Results Letter Report
for
Air Sparging/Soil Vapor Extraction System
System at Site 1 - Former Drum
Marshalling Area

Naval Weapons Industrial Reserve Plant
Bethpage, New York

Volume I - Text

Northern Division
Naval Facilities Engineering Command
Contract Number N62472-90-D-1298
Contract Task Order 0213

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C F BRAUN ENGINEERING CORPORATION

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1.0 INTRODUCTION

1.1 AUTHORIZATION

The Northern Division of the Naval Facilities Engineering Command has issued Contract Task Order (CTO) 0213 to CF Braun Engineering Corporation (CF Braun) under a master agreement with Brown & Root Environmental under Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract N62472-90-D-1298. Under CTO 0213, CF Braun installed a Pilot Scale Air Sparging/Soil Vapor Extraction (AS/SVE) System and is conducting a physical and chemical evaluation of the system. This work is part of the Remedial Design, Phase II, for Site 1 at the Naval Weapons Industrial Reserve Plant (NWIRP) located in Bethpage, New York.

1.2 OPERATION AND CONSTRUCTION SUMMARY

Construction of the pilot-scale AS/SVE system was started in mid-March 1997 and completed in April 1997. Startup and checkout of the system occurred the week of April 14, 1997. Radius of influence tests were conducted the weeks of April 21 and April 28, 1997. With the exception of maintenance and several power outages, the system operated continuously from May 2 to July 15, 1997. Because the vapor phase carbon units were not yet saturated with VOCs, the operation of the AS/SVE system was extended to September 17, 1997.

The AS/SVE pilot system was constructed in accordance with the "Pilot-Scale Air Sparging/Soil Vapor Extraction System Work Plan" for the NWIRP Bethpage, New York (CF Braun 1997). The AS/SVE system consisted of an air injection system, a soil vapor extraction system, a vapor phase carbon treatment system, one air injection well, five soil vapor extraction wells, and eight monitoring wells (soil vapor pressure and/or groundwater monitoring).

1.3 PURPOSE AND OBJECTIVES

The purpose of this letter report is to present the results of the physical parameter testing and thereby achieve the first objective. As stated in the project Work Plan, the specific objectives of the pilot study are as follows.

- Determine the physical parameters required for a full scale system design (well spacing, extraction/injection rates, and well depths).
- Evaluate the effectiveness of air sparging/soil vapor extraction in removing VOCs from site soils, cesspools, and shallow groundwater.
- Estimate the time required for cleanup of soils, groundwater, and cesspool contents.
- Determine the requirements for offgas treatment.

1.4 BACKGROUND INFORMATION

Site 1 - Former Drum Marshaling Area occupies an area of approximately 4 acres. It is surrounded on three sides by a fence and on the fourth side by Plant No. 3. The site is relatively flat, with the eastern portion covered with bare sandy soils, gravel, grass, and one concrete pad. The western portion of the site is predominantly covered with concrete. A vegetated wind row (pine) and fence are present along the eastern edge of the site to reduce community visibility.

The original basis for the work conducted at the Navy's Site 1 resulted from pubic water supply wells being impacted by VOC contamination. In response to this impact, a regional groundwater quality study was conducted in the 1980s. The results of this study indicated the Navy's Site 1 to be one of several potential sources of a relatively large groundwater VOC plume originating near this area and extending for several thousand feet to the south (hydraulic downgradient direction).

The Navy conducted a Remedial Investigation in the early 1990s to investigate potential sources of the VOC contamination, (Halliburton NUS, May 1992 and Halliburton NUS July, 1993). Based on this investigation, the source of the groundwater contamination at Site 1 was determined to originate near the former drum marshaling pads. All shallow groundwater samples collected south of the Former Cinder Drum Marshaling Pad, and a few shallow groundwater samples collected north of the pad, exhibited VOC contamination. However, this area of groundwater contamination also coincides with the location of cesspools at the site. The cesspools could also be a source of the VOC contamination.

Soil testing during the Remedial Investigation determined that Site 1 soils contained VOC, PCB, and arsenic contamination. Subsequent soil testing at the site confirmed the presence of PCB and VOC contamination; however, the arsenic contamination could not be confirmed. In addition, testing of the cesspool contents revealed even higher concentrations of VOCs and PCBs in the cesspools than in the surrounding soils, and revealed the presence of cadmium contamination.

1.5 REPORT FORMAT

This report is divided into four sections. Section 1.0 is this Introduction. Section 2.0 provides a brief description of the system construction. Results are presented in Section 3.0 and Conclusions and Recommendations are provided in Section 4.0.

2.0 SYSTEM CONSTRUCTION

Construction details for the AS/SVE pilot system at NWIRP Bethpage are summarized in this section. Complete details will be provided in the Results Report, scheduled for submittal in October 1997. Soil boring log sheets are provided in Appendix A. Well construction sheets for the air injection/soil vapor extraction wells and groundwater/soil vapor pressure monitoring wells are provided in Appendix B.

The layout of the AS/SVE pilot study is presented in Figure 1. Process flow schematics for the air injection and soil vapor extraction systems are presented in Figures 2 and 3, respectively.

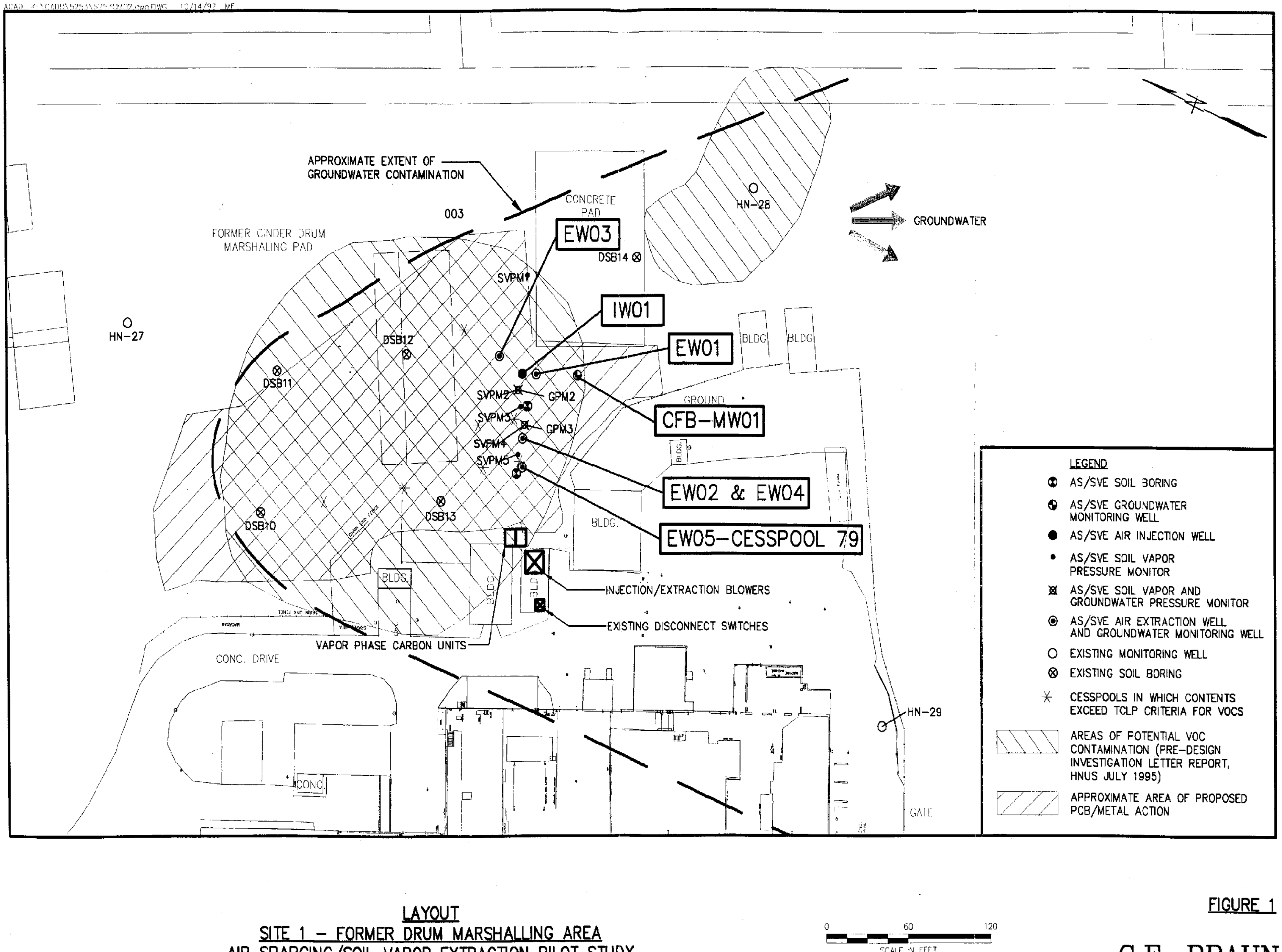
2.1 PILOT SCALE CONSTRUCTION

The AS/SVE pilot scale system was constructed during the period of March 26 to April 16, 1997. The pilot scale system consisted of an air injection system, a soil vapor extraction system, an offgas treatment system consisting of vapor phase carbon units, and soil vapor/groundwater monitoring points. During construction, subsurface soil and groundwater samples were collected to evaluate environmental conditions prior to the study to establish a baseline for comparison to future samples.

Subsurface Soil Samples

Two rounds of subsurface soils samples were collected during the pilot study. The first round was collected on March 26, 1997 and represents soil conditions prior to the trial. The second round was collected on July 15, 1997 and represents soil conditions at the end of the pilot trial (July 15, 1997). Since the vapor phase carbon was not yet saturated with VOCs, the AS/SVE system continued to operate from July 15 to September 17, 1997.

Each round of subsurface soil samples consisted of seven split spoon soil boring samples, including one duplicate. These samples were analyzed at Kemron for Volatile Organic Compound (VOC) analysis. The soil samples were collected at the three soil boring locations shown on Figure 1.



LAYOUT
SITE 1 - FORMER DRUM MARSHALLING AREA
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK

FIGURE 1

C.F. BRAUN

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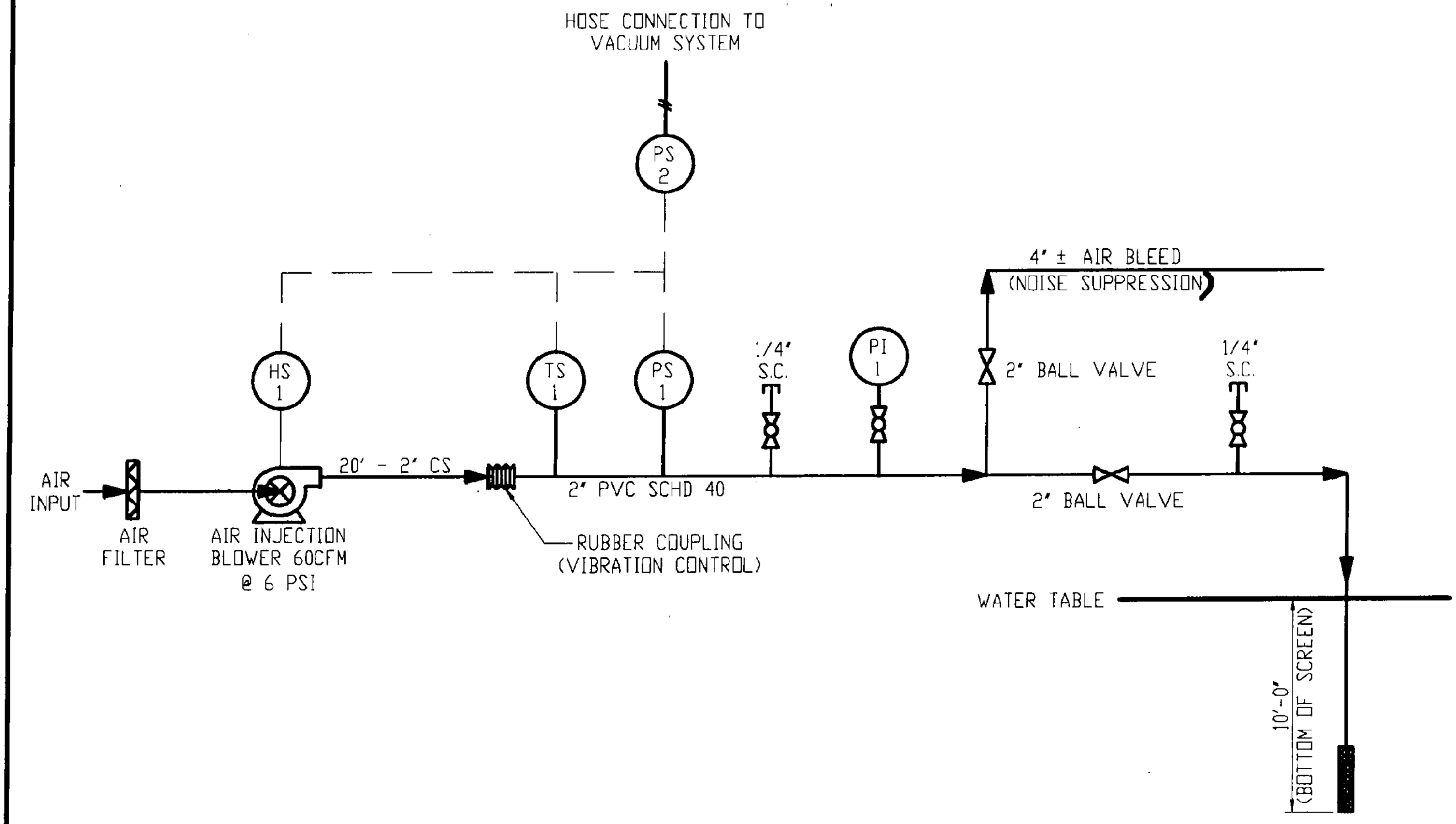

DRAWN BY MF DATE 10/10/97	C.F. BRAUN	CONTRACT NO. 5253	OWNER NO.
CHECKED BY DATE	PROCESS FLOW SCHEMATIC AIR INJECTION SYSTEM SITE 1 – FORMER DRUM MARHALLING AREA AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY NWIRP BETHPAGE, NEW YORK	APPROVED BY	DATE
COST/SCHED-AREA		APPROVED BY	DATE
NONE NONE		DRAWING NO. FIGURE 2	REV. 0

FORM CADD NO. SOUTH_AV.DWG - REV 0 - 02/07/97

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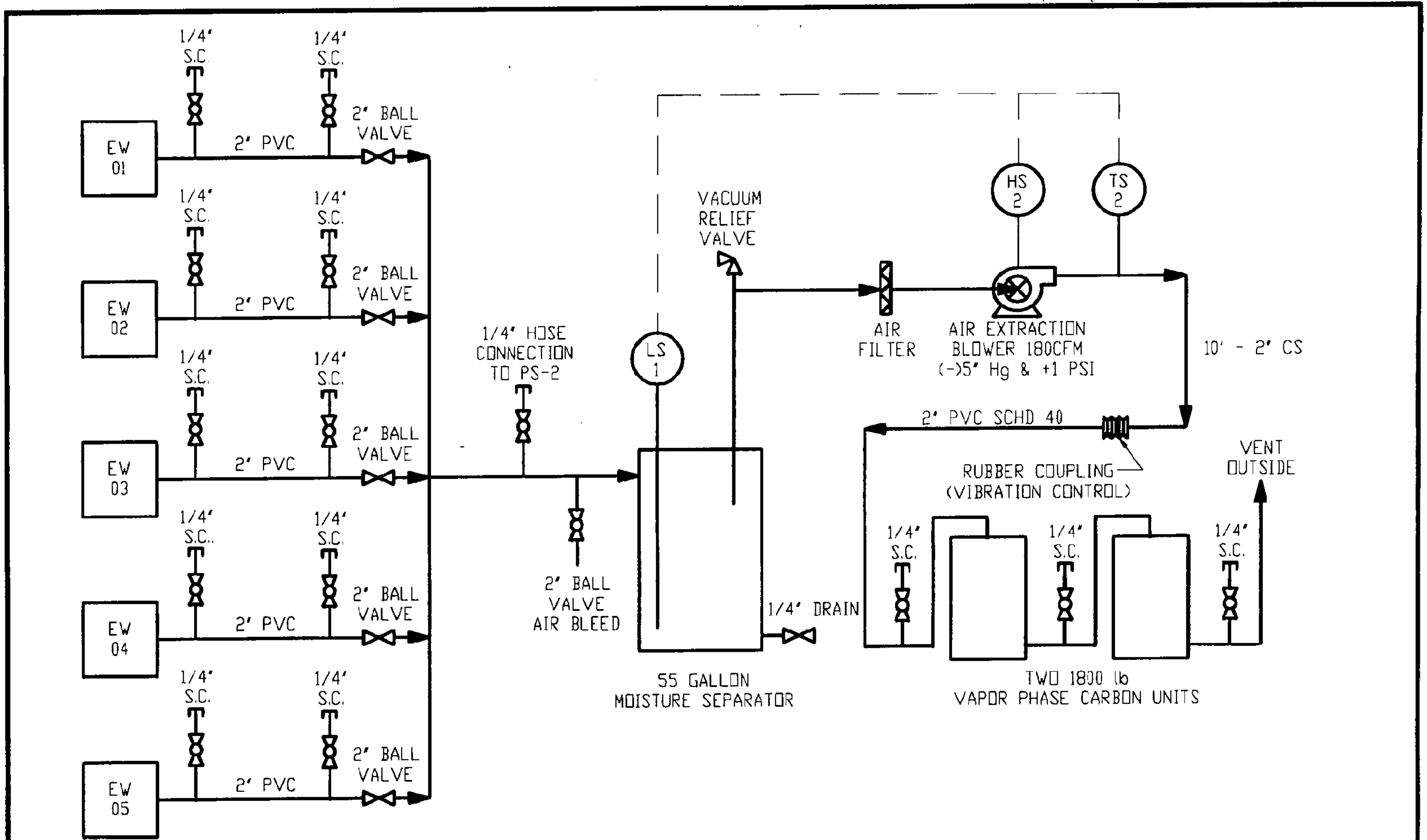

DRAWN BY MF DATE 10/10/97	**C.F. BRAUN**	CONTRACT NO. 5253 / OWNER NO.
CHECKED BY DATE	**PROCESS FLOW SCHEMATIC**	APPROVED BY DATE
COST/SCHED-AREA	**SOIL VAPOR EXTRACTION SYSTEM** **SITE 1 - FORMER DRUM MARHALLING AREA**	APPROVED BY DATE
NONE NONE	**AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY** **NWIRP BETHPAGE, NEW YORK**	DRAWING NO. **FIGURE 3** REV. 0

FORM CADD NO. SOUTH_AV.DWG - REV 0 - 02/07/97

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One soil boring (SB02) was placed inside cesspool number 79. Split spoon samples were collected at depths of 10 and 40 feet below ground surface (bgs) and correspond to cesspool contents and soil underlying the cesspool, respectively. This cesspool also corresponds to the location of extraction well EW-05.

The other two soil borings were located outside the cesspools. The location and depth of these soil samples were based on field measurements conducted during the installation of the extraction wells, injection well, and monitoring wells. Three split spoon samples including one duplicate sample were collected from soil boring SB03 at depths of 20 and 40 feet bgs. Soil boring SB03 was installed at a location where a moderate concentration of VOCs was expected, (as determined during by PID readings during well installation). This location was near the edge of the suspected VOC-contaminated soils.

Split spoon samples were collected at depths of 30 and 40 feet bgs from soil boring SB04 and correspond to the location of the highest PID readings observed during well installation. This soil boring is also near the location of the two former drum marshalling pads. The same soil boring locations and sampling depths will be used for the final sampling event at the end of the pilot study.

In addition, three split spoon soil boring samples were collected for geotechnical parameters during the installation of two of the monitoring points. Samples were collected at 10 to 12 feet bgs and 28 to 29 feet bgs during the installation of SVPM 3 and 66 to 68 feet bgs during the installation of GPM 3. A grain size distribution geotechnical analysis was performed on each to provide data representative of conditions throughout the site, (see Appendix C).

A clay layer (approximately 2 feet thick) was encountered at approximately 50 to 52 feet bgs during the installation of the injection well, extraction wells, and monitoring points. A perched water layer of approximately one foot thick was encountered during the installation of EW-01 and EW-02. The area-wide water table was encountered at a depth of approximately 57 bgs. The presence of this clay layer requires consideration to ensure capture of all injected air.

Air Injection System

The air injection system consists of an injection well, a blower, and conveyance piping, (see Figures 1 and 2).

The air injection well is a 2-inch PVC riser pipe and screen installed to a total depth of 66.5 feet bgs. This well was installed on March 18, 1997. A 2-feet long 0.020 inch slot size well screen was installed 8 feet below the water table (between 64.5 to 66.5 feet bgs).

The blower is a rotary lobe-type Frame 32 Universal RAI Blower rated for 35 to 60 standard cubic feet per minute (SCFM) at a pressure of 6 pounds per square inch (PSI). The blower was manufactured by the Roots Division of Dresser Industries Inc.. The blower, an associated control panel, and a 7.5 horsepower (HP) motor were pre-assembled and mounted on a skid by Airtek Inc. Temperature and pressure cutoff switches were set at approximately 240 degrees Fahrenheit and 8 psi, respectively. The temperature set point is used to protect the plastic piping. The pressure set point is based on protecting the motor from overload.

In addition, a vacuum switch was installed on the soil vapor extraction suction line to provide an interlock between the injection blower and the extraction blower. As currently set, the injection blower will only operate when a vacuum is present in the soil vapor extraction piping. The exact set point was not measured, but was estimated to be in the range of 1 to 2 inches of water column. Based on the relatively low vacuum required for the soil vapor extraction system and the magnitude of the switch dead band, the injection blower shutdown switch must be manually reset prior to re-starting the injection blower. To simplify full scale operation, a more sensitive switch is required.

Conveyance piping for the injection line consists of a 40 foot length of 2-inch carbon steel pipe adjacent to the blower to dissipate heat, a rubber coupling for vibration control, 2-inch schedule 40 PVC pipe, two 2-inch ball valves to control air flow to the injection well and provide a manual pressure/air flow bleed off, and a 4-inch noise suppresser on the pressure bleed off. An automatic pressure relief valve is also present on the blower.

Soil Vapor Extraction System

The soil vapor extraction system consists of soil vapor extraction wells, a moisture separator, a blower, and conveyance piping, (see Figures 1 and 3).

There are five soil vapor extraction wells. Each well consists of a 2-inch PVC riser pipe and a 0.020 slot size screen. Total depth and screened intervals are summarized as follows.

Extraction Well	Installation Date	Total Depth (feet bgs)	Screen Length and Interval
EW-01	3/18/97	61.5	15 feet long, 10 feet above water table to 5 feet below water table (46 to 61 feet bgs)
EW-02	3/24/97	62	15 feet long, 10 feet above water table to 5 feet below water table (47 to 62 feet bgs)
EW-03	3/19/97	61	15 feet long, 10 feet above water table to 5 feet below water table (46 to 61 feet bgs)
EW-04	3/25/97	30	10 feet long, located at middle of unsaturated zone (20 to 30 feet bgs)
EW-05	3/25/97	20	5 feet long, located near the bottom of the cesspool (15 to 20 feet bgs)

The extraction blower is a positive displacement rotary lobe-type blower. The blower is a Frame 36 Universal RAI Blower rated for 100 to 150 scfm at +1 psi/-5 inches of mercury, manufactured by the Roots Division of Dresser Industries Inc. The blower, an associated control panel, a 55-gallon moisture separator, and a 7.5 HP motor were pre-assembled and mounted to a skid by Airtek Inc.

Temperature and vacuum pressure cutoff switches were set at approximately 250 degrees Fahrenheit and (-)5 inches of mercury, respectively. The temperature set point is used to protect the plastic piping. The pressure switch set point is based on protecting the motor from overload. An automatic vacuum relief valve is also present on the inlet to the blower.

Conveyance piping for the extraction lines consists of a flexible rubber coupling for vibration control, a 4-inch PVC header, five 2-inch schedule 40 PVC lines (one to each well), and one vacuum bleed valve. Each extraction line has a 2-inch ball valve to control air flow.

Offgas Treatment System

VOCs removed by the soil vapor extraction system were treated prior to discharge with two 1,800-pound vapor phase activated carbon units connected in series. The carbon units were provided by General Carbon Corporation. Pressure piping consisted of a 20 foot length of 3-inch carbon steel at the blower outlet, a rubber coupling for vibration control, and 4-inch schedule 40 PVC pipe leading to, between, and after the carbon unit. The 3-inch carbon steel pipe is used to dissipate heat from the blower.

Monitoring Points

A series of monitoring points was used to determine the effective radius of influence and monitor groundwater quality. The monitor points consist of one water table groundwater monitoring well, 5 soil vapor pressure monitors (SVPM), and 2 groundwater pressure monitors (GPM), as well as the 5 soil vapor extraction wells. The monitoring point locations are presented in Figure 1.

Groundwater monitoring well CFB-MW-01 consists of a 2-inch PVC riser pipe and screen installed to a total depth of 64 feet bgs on March 20, 1997. A 10-feet long 0.020 inch slot size well screen was installed from 2 feet above the water table to 8 feet below the water table (54 to 64 feet bgs). The monitoring well is located 30 feet hydraulically downgradient from the injection well.

Two dedicated groundwater pressure monitors (GPM 2 and GPM 3) were installed. Each monitor consists of 2-inch riser pipe and screen with total depth and screened interval as follows. A 0.020 slot screen size was used.

Groundwater Pressure Monitors	Installation Date	Total Depth (feet bgs)	Screened Interval
GPM 2	3/20/97	62	2 feet long, 4 feet below the water table (60 to 62 feet bgs)
GPM 3	3/21/97	66	2 feet long, 4 feet below the water table (61 to 63 feet bgs)

These wells were used in junction with water table wells to determine if vertical groundwater flow gradients exist as a result of air injection.

There are five soil vapor pressure monitoring wells, (see Figure 1). Each well consists of a 2-inch PVC riser pipe and a 0.020 slot size screen. Total depth and screened intervals are summarized as follows.

Soil Vapor Pressure Monitors	Installation Date	Total Depth (feet bgs)	Screened Interval
SVPM 1	3/19/97	30	5 feet long, located at middle of unsaturated zone (25 to 30 feet bgs)
SVPM 2	3/21/97	30	5 feet long at middle of unsaturated zone (25 to 30 feet bgs)
SVPM 3	3/21/97	30	5 feet long at middle of unsaturated zone (25 to 30 feet bgs)
SVPM 4	3/24/97	30	5 feet long at middle of unsaturated zone (25 to 30 feet bgs)
SVPM 5	3/25/97	20	5 feet long at middle of unsaturated zone (15 to 20 feet bgs)

The soil vapor extraction wells were also used to supplement the soil vapor pressure monitors during the air injection and extraction system testing. In addition, the three air extraction wells located at the water table (EW-01, EW-02, and EW-03), were used to monitor groundwater table fluctuations during testing.

3.0 TEST RESULTS

3.1 PHYSICAL PARAMETERS

Stratification Testing

The purpose of the stratification tests was to determine whether the presence of a denser than air gas (such as trichloroethane and tetrachloroethene) would cause contaminant stratification to occur within the screened interval of the soil vapor extraction well. The implication being that stratification within the unsaturated zone may prevent or inhibit the primary chemicals of concern from being extracted from the contaminated soils. If stratification was observed, then a second test would be conducted during operation of the system to determine whether the stratification could be minimized or eliminated by adjusting soil vapor extraction rates or by the injection of air. A second objective of the test was to confirm that excessive LEL or low oxygen conditions were not present in the system prior to the startup of the test.

Soil stratification testing of the soil vapor extraction wells was conducted on April 9, 1997. The test consisted of using a low-flow air pump to withdraw soil vapor from the top, middle, and bottom of the 10-foot section of screen located above the water table. The tests were conducted a minimum of 5 days after well development to allow static conditions to develop.

To conduct the test, a weighted 1/4-inch ID tube was lowered into the Extraction Well (EW01, EW02, or EW03) to appropriate depth relative to the screen position. The well was sealed with a cap to minimize air intrusion from the surface. A positive displacement air pump (operating at approximately 0.044 CFM (1.3 liter per minute) was used to extract the soil vapor from the tube. The pump discharged into a 0.017 CF flow through cell, where PID and LEL/O_2 probes were mounted. PID and LEL/O_2 readings were then taken every 5 to 10 minutes to confirm that the readings had stabilized.

The results of this testing are provided in Table 1. To conduct the evaluation, a comparison of the PID readings in each well with the average PID reading across the well was conducted. This comparison found an individual variance of only 19% to 55% from the mean. If stratification was present, a variance of several hundred to several thousand percent would be expected, with highest PID readings near at the bottom of the well screen. Since this is not the case, stratification within the wells is not expected to be significant.

Radius of Influence Testing

The radius of influence of the AS/SVE system describes the distance through which a well can obtain a measurable flow rate of groundwater or soil vapor. The radius depends on several factors including the soil type (e.g. sand or clay), soil homogeneity, depth of injection below the water table, injection/extraction air pressure and flow rate.

Since soil vapor and groundwater flow rates cannot be measured reliability insitu, soil vapor pressure and groundwater level/pressure differences are used as a positive indication of flow. The assumption is generally valid as long as there is no continuous barrier to flow between the points monitored. Based on the behavior of the monitoring wells during testing, this assumption is believed to be reasonably valid at this site. However, as indicated previously, there is a thin horizontal clay layer approximately 5 feet above the water table which requires consideration. Monitoring wells above this clay layer did not respond conclusively during all air injection tests, indicating that a continuous flow path may not exist.

During the radius of influence tests, water level measurements and soil vapor pressures/ vacuums were obtained at the start of each test. Flow rates were controlled by a 2-inch ball valve on the injection and extraction lines and measured with a Dwyer Thermal Anemometer Series 470 instrument. The Dwyer Magnehelic pressure gauges allowed pressure/vacuum readings from 0.02 to 1.00, 0.2 to 10, and 2 to 100 inches of water column (gauge).

TABLE 1

SOIL GAS STRATIFICATION TESTING
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK

1.0 Extraction Well EW-01

Time (minutes)	PID (ppm)	LEL (%)	O_2 (%)
Test Location - Top of Well Screen			
0.0	300	0.0	20.9
15	353	-	-
30	338	0.0	20.9
Test Location - Middle of Well Screen			
0.0	439	3.0	18.2
15	435	3.0	20.2
Test Location - Bottom of Well Screen			
0.0	388	2.0	20.9
15	239	0.0	20.9
37	150	0.0	20.9

2.0 Extraction Well EW-02

Time (minutes)	PID (ppm)	LEL (%)	O_2 (%)
Test Location - Top of Well Screen			
0.0	32	0.0	20.7
15	25	0.0	20.6
35	35	0.0	20.6
50	26	0.0	20.6
Test Location - Middle of Well Screen			
0.0	35	0.0	20.6
15	26	0.0	20.6
Test Location - Bottom of Well Screen			
0.0	44	0.0	20.6
15	43	0.0	20.4

TABLE 1 (CONTINUED) - PAGE 2
SOIL GAS STRATIFICATION TESTING
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK

3.0 Extraction Well EW-03

Time (minutes)	PID (ppm)	LEL (%)	O_2 (%)
Test Location - Top of Well Screen			
0.0	64	0.0	20.9
20	43	0.0	20.9
Test Location - Middle of Well Screen			
0.0	73	0.0	20.9
15	71	0.0	20.9
Test Location - Bottom of Well Screen			
0.0	80	0.0	20.7
15	73	0.0	20.7

PID: Photoionization Detector measures in parts per million (ppm).
LEL: Lower Explosive (flammable) Limit in air.

Soil Vapor Extraction Tests

The radius of influence testing consisted of measuring pressures/vacuums and/or water levels while operating one extraction well or injection well at a time at varied flow rates. The soil vapor extraction rates were generally conducted at 5, 20, and 80 scfm. During each of the extraction well tests, soil vapor pressures readings were recorded from all extraction wells, groundwater monitoring well MW-01, and the soil vapor pressure monitoring points. The readings were collected over time until they were stable, (less than 10% change over three consecutive readings).

Table 2 presents the results of the radius of influence testing for the soil vapor extraction well testing. An evaluation of the measurable vacuum as a function of distance was performed using statistical analysis. The analysis included linear regressions on the data as received, as well as on semi-logarithmic plots. The regressions generally found correlation coefficients of greater than 0.8, and in most cases, the semi-logarithmic evaluation resulted in a better correlation than analysis of the non-logarithmic evaluation. These correlation coefficients are considered to be reasonable and the semi-logarithmic correlations are typical for flow in radial directions. Linear regression calculations are presented in Appendix D.

The soil vapor extraction tests conducted are summarized as follows.

Soil Vapor Extraction Point	Monitoring Location
EW01 (water table)	Pressure at water table Pressure at middle of unsaturated zone
EW02 (water table)	Pressure at water table Pressure at middle of unsaturated zone
EW04 (middle of unsaturated zone)	Pressure at water table Pressure at middle of unsaturated zone
EW05 (middle of unsaturated zone)	Pressure at water table Pressure at middle of unsaturated zone

TABLE 2

RADIUS OF INFLUENCE TEST RESULTS
SOIL VAPOR EXTRACTION WELLS
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK

EW-01 tests (SVE and monitoring performed at water table)

Well ID	Distance from SVE Well (ft)	Soil Vapor Pressure (inches of water column)				
		5 cfm	10 cfm	20 cfm	40 cfm	80 cfm
EW-01	0	-0.86	-1.5	-4.7	-14	-25
MW-01	21.3	-0.2	-0.36	-0.88	-1.6	-3.2
EW-03	27.5	-0.11	-0.18	-0.48	-0.96	-1.5
EW-02	44	-0.11	-0.15	-0.35	-0.82	-1.3

EW-01 tests (SVE performed at water table, monitoring points at middle of unsaturated zone)

Well ID	Distance from SVE Well (ft)	Soil Vapor Pressure (inches of water column)				
		5 cfm	10 cfm	20 cfm	40 cfm	80 cfm
SVPM 2	16.8	-0.007	-0.02	-0.03	-0.06	-0.07
SVPM 3	25.9	-0.007	-0.02	-0.03	-0.05	-0.06
SVPM 1	61	-0.007	-0.01	-0.02	-0.08	-0.11
SVPM 4	35.1	-	-0.02	-0.03	-0.06	-0.05
EW-04	45	-	-0.01	-0.03	-0.06	-0.06
SVPM 5	53.3	-	-0.02	-0.03	-0.05	-0.05
EW-O5	64	-	-0.02	-0.03	-0.05	-0.05

TABLE 2 (CONTINUED) - PAGE 2
RADIUS OF INFLUENCE TEST RESULTS
SOIL VAPOR EXTRACTION WELLS

EW-02 tests (SVE performed and monitoring performed at water table)

Well ID	Distance from SVE Well (ft)	Soil Vapor Pressure (inches of water column)		
		5 cfm	20 cfm	80 cfm
EW-02	0	-0.06	-2.4	-13
EW-01	44	-0.06	-0.46	-1.3
EW-03	55.6	-0.06	-0.41	-1.2
MW-01	56.1	-0.02	-0.3	-0.98
27-S3	98		-0.04	

EW-02 tests (SVE performed at water table, monitoring at middle of unsaturated zone)

Well ID	Distance from SVE Well (ft)	Soil Vapor Pressure (inches of water column)		
		5 cfm	20 cfm	80 cfm
EW-04	3.7	0.003	-0.05	-0.09
SVPM 4	10.1	-0.01	-0.03	-0.09
SVPM 5	10.5	-0.003	-0.04	-0.07
SVPM 3	19.3	0.003	-0.03	-0.09
EW-05	21.2	-0.02	-0.04	-0.07
SVPM 2	31.7	0.003	-0.03	-0.07
SVPM 1	98.1	0.01	-0.03	-0.12

EW-04 tests (SVE performed at middle of unsaturated zone, monitoring at water table)

Well ID	Distance from SVE Well (ft)	Soil Vapor Pressure (inches of water column)		
		5 cfm	20 cfm	80 cfm
EW-02	3.7	-0.11	-0.07	-0.08
EW-01	55.3	-0.11	-0.03	-0.06
MW-01	74.6	-0.11	-0.06	-0.06
EW-03	75	-0.1	-0.06	-0.06

TABLE 2 (CONTINUED) - PAGE 3
RADIUS OF INFLUENCE TEST RESULTS
SOIL VAPOR EXTRACTION WELLS

EW-04 tests (SVE and monitoring performed at middle of unsaturated zone)

Well ID	Distance from SVE Well (ft)	Soil Vapor Pressure (inches of water column)		
		5 cfm	20 cfm	80 cfm
EW-04	0	-0.11	-0.75	-4.8
SVPM-5	10.1	-0.06	-0.11	-0.43
SVPM-4	10.9	-0.05	-0.14	-0.47
SVPM-3	20.1	-0.05	-0.07	-0.33
EW-05	20.7	-0.06	-0.08	-0.31
SVPM-2	31.2	-0.07	-0.06	-0.23
SVPM-1	98	-0.05	-0.02	-0.06

EW-05 tests (SVE performed at middle of unsaturated zone, monitoring at water table)

Well ID	Distance from SVE Well (ft)	Soil Vapor Pressure (inches of water column)		
		5 cfm	20 cfm	80 cfm
EW-02	21.2	0.02	0.07	0.04
EW-01	64	0.02	0.05	0.01
MW-01	74.6	0.003	0.03	0.01
EW-03	75	0.02	0.05	0.02

EW-05 tests (SVE and monitoring performed at middle of unsaturated zone, monitoring at water table)

Well ID	Distance from SVE Well (ft)	Soil Vapor Pressure (inches of water column)		
		5 cfm	20 cfm	80 cfm
EW-05	0	-0.25	-1.4	-8.3
SVPM 5	11.7	-0.04	-0.11	-0.43
EW-04	20.7	-0.01	-0.08	-0.28
SVPM 4	30.4	-0.02	-0.04	-0.21
SVPM 3	39.6	-0.01	-0.04	-0.17
SVPM 2	50.9	-0.01	-0.03	-0.13
SVPM 1	117.6	-0.01	-0.02	-0.03

cfm: cubic feet per minute SVE: Soil Vapor Extraction
A negative pressure (e.g. -1.4) indicates that the monitoring are reading a vacuum relative to atmospheric pressure.

Figure 4 provides a graphic presentation of the natural log of the soil vapor pressures at the water table as a function of distance from the operating extraction well EW-01, (which is screened at the water table, see also Table 2 - page 1). Based on this data, the significant findings are as follows.

- For each monitoring point, as the soil vapor extraction rate increases, the soil vapor vacuum pressure also increases. This finding indicates a flow path between the extraction point and the monitoring point.

- For each soil vapor extraction rate, the soil vapor vacuum pressure decreases with distance from the extraction well. This finding is consistent with radial horizontal flow from the perimeter into the extraction well.

- The change in soil vapor vacuum pressure as a function of distance and flow is relatively uniform. This finding indicates that the soil is relatively homogeneous at the location tested.

Figure 5 provides a graphic presentation of the natural log of the soil vapor pressures at the middle of the unsaturated zone as a function of distance from the operating extraction well EW-01, (which is screened at the water table, see also Table 2 - page 1). Based on these data, the significant findings are as follows.

- For each monitoring point, as the soil vapor extraction rate increases, the soil vapor vacuum pressure also increases. This finding indicates a flow path between the extraction well and the monitoring point.

- For each soil vapor extraction rate, the soil vapor vacuum pressure is <u>not</u> a function of horizontal distance from the extraction well. This lack of correlation is likely an indication that horizontal conductivity is much higher than vertical conductivity, as is common for this area.

FIGURE 4
SOIL VAPOR PRESSURES AT WATER TABLE AS A FUNCTION OF DISTANCE FROM EXTRACTION WELL EW-01
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK

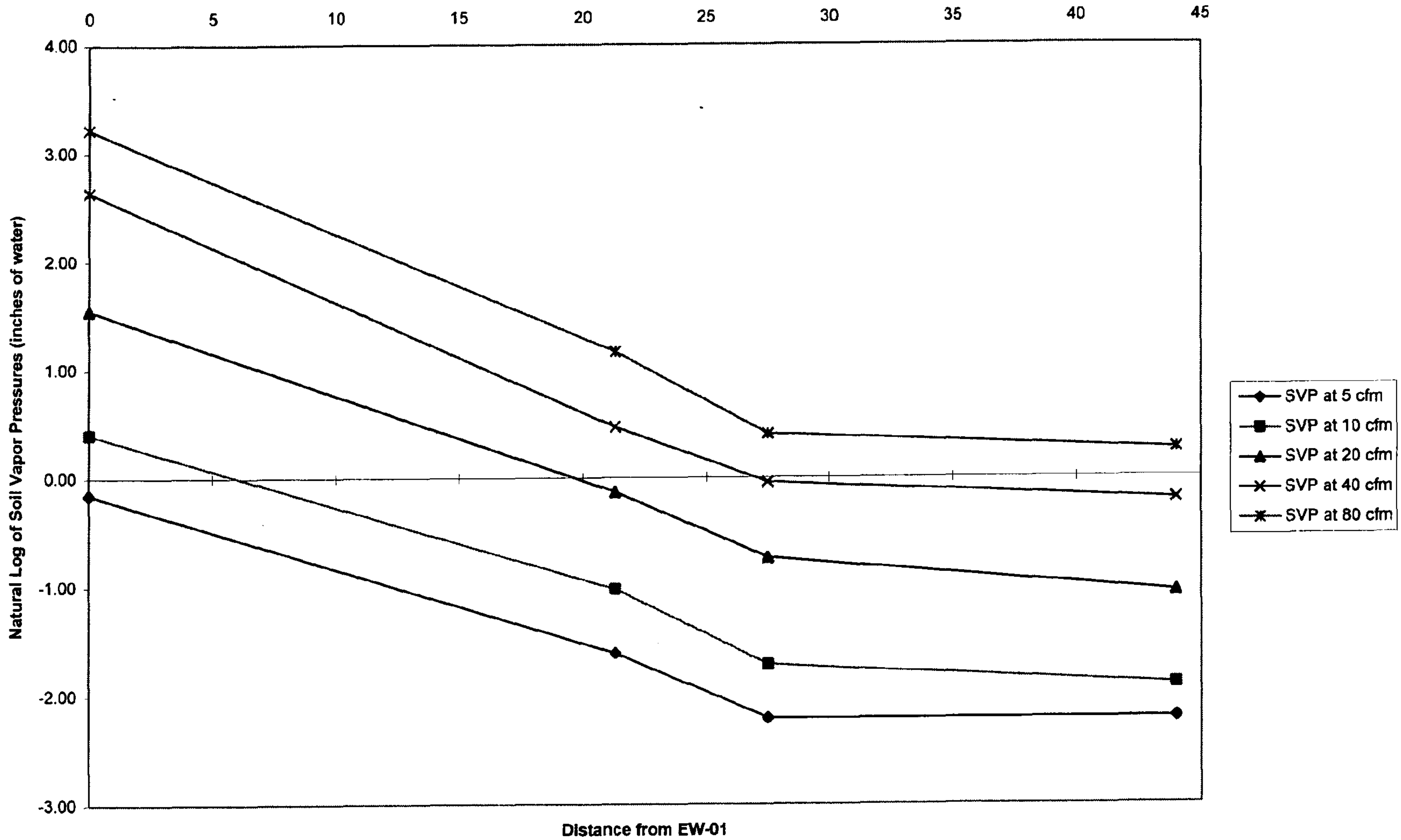
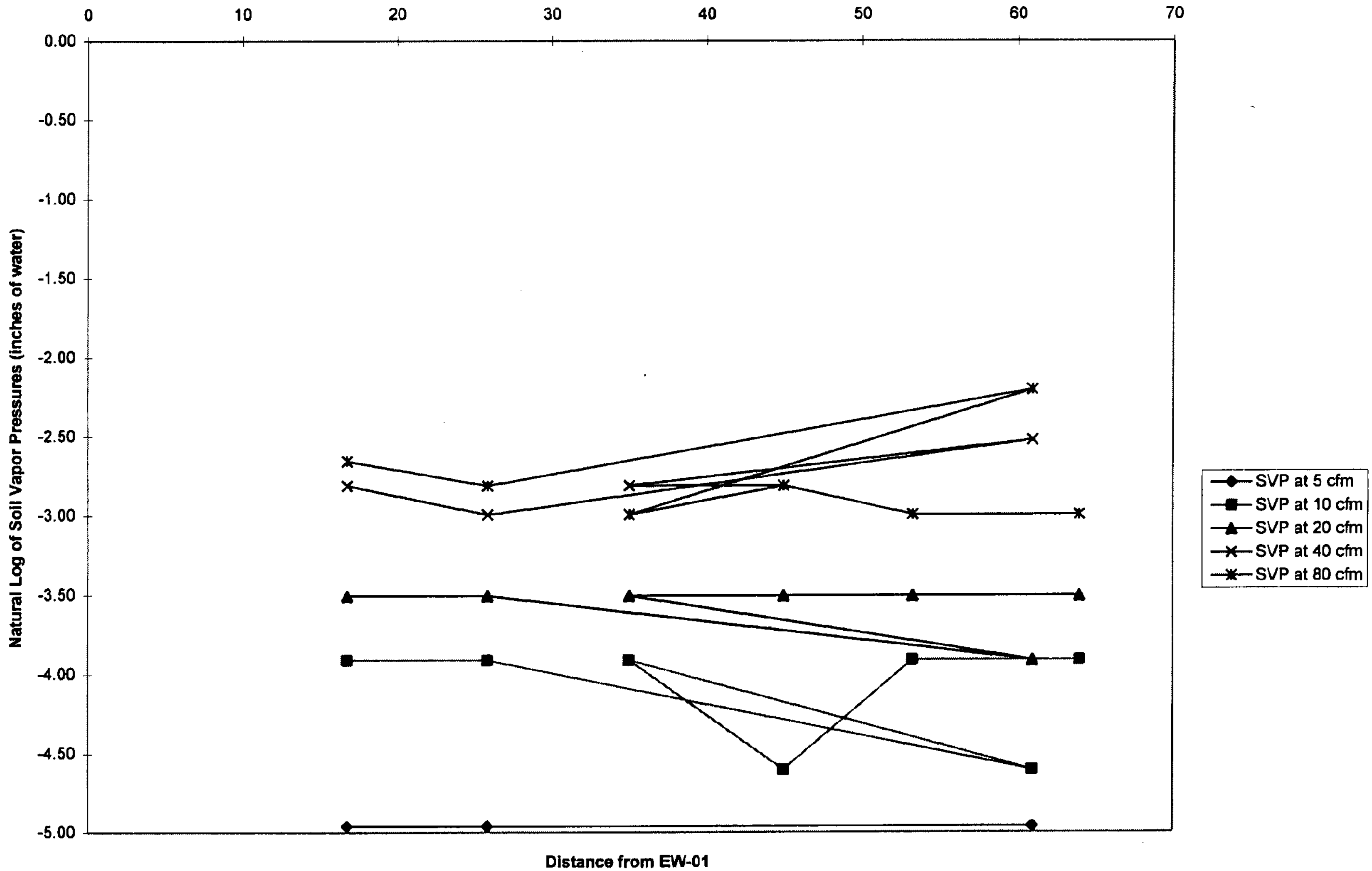


FIGURE 5
SOIL VAPOR PRESSURES AT MIDDLE OF UNSATURATED ZONE AS A FUNCTION OF DISTANCE FROM EXTRACTION WELL EW-01
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK



- For each soil vapor extraction rate, the soil vapor vacuum pressure is relatively uniform. This finding indicates that the soil is relatively homogeneous at the location tested, and that significant barriers or conduits to vertical flow are not present.

Trends for the EW-02 tests are very similar to those for EW-01, with on the magnitude and slope of the trends being different, (see Table 2 - page 2). This finding again indicates that the site soils are relatively homogeneous.

Figure 6 presents the natural log of soil vapor pressures at the water table as a function of distance from EW-05 (which is screened at the middle of the unsaturated zone and in a cesspool, (see also Table 2 - page 3). The findings of these tests are summarized as follows.

- The operation of extraction well EW-05 did not cause of significant vacuum to form at the water table (Figure 6). In fact, during this test, only positive pressures were noted at the water table.

- The pressure readings were not dependent on either distance or soil vapor extraction rates. These findings indicate that soil vapor extraction at the middle of the unsaturated zone will not cause significant soil vapor flow at the water table.

Figure 7 presents the natural log of soil vapor pressures at the middle of the unsaturated zone as a function of distance from EW-05 (which is screened at the middle of the unsaturated zone and in a cesspool, (see also Table 2 - page 3). The findings of these tests are summarized as follows.

- For each monitoring point, as the soil vapor extraction rate increases, the soil vapor vacuum pressure also increases. This finding indicates a direct flow path between the extraction point and the monitoring point.

FIGURE 6
SOIL VAPOR PRESSURES AT WATER TABLE AS A FUNCTION OF DISTANCE FROM EXTRACTION WELL EW-05
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK

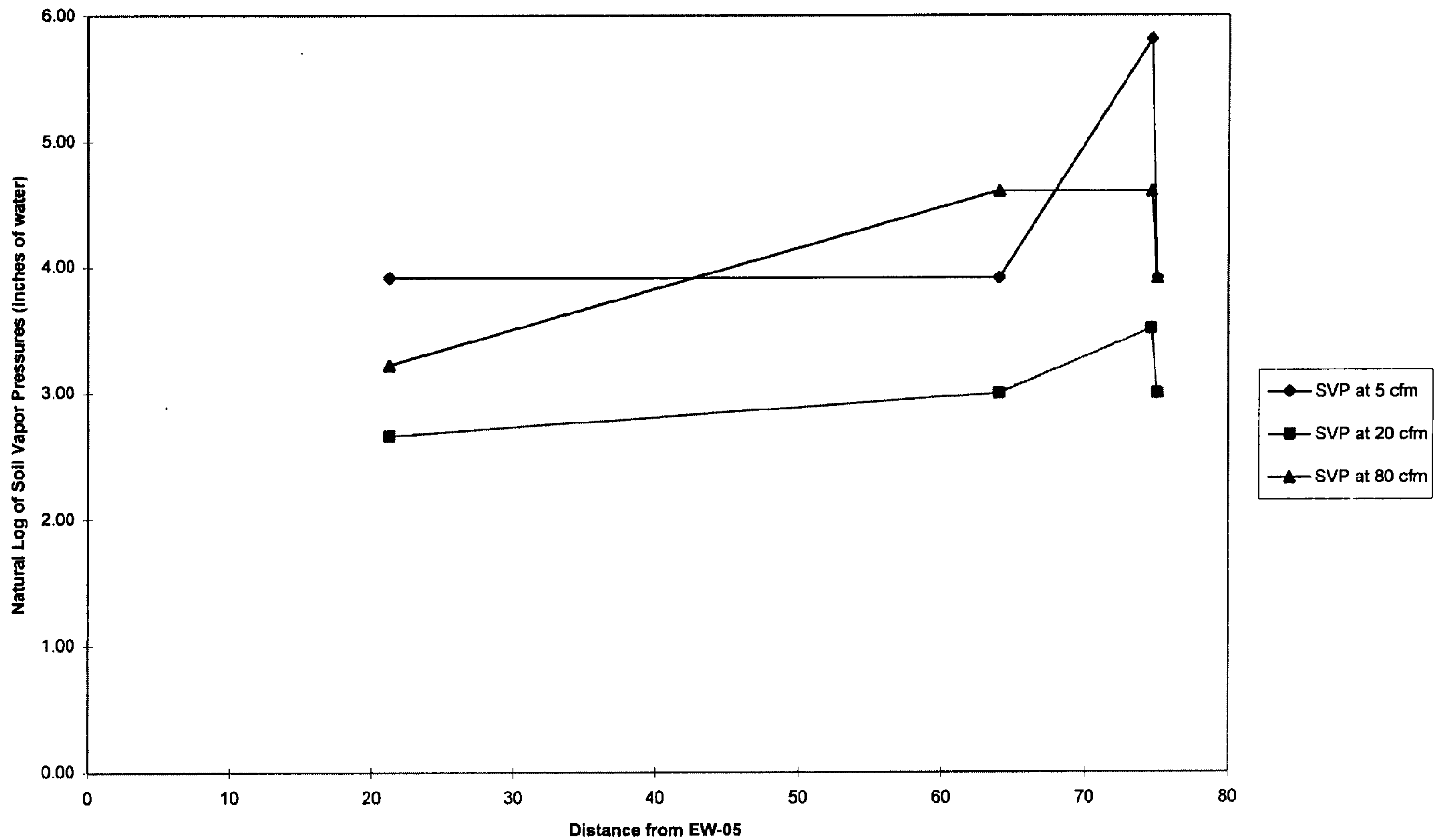
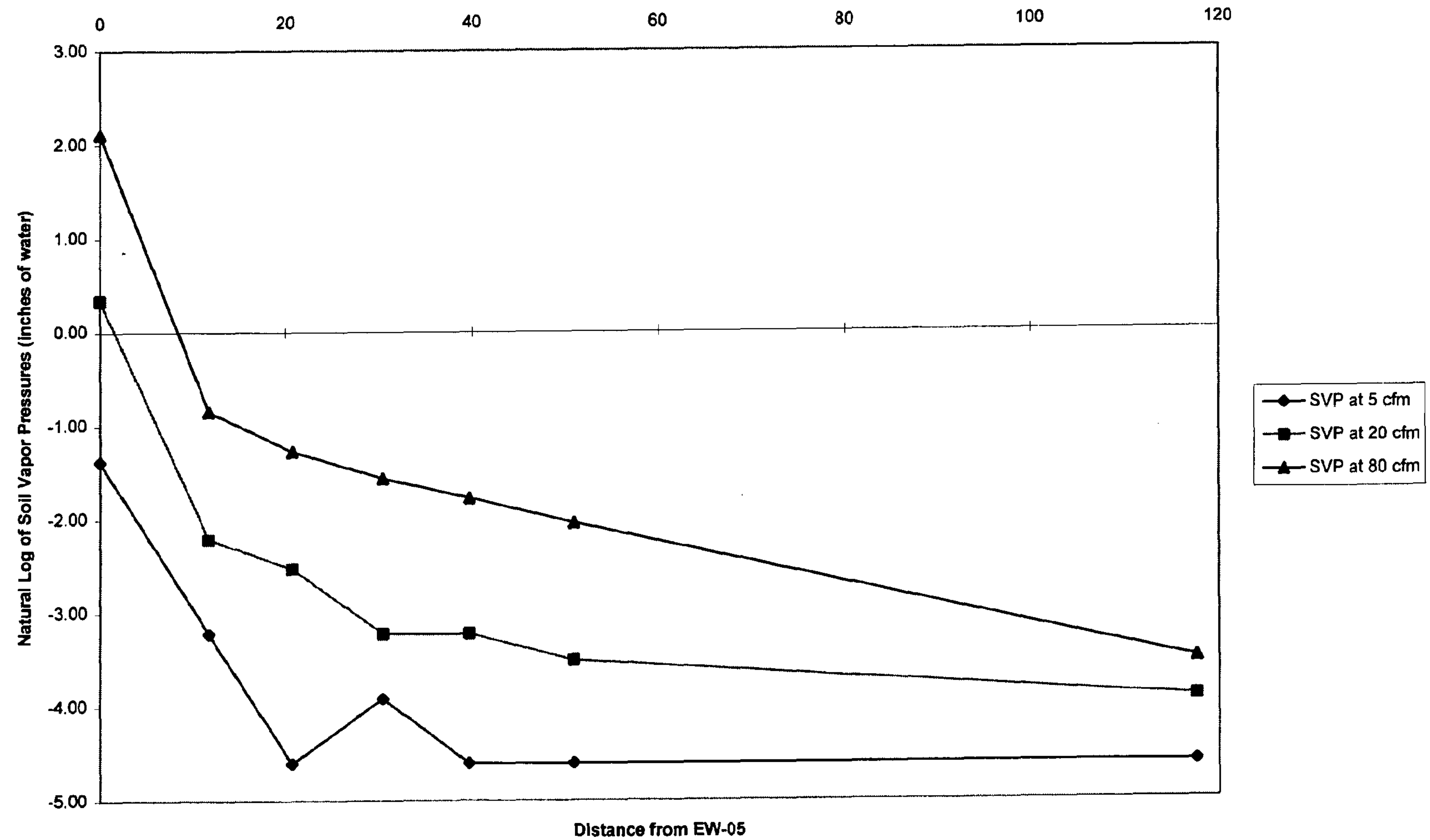


FIGURE 7
SOIL VAPOR PRESSURES AT MIDDLE OF UNSATURATED ZONE AS A FUNCTION OF DISTANCE FROM EXTRACTION WELL EW-05
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK



- For each soil vapor extraction rate, the soil vapor vacuum pressure decreases with distance from the extraction well. This finding is consistent with radial horizontal flow from the perimeter into the extraction well.

- The relationship between soil vapor extraction rate, distance, and soil vapor vacuum pressure is relatively uniform. This finding indicates that the soil is relatively homogeneous at the location tested.

The test results for soil vapor extraction at extraction well EW-04 are very similar to that for EW-05. Based on this similarity, one can conclude that the cesspool structure does not appreciably inhibit air flow rate, or serve as a preferred pathway for air flow.

Air Injection Tests

The injection well was evaluated at flow rates of 10, 20, 30, and 60 scfm. During the testing, it was noted that air injection rates of 10 to 20 cfm could routinely be achieved. However, injection rates of 30 and 60 scfm could not be consistently achieved. The higher flow rates were only achieved after a consistent air injection rate of 10 to 20 cfm for a period of several days. After a system shutdown, it took as long as one or more days to again establish a flow rate of 30 cfm. If the air injection rate was increased to rapidly, then the high pressure switch on the blower would trip.

Monitoring points consisted of water level measurements at EW-01, EW-02, EW-03, MW-01, GPM 2, GPM 3, and HN-27-S3 (background monitoring well) over time until a change of less than 10% was noted over three consecutive readings. Soil vapor pressures were also monitored during the testing. The results of this testing are presented in Table 3 and are graphed in Figure 8.

TABLE 3

INJECTION WELL TEST RESULTS AND INJECTION TO EXTRACTION FLOW RATIOS AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY NWIRP BETHPAGE, NEW YORK

Injection Well IW-01 Tests

Well ID	Distance from AS Well (ft)	Hydrostatic Head (feet of water column)[1]			
		10 cfm	20 cfm	30 cfm	60 cfm
EW-01	8	1.97	3.61	3.61	4.3
EW-03	20	0.07	0.05	0.05	0.19
MW-01	30	0.13	0.22	0.22	0.44
EW-02	40	0.06	0.09	0.09	0.11
27-S3	98	-0.02	0.01	0.09	0.11

Injection Well IW-01/Extraction Well EW-02 Tests (Monitoring at water table)

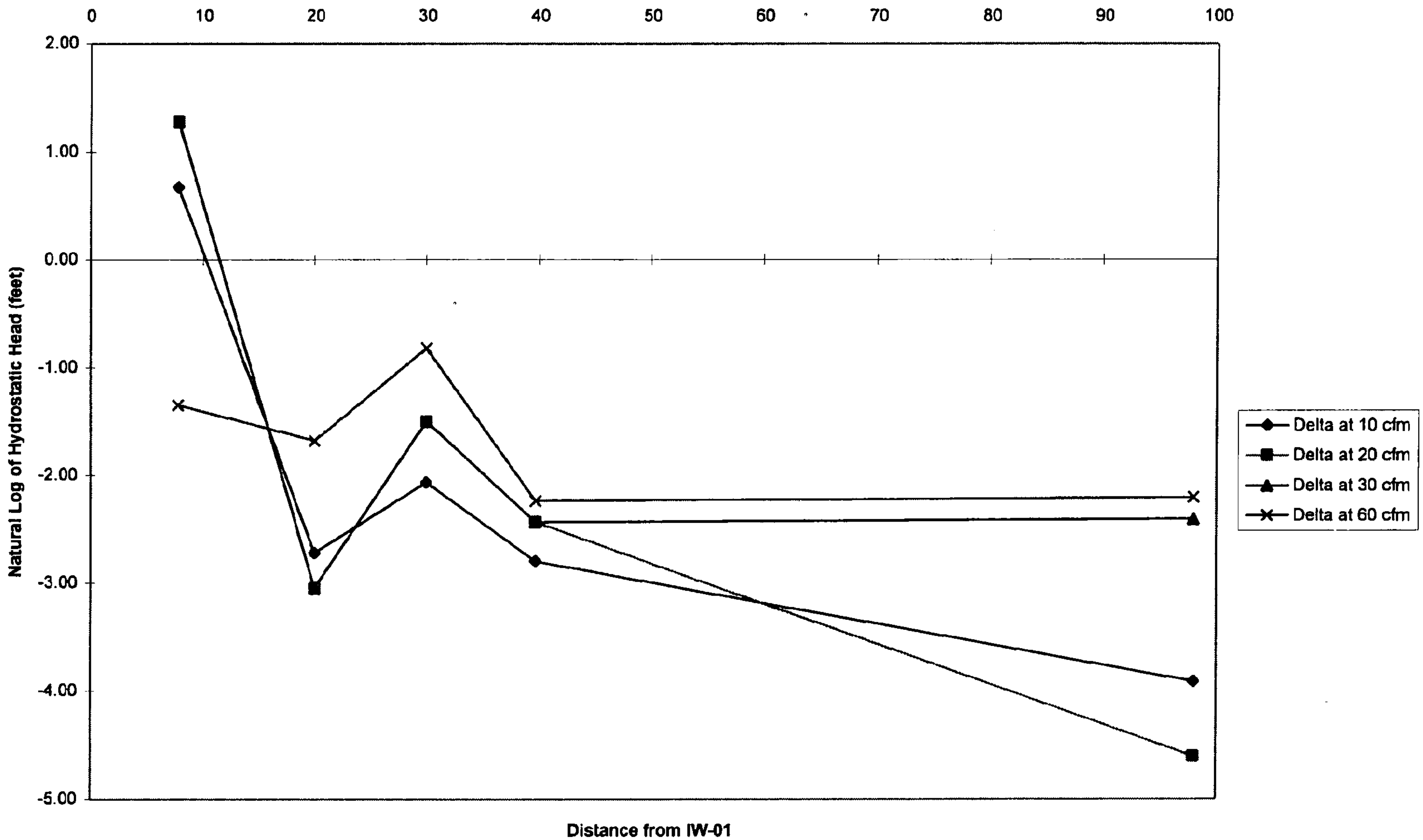
Well ID	Distance from AS Well (ft)	Soil Vapor Pressure[2] (inches of water column)		
		SVE/AS Ratio: 1.5	SVE/AS Ratio: 2.0	SVE/AS Ratio: 3.0
EW-01	8	0.21	0.17	-0.33
EW-03	20	0.05	0.03	-0.38
MW-01	30	1.0	1.2	1.0
EW-02	40	-4.3	-5.9	-12

Injection Well IW-01/Extraction Well EW-02 Tests (Monitoring at middle of unsaturated zone)

Well ID	Distance from AS Well (ft)	Soil Vapor Pressure[2] (inches of water column)		
		SVE/AS Ratio: 1.5	SVE/AS Ratio: 2.0	SVE/AS Ratio: 3.0
SVPM 2	10	0.02	0.03	-0.03
SVPM 3	21	-0.01	0.03	-0.03
SVPM 4	29	-0.01	0.03	-0.03
EW-04	41	-0.03	0.04	-0.04
SVPM 1	48.5	0.03	-0.003	-0.03
SVPM 5	49	-0.04	0.03	-0.04
EW-05	59.5	-0.04	0.03	-0.03

1. A positive increase in hydrostatic head indicates that the water level increased by that height, with the change adjusted for soil vapor pressure.
2. A negative soil vapor pressure reading indicates a vacuum.

FIGURE 8
HYDROSTATIC HEAD AS A FUNCTION OF DISTANCE FROM INJECTION WELL IW-01
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK



These data were analyzed similar to the soil vapor extraction data, except that pressure gradients in the water were evaluated. Also, linear regressions were calculated for both the normal (non-log) and semi-log plots. Correlation coefficients of only 0.4 to 0.6 were obtained with this analysis, indicating a correlation did exist, but that is was relatively weak. Again the correlation was better for the semi-log analysis, which would be expected for radial flow outward, (see Appendix D).

Qualitative analysis of the results found a significant impact in the wells at a distance of 8 feet (EW01) and 30 feet (MW01) hydraulically downgradient from the air injection well. The water table was measured to rise by 1.97 to 4.3 feet and 0.13 to 0.44 feet, respectively. Also, as the air flow rate to the injection well increased, the water level in these two wells increased. Groundwater monitoring wells located 20 feet upgradient (EW03) and 40 feet side-gradient (EW02) of the air injection well may have been effected. However, consistent changes in water level were not observed as a function of flowrate.

Based on analytical data presented in Section 3.2, the groundwater VOC concentration in well EW03 remained relatively constant throughout the trial, indicating that air injection did not affect the groundwater at a distance of 20 feet upgradient of the injection well. However, the groundwater VOC concentration in well EW04, which is located 40 feet side-gradient of the air injection well, decreased by approximately 75% during the trial. This decrease indicates that the air injection well may have affected the groundwater at this well. For comparison, the groundwater VOC concentration in wells EW01 (which is located 10 feet upgradient of the injection well) and MW01 (which is located 30 feet downgradient of the injection well) decreased by 97% and 89%, respectively.

Air Injection/Soil Vapor Extraction Tests

A test was conducted in which air was injected in well IW01 and extracted from well EW-02. The test was conducted with a fixed air injection rate of 20 scfm. The soil vapor extraction rate was then set at 1.5, 2.0, and 3.0 times the injection rate. Water levels and soil vapor pressures/vacuums were measured during this test.

Table 3 presents the results of the injection well testing and simultaneous injection/extraction testing. Qualitative analysis of these results indicates that an extraction ratio of 2 to 3 times the air injection rates is needed to assure capture of all injected air.

RADIUS OF INFLUENCE AS A FUNCTION OF FLOW RATE

Soil Vapor Extraction

Table 4 presents the data representing the calculated radius of influence as a function of flow rate for extraction tests performed at the water table and the middle of the unsaturated zone. The radius of influence is calculated based on a linear regression analysis of soil vapor pressures, (see Appendix D). The baseline for declaring a vacuum present was 0.05 inches of water column for measurements at the water table and 0.02 inches of water column at the middle of the unsaturated zone. These values were selected based on the accuracy of the instrument (detection limit equal to 0.02 inches water column), the observed effects of atmospheric disturbances (weather systems), and the time for the soil vapor system to respond to changes.

Figures 9 and 10 present the calculated radius of influence as a function of flowrate for the tests conducted at the water table and the middle of unsaturated zone, respectively. For soil vapor extraction at the water table, a similar radius of influence was noted for the shallow soils. However for extraction at the middle of the unsaturated zone, it is apparent that stagnant (no flow) zones may have developed at the water table.

Air Injection

Since there was not a direct correlation between air injection rates and observed water level fluctuations at each of the monitoring wells, radius of influence curves for air injection could not be developed. A general observation is that at an air injection rate of 10 cfm and greater, the radius of influence is not a function of the air injection rate. However, based on a qualitative evaluation, at an air injection rate of 10 cfm and greater, the radius of influence is estimated to be between 20 and 40 feet. For current purposes, the design radius of influence for air injection at 10 cfm per well will be assumed to be 30 feet.

TABLE 4

RESULTS OF
RADIUS OF INFLUENCE AS A FUNCTION OF SOIL VAPOR EXTRACTION RATES
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK

EW-01 & EW-02 tests (SVE at water table, monitoring points at water table)

SVE Flow Rate (cfm)	EW-01 - Radius of Influence (feet)[1]	EW-02 - Radius of Influence (feet)[1]
5	53	48
10	59	-
20	71	98
40	79	-
80	84	121

EW-04 & EW-05 tests (SVE and monitoring points at middle of unsaturated zone)

	Calculated Radius of Influence (in feet using 0.05 inches of water reference point)	
SVE Flow Rate (cfm)	**EW-04 - Radius of Influence (feet)[2]**	**EW-05 - Radius of Influence (feet)[2]**
5	-	42
20	51	88
80	91	111

1. 0.05 feet of vacuum (water) is used as the reference point.
2. 0.02 feet of vaccum (water) is used as the reference point.

cfm: cubic feet per minute.
SVE: Soil Vapor Extraction

FIGURE 9
CALCULATED RADIUS OF INFLUENCE AS A FUNCTION OF FLOW RATE FROM EXTRACTION WELLS EW-01 AND EW-02
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK

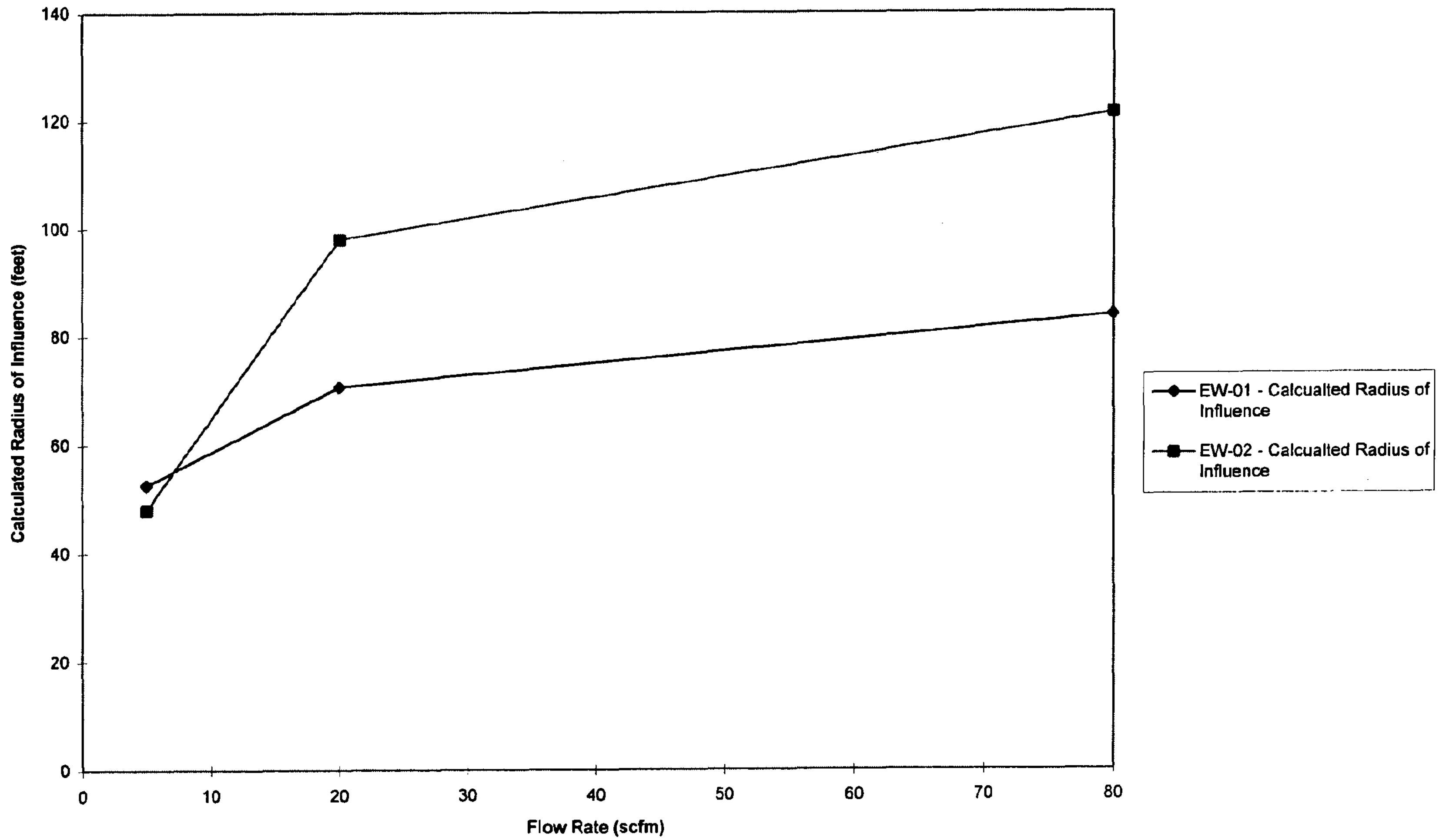
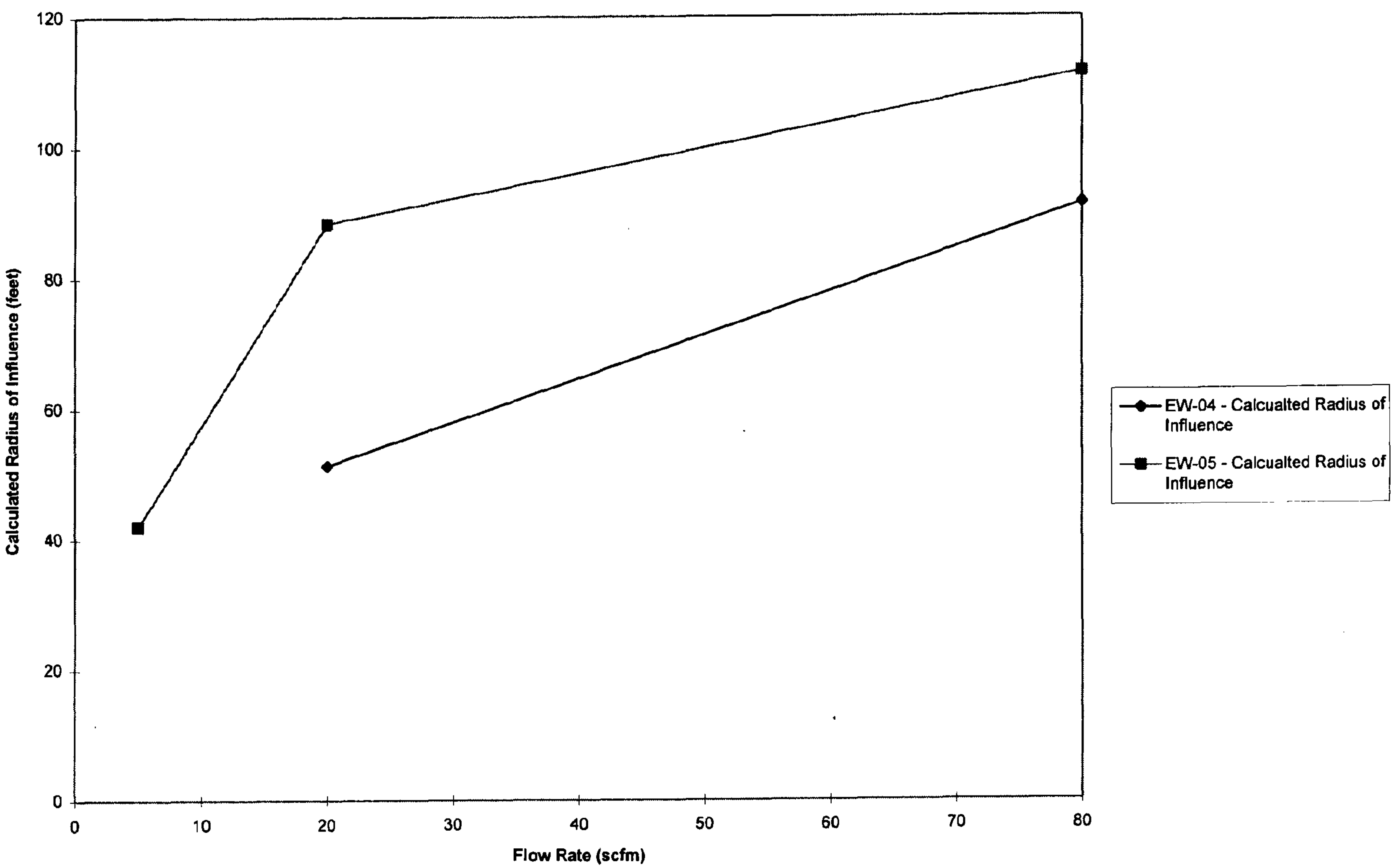


FIGURE 10
CALCULATED RADIUS OF INFLUENCE AS A FUNCTION OF FLOW RATE FROM EXTRACTION WELLS EW-04 AND EW-05
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK



3.2 CHEMICAL PARAMETERS

Carbon System Data

General operating parameters of the vapor phase activated carbon system are presented in Table 5. PID readings are used to identify breakthrough of contaminants through the carbon units. Initial breakthrough of the first carbon unit occurred approximately June 5, 1997. However, as of September 15, 1997, when the system was shut down, the first carbon unit continued to remove approximately 50% of the VOCs. VOC breakthrough on the second carbon unit was not observed during the trial.

System Operation Data

General system data collected to date is provided in Table 6. During the 4.5 months of operation, four unscheduled system outages occurred. Each outage lasted approximately 5 to 6 days. The first outage occurred while the power was shut off by Northrop Grumman personnel during the demolition of an adjacent building. The last three outages resulted from power surges during thunderstorms. The blowers are not set to automatically restart without operator attention.

Other notable findings of the study are as follows.

- SVPM-1, which is the soil vapor pressure monitor located at the middle of the unsaturated zone and nearest the residential neighborhood, was consistently maintained at a vacuum. This finding indicates that soil vapor flow in this area would be from the east toward the extraction system.

- The pressure in the monitoring well (MW-01), which is screened entirely below the clay lens, has shown both positive and negative readings. Even though it is unlikely that injected air is reaching the fence line, a negative vacuum at this location should be maintained to confirm capture. As a result, the air injection rate was decreased and the air extraction rate around the injection well was increased in July 1997.

TABLE 5

CARBON SYSTEM OPERATION DATA
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK

1. PRE-CARBON Treatment Units

Parameter/Date (1997)	**4/23**	**5/2**	**5/7**	**5/15**	**5/20**	**5/29**	**6/5**	**6/12**	**6/19**	**6/24**	**7/2**	**7/11**	**7/15**	**9/17**
Pressure (inches of H_2O)	2.9	2.3	2.7	2.4	2.7	6.2	5.7	5.7	6.3	6.0	6.2	*	*	6.3
Flow Rate (scfm)	23	104	104	108	108	152	170	170	166	166	158	166	175	166
PID Reading (ppm)	1,106	1,097	*	185	125	62	58	51	68	60	60	54	48	42

2. BETWEEN CARBON Treatment Units

Parameter/Date (1997)	**4/23**	**5/2**	**5/7**	**5/15**	**5/20**	**5/29**	**6/5**	**6/12**	**6/19**	**6/24**	**7/2**	**7/11**	**7/15**	**9/17**
Pressure (inches of H_2O)	1.3	1.1	1.4	1.7	1.4	3.1	2.8	3.0	3.1	2.8	3,0	*	*	3.0
Flow Rate (scfm)	21	100	100	104	104	152	170	170	156	153	153	*	*	*
PID Reading (ppm)	0	0	*	0	0	0	5.3	0	2.5	4.2	2.4	11.2	*	23

3. POST CARBON Treatment Units

Parameter/Date (1997)	**4/23**	**5/2**	**5/7**	**5/15**	**5/20**	**5/29**	**6/5**	**6/12**	**6/19**	**6/24**	**7/2**	**7/11**	**7/15**	**9/17**
Pressure (inches of H_2O)	0.09	0.60	0.81	0.09	0.9	0.09	0.03	0.04	0.12	0.15	0.16	*	*	0.04
Flow Rate (scfm)	20	100	100	104	104	148	148	166	156	153	153	*	*	*
PID Reading (ppm)	0	0	*	0	0	0	3.8	0	0	0	0	0	0	0

SCFM Standard Cubic Feet per Minute
PID Photoionization Detector measures in Parts Per Million.
* Reading was not obtained.

TABLE 6

1997 SYSTEM OPERATION DATA
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK

1. Extraction Well EW01

Check List Date	4/23	5/2	5/7	5/15	5/20	5/29	6/5	6/12	6/19	6/24	7/2	9/17
Flow Rate (scfm)	24.0	21.8	22.9	22.9	22.9	36.0	38.2	15.3	21.8	28.4	32	28
PID Reading (ppm)	1,147	1,076	**	94.4	15.9	9.7	13.5	21.1	16.5	20.4	20.3	13.2
Pressure (" water)	-5.6	-2.4	-5.7	-5.9	-4.5	-9.4	-17	-9.5	-9.7	-8.9	-8.0	-9.4
Level Change (ft)*	2.92	0.08	1.52	1.67	0.35	2.5	1.8	3.3	3.9	2.0	2.7	4.2
TCA (ppm)	T	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO_2 (0.5-10 Vol.%)	4.5	0.5	0.75	0.75	0.75	0.75	0.75	1.0	1.0	1.0	1.0	1.25
V. Chloride (ppm)	T	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

2. Extraction Well EW02

Check List Date	4/23	5/2	5/7	5/15	5/20	5/29	6/5	6/12	6/19	6/24	7/2	9/17
Flow Rate (scfm)	24.0	24.0	21.8	21.8	20.7	32.7	34.9	40	40	39	41	34
PID Reading (ppm)	789	694	**	122	152	85.8	61.8	53.7	63	75	73	43
Pressure (" water)	-3.1	-3.5	-2.8	-3.4	-3.4	-5.4	-6.2	-7.4	-7.5	-6.9	-6.7	-7.5
Level Change (ft)*	0.23	0.27	0.45	0.5	1.0	1.57	1.57	1.97	2.7	2.4	2.7	3.6
TCA (ppm)	75	ND	40	75	25	25	25	15	T	25	ND	ND
CO_2 (0.5-10 Vol.%)	1.5	2.0	2.0	3.5	3.75	1.25	1.0	1.0	0.75	1.25	1.25	1.0
V. Chloride (ppm)	T	T	T	T	T	T	ND	ND	ND	ND	ND	ND

TABLE 6 (CONTINUED) - PAGE 2
1997 SYSTEM OPERATION DATA
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK

3. **Extraction Well EW03**

Check List Date	**4/23**	**5/2**	**5/7**	**5/15**	**5/20**	**5/29**	**6/5**	**6/12**	**6/19**	**6/24**	**7/2**	**9/17**
Flow Rate (scfm)	24.0	21.8	22.9	21.8	21.8	34.9	38.2	45.8	38.2	32.7	27	27
PID Reading (ppm)	1,967	1,834	**	46.1	101	64.7	48.5	52.0	95	67	73	49
Pressure (" water)	-4.9	-5.5	-4.5	-5.1	-4.9	-8.1	-8.9	-9.8	-9.8	-8.6	-8.4	-9.5
Level Change (ft)*	0.34	0.22	0.34	0.28	0.16	0.41	4.63	2.43	3.1	2.6	2.8	3.6
TCA (ppm)	50	ND	ND	T	ND	ND	ND	ND	ND	ND	ND	ND
CO_2 (0.5-10 Vol.%)	7.0	3.0	2.5	2.25	1.5	1.0	1.25	1.5	1.75	1.75	1.6	T
V. Chloride (ppm)	10	15	T	T	T	T	T	ND	T	ND	2.3	ND

4. **Extraction Well EW04**

Check List Date	**4/23**	**5/2**	**5/7**	**5/15**	**5/20**	**5/29**	**6/5**	**6/12**	**6/19**	**6/24**	**7/2**	**9/17**
Flow Rate (scfm)	24.0	22.9	22.9	22.9	20.7	32.7	33.8	45.8	46	45	50	38
PID Reading (ppm)	878	782	**	73.7	63.3	61.8	52.0	43.2	45	46	50	27
Pressure (" water)	-0.9	-0.33	-0.82	-0.73	-0.79	-1.3	-1.6	-2.4	-2.4	-2.3	-2.1	-1.9
Level Change (ft)	-	-	-	-	-	-	-	-	-	-	-	-
TCA (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO_2 (0.5-10 Vol.%)	3.5	0.75	1.75	1.25	1.25	1.0	0.5	0.5	0.5	0.5	0.75	0.5
Vinylchloride (ppm)	T	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 6 (CONTINUED) - PAGE 3
1997 SYSTEM OPERATION DATA
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK

5. Extraction Well EW05

Check List Date	4/23	5/2	5/7	5/15	5/20	5/29	6/5	6/12	6/19	6/24	7/2	9/17
Flow Rate (scfm)	24.0	22.9	22.9	22.9	20.7	32.7	28.4	17.4	17	22	19	27
PID Reading (ppm)	274	253	**	26.6	22.4	19.2	13.2	6.7	2.1	12.2	8.2	3.9
Pressure (" water)	-1.4	-1.9	-1.4	-1.7	-1.7	-2.5	-3.1	-1.4	-1.2	-1.8	-1.5	-1.6
Level Change (ft)	-	-	-	-	-	-	-	-	-	-	-	-
TCA (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO_2 (0.5-10 Vol.%)	2.0	0.5	0.5	0.5	T	T	0.5	0.25	T	T	T	T
Vinylchloride (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

6. Air Injection Well

Check List Date	4/23	5/2	5/7	5/15	5/20	5/29	6/5	6/12	6/19	6/24	7/2	9/17
Pressure (psi)	4.0	4.0	4.0	3.8	3.5	3.5	4.0	3.0	5.0	4.0	4.0	4.5
Flow Rate (scfm)	9.8	9.8	10.0	9.3	10.9	37.1	38.2	37.1	12	13	4	4

7.0 Soil Vapor Pressure Monitor Readings (inches of water)

Check List Date	4/23	5/2	5/7	5/15	5/20	5/29	6/5	6/12	6/19	6/24	7/2	9/17
MW01	-0.49	-0.77	0.14	0.07	-0.93	1.6	3.5	5.4	-0.01	1.7	-2.5	0
SVPM 1	-0.16	-0.10	-0.12	-0.10	-0.14	-0.15	-0.15	-0.16	-0.24	-0.25	-0.18	-0.19
SVPM 2	-0.19	-0.19	-0.13	-0.15	-0.16	-0.21	-0.25	-0.23	-0.29	-0.28	-0.25	-0.26
SVPM 3	-0.21	-0.16	-0.12	-0.10	-0.14	-0.15	-0.28	-0.32	-0.35	-0.35	-0.32	-0.33
SVPM 4	-0.29	-0.18	-0.13	-0.15	-0.16	-0.21	-0.36	-0.39	-0.43	-0.45	-0.41	-0.42
SVPM 5	-0.03	-0.22	-0.22	-0.17	-0.20	-0.26	-0.41	-0.36	-0.41	-0.43	-0.41	-0.39

TABLE 6 (CONTINUED) - PAGE 4
1997 SYSTEM OPERATION DATA
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK

8. Groundwater Level Change From Start (feet)

Check List Date	4/23	5/2	5/7	5/15	5/20	5/29	6/5	6/12	6/19	6/24	7/2	9/17
GPM 2	0.02	-0.10	0.09	0.02	-0.13	-0.01	0.99	1.59	2.46	1.58	2.2	3.6
GPM 3	0.02	-0.09	0.07	0.0	-0.13	-0.04	0.89	1.55	2.37	1.76	2.2	3.5
MW01	0.02	-0.08	0.05	-0.01	-0.13	-0.03	0.83	1.51	2.28	1.68	2.2	3.5
HN27-S3	0.09	-0.15	-0.08	-0.11	-0.21	-0.11	-0.08	1.95	2.58	1.88	2.4	3.8

* Approximate water level change due to bubbling in extraction wells.
** Photoionization detector (PID) reading was not obtained.
PPM PID readings are measured in Parts Per Million.
SCFM Flow rates are measured in Standard Cubic Feet per Minute.
PSI Injection pressure is measured in Pounds-Force per Square Inch.
T Trace indicates slight color change in Drager Tube.
ND Not Detected no color change in Drager Tube

Drager Tube	Trace	Not Detected
TCA (ppm)	Less than 25 ppm color change.	Less than 10 ppm color change.
CO_2 (%)	Less than 0.25 % color change.	Less than 0.1% color change.
Vinyl Chloride (ppm)	Less than 5 ppm color change.	Less than 2 ppm color change.

Well ID	Initial Water Level (feet)
EW-01	58.10
EW-02	58.77
EW-03	58.03
GPM 2	59.16
GPM 3	59.10
MW-01	59.16
HN-27-S3	56.81

- The carbon dioxide concentration in the deep soil vapor extraction wells was generally in the range of 1% to 2% throughout the trial. This concentration is relatively high for sandy soils, in the absence of carbonate minerals. Since petroleum hydrocarbons were not identified as a concern at this site, carbon dioxide (which is associated with biodegradation) was not considered as a primary indicator parameter. The levels of carbon dioxide detected may result from the degradation of historic sanitary wastes in the drain field.

- The groundwater water level rose by approximately 3 to 4 feet from May 1997 to September 1997. This change may have resulted from either a regional water change, or may be associated with the operation of the Plant 3 - Recharge Basins.

Chemical Data - Soils

The results of the soil testing are presented in Table 7. Sample log sheets, chain of custody forms, and laboratory data sheets are provided in Appendices E, F, and G, respectively. The VOCs detected in the soil consist of acetone, tetrachloroethene (PCE), 1,1 dichloroethane (DCA), 1,2 dichloroethene (DCE), 1,1,1 trichloroethane (TCA), and trichloroethene (TCE). With the exception of acetone, each of these chemicals was detected in the site groundwater at concentrations of 34 to 2800 groundwater preliminary remediation goals. Acetone is suspected to be a laboratory contaminant and may not be a site contaminant. As a result, discussion will be limited to the other VOCs detected.

The soil VOC PRGs are 10 to 27 ug/kg. VOCs in four out of six of the initial soil samples exceeded PRGs included PCE (SB-0210, SB-0240, SB-0320, and SB-0430), TCE (SB-0430), and TCA (SB-0430). After 2.5 months of operation the VOCs in three of the four samples decreased to below the PRGs.

However, for samples SB-0320 and SB-0340, the PCE concentration increased. For SB0320, the PCE concentration increased from 47 ug/kg to 160 ug/kg. For SB0340, the PCE concentration increased from none detected to 660,000 ug/kg. This increase in PCE concentration is believed to result from one of the following.

TABLE 7

SOIL RESULTS
FORMER DRUM MARSHALLING AREA
PILOT SCALE - AIR SPARGE/SOIL VAPOR EXTRACTION SYSTEM
NWIRP BETHPAGE, NEW YORK

Sample Location	Parameter	Pre-test Result (ug/kg) (April 1997)	Post-test Result (ug/kg) (July 1997)
PS-SB-0210	Acetone	890	
	Tetrachloroethene	80	
PS-SB-0240	Acetone	18,000	
	Tetrachloroethene	59	
PS-SB-0320	Acetone	3,600	
	Tetrachloroethene	47	160
PS-SB-0340	Acetone	47	
	Tetrachloroethene		660,000
PS-SB-0430	Acetone	48	
	1,1-Dichloroethane	17	
	1,2-Dichloroethene	150	
	1,1,1-Trichloroethane	50	
	Trichloroethene	120	
	Tetrachloroethene	170	
PS-SB-0440	Acetone		15

Sample Location Description

PS-SB-xxyy

PS AS/SVE Pilot Study, NWIRP Bethpage
SB Soil boring
xx Soil boring number
yy Sample depth, in feet below ground surface.

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- Chance sampling of small pockets of VOC contaminated soils. However, the samples from April and July 1997 were collected from within 3 to 6 feet of each other.

- PCE is migrating through the soils, either as a result of the AS/SVE operation, or from other disturbances at the site. These other disturbances include the demolition of site structures, removal of equipment covering the site, and/or modification of surface water flow paths.

The overall conclusion from the soil testing is that VOCs in some of the site soils respond very well to SVE, with cleanup times potentially as short as several months. However, the finding of a relatively high VOC concentration in one location indicates that pockets of VOCs may exist throughout the site. Cleanup at these locations could take approximately two years.

Chemical Data - Groundwater

The groundwater results are presented in Table 8. Sample log sheets, chain of custody forms, and laboratory data sheets are provided in Appendices E, F, and G, respectively. Based on these results, there was a general downward trend in VOC concentrations in four of the five monitoring wells. Only monitoring well PS-EW03, which is located 20 feet hydraulically upgradient of the injection well did not follow this trend.

For monitoring well PS-MW01 (which is only a groundwater monitoring well and located 30 feet downgradient of the air injection well), the total groundwater VOC concentration started at approximately 4,400 ug/l and decreased to a low of 30 ug/l, after two months of operation, (see Figure 11). At the end of the trial - one month later, the total VOC concentration had increased to 474 ug/l. This increase may have resulted from the air injection rate being decreased from approximately 12 to 38 cfm in May and June to only 4 cfm in July.

TABLE 8

GROUNDWATER RESULTS (ug/l)
FORMER DRUM MARSHALLING AREA
PILOT SCALE AIR SPARGE/SOIL VAPOR EXTRACTION SYSTEM
NWIRP BETHPAGE, NEW YORK

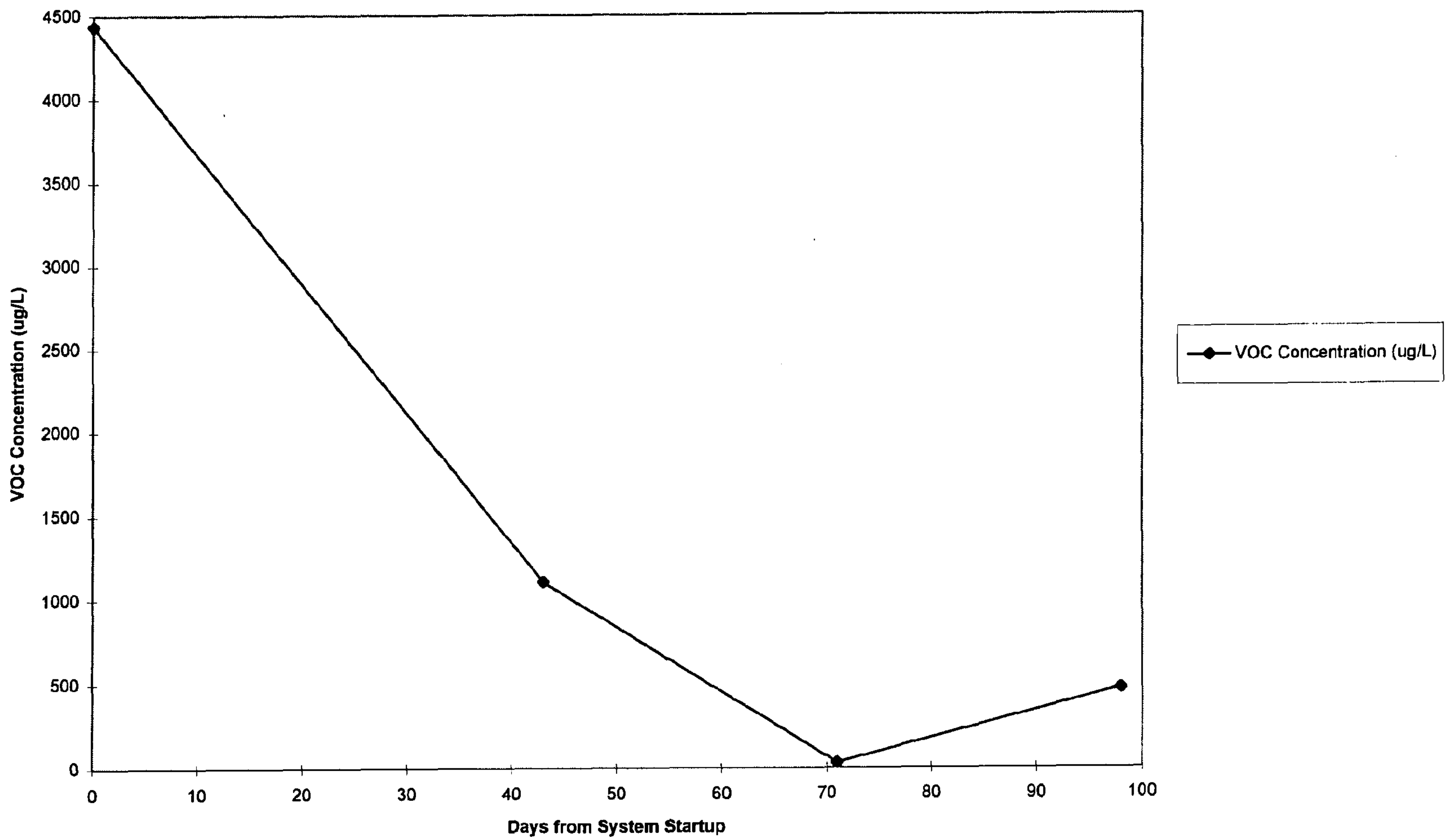
Sample Location	Parameter	Pre-test Results (04/08/97)	Mid-Test Results (One Month - 05/21/97)	Mid-Test Results (Two Months - 06/18/97)	End of Test Results (Three Months - 07/15/97)
PS-MW01	1,1-Dichloroethene	6			
	1,1-Dichloroethane	110	36		60
	c-1,2-Dichloroethene	500	110	7	77
	1,1,1-Trichloroethane	390	94	6	120
	Trichloroethene	630	160	17	47
	Tetrachloroethene	2,800	710		170
	Total	4,436	1,110	30	474
PS-IW01	Acetone	560			
	2-Butanone	1,700			
	1,1,1-Trichloroethane	7	8		
	Tetrachloroethene	19	15	4	10
	Total[1]	26	23	4	10
PS-EW01	1,1-Dichloroethene				
	1,1-Dichloroethane	80		15	7
	c-1,2-Dichloroethene	380	15	15	10
	1,1,1-Trichloroethane	220	5	50	12
	Trichloroethene	370	9	18	12
	Tetrachloroethene	1600	27	71	27
	Total	2,650	56	169	68

TABLE 8 (CONTINUED) - PAGE 2
GROUNDWATER RESULTS (ug/l)
FORMER DRUM MARSHALLING AREA
PILOT SCALE AIR SPARGE/SOIL VAPOR EXTRACTION SYSTEM
NWIRP BETHPAGE, NEW YORK

Sample Location	Parameter	Pre-test Results (04/08/97)	Mid-Test Results (One Month - 05/21/97)	Mid-Test Results (Two Months - 06/18/97)	End of Test Results (Three Months - 07/15/97)
PS-EW02	1,1-Dichloroethene	11	12		9/8
	1,1-Dichloroethane	170	160	91/74	410/490
	c-1,2-Dichloroethene	840	340	190/140	200/210
	t-1,2-Dichloroethene	6			
	Chloroform	5			
	1,1,1-Trichloroethane	1,200	770	410/340	1200/1400
	Trichloroethene	1,500	580	270/220	140/140
	Tetrachloroethene	11,000	4,500	2200/1700	1400/1300
	Total	14,732	6,362	3161/2474	3359/3548
PS-EW03	Acetone		83		
	1,1-Dichloroethane	49	51	46	57
	c-1,2-Dichloroethene	240	160	160	130
	1,1,1-Trichloroethane	200	170	250	210
	Trichloroethene	380	230	320	180
	Tetrachloroethene	1,400	920	1800	840
	Total[1]	2,269	1,531	2576	1417

1. Total does not include acetone and 2-butanone, which are believed to be laboratory contaminants.

FIGURE 11
VOC CONCENTRATION IN GROUNDWATER VERSUS TIME MONITORING WELL MW-01
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK



For monitoring well PS-IW01 (which was the air injection well), the total groundwater VOC concentration (except acetone and 2-butanone) started at 26 ug/l and decreased to a low of 4 ug/l, after two months of operation, (see Figure 12). At the end of the trial - one month later, the total VOC concentration had increased to 10 ug/l. Again, this increase may have resulted from the air injection rate being decreased from approximately 12 to 38 cfm in May and June to only 4 cfm in July.

For monitoring well PS-EW01 (which was a soil vapor extraction well located 10 feet downgradient from the air injection well), the total groundwater VOC concentration started at approximately 2,650 ug/l and then decreased to a low of 56 ug/l, after one month of operation, (see Figure 13). During the next two months of operation, the total VOC concentration first increased to 169 ug/l and then decreased to 68 ug/l at the end of the trial. Based on the relatively high initial concentration, the VOC concentration in the last three sample events could be an indication of a pseudo-steady state condition, with the range of VOCs detected (56 to 169 ug/l) accounted for by normal variability in analytical results.

For monitoring well PS-EW02 (which was a soil vapor extraction well located 40 feet side gradient of the air injection well), the total groundwater VOC concentration started at approximately 15,000 ug/l and consistently decreased to a low of approximately 3000 ug/l, after two months of operation, (see Figure 14). At the end of the trial - one month later, the total VOC concentration had increased to approximately 3400 ug/l. This increase in VOCs may have resulted from the air injection rate being decreased from approximately 12 to 38 cfm in May and June to only 4 cfm in July.

For monitoring well PS-EW03 (which was a soil vapor extraction well located 20 feet upgradient of the air injection well), the total groundwater VOC concentration started at approximately 2,300 ug/l. During the course of the trial, the total VOC concentration first decreased to 1,531 ug/l, then increased to 2,576 ug/l, and finally decreased to 1,417 ug/l, (see Figure 15). This relatively random fluctuation in VOC concentrations is believed to be an indication that the air injection well did not influence the groundwater at that location (PS-EW03). Rather the range of VOCs detected is the result of normal variability in analytical results.

FIGURE 12
VOC CONCENTRATION IN GROUNDWATER VERSUS TIME INJECTION WELL IW-01
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK

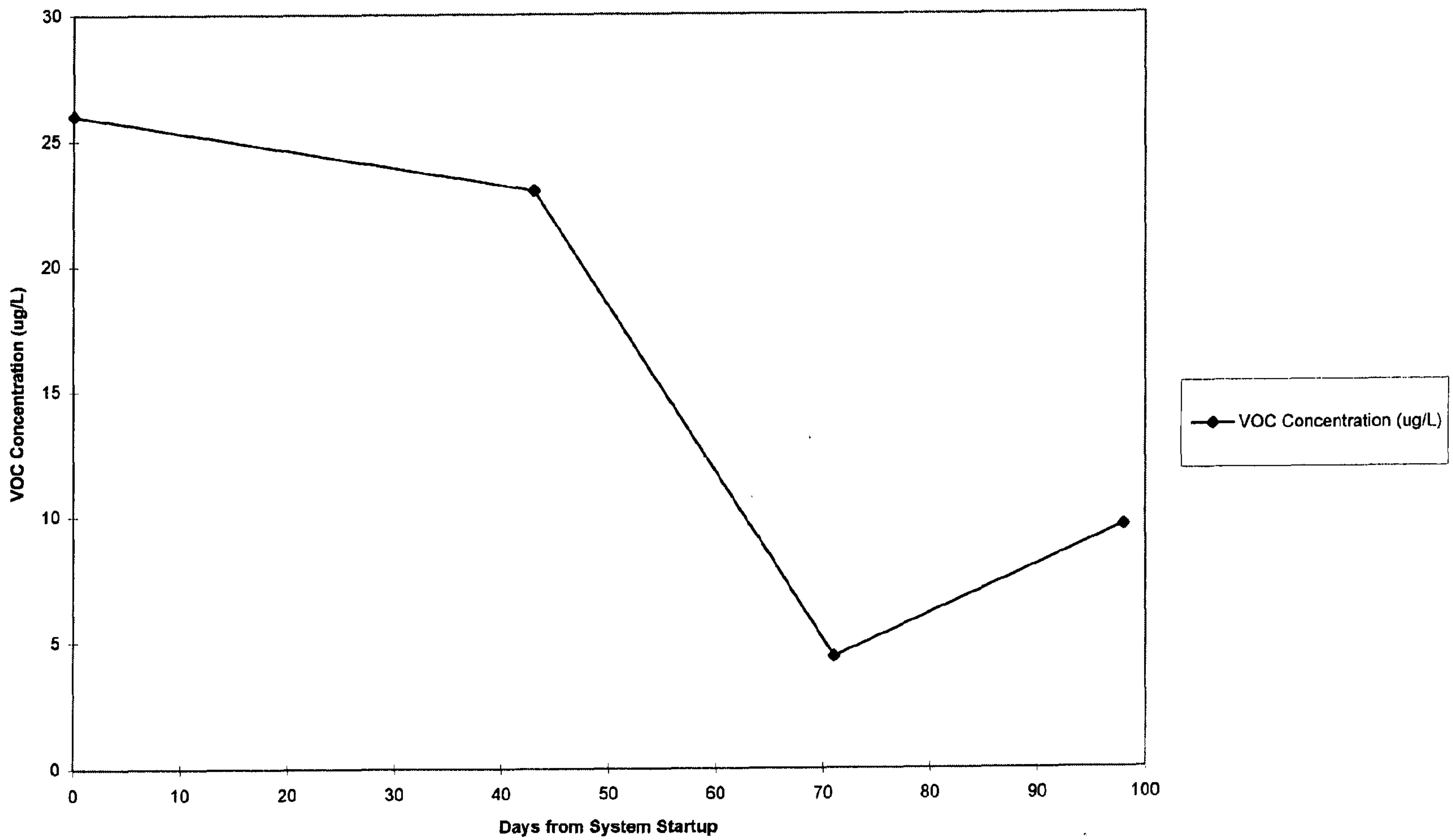


FIGURE 13
VOC CONCENTRATION IN GROUNDWATER VERSUS TIME AIR EXTRACTION WELL EW-01
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK

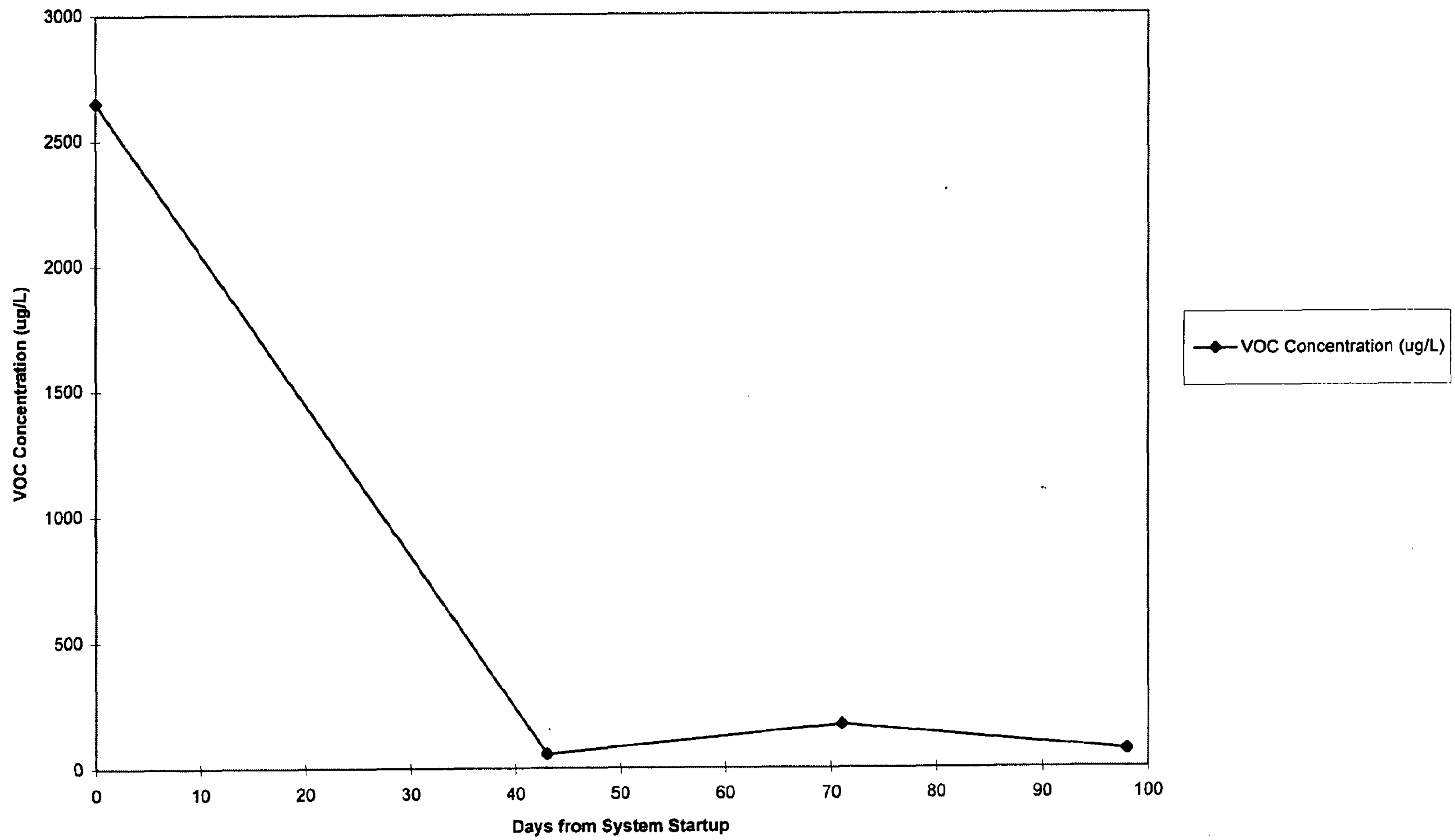


FIGURE 14
VOC CONCENTRATION IN GROUNDWATER VERSUS TIME AIR EXTRACTION WELL EW-02
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK

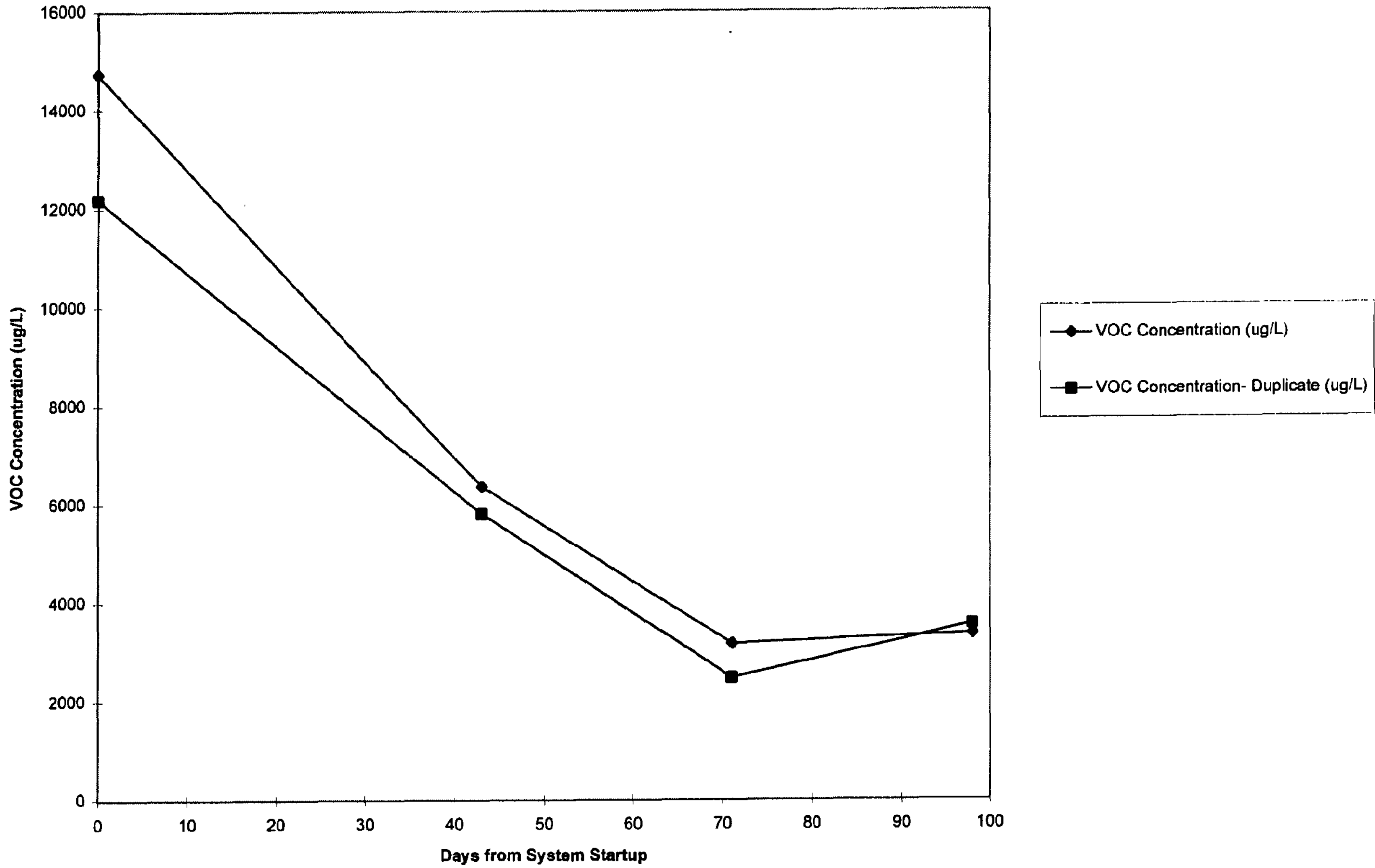
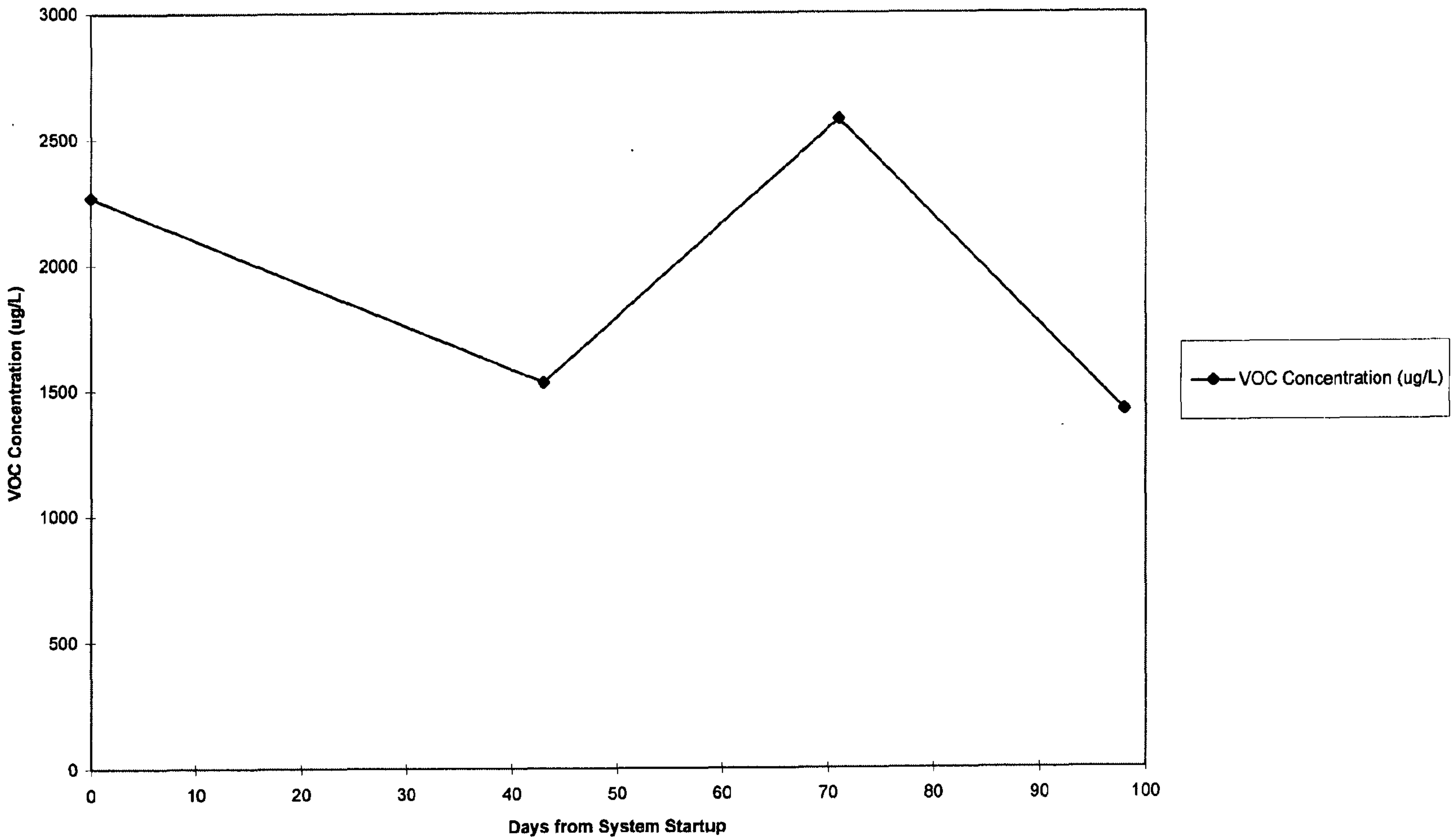


FIGURE 15
VOC CONCENTRATION IN GROUNDWATER VERSUS TIME AIR EXTRACTION WELL EW-03
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK



Overall based on the groundwater VOC concentrations as a function of time and air injection rates, one can conclude that air injection affected groundwater at locations PS-MW01, PS-EW01, PS-EW02, and PS-IW01; but it did not affect the groundwater at location PS-EW03.

Chemical Data - Soil Vapor

The soil vapor data is presented in Table 9. Chain of custody forms and laboratory data sheets are provided in Appendices F and G, respectively. The pre-carbon sample represents the combined soil gas extracted from the five extraction wells and the post-carbon sample represents treated soil gas prior to discharge.

The type of VOCs detected in the extracted soil gas are consistent with those detected in the soils and groundwater. In addition, the three VOCs detected at the highest concentration in the soil gas are TCA, TCE, and PCE, which are also the three primary chemicals of concern at the site. The total soil gas VOC concentration started at a high of approximately 750 ppm during the first week of operation and then decreased to approximately 50 ppm during the second and third month of the trial.

Based on these soil gas concentrations and the measured extraction rates, relatively high quantities of VOCs were removed from the soil vapor extraction system. Near the beginning of the study, approximately 50 pounds per day of VOCs were being removed. By one month in the study, the removal had decreased to approximately 7 pounds per day and by the end of the AS/SVE operation in September 1997, approximately 6 pounds per day of VOCs were continuing to be removed. The total estimated VOC removal, from April to September 1997 is calculated to be approximately 900 pounds. The measured soil gas VOC concentration and incremental pounds of VOCs removed are presented in Figure 16, calculations are presented in Appendix H.

TABLE 9

SOIL VAPOR RESULTS (PPM-V)
PILOT SCALE AIR SPARGE/SOIL VAPOR EXTRACTION SYSTEM
NWIRP BETHPAGE, NEW YORK

Sample Location	Parameter	Initial Results (April 1997)	Mid-Test Results (One Month - May 1997)	Mid-Test Results (Two Months - 06/19/97)	End of Test Results (Three Months - 07/15/97)
Pre-carbon gas	Freon 113	22	2.8	1.1	1.1
	1,1-Dichloroethane	5.2	2.5	0.96	2.3
	1,1-Dichloroethene		0.41	0.14	0.3
	1,2-Dichlorothene	20	2.6	1.0	1.4
	1,1,1 Trichloroethane	75	27	14	26
	Trichloroethene	51	4.6	3.4	3.8
	Tetrachloroethene	580	52	23	21
	Total	753.2	91.9	43.6	55.8

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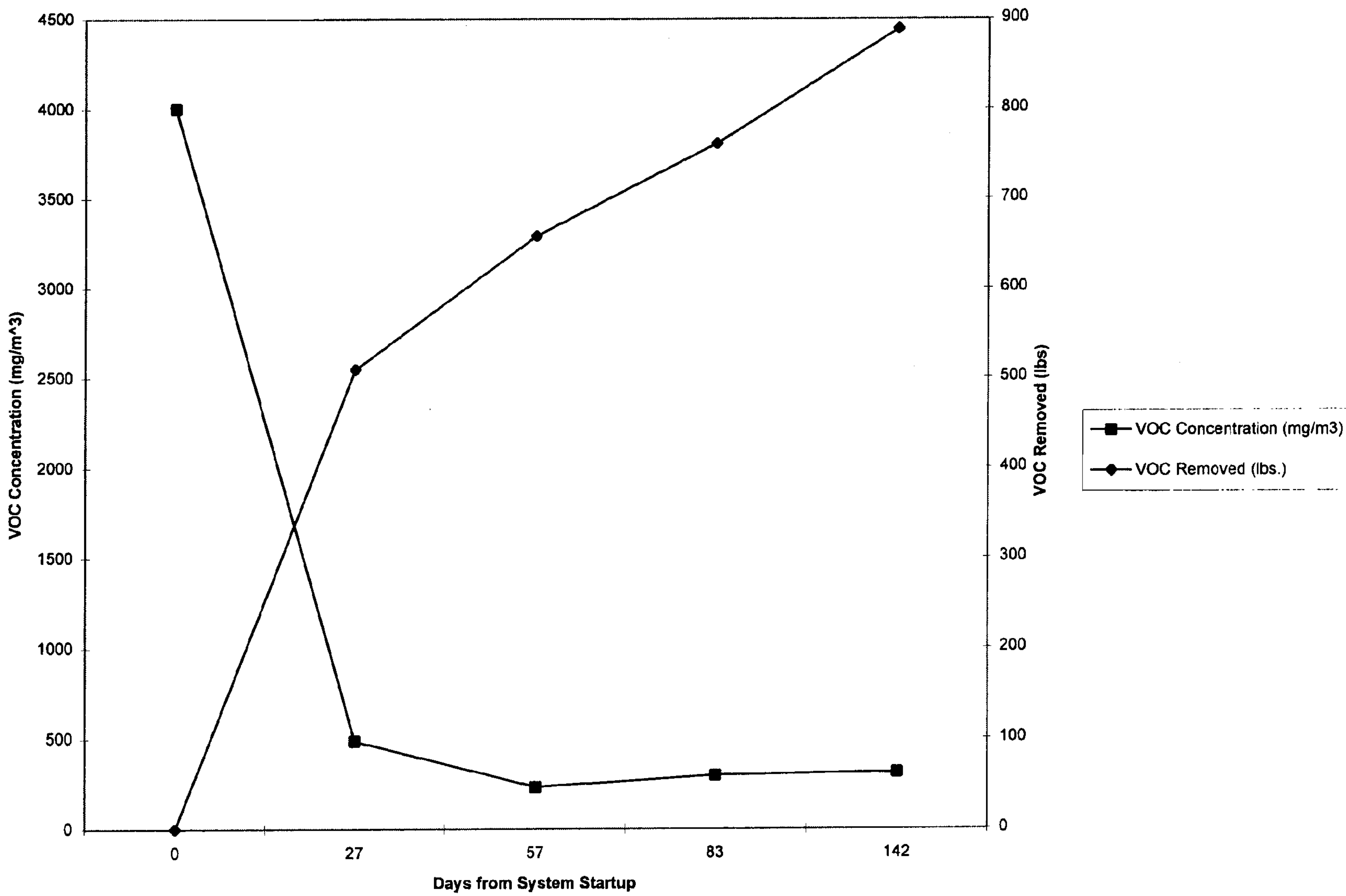
TABLE 9 (CONTINUED) - PAGE 2
SOIL VAPOR RESULTS (PPM-V)
PILOT SCALE AIR SPARGE/SOIL VAPOR EXTRACTION SYSTEM
NWIRP BETHPAGE, NEW YORK

Sample Location	Parameter	Initial Results (April 1997)	Mid-Test Results (One Month - May 1997)	Mid-Test Results (Two Months - 06/19/97)	End of Test Results (Three Months - 07/15/97)
Post-carbon gas sample	Freon 113				0.0086
	2-Butanone	0.013			0.0043
	Tetrahydrofuran	0.015	0.019		
	Acetone	0.006	0.019	0.0051	0.0068
	Chloroethane			0.024	0.019
	Methylene Chloride	0.004	0.005	0.0074	0.011
	Vinyl Chloride		0.012	0.0016	0.0051
	1,1-Dichloroethane				0.014
	1,1-Dichloroethene				0.0014
	1,2-Dichlorothene				0.024
	1,1,1 Trichloroethane				0.23
	Propylene			0.013	
	2-Propanol			0.0041	0.0053
	1,2,4-Trimethylbenzene			0.0012	
	Toluene	0.002		0.003	0.0035
	Trichloroethene				0.05
	Tetrachloroethene		0.006		0.038
	Total	0.040	0.061	0.0594	0.421

FIGURE 16
VOC CONCENTRATION IN LOADING IN AIR VERSUS TIME AIR EXTRACTION SYSTEM
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK



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4.0 CONCLUSIONS

The conclusions derived from the pilot study are summarized as follows.

1. Stratification testing results indicate that dense VOCs do not preferentially accumulate near the bottom of an extraction well.

2. Soil vapor extraction radius of influence testing found that the site soils are highly permeable, with extraction rates of 80 cfm per well achievable. Measured radius of influences ranged from 50 feet at 5 cfm to approximately 100 feet at 80 cfm. A reasonable correlation was developed between flow rate and radius of influence.

3. Soil vapor extraction at the water table resulted in flow through both the upper and lower soil zones. Soil vapor extraction at the middle of the unsaturated zone resulted in flow through the middle of the unsaturated zone, but may have created stagnant conditions near the water table.

4. The cesspool structures do not appear to restrict air flow through them.

5. Air injection rates as high as 60 cfm were achieved. However, rates greater than 20 cfm were difficult to consistently achieve and maintain.

6. The air injection tests were partially successful. An estimated radius of influence for air injection of 10 to 40 feet was obtained. Based on the testing data, at air injection rates of 10 cfm and greater, the radius of influence for air injection is not a strong function of air flow rate. Based on chemical test results, air injection had a measurable effect on the groundwater at distances of 10, 30 and 40 feet side-gradient and downgradient of the injection well. One groundwater well located 20 feet upgradient of the injection point was not affected by air injection.

7. The presence of a clay lens within approximately 5 feet of the water table at the site requires special consideration for the design of air injection wells. To ensure capture of

injected air, soil vapor extraction must be implemented between clay lens and air injection points. Soil boring samples will be required during installation for confirm location of clay lens.

8. Based on the testing, a soil vapor extraction to air injection ratio of approximately 2 to 3 is required to capture all of the injected air.

9. Preliminary design criteria for the full scale system are summarized as follows.

- Two to three lines of air injection wells located near the center of the groundwater contamination and near the downgradient border of the site to treat the most contaminated groundwater and soil contamination along the interface between groundwater and soil.

- The preliminary design injection wells should be on 50 foot centers. Each line of wells will contain 3 to 4 air injections wells (total of approximately 11).

- Air injection rates for each well will be approximately 10 cfm (110 cfm total air injection).

- Soil vapor extraction wells should be on approximately 100 foot centers. Approximately 4 lines of soil vapor extraction wells should be located near the northern and southeast soil contaminant zones. These wells will be used to extract soil vapors and injected air.

- Each line of wells will contain approximately 3 to 4 wells, (total of approximately 14 wells).

- Soil vapor extraction rates will be approximately 20 to 30 cfm per well (300 cfm total soil vapor extraction). This rate includes criteria for both radius of influence and a SVE to AS ratio of greater than 2.0.

10. Based on the soil data, some soils at Site 1 can possibly be cleaned up in as little as three months. However, because of the presence of pockets of contamination at the site, and potential interferences to uniform flow (i.e. sludges or clay lenses), the total site remediation schedule for VOCs is expected to be approximately two years.

11. Air sparging system can effectively remove VOCs from groundwater. The time to comply with groundwater PRGs is uncertain at this time.