AP - 001

STAGE 1 & 2 REPORTS

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SITE CHARACTERIZATION AND RISK ASSESSMENT FOR THE FORMER BRICKLAND REFINERY

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VOLUME 1

Prepared for:

REXENE

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1.0 Executive Summary

1.1 Site History

The Brickland Refinery site is currently owned by Rexene Corporation (Rexene) and consists of 35 acres located in Sunland Park, Doña Ana County, New Mexico. The former petroleum refinery operated from 1933 to 1958 and was subsequently dismantled. No refinery operations have occurred for approximately 37 years. Hydrocarbons released during the refinery's operational life have been detected in soils and groundwater at the site.

Two major environmental investigations have been conducted to evaluate current trends in groundwater chemistry and regional and local hydrogeologic conditions that influence the fate and transport of compounds in subsurface soils and the underlying shallow aquifer. These investigations were also conducted to establish baseline conditions for conducting a human health risk assessment.

1.2 Site Characterization

Data obtained from site investigations conducted by Geoscience Consultants, Ltd. (GCL) and Eder and Associates, Inc. has been used to characterize the physical and chemical properties of the current environmental setting. Results indicate that hydrocarbons that remain in on-site soils are restricted to the southern two-thirds of the facility. Hydrocarbon constituents detected in groundwater monitoring wells show a spatial correlation with those found in soils and indicate some migration of hydrocarbons from soil to groundwater. Local occurrences of free-phase hydrocarbons have been observed in several wells and well points in the southern portion of the site, and the measured amount is from several tenths of a foot or less to several feet in MW-10 and WP-26S. However, recent studies indicate this is not representative of existing aquifer conditions and that the areal extent and potential impacts of free-phase hydrocarbons is much less than originally projected.

Evaluations of regional and local geologic and hydrologic conditions indicate that groundwater flow velocity in the shallow aquifer beneath the site is low at about 20 feet per year and the heterogeneous clays and silts in subsurface soils have acted to restrict migration of organics and inorganics within the soils and aquifer.

1.3 Health Risk Assessment

The initial screening process identified 189 potential exposure route-pathways representing a number of different conditions at the site. Further analyses were conducted to determine which route-pathways were complete and which could pose possible threats from on- and off-site exposure to compounds at the site. An exposure pathway is only considered complete when each of the following elements is present: (1) a source or media of concern and a mechanism of release (e.g., volatilization, runoff); (2) a retention or transport medium (or media in cases involving transfer of compounds); (3) a potential exposure point for contact with the medium of concern (a receptor location); and (4) an exposure route (e.eg., ingestion) at the exposure point. Each pathway examined health risks associated with exposure to the following compounds of concern:

- Benzene, toluene, ethylbenzene, and xylenes (BTEX)
- Polycyclic aromatic hydrocarbons
- Phenols
- Heavy metals

Inhalation of soil-gas, soil particles, and volatiles from LNAPL and groundwater were found to be the only potential exposure routes at this site.

After evaluation, twenty-one exposure route-pathways were judged to have the potential to be complete. These were analyzed based on site conditions as they currently exist and for two projected future scenarios. Exhibit ES1 summarizes the results of the health risk assessment. Using very conservative input parameters for the health risk assessment and the 95th percentile upper confidence levels (UCL) for exposure to carcinogens and non-carcinogens, the following conclusions were reached:

- Non-Carcinogens: The numerical values found in Exhibit ES1 for each on- and off-site condition and associated route-pathways show that the summed Hazard Indices for the total risk for each scenario are less than 1 (HI Maximum = 0.649) which is below suggested U.S. Environmental Protection Agency criteria. This is further depicted in Exhibits ES2 through ES5 which graphically present the individual contributions of each route-pathway to the Hazard Index for the four worst case on- and off-site scenarios.

- Lead: Lead is considered a unique compound of concern among non-carcinogens and potential health risks are evaluated using a biokinetic uptake model. As indicated in Exhibit ES6, all values for adults and the typical child were below the U.S. Environmental Protection Agency (EPA) standard of 10 micrograms/ deciliter (µg/dL) for combined exposure to all environmental media. This again is a very conservative approach and helps to ensure no significant potential health risks.

- Carcinogens: Lifetime cancer risks (70-year exposure) were also evaluated for each exposure scenario and all compounds of concern. As indicated in Exhibit 1, all summed cancer risks for each on- and off-site scenario were below or near the suggested EPA "Point of Departure" (1×10^{-6}). The highest value determined was for on-site industrial use under Current I (on site) use conditions (6.72×10^{-6}) which can be easily remedied by the use of personnel protection devices. The 1×10^{-6} value was also exceeded for Future I (on site) industrial conditions and Future II (on site) industrial conditions.

The risk assessment of several scenarios is presented graphically in Exhibits ES7-ES10.

The overall results of the health risk assessment indicate that maintaining site conditions as they currently exist with the implementation of administrative and engineering controls will prevent threats to human health from the compounds of concern at the site and model simulations indicate that hydrocarbon concentrations will continue to diminish with time. The health risk assessment also indicates that the site should not be developed. Conservative projections of hydrocarbon degradation indicate that all health risks will fall below EPA guidelines when the total benzene concentration in the groundwater falls below 3 ppm which should occur within 10 years.

Recent site investigations and the results of the health risk assessment demonstrate that the only health risks associated with exposure to compounds at the site are from on-site activities. The implementation of administrative and engineering controls, security measures, and continued monitoring will eliminate these potential threats until site conditions no longer pose a health risk.

ES 1 HUMAN-HEALTH RISK SUMMARY*

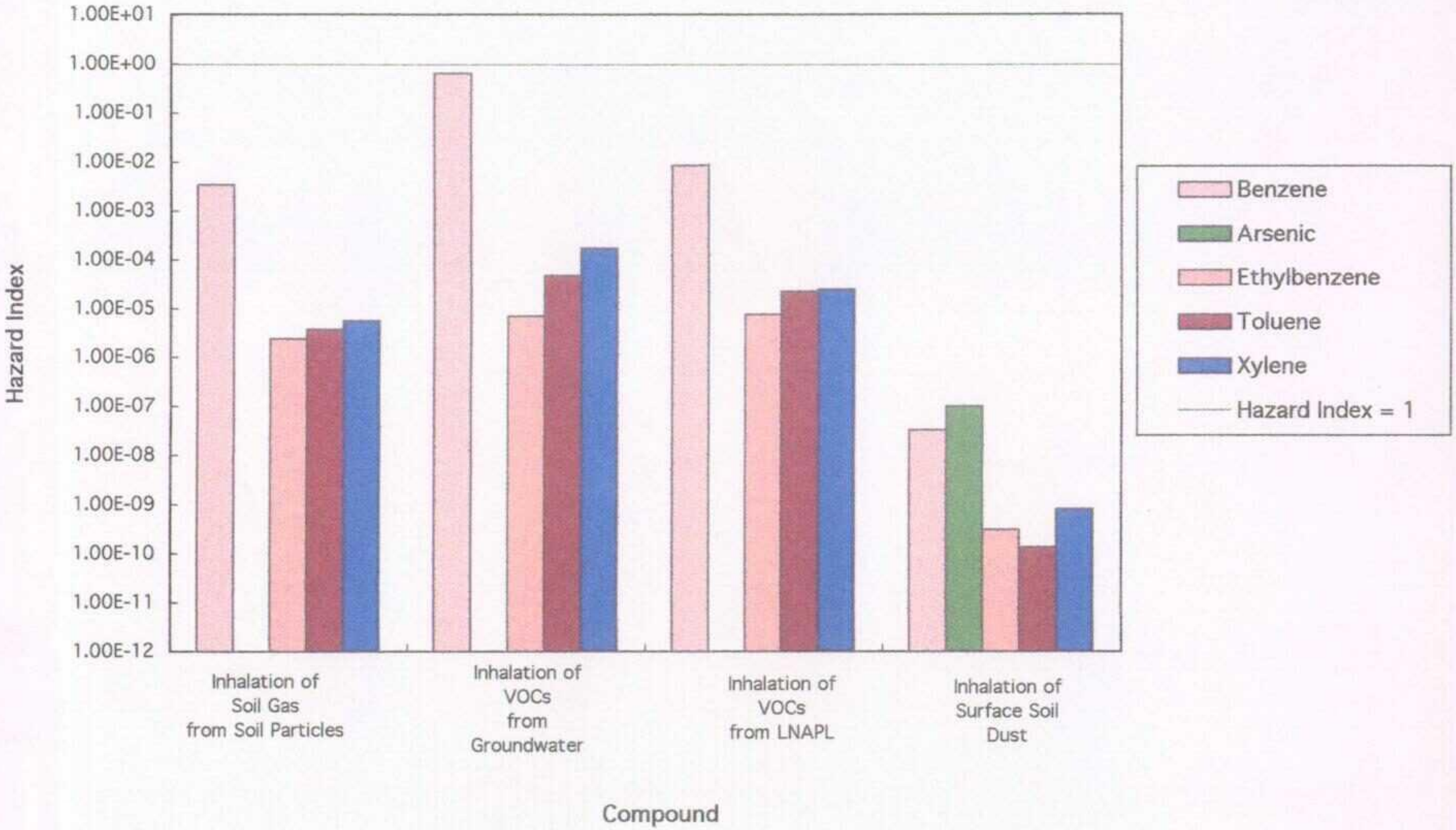
Brickland Refinery Site, Sunland Park, New Mexico

Exposure Route – Pathway	Noncancer Risk (HI) ucl	Noncancer Risk (HI) mean	Cancer Risk ucl	Cancer Risk mean
CURRENT I CONDITIONS (*on site*)—Industrial				
RP1: inhalation of soil gas from soil particles	0.003	0.002	3.45E-08	7.77E-09
RP2: inhalation of soil gas from ground water	0.637	0.398	6.60E-06	1.48E-06
RP3: inhalation of soil gas from LNAPL	0.008	0.005	8.64E-08	1.94E-08
RP4: inhalation of surface soil dust	0.000	0.000	1.95E-10	4.39E-11
Total Risk =	**0.649**	**0.406**	**6.72E-06**	**1.51E-06**
FUTURE I CONDITIONS (*on site*)—Industrial				
RP5: inhalation of soil gas from soil particles	0.001	0.000	6.90E-09	1.55E-09
RP6: inhalation of soil gas from ground water	0.127	0.080	1.32E-06	2.97E-07
RP7: inhalation of soil gas from LNAPL	0.000	0.000	0.00E+00	0.00E+00
RP8: inhalation of surface soil dust	0.000	0.000	1.95E-10	4.38E-11
Total Risk =	**0.128**	**0.080**	**1.33E-06**	**2.99E-07**
FUTURE II CONDITIONS (*on site*)—Industrial				
RP9: inhalation of soil gas from soil particles	0.002	0.002	2.16E-08	7.77E-09
RP10: inhalation of soil gas from ground water	0.398	0.398	4.12E-06	1.48E-06
RP11: inhalation of soil gas from LNAPL	0.000	0.000	0.00E+00	0.00E+00
RP12: inhalation of surface soil dust	0.000	0.000	1.63E-09	5.88E-10
Total Risk =	**0.401**	**0.401**	**4.15E-06**	**1.49E-06**
CURRENT CONDITIONS (*off site*)—Residential				
RP13: inhalation of soil gas from LNAPL	0.021	0.021	7.86E-08	2.47E-08
RP14: inhalation of surface soil dust	0.000	0.000	1.77E-10	5.57E-11
Total Risk =	**0.021**	**0.021**	**7.88E-08**	**2.48E-08**
CURRENT CONDITIONS (*off site*)—Industrial				
RP15: inhalation of soil gas from soil particles	0.000	0.000	3.45E-09	7.77E-10
RP16: inhalation of soil gas from ground water	0.064	0.040	6.60E-07	1.48E-07
RP17: inhalation of soil gas from LNAPL	0.001	0.001	8.64E-09	1.94E-09
RP18: inhalation of surface soil dust	0.000	0.000	1.95E-11	4.39E-12
Total Risk =	**0.065**	**0.041**	**6.72E-07**	**1.51E-07**
FUTURE I CONDITIONS (*off site*)—Residential				
RP19: inhalation of soil gas from LNAPL	0.000	0.000	0.00E+00	0.00E+00
RP20: inhalation of surface soil dust	0.000	0.000	1.77E-10	5.56E-11
Total Risk =	**0.000**	**0.000**	**1.77E-10**	**5.56E-11**
FUTURE I CONDITIONS (*off site*)—Industrial				
RP21: inhalation of soil gas from LNAPL	0.000	0.000	0.00E+00	0.00E+00
Total Risk =	**0.000**	**0.000**	**0.00E+00**	**0.00E+00**
CURRENT II CONDITIONS (*on site*)—Industrial**				
Total Risk =	**zero**	**zero**	**zero**	**zero**

*Results in table are rounded off to 3 significant figures. HIs listed as 0.000 are <0.001 but not zero. Cancer risk listed as 0.00E+00 is zero (concentration of carcinogenic constituent is zero).

**No risk because there is no complete route–pathway (full on-site control).

ES 2 Hazard Index (UCL) for Each Compound by Route-Pathway
Current Conditions Industrial On Site (RP-1, RP-2, RP-3, & RP-4)



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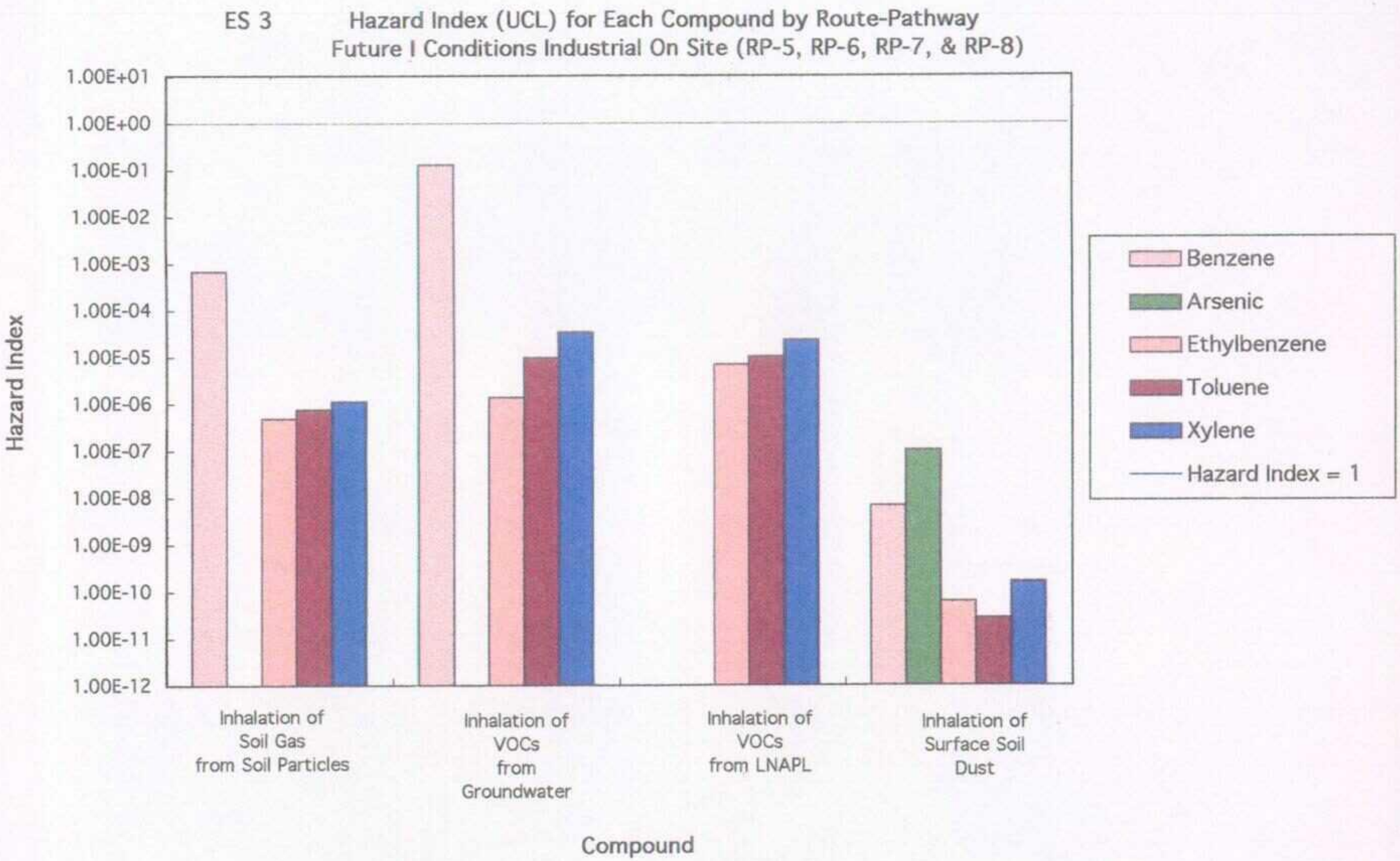

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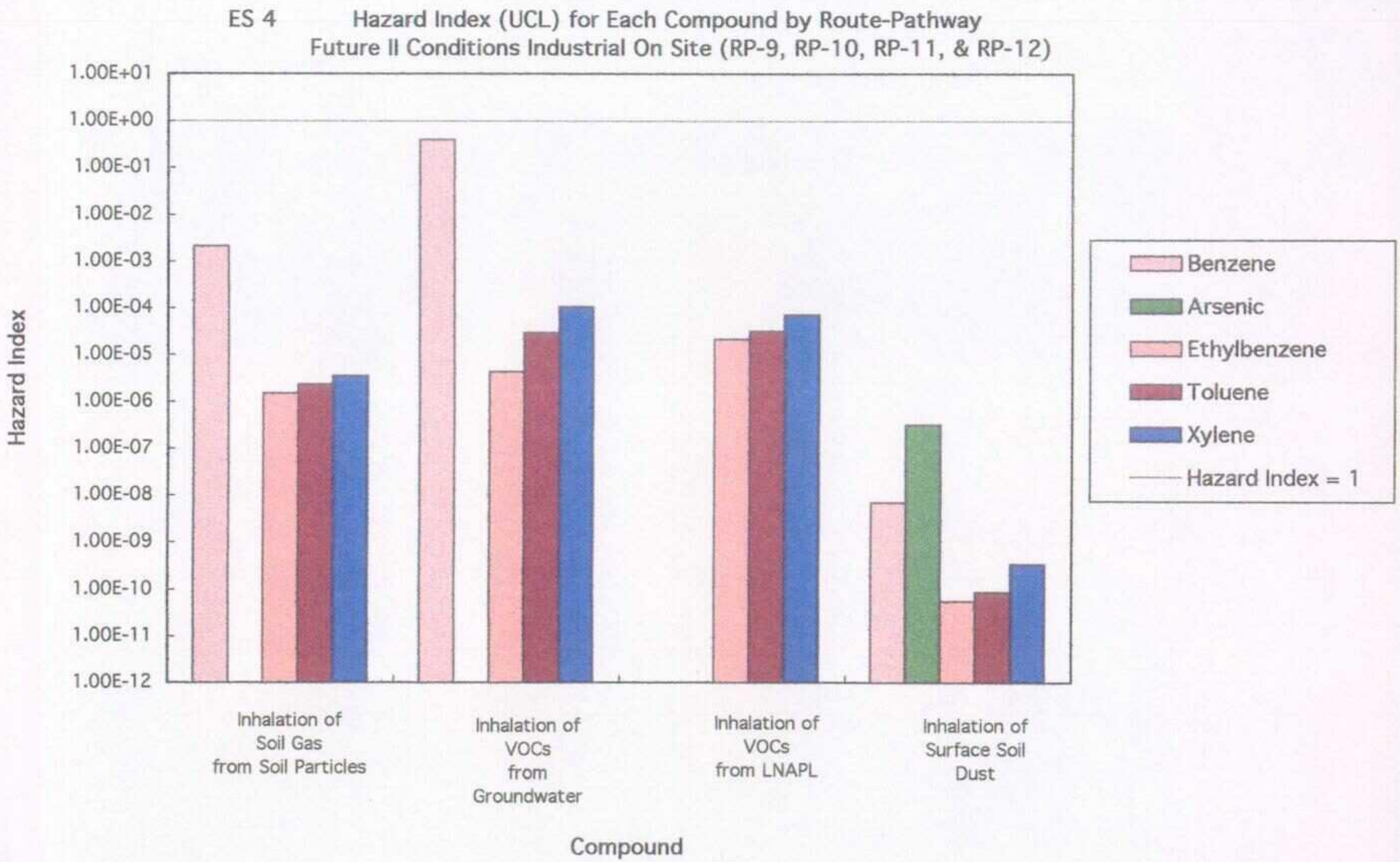

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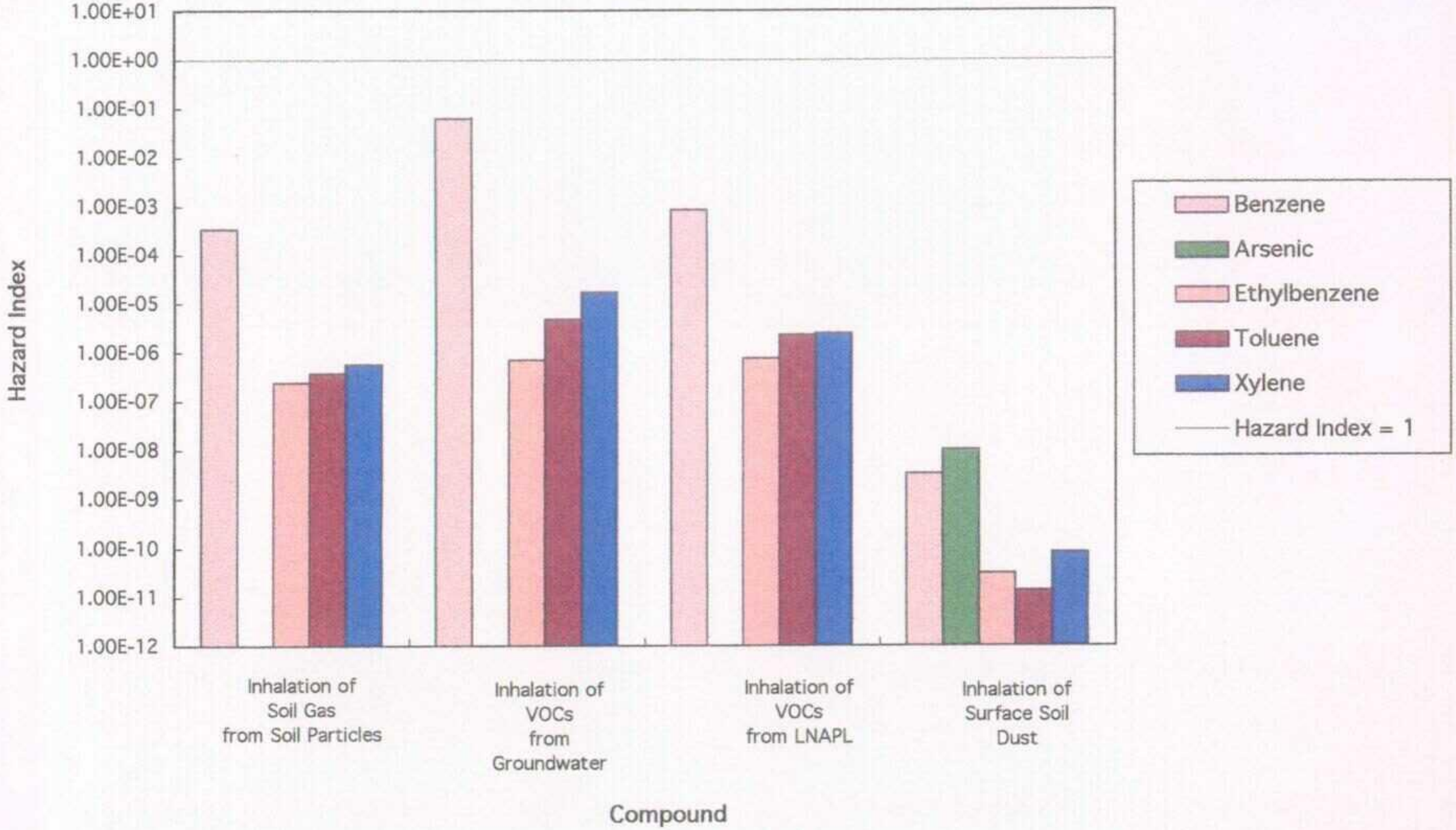
ES 5 Hazard Index (UCL) for Each Compound by Route-Pathway
Current Conditions Industrial Off Site (RP-15, RP-16, RP-17, & RP-18)



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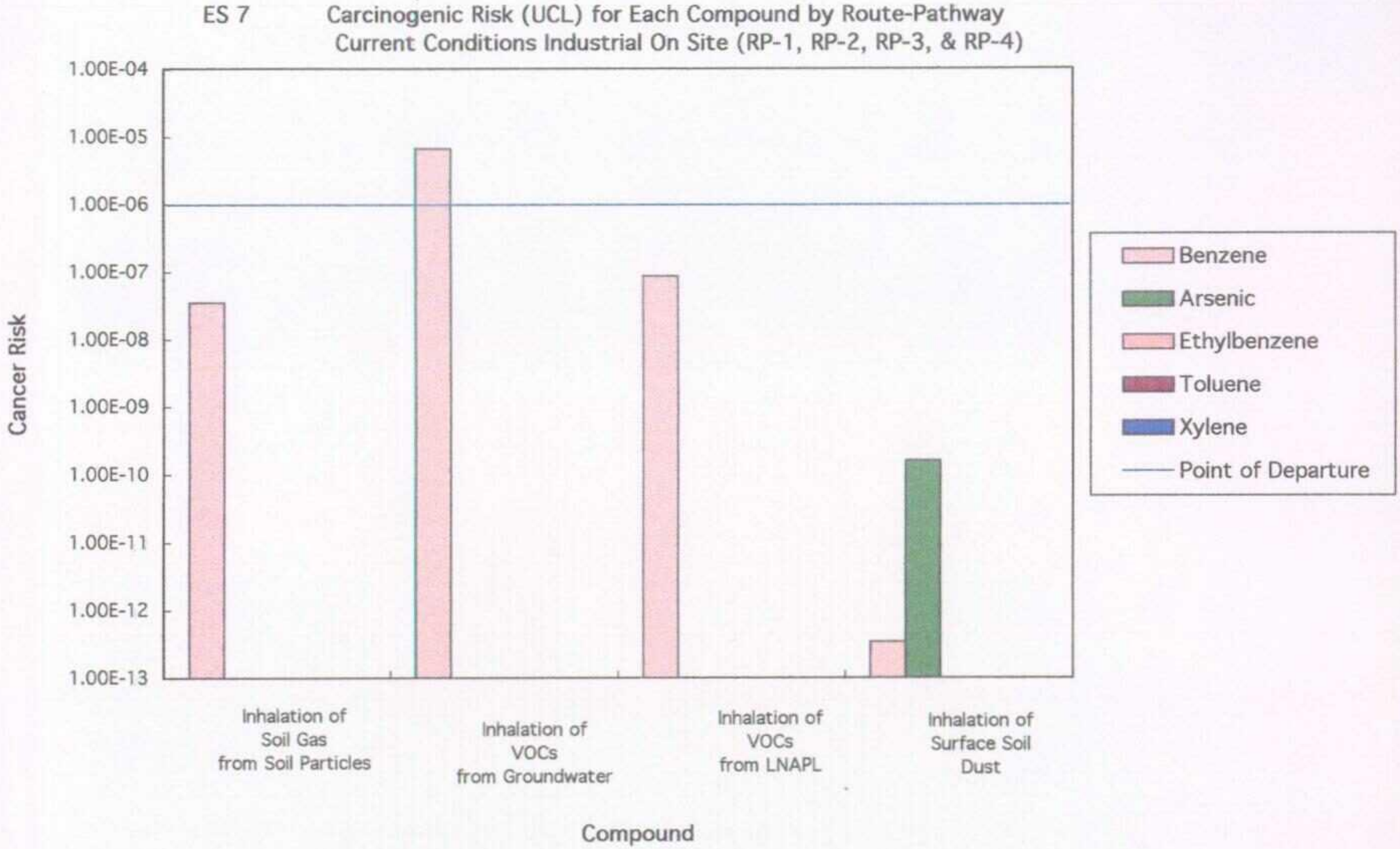
ES - 6 Lead Risk Assessment Results*
For all exposure media

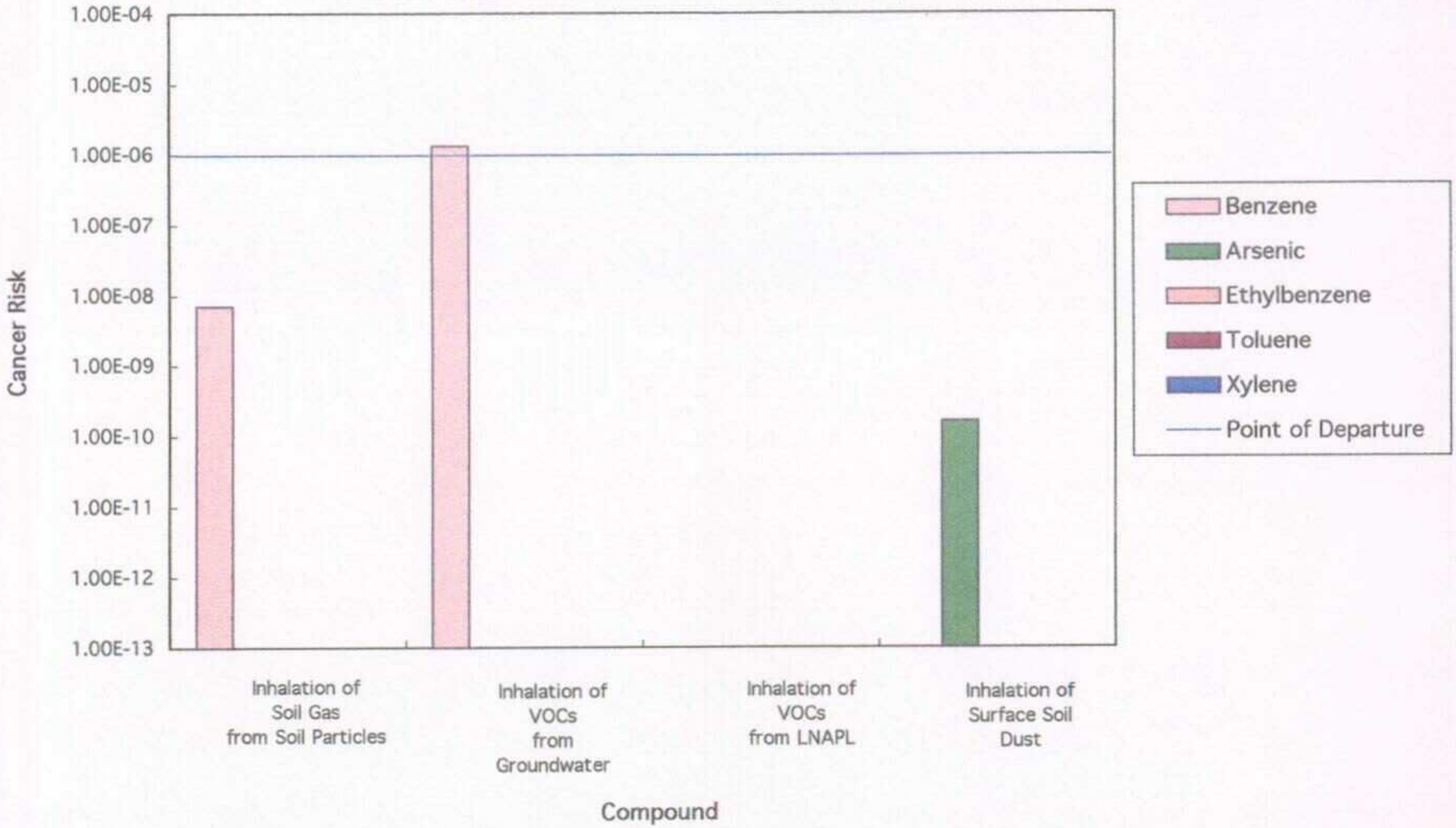
			PERCENTILE				
			50th	90th	95th	98th	99th
maximum concentration of lead in soil	74 mg/kg	blood lead, µg/dL, adult	1.1	1.6	1.9	2.2	2.4
		blood lead, µg/dL, child	2.7	4.2	4.8	5.5	6.1

* Results estimated from EPA's Uptake Biokinetic Model. A maximum concentration of 74 mg/kg of lead in soil was used to estimate the percent of exposed children and adults estimated to have blood lead levels exceeding EPA's 10 µg/dL threshold level at the 95th percentile upper confidence level.



g:\rexwork\ESR7.XLS

ES 8 Carcinogenic Risk (UCL) for Each Compound by Route-Pathway Future I Conditions Industrial On Site (RP-5, RP-6, RP-7, & RP-8)



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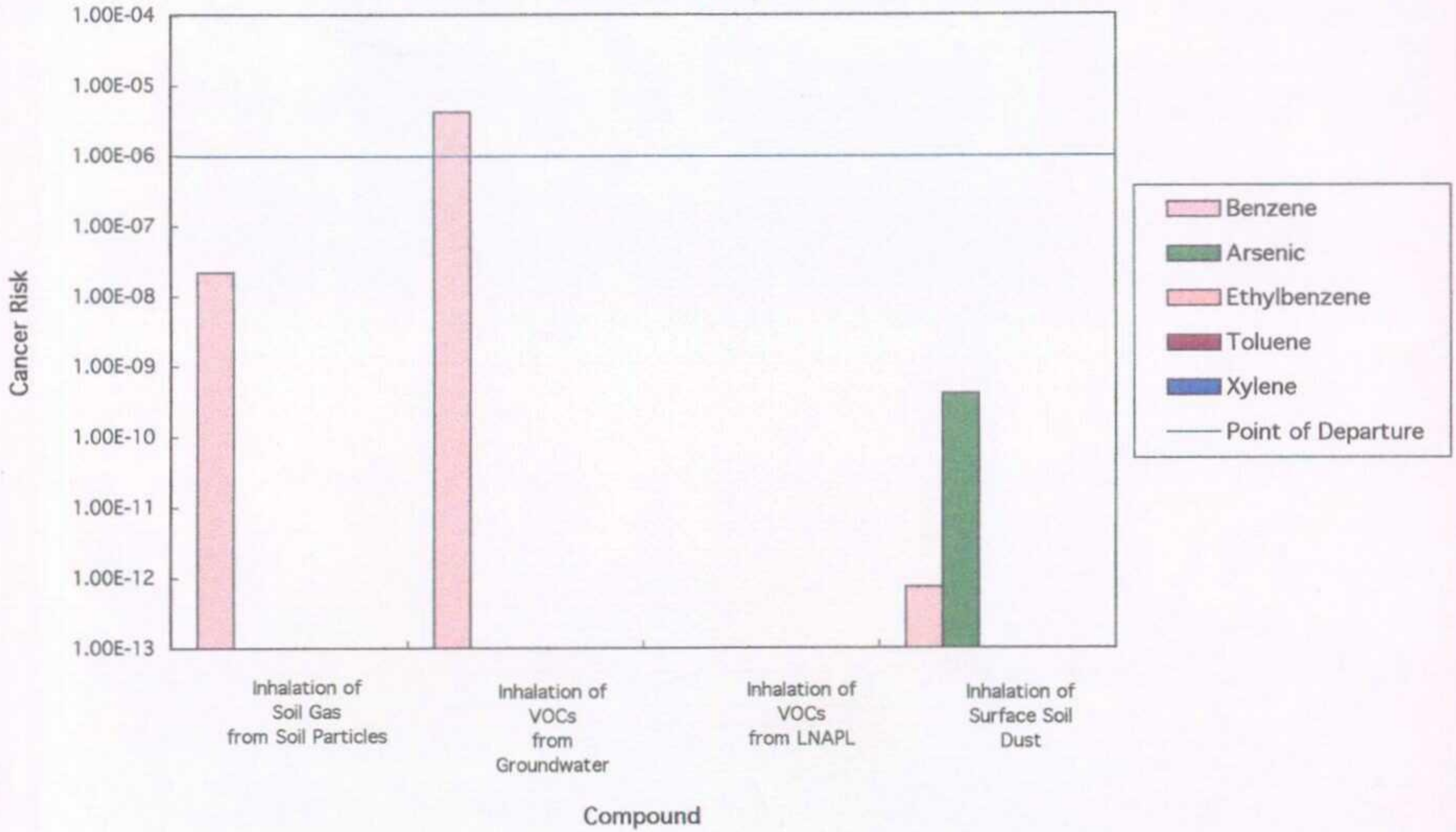
ES 9 Carcinogenic Risk (UCL) for Each Compound by Route-Pathway
Future II Conditions Industrial On Site (RP-9, RP-10, RP-11, & RP-12)



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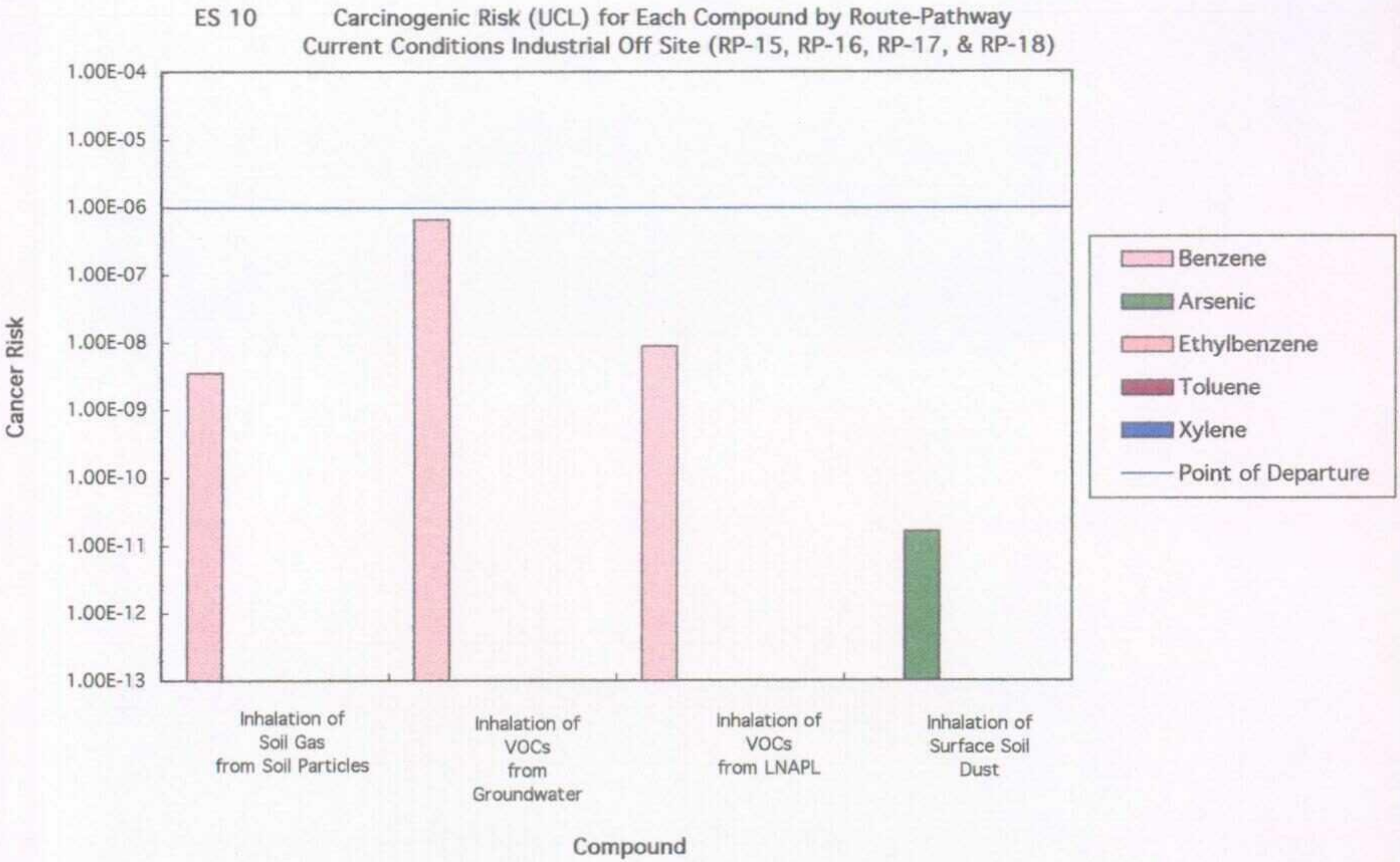

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2.0 Site History

Located in Sunland Park, New Mexico, the Brickland Refinery site consists of approximately 35 acres next to the Rio Grande (Figure 1). From 1933 to 1958, the site was operated as a petroleum refinery. Rexene currently owns the site and operated it from 1955 to 1958. No refinery operations have been conducted for approximately 37 years and virtually all processing equipment and buildings associated with refinery activities have been dismantled and removed. All that remains on site are concrete foundations and rubble. Releases of hydrocarbons during the operational life of the facility resulted in varying impacts to soil and groundwater at the site. The nature and extent of releases were initially investigated by Eder and Associates (Eder and Associates, 1990), and further quantified by GCL (GCL, 1994).

In 1989, the former New Mexico Environmental Improvement Division (NMEID), conducted a Screening Site Inspection (SSI) (NMEID, 1989). The findings of the SSI were submitted to the EPA Region VI for review and possible inclusion on the Superfund National Priority List (NPL). However, Region VI concluded the site did not warrant inclusion on the NPL and ceded jurisdiction to the state of New Mexico.

New Mexico jurisdiction resides within the statutory and regulatory authorities of the New Mexico Water Quality Control Commission (WQCC). Because a refinery formerly occupied the site, WQCC jurisdiction is administered by the New Mexico Oil Conservation Division (NMOCD).

2.1 Nature of Releases

During the refinery's operation, hydrocarbon releases apparently originated from spills and leaks in storage tanks and underground piping between refinery units. Leaking pipes and tanks were either repaired or replaced, as necessary. The refinery recovered released hydrocarbons by excavating small pits and removing the accumulated material with a vacuum pump. The recovered hydrocarbon was reprocessed or returned to storage, depending on its condition.

2.2 Activities

The Brickland Refinery was operated from 1933 to 1958 and processed crude oil into consumer-oriented petroleum products. Typical refinery operations identified at the site in the 1950s included:

- "Petreco" de-salting to remove salt and water from crude oil feed stock.
- Single-column crude oil distillation.
- Thermal cracking of "heavy" (high boiling point) distillation ends.
- Polymerization of "light" (low boiling point) distillation ends into gasoline range fractions.
- Platformer reforming of naphtha range fractions into higher octane products (added in early 1950s).
- Clay tower filtration of some petroleum fractions.
- Gasoline and kerosene treatment.
- Tetra ethyl lead blending.

Finished products were stored in tanks on the site (Eder and Associates, 1990).

In 1958, the Brickland Refinery processed approximately 4,000 barrels of crude oil feed stock each day. By comparison, a typical larger refinery processed 168,000 barrels each day of crude oil feed stock in 1958 (Eder and Associates, 1990). The Brickland Refinery was relatively small.

2.3 General Site Conditions

The site is adjacent to the Rio Grande, and is presently vacant except for foundations from former refinery structures. Some construction and demolition debris is present on the site, including concrete from the refinery structures and rubble from road construction. Native vegetation grows over most of the site, but is more concentrated at the northern portion of the property.

The site adjoins several private and government land parcels. A railroad track owned by the Union Pacific Railroad and a small parcel of privately owned vacant land are located to the south and west along the base of Mount Cristo Rey. A private residence is located directly north of the site. The International Boundary Water Commission (IBWC) owns a small strip of land between the site and the Rio Grande.

Climate in the lower Mesilla Valley is characterized as arid continental with wide temperature ranges, low humidity, high evaporation, and low precipitation. Precipitation occurs mostly as rain; about one-half of the total annual precipitation occurs from July to September. Rainfall during these three months is usually from brief, intense thunderstorms (Eder and Associates, 1990). Annual precipitation at the site averages 10 inches per year. Pan evaporation is in excess of 90 inches per year and much of the precipitation evaporates.

2.4 Previous Site Investigations

In response to a neighbor's complaint about the death of shade trees on his property, located just north of the site, the NMEID conducted an SSI (NMEID, 1989). The NMEID concluded that the results of soil and groundwater sampling indicated the presence of many Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) substances on site, some of which had migrated to groundwater. The NMEID did not observe releases to surface water. In addition, no groundwater users were identified within three miles of the site.

Releases of hydrocarbons do not extend into the northern portion of the site. In addition, groundwater flow from beneath the site is to the south or southeast. Therefore, hydrocarbon releases at the site can be eliminated as a cause for the death of the shade trees.

In 1990, Rexene selected Eder and Associates to conduct an expanded Phase I investigation of the site (Eder and Associates, 1990). The investigation focused on determining the nature and extent of hydrocarbon releases to subsurface soils and groundwater beneath the site. This investigation included 15 monitoring wells, 24 soil borings, 91 backhoe test pits, and the collection of 20 surface soil, hand auger, river, and stream-bank samples. Some general conclusions of this report were:

- "Ambient groundwater chemistry would be characterized as saline and would not meet drinking water standards without regard to the petroleum-related contaminants found beneath the former refinery."

- " A review of the available data and reports for the 3-mile radius from the site did not reveal any drinking water wells that could intercept groundwater from the site. Surface water samples collected from the Rio Grande at points upstream, adjacent to, and downstream of the site were essentially indistinguishable in chemical quality."

- "There does not appear to be significant human or environmental exposure to this contamination. Heavy metals found in the soil appear to be chemically bound to the soil and are not readily leaching into the groundwater. Groundwater does contain dissolved volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs), which relate to petroleum, however, no halogenated or solvent-related VOCs were found."

GCL conducted a remedial investigation at the site in June and July of 1994 (GCL, 1994). The objectives of this investigation were to better characterize the chemical, physical, and biological properties of site soils to determine the influence these factors might have on natural degradation, dispersion, and attenuation of hydrocarbon constituents and to evaluate potential remedial actions appropriate for site conditions.

As part of the investigation, GCL completed 14 soil borings, excavated six test trenches, and installed four monitoring wells and numerous well points. The screened interval of all monitoring wells and well points at the site are shown on Figure 2 and listed on Table 1. Over 100 soil samples were collected as part of the investigation. These samples were used to characterize the geological, chemical, physical, and biological subsurface conditions. The results also provided an estimate of the vertical and horizontal extent of hydrocarbons occurring in the subsurface. The results of this investigation are summarized in Section 3.0. Detailed descriptions can be found in the Remedial Investigation Report for the Former Brickland Refinery (GCL, 1994).

3.0 Site Characterization

3.1 Hydrogeology

3.1.1 Regional Hydrogeology

The Brickland Refinery site is located at the southern end of the Mesilla Valley near the United States and Mexico border on the western flood plain of the Rio Grande, northeast of the Cerro de Cristo Rey uplift (Figure 1). The southern end of the Mesilla Valley is bounded by the Franklin Mountains on the east and the Cerro de Cristo Rey uplift on the west.

Surficial unconsolidated material in the valley consists of the Quaternary Rio Grande alluvium. This alluvium is estimated to be about 70 to 80 feet thick in the central portions of the valley becoming very thin near the bedrock highs at valley margins. Below the alluvium is the folded Muleros formation comprised of shaley limestones and siltstones.

Groundwater occurs within the alluvium with a regional groundwater flow direction toward the southeast. Sources of groundwater are from upgradient throughflow, upland runoff, direct infiltration of precipitation, and recharge from the Rio Grande when, during high-flow times, it is a losing stream. Groundwater discharges in the valley are primarily pumpage, evapotranspiration, downgradient throughflow, and discharge to the river at low-flow times, when the river is a gaining stream. Surface water is dominated by the Rio Grande whose flow is predominantly controlled by upstream Elephant Butte and Caballo reservoirs (Lovejoy, 1976).

3.1.2 Site Hydrogeology

The site is situated on Quaternary alluvial deposits of the Rio Grande consisting of clay, silt, sand, and gravel. According to soil borings, trenching operations, and monitoring well lithologic logs, the sediments at the site can be placed into two general categories: shallow, thin-interbedded heterogeneous clastic sediments and deeper homogeneous sands. The shallow lithology occurs from the surface to approximately 15 feet below ground surface (bgs), as shown in the lithologic descriptions (Appendices A, B) and geologic cross-sections (Plates A, B, C). The deeper lithology is observed in the deepest borehole at about 30 to 35 feet bgs.

The shallow lithology consists of thin-bedded, fine-grained sand, silt, and silty clays. The deeper lithology consists of fine-grained sand characterized by well-sorted, subrounded sand grains that appear to coarsen with depth.

Groundwater beneath the site occurs under confined to unconfined conditions, and much of the shallow groundwater occurs in thin lenses of silt and fine sand interbedded with clay-rich sediments that do not readily transmit water. The depth to water measured in monitoring wells ranges from about 1.7 to 11.4 feet bgs; water level elevations are listed in Table 2 for each quarter. The water table varies up to about 3.5 feet with levels typically highest in summer and lowest in winter, which is attributable to changes in flow in the Rio Grande. Plots of water levels versus time for individual monitoring wells are included in Figure 3 and Appendix C.

Groundwater flows primarily from the northwest to southeast under a very shallow hydraulic gradient of about 0.0007 to 0.0010 feet/foot in the northern and southern portions of the site, respectively. A groundwater elevation contour map for June 1995 is shown in Figure 4. Groundwater flow velocity within the shallow materials is estimated at about 14 to 20 feet per year. Based on water level differences in monitoring well clusters (deep and shallow), small vertically downward and upward hydraulic gradients have been observed. However, they are insignificant and groundwater primarily flows in a horizontal direction.

Surface water is controlled by the Rio Grande, which is located on the eastern boundary of the site. River flow rates between 1990 and 1995 average approximately 700 cubic feet per second (cfs). During high flow times of the year, the river will recharge the shallow aquifer, and, during low-flow times, the aquifer will recharge the river.

Slug test results show an average hydraulic conductivity of 14 feet per day for the shallow interbedded sands, silts, and clays. The slug test data and results are in Appendix D. An overall porosity of 25 percent is assumed to be representative of such materials (McWhorter and Sunada, 1977).

3.2 Soil

Most of the information on site soils was collected in June and July of 1994 and reported in GCL's Remedial Investigation Report (GCL, 1994). Fourteen boreholes were drilled and six trenches were excavated. Lithologic logs were compiled for each during field operations. Over 70 soil samples were collected for chemical analysis to further characterize hydrocarbon releases and locate potential source areas contributing to groundwater impacts. Selected soil samples were analyzed for physical and biological properties. The results are briefly summarized in this section. Supporting boring logs and trench diagrams from GCL (1994) are provided in Appendix B and Plates A, B, and C.

To characterize the nature and extent of hydrocarbon releases associated with past petroleum refining operations, soil samples were collected and analyzed for total petroleum hydrocarbons (TPH), BTEX, and PAHs. In addition, soil samples were collected from several areas of the site to identify potential source areas. These samples were analyzed for metals, including arsenic, barium, cadmium, chromium, lead, mercury, silver, and selenium.

Total Petroleum Hydrocarbons

Thirty-six samples were collected from across the site and analyzed for TPH to provide a general indication of the total aromatic, aliphatic, and paraffinic components of hydrocarbon constituents in soils.

The highest TPH values (greater than 1,000 milligrams/kilogram, or mg/kg) were obtained from samples collected in the central portion of the site. However, the majority of the southern half of the site has also been impacted by hydrocarbon releases. TPH was observed in samples collected from depths ranging from 6 inches to 12 feet below the site surface.

Benzene, Toluene, Ethylbenzene, and Xylenes

Ten soil samples were collected from across the site and analyzed for BTEX components. BTEX includes the lower molecular weight and more volatile hydrocarbon components commonly found in petroleum feedstocks and refined products. Relatively high levels (>10,000 micrograms per kilogram, or µg/kg) of total BTEX concentrations were detected in samples collected near the center of the site. Samples from the site had total BTEX concentration levels ranging up to 219 mg/kg.

Polycyclic Aromatic Hydrocarbons

Ten soil samples were collected from various locations across the site for PAH analysis. PAHs comprise some of the heavier molecular weight hydrocarbon constituents and are considered semi-volatile compounds. The highest concentrations (greater than 10,000 μg/kg) occur in the central to southern portions of the site.

Metals

Seventeen soil samples were collected for metals analysis to identify potential source areas. As indicated, samples were analyzed for arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. Elevated levels of arsenic, barium, chromium, and lead were found in some soil samples, however, these metals appear to be tightly bound or complexed to soil constituents as evidenced by the low levels observed in Toxicity Characteristic Leachate Procedure (TCLP) analyses and the lack of any statistically significant concentrations in site monitoring wells. Additionally, the concentration observed in samples from the recent site investigation are in the range of background concentrations reported in previous studies (Eder and Associates, 1991).

Barium levels are believed to be indicative of existing background concentrations resulting from volcanic activity associated with the formation of the Rio Grande Rift.

Studies conducted by the El Paso City-County Health Department and the Texas Air Control Board (Appendix E) have indicated that background surface soil metal concentrations are very likely related to airborne deposition from stack emissions at the nearby Asarco smelter. Background concentration levels in areas near the refinery have ranged from 400 to 600 parts per million (ppm) for lead and 20 to 1,100 ppm for arsenic. The quantities of lead and arsenic detected at the Brickland site are believed to have resulted at least in part from smelter operations.

3.3 Groundwater

To document and determine trends in groundwater chemistry, groundwater samples were collected and free-phase hydrocarbon thicknesses were measured on a quarterly basis since December 1993. These samples are briefly summarized below and more extensive discussions can be found in the Remedial Investigation Report (GCL, 1994).

Free-Phase Hydrocarbon

Free-phase hydrocarbon thickness has been measured on a quarterly basis since December 1993. A summary of free-phase hydrocarbon thicknesses are shown on Figure 5 and listed in Table 3. Variations in free-phase hydrocarbon thicknesses over time are shown in Figure 6 for monitoring wells MW-10, WP-25, WP-26S, and WP-27D.

Free-phase hydrocarbon occurs locally and appears to be associated primarily with saturated lenses of silt and fine sand. These lenses are discontinuous throughout the site, and, although somewhat conductive horizontally, have not been found to contain significant volumes of free-phase hydrocarbons. Hydrocarbons occurring in the subsurface in this manner are effectively trapped.

Benzene, Toluene, Ethylbenzene, and Xylenes Concentrations

Quarterly analytical results for BTEX constituents are listed in Appendix F, total BTEX concentrations versus time plots are shown in Appendix G, and the most recent (June 1995) total BTEX concentration contour map can be found in Figure 7. Benzene is shown on Figure 8. Figures 9 and 10 show BTEX concentrations over time in monitoring wells MW-4, MW-6S, MW-8, MW-14, and MW-17. The plots indicate considerable variability in BTEX levels over time, with no clearly defined trends.

Well locations with high BTEX concentrations coincide with areas of known hydrocarbon occurrences in soil. They are associated with historic site operations in the former refinery areas near the west-central portion of the facility and the sludge pond area near the southern boundary of the site.

Monitoring well MW-6S is an off-site groundwater monitoring well located east of the southeastern portion of the site. This well is the only off-site well adjacent to the river that has consistently shown the presence of benzene. MW-6S does not appear to have had an impact on sediments and surface water because benzene has not been observed in sediment and surface water samples.

GCL collected surface water samples from the Rio Grande adjacent to the site to determine if benzene from the site is impacting the Rio Grande. Since sampling of the Rio Grande water over three quarters has failed to detect benzene, direct sampling of soils immediately adjacent to MW-6S and from the nearby river bed was recommended.

It was suspected that samples taken of sediments near the well would contain benzene due to sorption onto clay and silt size fractions within the sediment, if a pathway exists. The analytical results of 20 sediment samples indicate only one analyte, total xylenes, is present at the detection limit (1 parts per billion, or ppb) in the sediments adjacent to the Rio Grande. However, at this low level, xylenes are not a threat to human health or the environment.

Polycyclic Aromatic Hydrocarbons, Phenols, Water Quality Control Commission Metals/Major Cations and Anions

Samples collected during quarterly sampling events have also been analyzed for PAHs, phenols, WQCC metals, and major cations and anions.

PAHs have been detected in MW-5, MW-8, MW-11 and MW-15 and well points located in the interior of the site; results are summarized in Table 5. PAH results for March 1995 are shown in Figure 11. Concentrations have ranged as high as 5,600 ppb at interior locations. Only one off-site well (MW-6S) has shown the presence of any PAHs, which was detected in only one sampling event. Off-site migration of these heavier molecular weight compounds does not appear to be a problem. Quarterly results for individual wells and detected PAH analytes can be found in Figure 12 and Appendix H. Concentration vs. time plots can be found in Appendix I.

Phenols were detected in 10 on-site monitoring wells during the investigation at concentrations as high as 6,000 ppb (Table 6). Phenol results for March 1995 are shown on Figure 13. Phenols have not been detected in off-site wells. Quarterly results for individual wells and analytes can be found in Figure 14 and Appendix J.

Various WQCC metals have been detected in monitoring wells during the investigation. However, most have appeared sporadically and no apparent trends have been observed. Aluminum, arsenic, barium, copper, iron, and manganese have appeared most frequently, but the concentrations observed do not pose any environmental problem. Mercury and arsenic results are shown in Figure 15 and 16, respectively. The most significant finding of the metals analyses was the total absence of lead in any monitoring well on or off site. The concentrations observed in site soils appear to be tightly bound or complexed within the naturally occurring clayey/silty soils.

Results from the other metals follow a similar pattern and this analytical suite was dropped from the quarterly monitoring program and has been replaced by an annual surveillance sampling event. Quarterly results for individual wells and WQCC metals can be found in Appendix K.

All major anions and cations have been observed in wells at the site with the exception of nitrate. Chloride and sulfate are above WQCC groundwater standards. However, some of the highest observed concentrations of chloride and sulfate are observed in the upgradient well MW-12. Based on these observations, these parameters were dropped from the quarterly sampling. Quarterly results for individual wells and major ions can be found in Appendix K.

In summary, observed PAH and phenol detections coincide spatially with BTEX values and areas of known hydrocarbon occurrences in the soil. Off-site migration has been minimal and the age of the site (approximately 37 years) indicates that future impacts will be minimal. Metals do not pose a threat to groundwater and are tightly bound within the site soils. The shallow groundwater upgradient of the site is saline and sulfate-rich, suggesting that the shallow groundwater is not suitable as a drinking water source.

3.4 Surface Water

The primary surface water concern at this site is hydrocarbon impacting the Rio Grande via stormwater runoff. No sampling of runoff has been performed to date because there has not been adequate precipitation to overcome infiltration and evaporation to create enough runoff to accumulate an adequate sample volume.

The Rio Grande provides water for a variety of domestic, industrial, and agricultural uses in El Paso. Additional, non-quantified usage by Ciudad Juarez occurs as well. Grab samples have been collected from the river by GCL and Eder and Associates. Analysis of these samples indicated no traces of compounds attributable to the Brickland Refinery. Additionally, the IBWC issued its final report in September 1994 (Appendix L) detailing a major sampling and analysis project along the Rio Grande conducted during 1992 and 1993. Water, sediment, and biota samples were collected from areas upgradient and downgradient of the

Brickland Refinery and analyzed for a number of inorganic and organic compounds. Analytical reports indicate there is no significant difference between results from the upgradient and downgradient sampling location, and no long-term or accumulative impacts have resulted from materials at the site.

Benzene is the primary compound of concern, but it volatilizes and biodegrades readily. Therefore, the concentration of benzene in the upper-most soil horizon is not expected to occur in appreciable amounts that could be transported off-site by storm water.

4.0 Risk Assessment

4.1 Overview

Human health risk assessment provides an estimate of the probability of an adverse effect resulting from exposure to one or more toxic compounds. These adverse effects are directly related to the compound's intrinsic toxicity and the rate of intake into the body. The purpose of the risk assessment was to provide a technical basis for identifying and prioritizing potential risks associated with the Brickland Refinery site.

The risk assessment protocols in this document conform to the EPA guidelines for conducting human health risk assessments (EPA, 1989, 1990, 1991, 1992a, 1992b, 1992c). The detailed procedures used in conducting the health risk assessment and the results are found in Appendix M. The following sections provide an explanation of the methodology and a brief summary of the elements of the health risk assessment process.

The methodology for assessing human health risk from exposure to environmental compounds consists of the following steps (Figure 17).

- Identify Compounds of Concern
  - Evaluate data from all environmental media from investigations at the site
  - Select chemical data for use in the risk assessment
- Exposure Assessment
  - Evaluate exposure route pathways for completeness
  - Identify exposure points and duration
  - Estimate exposure point concentrations
  - Quantify compound intake rate at exposure points
- Toxicity Assessment
  - Identify toxicity values
  - Evaluate non-carcinogenic effects
  - Evaluate carcinogenic effects

- Risk Characterization

    - Risk calculations
    - Combining risks across exposure pathways and multiple components

- Determine uncertainty and assumptions

The individual elements of this methodology are discussed in the sections that follow.

4.2 Identification of Compounds of Concern (COCs)

The compounds of concern in soil are summarized in Table 4. Soil sampling locations are found in Appendix N (Figures F, G, and H). Compounds of concern in groundwater are summarized in Tables 5 and 6. Off- and on-site well locations are found in Figure 4. Compounds of concern detected in the LNAPL are summarized in Table 7.

As part of the analytical method for the compounds of concern, selenium and silver were evaluated. Thus, selenium and silver are listed in Table 4 even though they were never detected in the soil. No inorganic compounds of concern were detected in groundwater.

Total petroleum hydrocarbons (TPH), as such, were not evaluated in the risk assessment. Instead, the individual compounds of concern found in the LNAPL were evaluated as appropriate.

4.3 Exposure Assessment

The objectives of an exposure assessment are to identify actual and potential complete exposure pathways, characterize receptor populations, and estimate the magnitude and rate of exposure at contact points. The most probable routes of human exposure were identified in this step of the risk assessment. The exposure assessment identified two current and two future exposure scenarios for the site assuming existing conditions (Current I); continued normal activities (Future I); the development of the site, such as operation of an on-site museum, including public access (Future II); and existing conditions with administrative and engineering controls installed at the site (Current II). Currently, there are no plans to develop the Brickland Refinery site to uses other than industrial. However, EPA risk assessment guidance documents under the Reasonable Maximum Exposure (RME) methodology (EPA, 1989a), suggest that the risk analysis assume future residential uses for the property. This provides a very conservative approach for estimating potential human health risks and examines potential "worst case" scenarios. The exposure evaluation included:

- Identification of relevant and significant pathways of residential and worker exposure
- Identification of potential receptor locations
- Estimation of exposure point concentrations for each COC in each medium of concern
- Estimation of compound intake rate for all exposure routes.

4.3.1 Exposure Route-Pathways

In order to identify all possible exposure route pathways, anticipated or previously documented activities on or around the site were categorized as occurring either on or off site. On- and off-site activities were then evaluated for site conditions as they currently exist and for two future scenarios. A potential receptor was identified and characterized as being a possible current, on- or off-site receptor, or a possible Future I or Future II on- or off-site receptor. Environmental media likely to be contacted (i.e., air, soil, groundwater, LNAPL) and the potential routes of exposure (i.e., oral, inhalation, dermal) were then identified for each receptor and activity resulting in approximately 189 possible route-pathways.

Appendix O evaluates all possible exposure route-pathways and explains whether they have the potential to be complete (i.e., that a mechanism exists for contaminants to come in contact with a receptor via this pathway).

The selected route-pathways were given an RP designation (RP1 to RP21). RP 22 to RP25 were evaluated for Current II conditions with administrative and engineering controls. The implementation of these controls makes these route-pathways incomplete and further analysis of health risks were not performed for these pathways. Tables 8 and 9 summarize the significant exposure route-pathways that may "occur" and were quantitatively evaluated in this risk assessment.

Exposure route-pathways RP 1 to RP 4 are potentially present at the site under current conditions (Current I), RP 5 to RP 8 (Future I) assume the current conditions do not change in the future, and RP 9 to RP 12 (Future II) assume site development.

Exposure route-pathways RP 13 and RP 14 are potentially present off-site under current residential conditions (Current I). Exposure route-pathways RP 15 to RP 18 represent off-site under current industrial conditions, and RP 19 and RP 20 represent Future I residential off site, whereas RP 21 represents Future I off site industrial conditions.

All of the potential exposure route-pathways that are present in Current I are eliminated in Current II by installing administrative and engineering controls on the site.

The following rationale was used to identify the exposure route-pathways included in the risk assessment and eliminate other route-pathways from further consideration:

Excluded Route-Pathways

- Dermal exposure of workers to groundwater during sampling events is prevented by protective clothing.

- Surface water exposure route-pathways were eliminated based on contaminant transport modeling, river sediment sampling, and results from the IBWC study.

- No receptor locations were identified for ingestion of groundwater and exposure does not exist owing to the absence of off- and on-site drinking water wells.

- Direct exposure of residents and transient visitors to on-site compounds is unlikely to occur due to administrative controls and security.

Included Route-Pathways

- Inhalation by industrial workers of volatile organics originating from soil-gas, soil particles, groundwater, and LNAPL, and organics and inorganics from airborne soil particles.

- Inhalation by residents (adult and child) of volatile organics originating from soil-gas, soil particles, groundwater, and LNAPL, and organics and inorganics from airborne soil particles.

4.3.2 Exposure Points and Durations

Exposure points are the assumed off- and on-site locations where potentially exposed populations may come in contact with detected compounds. Exposure points and potential exposure points for both current and future on- and off-site land use conditions were reviewed.

Water well and adjacent land use surveys were reviewed to identify potential exposure points for the risk assessment. Adjacent land use, on-site activities, and area surface waters were evaluated to identify exposure points for soil, groundwater, and air impacts.

Groundwater is not used as a drinking water source in the immediate vicinity. There are no on-site water wells, and a review of water well and land use surveys indicate that no public, domestic, or industrial water wells are within 0.5-mile radius of the site. Therefore, no exposure points were identified for use of groundwater. Also, future beneficial use of off-site groundwater is unlikely because of the following:

- Municipal water is available.

- Off-site mountains restrict groundwater flow from the site.

- Nearby interstate roadway will make it unlikely that any wells would be installed.

- The shallow groundwater upgradient of the site is saline and sulfate-rich, suggesting that the shallow groundwater is not suitable as a drinking water source.

Surface water from the Rio Grande is diverted 1 mile downgradient from the site for use by the city of El Paso. Additional, non-quantified usage by Ciudad Juarez occurs as well. However, the IBWC report (Appendix L), river sampling, and river sediment sampling indicate that health based standards for the compounds of concern have not been exceeded. Contaminant transport modeling indicates that future exceedances are highly unlikely (Appendix P). Therefore, there are no demonstratable adverse impacts to Rio Grande water quality from the Brickland site. In addition, surface water runoff from precipitation is minimal due to low annual rainfall and high evapotranspiration. Surface water pathways were therefore not considered.

On-site workers may also be exposed to volatile organics and soil particles during installation and inspection of monitoring well and well points and collection of groundwater samples and measurements of water level elevations. Thus, site workers were considered as potential exposure receptors.

Adjacent land use was characterized as primarily undeveloped or rural. The closest residence is approximately 20 feet from the northern perimeter of the site and additional residences are located to the northwest and within a 1-mile radius.

Potential off-site exposure from inhalation of volatile organics and soil particles does exist. Therefore, this was considered as a route-pathway.

Since the maximum concentration of each COC was used as the baseline value for determining health risks, the 95th percentile UCL and mean for route-pathway specific HQs, HIs, and lifetime cancer risks were calculated using an alternate U.S. EPA method (EPA, 1989). This procedure involves varying the exposure duration (ED) to evaluate the 95th percentile UCL and mean exposure risk when using the maximum observed concentration.

4.3.3 Estimation of Exposure Point Concentrations

Potential current and future exposure of workers and residents to compounds was estimated during this phase. EPA approved soil and air dispersion models (Appendix Q) were used to project current and future concentrations in media at exposure locations.

Results of the soil and air dispersion models were used to compute compound intake rates (Section 4.3.4) and are provided in Appendix R.

Many of the on-site inorganic COCs are naturally occurring or the result of off-site impacts. However, they have been included to provide a more complete and conservative risk assessment.

4.3.4 Estimation of Compound Intake Rate

Intake rate is determined by calculating compound-specific exposures for each exposure route-pathway identified in Table 9. These calculated intake rates are based on EPA protocols and are expressed in terms of the mass of compound in contact with the body per unit body mass (e.g., mg compound per kg body mass per day - mg/[(kg body mass)/d]).

A generic equation/algorithm used to calculate intake rate is provided in Appendix Q-1. A description of the specific algorithms used to calculate compound intake rate is in Appendices Q-2 to Q-5 and detailed calculations (spreadsheets) are provided in Appendix R. Table 10 summarizes the physical and chemical parameters used to calculate intake rate.

4.4 Toxicity Assessment

Although the toxicity of a compound depends on the intake quantity and the duration of intake, it is its *intrinsic* toxicity that is the focus of toxicity assessment. Toxicity information for effects on humans is sparse (epidemiology studies, accidental exposures, and workers exposures). In most cases toxicity data come from controlled animal studies and are applied conservatively to humans. This information is published by:

- EPA (including the Integrated Risk Information System [IRIS])
- Health Effects Assessment Summary Table (HEAST): EPA Office of Solid Waste
- Agency for Toxic Substances and Disease Registry (ATSDR): U.S. Department of Health Services
- The Cancer Assessment Group (CAG)
- International Agency for Research on Cancer (IARC)

There are two main kinds of toxicity: *carcinogenic* effects and *non-carcinogenic* effects (usually acute, or short-term, but also intermediate and chronic). This report separates risk estimates into these two classifications. A more detailed discussion of toxicity is in Appendix M. Tables 11a and 11b list toxicity data for the specific COCs identified.

4.5 Risk Characterization

As previously mentioned, risk is estimated from intake rates and toxicity. Specific equations are found in Appendix M.

For cancer risk, estimates are expressed as statistical incremental lifetime cancer risks. These incremental cancer risks indicate that one cancer may result in the specified population if they are exposed to a carcinogenic compound over a 70-year lifetime. This is typically considered to be one additional cancer in a population of one million people (1×10^{-6} or 10^{-6}) and is in addition to the baseline probability of developing cancer from exposure to all other environmental carcinogens, either naturally occurring or man-made.

The National Oil and Hazardous Substance Pollution Contingency Plan, 40 CFR Subpart E, S300.430, states that, "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} to 10^{-6} using information on the relationship between the dose and response. The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure."

Therefore an incremental lifetime cancer risk of 10^{-6} or less is considered protective of human health and the environment at the Brickland site.

For non-cancer risk, the EPA uses a Hazard Quotient (HQ) and Hazard Index (HI) system to qualitatively evaluate potential hazards. The EPA considers a HQ ≤ 1 or HI ≤ 1 as an acceptable non-cancer risk, and no adverse health effects are expected. According to EPA guidelines, an HI ≤ 1 means that it is unlikely for even sensitive populations to experience any adverse health effects from exposure to environmental COCs.

Table 12 summarizes the risk estimates for the related exposure route-pathways, RP1 to RP21. Inhalation of soil-gas, soil particles, and volatiles from LNAPL and groundwater are the only potential routes of exposure at this site.

Cancer Risk

Benzene contributes more than 95 percent of the total cancer risk from all COCs detected at the site. A review of the risk assessment results shows the pathway of concern is the inhalation of volatile organics from groundwater. For the UCL, this exposure route pathway results in an incremental cancer risk factor greater than 10^{-6} in Current I conditions (on site - no controls) - Industrial as RP2, in Future I conditions (on site) - Industrial as RP6, and in Future II conditions as RP10.

Since the inhalation pathway must be addressed, Current II conditions were evaluated to determine potential methods to mitigate exposure from this pathway. It implements on-site administrative and engineering controls to eliminate this pathway. The result is a total incremental cancer risk factor of zero for this pathway. The recommended on-site institutional controls are discussed in Section 6.0.

As discussed in Section 4.3, Future II conditions assumes a museum on the site and estimates the exposure of museum workers (the population with the highest exposure). Since institutional controls are not practical in this situation, this site should not be developed given the current risk assumptions.

Current I conditions (on site - no controls) were re-evaluated to determine what concentration of benzene in groundwater caused the incremental lifetime cancer risk to exceed 10^{-6}. That concentration was determined to be 3 ppm (Table 14), or approximately one order of magnitude below the highest observed benzene concentration observed at the site.

Non-Cancer Risk

Benzene also contributes more than 95 percent of the total non-cancer risk from exposure to all compounds detected at the site, excluding lead. These non-cancer effects include long- and short-term, reversible and irreversible adverse effects such as sub-lethal poisoning, etc. The non-cancer risk HI is below one for all scenarios.

Lead Risk

Non-cancer risks for exposure to lead were evaluated using the EPA Uptake-Biokinetic Model (UBM 1994 [0.99D]). To characterize health risks due to lead exposure, blood-lead concentrations estimated by the UBM model are compared to 10 µg/dL, the concentration of lead in blood believed by the EPA to be without adverse effect. Lead risk is considered acceptable when 95 percent of exposed children are estimated to have blood-lead concentrations below this value (upper 95th percentile confidence statistics). As shown in Appendix R, the percentage of children (typical) estimated to have blood-lead concentrations exceeding 10 µg/dl is considerably less than 1 percent (i.e., when calculations are based on the maximum measured lead-soil concentration 74 mg/kg). This suggests that there is little or no risk from exposure to lead in soil for current and anticipated future land use at the Brickland Refinery site.

4.6 Determining Uncertainty and Risk Assessment Assumptions

4.6.1 Uncertainty (error)

Uncertainties are associated with each step in a health risk assessment and may lead to an underestimation or overestimation of risk. For a complete discussion on uncertainties associated with this risk assessment, refer to Section 2 of the detailed risk assessment (Appendix M).

4.6.2 Assumptions Used in the Risk Assessment

Because many of the parameters used to calculate intake rate and specific toxicity are not accurately known (Table 13), the risk assessment follows conservative guidelines suggested by the EPA and other agencies in deriving estimates for these parameters. This likely overestimates risk and maximizes protection of public health. For a detailed explanation of the assumptions used, refer to Appendix M.

5.0 Conclusions

A site characterization and risk assessment have been conducted at the Brickland Refinery site to determine the current extent and nature of hydrocarbon releases that occurred approximately 37 to 65 years ago and potential risk to public health and the environment. Releases have been confined within the facility and no off site migration has been identified with the exception of low concentrations of BTEX in groundwater at MW-6S. The results of soil and groundwater sampling demonstrate that hydrocarbon releases from this site have not impacted water quality in the Rio Grande. Furthermore, contaminant transport modeling demonstrates that on-site hydrocarbon releases will not impact the Rio Grande in the future as long as the local groundwater conditions remain unchanged.

The health risk assessment presents three scenarios that slightly exceed an incremental lifetime cancer risk of 10^{-6}. The pathway of concern is the inhalation of soil gas from groundwater. Administrative and engineering controls will eliminate this pathway. With the implementation of institutional controls, the risk assessment supports a finding of "No Significant Risk."

The results of the environmental investigations and the health risk assessment are briefly described below.

5.1 Site Characterization

Of the compounds that have been detected to date, the following presented the greatest concerns and were critically examined in subsequent evaluations:

- Hydrocarbon releases in on-site soils and groundwater are restricted to the southern two thirds of the facility.

- Hydrocarbons have been observed off site in MW-6S. However, the absence of hydrocarbon constituents in all other off-site wells and river samples (with the exception of a single sample of total xylenes at the detection limit) indicate that the majority of the on-site compounds are held on-site by the interbedded silty/clayey sediments and the relatively flat, shallow water table. The minor amount of COC migration that occurs is attenuated by biodegradation and dispersion.

- TPH was identified through chemical analysis. However, TPH is not regulated specifically, and the regulated constituents of TPH are addressed in the risk assessment on a compound-specific basis.

- BTEX has been detected to varying degrees in soils and the underlying on-site aquifer. Benzene has been detected in groundwater at concentrations greater than health based standards at only one off-site location (MW-6S). The other BTEX compounds have either not been detected or have been below WQCC standards in off-site monitoring wells.

- No BTEX compounds have been detected in water samples collected from the Rio Grande at locations upgradient and downgradient from the site, and contaminant transport modeling (Appendix P) has shown no significant risk of benzene entering the Rio Grande in the future.

- PAHs and phenols have been detected in soils and the shallow aquifer at the site. None have been detected in off-site monitoring wells since the quarterly sampling program was initiated in December 1993.

- Soil samples collected at the site were analyzed for arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. Measured concentrations of arsenic, barium, chromium, and lead are within background ranges. However, TCLP testing and groundwater monitoring data demonstrate these elements have limited leaching potential and are highly unlikely to migrate to groundwater.

- The quantities of lead and arsenic detected are believed to have resulted at least in part from smelter operations at the nearby Asarco smelter. Concentrations in the upper soil layers are comparable to background concentrations previously reported by Texas city/county and state agencies. Lead has not been detected in any off- or on-site well since the quarterly sampling program was initiated in December 1993 and the concentrations of all other metals are low. All detected metal species appear to be tightly bound to the silts and clays in the subsurface soils.

- Free-phase hydrocarbon has been observed in monitoring well MW-10 and several well points in the immediate vicinity. The recent investigation determined that this free-phase hydrocarbon occurs locally in discontinuous pockets associated with thin, discontinuous, sand lenses. No free-phase hydrocarbons have been observed in off-site wells.

5.2 Risk Assessment

One hundred eighty nine exposure route-pathways were evaluated for potential on- and off-site human exposure through air, soil, groundwater, and surface water routes. After the initial analysis, 21 route-pathways were identified as potentially complete and were included in the health risk assessment.

The risk assessment was constructed to evaluate two current site conditions and two projected "future" scenarios. The risk assessment calculated the combined, incremental adverse health effects (carcinogenic and non-carcinogenic) that might result from exposure to benzene, toluene, ethylbenzene, xylenes, PAHs, phenols, and inorganics (including lead) at concentrations that might occur under current site conditions or future scenarios. Initial COC exposure point concentrations for each media were based on the maximum values found at the site. Results of the risk assessment indicate the following:

- Non-cancer risk (Hazard Indices) for all scenarios was less than 1.

- Benzene contributes more than 95 percent of the total cancer risk from all COCs detected at the site.

- At the UCL of exposure duration, incremental lifetime cancer risk for Current I conditions (no controls) exceeds 10^{-6} due to the potential inhalation of benzene in soil gas from groundwater.

- Future I conditions (i.e. no remedial action and continued intermittent industrial use) reveal a slight risk to human health. The incremental lifetime cancer risk was 1.33×10^{-6}.

- Future II conditions, resulting from hypothetical operation of an on-site museum including public access revealed a "worst" case UCL cancer risk of 4.15×10^{-6} and a non-cancer Hazard Index of 0.401 for potential human exposures under this scenario.

- All off-site scenarios, current and future, had incremental lifetime cancer risks of less than 10^{-6}. Therefore all off-site scenarios, current and future, presented no significant risk to human health.

- Current II conditions (administrative and engineering controls) assume the implementation of institutional controls to eliminate the inhalation of soil gas. This results in an incremental lifetime cancer risk of zero.

- A benzene concentration of 3 ppm or less in groundwater causes the incremental cancer risk for all scenarios, as demonstrated in the recalculation of Current I conditions (Table 14), to be less than 10^{-6} and results in a finding of no significant risk to human health.

6.0 Recommendations

The site characterization has determined that the local hydrogeology works to minimize hydrocarbon migration from the site and limits it to the immediate vicinity with little or no discharge to the Rio Grande. The risk assessment has shown that with minimal administrative and engineering control of the site, the site does not pose a significant threat to human health. Based on these results, the following action is recommended:

- Control access to the site by inspecting and maintaining the existing perimeter fencing on a quarterly basis.

- Require all on-site workers to maintain current health and safety status under 40 CFR 1910.120 and work under the conditions of the site health and safety plan (HASP). At any time that organic vapors exceed the permissible exposure limit (PEL), cited in the HASP, workers must either use a respirator or remove the hazardous material from the site.

- Remove free-phase hydrocarbon from MW-10 to speed up natural "loss" processes.

- Monitor the off-site monitoring wells and selected on-site monitoring wells semi-annually until the highest observed benzene concentrations are less than 3 ppm. After four consecutive monitoring events resulting in no benzene results higher than 3 ppm, and no increases in the other regulated parameters from current conditions, cease all actions and monitoring.

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Table 1
Monitoring Well and Well Point Elevation Data
(feet amsl)

Well ID	Ground Surface	Top of Casing	Top of Screen	Bottom of Screen
Monitor Wells:				
MW-1	3728.87	3730.57	3723.92	3712.17
MW-2	NA	3730.49	NA	NA
MW-3S	3727.81	3730.00	3723.50	3711.43
MW-3D	3727.93	3730.00	3707.00	3695.10
MW-4	3727.50	3728.86	3722.76	3711.76
MW-5	3728.29	3729.70	3725.20	3714.20
MW-6S	3728.46	3730.65	3724.05	3713.05
MW-6D	3728.59	3730.62	3703.12	3690.12
MW-7	3727.75	3728.96	3723.16	3711.50
MW-8	3727.72	3729.22	3724.52	3713.48
MW-9S	3728.24	3730.01	3724.31	3713.31
MW-9D	3728.59	3730.08	NA	NA
MW-10	3731.12	3732.54	3723.54	3712.54
MW-11	3729.84	3731.40	3721.60	3709.10
MW-12	3728.88	3730.35	3713.45	3701.45
MW-13	3729.53	3732.36	NA	NA
MW-14	3727.91	3730.46	3725.46	3709.86
MW-15	NA	3738.62	3724.92	3708.92
MW-16	3734.35	3736.78	3726.78	3710.78
MW-17	3731.98	3731.98	3726.58	3711.88
Well Points:				
WP-1	3730.15	3733.40	3726.99	3721.39
WP-2	3730.40	3731.65	3718.64	3713.04
WP-3	3728.50	3731.17	3726.77	3720.57
WP-4	3727.74	3731.85	3726.84	3721.14
WP-5	3727.58	3731.99	3726.92	3721.22
WP-6	3728.35	3731.70	3727.26	3721.56
WP-7	3730.70	3733.12	3720.71	3715.01
WP-8	3727.00	3729.67	3726.77	3722.07
WP-9	3727.24	3730.89	3725.87	3721.07
WP-10	3727.30	3731.37	3726.51	3722.81
WP-11	3727.49	3731.50	3726.61	3722.91
WP-12	3727.40	3731.35	3726.59	3722.89

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Table 1(Cont'd)

Monitoring Well and Well Point Elevation Data

(feet amsl)

Well ID	Ground Surface	Top of Casing	Top of Screen	Bottom of Screen
Well Points (Cont'd):				
WP-13	3726.72	3730.82	3725.39	3721.69
WP-14	3727.38	3730.50	3726.42	3722.72
WP-15	3729.57	3732.97	3726.31	3722.61
WP-16	3728.60	3730.25	3726.20	3722.50
WP-17	3727.93	3731.28	3726.21	3722.51
WP-18	3727.34	3728.56	3718.34	3714.64
WP-19	3728.29	3729.65	3724.59	3720.87
WP-20	3727.60	3731.46	3726.57	3722.87
WP-21	3727.38	3730.38	3725.90	3722.20
WP-22	3727.50	3728.85	3718.70	3715.00
WP-23	3728.00	3729.11	3724.03	3720.33
WP-24	3727.40	3731.75	3726.77	3721.07
WP-25	3730.48	3733.54	3721.69	3715.99
WP-26S	3730.40	3732.44	3727.15	3721.65
WP-26D	3730.30	3733.28	3717.90	3714.40
WP-27S	3732.77	3736.82	3726.47	3720.97
WP-27D	3732.77	3736.86	3725.46	3721.96
WP-28	3727.39	3731.62	3726.39	3722.79
WP-29	3726.97	3731.19	3725.97	3722.37
WP-30	3729.60	3733.41	3725.20	3719.50
WP-31	3734.47	3737.21	3726.57	3720.97
WP-32	3735.30	3736.80	3726.30	3722.70
WP-33	3729.00	3732.74	3722.65	3716.95
WP-34	3727.20	3731.53	3726.34	3720.74
WP-35	3727.08	3728.71	3723.64	3720.04
WP-36	3726.87	3729.52	3724.50	3720.90
WP-37	3727.70	3730.13	3725.05	3721.45

Notes:

NA = Data not available.

amsl = Above mean seal level.

Table 2
Water Level Elevations in Monitoring Wells
(feet amsl)

Well ID	Jul. 93	Dec. 93	Mar. 94	Jul. 94	Sept. 94	Dec. 94	Mar. 95	Jun. 95
MW-1	3725.78	3724.30	3725.27	3726.54	3725.37	3724.35	NM	3726.66
MW-2	NM	NM	3726.39	3726.54	3725.89	3723.97	NM	3726.81
MW-3S	3725.29	3723.27	3725.20	3725.87	3724.50	3723.44	3725.35	3725.68
MW-3D	3725.22	3723.30	3725.10	3725.78	3724.42	3723.35	3725.26	3725.75
MW-4	3725.21	3723.59	3725.36	3725.56	3724.68	3723.64	3725.56	3725.66
MW-5	3725.11	3723.59	3725.30	3725.88	3724.70	3723.65	3725.40	3725.86
MW-6S	3725.08	3723.78	3724.85	3725.55	3724.20	3723.03	3725.05	3725.53
MW-6D	3725.00	3723.75	3724.82	3725.57	3724.22	3723.00	3725.02	3725.48
MW-7	3725.16	3723.72	3725.16	3725.89	3724.46	3723.16	3725.36	3725.32
MW-8	3725.10	3723.42	3725.12	3725.77	3724.49	3723.45	3725.42	3725.74
MW-9S	3724.84	3723.52	3724.56	3725.29	3723.91	3722.81	3724.81	3725.21
MW-10	P	P	P	P	P	P	P	P
MW-11	3724.91	3722.90	3725.10	3725.75	P	3723.40	3725.35	3725.86
MW-12	3726.09	3724.91	3726.45	3727.05	3725.70	3723.65	NM	3727.15
MW-13	3725.22	NM	NM	3725.82	3724.71	3724.44	NM	3726.05
MW-14	-	-	NM	3726.03	3724.61	3723.58	3725.56	3726.01
MW-15	-	-	NM	3725.62	3724.28	3723.19	3724.97	3725.58
MW-16	-	-	NM	3725.43	3724.06	3722.93	3724.88	3725.44
MW-17	-	-	NM	3725.90	3724.46	3723.36	3725.38	3726.82

Notes:

NM = Not measured.
amsl = Above mean sea level.
P = Product observed.
- = Well was not yet drilled.

Table 3
Free Phase Hydrocarbon Thickness in Monitoring Wells and Well Points
(feet)

Well ID	Sept. 93	Dec. 93	Mar. 94	Jul. 94	Sept. 94	Dec. 94	Mar. 95	Jun. 95
MW-1	-	-	NP	NP	NP	NP	-	NP
MW-2	-	-	NP	NP	NP	NP	-	NP
MW-3S	-	-	NP	NP	NP	NP	NP	NP
MW-3D	-	-	NP	NP	NP	NP	NP	NP
MW-4	-	-	NP	NP	NP	NP	NP	NP
MW-5	-	-	NP	NP	NP	NP	NP	NP
MW-6S	-	-	NP	NP	NP	NP	NP	NP
MW-6D	-	-	NP	NP	NP	NP	NP	NP
MW-7	-	-	NP	NP	NP	NP	NP	NP
MW-8	-	-	NP	NP	NP	NP	NP	NP
MW-9S	-	-	NP	NP	NP	NP	NP	NP
MW-10	5.42	3.58	-	3.45	2.40	2.46	-	2.29
MW-11	-	-	NP	NP	0.05	-	-	0.16
MW-12	-	-	NP	NP	NP	NP	-	NP
MW-13	-	-	-	NP	NP	NP	-	NP
MW-14	-	-	-	NP	NP	NP	NP	NP
MW-15	-	-	-	NP	NP	NP	NP	NP
MW-16	-	-	-	NP	NP	NP	NP	NP
MW-17	-	-	-	NP	NP	NP	NP	NP
WP-1	-	-	-	NP	NP	NP	-	0.16
WP-2	-	-	-	NP	NP	NP	-	NP
WP-3	-	-	-	NP	NP	NP	-	NP
WP-4	-	-	-	NP	NP	NP	-	NP
WP-5	-	-	-	NP	NP	NP	-	NP
WP-6	-	-	-	NP	NP	NP	-	NP
WP-7	-	-	-	NP	NP	NP	-	Trace
WP-8	-	-	-	NP	NP	NP	-	NP
WP-9	0.01	-	-	NP	NP	NP	-	NP
WP-10	-	-	-	NP	0.20	Dry	-	NP
WP-11	0.01	-	-	NP	Dry	Dry	-	Thick
WP-12	-	-	-	NP	Dry	-	-	NP

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Table 3 (Cont'd)
Free Phase Hydrocarbon Thickness in Monitoring Wells and Well Points
(feet)

Well ID	Sept. 93	Dec. 93	Mar. 94	Jul. 94	Sept. 94	Dec. 94	Mar. 95	Jun. 95
WP-13	-	-	-	NP	NP	NP	-	NP
WP-14	-	-	-	NP	Tar	-	-	0.14
WP-15	-	-	-	NP	NP	NP	-	NP
WP-16	-	-	-	NP	In Silt	In Silt	-	NP
WP-17	-	-	-	NP	Dry	Dry	-	NP
WP-18	-	-	-	NP	NP	NP	-	NP
WP-19	-	0.01	-	NP	NP	NP	-	NP
WP-20	-	-	-	NP	Product	NP	-	NP
WP-21	-	-	-	NP	NP	NP	-	NP
WP-22	-	-	-	NP	NP	NP	-	NP
WP-23	-	-	-	NP	NP	NP	-	NP
WP-24	-	-	-	NP	NP	NP	-	NP
WP-25	0.05	0.05	-	0.22	Product	0.20	-	1.56
WP-26S	-	0.12	-	2.20	2.59	1.53	-	NP
WP-26D	-	-	-	NP	NP	NP	-	NP
WP-27S	-	-	-	NP	NP	NP	-	Trace
WP-27D	-	-	-	0.11	0.45	0.49	-	Trace
WP-28	-	-	-	NP	NP	NP	-	NP
WP-29	-	-	-	NP	NP	NP	-	NP
WP-30	-	-	-	NP	NP	NP	-	NP
WP-31	-	-	-	NP	NP	NP	-	NP
WP-32	-	-	-	Dry	Dry	Dry	-	Dry
WP-33	-	-	-	NP	NP	NP	-	NP
WP-34	-	-	-	NP	NP	NP	-	NP
WP-35	-	-	-	NP	NP	NP	-	NP
WP-36	-	-	-	NP	NP	NP	-	NP
WP-37	-	-	-	NP	NP	NP	-	NP

Notes: NP = Not present.
- = Not measured.

Table 4 Concentration of Substances in Soil[a] (mg/kg) - Used in Risk Assessment.

Substance	Mean[b]	Maximum[c]	Detection Limit	Mean[d]																		
				TR-01	TR-02	TR-03	TR-04	TR-05	B-01	B-02	B-03	B-04	B-05	B-06	B-07	B-08	B-09	B-10	B-11	B-12	B-13	B-14
Metals																						
Arsenic	6.11	22.00	0.5	9.00	12.00	3.75	7.75	2.50	10.25	0.25	NS	11.75	NS	NS	NS	NS	NS	2.50	2.50	NS	5.00	NS
Barium	111.31	204.00	0.5	111.33	127.00	136.50	114.50	48.50	158.00	2.10	NS	193.50	NS	NS	NS	NS	NS	136.00	140.00	NS	57.00	NS
Cadmium	0.32	1.10	0.01	0.43	0.50	0.25	0.43	0.25	0.25	0.005	NS	0.68	NS	NS	NS	NS	NS	0.25	0.25	NS	0.25	NS
Chromium	6.93	11.00	0.01	7.76	10.00	7.50	6.50	4.00	9.50	0.005	NS	9.50	NS	NS	NS	NS	NS	7.00	6.50	NS	8.00	NS
Lead	17.23	74.00	0.05	24.00	55.00	6.50	9.50	5.00	40.50	0.025	NS	27.50	NS	NS	NS	NS	NS	2.50	6.00	NS	13.00	NS
Mercury	0.08	0.41	0.003	0.10	0.05	0.05	0.17	0.05	0.10	0.0015	NS	0.23	NS	NS	NS	NS	NS	0.05	0.05	NS	0.05	NS
Selenium	ND	ND	0.1																			
Silver	ND	ND	0.01																			
PAH																						
1-Methylnaphthalene	11.954	79.0	0.99	1.8	12.0	7.4	5.3	0.495	0.495	NS	NS	NS	6.2	NS	NS	NS	NS	4.7	79.0	NS	NS	2.2
2-Methylnaphthalene	20.329	160.0	0.99	3.0	12.0	10.5	0.495	0.495	0.495	NS	NS	NS	9.5	NS	NS	NS	NS	3.0	160.0	NS	NS	3.8
Napthalene	6.653	51.0	0.99	2.4	0.495	5.0	0.495	0.495	0.495	NS	NS	NS	3.6	NS	NS	NS	NS	0.495	51.0	NS	NS	2.1
Phenanthrene	0.676	2.3	0.99	0.495	0.495	0.495	0.495	0.495	0.495	NS	NS	NS	0.495	NS	NS	NS	NS	2.3	0.495	NS	NS	0.495
Pyrene	0.726	17.0	0.99	0.495	0.495	0.495	1.7	1.6	0.495	NS	NS	NS	0.495	NS	NS	NS	NS	0.495	0.495	NS	NS	0.495
BTEX																						
Benzene	6.40	24.00	0.125	13.00	13.00	24.00	0.0625	0.063	0.0625	NS	NS	NS	12.00	NS	NS	NS	NS	0.0625	0.0625	NS	NS	1.70
Toluene	2.00	10.00	0.125	2.70	3.80	10.00	0.0625	0.09	0.0625	NS	NS	NS	2.80	NS	NS	NS	NS	0.34	0.0625	NS	NS	0.0625
Ethylbenzene	9.96	65.00	0.125	23.00	1.60	65.00	0.20	0.24	0.0625	NS	NS	NS	6.60	NS	NS	NS	NS	0.29	0.0625	NS	NS	2.50
Xylenes	18.63	120.00	0.125	33.00	8.90	120.00	0.92	0.44	0.0625	NS	NS	NS	16.00	NS	NS	NS	NS	1.50	2.80	NS	NS	2.70

[a] Appendix N figures F, G and H show sampling location.
[b] Mean concentration from GCL remedial investigation (Appedix N, Figure F G and H).
[c] Maximum concentration from GCL remedial investigation (Appendix N, Figure F, G and H).
[d] Mean concentration of specific borehole / trench at various depths.
Note: All NDs for PAH, BTEX and metals except selenium and silver were assigned half the detection limit. Selenium and silver were never detected.
NS = Not Sampled
ND = Not Detected

Table 5 Off-site Mean Concentration of BTEX and PAH in Groundwater (µg/L)[a] - Used in Risk Assessment.

Organic Substance	Mean[b]	Maximum[c]	Detection Limit	Mean[d] MW-1	MW-3S	MW-3D	MW-6S	MW-6D	MW-9S	MW-12
BTEX										
Benzene	10.760	220.000	0.500	0.460	0.329	0.300	92.686	0.250	0.250	0.525
Toluene	0.396	7.000	0.100	0.050	0.743	0.050	1.436	0.050	0.050	0.050
Ethylbenzene	4.030	180.000	0.500	0.250	0.250	0.250	48.607	0.250	0.250	0.250
Xylenes	4.379	260.000	0.500	0.250	2.786	0.250	59.300	0.443	0.350	0.250
2,4-Dimethylphenol	ND	ND	10.000							
Phenol	ND	ND	10.000							
PAH										
Fluorene	ND	ND	10.000							
1-Methylnaphthalene	ND	ND	10.000							
2-Methylnaphthalene	ND	ND	10.000							
Naphthalene	5.000	15.000	10.000	5.000	5.000	5.000	6.429	5.000	5.000	5.000
Phenanthrene	ND	ND	10.000							
Pyrene	ND	ND	10.000							

[a] Refer to figure 4 for well location

[b] Mean of all analytical data (4th quarter 1993 through 2nd quarter 1995)

[c] Maximum of all analytical data (4th quarter 1993 through 2nd quarter 1995)

[d] Mean off-site specific well concentration

Note: NDs for BTEX and Naphthalene were assighed half the detection limit. Fluorene, 1-Methylnaphthalene, 2-Methylnaphthalene, Phenanthrene and Pyrene were never detected.

ND = Not Detected

Table 6 On-site Mean Concentration of BTEX, Phenols and PAH in Groundwater (µg/L)[a] - Used in Risk Assessment.

Organic Substance	Mean[b]	Maximum[c]	Detection Limit	Mean[d] MW-2	MW-4	MW-5	MW-7	MW-8	MW-11	MW-14	MW-15	MW-16	MW-17
BTEX and Phenols													
Benzene	2295.561	23000.000	0.500	0.250	623.375	5320.000	33.500	8860.000	33.050	7586.000	198.000	0.250	420.200
Toluene	8.930	160.000	0.100	3.640	2.042	68.820	0.050	0.050	0.630	0.050	0.050	0.050	4.640
Ethylbenzene	7.746	70.000	0.500	0.840	13.717	24.750	1.290	0.250	2.870	5.200	11.417	0.250	24.250
Xylenes	70.106	1100.000	0.500	10.000	0.250	226.000	1.120	364.150	3.360	0.250	24.417	1.500	15.570
2,4-Dimethylphenol	12.556	110.000	10.000	5.000	5.000	7.200	5.000	70.800	5.000	5.000	5.000	5.000	5.000
Phenol	16.111	300.000	10.000	5.000	7.600	5.000	5.000	26.000	5.000	84.200	5.000	5.000	5.000
PAH													
Fluorene	5.132	12.000	10.000	5.000	5.000	5.000	5.000	5.000	6.400	5.000	5.000	5.000	5.000
1-Methylnaphthalene	27.472	165.000	10.000	5.000	15.600	80.600	5.000	40.800	45.600	35.500	30.833	5.000	7.500
2-Methylnaphthalene	14.981	185.000	10.000	5.000	5.000	17.200	5.000	48.000	7.600	35.667	12.000	5.000	6.500
Naphthalene	27.868	235.000	10.000	5.000	5.000	37.400	5.000	138.200	11.000	42.500	20.000	5.000	8.167
Phenanthrene	5.811	32.000	10.000	5.000	5.000	5.000	5.000	5.000	13.600	5.000	5.000	5.000	5.000
Pyrene	6.231	58.000	10.000	5.000	5.000	5.000	5.000	5.000	17.800	5.000	5.000	5.000	5.000

[a] Refer to figure 4 for well location
[b] Mean of all analytical data (4th quarter 1993 through 2nd quarter 1995)
[c] Maximum of all analytical data (4th quarter 1993 through 2nd quarter 1995)
[d] Mean off-site well concentration
Note: All NDs for BTEX, Phenols and PAH were assighed half the detection limit

Table 7 Concentration of Constituents of Concern in LNAPL from MW-10.

Organic Substances	Concentration (mg/kg)	Detection Limits (mg/kg)
benzene	ND	125
ethylbenzene	210	125
fluorene	ND	990
naphthalene	ND	990
1-methylnaphthalene	2000	990
2-methylnaphthalene	ND	990
phenanthrene	1300	990
phenol	ND	990
2,4-dimethylphenol	ND	990
pyrene	ND	990
toluene	ND	125
xylene (sum: o-, m-, p-)	540	125

ND = Not Detected.

TABLE 8
RECEPTOR EXPOSURE CONDITIONS
Brickland Refinery Site - Sunland Park, New Mexico

1.0 CURRENT I CONDITIONS (on site)[a]

1.1 Residential	--not applicable
1.2 Industrial	--service workers, excavation or drilling contractors
1.3 Visitors	--not applicable
1.4 Nonresidential[b]	--not applicable

2.0 FUTURE I CONDITIONS (on site)[c]

2.1 Residential	--not applicable
2.2 Industrial	--service workers, excavation or drilling contractors
2.3 Visitors	--not applicable
2.4 Nonresidential	--not applicable

3.0 FUTURE II CONDITIONS (on site)[d]

3.1 Residential	--not applicable
3.2 Industrial	--service workers, warehouse workers, vehicle drivers
3.3 Visitors	--visitors to museum
3.4 Nonresidential	--not applicable

4.0 CURRENT CONDITIONS (off site)

4.1 Residential	--nearby family homes
4.2 Industrial	--service workers, excavation or drilling contractors
4.3 Visitors	--visitors to nearby family homes
4.4 Nonresidential	--not applicable

5.0 FUTURE I CONDITIONS (off site)

5.1 Residential	--nearby family homes
5.2 Industrial	--service workers, excavation or drilling contractors
5.3 Visitors	--visitors to nearby family homes
5.4 Nonresidential	--not applicable

6.0 CURRENT II CONDITIONS (on site)[e]

6.1 Residential	--not applicable
6.2 Industrial[f]	--not applicable
6.3 Visitors	--not applicable
6.4 Nonresidential	--not applicable

a Current I scenario assumes site conditions as they exist at present
b Nonresidential workers are workers that are neither industrial, residential or visitors (e.g. agricultural or orchard workers)
c Future I scenario assumes site conditions in 10 years with continued normal operation.
d Future II scenario assumes that there will be a museum on site.
e Current II scenario assumes full on-site control
f Use of respirators by workers if permissible exposure limit (PEL) is exceeded or as stipulated in the health and safety plan

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Table 9 EXPOSURE ROUTE–PATHWAYS (RP)

RP Number	Condition	Receptor	Intake Route	Intake Matter	Algorithm
1	current, on site	industrial	inhalation	soil gas from soil particles	Appendix Q–2
2	current, on site	industrial	inhalation	volatiles from groundwater	Appendix Q–3
3	current, on site	industrial	inhalation	volatiles from LNAPL	Appendix Q–4
4	current, on site	industrial	inhalation	surface soil dust	Appendix Q–5
5	future I, on site	industrial	inhalation	soil gas from soil particles	Appendix Q–2
6	future I, on site	industrial	inhalation	volatiles from groundwater	Appendix Q–3
7	future I, on site	industrial	inhalation	volatiles from LNAPL	Appendix Q–4
8	future I, on site	industrial	inhalation	surface soil dust	Appendix Q–5
9	future II, on site	industrial	inhalation	soil gas from soil particles	Appendix Q–2

Table 9 (continued)

10	future II, on site	industrial	inhalation	volatiles from groundwater	Appendix Q–3
11	future II, on site	industrial	inhalation	volatiles from LNAPL	Appendix Q–4
12	future II, on site	industrial	inhalation	surface soil dust	Appendix Q–5
13	current, off site	residential	inhalation	volatiles from LNAPL	Appendix Q–4
14	current, off site	residential	inhalation	surface soil dust	Appendix Q–5
15	current, off site	industrial	inhalation	soil gas from soil particles	Appendix Q–2
16	current, off site	industrial	inhalation	volatiles from groundwater	Appendix Q–3
17	current, off site	industrial	inhalation	volatiles from LNAPL	Appendix Q–4
18	current, off site	industrial	inhalation	surface soil dust	Appendix Q–5
19	future I, off site	residential	inhalation	volatiles from LNAPL	Appendix Q–4
20	future I, off site	residential	inhalation	surface soil dust	Appendix Q–5
21	future I, off site	industrial	inhalation	volatiles from LNAPL	Appendix Q–4

Table 10 PARAMETERS[#] USED IN CALCULATION OF INTAKE RATE

Substance	MMi	pi* mmHg (20°C)	D_i air** cm^2/s	H** unitless (20°C)
benzene	78	95.0	8.70E–02	2.49E–01
ethyl benzene	106	9.5	6.60E–02	2.87E–01
fluorene	166	5.5E–03	6.34E–02	2.86E–03
naphthalene	128	8.7E–01	5.90E–02	5.78E–02
1-methyl naphthalene	142	4.5E–02[a]	4.40E–02[b]	1.25E–02[c]
2-methyl naphthalene	142	4.5E–02[a]	4.40E–02[b]	1.42E–02[c]
phenanthrene	178	2.5E–06	5.20E–02	7.11E–03
phenol	94	1E–01[a]	8.00E–02	5.73E–06[c]
2,4 dimethyl phenol	122	1E–02[a]	6.00E–02[b]	1.61E–06[c]
pyrene	202	2.5E–06	4.80E–02	2.28E–04
toluene	92	28.1	7.80E–02	2.84E–01
xylene *(mean: o-,m-,p-)*	106	7.7	7.20E–02	3.15E–01

[#] parameters defined in Appendix N
*review of chemical, physical, and toxicologic properties of components of TPH
**American Petroleum Institute Risk Assessment Decision Support System (DSS)
[a]value estimated by extrapolation of vapor pressure - temperature relationship
[b]value estimated from molecular structure relationship
[c] Hi′ is estimated from the following relationship: Hi′ = 16.04(MMi)(Pi)/(T[Si]), where Pi = vapor pressure of i (mmHg), T = temperature (Kelvin), and S = solubility of i (mg/L).

TABLE 12 HUMAN-HEALTH RISK SUMMARY*

Brickland Refinery Site, Sunland Park, New Mexico

Exposure Route – Pathway	Noncancer Risk (HI) ucl	Noncancer Risk (HI) mean	Cancer Risk ucl	Cancer Risk mean
CURRENT I CONDITIONS (*on site*)—Industrial				
RP1: inhalation of soil gas from soil particles	0.003	0.002	3.45E-08	7.77E-09
RP2: inhalation of soil gas from ground water	0.637	0.398	6.60E-06	1.48E-06
RP3: inhalation of soil gas from LNAPL	0.008	0.005	8.64E-08	1.94E-08
RP4: inhalation of surface soil dust	0.000	0.000	1.95E-10	4.39E-11
Total Risk =	**0.649**	**0.406**	**6.72E-06**	**1.51E-06**
FUTURE I CONDITIONS (*on site*)—Industrial				
RP5: inhalation of soil gas from soil particles	0.001	0.000	6.90E-09	1.55E-09
RP6: inhalation of soil gas from ground water	0.127	0.080	1.32E-06	2.97E-07
RP7: inhalation of soil gas from LNAPL	0.000	0.000	0.00E+00	0.00E+00
RP8: inhalation of surface soil dust	0.000	0.000	1.95E-10	4.38E-11
Total Risk =	**0.128**	**0.080**	**1.33E-06**	**2.99E-07**
FUTURE II CONDITIONS (*on site*)—Industrial				
RP9: inhalation of soil gas from soil particles	0.002	0.002	2.16E-08	7.77E-09
RP10: inhalation of soil gas from ground water	0.398	0.398	4.12E-06	1.48E-06
RP11: inhalation of soil gas from LNAPL	0.000	0.000	0.00E+00	0.00E+00
RP12: inhalation of surface soil dust	0.000	0.000	1.63E-09	5.88E-10
Total Risk =	**0.401**	**0.401**	**4.15E-06**	**1.49E-06**
CURRENT CONDITIONS (*off site*)—Residential				
RP13: inhalation of soil gas from LNAPL	0.021	0.021	7.86E-08	2.47E-08
RP14: inhalation of surface soil dust	0.000	0.000	1.77E-10	5.57E-11
Total Risk =	**0.021**	**0.021**	**7.88E-08**	**2.48E-08**
CURRENT CONDITIONS (*off site*)—Industrial				
RP15: inhalation of soil gas from soil particles	0.000	0.000	3.45E-09	7.77E-10
RP16: inhalation of soil gas from ground water	0.064	0.040	6.60E-07	1.48E-07
RP17: inhalation of soil gas from LNAPL	0.001	0.001	8.64E-09	1.94E-09
RP18: inhalation of surface soil dust	0.000	0.000	1.95E-11	4.39E-12
Total Risk =	**0.065**	**0.041**	**6.72E-07**	**1.51E-07**
FUTURE I CONDITIONS (*off site*)—Residential				
RP19: inhalation of soil gas from LNAPL	0.000	0.000	0.00E+00	0.00E+00
RP20: inhalation of surface soil dust	0.000	0.000	1.77E-10	5.56E-11
Total Risk =	**0.000**	**0.000**	**1.77E-10**	**5.56E-11**
FUTURE I CONDITIONS (*off site*)—Industrial				
RP21: inhalation of soil gas from LNAPL	0.000	0.000	0.00E+00	0.00E+00
Total Risk =	**0.000**	**0.000**	**0.00E+00**	**0.00E+00**
CURRENT II CONDITIONS (*on site*)—Industrial**				
Total Risk =	**zero**	**zero**	**zero**	**zero**

*Results in table are rounded off to 3 significant figures. HIs listed as 0.000 are <0.001 but not zero. Cancer risk listed as 0.00E+00 is zero (concentration of carcinogenic constituent is zero).

**No risk because there is no complete route–pathway (full on-site control).

TABLE 13 CONSERVATIVE ASSUMPTIONS (in addition to conservative default EPA parameters)

	Area of Soil Gas Emission: large	Air Dispersion at Receptor: little or none	Ground Cover: none	Constant Contaminant Source	No Contaminant Loss by Chemical/Biological Transformation	Other
RP1	✓	✓	✓	✓		• some use of site
RP2	✓	✓	✓	✓		• some use of site • no interaction with soil
RP3	✓	✓	✓	✓		• some use of site • no interaction of LNAPL with soil • measured free phase = constituents
RP4		✓	✓	✓		• some use of site • 100% sorption into lung fluid (ABSF = 1)
RP5	✓	✓	✓		✓	• some use of site
RP6	✓	✓	✓		✓	• some use of site • no interaction with soil • loss of constituents by volatilization only
RP7	✓	✓	✓		✓	• some use of site • no interaction of LNAPL with soil • loss of constituent: volatilization only,
RP8		✓	✓	✓	✓	• some use of site • 100% sorption into lung fluid (ABSF = 1)
RP9	✓		✓		✓	• full-time use of site: 24 h/d
RP10	✓		✓		✓	• dilution by only 10X from outdoor onsite source to indoor (Fla = 0.1) • full-time use of site: 24 h/d
RP11	✓	✓	✓	✓	✓	• full-time use of site: 24 h/d • dilution by only 10X from outdoor on-site source to indoor (Fla - 0.1)

"✓" conservative assumption applies—results in a more conservative risk estimate.

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	Area of Soil Gas Emission: large	Air Dispersion at Receptor: little or none	Ground Cover: none	Constant Contaminant Source	No Contaminant Loss by Chemical/Biological Transformation	Other
RP12			✓		✓	• full-time use of site: 24 h/d • dilution by only 10X from outdoor onsite source to indoor (Fla = 0.1) • 100% sorption into lung fluid (ABSF = 1)
RP13	✓		✓	✓	✓	• dilution by only 10X at distance 10 to 100 m from source plus only 10X attenuation for entering resident (Fla = 0.01)
RP14			✓	✓		• dilution by only 10X at distance • 10 to 100 m from source plus only 10X attenuation for entering resident (Fla = 0.01)
RP15	✓		✓	✓		• some individuals work near site • dilution by only 10X at distance 10 to 100 m from source (Fla = 0.1)
RP16	✓		✓	✓		• some individuals work near site • dilution by only 10X at distance 10 to 100 m from source (Fla = 0.1)
RP17	✓		✓	✓		• some individuals work near site • dilution by only 10X at distance 10 to 100 m from source (Fla = 0.1)
RP18			✓	✓		• some individuals work near site • dilution by only 10X at distance 10 to 100 m from source (Fla = 0.1) • 100% sorption into lung fluid (ABSF = 1)
RP19	✓		✓		✓	• dilution by only 10X at distance 10 to 100 m from source plus only 10X attenuation for entering resident (Fla = 0.01)
RP20			✓		✓	• dilution by only 10X at distance 10 to 100 m from source plus only 10X attenuation for entering resident • 100% sorption into lung fluid (ABSF = 1)
RP21	✓		✓		✓	• full-time use of site: 24 h/d • dilution by only 10X at distance 10 to 100 m from source (Fla = 0.1) • no interaction of LNAPL with soil

TABLE 14 Human-Health Risk Results with Benzene Concentrations in groundwater at 3 ppm
Brickland Refinery Site, Sunland Park, New Mexico

Exposure Route – Pathway	Noncancer Risk (HI) ucl	Noncancer Risk (HI) mean	Cancer Risk ucl	Cancer Risk mean
CURRENT I CONDITIONS (*on site*)—Industrial				
RP1: inhalation of soil gas from soil particles	0.003	0.002	3.45E-08	7.77E-09
RP2: inhalation of soil gas from ground water	0.083	0.052	8.61E-07	1.94E-07
RP3: inhalation of soil gas from LNAPL	0.008	0.005	8.64E-08	1.94E-08
RP4: inhalation of surface soil dust	0.000	0.000	1.95E-10	4.39E-11
Total Risk =	**0.095**	**0.059**	**9.82E-07**	**2.21E-07**

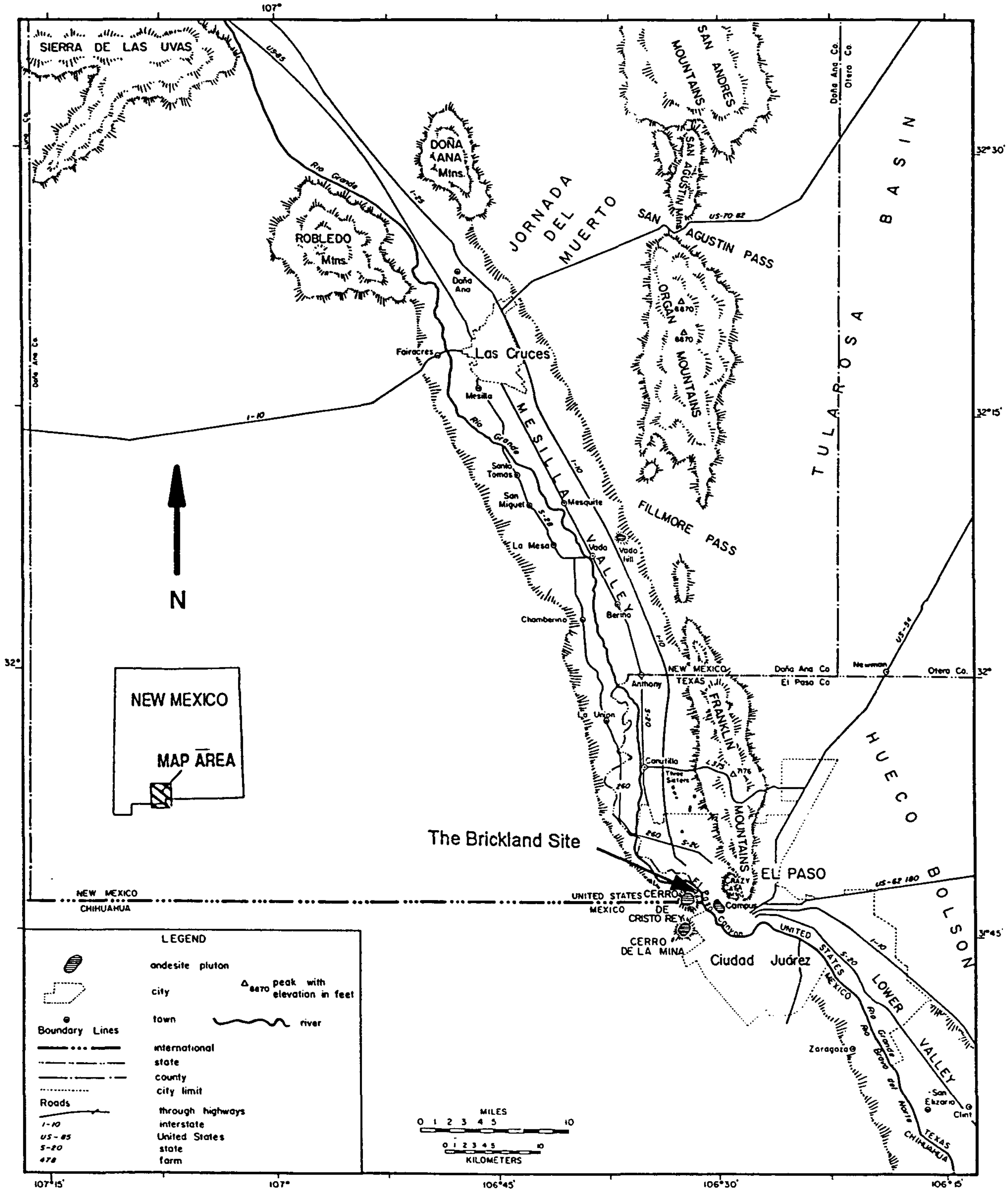
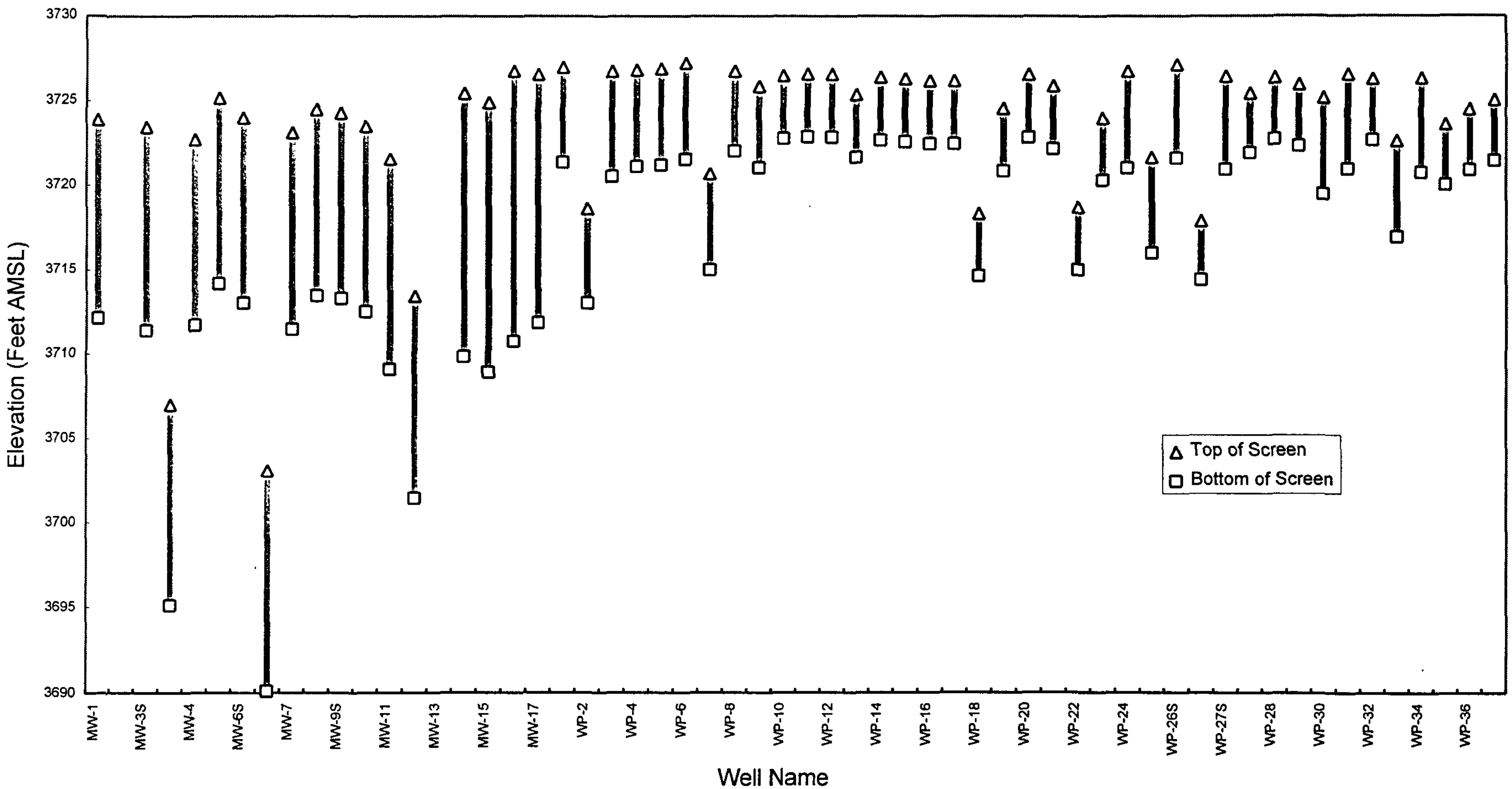


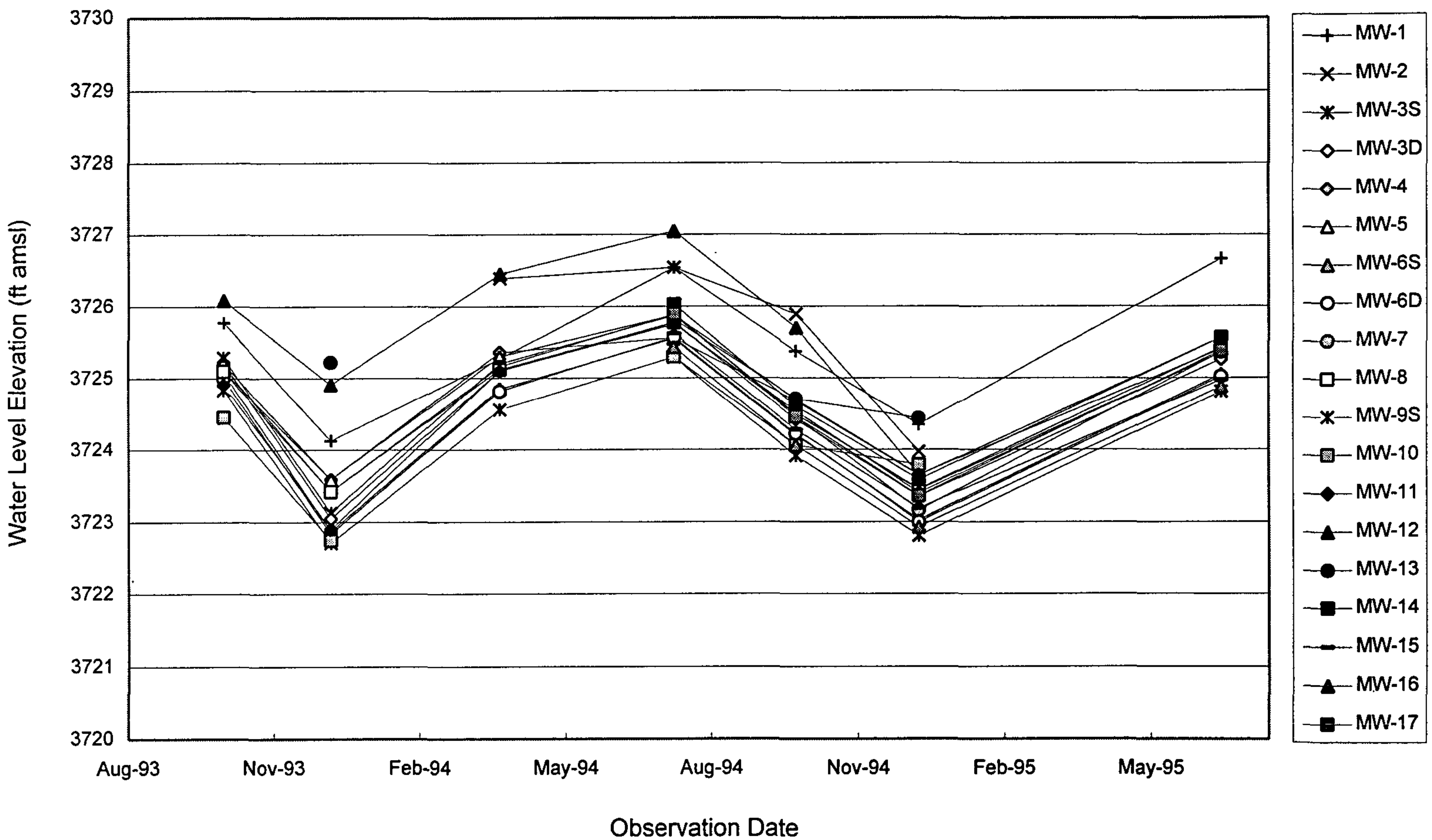
Figure 1 The Brickland Refinery Site Location Map

Figure 2
Screened Interval of Monitoring Wells at the Site

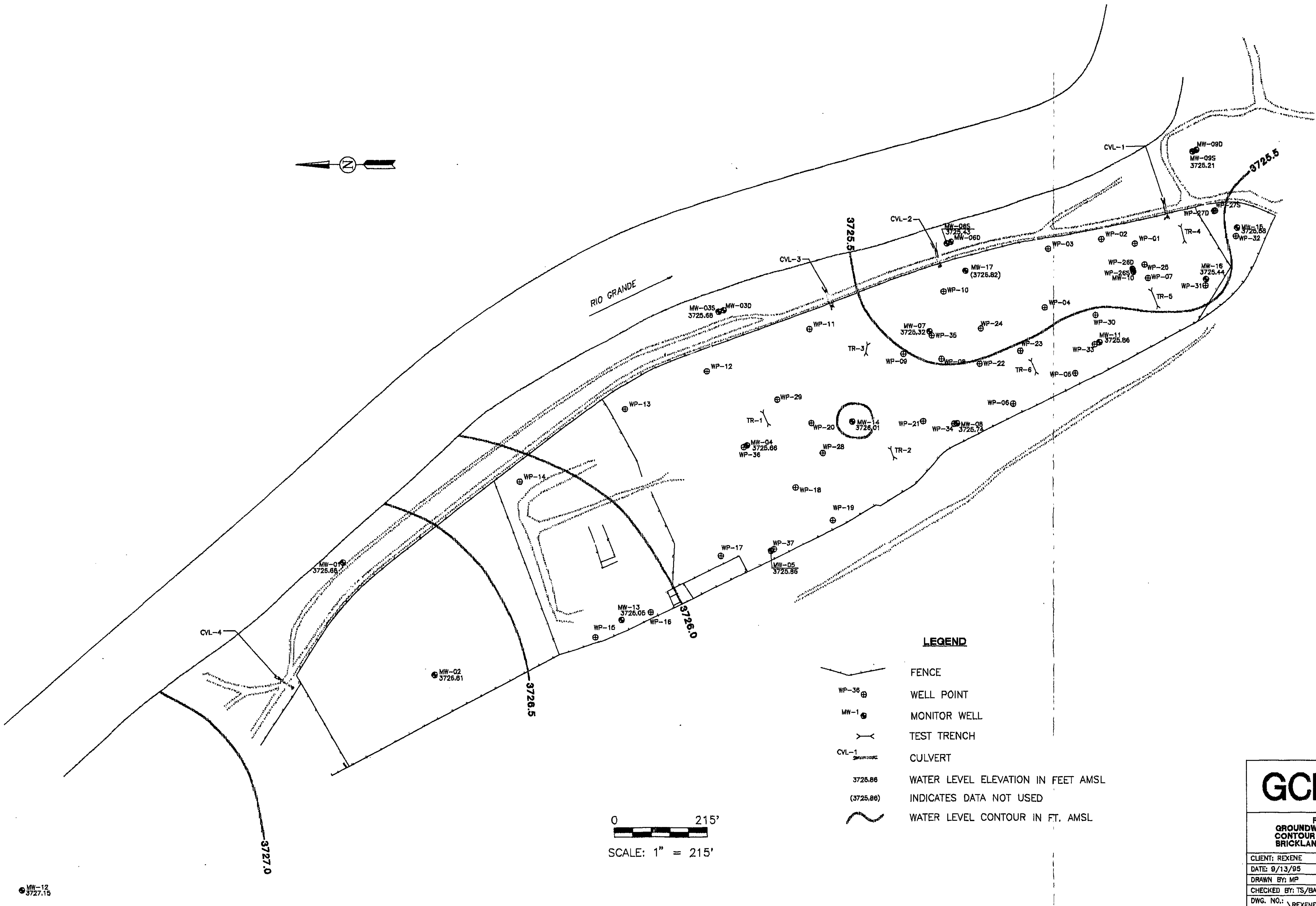


G:\REXWORK\FIGS.XLS:SCREEN.PLT

Figure 3
Water Level vs. Time for All Monitoring Wells



G:\REXWORK\FIGS.XLS:WL(MW).PLT



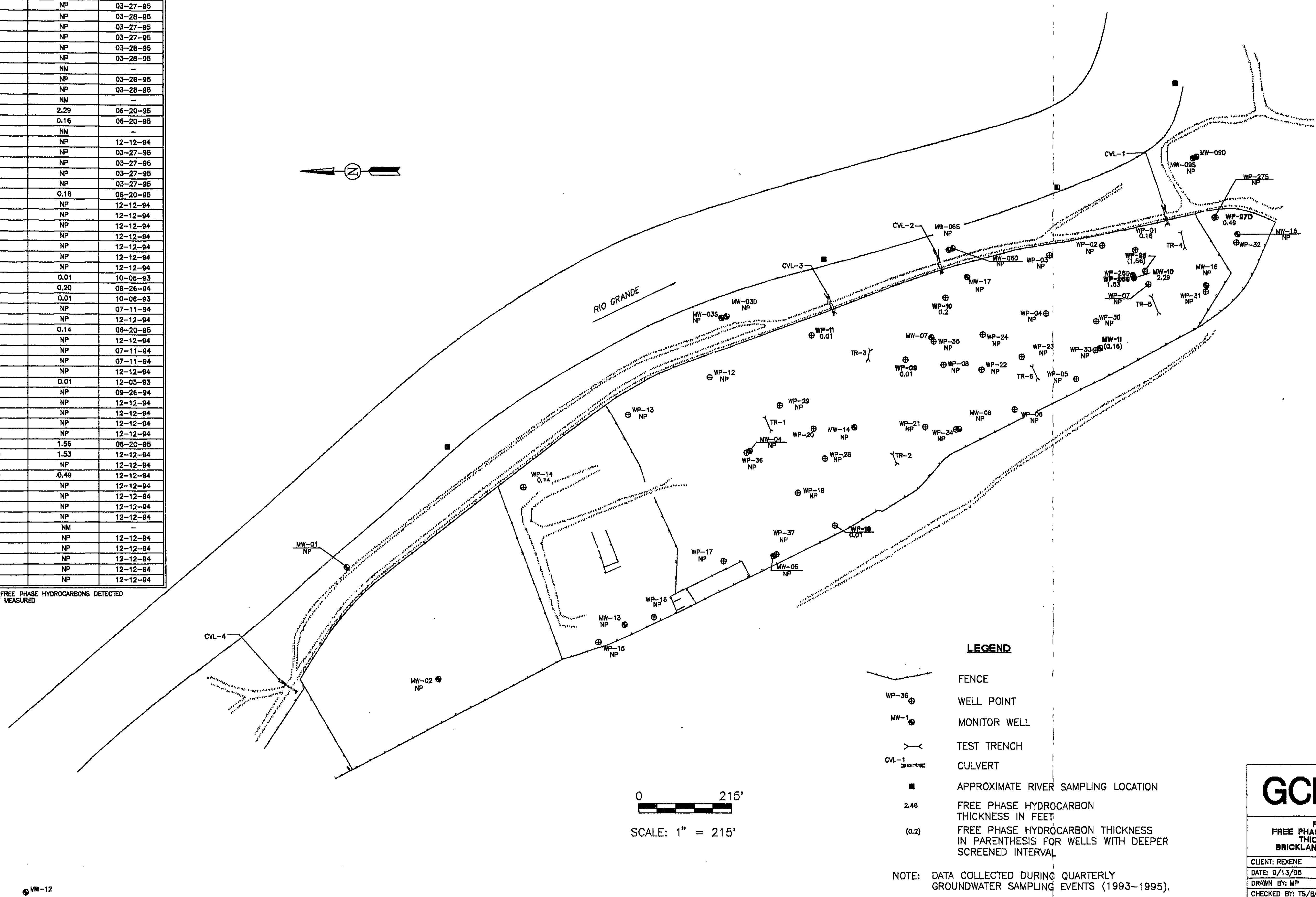
GCL

FIGURE 4
GROUNDWATER ELEVATION CONTOUR MAP (JUNE 1995)
BRICKLAND REFINERY SITE

CLIENT: REXENE
DATE: 9/13/95
DRAWN BY: MP
CHECKED BY: TS/BAL
DWG. NO.: \REXENE\2NDQTR95.DWG

MONITOR WELL/ WELL POINT	FREE PHASE HYDROCARBONS THICKNESS (FEET)	MEASUREMENT DATE
MW-01	NP	12-12-94
MW-02	NP	12-12-94
MW-03S	NP	03-27-95
MW-03D	NP	03-28-95
MW-04	NP	03-27-95
MW-05	NP	03-27-95
MW-06S	NP	03-28-95
MW-06D	NP	03-28-95
MW-07	NM	-
MW-08	NP	03-28-95
MW-9S	NP	03-28-95
MW-09D	NM	-
MW-10	2.29	06-20-95
MW-11	0.16	06-20-95
MW-12	NM	-
MW-13	NP	12-12-94
MW-14	NP	03-27-95
MW-15	NP	03-27-95
MW-16	NP	03-27-95
MW-17	NP	03-27-95
WP-01	0.16	06-20-95
WP-02	NP	12-12-94
WP-03	NP	12-12-94
WP-04	NP	12-12-94
WP-05	NP	12-12-94
WP-06	NP	12-12-94
WP-07	NP	12-12-94
WP-08	NP	12-12-94
WP-09	0.01	10-06-93
WP-10	0.20	09-26-94
WP-11	0.01	10-06-93
WP-12	NP	07-11-94
WP-13	NP	12-12-94
WP-14	0.14	06-20-95
WP-15	NP	12-12-94
WP-16	NP	07-11-94
WP-17	NP	07-11-94
WP-18	NP	12-12-94
WP-19	0.01	12-03-93
WP-20	NP	09-26-94
WP-21	NP	12-12-94
WP-22	NP	12-12-94
WP-23	NP	12-12-94
WP-24	NP	12-12-94
WP-26	1.56	06-20-95
WP-26D	1.53	12-12-94
WP-27S	NP	12-12-94
WP-27D	0.49	12-12-94
WP-28	NP	12-12-94
WP-29	NP	12-12-94
WP-30	NP	12-12-94
WP-31	NP	12-12-94
WP-32	NM	-
WP-33	NP	12-12-94
WP-34	NP	12-12-94
WP-35	NP	12-12-94
WP-36	NP	12-12-94
WP-37	NP	12-12-94

NP = NO FREE PHASE HYDROCARBONS DETECTED
NM = NOT MEASURED

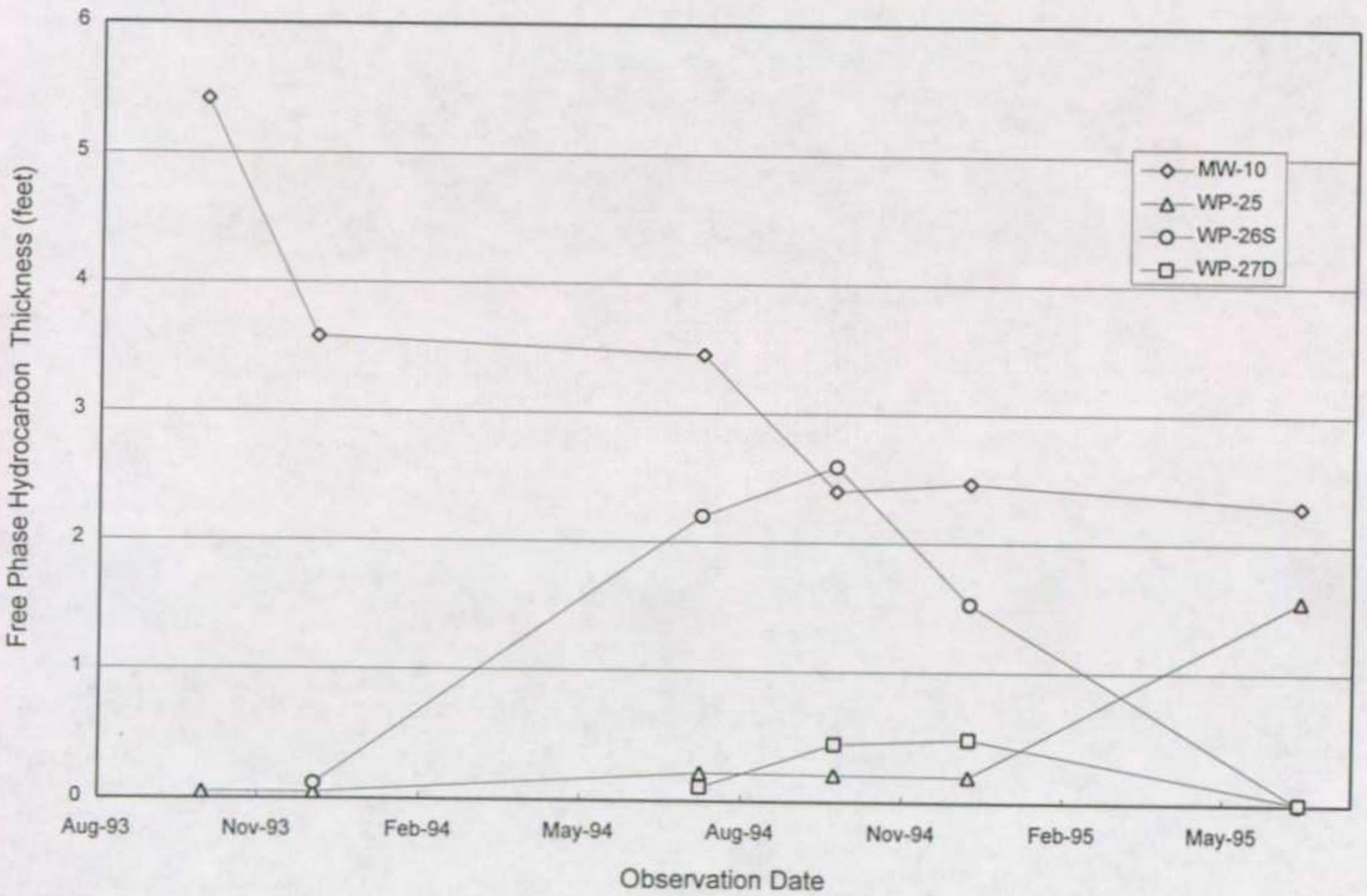


GCL

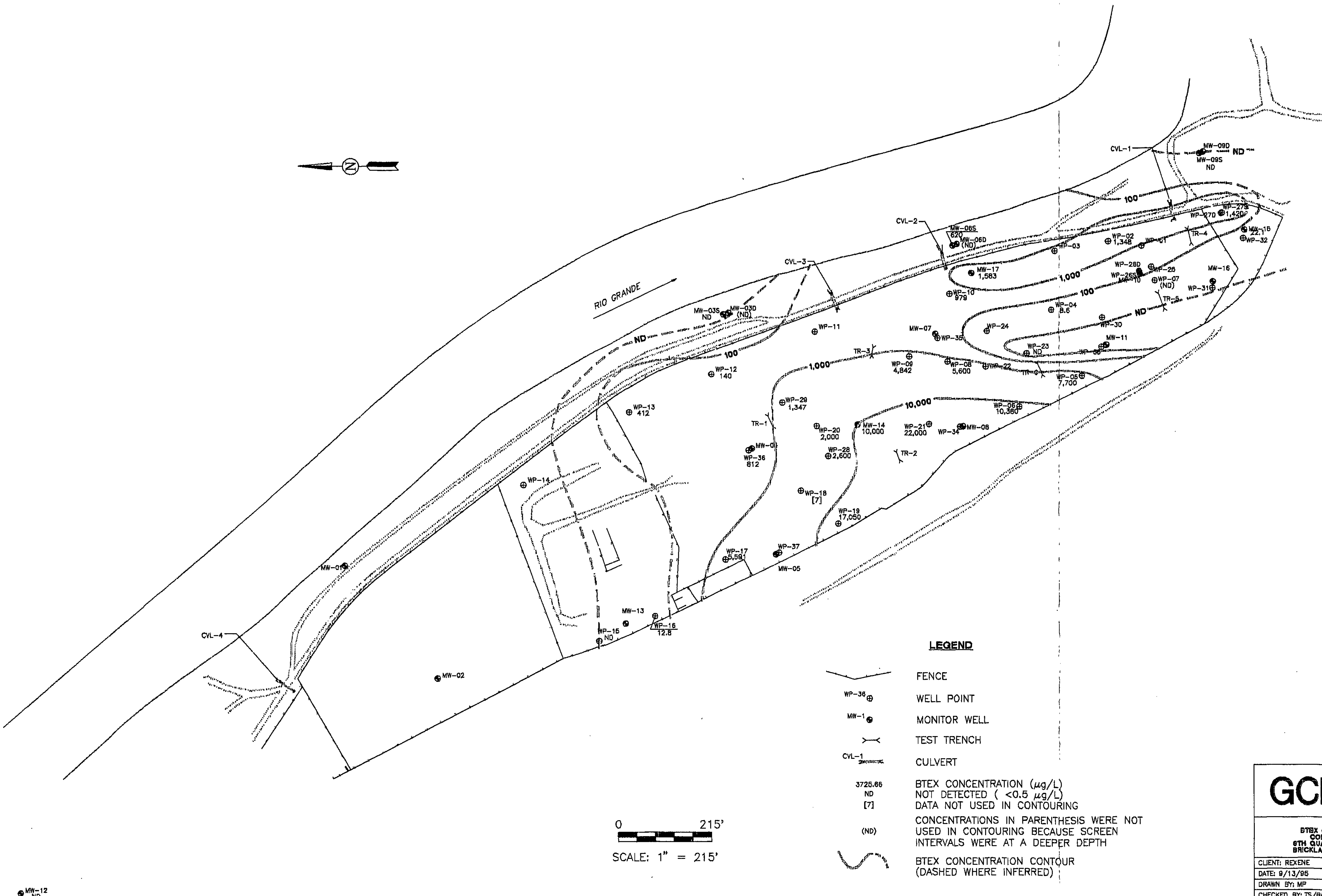
FIGURE 5
FREE PHASE HYDROCARBON THICKNESS MAP
BRICKLAND REFINERY SITE

CLIENT: REXENE
DATE: 9/13/95
DRAWN BY: MP
CHECKED BY: TS/BAL
DWG. NO.: \REXENE\FPRDCT2.DWG

Figure 6
Free Phase Hydrocarbon Thickness vs. Time



G:\REXWORK\FIGS.XLS



LEGEND

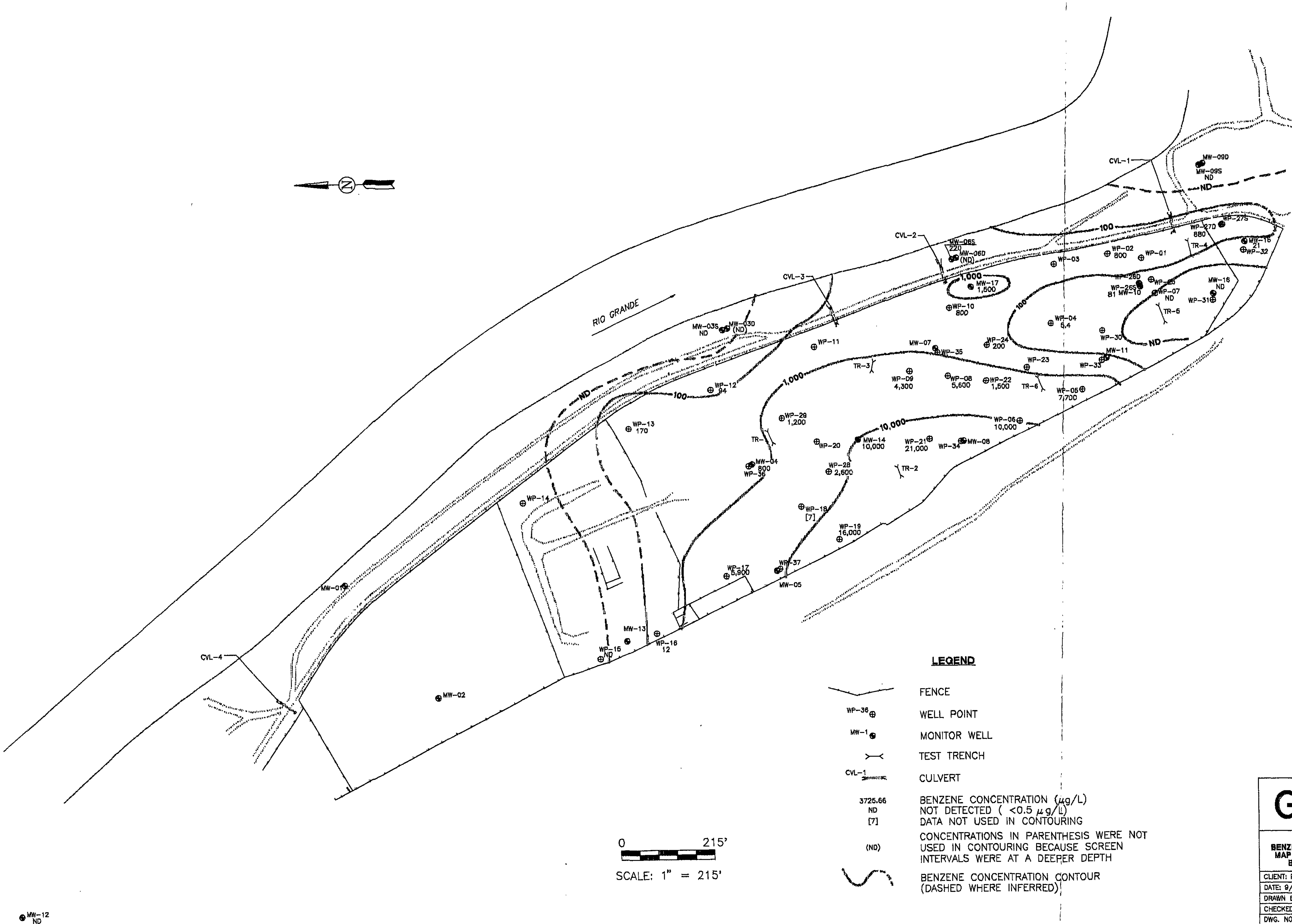
	FENCE
WP-36	WELL POINT
MW-1	MONITOR WELL
	TEST TRENCH
CVL-1	CULVERT
3725.66	BTEX CONCENTRATION ($\mu g/L$)
ND	NOT DETECTED (<0.5 $\mu g/L$)
[7]	DATA NOT USED IN CONTOURING
(ND)	CONCENTRATIONS IN PARENTHESIS WERE NOT USED IN CONTOURING BECAUSE SCREEN INTERVALS WERE AT A DEEPER DEPTH
	BTEX CONCENTRATION CONTOUR (DASHED WHERE INFERRED)

MW-12
ND

GCL

FIGURE 7
BTEX CONCENTRATION CONTOUR MAP IN 6TH QUARTER (JUNE 1995) BRICKLAND REFINERY SITE

CLIENT: REXENE
DATE: 9/13/95
DRAWN BY: MP
CHECKED BY: TS/BAL
DWG. NO.: \REXENE\2NDQTR95.DWG

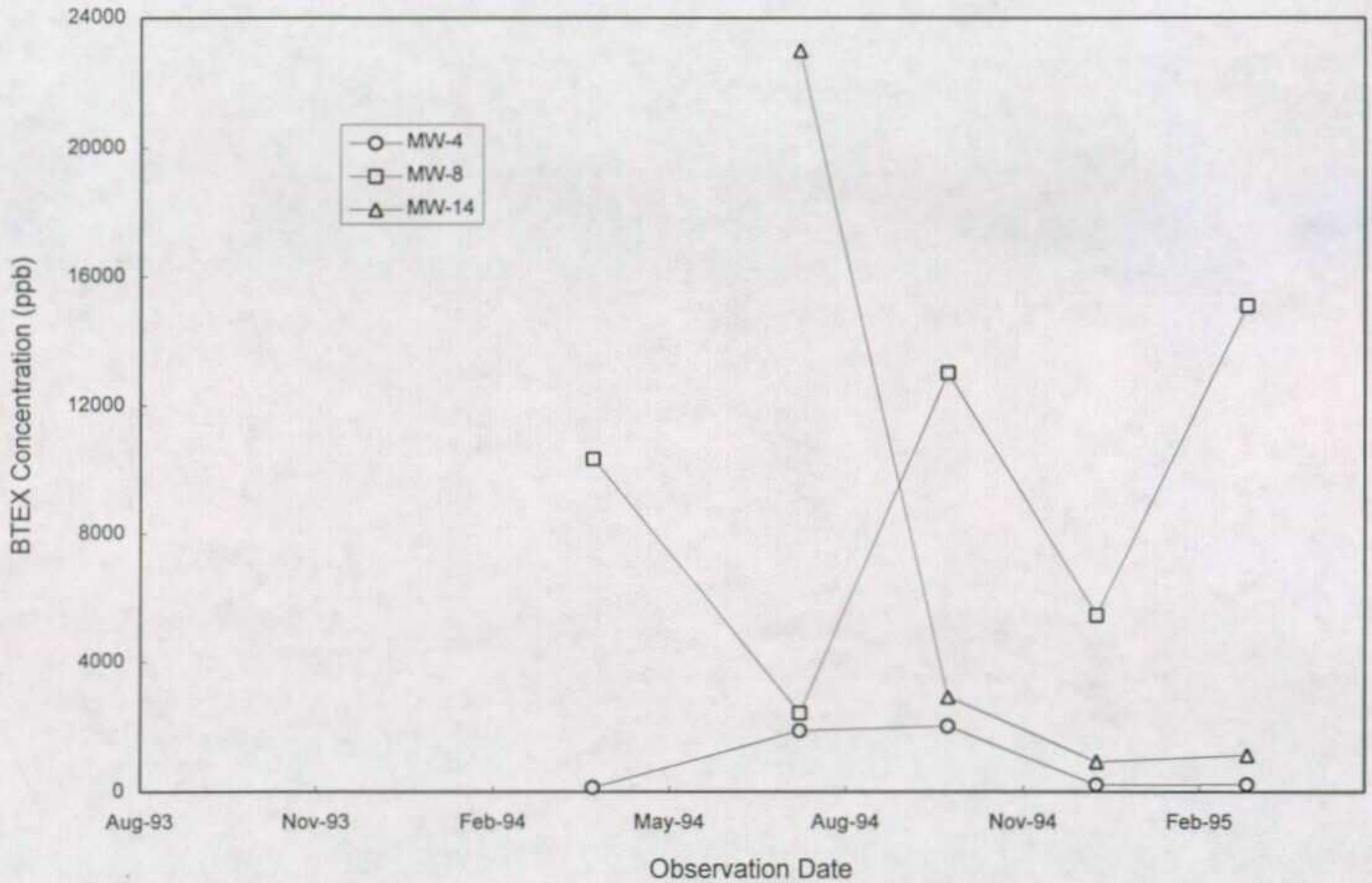


GCL

FIGURE 8
BENZENE CONCENTRATION CONTOUR MAP IN 6TH QUARTER (JUNE 1995)
BRICKLAND REFINERY SITE

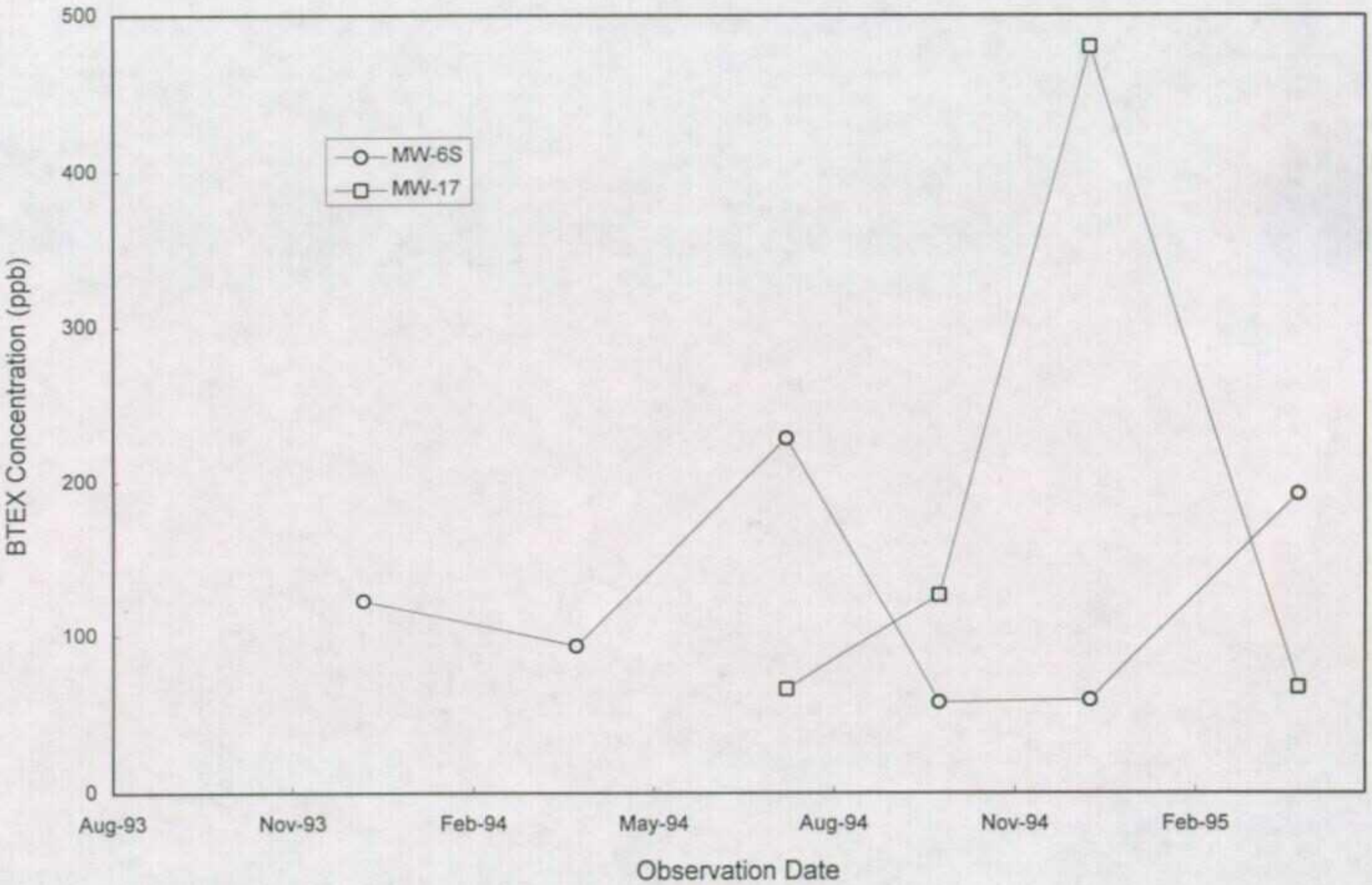
CLIENT: REXENE
DATE: 9/13/95
DRAWN BY: MP
CHECKED BY: TS/BAL
DWG. NO.: \REXENE\2NDQTR95.DWG

Figure 9
Total BTEX Concentration vs. Time for MW-4, MW-8, and MW-14

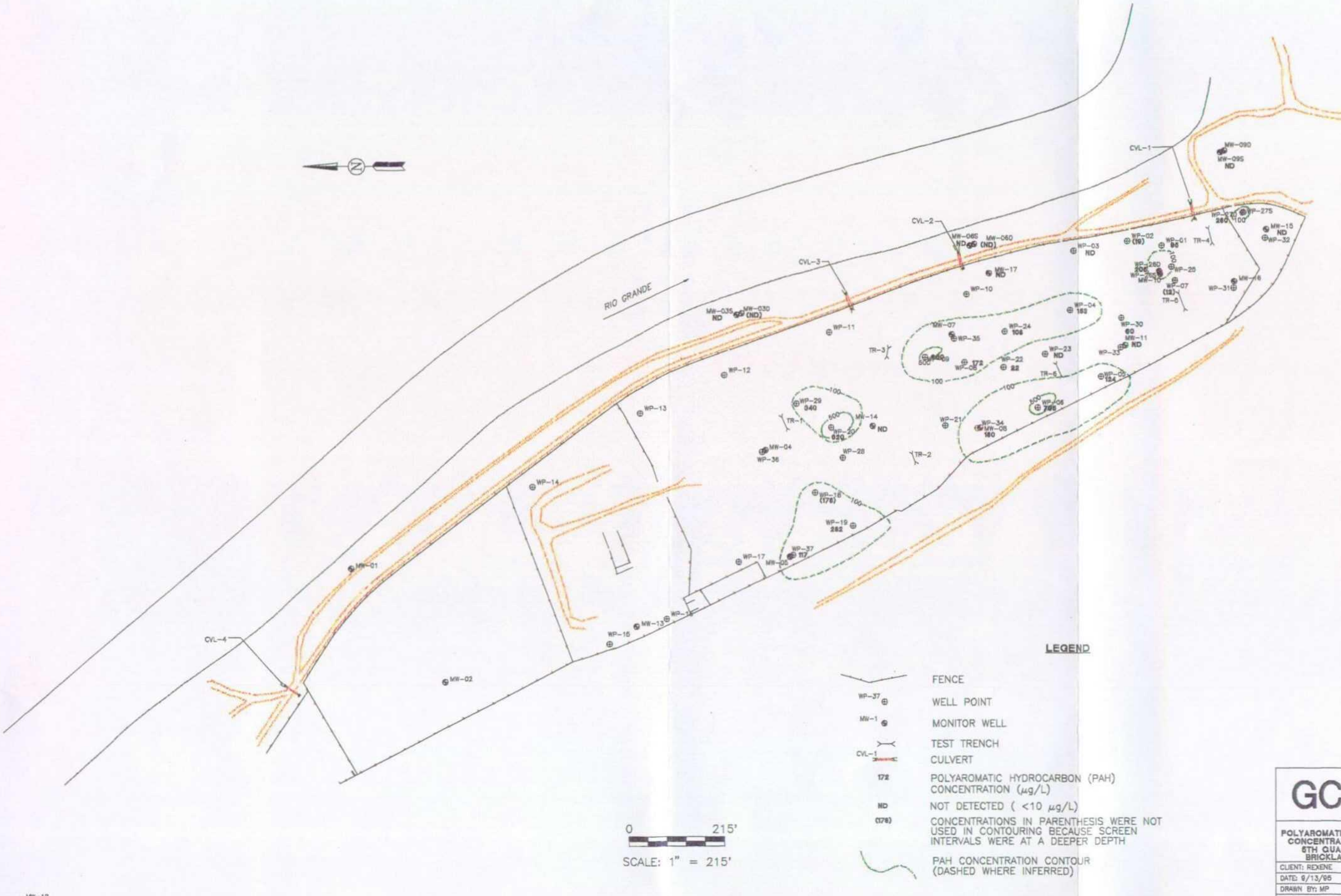


G:\REXWORK\FIGS.XLS:BTEXPLT

Figure 10
Total BTEX Concentration vs. Time for MW-6S and MW-17



G:\REXWORK\FIGS.XLS:MW6S/17(BTEX).PLT



0 215'

SCALE: 1" = 215'

LEGEND

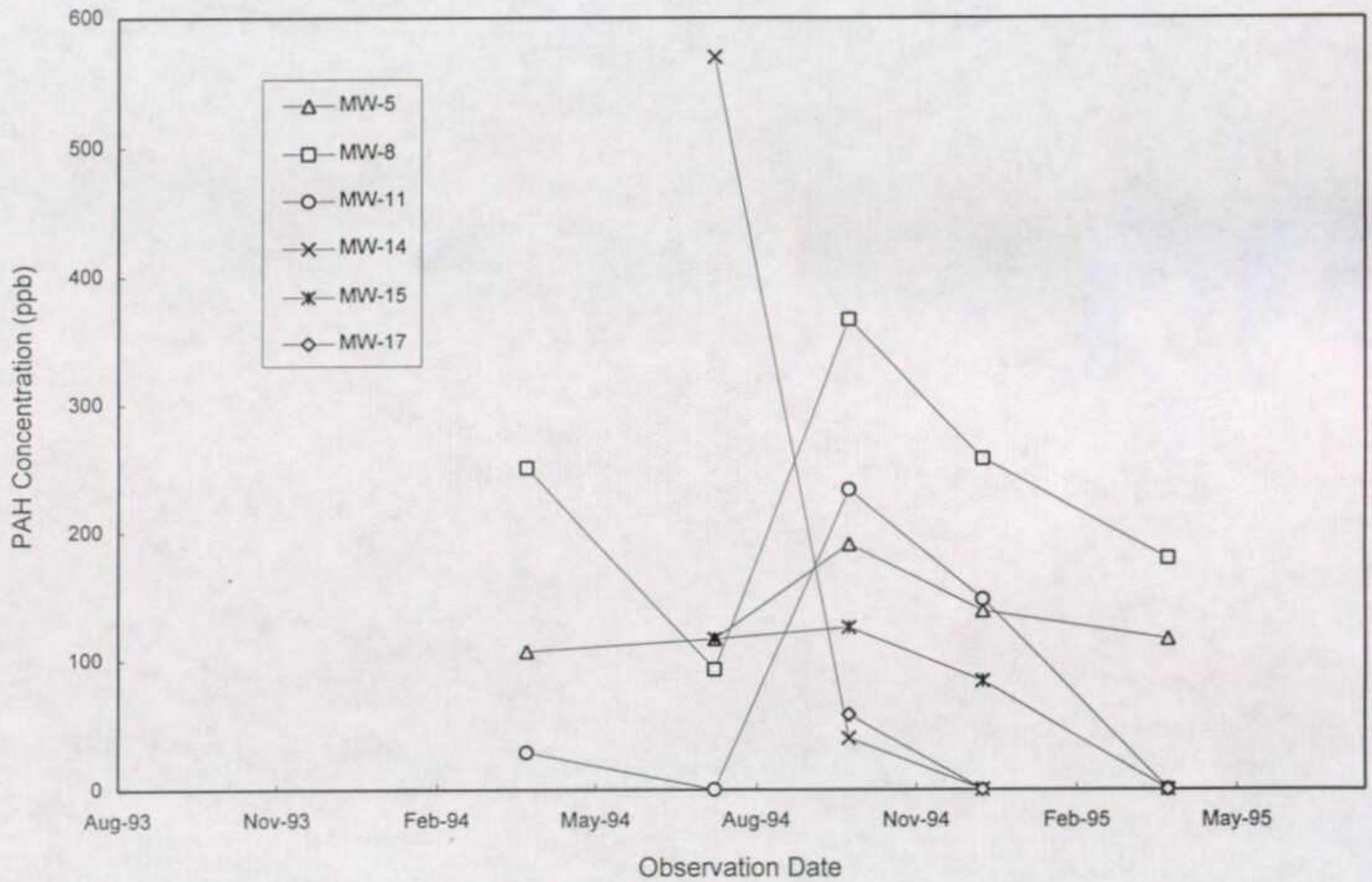
	FENCE
WP-37 ⊕	WELL POINT
MW-1	MONITOR WELL
	TEST TRENCH
CVL-1	CULVERT
172	POLYAROMATIC HYDROCARBON (PAH) CONCENTRATION (μg/L)
ND	NOT DETECTED (<10 μg/L)
(178)	CONCENTRATIONS IN PARENTHESIS WERE NOT USED IN CONTOURING BECAUSE SCREEN INTERVALS WERE AT A DEEPER DEPTH
	PAH CONCENTRATION CONTOUR (DASHED WHERE INFERRED)

GCL

FIGURE 11
POLYAROMATIC HYDROCARBON (PAH) CONCENTRATION CONTOUR MAP IN 5TH QUARTER (MARCH 1995) BRICKLAND REFINERY SITE

CLIENT: REXENE
DATE: 9/13/95
DRAWN BY: MP
CHECKED BY: TS/BAL
DWG. NO.: \REXENE\1STQTR95.DWG

Figure 12
Total PAH Concentration vs. Time



G:\REXWORK\FIGS.XLS:PAH.PLT

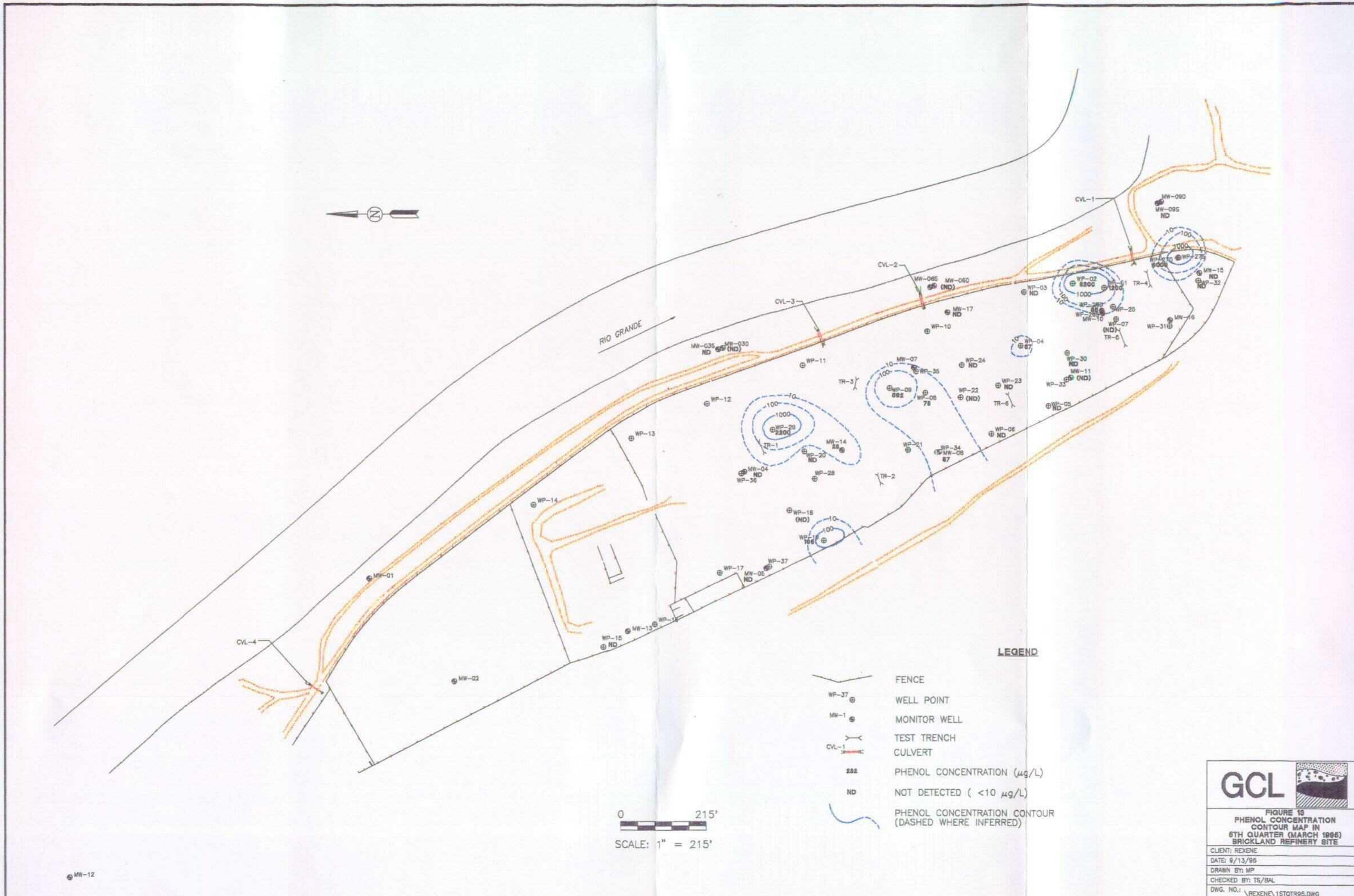
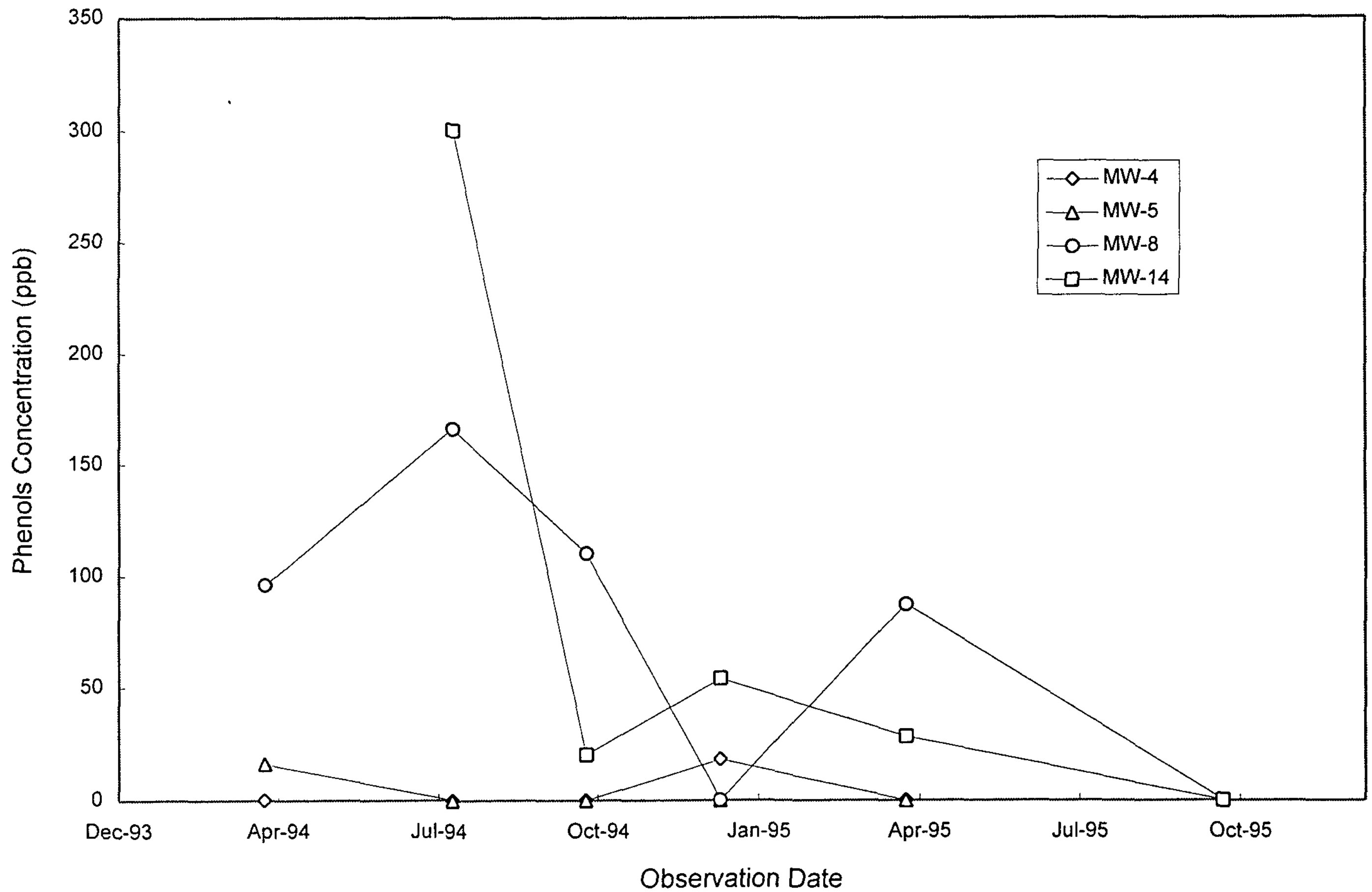
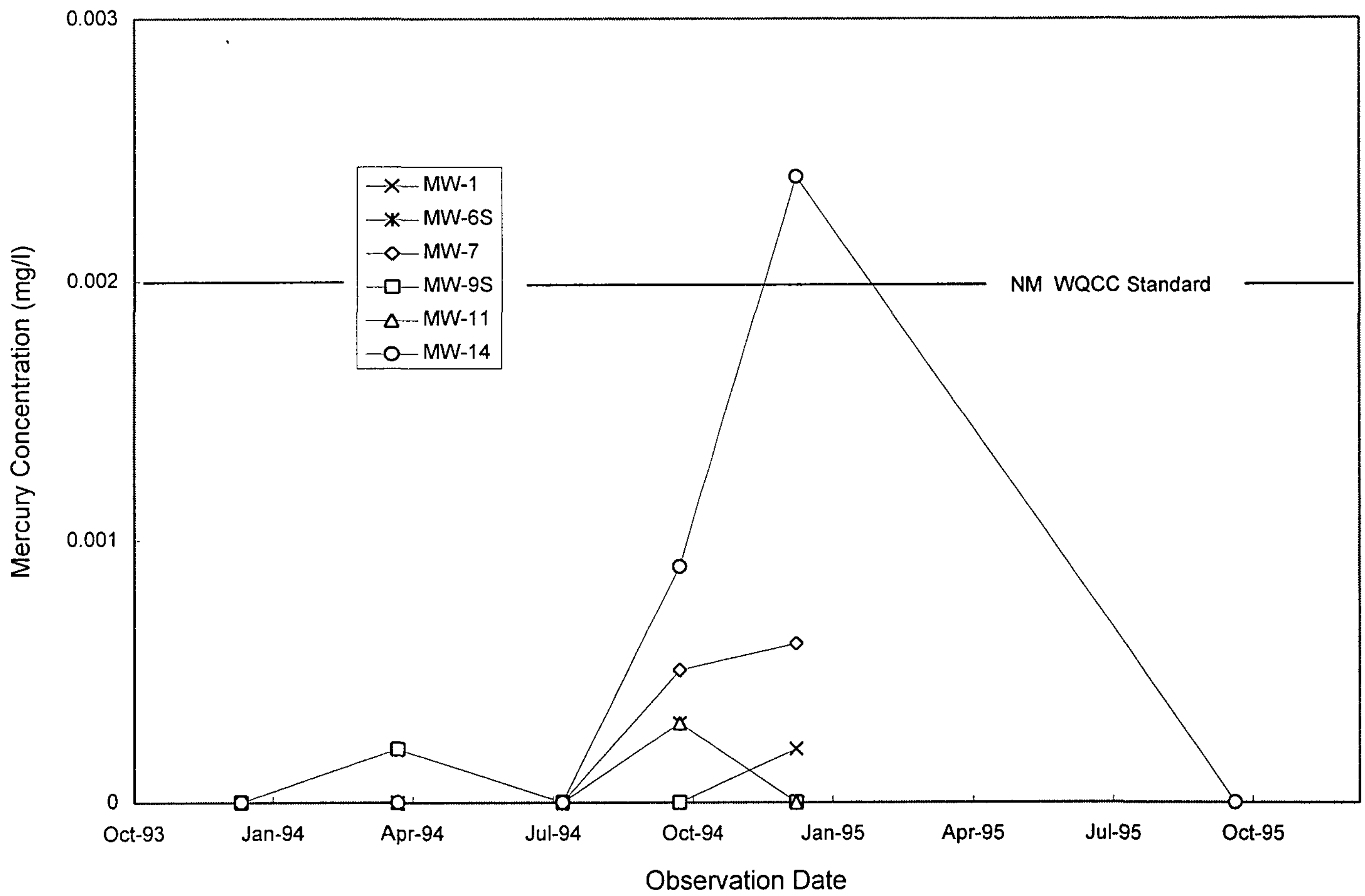

RIO GRANDE
CVL-1
CVL-2
CVL-3
CVL-4
MW-01
MW-02
MW-12
LEGEND
FENCE
WELL POINT
MONITOR WELL
TEST TRENCH
CULVERT
PHENOL CONCENTRATION (μg/L)
NOT DETECTED (<10 μg/L)
PHENOL CONCENTRATION CONTOUR (DASHED WHERE INFERRED)
0 215'
SCALE: 1" = 215'
GCL
FIGURE 13
PHENOL CONCENTRATION
CONTOUR MAP IN
6TH QUARTER (MARCH 1995)
BRICKLAND REFINERY SITE
CLIENT: REXENE
DATE: 9/13/95
DRAWN BY: MP
CHECKED BY: TS/BAL
DWG. NO.: \REXENE\1STQTR95.DWG

Figure 14
Total Phenols Concentration vs. Time



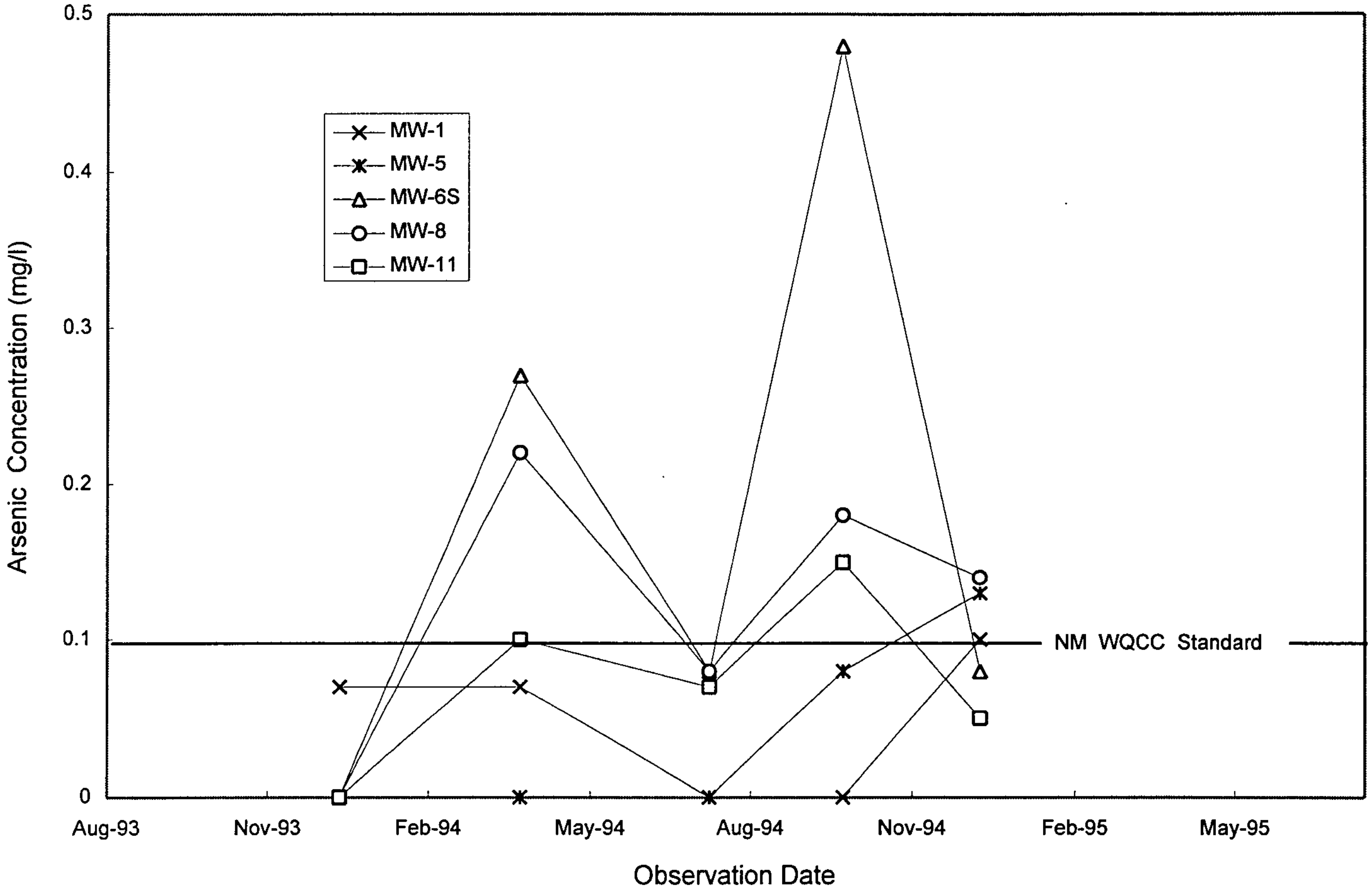
G:\REXWORK\FIGS.XLS:PHENOL.PLT

Figure 15
Mercury Concentration vs. Time



G:\REXWORK\FIGS.XLS:Hg.PLT

Figure 16
Arsenic Concentration vs. Time



G:\REXWORK\FIGS.XLS:As.PLT

Figure 17
Risk Assessment Methodology

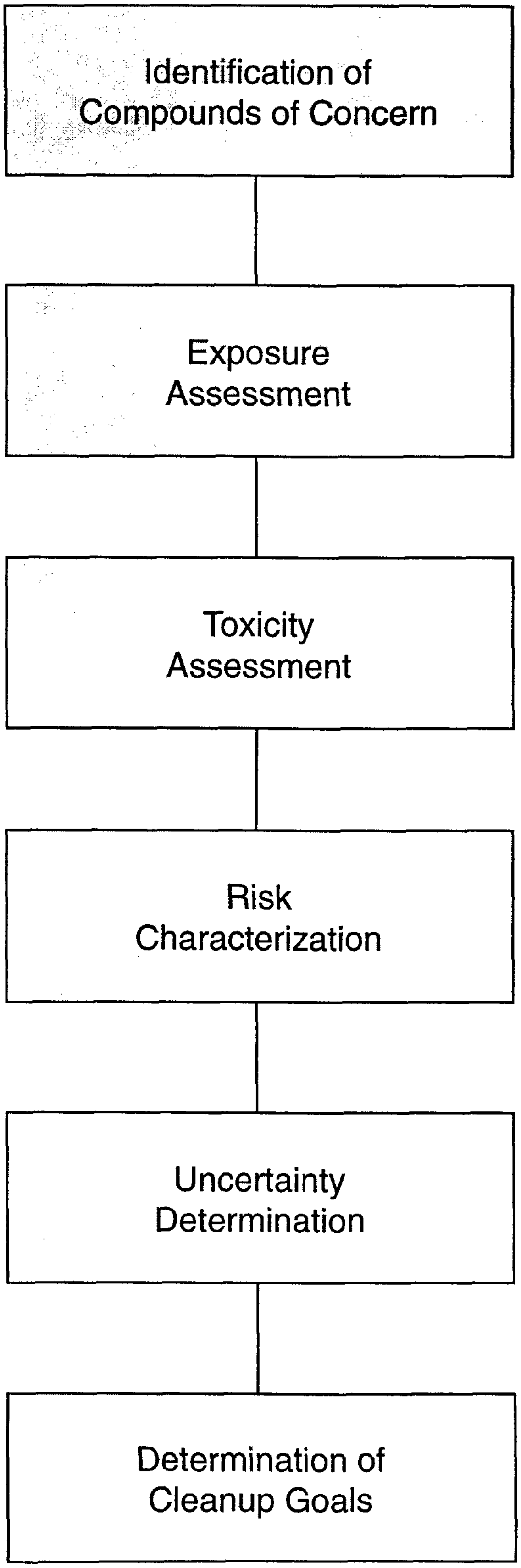
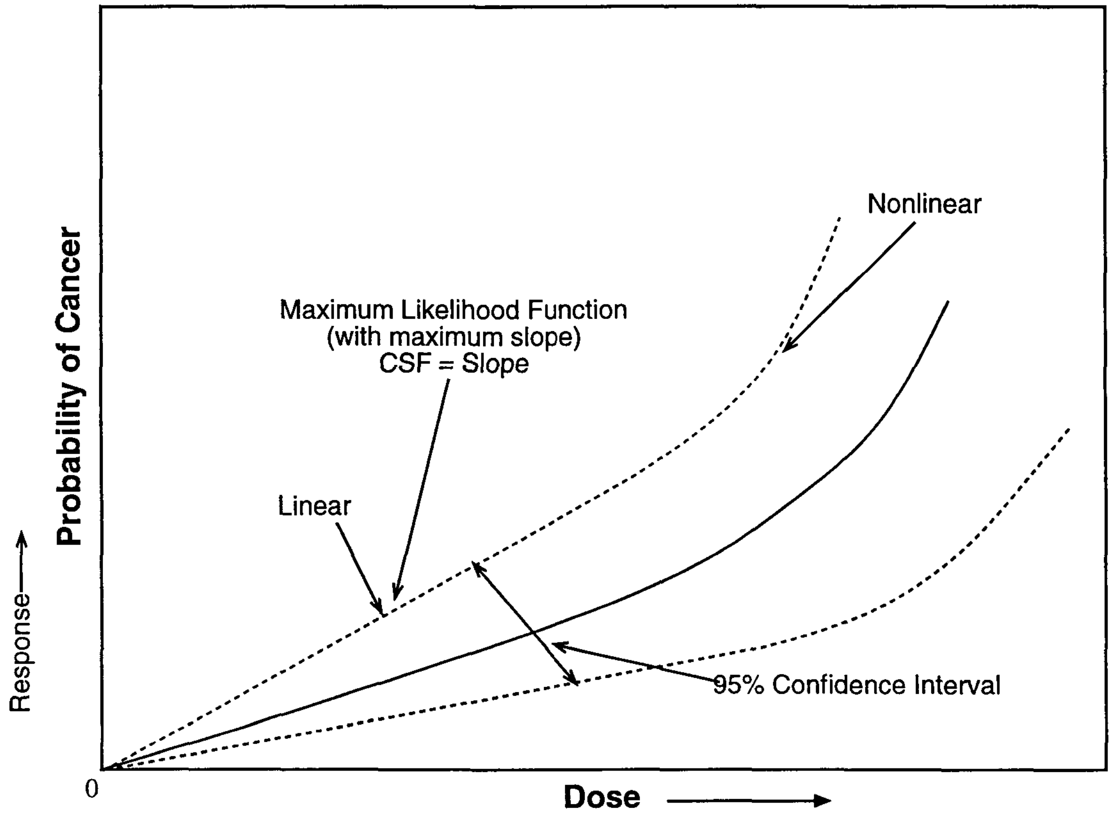


Figure 18
Conceptual Dose-Response Curve

Choosing the maximum likelihood function (i.e., lower dose giving a greater response) to calculate slope, the cancer slope factor, is the most conservative approach.



Appendix A

Lithologic Logs of Monitoring Wells MW-1 through MW-12
(Eder and Associates, 1990)

BORING REPORT

eder associates, consulting engineers p. c.
85 FOREST AVENUE LOCUST VALLEY, N.Y. 11560
2317 INTERNATIONAL LANE MADISON, WI. 53704

SHEET 1 OF 1

DATE STARTED : 4-10-90 | DATE FINISHED : 4-10-90 | BORING No. MW-1

CLIENT : REXENE | PROJECT No : 604-9

PROJECT NAME & LOCATION : PHASE 1 INVESTIGATION - SUNLAND PARK, NEW MEXICO

REMARKS:

DRILLING CONTRACTOR : I.T. | LOGGED BY: K. McHALE | DRILLER : T. DAVIS

EQUIPMENT :	CASING :	SOIL SAMPLER : SPLIT SPOON	SOIL SAMPLER :	CORE BARREL	AUGER	MON. WELL (MW) PIPE	MON. WELL (MW) CAP	DRILL RIG AND METHOD
TYPE :		STD.						MOBILE B-61
SIZE :		3"x24"						
HAMMER WT / FALL		140/30"		BIT				HSA

SURFACE ELEVATION :

SURFACE CONDITIONS :

WATER LEVEL AT FT. AFTER HRS. FT. AFTER HRS.

DEPTH BELOW GRADE	OVA READINGS	SAMPLE TYPE AND No.	SAMPLE DEPTH (FROM - TO)	SAMPLE MOISTURE CONTENT	SAMPLE RECOVERY	BLOWS / 6" OR CORE TIME	STRATA DEPTH / ELEV.	DESCRIPTION AND REMARKS TRACE=0-10% LITTLE=10-20% SOME=20-30% AND=35-50%
0								LIGHT BROWN SILTY SAND
	O		0-2	M	1.0	4-6 5-9		
	O		2-4	M	2.0	3-3 3-3		
5								
	O		4-6	W	2.0	2-2 3-4		RED/BROWN SILTY CLAY
			6-8					
10	O		8-10	W	2.0	4-5 4-7		RED/BROWN V. FINE SAND
15	O		13-15	W	2.0	4-3 2-5		
								EOB @ 15.0
20								

BORING — eder associates, consulting engineers p. c. — REPORT

85 FOREST AVENUE LOCUST VALLEY, N.Y. 11560
2317 INTERNATIONAL LANE MADISON, WI. 53704

SHEET 1 OF 1

DATE STARTED : 4-5-90	DATE FINISHED : 4-5-90	BORING No. MW-2
CLIENT : REXENE		PROJECT No : 604-9

PROJECT NAME & LOCATION : PHASE 1 INVESTIGATION – SUNLAND PARK,

REMARKS:

DRILLING CONTRACTOR : I. T. | LOGGED BY: K. MCHALE | DRILLER : T. DAVIS

EQUIPMENT :	CASING :	SOIL SAMPLER : SPLIT SPOON	SOIL SAMPLER :	CORE BARREL	AUGER	MON. WELL (MW) PIPE	MON. WELL (MW) CAP	DRILL RIG AND METHOD
TYPE :		STD.						MOBILE B-61
SIZE :		3" x 24"						
HAMMER WT / FALL		140/30"		BIT				HSA

SURFACE ELEVATION :

SURFACE CONDITIONS :

WATER LEVEL AT FT. AFTER HRS. FT. AFTER HRS.

DEPTH BELOW GRADE	OVA READINGS	SAMPLE TYPE AND No.	SAMPLE DEPTH (FROM – TO)	SAMPLE MOISTURE CONTENT	SAMPLE RECOVERY	BLOWS / 6" OR CORE TIME	STRATA DEPTH / ELEV.	DESCRIPTION AND REMARKS TRACE=0–10% LITTLE=10–20% SOME=20–30% AND=35–50%
0				M				RED/BROWN V.FINE SANDY SILT
	0		0-2	M	2.0	1-1 2-1		
				M				RED/BROWN CLAY (STIFF)
	0		2-4	M	2.0	3-4 4-4		
5				M				
	0		4-6	M	.75	2-2 4-4		
				W				RED/BROWN V.FINE SAND W/TRACE SILT - NATURAL BLACK + IRON STAINING.
	0		6-8	W	2.0	8-6 8-9		
				W				
10	0		8-10	W	2.0	6-7 9-10		
15	0		13-15	W	1.5	7-8 12		
								EOB @ 15.0
20								

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SHEET 1 OF 2

DATE STARTED : 4-9-90	DATE FINISHED : 4-9-90	BORING No. MW-3
CLIENT : REXENE		PROJECT No : 604-9

PROJECT NAME & LOCATION : PHASE 1 INVESTIGATION – SUNLAND PARK, NEW MEXICO

REMARKS:

DRILLING CONTRACTOR : I.T.	LOGGED BY: K. MCHALE	DRILLER : T. DAVIS

EQUIPMENT :	CASING :	SOIL SAMPLER : SPLIT SPOON	SOIL SAMPLER :	CORE BARREL	AUGER	MON. WELL (MW) PIPE	MON. WELL (MW) CAP	DRILL RIG AND METHOD
TYPE :		STD.						MOBILE B-61
SIZE :		3"x24"						
HAMMER WT / FALL		140/30"		BIT				HSA

SURFACE ELEVATION :

SURFACE CONDITIONS :

WATER LEVEL AT FT. AFTER HRS. FT. AFTER HRS.

DEPTH BELOW GRADE	OVA READINGS	SAMPLE TYPE AND No.	SAMPLE DEPTH (FROM – TO)	SAMPLE MOISTURE CONTENT	SAMPLE RECOVERY	BLOWS / 6" OR CORE TIME	STRATA DEPTH / ELEV.	DESCRIPTION AND REMARKS TRACE=0–10% LITTLE=10–20% SOME=20–30% AND=35–50%
0								
	0		0-2	M	1.2	4-8 14-15		TAN V.FINE SAND
	0		2-4	M	2.0	9-7 7-6		RED/BROWN SILTY V.FINE SAND
5								
	0		4-6	W	2.0	3-6 4-5		
	0		6-8					
10	0		8-10	W	2.0	WR-WR 1-2		RED/BROWN V.FINE SAND
15	0		13-15	W	2.0	14-23 27-26		
20	0		18-20	W	2.0	17-14 18-16		AS ABOVE W/SOME MED TO COARSE SAND/TRACE GRAVEL.

PROJECT NAME: PHASE I - BRICKLAND BORING No. MW-3 PROJECT No. 604-9 SHEET 2 OF 2

DEPTH BELOW GRADE	OVA READINGS	TYPE AND No.	DEPTH FROM - TO	MOISTURE	BLOW / 6" OR CORE TIME	SAMPLE RECOVERY	STRATA DEPTH / ELEV.	CLASSIFICATION AND REMARKS TRACE =0-10% LITTLE=10-20% SOME=20-30% AND=35-50%
25	0		23-25	W	8-7 9-10	2.0		RED/BROWN V. FINE SAND W/SOME SILT.
30	0		28-30	W	34-24 26-24	2.0		RED/BROWN FINE TO COARSE SAND W/LITTLE GRAVEL.
35	0		33-35	W	7-7 12-14	2.0		RED/BROWN SAND (FINE)
40								

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SHEET 1 OF 1

DATE STARTED : 3-27-90	DATE FINISHED : 3-28-90	BORING No. MW-4
CLIENT : REXENE		PROJECT No : 601-9

PROJECT NAME & LOCATION : PHASE 1 INVESTIGATION - SUNLAND PARK, NEW MEXICO.

REMARKS: APPROXIMATELY 75-100 GALLONS POTABLE WATER WERE ADDED DURING DRILLING TO PREVENT SAND HEAVING.

DRILLING CONTRACTOR : I. T. | LOGGED BY: K. McHALE | DRILLER : T. DAVIS

EQUIPMENT :	CASING :	SOIL SAMPLER : SPLIT SPOON	SOIL SAMPLER :	CORE BARREL	AUGER	MON. WELL (MW) PIPE	MON. WELL (MW) CAP	DRILL RIG AND METHOD
TYPE :		STD.						MOBILE B-61 HSA
SIZE :		3" x 24"						
HAMMER WT / FALL		140/30"		BIT				

SURFACE ELEVATION :

SURFACE CONDITIONS :

WATER LEVEL AT FT. AFTER HRS. FT. AFTER HRS.

DEPTH BELOW GRADE	OVA READINGS	SAMPLE TYPE AND No.	SAMPLE DEPTH (FROM – TO)	SAMPLE MOISTURE CONTENT	SAMPLE RECOVERY	BLOWS / 6" OR CORE TIME	STRATA DEPTH / ELEV.	DESCRIPTION AND REMARKS TRACE=0–10% LITTLE=10–20% SOME=20–30% AND=35–50%
0				D				TOPSOIL / FILL
	223		0-2	M	2.0	11-1 15-1		GRAY/BROWN SILTY V. FINE SAND - HEAVILY CONTAMINATED W/BLACK PETROLEUM. STRONG GASOLINE ODOR
			2-4	W	2.0	8-6 3-6		
5	356		4-6	W	1.7	7-9 11-10		
			6-8	W	1.8	4-5 6-7		GREY SILT W/TRACE V. FINE SAND.
10	85		8-10	W	1.5	4-4 5-6		
			10-12	W	1.4	6-7 9-11		
15								EOB @ 15.0'
20								

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SHEET 1 OF 1

DATE STARTED : 3-28-90 | DATE FINISHED : 3-28-90 | BORING No. MW-5

CLIENT : REXENE | PROJECT No : 604-9

PROJECT NAME & LOCATION : PHASE 1 INVESTIGATION - SUNLAND PARK, NEW MEXICO

REMARKS:

DRILLING CONTRACTOR : I.T. | LOGGED BY: K. McHALE | DRILLER : T. DAVIS

EQUIPMENT :	CASING :	SOIL SAMPLER : SPLIT SPOON	SOIL SAMPLER :	CORE BARREL	AUGER	MON. WELL (MW) PIPE	MON. WELL (MW) CAP	DRILL RIG AND METHOD
TYPE :		STD.						MOBILE B-61
SIZE :		3" x 24"						
HAMMER WT / FALL		140/30"		BIT				HSA

SURFACE ELEVATION :

SURFACE CONDITIONS :

WATER LEVEL AT FT. AFTER HRS. FT. AFTER HRS.

DEPTH BELOW GRADE	OVA READINGS	SAMPLE TYPE AND No.	SAMPLE DEPTH (FROM - TO)	SAMPLE MOISTURE CONTENT	SAMPLE RECOVERY	BLOWS / 6" OR CORE TIME	STRATA DEPTH / ELEV.	DESCRIPTION AND REMARKS TRACE=0-10% LITTLE=10-20% SOME=20-30% AND=35-50%
0								TAN DRY SAND W/PEBBLES.
	130		0-2	M	1.7	9-11 4-6		BLACK STAINED SILT - ODOR (CRUDE)
	140		2-4	M	2.0	3-4 5-6		GREY/BROWN STAINED SILTY CLAY W/STRONG ODOR.
5				W				
	145		4-6	W	2.0	2-2 3-4		
			6-8	W	1.8	4-8 9-13		GREY/BROWN STAINED V. FINE SAND W/ODORS FROM LIGHTER PETROLEUM FRACTIONS.
10	145		8-10	W	2.0	6-9 3-7		
			10-12	W	2.0	6-8 7-4		
15								
								EOB @ 15.0'
20								

PROJECT NAME: PHASE 1 - BRICKLAND BORING No. MW-6 PROJECT No. 601-9 SHEET 2 OF 2

DEPTH BELOW GRADE	OVA READINGS	TYPE AND No.	DEPTH FROM - TO	MOISTURE	BLOW / 6" OR CORE TIME	SAMPLE RECOVERY	STRATA DEPTH / ELEV.	CLASSIFICATION AND REMARKS TRACE =0-10% LITTLE=10-20% SOME=20-30% AND=35-50%
25	17		23-25	W	3-11 17-12			MED. TO COARSE SAND + GRAVEL
30	30		28-30	W	18-16 18-24			AS ABOVE W/RED/BROWN V. FINE SAND.
35	10		33-35	W	4-14 11-17			RED/BROWN V. FINE SAND W/SOME SILTY CLAY.
								EOB @ 35.0'
40								

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SHEET 1 OF 1

DATE STARTED : 3-30-90 | DATE FINISHED : 3-30-90 | BORING No. MW-7

CLIENT : REXENE | PROJECT No : 604-9

PROJECT NAME & LOCATION : PHASE 1 INVESTIGATION - SUNLAND PARK, NEW MEXICO

REMARKS:

DRILLING CONTRACTOR : I.T. | LOGGED BY: K. McHALE | DRILLER : T. DAVIS

EQUIPMENT :	CASING :	SOIL SAMPLER : SPLIT SPOON	SOIL SAMPLER :	CORE BARREL	AUGER	MON. WELL (MW) PIPE	MON. WELL (MW) CAP	DRILL RIG AND METHOD
TYPE :		STD.						MOBILE B-61
SIZE :		3"x24"						
HAMMER WT / FALL		140/30"		BIT				HSA

SURFACE ELEVATION :

SURFACE CONDITIONS :

WATER LEVEL AT FT. AFTER HRS. FT. AFTER HRS.

DEPTH BELOW GRADE	OVA READINGS	SAMPLE TYPE AND No.	SAMPLE DEPTH (FROM – TO)	SAMPLE MOISTURE CONTENT	SAMPLE RECOVERY	BLOWS / 6" OR CORE TIME	STRATA DEPTH / ELEV.	DESCRIPTION AND REMARKS TRACE=0-10% LITTLE=10-20% SOME=20-30% AND=35-50%
0								TAN V. FINE SAND (FILL)
	341		0-2	M	1.0			BLACK STAINED CLAY
			2-4	M	2.0			↓ STRONG ODOR.
5				W				GREY STAINED SILTY CLAY
	324		4-6	W	1.75			
			6-8	W	2.0			RED/BROWN SILTY BROWN CLAY W/STRONG PETRO ODOR.
10	212		8-10	W	2.0			
			10-12	W	2.0			
15								EOB @ 14.0'
20								

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DATE STARTED : 3-28-90 | DATE FINISHED : 3-28-90 | BORING No. MW-8

CLIENT : REXENE | PROJECT No : 604-9

PROJECT NAME & LOCATION : PHASE 1 INVESTIGATION - SUNLAND PARK, NEW MEXICO

REMARKS:

DRILLING CONTRACTOR : I.T. | LOGGED BY: K. McHALE | DRILLER : T. DAVIS

EQUIPMENT :	CASING :	SOIL SAMPLER : SPLIT SPOON	SOIL SAMPLER :	CORE BARREL	AUGER	MON. WELL (MW) PIPE	MON. WELL (MW) CAP	DRILL RIG AND METHOD
TYPE :		STD.						MOBILE B-61
SIZE :		3"x24"						
HAMMER WT / FALL		140/30"		BIT				HSA

SURFACE ELEVATION :

SURFACE CONDITIONS :

WATER LEVEL AT FT. AFTER HRS. FT. AFTER HRS.

DEPTH BELOW GRADE	OVA READINGS	SAMPLE TYPE AND No.	SAMPLE DEPTH (FROM - TO)	SAMPLE MOISTURE CONTENT	SAMPLE RECOVERY	BLOWS / 6" OR CORE TIME	STRATA DEPTH / ELEV.	DESCRIPTION AND REMARKS TRACE=0-10% LITTLE=10-20% SOME=20-30% AND=35-50%
0								FILL
	70		0-2	M	1.1			Dk Brown Clay.
								GREY STAINED SILTY CLAY.
			2-4	M	2.0			GAS ODOR
5				W				
	150		4-6	W	2.0			
			6-8	W	2.0			BROWN SILTY CLAY W/GAS ODOR.
10	250		8-10	W	2.0			
15								EOB @ 14.0'
20								

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SHEET 1 OF 1

DATE STARTED : 4-6-90 | DATE FINISHED : 4-6-90 | BORING No. MW-10

CLIENT : REXENE | PROJECT No : 604-9

PROJECT NAME & LOCATION : PHASE 1 INVESTIGATION – SUNLAND PARK, NEW MEXICO

REMARKS:

DRILLING CONTRACTOR : I.T. | LOGGED BY: K. McHALE | DRILLER : T. DAVIS

EQUIPMENT :	CASING :	SOIL SAMPLER : SPLIT SPOON	SOIL SAMPLER :	CORE BARREL	AUGER	MON. WELL (MW) PIPE	MON. WELL (MW) CAP	DRILL RIG AND METHOD
TYPE :		STD.						MOBILE B-61
SIZE :		3"x24"						
HAMMER WT / FALL		140/30"		BIT				HSA

SURFACE ELEVATION :

SURFACE CONDITIONS :

WATER LEVEL AT FT. AFTER HRS. FT. AFTER HRS.

DEPTH BELOW GRADE	OVA READINGS	SAMPLE TYPE AND No.	SAMPLE DEPTH (FROM – TO)	SAMPLE MOISTURE CONTENT	SAMPLE RECOVERY	BLOWS / 6" OR CORE TIME	STRATA DEPTH / ELEV.	DESCRIPTION AND REMARKS TRACE=0–10% LITTLE=10–20% SOME=20–30% AND=35–50%
0				D				TAN V. FINE SAND
	0		0-2	M		4-6 11-14		AS ABOVE
				M				
	167		2-4	M		9-8 7-6		BLACK STAINED SILTY CLAY
5				W				
	431		4-6	W		3-4 3-3		
	310		6-8	W		3-5 7-12		RED/BROWN CLAY (STIFF) W/PRODUCT.
10	366		8-10	W		6-6 12-15		
								RED/BROWN V. FINE SAND W/TRACE SILT & PRODUCT.
				M				RED/BROWN DENSE CLAY.
15	83		13-15	W		2-6 7-9		
								RED/BROWN V. FINE SAND W/TRACE PRODUCT
20			18-20	W				

PROJECT NAME : PHASE I - BRICKLAND BORING No. MW-9D PROJECT No. 604-9 SHEET 2 OF 2

DEPTH BELOW GRADE	OVA READINGS	TYPE AND No.	DEPTH FROM - TO	MOISTURE	BLOW / 6" OR CORE TIME	SAMPLE RECOVERY	STRATA DEPTH / ELEV.	CLASSIFICATION AND REMARKS TRACE =0-10% LITTLE=10-20% SOME=20-30% AND=35-50%
	O		23-25	W	9-6 9-12	2.0		
25								RED/BROWN V.FINE TO FINE SAND W/TRACE GRAVEL.
30	O		28-30	W	17-19 11-9	2.0		
35	O		33-35	W	15-29 17-11	2.0		
								EOB @ 35.0'
40								
45								

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2317 INTERNATIONAL LANE MADISON, WI. 53704

SHEET 1 OF 1

DATE STARTED: 3-28-90 | DATE FINISHED: 3-28-90 | BORING No. MW-5

CLIENT: REXENE | PROJECT No: 604-9

PROJECT NAME & LOCATION: PHASE 1 INVESTIGATION – SUNLAND PARK, NEW MEXICO

REMARKS:

DRILLING CONTRACTOR: I.T. | LOGGED BY: K. McHALE | DRILLER: T. DAVIS

EQUIPMENT:	CASING:	SOIL SAMPLER: SPLIT SPOON	SOIL SAMPLER:	CORE BARREL	AUGER	MON. WELL (MW) PIPE	MON. WELL (MW) CAP	DRILL RIG AND METHOD
TYPE:		STD.						MOBILE B-61
SIZE:		3"x24"						
HAMMER WT / FALL		140/30"		BIT				HSA

SURFACE ELEVATION:

SURFACE CONDITIONS:

WATER LEVEL AT FT. AFTER HRS. FT. AFTER HRS.

DEPTH BELOW GRADE	OVA READINGS	SAMPLE TYPE AND No.	SAMPLE DEPTH (FROM – TO)	SAMPLE MOISTURE CONTENT	SAMPLE RECOVERY	BLOWS / 6" OR CORE TIME	STRATA DEPTH / ELEV.	DESCRIPTION AND REMARKS TRACE=0–10% LITTLE=10–20% SOME=20–30% AND=35–50%
0								TAN DRY SAND W/PEBBLES.
	130		0-2	M	1.7	9-11 4-6		BLACK STAINED SILT – ODOR (CRUDE)
	140		2-4	M	2.0	3-4 5-6		GREY/BROWN STAINED SILTY CLAY W/STRONG ODOR.
5				W				
	145		4-6	W	2.0	2-2 3-4		
			6-8	W	1.8	4-6 9-13		GREY/BROWN STAINED V. FINE SAND W/ODORS FROM LIGHTER PETROLEUM FRACTIONS.
10	145		8-10	W	2.0	6-9 3-7		
			10-12	W	2.0	6-8 7-4		
15								EOB @ 15.0'
20								

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SHEET 1 OF 2

DATE STARTED : 4-8-90	DATE FINISHED : 4-8-90	BORING No. MW-6
CLIENT : REXENE		PROJECT No : 604-9
PROJECT NAME & LOCATION : PHASE 1 INVESTIGATION - SUNLAND PARK, NEW MEXICO		
REMARKS:		
DRILLING CONTRACTOR : I.T.	LOGGED BY: K. McHALE	DRILLER : T. DAVIS

EQUIPMENT :	CASING :	SOIL SAMPLER : SPLIT SPOON	SOIL SAMPLER :	CORE BARREL	AUGER	MON. WELL (MW) PIPE	MON. WELL (MW) CAP	DRILL RIG AND METHOD
TYPE :		STD.						MOBILE B-61
SIZE :		3"x24"						
HAMMER WT / FALL		140/30"		BIT				HSA

SURFACE ELEVATION :

SURFACE CONDITIONS :

WATER LEVEL AT FT. AFTER HRS. FT. AFTER HRS.

DEPTH BELOW GRADE	OVA READINGS	SAMPLE TYPE AND No.	SAMPLE DEPTH (FROM - TO)	SAMPLE MOISTURE CONTENT	SAMPLE RECOVERY	BLOWS / 6" OR CORE TIME	STRATA DEPTH / ELEV.	DESCRIPTION AND REMARKS TRACE=0-10% LITTLE=10-20% SOME=20-30% AND=35-50%
0								
	510		0-2	M	1.2	3-10 4-15		TAN V. FINE SILTY SAND W/DK. GREY → BLACK PETRO STAINING.
	518		2-4	M	2.0	8-3 5-5		
5								
	560		4-6	W	2.0	4-6 5-3		
	495		6-8	W	2.0	2-2 1-4		
10	80		8-10	W	2.0	3-2 1-1		
								RED/BROWN V. FINE SAND W/TRACE SILT AND GREY PETRO STAINING.
15	38		13-15	W	2.0	11-6 6-9		
20	24		18-20	W	2.0	14-18 13-20		

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SHEET 1 OF 1

DATE STARTED : 4-5-90	DATE FINISHED : 4-5-90	BORING No. MW-11
CLIENT : REXENE		PROJECT No : 604-9
PROJECT NAME & LOCATION : PHASE 1 INVESTIGATION - SUNLAND PARK, NEW MEXICO		
REMARKS:		
DRILLING CONTRACTOR : I.T.	LOGGED BY: K. McHALE	DRILLER : T. DAVIS

EQUIPMENT :	CASING :	SOIL SAMPLER : SPLIT SPOON	SOIL SAMPLER :	CORE BARREL	AUGER	MON. WELL (MW) PIPE	MON. WELL (MW) CAP	DRILL RIG AND METHOD
TYPE :		STD.						MOBILE B-61
SIZE :		3"x24"						
HAMMER WT / FALL		140/30"		BIT				HSA

SURFACE ELEVATION :

SURFACE CONDITIONS :

WATER LEVEL AT FT. AFTER HRS. FT. AFTER HRS.

DEPTH BELOW GRADE	OVA READINGS	SAMPLE TYPE AND No.	SAMPLE DEPTH (FROM - TO)	SAMPLE MOISTURE CONTENT	SAMPLE RECOVERY	BLOWS / 6" OR CORE TIME	STRATA DEPTH / ELEV.	DESCRIPTION AND REMARKS TRACE=0-10% LITTLE=10-20% SOME=20-30% AND=35-50%
0				D				TAN V. FINE SAND (FILL)
	0		0-2	M	1.5	3-11 11-12		
	376		2-4	M	1.0	17-21 17-10		RED/BROWN SANDY SILT W/GREY STAINING.
5	416		4-6	M	1.5	1-3 4-3		
	435		6-8	M	1.5	5-2 2-2		
10	464		8-10	M	2.0	3-2 4-3		RED/BROWN SILTY CLAY W/PETROLEUM PRODUCT.
								RED/BROWN SILTY V. FINE SAND
15	52		13-15	W	2.0	3-3 5-5		
								RED/BROWN V. FINE SAND W/PEBBLE FRAGMENTS.
20	0		18-20	W	2.0	17-10 19-21		

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SHEET 1 OF 2

DATE STARTED : 4-11-90	DATE FINISHED : 4-11-90	BORING No. MW-12
CLIENT : REXENE		PROJECT No : 604-9

PROJECT NAME & LOCATION : PHASE 1 INVESTIGATION – SUNLAND PARK, NEW MEXICO

REMARKS:

DRILLING CONTRACTOR : I.T.	LOGGED BY: K. McHALE	DRILLER : T. DAVIS

EQUIPMENT :	CASING :	SOIL SAMPLER : SPLIT SPOON	SOIL SAMPLER	CORE BARREL	AUGER	MON. WELL (MW) PIPE	MON. WELL (MW) CAP	DRILL RIG AND METHOD
TYPE :		STD.						MOBILE B-61
SIZE :		3"x24"						
HAMMER WT / FALL		140/30"		BIT				HSA

SURFACE ELEVATION :

SURFACE CONDITIONS :

WATER LEVEL AT FT. AFTER HRS. FT. AFTER HRS.

DEPTH BELOW GRADE	OVA READINGS	SAMPLE TYPE AND No.	SAMPLE DEPTH (FROM – TO)	SAMPLE MOISTURE CONTENT	SAMPLE RECOVERY	BLOWS / 6" OR CORE TIME	STRATA DEPTH / ELEV.	DESCRIPTION AND REMARKS TRACE=0-10% LITTLE=10-20% SOME=20-30% AND=35-50%
0								
	0		0-2	M	1.5	4-4 4-6		RED/BROWN SILTY CLAY.
	0		2-4	M	2.0	3-2 3-3		
5								
	0		4-6	W	2.0	2-2 4-6		RED/BROWN CLAY (STIFF)
								RED BROWN SILTY CLAY
			6-8					
								RED/BROWN CLAY (STIFF)
10	0		8-10	W	2.0	5-4 4-7		
								RED/BROWN V. FINE SAND
15	0		13-15	W	2.0	15-14 15-17		
20	0		18-20	W	2.0	7-10 17-16		MED SAND AND GRAVEL

PROJECT NAME : REXENE - BRICKLAND BORING No. MW-12 PROJECT No. 604-9 SHEET 2 OF 2

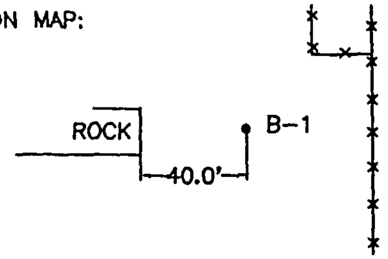
DEPTH BELOW GRADE	OVA READINGS	TYPE AND No.	DEPTH FROM - TO	MOISTURE	BLOW / 6" OR CORE TIME	SAMPLE RECOVERY	STRATA DEPTH / ELEV.	CLASSIFICATION AND REMARKS TRACE =0-10% LITTLE=10-20% SOME=20-30% AND=35-50%
25								
								EOB @ 25.0'
30								

Appendix B

Lithologic Logs of Monitoring Wells, Boreholes, and Trenches (GCL, 1994)

LITHOLOGIC LOG (CORE)

LOCATION MAP:



__1/4 __1/4 __1/4 __1/4 S__ T__ R__

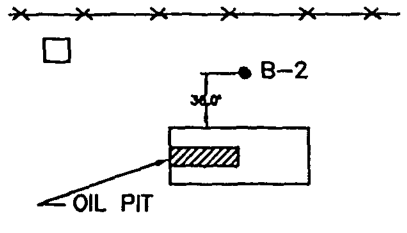
SITE ID: REXENE LOCATION ID: B-1
SITE COORDINATES (ft.):
N ______ E ______
GROUND ELEVATION (ft. MSL): ______
STATE: NEW MEXICO COUNTY: DONA ANA
DRILLING METHOD: HOLLOW STEM\LEXAN TUBE
DRILLING CONTR.: GEO PROJECTS
DATE STARTED: 6/17/94 DATE COMPLETED: 6/17/94
FIELD REP.: DALE LITTLEJOHN
COMMENTS: ONE FOOT AWAY FROM ATTEMPT MADE 6/16/94

LOCATION DESCRIPTION: ______

DEPTH	WELL CONST.	LITH.	SAMPLE USCS	FROM	TO	% REC	PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
0–2			PUSH W/ DRILL-ING	0	2	30		SILT AND CLAY LT. BROWN, OR ANGULAR GRAVEL W/ ORGANIC MATERIAL.
2–4			PUSH W/ DRILL-ING	2	4	60		CLAY REDDISH BRN TO DK BRN. W/O LITTLE < 5% UFN GR SAND, NO STRINGERS OF SAND. MOIST CLAY.
4–6			PUSH W/ DRILL-ING	4	6	100		CLAY BROWN W/ SOME VERY SMALL SAND POCKETS, AND SOME APPARENT N.C. STAINS UFN. OR SD. (NOT CONTINUOUS LAYERS) MOIST
6–8			PUSH W/ DRILL-ING	6	8	70		CLAY DK. BROWN, INCREASING SAD, UFN GR, W/S, SUB-ANGULAR, IN POORLY DEFINED LENSES WITHIN THE CLAY, WET
8–10								* SAMPLE WET BELOW ≈ 6.0' FL IN WELL 3.8' BELOW SURFACE BORING TO BE PLUGGED

LITHOLOGIC LOG

LOCATION MAP:



___1/4 ___1/4 ___1/4 ___1/4 S___ T___ R___

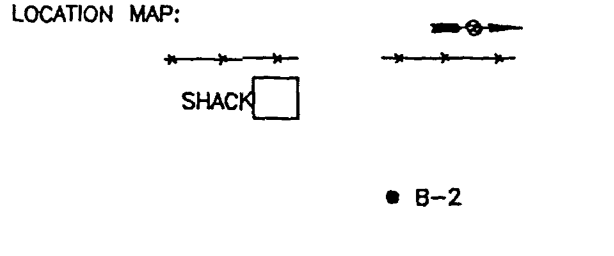
SITE ID: REXENE LOCATION ID: B-2
SITE COORDINATES (ft.):
N ______ E ______
GROUND ELEVATION (ft. MSL): ______
STATE: NEW MEXICO COUNTY: DONA ANA
DRILLING METHOD: HOLLOW STEM\LEXAN TUBE
DRILLING CONTR.: GEO PROJECTS
DATE STARTED: 6/17/94 DATE COMPLETED: 6/17/94
FIELD REP.: DALE LITTLEJOHN
COMMENTS: BORING TO BE PLUGGED

LOCATION DESCRIPTION: ______

DEPTH	WELL CONST.	LITH.	SAMPLE USCS	SAMPLE FROM	SAMPLE TO	SAMPLE % REC	SAMPLE PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
0–0.5								GRAVEL FILL 6" SILT W/ ANGULAR FRAG OF GRAVEL. LT BRN 10 YR 6/2
1			AUGER PUSH	6"	2'	60		CLAY W/ <5% FN GR SAND, BLK, HEAVY STAIN AND ODOR. N2
2–3			AUGER PUSH	2'	4'	60		CLAY (AS ABOVE) LESS STAIN AND ODOR SLIGHTLY W/ DEPTH, NO SAND STRINGERS N2
4–5			AUGER PUSH	4'	6'	100		SAND (AT 4-1/2 FT.) WITH CLAY ≈ 30% DK. BRN, (HC STAIN) FN GRAIN, W/S, SUB ROUNDED-ROUNDED, (WTR SAND) BTM OF SAND AT 5.75 (WET) SY 4/1
6–7			AUGER PUSH	6'	8'	70		CLAY, BRN-DK BRN, < 5% SAND INC. W/ DEPTH (WET) TD LITH HOLE AT 8' 5YR 5/2
8–9			AUGER PUSH	8'	10'	50		CLAY, 5YR 5/2, < 5% SAND, FN GR W/S , SUBANGULAR
10								FLUID LEVEL IN HOLE RECOVERED TO ≈

LITHOLOGIC LOG (CORE)

LOCATION MAP:



___1/4 ___1/4 ___1/4 ___1/4 S___ T___ R___

SITE ID: REXENE LOCATION ID: B-3
SITE COORDINATES (ft.):
N 289061.96163 E 1551880.27191
GROUND ELEVATION (ft. MSL): 3131.71
STATE: NEW MEXICO COUNTY: DONA ANA
DRILLING METHOD: HOLLOW STEM\LEXAN TUBE
DRILLING CONTR.: GEO PROJECTS
DATE STARTED: 6/17/94 DATE COMPLETED: 6/17/94
FIELD REP.: DALE LITTLEJOHN
COMMENTS:

LOCATION DESCRIPTION:

DEPTH	WELL CONST.	LITH.	SAMPLE USCS	FROM	TO	% REC	PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
								GRAVEL, DEBRIS, FILL
			PUSH WITH AUGER	6"	2'	40		SANDY SILT V. FN GR ≈ 10% SD DRY, LT BRN 10YR 6/2, ANGULAR, W/G, ROUNDED TO ANGULAR GRAVEL, DEC. W/ DEPTH
1								SAND, FN GRAIN– V. FN GRAIN, ≈ 15% CLAY MOIST, PALE BRN. 5YR 5/2, SUB RND, W/S, RELATIVELY CLEAN.
2								CLAY, NO GRAINS, < 5% SD, MOIST, BLACK, HEAVY STAIN, AND HEAVY ODOR, DENSE. STICKY.
3			PUSH WITH AUGER	2'	4'	40		
4								SILTY SAND, V. VN. GR, 10–20% SILT, WITH MINOR CLAY, WET, PALE BRN 5YR 5/2, SUB RND–SUB ANG., WELL SORTED, UNCONSOLID. H.C. ODOR. (SLIGHT)
5			PUSH WITH AUGER	4'	6'	100		
6								SILTY CLAY, V FN., 10% SILTY, WET PALE BROWN. 5YR 5/2, SAME HYDROC STAINING
7			PUSH WITH AUGER	6'	8'	90		SILTY SAND, V FN, GRN, 20–30% SILT, W/ MINOR CLAY, WET, PALE BRN 5YR 5/2, SUB RND–SUB ANG.
8								
9								
10								TD = 8' WATER LEVEL RECOVERED TO ≈ 2' BELOW SURF.

LITHOLOGIC LOG (CORE)

LOCATION MAP: SEE MAP

__1/4 __1/4 __1/4 __1/4 S__ T__ R__

SITE ID: REXENE LOCATION ID: B-4 (MW-14)
SITE COORDINATES (ft.):
N 288993.83608 E 1551953.24319
GROUND ELEVATION (ft. MSL): 3730.40
STATE: NEW MEXICO COUNTY: DONA ANA
DRILLING METHOD: HOLLOW STEM AUGER
DRILLING CONTR.: GEO PROJECTS
DATE STARTED: 6/19/94 DATE COMPLETED: 6/19/94
FIELD REP.: DALE LITTLEJOHN
COMMENTS: MUCH MOVE SAND IN THIS WELL. CONVERT TO MONITOR WELL #14

LOCATION DESCRIPTION:

DEPTH	WELL CONST.	LITH.	SAMPLE: USCS	FROM	TO	% REC	PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
								GRAVEL, FILL, DEBRIS
				6"	2'	20		SILT. V FN GR, < 10% SAND, 20% GRAVEL DRY, PALE YELLOW BRN (10YR 6/2), ANG, POOR SORT, CONSOLID.
2				2'	4' WET AT BASE	70		SILTY CLAY, 20% SILT, <10% SAND, DRY (10YR 5/2) HC STAIN, ANG, CONSOLID.
4				4'	6' WET, SANDY SILT PROD	80		SILTY SAND, 40% SILT, V FN GR., WET, DK YELLOWISH BRN, (10YR 4/20) ANG TO SUB-RNDED, W/S, MOD. CONSOLID, NO STAIN/ODOR CLAY, WET, PALE BRN (5YR 5/2) CONSOLID.
6								SILTY SAND (AS 3.5-5) NO STAIN OR ODOR
				6'	8' WET SAND/CLAY	100		SILTY SAND, V FN GR, 20% SILT, WET (5YR 5/2) RND, W/S UNCONSOLID.
8								SILTY CLAY (SEE 2')
				8'	10' WET SAND	90		SAND, FN GRN. TO MED GR, WET DK, YELLOWISH BRN, (10YR 4/2) SUB RND, W/S, UNCONSOLID (FLOW SAND)
10								GREAT DIFFICULTY CATCHING SPLIT SPOON SAMPLE.
				10'	12' WET SAND	50		
12					SAND TOO WET TO SAMPLE			
14								
16								SAND, MED GR, WET, DK YELLOWISH BRN, (10YR 4/2), RND-SUB RND, WELL SORTED, UNCONSOLID, 80% QTZ. (FLOW SAND)
18					MED GR SAND			
20								

LITHOLOGIC LOG (CORE)
(Continued)

LOCATION ID: B-4 (MW-14)

DEPTH	WELL CONST.	LITH.	SAMPLE USCS	FROM	TO	% REC	NUMBER OR PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
								SAND AS ABOVE
22								
								TD = 23'
24								
26								
28								
30								
32								
34								
36								
38								
40								
42								
44								
46								

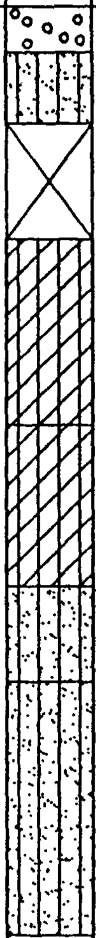
LITHOLOGIC LOG (CORE)

LOCATION MAP: SEE SITE MAP

__1/4 __1/4 __1/4 __1/4 S__ T__ R__

SITE ID: REXENE LOCATION ID: B-5
SITE COORDINATES (ft.):
N ______ E ______
GROUND ELEVATION (ft. MSL): ______
STATE: NEW MEXICO COUNTY: DONA ANA
DRILLING METHOD: HOLLOW STEM\LEXAN TUBE
DRILLING CONTR.: GEO PROJECTS
DATE STARTED: 6/17/94 DATE COMPLETED: 6/17/94
FIELD REP.: DALE LITTLEJOHN
COMMENTS: ______

LOCATION DESCRIPTION: ______



DEPTH	WELL CONST.	LITH.	SAMPLE USCS	FROM	TO	% REC	PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
0								GRAVEL, FILL AND DEBRIS
								SANDY SILT, V. FN FRN, < 10% SAND, WITH ≈ 10% CLAY, DRY. LT BRN, (10YR 6/2), ANGULAR, M/5, SAME SMALL GRAVEL
1			AUGER PUSH	6"	2'	30		
2								SILTY CLAY, V. FN GRN, ≈ 20-30% SILT, DRY, PALE BRN. (5YR 5/2), SUBRND. W/S, DENSE, STICKY. STAINED (HC) AT TOP OF UNIT, AND AT BASE, REL. CLEAN
3			AUGER PUSH	2'	4'	40		
4								CLAYEY SILT, V FN GRN, ≈ 50% CLAY, MOIST, DK BRN (HC STAINED), ROUNDED, W/S, STRONG HC ODOR.
5			AUGER PUSH	4'	6'	90		SILTY SAND, V FN GRN, ≈ 40% SILT, WET, GRAYISH BRN (5YR 3/2), SUB-RND TO ANG, WELL SORTED, UNCONSOL. HC ODOR.
6								SANDY SILT, V FN GRN, ≈ 30% SAND WET, PALE BRN (5YR 5/2) ANGULAR W/S, UNCONSOLID. TO REL CONSOLID, NO HC STAIN, SLIGHT HC ODOR TD = 8'
7			AUGER PUSH	6'	8'			
8								
9								
10								

LITHOLOGIC LOG (CORE)

Page 1 of 1

LOCATION MAP: SEE MAP

__1/4 __1/4 __1/4 __1/4 S__ T__ R__

SITE ID: REXENE LOCATION ID: B-6
SITE COORDINATES (ft.):
N 289167.85159 E 1552005.02334
GROUND ELEVATION (ft. MSL): 3731.37
STATE: NEW MEXICO COUNTY: DONA ANA
DRILLING METHOD: HOLLOW STEM AUGER
DRILLING CONTR.: GEO PROJECTS
DATE STARTED: 6/18/94 DATE COMPLETED: 6/18/94
FIELD REP.: DALE LITTLEJOHN
COMMENTS: ADJACENT TO WP # 29

LOCATION DESCRIPTION:

DEPTH	WELL CONST.	LITH.	SAMPLE USCS	FROM	TO	% REC	PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
0	WELL POINT 29 SCREEN							GRAVEL, DEBRIS AND FILL
								SANDY SILT, V FN GRAIN, ≈ 20% SILT, DRY, LT BRN (10YR 6/2) ANGULAR, M/S, CONSOLID. ANGULAR GRAVEL, SALT.
1				6"	2'	30		SILTY CLAY, V. FN GRAIN, < 10% SILT, MOIST NEAR BOTTOM, GRAYISH BRN, (5YR 3/2) SUB-RND, W/S, HS ODOR NO SIGNIF. STAINING.
2								
3				2'	4'	100		SILTY SAND, V. FN. GR. 20-30% SILT, WET, PALE BRN (3YR 5/2) SUB-ANG, W/S, (HC ODOR) UNCONSOLID, NO SIGNIF. STAIN.
4								
5				4'	6'	80		SILTY CLAY V FN. GR. ≈ 20% SILT, WET PALE BRN (5YR 5/2) SUB-RND, W/S.
								SILTY SAND (AS ABOVE 3-5')
6								SILTY CLAY (AS 5-5.5')
7				6'	8'	100		SAND, FN GRAIN, < 10% SILT, WET, PALE BRN (5YR 5/2) RND, W/S, HC ODOR, NO STAIN.
8								TD = 8'
								* LEL TO 1% DURING DRILLING
								FLUID LEVEL AFTER DRIL ≈ 1.0" B.S.
9								
10								

LITHOLOGIC LOG (CORE)

LOCATION MAP: SEE MAP

__1/4 __1/4 __1/4 __1/4 S__ T__ R__

SITE ID: REXENE LOCATION ID: B-7
SITE COORDINATES (ft.):
N ______ E ______
GROUND ELEVATION (ft. MSL): ______
STATE: NEW MEXICO COUNTY: DONA ANA
DRILLING METHOD: HOLLOW STEM AUGER
DRILLING CONTR.: GEO PROJECTS
DATE STARTED: 6/18/94 DATE COMPLETED: 6/18/94
FIELD REP.: DALE LITTLEJOHN
COMMENTS: ______

LOCATION DESCRIPTION: SAGE BRUSH AND DEBRIS. APPARENT SALT AT SURF.

DEPTH	WELL CONST.	LITH.	SAMPLE USCS	FROM	TO	% REC	PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
0								GRAVEL, FILL MATERIAL
1			PUSH WITH AUGER	6"	2'	15		SANDY SILT, FN GRAIN, 20% SAND, DRY, YELLOWISH BRN (10YR 5/4), ANGULAR, MED SORT (M/S), MOD. CONSOLID. SAND INC W/DEPTH. HC STAIN AT BASE OF UNIT.
2–3			PUSH WITH AUGER	2'	4'	70		SILTY CLAY, V FN GRN, <10% SILT, DRY, GRAYISH BRN (5YR 3/2), RND, W/S, MOD. CONSOLID. MOTTLED HC STAINING
4–5			PUSH WITH AUGER	4'	6'	90		SILTY SAND, FN GRN, 10% SILT, WET, YELLOWISH BRN (10YR 4/2), RND-TO WELL ROUDN, W/S, UNCONSOLID., THIN ZONE, WATER SAND. SILTY CLAY, V. FN. GRN, <10% SILT, WET, GRAYISH BRN (5YR 3/2), RND-SUB RND, W/S, SLIGHT HC ODOR, NO SIGNIF STAIN.
6–7			PUSH WITH AUGER	6'	8'	10		COULD NOT CATCH WET SAMPLE. APPEARED SANDIER THAN ABOVE UNIT, (CUTTINGS) WET.
8								FL ≈ 1.0 FT B.S. TD = 8'
9								
10								

LITHOLOGIC LOG (CORE)

LOCATION MAP: SEE MAP

__1/4 __1/4 __1/4 __1/4 S__ T__ R__

SITE ID: REXENE LOCATION ID: B-8
SITE COORDINATES (ft.):
N ____ E ____
GROUND ELEVATION (ft. MSL): ____
STATE: NEW MEXICO COUNTY: DONA ANA
DRILLING METHOD: HOLLOW STEM AUGER
DRILLING CONTR.: GEO PROJECTS
DATE STARTED: 6/18/94 DATE COMPLETED: 6/18/94
FIELD REP.: DALE LITTLEJOHN
COMMENTS: NEAR DUMPSITE

LOCATION DESCRIPTION: ____

DEPTH	WELL CONST.	LITH.	SAMPLE USCS	SAMPLE FROM	SAMPLE TO	SAMPLE % REC	SAMPLE PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
								GRAVEL, DEBRIS, SANDY FILL, BROWN, NO STAIN OR ODOR.
1				6"	2'	50		SANDY SILT, FINE GRAIN SD, ≈ 10% SAND, DRY, YELLOW BRN, (10YR 5/4) ANGULAR, M/S, CONSOLID. W/ ANGULAR, PEBBLE GRAVEL
2								SILTY CLAY, V FN GRAIN, 20-30% SILT, MINOR SAND, DRY, DUSKY YELLOWISH BRN (10YR 2/2) (HC STAINED), ANGULAR GRNS, W/S, CONSOLID, STRON HC ODOR AND STAIN.
3				2'	4'	25		
4								SILT, V FN GRAN, (W/ INTERBEDD- 6" SILTY CLAY BEDS) WET, BLACK (HC STAIN) ANG-SUB RND, W/S, GRAINS, MOD. CONSOLID, STRONG HC ODOR AND STAIN.
5				4'	6'	80		
6								SILTY SAND, V FN GR, 10-20% SILT. MINOR CLAY, WET, GRAYISH BRN, (5YR 3/2) RND-SUB RND, W/S, GRN, UNCONSOLID. HC STAIN AND ODOR IN UPPER UNIT, NO STAIN IN LOWER FOOT. TD = 8'
7				6'	8' WET SAND	90		
8								
9								
10								

LITHOLOGIC LOG (CORE)

LOCATION MAP: SEE MAP

__1/4 __1/4 __1/4 __1/4 S__ T__ R__

SITE ID: REXENE LOCATION ID: B-9
SITE COORDINATES (ft.):
N ______ E ______
GROUND ELEVATION (ft. MSL): ______
STATE: NEW MEXICO COUNTY: DONA ANA
DRILLING METHOD: HOLLOW STEM AUGER
DRILLING CONTR.: GEO PROJECTS
DATE STARTED: 6/18/94 DATE COMPLETED: 6/18/94
FIELD REP.: DALE LITTLEJOHN
COMMENTS: HEAVY BRUSH, NO GRAVEL, LESS DEBRIS

LOCATION DESCRIPTION: ______

DEPTH	WELL CONST.	LITH.	SAMPLE USCS	SAMPLE FROM	SAMPLE TO	SAMPLE % REC	SAMPLE PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
								SILTY FILL, ORGANIC MATERIAL AND DEBRIS
								SANDY SILT, V. FN GR, 20% SAND, CLAY DK YELLOWISH BRN (10YR 5/4) ANGULAR, MED/SORT, CONSOLID.. NO STAIN, OR ODOR.
1				6"	2'	30		
2								SILTY SAND, FN GRAIN, 30% SILT, DRY, GRAYISH BRN (5YR 5/2), RND-SUB RND, W/S, MOD. CONSOLID, NO ODOR OR STAIN. WET AT BTM. OF UNIT.
3				2'	4'	30		
4								SILTY CLAY, V,V, FN GR, 30-40% SILT, WET, GRAY (N4)(HC STAIN), WELL SORT, MOD. CONSOLID., LENSES OF LIGHT GRAY CLAY.
5				4'	6'	100		
6								SILTY SAND, V. FN GR, 20% SILT, WET GRAYISH BRN (5YR 5/2) RND-SUB RND, W/S, MOD CONSOLID, NOT STAIN OR ODOR.
								SILTY CLAY, V FN GR, 10% SILT WET, GRAYISH BRN (5YR 5/2), W/S. NO STAIN OR ODOR. SILTY INCREASE SLIGHTY W/ DEPTH. TO TD OF 12'.
7				6'	8'	90		
8								
9				8'	10'	90		
10								

LITHOLOGIC LOG (CORE)
(Continued)

LOCATION ID: B-9

DEPTH	WELL CONST.	LITH.	SAMPLE USCS	FROM	TO	% REC	NUMBER OR PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
11				10	12	90		
12								TD = 12' (SAME LITH)
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								

LITHOLOGIC LOG (CORE)

LOCATION MAP:

__1/4 __1/4 __1/4 __1/4 S__ T__ R__

SITE ID: REXENE LOCATION ID: B-10
SITE COORDINATES (ft.):
N 288429.59539 E 1552201.23136
GROUND ELEVATION (ft. MSL): 3733.52
STATE: NEW MEXICO COUNTY: DONA ANA
DRILLING METHOD: HOLLOW STEM AUGER
DRILLING CONTR.: GEO PROJECTS
DATE STARTED: 6/20/94 DATE COMPLETED: 6/20/94
FIELD REP.: DALE LITTLEJOHN
COMMENTS: BORING IN SAND AREA, USED TRACK HOE TO MOBILIZE RIG (NEAR WP 30)

LOCATION DESCRIPTION: SAND DUNED W/ SOME SPARSE VEG.

DEPTH	WELL CONST.	LITH.	SAMPLE USCS	FROM	TO	% REC	PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
0			AUGER PUSH					SAND, MED GR., <10% CLAY, DRY, PALE YELLOWISH BRN. (10YR 6/2), ANGULAR-SUB ANG, MED SORT, UNCOSOLID. (DUNES)
1				0	2	40		
2								
3				2	4	40		SAND, MD-FN GRN, ≈ 20% SILT, DRY, MOD. YELLOWISH BRN (10YR 5/4), SUB ANG-SUB RND, MOD. SORTED, UNCONSOLID.
4								SILTY CLAY, V FN GRN. 40% SILT, MOIST, PALE YELLOWISH BR. (10YR 6/2), CONSOLID. NO HC STAIN OR ODOR.
5				4	6	30		
6								SILTY CLAY, V. FN GR, <10%, SILT, DRY , GRAYISH BRN (5YR 7/2), CONSOLID. NO HC ODOR, STAIN AT BASE.
7				6	8	30		
8								SILTY SAND, V. FN GR, ≈ 20% WILT, WET, BROWNISH GRAY (5YR 4/1), ANG-SUB ANG, W/S, MOD CONSOLID, STRONG HC ODOR, POSS. HC STAIN.
9				8	10	70		
10								SANDY SILT, V FN GR, <10% SAD, WET PROD PRESENT CONSOLIDDATED (5YR 3/2)

LITHOLOGIC LOG (CORE)
(Continued)

LOCATION ID: B-10

DEPTH	WELL CONST.	LITH.	SAMPLE USCS	FROM	TO	% REC	NUMBER OR PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
11				10	12	60		
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								

LITHLOGIC LOG (CORE)

LOCATION MAP: SEE MAP

__1/4 __1/4 __1/4 __1/4 S__ T__ R__

SITE ID: REXENE LOCATION ID: B-11
SITE COORDINATES (ft.):
N ______ E ______
GROUND ELEVATION (ft. MSL): ______
STATE: NEW MEXICO COUNTY: DONA ANA
DRILLING METHOD: HOLLOW STEM AUGER
DRILLING CONTR.: GEO PROJECTS
DATE STARTED: 6/20/94 DATE COMPLETED: 6/20/94
FIELD REP.: DALE LITTLEJOHN
COMMENTS: ______

LOCATION DESCRIPTION: SAND DUNES

DEPTH	WELL CONST.	LITH.	SAMPLE USCS	SAMPLE FROM	SAMPLE TO	SAMPLE % REC	SAMPLE PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
								NO SAMPLE, SPUD IN SAND (AS BELOW)
				0	2	30		SAND, MED GRAIN, <5% SILT, DRY, PALE BROWN (5YR 5/2) RNDED - SUB RND, WELL SORTED, UNCOSOLIDATED, NO ODOR OR STAIN.
2				2	4	80		
4				4	6	40		SILT. V. FN GRN, <10% CLAY, MOIST, BLACK, HC STAINED, W/S, MOD. CONSOLIDATION, STR HC ODOR.
6				6	8	30		SILTY SAND, F FN GRN, 30% SILT, MINOR CLAY, WET, HEAVY HC STAIN AND ODOR (BLACK), SUB RND, W/S, MOD CONSOLIDATION.
8				8	10	90		SAND, VN GR, <10% SILT, WET, PROD. SATURATED, DK GRAY - BLK (HC STAIN) RND - SUB RND, W/S, MOD. CONSOLID TO UNCONSOLID. (STRONG HC ODOR/FREE PRODUCT.
10				10	12	100		SILTY CLAY, 10% SILT, DK BRN, MOTTLED WITH HC STAINING (BLK). MOD CONSOLID. STRONG HC ODOR.
12								TD = 12'
14								
16								
18								
20								

LITHOLOGIC LOG (CORE)

LOCATION MAP:

__1/4 __1/4 __1/4 __1/4 S__ T__ R__

SITE ID: REXENE LOCATION ID: B-12(MW-16)
SITE COORDINATES (ft.):
N 288172.59247 E 1552284.09469
GROUND ELEVATION (ft. MSL): 3737.07
STATE: NEW COUNTY: DONA ANAN
DRILLING METHOD: HOLLOW STEM AUGER
DRILLING CONTR.: DALE LITTLEJOHN
DATE STARTED: 6/21/94 DATE COMPLETED: 6/21/94
FIELD REP.: DALE LITTLEJOHN
COMMENTS: CONNECTED TO MONITOR WELL # 16

LOCATION DESCRIPTION:

DEPTH	WELL CONST.	LITH.	SAMPLE: USCS	FROM	TO	% REC	PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
0–5.2								SAND, MED GR., DRY, PALE YELLOWISH BRN (10YR 6/2), SUB-ANGULAR, MOD. SORTED, UNCONSOLID, NO STAIN OR ODOR.
5.2–7.6								SAND. FN GR, MOD. YELLOW BRN, (10YR 6/2), ANGULAR, WELL SORTED, UNCONSOLID. NO ODOR /OR STAIN.
7.6–10								CLAY, (V. FN SR. SILT) <10% SILT, DK. YELLOW BRN (10YR 4/2) CONSOLID. HC STAIN AT BASE OF UNIT ONLY. HC ODOR AT BASE OF UNIT.
10–12							NOTE : 8' TO 16' LOGGED FROM ___ HOLE, OTHER SAMP. DESC DETERM. FROM MON. WELL	SILT, V FN GR, 30% CLAY, MOIST, GRAY, HC STAIN AND ODOR, W/S CONSOLID.
12–14								SILTY SAND, FN GR, 50% SILT, WET, GRAY, HC STAIN AND ODOR, MOD. CONSOLID, SUB RND, MED SORT.
14–18								* [THIS INTERVAL WAS NOT STAINED BUT SATURATED WITH PROD. SOME INTERVAL IN MON. WELL (10's) DID NOT!] SILTY SAND. V FN GR., WET, 30% SILT, PALE BRN, (5YR 5/2), ANG-SUB ANG, WELL SORTED, CONSOLID. NO HC STAIN OR ODOR.
18–22								SAND. FN GRAIN, <55 SILT, WET, GRAYISH BROWN (5YR 3/2), SUB RND, W/S, MOD. CONSOLID. NO STAIN, OR HC ODOR.

LITHOLOGIC LOG (CORE)
(Continued)

LOCATION ID: B-12 (MW-16)

DEPTH	WELL CONST.	LITH.	SAMPLE USCS	SAMPLE FROM	SAMPLE TO	SAMPLE % REC	SAMPLE NUMBER OR PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
22								NO SAMPLES BELOW 22' (FLOW SAND)
24								
26								
28								* AQUIFER APPEARS TO BE CONFINED BY CLAY AT 8–11 FT. B.S.
30								
32								
34								
36								
38								
40								
42								
44								
46								

LITHOLOGIC LOG (CORE)

LOCATION MAP:

__1/4 __1/4 __1/4 __1/4 S__ T__ R__

SITE ID: REXENE LOCATION ID: B-13A (MW15)
SITE COORDINATES (ft.):
N 288099.5991 E 1552403.44909
GROUND ELEVATION (ft. MSL): 3738.62
STATE: NEW MEXICO COUNTY: DONA ANA
DRILLING METHOD: HOLLOW STEM AUGER
DRILLING CONTR.: GEO PROJECTS
DATE STARTED: 6/21/94 DATE COMPLETED: 6/21/94
FIELD REP.: DALE LITTLEJOHN
COMMENTS: INSTALLED ON HIGH SANDY AREA AT SOUTH END OF PROPERTY. B-13 (ORIGINAL LOCATION) IMPACTED AT BEDROCK AT = 10'

LOCATION DESCRIPTION:

DEPTH	WELL CONST.	LITH.	SAMPLE: USCS	SAMPLE: FROM	SAMPLE: TO	SAMPLE: % REC	SAMPLE: PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
0–9		Sand						SAND, FN GRN, <10% SILT, DRY, PALE YELLOWISH BRN (10YR 6/2), SUB ANGULAR, W/S, UNCONSOLID., NO STAINING OR ODOR.
4								SAND FROM RIVER DREDGING, FORMED DUNES.
9–12		Silt						SILT V. FN GRAIN, ≈ 20-30% CLAY, WET, BLACK (HC STAIN). W/S, MOD. CONSOLID. V. STRONG HC ODOR.
12–15		Sand						SAND. FN GRAIN, ≈10% SILT, WET, DK GRAY BLACK (HC STAIN). ANGULAR, MOD. SORTED, MOD. CONSOLID. V. STRONG HC ODOR. (FROM PROD)
15–22		Sand						SAND, FN GRAIN, ≈10% SILT, WET, GRAYISH BRN (5YR 3/2), ANGULAR, MED SORTED, UNCONSOLIDATED STRONG HC ODOR, (SATURATED W/ PRODUCT AND WTR)
20								* NO SPOON SAMPLES BELOW 20' (FLOWING SAND)

LITHOLOGIC LOG (CORE)
(Continued)

LOCATION ID: B-13A

DEPTH	WELL CONST.	LITH.	SAMPLE: USCS	FROM	TO	% REC	NUMBER OR PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
								SAND. FN-MED GRAIN, BLACK (HC STAINED) FREE PRODUCT PRESENT TO TD. RND-SUB-RND, W/S. UNCONSOLIDATED, "FLOWING" - NO SPOON SAMP. DESCRIPTION FROM CUTTINGS.
22								
24								
26								
28								
30								
32								TD = 32' * AQUIFER APPEARS TO BE UNCONFIRMED IN THIS AREA
34								
36								
38								
40								
42								
44								
46								

LITHOLOGIC LOG (CORE)

LOCATION MAP: SEE MAP

___1/4 ___1/4 ___1/4 ___1/4 S___ T___ R___

SITE ID: REXENE LOCATION ID: B-14 (MW17)
SITE COORDINATES (ft.):
N 288730.82473 E 1552304.16481
GROUND ELEVATION (ft. MSL): 3732.04
STATE: NEW MEXICO COUNTY: DONA ANA
DRILLING METHOD: HOLLOW STEM AUGER
DRILLING CONTR.: GEO PROJECTS
DATE STARTED: 6/20/94 DATE COMPLETED:
FIELD REP.: DALE LITTLEJOHN
COMMENTS:

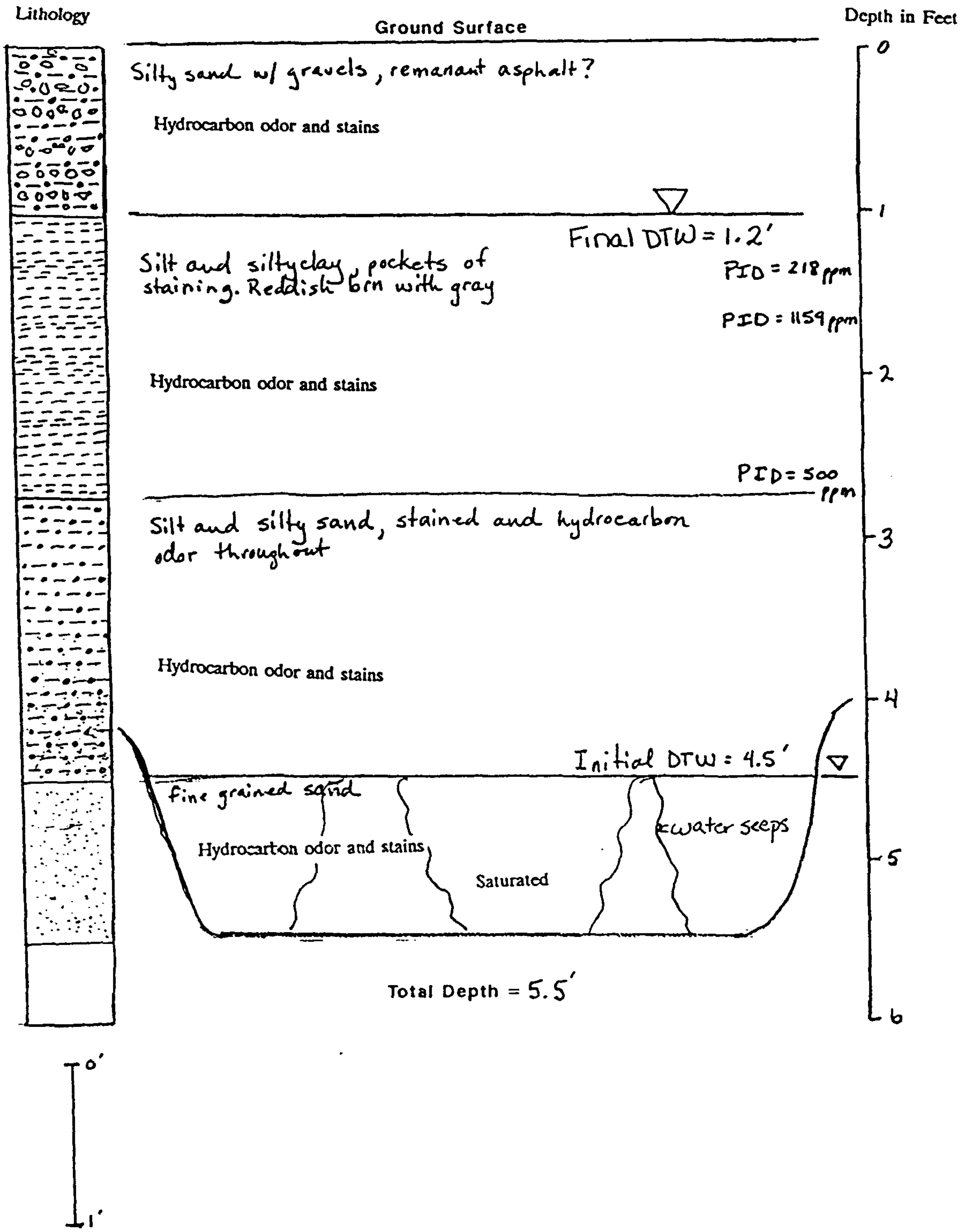
LOCATION DESCRIPTION: SITE LOCATED ON SAND AND GRAVEL HILL ≈ 1FT. ABOVE SURROUNDING AREA

DEPTH	WELL CONST.	LITH.	SAMPLE USCS	SAMPLE FROM	SAMPLE TO	SAMPLE % REC	SAMPLE PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
			PUSH W/ AUGER	0	2'	60		SILTY SAND, V FN GR, ≈ 20% SILT, DRY PALE YELLOWISH BRN (10YR 6/2), ANGULAR, W/S. UNCONSOLID, BLOW SAND.
2				2	4'	30		SILT, SAND. V FN GR ≈ 30-40% SILT, DRY, PALE BRN (5YR 5/2), SUB ROUND, W/S, UNCONSOLID. W/SM GRAVEL.
4				4'	6	100		MISSING, BELIEVE TO BE SANDY SILT, PALE YELLOWISH BRN (10YR 6/2), CONSOLID.
6				6	8	10		SILTY CLAY, 20% SILT, V. FN GR, DRY, GRAYISH BRN, (5YR 3/2), CONSOLID, ANG. W/S CLAYEY SILT, V. FN GR, 30-40% CLAY, <5% SAND, WET, DK YELLOWISH BRN, (10YR 4.2), SUB RND, W/S, HC STAIN.
8				8	10	100		SILTY SAND, V FN GRAIN, 20% SILT, WET DK YELLOW BRN (10YR 4/2), SUB RND, W/S, NO STAINING
10				FLOWING SAND, NO CATCH SAMP.				SILTY CLAY, 40% SILTY, WET. (10YR 4/2)
12				SAMPLE DESCRIP BASED OIL SPLIT SPOON ATTEMPTS (SAND FLOWING OUT OF AUGER) AND, SOIL ON BOTTOM FLIGHT OF AUGER.				SILTY SAND, 30% SILT (DEC W/ DEPTH) WET DK YELLOWISH BRN (10YR 4/2), RND TO SUB-ROUNDED, W/S. UNCONSOLID. NO STAIN OR ODOR.
14								V FN GRAIN SAND TO 16' INCREASING TO FN GR AT TD. SILT CONTENT DEC. TO ≈ 10% AT TD.
16								
18								SAND SEE NOTE.
20								

LITHOLOGIC LOG (CORE)
(Continued)

LOCATION ID: B-14 (MW-17)

DEPTH	WELL CONST.	LITH.	SAMPLE USCS	SAMPLE FROM	SAMPLE TO	SAMPLE % REC	SAMPLE NUMBER OR PID READING	LITHOLOGIC DESCRIPTION (LITH., USCS, GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SORT., CONSOL., DIST. FEATURES)
								SAND AS ABOVE.
22								
24								TD = 24'
26								
28								
30								
32								
34								
36								
38								
40								
42								
44								
46								

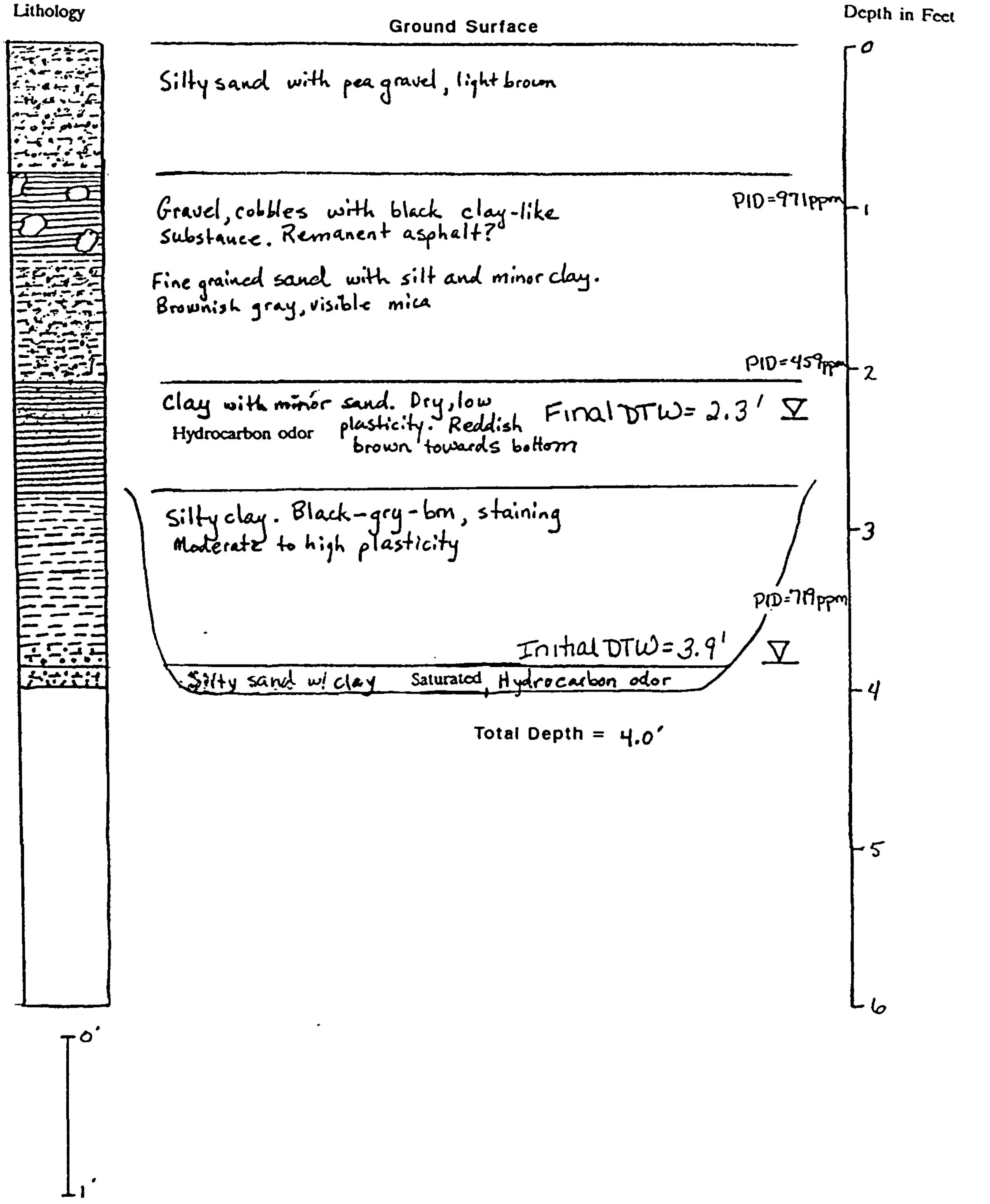


Vertical Scale: 1" = 1'

Horizontal Distance Not to Scale

GCL

TRENCH TR-01

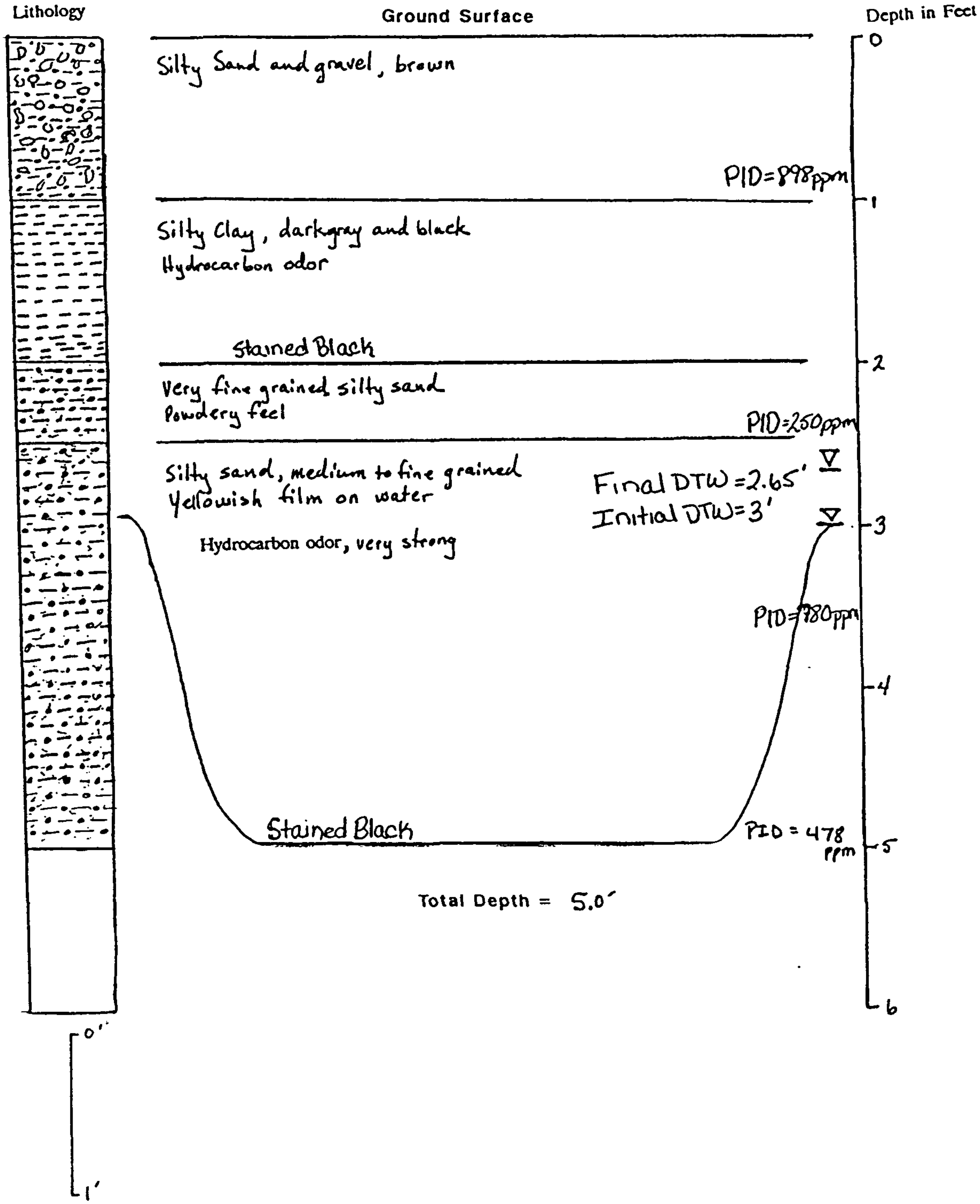


Vertical Scale: 1" = 1'

Horizontal Distance Not to Scale

GCL

TRENCH TR-02

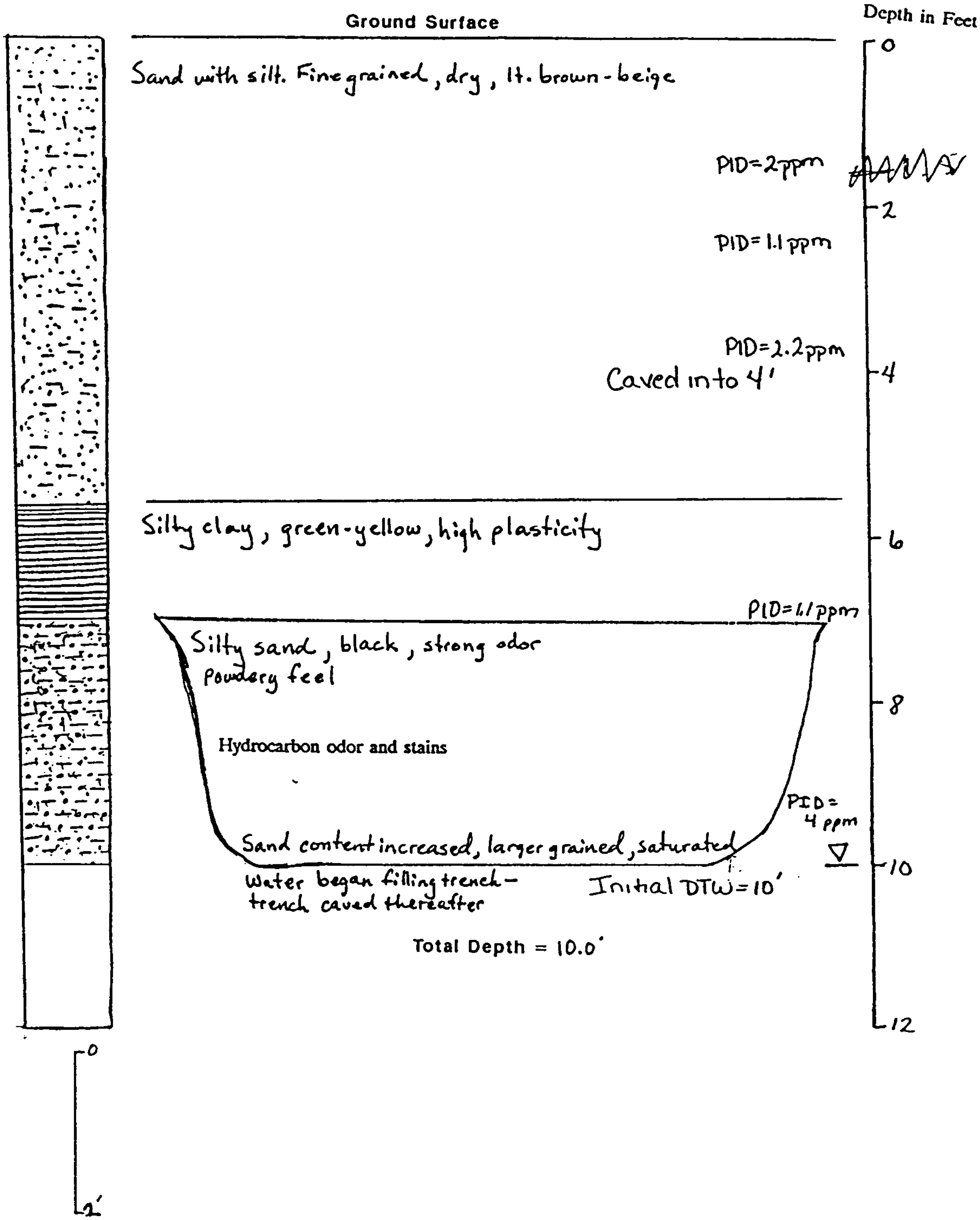


Vertical Scale: 1" = 1'

Horizontal Distance Not to Scale

GCL

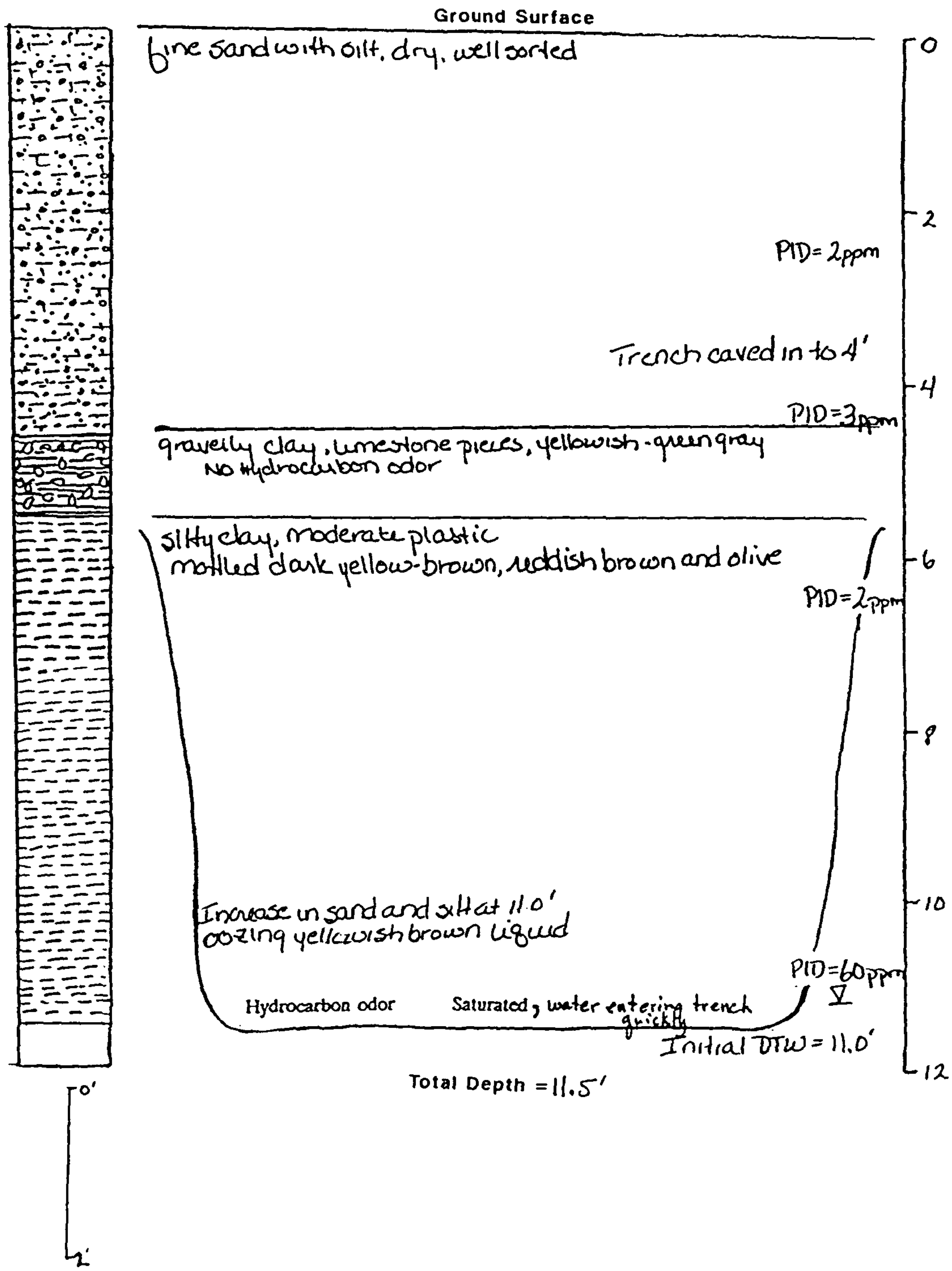
TRENCH TR-03



Vertical Scale: 1" = 2'
Horizontal Distance Not to Scale

GCL

TRENCH TR-04

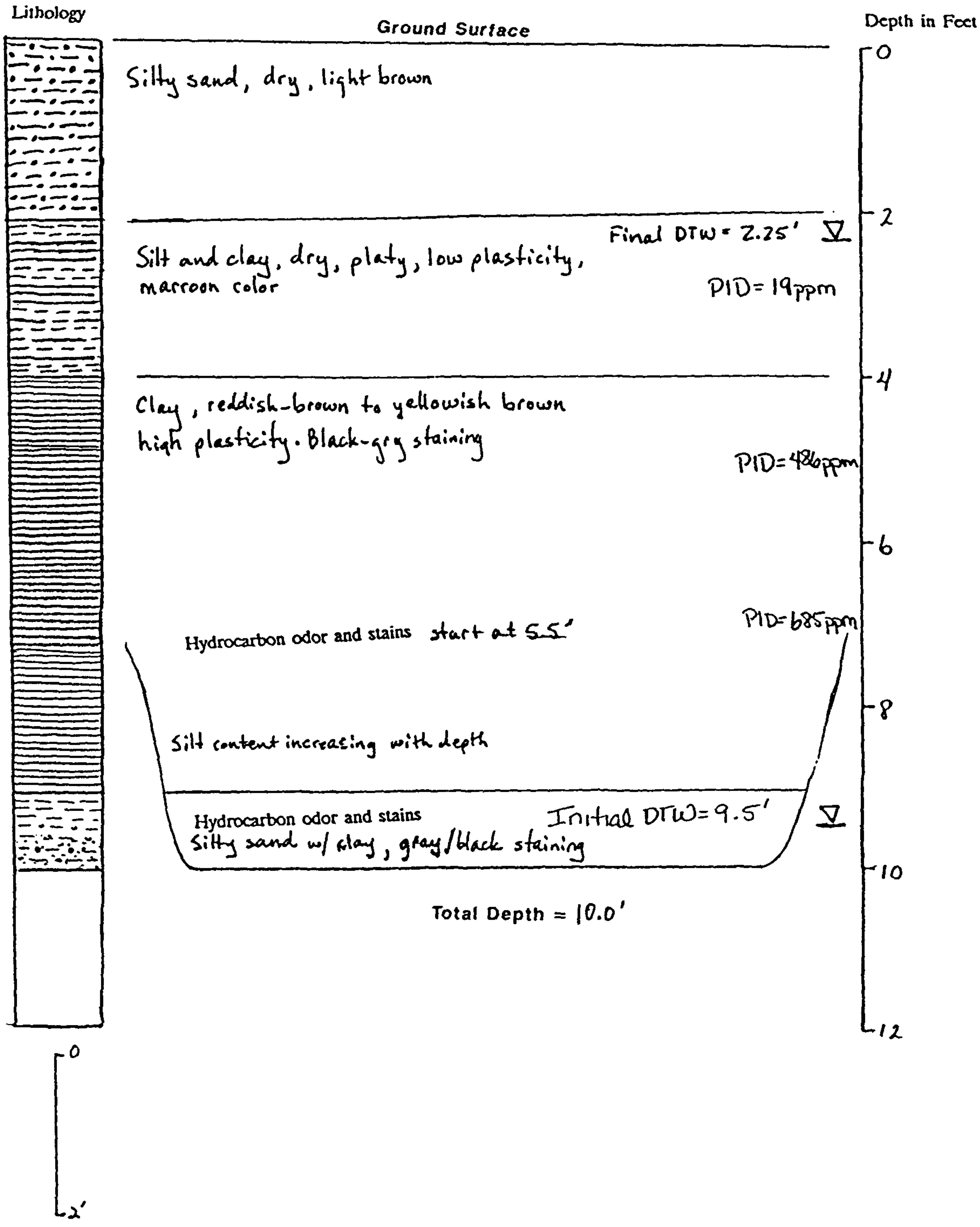


Vertical Scale: 1" = 1'

Horizontal Distance Not to Scale

GCL

TRENCH TR-05



Vertical Scale: 1" = 2'

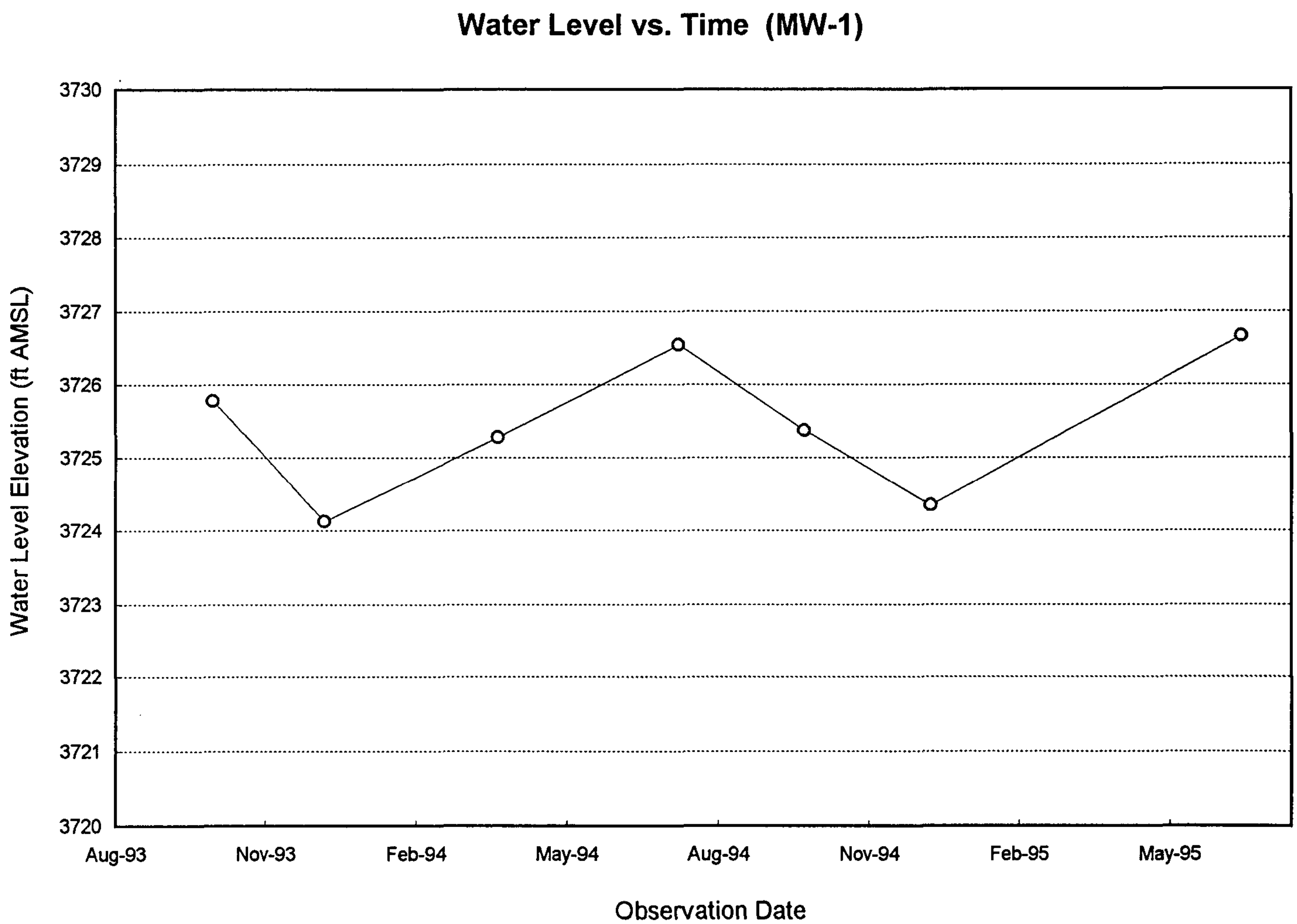
Horizontal Distance Not to Scale

GCL

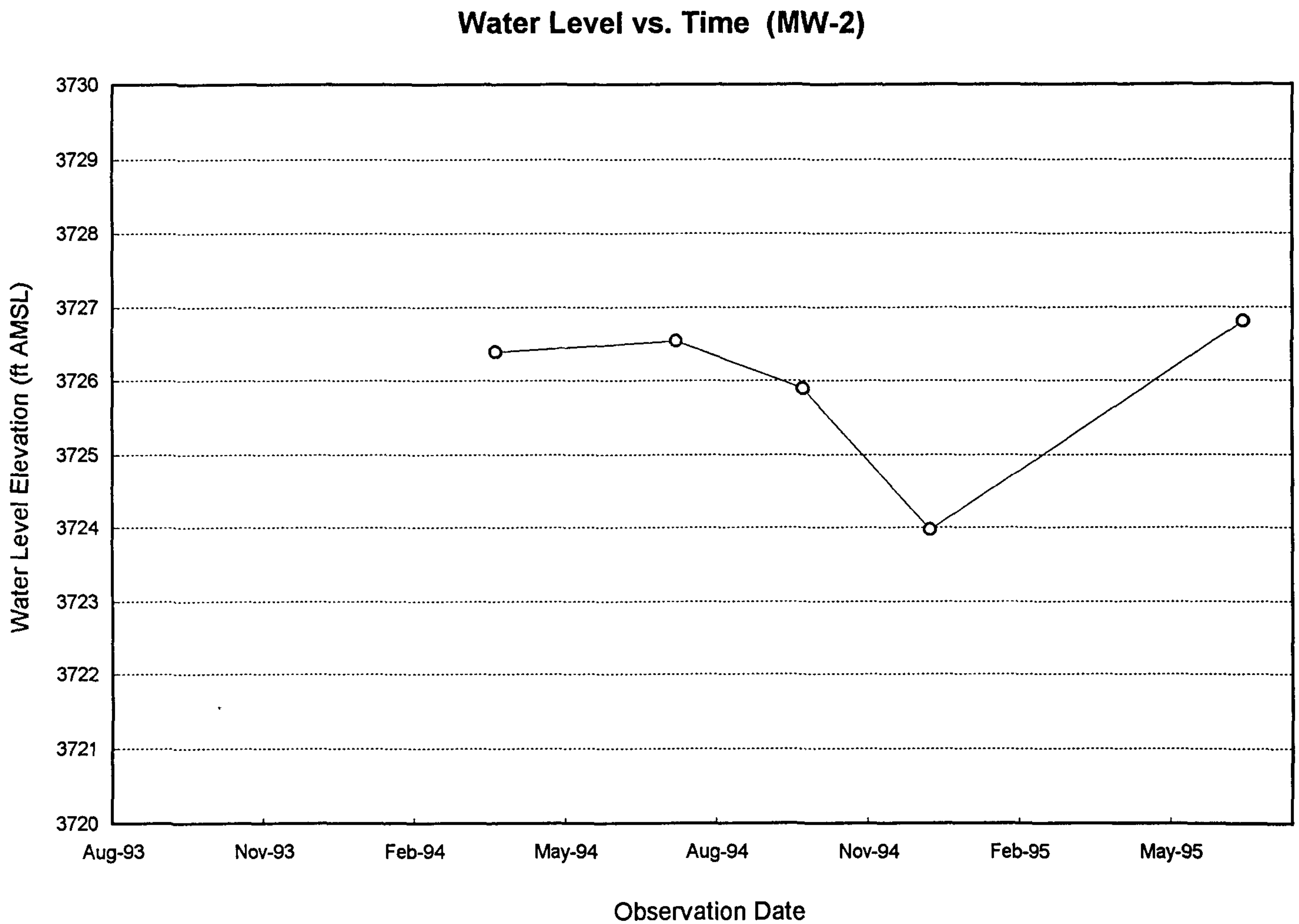
TRENCH TR-06

Appendix C

Water Levels vs. Time for Monitoring Wells MW-1 through MW-17

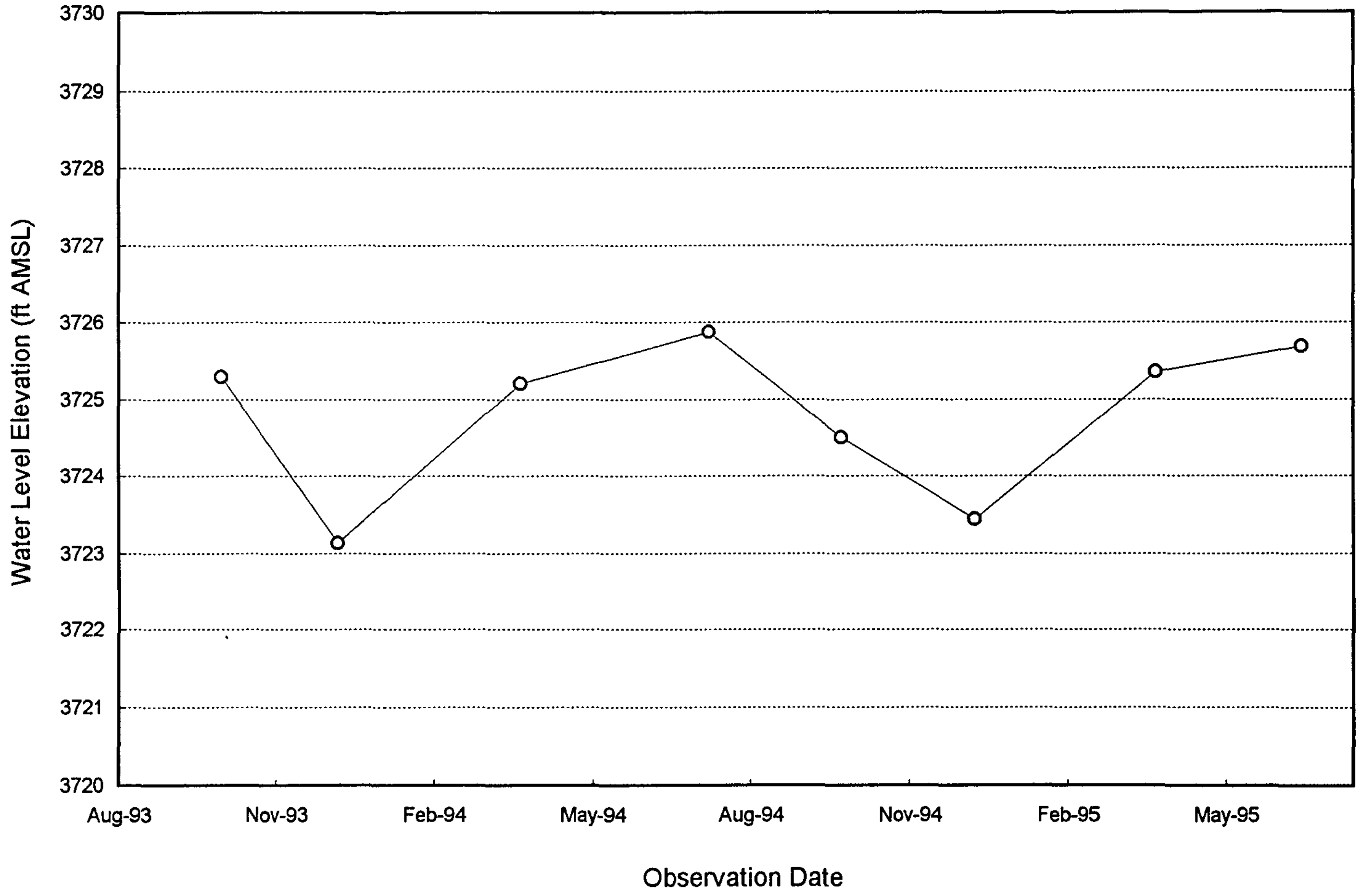


G:\REXWORK\FIGS.XLS

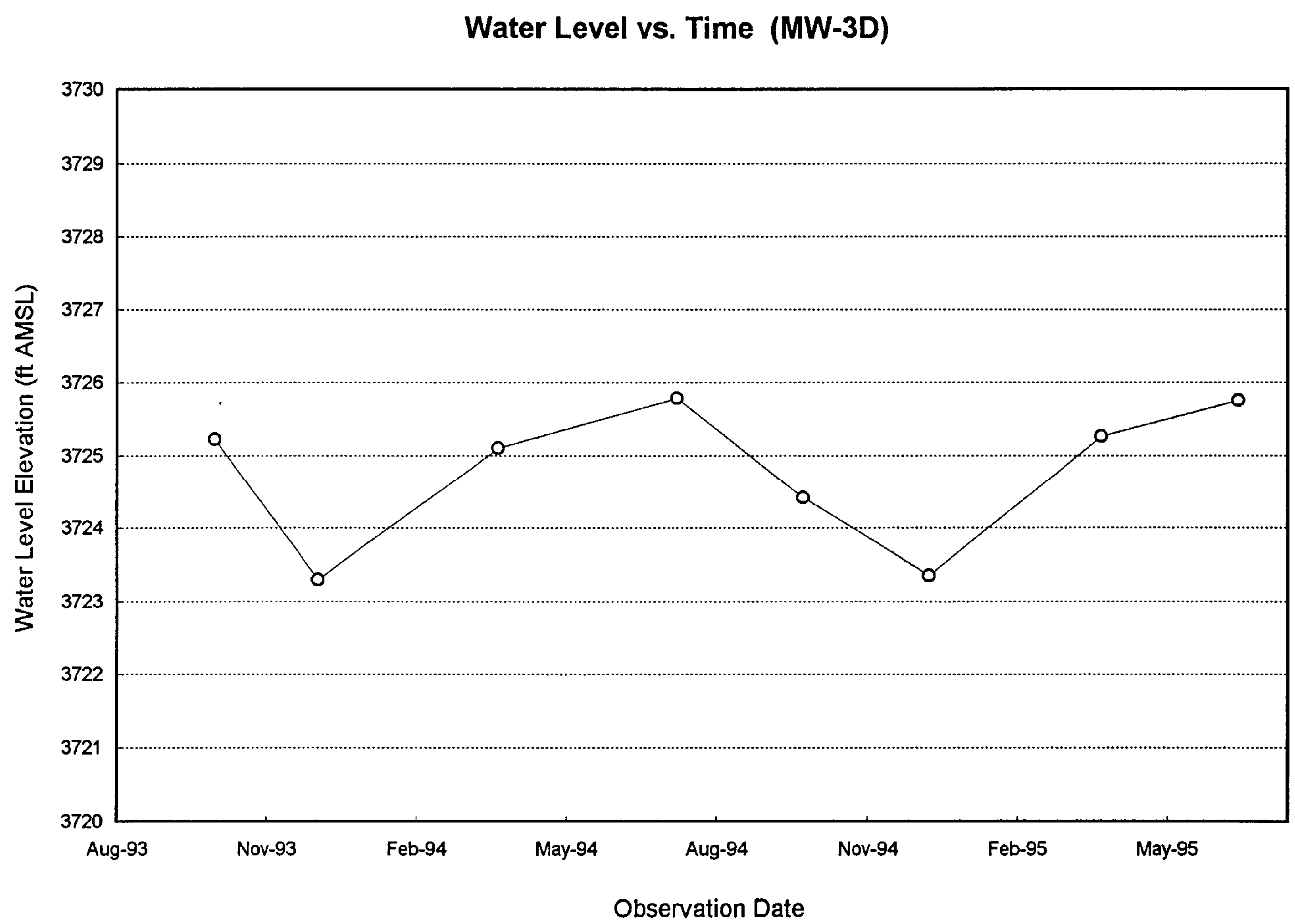


G:\REXWORK\FIGS.XLS

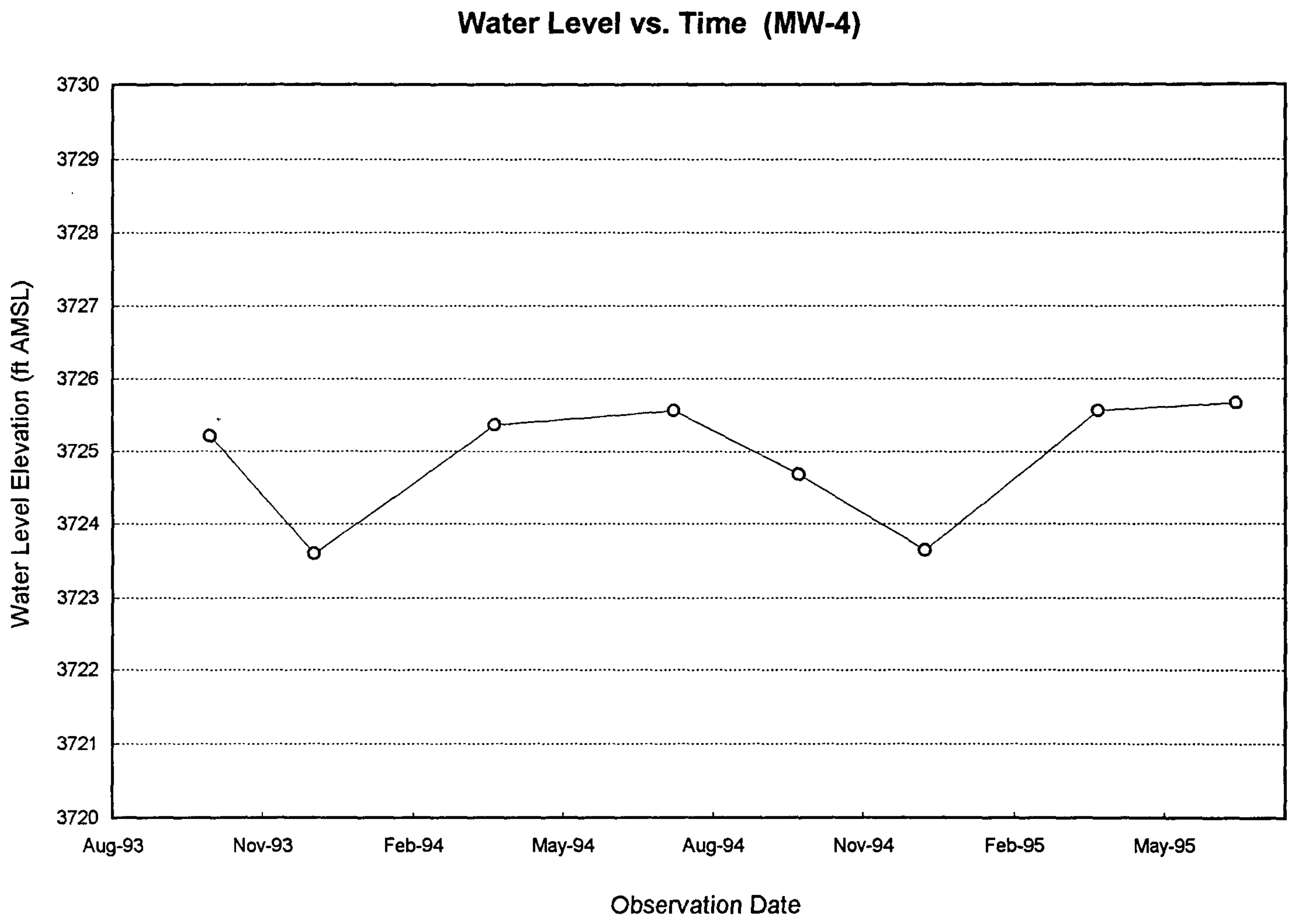
Water Level vs. Time (MW-3S)



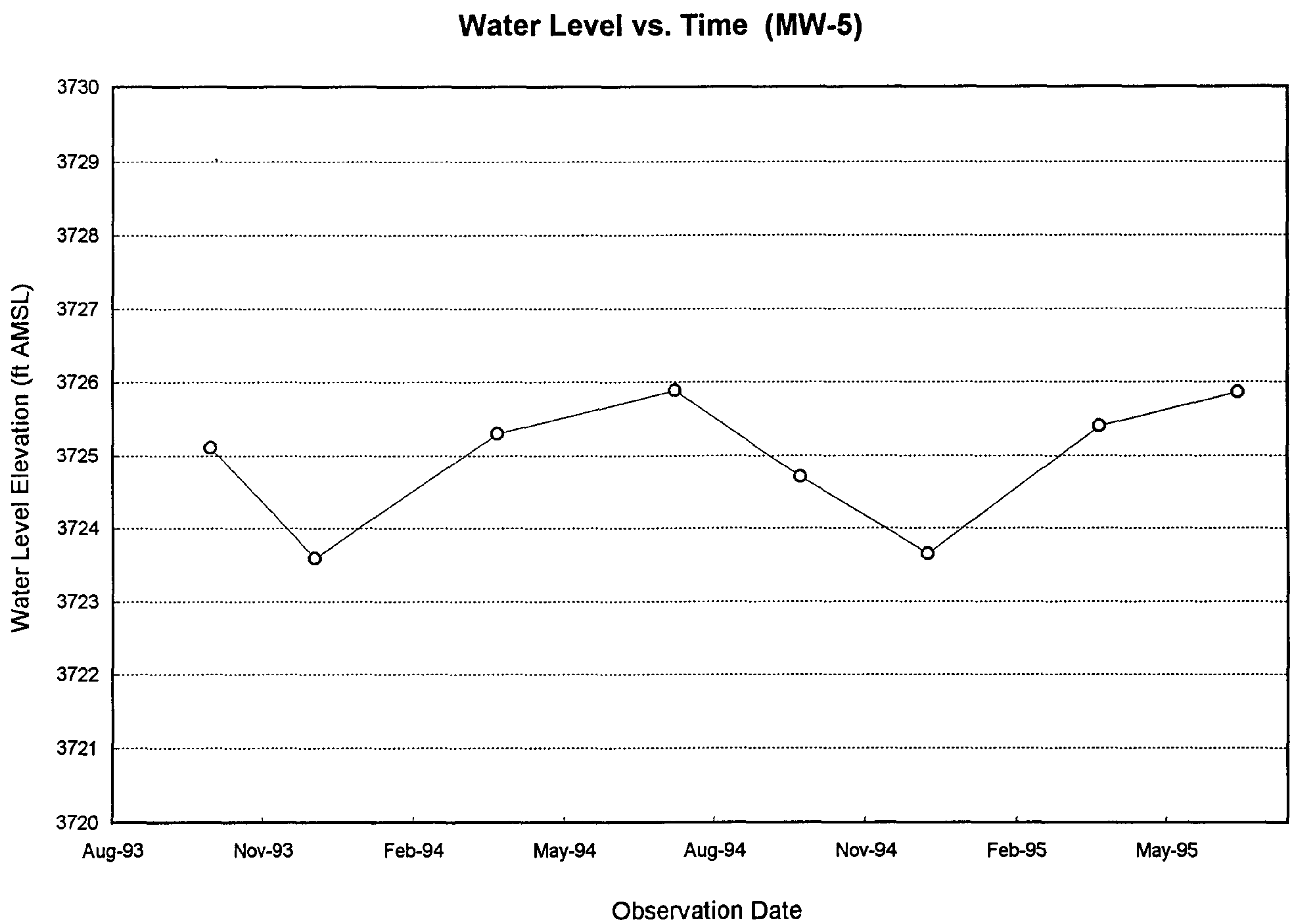
G:\REXWORK\FIGS.XLS



G:\REXWORK\FIGS.XLS

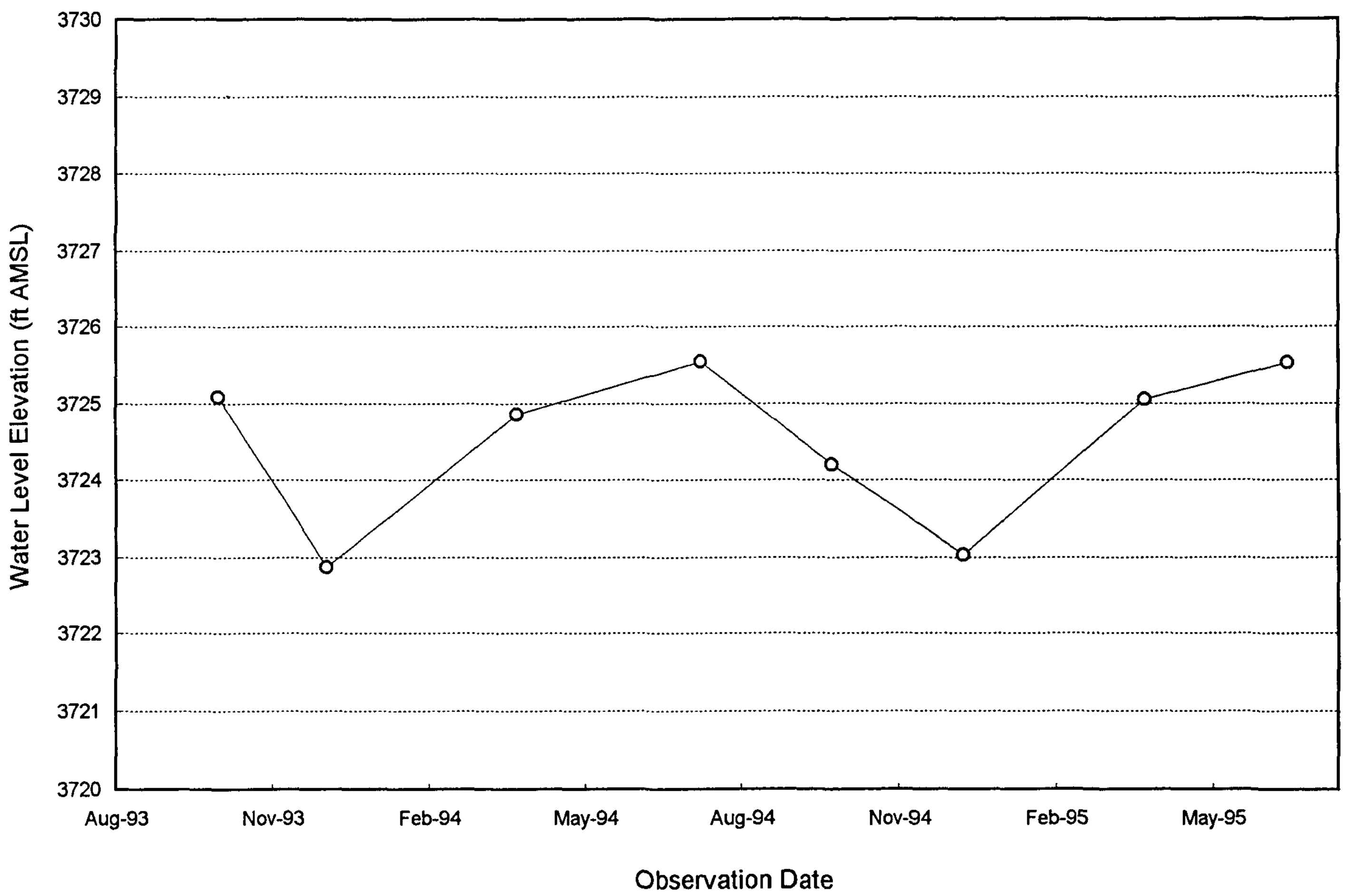


G:\REXWORK\FIGS.XLS



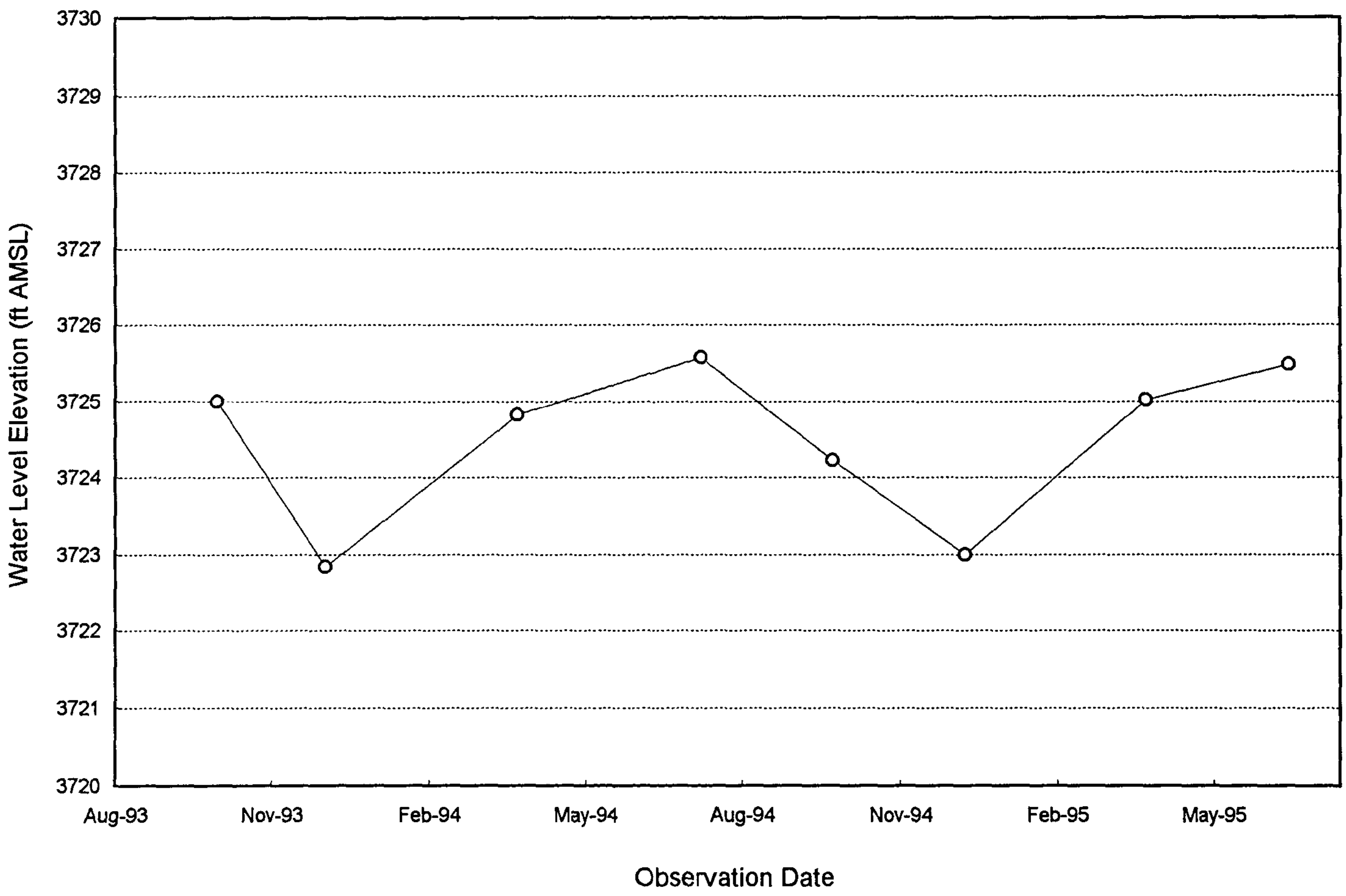
G:\REXWORK\FIGS.XLS

Water Level vs. Time (MW-6S)



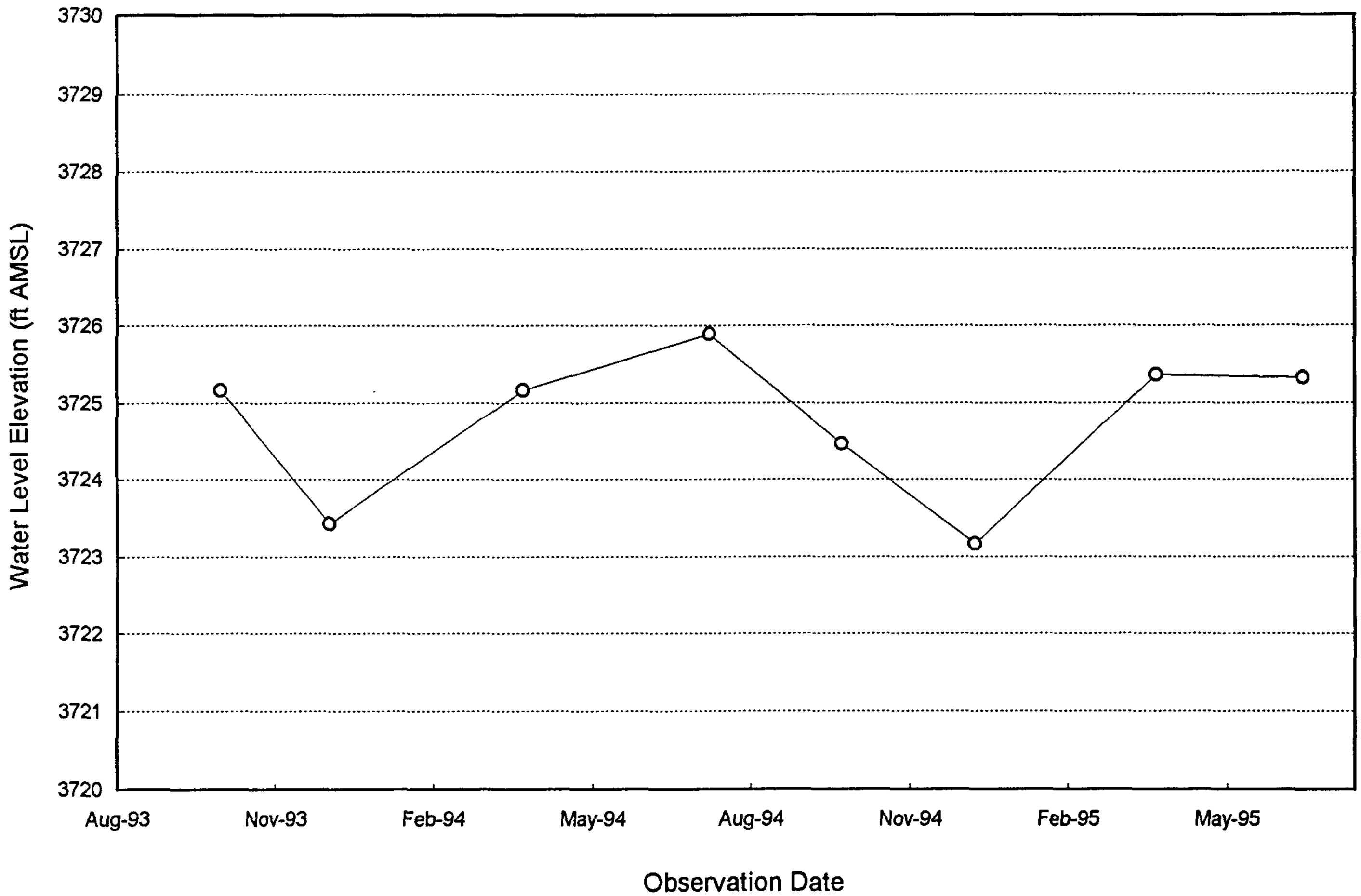
G:\REXWORK\FIGS.XLS

Water Level vs. Time (MW-6D)



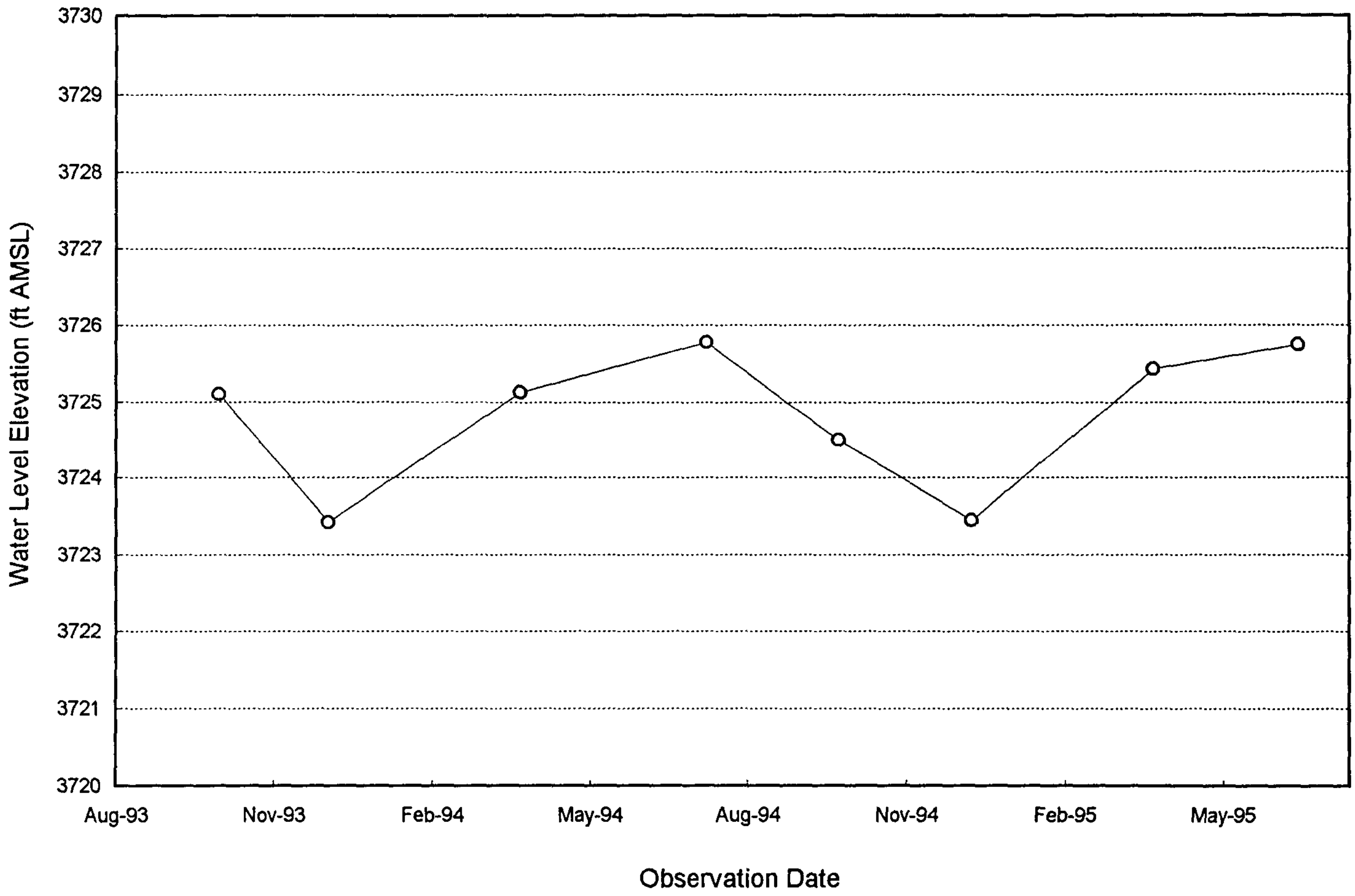
G:\REXWORK\FIGS.XLS

Water Level vs. Time (MW-7)

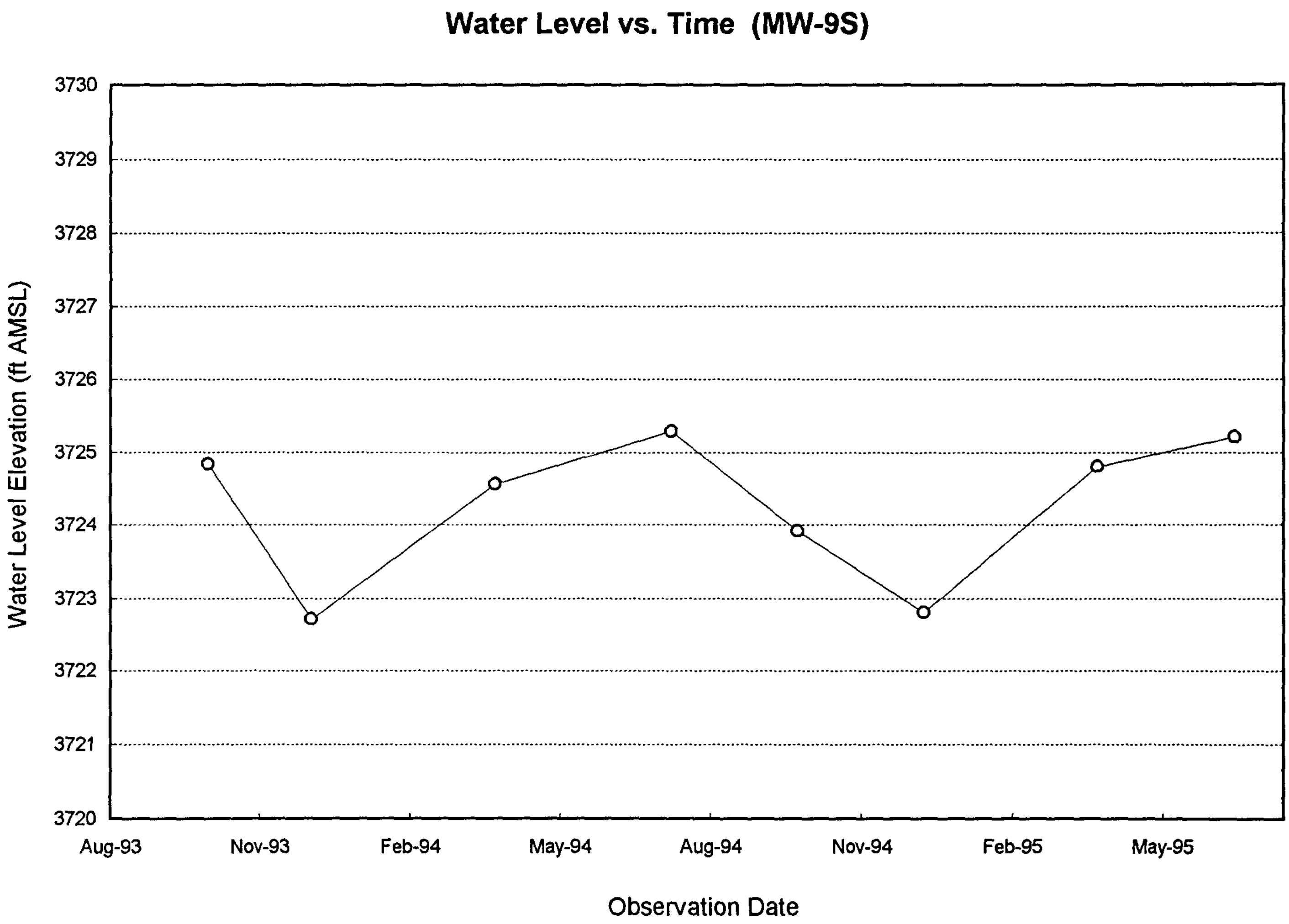


G:\REXWORK\FIGS.XLS

Water Level vs. Time (MW-8)

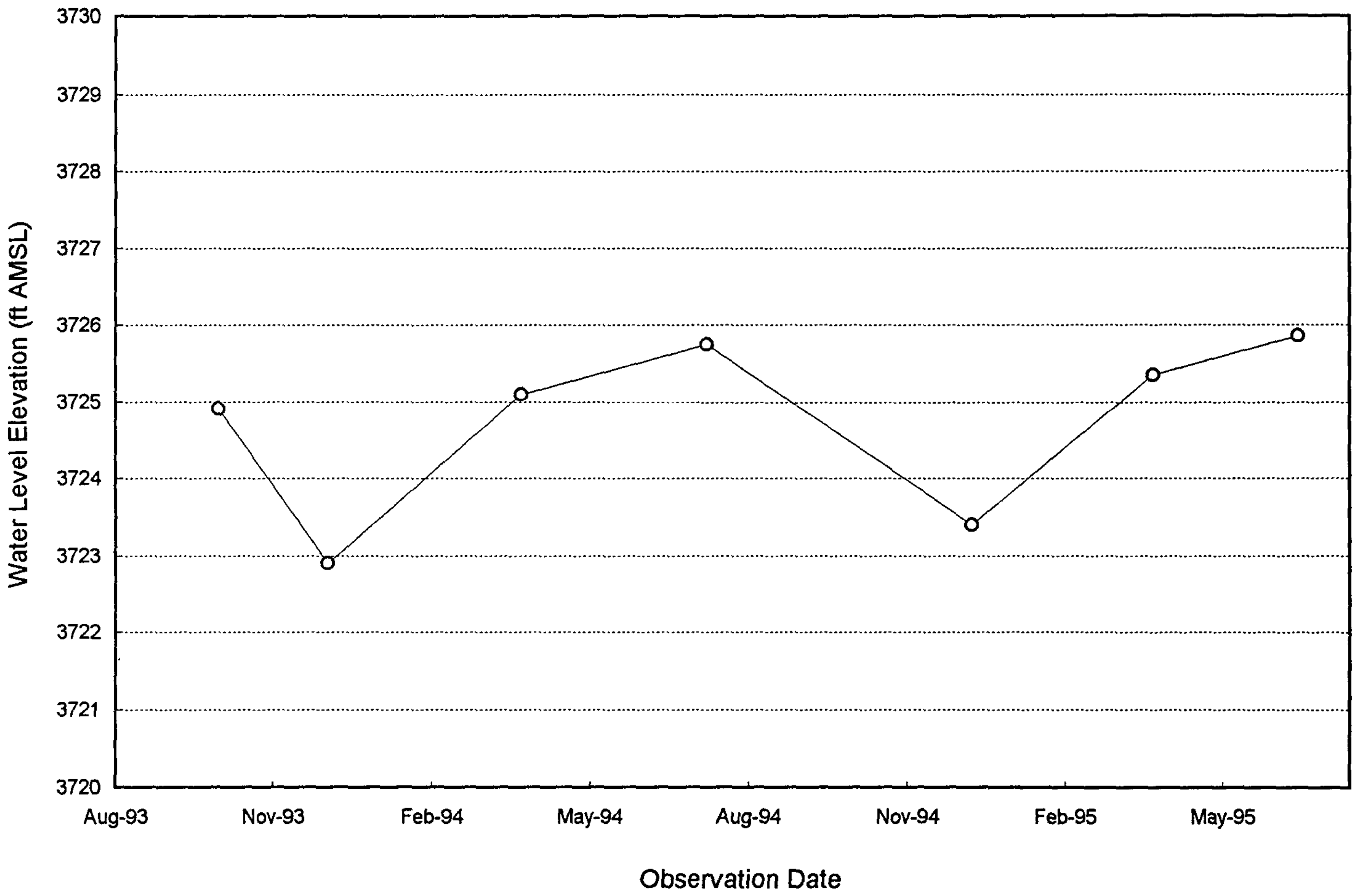


G:\REXWORK\FIGS.XLS



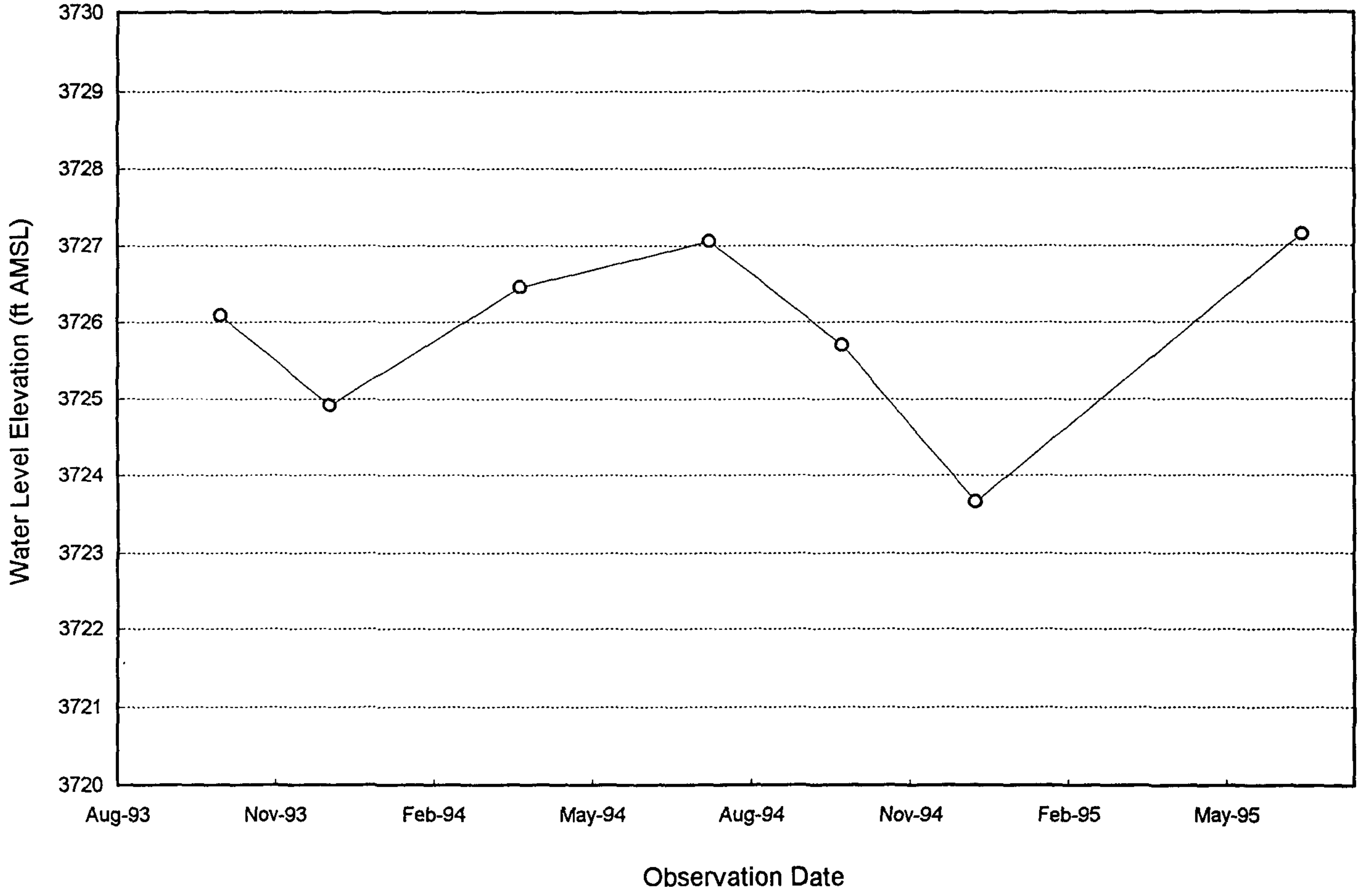
G:\REXWORK\FIGS.XLS

Water Level vs. Time (MW-11)



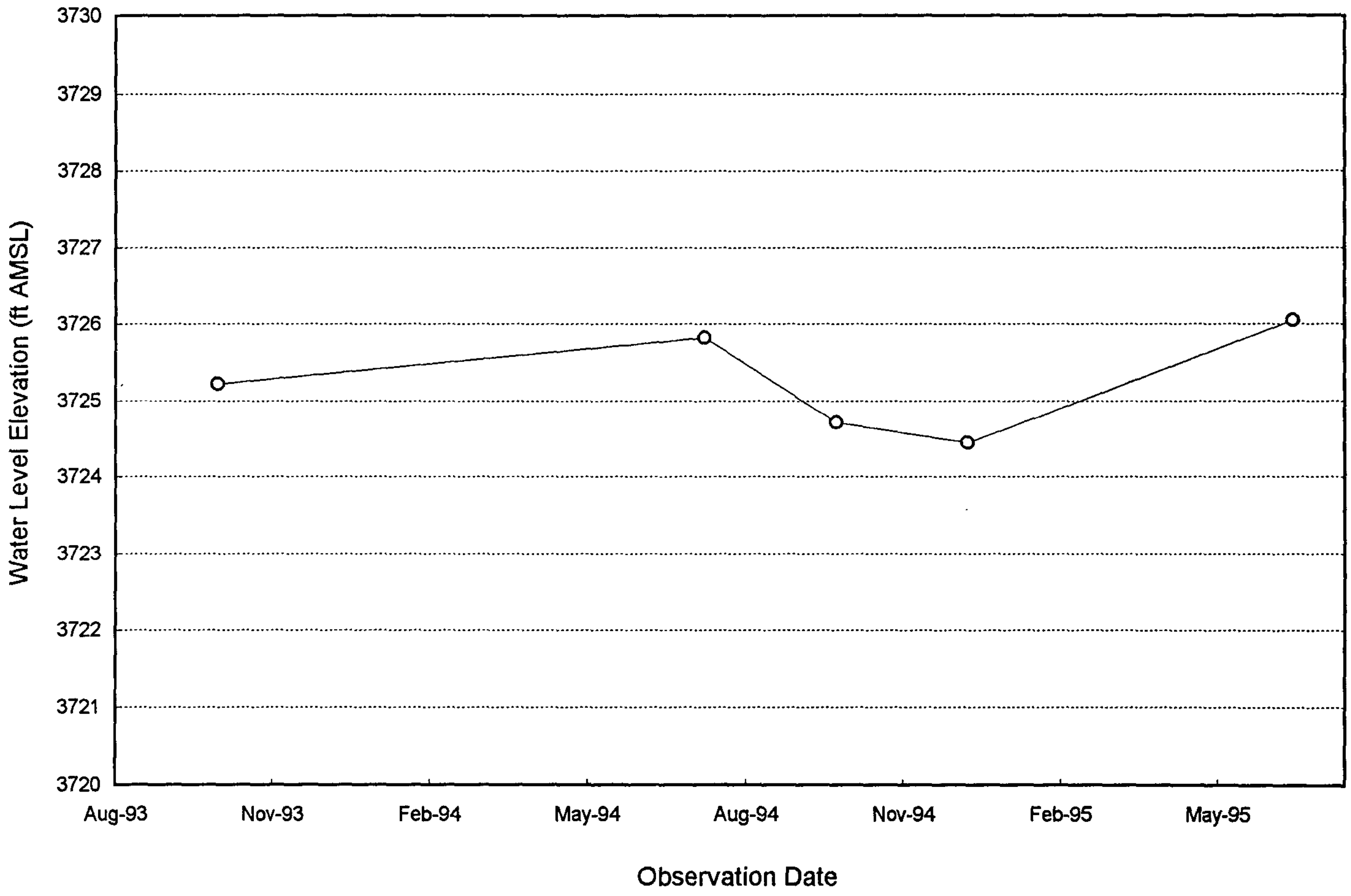
G:\REXWORK\FIGS.XLS

Water Level vs. Time (MW-12)

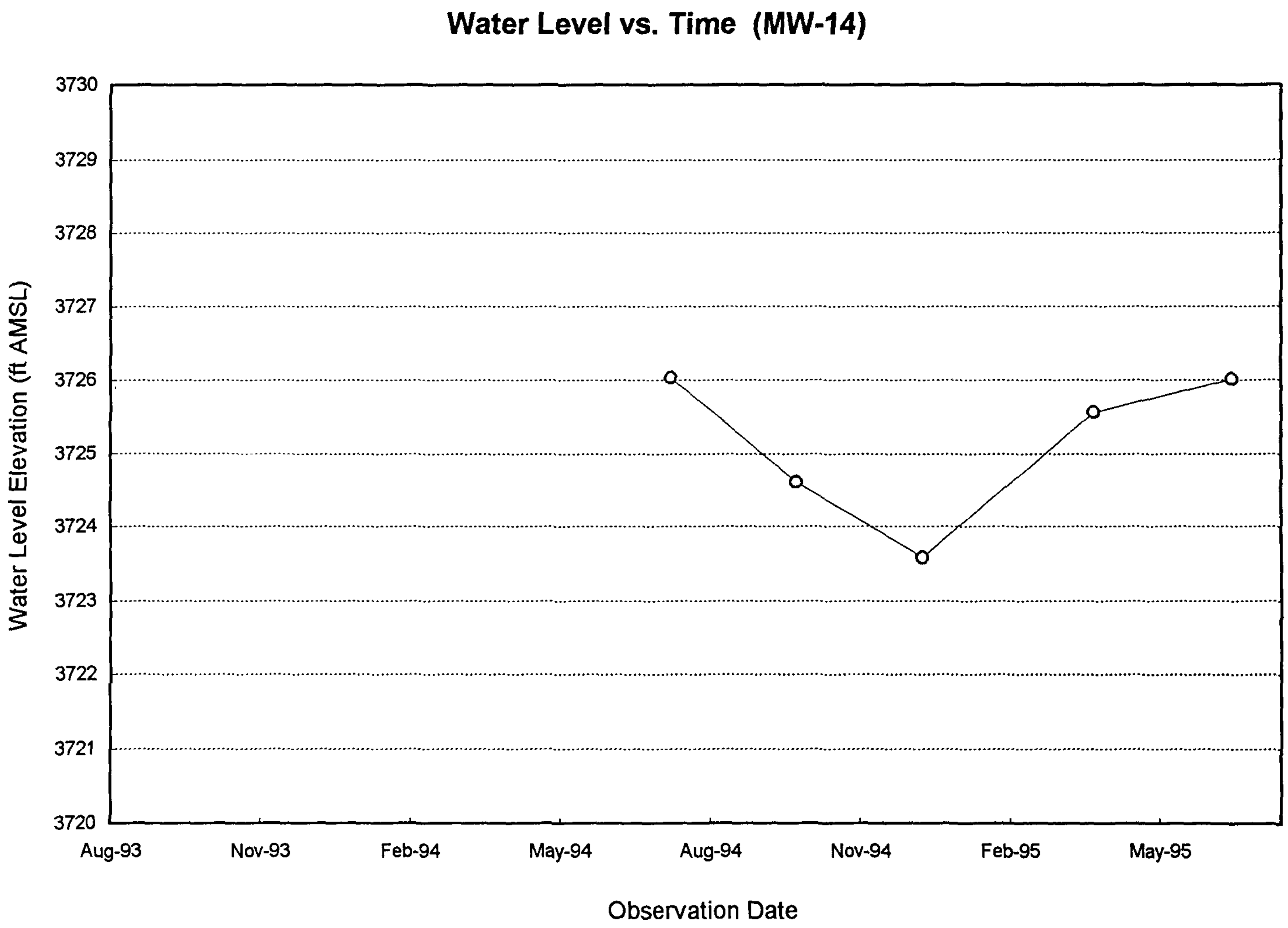


G:\REXWORK\FIGS.XLS

Water Level vs. Time (MW-13)

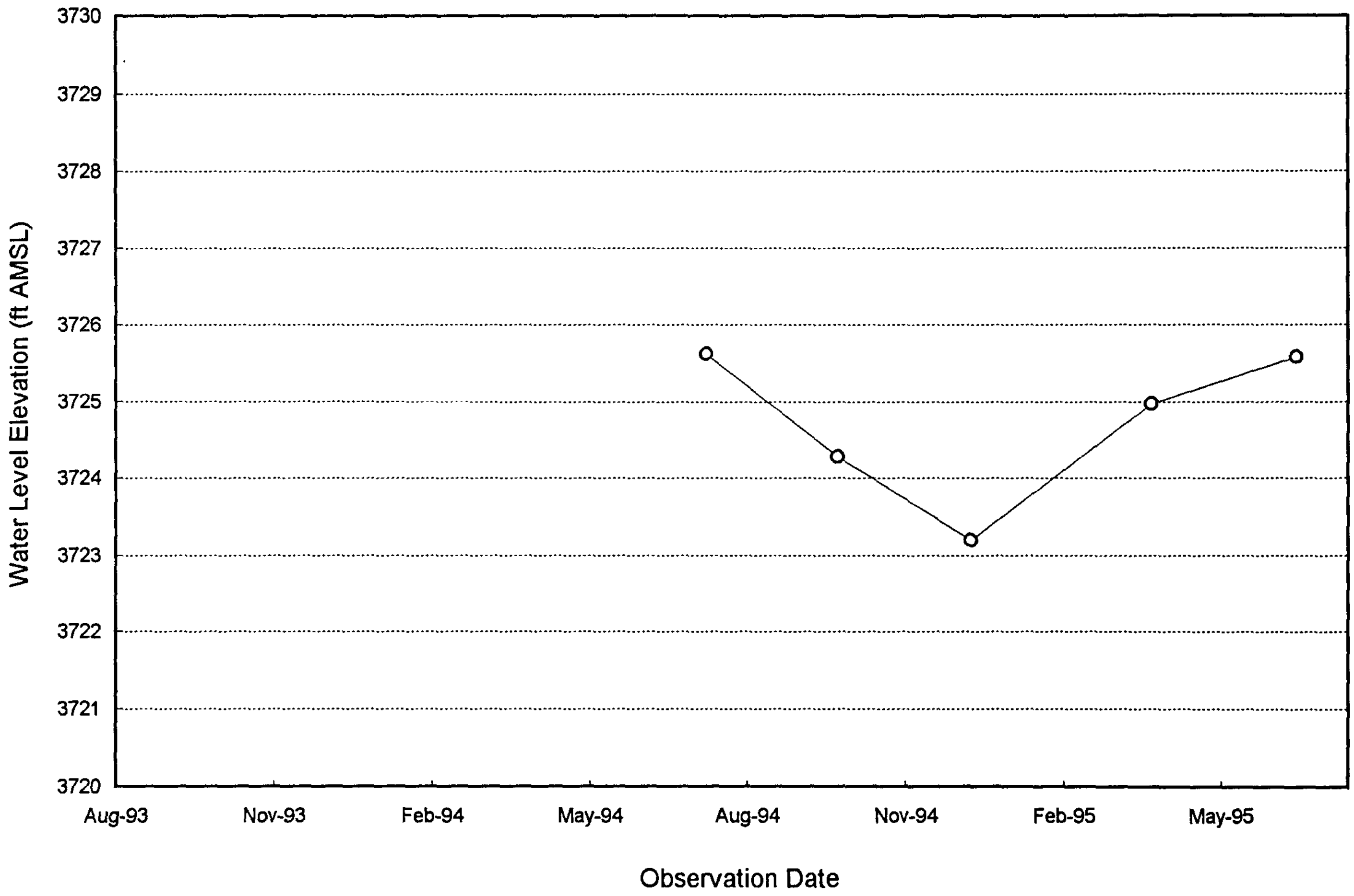


G:\REXWORK\FIGS.XLS



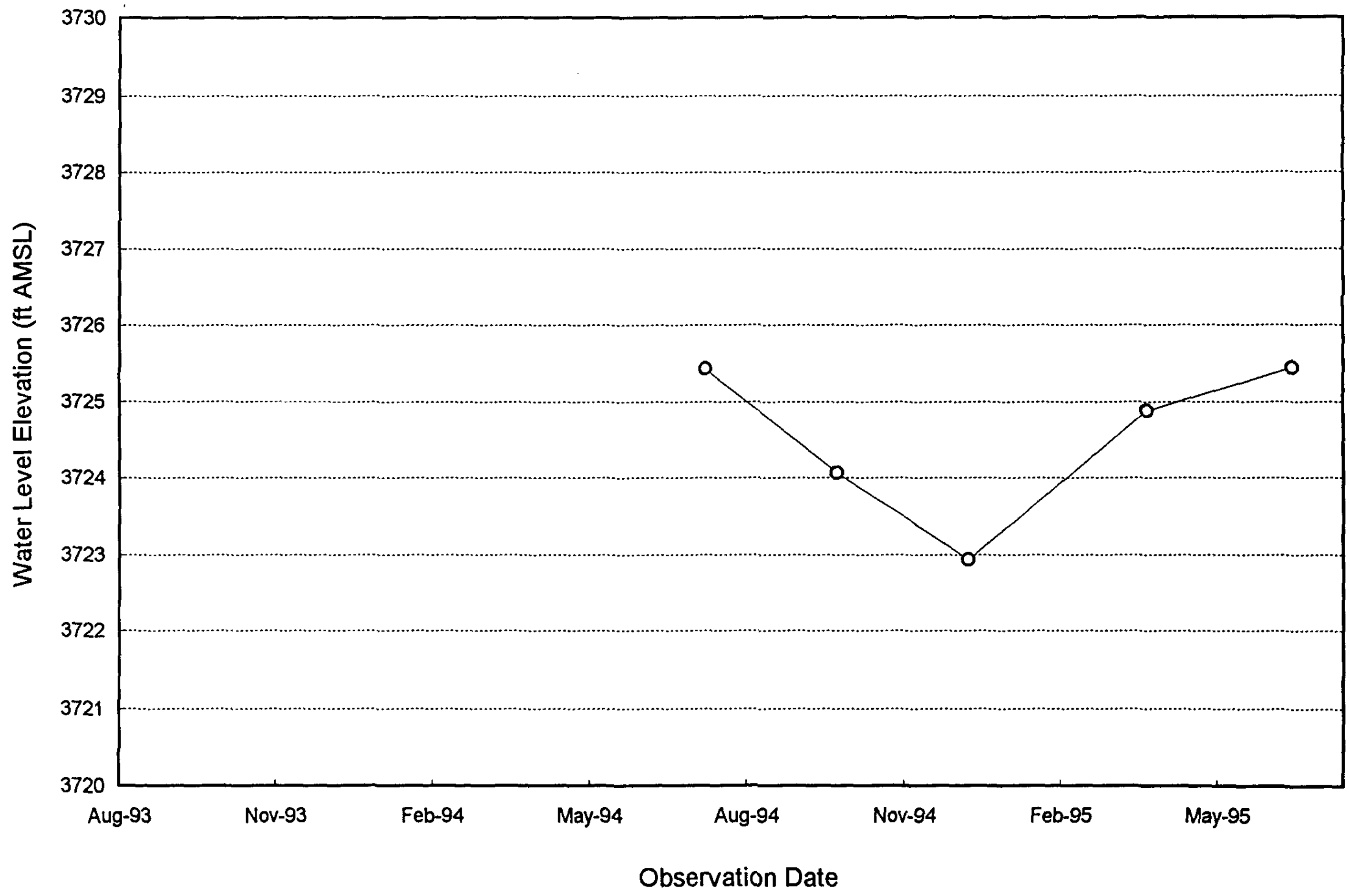
G:\REXWORK\FIGS.XLS

Water Level vs. Time (MW-15)



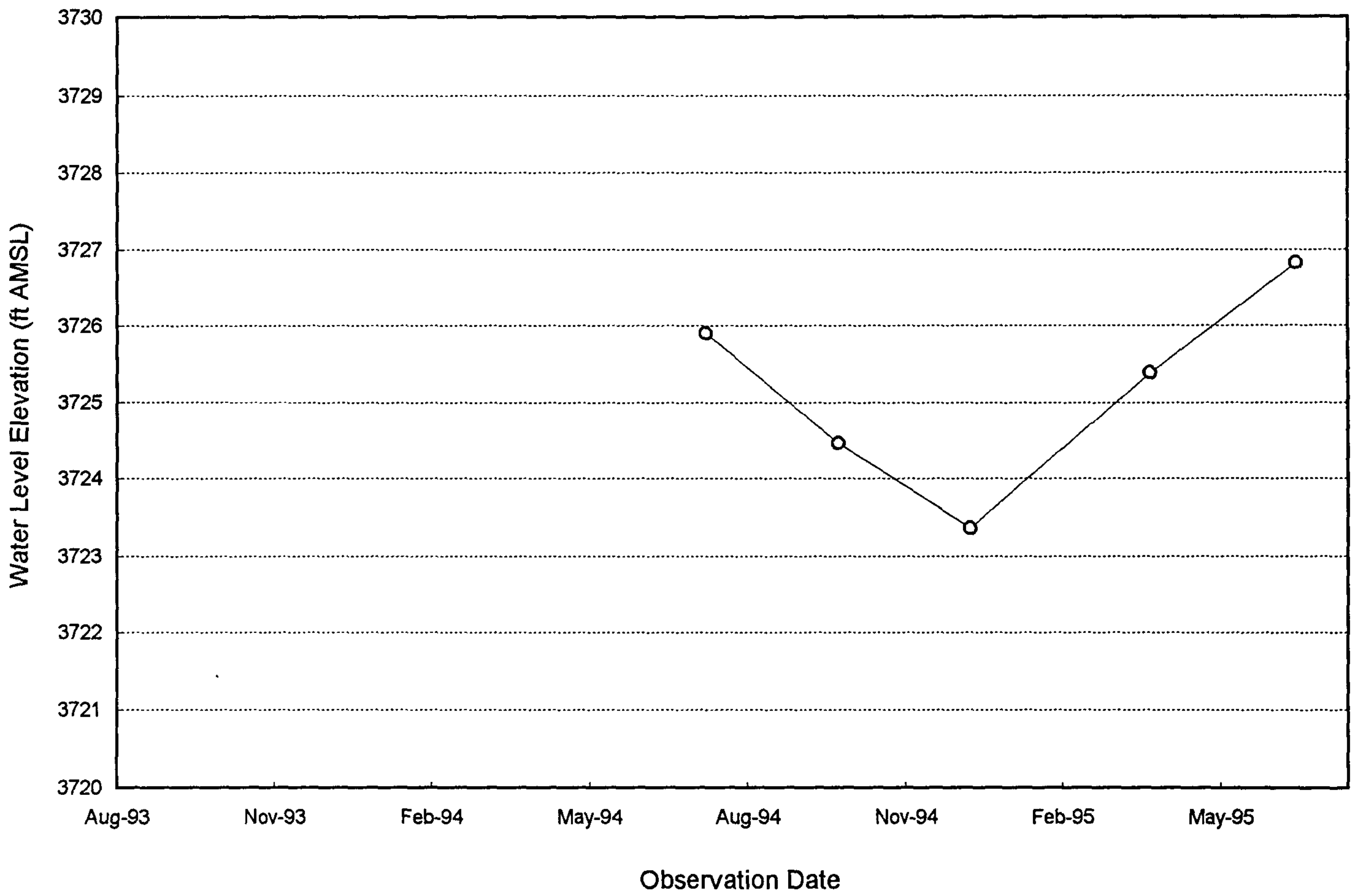
G:\REXWORK\FIGS.XLS

Water Level vs. Time (MW-16)



G:\REXWORK\FIGS.XLS

Water Level vs. Time (MW-17)



G:\REXWORK\FIGS.XLS

Appendix D

Analyses of Slug Tests at the Site

ANALYSES OF SLUG TESTS AT THE FORMER BRICKLAND REFINERY SITE

Introduction

Aquifer slug tests were performed by GCL at the former Brickland Refinery Site in July 1995. The site is located in Sunland Park County, New Mexico and consists of 35 acres along the Rio Grande, west of the city of El Paso, Texas. Soil and groundwater at the site are contaminated by BTEX, PAHs, and a number of metals. Slug tests were performed to determine the hydraulic conductivity of the saturated zone. The results of these slug tests are used to characterize groundwater flow and contaminant transport at the site and to help design a remediation work plan.

Local Hydrogeological Conditions

The shallow geology at the site is composed of Quaternary (Holocene) alluvium deposited by Rio Grande. The sediments can be divided into two lithologies: a shallow, thin-bedded heterogeneous clastics lithology and a deep, relatively homogeneous sand lithology. The shallow lithology extends from ground surface to about 10 to 15 feet below ground surface (bgs) and consists of silty clay, sand, silty sand, and gravelly sand. The deep lithology consists of a thick, homogeneous, well-sorted, subrounded sand that appears to coarsen with depth. The shallow aquifer occurs under confined and unconfined conditions.

General Well Information

Twenty monitor wells have been installed on- and off-site. Three of them (MW-3D, MW-6D and MW-9D) located nearest to the Rio Grande were completed to approximately 35 feet bgs in the deep sand unit, while the other wells were completed 15 to 20 feet bgs. The screen intervals of these wells are located either fully within the shallow unit, partially within the shallow unit, or fully within the deep unit. All boreholes were drilled with a 12-inch hollow stem auger and monitor wells were constructed using a 4-inch diameter PVC casing with 10 feet of screen. The annuli around screen sections of all wells were packed with #1C Lonestar sand that has an assumed porosity of 27%.

Slug tests were performed in monitor wells MW-1, MW-3S, MW-3D, MW-5, MW-6S, MW-6D, MW-8, MW-9S, and MW-11. Wells MW-3D, MW-6D, and MW-9D are completed in gravelly sand or sandy gravel. Well MW-6S is completed within sand and well MW-8 in silty clay. The other wells (MW-1, MW-3S, MW-5, and MW-11) are completed in silty clay, silty sand, and/or sand. These nine wells were selected to provide testing of a wide range of aquifer materials encountered all over the site.

Slug Test Theory

A slug test involves quickly raising or lowering the static water level in a monitor well and recording the subsequent falling or rising water levels over time. The water level is quickly raised by inserting a solid slug below the water table. The subsequent falling of water level versus time constitutes a falling-head slug test. Once the static conditions are achieved, the solid slug is quickly removed from the well. The subsequent rising of water level versus time constitutes a rising-head slug test.

The Bouwer and Rice analytical solution (Bouwer and Rice, 1976; Bouwer, 1989) was used to evaluate the data to estimate hydraulic conductivity. The computer program AQTESOLV (Duffield, 1995) was used to perform the necessary calculations.

Slug Test Instrumentation and Procedures

An In-Situ Hermit 1000 data logger was used to record water level versus time during all slug tests. For all tests, the time was set to minutes and water level to feet of water. Prior to each test, the static water level and the well depth were measured using a water level probe, and the height of the static water column in the well was calculated. An In-Situ 30-psig pressure transducer was set approximately 2 feet above the well bottom and connected to the data logger. All recorded water levels were the difference between the static water level and the instantaneous water level at a specific time during the test. Once the data logger and transducer were ready for testing, a stainless steel slug about 4 feet long and 2 inches in diameter was quickly submerged below the static water level and the data logger was started at the same time. After a few minutes, the static water level difference was manually read from the data logger and recorded in the fieldbook. The test was stopped when the water level difference approached zero, showed fluctuation, or had a very small decrease (<0.01 feet/2 minutes). Finally, the data logger was disconnected from the transducer and connected to a printer, and the results were printed.

Slug Test Results

The following basic data are needed to analyze a slug test:

1) Casing radius, r_c,
2) Screen length (L),
3) Wellbore radius, r_w,
4) *Static height of water in well (H = well depth minus water level in well)*,
5) Porosity of gravel pack around the casing screen (n),
6) Saturated thickness of aquifer (b),
7) Ratio of vertical to horizontal hydraulic conductivity (Kz/Kr), which is determined by local hydrogeological settings (for homogeneous and isotropic aquifer, Kz/Kr=1),
8) Initial water level (Ho).

Table 1 in this appendix summarizes all these data for all the slug tests performed at the former Brickland Refinery site.

With these data, the computer program AQTESOLV was used to analyze the slug test data. During the analyses, the raw field data was imported into the program and the basic data was provided. Then, a visual matching method was used to locate the straight line section of the test data and to calculate the hydraulic conductivity (See Table 1). Finally, the plot of each test was printed and is included in this appendix.

Table 1 shows that wells completed in the gravelly sand or sandy gravel formation (MW-3D, MW-6D, and MW-9S) have high conductivities (0.04-0.07 ft/min). The well completed fully in the silty clay formation (MW-8) has the lowest conductivity (0.00008 ft/min). Wells completed partially in silty clay or silty sand (MW-1, MW-3S, MW-5 and MW-11) have intermediate conductivities (0.0001-0.0015 ft/min). The only exception is well MW-6S, which was completed 100% in sand, but has a conductivity of 0.0009 ft/min, which is lower than the one for MW-3S completed 10% in silty sand (0.0015 ft/min). The inconstancy, however, is fairly small. It is possible that the sand grains at well MW-6S are finer than the sand grains at well MW-3S.

Both falling-head and rising-head tests were performed in wells MW-6S, MW-6D, and MW-9S. For comparison, the results are also provided in Table 1. It can be seen that for the same well, both tests gave very similar conductivity values.

Summary

Slug tests were performed in nine monitor wells at the former Brickland Refinery site. Results showed that wells completed partially in sandy gravel or gravelly sand (MW-3D, MW-6D, and MW-9S) had high conductivities (0.04-0.07 ft/min), wells completed partially in silty clay, silty sand, or in fine sand (MW-1, MW-3S, MW-5, MW-11, and MW-6S) had intermediate conductivities (0.0001-0.0015 ft/min), and the well completed fully in silty clay (MW-8) had the lowest conductivity (0.00008 ft/min). This indicates that the conductivities determined by these slug tests are consistent with the hydrogeological settings.

Table 1

Analyses of Aquifer Slug Test Using Bouwer-Rice Method

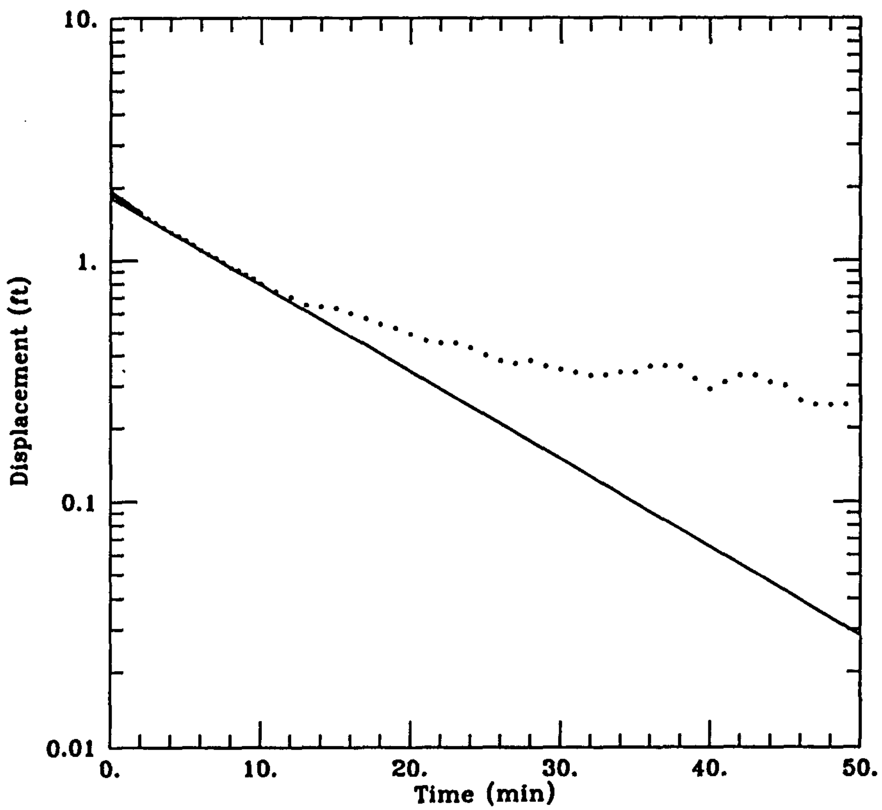
PVC Casing radius, rc =	0.167	ft
Wellbore radius, rw =	0.5	ft
Saturated Aquifer Thickness, b =	80	ft
Screen Length, L =	10	ft
Sand Pack Porosity, n =	0.27	
Conductivity ratio, Kz/Kr =	1	

Well Name	Lithologic Description	Ho ft	H ft	y0 ft	K ft/min
MW-6D-F	70% sand, 15% gravel sand, 15% silty clay	0.86	32.60	1.48	0.07000
MW-6D-R	70% sand, 15% gravel sand, 15% silty clay	1.69	32.60	3.65	0.07000
MW-3D-F	60% sand, 20% silty sand, 20% gravel sand	0.98	33.43	1.43	0.04500
MW-9S-R	75% sand, 25% sandy gravel	1.66	11.39	2.10	0.04200
MW-9S-F	75% sand, 25% sandy gravel	1.68	11.39	1.90	0.04000
MW-10-R	90% sand, 10% sandy clay	2.22	12.48	1.79	0.00400
MW-3S-F	90% sand, 10% silty sand	1.64	12.59	1.55	0.00150
MW-6S-F	100% sand	1.78	11.89	1.40	0.00090
MW-6S-R	100% sand	1.80	11.89	1.67	0.00086
MW-1-F	50% silty clay, 50% silty sand	1.94	12.26	1.81	0.00069
MW-11-F	50% sand, 50% silty clay	1.77	14.94	1.23	0.00034
MW-5-F	60% sand, 40% silty clay	1.68	10.65	0.95	0.00010
MW-8-F	100% silty clay	2.08	11.25	0.78	0.00008

Notes:
D - deep well,
S - shallow well,
F - falling-head test,
R - rising-head test,
Ho - initial displacment,
H - static water column height in well,
y0 - intersection with y axis, and
K - conductivity.

Client: **Rexene**	Company: **GCL**
Location: **Sunland Park, New Mexico**	Project: **3031004**

Aquifer Slug Test



DATA SET:
MW-1.DAT
07/25/95

AQUIFER MODEL:
Confined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: 7-7-95
test well: MW-1 (Falling-Head)

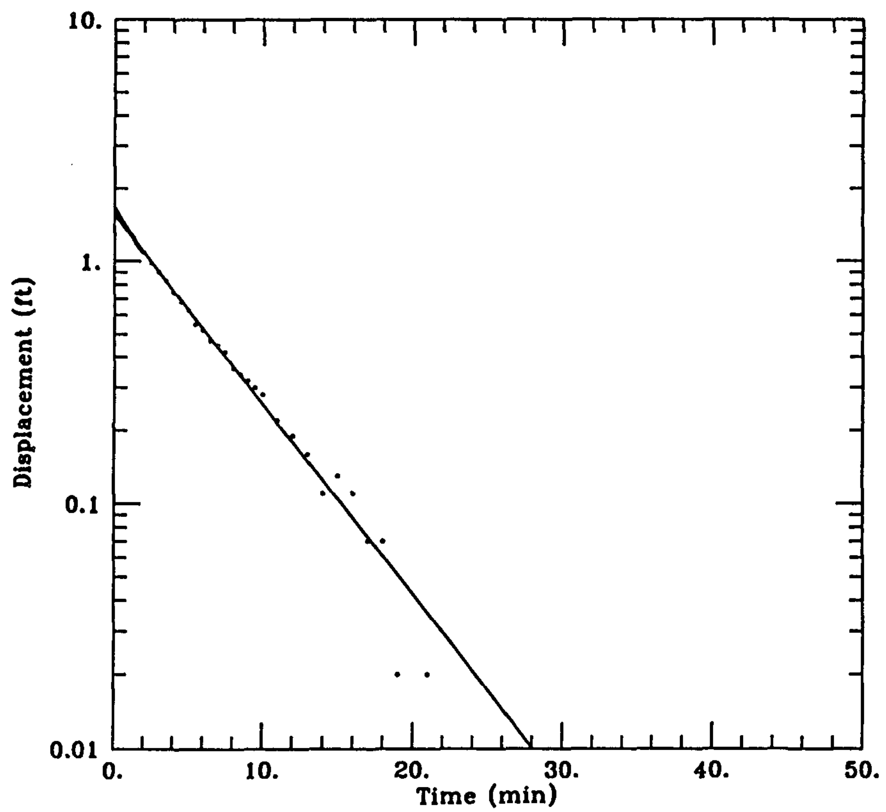
TEST DATA:
H0 = 1.94 ft
rc = 0.17 ft
rw = 0.5 ft
L = 10. ft
b = 80. ft
H = 12.26 ft

PARAMETER ESTIMATES:
K = 0.00069 ft/min
y0 = 1.81 ft

AQTESOLV

Client: **Rexene**	Company: **GCL**
Location: **Sunland Park, New Mexico**	Project: **3031004**

Aquifer Slug Test



DATA SET:
MW-3S.DAT
07/25/95

AQUIFER MODEL:
Confined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: 7-7-95
test well: MW-3S (Falling-Head)

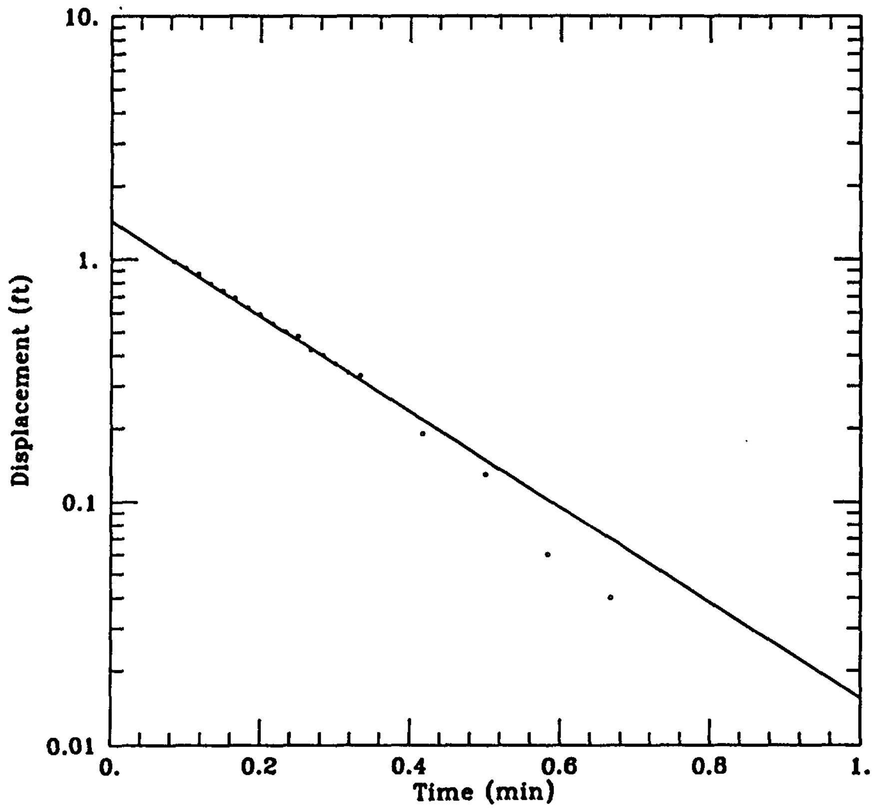
TEST DATA:
H0 = 1.64 ft
rc = 0.17 ft
rw = 0.5 ft
L = 10. ft
b = 80. ft
H = 12.59 ft

PARAMETER ESTIMATES:
K = 0.0015 ft/min
y0 = 1.55 ft

AQTESOLV

Client: **Rexene**	Company: **GCL**
Location: **Sunland Park, New Mexico**	Project: **3031004**

Aquifer Slug Test



DATA SET:
MW-30.DAT
07/25/95

AQUIFER MODEL:
Confined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: 7-7-95
test well: MW-30 (Falling-Head)

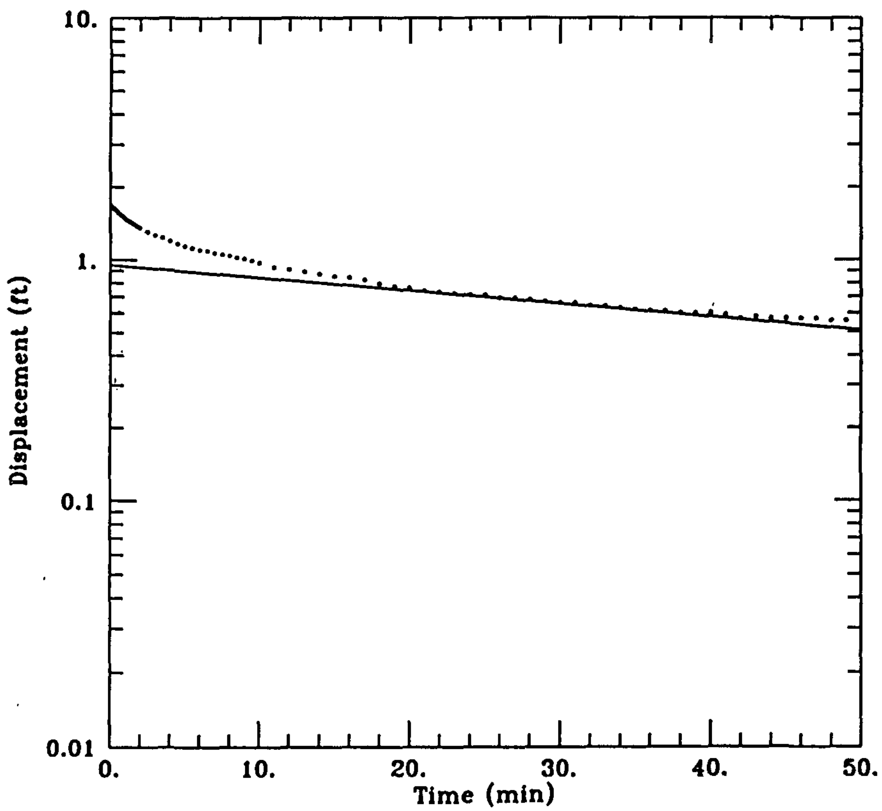
TEST DATA:
H0 = 0.98 ft
rc = 0.17 ft
rw = 0.5 ft
L = 10. ft
b = 80. ft
H = 33.43 ft

PARAMETER ESTIMATES:
K = 0.045 ft/min
y0 = 1.43 ft

AQTESOLV

Client: **Rexene**	Company: **GCL**
Location: **Sunland Park, New Mexico**	Project: **3031004**

Aquifer Slug Test



DATA SET:
MW-5.DAT
07/25/95

AQUIFER MODEL:
Confined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: 7-7-95
test well: MW-5 (Falling-Head)

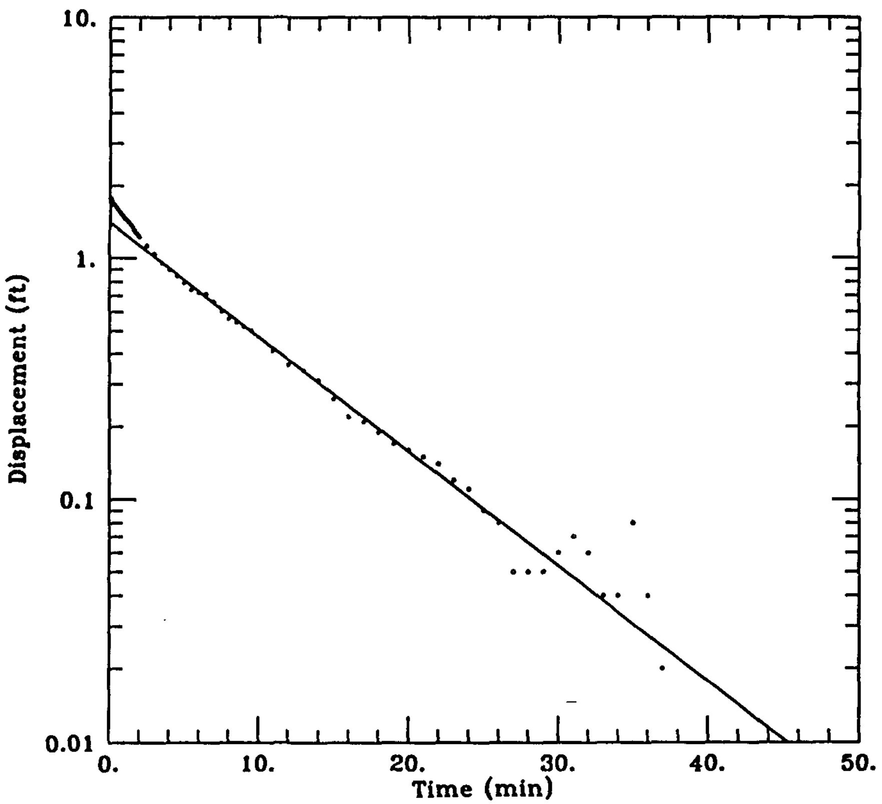
TEST DATA:
H0 = 1.68 ft
rc = 0.17 ft
rw = 0.5 ft
L = 10. ft
b = 80. ft
H = 10.65 ft

PARAMETER ESTIMATES:
K = 0.0001 ft/min
y0 = 0.95 ft

AQTESOLV

Client: Rexene	Company: GCL
Location: Sunland Park, New Mexico	Project: 3031004

Aquifer Slug Test



DATA SET:
MW-6S.DAT
07/25/95

AQUIFER MODEL:
Confined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: 7-6-95
test well: MW-6S (Falling-Head)

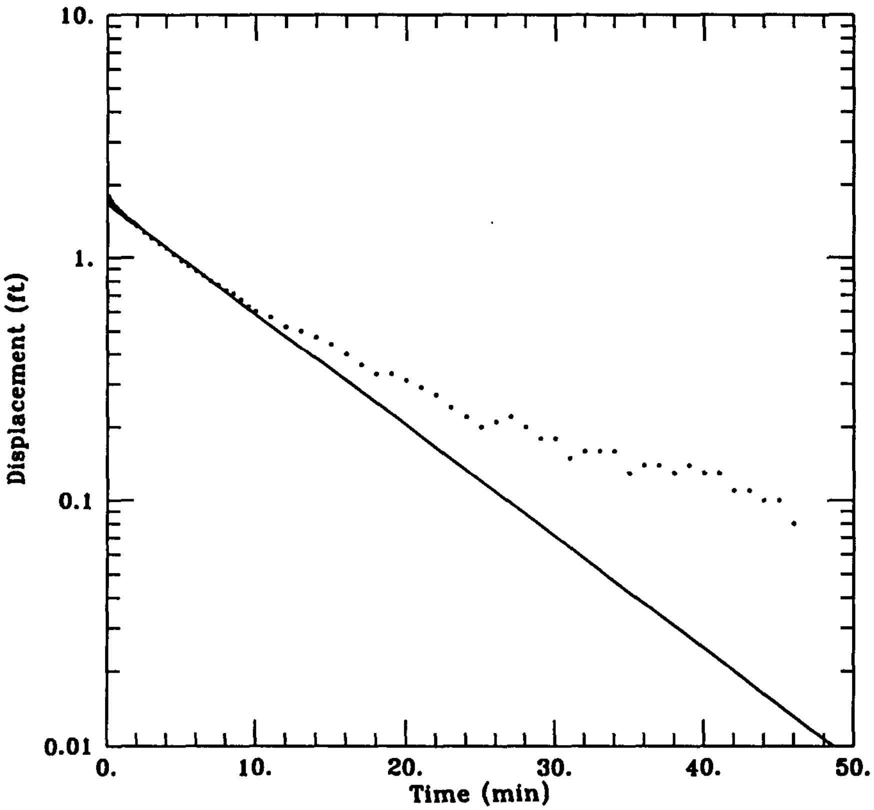
TEST DATA:
H0 = 1.78 ft
rc = 0.17 ft
rw = 0.5 ft
L = 10. ft
b = 80. ft
H = 11.89 ft

PARAMETER ESTIMATES:
K = 0.0009 ft/min
y0 = 1.4 ft

AQTESOLV

Client: **Rexene**	Company: **GCL**
Location: **Sunland Park, New Mexico**	Project: **3031004**

Aquifer Slug Test



DATA SET:
MW-6S-R.DAT
07/26/95

AQUIFER MODEL:
Confined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: 7-6-95
test well: MW-6S (Rising-Head)

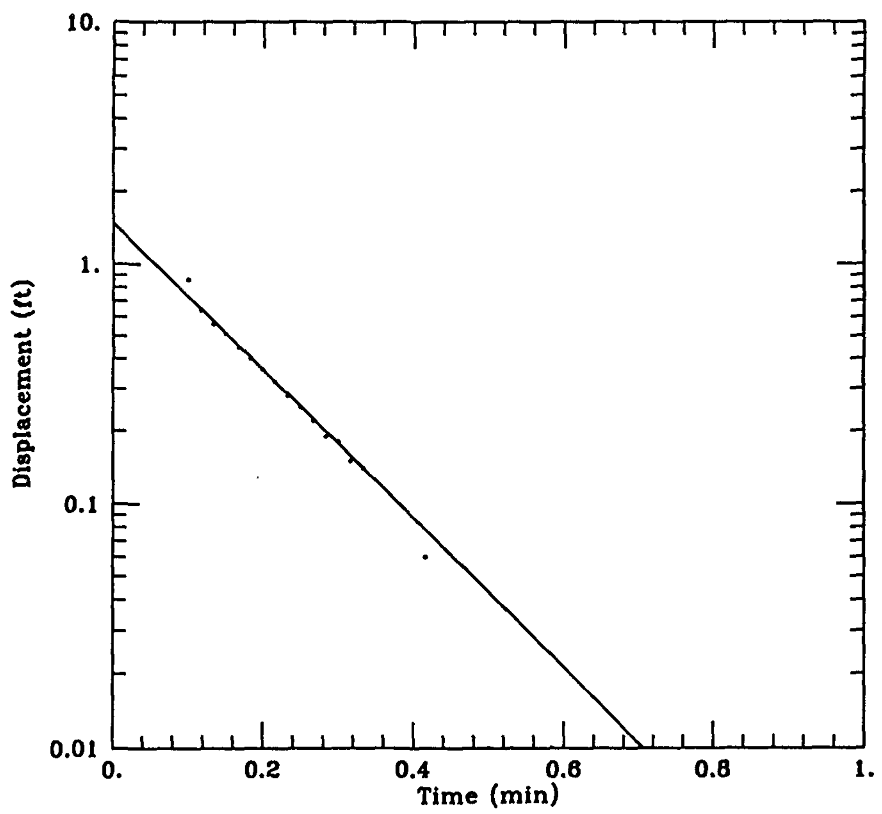
TEST DATA:
H0 = 1.8 ft
rc = 0.167 ft
rw = 0.5 ft
L = 10. ft
b = 80. ft
H = 11.89 ft

PARAMETER ESTIMATES:
K = 0.00086 ft/min
y0 = 1.67 ft

AQTESOLV

Client: Rexene	Company: GCL
Location: Sunland Park, New Mexico	Project: 3031004

Aquifer Slug Test



DATA SET:
MW-6D-F.DAT
07/25/95

AQUIFER MODEL:
Confined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: 7-7-95
test well: MW-6D (Falling-Head)

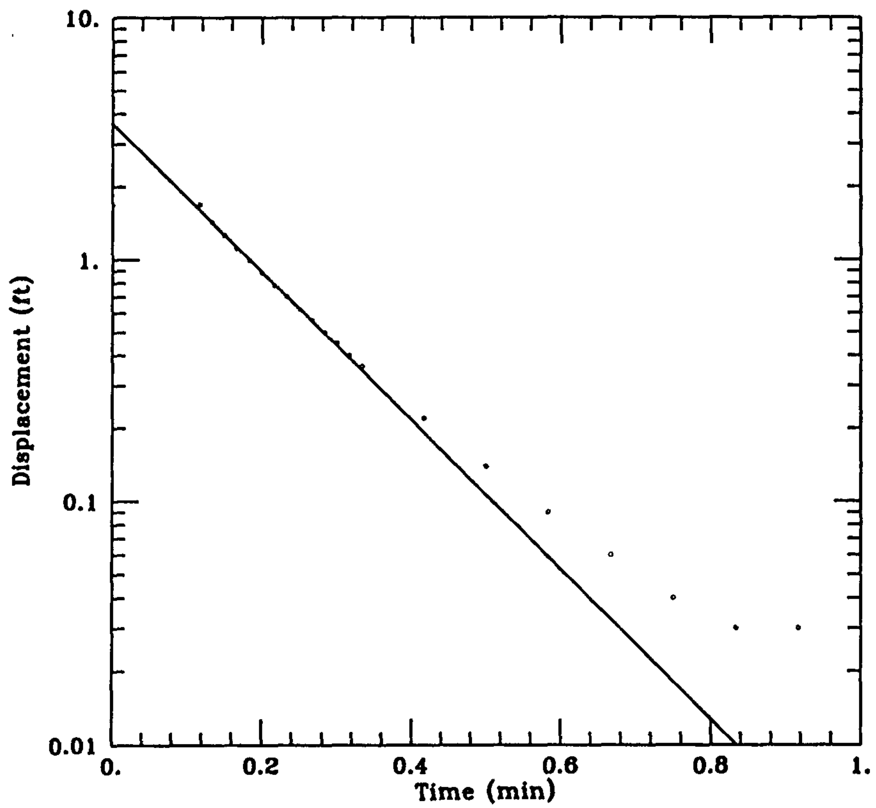
TEST DATA:
H0 = 0.86 ft
rc = 0.17 ft
rw = 0.5 ft
L = 10. ft
b = 80. ft
H = 32.6 ft

PARAMETER ESTIMATES:
K = 0.07 ft/min
y0 = 1.48 ft

AQTESOLV

Client: Rexene	Company: GCL
Location: Sunland Park, New Mexico	Project: 3031004

Aquifer Slug Test



DATA SET:
MW-6D-R.DAT
07/25/95

AQUIFER MODEL:
Confined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: 7-7-95
test well: MW-6D (Rising-Head)

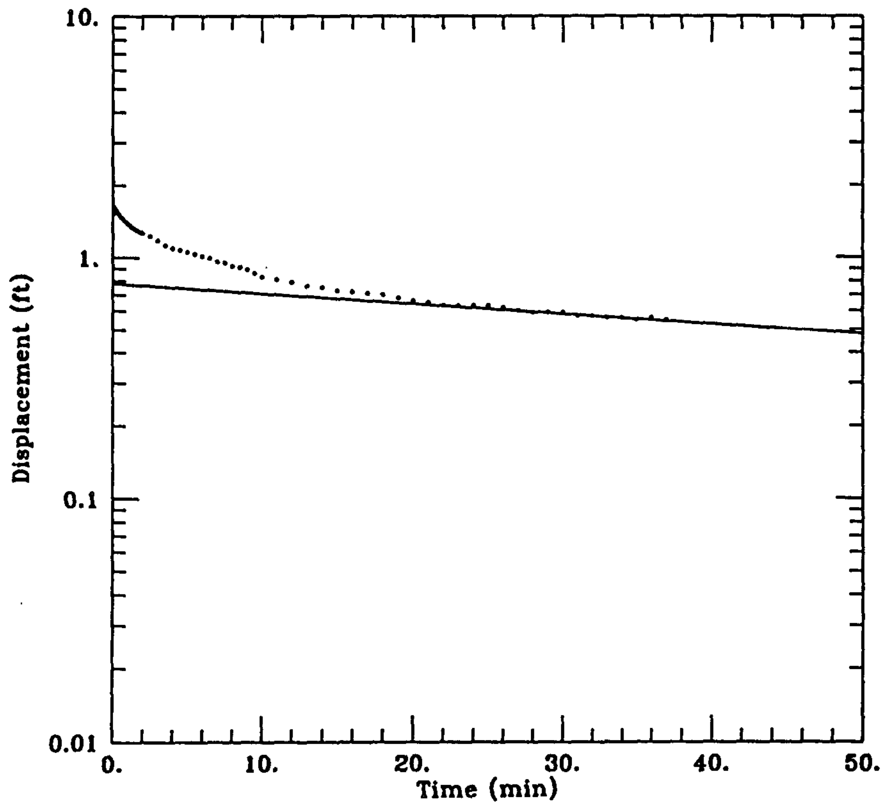
TEST DATA:
H0 = 1.69 ft
rc = 0.17 ft
rw = 0.5 ft
L = 10. ft
b = 80. ft
H = 32.6 ft

PARAMETER ESTIMATES:
K = 0.07 ft/min
y0 = 3.65 ft

AQTESOLV

Client: **Rexene**	Company: **GCL**
Location: **Sunland Park, New Mexico**	Project: **3031004**

Aquifer Slug Test



DATA SET:
MW-8.DAT
07/25/95

AQUIFER MODEL:
Confined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: 7-7-95
test well: MW-8 (Falling-Head)

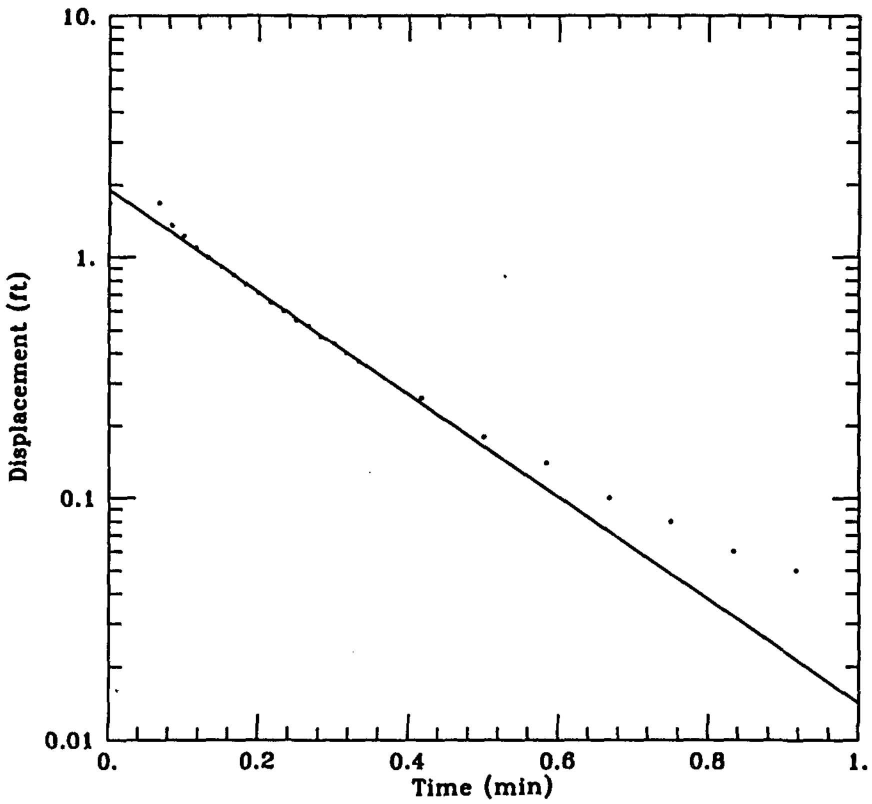
TEST DATA:
H0 = 2.08 ft
rc = 0.17 ft
rw = 0.5 ft
L = 10. ft
b = 80. ft
H = 11.25 ft

PARAMETER ESTIMATES:
K = 8.E-05 ft/min
y0 = 0.78 ft

AQTESOLV

Client: **Rexene**	Company: **GCL**
Location: **Sunland Park, New Mexico**	Project: **3031004**

Aquifer Slug Test



DATA SET:
MW-9S-F.DAT
07/25/95

AQUIFER MODEL:
Confined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: 7-6-95
test well: MW-9S (Falling-Head)

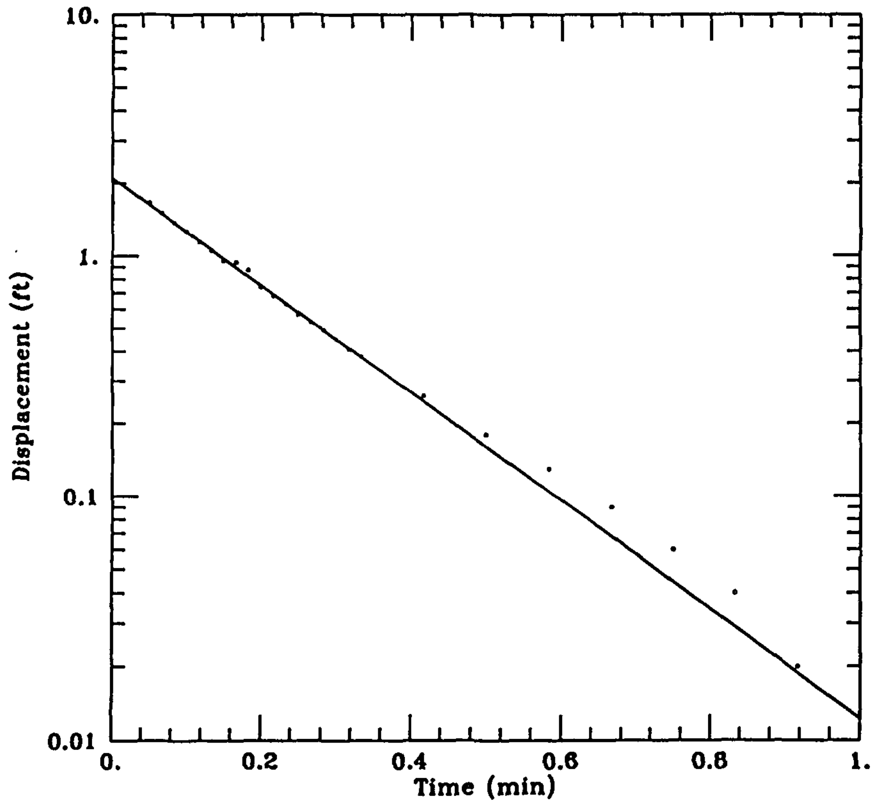
TEST DATA:
H0 = 1.68 ft
rc = 0.17 ft
rw = 0.5 ft
L = 10. ft
b = 80. ft
H = 11.39 ft

PARAMETER ESTIMATES:
K = 0.04 ft/min
y0 = 1.9 ft

AQTESOLV

Client: **Rexene**	Company: **GCL**
Location: **Sunland Park, New Mexico**	Project: **3031004**

Aquifer Slug Test



DATA SET:
MW-9S-R.DAT
07/25/95

AQUIFER MODEL:
Confined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: 7-6-95
test well: MW-9S (Rising-Head)

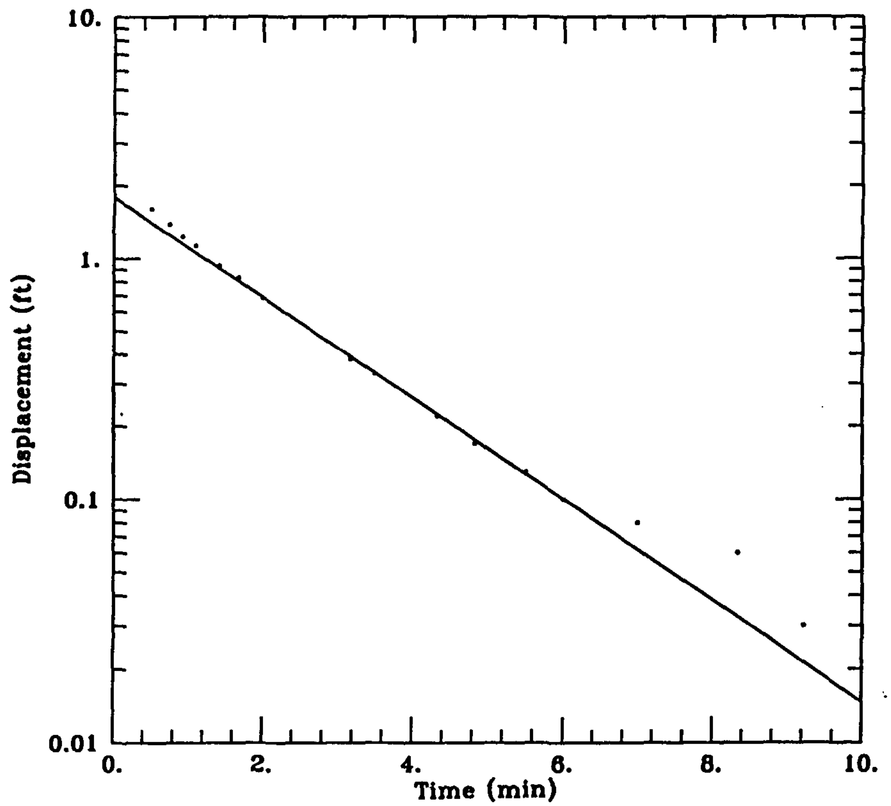
TEST DATA:
H0 = 1.66 ft
rc = 0.17 ft
rw = 0.5 ft
L = 10. ft
b = 80. ft
H = 11.39 ft

PARAMETER ESTIMATES:
K = 0.042 ft/min
y0 = 2.1 ft

AQTESOLV

Client: **Rexene**	Company: **GCL**
Location: **Sunland Park, New Mexico**	Project: **3031004**

Aquifer Slug Test



DATA SET:
MW-10.DAT
08/23/95

AQUIFER MODEL:
Confined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: 8-15-95
test well: MW-10 (Rising-Head)

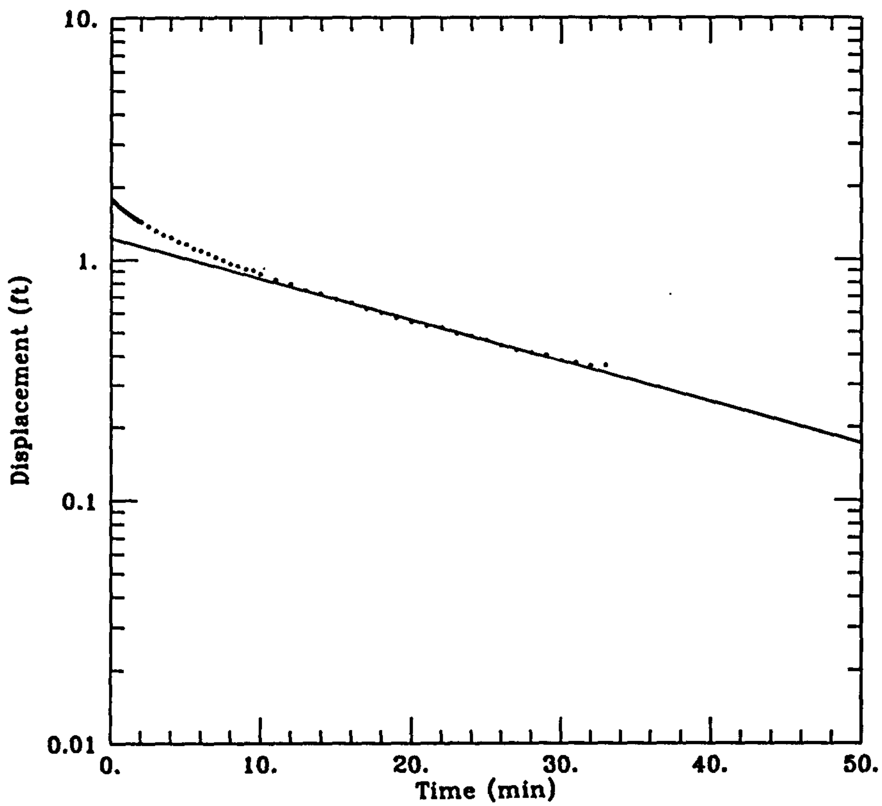
TEST DATA:
H0 = 2.22 ft
rc = 0.17 ft
rw = 0.5 ft
L = 10. ft
b = 80. ft
H = 12.48 ft

PARAMETER ESTIMATES:
K = 0.004 ft/min
y0 = 1.79 ft

AQTESOLV

Client: **Rexene**	Company: **GCL**
Location: **Sunland Park, New Mexico**	Project: **3031004**

Aquifer Slug Test



DATA SET:
MW-11.DAT
07/25/95

AQUIFER MODEL:
Confined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: 7-7-95
test well: MW-11 (Falling-Head)

TEST DATA:
H0 = 1.77 ft
rc = 0.17 ft
rw = 0.5 ft
L = 10. ft
b = 80. ft
H = 14.94 ft

PARAMETER ESTIMATES:
K = 0.00034 ft/min
y0 = 1.23 ft

AQTESOLV

Appendix E

El Paso City-County Health Department and Texas Air Control Board Reports

EPIDEMIC LEAD ABSORPTION NEAR AN ORE SMELTER:

THE ROLE OF PARTICULATE LEAD

Philip J. Landrigan, M.D.[1]
Stephen H. Gehlbach, M.D.[1]
Bernard F. Rosenblum, M.D., M.P.H.[2]
Jimmie M. Shoults, P.E.[3]
Robert M. Candelaria[4]
William F. Barthel[5]
John A. Liddle, Ph.D.[6]
Ann L. Smrek[7]
Norman W. Staehling[8]
JoDean F. Sanders[9]
J. Julian Chisolm, Jr., M.D.[10]

1. Medical Epidemiologist, Field Services Branch, Epidemiology Program, Center for Disease Control, Atlanta, Georgia 30333
2. Director, El Paso City-County Health Department, El Paso, Texas 79901
3. Environmental Engineer, El Paso City-County Health Department, El Paso, Texas 79901
4. Laboratory Director, El Paso City-County Health Department, El Paso, Texas 79901
5. Chief, Toxicology Section, Clinical Chemistry Division, Bureau of Laboratories, Center for Disease Control, Atlanta, Georgia 30333
6. Supervisor, Research Chemist, Toxicology Section, Clinical Chemistry Division, Bureau of Laboratories, Center for Disease Control, Atlanta, Georgia 30333
7. Research Chemist, Toxicology Section, Clinical Chemistry Division, Bureau of Laboratories, Center for Disease Control, Atlanta, Georgia 30333
8. Chief, Data Services Section, Smallpox Eradication Program, Center for Disease Control, Atlanta, Georgia 30333
9. Statistical Assistant, Immunization Branch, Bureau of State Services, Center for Disease Control, Atlanta, Georgia 30333
10. Johns Hopkins University, School of Medicine, Department of Pediatrics, and Baltimore City Hospitals, Department of Pediatrics, Baltimore, Maryland

ABSTRACT

In December 1971, the City-County Health Department in El Paso, Texas discovered that an ore smelter there had discharged 1,116 tons of lead, 560 tons of zinc, 12 tons of cadmium, and 1.2 tons of arsenic into the atmosphere in the preceding 3 years; environmental concentrations of particulate lead adjacent to the smelter were 100 times background values, fell rapidly within 1-2 miles, but remained elevated for as far as 6.5 miles.

To determine the extent and mechanisms of human lead uptake, blood levels were determined for a random sample of all persons living within 4.1 miles of the smelter. Highest levels were found within 1 mile, and values $\geq$ 40 μg/100 ml were widespread, but most prevalent in 1-4 year old children. There was a close relationship between blood lead levels and concentrations of lead in household dust; within 1 mile children with levels $\geq$ 40 μg/100 ml were exposed to 3.1 times as much lead in dust as those with lower blood values (6447 ppm versus 2067), ($p < 0.0001$). Exposure to particulate lead in air was also substantial within 1 mile (annual mean 8-10 μg lead/M^3 air). Exposure to lead-based paint was less than half that in New York City, and exposure to lead in water, food, and pottery was negligible.

It was concluded that chronic uptake of particulate lead, principally from dust and air, had been the major mechanism of absorption and that within a 1-2 mile radius of itself the smelter had been the predominant source of lead in dust and thus of absorbed lead. The arid climate may have facilitated absorption from dust.

INTRODUCTION

Particulate lead in contaminated dust, soil, and air has been recognized as a potentially widespread cause of chronic lead absorption among children in the United States.[1-4] Environmental concentrations of particulate lead may be especially high in the vicinity of point sources of lead emission such as smelters, and study of the mechanisms of lead uptake in such extreme environments might better define the extent to which particulate lead can contribute to human absorption.[5-8]

The present studies of lead uptake were conducted near an ore smelter on the outskirts of El Paso, Texas. In December 1971, the El Paso City-County Health Department found that this smelter had emitted 1,116 tons of lead, 560 tons of zinc, 12 tons of cadmium, and 1.2 tons of arsenic into the environment from 1969 through 1971.[9] Blood lead levels were determined in persons living throughout El Paso, and exposure to lead in dust, soil, air, paint, food, water, and pottery was measured. Our intents were (1) to ascertain the prevalence and severity of lead absorption in this locale, and (2) to evaluate the role of particulate lead in lead uptake.

BACKGROUND

El Paso, population 322,261 (1970 U.S. Census) is located in the Rio Grande Valley in west Texas. It is surrounded to the north, northwest, and west by high mountains. The climate is arid (4 to 10 inches of rainfall per year),[10] and a fine gritty dust is present in the air on many days. Winds are light,? and calm is observed in 25% of hourly readings.[11] Thermal inversions occur on 70% of mornings.[11]

showed concentrations of lead to be highest in particles below 1 micron (Figure 2).*

Additional high-volume air samples were analyzed** for lead and bromine content[18] as a measure of the contribution of automotive sources; in commerical gasolines[19] and in automotive exhausts[20] the ratio of lead to bromine is 2.6/1.0. Samples taken in February 1972 at a site 600 feet from the smelter showed a mean lead/bromine ratio of 62.8 (Figure 3). Samples from the same location in May 1973 had a ratio of 11.2. Additional 1973 samples showed that ratio to decrease rapidly with distance from the smelter and to approach a baseline value of approximately 2.6 at 3 to 4 miles.

Dustfall (settleable particulate) samples were obtained from October 1970 through July 1971 at the smelter and at 10 other sites (Figure 4).[11] Dustfall was greatest at the smelter and decreased with distance. Likewise, the content of each metal was highest at the smelter (10-month means: 204 $\mu g/M^2$-month for lead, 86 for cadmium, 999 for zinc, 553 for arsenic, and 1511 for copper). In areas shielded by mountains, background levels were observed significantly closer to the smelter than in open areas of the valley.

SOIL SAMPLING

Soil samples were collected from March 1972 through June 1973 at 99 sites

*Respiratory lead absorption is inversely proportional to particle size. Reports indicate that between 30 and 100% of particles below 2 μm in diameter are retained and subsequently absorbed in the lungs. Between 10 and 30% of 2-5 μm particles and almost none larger than 5 μm are retained.[1,16,17] Larger particles may, however, be swallowed and contribute to gastrointestinal absorption.

**Determinations kindly performed by Dr. Jimmy Payne of the Texas Air Control Board, Austin, Texas, using an X-ray fluorescence technique.

in El Paso and at 3 remote sites. Samples were taken at the surface and at depths of 1, 2, and 3 inches and analyzed for lead content by atomic absorption spectrophotometry. Only trace amounts of lead (< 50 ppm) were found at the remote sites. Within the city, highest levels in 1972 were found within 600 feet of the smelter (mean 3,457 ppm, range 560 - 11,450 for 54 samples); lead content was consistently highest at the surface. Levels fell rapidly in the first 1-2 miles from the smelter, but remained above background for as far as 6.5 miles (Figure 5). Similar though less extensive distributions were noted for zinc, cadmium, and arsenic. Distribution patterns for all of these metals in 1973 were virtually unchanged from 1972.

DUST SAMPLING

Household dust samples were obtained once monthly from July 1972 through June 1973 at 51 locations. Highest values were obtained in Smeltertown, a village adjacent to the smelter; arithmetic mean lead content in 53 samples there was 36,853 ppm (Table 1). Zinc, cadmium, and arsenic levels were also highest in Smeltertown, and all levels declined rapidly with distance.

FOOD AND WATER SAMPLING

Food and tap water samples were obtained in March 1972 from 13 homes, 9 of them in Smeltertown. No lead was detected in any of these samples; the lower limit of detection for lead was 0.05 μg/ml.

HUMAN STUDIES

In preliminary testing programs conducted throughout El Paso from January to April 1972, whole blood lead levels ≥ 40 μg/100 ml* were found in 97

*A whole blood lead level of 40 μg or more per 100 ml is considered by the Surgeon General to be indicative of "undue lead absorption."[21]

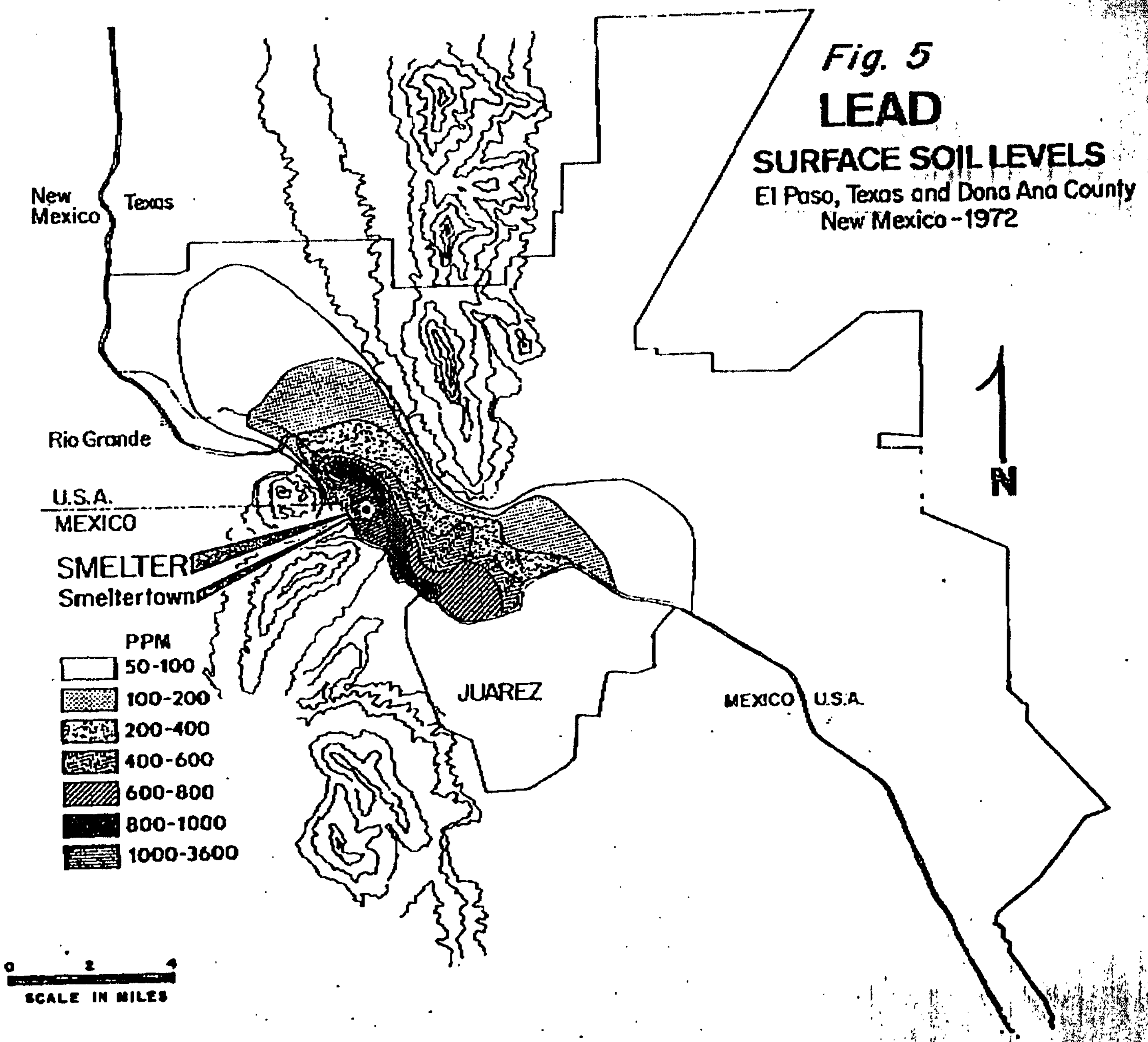
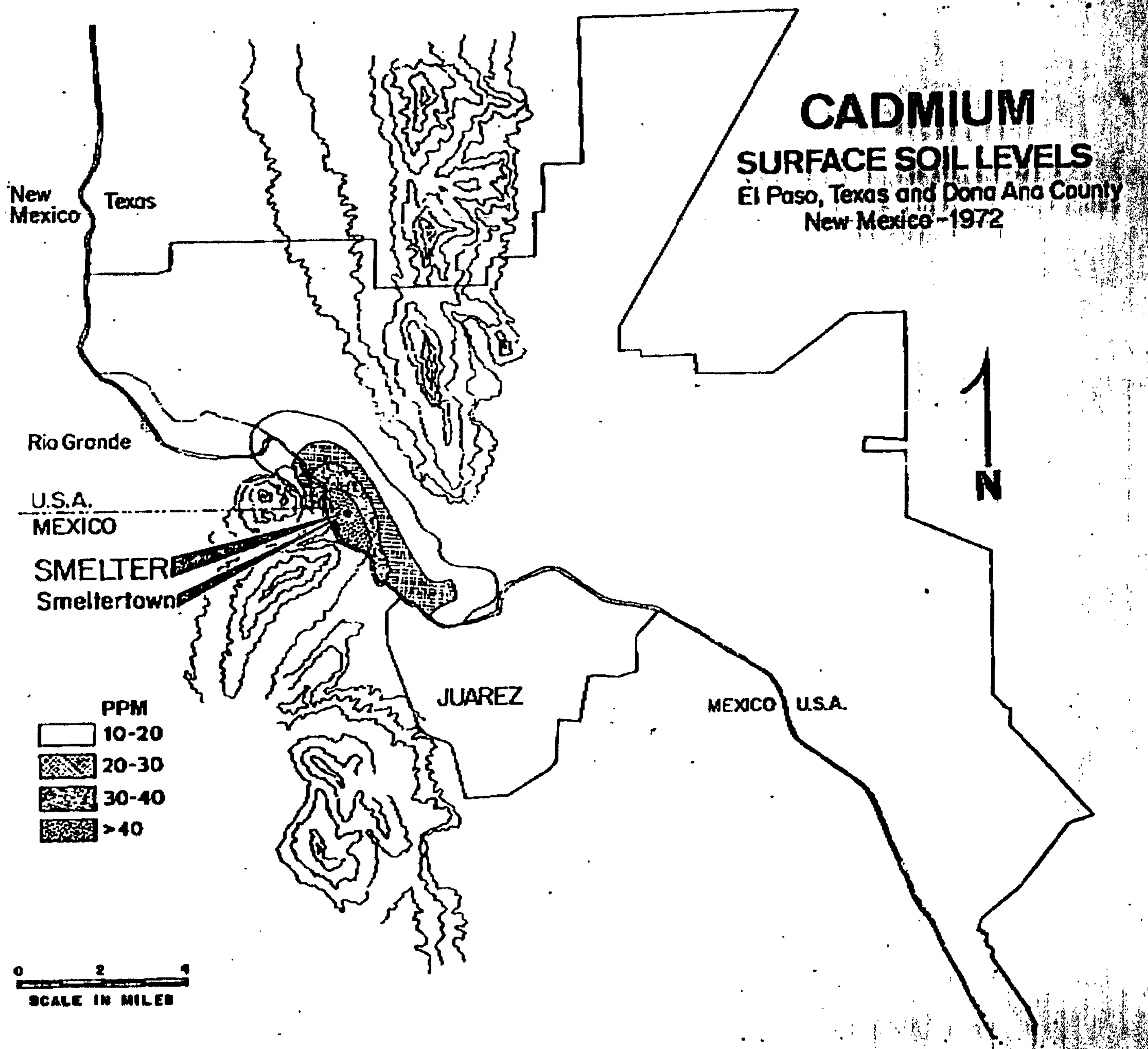
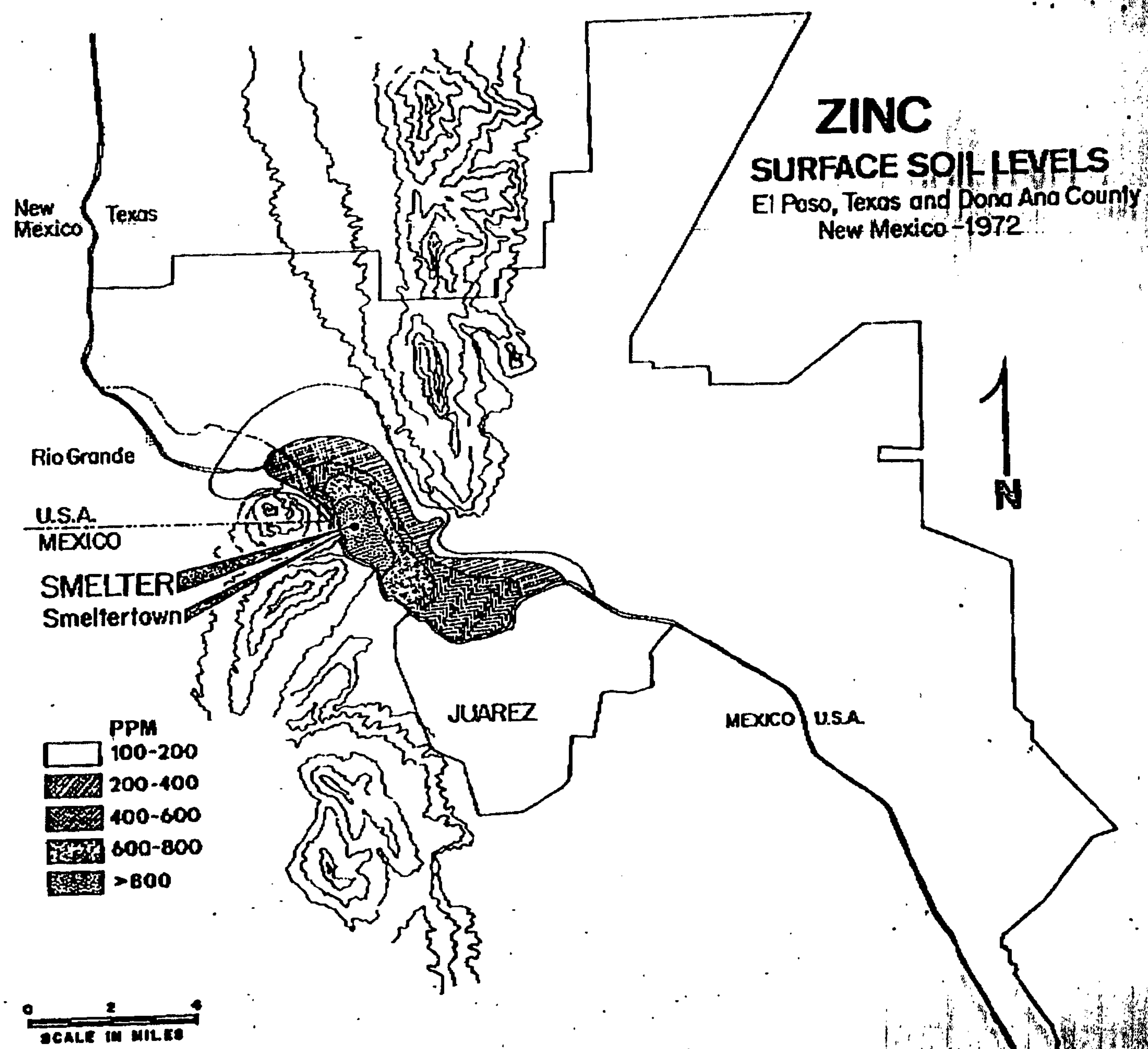
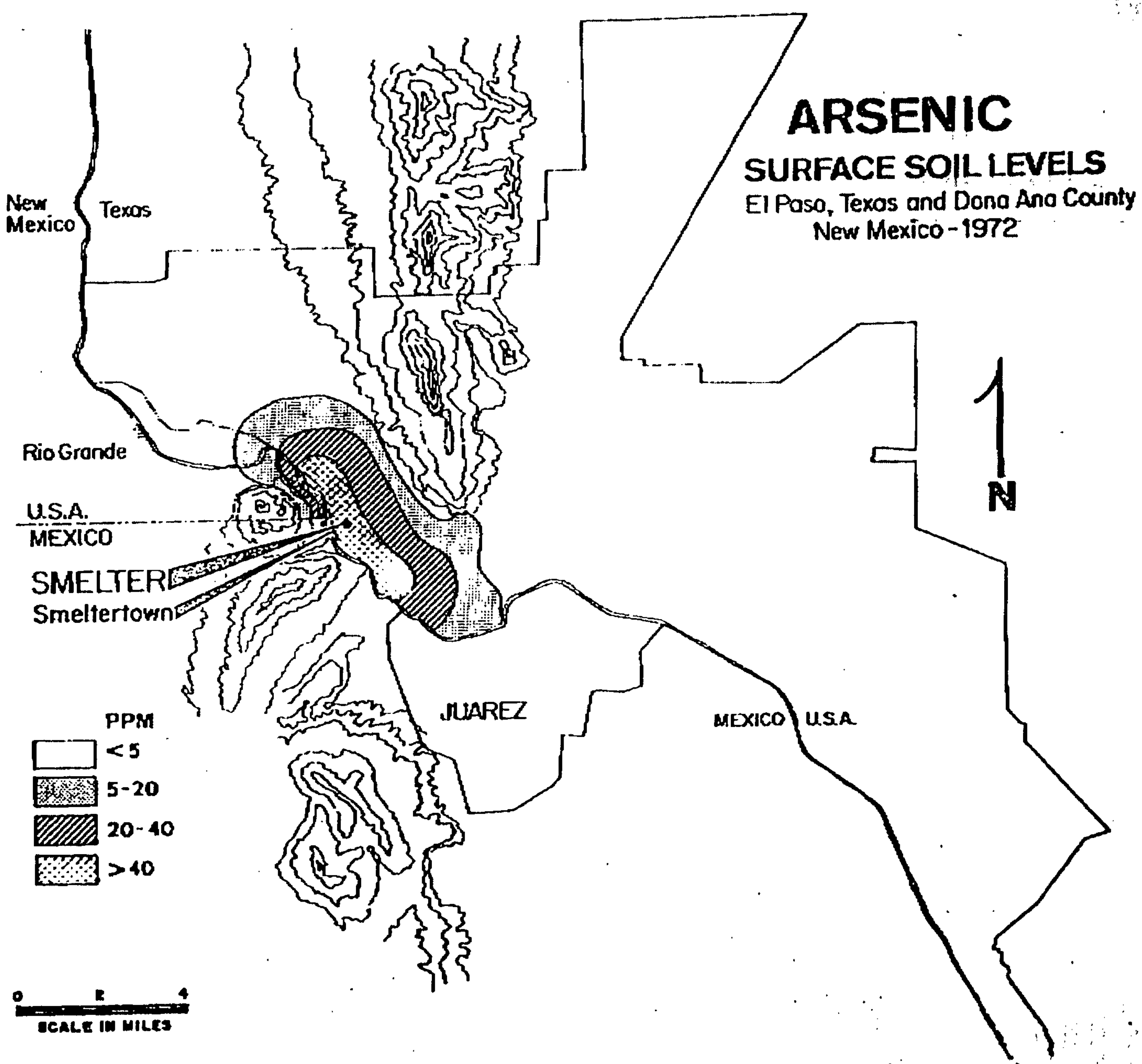


Fig. 5
LEAD
SURFACE SOIL LEVELS
El Paso, Texas and Dona Ana County New Mexico - 1972


CADMIUM
SURFACE SOIL LEVELS
El Paso, Texas and Dona Ana County
New Mexico - 1972
N
New Mexico
Texas
Rio Grande
U.S.A.
MEXICO
SMELTER
Smeltertown
JUAREZ
MEXICO
U.S.A.
PPM
10-20
20-30
30-40
>40
0
2
4
SCALE IN MILES


ZINC
SURFACE SOIL LEVELS
El Paso, Texas and Dona Ana County
New Mexico - 1972
N
New Mexico
Texas
Rio Grande
U.S.A.
MEXICO
SMELTER
Smeltertown
JUAREZ
MEXICO
U.S.A.
PPM
100-200
200-400
400-600
600-800
>800
0
2
4
SCALE IN MILES


ARSENIC
SURFACE SOIL LEVELS
El Paso, Texas and Dona Ana County
New Mexico - 1972
N
New Mexico
Texas
Rio Grande
U.S.A.
MEXICO
SMELTER
Smeltertown
JUAREZ
MEXICO
U.S.A.
PPM
< 5
5-20
20-40
> 40
0
2
4
SCALE IN MILES

Archie Clouse
Region 11

SAMPLING AND ANALYSIS OF SOIL IN THE VICINITY OF ASARCO IN EL PASO, TEXAS

FINAL REPORT

David Carmichael
Texas Air Control Board
Sampling and Analysis Division
Source Sampling Section
August 1989

1. PROJECT DESCRIPTION

1.1 Origin of Project

In response to a request from the Research Division of the Texas Air Control Board (TACB), the Sampling and Analysis Division conducted soil sampling in the vicinity of ASARCO in El Paso, Region 11. The plant is located at 2301 West Paisano Drive in El Paso County. Personnel from the Source Sampling Section collected the soil samples on July 12 and 13, 1989.

1.2 Summary

The project was designed to document the levels of arsenic in the top one-half inch of soil at selected sites in the vicinity of ASARCO. The highest single value of arsenic detected was 1100 micrograms of arsenic/gram of soil (μg/g). It should be noted that the 1100 μg/g sample site at the International Boundary and Water Commission was the closest to the ASARCO plant and was located directly across from a brick manufacturing company in Mexico. Figure 1 is a map of the general distribution of arsenic levels found in the soil samples collected in the El Paso area. The minimum detection limit (MDL) for the analysis was 3 μg/g. The background samples were determined to have an arsenic concentration less than the MDL. The results of the analysis were sent to the Effects Evaluation Section for a health effects determination.

2. SAMPLING, BANKING, AND ANALYTICAL PROCEDURES

2.1 Sampling

Sampling locations were selected by the project leader using maps of the area and on-site observations. An emphasis was placed on collecting soil samples in the vicinity of schools and recreational parks. The general location and description of the sampling sites can be found in Figure 2. Background samples were taken at two locations selected by the project leader. The background sites were in the El Paso area but in areas unaffected by emissions from ASARCO. At each sampling site, twelve samples were taken at evenly spaced locations on the circumference of a circle having a diameter of two feet. Sampling sites on the circumference of the circle were located with an aluminum template with holes numbered 1-12 (See Figure 3). At each location, a soil sample was obtained using a stainless steel coring device capable of removing a soil core 7/8" in diameter and 1/2" in depth.

The six samples from holes 1, 3, 5, 7, 9, and 11 were composited, placed in a polyethylene bag, assigned a sample ID and labeled with a sample collection tag which was filled out by the field sampler. The six samples from holes 2, 4, 6, 8, 10, and 12 were composited, bagged and labeled similarly. The sample ID, sample collection tag number and information regarding the sampling location were noted in a field sample logbook. The sampling locations and background sampling sites were also noted on a map of the area in the logbook. A Polaroid photograph was taken of the sampling location, labeled with the sample ID and photographer signature and stapled to the relevant page of the logbook. The samples were stored in a box which remained in the custody of the project leader.

The sampling equipment was cleaned at each location when sampling was completed. Cleaning consisted of removing loose soil particles using paper towels and distilled deionized (DDI) water.

2.2 Banking

The samples and field sampling logbook were returned to the TACB Laboratory and transferred to the custody of the staff member in charge of the sample bank. Each sample was assigned a sample bank number, transferred to a new polyethylene sample bag and labeled with a sample bank tag. As a cross reference, the sample bank number was recorded on the appropriate page of the field sample logbook. The original sample collection bag and tag were stored at the sample bank. The sample bank was responsible for drying, sieving, grinding and mixing each soil sample. Each sample was placed in a beaker and dried in an oven at 100° C for eight hours or until dry. The sample was then sieved using a brass 16-mesh sieve. Once sieved, the sample was ground in a laboratory grinder to approximately 100-mesh. The sample was weighed, mixed and divided into three equal portions. Each portion was placed in an individual polyethylene bag, assigned a sample analysis number and labeled with a sample analysis tag. As a cross reference, the sample analysis number was recorded on the appropriate page of the field sample logbook. The samples used for analysis or quality assurance (QA) were then transferred to the custody of the laboratory analyst. The sieve and laboratory grinder were cleaned with DDI water and paper towel after each sample was prepared.

2.3 Analytical Procedures

All soil samples were analyzed similarly. Each sample was mixed in its polyethylene bag by tumbling the bag three to five times. Approximately 2.0 grams of the sample were dried at 100° C for one hour and then cooled and reweighed. The sample was extracted with nitric acid and hydrogen peroxide according to Environmental Protection Agency (EPA) Method 3050, which can be found in Test Methods for Evaluating Solid Waste, Volume IA: Laboratory Manual: Physical /Chemical

Methods (November 1986 SW-846 Third Edition). The filtered extract solution was then analyzed for arsenic by inductively coupled plasma spectroscopy (ICP) according to EPA Method 6010 found in SW-846. The results of the analysis in µg/g were reported to the sample bank. The data was matched to the sample ID and reported in Table 1.

Like the soil samples, any particulate matter in the field blanks (rinses) or in the DDI water blank was weighed, extracted according to EPA Method 3050 and analyzed for arsenic by ICP.

3. QUALITY ASSURANCE PROCEDURES

3.1 Sampling

A field blank was collected for each group of ten or fewer samples. The field blank consisted of DDI water that had come in contact with the previously cleaned surfaces of the sampling equipment. The field blank was placed in a polyethylene bag and documented and handled in the same manner as the soil samples. The sample bank repackaged, documented and relabeled each field blank and transferred custody to the laboratory analyst. The analyst transferred the entire contents of the polyethylene bag to a tared beaker and evaporated the water at 100° C. Any remaining particulate matter was weighed, extracted using EPA Method 3050 and analyzed for arsenic using ICP. The results were reported in the same manner as that for the soil samples. A DDI water blank was collected once during the day's sampling. The DDI water blank was placed in a polyethylene bag and documented, banked, evaporated, weighed, extracted, analyzed and reported in the same manner as that for the field blanks.

The even-numbered soil samples from each sampling location were composited and used as site duplicates. A site duplicate sample was submitted to the laboratory analyst by the sample bank for each group of ten or fewer samples processed.

3.2 Banking

A banking blank was prepared for each group of ten or fewer samples processed. The banking blanks consisted of DDI water that had come in contact with the previously cleaned surfaces of the sieve and laboratory grinder. The blank sample was placed in a polyethylene bag, documented, analyzed and reported in the same manner as that for the field blanks.

A blind duplicate sample was submitted to the laboratory analyst by the sample bank for each group of ten or fewer samples processed. A blind duplicate sample was one-third of an original soil sample as described in Section 2.2. The blind duplicate samples were documented, analyzed and reported in the same manner as that for the soil samples. The results are reported in Table 2.

A spiked sample blank was submitted to the laboratory analyst by the sample bank for each group of ten or fewer samples processed. The sample bank only labeled the sample as a spiked sample blank. The analyst performed the spiking procedure. The results are reported in Table 2.

3.3 Analysis

Calibration control standards, spiked samples, duplicate samples, split extracts and extract re-analyses were prepared by the analyst and analyzed for each group of ten or fewer samples analyzed. The Sampling and Analysis QA officer prepared the audits for the analyst for each group of ten or fewer samples analyzed. The results are reported in Table 2.

4. SAMPLE CUSTODY

Chain of sample custody was established by using a log. Each time a sample or set of samples changed possession and/or control, the date, time and personnel involved were noted. The log was used from the time the samples were collected until they were relinquished by the sample bank. A new chain of custody log was prepared by the sample bank before transferring samples to the laboratory analyst.

5. CALIBRATION PROCEDURES AND FREQUENCY

The analyst calibrated the ICP during each analytical run by using standards prepared from a Fisher Certified arsenic reference solution containing 1000 micrograms of arsenic per milliliter of solution.

6. DISTRIBUTION

6.1 Distribution of Report

Mr. Doyle R. Pendleton, Director, Monitoring Program
Mr. Jim Myers, P.E., Director, Enforcement Program
Mr. Les Montgomery, P.E., Director, Technical Support and Regulation Development Program
Mr. Walter Bradley, Director, Research and Special Projects
Mr. Manuel Aguirre, P.E., Regional Director, Region 11
Mr. John Key, P.E., Assistant to the Director, Monitoring Program
Mr. Scott Mgebroff, Director, Sampling and Analysis Division
Mr. James H. Price, Jr., Ph.D., Director, Research Division

Arsenic Soil Concentrations in the Vicinity of ASARCO (µg/g)

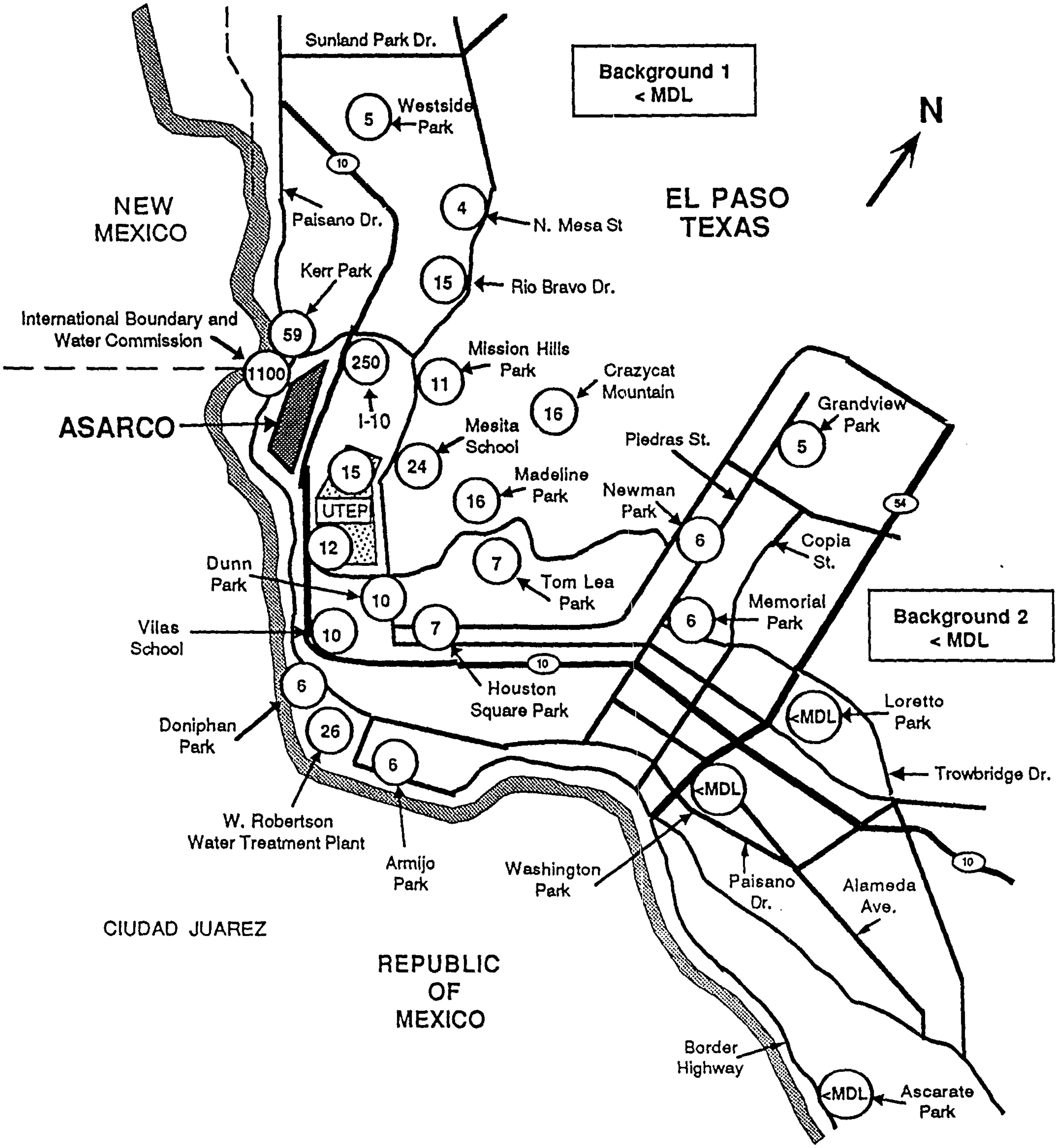


FIGURE 1

Mr. Paul W. Henry, P.E., Director, Technical Services Division
Mr. James P. Barta, Jr., P.E., Sampling and Analysis Division
Mr. Robert Brewer, Quality Assurance Division
Mr. Vince Anselmo, Ph.D., Sampling and Analysis Division
Mr. Wayne Burnop, P.E.,Technical Services Division
Ms. JoAnn Wiersema, Research Division
Mr. Tom Dydek, Ph.D., Research Division
Mr. George Dean, Sampling and Analysis Division
Mr. Dewayne Ehman, Ph.D., Sampling and Analysis Division
Ms. Peggy Zimmerman, Sampling and Analysis Division
Mr. Archie Clouse, Region 11

ASARCO Soil Sampling Sites

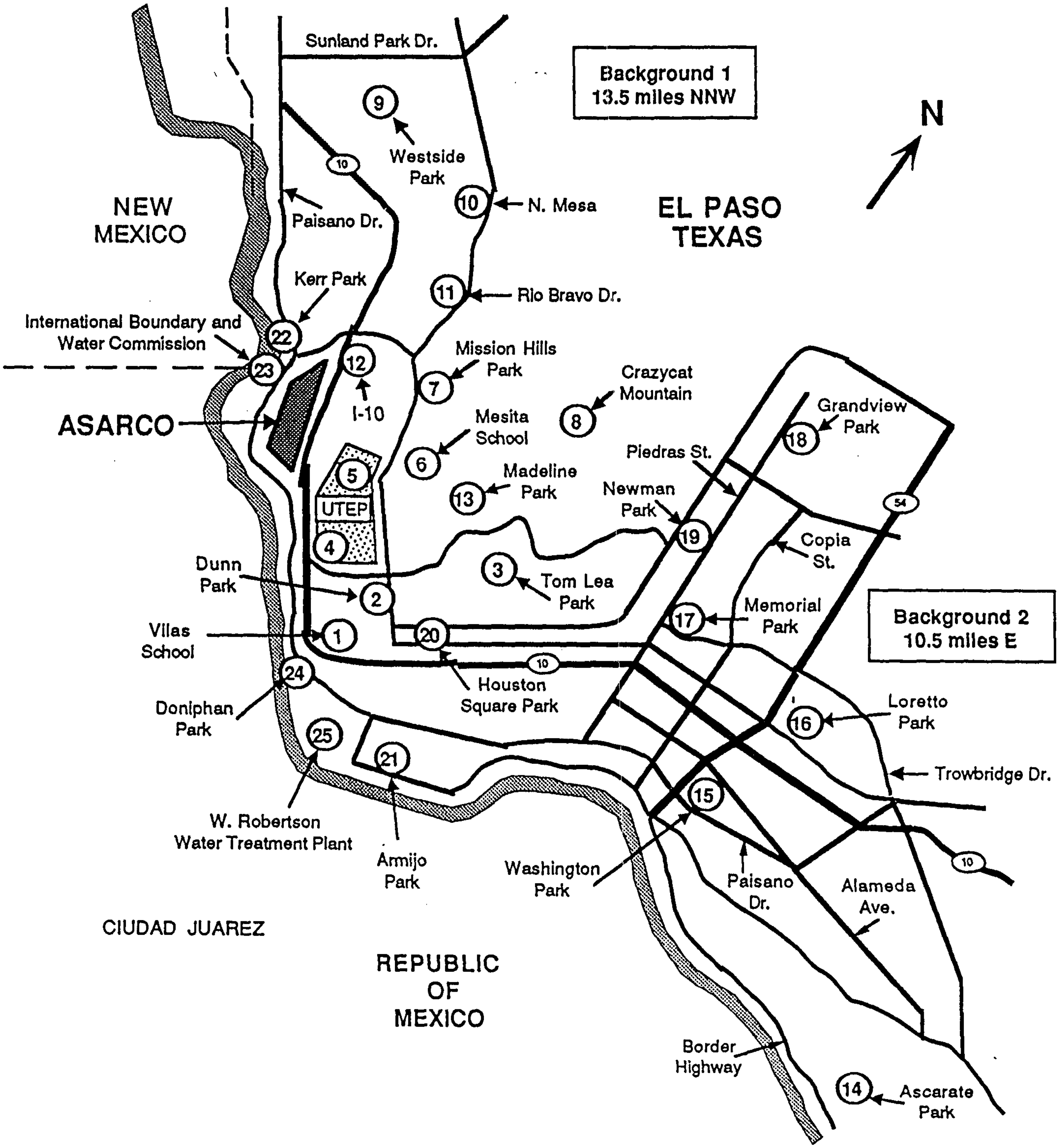


FIGURE 2

Aluminum Template

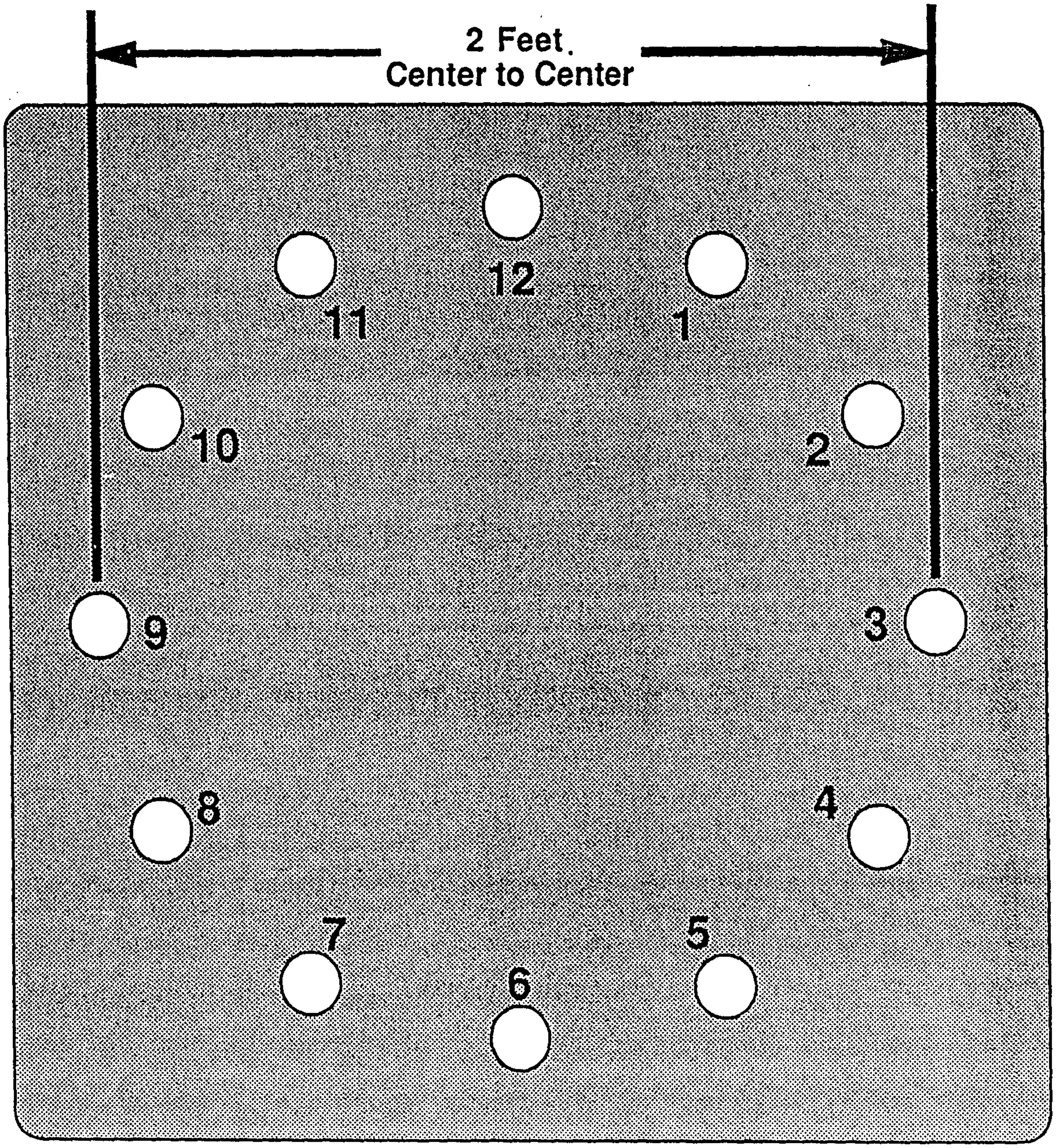


FIGURE 3

Analytical Results of Arsenic Sampling Performed in the Vincinity of ASARCO

Sampling Site	Location	Direction from ASARCO	Arsenic Concentration µg/g
1	Vilas Elem. School	1.85 miles SE	10
2	Dunn Park	1.75 miles ESE	10
3	Tom Lea Park	1.85 miles E	7
4	UTEP	1.40 miles SE	12
5	UTEP	0.90 miles E	15
6	Mesita Elem. School	1.10 miles ENE	24
7	Mission Hills Park	1.25 miles NE	11
8	Crazycat Mountain	1.75 miles NE	16
9	Westside Park	2.30 miles NNW	5
10	N. Mesa Street	1.75 miles NNE	4
11	Rio Bravo Drive	1.00 miles NNE	15
12	Interstate Hwy. 10	0.60 miles NNE	250
13	Madeline Park	1.55 miles ENE	16
14	Ascarte Park	6.75 miles ESE	< MDL
15	Washington Park	4.75 miles ESE	< MDL
16	Loretto Park	5.10 miles E	< MDL
17	Memorial Park	4.20 miles E	6
18	Grandview Park	4.40 miles NE	5
19	Newman Park	3.55 miles ENE	6
20	Houston Square Park	2.50 miles ESE	7
21	Armijo Park	3.25 miles SE	6
22	Kerr Park	0.35 miles NW	59
23	IBWC [1]	0.20 miles WNW	1100
24	Doniphan Park	1.45 miles SSE	6
25	W. Robertson WTP [2]	2.75 miles SE	26
Background 1	City of Vinton, Tx.	13.50 miles NNW	< MDL
Background 2	Montana/Yarbrough	10.50 miles E	< MDL

Minimum detection limit (MDL) for this method of analysis is 3 µg/g.
Mileage is an approximation.

1. International Boundary and Water Commission

2. W. Robertson Water Treatment Plant

TABLE 1

Quality Assurance Results

DUPLICATES CHOSEN BY BANKER	AVERAGE % DIFFERENCE
Lab Duplicates	+ 10.0
Site Duplicates	- 2.5
DUPLICATES CHOSEN BY ANALYST	- 8.2
SPLIT EXTRACTS	+ 0.5
EXTRACT RE-ANALYSES	- 2.8
STANDARDS AS UNKNOWNS	+ 1.0

	AVERAGE % RECOVERY
SPIKED SAMPLES	97.8

	AVERAGE % DISCREPANCY
AUDIT SAMPLES	+ 3.0

TABLE 2

Appendix F

Quarterly BTEX Analytical Results for Selected Monitoring Wells

MW-4
Brickland Refinery Site
Quarterly Analytical Results

(All results in ug/l except TPH)

Parameter	WQCC Std.	12/08/93	03/23/94	07/12/94	09/27/94	12/13/94	03/27/95	06/21/95	09/26/95
Benzene	10	NS	130,110	1800	2000	220	220	800	2200,ND
Toluene	750	NS	ND,ND	12	ND	ND	ND	ND	ND,ND
Ethyl Benzene	750	NS	2.5,1.6	50	ND	ND	6	12	ND,ND
Xylenes	620	NS	ND,ND	ND	ND	ND	ND	ND	ND,ND
Total Vol. Petroleum Hydrocarbon	None	NS	ND,ND	NA	NA	NA	NA	NA	NA,NA

Detection Limits (ug/l):

Benzene	0.5	Ethyl Benzene	0.5	Total Vol. Petroleum	
Toluene	0.5	Xylenes	0.5	Hydrocarbons	0.1 mg/l

(All results in mg/l)

Parameter	WQCC Std.	12/08/93	03/23/94	06/27/94	09/27/94	12/13/94	03/27/95	06/21/95	09/26/95
Calcium	None	NS	740,755	430	370	298	NS	NA	NA
Magnesium	None	NS	262,247	217	225	219	NS	NA	NA
Potassium	None	NS	57,69	66	65	27	NS	NA	NA
Sodium	None	NS	2920,2930	2050	2340	2360	NS	NA	NA
Bicarbonate	None	NS	924,908	1350	1470	1020	NS	NA	NA
Chloride	250	NS	4010,4330	4300	4360	4680	NS	NA	NA
Nitrate (N)	10	NS	ND,ND	2.8	0.4	ND	NS	NA	NA
Sulfate	600	NS	1820,2100	932	364	3060	NS	NA	NA

Detection Limits (mg/l):

Calcium	20.0	Bicarbonate	5.0	ND = Not detected
Magnesium	0.5	Chloride	25.0	NS = Not sampled
Potassium	5.0	Nitrate (N)	0.1	NA = Not analyzed
Sodium	20	Sulfate	100	

MW-5
Brickland Refinery Site
Quarterly Analytical Results

(All results in ug/l except TPH)

Parameter	WQCC Std.	12/08/93	03/24/94	07/12/94	09/27/94	12/13/94	03/27/95	06/21/95	09/25/95
Benzene	10	NS	7100	5000,4200	5600	4600	4700	NA	4400
Toluene	750	NS	160	ND,ND	ND	84	100	NA	ND
Ethyl Benzene	750	NS	53	ND,ND	ND	ND	70	NA	ND
Xylenes	620	NS	420	130,130	160	140	280	NA	ND
Total Vol. Petroleum Hydrocarbon	None	NS	12	NA,NA	NA	NA	NA	NA	NA

Detection Limits (ug/l):

Benzene	50	Ethyl Benzene	50	Total Vol. Petroleum	
Toluene	50	Xylenes	50	Hydrocarbons	0.1 mg/l

(All results in mg/l)

Parameter	WQCC Std.	12/08/93	03/23/94	06/27/94	09/27/94	12/13/94	03/27/95	06/21/95	09/25/95
Calcium	None	NS	402	500	620	503	NS	NA	NA
Magnesium	None	NS	180	160	186	184	NS	NA	NA
Potassium	None	NS	24.2	58	60	21	NS	NA	NA
Sodium	None	NS	2880	2230	3040	3070	NS	NA	NA
Bicarbonate	None	NS	1860	1710	1630	1830	NS	NA	NA
Chloride	250	NS	5280	5450	4310	2430	NS	NA	NA
Nitrate (N)	10	NS	ND	0.3	ND	1.1	NS	NA	NA
Sulfate	600	NS	505	962	904	705	NS	NA	NA

/BTEX602/1BTEX602.WQ2

Detection Limits (mg/l):

Calcium	1.0	Bicarbonate	5.0	ND = Not detected
Magnesium	0.5	Chloride	25.0	NS = Not sampled
Potassium	5.0	Nitrate (N)	0.1	NA = Not analyzed
Sodium	20	Sulfate	200	

MW-6S
Brickland Refinery Site
Quarterly Analytical Results

(All results in ug/l except TPH)

Parameter	WQCC Std.	12/08/93	03/25/94	07/12/94	09/28/94	12/13/94	03/28/95*	06/21/95	09/25/95
Benzene	10	71	74	110	4.8	59	110	220,220	180,180
Toluene	750	ND	ND	ND	2.8	ND	7	ND,ND	120,110
Ethyl Benzene	750	52	12	30	34	ND	31.5	180,150	ND,ND
Xylenes	620	ND	7.6	88	16	ND	43.5	260,210	30,30
Total Vol. Petroleum Hydrocarbon	None	2.9	1.8	NA	NA	NA	NA	NA,NA	NA,NA

Detection Limits (ug/l):

Benzene	0.5	Ethyl Benzene	0.5	Total Vol. Petroleum Hydrocarbons	0.1 mg/l
Toluene	0.5	Xylenes	0.5		

*Detection limit for BTEX constituents = 5 ug/l

(All results in mg/l)

Parameter	WQCC Std.	12/08/93	03/25/94	06/27/94	09/28/94	12/13/94	03/28/95	06/21/95	9/25/95
Calcium	None	NS	244	259	155	150	NS	NA	NA
Magnesium	None	NS	104	101	125	82.3	NS	NA	NA
Potassium	None	NS	19.4	40	25	14	NS	NA	NA
Sodium	None	NS	1550	1120	2980	1840	NS	NA	NA
Bicarbonate	None	NS	1690	2020	2550	2710	NS	NA	NA
Chloride	250	NS	5280	2090	1650	2180	NS	NA	NA
Nitrate (N)	10	NS	ND	0.4	ND	ND	NS	NA	NA
Sulfate	600	NS	505	84	130	209	NS	NA	NA

/BTEX602/1BTEX602.WQ2

Detection Limits (mg/l):

Calcium	1.0	Bicarbonate	5.0
Magnesium	0.1	Chloride	25
Potassium	0.1	Nitrate (N)	0.1
Sodium	5	Sulfate	50

ND = Not detected
NS = Not sampled
NA = Not analyzed

MW-7
Brickland Refinery Site
Quarterly Analytical Results

(All results in ug/l except TPH)

Parameter	WQCC Std.	12/08/93	03/24/94	07/12/94	09/27/94	12/13/94	03/27/95	06/21/95	09/26/95
Benzene	10	NS	31	ND	ND	36	100	NA	4.9,ND
Toluene	750	NS	ND	ND	ND	ND	ND	NA	ND,ND
Ethyl Benzene	750	NS	2.1	ND	3.6	ND	ND	NA	ND,ND
Xylenes	620	NS	0.6	3.2	1.3	ND	ND	NA	ND,ND
Total Vol. Petroleum Hydrocarbon	None	NS	ND	NA	NA	NA	NA	NA	NA,NA

Detection Limits (ug/l):

Benzene	0.5	Ethyl Benzene	0.5	Total Vol. Petroleum	
Toluene	0.5	Xylenes	0.5	Hydrocarbons	0.1 mg/l

(All results in mg/l)

Parameter	WQCC Std.	12/08/93	03/23/94	06/27/94	09/27/94	12/13/94	03/27/95	06/21/95	09/26/95
Calcium	None	NS	300	248	320	229	NS	NA	NA
Magnesium	None	NS	72.3	66.8	73	77.4	NS	NA	NA
Potassium	None	NS	22.1	37	41.5	15	NS	NA	NA
Sodium	None	NS	1620	710	1230	1100	NS	NA	NA
Bicarbonate	None	NS	1320	1330	1300	1500	NS	NA	NA
Chloride	250	NS	2220	1210	1580	1570	NS	NA	NA
Nitrate (N)	10	NS	ND	0.3	0.1	5.1	NS	NA	NA
Sulfate	600	NS	755	575	548	333	NS	NA	NA

/BTEX602/1BTEX602.WQ2

Detection Limits (mg/l):

Calcium	1.0	Bicarbonate	5.0	ND = Not detected
Magnesium	0.5	Chloride	5.0	NS = Not sampled
Potassium	5.0	Nitrate (N)	0.2	NA = Not analyzed
Sodium	5.0	Sulfate	30	

MW-8
Brickland Refinery Site
Quarterly Analytical Results

(All results in ug/l except TPH)

Parameter	WQCC Std.	12/08/93	03/24/94	07/12/94	09/27/94	12/13/94	03/27/95	06/21/95	09/25/95
Benzene	10	NS	9600	2400	13000	5300	14000	NA	13000
Toluene	750	NS	ND	ND	ND	ND	ND	NA	300
Ethyl Benzene	750	NS	ND	ND	ND	ND	ND	NA	ND
Xylenes	620	NS	720	ND	ND	140	1100	NA	800
Total Vol. Petroleum Hydrocarbon	None	NS	ND	NA	NA	NA	NA	NA	NA

Detection Limits (ug/l):

Benzene	125	Ethyl Benzene	125	Total Vol. Petroleum	
Toluene	125	Xylenes	125	Hydrocarbons	0.1 mg/l

(All results in mg/l)

Parameter	WQCC Std.	12/08/93	03/23/94	06/27/94	09/27/94	12/13/94	03/27/95	06/21/95	09/25/95
Calcium	None	NS	46.5	89.9	47.2	60.0	NS	NA	NA
Magnesium	None	NS	33.9	36.1	38.2	36.4	NS	NA	NA
Potassium	None	NS	10.2	20.0	29.8	13.1	NS	NA	NA
Sodium	None	NS	1560	1150	1550	1870	NS	NA	NA
Bicarbonate	None	NS	2680	2670	2930	2940	NS	NA	NA
Chloride	250	NS	1210	1380	1450	831	NS	NA	NA
Nitrate (N)	10	NS	ND	0.5	0.1	5.5	NS	NA	NA
Sulfate	600	NS	20	60	73	72	NS	NA	NA

/BTEX602/1BTEX602.WQ2

Detection Limits (mg/l):

Calcium	0.5	Bicarbonate	5.0	ND = Not detected
Magnesium	0.1	Chloride	5.0	NS = Not sampled
Potassium	0.2	Nitrate (N)	0.2	NA = Not analyzed
Sodium	20	Sulfate	10	

MW-11
Brickland Refinery Site
Quarterly Analytical Results

(All results in ug/l except TPH)

Parameter	WQCC Std.	12/08/93	03/24/94	07/12/94	09/27/94	12/13/94	03/27/95*	06/21/95	09/25/95
Benzene	10	NS	120	ND	15	15	15	NA	80
Toluene	750	NS	0.7	ND	2.3	ND	ND	NA	ND
Ethyl Benzene	750	NS	4.7	ND	8.9	ND	ND	NA	ND
Xylenes	620	NS	4.4	ND	9.4	2.5	ND	NA	10
Total Vol. Petroleum Hydrocarbon	None	NS	1.0	ND	NA	NA	NA	NA	NA

Detection Limits (ug/l):

Benzene	0.5	Ethyl Benzene	0.5	Total Vol. Petroleum	
Toluene	0.5	Xylenes	0.5	Hydrocarbons	0.1 mg/l

*Detection limit for BTEX constituents = 5 ug/l

(All results in mg/l)

Parameter	WQCC Std.	12/08/93	03/23/94	06/27/94	09/27/94	12/13/94	03/27/95	06/21/95	09/25/95
Calcium	None	NS	79	116	201	93.4	NS	NA	NA
Magnesium	None	NS	62.3	69.5	72.2	60.8	NS	NA	NA
Potassium	None	NS	18.3	29	39.4	12	NS	NA	NA
Sodium	None	NS	1050	820	950	985	NS	NA	NA
Bicarbonate	None	NS	1620	1830	2100	1980	NS	NA	NA
Chloride	250	NS	959	927	792	924	NS	NA	NA
Nitrate (N)	10	NS	0.2	1.3	0.6	0.2	NS	NA	NA
Sulfate	600	NS	ND	18	22	35	NS	NA	NA

/BTEX602/1BTEX602.WQ2

Detection Limits (mg/l):

Calcium	1.0	Bicarbonate	5.0	ND = Not detected
Magnesium	0.5	Chloride	3.0	NS = Not sampled
Potassium	5.0	Nitrate (N)	0.1	NA = Not analyzed
Sodium	5.0	Sulfate	20	

MW-14
Brickland Refinery Site
Quarterly Analytical Results

(All results in ug/l except TPH)

Parameter	WQCC Std.	07/12/94	09/27/94	12/13/94	03/27/95*	06/21/95	09/26/95
Benzene	10	23000	2900	930	1100	10000	5.7
Toluene	750	ND	ND	ND	ND	ND	ND
Ethyl Benzene	750	ND	ND	ND	25	ND	ND
Xylenes	620	ND	ND	ND	ND	ND	ND
Total Vol. Petroleum Hydrocarbon	None	NA	NA	NA	NA	NA	NA

Detection Limits (ug/l):

Benzene	10	Ethyl Benzene	10	Total Vol. Petroleum	
Toluene	10	Xylenes	10	Hydrocarbons	0.1 mg/l

*Detection limit for BTEX constituents = 25 ug/l

(All results in mg/l)

Parameter	WQCC Std.	07/12/94	09/27/94	12/13/94	03/27/95	06/21/95	09/26/95
Calcium	None	165	625	413	NS	NA	NA
Magnesium	None	81.3	154	154	NS	NA	NA
Potassium	None	11.4	42	19	NS	NA	NA
Sodium	None	730	1800	1720	NS	NA	NA
Bicarbonate	None	1490	1160	1510	NS	NA	NA
Chloride	250	910	3190	2430	NS	NA	NA
Nitrate (N)	10	ND	ND	ND	NS	NA	NA
Sulfate	600	200	986	1460	NS	NA	NA

Detection Limits (mg/l):

Calcium	1.0	Bicarbonate	5.0	ND = Not detected
Magnesium	0.5	Chloride	25	NS = Not sampled
Potassium	5.0	Nitrate (N)	0.1	NA = Not analyzed
Sodium	20	Sulfate	5.0	

MW-17
Brickland Refinery Site
Quarterly Analytical Results

(All results in ug/l except TPH)

Parameter	WQCC Std.	06/28/94	09/27/94	12/13/94	03/27/95	06/21/95	09/26/95
Benzene	10	17	46,68	460	67	1500	390
Toluene	750	ND	21,25	ND	ND	ND	ND
Ethyl Benzene	750	19	35,41	10	ND	54	ND
Xylenes	620	30	8,9.2	10	ND	29	ND
Total Vol. Petroleum Hydrocarbon	None	NA	NA	NA	NA	NA	NA

Detection Limits (ug/l):

Benzene	5	Ethyl Benzene	5	Total Vol. Petroleum Hydrocarbons	0.1 mg/l
Toluene	5	Xylenes	5		

(All results in mg/l)

Parameter	WQCC Std.	06/28/94	09/27/94	12/13/94	03/27/95	06/21/95	09/26/95
Calcium	None	218	241,237	278	NS	NA	NA
Magnesium	None	63.8	77,76.3	80	NS	NA	NA
Potassium	None	38	36.4,36.7	13	NS	NA	NA
Sodium	None	610	136,800	2090	NS	NA	NA
Bicarbonate	None	1100	1590,1650	1700	NS	NA	NA
Chloride	250	1350	2110,1930	2430	NS	NA	NA
Nitrate (N)	10	0.3	0.1,ND	ND	NS	NA	NA
Sulfate	600	318	239,198	407	NS	NA	NA

Detection Limits (mg/l):

Calcium	1.0	Bicarbonate	5.0	ND = Not detected
Magnesium	0.5	Chloride	5.0	NS = Not sampled
Potassium	5.0	Nitrate (N)	0.1	NA = Not analyzed
Sodium	20	Sulfate	100	