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REPORTS

DATE:

1994

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SITE CHARACTERIZATION AND FEASIBILITY TESTING

LEA STATION
LEA COUNTY, NEW MEXICO

CURA PROJECT NO. 15-93677.B3

SHELL PIPE LINE CORPORATION
TWO SHELL PLAZA
P.O. BOX 2099
HOUSTON, TEXAS 77252-2099

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CURA

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1.0 EXECUTIVE SUMMARY

CURA conducted additional site characterization and feasibility testing at the site, Lea Station, Lea County, New Mexico for the purpose of assessing site geologic and hydrogeologic conditions to determine potential remediation requirements. Previous activities had identified hydrocarbon impacted soils and groundwater on-site. This investigation included slug testing and soil vapor extraction (SVE) feasibility testing.

The soils penetrated by the existing monitor wells consist of fine-grained silty sands and calcareous sands, containing indurated caliche stringers. Depth to the water table ranges from 24 to 31 feet below ground surface. A hydraulic gradient of 0.01 was calculated for the site with groundwater movement toward the southeast.

A SVE feasibility test conducted on-site indicated that the effective radius of influence for vapor extraction well MW-8 is approximately 110 feet with an air flow rate of 13 standard cubic feet per minute (SCFM) per foot of available well screen. Analytical results of the air effluent indicate vapor phase hydrocarbons are present within the vadose zone. The effective radius of influence and flow rate indicate the air conductivity of the impacted soils is sufficient for vapor extraction.

Well development and slug test recovery data indicate the monitor wells have little or no sustainable well yield (estimated range from 0.1 to 0.5 gpm). Therefore CURA was not able to conduct a pumping test on site as originally intended.

Slug tests conducted on the on-site monitor wells recorded an average hydraulic conductivity of 8.5×10^{-4} centimeters per second (cm/s), typical of a silty fine-grained sand.

The existing monitor wells penetrate 10 feet of the saturated zone. Greater vertical penetration into the saturated interval is needed to evaluate well yields and delineate the vertical extent of the dissolved hydrocarbon plume. On-site water well data indicates that the installation of a downgradient monitor well to a depth of 60 feet should be sufficient to complete vertical delineation.

Characterization and feasibility test information obtained indicate that the impacted soils and groundwater near MW-8 in the western portion of the site and the area extending from MW-11 to MW-3 located in the northeastern portion of the site can be treated by a combination of active air venting/sparging with groundwater pumping to control plume migration. In addition, shallow hydrocarbon impacted soils identified in the eastern half of the site can be treated by in situ or ex-situ methods, namely bio-venting or landfarming.

2.0 INTRODUCTION

CURA was contracted by Shell Pipe Line Corporation to conduct site assessment activities for the purpose of assessing site hydrogeologic conditions at the Lea Station in Lea County, New Mexico. The investigation included performing five slug tests and a soil vapor extraction feasibility test on the hydrocarbon impacted zone.

Located in the Monument-Jal Oil Field, the site, Lea Station is utilized as a crude oil pipeline pumping station. Formerly operated by Shell Pipe Line Corporation, the site is presently operated by Enron (Appendix A, Figure 1).

2.1 SCOPE OF SERVICES

The following scope of services was conducted for the Site Characterization Study:

- Performed slug tests on five existing monitor wells to determine the hydraulic conductivity of the penetrated portion of the aquifer. The original scope of service called for a pumping test, however due to the insufficient well yields indicated during development testing, a pumping test was not feasible.

- Performed a SVE feasibility test to determine potential remediation options.

- Evaluated potential remedial methods based on characterization results.

- Summarized findings in the Site Characterization and Feasibility Testing Report.

2.2 BACKGROUND INFORMATION

Eleven monitor wells and 16 borings were installed by CURA during previous investigations from December 1992 to September 1993 to establish a baseline condition of the subsurface and to further delineate soil and groundwater hydrocarbon impact. Three primary issues were identified during the previous investigations, residual hydrocarbons in unsaturated soils above the water table, phase separated hydrocarbons (PSH) floating on top of the water table, and dissolved hydrocarbon constituents in the groundwater.

The previous investigations identified hydrocarbon-impacted soils in excess of New Mexico Oil Conservation Division (OCD) guidelines (>100 ppm TPH) in four separate areas of the site.

A1) Area south of Tank 1843 in the western portion of the site.
A2) Area centered on MW-11 in the northcentral portion of the site.
A3) Area extending from B-5 to MW-4 in the eastern portion of the site.
A4) Area extending from MW-2 to B-15 in the southeastern portion of the site.

The area containing the greatest hydrocarbon-impact is area A1. Hydrocarbon-impacted soils extend from the ground surface to a depth of 27 feet (depth to groundwater) and appear to be limited to an area approximately 250 by 400 feet with the greatest hydrocarbon concentration located southeast of Tank 1843. Approximately 2.84 feet of PSH was observed in MW-8. The PSH and dissolved hydrocarbon plume appear limited to the area between Tank 1843 and monitor wells MW-6 and MW-7.

Hydrocarbon-impacted soils and groundwater were identified in area A2 located south of an off-site tank battery. The hydrocarbon impacted soils were identified in MW-11 and extend from the ground surface to a depth of 31 feet (depth to groundwater). The horizontal extent of impacted soils and groundwater in area A2 has not been delineated.

Area A3 contains hydrocarbon-impacted soils in a two-foot thick interval above groundwater. The impacted soils extend from MW-2 approximately 200 feet to the southeast (B-15). The impact appears to be the result of PSH migration on the water table, however no PSH has been observed in the area monitor wells (MW-1, MW-2, or MW-10).

The depth of impact appears limited to soils above the water table in area A4. Results indicate the hydrocarbon-impacted soils are the result of a near surface crude oil release and/or releases where the hydrocarbon constituents were absorbed by the soils before downward migration reached groundwater.. Depth of impact in area A4 appears limited to 3 feet in a majority of the borings and extends to 12 feet near MW-4.

The previous investigations identified two dissolved hydrocarbon plumes containing detectable benzene concentrations. Results indicate a plume containing PSH extends southeast approximately 300 feet from Tank 1843 in the western portion of the site. The plume identified in MW-1, MW-11, MW-2, and MW-3, extends southeastward downgradient from MW-3 and MW-11 to MW-1 in the northern and eastern portions of the site.

Based on the previous findings, slug tests were performed on five monitor wells (MW-2, MW-3, MW-6, MW-9, and MW-11) to assess aquifer characteristics. In addition a SVE feasibility test was performed to evaluate site characteristics in the hydrocarbon-affected soils above the water table.

3.0 SUBSURFACE CONDITIONS

Previous subsurface investigations included soil and groundwater sampling during boring and monitor well operations performed by CURA. This investigation included monitor well slug tests and a SVE feasibility test.

3.1 SITE GEOLOGY

The site is located in Lea County, New Mexico, along the southwestern edge of the High Plains Region of New Mexico and Texas. The general trend of the local topography and surface drainage of the site area is to the southeast toward Monument Draw. The site surface sand and calcareous sands consist of Quaternary eolian and alluvial deposits overlying the tertiary-age Ogallala Formation.

The geology within the upper 40 feet beneath the site consists of 1 to 5 feet of brown to gray silty sand (SM) underlain by multi-colored slightly to strongly calcareous sand (caliche). Indurated calcareous zones (caliche) of varying thickness were encountered at depths ranging from 2.5 feet to 40 feet below ground surface across the entire site. The degree of induration of the caliche and the amount of calcite cement within the sands varied between borings and appears to be the primary influence on the permeability of the subsurface soils.

3.2 SITE HYDROLOGY

The saturated zone consists of fine-grained slightly to strongly calcareous sands containing indurated caliche stringers. Undifferentiated sands within the Quaternary deposits, and the Pliocene age Ogallala Formation form the major water bearing unit beneath the site area.

Drilling information from the abandoned on-site water well indicates a three foot thick water-bearing sand at a depth of 57 feet below ground surface is present beneath the site area. Gulf Refining Company drilled the water well (#L-2402) to a total depth of 60 feet below ground surface in January 1954 and produced water from the Ogallala/Quaternary Alluvium aquifer at 57 to 60 feet. Original depth-to-water was 40 feet upon completion. Depth-to-water measured 26 feet below ground surface in December 1992. The well is currently abandoned and open to a depth of 54 feet. During development prior to sampling in December 1992, a pumping rate of approximately 6 gpm for approximately 18 minutes created less than 1 foot of drawdown in the well, indicating that the 57 to 60 foot sand is significantly more permeable than the overlying portion of the aquifer. Analytical results indicate the sand contains little or no dissolved BTEX concentrations.

Depth to groundwater in the site area ranges from 24 to 31 feet below ground surface. PSH was observed in MW-8 during gauging operations, with the thickness increasing from 0.004 inches on September 28, 1993 to 2.84 feet on January 4, 1994. A hydraulic gradient of 0.01 was calculated for the site based on the groundwater gradient map (Appendix A, Figure 3). Groundwater data including well elevation, depth to water, and groundwater elevation based upon an arbitrary survey point datum of 100.00 feet are presented in Table 1.

TABLE 1
SUMMARY OF RELATIVE GROUNDWATER LEVEL ELEVATIONS AND PHASE-SEPARATED HYDROCARBON THICKNESSES

Monitor Well	Date Sampled	Relative Ground Surface Elevation (feet)	Relative Top of Casing Elevation (feet)*	Depth to Water Below Top of Casing (feet)	Corrected Relative Groundwater Elevation (feet)**	Phase-Separated Hydrocarbon Thickness (feet)
MW-1	12/21/92	98.88	100.73	28.32	72.41	0.00
	02/16/93	98.88	100.73	28.48	72.25	0.00
	09/28/93	98.88	100.73	29.18	71.55	0.00
MW-2	02/16/92	100.78	102.37	29.33	73.04	0.00
	09/28/93	100.78	102.37	30.23	72.14	0.00
MW-3	02/16/93	101.79	103.61	29.23	73.38	0.00
	09/28/93	101.79	103.61	30.04	73.57	0.00
MW-4	02/16/93	93.80	96.08	25.44	70.64	0.00
	09/28/93	93.80	96.08	26.12	69.96	0.00
MW-5	02/16/93	107.08	109.21	29.86	78.35	0.00
	09/28/93	107.08	109.21	30.42	79.35	0.00
MW-6	02/16/93	103.66	106.26	28.60	77.66	0.00
	09/28/93	103.66	106.26	29.96	76.30	0.00
MW-7	02/16/93	104.34	106.27	29.24	77.03	0.00
	09/28/93	104.34	106.27	30.65	75.62	0.00
MW-8	09/28/93	105.52	107.44	32.81	76.63	0.04
MW-9	09/28/93	93.76	97.21	28.60	68.61	0.00
MW-10	09/28/93	99.63	102.51	34.11	68.40	0.00
MW-11	09/28/93	104.48	105.62	31.38	74.24	0.00

* Measured from a relative datum (benchmark = 100.00 feet). The monitor well casings were marked to provide consistent reference points for future gauging operations.
** Correction Equation for Phase-Separated Hydrocarbons: Corrected Groundwater Elevation =
Top of Casing Elevation - (Depth to Water Below Top of Casing - [SG] [PSH Thickness])
Specific Gravity (SG) = 0.9 for crude oil.

3.3 SOIL ANALYTICAL RESULTS

A review of the analytical results from previous subsurface investigations, conducted in December 1992, March 1993, and October 1993, indicated hydrocarbon-affected soils in excess of the OCD guidelines (>100 ppm TPH) were limited to four general areas of the site.

A1) Area south of Tank 1843 in the western portion of the site.
A2) Area centered on MW-11 in the northcentral portion of the site.
A3) Area extending from B-5 to MW-4 in the eastern portion of the site.
A4) Area extending from MW-2 to B-15 in the southeastern portion of the site.

Hydrocarbon-impacted soils in the western portion of the site (area A1) ranged in depth from approximately 3 feet in boring B-3 to 27 feet (depth to groundwater) in B-8, B-11, and MW-5. Based on the data obtained, the extent of hydrocarbon-impacted soils in the western portion of the site is limited to an area approximately 250 feet by 400 feet with the greatest hydrocarbon concentration adjacent to boring B-11, MW-5, and MW-8.

Monitor well MW-11 identified hydrocarbon-impacted soils in the northcentral portion of the site (area A2) from a depth of approximately 10 feet to top of groundwater at 31 feet. However, no phase separated hydrocarbons (PSH) was observed in MW-11 during drilling operations.

Hydrocarbon-impacted soils in the eastern portion of the site (area A3) ranged from a depth of 3 feet in a majority of the borings to 12 feet in monitor well MW-4. The extent of hydrocarbon-impacted soils identified in the eastern portion of the site consists of a 3 foot deep area extending approximately 400 feet by 200 feet. However, hydrocarbon-impacted soils extend to a depth of 12 feet near boring MW-4.

An area containing hydrocarbon-impacted soils in the two foot interval above groundwater was identified in borings B-15 and MW-2. The area (area A4) is approximately 50 feet wide and extends approximately 200 feet downgradient (southeast) of the sump and pumps in the eastern portion of the site.

3.4 GROUNDWATER ANALYTICAL RESULTS

Hydrocarbon-impacted groundwater was previously identified in two areas of the site. A dissolved hydrocarbon plume identified in MW-1, MW-2, and MW-3, located in the northeast portion of the site and a plume containing PSH located in the western portion of the site.

The monitor wells were gauged on September 28, 1993 to determine the presence of PSH, groundwater elevation and gradient. Depth to groundwater on site ranged from 24 feet to 31 feet below ground surface with the apparent groundwater gradient toward the southeast. No PSH was observed in the monitor wells with the exception of 0.04 inches recorded in MW-8. Monitor well MW-8 is located approximately 200 feet downgradient (southeast) from Tank No. 1843. Approximately 2.84 feet of PSH was measured in MW-8 during slug test operations on January 12, 1994 subsequent to SVE testing. The western and southern extent of the PSH identified in MW-8 is limited to a radius of less than 300 feet from Tank No. 1843 based on field observations and analytical data from borings B-14, MW-6, and MW-7.

On September 30, 1993, groundwater samples obtained from monitor wells MW-9, MW-10, and MW-11 recorded benzene and total dissolved BTEX levels ranging from less than the method detection limit of 0.001 ppm in MW-9 to 0.24 and 0.63 ppm, respectively, in MW-11. Monitor well MW-8 was not sampled due to the presence of PSH. Based on the southeasterly groundwater gradient and water analytical results, off-site impact is not probable.

Possible source areas for the PSH in MW-8 include Tank 1843 and the associated piping. Possible source areas for the elevated hydrocarbon levels in MW-11 and MW-3 include subsurface crude pipelines and the off-site tank batteries north of the site.

A dissolved hydrocarbon concentration map is presented in Appendix A (Figure 2) and depicts the distribution of groundwater BTEX and TPH concentrations. The water analytical results are summarized in Table 2.

TABLE 2
WATER SAMPLE ANALYTICAL RESULTS

Monitor Well	Date Sampled	Benzene	Toluene	Ethyl-benzene	Xylenes	Total BTEX	TPH	TDS
MW-1	12/21/92	0.440	0.005	0.120	0.063	0.628	3	2,380
	02/16/93	0.350	0.010	0.095	0.070	0.525	5	--
MW-2	02/16/93	0.370	0.040	0.210	0.510	1.130	1	--
MW-3	02/16/93	2.500	0.010	0.370	0.640	3.520	2	--
MW-4	02/16/93	<0.001	<0.001	<0.001	<0.001	<0.001	<1	--
MW-5	02/16/93	<0.001	<0.001	0.002	0.004	0.006	<1	--
MW-6	02/16/93	0.002	0.001	<0.001	0.091	0.094	<1	2,500
MW-7	02/16/93	<0.001	<0.001	<0.001	<0.001	<0.001	<1	--
MW-8	09/30/93	PSH	PSH	PSH	PSH	PSH	PSH	PSH
MW-9	09/30/93	<0.001	<0.001	<0.001	<0.001	<0.001	<1	2,130
MW-10	09/30/93	<0.001	<0.001	0.009	0.001	0.010	7	--
MW-11	09/30/93	0.24	0.14	0.11	0.14	0.63	3	--
WW-1	12/08/92	<0.001	<0.001	<0.001	<0.001	<0.001	5	1,800

BTEX results listed in m/l (parts per million; ppm) with a method detection limit of 0.001 ppm.
TPH and DO results listed in mg/l (parts per million; ppm) with a method detection limit of 1 ppm.
Analyses were conducted using EPA Method 8020 (BTEX), EPA Method 418.1 (TPH), and EPA Method 160.1 (TDS) by SPL Environmental Laboratories and CEL Laboratories.

4.0 SOIL VENTING EVALUATION

CURA performed SVE testing to determine the feasibility of using venting technology to enhance the rate of volatilization and bio-degradation of the hydrocarbon-affected soils in the vadose zone.

4.1 SOIL VAPOR EXTRACTION TEST

On December 21 and 22, 1993, CURA performed a SVE feasibility test on site to determine the representative air flow rates and effective radius of influence for the site. Area A1 was selected for feasibility testing due to the extent of hydrocarbon impact.

Monitor well MW-8 was used as the SVE extraction well and is screened from the bottom of the well at 38 feet to 23 feet below ground surface. The static water level ranged from 27.7 to 31.7 feet below ground surface in the extraction well and monitoring points. Monitor wells MW-6 and MW-7, located 180 feet south and 195 feet southeast of MW-8, respectively, were used as monitor points during the test.

The installation of three additional monitor points was attempted to provide a more effective site characterization. Aluminum vacuum probes were chosen for the additional monitoring points based on the low cost of installation. The vacuum points were to be set at 10 feet, 20 feet, and 30 feet from the extraction well and 15 feet below surface grade. The installation of three additional monitor points was attempted to provide a more effective site characterization. During installation operations indurated caliche was encountered at depths ranging from 2.5 to 4 feet below ground surface. The monitor points could not be driven through the caliche layer. Monitor point

MP-1, located 32 feet northwest of MW-8 at a depth of 4 feet; MP-2, located 30 feet east of MW-8 at a depth of 2.5 feet; and MP-3, located 46 feet northwest of MW-8 at a depth of 3 feet were used as monitor points.

One 5 hp Rotron regenerative blower was connected to the designated extraction well (MW-8) using 2-inch flex piping and a 4-inch locking well seal. A Dwyer magnahelic vacuum gauge was connected to the inlet of the blower to measure the vacuum. In addition, magnahelic gauges were connected to the surrounding monitor points. The magnahelic gauges determined the vacuum induced at each monitor point. The manufactures performance specification chart was used to calculate the extraction flow rates.

When the blower was initially started, ambient air was bled into the system to produce the desired vacuum pressure and flow rate. Once the desired flow had been achieved in the extraction well, the feasibility test was initiated, and periodic readings from magnahelic gauges were obtained. The blower was allowed to run until the periodic measurements from each magnahelic gauge indicated that the system had reached equilibrium (16 hours).

A vacuum pressure of 73 inches of water was developed at the MW-8. Pressure changes were observed at monitor points MW-6, MW-7, and MP-2. No response was observed in monitor points MP-1, and MP-3. A summary of this data is presented in Table 3.

TABLE 3 SOIL VAPOR EXTRACTION FEASIBILITY TEST FIELD DATA Soil Vapor Extraction Feasibility Test Conducted December 21 and 22, 1993			
Monitor Point	**Screened Interval of Monitor Point (feet)**	**Distance From Extraction Well MW-8 (feet)**	**Equilibrium Pressure (inches of water) Vacuum @ MW-3: 72 inches of water**
MW-6	20 - 30	180	0.15
MW-7	20 - 31	195	0.03
MW-8	23 - 33	0	73
MP-1	4	32	0.00
MP-2	2.5	30	0.20
MP-3	3	46	0.00

4.2 PILOT TEST DATA REDUCTION

The data recorded during the test were used to determine an effective radius of influence (area within the radius of vacuum influence that promotes sufficient air flow through the soils to effectively remediate the soils in a reasonable period of time). The effective radius was calculated by plotting the normalized vacuum pressure versus the radial distance on semi-log graph paper and plotting a best fit straight line using a linear regression technique. The effective radius was then interpolated using 1% of the operating vacuum pressure. The plots are included in Appendix C.

The volume of air flow through the soils was determined at equilibrium vacuum pressure conditions. The air flow was calculated in SCFM using the blower performance curve.

The effective radius of influence for the soil vapor extraction trial was 110 feet. The air flow rate through the soils during the test was approximately 130 SCFM for MW-8. The flow rate and radius of influence indicate the air conductivity of the impacted soils is sufficient to promote an efficient recovery of vapor phase hydrocarbons in the unsaturated zone.

4.3 AIR EMISSIONS

During the SVE test, an air sample was obtained to assess the composition and concentration of the vapor phase hydrocarbon constituents. The laboratory analyses is presented in Table 4.

Due to deflation of the two sample containers during overnite-air shipment, analysis of BTEX concentrations could not be performed. The TPH concentration indicates volatile hydrocarbon vapors were being recovered during the SVE test.

TABLE 4
SUMMARY OF AIR SAMPLE ANALYTICAL RESULTS

Sample ID	Date	Benzene	Toluene	Ethyl-benzene	Xylenes	Total BTEX	TPH
SVE-EFF	06-03-93	--	--	--	--	--	1,780

BTEX and TPH results in mg/l parts per million (ppm).
Analyses were conducted using EPA Method 8020 (BTEX) and EPA Method 418.1 (TPH) by GTEL Laboratories and CEL.

AIR SAMPLE (mol %) in PPM (mg/l)

TPH - 1,780 ppm

$$\left[\frac{28.3137\ \ell}{cu.ft}\right] x \left[\frac{**78\ gram}{mole}\right] x \left[\frac{1x10^{-3}\ mg}{gram}\right] = 92.74x10^{-3} \frac{mg}{cu.ft.}$$

$$TPH\ 1{,}780\ (ppm)\ x \left[\frac{92.74x10^{-3}\ mg}{cu.ft.}\right] x \left[\frac{2.204x10^{-3}\ lb}{gram}\right] x$$

$$\left[\frac{1x10^{-3}\ gram}{mg}\right] x \left[\frac{130\ cu.ft.}{min.}\right] x \left[\frac{60\ min.}{hr.}\right] = 2.63\ \frac{lb.}{hr.}$$

*@ 60°F

** AVE Molecular Weight of TPH

*** Actual Air Flow Rate

5.0 BIOTREATABILITY CHARACTERISTICS

In order to evaluate the potential of in-situ bioremediation as a treatment alternative, primarily in area A1 and area A2, the collection of soil samples to be utilized in biotreatability evaluation was attempted. Due to the shallow indurated caliche zone present at a depth ranging from 2 to 4.5 feet below ground surface, no biotreatability samples were obtained. Biotreatability screening is used to determine the presence of absence of constituents in the soils necessary for successful bioremediation.

The analytical results from the previously sampled intervals of the borings indicate that the hydrocarbon impacted soils in the vadose zone contain moderate TPH concentrations ranging from 2,700 ppm to 14,000 ppm.

Results of biotreatability analysis on sites containing similar soils and hydrocarbon concentrations indicate that the indigenous bacteria population, oxygen, nutrients, and moisture content are generally below optimum concentrations for hydrocarbon degradation. Research indicates that these conditions are typical for soils containing elevated TPH concentrations and the microbial biodegradation levels can be significantly increased through the addition of oxygen. The addition of oxygen by injection of air into the subsurface should enhance the remediation efforts, however the addition of nutrients, and moisture may be required to enhance hydrocarbon degradation by indigenous bacteria.

6.0 GROUNDWATER EXTRACTION EVALUATION

Five on-site monitor wells (MW-2, MW-3, MW-6, MW-9, and MW-11) were selected for slug testing to determine aquifer characteristics (permeability). Test procedures, data, and analyses are described in Appendix C. The calcareous sands in the upper portion of the aquifer were found to have a variable hydraulic conductivity, typically averaging 18 gpd/ft^2 (8.5 X 10^{-4}).

The impacted soils in areas A1 and A2 and possibly the off-site tank batteries north of MW-11 appear to be the source of dissolved hydrocarbon impact. The degree of groundwater impact is primarily controlled by the ability of water to leach soluble hydrocarbon constituents from the soils through percolation and groundwater flow in the upper portion of the aquifer. In order to estimate aquifer characteristics in the upper portion of the aquifer, the total amount of groundwater flow in the upper 10 feet of the aquifer (interval screened in site monitor wells) was estimated using Darcy's Law:

$$Q = kiA$$

Where:

Q = Aquifer flow (gpd)

k - Hydraulic conductivity (gpd/ft^2)

i = Hydraulic gradient on water table

A = Crossectional area of flow (w x b)

b = Thickness of flow zone

w = Width of flow zone (feet)

Using the measured hydraulic gradient of 0.01, the average saturated thickness penetrated by the monitor wells of 10 feet, and an estimated maximum hydrocarbon-affected plume width of 800 feet (northeast portion of the site), the total hydrocarbon-affected groundwater flow identified by MW-11 and MW-3 is estimated to be 1,440 gpd for January 1994. Using an estimated maximum plume width of 260 feet (area A1) the total hydrocarbon-affected groundwater flow in the western portion of the site is estimated to be 470 gpd.

Based on well development and slug test recovery data the estimated long term well yield from the monitor wells on site is estimated to be below 1 gpm. Assuming a long term yield ranging from 0.1 gpm to 0.5 gpm, the wells would each have a capture zone width between 80 to 400 feet.

The low well yields and moderate hydraulic conductivity values of the monitor wells appear to be the result of two factors:

1) Heterogeneous nature of the aquifer; primarily caused by calcareous cementation.
2) Significantly higher horizontal versus vertical permeability.

7.0 CONCLUSIONS

- Data obtained during SVE testing from area A1 in the western portion of the site indicates that the calculated radius of influence and air flow rate from vapor extraction well MW-8 are feasible for consideration of soil venting to recover volatile hydrocarbons. In addition, soil bio-venting (air injection) is feasible to increase microbial degradation of the residual hydrocarbons upon confirmation of microbial presence in the soils at depth.

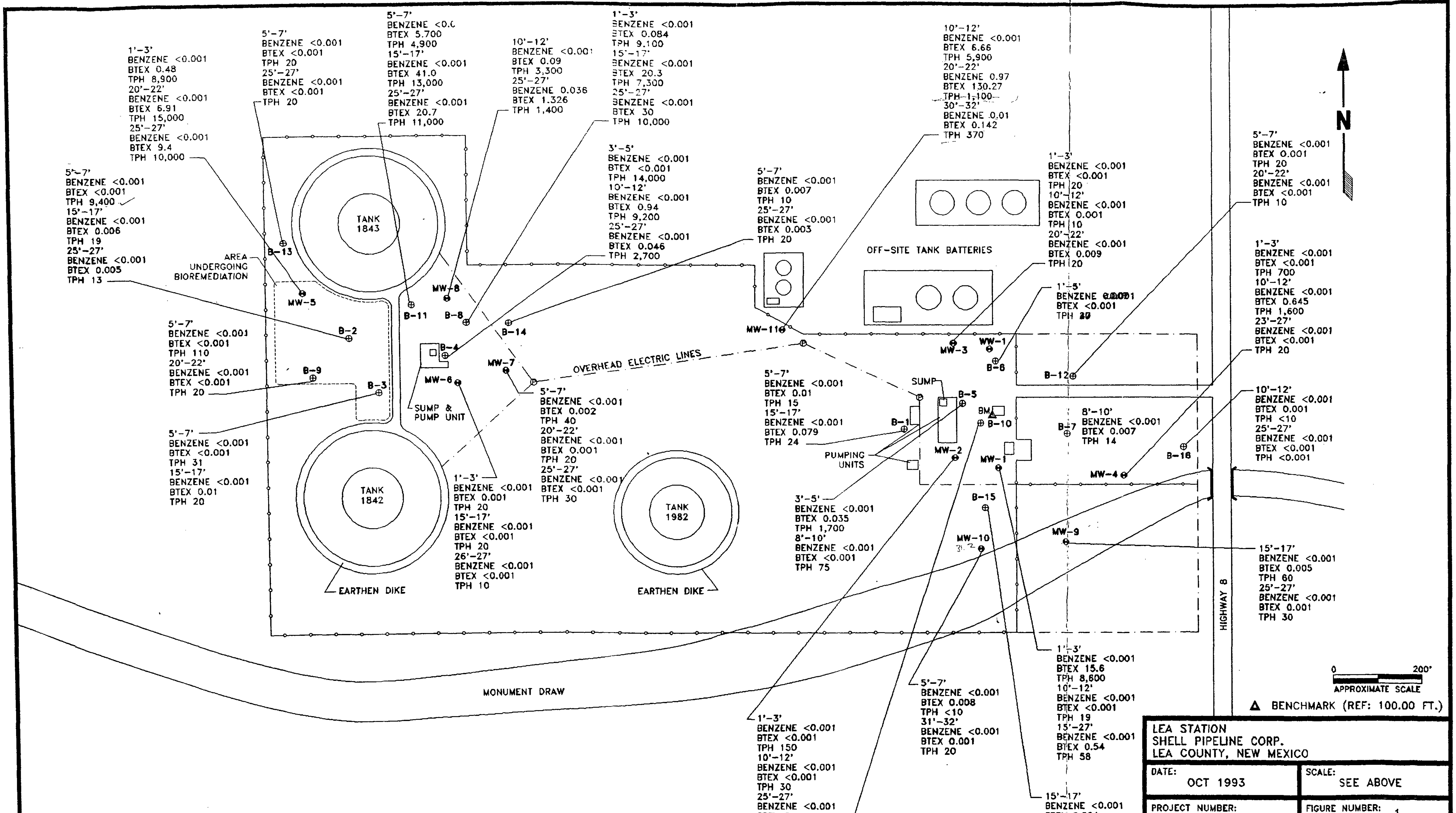
- Soil vapor extraction testing data indicated that the hydrocarbon impacted soils in area A1 and adjacent to MW-11 in the northern portion of the site (area A2) could be treated using a combination of vapor extraction and bio-venting. Due to the shallow depth of impact identified in the eastern half of the site (area A4) ex-situ bioremediation may be applicable as an alternative to an in-situ system.

- Information obtained indicates greater additional saturated zone thickness is needed to obtain sufficient well yields for groundwater recovery and migration control. This would require the installation of monitor well(s) to depths approaching sixty feet (depth of highly permeable sand in WW-1).

- The heterogeneous nature and low well yield exhibited in the upper portion of the aquifer indicate groundwater remediation alternatives are limited. Hydraulic conductivity values form the slug tests indicate air sparging into the saturated zone is one feasible method for treatment of volatile hydrocarbons in the groundwater.

8.0 APPENDICES

APPENDIX A
FIGURES



SOIL HYDROCARBON CONCENTRATION MAP

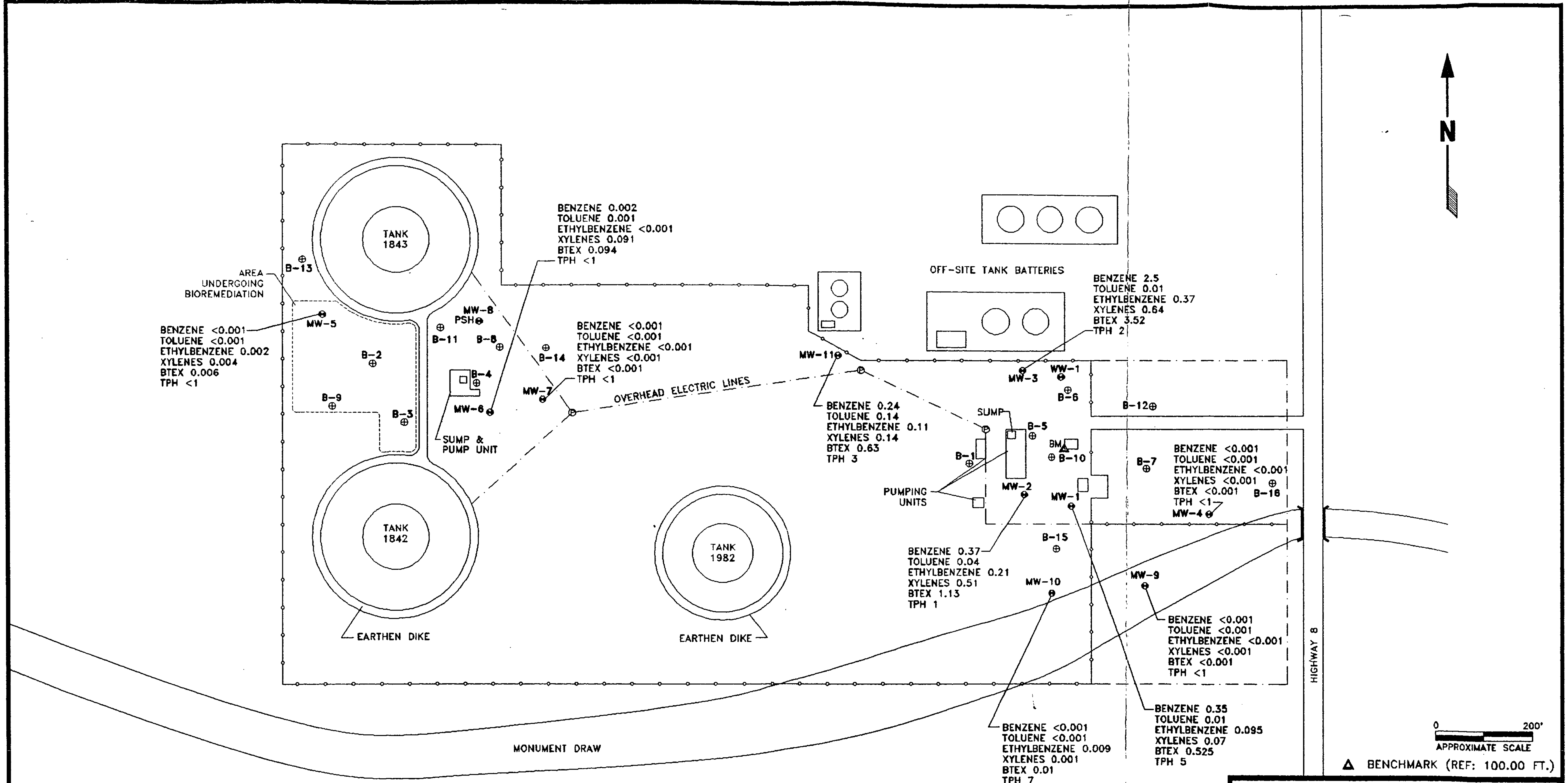
BTEX AND TPH CONCENTRATIONS IN mg/kg (ppm)

LEA STATION
SHELL PIPELINE CORP.
LEA COUNTY, NEW MEXICO

DATE: OCT 1993	SCALE: SEE ABOVE
PROJECT NUMBER: 15-93677	FIGURE NUMBER: 1

CURA INC.

2735 VILLA CREEK DRIVE - TWO METRO SQUARE
BLDG. C - SUITE 250 - DALLAS, TX 75234
620-7117 FAX - 620-8219



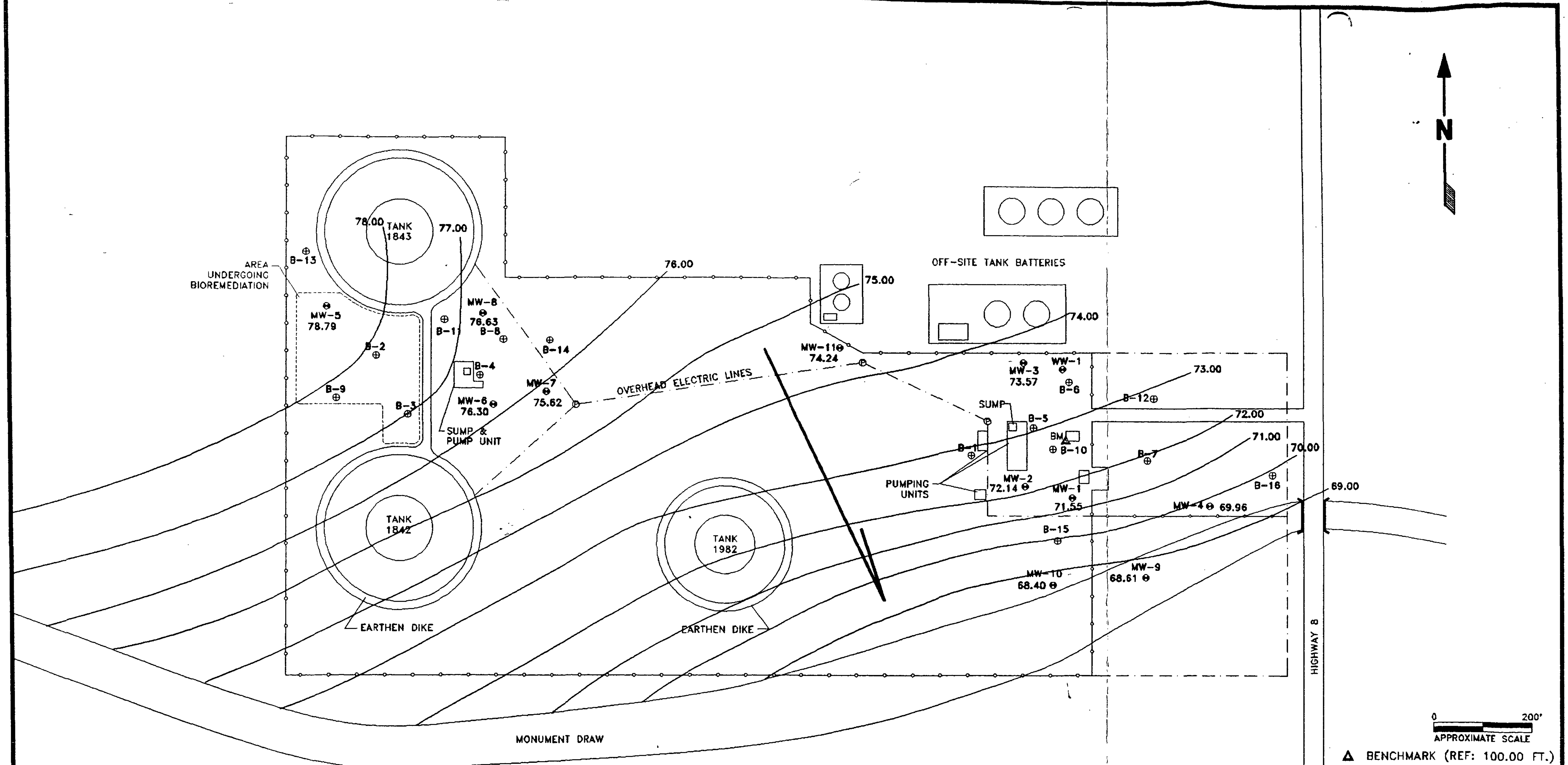
LEA STATION
SHELL PIPELINE CORP.
LEA COUNTY, NEW MEXICO

DATE: OCT 1993	SCALE: SEE ABOVE
PROJECT NUMBER: 15-93677	FIGURE NUMBER: 2

DISSOLVED HYDROCARBON MAP

RED NUMBERS INDICATE HYDROCARBON CONCENTRATIONS IN mg/l (ppm)
MW-1 THROUGH MW-7 SAMPLED ON 02/16/93
MW-8 THROUGH MW-11 SAMPLED ON 09/28/93

CURA INC.
2735 VILLA CREEK DRIVE - TWO METRO SQUARE
BLDG. C - SUITE 250 - DALLAS, TX 75234
620-7117 FAX - 620-8219



GROUNDWATER GRADIENT MAP

-WATER LEVELS OBTAINED 09/28/93
-CONTOUR INTERVAL = 1.00 FEET

LEA STATION SHELL PIPELINE CORP. LEA COUNTY, NEW MEXICO	
DATE: OCT 1993	SCALE: SEE ABOVE
PROJECT NUMBER: 15-93677	FIGURE NUMBER: 3

CURA INC.
2735 VILLA CREEK DRIVE - TWO METRO SQUARE
BLDG. C - SUITE 250 - DALLAS, TX 75234
620-7117 FAX - 620-8219

APPENDIX B
AQUIFER CHARACTERIZATION

B. AQUIFER CHARACTERIZATION

CURA performed aquifer testing on-site to determine permeability (hydraulic conductivity), transmissivity, well yield, and aquifer flow and drawdown. This information is needed to characterize the hydrogeologic conditions of the site and to develop an appropriate remedial action plan.

B.1 WELL DEVELOPMENT TEST

Well development information obtained during gauging and sampling operations on September 28, 1993, demonstrated that a pump test utilizing the existing monitor wells was not feasible since a bailing rate greater than 1 gallon per minute (gpm) could not be sustained without bailing the wellbore dry. During the well development operations, a bailing rate of approximately 1 gpm bailed the monitor wells dry after approximately 20 minutes. Calculated drawdown during the development operations was approximately 5 to 12 feet.

B.2 SLUG TESTS

Because of the expected lower permeability and yield of the upper 15 feet of the aquifer (calcareous silty fine-grained sands), a pumping test utilizing the shallow wells was not feasible. Therefore, slug tests were conducted on January 12, 1994, using MW-2, MW-3, MW-6, MW-9, and MW-11, to determine the hydraulic conductivity of the zone.

The tests involved removing a slug (3.5-inch diameter by 3 feet long) from the monitor wells and recording the water level recovery rates utilizing a pressure transducer and data logger. The data was analyzed using the Bouwer and Rice method.

Based on the results of the slug test analysis, the hydraulic conductivities ranged from 10 gallons per day per square-foot (gpd/ft^2) in MW-9 to 29 gpd/ft^2 in MW-2 with an average hydraulic conductivity of 18 gpd/ft^2.

The calculated hydraulic conductivities are typical of a silty fine-grained sand. A summary of the slug test results is presented in Table B1. A listing of slug test data and the plotted relationships are included in Appendix B. Based on the hydrologic parameters determined for the site the existing monitor wells are not capable of capturing the dissolved hydrocarbon plume for potential groundwater remediation operations.

TABLE B1
SUMMARY OF SLUG TEST RESULTS
Based On Slug Test Conducted on January 12, 1994

Well	Hydraulic Conductivity (gpd/ft^2)	Hydraulic Conductivity (cm/sec)	Saturated Thickness (feet)*
MW-2	29	1.4×10^{-3}	9.1
MW-3	12	5.7×10^{-4}	11
MW-6	24	1.1×10^{-3}	12
MW-9	10	4.7×10^{-4}	11
MW-11	14	6.6×10^{-4}	8.5
Average	**18**	**8.5×10^{-4}**	**10**

Hydrologic parameters have been rounded to two significant figures.
* Saturated thickness of aquifer (screened interval) penetrated by monitor wells.

SLUG TEST RESULTS

:OJECT NAME: LEA STATION
:OJECT NUMBER: 15-9367700B.3
.TE: JANUARY 12, 1994

SLUG TEST DATA (RISING HEAD - SLUG OUT)

TIME minutes)	MW-2	MW-3	MW-6	MW-9	MW-11
0	2.04	2.97	2.26	2.27	2.46
3	1.94	1.86	1.82	1.8	1.94
5	1.85	1.62	1.62	1.6	1.84
7	1.77	1.41	1.46	1.47	1.74
10	1.67	1.15	1.31	1.35	1.65
15	1.5	0.95	1.21	1.28	1.58
20	1.38	0.9	1.15	1.23	1.53
25	1.31	0.87	1.1	1.21	1.49
30	1.27	0.85	1.07	1.18	1.47
35	1.23	0.84	1.03	1.15	1.44

LEA STATION Rising Head (Slug out) Results

WELL CONSTRUCTION DATA MW-2 RUN NUMBER: 1

GREATEST PULSE: 1.48

WELL LABEL: MW-2
STATIC WATER_LEVEL DEPTH FROM GROUND SURFACE (FEET): 30.91
TOTAL DEPTH OF WELL OR SAND PACK FROM GROUND SURFACE (FEET): 40
LENGTH OF SCREEN OR SAND PACK (FEET): 9.100001
WELL/BOREHOLE DIAMETER (INCHES): 8
SLUG DIAMETER (INCHES): 3
LENGTH OF SLUG (FEET): 3
CASING DIAMETER (INCHES): 4
DEPTH TO LOWER IMPERMEABLE LAYER FROM GROUND SURFACE (FEET): 40
L/RW RATIO : 27.3
C COEFFICIENT: 1.8

TIME (SECONDS)	PULSE LEVEL	T GPD/FT (FEET)	K GPD/FT2
15.00	1.21	301.99	33.22
20.00	1.16	273.94	30.14
25.00	1.11	258.79	28.47
30.00	1.07	243.17	26.75
35.00	1.02	239.18	26.31

Avg. = 29

WELL CONSTRUCTION DATA MW-3 RUN NUMBER: 1

GREATEST PULSE: 1.01

WELL LABEL: MW-3
STATIC WATER LEVEL DEPTH FROM GROUND SURFACE (FEET): 30.74
TOTAL DEPTH OF WELL OR SAND PACK FROM GROUND SURFACE (FEET): 42
LENGTH OF SCREEN OR SAND PACK (FEET): 11.1
WELL/BOREHOLE DIAMETER (INCHES): 8
SLUG DIAMETER (INCHES): 3
LENGTH OF SLUG (FEET): 3
CASING DIAMETER (INCHES): 4
DEPTH TO LOWER IMPERMEABLE LAYER FROM GROUND SURFACE (FEET): 42
L/RW RATIO : 33.3
C COEFFICIENT: 2.1

TIME (SECONDS)	PULSE LEVEL	T GPD/FT (FEET)	K GPD/FT2
20.00	0.90	139.78	12.41
25.00	0.88	133.62	11.87
30.00	0.85	139.38	12.38

Avg = 12

WELL CONSTRUCTION DATA MW-6 RUN NUMBER: 1

GREATEST PULSE: 1.48

WELL LABEL: MW-6
STATIC WATER LEVEL DEPTH FROM GROUND SURFACE (FEET): 30.24
TOTAL DEPTH OF WELL OR SAND PACK FROM GROUND SURFACE (FEET): 42
LENGTH OF SCREEN OR SAND PACK (FEET): 11.8
WELL/BOREHOLE DIAMETER (INCHES): 8
SLUG DIAMETER (INCHES): 3
LENGTH OF SLUG (FEET): 3
CASING DIAMETER (INCHES): 4
DEPTH TO LOWER IMPERMEABLE LAYER FROM GROUND SURFACE (FEET): 42
L/RW RATIO : 35.4
C COEFFICIENT: 2.1

TIME (SECONDS)	PULSE LEVEL	T GPD/FT (FEET)	K GPD/FT2
15.00	1.21	326.40	27.75
20.00	1.16	296.09	25.18
25.00	1.11	279.71	23.78
30.00	1.07	262.83	22.35
35.00	1.02	258.52	21.98

Avg = 24

LEA STATION
Rising Head (Slug out) Results

WELL CONSTRUCTION DATA

MW-9 RUN NUMBER: 1

GREATEST PULSE: 1.36

WELL LABEL: MW-9
STATIC WATER LEVEL DEPTH FROM GROUND SURFACE (FEET): 28.85
TOTAL DEPTH OF WELL OR SAND PACK FROM GROUND SURFACE (FEET): 40
LENGTH OF SCREEN OR SAND PACK (FEET): 11.2
WELL/BOREHOLE DIAMETER (INCHES): 8
SLUG DIAMETER (INCHES): 3
LENGTH OF SLUG (FEET): 3
CASING DIAMETER (INCHES): 4
DEPTH TO LOWER IMPERMEABLE LAYER FROM GROUND SURFACE (FEET): 40
L/RW RATIO : 33.6
C COEFFICIENT: 2.1

TIME (SECONDS)	PULSE LEVEL (FEET)	T GPD/FT	K GPD/FT2
20.00	1.23	119.42	10.71
25.00	1.21	111.13	9.97
30.00	1.18	112.50	10.09
35.00	1.15	113.92	10.22

Avg = 10

WELL CONSTRUCTION DATA

MW-11 RUN NUMBER: 1

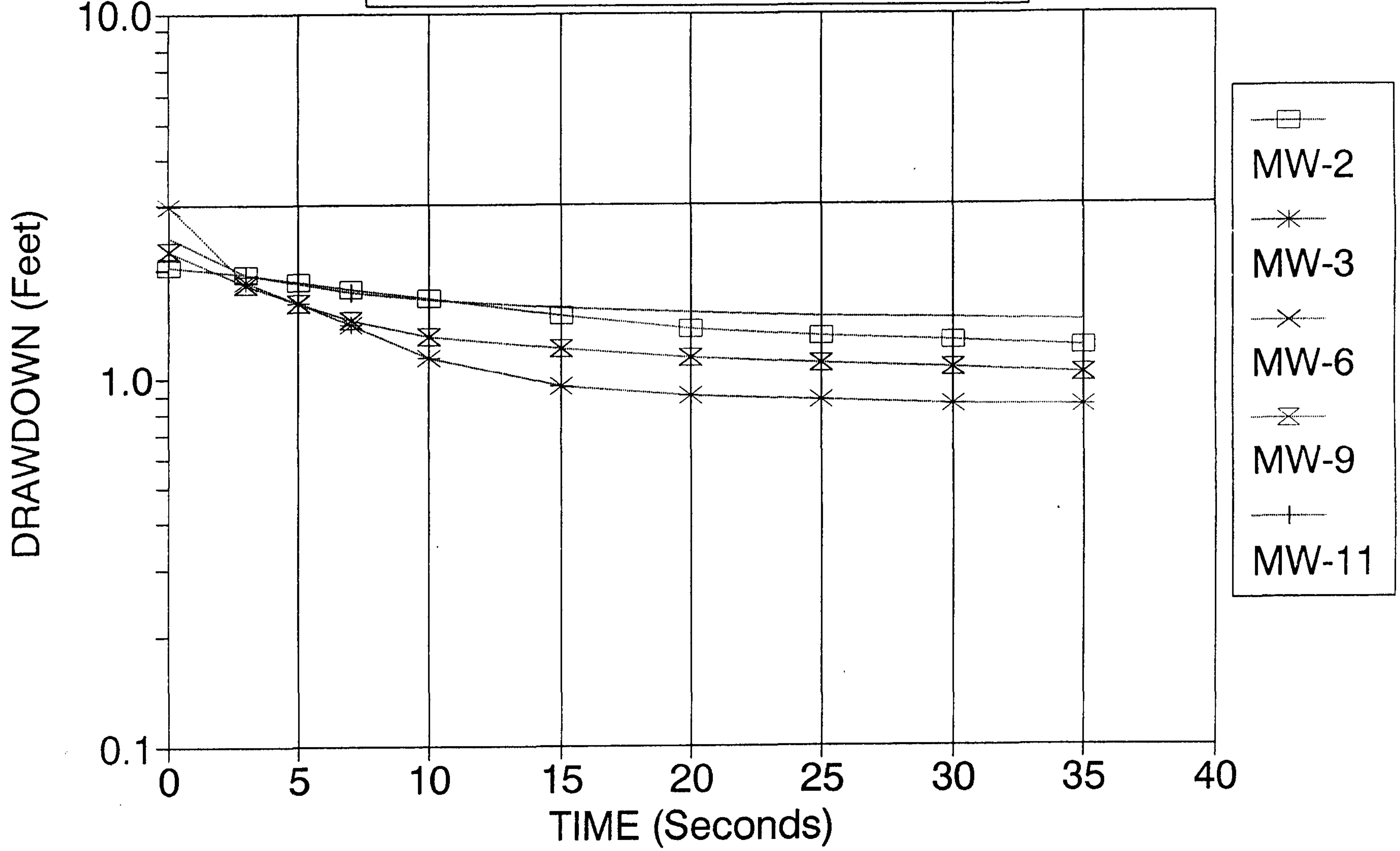
GREATEST PULSE: 1.7

WELL LABEL: MW-11
STATIC WATER LEVEL DEPTH FROM GROUND SURFACE (FEET): 31.53
TOTAL DEPTH OF WELL OR SAND PACK FROM GROUND SURFACE (FEET): 40
LENGTH OF SCREEN OR SAND PACK (FEET): 8.5
WELL/BOREHOLE DIAMETER (INCHES): 8
SLUG DIAMETER (INCHES): 3
LENGTH OF SLUG (FEET): 3
CASING DIAMETER (INCHES): 4
DEPTH TO LOWER IMPERMEABLE LAYER FROM GROUND SURFACE (FEET): 40
L/RW RATIO : 25.5
C COEFFICIENT: 1.8

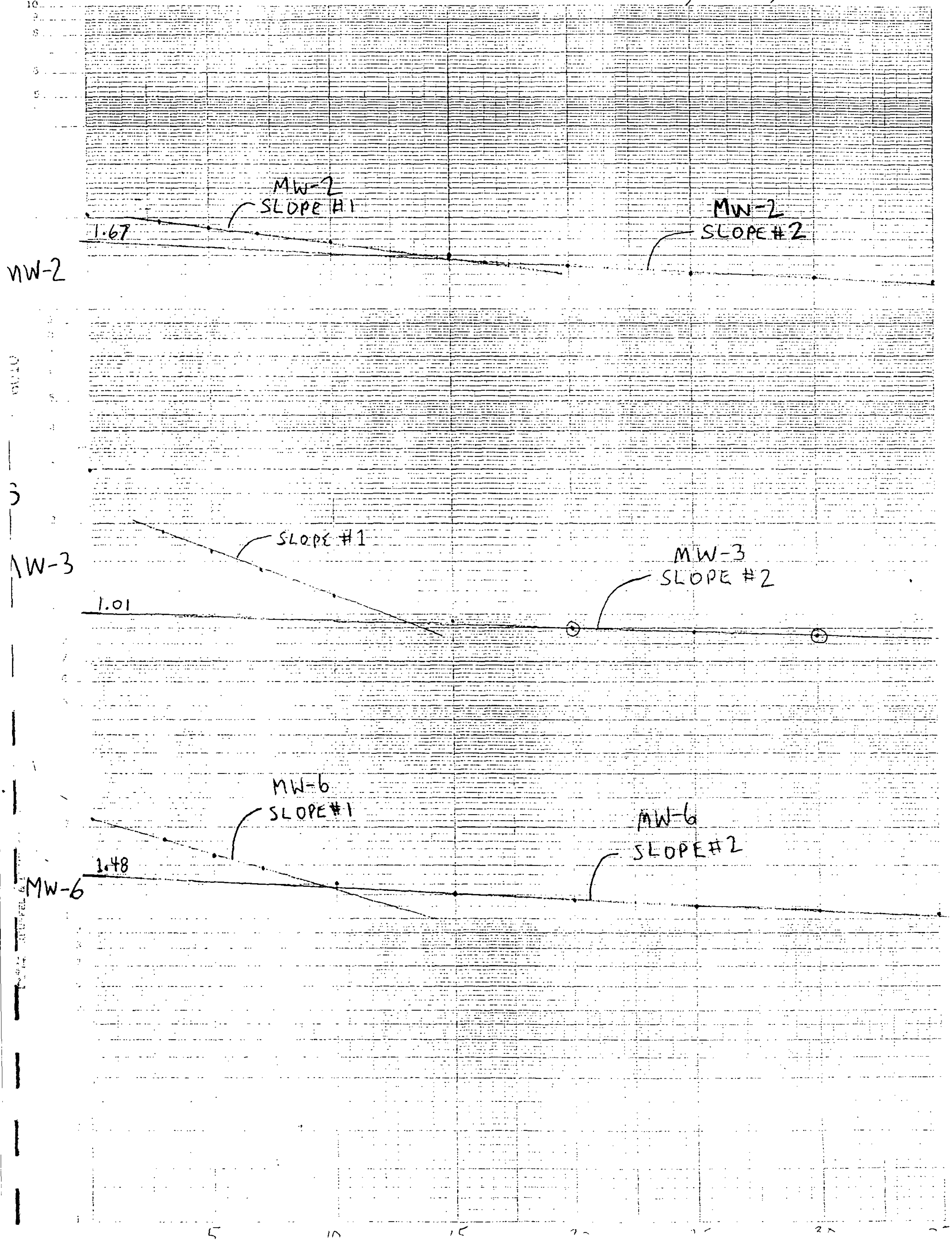
TIME (SECONDS)	PULSE LEVEL (FEET)	T GPD/FT	K GPD/FT2
15.00	1.57	115.53	13.64
20.00	1.52	121.90	14.39
25.00	1.50	109.06	12.88
30.00	1.44	120.52	14.23

Avg = 14

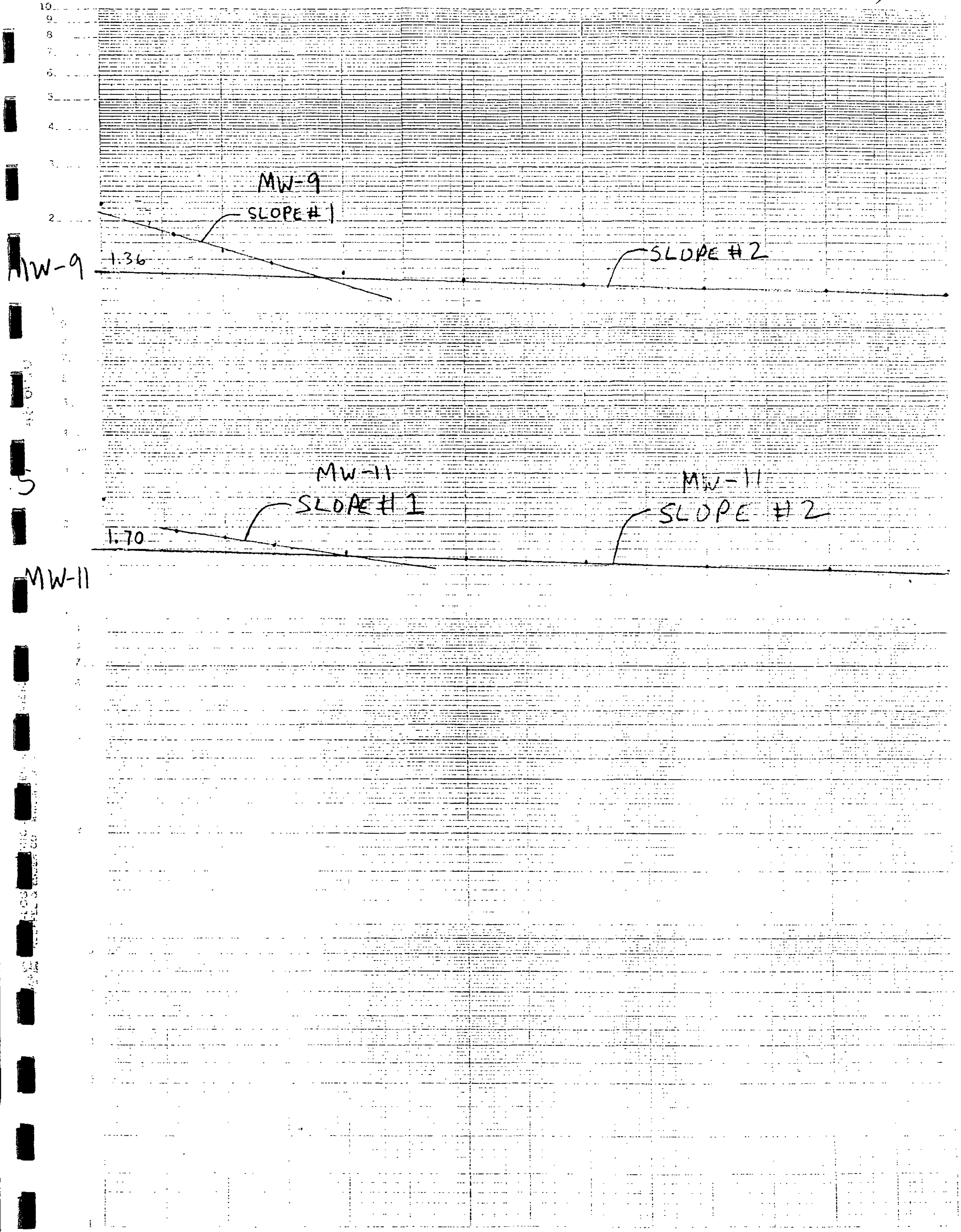
LEA STATION
SLUG TEST DATA PLOT



LEA STATION SLUG-OUT PLOTS (MW-2, MW-3, & MW-6)



LEA STATION SLUG-OUT PLOTS (MW-9 & MW-11)



PROJECT NAME: LEA STATION SLUG TEST DATA

Rising Head (Slug out)

PROJECT NUMBER: 15-9367700B.3
DATE: JANUARY 12, 1994
CURA EMPLOYEE: GJV

MW-2		MW-3		MW-6		MW-9		MW-11	
SE1000C Environmental Logger 01/12 20:33		SE1000C Environmental Logger 01/12 20:56		SE1000C Environmental Logger 01/12 20:50		SE1000C Environmental Logger 01/12 20:39		SE1000C Environmental Logger 01/12 20:44	
Unit# 01523	Test 10	Unit# 01523	Test 14	Unit# 01523	Test 13	Unit# 01523	Test 11	Unit# 01523	Test 12
Setups:	INPUT 1	Setups:	INPUT 1	Setups:	INPUT 1	Setups:	INPUT 1	Setups:	INPUT 1
Type	Level (F)	Type	Level (F)	Type	Level (F)	Type	Level (F)	Type	Level (F)
Mode	TOC	Mode	TOC	Mode	TOC	Mode	TOC	Mode	TOC
I.D.	00009	I.D.	00003	I.D.	00003	I.D.	00011	I.D.	00011
Reference	10.510	Reference	10.490	Reference	10.610	Reference	7.910	Reference	7.810
Linearity	-0.010	Linearity	-0.010	Linearity	-0.010	Linearity	-0.010	Linearity	-0.010
Scale factor	9.990	Scale factor	9.990	Scale factor	9.990	Scale factor	9.990	Scale factor	9.990
Offset	0.010	Offset	0.010	Offset	0.010	Offset	0.010	Offset	0.010
Delay mSEC	50.000	Delay mSEC	50.000	Delay mSEC	50.000	Delay mSEC	50.000	Delay mSEC	50.000
Step 1	01/12 11:10:10	Step 1	01/12 14:11:43	Step 1	01/12 13:27:09	Step 1	01/12 11:50:38	Step 1	01/12 12:44:17
Elapsed Time	INPUT 1	Elapsed Time	INPUT 1	Elapsed Time	INPUT 1	Elapsed Time	INPUT 1	Elapsed Time	INPUT 1
0.0000	11.367	0.0000	10.490	0.0000	9.462	0.0000	5.216	0.0000	7.813
0.0033	11.314	0.0033	10.486	0.0033	9.471	0.0033	5.219	0.0033	7.806
0.0066	11.389	0.0066	10.477	0.0066	9.487	0.0066	5.238	0.0066	7.787
0.0100	11.433	0.0100	10.332	0.0100	9.749	0.0100	5.207	0.0100	7.759
0.0133	13.020	0.0133	10.654	0.0133	11.675	0.0133	7.074	0.0133	7.828
0.0166	13.244	0.0166	11.281	0.0166	10.997	0.0166	6.547	0.0166	7.828
0.0200	12.525	0.0200	12.684	0.0200	10.941	0.0200	6.437	0.0200	7.945
0.0233	12.853	0.0233	12.505	0.0233	11.158	0.0233	6.790	0.0233	9.730
0.0266	13.178	0.0266	12.798	0.0266	11.284	0.0266	5.964	0.0266	9.588
0.0300	12.578	0.0300	12.971	0.0300	10.449	0.0300	5.882	0.0300	9.551
0.0333	12.540	0.0333 0	13.451	0.0333	10.792	0.0333	6.342	0.0333	9.541
0.0366	13.102	0.0366 2.97	13.031	0.0366	11.369	0.0366	5.901	0.0366	9.396
0.0400	13.411	0.0400	12.666	0.0400 0	11.726	0.0400	6.238	0.0400	9.068
0.0433	13.357	0.0433	11.442	0.0433 2.20	11.638	0.0433	6.657	0.0433	9.491
0.0466	13.442	0.0466	12.571	0.0466	11.612	0.0466	6.910	0.0466	9.096
0.0500 0	13.408	0.0500	12.606	0.0500	11.578	0.0500 0	7.231	0.0500	8.809
0.0533 2.04	13.398	0.0533	12.593	0.0533	11.565	0.0533 2.27	7.481	0.0533	9.242
0.0566	13.386	0.0566	12.561	0.0566	11.524	0.0566	7.358	0.0566	9.579
0.0600	13.386	0.0600	12.524	0.0600	11.496	0.0600	7.291	0.0600	9.910
0.0633	13.379	0.0633	12.498	0.0633	11.480	0.0633	7.253	0.0633	10.065
0.0666	13.370	0.0666	12.470	0.0666	11.458	0.0666	7.260	0.0666	10.008
0.0700	13.367	0.0700	12.445	0.0700	11.442	0.0700	7.206	0.0700	9.614

0.0733		13.364	0.0733		12.420	0.0733		11.420	0.0733		7.171	0.0733		9.958
0.0766		13.357	0.0766		12.401	0.0766		11.395	0.0766		7.149	0.0766		10.090
0.0800		13.348	0.0800		12.369	0.0800		11.373	0.0800		7.131	0.0800		9.961
0.0833		13.360	0.0833	3	12.347	0.0833		11.360	0.0833		7.099	0.0833	0	10.270
0.0866		13.342	0.0866	1.86	12.322	0.0866		11.344	0.0866		7.074	0.0866	2.46	10.014
0.0900		13.332	0.0900		12.293	0.0900		11.325	0.0900		7.058	0.0900		9.923
0.0933		13.335	0.0933		12.278	0.0933		11.306	0.0933		7.033	0.0933		9.891
0.0966		13.323	0.0966		12.262	0.0966		11.291	0.0966		7.011	0.0966		9.882
0.1000	3	13.310	0.1000		12.240	0.1000	3	11.278	0.1000	3	7.020	0.1000		9.863
0.1033	1.94	13.288	0.1033		12.211	0.1033	1.82	11.259	0.1033	1.80	6.979	0.1033		9.847
0.1066		13.285	0.1066		12.189	0.1066		11.240	0.1066		6.954	0.1066		9.857
0.1100		13.272	0.1100		12.158	0.1100		11.218	0.1100		6.929	0.1100		9.835
0.1133		13.263	0.1133		12.126	0.1133		11.190	0.1133		6.922	0.1133		9.825
0.1166		13.260	0.1166	5	12.107	0.1166		11.174	0.1166		6.888	0.1166		9.794
0.1200		13.250	0.1200	1.62	12.085	0.1200		11.149	0.1200		6.872	0.1200		9.790
0.1233		13.247	0.1233		12.060	0.1233		11.136	0.1233		6.888	0.1233		9.784
0.1266		13.247	0.1266		12.044	0.1266		11.108	0.1266		6.853	0.1266		9.775
0.1300		13.228	0.1300		12.035	0.1300		11.089	0.1300		6.828	0.1300		9.762
0.1333	5	13.219	0.1333		12.013	0.1333	5	11.079	0.1333	5	6.812	0.1333	3	9.749
0.1366	1.85	13.203	0.1366		11.997	0.1366	1.62	11.051	0.1366	1.60	6.796	0.1366	1.94	9.734
0.1400		13.200	0.1400		11.981	0.1400		11.076	0.1400		6.777	0.1400		9.724
0.1433		13.190	0.1433		11.940	0.1433		11.029	0.1433		6.765	0.1433		9.712
0.1466		13.181	0.1466		11.912	0.1466		11.013	0.1466		6.749	0.1466		9.715
0.1500		13.171	0.1500	7	11.893	0.1500		10.985	0.1500		6.736	0.1500		9.696
0.1533		13.171	0.1533	1.41	11.864	0.1533		10.994	0.1533		6.720	0.1533		9.689
0.1566		13.165	0.1566		11.849	0.1566		10.969	0.1566		6.708	0.1566		9.696
0.1600		13.159	0.1600		11.833	0.1600		10.950	0.1600		6.698	0.1600		9.677
0.1633		13.137	0.1633		11.817	0.1633		10.937	0.1633		6.702	0.1633		9.664
0.1666	7	13.137	0.1666		11.798	0.1666	7	10.925	0.1666	7	6.689	0.1666	5	9.655
0.1700	1.77	13.130	0.1700		11.779	0.1700	1.46	10.906	0.1700	1.47	6.673	0.1700	1.84	9.645
0.1733		13.118	0.1733		11.764	0.1733		10.893	0.1733		6.654	0.1733		9.633
0.1766		13.114	0.1766		11.742	0.1766		10.884	0.1766		6.657	0.1766		9.626
0.1800		13.105	0.1800		11.726	0.1800		10.868	0.1800		6.670	0.1800		9.611
0.1833		13.102	0.1833		11.710	0.1833		10.859	0.1833		6.635	0.1833		9.598
0.1866		13.092	0.1866		11.691	0.1866		10.846	0.1866		6.632	0.1866		9.595
0.1900		13.089	0.1900		11.682	0.1900		10.843	0.1900		6.629	0.1900		9.592
0.1933		13.080	0.1933		11.666	0.1933		10.827	0.1933		6.623	0.1933		9.576
0.1966		13.073	0.1966		11.650	0.1966		10.815	0.1966		6.601	0.1966		9.570
0.2000		13.067	0.2000	10	11.634	0.2000		10.792	0.2000		6.591	0.2000	7	9.557
0.2033		13.061	0.2033	1.15	11.625	0.2033		10.796	0.2033		6.594	0.2033	1.74	9.554
0.2066		13.051	0.2066		11.606	0.2066		10.789	0.2066		6.585	0.2066		9.541
0.2100		13.045	0.2100		11.596	0.2100		10.777	0.2100		6.579	0.2100		9.535
0.2133		13.039	0.2133		11.590	0.2133		10.774	0.2133		6.575	0.2133		9.532
0.2166	10	13.032	0.2166		11.581	0.2166	10	10.767	0.2166	10	6.566	0.2166		9.519
0.2200	1.67	13.023	0.2200		11.574	0.2200	1.31	10.755	0.2200	1.35	6.579	0.2200		9.510
0.2233		13.017	0.2233		11.559	0.2233		10.751	0.2233		6.563	0.2233		9.519
0.2266		13.010	0.2266		11.549	0.2266		10.748	0.2266		6.553	0.2266		9.494
0.2300		13.001	0.2300		11.536	0.2300		10.745	0.2300		6.553	0.2300		9.494
0.2333		12.995	0.2333		11.527	0.2333		10.739	0.2333		6.553	0.2333		9.491
0.2366		12.988	0.2366		11.518	0.2366		10.733	0.2366		6.550	0.2366		9.481
0.2400		12.982	0.2400		11.505	0.2400		10.733	0.2400		6.547	0.2400		9.491
0.2433		12.976	0.2433		11.499	0.2433		10.720	0.2433		6.538	0.2433		9.465
0.2466		12.963	0.2466		11.495	0.2466		10.720	0.2466		6.541	0.2466		9.465
0.2500		12.960	0.2500		11.499	0.2500		10.707	0.2500		6.544	0.2500	10	9.462

0.2533		12.957	0.2533		11.495	0.2533		10.704	0.2533		6.534	0.2533		9.456
0.2566		12.947	0.2566		11.470	0.2566		10.704	0.2566		6.528	0.2566		9.443
0.2600		12.941	0.2600		11.464	0.2600		10.707	0.2600		6.525	0.2600		9.447
0.2633		12.935	0.2633		11.480	0.2633		10.701	0.2633		6.509	0.2633		9.447
0.2666		12.928	0.2666		11.499	0.2666		10.701	0.2666		6.519	0.2666		9.443
0.2700		12.922	0.2700		11.483	0.2700		10.695	0.2700		6.500	0.2700		9.437
0.2733		12.916	0.2733		11.467	0.2733		10.692	0.2733		6.506	0.2733		9.434
0.2766		12.909	0.2766		11.464	0.2766		10.688	0.2766		6.506	0.2766		9.431
0.2800		12.903	0.2800		11.451	0.2800		10.685	0.2800		6.519	0.2800		9.428
0.2833		12.897	0.2833	15	11.439	0.2833		10.682	0.2833		6.512	0.2833		9.431
0.2866		12.891	0.2866	.95	11.442	0.2866		10.679	0.2866		6.509	0.2866		9.421
0.2900		12.884	0.2900		11.439	0.2900		10.676	0.2900		6.506	0.2900		9.418
0.2933		12.878	0.2933		11.432	0.2933		10.669	0.2933		6.516	0.2933		9.415
0.2966		12.875	0.2966		11.432	0.2966		10.685	0.2966		6.506	0.2966		9.412
0.3000	15	12.868	0.3000		11.426	0.3000	15	10.669	0.3000	15	6.493	0.3000		9.409
0.3033	1.50	12.862	0.3033		11.423	0.3033	1.21	10.663	0.3033	1.28	6.512	0.3033		9.409
0.3066		12.856	0.3066		11.420	0.3066		10.660	0.3066		6.497	0.3066		9.406
0.3100		12.850	0.3100		11.410	0.3100		10.657	0.3100		6.500	0.3100		9.399
0.3133		12.843	0.3133		11.410	0.3133		10.657	0.3133		6.490	0.3133		9.399
0.3166		12.840	0.3166		11.404	0.3166		10.654	0.3166		6.493	0.3166		9.399
0.3200		12.834	0.3200		11.407	0.3200		10.651	0.3200		6.493	0.3200		9.396
0.3233		12.831	0.3233		11.410	0.3233		10.647	0.3233		6.516	0.3233		9.396
0.3266		12.824	0.3266		11.407	0.3266		10.644	0.3266		6.497	0.3266		9.390
0.3300		12.818	0.3300		11.401	0.3300		10.641	0.3300		6.487	0.3300	15	9.390
0.3333		12.815	0.3333		11.401	0.3333		10.641	0.3333		6.484	0.3333	1.58	9.393
0.3500		12.786	0.3500		11.388	0.3500		10.632	0.3500		6.475	0.3500		9.374
0.3666		12.768	0.3666	20	11.385	0.3666		10.619	0.3666		6.465	0.3666		9.368
0.3833	20	12.745	0.3833	.90	11.376	0.3833	20	10.610	0.3833	20	6.446	0.3833		9.355
0.4000	1.38	12.727	0.4000		11.369	0.4000	1.15	10.600	0.4000	1.23	6.449	0.4000		9.339
0.4166		12.714	0.4166		11.363	0.4166		10.591	0.4166		6.446	0.4166	20	9.339
0.4333		12.698	0.4333		11.357	0.4333		10.581	0.4333		6.449	0.4333	1.53	9.333
0.4500		12.686	0.4500	25	11.354	0.4500		10.572	0.4500		6.452	0.4500		9.330
0.4666	25	12.676	0.4666	.87	11.347	0.4666	25	10.565	0.4666	25	6.424	0.4666		9.317
0.4833	1.31	12.667	0.4833		11.344	0.4833	1.10	10.556	0.4833	1.21	6.427	0.4833		9.311
0.5000		12.657	0.5000		11.341	0.5000		10.550	0.5000		6.415	0.5000	25	9.305
0.5166		12.648	0.5166		11.335	0.5166		10.540	0.5166		6.408	0.5166	1.49	9.298
0.5333		12.641	0.5333	30	11.335	0.5333		10.534	0.5333		6.405	0.5333		9.305
0.5500	30	12.632	0.5500	.85	11.328	0.5500	30	10.528	0.5500	30	6.393	0.5500		9.289
0.5666	1.27	12.626	0.5666		11.328	0.5666	1.07	10.518	0.5666	1.18	6.389	0.5666		9.283
0.5833		12.619	0.5833		11.325	0.5833		10.512	0.5833		6.386	0.5833	30	9.279
0.6000		12.610	0.6000		11.322	0.6000		10.505	0.6000		6.380	0.6000	1.47	9.273
0.6166		12.607	0.6166		11.322	0.6166		10.499	0.6166		6.374	0.6166		9.267
0.6333	35	12.600	0.6333		11.319	0.6333	35	10.493	0.6333	35	6.367	0.6333		9.264
0.6500	1.23	12.594	0.6500		11.316	0.6500	1.03	10.493	0.6500	1.15	6.370	0.6500		9.257
0.6666		12.588	0.6666		11.316	0.6666		10.487	0.6666		6.358	0.6666	35	9.254
0.6833		12.581	0.6833		11.306	0.6833		10.480	0.6833		6.352	0.6833	1.44	9.254
0.7000		12.578	0.7000		11.309	0.7000		10.474	0.7000		6.352	0.7000		9.245
0.7166		12.572	0.7166		11.306	0.7166		10.461	0.7166		6.345	0.7166		9.238
0.7333		12.569	0.7333		11.303	0.7333		10.461	0.7333		6.342	0.7333		9.245
0.7500		12.563	0.7500		11.303	0.7500		10.458	0.7500		6.336	0.7500		9.232
0.7666		12.559	0.7666		11.300	0.7666		10.452	0.7666		6.333	0.7666		9.226
0.7833		12.553	0.7833		11.300	0.7833		10.446	0.7833		6.326	0.7833		9.223
0.8000		12.550	0.8000		11.297	0.8000		10.442	0.8000		6.323	0.8000		9.229
0.8166		12.544	0.8166		11.294	0.8166		10.436	0.8166		6.320	0.8166		9.213

0.8333	12.540	0.8333	11.294	0.8333	10.430	0.8333	6.314	0.8333	9.210
0.8500	12.537	0.8500	11.294	0.8500	10.427	0.8500	6.307	0.8500	9.207
0.8666	12.534	0.8666	11.291	0.8666	10.420	0.8666	6.304	0.8666	9.204
0.8833	12.528	0.8833	11.291	0.8833	10.417	0.8833	6.301	0.8833	9.200
0.9000	12.525	0.9000	11.287	0.9000	10.411	0.9000	6.295	0.9000	9.197
0.9166	12.522	0.9166	11.284	0.9166	10.408	0.9166	6.292	0.9166	9.191
0.9333	12.518	0.9333	11.284	0.9333	10.401	0.9333	6.288	0.9333	9.188
0.9500	12.515	0.9500	11.281	0.9500	10.398	0.9500	6.285	0.9500	9.185
0.9666	12.512	0.9666	11.281	0.9666	10.392	0.9666	6.279	0.9666	9.185
0.9833	12.506	0.9833	11.281	0.9833	10.389	0.9833	6.276	0.9833	9.178
1.0000	12.506	1.0000	11.278	1.0000	10.383	1.0000	6.270	1.0000	9.175
1.2000	12.458	1.2000	11.262	1.2000	10.323	1.2000	6.219	1.2000	9.122
1.4000	12.424	1.4000	11.246	1.4000	10.278	1.4000	6.178	1.4000	9.084
1.6000	12.395	1.6000	11.234	1.6000	10.237	1.6000	6.140	1.6000	9.046
1.8000	12.367	1.8000	11.221	1.8000	10.200	1.8000	6.109	1.8000	9.008
2.0000	12.342	2.0000	11.209	2.0000	10.165	2.0000	6.074	2.0000	8.973
2.2000	12.317	2.2000	11.199	2.2000	10.137	2.2000	6.046	2.2000	8.942
2.4000	12.294	2.4000	11.186	2.4000	10.105	2.4000	6.011	2.4000	8.907
2.6000	12.276	2.6000	11.177	2.6000	10.077	2.6000	5.983	2.6000	8.879
2.8000	12.253	2.8000	11.161	2.8000	10.051	2.8000	5.954	2.8000	8.850
3.0000	12.235	3.0000	11.155	3.0000	10.029	3.0000	5.926	3.0000	8.825
3.2000	12.212	3.2000	11.145	3.2000	10.004			3.2000	8.800
		3.4000	11.136	3.4000	9.982			3.4000	8.771
		3.6000	11.130	3.6000	11.130			3.6000	8.746
								3.8000	8.724
								4.0000	8.699

LEA STATION

Monitor Well	Hydraulic Conductivity (gpd/ft²) (Falling Head-Slug in)	Hydraulic Conductivity (gpd/ft²) (Rising Head-Slug out)	Aquifer Thickness (feet)	T Falling Head Slug in (gpd/ft)	T Rising Head Slug out (gpd/ft)
MW-2	8.9	29.0	9.1	80	260
MW-3	9.6	12.2	11.1	110	140
MW-6	11.0	24.2	11.8	130	290
MW-9	15.1	10.2	11.2	170	110
MW-11	14.2	13.8	8.5	120	120
Average	11.8	17.9	--	120	180

CURA INC. DALLAS - HOUSTON - MIDLAND	CLIENT: SPLC	SCALE:	SHEET OF
	SUBJECT: Lea Station	PROJECT NUMBER: 15-9367700B,3	
	PREPARED BY: GJV DATE: 1/20/94	CHECKED BY:	DATE:

Short-term Well Yield Calculations

Method #1:
Yields based on slug test (rising head) water level recovery rates during the 15 second to 35 second recovery period.

MW-2 $\frac{(1.50' - 1.23')}{20 \text{ sec}} \times \frac{60 \text{ sec}}{\text{minute}} \times \frac{0.6 \text{ gal}}{\text{foot}} = 0.53 \text{ gpm} \cong 0.5 \text{ gpm}$

MW-3 $\frac{0.95 - 0.84}{20} \times 60 \times 0.65 = 0.21 \text{ gpm} \cong 0.2 \text{ gpm}$

MW-6 $\frac{1.21 - 1.03}{20} \times 60 \times 0.65 = 0.35 \text{ gpm} \cong 0.4 \text{ gpm}$

MW-9 $\frac{1.28 - 1.15}{20} \times 60 \times 0.65 = 0.25 \text{ gpm} \cong 0.3 \text{ gpm}$

MW-11 $\frac{1.58 - 1.44}{20} \times 60 \times 0.65 = 0.27 \text{ gpm} = 0.3 \text{ gpm}$

Method #2 use $T = 1550\, Q/s$ where s = available drawdown & solve for Q

MW-2 $Q = \frac{T \times s}{1550} = \frac{260 \times (\sim 5')}{1550} = 0.84 \text{ gpm} \cong 0.8$

MW-3 $Q = \frac{(140)(5)}{1550} = 0.45 \text{ gpm} \cong 0.4 \text{ gpm}$

MW-6 $Q = \frac{(290)(5)}{1550} = 0.93 \text{ gpm} \cong 0.9 \text{ gpm}$

MW-9 $Q = \frac{(110)(5)}{1550} = 0.35 \text{ gpm} \cong 0.3 \text{ gpm}$

CURA INC. DALLAS - HOUSTON - MIDLAND	CLIENT: SPCC	SCALE:	SHEET	OF
	SUBJECT: Lea Station	PROJECT NUMBER:		
	PREPARED BY: GJV	DATE: 1/20/94	CHECKED BY:	DATE:

Capture Zone Width Calculation

Total hydrocarbon-impacted flow (Q_A) =

$$Q_A = T i w = (180\ gpd/ft)(0.01)(1,800\ feet) = 324.0\ gpd$$

Theoretical capture zone (W_{cz}) for typical monitor well on site with an approximate well yield of 0.3 gpm (432 gpd) ≃

$$W_{cz} = \frac{Q}{Ti} = \frac{432\ gpd}{(180\ gpd/ft)(0.01)} = 240\ ft$$

Groundwater Flow Velocity Calculation:

$$v = \frac{ki}{e} = \frac{(18\ gpd/ft^2)(0.01)}{25\%} = 0.72\ ft/day$$

EMCON INC. DALLAS - HOUSTON - MIDLAND	CLIENT: SPLC	SCALE: SHEET OF
	SUBJECT: Lea Station	PROJECT NUMBER: 15-93677.00B.3
	PREPARED BY: FWR DATE:	CHECKED BY: DATE:

Northeast Portion of Site (MW-3, MW-11)

Groundwater Capture Width Calculation

$$W = \frac{\text{Long term Pumping Rate}}{\text{Total Groundwater Flow}} \times \text{Plume Width}$$

$$W = \frac{(0.5 \text{ gpm})(1440 \text{ min/day})}{1{,}440 \text{ gpd}} \times 800 \text{ ft} = 400 \text{ ft}$$

$$W = \frac{(0.1 \text{ gpm})(1440 \text{ min/day})}{1{,}440 \text{ gpd}} \times 800 \text{ ft} = 80 \text{ ft}$$

Western Portion of Site (MW-8)

Groundwater Capture Width Calculation

$$W = \frac{(0.5)(1440)}{470} \times 260 = 400 \text{ ft}$$

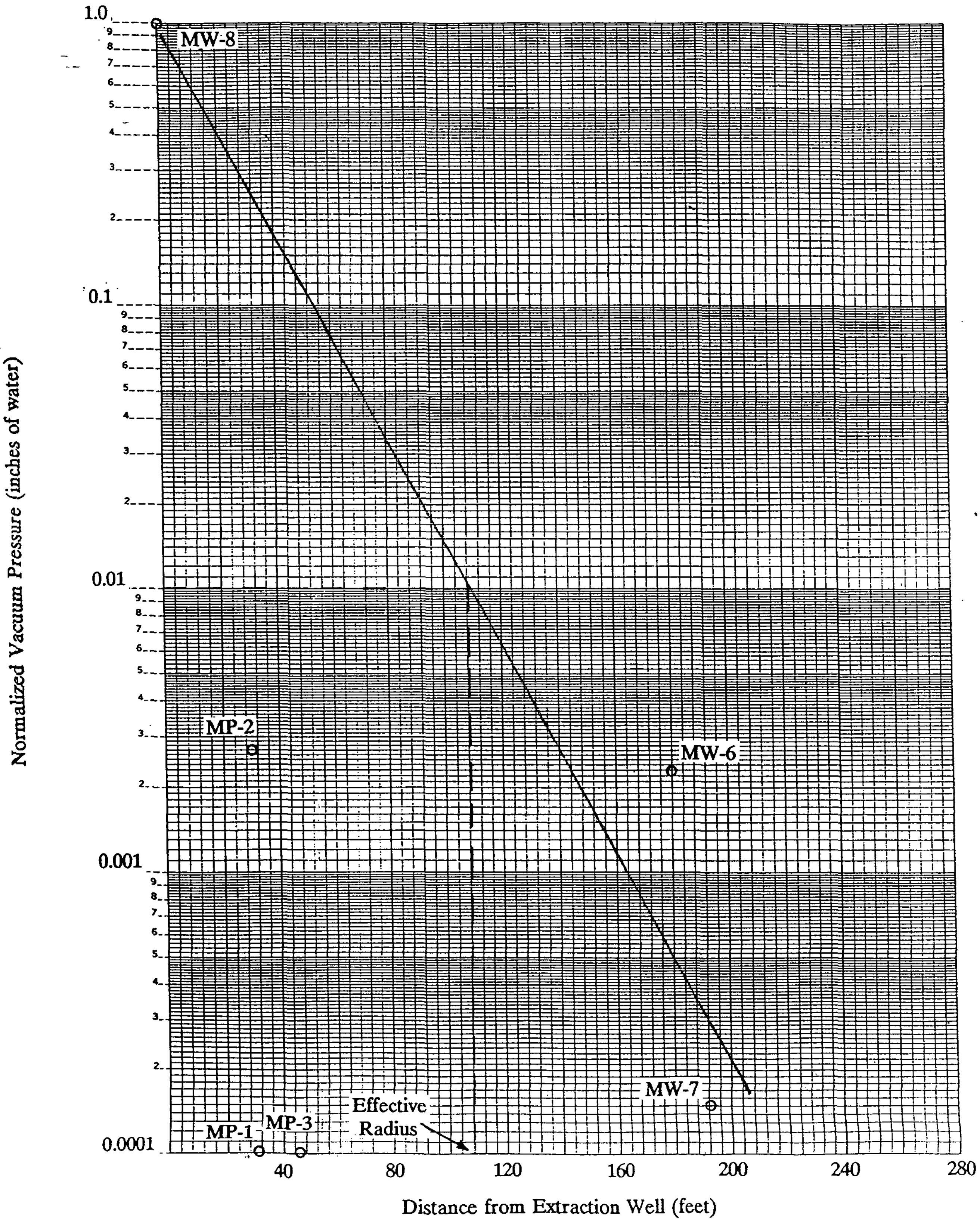
$$W = \frac{(0.1)(1440)}{470} \times 260 = 80 \text{ ft}$$

APPENDIX C

SOIL VAPOR EXTRACTION RESULTS

CURA INC. DALLAS - HOUSTON - MIDLAND	CLIENT: Shell Pipe Line Corp	SCALE:
	SHEET 1 OF 2	
	SUBJECT: SVE Test, Lea Station	PROJECT NUMBER: 15-93677.00B.03
	PREPARED BY: FWR	DATE: 12-22-93
	CHECKED BY:	DATE:

SOIL VAPOR EXTRACTION TEST



CHAIN OF CUSTODY

CURA ENVIRONMENTAL LABORATORIES
2209 WISCONSIN #300 · DALLAS, TX 75229
(214) 620-7966 FAX · (214) 620-7963

CLIENT: CURA, Inc.

CLIENT ADDRESS: 731 W. Wadley, Suite L200, Midland, Texas 79705

BILLING ADDRESS:

CONTACT/PHONE: Wes Root P.M. GCW (915) 570-8408 FAX (915) 570-8409

P.O. NUMBER:

PROJECT NUMBER: 159367700B PHASE/SUBTASK: 03

PROJECT NAME/ADDRESS: Shell Pipe LINE Lea Station, New Mexico

SAMPLERS (Signature): J. Wesley Root

DATE	TIME	MATRIX TYPE	Comp	Grab	STATION LOCATION/IDENTIFICATION	Number of containers	Preservations	TPH	~~O_2~~						SPECIAL REQUIREMENTS/TAT
12-22-93	0715	Air		✓	SUE-test - EFF	2	-	✓	✓						NORMAL
															Only TPH tested
															per GVD [illegible]

G | D | O | Other

SAMPLE REMAINDER DISPOSAL

☐ Return via ______ (shipping charges may be incurred) OR ☐ Request CEL to dispose of all sample remainders*

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME
Bell Smith	1000 12-23-93		
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED FOR CEL LABORATORY BY: (Signature) Melanie Gelen	DATE/TIME 12-23-93 3:36

CONDITION OF SAMPLES:
1 BAG WAS EMPTY
1 BAG GOOD
CEL #1114

DUE DATE

* If sample remainder is determined to be hazardous a minimum additional charge of $20.00 per sample will be assessed prior to disposal and billed to client.

PF92013D.FRM (rev. 10/14/92)

CURA ENVIRONMENTAL LABORATORIES
2209 Wisconsin Street, Suite 200 • Dallas, Texas 75229 • 214/241-3745 • FAX 620-7963

Project No: 15-93-677B.3
Sample Type: Air
Analyst: YQL
Method: EPA 8020

Date Reported: 01/05/94
Date Received: 12/23/93
Date Analyzed: 12/23/93

AIR SAMPLE-TPH

REPORT NUMBER	SAMPLE ID	TPH ppm
93-1114-01	SVE-EFF	1,780

Chuck Ables
Laboratory Manager

Yanqi Li
Analytical Chemist

9.0 REFERENCES

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