

FEASIBILITY STUDIES AND REMEDIAL ACTIVITIES

CONDUCTED AT JIM'S BP

Prepared by the

Department of Ecology

Toxics Cleanup Program

Southwest Regional Office

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Feasibility Studies and Remedial Activities Conducted at Jim's BP

June 2000

Executive Summary

February 1991, a release of gasoline contamination was discovered at Jim's BP in Battle Ground, Washington. The Department of Ecology (Ecology), under Consent Decree No. DE 91TC-S266, completed a site characterization, remedial investigations and feasibility studies between October 1992 and December 1999. The results of these studies confirmed that soil and ground water gasoline contamination had occurred at the site and that gasoline contamination had migrated off site in a southwesterly direction. Approximately 140 cubic yards of petroleum contaminated soil was excavated from Jim's BP tank farm and bioremediated off site. Four monitoring wells were installed and monitored between 1992 and 1999. Science Applications International Corporation (SAIC) conducted a remedial investigation and feasibility study (RI/FS) and Ecology conducted three pilot studies. The pilot studies were as follows: (1) soil and ground water sampling and analysis using a strata-probe; (2) pumping of ground water and analysis of recharged water; and (3) injection of an oxygen-releasing compound into the soil-water interface at the site. Results of the RI/FS and pilot tests confirmed that a limited amount of petroleum contamination remains on site. Levels of petroleum compounds in the perched ground water were found to have dramatically reduced after the injection of an oxygen-releasing compound into the upper three to 15 feet of subsurface. Ecology has determined that the remaining petroleum contamination in soil and perched ground water is minor in extent and that it does not pose a threat to human health or the environment.

I. Introduction:

Jim's BP is an active service station/auto repair business located at 13 Main Street, Battle Ground, Washington. Figure 1 is a vicinity map of the Battle Ground area and Figure 2 is a detailed site map of Jim's BP. The service station is located in a mixed-use community that includes active businesses, public library, Battle Ground High School and single and multiple residential housing. The service station has been active since the nineteen seventies. The service station and surrounding area topography is relatively flat.

In February 1991, soil and ground water contamination was discovered during tank decommissioning and tank upgrade activities. (One 6,000 gallon unleaded gasoline tank was removed and one 8,000 gallon tank was installed.) Cleanup activities were started under independent supervision and completed with Ecology oversight under a Consent Decree No. DE 91TC-S266.

Results of investigative studies showed that petroleum contamination had migrated off the BP property and had impacted the adjacent property to the East. The adjacent property is a mini-mall comprised of three businesses and a parking lot. The 'Site' is defined as the area where petroleum contamination was discovered. The Site encompassed the tank farm in the northeast corner of Jim's BP and the northwest corner of the adjacent strip mall parking lot. Figure 3 displays a diagram of the estimated area of contamination at the Jim's BP site.

II. History of Investigative and Remedial Actions

During tank decommissioning activities in January 1991, an independent contractor excavated approximately 140 cubic yards of gasoline contaminated soil from the tank farm area. The excavated area extended to the property line between the service station and the adjacent mini-mall. Soil and ground water sampling results confirmed gasoline contamination along the Northeast wall of the excavation and in the perched water in the excavation. The excavated soil was stockpiled on site behind the service station building. The stockpiled soil remained on site until December 1991 at which time it was transported to a property a few miles outside of Battle Ground. A consent decree was negotiated with Ecology in October 1991.

The work that was required to be completed under Consent Decree No. DE 91TC-S266 included the remediation of the stockpiled soils and the completion of a remedial investigation and feasibility study (RI/FS). The stockpiled soils were remediated by a combination of aeration, bioremediation, and by vapor extraction and incineration. Details of the activities conducted during the remediation of the stockpiled soil are documented in the report prepared by Technical Action Group, Inc. entitled 'Soil Bioremediation and Vapor Incineration of Jim's BP Soils', dated October 28, 1992. Science Applications International Corporation (SAIC) was contracted to conduct a remedial investigation and feasibility study (RI/FS). SAIC's work is documented in their report entitled 'Final Remedial Investigation/Feasibility Study for Jim's BP', dated July 2, 1992.

The extent of soil and ground water contamination at the Site was found to be confined to the northeast corner of the BP service station and the northwest corner of the adjacent property in a 25- to 50-foot area as shown on Figure 3. This estimate is based on the assumption that the contamination is due to a previous release and is not indicative of an ongoing source.

III. Subsurface Explorations

SAIC conducted a soil gas survey in the spring of 1992 during the RI/FS phase of the site investigation. It was conducted to help guide placement of monitoring wells. A total of 31 samples were analyzed from 27 sampling locations as shown in Figure 4. A summary of contaminant detections is presented in Table I. The soil gas survey was hampered by subsurface conditions. The water table was approximately four feet below ground surface (bgs) and the formation materials were dense and compacted. Both conditions reduced vapor generation and transport.

SAIC installed four monitoring wells in the spring of 1992. These wells were drilled to a depth of 20 to 33 feet bgs. The monitoring well locations are shown in Figure 3. Perched ground water was encountered between 12 to 20 feet below ground surface during monitoring well installation. Downward movement of perched water was found to be impeded by an impermeable unit of clay between 18 to 22 feet bgs. SAIC estimated the volume of perched contaminated ground water to be 1,300 to 1,400 gallons. No petroleum contaminated soil was encountered during monitoring well installation.

The City of Battle Ground draws water for a public drinking system from five municipal wells screened at depths of approximately 110 feet bgs or greater. These wells are located within one mile from the site. A summary of well logs within a one-mile radius of Jim's BP is displayed in Table II.

IV. Ground Water Characteristics

The four monitoring wells were monitored quarterly from April 1992 to July 1993 and monitored semi-annually from April 1994 to December 1995. Four additional monitoring events occurred in August 1998, December 1998, April 1999 and December 1999. A summary of all ground water data is displayed in Table III and Table IV.

Four petroleum compounds including total petroleum hydrocarbon as gasoline (TPH-G), benzene, ethylbenzene, and xylenes, were found to be present in ground water in concentrations in excess of their respective Model Toxics Control Act (MTCA) Method A cleanup levels. The most significant ground water contamination was present in monitoring well (MW) 5 and MW-6 that were installed adjacent to the UST pit. The northeast edge of the plume appears to be at MW-1, the southwest edge at MW-3. It is believed that significant downward migration of perched ground water has not occurred at this site because of the low permeability soil that exists beneath of perched ground water.

Interpretation of monitoring well data established ground water gradient to be to the north-northeast. Cross-sections of the site stratigraphy and static water levels are presented in Figure 5. From the cross-section, it is observed that the static ground water level is within the compacted silty clay layer containing cemented gravel. This layer, based on slug tests conducted in each of the monitoring wells, the perched ground water has a horizontal hydraulic conductivity range of 8×10^{-5} to 7×10^{-4} cm/sec. Typically, vertical hydraulic conductivities are several orders of magnitude lower than the horizontal values. These values indicate a relatively low permeability layer underlying Jim's BP site.

After SAIC completed a RI/FS study, Ecology decided to monitor and sample ground water over a period of time to determine if ground water contamination would diminish with natural attenuation since the majority of the petroleum source was removed. Two years of quarterly ground water sampling was followed by two years of semi-annual ground water sampling. After four years, it was evident that the rate of petroleum contamination degradation was very slow. The gasoline contamination showed evidence of aging but did not greatly diminish in concentration.

V. Feasibility Studies

In 1998 and 1999, several feasibility studies were conducted to determine if certain treatment technologies would be effective in remediating the contaminated perched ground water. These pilot studies included the following:

- (A) Collection and analyses of soil and ground water samples taken at five-foot intervals using a strata-probe sampler.
- (B) Removal by pumping of a volume of ground water from monitoring well 5 and monitoring well 6 and analyses of recharged ground water samples.
- (C) Injection of oxygen releasing compounds (ORC) into the subsoil and followed by a minimum of six months of residence time and analyses of water samples for petroleum compounds.

These pilot studies are described below.

A. Strata-probe Sampling of Soil and Ground Water

1. Field Method

On August 3, 1998, Transglobal Environmental Geosciences Northwest, Inc. (TEG), under contract to Ecology, advanced eight (8) strata-probe exploration borings at the locations shown in Figure 6. Strata-probes were advanced to the depth where ground water was encountered (approximately 12 to 15 feet bgs, using 2-inch diameter rods and a split-barrel sampler. The decision for placement of boreholes was based on Site history, proximity to the tank farm, and avoidance of utility corridors. Soil and ground water samples were collected at each of the strata-probe boring locations and chemically analyzed by an on-site mobile laboratory.

Prior to the field investigation, a request was placed with Utilities Notification Center to conduct an underground utility survey in the vicinity of the site. Start cards for drilling borings were filed with Ecology as required by the Water Quality Program.

Soil samples were retrieved using a 3-foot long, 2-inch diameter split barrel sampler attached to the end of the strata-probe rods. The sampling tools were advanced using a 90-lb. hydraulic hammer and the weight of the strataprobe truck. The rods were then removed from the hole and the sampler detached and opened to allow collection of the soil sample. Samples were placed immediately in laboratory-prepared glass jars, placed on ice, and transported to an on-site mobile laboratory for analysis.

A typical subsurface profile at each boring location consisted of 2 to 3 inches of asphalt overlying approximately 4 -5 inches of gravel fill. A native soil clayey/silt unit underlies the fill to approximately 15 feet bgs. The first occurrence of ground water was observed at a depth of approximately 12 to 13 feet bgs. The clayey/silt unit was found to be underlain with a dense silty clay unit.

Ground water samples were collected from each boring. A temporary screen was attached to the strataprobe rods and installed to a depth where ground water was encountered (approximately 12 to 15 feet bgs). A peristaltic pump and plastic hand syringe were used to obtain water sufficient to fill three 40-ml volatile organic analysis (VOA) vials. After collection, the ground water samples were taken to TEG's on-site mobile laboratory for chemical analyses.

After sampling was completed, the boreholes were backfilled from the bottom to approximately one-foot bgs using hydrated bentonite chips. Asphalt cold-patch was used to complete backfilling to match existing grade.

2. Soil and Water Analytical Results

A total of 16 soil samples and 8 water samples were collected from the strata-probe explorations and submitted to TEG for chemical analyses for total petroleum hydrocarbons as gasoline, (TPH-G) and benzene, toluene, ethylbenzene and xylenes (BTEX). None of the 16 soil or 8 water samples analyzed contained detectable concentrations of TPH-G or BTEX. Results of laboratory analysis of soil and ground water samples are presented in Table V. Laboratory data is presented in Appendix A.

3. Discussion

Evaluation of the data obtained during this investigation indicates that soil and ground water in the vicinity of the tank farm and adjacent property defined by the eight (8) strata-probe locations do not contain petroleum hydrocarbon concentration above cleanup levels established under the Model Toxics Control Act Cleanup Regulation Chapter 173-340 WAC (MTCA) Method A cleanup Levels. This observation is supported by the non-detect soil sample results collected during the installation of the monitoring of the monitoring wells and results of the soil-gas survey.

B. Ground Water Withdrawal, Recharge, and Analytical Testing

1. Field Method

November 23, 1998, West Coast Marine Cleaning, Inc. under contract by Ecology, mobilized a vacuum truck to Jim's BP. Once there, water was withdrawn from MW-5 and MW-6 respectively using a vacuum hose. The withdrawn water was pumped into a holding tank on the vacuum truck. Water was withdrawn by suction from each well to a depth of approximately 15 feet then ground water was allowed to recharge before repeating the process. The process was repeated approximately 10 times at each well. The total amount of water pumped from both wells was 300 gallons. The withdrawn water was hauled to a publicly owned water treatment facility for disposal.

December 8, 1998, Ecology collected water samples from MW-5 and MW-6. Depth to ground water was measured and well volume of water was calculated. Three volumes of water were extracted from each well using dedicated Teflon bailers. Water samples were collected in three 40-ml volatile organic analysis (VOA) vials, placed on ice and transported to Manchester Environmental Laboratory for analysis for petroleum products.

2. Water Analytical Results

Ground water samples collected from MW-5 and MW-6 were submitted to Manchester Testing Laboratory for TPH-G and BTEX analysis. MW-5 water sample analytical test results for TPH-G, benzene, ethylbenzene, and xylenes respectively, were as follows: 5,500 ug/l, 81 ug/l, 240 ug/l, and 510 ug/l. MW-6 water sample test results for TPH-G, benzene, and ethylbenzene respectfully were as follows: 4,100 ug/l, and 22 ug/l. MTCA cleanup levels and sample analytical results are listed in Table VI. Laboratory analytical data is presented in appendix A.

The analytical sample results indicate that petroleum contamination levels in ground water samples from MW-5 and MW-6 remain above MTCA cleanup levels. MW-5 petroleum contaminant levels remain at similar levels measured prior to withdrawing water from MW-5. Benzene, ethylbenzene and xylenes levels in MW-6 were somewhat reduced from levels measured prior to withdrawing water, whereas, TPH-G levels remained similar to past measurements.

3. Discussion

Analytical test results of the data obtained during this investigation confirmed that ground water in the vicinity of MW-5 and MW-6 continue to contain gasoline-range petroleum hydrocarbons at concentrations above MTCA Method A cleanup levels. Pumping petroleum contaminated water from the monitoring wells did not change petroleum analyte levels in MW-5. It did appear to have reduced levels of benzene, ethylbenzene and xylenes in MW-6, but not on TPH-G levels in MW-6.

C. Injection of Oxygen-Releasing Compound (ORC)

One of the major limiting factors in the attenuation of petroleum compounds *in situ* is the availability of oxygen. One type of technology that is commonly used to increase the rate of natural attenuation and/or bioremediation of petroleum contamination in soil and ground water is the injection of an oxygen source such as hydrogen peroxide. Oxygen Releasing Compound (ORC) is a trade name for a product that contains mainly magnesium oxide; magnesium oxide acts as a source of oxygen. Injection of ORC is a method of *in situ* bioremediation, which, like air sparging, introduces oxygen into the ground water environment and causes in-place microbes to flourish and assimilate petroleum hydrocarbons. The injection of ORC in to soil and/or ground water has become a common technology used at petroleum contaminated sites. Literature studies indicate that it is most effective on the remediation of limited residual contamination.

1. Field Method

(a) Injection of ORC

TEG was contracted to complete the injection of magnesium oxide, an oxygen-releasing compound (ORC) into the subsurface at the Site using strata-probes. TEG arrived on Site on April 27, 1999. The method of drilling strata-probe borings and injecting ORC is an 'injection well' activity under 173-216 WAC and requires registration as such. Therefore, start cards were obtained for the project.

The volume of petroleum contaminated soil remaining on Site was estimated to cover an area described in Figure 3. Regensis, manufacturer of the ORC used at Jim's BP, was sent Site specific data. Regensis recommended that 300 pounds of ORC was needed to remediate the remaining soil and ground water contamination.

TEG utilized a truck mounted with a 2-inch hydraulic driven punch to advance nineteen (19) borings to a depth of about 15 feet bgs. A grid with 2.5 foot and 5 foot intervals was pre-marked on the asphalt for the location of each of the nineteen borings. TEG drilled 14 borings in the mall parking lot and five borings around Jim's BP tank farm. The locations of the borings are shown on Figure 7. A detailed field map with designation measurements between borings can be found in Appendix A.

Each boring was back-filled, under pressure, with a pre-determined quantity of ORC slurry. ORC was injected into a zone between three feet and fifteen feet bgs in each boring. Approximately sixteen pounds of ORC was injected into 19 borings using a 50 % slurry of ORC and water. The ORC slurry was mixed in batches and used within 30 minutes to prevent the compound from solidifying during injection procedures. Each boring was injected with a bentonite seal to near surface and capped with an asphalt seal to assure that the slurry would stay in place.

(b) Follow-up Ground Water Sampling

December 1, 1999, Ecology collected water samples from MW-5 and MW-6. Depth to ground water was measured and well volume of water was calculated. Three volumes of water were extracted from each well using dedicated Teflon bailers. Water samples were collected in three 40-ml volatile organic analysis (VOA) vials, placed on ice and transported to Manchester Environmental Laboratory for analysis for petroleum analytes.

2. Analytical Results

Ground water samples collected from MW-5 and MW-6 were submitted to Manchester Environmental Laboratory for TPH-G and BTEX analysis. MW-5 water sample analytical test results were: 1,100 ug/l for TPH-G, 7.3 ug/l for benzene, 32 ug/l for ethylbenzene, and 64 ug/l for xylenes. MW-6 water sample analytical test results were 1,700 ug/l for TPH-G, 8.3 ug/l for ethylbenzene, and 1.1 ug/l for xylenes. MTCA cleanup levels and water sample analytical results are listed in Table III.

MW-5 water sample test results were slightly above MTCA cleanup level for TPH-G, benzene and xylenes and MW-6 water sample test results were slightly above MTCA cleanup levels for TPH-G. Analytical results from past sampling events as well as analytical results from the December 1, 1999 sampling event are displayed in Table I.

3. Discussion

The analytical results of water samples taken from MW-5 and MW-6 in December 1999 compared to those taken in December 1998 appear to reflect the effect of the injection of ORC. All levels of petroleum analytes decreased dramatically in both wells. MW-5 sample results remain slightly above MCTA cleanup levels for benzene, 7 ug/l (MTCA 5 ug/l), ethylbenzene, 32 ug/l (MTCA 30 ug/l), xylenes 64 ug/l (MTCA 20 ug/l) and 1,100 ug/l (MTCA 1,000 ug/l). MW-6 sample results remain slightly above MTCA for TPH-G at 1,700 ug/l, (MTCA 1,000 ug/l), and all other petroleum analytes tested below MTCA cleanup levels.

VI. Conclusions

The 1992 SAIC report evaluated several cleanup alternatives to address the petroleum contamination in ground water based on the information gathered during the RI. SAIC made two recommendations: either pump ground water to surface and treat the collected water or perform no action. The latter action would depend on biodegradation and natural attenuation to reduce hydrocarbon levels that remained in the soil and ground water.

The results of the pumping test conducted by Ecology in November 1998 indicated that to pump and treat ground water might not be effective. The injection of an ORC in April 1999 did dramatically lower petroleum contaminant levels in perched water as measured by testing MW-5 and MW-6. The results of this remedial action indicate that the majority of petroleum contamination has been removed. The remediation of any remaining soil or perched water petroleum contamination will depend on biodegradation and natural attenuation.

The majority of petroleum contaminated soil has been removed from the Site and remediated. It does not appear that any contaminated soil remains on Site in excess of the MTCA cleanup levels. The analytical test results of strata-probe soil sampling conducted in August 1998 were non-detect for samples taken at 5-foot intervals to a depth of approximately 12 feet bgs. Analytical results of soil samples taken at two-foot intervals during the installation of the monitoring wells were all below MTCA Method cleanup levels. The entire site is capped with an asphalt or concrete. This cover acts to minimize airborne emissions and fugitive dusts as well as diverts or minimizes rainwater infiltration into Site soils.

Perched ground water located beneath the site was encountered at approximately 12 to 15 feet bgs. Ground water flow appears to be to the northeast. Water samples from both MW-1 and MW-3 test non-detect for petroleum compounds. MW-1 is a down gradient well. The extent of perched water contamination appears to be limited. A dense silty clay lay unit was encountered at 18 feet bgs in all four monitoring wells. Ground water sampling data indicated a degradation of petroleum compounds with time with no new influx of petroleum compounds.

The perched ground water is not used for drinking water or other domestic purposes. The perched ground water has a horizontal hydraulic conductivity range of 8×10^{-5} to 7×10^{-4} cm/sec according to slug test data. Vertical hydraulic conductivities are probably several orders of magnitude lower than the horizontal values. These values indicate a relatively low permeability layer underlying Jim's BP site. This low permeability unit does not transmit water easily in either the horizontal or vertical direction.

The City of Battle Ground water supply comes from municipal wells that are screened at depths of approximately 110 feet below ground surface or greater. Domestic wells in the geographic area have a completion depth of at least 40 feet below ground surface.

Ecology has determined that the remaining petroleum contamination is minor and that this site does not pose a threat to human health or the environment and recommends that no further remedial actions are necessary.

References

'Remedial Investigation/Feasibility Study for Jim's BP', Science applications International Corporation (SAIC), July 1, 1992.

'Soil Bioremediation and Vapor Incineration of Jim's BP Soils', Technical Action Group, Inc., October 28, 1992.

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'Jim's BP Semi-annual Ground Water Monitoring Report for April 1994', Department of Ecology, June 30, 1994.

'Jim's BP November 1994 and May 1995 Semi-Annual Ground water Sampling Report', Department of Ecology, July 11, 1995.

'November 14, 1995 Ground water Monitoring Report', Manchester Environmental Laboratory Case Narrative, December 20, 1995

'Strata-Probe Soil and Ground water Analytical Data Report', Transglobal Environmental Geosciences, August 10, 1998.

'December 8, 1998 Ground water Monitoring Report', Manchester Environmental Laboratory Case Narrative, December 11, 1998.

'December 1, 1999 Ground water Monitoring Report', Manchester Environmental Laboratory Case Narrative, December 7, 1999.

FIGURES

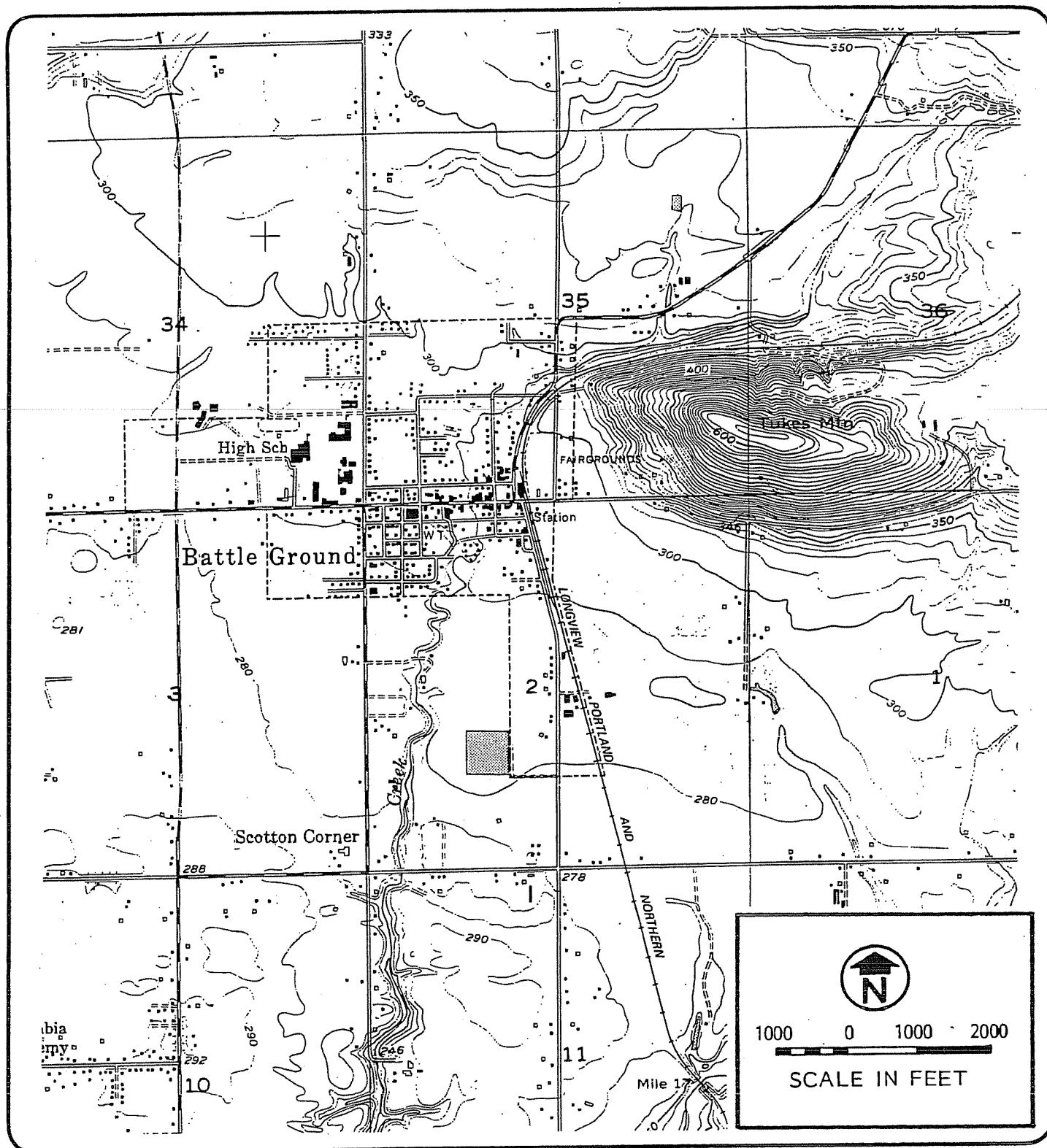


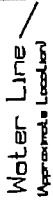
Figure 1
Site Vicinity Map
Jim's BP
Battle Ground, Washington

MAIN STREET

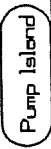
Sidewalk



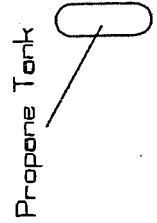
Phone Booth



Water Line
Approximate Location

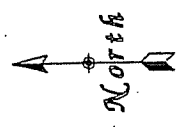


Pump Island

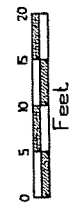


Propane Tank

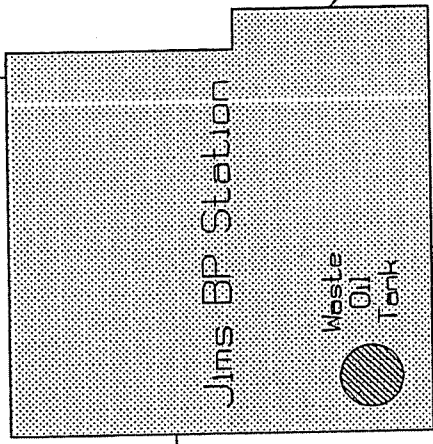
LP Gas Line



North



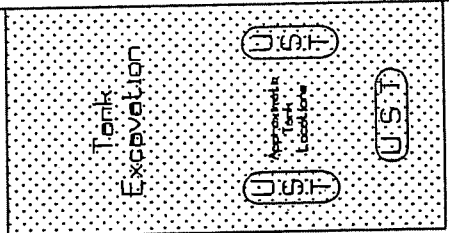
0 5 10 15 20
Feet



Jim's BP Station



Waste Oil Tank



Tank Excavation

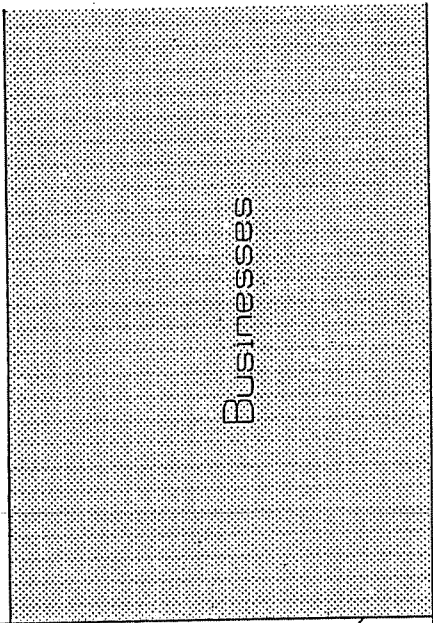
U.S.T.

U.S.T.

Approximate Tank Location

U.S.T.

Sewer Line



Businesses

Sidewalk

PARKWAY AVENUE

Figure 2

Jim's BP site Map

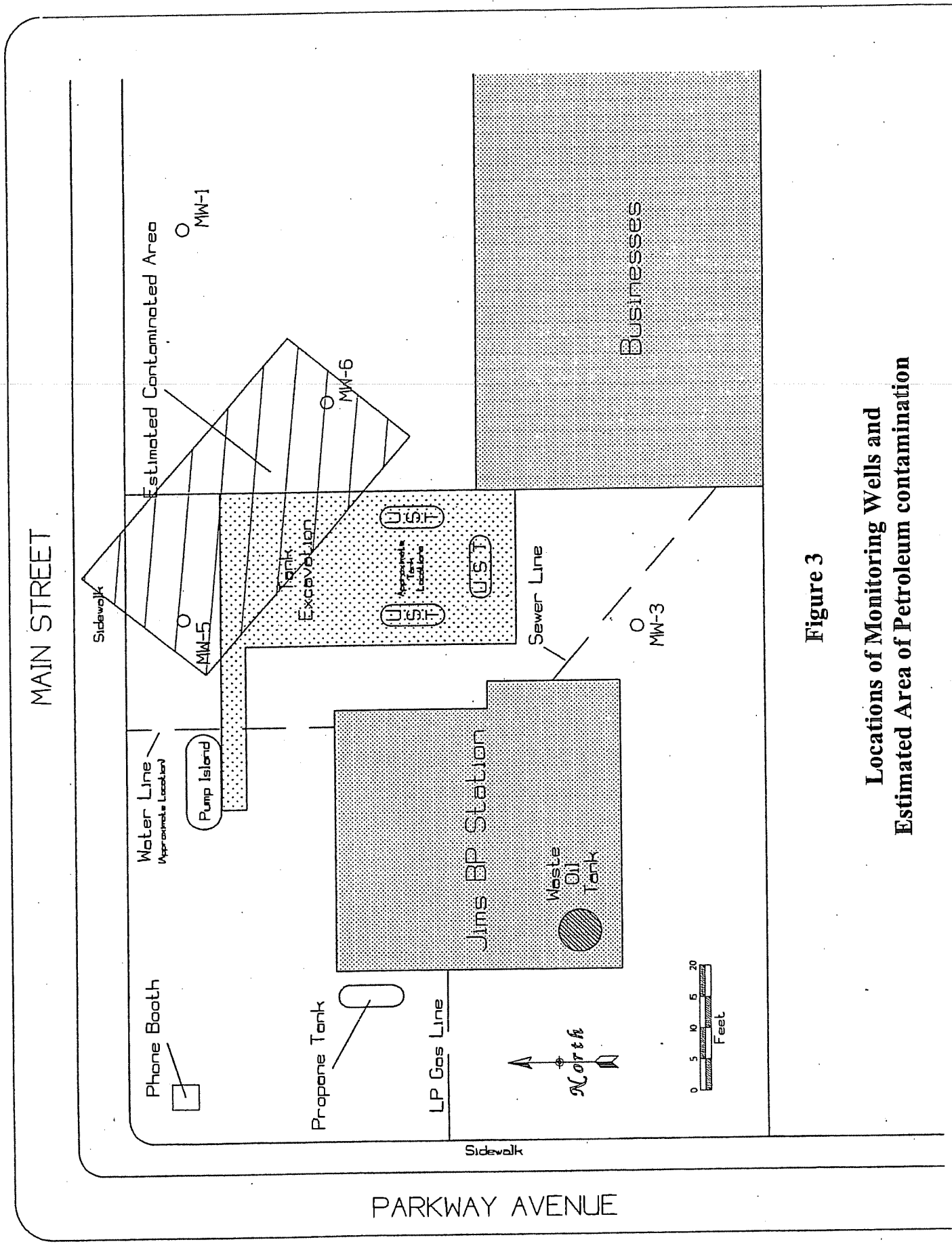


Figure 3

Locations of Monitoring Wells and Estimated Area of Petroleum contamination

MAIN STREET

Sidewalk

Water Line
(Approximate Location)

Pump Island

Propane Tank

LP Gas Line

Sidewalk

PARKWAY AVENUE

Jims BP Station

Waste Oil Tank

Tank Excavation

U.S.T. *(Underground Storage Tank)*

Sewer Line

Businesses

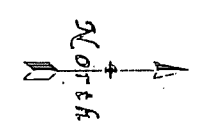
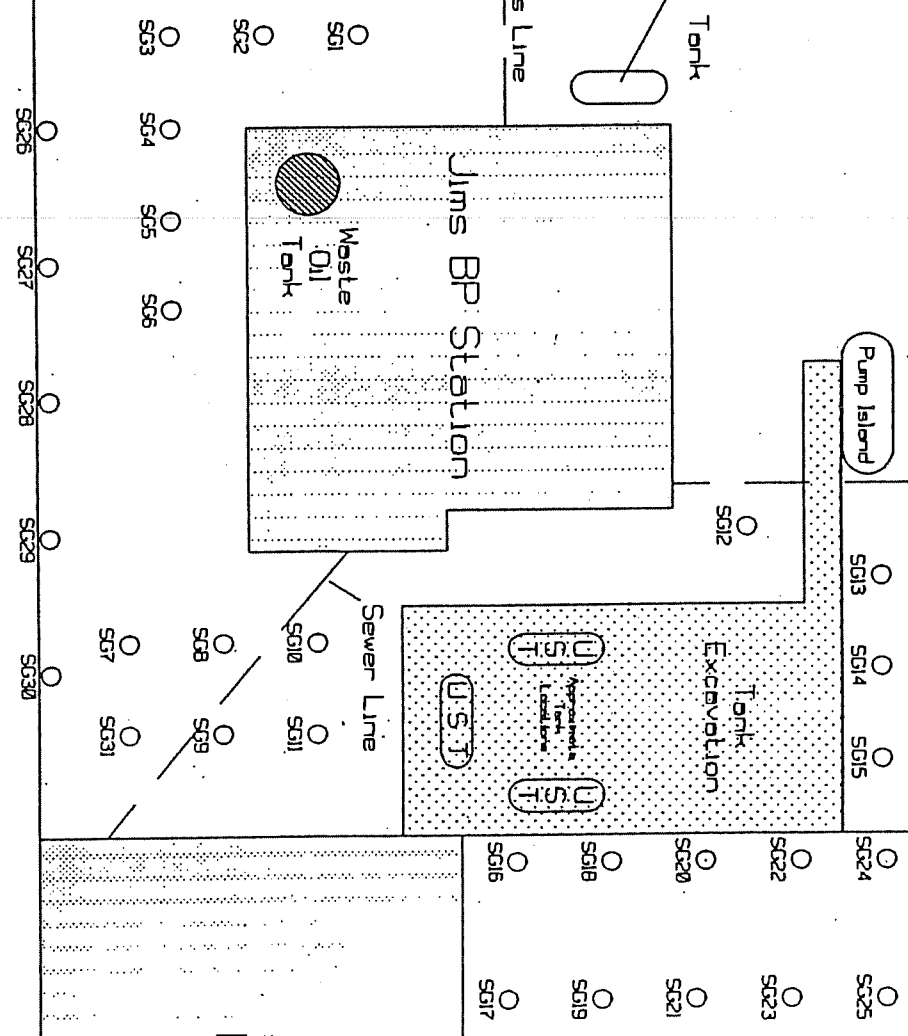


Figure 4

Soil Gas Sampling Points

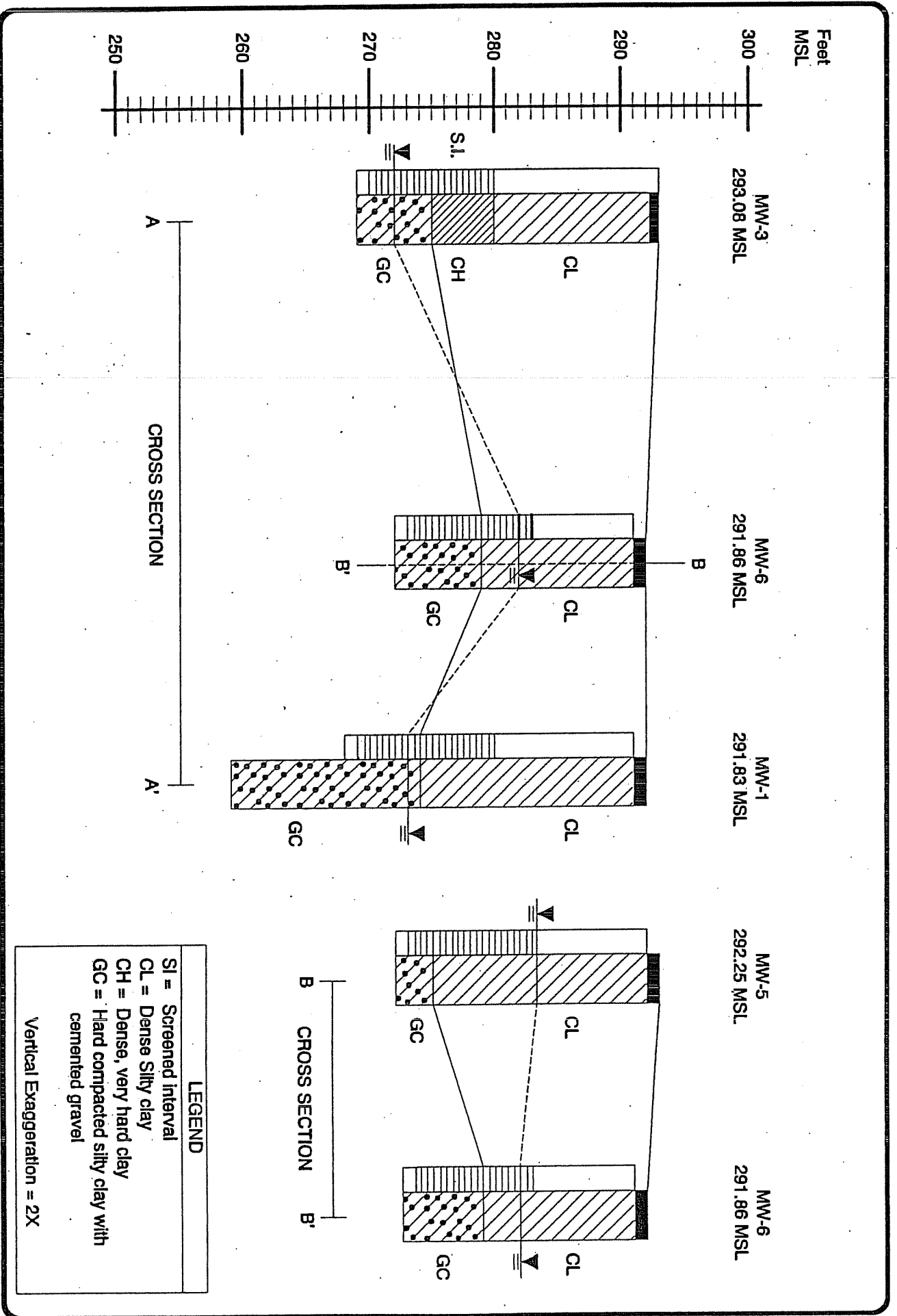


Figure 5

Stratigraphic Cross Sections

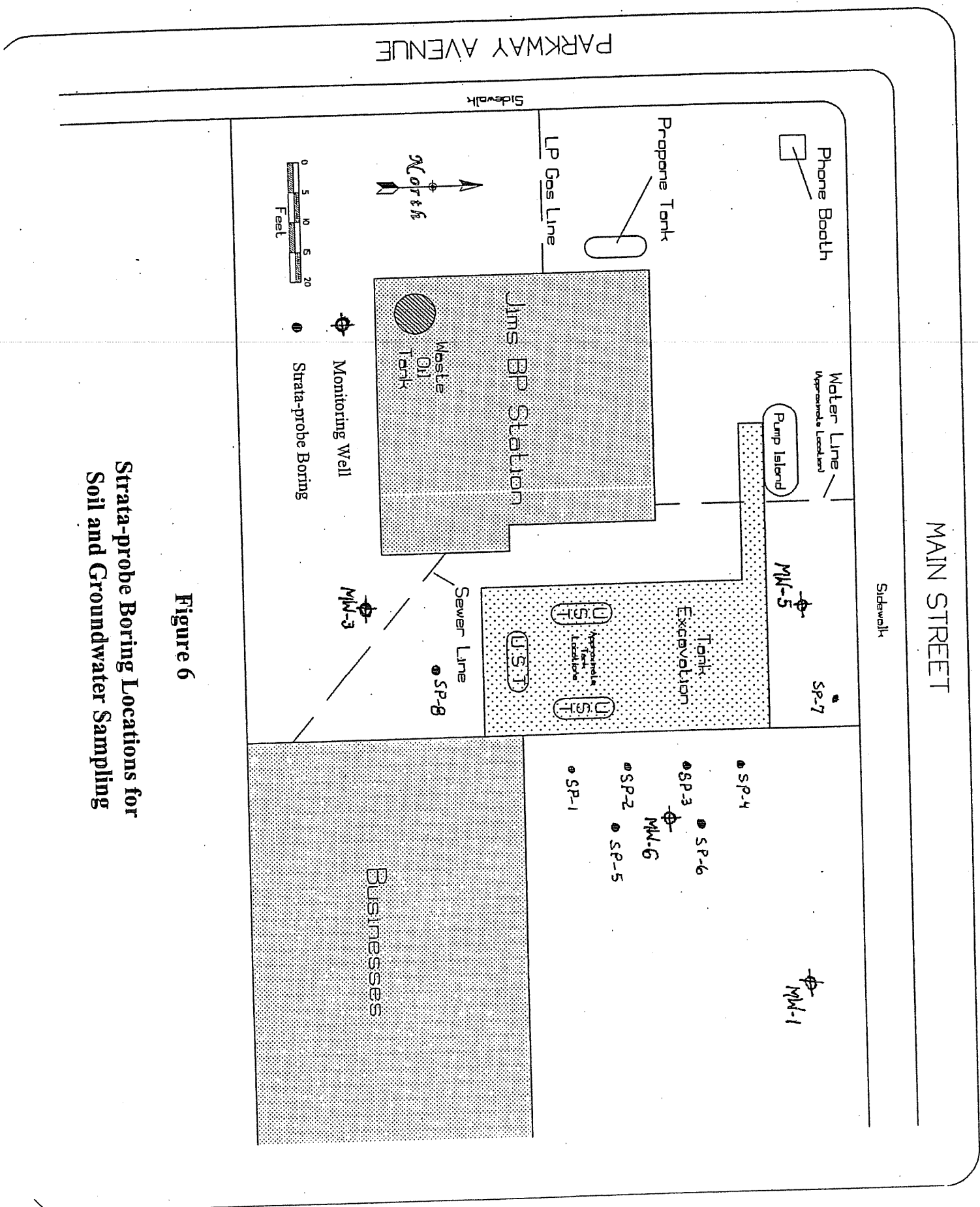


Figure 6
Strata-probe Boring Locations for
Soil and Groundwater Sampling

MAIN STREET

Sidewalk

Phone Booth

Water Line
(Approximate Location)

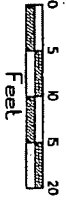
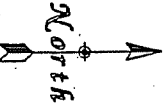
Pump Island

MW-5

Propane Tank



LP Gas Line



Jim's BP Station

Moisture Oil Tank

Sewer Line

Excavation Tank

U.S.T. (Underground Storage Tank)

Approximate Location

U.S.T.

MW-6

MW-1

Businesses

MW-3

Strata-probe Boring Locations for
Injection of ORC

Figure 7

TABLES

Table I

SOIL GAS SURVEY
Summary of Contaminant Detections

SAMPLE ID	DEPTH	CONTAMINANT CONCENTRATION (ppb)				Total No. of Unknown Compounds Detected
		Benzene	Toluene	Ethylbenzene	Total Xylenes	
SG#1	1'	0.1 U	0.3 U	0.5 U	0.9 U	1
SG#4	1'4"	0.1 U	0.1 ¹	0.5 U	0.9 U	5
SG#4 A.D.	1'4"	0.1 U	0.1 ¹	0.5 U	0.9 U	5
SG#4 F.D.	1'4"	0.1 U	0.04 ¹	0.5 U	0.9 U	1
SG#5	1'6"	0.1 U	0.3 U	0.5 U	0.9 U	1
SG#6	3'	0.1 U	0.3 U	0.5 U	0.9 U	3
SG#7	2'10"	0.1 U	0.1 ¹	0.5 U	0.9 U	3
SG#8	3'	1.0	0.3 U	0.5 U	0.9 U	3
SG#9	2'6"	0.1 U	0.3 U	0.5 U	0.9 U	1
SG#13	3'	0.2	0.6	0.5 U	0.9 U	4
SG#14	1'	0.1 U	0.3 U	0.5 U	0.9 U	8
SG#18	2'8"	0.1 U	0.3 U	0.5 U	0.9 U	4
SG#19	3'	0.1 U	0.3 U	0.5 U	0.9 U	1
SG#20	3'	0.1 U	0.3 U	0.5 U	0.9 U	1

A.D.= Analytical duplicate

F.D.= Field duplicate

¹ Value is estimated

U = Compound undetected at concentration shown

NOTE: Shaded values indicate detections above the Practical Quantitation Limit (PQL)

Table II

SUMMARY OF WELL LOGS WITHIN A ONE-MILE RADIUS OF JIM'S BP

WELL LOCATION				DATE DRILLED	USE	TOTAL DEPTH OF WELL (feet BLS)	STATIC WATER LEVEL (feet BTC)	SCREENED INTERVAL (feet BTC)
Quarter	Section	Township	Range					
NW 1/4 NE 1/4	2	3N	2E	4-20-72	Domestic	116	57	None
NW 1/4 SE 1/4	2	3N	2E	12-26-79	Domestic	98	54	None
NE 1/4 NW 1/4	2	3N	2E	7-3-84	Domestic	207	75	None
NE 1/4 NW 1/4	2	3N	2E	8-8-89	Domestic	95	69	None
SW 1/4 NW 1/4	3	3N	2E	9-27-50	Unknown	177	47	65-120
SE 1/4 NE 1/4	3	3N	2E	4-25-52	Unknown	Unknown	40	Unknown
NW 1/4 NE 1/4	3	3N	2E	3-30-54	Municipal	144	Unknown	Unknown
NW 1/4 NE 1/4	3	3N	2E	9-15-54	Municipal	152	54	Unknown
SE 1/4 SE 1/4	3	3N	2E	8-17-67	Municipal (Meadow Glade)	110	53	100-110
NE 1/4 SE 1/4	3	3N	2E	6-25-76	Municipal	180	62	105-135
NE 1/4 SE 1/4	3	3N	2E	8-22-75	Municipal	140	60	105-135
NW 1/4 NW 1/4	34	4N	2E	7-11-74	Domestic	99	65	None
NE 1/4 SW 1/4	34	4N	2E	10-25-84	Domestic	115	63	None
SE 1/4 NE 1/4	34	4N	2E	7-14-89	Domestic	161	74	113-161 ¹
SE 1/4 NE 1/4	34	4N	2E	3-1-90	School	170	73	160-170
SE 1/4 NE 1/4	34	4N	2E	3-7-90	School	163	77	153-163
NE 1/4 NE 1/4	34	4N	2E	1-25-91	Domestic	122	97	117-122 ¹
SE 1/4 SE 1/4	34	4N	2E	2-14-91	Monitoring	50	32	30-50
SE 1/4 SE 1/4	34	4N	2E	2-14-91	Monitoring	50	32	30-50
SE 1/4 SE 1/4	34	4N	2E	6-17-91	Monitoring	42	Unknown	8.5-38.5
SE 1/4 SE 1/4	34	4N	2E	6-18-91	Monitoring	39	28	9-39
SE 1/4 SE 1/4	34	4N	2E	6-18-91	Monitoring	39	Unknown	8-39
NE 1/4 NE 1/4	34	4N	2E	10-28-91	Domestic	115	85	None
NE 1/4 NE 1/4	34	4N	2E	2-21-92	Domestic	130	92	None
NE 1/4 NE 1/4	34	4N	2E	4-28-92	Domestic	138	95	None

¹ Perforated, not screened.² Deepened well listed immediately above entry.

BLS = Below land surface

BTC = Below top of casing

Table II Continued

SUMMARY OF WELL LOGS WITHIN A ONE-MILE RADIUS OF JIM'S BP

WELL LOCATION				DATE DRILLED	USE	TOTAL DEPTH OF WELL (feet BLS)	STATIC WATER LEVEL (feet BTC)	SCREENED INTERVAL (feet BTC)
Quarter	Section	Township	Range					
NE 1/4 NW 1/4	35	4N	2E	6-21-74	Domestic	115	45	50-75 ¹
SE 1/4 SE 1/4 NE 1/4	35	4N	2E	8-5-75	Domestic	58	18	None
NW 1/4 NW 1/4	35	4N	2E	7-11-77	Domestic	99	80	None
NW 1/4 NW 1/4	35	4N	2E	3-21-78	Domestic	75	42	None
NW 1/4 NW 1/4	35	4N	2E	3-30-78	Domestic	152	105	None
NW 1/4 NW 1/4	35	4N	2E	3-31-78	Domestic	77	42	None
NW 1/4 NW 1/4	35	4N	2E	4-4-78	Domestic	82	41	None
NW 1/4 NW 1/4 NW 1/4	35	4N	2E	6-28-79	Domestic	77	51	None
NW 1/4 NW 1/4	35	4N	2E	7-19-79	Domestic	80	53	None
NW 1/4 NW 1/4	35	4N	2E	11-7-79	Domestic	137	96	None
NE 1/4 SE 1/4	35	4N	2E	6-4-80	Domestic	548	245	498-548 ¹
NE 1/4 NW 1/4	35	4N	2E	11-4-80	Domestic	82	62	62-82 ¹
NW 1/4 NW 1/4	35	4N	2E	4-15-81	Domestic	120	Unknown	None
NE 1/4 NW 1/4	35	4N	2E	8-26-82	Domestic	104	65	84-104 ¹
NE 1/4 NW 1/4	35	4N	2E	3-18-83	Domestic	67	30	None
NE 1/4 NW 1/4	35	4N	2E	6-20-83	Domestic	445	170	320-335 ¹ 420-430 ¹
NW 1/4 NW 1/4	35	4N	2E	7-25-86	Domestic	132	107	None
SE 1/4 SE 1/4	35	4N	2E	7-20-89	Domestic	250	59	244-250
NW 1/4 NE 1/4	35	4N	2E	9-29-89	Domestic	263	82	400-412
SE 1/4 SE 1/4	35	4N	2E	9-5-90	Domestic ²	417	140	160-180 243-263
SW 1/4 NE 1/4	35	4N	2E	9-28-90	Domestic	367	218	362-365
SW 1/4 SW 1/4	35	4N	2E	5-22-91	Monitoring	8	4.7	3-8
SW 1/4 SW 1/4	35	4N	2E	5-23-91	Monitoring	8	4.5	3-8

¹ Perforated, not screened.² Deepened well listed immediately above entry.

BLS = Below land surface

BTC = Below top of casing

**Table III
Groundwater Sample Results**

Analyte (ug/l) ^a	Date	MW-1	MW-3	MW-5	MW-6	MTCA Cleanup STDD ^b
Benzene	Oct 92	Dry ^c	ND ^d	1	12	5
	Jan 93	8	3	180	120	
	Apr 93	13	ND	370	140	
	Jul 93	Dry	ND	72	3	
	Apr 94	ND	ND	165	28	
	Nov 94	ND	ND	158	35	
	May 95	ND	ND	240	31	
	Nov 95	ND	ND	89	8	
	Dec 98	NS ^c	NS	81	1	
	Dec 99	NS	NS	7	ND	
Toluene	Oct 92	Dry	ND	ND	ND	40
	Jan 93	5	2	27	11	
	Apr 93	ND	ND	16	ND	
	Jul 93	Dry	ND	ND	ND	
	Apr 94	ND	ND	3	ND	
	Nov 94	ND	ND	15	ND	
	May 95	ND	ND	ND	ND	
	Nov 95	ND	ND	ND	ND	
	Dec 98	NS	NS	ND	ND	
	Dec 99	NS	NS	ND	ND	
Ethyl-benzene	Oct 92	Dry	ND	ND	1	30
	Jan 93	ND	ND	110	240	
	Apr 93	ND	ND	260	240	
	Jul 93	ND	ND	2	5	
	Apr 94	ND	ND	128	108	
	Nov 94	ND	ND	216	314	
	May 95	ND	ND	300	280	
	Nov 95	ND	ND	190	170	
	Dec 98	NS	NS	240	22	
	Dec 99	NS	NS	32	8	

Table III Continued

Analyte (ug/l)	MW-1	MW-1	MW-3	MW-5	MW-6	MTCA Cleanup STDD
Xylenes	Oct 92	Dry	ND	1	1	20
	Jan 93	4	ND	130	68	
	Apr 93	2	ND	210	100	
	Jul 93	Dry	ND	2	1	
	Apr 94	ND	ND	75	36	
	Nov 94	ND	ND	228	74	
	May 95	ND	ND	280	50	
	Nov 95	ND	ND	64	16	
	Dec 98	NS	NS	510	3	
	Dec 99	NS	NS	64	1	
TPH - G	Oct 92	Dry	ND	350	450	1,000
	Jan 93	360	ND	1,900	2,300	
	Apr 93	ND	ND	2,800	2,000	
	Jul 93	Dry	ND	310	130	
	Apr 94	ND	ND	1,000	1,200	
	Nov 94	ND	ND	3,300	4,900	
	May 95	ND	ND	4,400	4,500	
	Nov 95	ND	ND	1,900	3,900	
	Dec 98	NS	NS	5,500	4,100	
Dec 99	NS	NS	1,100	1,700		

^a - MTCA Cleanup STDD = Model Toxics Cleanup Act Method A cleanup standards.

^b - ug/l = micrograms per liter or parts per billion (ppb).

^c - Dry = Monitoring well was dry.

^d - ND = Analyte concentration less than applicable listed reporting limit.

^e - NS = Not sampled.

Table IV

Depth to Groundwater and Feet of water In Monitoring Wells (MW)

Date Measured	MW - 1		MW - 3		MW - 5		MW - 6	
	(depth, in feet)	(feet of water)	(depth, in feet)	(feet of water)	(depth, in feet)	(feet of water)	(depth, in feet)	(feet of water)
March 1992	13.0	7.5	14.0	10	9.5	11.0	9.0	11.0
April 1992	15.6	5.0	20.4	3.6	8.3	12.2	5.8	14.2
May 1992	17.7	2.8	20.7	3.3	8.6	11.9	9.1	10.9
October 1992	Dry	0	22.7	1.3	17.6	2.9	8.1	11.9
January 1993	19.3	1.2	21.0	3.0	12.6	7.9	5.8	14.2
April 1993	19.2	1.3	21.2	2.8	11.8	8.5	5.0	15.0
April 1994	19.6	0.9	21.3	2.7	13.5	7.0	6.1	13.9
November 1994	18.8	1.8	20.0	4.0	13.9	6.6	5.5	14.5
May 1995	19.1	1.4	21.1	2.9	11.4	9.1	4.8	15.2
November 1995	19.3	1.2	20.8	3.2	9.46	11.0	4.5	15.5
September 1998	Dry	0	22.3	1.7	15.6	4.9	7.6	12.4
December 1999	19.2	1.3	21.0	3.0	7.3	17.2	4.7	15.3
Finished Depth (feet)	20.5		24.0		20.5		20.0	

Table V

Depth to Groundwater and Feet of water In Monitoring Wells (MW)

Date Measured	MW - 1		MW - 3		MW - 5		MW - 6	
	(depth, in feet)	(feet of water)	(depth, in feet)	(feet of water)	(depth, in feet)	(feet of water)	(depth, in feet)	(feet of water)
March 1992	13.0	7.5	14.0	10	9.5	11.0	9.0	11.0
April 1992	15.6	5.0	20.4	3.6	8.3	12.2	5.8	14.2
May 1992	17.7	2.8	20.7	3.3	8.6	11.9	9.1	10.9
October 1992	Dry	0	22.7	1.3	17.6	2.9	8.1	11.9
January 1993	19.3	1.2	21.0	3.0	12.6	7.9	5.8	14.2
April 1993	19.2	1.3	21.2	2.8	11.8	8.5	5.0	15.0
April 1994	19.6	0.9	21.3	2.7	13.5	7.0	6.1	13.9
November 1994	18.8	1.8	20.0	4.0	13.9	6.6	5.5	14.5
May 1995	19.1	1.4	21.1	2.9	11.4	9.1	4.8	15.2
November 1995	19.3	1.2	20.8	3.2	9.46	11.0	4.5	15.5
September 1998	Dry	0	22.3	1.7	15.6	4.9	7.6	12.4
December 1999	19.2	1.3	21.0	3.0	7.3	17.2	4.7	15.3
Finished Depth (feet)	20.5		24.0		20.5		20.0	

Table VI

December 8, 1998
Recharge Groundwater Sample Results

Analyte (ug/l)	MW-5		MW-6		MTCA Cleanup STDD
	Dec 98	Nov 95	Dec 98	Nov 95	
Benzene	81 ug/l	89 ug/l	1 ug/l	8 ug/l	5 ug/l
Toluene	ND	ND	ND	ND	40 ug/l
Ethylbenzene	240 ug/l	190 ug/l	22 ug/l	170 ug/l	30 ug/l
Xylenes	510 ug/l	64 ug/l	3 ug/l	16 ug/l	20 ug/l
TPH-G	5,500 ug/l	1,900 ug/l	4,100 ug/l	3,900 ug/l	1,000 ug/l