVA, open the bag nozzle and sample the air with the TOVA - record the instrument's response.
15. Repeat steps 4-14 for each calibration concentration level.
16. Flush out all the bags as described in 1 and 2 above and store them away.
17. Clean up all other materials.
18. Use Lotus 123 to generate a calibration curve and equation. Because TOVA's operate over a wide range of concentration, the resultant curve may not exactly conform linearly. This may be a result of the instrument's attenuation settings. Therefore, to attain linearity and to allow for a linear regression analysis, it may be necessary to analyze the data between attenuation settings and generate calibration curves for each attenuation. This is particularly relevant to the PID because of the effects of concentration on PID response as defined by Beer's law.
19. To verify the calibration curve, a test sample of known concentration is prepared and sampled by the instrument and its response is recorded and compared to the calibration curve. If the response does not agree with the calibration curve, repeat. If response discrepancies continue, the calibration curve or the instrument may be suspect. A new calibration curve should be generated.
20. The calibration data and data analysis should be recorded in the *Total Instrument Calibration Notebook* for future reference.

PROCEDURE NO.2: Scott Specialty Gas Benzene Standards

Note: Calibration of an instrument to any chemical other than benzene will require Procedure No.1.

Refer to Figure 1 for the following procedure.

Scott Specialty Benzene Gas Standards are pre-prepared benzene (in air) standards. Scott gases are accurate, reliable sources of calibrant gas for FID (occationally PID) calibration and can be used to calibrate the instrument in a very short time. Scott gases are stored in three large (AL-size) cylinders which are located in the back room along the far wall.

Materials:

1. Three AL-size cylinders of Scott Specialty benzene gas standard - each tank equipped with a Tedlar gas sampling bag.
2. Sampling pump equipped with fresh tygon tubing.
3. Tygon tubing for attachment from bag to instrument.
4. TOVA
5. Computer with Lotus 123.

Procedure:

1. Set a small section of 3/16 inch tygon tubing aside for use when connecting the FID probe to the gas sampling bag.
2. Remove the sample bag which is stored hanging above the gas cylinder and attach it to the cylinder regulator using a three to six inch length of tygon tubing - this should already be attached to the cylinder regulator. Make certain that the bag is completely emptied - you may wish to connect a sampling pump to the bag to evacuate any residual air.
3. With the bag connected to the regulator, open the sample bag valve. Two turns to the left will open bag sufficiently.
4. Open the middle regulator valve counter clockwise until it turns easily. When the regulator valve is turned in this fashion it is actually closing the valve off, so no gas can travel from the regulator valve to the fill valve and the bag.
5. Open the 51.7 ppm (or lowest concentration) cylinder by opening the screw valve on TOP of the CYLINDER. The pressure guage on top of the cylinder should read between 500 and 2000 psi.
6. Carefully begin to close the REGULATOR VALVE (clockwise) to pressurize the regulator. Note the incremental increase in pressure on the REGULATOR PRESSURE GUAGE. Continue pressurizing the regulator until approximately 10-20 psi has been achieved.
7. Shut the CYLINDER off by closing the CYLINDER VALVE at the TOP of the CYLINDER (leave the regulator pressurized).
8. Carefully begin to open the STOPCOCK VALVE and begin to fill up the sample bag. When the bag is NEAR full, close the STOPCOCK VALVE and simultaneously "open" the REGULATOR VALVE by turning it counter-clockwise.
9. Since the regulator flow has been shut off, the residual psi between the REGULATOR and the STOPCOCK can be emptied into the sample bag without danger of overfilling. Note that there may be some residual pressure between the REGULATOR and the CYLINDER - this is acceptable. If more standard is desired in the sampling bag, the residual pressure can be released into the bag by "closing" the REGULATOR

VALVE (clockwise) until it reads a maximum value. At this point, opening of the STOPCOCK will allow the residual pressure to escape into the bag.

10. Close the sample bag; close the STOPCOCK; "open" the REGULATOR VALVE (counter-clockwise).
11. The bag sample can now be analyzed with the total instrument.
12. Hook up the bag directly to the TOVA, open the bag nozzle and sample the air with the TOVA - record the instrument's response. The response should be close to the actual concentration of the gas. If it is not, the instrument may need adjusting - notify a person who is qualified to work on the instrument or if you think you understand the instrument, go to the section on Instrument Calibration Parameter Adjustments.
15. Repeat steps 2-12 for each Scott gas concentration level.
16. Flush out all the bags as described in steps 1 and 2 of Procedure No. 1 above and store them away.
17. Clean up all other materials.
18. Use Lotus 123 to generate a calibration curve and equation. Because TOVA's operate over a wide range of concentration, the resultant curve may not exactly conform linearly. This may be a result of the instrument's attenuation settings. Therefore, to attain linearity and to allow for a linear regression analysis, it may be necessary to analyze the data between attenuation settings and generate calibration curves for each attenuation. This is particularly relevant to the PID because of the effects of concentration on PID response as defined by Beer's law.
19. To verify the calibration curve, a test sample of known concentration is prepared and sampled by the instrument and its response is recorded and compared to the calibration curve. If the response does not agree with the calibration curve, repeat. If response discrepancies continue, the calibration curve or the instrument may be suspect. A new calibration curve should be generated.
20. The calibration data and data analysis should be recorded in the *Total Instrument Calibration Notebook* for future reference.

FIELD CALIBRATION

Empirical data indicates that the OVA 108 is the only TOVA whose performance deviates significantly on a regular basis. Such data warrents that a quick field QA test be performed on the 108 to ensure that it is operating within the bounds of the laboratory calibration. Since the other TOVAs are more consistent in their response, a field calibration is optional.

PROCEDURE NO.3: Field Calibration Check: OVA 108

The field calibration check is designed to allow a rapid, yet controlled, one-point QA evaluation of the response of the OVA 108; the response is evaluated for statistical consistency with the laboratory calibration. For calibration ponts above 1000 ppm, liquid benzene (described in Procedure No.1) is the only available alternative. Note: analysis by GC of Calgaz standards have determined Calgaz concentrations to be as much as 44 percent off the stated concentration. Therefore, if Calgaz is to be used, it must first be analyzed by GC to determine the correct concentration. Generally, unless the GC is already set up, it is easier to use liquid benzene.

1. Use the worksheet form in Figure 2 as a template to record all calculations and measurements. The worksheet has information on each of the chemicals on the back of the sheet to assist in calculations.

2. Determine the type of calibration procedure to apply (Calgaz or liquid sample). If liquid sample, refer to Procedure No.1 and Figure 2 for materials and explanations. For calibration with Calgaz, you will need the following materials:

1. One, 1-2 liter Tedlar gas sampling bag with valve.
2. Two feet of Tygon tubing
3. One cannister of 1,020 ppm benzene gas
4. TOVA: OVA or PID.
5. Field Notebook

Procedure:

1. Using a short section (approximately three to six inches) of Tygon tubing, connect the 1020 ppm benzene standard cannister to the on/off valve of the Tedlar bag.
2. Connect the small Calgaz cylinder regulator to the Calgaz cylinder and attach a clean Tedlar bag.
3. Fill the Tedlar bag with approximately one liter of the gas standard. Close the Calgaz cylinder, close the bag and disconnect the cannister from the regulator valve.
3. Connect the sampling probe of the TOVA to the Tedlar bag using a short section of Tygon tubing.
4. Record the total hydrocarbon reading from the instrument once a steady reading is observed.
5. Compare the instrument's response to the laboratory calibration data. Does it agree?
7. If the response is in agreement, clean up materials and record the result in the field notebook. If not, perform another calibration point (Procedure No.1) to verify the previous results. If this new calibration point is consistent with the prior sample, then a calibration adjustment may need to be performed - but the data obtained from the field calibration should be enough to delineate the instrument's performance.

Instrument Calibration Parameter Adjustments
OVA 108:

A. If the instrument response from above indicates an adjustment of the instrument's calibration parameters is necessary, fill up a sample bag with the higher concentration Scott gas as in Steps 2-11.
B. As the sample is being analyzed by the instrument, carefully adjust the "zero adjust screw" until the meter reading corresponds to the actual concentration of the sample.
C. Close the "Hydrogen Supply" valve and subsequently, the "Hydrogen Tank" valve.
D. When the FID has been extinguished (the meter will suddenly drop to zero), turn off the pump.
E. Move the "Calibrate Switch" to HIGH.
F. If the meter is not reading 10,000 (or 10X), unlock the "Gas Select" and adjust the span until the meter reads 10,000 (10X) corresponding to full scale deflection.

G. Lock in the "Gas Select" reading.
H. Report the latest changes into calibration notebook, making certain to record the new "Gas Select" setting.

OVA 128

A. After the instrument is in operation and the normal background is zeroed, draw a sample of the calibration gas into the instrument. The "Gas Select" knob is then used to adjust the probe meter to correspond to the concentration of the calibration gas.

B. The new "Gas Select" setting should be recorded.

HNU HW-101

A. After the instrument is in operation and the normal background is zeroed, draw a sample of the calibration gas into the instrument. Adjust the "Span Control" so the meter reading corresponds to the concentration of the standard vapor.

B. Turn the "Function Switch" back to the STANDBY position. Check and reset the zero setting if necessary. If this setting is changed, recheck the calibration setting.

Note: If the span setting resulting from the calibration is 0.0 or if the calibration cannot be achieved, then the PID lamp may need cleaning. Under such conditions, inform a person who is qualified to work on these instruments - do not attempt to take apart the instrument.

APPENDIX C

CHROMATOGRAM INDEX

CHROMATOGRAMS

a. Vacuum Well Ex1 - Ex11
b. Vacuum Well Ex12 - Ex15
c. Blanks
d. Standards

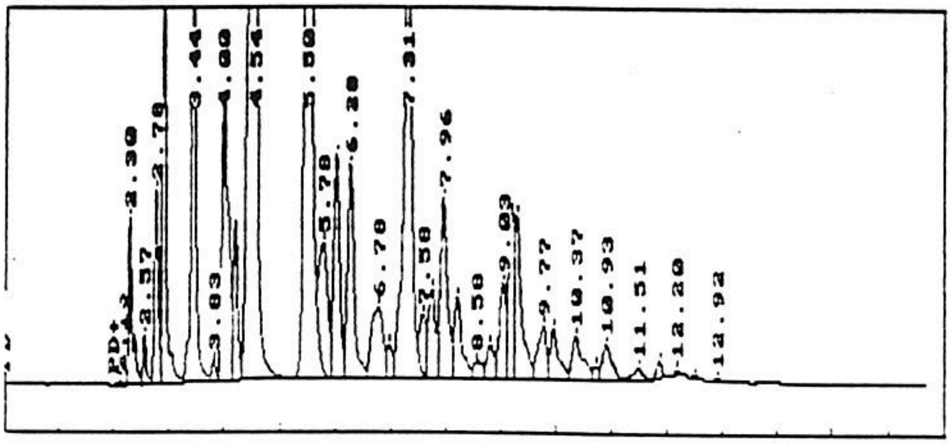
RETENTION TIME (Rt) INDEX^

	COMPOUND	**ABBREVIATION**	**Rt (min)**
1.	methylchloride	MC	2.97
2.	methylethyl ketone	MEK	3.51
3.	benzene	Benz	4.85
4.	toluene	Tol	7.71
5.	ethylbenzene	EB	10.73
6.	m-xylene	m-xy	10.77

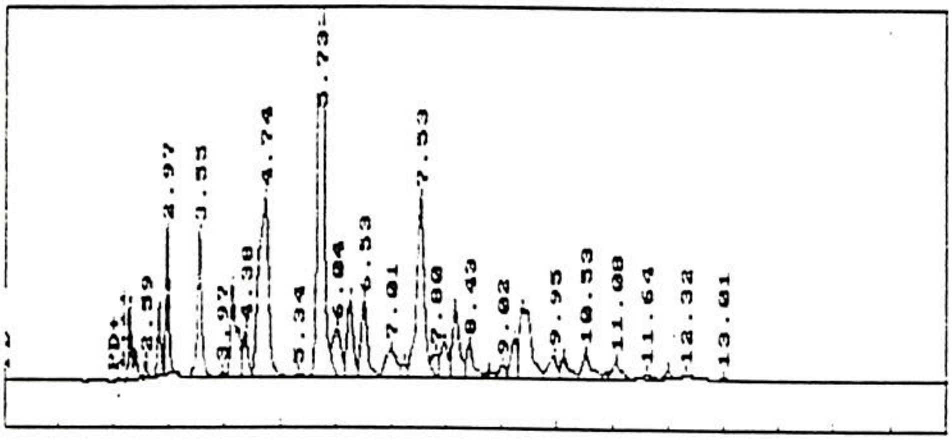
^ Retention times may differ with each run. The Rt index is an average of all the field standard Rts.

A. Vacuum Well #1 Ex1 - Ex11
(5cfm)

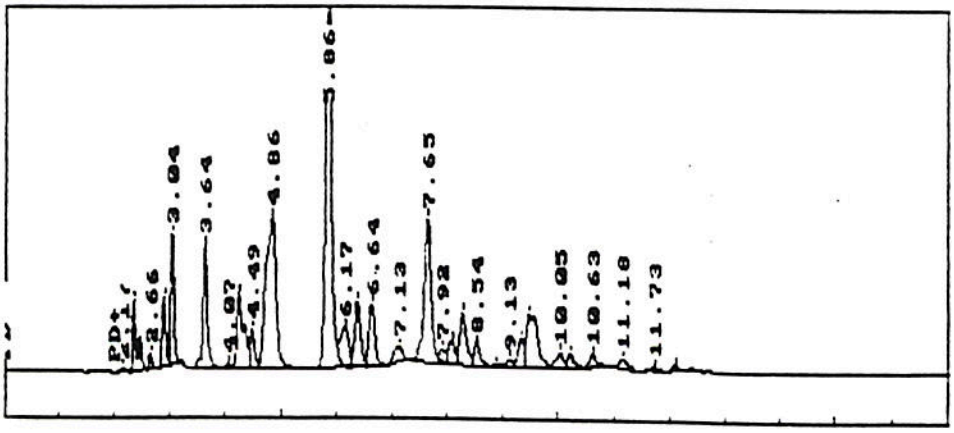
:ta File = B:ex1.PTS Printed on 09-25-1990 at 13:41:05
:art time: 0.00 min. Stop time: 17.00 min.   Offset: 20 mv.
:il Range: 200 millivolts



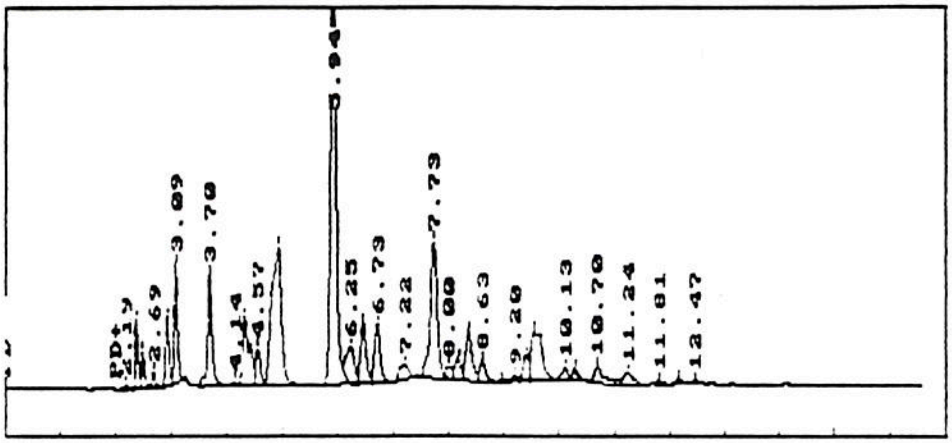
:ta File = B:ex2.PTS Printed on 09-25-1990 at 13:44:53
:art time: 0.00 min. Stop time: 17.00 min.   Offset: 20 mv.
:il Range: 200 millivolts



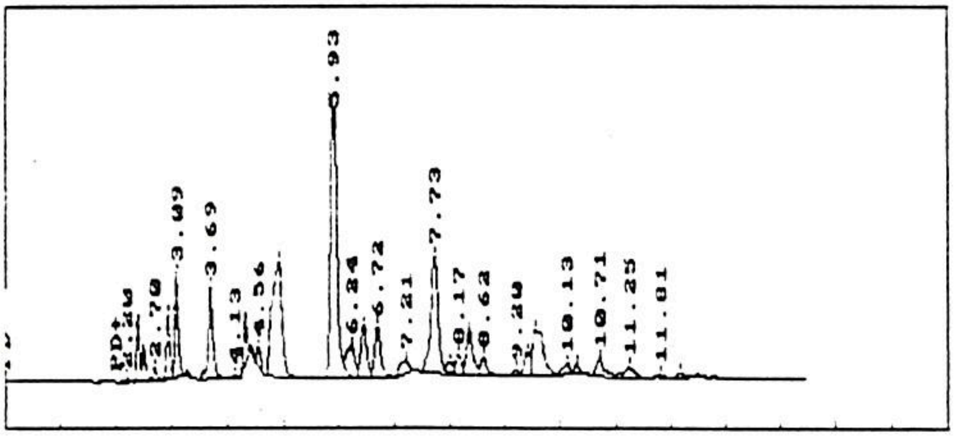
:ot of data file: B:ex3.PTS
:te: 09-25-1990   Time: 13:46:17
:mple Name: Ex.#3 100uL   H8
:art Time=   0.01Stop Time = 17.01Min. Scale= 24331Max. Scale= 224331



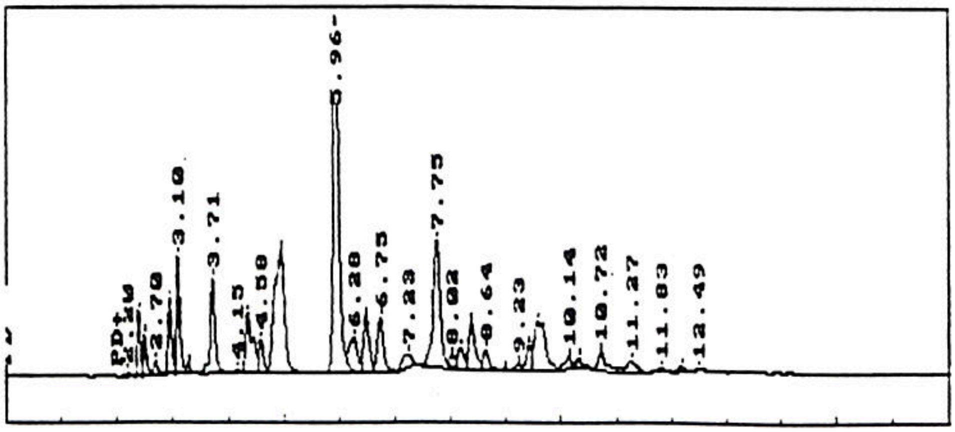
```
ata File = B:ex4.PTS  Printed on 09-25-1990 at 13:49:20
art time:    0.00 min.  Stop time:   17.00 min.      Offset:  20 mv.
il Range:  200  millivolts
```



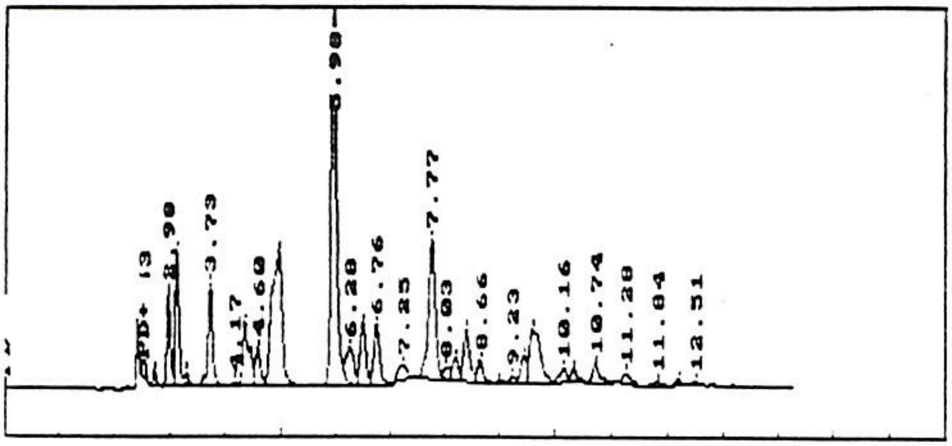
```
ata File = B:ex5.PTS  Printed on 09-25-1990 at 13:52:02
art time:    0.00 min.  Stop time:   17.00 min.      Offset:  20 mv.
il Range:  200  millivolts
```



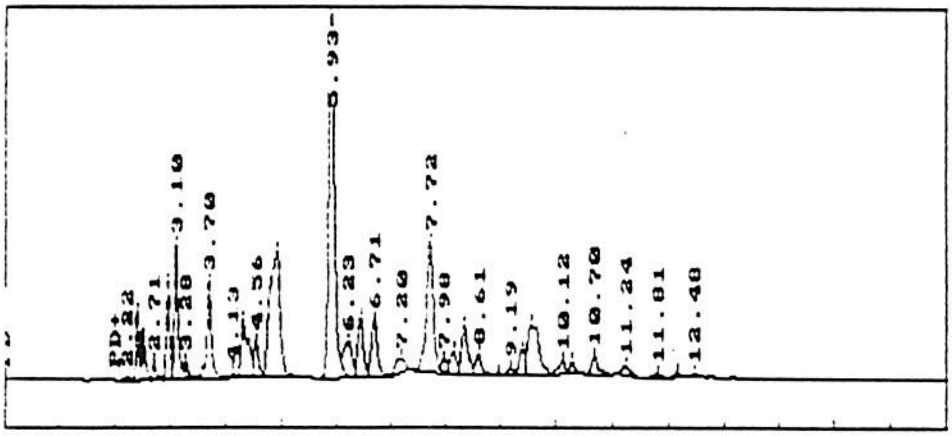
```
ata File = B:ex6.PTS  Printed on 09-25-1990 at 13:53:47
art time:    0.00 min.  Stop time:   17.00 min.      Offset:  20 mv.
il Range:  200  millivolts
```



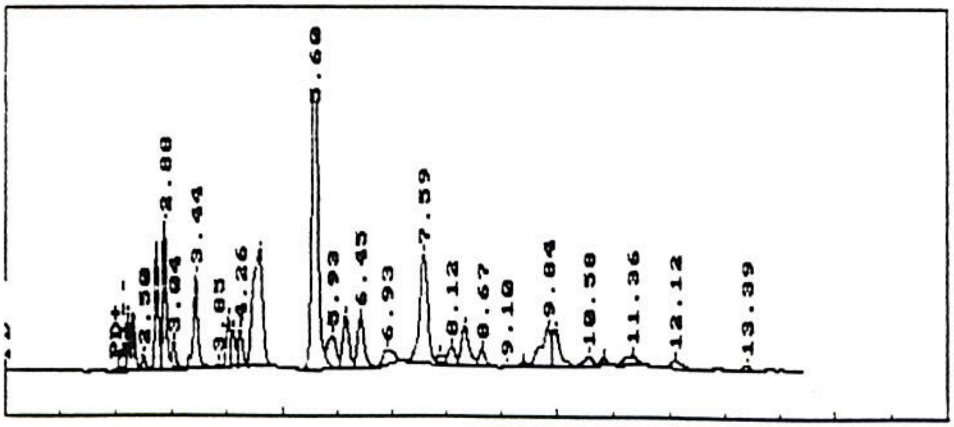
ta File = B:ex7.PTS Printed on 09-25-1990 at 13:55:29
art time: 0.00 min. Stop time: 17.00 min. Offset: 20 mv.
l Range: 200 millivolts



ta File = B:ex8.PTS Printed on 09-25-1990 at 13:57:46
art time: 0.00 min. Stop time: 17.00 min. Offset: 20 mv.
l Range: 200 millivolts

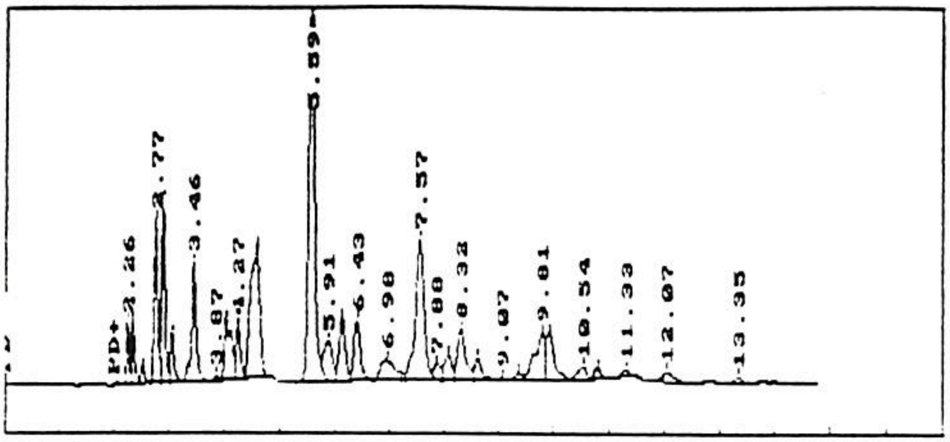


ta File = B:ex9.PTS Printed on 09-25-1990 at 14:01:34
art time: 0.00 min. Stop time: 17.00 min. Offset: 20 mv.
l Range: 200 millivolts

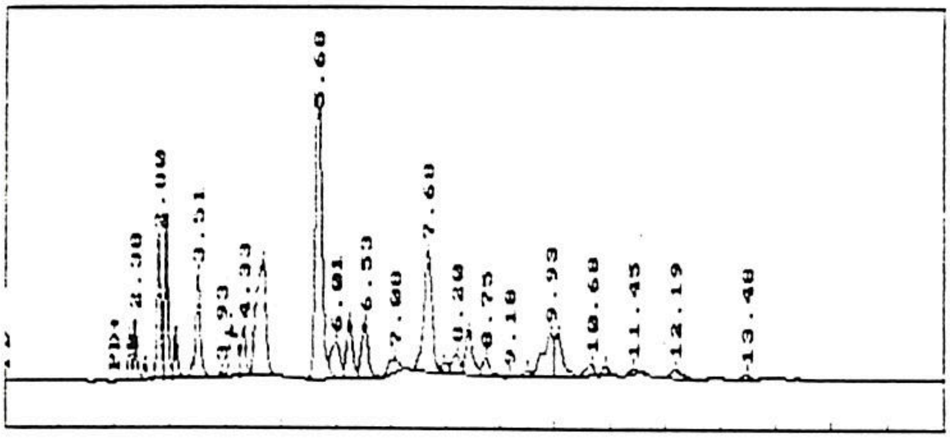


B. Vacuum Well #1 Ex12 - Ex15
(7cfm)

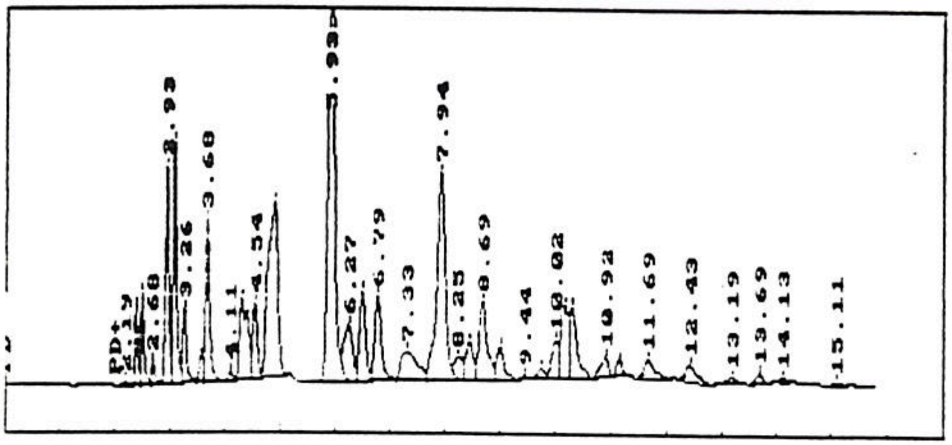
ata File = A:ex10.PTS Printed on 10-03-1990 at 10:37:21
tart time: 0.00 min. Stop time: 17.00 min.   Offset: 20 mv.
ll Range: 200 millivolts



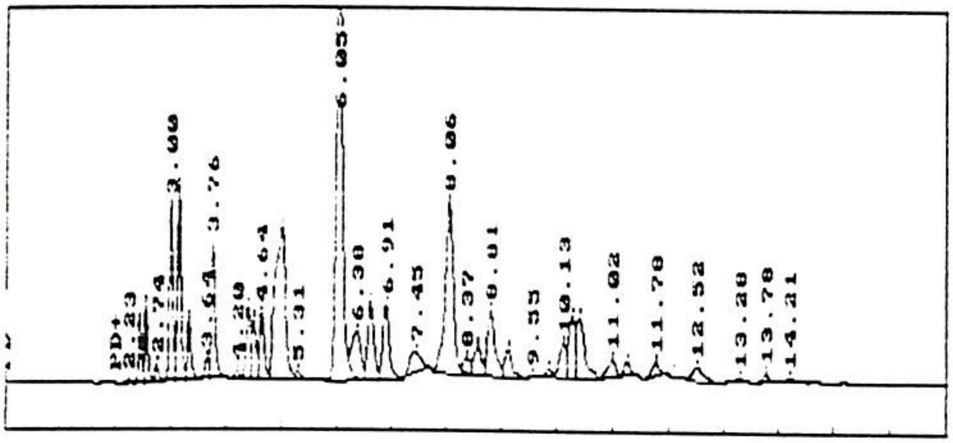
ata File = A:exi1.PTS Printed on 10-03-1990 at 10:38:30
tart time: 0.00 min. Stop time: 17.00 min.   Offset: 20 mv.
ll Range: 200 millivolts



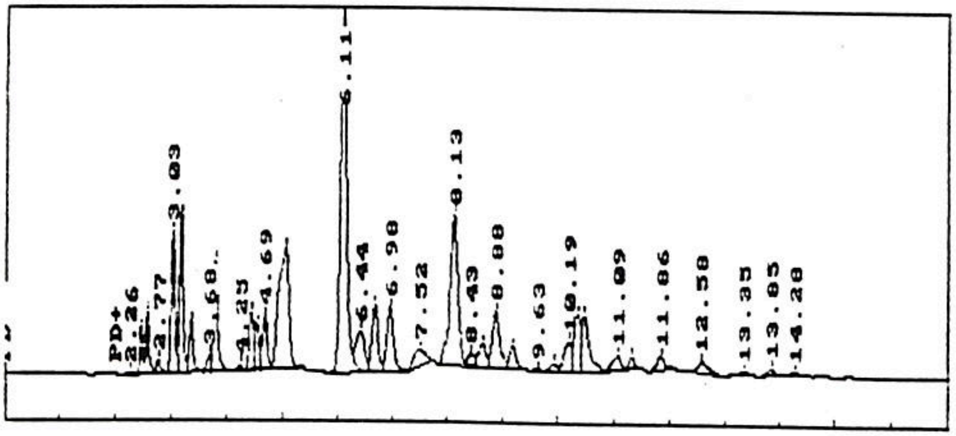
ta File = A:ex12.PTS Printed on 10-03-1990 at 10:28:45
art time: 0.00 min. Stop time: 17.00 min.   Offset: 20 mv.
il Range: 200 millivolts



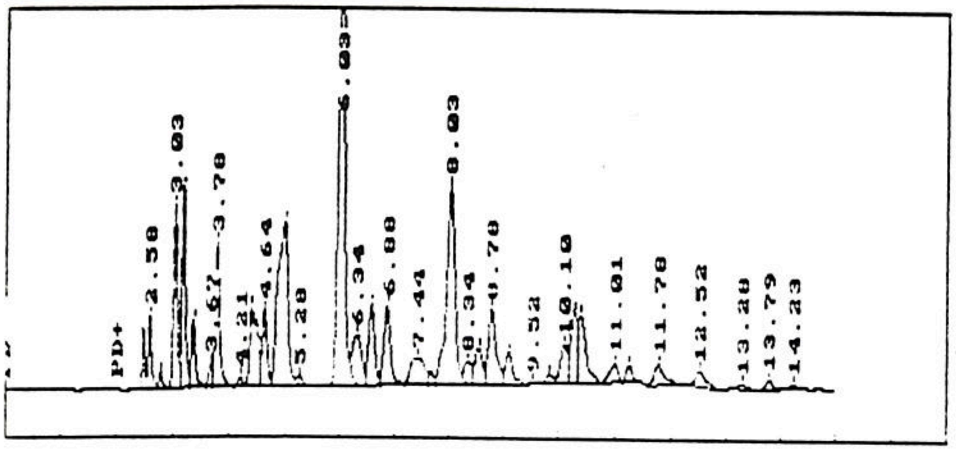
ta File = A:ex13.PTS Printed on 10-03-1990 at 10:30:00
art time: 0.00 min. Stop time: 17.00 min.   Offset: 20 mv.
il Range: 200 millivolts



ta File = A:ex14.PTS Printed on 10-03-1990 at 10:31:30
art time: 0.00 min. Stop time: 17.00 min.   Offset: 20 mv.
il Range: 200 millivolts

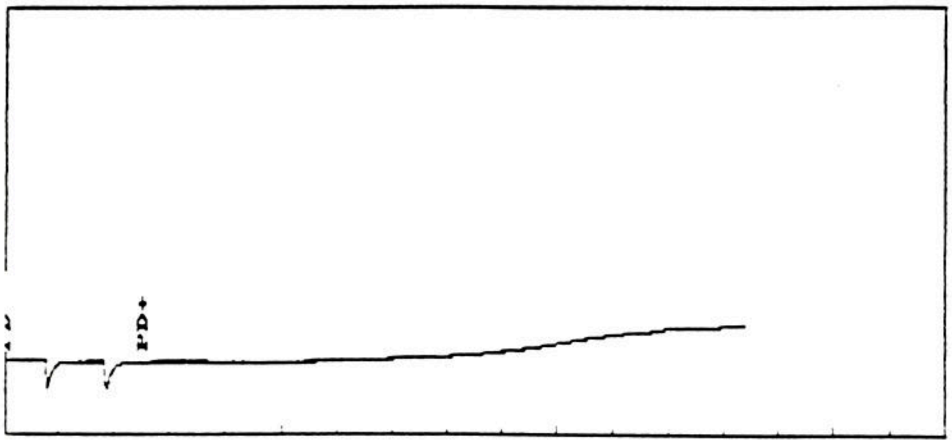


ta File = A:ex15.PTS Printed on 10-03-1990 at 10:33:05
art time: 0.00 min. Stop time: 17.00 min. Offset: 20 mv.
ll Range: 200 millivolts

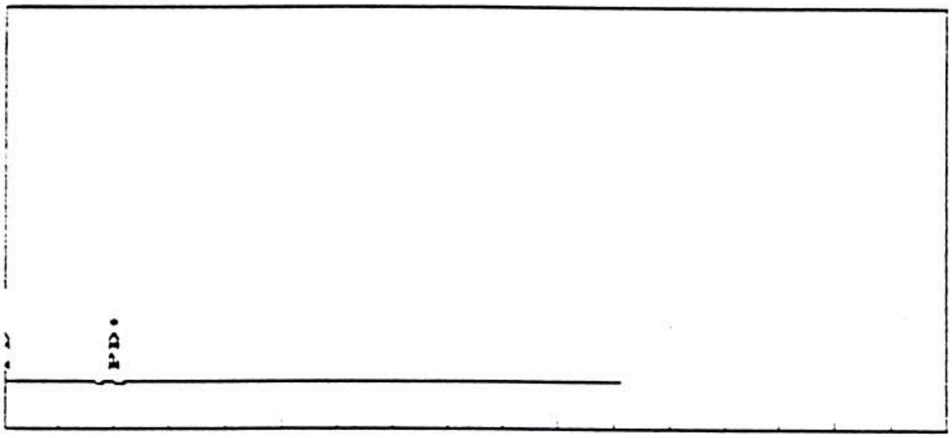


C. Blanks

ata File = A:blk1.PTS Printed on 10-03-1990 at 11:19:36
tart time: 0.00 min. Stop time: 17.00 min.   Offset: 20 mv.
ill Range: 200 millivolts

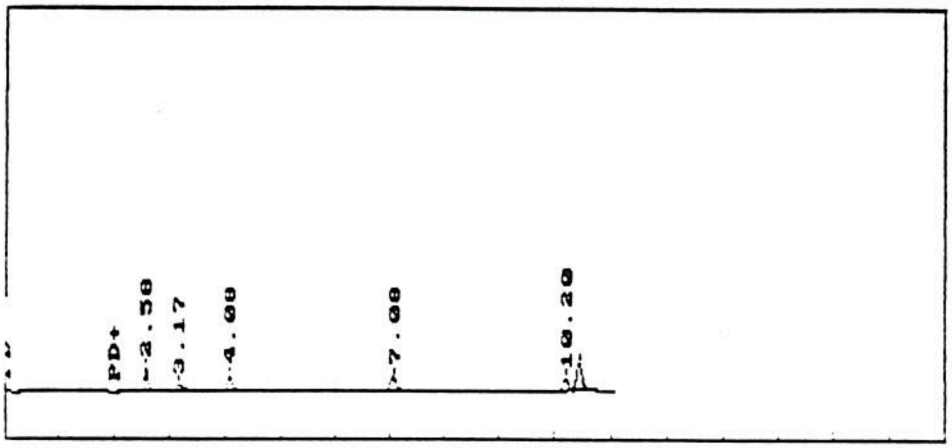


ata File = A:blk2.PTS Printed on 10-03-1990 at 11:20:51
tart time: 0.00 min. Stop time: 17.00 min.   Offset: 20 mv.
ill Range: 200 millivolts

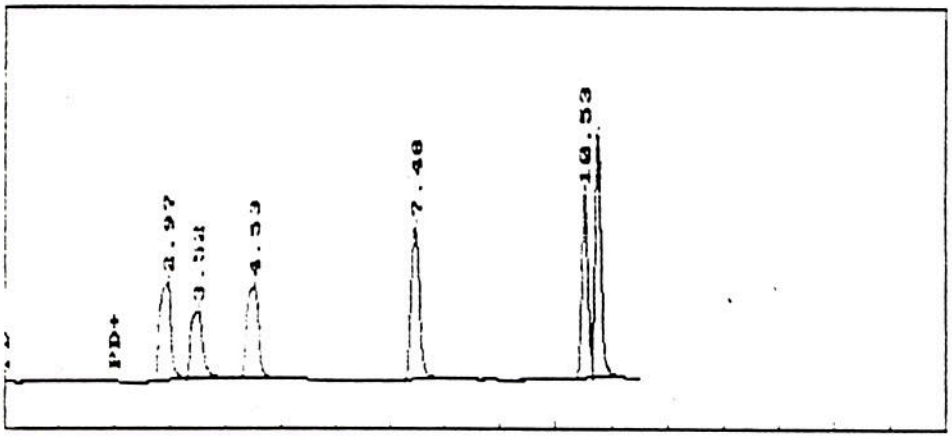


D. Standards

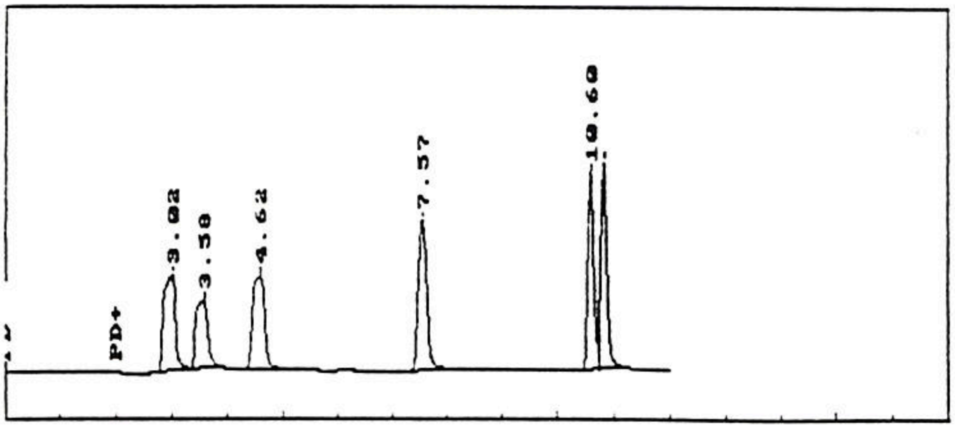
```
ta File = A:stda-1.PTS  Printed on 10-03-1990 at 11:26:38
art time:    0.00 min.  Stop time:   17.00 min.     Offset:  20 mv.
il Range:  200  millivolts
```



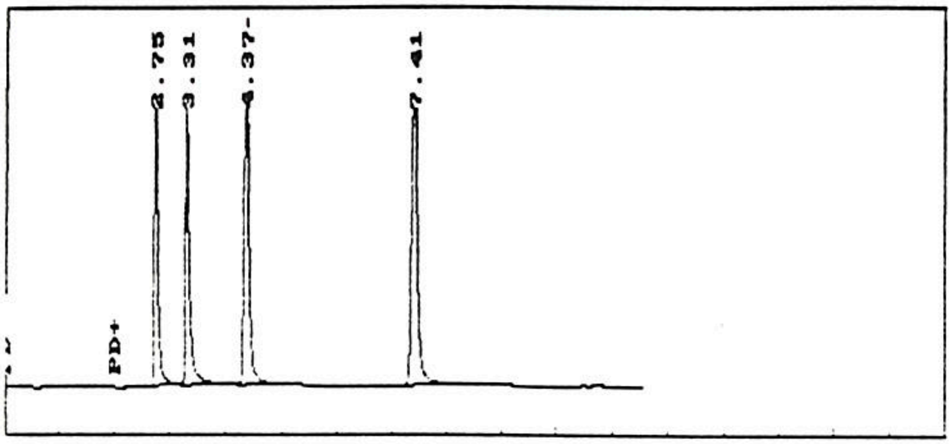
```
ta File = A:stda-2.PTS  Printed on 10-03-1990 at 11:27:34
art time:    0.00 min.  Stop time:   17.00 min.     Offset:  20 mv.
il Range:  200  millivolts
```



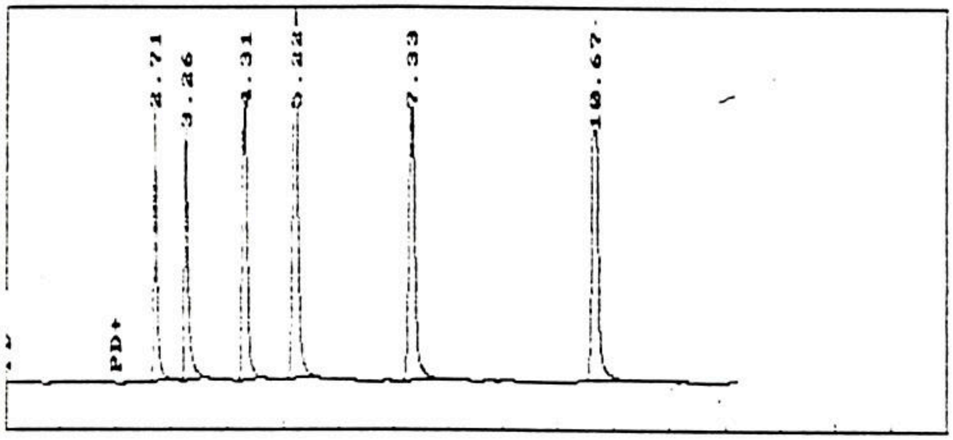
```
ta File = A:stda-3.PTS  Printed on 10-03-1990 at 11:28:40
art time:    0.00 min.  Stop time:   17.00 min.     Offset:  20 mv.
l Range:  200  millivolts
```



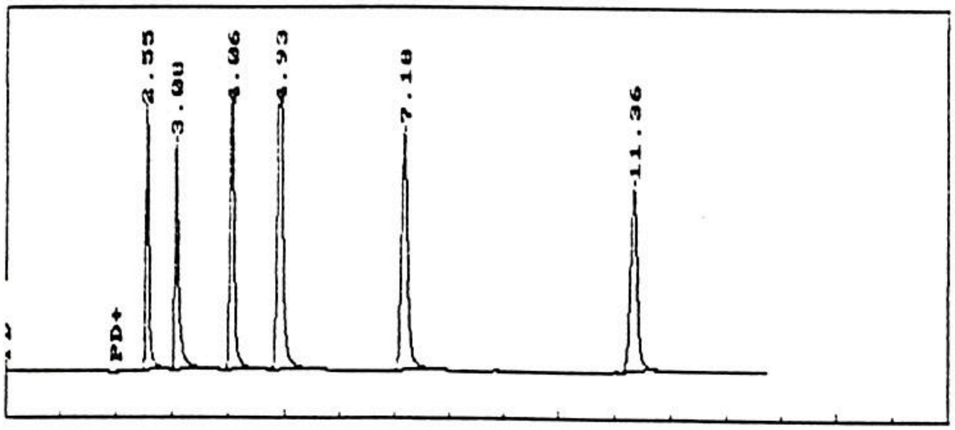
```
ata File = A:stdb-1.PTS  Printed on 10-03-1990 at 11:29:55
tart time:    0.00 min.  Stop time:   17.00 min.    Offset:  20 mv.
ull Range:  200  millivolts
```



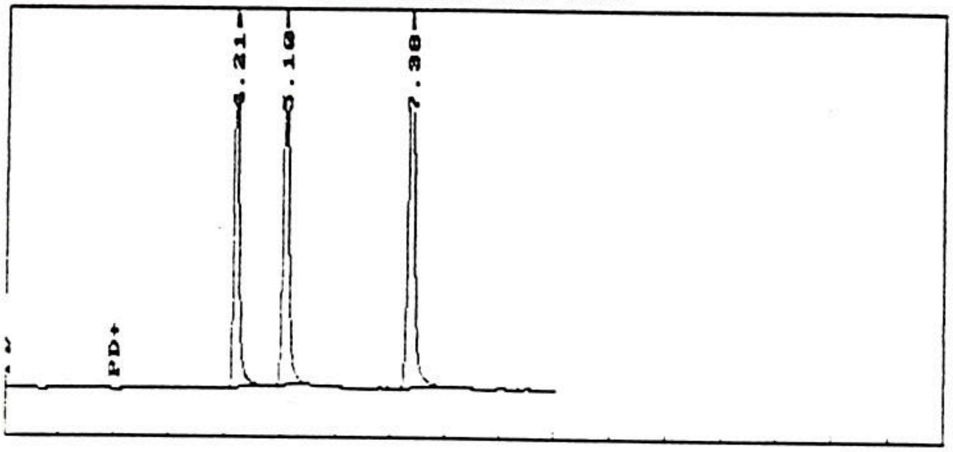
```
ata File = A:stdb-2.PTS  Printed on 10-03-1990 at 11:31:07
tart time:    0.00 min.  Stop time:   17.00 min.    Offset:  20 mv.
ll Range:  200  millivolts
```



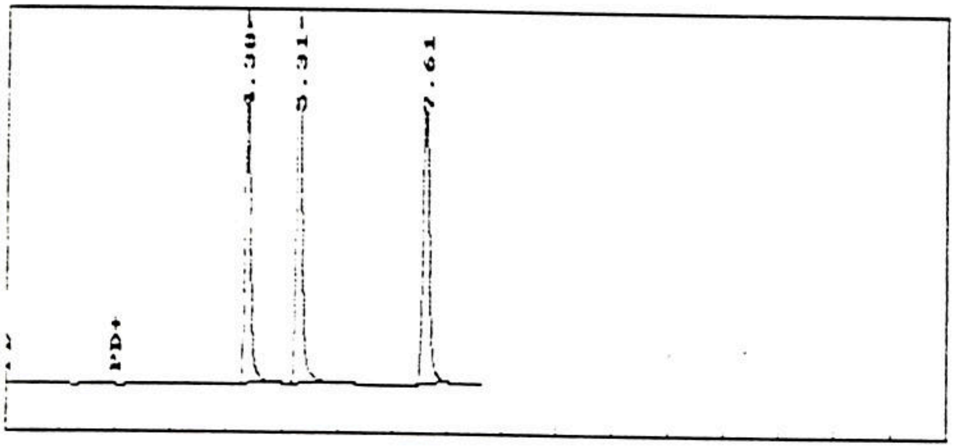
```
ata File = A:stdb-3.PTS  Printed on 10-03-1990 at 11:32:05
tart time:    0.00 min.  Stop time:   17.00 min.    Offset:  20 mv.
ll Range:  200  millivolts
```



ot of data file: A:stdc-1.PTS
te: 10-03-1990   Time: 11:33:14
mple Name: Std C #1   H8
rt Time=   0.01Stop Time = 17.01Min. Scale= 24799Max. Scale= 224799



ta File = A:stdc-2.PTS Printed on 10-03-1990 at 11:34:10
rt time: 0.00 min. Stop time: 17.00 min.   Offset: 20 mv.
l Range: 200 millivolts



APPENDIX D

DETAILED CHRONOLOGICAL DESCRIPTION OF ACTIVITIES

VAPEX performed soil vapor extraction feasibility tests for Malcolm Pirnie, Inc. in Minetto, NY during the week of September 14, 1990. The scope of the tests included the following:

September 11

1. Set up the HNU Gas Chromatograph Model 321, equipped with an 11.7 eV photoionization detector (GC).
2. Sealed test pit in vacinity of extraction well with sheet polyethylene.
3. Set up 20 cfm rotary vaned vacuum pump (20 cfm pump) at extraction well. Pump soil vapor discharge was manifolded to 2 carbon drums in series prior to venting to ambient air.

September 12

1. Measured background vacuum pressure and obtained soil vapor samples from vapor probes and analyzed using Thermo Environmental 580B with 11.8 eV lamp.
2. Initiated 5 cfm test at 10:30 a.m.. Soil vapor discharge samples (pre and post carbon), vacuum pressure measurements (at the wellhead and vapor probes) and ground water elevations (at monitoring wells and piezometer locations) were obtained periodically throughout the test. Vapor samples were analyzed using the PID and the GC.

September 13

1. Conducted final round of vacuum pressure monitoring and obtained final discharge samples for the 5 cfm flow rate test. Terminated 5cfm test at 10:30 a.m. and bailed extraction well of all accumulated water.
2. Initiated 7 cfm test at 12:08 p.m. Soil vapor discharge samples (pre and post carbon), vacuum pressure measurements (at the wellhead and vapor probes) and ground water elevations (at monitoring wells and piezometer locations) were obtained periodically throughout the test. Vapor samples were analyzed using the PID and the GC. Extraction well was bailed of accumulated water periodically to maintain desired vacuum and flow rate.
3. Conducted final round of vacuum pressure monitoring and obtained final discharge samples for the 7 cfm flow rate test. Terminated 7 cfm test at 4:30 p.m..

September 14

1. Demobilized equipment. Carbon drums left on site.
2. VAPEX personnel left site at 10:00 a.m..

APPENDIX E

SOILVENT.XLS

Soil Venting Data Sheet		
Sample Name : Vapex Job 90-127		
Soil Column Diameter (cm):	7.6	
Packing Length(cm):	33.0	
Packing Volume (ml):	1496.3	
Packing Density (g/ml):	1.7	
Mass of Soil Before Venting(g)	2618	
Mass of Soil After Venting(g)	2370	
Concentration* before Venting(mg/kg)	68.5	
Concentration* after Venting(mg/kg)	1	
Moisture before venting (%)	17	
Moisture after venting (%)	5.6	
*concentration is calculated as dimethyl cyclohexane		
Permiability Data		
air flow rate ml/min	Flow rate	Pressure
pressure difference (between 20.5 cm	50	3.1
soil in the colume) as cm water	100	4
	150	5.2
	200	6.4
	250	7.5

Soil Venting Data

Date Received: Date Analyzed:

DATE	TIME	GC File	Volume ml	Peak Area	Amount ug	Flow ml/min
09/20	9:25	#285	2.50	8.3E6	0.1038	100
09/21	9:01	#295	2.50	24.6E6	0.3495	100
09/21	16:22	#307	2.50	24.5E6	0.3079	100
09/22	14:40	#316	2.50	24.2E6	0.3044	100
09/23	10:07	#317	2.50	21.0E6	0.2636	100
09/23	18:04	#318	2.50	20.0E6	0.2506	100
09/24	9:01	#319	2.50	17.6E6	0.2214	100
09/24	16:13	#321	2.50	16.4E6	0.2059	100
09/25	9:02	#322	2.50	12.2E6	0.1532	100
09/25	15:17	#323	2.50	12.4E6	0.1562	100
09/26	9:13	#324	2.50	8.96E6	0.1125	100
09/26	14:47	#325	2.50	7.78E6	0.0977	100
09/27	9:09	#327	2.50	4.80E6	0.0603	100
09/27	15:12	#328	2.50	4.51E6	0.0567	100
09/28	9:18	#329	2.50	2.15E6	0.0270	100
10/01	12:01	#334	2.50	0.57E6	0.0071	100

The Summary of the GCMS Analyses

Samples of the soil before venting and after venting were analyzed for volatile organic compounds and semi-volatile organic compounds. All the target compounds listed in the volatile and semi-volatile data sheets have been analyzed. None of those target compounds has been found above its detection limit. In the total ion chromatograms for volatile organic (VOC6A31A and VOC6A32A), many peaks are found. According to the spectra search results, these compounds are tentatively identified as C_7 to C_9 hydrocarbon. The example of the tentative identification are as following:

Retention Time (min.)	Compound
9.8 to 9.9	methyl cyclohexane
10.5 to 10.6	trimethyl cyclopetane
12.3 to 12.5	dimethyl cyclohexane
15.0 to 15.5	trimethyl cyclohexane

The ratios of peak height for same compound before and after venting are about 200 to 6.

GCMS VOLATILE ORGANICS ANALYSIS DATA SHEET

Sample ID: VAPEX Job127 Before Venting
Matrix (soil/water): Soil
Level (Low/High): Low
Dilution Factor: 4

Report File ID:VP127VC1
Data File ID: VOV6A32A
Date Received: 09/17/90
Date Analyzed: 10/02/90
Date Reported: 10/18/90

CAS NO .	COMPOUND	CONCENTRATION ug/kg	Q*
74-78-3	Chloromethane	< 50	U
74-83-9	Bromomethane	< 50	U
75-01-4	Vinyl Chloride	< 50	U
75-00-3	Chloroethane	< 50	U
75-09-2	Methylene Chloride	< 25	U
67-64-1	Acetone	< 50	U
75-15-0	Carbon Disulfide	< 50	U
75-35-4	1,1-dichloroethene	< 25	U
75-34-3	1,1-dichloroethane	< 25	U
540-59-0	1,2-Dichloroethene (total)	< 25	U
67-66-3	Chloroform	< 25	U
107-06-2	1,2-Dichloroethane	< 25	U
78-93-3	2-Butanone	< 50	U
71-55-6	1,1,1-Trichloroethane	< 25	U
56-23-5	Carbon Tetrachloride	< 25	U
108-05-4	Vinyl Acetate	< 50	U
75-27-4	Bromodichloromethane	< 25	U
78-87-5	1,2-Dichloropropane	< 25	U
10061-01-5	cis-1,3-Dichlorpropene	< 25	U
79-01-6	Trichloroethene	< 25	U
124-48-1	Dibromochloromethane	< 25	U
79-00-5	1,1,2-Trichloroethane	< 25	U
71-43-2	Benzene	< 25	U
10061-02-6	trans-1,3-Dichloropropene	< 25	U
75-25-2	Bromoform	< 25	U
108-10-1	4-Mehtyl-2-Pentanone	< 50	U
591-78-6	2-Hexanone	< 50	U
127-18-4	Tetrachloroethene	< 25	U
79-34-5	1,1,2,2-Tetrachloroethane	< 25	U
108-88-3	Toluene	< 25	U
108-90-7	Chlorobenzene	< 25	U
100-41-4	Ethylbenzen	< 25	U
100-42-5	Styrene	< 25	U
1330-20-7	Xylene (total)	< 25	U

U - Indicates the analyte was analyzed for but below the detection limit.

GCMS VOLATILE ORGANICS ANALYSIS DATA SHEET

Sample ID: VAPEX Job127 After Venting
Matrix (soil/water): Soil
Level (Low/High): Low
Dilution Factor: 4

Report File ID:VP127VC2
Data File ID: VOV6A31A
Date Received: 09/17/90
Date Analyzed: 10/02/90
Date Reported: 10/18/90

CAS NO .	COMPOUND	CONCENTRATION ug/kg	Q*
74-78-3	Chloromethane	< 50	U
74-83-9	Bromomethane	< 50	U
75-01-4	Vinyl Chloride	< 50	U
75-00-3	Chloroethane	< 50	U
75-09-2	Methylene Chloride	< 25	U
67-64-1	Acetone	< 50	U
75-15-0	Carbon Disulfide	< 50	U
75-35-4	1,1-dichloroethene	< 25	U
75-34-3	1,1-dichloroethane	< 25	U
540-59-0	1,2-Dichloroethene (total)	< 25	U
67-66-3	Chloroform	< 25	U
107-06-2	1,2-Dichloroethane	< 25	U
78-93-3	2-Butanone	< 50	U
71-55-6	1,1,1-Trichloroethane	< 25	U
56-23-5	Carbon Tetrachloride	< 25	U
108-05-4	Vinyl Acetate	< 50	U
75-27-4	Bromodichloromethane	< 25	U
78-87-5	1,2-Dichloropropane	< 25	U
10061-01-5	cis-1,3-Dichlorpropene	< 25	U
79-01-6	Trichloroethene	< 25	U
124-48-1	Dibromochloromethane	< 25	U
79-00-5	1,1,2-Trichloroethane	< 25	U
71-43-2	Benzene	< 25	U
10061-02-6	trans-1,3-Dichloropropene	< 25	U
75-25-2	Bromoform	< 25	U
108-10-1	4-Mehtyl-2-Pentanone	< 50	U
591-78-6	2-Hexanone	< 50	U
127-18-4	Tetrachloroethene	< 25	U
79-34-5	1,1,2,2-Tetrachloroethane	< 25	U
108-88-3	Toluene	< 25	U
108-90-7	Chlorobenzene	< 25	U
100-41-4	Ethylbenzen	< 25	U
100-42-5	Styrene	< 25	U
1330-20-7	Xylene (total)	< 25	U

U - Indicates the analyte was analyzed for but below the detection limit.

GCMS VOLATILE ORGANICS ANALYSIS DATA SHEET

Sample ID: VAPEX Job127 Before Venting
Matrix (soil/water): Soil
Level (Low/High): Low
Dilution Factor: 4

Report File ID: VP127VC1
Data File ID: VOV6A32A
Date Received: 09/17/90
Date Analyzed: 10/02/90
Date Reported: 10/18/90

CAS NO .	COMPOUND	CONCENTRATION ug/kg	Q*
74-78-3	Chloromethane	< 50	U
74-83-9	Bromomethane	< 50	U
75-01-4	Vinyl Chloride	< 50	U
75-00-3	Chloroethane	< 50	U
75-09-2	Methylene Chloride	< 25	U
67-64-1	Acetone	< 50	U
75-15-0	Carbon Disulfide	< 50	U
75-35-4	1,1-dichloroethene	< 25	U
75-34-3	1,1-dichloroethane	< 25	U
540-59-0	1,2-Dichloroethene (total)	< 25	U
67-66-3	Chloroform	< 25	U
107-06-2	1,2-Dichloroethane	< 25	U
78-93-3	2-Butanone	< 50	U
71-55-6	1,1,1-Trichloroethane	< 25	U
56-23-5	Carbon Tetrachloride	< 25	U
108-05-4	Vinyl Acetate	< 50	U
75-27-4	Bromodichloromethane	< 25	U
78-87-5	1,2-Dichloropropane	< 25	U
10061-01-5	cis-1,3-Dichlorpropene	< 25	U
79-01-6	Trichloroethene	< 25	U
124-48-1	Dibromochloromethane	< 25	U
79-00-5	1,1,2-Trichloroethane	< 25	U
71-43-2	Benzene	< 25	U
10061-02-6	trans-1,3-Dichloropropene	< 25	U
75-25-2	Bromoform	< 25	U
108-10-1	4-Mehtyl-2-Pentanone	< 50	U
591-78-6	2-Hexanone	< 50	U
127-18-4	Tetrachloroethene	< 25	U
79-34-5	1,1,2,2-Tetrachloroethane	< 25	U
108-88-3	Toluene	< 25	U
108-90-7	Chlorobenzene	< 25	U
100-41-4	Ethylbenzen	< 25	U
100-42-5	Styrene	< 25	U
1330-20-7	Xylene (total)	< 25	U

U - Indicates the analyte was analyzed for but low than detection limit.

GCMS VOLATILE ORGANICS ANALYSIS DATA SHEET

Sample ID: VAPEX Job127 After Venting
Matrix (soil/water): Soil
Level (Low/High): Low
Dilution Factor: 4

Report File ID:VP127VC2
Data File ID: VOV6A31A
Date Received: 09/17/90
Date Analyzed: 10/02/90
Date Reported: 10/18/90

CAS NO .	COMPOUND	CONCENTRATION ug/kg	Q*
74-78-3	Chloromethane	< 50	U
74-83-9	Bromomethane	< 50	U
75-01-4	Vinyl Chloride	< 50	U
75-00-3	Chloroethane	< 50	U
75-09-2	Methylene Chloride	< 25	U
67-64-1	Acetone	< 50	U
75-15-0	Carbon Disulfide	< 50	U
75-35-4	1,1-dichloroethene	< 25	U
75-34-3	1,1-dichloroethane	< 25	U
540-59-0	1,2-Dichloroethene (total)	< 25	U
67-66-3	Chloroform	< 25	U
107-06-2	1,2-Dichloroethane	< 25	U
78-93-3	2-Butanone	< 50	U
71-55-6	1,1,1-Trichloroethane	< 25	U
56-23-5	Carbon Tetrachloride	< 25	U
108-05-4	Vinyl Acetate	< 50	U
75-27-4	Bromodichloromethane	< 25	U
78-87-5	1,2-Dichloropropane	< 25	U
10061-01-5	cis-1,3-Dichlorpropene	< 25	U
79-01-6	Trichloroethene	< 25	U
124-48-1	Dibromochloromethane	< 25	U
79-00-5	1,1,2-Trichloroethane	< 25	U
71-43-2	Benzene	< 25	U
10061-02-6	trans-1,3-Dichloropropene	< 25	U
75-25-2	Bromoform	< 25	U
108-10-1	4-Mehtyl-2-Pentanone	< 50	U
591-78-6	2-Hexanone	< 50	U
127-18-4	Tetrachloroethene	< 25	U
79-34-5	1,1,2,2-Tetrachloroethane	< 25	U
108-88-3	Toluene	< 25	U
108-90-7	Chlorobenzene	< 25	U
100-41-4	Ethylbenzen	< 25	U
100-42-5	Styrene	< 25	U
1330-20-7	Xylene (total)	< 25	U

U - Indicates the analyte was analyzed for but low than detection limit.

GCMS SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

Sample ID: VAPEX Job# 90-127
Before Venting
Matrix: (soil/water): soil
level: (low/med) low
% Moisture: 17
Extraction: hexane-acetone (1+1)
GPC Cleanup: (Y/N) N

Report File ID: VP127SV1
Lab File ID: BNA1A20A
Date Received: 09-17-90
Date Extracted: 09-19-89
Date Analyzed: 10-11-89

CAS NO .	COMPOUND	CONCENTRATION(ug/kg)	Q
108-95-2	Phenol	< 330	U
111-44-4	bis(2-Chlorophenol)ether	< 330	U
95-57-8	2-Chlorophenol	< 330	U
541-73-1	1,3-Dichlorobenzene	< 330	U
106-46-7	1,4-Dichlorobenzene	< 330	U
100-51-6	Benzyl alcohol	< 330	U
95-50-1	1,2-Dichlorobenzene	< 330	U
95-48-7	2-Methylphenol	< 330	U
108-60-1	bis(2-Chlorophenol)ether	< 330	U
106-44-5	4-Methylphenol	< 330	U
621-64-7	N-Nitroso-di-n-propylamine	< 330	U
67-72-1	Hexachloroethane	< 330	U
98-95-3	Nitrobenzene	< 330	U
78-59-1	Isophorone	< 330	U
88-75-5	2-nitrophenol	< 330	U
105-67-9	2,4-Dimethylphenol	< 330	U
65-85-0	Benzoic acid	< 1600	U
111-91-1	bis(2-Chorophenol)methane	< 330	U
120-83-2	2,4-Diclorobenzene	< 330	U
120-82-1	1,2,4-Trichlorobenzene	< 330	U
91-20-3	Naphthalene	< 330	U
106-47-8	4-Chloroaniline	< 330	U
87-68-3	Hexachlorobutadiene	< 330	U
59-50-7	4-Chloro-3-Methlphenol	< 330	U
91-57-6	2-Methylnaphthalene	< 330	U
77-47-4	Hexachlorocyclopentadiene	< 330	U
88-06-2	2,4,6-Trichlorophenol	< 330	U
95-95-4	2,4,5-Trichlorophenol	< 1600	U
91-58-7	2-Chloronaphthalene	< 330	U
88-74-4	2-Nitroaniline	< 1600	U
131-11-3	Dimethylphthalate	< 330	U
208-96-8	Acenaphthylphthylene	< 330	U
606-20-2	2,6-Dinitrotoluene	< 330	U

GCMS SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

Sample ID: VAPEX Job# 90-127 Before venting

CAS NO .	COMPOUND	CONCENTRATION ug/kg	Q
99-09-2	3-Nitroaniline	< 1600	U
83-32-9	Acenaphthene	< 330	U
51-28-5	2,4-Dinitrophenol	< 1600	U
100-02-7	4-Nitrophenol	< 1600	U
132-64-9	Dibenzofuran	< 330	U
121-14-2	2,4-Dinitrotoluene	< 330	U
84-66-2	Diethylphthalate	< 330	U
7005-72-3	4-Chlorophenyl-phenylether	< 330	U
86-73-7	Fluorene	< 330	U
100-01-6	4-Nitroaniline	< 1600	U
534-52-1	4,6-Dinitro-2-methylphenol	< 1600	U
86-30-6	N-Nitrosodiphenylamine	< 330	U
101-55-3	4-BromophenyI-phenylether	< 330	U
118-74-1	Hexachlorobenzene	< 330	U
87-86-5	Pentachlorophenol	< 1600	U
85-01-8	Phenanthene	< 330	U
120-12-7	Anthracene	< 330	U
84-74-2	Di-n-butylphthalate	< 330	U
206-44-0	Fluoranthene	< 330	U
129-00-0	Pyrene	< 330	U
85-68-7	Butylbenzylphthalate	< 330	U
91-94-1	3,3'-Dichlorobenzidine	< 660	U
56-55-3	Benzo(a)anthracene	< 330	U
218-01-9	Chrysene	< 330	U
117-81-7	bis(2-Ethylhexyl)phthalate	< 330	U
117-84-0	Di-n-octylphalate	< 330	U
205-99-2	Benzo(b)fluoranthene	< 330	U
207-08-9	Benzo(k)fluoranthene	< 330	U
50-32-8	Benzo(a)pyrene	< 330	U
193-39-5	Indeno(1,2,3-cd)pyrene	< 330	U
53-70-3	Dibenz(a,h)anthracene	< 330	U
191-24-2	Benz(g,h,i)perylene	< 330	U

GCMS SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

Sample ID: VAPEX Job# 90-127
After Venting
Matrix: (soil/water): soil
level: (low/med) low
% Moisture: 5.6
Extraction: hexane-acetone (1+1)
GPC Cleanup: (Y/N) N

Report File ID: VP127SV3
Lab File ID: BNA1A19A
Date Received: 09-17-90
Date Extracted: 10-09-89
Date Analyzed: 10-11-89

CAS NO .	COMPOUND	CONCENTRATION(ug/kg)	Q
108-95-2	Phenol	< 330	U
111-44-4	bis(2-Chlorophenol)ether	< 330	U
95-57-8	2-Chlorophenol	< 330	U
541-73-1	1,3-Dichlorobenzene	< 330	U
106-46-7	1,4-Dichlorobenzene	< 330	U
100-51-6	Benzyl alcohol	< 330	U
95-50-1	1,2-Dichlorobenzene	< 330	U
95-48-7	2-Methylphenol	< 330	U
108-60-1	bis(2-Chlorophenol)ether	< 330	U
106-44-5	4-Methylphenol	< 330	U
621-64-7	N-Nitroso-di-n-propylamine	< 330	U
67-72-1	Hexachloroethane	< 330	U
98-95-3	Nitrobenzene	< 330	U
78-59-1	Isophorone	< 330	U
88-75-5	2-nitrophenol	< 330	U
105-67-9	2,4-Dimethylphenol	< 330	U
65-85-0	Benzoic acid	< 1600	U
111-91-1	bis(2-Chorophenol)methane	< 330	U
120-83-2	2,4-Diclorobenzene	< 330	U
120-82-1	1,2,4-Trichlorobenzene	< 330	U
91-20-3	Naphthalene	< 330	U
106-47-8	4-Chloroaniline	< 330	U
87-68-3	Hexachlorobutadiene	< 330	U
59-50-7	4-Chloro-3-Methlphenol	< 330	U
91-57-6	2-Methylnaphthalene	< 330	U
77-47-4	Hexachlorocyclopentadiene	< 330	U
88-06-2	2,4,6-Trichlorophenol	< 330	U
95-95-4	2,4,5-Trichlorophenol	< 1600	U
91-58-7	2-Chloronaphthalene	< 330	U
88-74-4	2-Nitroaniline	< 1600	U
131-11-3	Dimethylphthalate	< 330	U
208-96-8	Acenaphthylphthylene	< 330	U
606-20-2	2,6-Dinitrotoluene	< 330	U

GCMS SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

Sample ID: VAPEX Job# 90-127 After venting

CAS NO .	COMPOUND	CONCENTRATION ug/kg	Q
99-09-2	3-Nitroaniline	< 1600	U
83-32-9	Acenaphthene	< 330	U
51-28-5	2,4-Dinitrophenol	< 1600	U
100-02-7	4-Nitrophenol	< 1600	U
132-64-9	Dibenzofuran	< 330	U
121-14-2	2,4-Dinitrotoluene	< 330	U
84-66-2	Diethylphthalate	< 330	U
7005-72-3	4-Chlorophenyl-phenylether	< 330	U
86-73-7	Fluorene	< 330	U
100-01-6	4-Nitroaniline	< 1600	U
534-52-1	4,6-Dinitro-2-methylphenol	< 1600	U
86-30-6	N-Nitrosodiphenylamine	< 330	U
101-55-3	4-BromophenyI-phenylether	< 330	U
118-74-1	Hexachlorobenzene	< 330	U
87-86-5	Pentachlorophenol	< 1600	U
85-01-8	Phenanthene	< 330	U
120-12-7	Anthracene	< 330	U
84-74-2	Di-n-butylphthalate	< 330	U
206-44-0	Fluoranthene	< 330	U
129-00-0	Pyrene	< 330	U
85-68-7	Butylbenzylphthalate	< 330	U
91-94-1	3,3'-Dichlorobenzidine	< 660	U
56-55-3	Benzo(a)anthracene	< 330	U
218-01-9	Chrysene	< 330	U
117-81-7	bis(2-Ethylhexyl)phthalate	< 330	U
117-84-0	Di-n-octylphalate	< 330	U
205-99-2	Benzo(b)fluoranthene	< 330	U
207-08-9	Benzo(k)fluoranthene	< 330	U
50-32-8	Benzo(a)pyrene	< 330	U
193-39-5	Indeno(1,2,3-cd)pyrene	< 330	U
53-70-3	Dibenz(a,h)anthracene	< 330	U
191-24-2	Benz(g,h,i)perylene	< 330	U

SEMIVOLATILE ORGANIC AFTER VENTING

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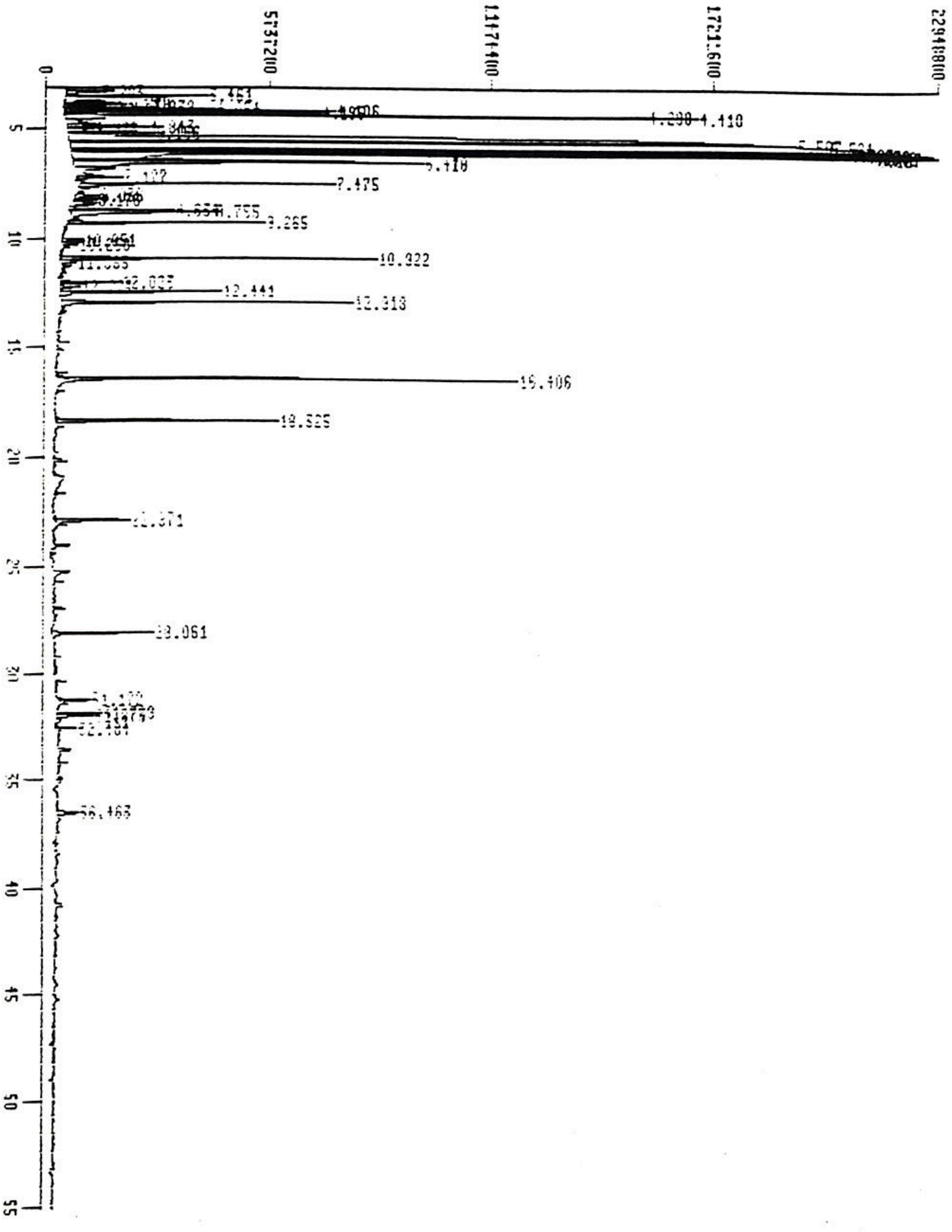

SEMIVOLATILE ORGANIC BEFORE VENTING

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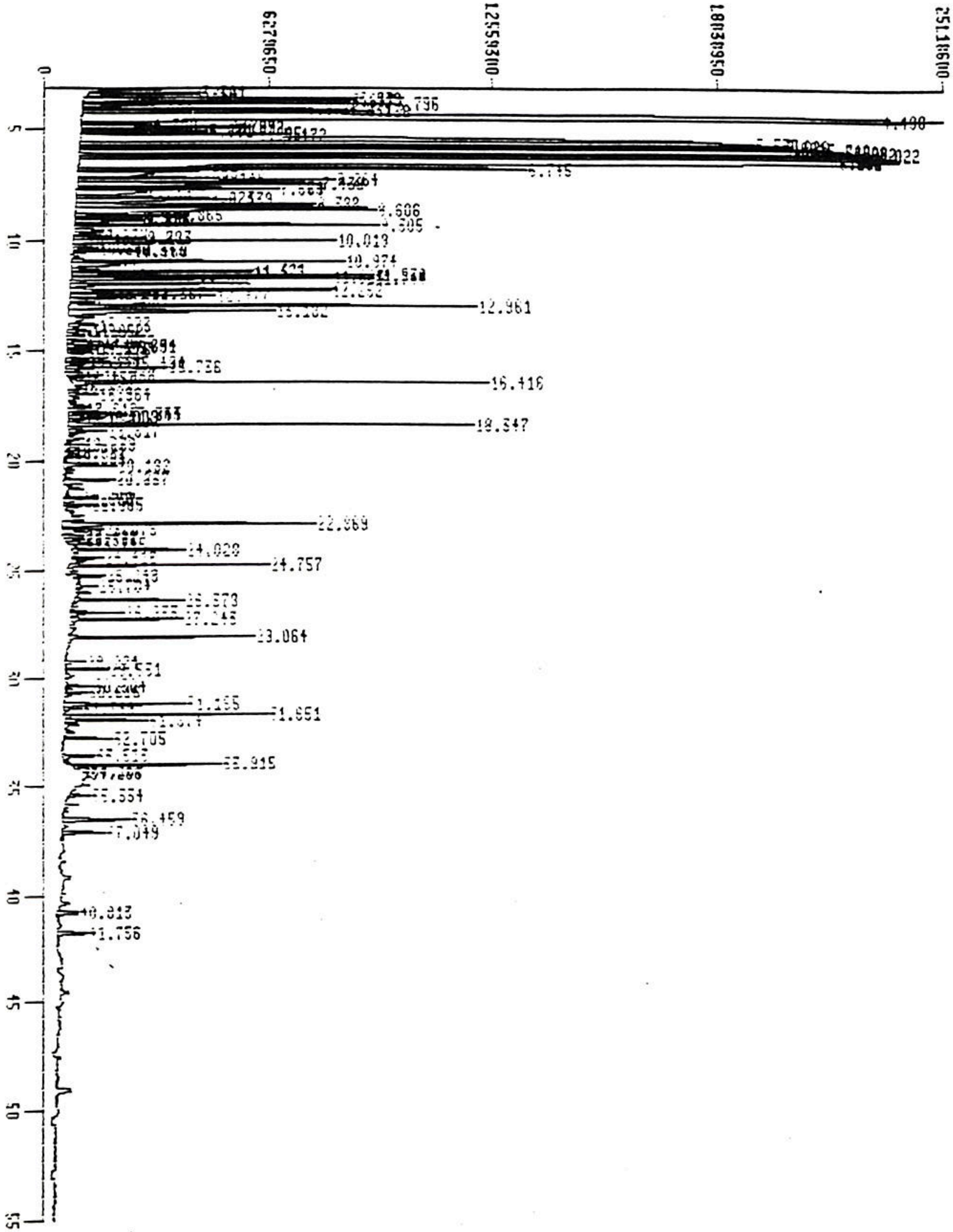

VOLATILE ORGANIC AFTER VENTING

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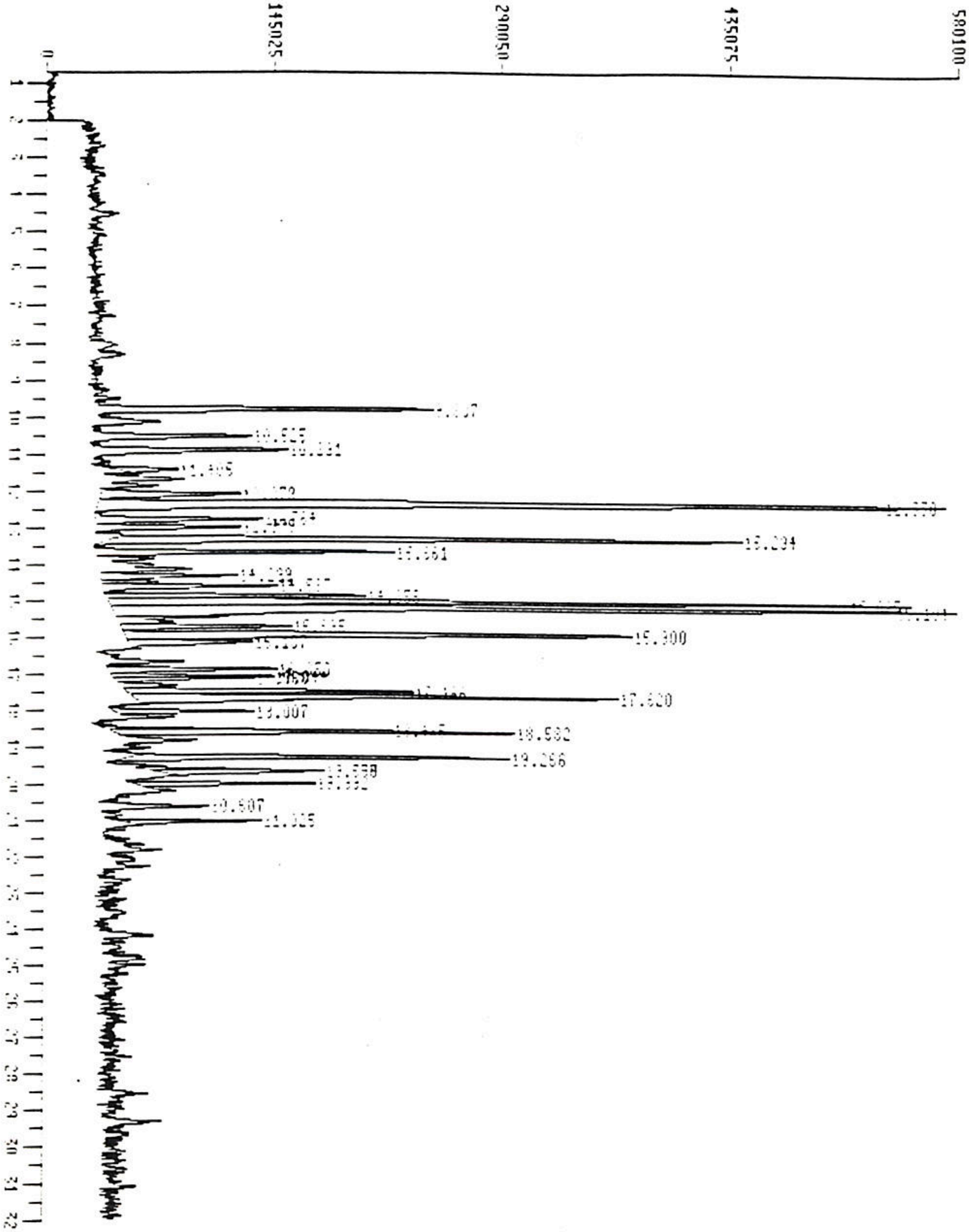

VOLATILE ORGANIC BEFORE VENTING

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