GERAGHTY
& MILLER, INC.
Environmental Services

94-511

Ground Water *Engineering* *Hydrocarbon* *Remediation* *Education*

May 13, 1992

Mr. Kyle Christie
ARCO Products Company
2000 Alameda de las Pulgas
San Mateo, California 94403

RE: Bioventing Pilot Test Results
ARCO Service Station No. 4351, 14424 N. Greenwood Avenue, Seattle, Washington;
Project No. WA179.30, Task Order No. 4351-91-2A

Dear Mr. Christie:

At the request of ARCO Products Company, on January 21 and January 22, 1992, Geraghty & Miller, Inc. performed a bioventing pilot test on existing vapor recovery wells at ARCO Service Station No. 4351 located at 14424 North Greenwood Avenue in Seattle, Washington (the site).

PURPOSE

The purpose of the test was threefold: (1) to determine the suitability of bioventing for soil remediation near the former underground storage tank (UST) complex and pump islands at the site, (2) to determine if the spacing of the existing bioventing wells is sufficient to affect soils in areas where residual hydrocarbons are known to be above Washington State Model Toxics Control Act (MTCA) Method A cleanup levels for soils, and (3) to obtain data necessary for selecting an off-gas treatment unit and prepare an air permit application. Hydrocarbon removal will be accomplished as a result of both the volatilization of the lighter petroleum fraction of gasoline and the increased biodegradation of the residual petroleum hydrocarbons.

SUBSURFACE CONDITIONS

Geologic Conditions

The site is underlain by unconsolidated sediments that include recent fill and Pleistocene Age drift deposits. Fill materials beneath the site consist of a mixture of fine to coarse gravel, very-fine- to fine-grained sand, and silt. The fill materials are generally well-graded,

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brown to reddish-brown, and dry to moist. Gravel clasts in the fill material range in size from 0.25- to 1-inch in diameter. Depth to the bottom of the fill ranges from approximately 3 feet bls near Bioventing Well BV-1 to approximately 9 feet bls near Bioventing Well BV-4 and up to 15 feet bls beneath the tank complex. No waste debris was encountered in the fill material.

Glacial drift deposits underlying the fill predominantly consist of well-graded sand with gravel and cobbles. The drift deposits are grey, moist to wet, and contain very-fine- to coarse-grained sand, fine to coarse gravel, and cobbles. Silt content increases approximately 20 feet bls, and lenses of grey, dry silt with clay occur between approximately 25 and 50 feet bls. Gravel and sand content increases between approximately 50 and 72-plus feet bls.

Other than minor amounts of perched water at about 30 feet bls, no ground water was encountered beneath the site.

Bioventing Well Structure

Each bioventing well is 2 inches in diameter and is constructed of a five-foot-long section of 0.02-inch machine slotted PVC screen and Schedule 40 PVC riser. The screens are situated at depths ranging from 15 to 30 feet bls. Table 1 contains specific well construction data and Figure 1 indicates their location.

Residual Hydrocarbon Distribution

During site assessment, UST removal, and site characterization activities performed by Geraghty & Miller from 1989 through 1992, residual hydrocarbons were encountered in the subsurface at the site. Those activities found that residual hydrocarbons existed in the subsurface soils in and around the UST complex and near both pump islands. The concentrations of hydrocarbons detected near the UST complex at depths from 30 to 32 feet bls are consistent with the increased silt and clay content found at that depth which inhibits downward migration of liquids. In some areas perched ground water was encountered just above the silt and clay layer. No residual hydrocarbons have been detected in soil samples collected from depths of greater than 32 feet bls.

METHODOLOGY

The bioventing pilot test utilized five 2-inch diameter vapor recovery wells (BV-1 through BV-5) installed in June 1991 by Holt Testing, Inc. (subcontracted by Geraghty & Miller) and one existing 4-inch diameter well of unknown origin (WC-1) (Figure 1). The recovery wells surround the UST complex.

During the pilot test, Geraghty & Miller's pilot test unit was used to create a vacuum on each recovery well independently. As the soil vapors were removed, induced vacuums were measured in the remaining wells to determine the extent of the influence that could be obtained with the bioventing vapor recovery system (BVRS). Percentages of oxygen and lower explosive limit (LEL) were measured in the recovered soil vapors and compared to ambient air concentrations. These comparisons indicate the relative concentrations of constituents in the soil and soil vapors. One vapor sample was collected from each recovery well and placed in a Tedlar™ bag and submitted to a laboratory for chemical analyses. These data were used to correlate and calibrate data acquired by direct reading field instruments.

Physical Analysis

The pilot test was initiated at each of the recovery wells by temporarily piping the bioventing test unit to one well at a time while sealing the remaining wells with caps fitted with hose barb connections for measuring induced vacuum. A Rotron™ regenerative blower (model number DR404-AR58M) was used to create the vacuum necessary for the test. As a vacuum of approximately 60 inches of water column was created at the recovery well, induced vacuums were recorded at the observation wells to determine the radius of vacuum influence (Table 2). The magnitude and distribution of induced vacuums indicated that the stratigraphy and soil characteristics at the site are favorable for implementation of a BVRS.

Test results indicated that a vacuum of 60 inches of water column applied simultaneously to Wells BV-2, BV-4, and BV-5 would sufficiently influence the area where residual hydrocarbons are known to exist. Installation of additional bioventing wells is not necessary at this time. The induced vacuums on Wells BV-1 and WC-1 showed that the extent of vacuum influence when recovering vapors from BV-2, BV-4, and BV-5 will likely cover not only the area of the USTs, but also the area around both pump islands (Figure 2).

Chemical Analyses

Extracted vapors were monitored for hydrocarbon vapor concentrations, oxygen levels, and LEL percentages during the test using a Bacharach™ Sentinel 4 personal gas monitor. However, the elevated hydrocarbon vapor concentrations encountered during the test were in excess of 100 percent LEL as measured by the vapor analyzer, which are beyond the capability of the gas monitor. Therefore, field measurements for LEL are not reliable. Summaries of field and laboratory analytical data can be found in Tables 2 and 3, respectively.

GTEL Environmental Laboratories, an ARCO-contracted laboratory, was selected to perform analyses on vapor samples for total petroleum hydrocarbons as gasoline (TPH-G) using modified U.S. Environmental Protection Agency (EPA) Method 8015; benzene, toluene, ethylbenzene, and total xylenes (BTEX) using EPA Method 8020; methane; oxygen; and carbon dioxide. The results of these analyses are included in Table 3 and Appendix A. Analytical data of the extracted soil vapors show lower-than-normal oxygen levels and relatively high concentrations of carbon dioxide (CO_2) and methane. Oxygen concentrations were 5.3 to 11.3 percent and CO_2 concentrations ranged from 2.7 to 4.3 percent by volume. By comparison, the normal atmospheric oxygen concentration is 20.8 percent and CO_2 concentration is approximately 0.03 percent by volume. Methane was detected at 560 to 4,700 parts per million, where normal atmospheric concentration is approximately 2 parts per million. Elevated CO_2 and methane concentrations indicate microbial activity in the vadose zone assisting in petroleum degradation. However, the reduced oxygen levels and elevated methane concentrations imply that some of the microbial activity has been anaerobic. A bioventing system will introduce more oxygen into the vadose zone, which will, in turn, enhance aerobic bacterial activity and expedite the removal of residual hydrocarbons.

SUMMARY AND CONCLUSIONS

The bioventing pilot test demonstrated that conditions at the site favor the use of a bioventing system to remove residual petroleum hydrocarbons in the vadose zone beneath the site.

The spacing and location of recovery wells installed will be sufficient for the remediation objectives. It is anticipated that by extracting soil vapors from Recovery Wells BV-2, BV-4, and BV-5, hydrocarbon removal will be accomplished as a result of both the volatilization of the lighter petroleum fraction of gasoline and the increased biodegradation of the residual petroleum hydrocarbons.

Concentrations of volatile hydrocarbons measured during the pilot test in the off-gasses indicate that operation of the bioventing system would be initially limited to less than one hour per day without the use of an off-gas treatment unit. Recommendations for the selection of the off-gas treatment unit are forthcoming. Recommendations will be based on cost, off-gas concentrations, volume of residual hydrocarbons to be removed, projected flow rates, safety, and reuse.

Geraghty and Miller has used the data obtained from the pilot test to apply for approval from Puget Sound Air Pollution Control Agency (PSAPCA) to construct a soil remediation system utilizing bioventing. Once authorization is obtained from PSAPCA and ARCO, the final design and installation of the bioventing system will proceed.

Geraghty & Miller appreciates the opportunity to work with you on this project. Please call if you have any questions regarding the contents of this report or if you require any further information.

Sincerely,

GERAGHTY & MILLER, INC.

Michael J. Smith
Staff Engineer/Project Manager

Kurt S. Anderson
Office Program Manager, Hydrocarbon Services

Susan J. Keith
Principal Scientist and Associate/
Project Officer

MJS/kkj

Enclosure

REFERENCES

Geraghty & Miller, Inc. 1989. Preliminary Subsurface Assessment at ARCO Service Station No. 4351, SE Corner of NE 145th Street and Greenwood Avenue, Seattle, Washington, Project No. WA536SS07, October 18, 1989.

_____. 1991a. Site Health & Safety Plan for Hydrocarbon Assessment, ARCO Service Station No. 4351, Seattle, Washington, Project No. WA179.2A, March 31, 1991.

_____. 1991b. Environmental Oversight of Underground Storage Tank Removal, ARCO Service Station No. 4351, Seattle, Washington, Project No. WA131.1A, April 8, 1991.

_____. 1991c. Soil Removal Report, ARCO Service Station No. 4351, Seattle, Washington, Task Order No. 4351-91-1B, Project No. WA157.50, May 17, 1991.

_____. 1991d. Site Characterization, ARCO Service Station No. 4351, Seattle, Washington, Task Order No. 4351-91-2, Project No. WA179.2A, January 20, 1992.

TABLES

Table 1. Summary of Well Construction Details
ARCO Service Station No. 4351, Seattle, Washington
Project No. WA179.30

Well ID	Installation Date	Total Well Depth (ft bls)	Screened Interval (ft bls)	Measuring Point Elevation (ft NGVD29)	Ground Surface Elevation (ft NGVD29)
BV-1	05-Jun-91	25.0	20 - 25	NA	NA
BV-2	05-Jun-91	30.0	25 - 30	NA	NA
BV-3	06-Jun-91	20.0	15 - 20	NA	NA
BV-4	06-Jun-91	27.0	22 - 27	NA	NA
BV-5	06-Jun-91	25.0	20 - 25	NA	NA

ft bls Feet below land surface
ft NGVD29 Feet above mean National Geodetic Vertical Datum established in 1929
NA Not available
Measuring point on each well is the north rim of inner well casing.

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Table 2. Summary of Bioventing System Pilot Test Field Data
ARCO Service Station No. 4351, Seattle, Washington
Project No. WA179.30

Recovery Well	Elapsed Time (minutes)	Percent LEL (*)	Percent Oxygen (**)	Applied Vacuum (inches of water)	Induced Vacuum (inches of water)					
					BV-1	BV-2	BV-3	BV-4	BV-5	WC-1
Ambient Conditions		0.00	20.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BV-1	1	100	11.7	58	-	0.85	0.66	1.55	1.38	0.56
	13	NRT	NRT	56	-	1.50	0.55	1.65	2.05	0.72
	26	100	10.6	55	-	1.75	0.45	1.50	2.25	0.71
	47	100	10.6	56	-	1.85	0.37	1.44	2.40	0.68
BV-2	1	100	5.8	54	1.22	-	0.29	0.79	1.05	0.73
	15	NRT	NRT	58	3.00	-	1.08	4.30	8.20	1.90
	33	100	4.7	59	4.50	-	1.55	6.50	11.90	2.40
	55	100	4.7	59	5.10	-	1.99	7.50	13.40	2.70
BV-3	1	100	11.8	61	0.00	0.00	-	0.05	0.00	NRT
	12	100	11.8	56	0.00	0.10	-	0.20	0.00	NRT
	22	100	11.8	56	0.00	0.20	-	0.40	0.10	NRT
	32	100	11.8	56	0.00	0.25	-	0.50	0.15	NRT
	42	100	11.8	55	0.00	0.30	-	0.55	0.15	NRT
	62	NRT	NRT	56	0.05	0.40	-	0.70	0.25	0.45
	72	100	11.8	55	0.05	0.43	-	0.70	0.30	0.50
	82	NRT	NRT	NRT	0.06	0.47	-	0.80	0.30	0.54
BV-4	1	100	7.4	57	0.80	2.00	0.95	-	2.40	1.00
	12	NRT	NRT	58	0.90	2.90	1.31	-	5.20	0.94
	23	100	7.4	58	1.10	4.00	1.56	-	6.80	1.02
	40	NRT	NRT	58	1.05	4.05	1.81	-	7.10	1.00
BV-5	1	100	4.5	57	0.15	0.28	0.55	1.55	-	0.50
	12	NRT	NRT	59	2.80	7.10	0.80	6.90	-	0.70
	22	100	5.2	60	4.20	9.00	1.10	9.60	-	1.00
	37	100	5.4	61	5.10	11.20	1.55	11.10	-	1.20
	52	NRT	NRT	60	5.60	11.90	1.75	12.20	-	1.40
	67	100	5.6	61	6.00	12.30	1.80	12.50	-	1.50

NRT No reading taken
LEL Lower explosive limit
* LEL meter would not zero correctly due to extremely high concentrations being measured
** Percent by volume

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Table 3. Summary of Bioventing System Pilot Test Field Data
ARCO Service Station No. 4351, Seattle, Washington
Project No. WA179.30

Recovery Well	Benzene (ug/L)	Toluene (ug/L)	Ethyl-benzene (ug/L)	Xylene (ug/L)	Total BTEX (ug/L)	TPH-G (ug/L)	O2 (ug/L)	CO2 (ug/L)	Methane (ug/L)
BV-1	200	65	33	100	400	26,000	150,000	69,000	3,300
BV-2	4,900	5,400	400	1,500	12,000	140,000	70,000	80,000	560
BV-3	450	450	120	370	1,400	27,000	150,000	49,000	640
BV-4	860	370	110	310	1,700	39,000	110,000	62,000	4,700
BV-5	1,500	2,100	270	1,200	5,100	91,000	81,000	80,000	2,900

CO2 Carbon dioxide
O2 Oxygen

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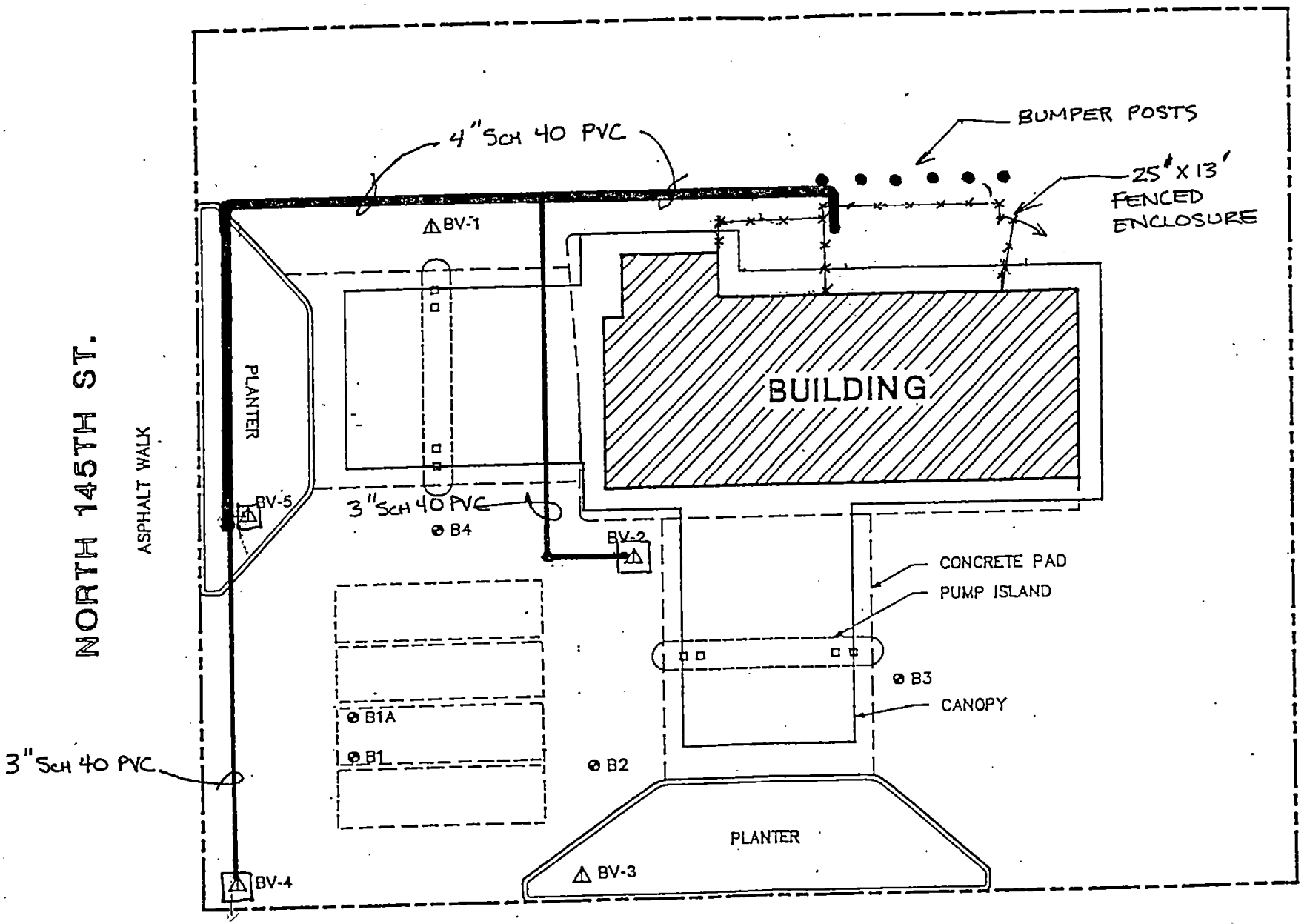
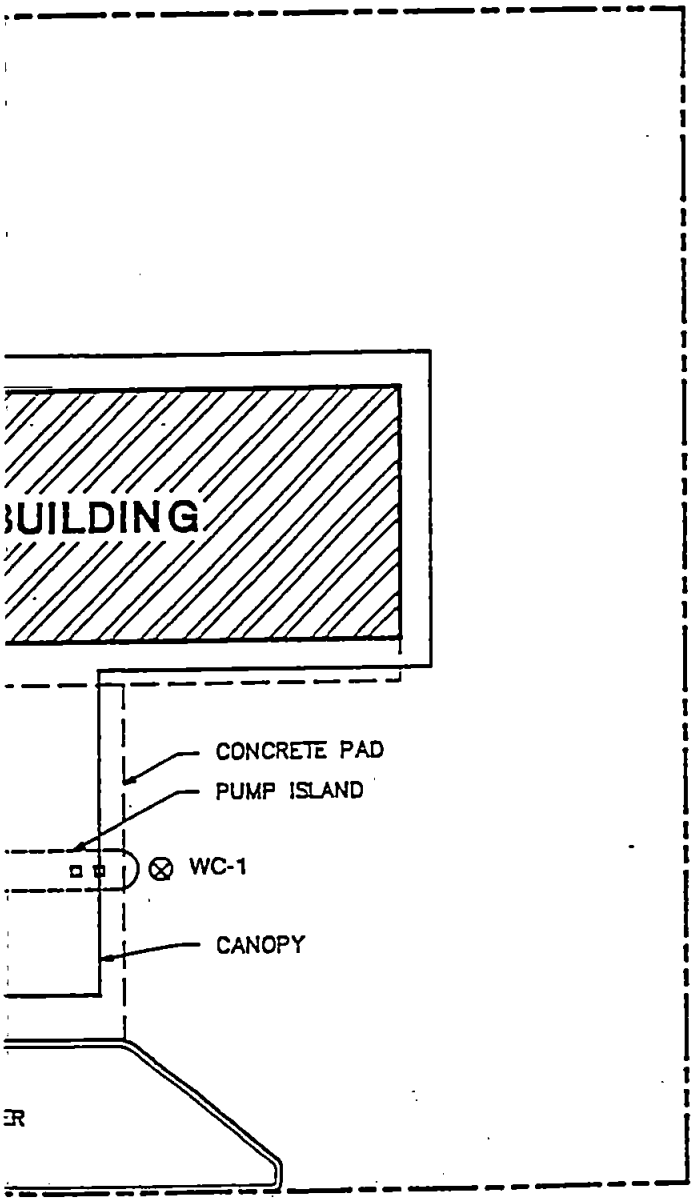
FIGURES


4" SCH 40 PVC
BUMPER POSTS
25' X 13'
FENCED
ENCLOSURE
BV-1
BUILDING
PLANTER
ASPHALT WALK
NORTH 145TH ST.
BV-5
3" SCH 40 PVC
B4
BV-2
CONCRETE PAD
PUMP ISLAND
B3
CANOPY
B1A
B1
B2
3" SCH 40 PVC
PLANTER
BV-3
BV-4
GREENWOOD AVE.



LEGEND

	APPROXIMATE TANK LOCATION
	PROPERTY BOUNDARY
⚠ BV-1	BIOVENTING WELL
⊗ WC-1	WELL CASING

SCALE IN FEET
0 10 20

D AVE.

GERAGHTY & MILLER, INC.
Environmental Services

BIOVENTING WELL LOCATION MAP

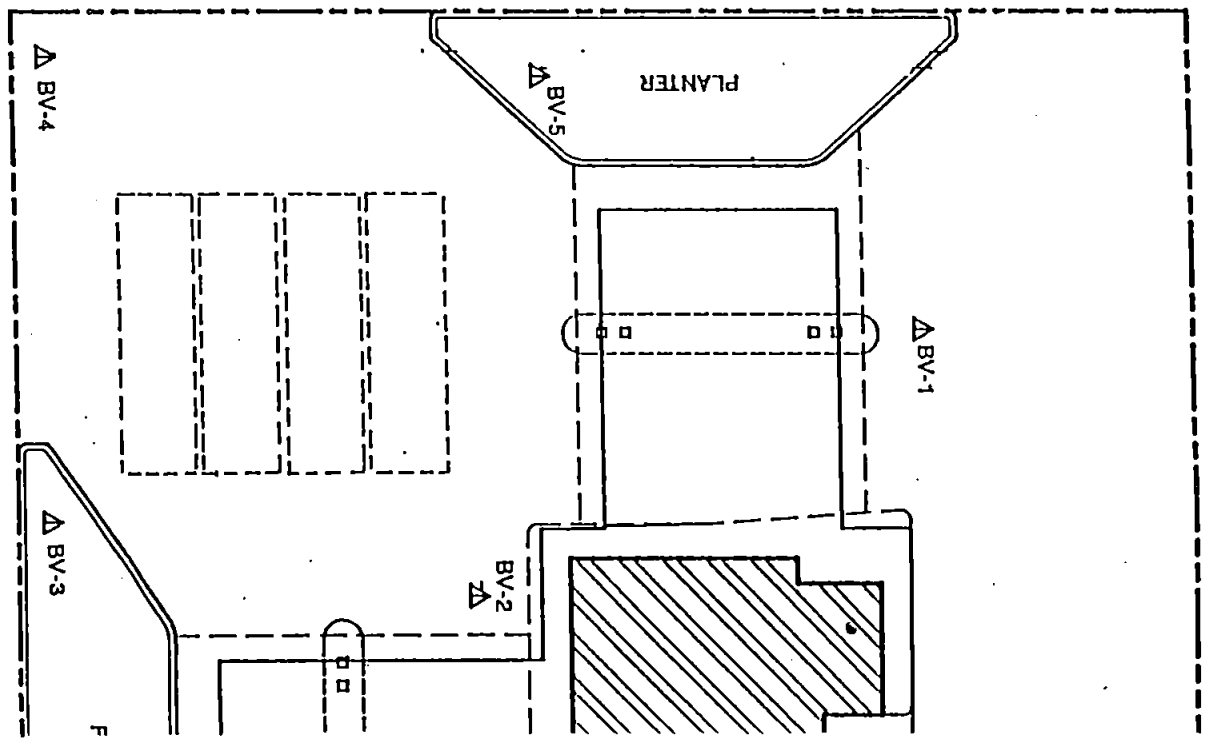
ARCO PRODUCTS COMPANY
Service Station # 4351
Greenwood Ave. & North 145th St.
Seattle, Washington

FIGURE
1

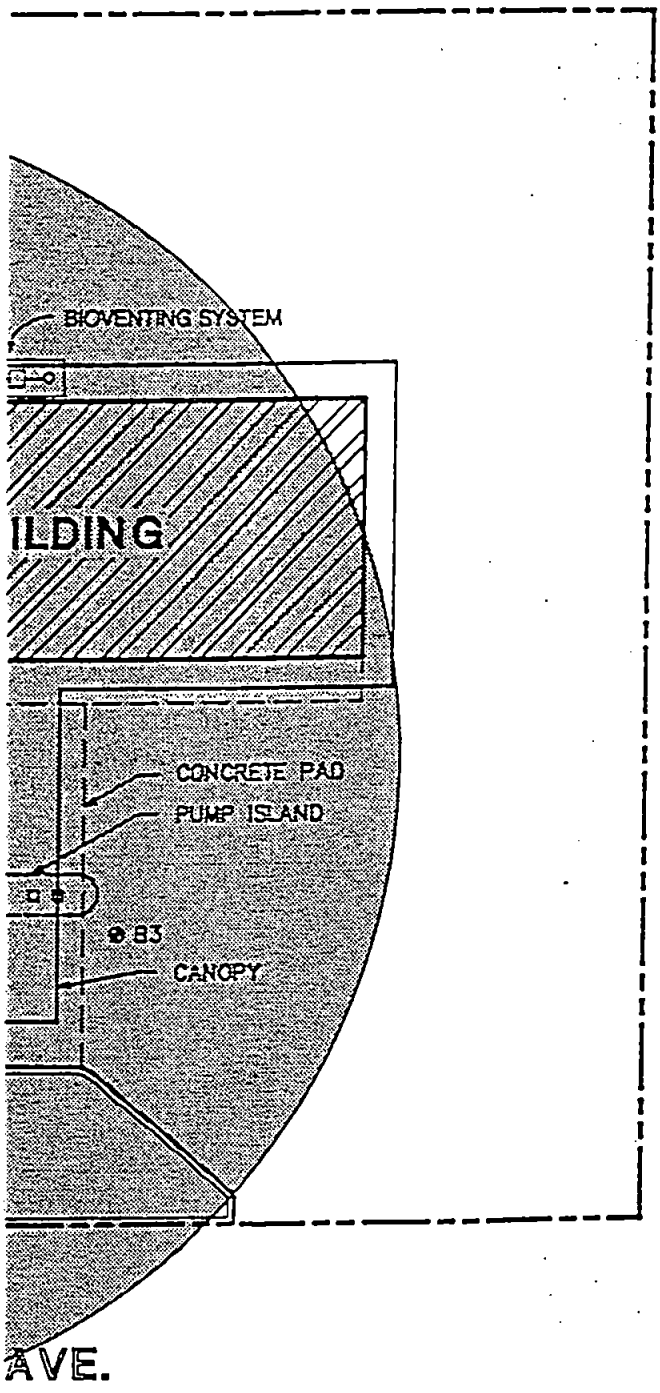
DWG DATE: 3-26-91	PRJCT NO.: WA179.30	FILE NO.: 50071.WA	DRAWING: 1	CHECKED: MJS	APPROVED: KSA	DRAFTER: MS

NORTH 145TH ST.

ASPHALT WALK



GREENW



LEGEND

- Approximate Tank Location
- Property Boundary
- BV-1 — Bioventing Well
- B1 — Soil Boring
- Approximate Area of Influence of Proposed Bioventing System

GERAGHTY & MILLER, INC.
Environmental Services

BIOVENTING SYSTEM AREA INFLUENCE

ARCO Products Company
Service Station No. 4351
14424 Greenwood Avenue North
Seattle, Washington

FIGURE
2

DWG DATE: 3-26-91	PRJCT NO.: WA179.30	FILE NO.: 50071.WA	DRAWING: 1	CHECKED: MJS	APPROVED: KSA	DRAFTER: MS