AP - 010

STAGE 1 & 2 WORKPLANS

DATE:
April 20, 2000

Higgins and Associates, LLC

April 20, 2000

Mr. Anthony "Tony" C. Walker
Staff Environmental Scientist
Phillips Pipe Line Company
3B11 Adams Building
Bartlesville, Oklahoma 74004

RE: Stage 2 Abatement Plan for Groundwater Abatement Plan AP-10
Line NM-1-1 Site
Phillips Pipe Line Company
Hobbs, New Mexico

Dear Mr. Walker:

Higgins and Associates, L.L.C. (Higgins and Associates) has prepared the following Stage 2 Abatement Plan for Groundwater Abatement Plan AP-10 at the Line NM-1-1 Site located in Hobbs, New Mexico. The abatement plan presents a summary of the project background, a description of assessment activities conducted to date, a general description of the geology/hydrogeology, a discussion of the distribution of the hydrocarbon impacts, a summary of pilot test results and abatement options, and a discussion of the conceptual design using groundwater pumping/product recovery working concurrently with a biovent system.

Higgins and Associates is pleased to provide environmental consulting services for Phillips Pipe Line Company. If you have any questions or comments regarding the following report please call me at (303) 708-9846.

Sincerely,
Higgins and Associates, L.L.C.

Chris Higgins

Chris Higgins
NMUSTB Certified Scientist #234
President

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ENVIRONMENTAL CONSULTANTS

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OIL CONSERVATION DIVISION

Stage 2 Abatement Plan for Groundwater Abatement Plan AP-10

Line NM-1-1 Site
Phillips Pipe Line Company
Hobbs, New Mexico

Prepared For:

Mr. Anthony "Tony" C. Walker
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1.0 Description and Current Situation of Project Site

1.1 Initial Abatement Summary

The subject site is located in Unit N, Section 9, Township 19 South, Range 38 East, N.M.P.M., Lea County, New Mexico. The property on which the release occurred is largely undeveloped arid land. The primary land use is grazing land for cattle. There are no surface bodies of water within 0.5 miles of the site. Several pipelines and crude oil production wells are located in the area. Two crude oil production wells are located near the pipeline release, of which one is located approximately 400 feet east/southeast of the pipeline release.

On October 27, 1998, Phillips personnel discovered a release of unrefined petroleum products (crude oil) associated with a local well field gathering pipeline located near the town of Hobbs, New Mexico. Two gathering lines parallel each other at the release site. One line is a six inch diameter line and the second line is an eight inch diameter line. The lines are separated by approximately one foot and are installed three to four feet beneath ground surface. The line leak was discovered by the detection of oil impacts on the ground surface in the area of the release. The amount of crude oil released is unknown.

Phillips excavated approximately 1,500 cubic yards of petroleum impacted soil from around and below the release location. The limits of the excavation were approximately 30 feet wide by 120 feet long and averaged approximately 12 feet deep with the deepest extent around 18 feet. Petroleum impacts remained in the base and side walls of the excavation and therefore excavation activities were halted until the lateral extent of the hydrocarbon impacts could be defined.

Phillips personnel supervised the installation of a 4-inch diameter, 46 foot deep, monitoring well (MW-1) to determine the vertical extent of soil impacts and to determine if the groundwater had been impacted. The well was located approximately 10 feet north of the excavation. Visual contamination was observed during drilling activities from a depth of two feet to total depth. Groundwater was reportedly encountered at about 40 feet below ground surface. Approximately 13 feet of crude oil was detected on the water table.

Phillips initiated a product recovery program from monitoring well MW-1 on December 12, 1998. The program consisted of periodic bailing of the product from MW-1 utilizing a bailer. As of February 19, 1999, approximately 1,243 gallons of crude oil had been recovered from the water table by hand bailing.

1.2 Stage 1 Abatement Summary

A geophysical survey was conducted at the site by Ground Truth Technology, Inc. (GTT) from February 1, 1999 to February 8, 1999. The objective of the survey was to obtain preliminary information on the lateral and vertical distribution of petroleum hydrocarbons prior to the installation of additional monitoring wells. A detailed description of the geophysical survey was presented to OCD in the Stage 1 Abatement Plan and Comprehensive Report.

During the week of March 22, 1999, an Abanaki Corporation PetroXtractor product recovery system was installed in monitoring well MW-1. Approximately 1,006 gallons of crude oil have been recovered utilizing the PetroXtractor system. As of September 10, 1999, a total of approximately 2,249 gallons (53.5 barrels) of crude oil had been recovered.

On July 13, 1999 through July 16, 1999, Higgins and Associates supervised the drilling and installation of monitoring wells MW-2 through MW-10 and two shallow soil borings (SB-1 and SB-2) (Figure 1). The results of the SIP and VIP geophysical surveys were taken into account for the locations of wells MW-2 through MW-10. The drilling activities were accomplished utilizing a truck mounted air rotary drill rig. Grab soil samples were collected at two foot intervals. An attempt was made to continuous core well MW-6. Due to poor core recovery and difficult drilling the continuous coring was stopped.

On July 15, 1999, rising head permeability tests (slug out tests) were conducted in wells MW-2 and MW-9. The tests were conducted by instantaneous removal of a volume of water from the wells and measuring the rate of groundwater recharge into the well. The rate of groundwater recharge was measured using a data logger connected to a transducer probe deployed in the wells. The data was evaluated using the Graphical Well Analysis Package (GWAP).

On October 18, 1999 through October 19, 1999, Higgins and Associates supervised the drilling and installation of monitoring wells MW-11, MW-12, monitoring points MP-1, MP-2, and vapor extraction wells SV-1 and SV-2. Monitoring wells MW-11 and MW-12 were installed to further delineate the dissolved hydrocarbon plume. Monitoring points MP-1 and MP-2, and vapor extraction wells SV-1 and SV-2 were installed within the hydrocarbon plume for the purpose of performing soil vapor extraction and biovent pilot tests. The pilot tests were performed on October 20, 1999 through October 24, 1999.

On November 16, 1999 through November 18, 1999, Higgins and Associates supervised excavation activities adjacent to the crude oil release point. The excavation activities during this period consisted of using a track hoe to "pothole" down to the oil/water interface to facilitate more aggressive product recovery. A vacuum truck is utilized periodically to pump the product from the excavation. As of December 10, 1999, approximately 5,000 gallons (119 barrels) of crude oil have been recovered utilizing this recovery method.

1.3 Chronology of Reports Submitted to OCD

- Stage 1 Abatement Plan - dated March 22, 1999
- Comprehensive Report - dated September 15, 1999
- Comprehensive Addendum Report - dated December 28, 1999

1.4 Current Soil and Groundwater Analytical Data

The known phases of petroleum impacts associated with this site are adsorbed phase hydrocarbons, dissolved phase, and liquid phase hydrocarbons. The lateral extent of petroleum impacts to the soil and groundwater have been defined. The following is a summary of each of these phases as defined by the assessment activities.

1.4.1 Adsorbed Phase Hydrocarbons

Petroleum impacts were apparent throughout the limits of the excavation from near surface to the total depth. Fingers of petroleum were apparent in the side walls of the excavation indicating that shallow migration of crude oil occurred along zones of increased permeability. Results of the Stage I assessment activities have detected petroleum hydrocarbon impacts exceeding the New Mexico action level of 100 mg/kg TPH for soil in borings for MW-4, MW-5, MW-6, MW-7, and MW-8. The levels exceeding 100 mg/kg TPH for the above referenced borings are limited to the water table interface. The following table summarizes the soil analytical data during the assessment activities.

Table 1
Soil Analytical Results for NM-1-1 Site
Hobbs, New Mexico

All results reported in mg/kg.

Well ID	Date	Depth (ft)	PID reading (ppmv)	Benzene	Toluene	Ethyl benzene	Total Xylenes	TPH
NM Action Levels			**100**	**10**				**100**
MW-2	07/13/99	10 - 12	26	<0.025	<0.025	<0.025	<0.025	<10
MW-2	07/13/99	30 - 32	16	<0.025	<0.025	<0.025	<0.025	39.6
MW-3	07/15/99	20 - 22	48	<0.025	<0.025	<0.025	<0.025	<10
MW-3	07/15/99	30 - 32	**140**	<0.025	<0.025	<0.025	<0.025	<10
MW-4	07/14/99	20 - 22	0	<0.025	<0.025	<0.025	0.032	<10
MW-4	07/14/99	30 - 32	**134**	0.029	0.16	0.25	0.27	**286**
MW-5	07/15/99	20 - 22	**314**	<0.025	<0.025	<0.025	<0.025	<10
MW-5	07/15/99	30 - 32	**>2,000**	**12**	94	95	150	**50,600**
MW-6	07/14/99	24 - 26	16	<0.025	<0.025	<0.025	<0.025	<10
MW-6	07/14/99	30 - 32	**331**	0.074	0.62	0.98	1.3	**1,762**
MW-7	07/13/99	14 - 16	16	<0.025	<0.025	<0.025	<0.025	<10
MW-7	07/13/99	30 - 32	**672**	0.14	1.8	3.2	4.7	**756**
MW-8	07/13/99	20 - 22	1	<0.025	<0.025	<0.025	<0.025	<10
MW-8	07/13/99	30 - 32	**235**	0.15	0.99	1.2	1.6	**912**
MW-9	07/14/99	20 - 22	3	<0.025	<0.025	<0.025	<0.025	<10

Well ID	Date	Depth (ft)	PID reading (ppmv)	Benzene	Toluene	Ethyl benzene	Total Xylenes	TPH
NM Action Levels			**100**	**10**				**100**
MW-9	07/14/99	30 - 32	15	<0.025	<0.025	<0.025	<0.025	<10
MW-10	07/15/99	20 - 22	10	<0.025	<0.025	<0.025	<0.025	<10
MW-10	07/15/99	30 - 32	40	<0.025	<0.025	<0.025	<0.025	<10
MW-11	10/19/99	14 - 16	2	<0.025	<0.025	<0.025	<0.025	<10
MW-11	10/19/99	30 - 32	3	<0.025	<0.025	<0.025	<0.025	<10
MW-12	10/19/99	14 - 16	1.1	<0.025	<0.025	<0.025	<0.025	<10
MW-12	10/19/99	30 - 32	2.4	<0.025	<0.025	<0.025	<0.025	<10
SB-1	07/15/99	10	0	-	-	-	-	-
SB-2	07/15/99	10	0	-	-	-	-	-

Concentrations of adsorbed phase hydrocarbons appear to be isolated to the water table interface outside of the excavated area. The migration of crude oil appears to have limited lateral migration prior to reaching the water table. The analytical data shows soil impacts are defined to the north by MW-2, to the south and east by borings MW-3, MW-9, and MW-10, and to the south and west by MW-11 and MW-12.

1.4.2 Dissolved Phase Hydrocarbons

The lateral extent of the dissolved phase hydrocarbons has been defined to the north (MW-2), to the east (MW-3), to the south/southeast (MW-10), and to the south/southwest (MW-11 and MW-12). In January 2000, well MW-9 had dissolved hydrocarbon concentrations above the New Mexico standard of 10 ug/L benzene. In April 2000, an additional well was installed downgradient of MW-9. The following table summarizes the groundwater analytical data for BTEX and TPH during the assessment activities.

Table 2
Groundwater Analytical Results for NM-1-1 Site
Hobbs, New Mexico

All results reported in ug/L.

Well ID	Date	Benzene	Toluene	Ethyl benzene	Total Xylenes	TPH
NM Action Levels		**10**	**750**	**750**	**620**	
MW-2	07/16/99	3.6	2.7	1.3	0.5	<2,000

Well ID	Date	Benzene	Toluene	Ethyl benzene	Total Xylenes	TPH
NM Action Levels		**10**	**750**	**750**	**620**	
MW-2	10/20/99	4.2	2.5	1.3	1.3	<2,000
MW-2	01/13/00	1.9	0.5	<0.5	<0.5	<2,000
MW-3	07/16/99	<0.5	<0.5	<0.5	<0.5	<2,000
MW-3	10/20/99	2.6	1.0	<0.5	<0.5	<2,000
MW-3	01/13/00	20	16	9.2	20	<2,000
MW-4	07/16/99	**720**	**1,100**	260	280	3,000
MW-9	07/16/99	<0.5	<0.5	<0.5	<0.5	<2,000
MW-9	10/20/99	2.8	<0.5	<0.5	<0.5	<2,000
MW-9	01/13/00	110	2	20	15	<2,000
MW-10	07/16/99	1.8	<0.5	<0.5	<0.5	<2,000
MW-10	10/20/99	3.8	2.3	<0.5	<0.5	<2,000
MW-10	01/13/00	2	1	2.5	2	<2,000
MW-11	10/20/99	<0.5	<0.5	1.2	1.3	<2,000
MW-11	01/13/00	<0.5	<0.5	<0.5	<0.5	<2,000
MW-12	10/20/99	1.1	<0.5	<0.5	<0.5	<2,000
MW-12	01/13/00	<0.5	<0.5	<0.5	<0.5	<2,000

In January 2000, monitoring wells MW-1 and MW-4 through MW-8 were not sampled due to the presence of LPH. Figure 1 (Appendix B) is the Hydrocarbon Concentration Map which shows the analytical data for BTEX and TPH.

1.4.3 Dissolved Phase Polyaromatic Hydrocarbons

In July 1999, the groundwater samples were analyzed for polyaromatic hydrocarbons (PAHs). PAHs were not detected in wells MW-2, MW-3, MW-9, and MW-10. Well MW-4 had detectable concentrations of 1-methylnaphthalene (10.8 ug/L), 2-methlnaphthalene (10.3 ug/L), naphthalene (7.76 ug/L), fluorene (0.76 ug/L), and phenanthrene (1.08 ug/L). These concentrations are below the New Mexico action levels.

1.4.4 Liquid Phase Hydrocarbons

On July 16, 1999, liquid phase hydrocarbons (LPH) were detected in wells MW-1, MW-5, MW-6, MW-7, and MW-8. The LPH thickness ranged from 0.35 feet in MW-6 to 6.08 feet in MW-5. LPH is present in MW-1 but the thickness was not measured because the PetroXtractor product recovery system is deployed in the well. On October 20, 1999, LPH was detected in wells MW-1, MW-4, MW-5, MW-6, MW-7, and MW-8. The LPH thickness ranged from 0.85 feet in MW-4 to 14.88 feet in MW-1. On January 12, 2000, and February 29, 2000, LPH was detected in wells MW-1, MW-4 through MW-8 and SVE-2. The LPH thickness ranged from 2.95 feet in MW-4 to 6.65 feet in MW-5. The LPH thickness in MW-1 was not measured because of the deployment of the product recovery system.

1.5 Summary of Geology and Hydrogeology

1.5.1 Regional Setting

The regional geology surrounding the site is alluvium (unconsolidated) overlaying the Ogalalla Formation. The Ogalalla is also known as the High Plains aquifer which extends north to south from South Dakota to New Mexico and Texas. The Ogalalla was formed during the formation of the Rocky Mountains (Larimide orogeny - late Cretaceous to end of Paleocene). The Ogalalla Formation primarily consists of outwash alluvium deposited by the streams draining the newly formed Rocky Mountains. Caliche deposits are encountered in those areas considered under semiarid to arid conditions. The caliche was (and continues to be) formed as a result of the vertical movement of water through the unconsolidated alluvium from rainfall recharge (downward) and evaporation (upward). The calcium carbonate and/or calcium sulfate forms out of solution and creates a cementation effect. The origin of the calcarious material is either eolian (wind blown dust) or eroded limestone within the alluvium of the Ogalalla.

The hydrogeology of the Ogalalla aquifer can vary tremendously on a relatively small scale due to the wide grain-size distribution of the alluvial sediments. The regional water table slopes from west to east. The saturated thickness of the Ogalalla ranges from 0 feet to the west to upwards of 1,000 feet to the east. In the area of Hobbs, New Mexico, the saturated thickness may be 10 to 150 feet. Depth to groundwater is shallower to the west and gradually gets deeper to the east. Aquifer recharge is primarily rainfall; aquifer discharge is a combination of streams or springs and evapotranspiration.

1.5.2 Local Setting

Based on information obtained from the soil borings and the drilling of monitoring wells, the site specific geology consists primarily of caliche mixed with sands and some gravel. The caliche was encountered from ground surface to approximately 20 feet below ground surface. The sands and gravels were encountered below the caliche to total depth. A limestone layer was encountered approximately 20 to 24 feet below ground surface is borings located east of the excavation. The monitoring wells were surveyed for locations and elevations by a New Mexico licensed surveyor. The survey provides data which is used to create the groundwater potentiometric surface map.

Groundwater was encountered in the monitoring wells at approximately 27 feet below ground surface. In

January 2000, crude oil was detected in wells MW-1, MW-5, MW-6, MW-7, MW-8 and SVE-2. The groundwater elevation and LPH thickness data for January 12, 2000 is in Appendix A. Figure 2 (Appendix B) depicts the groundwater potentiometric surface map for the January 12, 2000 data. The current groundwater flow direction and gradient is to the southeast. The groundwater gradient is approximately 0.004 ft/ft. Based on the rising head permeability test data from wells MW-2 and MW-9, the site specific hydraulic conductivity ranges from 5.9 x 10^{-3} cm/sec to 3.5 x 10^{-4} cm/sec. Based on an estimated porosity of 30%, average hydraulic conductivity of 3.1 x 10^{-3} cm/sec, and a gradient of 0.004 ft/ft, the average linear groundwater velocity is approximately 42 feet per year.

2.0 Development and Assessment of Abatement Options

The development of a corrective action plan for the NM-1-1 site is based on experience with various remedial technologies, experience with projects associated with the Ogalalla Aquifer, and knowledge of the regulatory compliance and cleanup goals of the OCD. The following conclusions were also influential during the development of the abatement options under consideration.

- The migration of crude oil appears to have limited shallow, lateral migration prior to reaching the water table. Concentrations of adsorbed phase hydrocarbons appear to be isolated to the water table interface outside of the excavated area. The analytical data shows soil impacts are defined to the north by boring MW-2, to the south and east by borings MW-3, MW-9, and MW-10, and to the south and west by borings MW-11 and MW-12.

- On January 12, 2000, liquid phase hydrocarbons (LPH) were detected in wells MW-1, MW-4, MW-5, MW-6, MW-7, MW-8, and SVE-2. The LPH plume appears to have been defined.

- In November 1999, aggressive crude oil product recovery continued. A "pothole" within the existing excavation was advanced to a depth of 35 feet to enhance crude oil recovery. A vacuum truck is removing crude oil periodically. As of March 27, 2000, approximately 21,042 gallons (501 barrels) of total fluids have been recovered using the vacuum truck. It is estimated that 12,625 gallons (60%) of the total fluids is crude oil.

- The lateral extent of the dissolved phase hydrocarbons has been defined to the north (MW-2), to the east (MW-3), to the south/southeast (MW-10), and to the south/southwest (MW-11 and MW-12). In October 1999, monitoring wells MW-1 and MW-4 through MW-8 were not sampled due to the presence of LPH.

- As of March 27, 2000, a total of approximately 14,874 gallons (354 barrels) of crude oil have been recovered by hand bailing, the product removal system, and the use of the vacuum truck.

A series of technological feasibility studies were completed to evaluate various abatement options.

2.1 Economic and Technical Feasibility of Remediation Technologies

2.1.1 Soil and Groundwater Remediation Goals

According to the OCD Guidance Document, remedial goals for the soil is 10 mg/kg benzene and 100 mg/kg TPH. Groundwater standards are 10 ug/L benzene, 750 ug/L toluene, 750 ug/L ethylbenzene, and 620 ug/L xylenes. Soils encountered at the NM-1-1 site may be remediated to concentrations of less than or equal to 10 mg/kg benzene and 100 mg/kg TPH. Groundwater encountered may be remediated to concentrations of 10 ug/L benzene, 750 ug/L toluene, 750 ug/L ethylbenzene, and 620 ug/L xylenes.

The presence of LPH should also be removed. Asymptotic remediation efforts may be reached and the above referenced standards may not be attainable due to the type of contaminant.

2.1.2 Evaluation of Remediation Techniques

Many technologies are available to facilitate the remediation of petroleum hydrocarbon-affected soils and groundwater. These range from traditional excavation and hauling of affected soils to aquifer air sparging and aerobic/anaerobic bioremediation. Most technologies are well suited to high permeability conditions, and only a few work well in low permeability conditions. The following technologies, alone or in combination, were considered for incorporation in the remedial action plan for this site:

- Excavation,
- Soil vapor extraction,
- Aerobic and anaerobic bioremediation,
- Aquifer sparging, and
- Groundwater pumping.

2.1.3 Excavation

Excavation may be considered for petroleum hydrocarbon-related remediation in three general circumstances: 1) when there are relatively small volumes of affected soils, 2) when the affected soils have a very low permeability, 3) if removal of relatively small quantities of soil will facilitate other remediation technologies by eliminating the concentrated source of petroleum hydrocarbons.

Excavation is not a practical solution at present, since soil contamination involves a large volume of affected soils. The site lithology of caliche would make excavation difficult. The depth of the petroleum impacts would result in numerous safety issues during excavation activities and the presence of LPH on the water table. Therefore, excavation activities are not applicable at this time.

2.1.4 Soil Vapor Extraction/Biovent System

Soil vapor extraction is a good mechanism for *in situ* reduction of petroleum hydrocarbon concentrations in the unsaturated zone through volatilization of petroleum hydrocarbon constituents and by increasing the oxygen content within the soil, thereby facilitating the natural biodegradation of petroleum hydrocarbons in the unsaturated zone.

Advantages for incorporation of a soil vapor extraction/biovent system at this site are:

- Disruption to the current use of the property as grazing land would be minimal. Excavation activities will be limited to trenches for installation of piping running from the vapor recovery wells to the equipment compound.

- Excavation of contaminated soil will be minimal. Remediation of contaminated soils will be accomplished *in situ*, reducing long term liabilities associated with off-site treatment and disposal of contaminated soil.
- The biodegradability of the petroleum hydrocarbon components are conducive to soil vapor extraction and bioventing, resulting in shorter remediation time frames than with most remediation technologies.
- A soil vapor extraction and biovent system can enhance contaminant recovery from preferential pathways such as fracturing within the caliche.

Disadvantages of soil vapor extraction/bioventing are:

- Off gas treatment cost, if required.
- This technology primarily addresses the vadose zone. It's effectiveness in the saturated zone is limited.

Soil vapor extraction/bioventing has practical applications at this site.

2.1.5 Aerobic and Anaerobic Bioremediation

In situ bioremediation is effective for saturated and unsaturated zone soils affected by petroleum hydrocarbons. Bioremediation technologies considered for this site enhance the populations of naturally occurring hydrocarbon utilizing bacteria. This process can be accomplished by simply increasing the oxygen content in the vadose zone by soil vapor extraction or by inducing nutrients and/or alternative electron acceptors into the subsurface to facilitate anerobic bioremediation. If anerobic bioremediation were implemented to address dissolved phase hydrocarbons, the process would consist of the addition of nitrate or sulfate and various nutrients to the subsurface through injection wells.

Advantages for bioremediation are:

- Bioremediation is an effective technology for addressing crude oil impacts.
- If necessary, nutrient addition may enhance biodegradation reducing remediation time frames.

Disadvantages to bioremediation are as follows:

- Permitting and additional monitoring requirements.

Bioremediation has practical application at this site. The *in situ* biremediation can be applied through the use of the soil vapor extraction/biovent system.

2.1.6 Aquifer Sparging

Aquifer sparging is a technology used to reduce concentrations of petroleum hydrocarbons in the saturated zone. Aquifer sparging is the injection of air, under pressure, at a point beneath the contamination within the saturated zone. This removes petroleum hydrocarbons directly from the saturated zone soils through volatilization and enhanced bioremediation. The air rises to the surface of the water table, where it is collected and removed by a soil vapor extraction system.

Advantages of aquifer sparging are:

- Removal rates of dissolved and adsorbed hydrocarbons are rapid.
- Equipment costs are low in comparison to groundwater pumping.
- Operation and maintenance of the remediation equipment is low.
- Removal efficiencies of volatile hydrocarbons from the saturated zone are high, resulting in reduced residual hydrocarbon concentrations at closure.

Disadvantages of aquifer sparging are as follows:

- Improper application of design of an aquifer sparge system can result in spreading of the contaminant (especially with the presence of LPH) instead of removal.
- Hydrocarbon vapors generated by the sparge system, if not captured by a vapor extraction system, can impact surrounding structures and utilities.

Aquifer sparging is not a practical application at this site because of the presence and amount of LPH.

2.1.7 Groundwater Pumping

Groundwater pumping is the removal of groundwater from the subsurface with either surface mounted or submersible electric pumps, or total fluid pneumatic pumps. Groundwater pumping provides hydraulic control of dissolved-phase and liquid-phase petroleum hydrocarbons, but often does not efficiently remove petroleum contamination when employed as the only remedial technology. Groundwater pumping is frequently combined with soil vapor extraction. The vapor extraction/biovent system works more efficiently when the water table is lowered and more contaminated soil is exposed to the vapor extraction process.

Advantages for groundwater pumping are:

- Migration of dissolved-phase and liquid-phase hydrocarbons are controlled.

- Soil vapor extraction/biovent system efficiency is increased due to control of groundwater fluctuations by the pumping system.

Disadvantages to groundwater pumping are as follows:

- Groundwater removed from the subsurface will require treatment prior to reinjection. The cost of the treatment system can be expensive.

- The high permeability of the saturated zone within the Ogalalla would result in high volumes of water to be treated.

Groundwater pumping is applicable for the site.

3.0 Preferred Abatement Options

After careful consideration and completion of a technological and economical feasibility study, the following remedial technologies were selected to perform abatement tasks which address the adsorbed-phase, dissolved-phase, and liquid-phase petroleum hydrocarbons. The remedial technologies proposed are a biovent system (utilizing a soil vapor extraction system) and a product skimming system combined with groundwater pumping for hydraulic control.

3.1 Soil Vapor Extraction and Biovent Pilot Testing

On October 20, 1999 through October 25, 1999, soil vapor extraction pilot tests and a biovent system pilot test was conducted. Wells MP-1 and SVE-1 were completed to a depth of 20 feet to perform a test within the caliche lithology and wells MP-2 and SVE-2 were completed to a depth of 35 feet for a test within the sandy lithology.

3.1.1 Soil Vapor Extraction Pilot Test Results

On October 20, 1999, a soil vapor extraction pilot test was performed on well SVE-1. On October 23, 1999, a second soil vapor extraction pilot test was conducted on well SVE-2. A 4.5 hp regenerative blower was applied to each SVE well. Influent and effluent measurements of air flow, VOCs, and vacuum were obtained. Surrounding wells were measured for induced vacuum, if any. The results of the tests are documented in the following tables.

Table 3
SVE Pilot Test at SVE-1
Applied Vacuum @ SVE-1 = 66 inches H2O

Time (min.)	Effluent Air Flow (cfm)	Effluent PID (ppm)	Vacuum @ SVE-2 (50 ft)*	Vacuum @ MP-1 (23 ft)	Vacuum @ MP-2 (35 ft)	Vacuum @ MW-4 (95 ft)	Vacuum @ MW-5 (60 ft)	Vacuum @ MW-6 (160 ft)
5	85	145	0.4	1	0.03	0.28	0.01	0
15	85	885	0.4	1	0.03	0.28	0.01	0
30	88	888	0.4	1	0.04	0.28	0.01	0

*Distance from SVE-1.

Table 4
SVE Pilot Test at SVE-2
Applied Vacuum @ SVE-2 = 68 inches H2O

Time (min.)	Effluent Air Flow (cfm)	Effluent PID (ppm)	Vac. @ SVE-1 (50 ft)*	Vac. @ MP-1 (45 ft)	Vac. @ MP-2 (30 ft)	Vac. @ MW-4 (95 ft)	Vac. @ MW-5 (30 ft)	Vac. @ MW-6 (120 ft)	Vac. @ MW-11 (200 ft)
5	83	844	0.5	0.8	1.5	0.32	1	0.18	0.1
30	80	747	0.5	0.76	1.4	0.32	1.2	0.18	0.1
60	82	595	0.6	0.78	1.4	0.32	1.2	0.18	0.1

* Distance from SVE-2.

The induced vacuum is measured in inches of water. Based on the results of the pilot tests, the radius of influence of an individual SVE well is up to approximately 200 feet with an applied vacuum of 68 inches of water at a flow rate of 80 cfm from each SVE well. Additional pilot test data is included in Appendix C.

3.1.2 Biovent Pilot Test Summary

On October 21, 1999 through October 25, 1999, a biovent system pilot test was conducted. The biovent test utilized wells MP-1, MP-2, SVE-1, and SVE-2. The biovent system consisted of using the 4.5 hp regenerative blower for increasing the oxygen concentrations within the surrounding wells. An inert gas (helium) was also injected into the subsurface at well MP-2 to aid in measuring gaseous dispersal rates within the vadose zone. Because of the elevated oxygen consumption rates due to the intrinsic biodegradation occurring at the site, dispersal rates may be inaccurate if measuring oxygen alone.

Prior to the biovent test, background concentrations of oxygen, carbon dioxide, carbon monoxide, helium, and VOCs were measured from the headspace of wells MW-5, MP-1, MP-2, SVE-1, and SVE-2. During the first part of the biovent test, a vacuum was applied to well SVE-2 for approximately two hours. Soon after the blower was turned off, a series of measurements of the above mentioned parameters were measured from each well headspace. The measurements occurred at specific intervals until headspace readings measured at or close to background concentrations.

In summary, the oxygen levels in the headspace of each well increased from their respective background concentrations of as low as 9.7 percent to 20.9 percent within two hours of blower operation. Rapid consumption of oxygen was observed each Initial carbon dioxide concentrations of as high as 3.8 percent decreased to 0 percent and initial carbon monoxide levels of 5 to 16 ppm decreased to 0 ppm. VOCs concentrations remained high in each well prior to the operation of the blower and after the blower was turned off (>2,000 ppm).

Once the well headspace concentrations reached background levels, helium was injected into well MP-2 at a set concentration (2%) and set flow rate (2 cfm at approximately 5 psi). The helium injection process lasted approximately 12 hours. Measurements of the above mentioned parameters, including helium, were taken during and after the injection process.

In summary, the helium concentration at the injection well MP-2 was as high as 20 percent. Helium concentrations in the near by wells ranged from 0 percent prior to the injection to as high as 0.84 percent observed in well MP-1. No helium was observed in well SVE-1 during the test. The low levels of helium observed in wells MP-1, MW-5, and SVE-2 during the test are attributed to "short circuiting" and storage within the pore spaces and fractures of the caliche. During the helium injection, slight increases in the parameters of oxygen, carbon dioxide, and carbon monoxide were observed. The slight increases may be attributed to pore space volume displacement of the air/helium injection mixture entering the vadose zone. After injection, the helium concentration at well MP-2 decreased from 20 percent to 0 percent within 48 hours. Concentrations of the other parameters returned to background levels within 12 hours of helium injection.

Based on the soil vapor extraction and biovent pilot tests, the operation of a blower at 70 inches of water applied vacuum, at an air flow of 80 cfm per well with an approximate radius of influence of 200 feet, operating for two hours every half day would provide and sustain oxygen concentrations within the vadose zone to promote active aerobic bioremediation. Initial background concentrations of carbon dioxide show evidence of intrinsic bioremediation occurring at the site. All the data and graphics for the soil vapor extraction and biovent tests are included in Appendix C.

3.2 Groundwater Modeling

In addition to the slug test data obtained in July 1999, geotechnical soil samples were obtained from the project site to obtain specific data parameters in January 2000. The data included soil density, permeability, porosity, grain size analysis, and moisture content. The data from the slug tests and the geotechnical samples were used in performing groundwater models.

The groundwater modeling was used to assist in developing a groundwater pumping system to control the migration and facilitate recovery of the LPH plume. The modeling program which was used is Modflow. The groundwater modeling was designed to simulate a recovery well field which would contain the migration of the LPH plume and enhance the rate of recovery for dedicated product recovery pumps. The groundwater model with the best fit for this site consisted of the following:

- Two (2) recovery pumping wells aligned perpendicular to the hydraulic gradient located approximately 350 feet from each other within the LPH plume. One well is projected to be located next to MW-5 and one well is projected to be located between MW-8 and MW-9.

- The recovery wells simulated at 25 gpm at the well next to MW-5 and 15 gpm for the well between MW-8 and MW-9. Various simulated pumping rates were applied in the model; the 25 and 15 gpm rate best fit for drawdown, radius of influence, and well efficiency.

- A series of groundwater injection wells was incorporated into the groundwater model. With the use of the two recovery pumping wells, the injection wells were shown to help in providing hydraulic control of the LPH plume. There are eight proposed injection wells designed to take an estimated 5 gpm per well. The groundwater from the two recovery wells will be treated prior to reinjection at the injection wells. A site map showing the projected groundwater potentiometric surface under pumping conditions is included as Figure 3 (Appendix B).

The groundwater pumping and product skimming will work effectively with the proposed biovent system. However, the effectiveness of the groundwater pumping will be contingent on the injection of the groundwater as proposed. If injection of the groundwater occurs as a closed loop system (injection upgradient of the recovery wells) then the effectiveness of the system will be greatly reduced.

3.3 Conceptual System Design

The conceptual system design will incorporate two major components: a biovent system and a groundwater pump and treat system with product recovery. The overall proposed conceptual system layout is presented in Figure 4 (Appendix B). Included on the figure is the proposed trench locations (for manifolded piping) and equipment compound.

3.3.1 Biovent System Design

The biovent system is designed to address the adsorbed phase hydrocarbons. Based on the results of the pilot testing, the biovent system is proposed to consist of six vapor extraction wells and 11 nutrient injection wells. The number of wells for the biovent system are placed strategically on site to encompass the area of hydrocarbon impacts. The six soil vapor extraction wells will be manifolded separately to an equipment compound housing a blower. A vacuum will be applied to the wells and operated intermittently so as to supply and sustain vadose zone oxygen of approximately 20.9 percent.

The 11 nutrient wells are proposed to supply nitrous oxide into the vadose zone. The nitrous oxide will provide a nutrient source of nitrogen for cell growth into the vadose to promote enhanced bioremediation through denitrification. The nutrient wells will be manifolded to the equipment compound to a supply of nitrous oxide. The nitrous oxide will be applied on an as needed basis based on nitrous oxide concentrations within the vadose zone. The equipment specifications are currently being designed and will be presented in the forthcoming Stage 2 Implementation Report following system installation.

3.3.2 Groundwater Pump and Treat/Product Skimming System

The proposed groundwater pump and treat system will compose of two recovery wells. A product skimming system will be deployed in the same recovery wells. One recovery well will be existing well MW-5 near the excavation. The other recovery well will be place between wells MW-8 and MW-9. The placement of the recovery wells are based on the groundwater modeling discussed in Section 3.2. The recovery wells will be pumping groundwater at approximately 25 gpm and 15 gpm. The product skimmers will be deployed above the pumps. Groundwater will be pumped through a manifolded system to the equipment compound, treated, and then injected into the aquifer at the proposed eight injection wells. The eight injection wells are located down and cross gradient to act as a barrier to help in preventing LPH plume migration. The actual location will be based on further evaluation of the hydrogeologic parameters at the site. All wells are anticipated to be north of the truck loop. The product skimmers will pump the crude oil to an above ground storage tank located adjacent to the equipment compound. The equipment specifications are currently being designed and will be presented in the Stage 2 Implementation Report following system installation.

3.3.3 Permitting

Any or all air, water, construction, and electrical permits will be filed and maintained. A specific groundwater reinjection permit will also be applied for.

3.3.4 Vacuum Truck Usage/Possible Usage of Oleophilic Fertilizer

The use of the vacuum truck to routinely pump out crude oil from the "pothole" excavation will continue as long as the excavation is open. There is an additional abatement option under consideration which would apply an oleophilic fertilizer to the wall of the open excavation and the LPH in the pothole. The fertilizer may be nitrate or sulfate based and applied directly to the impacted soils within the excavation prior to backfilling operations.

4.0 Monitoring Program

4.1 Groundwater Monitoring and Sampling

Groundwater samples will continue to be collected from all wells absent of LPH on a quarterly basis. The sampling scope of work will be as follows:

- All wells will be gauged for depth to water, depth to product (if any), and total depth.
- All wells absent of liquid phase hydrocarbons will be purged a minimum of three well volumes. Measurements of temperature, pH, and conductivity will be collected during well development to insure the water sampled is from the surrounding aquifer.
- Groundwater samples will be collected from all wells absent of liquid phase hydrocarbons. The groundwater samples will be analyzed for BTEX and TPH by EPA Method 8021/8015 Modified and chloride.
- Samples will be collected from the pump and treat system and analyzed for BTEX and TPH. Samples will also be analyzed for any other parameters according to future permit requirements. This may be on a separate schedule other than on quarterly basis.

4.2 Quality Assurance Plan

Industry accepted standard operating practices will be followed for all field activities to insure the quality of the data obtained. These procedures are summarized as follows:

- Well development and purging activities for the monitoring wells will be conducted from the cleanest well (based on past data and field observations) to the most contaminated well to minimize potential cross contamination between wells.
- All reusable groundwater sampling equipment will be decontaminated utilizing an alconox wash and distilled water rinse prior to sampling activities and between each well.
- Groundwater samples will be collected utilizing new disposable bailers. One duplicate sample will be collected during the sampling activities. In addition to the duplicate sample, one trip blank sample will be analyzed for the cooler containing the samples for BTEX analysis.
- The groundwater samples will be collected in the appropriate sample containers, labeled, sealed with custody seals, and placed on ice. The samples will be logged on a chain-of-custody form and submitted to the laboratory for analysis.
- New disposable gloves will be utilized for all sampling activities and will be discarded between samples.

5.0 Site Maintenance Activities

5.1 Biovent System Monitoring

Volatile organic compound emissions will be monitored using a PID at system activation. Air flow rates will be measured and used to calculate the mass of total hydrocarbons recovered and emitted. Once the biovent system is in place, monitoring will occur daily for one week and monthly thereafter. Oxygen, carbon dioxide, carbon monoxide, and nitrous oxide will also be monitored. The data gathered from the air monitoring will help track the progress of the biovent system. The progress of the biovent system will be included in the quarterly updates.

5.2 Groundwater Pumping/Product Skimming Monitoring

During each site visit, the groundwater pumping and product skimming system will be checked for proper operation. The groundwater from the treatment system will be sampled according to any discharge permit requirements. Point of compliance wells are proposed to be installed just down gradient of the groundwater injection wells. These wells are proposed to be sampled on a quarterly basis for BTEX and TPH to help monitor the effectiveness and integrity of the pumping system.

5.3 Equipment Maintenance

The remediation system will be monitored and maintained on a monthly schedule or on an as needed basis. This will ensure that the system is operating as designed. Checking control panel operation, fail safe alarms, and equipment cleaning will be an integral part of the routine maintenance. Emergency contact list with phone numbers will be posted outside of the equipment compound.

5.4 Closure Plan

The system will be operated until the criteria for closure are achieved or until dissolved hydrocarbon concentrations in the groundwater and/or the effluent from the soil vapor extraction system reach asymptotic concentrations. At this point in the project, a petition for system shut down will be prepared and submitted to the OCD for approval. This petition will contain system performance data and hydrocarbon removal results, and will outline the closure monitoring plan.

Confirmatory soil borings will be completed within the historical plume to track the remedial progress. The soil samples collected will be analyzed for BTEX and TPH.

The anticipated closure monitoring program will include collecting groundwater samples quarterly from the monitoring wells, for a total of four quarters. The groundwater samples will be analyzed for concentrations of BTEX and TPH. If the concentrations of dissolved BTEX exceed New Mexico Water Quality Standards in any compliance well, recommendations will be prepared. The proposed compliance wells are MW-2, MW-9, MW-10, and MW-12.

When closure monitoring has been successfully completed, the closure monitoring data will be submitted to OCD and a request for official closure will be made. At this time the remediation equipment will be dismantled and the site wells will be properly abandoned.

6.0 Schedule of Abatement Activities

Implementation of the Stage 2 Abatement Plan will commence within 30 to 60 days upon approval of the OCD. The remediation system installation is anticipated to take 3 to 4 weeks. Remediation equipment such as the biovent system blower and groundwater pumps will require a 4 to 6 week delivery schedule.

Regular quarterly reports will be sent to the OCD. The first quarterly report will include a summary of the remediation system startup and list specific equipment specifications. The quarterly reports will include a summary of groundwater analytical data, remediation equipment efficiency, and LPH recovery to date. A map of the current groundwater potentiometric surface, LPH thickness, and dissolved hydrocarbon concentrations will be attached to the quarterly reports. Any changes to the scope of work or sampling schedule will be made in the quarterly reports as necessary. Additional reporting will be completed on an as needed or as requested basis. Routine database management will commence throughout the project.

7.0 Public Notification Proposal

The following public notification proposal is based on OCD requirements from 19 NMAC 15.A.19.

Phillips Pipe Line will distribute the Public Notice written and provided by the OCD to the following persons by certified mail prior to publishing the Public Notice:

- land owners of record within a one-mile radius,
- the Lea County commission,
- appropriate City of Hobbs officials,
- and the New Mexico Trustee for Natural Resources.

The Public Notice will be provided via the United States Postal Service to other persons identified by the OCD. After distributing the aforementioned Public Notice to the persons indicated, Phillips Pipe Line will publish the Notice in the following newspapers by the deadline indicated in the OCD's Stage 2 Abatement Plan approval letter: The Hobbs News-Sun, The Lovington Daily Leader, and The Albuquerque Journal.

Appendix A

Groundwater Elevation/LPH Thickness Data
January 12, 2000

GROUNDWATER ELEVATION DATA

CLIENT: Phillips Pipe Line
FACILITY: Hobbs, NM
LOCATION: Section 9, Township 19 S, Range 38 E
Hobbs, New Mexico
DATE: January 12, 2000

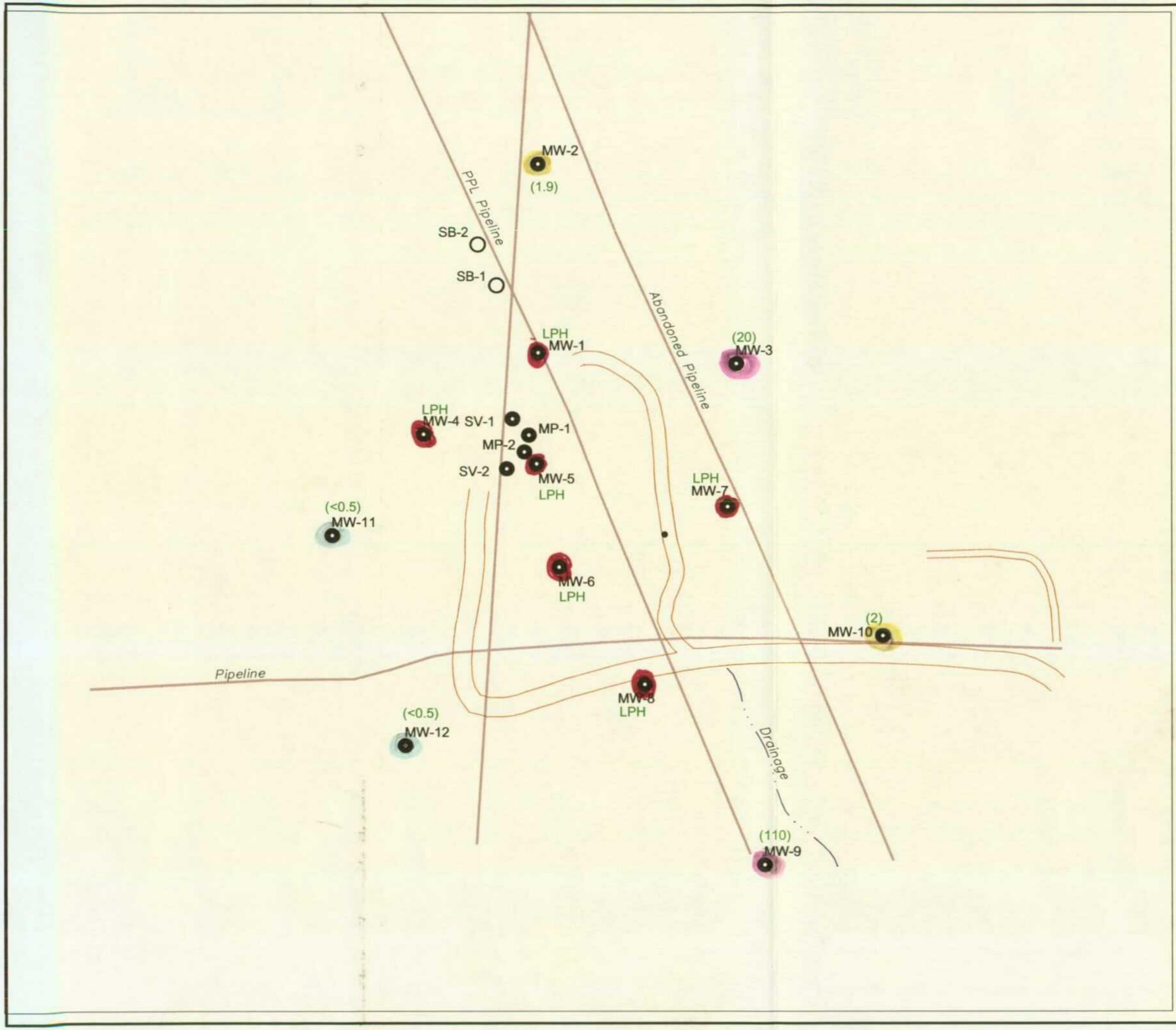
WELL ID	ETC	DTW	DTP	PT	PT X.8	ADJ DTW	WTE	COMMENTS
MW-1	3603.30			0.00	0.00	0.00		inaccessible
MW-2	3601.57	31.26		0.00	0.00	31.26	3570.31	
MW-3	3602.77	33.78		0.00	0.00	33.78	3568.99	
MW-4	3601.70	34.63	31.68	2.95	2.36	32.27	3569.43	
MW-5	3601.54	37.98	31.33	6.65	5.32	32.66	3568.88	
MW-6	3599.83	34.81	30.46	4.35	3.48	31.33	3568.50	
MW-7	3602.11	38.16	32.80	5.36	4.29	33.87	3568.24	
MW-8	3598.87	33.36	30.30	3.06	2.45	30.91	3567.96	
MW-9	3601.05	33.83		0.00	0.00	33.83	3567.22	
MW-10	3602.96	35.32		0.00	0.00	35.32	3567.64	
MW-11	3600.67	31.23		0.00	0.00	31.23	3569.44	
MW-12	3599.35	30.92		0.00	0.00	30.92	3568.43	
SVE-1	3602.16			0.00	0.00	0.00		Dry
SVE-2	3601.17	37.08	31.33	5.75	4.60	32.48	3568.69	
MP-1	3601.87			0.00	0.00	0.00		Dry
MP-2	3601.87			0.00	0.00	0.00		not recorded

ETC = Elevation Top of Casing
DTW = Depth to water
DTP = Depth to Petroleum Hydrocarbons
PT = Measured Petroleum Thickness

ADJ. DTW = Adjusted Depth to Water
WTE = Water Table Elevation
PTE = Elevation Top of Petroleum
N.A. = Not Applicable
All measurements in linear feet

Appendix B

Figures



LEGEND

MW-1 ● Monitor Well
(excavation size is approximate)

SB-1 ○ Soil Boring

(<0.5) Benzene Concentration
(parts per billion)

N

0 100 200
Scale (ft)

HIGGINS AND ASSOCIATES, L.L.C.

Project No.:	Date Map Generated: 02/25/00	Date Data Collected: -	Figure No. 1

Authored: CH

Checked: CH

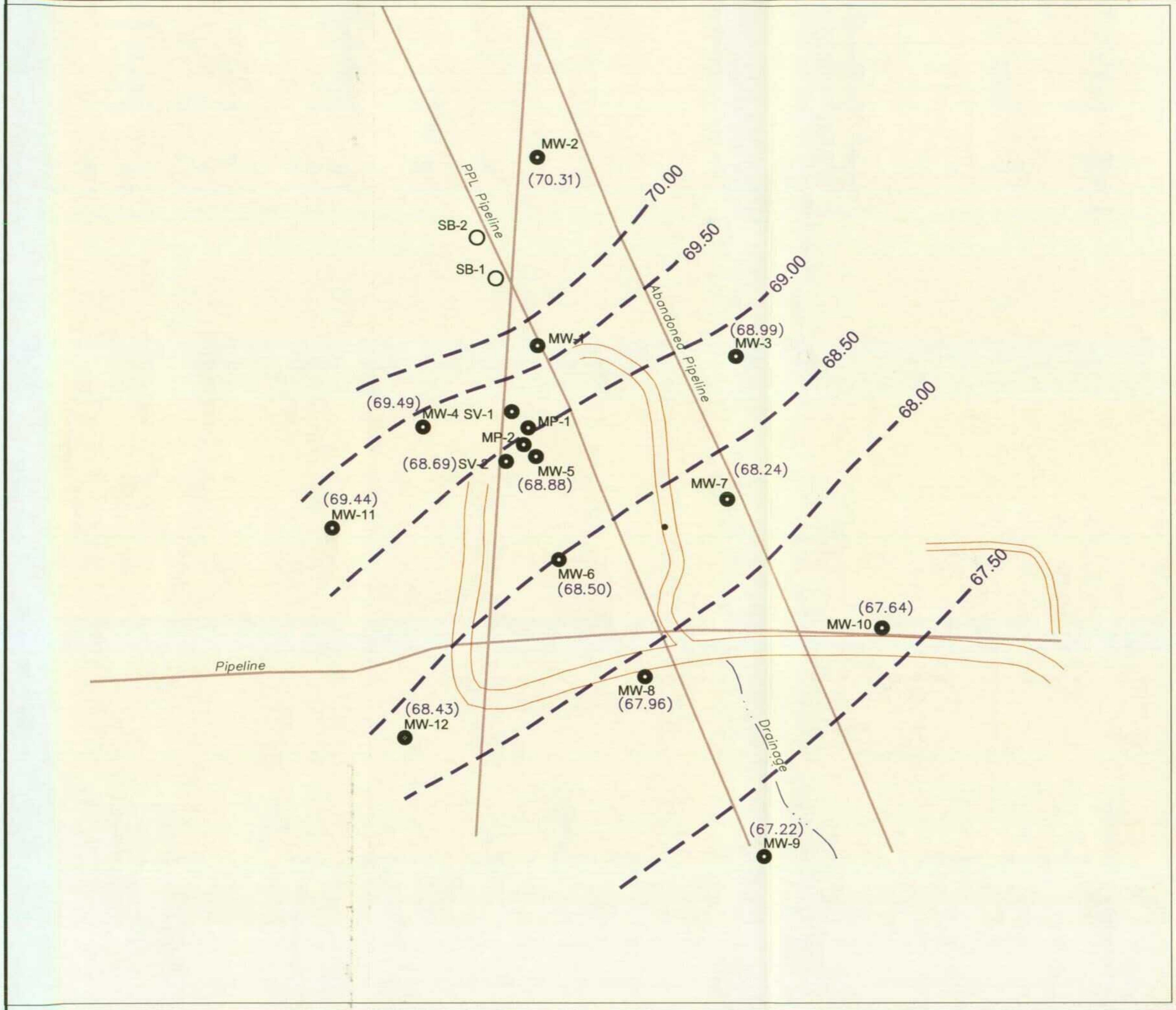
Detailed: ML

Title:
PPL Line NM-1-1
Liquid Phase Hydrocarbons and
Dissolved Phase Benzene
January 2000

Client: Phillips Pipe Line Company

ACAD File:

Location: Hobbs
New Mexico



LEGEND

MW-1 ⊙	Monitor Well (excavation size is approximate)
SB-1 ○	Soil Boring

N

0 100 200

Scale (ft)

HIGGINS AND ASSOCIATES, L.L.C.

Project No.:	Date Map Generated:	Date Data Collected:	Figure No.
	02/25/00	01/00	2

Authored: CH

Checked: CH

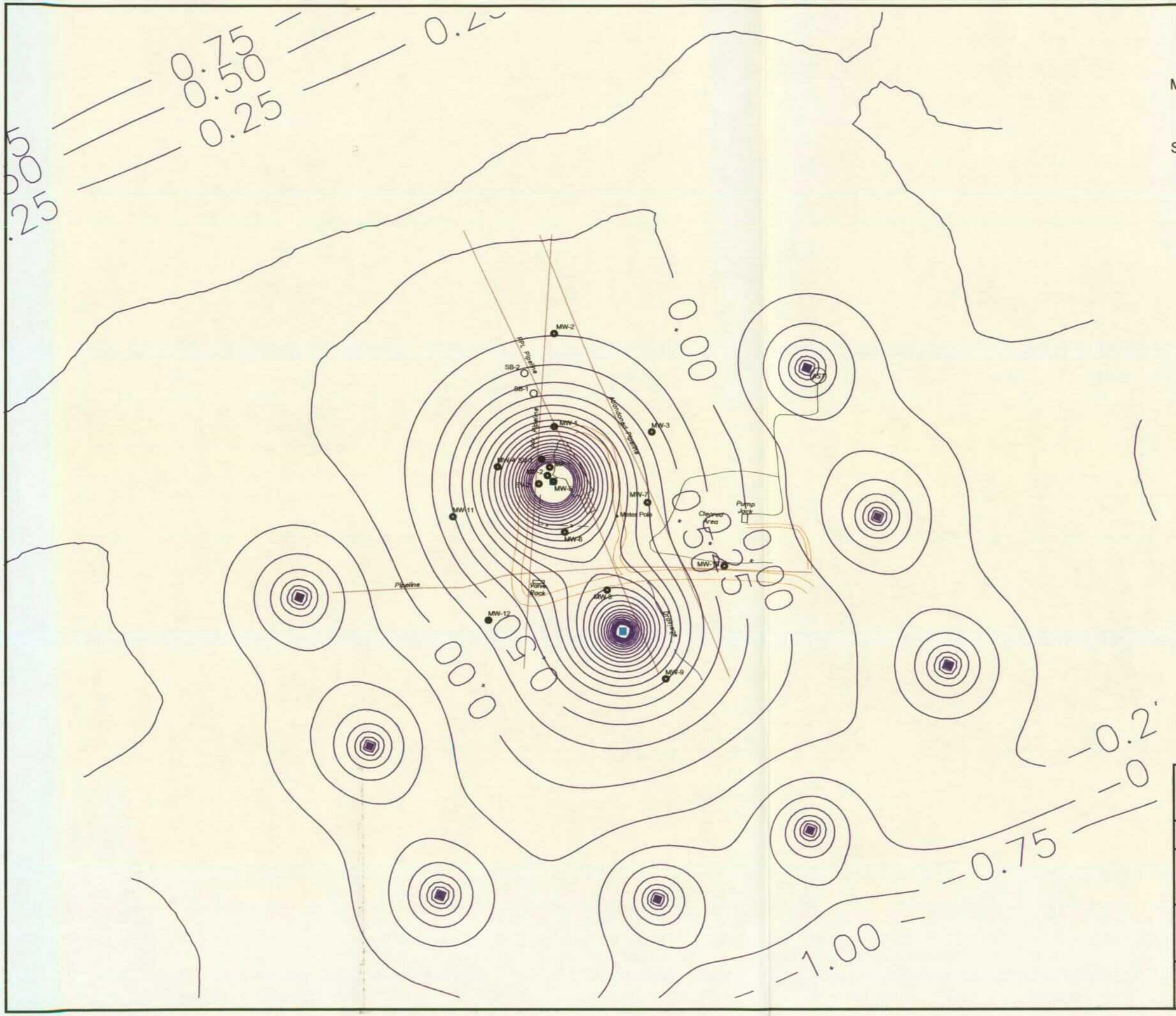
Detailed: ML

Title:
PPL Line NM-1-1
Groundwater Potentiometric Surface
January 2000

Client: Phillips Pipe Line Company

Location: Hobbs
New Mexico

ACAD File:



LEGEND

MW-1 ● Monitor Well (excavation size is approximate)

SB-1 ○ Soil Boring

■ Groundwater/Product Recovery Wells

N

0 200 400

Scale (ft)

HIGGINS AND ASSOCIATES, L.L.C.

Project No.:	Date Map Generated:	Date Data Collected:	Figure No.
	02/25/00	-	3

Authored: CH

Checked: CH

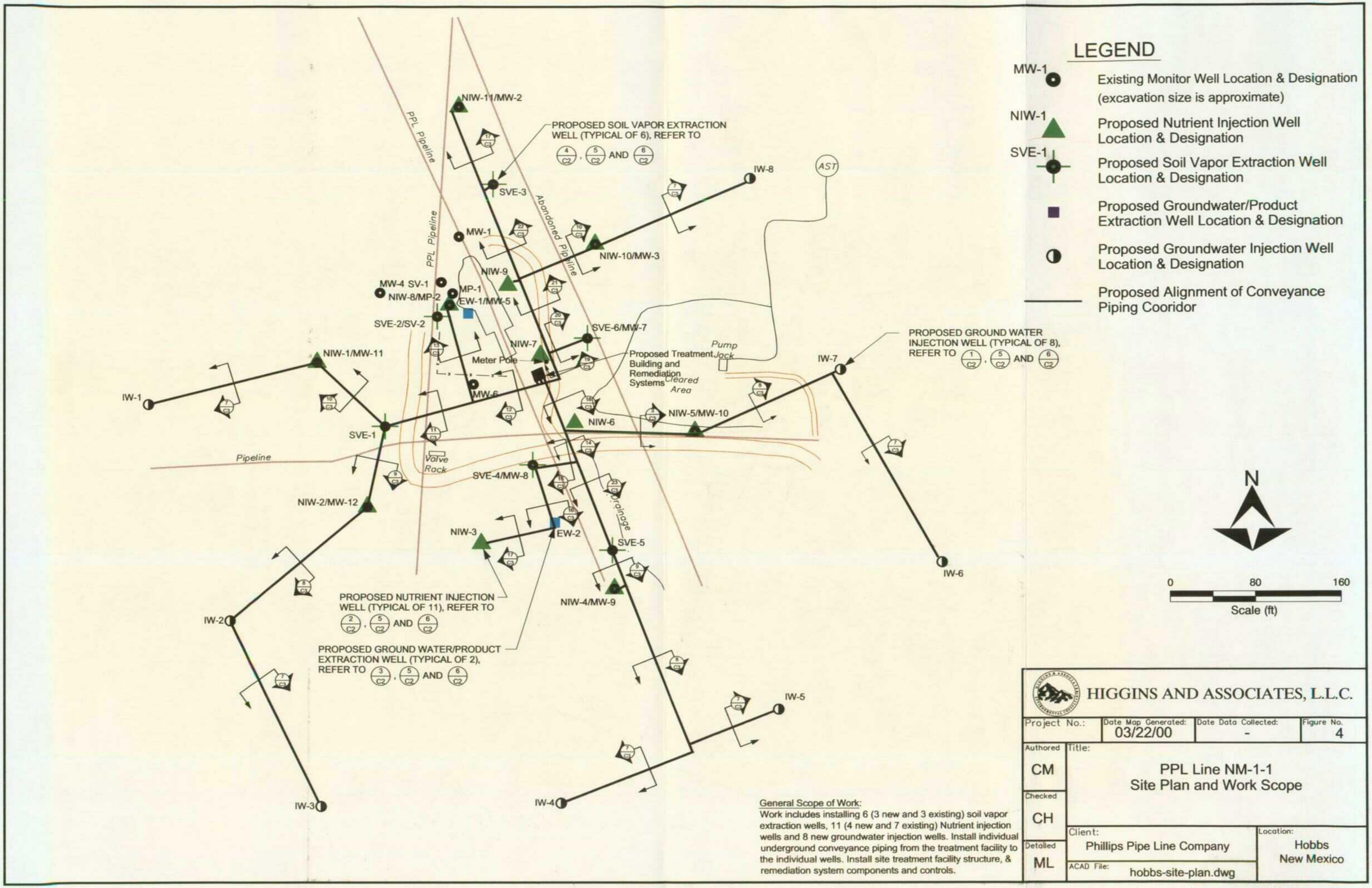
Detailed: ML

Title:
PPL Line NM-1-1
Projected Groundwater Potentiometric
Surface Under Pumping Conditions

Client: Phillips Pipe Line Company

ACAD File:

Location: Hobbs
New Mexico



LEGEND

- MW-1 ● Existing Monitor Well Location & Designation (excavation size is approximate)
- NIW-1 ▲ Proposed Nutrient Injection Well Location & Designation
- SVE-1 ⊕ Proposed Soil Vapor Extraction Well Location & Designation
- ■ Proposed Groundwater/Product Extraction Well Location & Designation
- ◑ Proposed Groundwater Injection Well Location & Designation
- — Proposed Alignment of Conveyance Piping Cooridor

PROPOSED SOIL VAPOR EXTRACTION WELL (TYPICAL OF 6), REFER TO 4/C2, 5/C2 AND 6/C2

Proposed Treatment Building and Remediation Systems

PROPOSED GROUND WATER INJECTION WELL (TYPICAL OF 8), REFER TO 1/C2, 5/C2 AND 6/C2

PROPOSED NUTRIENT INJECTION WELL (TYPICAL OF 11), REFER TO 2/C2, 5/C2 AND 6/C2

PROPOSED GROUND WATER/PRODUCT EXTRACTION WELL (TYPICAL OF 2), REFER TO 3/C2, 5/C2 AND 6/C2

General Scope of Work:
Work includes installing 6 (3 new and 3 existing) soil vapor extraction wells, 11 (4 new and 7 existing) Nutrient injection wells and 8 new groundwater injection wells. Install individual underground conveyance piping from the treatment facility to the individual wells. Install site treatment facility structure, & remediation system components and controls.

HIGGINS AND ASSOCIATES, L.L.C.

Project No.:
Date Map Generated: 03/22/00
Date Data Collected: -
Figure No. 4
Authored CM
Checked CH
Detailed ML
Title: PPL Line NM-1-1
Site Plan and Work Scope
Client: Phillips Pipe Line Company
Location: Hobbs
New Mexico
ACAD File: hobbs-site-plan.dwg

Appendix C

Pilot Test Data

Pelorus EnBiotech Corporation

Project: NM-1-1 20-Oct Site:
Sampler:
Location: Well MP-1

DATE	TIME	TEMP	ElapsedHr	% O_2	% CO_2	% He	% CO	VOC (ppm)	Comments
10/20/99	1453		0	14	2		16	10000	
	1816		0	20.9	0		0	0	
10/21/99	920		10	16	1		7	10000	Started HE injection @1358
	1457		15.5	14.9	1.2	0	17	10000	
10/21/99	2307		11	17.8	2	1	5	10000	
10/22/99	613		18	17.9	1.8	0.8	5	10000	
	613		0	17.9	1.8	0.8	5	10000	Baseline condition after injection air/He
	915		3	16.3	2.2	0.84	5	10000	
	1046		4.5	15.7	2.2	0.72	6		
	1158		5.5	15.2	2.1	0.65	9		
	1342		7.5	16	1.8	0.62	12		
	1601		9.75	16.1	1.7	0.69	13		
	1855		12.75	16.5	2	0.61	10		
10/23/99	1420		0	20.9	0	0	0	500	SVE2
	1625		2	20.7	0.1	0	0	500	
24-Oct	853		18.5	17.4	0.8	0.09	0	10000	
	1047		20.5	14.2	1.8	0.13	12		
	1445		24.5	13.9	2	0.09	15		

Biovent_Pilot_10-20 Page______ Sample Location:__________

Pelorus EnBiotech Corporation

Project: NM-1-1
Sampler:

Site:
Location: Well SVE-1

DATE	TIME	TEMP	ElapsedHr	% O_2	% CO_2	% He	% CO	VOC (ppm)	Comments
			0	20.8	0.2	0	0	8500	
			5	16	1	0	9		
			5.5	15.7	1	0.01	13		
			13.75	14.8	1.6	0	8		
			20.75	15.6	1.4	0	9		
			25.5	14.3	1.5	0	11		
			39	13.9	2.3	0	14		
									SVE TEST 2
			0	20.9	0	0	0	280	
			2	20.9	0	0	0	260	
			16.5	17.2	0.6	0	0	9400	
			18.5	15.4	1.6	0	10	10000	
			20.5	15.4	1.4	0	12	10000	

Pelorus EnBiotech Corporation

Project: NM-1-1
Sampler:

Site:
Location: Well SVE -2

DATE	TIME	TEMP	ElapsedHr	% O_2	% CO_2	% He	% CO	VOC (ppm)	Comments
10/20/99	1428			18.6	0.6	0	5	10000	
	1830			20.9	0		0	40	
10/21/99	815		0	20.9	0	0	0	2640	
	1400		6	13.6	2	0	14	10000	
	2300		15	13.9	2.6	0	9	10000	
10/22/99	630		0	20	0.4	0	0	10000	
	900		2.5	19.8	0.4	0	0	10000	
	1030		4	19.5	0.4	0	0	10000	
	1150		5.5	18.9	0.3	0.02	3	10000	
	1330		7	15.8	1.2	0.03	10	10000	
	1550		9.5	14.4	1.4	0.03	16	10000	
	1845		12.5	14.8	1	0.02	8	10000	
10/23/99	1106		28.5	13.6	2.4	0.12	10	10000	
SVE TEST									
10/23/99	1400		0	20.9	0	0	0	480	
	1612		2	20.7	0	0	0	1020	
10/24/99	842		16.75	18.2	0.6	0.02	1	8500	
	1036		18.75	11.4	3	0.06	16	10000	
	1435		22.75	12.9	2.8	0.02	14	10000	

Sample Location:__________

Project: NM-1-1
Sampler:

Site:
Location: Well MP-2

DATE	TIME	TEMP	ElapsedHr	% O_2	% CO_2	% He	% CO	VOC (ppm)	Comments
10/20/99	1420			12.7	2.6	0	16	10000	
	1810		start	20.9	0		0	0	
10/21/99	850		15	13.6	2.6	0	12	10000	
	1600		22	8.8		2	12	10000	
	2255		start			2.4			
	2330		0	20.9	0	1.8	0	1100	
10/22/99	610		6.5	20.9	0	2	0	1140	
	900		9.5	20.5	0	1.7	0	1520	
	1030		11	20.5	0	1.5	0	1480	
	1145		12.25	20.4	0	1.6	0	2200	
	1330		16	20.3	0	1.6	0	2240	
	1545		18.25	20	0	1.2	0	2300	
	1842		21.25	19.8	0	1.1	0	2480	
10/23/99	827		30	18.6	0	1	0	3690	
	1100		32.5	18.2	0.4	0.76	0	6900	
SVE TEST									
10/23/99	1400		0	20.9	0	0	0	0	
	1602		2	20.8	0.05	0	0	200	
10/24/99	832		16.5	19.8	0.1	0.29	0	4280	
	1025		18.5	17.4	0.4	0.7	4	10000	
	1430		22.5	17.3	0.6	0.5	5	10000	

Project: NM-1-1
Sampler:

Site:
Location: Well MW-5

DATE	TIME	TEMP	ElapsedHr	% O_2	% CO_2	% He	% CO	VOC (ppm)	Comments
10/20/99	1440			9.7	3.8	0	30	10000	
	1830		0	20.9	0		0	0	
10/21/99	840		14	19.9	0.2	0	1	9140	
	1400		18	9.4	3	0.01	26	10000	
	1500		19	9.3	3.2	0.05	31	10000	
	2300		27	11.1	3.8	0.23	18	10000	
10/22/99	610		0	11.5	3.2	0.14	16	10000	
	900		3	11.7	3.2	0.12	15	1520	
	1030		4.5	13.4	2.3	0.09	13	1480	
	1145		5.75	13.9	1.7	0.08	12	2200	
	1330		9.5	12	2.2	0.12	22	2240	
	1545		11.75	15.6	1	0.09	13	2300	
	1842		14.75	15.1	1.8	0.07	17	2480	
10/23/99	827		23.5	14.8	1.2	0.02	10	3690	
	1100		26	15.7	2	0.06	11	6900	
SVE TEST									
10/23/99	1400		0	20.9	0	0	0	100	
	1615		2	20.9	0	0	0	140	
	2047		6.5	19.2	0.2	0	0	2000	
10/24/99	1041		20	12.4	2.4	0	0	2000	
	1440		24.5	12.4	2.2	0.05	15	10000	
10/25/99	830		48	12.8	2	0.02	13	10000	

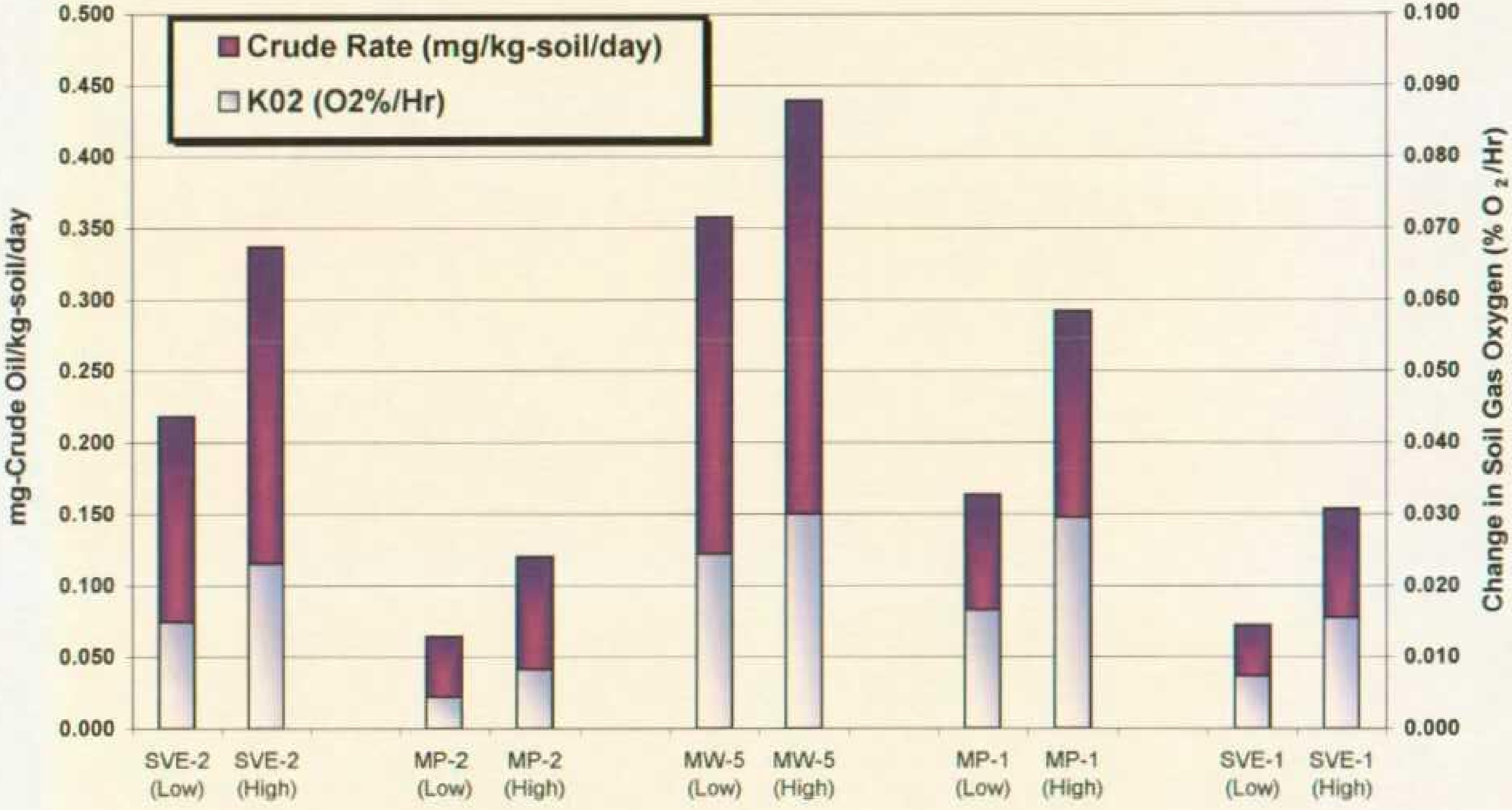
WELL	**K_{02} (O_2%/Hr)**	**Crude Rate (mg/kg-soil/day)**	**Hexane Rate (mg/kg-soil/day)**
SVE-2 (Low)	0.015	0.2183	0.2138
SVE-2 (High)	0.023	0.3370	0.3300
MP-2 (Low)	0.004	0.0645	0.0631
MP-2 (High)	0.008	0.1202	0.1176
MW-5 (Low)	0.024	0.3575	0.3501
MW-5 (High)	0.030	0.4396	0.4304
MP-1 (Low)	0.017	0.1634	0.1600
MP-1 (High)	0.030	0.2922	0.2861
SVE-1 (Low)	0.007	0.0723	0.0708
SVE-1 (High)	0.016	0.1535	0.1503

	Carbon %	**MW**	**Density (g/mL)**	**Density (lbs/gal)**
Crude	86.00%	282	0.82	6.8
Hexane	83.72%	86	0.66	5.45

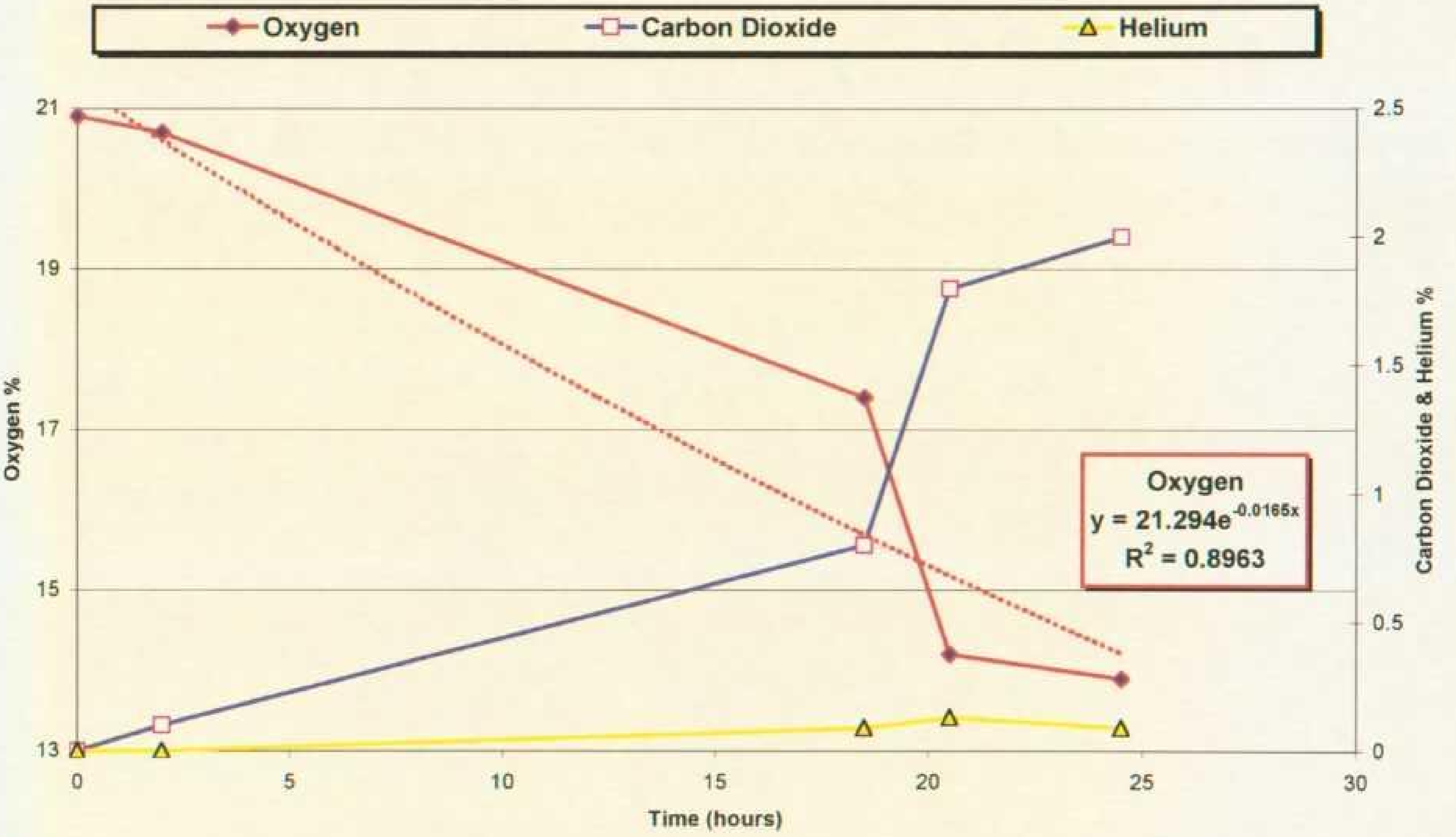
HC Center of Mass	
$C_{24}H_{50}$	338
$C_{20}H_{42}$	282

Matrix	**Porosity**	**SG**	**Density (lbs/ft^3)**	**Density (kg/m^3)**	**Well Location**
Caliche	30.00%	2.75	171.6	2748.6888	SVE-1, MP-1
Sand	30.00%	1.86	116	1858.088	SVE-2, MP-2, MW-5

Biodegradation Kinetics: Hobbs, NM



SVE TEST RESULTS (MP-1)

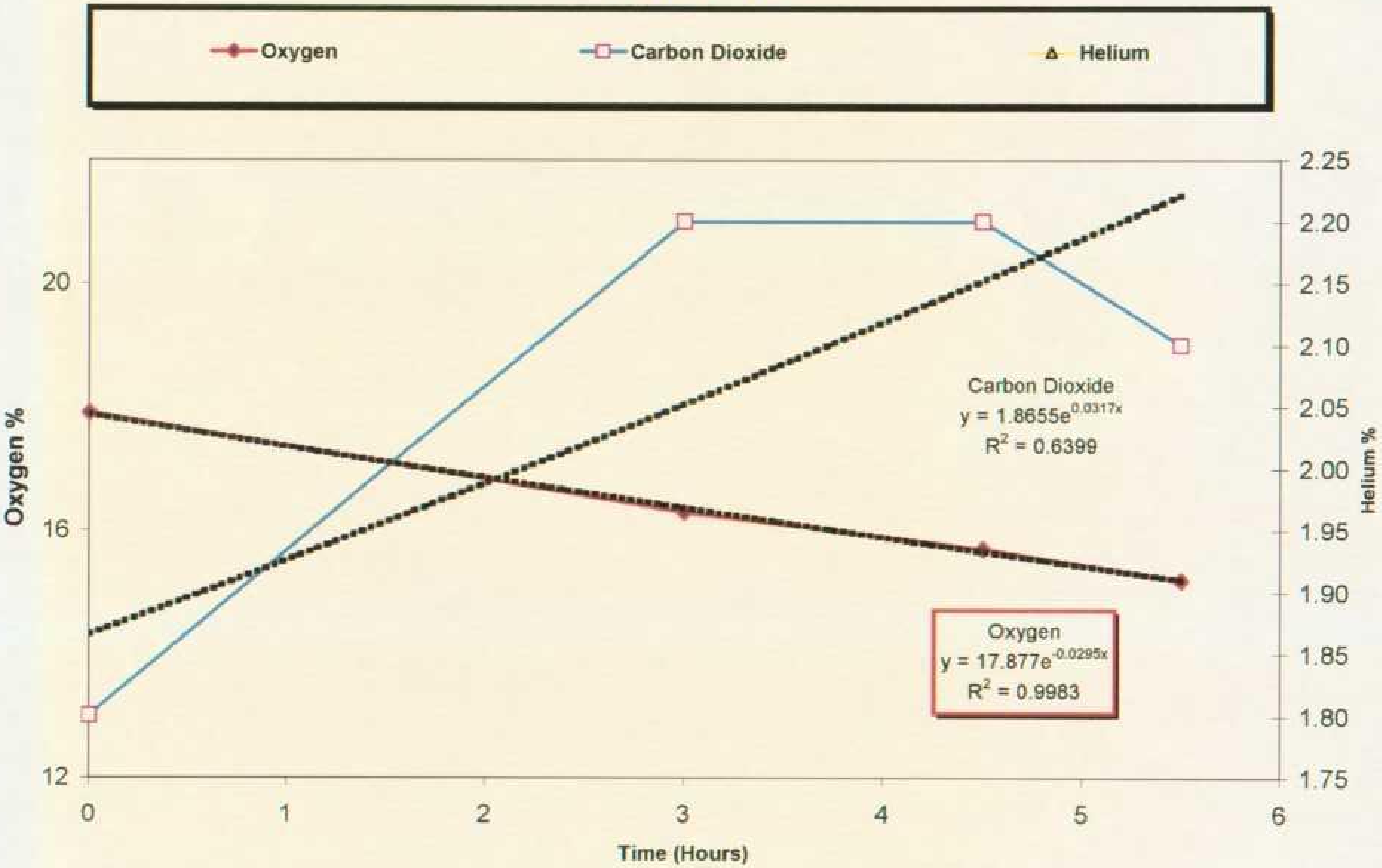


Pelorus EnBiotech Corporation

Client: Phillips Pipe Line Co
Site: Hobbs, NM

Project: SVE/Biovent Pilot Test
Date: October 19 - 25, 1999

Soil Gas Trends MP-1

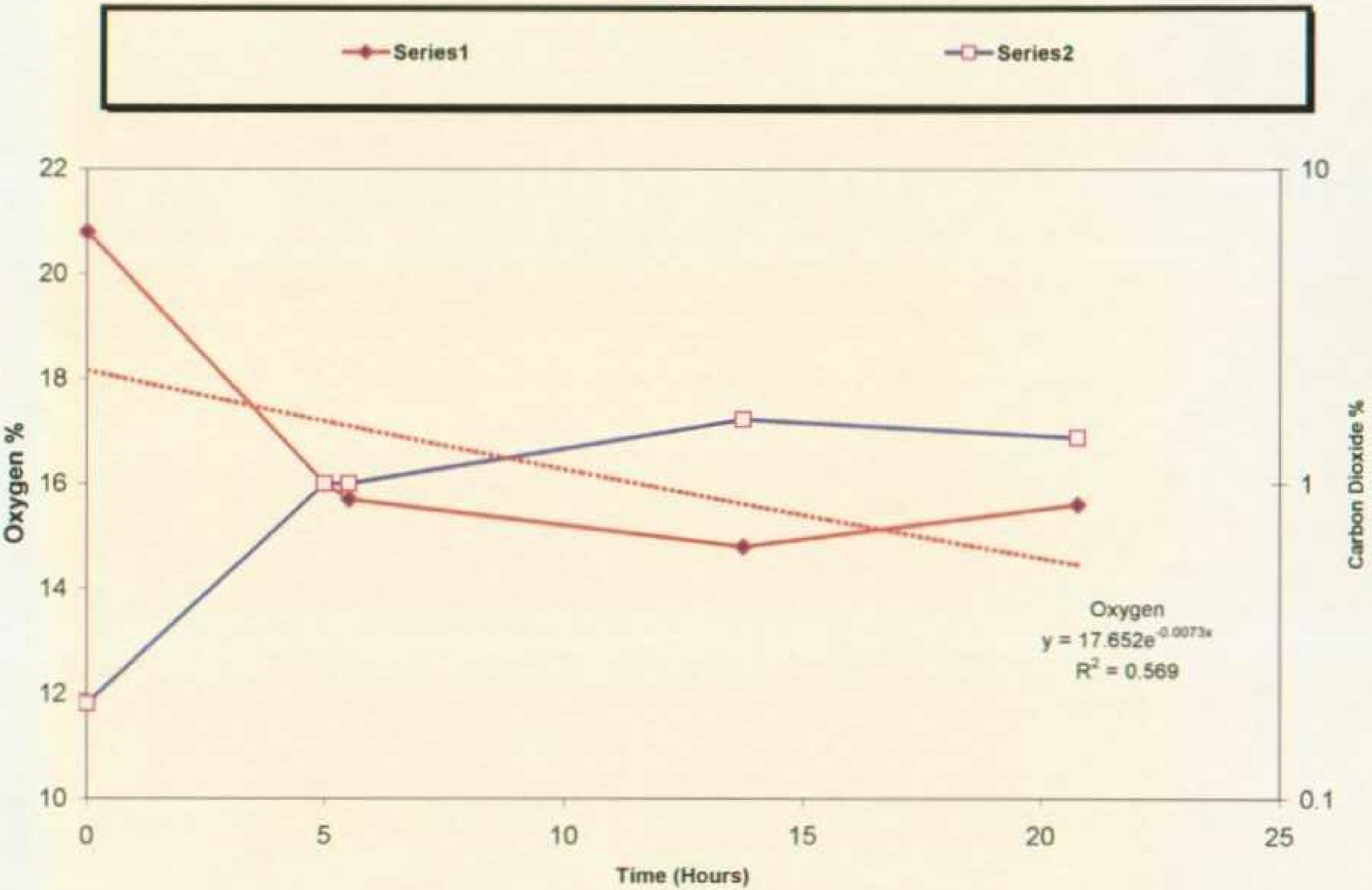


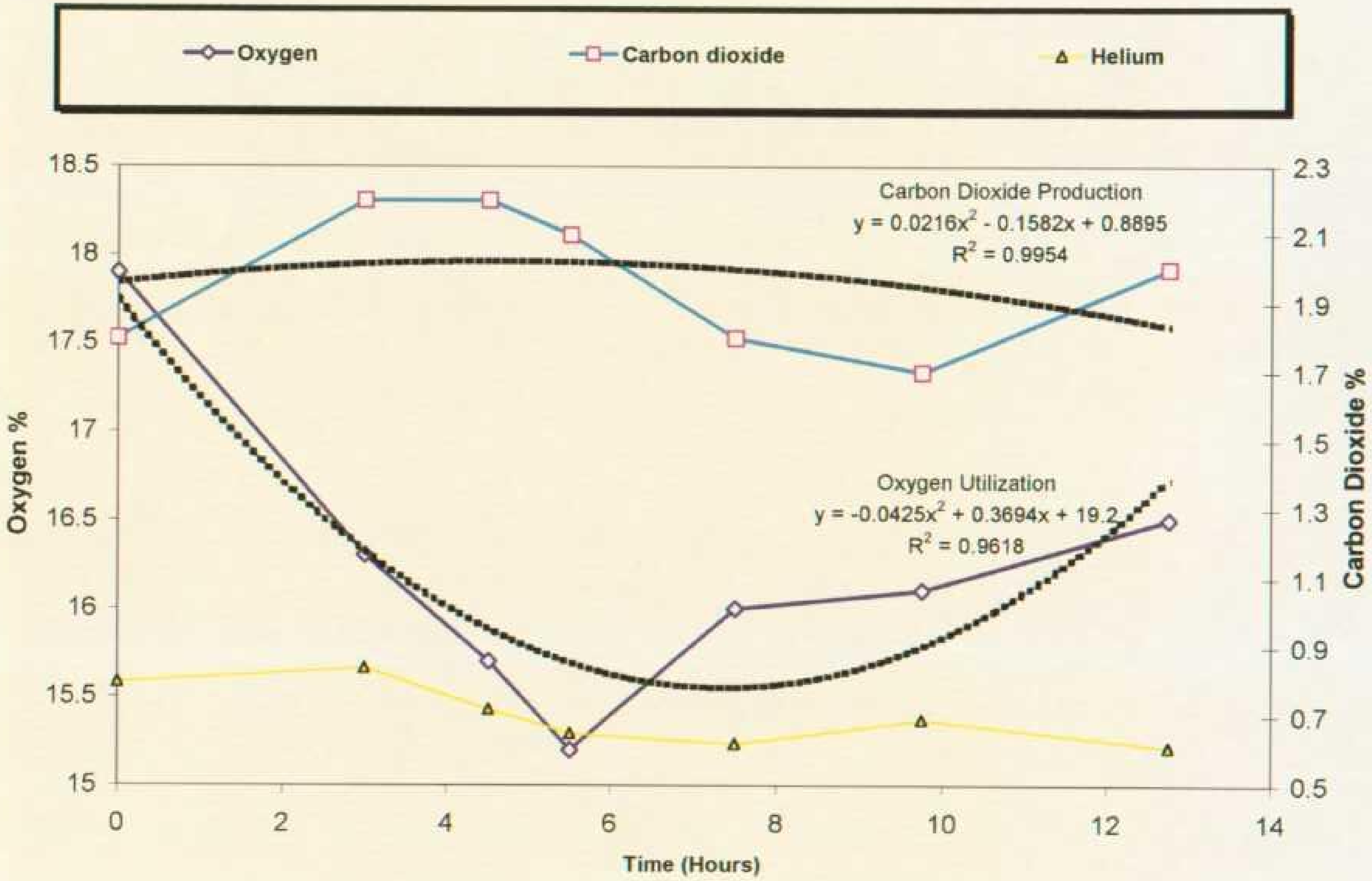
Client: Phillips Pipe Line Co
Site: Hobbs, NM

Pelorus EnBiotech Corporation

Project: SVE/Biovent Pilot Test
Date: October 19 - 25, 1999

Soil Gas Trends MP-1

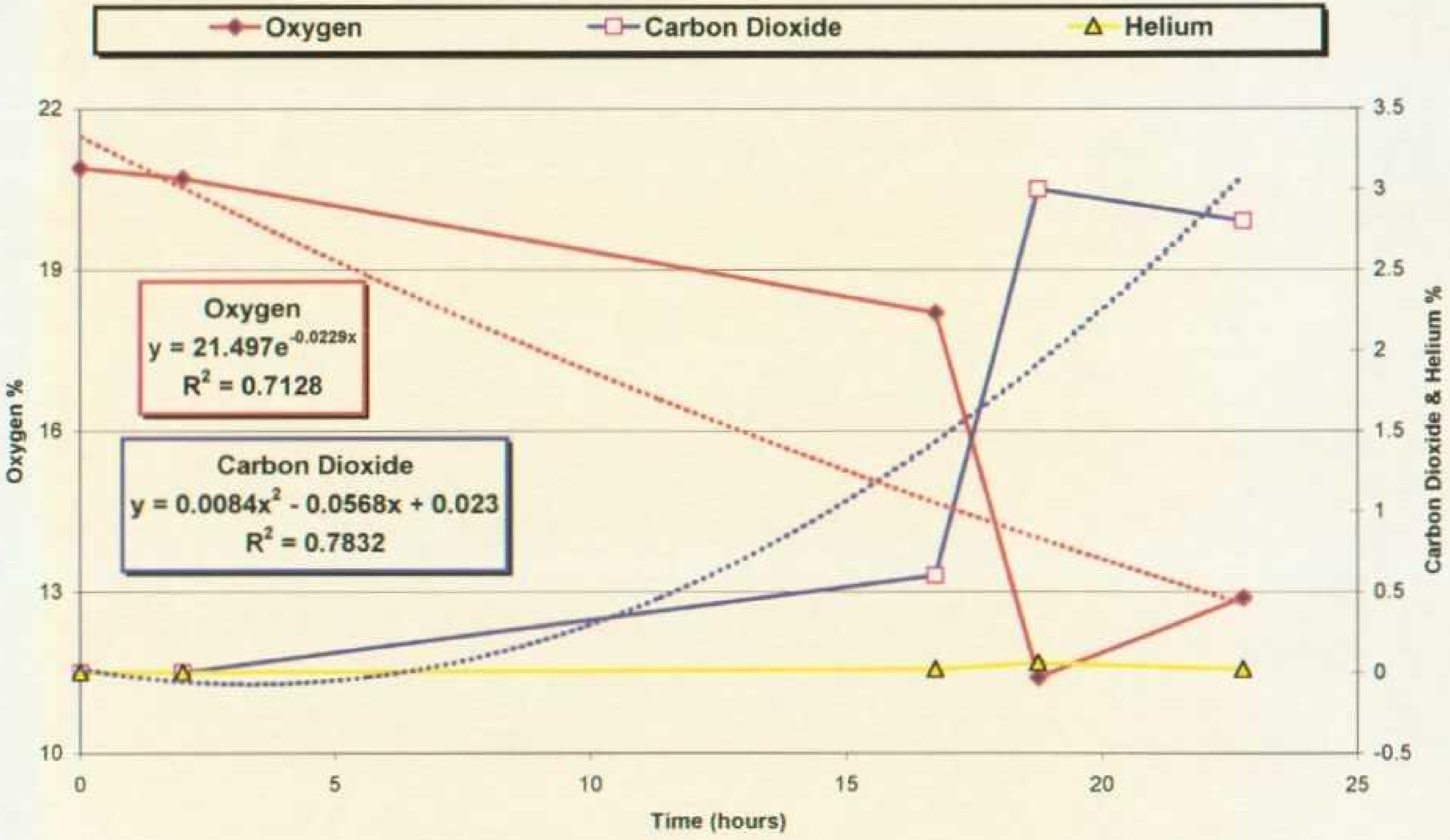



Oxygen
Carbon dioxide
Helium
Carbon Dioxide Production
y = 0.0216x^2 - 0.1582x + 0.8895
R^2 = 0.9954
Oxygen Utilization
y = -0.0425x^2 + 0.3694x + 19.2
R^2 = 0.9618
Oxygen %
18.5
18
17.5
17
16.5
16
15.5
15
Carbon Dioxide %
2.3
2.1
1.9
1.7
1.5
1.3
1.1
0.9
0.7
0.5
0
2
4
6
8
10
12
14
Time (Hours)

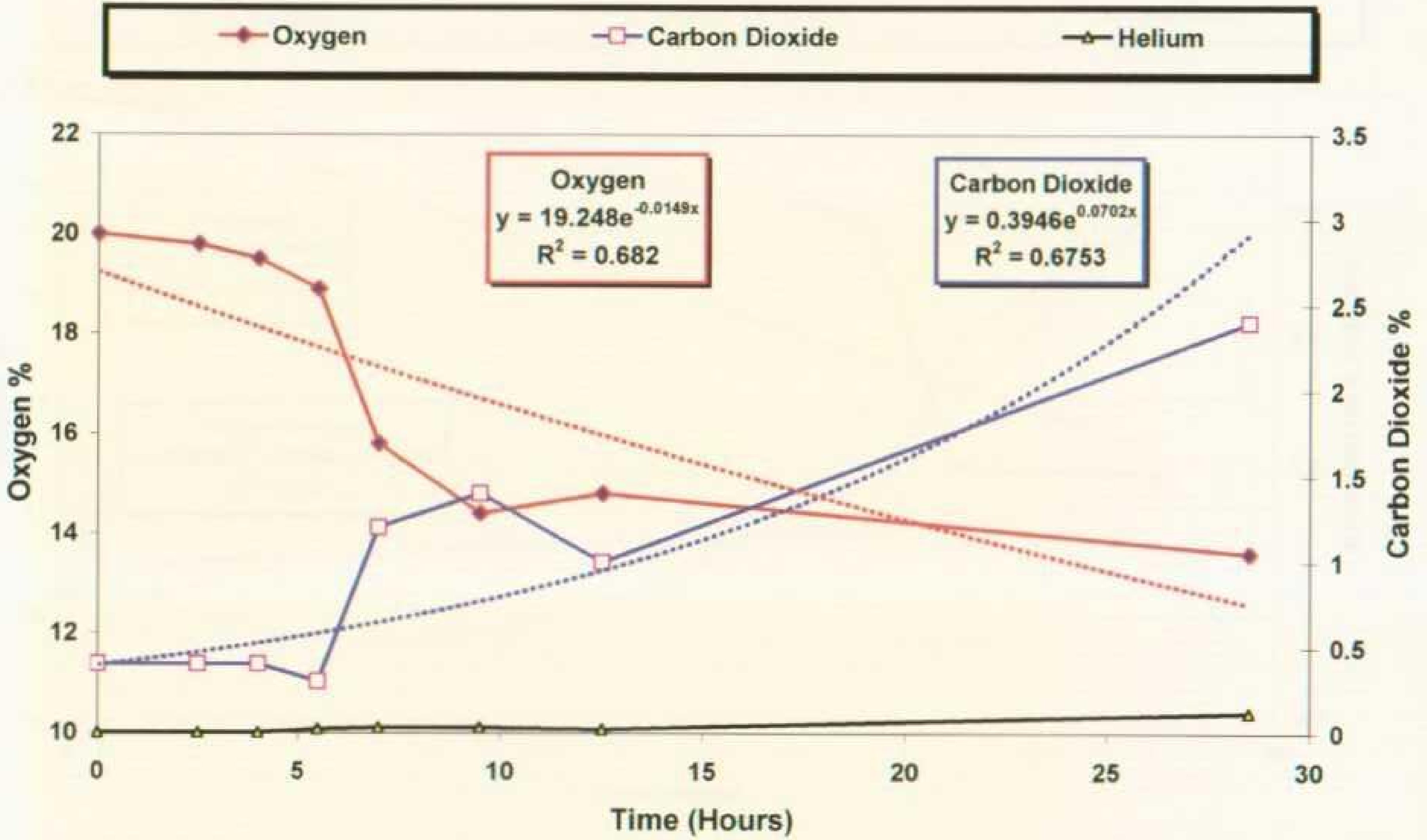
MP-1 Trend

SVE TEST RESULTS (SVE-1)

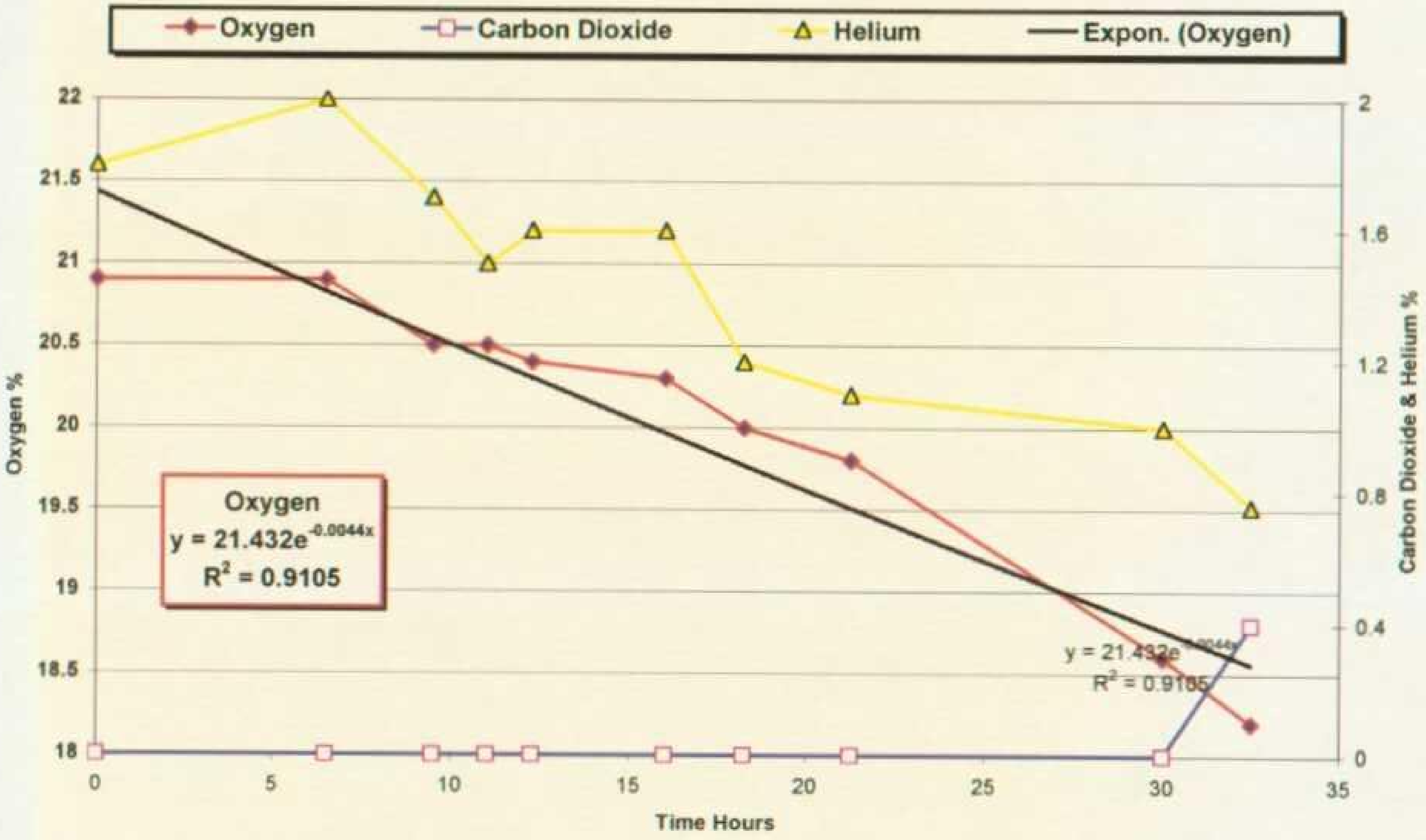
SVE TEST RESULTS (SVE-2)



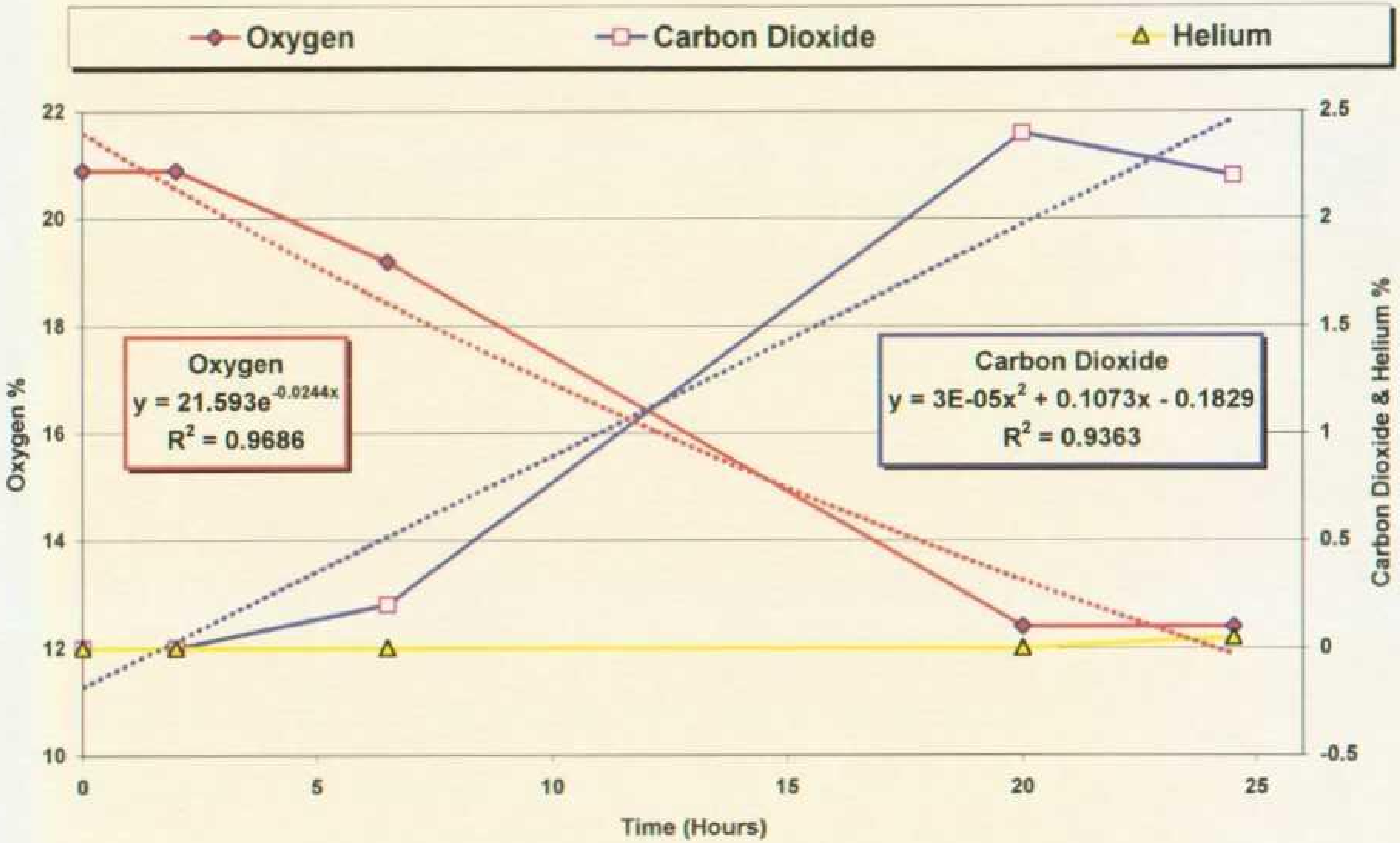
Soil Gas Trends SVE-2



Soil Gas Trends MP-2



SVE Test MW- 5


Oxygen
Carbon Dioxide
Helium
22
20
18
16
14
12
10
Oxygen %
2.5
2
1.5
1
0.5
0
-0.5
Carbon Dioxide & Helium %
0
5
10
15
20
25
Time (Hours)
Oxygen
y = 21.593e^-0.0244x
R^2 = 0.9686
Carbon Dioxide
y = 3E-05x^2 + 0.1073x - 0.1829
R^2 = 0.9363

Soil Gas Trends MW- 5