SDMS# 88111319

SFUND RECORDS CTR
1738-00410

FINAL PHASE 2 DESIGN REPORT

Pacific Coast Pipeline (PCPL) Superfund Site
Fillmore, California

Project No. 225-F

ENGLAND
SHAHIN &
ASSOCIATES

ENVIRONMENTAL ENGINEERING

15375 BARRANCA PARKWAY, SUITE F-106
IRVINE, CALIFORNIA 92718

TELEPHONE (714) 453-8085
FAX (714) 453-0733

1738-00410

FINAL PHASE 2 DESIGN REPORT
Pacific Coast Pipeline (PCPL) Superfund Site
Fillmore, California

Project No. 225-F

PREPARED FOR:

Texaco Environmental Services
Texaco Refining and Marketing, Inc.
10 Universal City Plaza
Universal City, California 91608

PREPARED BY

England, Shahin and Associates
15375 Barranca Parkway, Suite F-106
Irvine, California 92718

December 16, 1994

ENGLAND
SHAHIN &
ASSOCIATES

Page

TABLE OF CONTENTS i

LIST OF TABLES v

LIST OF FIGURES vi

LIST OF APPENDICES viii

LIST OF DRAWINGS ix

GLOSSARY OF ACRONYMS x

EXECUTIVE SUMMARY ES-1

1.0 INTRODUCTION 1-1

1.1 Background 1-1
1.2 Previous Investigations 1-1
1.3 ROD Requirements 1-2
1.4 Cleanup Goals 1-3
1.5 Objectives and Scope 1-4

2.0 SITE DESCRIPTION AND REFINED SITE HYPOTHESIS 2-1

2.1 Site Location and Surface Facilities 2-1
2.1.1 Location 2-1
2.1.2 Surface Facilities 2-1
2.1.3 Topography 2-2
2.1.4 Surrounding Area 2-2
2.2 Climate 2-3
2.3 Regional Geology and Hydrogeology 2-3
2.3.1 Regional Geology 2-3
2.3.2 Regional Hydrogeology 2-5
2.3.3 Surface Hydrology 2-7
2.4 Regional Petroleum Geology 2-7
2.5 Local Geology and Hydrogeology 2-8
2.5.1 Local Geology 2-8
2.5.2 Local Hydrogeology 2-9
2.6 Refined Site Hypothesis 2-11

TABLE OF CONTENTS

3.0 ADDITIONAL SUBSURFACE INVESTIGATION 3-1

3.1 Ground Water Extraction Well Installation 3-1
3.2 Ground Water Monitoring Well Construction 3-2
3.3 Vapor Extraction (Vadose Monitoring) Well Installation 3-3

4.0 SUBSURFACE HYDROCARBON DISTRIBUTION 4-1

4.1 Vadose Zone 4-1
4.1.1 Residual Hydrocarbons in Soil 4-1
4.1.2 Liquid Hydrocarbons 4-3
4.1.3 Soil Gas 4-3
4.1.3.1 Benzene Vapor 4-4
4.1.3.2 Gas Condensate 4-4
4.2 Saturated Zone 4-5
4.2.1 Residual Hydrocarbons 4-5
4.2.2 Dissolved Phase Hydrocarbons 4-6
4.3 Naturally Occurring Hydrocarbons 4-7
4.3.1 Natural Seeps 4-7
4.3.2 Natural Gas and Gas Condensates 4-8
4.4 Benzene Fate and Transport 4-11
4.4.1 Benzene Partitioning Among Phases 4-11
4.4.1.1 Benzene Oil/Water Partition Coefficient 4-11
4.4.1.2 Benzene Equilibrium in Soil Gas 4-13
4.4.1.3 Benzene Distribution 4-13
4.4.2 Potential for Benzene Migration from Vadose Zone to Ground Water 4-15
4.4.3 Natural Degradation of Benzene 4-16

5.0 PHASE 1 REMEDIATION 5-1

5.1 Vapor Extraction System 5-1
5.1.1 System Operation 5-1
5.1.2 Condensate 5-2
5.2 Ground Water Treatment System 5-2
5.2.1 System Operation 5-2
5.2.2 Solids Removal 5-3
5.2.3 Granular Activated Carbon 5-4
5.2.4 NPDES Testing 5-4

TABLE OF CONTENTS

6.0 ADDITIONAL REMEDIAL TESTING AND EVALUATION 6-1

6.1 Vapor Extraction Testing 6-1
6.2 Vapor Condensation 6-5
6.3 Biotechnical Evaluation 6-6
6.3.1 Baseline Physicochemistry and Microbiology 6-6
6.3.1.1 Sample Collection 6-6
6.3.1.2 Laboratory Testing 6-7
6.3.2 Biotreatability Studies 6-8
6.3.2.1 Pilot Bioremedial Treatment of Ground Water 6-8
6.3.2.2 Pilot Bioremedial Treatment of Soil and Ground Water 6-8
6.3.3 Conclusions 6-9
6.4 In-Situ Treatment Study 6-10
6.4.1 Process Descriptions 6-10
6.4.1.1 Air Sparging 6-10
6.4.1.2 Bioventing 6-11
6.4.2 Summary of Applicability of these Methods to the Subject Site 6-11
6.5 Evaluation of Ground Water Solids Removal Alternatives 6-12
6.6 Geophysical Logging 6-14
6.7 Ground Water Pumping Tests 6-15
6.7.1 Phase 1 Aquifer Testing Summary 6-15
6.8 Evaluation of Treated Water Disposal Alternative 6-17

7.0 SITE SIMULATIONS 7-1

7.1 Stick Model 7-1
7.2 Vapor Extraction Modeling 7-1
7.2.1 Methodology 7-2
7.3 Ground Water Modeling 7-3
7.3.1 Conceptual Model 7-3
7.3.2 Model Selection 7-4
7.3.3 Grid Generation and Data Input 7-4
7.3.4 Calibration 7-4
7.3.5 Application 7-5

8.0 EVALUATION OF REMEDIAL OPTIONS 8-1

8.1 Approach to Meeting Cleanup Criteria and Goals 8-1
8.1.1 Vadose Zone 8-1
8.1.2 Ground Water 8-3

TABLE OF CONTENTS

8.2 Vadose Zone Remedial Options 8-4
8.3 Perched and Ground Water Remedial Options 8-6
8.4 Recommended Remediation Approach 8-7
8.4.1 Soil Vapor Extraction 8-7
8.4.2 Ground Water Extraction and Treatment 8-8

9.0 PHASE 2 DESIGN OUTLINE 9-1

9.1 Soil Vapor Extraction System 9-1
9.2 Perched Water Extraction and Treatment System 9-2
9.3 Ground Water Extraction and Treatment System 9-2

10.0 PHASE 2 DESIGN SPECIFICATIONS AND REMEDIAL PROGRAM . . . 10-1

10.1 Objectives and Scope 10-1
10.2 New Extraction Well Installation 10-2
10.3 Soil Vapor Extraction System 10-3
10.3.1 System Outline 10-3
10.3.2 Equipment Specification 10-3
10.3.3 Operating Plan and Schedule 10-5
10.3.4 Monitoring and Sampling Schedule 10-5
10.4 Perched and Ground Water Extraction and Treatment System 10-6
10.4.1 Equipment Specifications 10-6
10.4.1.1 Major Equipment Components 10-6
10.4.1.2 Instrumentation and Controls Specifications 10-8
10.4.1.3 Minor Equipment Specifications 10-10
10.4.1.4 Electrical Specifications 10-11
10.4.2 Operating Plan and Schedule 10-12
10.4.3 Monitoring and Sampling Schedule 10-12

11.0 PHASE 2 REMEDIAL ACTION IMPLEMENTATION 11-1

11.1 Introduction 11-1
11.2 Remedial Action Work Plan 11-1
11.3 Construction and System Permitting 11-1
11.4 Remediation System Installation and Startup 11-2
11.5 Remediation System Operation and Maintenance 11-3
11.6 Project Management 11-3
11.7 Quality Assurance/Quality Control 11-3

12.0 REFERENCES 12-1

Table No.	Description
2-1	Mean Monthly Flow in Pole Creek Upgradient of PCPL Site
4-1	Free Oil Noted on Soil
4-2	Summary of LNAPL Removal
4-3	BTEX and Volatile Fuel Hydrocarbons in Soil
4-4	Fixed Gas Concentrations in Soil Gas
4-5	Soil Gas Hydrocarbon Distributions
4-6	Comparison of Benzene Content of Samples from Various Sources
4-7	Benzene Equilibrium Concentrations and Mass Distribution Among Phases
4-8	Comparison of Equilibrium and Measured Benzene Concentrations in Water
5-1	Phase 1 Vapor Extraction System Operation
5-2	Phase 1 Ground Water Treatment System Operation
5-3	NPDES Monitoring and Sampling Schedule
5-4	NPDES Discharge Limits
6-1	Results of Vapor Extraction Data Analysis
6-2	Soil Gas Analytical Results
6-3	Vapor Extraction Mass Balance
6-4	Results of Vapor Extraction Data Analysis
6-5	Comparative Analysis of Solids Removal Technologies
6-6	Boreholes Selected for Geophysical Logging
6-7	Aquifer Test Summary
6-8	General Minerals Summary
7-1	Capture Zone Scenarios
10-1	Well Pump Specifications

LIST OF FIGURES

Figure	Description
1-1	Site Location Map
1-2	Site Plan (with Historic Facilities Overlay)
1-3	Site Remedial Design/Remedial Action Schedule
2-1	Aerial Photo with Historic Facilities
2-2	Regional Geology
2-3	Structural Cross Section
2-4	Regional Ground Water Contour Map
2-5	Historic Water Levels, Flow, and Precipitation, 1925 to Present
2-6	Historic Water Levels, Flow, and Precipitation, 1985 to Present
2-7	Eastern Ventura Basin Oil Fields
2-8	Location of Borings and Cross Sections
2-9	Cross Section A-A'
2-10	Cross Section B-B'
2-11	Cross Section C-C'
2-12	Cross Section D-D'
2-13	Cross Section E-E'
2-14	Perched Zone Ground Water Elevation Map, Third Quarter 1994
2-15	Aquifer I Ground Water Elevation Map, Third Quarter 1994
2-16	Aquifer II Potentiometric Elevation Map, Third Quarter 1994
2-17	Representative Aquifer I Hydrograph
3-1	Map Showing Location of New Wells
4-1	Confirmed Benzene in Soil and Locations of Oily Soil
4-2	Benzene Distribution in Soil Gas
4-3	Benzene Distribution in Aquifer I Wells, Third Quarter 1994
4-4	Methane Distribution in Soil Gas
4-5	Conceptual Model of Benzene in Soil
4-6	Areas with Benzene Vapor Concentrations Greater than Equilibrium
4-7	CO_2/N_2 and O_2/N_2 Distribution in Soil Gas
5-1	Locations of Phase I Vapor Extraction and Ground Water Pumping Wells

LIST OF FIGURES

Figure	Description
6-1	Concentrations of Oxygen and Hydrocarbons from PEW-2
6-2	Cumulative Hydrocarbon Removal from PEW-2
6-3	Methane Concentration in PEW-2
6-4	Locations of Vapor Extraction Test Wells
7-1	Stick Model
7-2	Model Grid
7-3	Vapor Model Permeability Distribution
7-4	Modeled Soil Gas Pressure Decline
7-5	Ground Water Model Permeability Distribution
7-6	Existing Phase 1 System Capture Zone
7-7	Recommended Scenario Capture Zone
7-8	Maximum Capture Scenario
7-9	Modeled Velocities Downgradient of Capture Zone
8-1	Vapor Extraction Target Areas
8-2	Ground Water Remediation Target Areas and Capture Zones
9-1	Decision Tree for Modifying or Shutting Off Soil Vapor Extraction System
9-2	Decision Tree for Modifying or Shutting Off Ground Water Treatment System

LIST OF APPENDICES

APPENDIX A Summary of TPH, Benzene, Toluene, Ethylbenzene, and Xylene Concentrations in Soil

APPENDIX B Summary of LNAPL Monitoring and Removal

APPENDIX C Global Geochemistry Corporation (GGC) Report, January 1994. "Analysis of Four Gas Samples for Chemical and Isotopic Composition"

APPENDIX D Excerpt from The Texas Corporation Annual Report for the Year 1928

APPENDIX E NPDES Correspondence and TDS Data

APPENDIX F Analytical Laboratory Reports associated with soil gas testing in August 1994

APPENDIX G Summary Report - Biotreatability and Pilot-Scale Evaluations of TPH-Impacted Soil and Ground Water for Prospective Bioremedial Treatment

APPENDIX H Geophysical Logs

APPENDIX I Montgomery Watson letter dated October 12, 1994 regarding "Suitability of Treatment System Effluent for Irrigation."

APPENDIX J Equipment Manufacturer Specification Sheets

APPENDIX K Excerpt from Petroleum Processing (Hengstebeck, 1959)

LIST OF DRAWINGS

Drawing No.	Title
M-1	Site Location Map and General Notes
M-2	Ground Water Treatment System Piping & Instrumentation Diagram
M-3	Ground Water Treatment System Equipment Layout
M-4	Ground Water Treatment System Piping Layout
M-5	Vapor Extraction System Piping & Instrumentation
M-6	Vapor Extraction Piping Layout
M-7	Vapor Extraction System and Piping Details
M-8	Extraction Well Details
E-1	Single-Line Diagram, Load Schedule, and General Notes
E-2	Schematic Wiring Diagram

AAPG	American Association of Petroleum Geologists
AMSL	above mean sea level
ASTM	American Society for Testing and Materials
bgs	below ground surface
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
CD	Consent Decree
CDOG	California Division of Oil & Gas
CDWR	California Department of Water Resources
CGS	Coast Geologic Society
CUP	Conditional Use Permit
DAF	dissolved air flotation
DO	dissolved oxygen
DOHS	Department of Health Services
EPA	United States Environmental Protection Agency
ERI	effective radius of influence
ESA	England, Shahin & Associates
ESI	Environmental Solutions, Inc.
GAC	granular activated carbon
GGC	Global Geochemistry Corporation
GWTS	Ground Water Treatment System
IC engine	internal combustion engine
IMT	intermediate metal conduit
INPT	Internal National Pipe Thread
LNAPL	Light Non-Aqueous Phase Liquid
MCC	Motor Control Center
MNPT	Male National Pipe Thread
NEC	National Electrical Code
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
O&M	operation and maintenance
P&ID	Piping and Instrumentation Diagram
PCPL	Pacific Coast Pipeline Superfund Site
PDW	Preliminary Design Workplan
PLC	Programmable Logic Controller
psi	pounds per square inch
PVC	polyvinylchloride

QA/QC	Quality Assurance/Quality Control
RI/FS	Remedial Investigation/ Feasibility Study
RETOX	regenerative thermal oxidation
ROD	Record of Decision
RWQCB	Regional Water Quality Control Board
SCG	Southern California Gas Company
SOW	Statement of Work
SVE	soil vapor extraction
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TES	Texaco Environmental Services
TPH/TPHG	total petroleum hydrocarbons/gasoline
TSS	total suspended solids
USCS	Unified Soil Classification System
UVB	Underdruck-Verdampfer-Brunnen Method
V4	VR Systems Model V4
VCAPCD	Ventura County Air Pollution Control District
VOC	volatile organic compound

EXECUTIVE SUMMARY

INTRODUCTION

This Phase 2 Design Report summarizes the Phase 1 remedial program and presents the proposed Phase 2 remedial activities at the Pacific Coast Pipeline (PCPL) Superfund site in Fillmore, California. An oil refinery operated at the site from sometime prior to 1917 until the early 1950s and has since been dismantled. While the refinery was in operation, miscellaneous hydrocarbon wastes were disposed of onsite in a large pit referred to as the Main Waste Pit and in several smaller pits located throughout the property.

In 1986, Texaco excavated and removed 38,000 tons of waste and contaminated soil from the former Main Waste Pit and other small waste disposal areas. From 1983 through 1989, Texaco voluntarily conducted ground water and soil assessment programs. In June 1989, the site was added to the United States Environmental Protection Agency (EPA) National Priority List. Subsequent remedial investigations revealed elevated levels of petroleum hydrocarbons, benzene and other volatile organic compounds in ground water and significant concentrations of TPH, and to a much lesser extent BTEX, in the vadose zone. In March 1992, the EPA issued a Record of Decision (ROD) on the site which established the selected remedy and documented the goals for remediation.

The selected remedy established by the ROD was for implementation of a ground water extraction and treatment system (GWTS) to treat extracted ground water to designated cleanup standards. The ROD also called for soil vapor extraction for those areas which threaten to contaminate ground water above cleanup standards. A Consent Decree (CD) was entered in August 1993. The CD established a phased schedule for completion of the remedial design and remedial action.

The ROD specifies ground water cleanup standards for five compounds: benzene, toluene, ethyl benzene, 1,2-dichloroethane, and methylene chloride. Of these, benzene and toluene are the only compounds that currently exceed the cleanup standard. Historic analytical data in the ground water database (includes samples collected from August 1990 to August 1994) indicate that forty-three Texaco wells have had concentrations which exceed the cleanup standard for benzene of 1 ug/L. During the same period, only thirteen Texaco wells have had concentrations which exceed the cleanup standard for toluene of 100 ug/L, and only three of these wells have exceeded the toluene cleanup standard on more than one occasion. These three wells also exceed the cleanup level for benzene.

Of the remaining three compounds for which cleanup standards have been set, historic data indicates that 1,2-dichloroethane has only been detected three times and has not been

detected in the last three years while ethyl benzene and methylene chloride have not been found at levels above the cleanup standard in any Texaco well.

Of the two compounds that currently exceed the cleanup standard, benzene exceeds its cleanup standard in far more wells than toluene and the cleanup standard for benzene of 1 ug/L is much lower than the cleanup standard for toluene of 100 ug/L. In wells where toluene is found at levels above the cleanup standard, benzene is also present at significant concentrations. The remediation of benzene to its cleanup standard should ensure that the cleanup of toluene is surpassed, therefore, benzene is the target compound for this remediation program and the design report is focused on benzene.

The Phase 1 Design Report was finalized in September 1993. The Phase 1 remedial program included soil vapor extraction and ground water pumping and treating with activated carbon. The program was implemented in December 1993 to provide data for design of the Phase 2 system. The objectives and scope of the Phase 2 Design and activities in support of that design are as follows:

- Presentation of the results of the Phase 1 operation and testing.
- Refinement of the site hypothesis.
- Evaluation and selection of the appropriate option for disposal of the treated ground water.
- Development and preparation of the Phase 2 Final Design for the selected remedy.

SITE DESCRIPTION AND REFINED SITE HYPOTHESIS

Site Location and Surface Facilities

The PCPL site occupies approximately 20 acres on the eastern edge of the city of Fillmore, in Ventura County, California. The site is presently used as a crude oil pumping station. Site structures include buried pipelines, pumping equipment, above ground storage tanks, and miscellaneous buildings. Other equipment on the property include the Phase 1 GWTS and the soil vapor extraction (SVE) system.

The site is surrounded by areas of agricultural, industrial and residential use. An Ultramar gasoline service station is located south of the site. The service station had an

underground fuel tank leak which was discovered in the 1980s and is currently undergoing remediation by soil vapor extraction.

Regional Geology and Hydrogeology

Geologically, the PCPL site lies along the northern boundary of the Santa Clara Trough. Sedimentary deposits in the Santa Clara Trough range from Cretaceous to Recent in age and have an aggregate thickness of over 40,000 feet. In the Fillmore area, the Trough is bordered on the north by the San Cayetano Fault and on the south by the Oakridge Fault. The San Cayetano Fault passes beneath the PCPL site approximately parallel to the eastern property boundary. Pervasive fracturing of bedrock bordering the fault has resulted in extensive landsliding. This fractured rock has also provided a conduit for naturally occurring hydrocarbon to reach the Earth's surface. Crude oil seeps and tar sands are common features in the site vicinity.

The PCPL site is located within the Fillmore Ground Water Basin. Sources of ground water recharge include ground water inflow and stream and precipitation infiltration. In the eastern portion of the basin where the PCPL site is located, the alluvial deposits and the underlying San Pedro Formation are the major water-bearing units.

Ground water levels in the Fillmore Basin routinely fluctuate by 30 feet or more in response to short term (1-3 years) climatic changes. The maximum recorded long-term fluctuation in ground water levels was 50 feet, measured in a Ventura County Flood Control District well located near the site.

Regional Petroleum and Geology

The PCPL site lies within the eastern portion of the Ventura Basin petroleum province. Oil fields located within the site vicinity include the Fillmore, Shiells Canyon and Bardsdale fields. In addition to the oil fields, several surface oil and tar sand accumulations or seeps have been mapped near the PCPL site. These occur in the fractured sands and shales of the Monterey Formation north of the site along Pole Creek and in recent landslide debris directly adjacent to the site. It is likely that the observed oil seeps resulted from the migration of hydrocarbons along fractures in the Monterey Formation associated with the San Cayetano Fault.

Local Geology and Hydrogeology

The near-surface geology of the PCPL site can be characterized as consisting of laterally discontinuous, interlayers of unconsolidated, fine- to coarse-grained detritus deposited in

stream channel, alluvial fan, and mass wasting depositional environments. The extreme heterogeneity of the subsurface strata has created a complex hydrogeologic environment. Previous investigations have identified three water-bearing zones beneath the PCPL site:

- Perched Zone -- Zone of discontinuous perched water generally above a reddish-brown clay layer.
- Aquifer I -- Unconfined to semi-confined shallow aquifer.
- Aquifer II -- Partially confined to confined aquifer below aquifer I.

To a limited degree, ground water flow direction beneath the site changes in response to changing ground water elevations. Third quarter 1994 ground water monitoring results indicate that flow occurs in a north-west direction across the site which is consistent with historical data. The average gradient across the site in aquifer I is approximately 0.006 ft/ft. Permeability of the aquifer I materials ranges from 1 ft/day to 15 ft/day.

Water level fluctuations of more than 30 feet were recorded at the PCPL site between April 1990 and April 1993 and ground water is currently near its historical high. Changes in water elevation with time for aquifer II roughly parallel that of aquifer I suggesting some degree of communication between aquifer I and aquifer II. Aquifer II has historically shown little or no hydrocarbon contamination.

Refined Site Hypothesis

Several refinements have been made to the site hypothesis presented in the Phase I Design Report.

- The lateral extent and concentration of the dissolved phase benzene plume have increased since 1992 as a result of water levels rising into the "smeared zone" where residual TPH and benzene are present in the soil.
- Some portion of the hydrocarbons found onsite are naturally occurring. Methane has been detected in many soil gas samples collected both offsite and onsite. It has been established by carbon isotope testing that a significant portion of this methane is deep earth methane. The compound 2,2,4-trimethylpentane found in the natural seep hydrocarbons was also found in soil gas and condensate samples from well PEW-3 at the site. Since the compound is present in the natural seep liquids, but is not a significant component of the raw material to the refinery (crude oil), and was not produced in the refinery processes (distillation, thermal cracking and

polymerization), leads to the conclusion that its source to well PEW-3 is natural seep liquids in the subsurface.

- The perched zone water has largely disappeared.
- A larger mass of benzene exists in the subsurface than was previously estimated. It is estimated that 80 to 90 percent of this benzene is in the vadose zone above the high water elevation.
- The Phase 1 Design Report incorrectly identified the ethyl plant (tetraethyl lead blending) and naphtha treating plant as Ethylene Plant and Naphthalene Plant. These have been corrected in the present design report.
- Additional potential on- and offsite sources of hydrocarbon have been identified: a former onsite Richfield Oil Company gas separator plant, and two offsite bulk loading facilities along Santa Clara Avenue that had gasoline and oil storage tanks.

ADDITIONAL SUBSURFACE INVESTIGATION

To obtain additional subsurface information for the Phase 2 design, five additional ground water monitoring wells, three additional ground water extraction wells, and three vapor extraction wells were installed on or near the PCPL site. Ground water extraction wells EW-2, EW-4 and EW-5 were subsequently used for Phase 1 testing and evaluation. The data were used for further characterization of the subsurface geology and hydrocarbon distribution.

SUBSURFACE HYDROCARBON DISTRIBUTION

Data from boring logs and soil samples, ground water monitoring and soil gas testing and sampling have been interpreted to estimate concentration and mass distributions of benzene in soil, water and gas phases in the subsurface.

Vadose Zone

Cross sections prepared through various portions of the site (Figures 2-9 through 2-13) show soil characteristics and interpreted distribution of benzene in the subsurface. Figure 4-1 shows in plan view approximate areas in which significant concentrations of benzene have been confirmed in the vadose zone above the historic high water elevation, and, in the zone between the high and low water elevations in which hydrocarbons have been smeared by rising and falling water table (smeared zone).

Figure 4-1 and Table 4-1 show the observed distribution of free oil in the soil at the site. It appears that free oil is not present in sufficient amounts to flow freely to the many wells at the site. In seven months, (Table 4-2) less than five gallons has been recovered from five wells on the site which contain liquid hydrocarbons (LNAPL).

Soil gas samples were collected from 36 wells at the site and were analyzed for fixed gases, benzene, toluene, ethylbenzene and xylenes (BTEX) and volatile fuel hydrocarbons (VFH). The results are summarized in Tables 4-3 and 4-4. A lower and upper vadose zone have been defined based on the observation that gas compositions vary considerably with depth. Figure 4-2 shows a different distribution for benzene in the upper vadose zone than in the lower zone. Benzene in the soil gas was generally limited to the east side of Pole Creek. Benzene concentrations exceeded 100 parts per million (ppmv) in several wells within the property boundary.

Saturated Zone

Hydrocarbons in this zone consist of the residual hydrocarbons in the soil and dissolved phase hydrocarbons in the ground water. Residual hydrocarbons in the smeared zone are depicted on the cross sections presented in Figures 2-9 through 2-13. The distribution of borings with measured benzene and observed free oil in the smeared zone is found in Figure 4-1.

Benzene concentrations for the third quarter 1994 ground water samples (Figure 4-3) indicate there are two primary ground water plumes plus the plume associated with the Ultramar service station underground storage tank gasoline releases. Highest concentrations are in the north plume, however, the south plume covers a much larger area than the north plume.

Dissolved benzene is limited to near the ground water table and benzene concentration in the ground water varies with water elevation. When water level was at its highest, benzene concentrations were generally highest (Second Quarter 1993). When water level was at its lowest, benzene was not detectable in most wells (Second Quarter 1991). This implies that concentrations of benzene in the ground water are significant only when the water is moving directly through oily soil.

Naturally Occurring Hydrocarbons

There is substantial evidence that the site has been impacted by naturally occurring hydrocarbons:

- Methane and hydrocarbon vapors are apparently migrating from deep within the earth through the San Cayetano fault zone under the site.

- The presence of several natural oil seeps in the site vicinity have been previously documented. It is very likely that the faulting and landslides at the site have placed such natural liquids in the saturated and vadose zones at the site.

The compound 2,2,4-trimethylpentane (iso-octane) is found at significant concentrations in samples from the oil seeps and from gas and gas condensates from onsite well PEW-3. The presence of iso-octane indicates hydrocarbons from the oil seeps may be under the site. Iso-octane is unusual in nature and is not found in significant concentrations in the crude oils of the Ventura Basin. Also, the refinery did not have processes (e.g. alkylation) that would have produced significant yields of 2,2,4-trimethylpentane.

Benzene Fate and Transport

Benzene Distribution

Several conclusions can be made based on equilibrium distribution of benzene among the various phases present: (1) the oil phase (residual hydrocarbons or free LNAPL), (2) the water phase (soil moisture in the vadose zone, ground water in the saturated zone), and (3) in the vadose zone, the soil gas phase. These are:

- Benzene concentrations in the soil are generally higher in the vadose zone than in the smeared zone.

- On the order of 80 to 90 percent of all the benzene present is in the oil phase.

- Equilibrium benzene vapor concentrations in the vadose zone average between 120 and 180 ppm.

- Equilibrium benzene concentrations in ground water in the smear zone samples average between 0.6 and 1.2 mg/l.

Based on distribution of benzene in soil samples, more than 70 percent of the soil containing benzene is above the high water elevation. This coupled with the concentration averages discussed above indicates that 80 to 90 percent of the benzene present is above high water elevation, and 10 to 20 percent is within the smeared zone, distributed between the soil and ground water.

Benzene Migration Potential

The potential for benzene migration from the vadose zone to the ground water exists where concentrations are significantly in excess of equilibrium concentrations with the underlying ground water. However, the concentration difference alone is not sufficient to result in contamination. There must also be a pathway from the soil gas in the ground water. There is significant evidence that migration of benzene from the upper portions of the vadose zone may be severely restricted by intervening fine-grained soils.

Natural Degradation of Benzene

There is strong evidence that natural degradation of benzene is limiting the size of the benzene plume in the ground water downgradient of the site. The following is evidence of the natural limitations:

- Benzene in the ground water has not moved far from the site. If benzene were not being degraded, it would be present in detectable quantities thousands of feet downgradient of the site. In fact, detectable benzene is limited to within one or two hundred feet of the site boundary.

- Biodegradation testing, carbon isotope testing, and soil gas composition all provide evidence of significant biological degradation of hydrocarbons under the site..

- In 1991, when ground water level dropped below the smeared zone, benzene virtually disappeared from the water. This indicates that natural forces deplete the benzene from the water as soon as the water is no longer in contact with the residual hydrocarbons which function as a reservoir for the benzene.

PHASE 1 REMEDIATION

Vapor Extraction System

A RETOX vapor extraction unit operated at the site from December 1993 through mid-May 1994. Unexpected high concentrations of volatile organic compounds and methane in the extracted soil gas required the addition of a high percentage of dilution air to stay within the treatment capacity of the RETOX system. The addition of this dilution air severely limited the flowrate from the extraction wells. The RETOX system was subsequently shut down in May 1994. It is estimated that the RETOX unit removed about 12,000 pounds of total hydrocarbons and about 120 pounds of benzene during this operation.

Tests were run using a VR Systems Model V4 internal combustion engine (IC engine) to extract and burn the hydrocarbon vapors. These tests indicated a much greater extraction rate could be realized for the soil gas wells. On June 10, 1994, a VR Systems Model V4 was installed on extraction well PEW-2 and has been operated since that time. Through December 7, 1994, a total of 70,000 pounds of hydrocarbons, including about 400 pounds of benzene, are estimated to have been removed.

Ground Water Treatment System

The Phase 1 GWTS was installed and began operation at the site in December 1993. The system consisted of three extraction wells, two bag filters for suspended solids removal and granular activated carbon (GAC) adsorption system (two vessels in series). The system was shut down on February 25, 1994, after detection of benzene in the effluent from the activated carbon vessels. During that initial few months of operation, the system was frequently shut down to change clogged bag filters.

To reduce the amount of solids entering the system, three new extraction wells were designed and installed in May and June of 1994. These wells had carefully engineered well screens to minimize the entrainment of fine solids with the extracted ground water. The three wells used initially were disconnected from the system. A series of tests of the wells and various pretreatment options were conducted during July and August of 1994 to aid in the Phase 2 design. Ground water flow rates ranged from 5 to 20 gpm during this period.

During Phase 1 GWTS operation (through November 1994), approximately 4,913,000 gallons of water were extracted and treated. It is estimated that approximately 140 pounds of TPH and 12.6 pounds of benzene were removed with the extracted ground water.

The system has been shut down three times as a result of upsets from the NPDES limits. The first time was in February 1994, when benzene exceeded the discharge limit. After an investigation, remedies were implemented and the carbon was replaced. System operation resumed on July 1, 1994.

The second upset occurred in September, 1994 when the total dissolved solids (TDS) concentration exceeded the daily limit. The system was shut down on September 14. The Regional Water Quality Control Board (RWQCB) authorized continued operation of the Phase 1 system with a stipulation that the mass discharge rate of TDS in the effluent must not exceed the permitted daily maximum of 1,000 lbs/day and the discharge must not cause

the water quality objectives in the Santa Clara River to be exceeded. GWTS operation resumed on October 25, 1994.

The third upset occurred in November 1994 when the sulfate concentration exceeded the daily limit. The system was shut down on December 3, 1994. A sample collected prior to system shut down was analyzed for sulfate and found to be below the limit. The RWQCB indicated that system operation could resume provided four consecutive weekly samples remain below the sulfate limit. System operation resumed on December 7, 1994.

In order to optimize Phase 1 remediation efforts, well MW-28S will be operated in place of EW-2. MW-28S is located in an area with higher benzene concentrations (in the center of the northern plume) and can be pumped at a higher rate than EW-2. MW-28S was placed in operation on November 30, 1994.

ADDITIONAL REMEDIAL TESTING AND EVALUATION

In the course of the Phase 1 operation, a number of additional tests and studies were conducted to aid in the Phase 2 design.

Vapor Extraction Testing

A number of short-term vapor extraction tests were run to provide information on soil gas component concentrations, vapor extraction rates, vacuum requirements, and to estimate air permeabilities and hydrocarbon removal rates. A long-term vapor extraction test on well PEW-2 has been on-going since June 10, 1994. The purpose of this test is to evaluate the change in concentrations of hydrocarbons and other components of the soil gas as vapor extraction proceeds. After about six months of testing, the results indicate that flow to the well is almost entirely horizontal. There is little vertical fresh air infiltration from the ground surface and there is minimal vertical communication with the deeper vadose zone. However, the increased oxygen content from 2 percent to 4 percent indicates some air may be infiltrating the extraction zone and/or soil gas outside the zone of hydrocarbon contamination, with higher oxygen content, is being drawn into the area.

Vapor Condensation

Condensation of hydrocarbons in the soil gas was evaluated. The concept is to compress soil gas and partially condense the hydrocarbons using refrigeration. The uncondensed light hydrocarbons would then be burned in a flare. The preliminary calculations indicate that the concept is technically feasible. However, as a result of considerable other uncertainties, this alternative has not been considered further.

Biotechnical Evaluation

Several soil and water samples from the site were subjected to biotreatability studies. These studies show presence of hydrocarbon degrading microbes in each of the samples. The results of the biotechnical evaluation indicate that hydrocarbon biodegradation is taking place at the site, although at a relatively slow pace that is limited by the availability of oxygen and nutrients.

Long-term vapor extraction at the site will increase the oxygen content of the soil gas and improve the biodegradation rates. Dissolved hydrocarbons in ground water moving away from areas of residual hydrocarbon and soil will continue to biodegrade, effectively limiting further plume migration.

In-Situ Treatment Study

The technical feasibility of air sparging and bioventing for in-situ treatment of ground water was considered. Bench scale tests, conducted during solids removal testing (section 6.5), have shown that air sparging of the ground water results in considerable precipitation of calcium carbonate and iron and manganese compounds. It is apparent that any injection of air, whether for bioventing or air sparging, in the ground water aquifer will likely result in the precipitation and formation of total hardness minerals in the vicinity of the sparging or injection wells. It is concluded that air sparging and bioventing are not appropriate technologies for ground water treatment at the PCPL site. Bioventing may aid in vadose zone remediation, however.

Evaluation of Ground Water Solids Removal Alternatives

A number of suspended solids removal methods were evaluated. These included dissolved air flotation, centrifuge, aeration, lime treatment, sand filter, bag filter, settling tank, and chemical addition. None of the methods tested achieved more than about 50 percent reduction in suspended solids. Some of these, such as dissolved air flotation and aeration, resulted in a considerable increase of suspended solids. It is concluded that periodic backwashing of the activated carbon, with no pretreatment of the raw water, appears to be the most cost effective approach.

Geophysical Logging

Eleven boreholes were subjected to geophysical logging using Gamma logs and electromagnetic response logs. The data generated from the geophysical logs was used to supplement geologic information presented in the cross sections included in this report.

Ground Water Pumping Tests

Ground water pumping tests have been conducted at the PCPL site to characterize hydrogeologic properties of the aquifer I material. Results have been incorporated into a series of permeability distribution maps for the site, which were used for predictive modeling of ground water flow and subsequent capture zone analyses.

The results indicate the aquifer permeability decreases to the west and north of the PCPL site. The highest permeabilities appear to follow a linear trend from the vicinity of MW-28S southwesterly to EW-4 and MW-39S.

Evaluation of Treated Water Disposal Alternative

Treated ground water was evaluated for its suitability as irrigation water for local crops. The water was found to be poorly suited for this application as a result of high concentrations of boron and sodium, high concentrations of total dissolved solids which would result in increasing problems with salinity and soil permeability, and high concentrations of bicarbonate. Also, the extreme hardness of the water would result in clogging of drip systems and spray systems by precipitated salts. It is concluded that use of treated ground water for irrigation is not a viable reuse option.

In the Phase 1 operation, the treated water is discharged to Pole Creek where it combines with the waters of the creek. Pole Creek is concrete-lined at the discharge point, but is unlined approximately 1,300 feet to the south. Primary source of recharge to the Fillmore Basin is by percolation of stream flows. Therefore, there is substantial recharge of the water to the Fillmore ground water basin. This is the recommended reuse of the water for Phase 2 operation.

SITE SIMULATIONS

Stick Model

A three-dimensional subsurface lithologic model was constructed from the data reported on boring logs from over 100 borings and wells installed near the site. This model was used to help understand the lithology of the subsurface of the site.

Vapor Extraction Modeling

Vapor extraction modeling was conducted to estimate pressure declines within the unsaturated zone beneath the site resulting from extracting gas at various rates from

several onsite locations. The vapor extraction modeling estimates that the extraction of three wells will effectively capture hydrocarbon vapors within the vadose zone target areas.

Ground Water Modeling

A numerical ground water flow model of aquifer I at the PCPL site was constructed to (1) provide information on flow direction and velocity, (2) assist in identifying recharge/discharge volumes and locations, and (3) provide base information for performing capture zone analysis.

Modeling results have shown that five existing wells and two new extraction wells are sufficient to capture ground water from the identified target zones. The recommended pumping scenario is shown on Figure 7-7.

EVALUATION OF REMEDIAL OPTIONS

Approach to Meeting Cleanup Criteria and Goals

The selected remedy described in the ROD calls for, "Soil vapor extraction for those areas that threaten to contaminate ground water at levels above site cleanup standards." Areas have been identified in the vadose zone in which there is potential for migration of benzene vapors from the vadose zone to the ground water. It has also been shown that in some areas there is little potential for gas with elevated concentrations of benzene to contact the ground water as a result of low permeability intervening soil layers.

Target zones for soil vapor extraction have been identified and are shown in Figure 8-1. These are areas in which, by virtue of high benzene concentrations in the vapor, there is potential for ground water contamination and there are identified pathways to the ground water. Wells have been selected for vapor extraction within these target areas. Additional wells will be added based on the results of extraction from the initially selected wells.

The approach to remediation of the ground water is to create capture zones around the benzene sources and allow any benzene which has moved beyond those capture zones to degrade naturally. Without a continuing source, benzene which has moved beyond the capture zone will degrade. The ground water target areas have been selected on the basis of the areas of highest benzene concentrations in the ground water on the site. A central target area has been added in the vicinity of proposed well EW-7. There is no

known benzene plume in this area, but there is currently no monitoring well suitably located in this area. If initial sampling of well EW-7 indicates no upgradient source, this well will be used solely as a monitoring well.

Vadose Zone Remedial Options

Remedial options considered for vapor extraction include IC engines, thermal/catalytic oxidation, carbon adsorption, and condensation and flaring. Carbon adsorption, and condensation and flaring have been ruled out as inappropriate for this application. IC engines have been proven on site and have operated successfully for several months. Thermal/catalytic oxidation appears to have application at this site and should be considered as an attractive alternative for vapor destruction.

Recommended Vadose Zone Remedial Approach

The VR System Model V4 using IC engines is the recommended alternative for soil gas extraction treatment. However, the design is sufficiently flexible to accommodate a thermal/catalytic oxidizer in place of, or in combination with, IC engines. Soil gas will be initially extracted from wells PEW-1, SBD-3, and EW-4. Well PEW-3 will be added to the network later, and other wells may be added as needed.

Perched and Ground Water Remedial Options

Perched water wells have been mostly dry since the first quarter of 1994. Therefore, perched water will not be extracted and treated as part of the Phase 2 design.

The aquifer I extraction well field design is based on the results of the ground water modeling. Estimated extraction rates, including well EW-7, is 113 gpm. Activated carbon is the primary method for the treating of ground water at the site. Backwashing of the carbon is planned in lieu of secondary treatment. However, provision is made in the design for addition of a high capacity bag filter system, to be used when a new well is put on line or after restarting pumping from a well that has been idle for some time. The filters may be used continuously if this proves necessary during Phase 2 operation.

The selected discharge option is to discharge into Pole Creek under a NPDES permit. This method can be categorized as beneficial reuse, since the creek is unlined south of the site and much of the water will percolate into the ground water basin.

Recommended Ground Water Remedial Approach

Phase 2 ground water extraction and treatment will consist of pumping of aquifer I ground water from either six or seven wells, as shown on Figure 8-2, activated carbon treatment of the extraction water and discharge of the treated water to Pole Creek under a new NPDES permit. Based on a continuing evaluation, the well field or extraction rates may be modified.

PHASE 2 DESIGN OUTLINE

Soil Vapor Extraction System

Within the vadose zone target areas, extraction will initially be limited to wells described above. As hydrocarbon concentrations decrease in these wells, additional vapor extraction wells will be connected as needed. Wells will be disconnected from the system when major component concentrations indicate an approach to asymptotic values that appears to match natural emissions.

A decision tree is presented in Figure 9-1 that outlines the process for modifying or shutting down the vapor extraction system.

Ground Water Extraction and Treatment System

The concept for ground water extraction and treatment has been previously described. In wells where LNAPL is detected, LNAPL absorbers will be installed. In addition, pump shut-off sensors will be installed above the pump to prevent the introduction of LNAPL into the pumps. A multi-bag filter unit will be installed upstream of the GAC vessels to be used on start of pumping at a new well, or as necessary during continuous operation. To remove suspended solids that may accumulate on the top layers of the GAC vessels, the vessels will be periodically backwashed.

The necessary modifications to the Phase 1 system will consist of installing additional piping to existing extraction wells, upgrading the piping in the equipment area for higher flow capacity, installation of additional extraction wells and upgrading the electrical controls for additional pumps.

A decision tree presented in Figure 9-2 shows criteria for modifications and operating time. As stated in the ROD, "Because this remedy will not result in hazardous substances remaining on the site above health-based levels, a five-year review will not apply to this

action. The selected remedy will undergo periodic performance evaluations at a frequency to be determined in the Remedial Design Work Plan."

PHASE 2 DESIGN SPECIFICATIONS AND REMEDIAL PROGRAM

This section provides design details and specifications for the vapor extraction system and the ground water treatment system. Details are shown on Design Drawings M-1 through M-8, and E-1 and E-2.

PHASE 2 REMEDIAL ACTION IMPLEMENTATION

The remedial action implementation will follow the EPA approval of final design. This includes development of a Remedial Action Workplan and submittal of a number of remedial action deliverables. A number of permits may be required for installation and operation of the systems. Implementation includes installation and start-up of the systems and ongoing maintenance and monitoring of the systems.

1.0 INTRODUCTION

This Phase 2 Design Report summarizes the Phase 1 remedial program and presents the proposed Phase 2 remedial activities at the Pacific Coast Pipeline (PCPL) Superfund Site in Fillmore, California.

1.1 Background

The PCPL site is located at 67 East Telegraph Road on the eastern edge of the City of Fillmore. A site location map is shown in Figure 1-1. The site, which covers approximately 20 acres, was formerly an oil refinery which has since been dismantled. The earliest known reference to refinery operations at the site prior to acquisition by Texaco was a reference to oil transported to the Ventura Refinery in 1917. In 1928, Texaco purchased the refinery and operated it until the early 1950s. An early reference indicates that Richfield Oil Co. operated a gas separator plant on a portion of the site in the early 1950s. Since closure of the refinery, the site has been used by Texaco as a pumping station for crude oil produced from local oil fields.

While the refinery was in operation, miscellaneous hydrocarbon wastes believed to consist primarily of tank bottoms, filter cake, and sludge were disposed of onsite in a large pit, referred to as the Main Waste Pit and in several smaller pits located throughout the property. The approximate location of the former pits and former refinery layout are superimposed on the site plan as shown in Figure 1-2.

1.2 Previous Investigations

In 1980, Texaco submitted a proposal to the California Regional Water Quality Control Board (RWQCB) - Los Angeles Region to remove waste material from the pits and apply it to site roads. Chemical evaluation of the waste indicated that portions of the wastes were hazardous and additional investigations were requested. From 1983 through 1989, Texaco voluntarily conducted ground water and soil assessment programs under the direction of the California Department of Health Services (DOHS) and the RWQCB. In 1986, Texaco excavated and removed 38,000 tons of waste and contaminated soil from the former Main Waste Pit and other small waste disposal areas.

In June 1989, the site was added to the United States Environmental Protection Agency (EPA) National Priority List (NPL). Between 1990 and 1992, a Remedial Investigation/ Feasibility Study (RI/FS) was conducted by ENSR to delineate the nature and extent of contamination in the soil and ground water at the site and develop a remedial plan. The RI/FS (ENSR, 1991a, 1992a) concluded that there were significant levels of total petroleum

hydrocarbons (TPH) and benzene, toluene, ethyl benzene, and xylenes (BTEX) in ground water at various locations and significant concentrations of TPH in the vadose zone, but very little evidence of BTEX in the vadose zone. The RI/FS concluded that ground water pump-and-treat coupled with limited soil vapor extraction (SVE) in the vadose zone were the appropriate remediation technologies for the site.

In February 1992, the EPA issued a Proposed (Cleanup) Plan outlining the remedial action alternatives for the site and a public hearing was held in March 1992 to obtain comments from interested parties on the plan. The EPA Record of Decision (ROD) was then issued in March 1992 (USEPA, 1992b) followed by the Statement of Work (SOW) in August 1992 (USEPA, 1992c) outlining the work required for designing and implementing remedial activities at the site. A Preliminary Design Workplan (PDW)(ESI, 1992) was submitted and approved by the EPA in December 1992.

The Consent Decree (CD) (USEPA, 1993a) was entered in August 1993. During CD negotiations, it was agreed that the remedial design would be completed in phases. The Phase 1 Design Report was completed in September 1993 (ESI, 1993c).

The Phase 1 remedial program, which included SVE and ground water pump-and treat, was implemented in December 1993. Several factors were encountered during Phase 1 which required revisions to the site remediation schedule as presented in the Phase 1 Design Report (ESI, 1993c). The revised schedule was approved by the EPA in March 1993. See Figure 1-3 for the revised site remediation schedule.

This report summarizes the Phase 1 remedial program and describes the proposed Phase 2 design.

1.3 ROD Requirements

The Record of Decision (ROD) for the site established the selected remedy and documented the goals for remediation. The following description of the selected remedy is excerpted from the Declaration for the Record of Decision:

- "Design, construction and operation of a ground water extraction and treatment system to treat extracted ground water to levels that meet the cleanup standard set forth in this ROD;"

- "Discharge of treated ground water to the aquifer at the Site by injection or provision of the treated ground water to beneficial users of the treated ground water;"

- "Soil Vapor Extraction for those areas that threaten to contaminate ground water at levels above Site cleanup standards following a one year subsurface study;"

- "Ground water monitoring to demonstrate that the extraction system is effectively capturing the contaminant plume and ultimately, to demonstrate achievement of the cleanup standards throughout the aquifer," and

- "Maintenance of perimeter fencing at the Site until cleanup standards are met."

The selected remedy is Alternative 6 of seven alternatives evaluated. The ground water treatment system in Alternative 6 is carbon treatment.

1.4 Cleanup Goals

The aquifer cleanup standards are specified in the ROD for five volatile organic compounds (VOCs) and are reiterated in the SOW. The five VOCs and their respective cleanup standards for ground water are:

Contaminant	Standard (ppb)
Benzene	1
1,2-Dichloroethane	0.5
Ethylbenzene	680
Methylene Chloride	5
Toluene	100

Of these, benzene and toluene are the only compounds that currently exceed the cleanup standard. Historic analytical data in the ground water database (includes samples collected from August 1990 to August 1994) indicate that forty-three Texaco wells have had concentrations which exceed the cleanup standard for benzene of 1 ug/L. During the same period, only thirteen Texaco wells have had concentrations which exceed the cleanup standard for toluene of 100 ug/L, and only three of these wells have exceeded the toluene

cleanup standard on more than one occasion. These three wells also exceed the cleanup level for benzene.

Of the remaining three compounds for which cleanup standards have been set, historic data indicates that 1,2-dichloroethane has only been detected three times and has not been detected in the last three years while ethyl benzene and methylene chloride have not been found at levels above the cleanup standard in any Texaco well.

Of the two compounds that currently exceed the cleanup standard, benzene exceeds its cleanup standard in far more wells than toluene and the cleanup standard for benzene of 1 ug/L is much lower than the cleanup standard for toluene of 100 ug/L. In wells where toluene is found at levels above the cleanup standard, benzene is also present at significant concentrations. The remediation of benzene to its cleanup standard should ensure that the cleanup of toluene is surpassed, therefore, benzene is the target compound for this remediation program and the design report is focused on benzene.

The SOW states that:

> "Achievement of the cleanup standards shall be measured by the approach recommended in EPA guidance or policy. In the event no such guidance is available, achievement of the cleanup standards shall be measured using the following factors:
>
> - an average of water quality data from wells within the former plume excluding background wells and historically non-detect wells; and
> - from more than 3 quarters that include seasonal high [and] low water elevations.
>
> EPA may require adjustments to the monitoring system to collect the appropriate data."

1.5 Objectives and Scope

The objectives and scope of the Phase 2 Final Design and activities in support of the design are defined in the SOW and PDW. These are described below:

- Presentation of the results of the Phase 1 operation and description of how this information has been incorporated into the Phase 2 design.

- Development of a conceptual design for Phase 2 which includes ground water extraction based on capture zone analysis, treatment of ground water by activated carbon, soil vapor extraction, and evaluation of air sparging.
- Refinement of the site hypothesis.
- Evaluation and selection of an appropriate option for disposal of treated ground water.
- Reporting and evaluation of additional field data collected in support of the design.
- Conducting pilot scale tests of candidate remedial technologies.
- Conducting bench scale tests of biodegradation.
- Preparation of the Phase 2 Final Design for the selected remedy.

2.0 SITE DESCRIPTION AND REFINED SITE HYPOTHESIS

2.1 Site Location and Surface Facilities

2.1.1 Location

The PCPL site is located on the eastern edge of the City of Fillmore in Ventura County. The property is approximately 20 acres in size and is elongated in a north-northwest to south-southeast direction. It is bounded to the west by a concrete lined channel, Pole Creek, and on the east by the southwestern edge of the Piru Mountains. It is bounded to the south by State Highway 126 (also referred to as Ventura Street and Telegraph Road) and to the north by vacant land (Figure 2-1).

2.1.2 Surface Facilities

The current surface facilities include buried crude oil transport pipelines, a pipeline manifold yard, a surface pumping station, above ground storage tanks and administration buildings. As shown in Figure 2-1, the majority of the site consists of open, unpaved area.

The small building near the middle of the site is used as an office for the crude oil pumping operations, the buildings near the southeast portion of the site are meeting and storage rooms. A road runs through the middle of the site in a north-northwest direction and is paved up through the central portion of the site. There are five large above ground crude oil storage tanks and three smaller tanks which are all located within bermed areas.

An above ground water tank, located on the side of the hill, stores water pumped from a deep ground water production well located just east of monitoring well MW-29D. The pumped water is used at the office building and is also used as irrigation water for an avocado orchard located in the hills to the east. There is a large depression located in the west central portion of the property where the former Main Waste Pit was located.

A concrete treatment pad is located just south of the two smaller storage tanks (not shown in Figure 2-1 as it did not exist at the time of the photo). The treatment pad currently contains granular activated carbon canisters that are used to treat the pumped ground water. Southern Pacific Railroad tracks run through the southern portion of the site in an east-west direction. The facility is fenced north of the railroad tracks. South of the railroad tracks and west of the entrance road, there is a small grassy area with the "Welcome to the City of Fillmore" sign. East of the entrance road there is a fenced area which contains an orange grove.

There are approximately fifty monitoring/extraction wells onsite and approximately twenty Texaco wells offsite. The depth of the wells ranges from 44 feet to 164 feet below ground surface (bgs). The ground water production well is 500 feet deep with the first perforations at 138 feet below ground surface.

2.1.3 Topography

The elevation of the relatively flat portion of the site ranges from approximately 470 feet above mean sea level (AMSL) in the southern portion of the site to approximately 570 AMSL in the northern portion of the site. The elevation of the hill to the east that is considered part of the site reaches a maximum elevation of 725 feet AMSL.

2.1.4 Surrounding Area

The site is surrounded by areas of agricultural, industrial, and residential use. The area to the north and east consists of vacant and agricultural land. There is a large avocado orchard up the hill to the east. Just east of the southeastern boundary of the property there is a small nursery. Across State Highway 126 to the south of the site is Barnett Trucking and a mobile home park.

There is a residential area and public school (San Cayetano School) west of Pole Creek and north of the Southern Pacific Railroad tracks. Immediately south of the railroad tracks is a small industrial area which contains an auto wrecking yard. To the west of the yard are undeveloped areas which were historically used for bulk petroleum product loading.

A gasoline service station currently operated by Ultramar Inc. is located on State Highway 126 just south of the wrecking yard. The service station had an underground fuel tank leak which was discovered in the 1980s by the former owner, Conoco. Hydrocarbons were detected in soil and ground water below the site. Conoco replaced the underground fuel tanks in the late 1980s and submitted a plan for soil remediation (vapor extraction) to Ventura County. Ultramar purchased the site from Conoco and continued with the monitoring and remediation plans. Ultramar operated a vapor extraction system from January through September 1992 and reported that over 3,000 lbs of hydrocarbons were extracted during this period. According to Ultramar's second quarter report (submitted to the RWQCB), the vapor extraction system was also operating from March through July 1994.

Texaco and Ultramar have worked cooperatively over the past few years, coordinating the quarterly ground water sampling events in order to share split samples from certain of each other's wells.

2.2 Climate

The climate at the PCPL site is semi-arid, Mediterranean. The mean annual rainfall is approximately 18 inches. About 75 percent of the precipitation occurs between December and March. Gross pan evaporation averages 62 inches. Mean daily temperatures range between 41 and 69 degrees Fahrenheit in the winter to between 55 and 88 degrees Fahrenheit in the summer.

2.3 Regional Geology and Hydrogeology

2.3.1 Regional Geology

The regional topography and landforms are primarily a reflection of Pleistocene and later tectonic activity with mass wasting and differential stream erosion overprints on the structural surface. A geologic map for the region (Figure 2-2) and cross section from north to south across the Santa Clara Valley (Figure 2-3) show that the regional stratigraphy is largely structurally controlled. The area is comprised of three regional east-west trending structural provinces that are divided by major faults. The major structure features from north to south are as follows:

Topatopa-Piru Anticline (includes Topatopa and Piru Mountains)

----------San Cayetano Thrust Fault Zone----------

Santa Clara Trough (includes Santa Clara River Valley)

----------Oak Ridge Fault Zone----------

Oak Ridge Anticline (includes Santa Susana Mountains)

The PCPL site lies along the northern boundary of the Santa Clara Trough. In the Fillmore area, the Trough is bordered on the north by the Topatopa and Piru Mountains and on the south by the Santa Susana Mountains. A basic description of the major structural features follows:

Santa Clara Trough

The Santa Clara Trough (regionally referred to as the Ventura Basin Syncline) is an east-west trending valley which contains the west flowing Santa Clara River. The trough is a deep syncline with both limbs overturned. The north limb is terminated by the San

Cayetano Thrust Fault and the south limb is broken by the Oak Ridge Fault. Both faults dip away from the valley with overlying geologic strata of the Topatopa-Piru Anticline and Oak Ridge Anticline provinces moving toward the center of the valley.

The strata in the Santa Clara Trough are younger than the strata in the mountains to the north and south. Cenozoic strata with an aggregate thickness of over 40,000 feet are exposed or known from oil and gas well logs in the Fillmore area (Eschner, 1957). The surface of the Trough is covered with Recent deposits consisting primarily of unconsolidated alluvial and colluvial sequences. The alluvial sequences include both fan and stream deposits along and near the Sespe Creek, Pole Creek and Santa Clara River drainages. Colluvial, landslide and mass wasting deposits associated with landslides and ground creep are found primarily along the topographic break between the river valley and the adjacent highlands. The Recent deposits overlie Pleistocene age deposits of (San Pedro or Saugus Formation).

Topatopa-Piru Anticline

The Topatopa-Piru anticline (also referred to as the Topatopa Uplift) is an eastward continuation of the Santa Ynez Anticline. The nearest named peak of the Topatopa Range, San Cayetano Mountain, is located approximately 4-1/2 miles to the northwest of the PCPL site and rises to almost 4,180 feet above sea level. The nearest named peak of the Piru Ranges, Oat Mountain, is located approximately 2-3/4 miles to the north of the site and rises to over 3,120 feet above sea level with over 2,500 feet of relief down to the site (USGS, 1988).

Locally, the mountains are composed of early Tertiary age sedimentary deposits that were intensely folded as they were thrust southward over less-resistant, younger sedimentary strata of the Santa Clara Trough (along the San Cayetano Thrust Fault). San Cayetano and Oat Mountains, and the hills immediately to their north (which represent the southern margin of Topatopa and Piru Ranges, respectively) contain asymmetric, overturned, and inclined isolcinal folds. Miocene Monterey Formation and landslide debris outcrop at the surface in the vicinity of the site.

Oak Ridge Anticline

The Oak Ridge Anticline (also referred to as the Oak Ridge Uplift) was formed by reverse fault movement along the Oak Ridge Fault. Older strata has moved upward over the younger strata of the Santa Clara Trough. The Topanga Sandstone Formation is exposed at the surface, south of the Oak Ridge Fault.

San Cayetano Fault Thrust Zone

The San Cayetano Fault Thrust is an east-west trending, northerly dipping thrust fault which forms the topographic break between the northern mountains (Topatopa-Piru Anticline) and the Santa Clara Valley (Santa Clara Trough). Movement along the San Cayetano began during the Pleistocene. Fine (1954) reported 30,000 feet of throw along the fault. Landslides are common along the fault front and obscure the surface geology. Faulting associated with the San Cayetano can be identified by locally offset bedding and in many locations, surface oil seeps.

The San Cayetano Fault Zone has been designated as a zoned fault under the Alquist-Priolo Earthquake Fault Zoning Act. This Act delineates a one-quarter mile zone along active faults where building restrictions apply. An active fault is a fault that has had surface displacement within Holocene time (last 11,000 years). The fault trace in the vicinity of the site has been buried by alluvial and colluvial material and is not visible. Most references show the fault trace along the base of the hills, but other references show the fault trace across the middle of the site or across the hills. It is better to visualize the thrust fault as a zone, rather than a single line trace along the surface.

Oak Ridge Fault Zone

The Oak Ridge Fault Zone is a northeast trending, southerly dipping reverse fault which forms the topographic break between the mountains to the south (Oak Ridge Anticline) and the Santa Clara River Valley (Santa Clara Trough). Compressional tectonics during the mid-Pleistocene formed the Oak Ridge Anticline.

2.3.2 Regional Hydrogeology

The PCPL site is located within the Fillmore Basin as described by Mann & Associates (1959). The sources of water for underlying water bearing units are ground water inflow and stream and precipitation recharge. The Fillmore sewage treatment facility (located on Sespe Creek) recharge and the city water supply well withdrawals are both sufficient to contribute to the overall basin water balance. Ground water flow through the basin is predominately west-southwest roughly paralleling the Santa Clara River. Sespe Creek and its tributaries add a southerly component to the ground water flow direction. A ground water contour map of the near surface aquifer is shown in Figure 2-4.

Inflow to the basin is through alluvial deposits and the San Pedro Formation located east of the basin, traveling more or less along the Santa Clara River. The primary recharge to water bearing units is from the Santa Clara River and Sespe Creek. Secondary recharge and

some indirect recharge originates at Lake Piru. There is additional alluvial recharge from precipitation on the alluvial fan deposits along the mountain front. The volume of precipitation recharge from adjacent terrace areas is limited by the low vertical and horizontal permeability of those units. At the western boundary of the basin, the alluvium and upper permeable San Pedro are constricted and underflow out of the Basin is fairly constant. Enough ground water rises to the surface at the western end of the basin to create perennial surface flow out of the basin.

Because of the geometry of the basin, the ground water hydraulics and the geologic conditions, aquifer water level response to changes in recharge are manifested relatively rapidly. In most cases, after a drought period, one year of above average precipitation will replace the withdrawn storage from the aquifer. The magnitude of the maximum water level change in the upper aquifer is probably limited by the down basin discharge point. At some upstream ground water elevation a steady state discharge condition will be met where surface flow at the western discharge will increase and therefore maintain a maximum elevation.

Within the eastern portion of the Basin where the PCPL site is located, the alluvial deposits and the underlying San Pedro Formation are the major water bearing units. The boundary between the alluvium and San Pedro Formation is difficult to accurately locate because of lithologic similarities. The thickness of these units vary. Mann (1959) reported thicknesses of 60 to 100 feet while CDWR (1953) reported alluvial thicknesses of 180 to 250 feet.

Figure 2-5 is a hydrograph showing the relationship in water level changes at several wells compared to flow in upgradient rivers and creeks, storage in Lake Piru and local precipitation from 1925 to present. Figure 2-6 shows the same information for the last ten years. The hydrograph shows that fluctuations of 30 feet are common with maximum long-term fluctuation of 50 feet observed in a well located 0.3 miles south-southwest of the site (1961-1969).

The data indicates that surface flows, surface storage volume and ground water levels vary according to precipitation. However, there is not a strong correlation between surface flow and ground water elevations on a regional basis. Precipitation appears to be the major factor in ground water elevation control the bulk of the precipitation occurs from January to March and the ground water levels generally show the highest seasonal level in March. Changes in precipitation over the longer-term also show a direct affect on ground water levels. During the relatively dry period from 1972 to 1976, ground water elevations in the selected wells dropped approximately 40 feet. Water levels rebounded rapidly during the 1977-1978 storm season. Figure 2-6 shows that 1991 to 1993 were also relatively wet years with a corresponding increase of 25 to 30 feet in the regional water levels.

2.3.3 Surface Hydrology

The Santa Clara River (located approximately 1/2 mile south of the site) is a mature, west flowing river that has developed upon the less-resistant sedimentary strata described above. The location of the river along the southern boundary of the river valley is due primarily to the heavy tributary flow into the river from the north and local uplifts within the basin (Mann and Associates, 1959). A hydrograph of flow in the Santa Clara River at the Los Angeles and Ventura County line shows both the annual and long-term variation in flow. As expected, peak flows occur in March or April and low flow in October or November. The long-term base flow in the river is approximately 48.3 cfs (31 million gallons per day) (Earthinfo, Inc., 1994).

Within the Fillmore Basin, the majority of the perennial and intermittent streams drain the mountains from the north into Sespe Creek which in turn descends southward, emptying into the Santa Clara River just west of the City of Fillmore (approximately 2.5 miles west-southwest of the site).

Pole Creek, a perennial stream, located at the eastern boundary of the Fillmore Basin drains an area of approximately 7.5 square miles. It generally flows from the highlands east of the Fillmore Basin and then turns abruptly southeasterly flowing past the PCPL site into the Santa Clara River. The rapid change in channel orientation suggests that the channel has been influenced by geologic control. The lower portion of the Pole Creek channel was improved in the early 1970s with the construction of a concrete-lined box channel which runs along the western edge of the site. There is a stream gaging station in the portion of the channel located upstream from the confluence of Pole Creek and the Santa Clara River. Flow from Pole Creek for water year 1993 is included in Table 2-1.

Flow in the Santa Clara River in the Fillmore area and recharge to underlying aquifers is in part controlled by discharges from Lake Piru which began storage in 1955 and then from Pyramid Lake since 1977. Both of these reservoirs are part of the California Water Project. Storage in Lake Piru is shown in Figure 2-6.

2.4 Regional Petroleum Geology

The PCPL site lies within the eastern portion of the Ventura Basin petroleum province (Figure 2-7). The petroleum accumulations are predominantly controlled by structural (anticlines and faults) and stratigraphic (depositional thinning or "pinch outs") elements of the basin which provide the hydrocarbon trap. Approximately 85 percent of the oil generated from the Ventura Basin fields has been produced from marine sediments of the

Pliocene-aged Pico and Repetto Formations and the Upper Miocene-aged Santa Margarita, Monterey and Modelo Formations (Nagle and Parker, 1971).

Oil fields located within the site vicinity include the Fillmore, Shiells Canyon and Bardsdale fields. Through 1987, these three fields have produced a combined 53.5 million barrels of oil (CDOG, 1988). The Bardsdale Field was discovered by Union Oil Company of California (Unocal) in 1891 (California Division of Oil and Gas [CDOG], 1960; revised 1991). The most recently discovered of these fields, the Fillmore field, was discovered in 1954 by Standard Oil Company of California (Chevron U.S.A.) (Schultz, 1959). The Bardsdale and Shiells Canyon fields formed as a result of displacement along the Oak Ridge thrust fault (Sylvester and Brown, 1988). Repeated displacements along the Oak Ridge fault have generated a series of anticlines that form a hydrocarbon trap. Minor oil production originating from strata truncated by the Oak Ridge fault has also been noted (Sylvester and Brown, 1988). In contrast to fields associated with the Oak Ridge Trend, the mechanism responsible for trapping oil accumulations within the Fillmore field is predominantly stratigraphic in nature.

In addition to the oil fields discussed above, several surface oil and tar sand accumulations or seeps have been mapped (Dibblee, 1990) near the PCPL site. These occur in the fractured sands and shales of the Monterey Formation north of the site along Pole Creek and in recent landslide debris directly adjacent to the site (Figure 2-2). It is likely that the observed tar seeps resulted from the migration of crude oil along shallow fractures present within the highly fractured brittle rock outcrops of the Monterey Formation and along the diffuse subsurface fractured network associated with the San Cayetano Fault shear zone. It is important to note that the existence of these naturally occurring migration pathways may have potentially impacted the distribution of hydrocarbon constituents beneath the site. Fault movements may have also contributed or facilitated landslide accumulations.

2.5 Local Geology and Hydrogeology

A series of cross sections have been constructed for the site (Figure 2-8 shows locations of the cross sections). The sections (Figures 2-9 through 2-13) include subsurface geologic, hydrologic and hydrocarbon concentration information.

2.5.1 Local Geology

The near surface geology of the PCPL site can be characterized as being discontinuous, unconsolidated geologic strata deposited in stream channel, alluvial fan (fluvial), mass wasting and landslide depositional environments. The geology is further complicated by the

proximity of San Cayetano Fault Zone which appears to have caused some general reworking and offsets of strata beneath the site.

Some general geologic descriptions and correlations can be made based on both geologic and geophysical logging of boreholes drilled on and near the PCPL site. A relatively thin reddish-brown clay has been noted in many of the boreholes drilled on site.

2.5.2 Local Hydrogeology

The PCPL site lies on a series of fluvial deposits which includes a portion of the alluvial fan formed by Pole Creek. Pole Creek currently runs along the western edge of the site. The San Cayetano Fault is mapped along the eastern edge of the site. The fault trace has been buried by alluvial and colluvial material and is not visible in the site vicinity.

The fan deposits are interlayered with colluvium and coarse detritus of the Monterey Formation (sandstones and shales) which have been deposited during several episodes of landsliding originating from the hills to the east. As a result, this tectonically overprinted depositional environment has resulted in very complex subsurface conditions. Subsurface soils consist of laterally discontinuous and disrupted interlayered gravels, sands, silts and clays.

The extreme variability of the subsurface (discontinuous layers of material with highly variable hydraulic properties which dip in different directions) creates a complex hydrogeologic environment. Previous investigations have identified three water bearing zones:

- Perched Zone — Zone of discontinuous perched water generally above a reddish-brown clay layer.
- Aquifer I — Unconfined to semi-confined shallow aquifer
- Aquifer II — Partially confined to confined aquifer below aquifer I

Due to the discontinuous layering and variable hydraulic properties identified in the subsurface beneath the site, the three water bearing zones are locally interconnected. Moreover, because of the complex stratigraphy, the water bearing zones are typically semi-confined. During aquifer testing, the majority of the wells monitored exhibited behavior similar to an unconfined aquifer. However, during long-term ground water elevation monitoring, aquifer I in some locations has appeared to function as a confined system.

Recharge of the water bearing units beneath the site is primarily the result of infiltration due to precipitation and runoff from the surrounding hills. Some underflow from adjacent units may occur on the eastern boundary of the site. Flow direction has changed over time with increasing ground water elevations. Third quarter ground water monitoring results indicate that flow occurs in a northwest direction across the site and is deflected to the west across Pole Creek with a minor southerly component. The average gradient across the site for aquifer I is approximately 0.006 ft/ft. There are no onsite discharge zones for ground water. Flow continues to the west and south, eventually discharging at the western end of the basin.

During prior site investigations, aquifer properties have been primarily evaluated for the aquifer I zone. In general, permeabilities for aquifer I decrease to the west and north of the site. The average permeability of the aquifer I materials is variable, ranging from approximately 1 ft/day to 15 ft/day. The storativity of the unit can be divided into a storage coefficient and a specific yield. Values for those two properties are 4.5×10^{-3} and 0.15, respectively. Permeability distribution maps have been developed for the site ground water model and are discussed more fully in Sections 6.7 and 7.3, of this report.

Water level elevations in onsite monitoring wells are regularly monitored. Third quarter 1994 ground water elevation maps (Figures 2-14 through 2-16) have been included for reference. Of the 14 perched zone wells, only three currently have measurable water in them (Figure 2-14). The measured water levels in aquifer I wells (Figure 2-15) have dropped approximately 5 to 6 feet from their historically high values exhibited during second quarter 1993 (see Figure 2-17 for representative aquifer I hydrograph).

As shown on Figure 2-6, ground water levels at the site have fluctuated significantly over the past several years. For example, over the August 1990 through April 1993 period, water levels in MW-22S increased by over 30 feet. This increase is thought to be the result of precipitation following an extended period of drought and/or releases of water from Piru Dam. Since April 1993, water levels have declined 5 to 6 feet over the site. These fluctuations play a significant role in the implementation of remedial actions at the site.

The differentiation between aquifer I and aquifer II is not as clear as once proposed. Information collected during Phase 1 activities indicate that there is an increase in fine material with depth in aquifer II. However, based on borehole logs and geologic cross sections (Figures 2-9 and 2-13) there does not appear to be a laterally continuous, confining layer or fine-grained geologic unit that separates the two zones. The water level data for aquifer II wells collected over time (Figure 2-16) tends to support the contention that the two aquifers are not entirely independent. Figure 2-16 shows that water levels in aquifer II have declined approximately 4 to 6 feet since their highs reported in 1993. These declines

are approximately the same as those observed in aquifer I wells. The fact that water levels are lower in the aquifer II wells indicates that there is a vertical gradient downward between the two units which also lends support to the contention that there is some connection between the units.

The important distinction between the aquifer I and aquifer II wells is that the aquifer II wells have historically shown little to no hydrocarbon contamination. This is probably in part due to the depth of the unit below the historic ground water lows and the general fining downward of the aquifer I materials.

During the third quarter 1994 monitoring period, water levels in aquifer II continued to generally decline. The average gradient across the site is approximately 0.006 ft/ft to the northwest.

There are fifty reported water wells within a one mile radius of the site. Seventeen of those wells are within a 0.5 mile radius of the site. Information indicates that those seventeen wells are completed at elevations generally lower than the monitored portion of aquifer II beneath the PCPL site. The onsite production well described in previous reports continues to operate, supplying irrigation water for the site and avocado orchard east of the site. The well yields up to 180,000 gallons per day (125 gallons per minute) during the summer irrigation season.

2.6 Refined Site Hypothesis

The site hypothesis presented in the Phase I report is still generally accepted. However, with the additional data collected, several refinements can be added to the hypothesis:

- The lateral extent and concentrations of the dissolved-phase benzene plume have increased since 1992. The occurrence of benzene is primarily due to the increased contact of ground water with benzene-containing hydrocarbons in the vadose zone as a result of increases in regional ground water level. When ground water elevations increased during 1992 to 1993, the benzene mixed with the rising water in a "smear zone." Thus, the increased concentrations of dissolved-phase benzene is the result of water level rising.

- Data collected during quarterly monitoring and vapor extraction testing indicate that some portion of the hydrocarbons found onsite are naturally occurring. Methane, which has been detected in many gas samples collected both offsite and onsite is most likely naturally occurring deep earth methane (Section 4.3, Naturally Occurring Hydrocarbons). The component 2,2,4-trimethylpentane found in the natural

seep hydrocarbons, was also found in soil gas and condensate samples from well PEW-3 at the site. This component is not a normal component of crude oil and the Fillmore Refinery had no chemical conversion process which would produce 2,2,4-trimethylpentane. That it is present in the natural seep liquids leads to the conclusion that its source to well PEW-3 is natural seep liquids in the subsurface.

- The perched zone has largely disappeared, probably due to the downward percolation of areal recharge water beneath the reddish-brown clay that had acted as a barrier to downward flow. However, should precipitation increase, perched water could potentially reappear in those wells.

- A much larger mass quantity of benzene exists in the subsurface than previously reported. Moreover, the distribution of the benzene is also somewhat different. Based mainly on soil sample analyses, but supported by the results of vapor extraction tests and operational monitoring of the vapor extraction system, it is estimated that approximately 70% of the soil which contains benzene and approximately 80-90% of the benzene mass in the subsurface is present above the high water elevation (Section 4.4.1.3, Benzene Distribution).

- Less emphasis is now placed on the reddish-brown clay as a semi-continuous lithologic unit acting as a barrier to the downward migration of hydrocarbons.

- The area previously identified as aquifer II is generally free of dissolved-phase hydrocarbons primarily due to the general fining downward of the aquifer I material and a higher percentage of fine material with depth. Also, the density of the hydrocarbon is such that any free hydrocarbon present floats on the water. Therefore, it would not be expected to occur at depth, except in smear zones.

- Historic facilities previously identified as the Ethylene Plant and the Naphthalene Plant (ESI, 1993c) have been renamed the Ethyl Plant and Naphtha Plant, respectively, to more accurately reflect the nature of the activities and processes which took place there (tetraethyl lead blending and naphtha treating to remove sulfur compounds). The previous names implied more complex technologies than were available in the pre-1950 time periods.

- Additional potential sources of hydrocarbon have been identified, (1) Richfield Oil Co. Gas Separator Plant, and (2) two bulk loading facilities along Santa Clara Avenue that had gasoline and oil storage tanks. Figure 2-1 shows the location of these sites.

- The elevation of the ground water surface appears to be generally decreasing in response to decreased precipitation. Water levels in aquifer I monitoring wells are approximately 5 to 6 feet below reported previous high water elevations.

3.0 ADDITIONAL SUBSURFACE INVESTIGATION

In order to obtain additional subsurface information for the Phase 2 design, five additional ground water monitoring wells, three additional ground water extraction wells, and three vapor extraction wells were installed on or near the PCPL site. In addition, one deep ground water monitoring well was destroyed. Following is a brief summary of the subsurface activities performed during the Phase 1 design investigation. For a more detailed description of the field activities, boring logs and well construction details, and soil analytical results, refer to Appendices A, B and C, respectively of the Second Quarter 1994 Quarterly Status Report (ESA, 1994g). Soil analytical results are also included in Appendix A of this report.

3.1 Ground Water Extraction Well Installation

The ground water extraction wells were installed to evaluate the hypothesis that a well with a design tailored to the location-specific subsurface conditions would reduce the concentration of suspended and settleable solids which were complicating design of the ground water treatment system. The locations of the ground water extraction wells were selected on the basis of the known extent of ground water contamination and the preliminary ground water modeling results. Figure 3-1 depicts the locations of the new wells including the three extraction wells (EW-2, EW-4, and EW-5).

To ensure that the wells were designed for the location-specific subsurface conditions, pilot borings for the three extraction wells were drilled on May 2 through 5, 1994 using a Failing F-10 drill rig equipped with nine-inch outside diameter hollow stem augers. Discreet, relatively undisturbed soil samples were collected at five-foot depth intervals using a California-modified split-spoon sampler down to a depth of approximately 10 feet above the anticipated ground water table. At this depth the rig was converted to recover continuous core (soil samples) down to the total depth of the borings (96.5 to 131.5 feet below ground surface [bgs]).

When all three pilot borings were drilled, COLOG, Inc., was notified and a geophysical van was sent to the site. Natural gamma and induction (electrical conductivity) logs were run on all three wells. The geophysical data are described further in Section 6.6, Geophysical Logging.

Twenty-five soil samples collected from the three pilot borings were submitted to a geomechanical laboratory for sieve analysis. The results, together with the lithologic and geophysical logs were used to design the extraction wells. Well design details included

casing diameter and material, screen intervals, well screen slot size, pre-pack sand gradation, and annulus sand pack gradation.

Thirty-two soil samples collected from the pilot borings were also sent to Del Mar Analytical and analyzed for TPHG and BTEX.

The extraction wells were installed during June 1 through 10, 1994. A conventional, direct rotary drill rig was used to ream the pilot borings to a diameter of 16-inches. The wells were constructed of 6-inch diameter casing. Screen intervals consisted of stainless steel, continuous-slot, Johnson Channel-Pack. Screen slot sizes ranged from 0.008-inches to 0.02-inches, depending upon the gradation characteristics of the formation. Screen interval lengths ranged from 2.5 feet to 17 feet, depending upon the thickness of coarse-grained materials in the saturated zone. Wells EW-4 and EW-5 were completed with three separated screened intervals and well EW-2 was constructed with two separate screen intervals.

The extraction wells were developed by a combination of surging, bailing and pumping on June 13 through 17, 1994. Approximately three thousand gallons of water were removed from each well as part of the development process. Both the entire well and isolated screen intervals were pumped separately. The screen intervals were isolated using a packer assembly which allowed each screen interval to be efficiently developed. The wells were developed until the solids content (turbidity) stabilized.

3.2 Ground Water Monitoring Well Construction

Four (4) additional aquifer I ground water monitoring wells (MW-43S through MW-46S) were drilled, sampled and installed on May 9 through 17, 1994 (Figure 3-1). Three of the wells (MW-43S, MW-45S and MW-46S) were installed to further delineate the contaminant plumes in areas of limited information and one (MW-44S) was installed to replace well MW-34S which was rendered ineffective by a submerged screen. One monitoring well (MW-47D) was completed in aquifer II to replace monitoring well MW-25D, which was suspected of allowing contaminants to migrate from aquifer I to aquifer II. Well MW-25D was subsequently abandoned on May 13, 1994 by pulling the 4-inch diameter PVC casing from the ground and "drilling-out" the annular material. The resultant bore was then backfilled with neat cement grout, pumped under pressure through a tremie pipe, to the ground surface.

The borings were drilled using a Failing F-10 hollow-stem auger drill rig retained from H-F Drilling of Orange, California. Forty-one soil samples collected from the five monitoring wells were sent to Del Mar Analytical and analyzed for TPHG and BTEX.

The wells were developed on May 16 through 18, 1994, a minimum of 24 hours after installation. The wells were developed by a combination of surging, bailing and pumping. Development was conducted until temperature, pH, conductivity and turbidity measurements stabilized and at least 5 well volumes had been removed from each well. Approximately 270 gallons of water were removed from each well as part of the development process.

3.3 Vapor Extraction (Vadose Monitoring) Well Installation

To more efficiently monitor the extended vapor extraction pilot test, three additional vadose zone monitoring wells (PEW-4, PEW-5 and PEW-6) were installed at the site (see Figure 3-1 for well locations). Well installation services were provided by West Hazmat Drilling Corp. of Anaheim, California. Each boring was drilled to a depth of 45 feet and completed using 4-inch diameter, Schedule 40 PVC casing. Thirteen soil samples collected from the borings were submitted to Del Mar Analytical and analyzed for TPHG and BTEX.

4.0 SUBSURFACE HYDROCARBON DISTRIBUTION

Data from boring logs and soil samples, ground water monitoring and soil gas testing and sampling have been interpreted to estimate concentration and mass distributions of benzene in soil, water and gas phases in the subsurface. The data have been presented in several past site reports (ENSR, 1990a,b; ENSR, 1991a; ESI, 1993c; Second Quarterly Status Report, 1994 [ESA, 1994g]) and are summarized for soil samples in Appendix A. Benzene is the primary component of interest, but the distribution and characterization of other components provide supplemental information which aid in interpretation.

4.1 Vadose Zone

Hydrocarbons in the vadose zone reside primarily in the soil matrix, with some in the form of free oil, some dissolved in soil moisture and some in the vapor phase in soil gas. The following sections describe the distribution of benzene and other hydrocarbons in soil and soil gas.

4.1.1 Residual Hydrocarbons in Soil

Residual hydrocarbons have been observed and measured in soil borings at several locations at the project site. In some samples both benzene and TPH were measured, in others (early investigations) only TPH was measured, and in some samples only visual observations of soil staining with oil or presence of liquid hydrocarbons in soil samples was noted in boring logs, but no measurements were taken. There is potential for benzene to be present in some of the areas in which other hydrocarbons are present in significant concentrations, i.e., in areas in which elevated concentrations of TPH have been measured or in which the boring logs indicate the presence of oily soil.

However, it must be kept in mind that TPH presence alone is not sufficient for establishing the presence of benzene. Consider the following two examples:

1. TriHydro collected 13 samples at 20 feet below the bottom of the excavated main waste pit, plus one at 40 feet deep and one at 5 feet (ENSR, 1990a). Only two samples had detectable benzene, FWP-15 with 0.7 mg/kg at 20 feet and FWP-1 with 2.0 mg/kg at 5 feet. Hydrocarbons were measured as "Hydrocarbon Matrix" by EPA Method 8270 and ranged from one non-detected to 20,000 mg/kg with a median of 6,000 mg/kg and mean of 5,740 mg/kg. FWP-15 had 8,000 mg/kg hydrocarbons and FWP-1 had 1,000 mg/kg.

2. ENSR collected and analyzed 587 samples from 46 borings and depths ranging from 5 feet to 95 feet (ENSR, 1991a). About half of these were from the Main Waste Pit area. The samples were analyzed for TPH by EPA Method 8015 as diesel. ENSR selected 142 samples based on high TPH and high field OVA readings and had these analyzed for VOCs using the Toxic Characteristic Leaching Procedure (TCLP) method . Benzene was not detected in 127 of the 142 samples, even though TPH was found at several thousand mg/kg in many of those samples. In fact, only four of the samples even exceeded the Field Sampling Plan designated threshold level of 11 $\mu g/l$ for benzene.

The cross sections shown in Figures 2-9 through 2-13 show interpreted zones in which benzene is present, based on benzene measured in soil samples, and zones in which there is potential for benzene to be present based on TPH measurements or presence of oily soil. The Phase 1 Design Report (ESI, 1993c) described a fine-grained "red clay layer" which has reportedly affected migration and distribution of hydrocarbons in the vadose zone. In addition, perched ground water which locally occurs across the site has also been associated with this fine-grained layer.

The cross sections depict the spatial distribution of fine-grained lithologies (silt and clay) which could potentially facilitate the subsurface lateral migration of hydrocarbons. These figures indicate that the fine-grained lithologies do not form a continuous layer across much of the site, and may only serve to locally retard the downward migration of hydrocarbons. Although hydrocarbons are commonly associated with these fine-grained lithologies, it is unclear as to what degree lateral and downward contaminant migration is affected by their presence.

Figure 4-1 shows, in plan view, approximate areas in which significant concentrations of benzene have been confirmed in the vadose zone above the historic high water elevation, and in the zone between the high and low water elevations in which hydrocarbons have been smeared by a rising or falling water table (smeared zone).

Significant concentrations are defined for Figure 4-1 as 1 mg/kg in the vadose zone and 0.1 mg/kg in the smeared zone. These concentrations were chosen to aid in depicting benzene distribution and are not related to cleanup levels. The rationale for using a lower threshold concentration in the smeared zone is that there is greater potential for ground water contamination when the ground water directly contacts the soil containing benzene. Benzene in the vadose zone must migrate to the ground water to impact the water, therefore a higher concentration in the upper zone is less of a threat to ground water.

4.1.2 Liquid Hydrocarbons

Free oil in soil has been reported in several boring logs (Table 4-1). Also, liquid hydrocarbons, often referred to as Light Non-Aqueous Phase Liquid (LNAPL) have been observed in a few of the extraction and monitoring wells at the site (ESI, 1993c [ESA, 1994g]). Figure 4-1 also shows the observed distribution of borings with observed free oil in soil at the site. It is interesting to note that in most cases in which free hydrocarbons have been reported in the boring logs, it is in association with fractured shale (Table 4-1). The meaning of this is not clear, but it may indicate the presence of natural seep liquids in Monterey shale fractured by earthquakes and landslides.

Recoverable quantities of these liquid hydrocarbons are very small. Free oil is continually removed by absorption in an oleophylic fibrous material (SoakEase™) or by bailing from wells in which LNAPL is present. Since March 1, 1994, the SoakEase™ absorbent has been inspected weekly and replaced when saturated. Table 4-2 summarizes the results of LNAPL removal (a detailed table is included in Appendix B). As of this report, less than 5 gallons have been recovered from the entire site in seven months. It is not possible to accurately estimate the quantity of LNAPL at the site, but it appears that there is not enough to flow freely to the many wells at the site.

Qualitative observations of LNAPL samples from different locations show some variability in density and viscosity which indicate different sources. A sample recovered from well EW-4 was analyzed for various parameters. A simulated distillation indicates that it is mostly naphtha in the gasoline range, but also contains some heavier oil in the kerosene range. This particular sample contained 490 mg/l benzene. It should be noted, however, that not all LNAPL on the site contain as much benzene. For example, LNAPL is in contact with water in well MW-9S, but water samples from that well show relatively low benzene concentrations (42 ug/l vs. 200 ug/l for EW-4 in August 1994 samples). LNAPL has great capacity to absorb benzene (Section 4.4.1, Benzene Partitioning Among Phases). It is possible that benzene rich soil gas has caused an increase in benzene concentrations in LNAPL that it has contacted.

4.1.3 Soil Gas

In August 1994, soil gas samples were collected from 36 wells at the site and were analyzed for fixed gases, benzene, toluene, ethylbenzene and xylenes (BTEX) and volatile fuel hydrocarbons. The results are summarized in Table 4-3 and Table 4-4. These tables also include data for samples collected from some of the wells on other dates.

4.1.3.1 Benzene Vapor

In general, benzene is in greater concentration in the vapor phase than are the other BTEX components and makes up about one percent of the volatile fuel hydrocarbons. However, in some cases, volatile fuel hydrocarbons were present in significant concentrations, but benzene was not detected (Table 4-3).

Distribution of benzene in the soil gas is shown in Figure 4-2. Two depth intervals within the vadose zone are depicted, based on depth of the screen interval in the well. The lower vadose zone extends from the water table to nominally 10 feet above the water table and the upper vadose zone is greater than 20 feet above the water table. This division of the vadose zone into two sub-zones is supported by observations of marked differences in gas compositions between wells close to one another but screened at different depths. Three pair of such wells (SBB-1 and PEW-1, AEW-1 and MW-37S, and PEW-2 and MW-38S) show considerable differences in soil gas compositions (not just benzene). The northernmost and middle pair of wells show higher benzene concentrations in the lower vadose zone, the southernmost pair shows the highest concentration in the upper vadose zone.

The south plume includes only a lower vadose zone, as all wells sampled in this area were either ground water wells or were gas wells with the bottom of the screen within 10 feet of the water table. However, some of these, installed as vadose wells, did have the tops of the screens within 15 to 20 feet of ground surface.

Except for two wells with low concentrations, benzene in the gas was generally not detected west of Pole Creek. Benzene concentrations exceeded 100 ppmv in several wells within the property boundary. In the northern portion of the site, the upper and lower benzene plumes do not coincide. The upper plume is shifted more to the south. The fine-grained soil depicted in the cross sections appears to be limiting the vertical movement of benzene between these two depth zones.

A soil gas extraction system had been operating on well PEW-2 for two months prior to the August sample collection. This has probably affected the gas distribution in the vicinity of PEW-2. Benzene concentrations in the soil gas at PEW-2 are about half the concentrations at the start of the test. Benzene concentrations in nearby wells have probably been similarly reduced as a result of the extraction operation.

4.1.3.2 Gas Condensate

Gas condensates were found in the vapor lines and knock out drum of the RETOX vapor extraction system which was operated during the first few months of Phase 1. Samples of

this condensate were collected and analyzed and additional samples were collected by chilling the extraction gas at the wellhead of well PEW-3. The test report by Global Geochemistry Corporation (GGC) is included as Appendix H to the Second Quarter 1994 - Quarterly Status Report (ESA, 1994g).

The GGC report stated that the liquid samples resembled white gas in composition. However, more recently, samples of natural gas condensates from local gas fields have been analyzed by GGC and have been found to be similar to the condensate samples from the project site. In the later report (included in the Third Quarter 1994 - Quarterly Status Report), GGC concludes that the hydrocarbon distribution patterns of neither the onsite nor offsite condensates closely match any type of refined products, "although their alkylcyclohexane and normal alkane mass fragmentograms fairly match those of a white gas." The comparison of various hydrocarbon liquids is discussed further in Section 4.3.2, Natural Gas and Gas Condensates.

The analysis of the gas and the gas condensate from well PEW-3 revealed the presence of the compound 2,2,4-trimethylpentane in both samples. This finding is very significant in that it indicates that at least some of the hydrocarbons are from the same source as the natural seeps found in the site vicinity. This is discussed in more detail in Section 4.3.1, Natural Seeps.

4.2 Saturated Zone

4.2.1 Residual Hydrocarbons

Residual hydrocarbons below the high water table (smeared zone) are depicted on the cross sections presented in Figures 2-9 through 2-13. The borings with measured benzene in the soil at concentrations of 0.1 mg/kg or greater in this zone are shown in Figure 4-1. The hypothesis for deposition of hydrocarbons in the smeared zone is described in the book, Contaminant Hydrogeology (Fetter, 1993). In section 5.5 of Fetter, Effect of the Rise and Fall of the Water Table on the Distribution of LNAPLs, describes the process as follows : Liquid hydrocarbons drain into the zone by leaks or seeps from above, forming a layer of mobile, floating oil on the surface of the capillary zone. Residual oil is left in the vadose zone above the oil table as it falls. When the water table rises, the oil table also rises. However, residual oil is left behind in the saturated zone. If the water table rises faster than the oil table can rise, pockets of free oil might be left below the water table.

Hydrocarbon removal from the smeared zone in saturated condition will be relatively slow by dissolution of benzene and other hydrocarbons in the ground water since partitioning

greatly favors the hydrocarbon phase. Also, biodegradation in the saturated zone will be slow due to lack of oxygen.

When water levels drop such that the smeared zone becomes unsaturated, the opportunity for remediation is greatly improved. The volatile components, including benzene, are relatively easily removed by vapor extraction. In addition, the "unsaturated zone... is the most biologically active and varied subsurface environment," (Chapelle, 1993). The vapor extraction will result in an increase in biological activity by increasing the amount of oxygen available, as soil gas containing higher concentrations of oxygen flows in to replace the extracted gas.

4.2.2 Dissolved Phase Hydrocarbons

Ground water samples are collected quarterly from several offsite and onsite wells. These are analyzed for BTEX and Total Petroleum Hydrocarbons as Gasoline (TPHG). The results are documented in quarterly ground water monitoring reports. The distribution of benzene concentrations for the third quarter 1994 ground water samples are shown in Figure 4-3.

The concentration contours indicate there are two primary ground water plumes plus the plume associated with the Ultramar Service Station underground tank leak. Highest concentrations are in the north plume in wells P2 (1,800 ug/l) and MW-28S (1,200 ug/l). Concentrations in the south plume are much lower, but the plume covers about twice the area of the north plume.

Based on concentrations of benzene in soil samples at or below the water table in the vicinity of wells MW-25D and MW-47D (Figure 2-12, Cross Section D-D'), it is possible that another plume exists in this area. The shallow ground water well MW-25S may be screened too deep to have detected the plume. This possibility is addressed in other sections of this report (Sections 7.3, 8.1 and 9.3).

Dissolved benzene is limited to near the ground water table. This is substantiated by the observations that (1) deeper wells into aquifer 2 consistently show no detected benzene and (2) shallow wells with submerged screens show much lower concentrations (often non-detected) than nearby wells screened within the water table.

Benzene in the ground water varies with water elevation. When water level was at its highest, in the second quarter of 1993, benzene concentrations were generally highest. In November 1991 when water levels were at the lowest since monitoring began, benzene was

not detectable in most wells. This implies that concentrations of benzene in the ground water are significant only when the water is moving directly through oily soil.

4.3 Naturally Occurring Hydrocarbons

Naturally occurring hydrocarbons have been identified in and around the site. These include liquids from natural seeps (Technical Memorandum No. 2 [ESI, 1993a]) and natural gases emitting from deep within the earth. As described in Section 2.0, Site Description and Refined Site Hypothesis, the San Cayetano Fault zone apparently underlies the site and provides a potential pathway for both gas and liquid to contact the ground water.

4.3.1 Natural Seeps

Several natural seeps have been identified in areas around the site (Technical Memorandum No. 2 [ESI 1993a]). It is very likely that the faulting and landslides at the site have placed such natural liquids in the saturated and vadose zones at the site. Frequent reference in the boring logs to oil in fractured shale (Table 4-1), and even "oil shale," support this hypothesis.

The forensic studies reported in Technical Memorandum No. 2 showed benzene in the seep samples ranging from 220 mg/l to 900 mg/l. Such material could certainly represent a significant source for benzene.

An unusual finding of the forensic studies was the presence of the compound 2,2,4-trimethylpentane (iso-octane) at concentrations on the order of several percent in the seep liquids, but not in a crude oil sample from an oil field in the area. This compound is generally found only in trace amounts in nature. In fact, it is so unusual that the laboratory ran confirmatory tests using GC-MS, before they even reported it. It is not apparent why the compound is present in the seep oils, but the fact that it has been confirmed in samples from two widely separated natural seeps is significant.

The presence of this compound is significant in that it also has been found in the vapor and condensate samples from well PEW-3 at the site, yet the refining processes (distillation, thermal cracking and polymerization) would not have produced significant yields of 2,2,4-trimethylpentane. This compound is made in refineries by alkylation reactions in which butane and isobutylene react catalytically to form iso-octane. The Fillmore refinery did not have an alkylation process. Chemical conversion at Fillmore was limited to thermal cracking of heavy oils and thermal and catalytic polymerization of the olefins produced by the cracking. These processes do not produce 2,2,4-trimethylpentane.

Thermal cracking processes tear apart the larger molecules and produce smaller molecules, including a large proportion of olefins. Olefins are unsaturated, reactive hydrocarbons. The cracking reaction is summarized as:

$$\text{Heavy oil} \xrightarrow[1000°F]{} CH_4 + H_2 + \text{olefins} + \text{paraffins} + \text{aromatics} + \text{coke}$$

The light olefins are polymerized over a catalyst to produce gasoline range hydrocarbons. The following example shows how isobutylene is polymerized to make iso-octene.

$$\underset{\text{isobutylene}}{2\,C_4H_8} \rightarrow \underset{\text{iso-octene}}{C_8H_{16}}$$

Note that iso-octene is an olefin and differs from iso-octane which is a paraffin and which is made in the following alkylation reaction:

$$\underset{\text{butane}}{C_4H_{10}} + \underset{\text{isobutylene}}{C_4H_8} \rightarrow \underset{\text{iso-octane}}{C_8H_{18}}$$

An excerpt from the textbook "Petroleum Processing" (Hengstebeck, 1959) is included as Appendix K for the reader who wishes to learn more about polymerization and alkylation.

It is concluded that the presence of 2,2,4-trimethylpentane in the vapor and condensate samples is evidence of the presence of natural seep liquids at the site.

4.3.2 Natural Gas and Gas Condensates

Gas samples from the site have shown very high concentrations of methane in many wells, both on and offsite. As high as 56 percent methane was measured in gas well PEW-1. The distribution of methane in the soil gas is shown in Figure 4-4.

The highest concentrations of methane are present in wells in the lower vadose zone next to the water table. Wells with screens more than 20 feet above the water table still showed significant methane concentrations, but these were about an order of magnitude lower than in the deeper wells. This indicates the methane is somewhat confined below a low-permeability soil unit. It apparently is emitted through the fault zone and spreads laterally toward the west.

Further evidence of a layer confining the gas is provided by pressure measurements during soil gas extraction from PEW-2 in September 1994. Well MW-38S, only 12 feet from

PEW-2, but screened starting 11 feet below the bottom of PEW-2, showed a positive pressure of 0.2 inches water while PEW-2 was under a negative pressure (i.e., vacuum) of 4.4 inches water. Well PEW-4, 30 feet from PEW-2 and screened in about the same depth interval as PEW-2, showed a negative pressure of 0.1 inches water (Figure 2-12, Cross Section D-D'). This shows significant vertical resistance to gas movement.

Table 4-5 shows the soil gas hydrocarbon distributions for samples from six wells. Gas samples collected from these wells show notable concentrations of light hydrocarbons in the carbon number range 3 to 5 (propane, butane and isobutane, and pentane and its isomers) (Addendum No. 2 to Technical Memorandum No. 6, [ESA, 1994d]) These are very volatile compounds (propane, butane and isobutane are gases at ambient conditions) and are the first to disappear from spills of gasoline and other light hydrocarbons. Since the refinery has been shut down for more than 40 years, it is highly unlikely that these would still be present from refinery operations. In addition, such hydrocarbons in a refinery are valuable products that certainly would not be part of the waste streams. That these are present in high concentrations in gas samples indicates that they are coming from the deep earth along with the methane.

To confirm the hypothesis that the methane is natural deep earth methane, gas samples were collected from four wells (Appendix C) and gas condensate samples from well PEW-3. These were tested at GGC (ESA, 1994g). Carbon isotope ratio tests indicated the methane is mostly thermogenic (deep earth origin), but includes some biogenic (produced by biodegradation of hydrocarbons) methane. The tests indicate that carbon dioxide in the gas is of more recent origin and is probably produced in the biodegradation processes. The compound 2,2,4-trimethylpentane found at relatively high concentrations in the gas and condensate from well PEW-3 indicate that at least some of the hydrocarbons are from the natural seep liquids discussed in Section 4.3.1, Natural Seeps.

Natural gas produced in this area is from oil fields, and as such is saturated with light hydrocarbons from the crude oil. Such gas is referred to in the oil and gas industry as "wet gas" because hydrocarbon liquids condense when the gas is cooled and/or compressed. A 1928 annual report for the Texas Company described the collection of such condensates from raw natural gas pipelines to use as fuel in the engines that powered the gas compressors (Appendix D).

Figure 2-1 shows the presence on the site of an historic gas separation plant operated by the Richfield Oil Company. Gas separation plants recover the higher molecular weight hydrocarbons from natural gas and produce a high purity methane for distribution to consumers. The presence of this plant is further evidence that the natural gas produced from nearby oil fields contained higher molecular weight hydrocarbons. Gas coming up

through the fault zone would contain these same condensable hydrocarbons which include benzene.

Samples of gas and gas condensates from the Shiells Canyon field about a mile or so south of the site were collected for comparison with samples from the project site wells. Gas pipelines from several Ventura County gas fields join at the Shiells Canyon field. A condensate sample from the combined gas was also collected for comparison. The gas and condensate samples were analyzed by GGC for the same parameters as for the project site gas and condensate samples. The results show the following:

- **Benzene concentrations of all the condensates were fairly high**, ranging from 2,600 mg/l for condensate from PEW-3 (condensed using ice water) to 8,250 mg/l for the combined natural condensate collected from the Shiells Canyon site. By contrast, benzene in a white gas sample was only 98 mg/l (Table 4-6).

- **Natural gas from Shiells Canyon contained 89 ppmv benzene.** A duplicate sample showed 97.5 ppmv.

- **Hydrocarbon distribution patterns of the natural condensates and the PEW-3 condensate are closely similar to each other but do not match those of any refined products.**

- **Carbon isotope ratios of methane in gas samples show that at least some of the samples appear to be from the same source as the natural gas from Shiells Canyon.** Carbon isotope ratios of methane from a January 1994 gas sample from PEW-3 (-42.96°/oo) and the sample from Shiells Canyon (-44.17°/oo) indicate these are probably source related. The carbon isotope ratio of methane in the April 1994 sample from PEW-3 (-52.73°/oo) and in January 1994 samples from PEW-1, AEW-1 and MW-39S (-50.12°/oo, -52.57°/oo and -54.19°/oo) indicate there is some biogenic methane mixed with the thermogenic methane, thus complicating the comparison. (The more recently formed biogenic methane contains higher proportions of the ^{12}C isotope, resulting in much larger negative numbers for the isotope ratio.)

  Carbon isotope ratios of the Shiells Canyon and onsite liquid samples (including the oil sample from well EW-4) fall in a very narrow range of -22.26°/oo to -22.41°/oo which are typical of California type Monterey Formation crude oils and/or condensates. This finding indicates that they are probably source related.

Additional evidence of gas emissions from natural sources comes from reports by Southern California Gas Company (SCG) of suspected gas leaks in the Fillmore area (SCG, 1994).

SCG had these analyzed and confirmed that this was not gas from their pipeline. Two recent reports are as follows:

- March, 1994. About 2.5 miles southeast of the site across the Santa Clara River. Reported as 1/5 mile east of 202 Guilberson Road.
- June, 1994. About 1 mile southwest of the site across Telegraph Road. Reported at River Street and Highway 23.

4.4 Benzene Fate and Transport

4.4.1 Benzene Partitioning Among Phases

Benzene in the soil partitions among the various phases present (1) the oil phase (residual hydrocarbons or free LNAPL), (2) the water phase (soil moisture in the vadose zone, ground water in the saturated zone), and (3) in the vadose zone, the soil gas phase. If organic matter such as humic and fulvic acids are present in the soil, benzene will also adsorb onto whatever portion of this organic matter is accessible. (Adsorption of benzene on soil organic carbon is relatively minor compared to benzene in the oil phase and is not considered in the analysis that follows.) Benzene will diffuse out of the source material and into the other phases in an attempt to establish equilibrium among all phases present. Figure 4-6 illustrates phases which may be present in vadose soil.

Benzene is by far the most water soluble of all the hydrocarbons. The higher molecular weight hydrocarbons which make up the bulk of the TPH at the site have very low solubilities in water and tend to stay mainly in the oil phase. The lower molecular weight hydrocarbons, containing up to about 12 or 13 carbon atoms will also distribute to the gas phase.

4.4.1.1 Benzene Oil/Water Partition Coefficient

All hydrocarbons, including benzene, are much more soluble in the oil phase than in the water. A partition coefficient may be estimated to enable calculation of the equilibrium concentrations in the oil and water phases. For all practical purposes that partition coefficient is constant at constant temperature. At equilibrium between two liquid phases, the activity of a compound in Phase 1 must equal the activity of the compound in Phase 2. Activity is defined as concentration, expressed as mole fraction, multiplied by activity coefficient. This is expressed as follows:

$$\gamma_1 x_1 = \gamma_2 x_2$$

$$x_1/x_2 = \gamma_2/\gamma_1$$

where x_1 and x_2 are concentrations in Phase 1 and Phase 2 and γ_1 and γ_2 are activity coefficients for the compound in each of those two phases. This says the concentration ratios are inversely proportional to the activity coefficient ratios.

The more non-ideal the solution, the larger the activity coefficient. Benzene in a mixture of similar compounds, such as toluene, ethyl benzene and xylenes would be nearly an ideal solution and the activity coefficient would be essentially equal to 1.0. For other oil mixtures the activity coefficient would be slightly higher, depending on the types of molecules present. An activity coefficient of 1.15 has been assumed for this analysis.

The activity coefficient of benzene in water is simply the inverse of the solubility, with concentration expressed as mole fraction rather than the usual mg/l. Thus, at 25° C the activity coefficient of benzene in water is:

$$\gamma_2 = 1/(1.75\ g/l \times 1 gmole\ benzene/78\ g \times 1l\ water/1{,}000g \times 18g\ water/gmole)$$

$$\gamma_2 = 2{,}480$$

Then, $x_1/x_2 = \gamma_2/\gamma_1 = 2{,}480/1.15 = 2{,}150$

That means on a mole fraction basis, the equilibrium concentration of benzene in the oil phase is 2,150 times the concentration in the water phase. To convert this to more familiar units of concentration, mg benzene/kg oil and mg benzene/l water, assume an average molecular weight of 140 for the oil. Then,

$$c_1/c_2 = (x_1/x_2) \times (MW_2/MW_1) = 2{,}150 \times (18/140) \approx 280$$

At 20° C the ratio will be a few percent higher than at 25° C, but the oil phase average molecular weight and benzene activity coefficient in the oil are not known with sufficient accuracy to justify an adjustment. Therefore, at equilibrium, the concentration of benzene in the oil phase will be about 280 times the concentration in the water phase using typical reporting units. The practical implication of this is that to reach the ground water concentration goal for benzene of 1 μg/l, the concentration in the TPH phase in the saturated zone must be less than 0.3 mg/l for stagnant ground water conditions. With moving ground water, equilibrium will never be reached and residual concentrations of benzene in TPH can be much higher.

4.4.1.2 Benzene Equilibrium in Soil Gas

The equilibrium concentration of benzene in the soil gas is calculated using the Henry's Law Constant and the concentration of benzene in water. Henry's Law Constant for benzene at 20° C is:

$$H = 5.6 \times 10^{-5} \text{ atm/(mg/l)}$$

and concentration in the gas in parts per million by volume (ppmv) is:

$$p_2 = H \times c_2 \times 10^6 \text{ ppmv}$$

or, at 20° C, $p_2 = 56\ c_2$ ppmv. This means to achieve 0.001 mg/l benzene in ground water under conditions of equilibrium with the vapor, the vapor concentration in contact with the water can be no more than 0.056 ppmv. (Moving ground water and poor contact between soil gas and water will result in non-equilibrium conditions and lower concentrations in the water where the benzene is transferring from the gas phase to the water phase.)

4.4.1.3 Benzene Distribution

Based on the equilibrium considerations discussed above and measured concentrations of TPH and benzene in soil samples, the equilibrium distribution of benzene has been estimated for several samples in the vadose zone and the smeared zone. The smeared zone has been treated as a saturated zone for the purposes of these calculations. Calculated equilibrium concentrations in the TPH, water and gas phases and their averages are presented in Table 4-7. The key assumptions for the calculations are listed on the table.

Relative distribution of the benzene mass among the three phases is also shown in Table 4-7 as a percent of total benzene in the subject sample. Also, an average weighted by TPH concentration in soil is calculated for the concentrations in each phase and for the mass distribution among phases. The weighted average probably better represents the mass distribution. The median of each is presented as well.

From Table 4-7, the following observations are made:

- Based on medians, averages and ranges of concentrations it appears that **benzene concentrations in the soil are generally higher in the vadose zone** than in the smeared zone. Three very high concentrations of benzene in soil (94, 24, and 18 mg/kg) distort the vadose zone range, but even without these, the next highest

benzene concentration is 4.6 mg/kg. The highest concentration found in the smeared zone is 1.8 mg/kg.

- **Most of the benzene is present in the oil (TPH) phase**, on the order of 80 to 90 percent. In the saturated zone at equilibrium, the mass of benzene in the oil phase would be about six times the amount in the ground water. In the vadose zone, at equilibrium there would be about 30 times as much benzene in the TPH and soil moisture as in the gas phase.

- **Equilibrium benzene vapor concentrations** in the vadose zone range from 1 to 580 ppmv, **average between 120 and 180 ppmv**, and have a median of 73 ppmv.

- **Equilibrium benzene concentrations in ground water** in the smeared zone samples range from about 0.01 to 5.6 mg/l, **average between 0.6 and 1.2 mg/l** and have a median of 0.45 mg/l.

This analysis indicates that in order to attain equilibrium concentrations of benzene in ground water equal to the clean up goal of 1 μg/l, the concentrations of benzene in the oil phase in the saturated zone must be no more than 0.28 mg/kg. This means for TPH in soil at 1,000 mg/kg, benzene in soil must be no more than 0.0004 mg/kg. For 4,000 mg/kg TPH benzene must be less than 0.0012 mg/kg. True equilibrium will not be attained, so residual benzene would be much higher, but still would be quite low.

For further insight into the benzene distribution, the areas of known and potential benzene on the cross sections (Figures 2-9 through 2-13) were estimated and compared as shown in the table below. The comparison indicates that, of the soil containing benzene, over 70 percent is above the high water elevation. This, coupled with the concentration averages discussed above, indicates that 80 to 90 percent of the benzene present is above the high water elevation, and 10 to 20 percent is within the smeared zone. The following example shows how the relative mass distributions of benzene were estimated:

From the soil distribution table, for all five cross-sections, 71.5 percent of <u>soil</u> which may contain benzene is above the smeared zone. From Table 4-7, average benzene concentration in soil above the smeared zone is 1.6 mg/l and within the smeared zone is 0.6 mg/l. Then the relative mass of benzene above the smeared zone is estimated as:

$$(71.5 \times 1.6) / (71.5 \times 1.6 + 28.5 \times 0.6) \times 100\% = 87\%.$$

For a given section the relative amount may be more or less.

Relative Distribution of Benzene-Containing Soil

Confirmed or Potential Benzene	Above or Below Smeared Zone	Cross Section					Total
		A	B	C	D	E	
Confirmed	Above	1.5	1.3	3.2	10.8	2.3	19.1
Potential		17.4	21.0	4.6	7.0	2.3	52.4
Subtotal		*18.9*	*22.3*	*7.8*	*17.9*	*4.6*	*71.5*
Confirmed	Below	0.0	2.7	0.2	2.8	1.4	7.0
Potential		0.8	12.1	1.9	3.2	3.4	21.5
Subtotal		*0.8*	*14.8*	*2.1*	*6.0*	*4.8*	*28.5*
Total		19.7	37.1	9.9	23.8	9.4	100.0

4.4.2 Potential for Benzene Migration from Vadose Zone to Ground Water

Benzene in the soil gas is much more mobile than benzene in the other phases. As such, there is potential for benzene at high concentrations in the soil gas to migrate to the ground water. By comparing the measured concentration of benzene in ground water with the concentrations which would be in equilibrium with the measured benzene vapor concentrations, it can be determined whether the potential diffusion driving force is from the gas phase to the water phase or from the water phase to the gas phase. Table 4-8 shows the results of such calculation for all the benzene vapor measurements made through August 12, 1994.

The column labeled "Migration Potential" in Table 4-8 indicates the potential for benzene to migrate between the ground water and soil gas phases. The check mark indicates that the equilibrium and measured water concentrations are in order of magnitude agreement so there is little or no potential to migrate between phases. A downward arrow indicates there is benzene migration potential from gas to water, and an upward arrow indicates potential migration from water to gas. Areas in which the migration potential is from the gas phase to the liquid phase are shown in Figure 4-6.

However, the potential alone is not sufficient to result in contamination. There must also be a pathway from the soil gas to the ground water. As discussed in Section 4.1.3, Soil Gas, migration of benzene from the upper portions of the vadose zone (Figure 4-2) may be severely restricted by the intervening fine-grained soils. In those areas in which the

equilibrium benzene concentrations are much larger than the measured water concentrations, the benzene vapor apparently is not in intimate contact with the ground water. Areas in which such resistance to migration is particularly apparent are those around;

- PEW wells 2 through 6, and well MW-38S,
- wells AEW-1 and MW-37S, and
- well EW-4.

It is not clear why ground water wells MW-37S, MW-38S and EW-4 show such a large difference between equilibrium and measured benzene concentrations since the well screen is continuous from the saturated zone into the vadose zone. The soil immediately above the water table must be sufficiently tight to minimize contact between the benzene vapor and the water.

4.4.3 Natural Degradation of Benzene

There is strong evidence that natural degradation of benzene is limiting the size of the benzene plume. Consider the following:

- **Benzene in the ground water has not moved far from the site.** Detectable benzene in ground water is limited to a few hundred feet downgradient of the site boundary. Plant operations started more than 70 years ago and ended more than 40 years ago. With ground water velocities on the order of a few hundred feet per year, the ground water would have carried the plume thousands of feet from the site in that time. Also, any natural hydrocarbons under the site would have been supplying benzene to the subsurface for centuries.

- **Aerobic biodegrading bacteria are present.** The biodegradation testing discussed in Section 6.0, Remedial Testing and Research, shows the presence of aerobic hydrocarbon degraders in each of three soil samples and three water samples from six different locations at the site. Low concentrations of oxygen and nutrients result in slow degradation, but with sufficient time the dissolved hydrocarbons will be biologically degraded. Benzene is one of the easier hydrocarbons to biodegrade (Chapelle, 1993). A simplified representation of the degradation reaction is:

  $$\text{Benzene} + O_2 \rightarrow CO_2 + H_2O + \text{biomass}$$

- **Anaerobic biodegradation is also active at the site.** Carbon isotope testing of methane in several gas samples from wells at the site indicate a mixture of biogenic and thermogenic methane. Biogenic methane is produced by anaerobic

biodegradation of hydrocarbons. One possible route for anaerobic degradation of benzene makes use of the reduction of iron from the ferric form (Fe^{+3}) to the ferrous form (Fe^{+2}) (Chapelle, 1993):

$$\text{Benzene} + Fe^{+3} + H_2O \rightarrow Fe^{+2} + CO_2 + CH_4 + \text{biomass}$$

Thermogenic methane is from oil and gas reservoirs deep in the earth. The test report by GGC for four gas samples is included as Appendix C.

- **Disappearance of benzene when water table is low.** In 1991, when ground water level dropped below the smeared zone, benzene virtually disappeared from the water. This indicates that natural forces deplete the benzene from the water as soon as the water is no longer in contact with the residual hydrocarbons which function as a reservoir for the benzene.

- **High ratios of carbon dioxide to nitrogen in the soil gas indicate biological activity.** A deficiency of oxygen and elevated concentrations of carbon dioxide in the soil gas are indications of biological activity in the subsurface. These components are assumed to be derived from oxygen in air which has entered the subsurface, but dilution of infiltrated air by other gases such as methane complicates testing of the assumption. Air is about 21 percent oxygen and 78 percent nitrogen by volume, so the oxygen/nitrogen volume ratio of air is about 0.27. (Carbon dioxide in atmospheric air is only about 0.03 percent.) The ratios of oxygen to nitrogen and carbon dioxide to nitrogen are compared, rather than the actual concentrations, to eliminate the effect of dilution by other gases such as methane, because the ratio will stay the same whether no methane has entered the area or 50 percent of the gas is methane.

Aerobic biodegradation of hydrocarbons causes depletion of oxygen and generation of carbon dioxide. Based on complete oxidation of an assumed average hydrocarbon composed of two hydrogen atoms per carbon atom (H/C = 2), for each one and a half moles of oxygen consumed, one mole of carbon dioxide would be generated according to the following equation:

$$-CH_2- + 1.5O_2 \rightarrow CO_2 + H_2O$$

If consumption of the oxygen were complete, the O_2/N_2 ratio would be zero and the CO_2/N_2 ratio would be 0.18 (= 0.27/1.5). If the oxygen were not all consumed the CO_2/N_2 ratio would be less than 0.18. Factors that could result in ratios higher than 0.18 are (1) off-gassing of CO_2 from the bicarbonate rich ground water and (2)

oxidation of hydrocarbons with lower hydrogen to carbon ratios. (However, H/C is expected to be closer to 2 than to 1. On average, crude oil H/C ratio is about 1.85 (Testa, 1991)).

Figure 4-7 shows the ratios of carbon dioxide to nitrogen and oxygen to nitrogen in the soil gas in and around the site. The coincidence of areas of high CO_2 and low O_2 with areas of elevated hydrocarbon content of soil or soil gas indicates significant biodegradation has taken place in areas containing the food supply (hydrocarbons) for the bacteria. A relatively high O_2/N_2 ratio (e.g., >0.1) indicates either a slower rate of biodegradation than in other areas or a higher rate of fresh air infiltration into this area.

These factors indicate that if the benzene source areas were controlled to prevent migration of benzene from the site, benzene downgradient of the site would disappear naturally.

5.0 PHASE 1 REMEDIATION

5.1 Vapor Extraction System

5.1.1 System Operation

RETOX Operation: A regenerative thermal oxidation (RETOX) vapor extraction unit was installed and began operation at the site in December 1993, under permission granted by the EPA in their letter dated December 9, 1993. The purpose of installing the RETOX system at the site was to achieve some degree of remediation and to obtain information for Phase 2 remedial system design.

The system operation was started on January 3, 1994. See Table 5-1 for system operating data and estimated amount of hydrocarbons removed during RETOX operation. A total of 12,100 pounds of hydrocarbons is estimated to have been removed by the RETOX during the Phase 1 period, mostly from well PEW-3. Benzene has averaged about one percent of volatile fuel hydrocarbons, so estimated benzene removal is approximately 120 pounds during RETOX operation.

Upon commencing operation of the system, unexpected high concentrations of volatile organic compounds (VOCs) and methane in the extracted soil gas required the addition of a high percentage of dilution air so as to not exceed the treatment capacity of the RETOX system. The addition of this dilution air significantly reduced the flow rate from the extraction wells, thus, severely compromising the value of information gathered by this system. The RETOX system ceased operation on May 11, 1994 and was consequently disconnected and removed from the treatment compound.

VR Systems Model V4 Operation, Short-term and Long-term: A 5-day vapor extraction test, using a VR Systems Model V4, was conducted on March 14 through 18, 1994 to provide information to aid in the selection of a more optimal system than RETOX. The testing results are presented in Addendum No. 2 to Technical Memorandum No. 6, dated May 4, 1994, and are summarized in Section 6.0, Remedial Testing and Research, of this design report.

Based on results of the 5-day vapor extraction test, a VR Systems Model V4 (V4) was installed and connected to well PEW-2 in June 1994 to provide design data for longer-term operation. Three additional vapor extraction/monitoring wells (PEW-4 through PEW-6) were installed in the vicinity of well PEW-2. These new vapor wells were used to obtain vacuum response data during vapor extraction at well PEW-2 and to estimate the effective radius of influence (ERI) in this vicinity.

Vapor extraction system operation in well PEW-2 started on June 10, 1994. Through December 7, 1994, a total of 70,000 pounds of hydrocarbons, including about 400 pounds of benzene, are estimated to have been removed by the V4 from the site. System operating data and estimated quantity of hydrocarbons removed during V4 system operation are presented in Table 5-1. Detailed test results are presented in Section 6.0, Remedial Testing and Research.

5.1.2 Condensate

During operation of the RETOX system, hydrocarbon condensate was observed in the knock-out pot of the system and subsequently was transferred to a 4,000-gallon holding tank. On April 1, 1994, approximately 23 gallons (150 pounds) of the condensate was collected and disposed of during Phase 1 operation. Refer to Section 4.0, Subsurface Hydrocarbon Distribution, for the results of the laboratory analysis of the condensate and further discussion.

5.2 Ground Water Treatment System

5.2.1 System Operation

The Phase 1 ground water extraction and treatment system was installed and began operation at the site in December 1993. The system consisted of three extraction wells, two bag filters for suspended solids removal, and a granular activated carbon (GAC) adsorption system (two vessels in series) for treating dissolved hydrocarbons in the extracted water. The treated water was discharged into Pole Creek under a NPDES permit.

The purpose of the Phase 1 ground water treatment system operation is to achieve a degree of remediation and to capture ground water containing high levels of benzene. In addition, the Phase 1 system operation was also designed to provide data necessary for the design of a full scale Phase 2 remediation system. As discussed in Section 6.0, Remedial Testing and Research, several tests were incorporated into the Phase 1 system operations. As a result of tests conducted and problems experienced with suspended solids in the extracted water and carbon fouling, the ground water treatment system operation was disrupted several times during the Phase 1 period.

Three extraction wells, EW-1, MW-19S, and MW-28S were initially connected to the treatment system. The system operated with this well field configuration from December 15, 1993 through February 24, 1994, when the system was shut down after detection of GAC vessel breakthrough of benzene. During this period, the system was operated continuously except for frequent shutdowns resulting from bag filter clogging and changeouts.

In an effort to reduce the amount of solids entering the system, three new extraction wells, EW-2, EW-4 and EW-5, were designed and installed in May and June 1994. Upon installation, the three new wells were connected to the treatment system and wells MW-19S, EW-1, and MW-28S were disconnected. A series of tests were conducted in July and August 1994. Due to flow capacity limitations of the equipment being tested, flow rates ranged from 5 to 20 gpm for system operations during this period.

When the ground water treatment system was in operation, weekly system monitoring was conducted. Samples were collected in accordance with NPDES permit requirements and/or for evaluation of the treatment system and testing. During Phase 1 ground water system operation (through November 1994), approximately 4,913,000 gallons of water was extracted and treated. Based on the total volume of water extracted and TPH and benzene concentrations detected in the water samples, it is estimated that approximately 142 pounds of TPH and 12.6 pounds of benzene were removed in the dissolved phase with the extracted ground water. Table 5-2 summarizes the Phase 1 ground water treatment system operations and the amount of hydrocarbons removed.

5.2.2 Solids Removal

The presence of extremely fine suspended solids and high concentrations of certain dissolved solids in the ground water resulted in a decrease in the performance of the ground water treatment system. Oily suspended solids fouled the activated carbon which contributed to premature breakthrough of benzene. Additional studies revealed formation of some of the suspended solids was the result of precipitation of dissolved solids after extraction from the wells.

Studies and bench scale testing focused on suspended and dissolved solids removal or fixation during the Phase 1 testing program. The following pilot systems or testing programs were evaluated:

- Dissolved Air Flotation System
- Reverse Flow Centrifuge System
- Solids Settling
- Granular Media Filter
- Lime Treatment

Refer to Section 6.5, Evaluation of Ground Water Solids Removal Alternatives, for the details and results of these tests.

5.2.3 Granular Activated Carbon

Breakthrough of benzene from the GAC beds was detected on February 11, 1994, after approximately 2 months of system operation. During the 2 months of operation, influent water flow ranged from 0 to 50 gpm and hydrocarbon concentrations averaged 4 mg/l TPH and 350 μg/l benzene. Based on the information provided by the GAC vendor, each carbon bed should have lasted more than 300 days at these concentrations and flow rates. During the investigation of this early fouling of GAC vessels, visual and lab tests were performed. It was determined that vessels were about two-thirds filled with gas and the carbon was encrusted with solids. The vessels were subsequently modified to vent gases and to keep them liquid-full. Refer to Addendum No. 1 to Technical Memorandum No. 8, (ESA, 1994e) for details of the testing results and modifications performed for the carbon vessels.

After the modifications were completed, the spent carbon was replaced with 20,000 pounds of virgin bituminous carbon (mesh size 8 x 30) by Northwestern Carbon. The spent carbon was manifested and transported offsite for regeneration.

The modified carbon vessels began treating ground water on July 1, 1994. The ground water treatment system was shut down on September 14, 1994, when naturally occurring concentrations of total dissolved solids (TDS) exceeded the NPDES permit limit. The carbon vessels were opened and examined after the system was shut down. A thin layer of orange solids was observed at the very top of the carbon in vessel A. Samples collected about a foot below the top of the carbon appeared clean and normal in appearance. The layer of solids was thin and segregated and is most likely the result of hard water and iron deposits from the extracted ground water. Backwashing should prove helpful in removing most of this layer of solids.

5.2.4 NPDES Testing

The NPDES permit was granted on December 6, 1993 and the ground water treatment system began operation on December 17, 1993. The treated water is discharged to Pole Creek approximately one hundred feet southwest of the treatment pad (Figure 1-2). Pole Creek flows into the Santa Clara River approximately one-half mile south of the discharge point. Table 5-3 presents the required monitoring and sampling schedule for the current NPDES permit and Table 5-4 indicates the discharge limits.

The system was shut down on February 25, 1994 when effluent concentrations of TPH and benzene were found to be slightly above the daily maximum discharge limit of the permit (Texaco, Inc., 1994a). An investigation was conducted and remedies were implemented in June 1994.

System operation resumed on July 1, 1994 and continued through September 14, 1994 at which time the effluent concentration of total dissolved solids (TDS) was found to exceed the daily maximum discharge limit of 1,200 mg/L. Table E-1 summarizes historic TDS concentrations in site wells and Figure E-1 is a graphical representation of historic TDS in offsite wells located near the PCPL site. As shown by Figure E-1, natural TDS concentrations in the area are relatively high. Therefore, the TDS upset is the result of naturally occurring water components, rather than contamination resulting from activities at the site. General mineral analyses from site wells indicate that the TDS consists of about two-thirds bicarbonates of calcium and magnesium.

Measured TDS levels upstream of the discharge point in Pole Creek and in the receiving waters (Santa Clara River) have frequently exceeded the TDS discharge limit (WWI, 1994;ESA, 1994f,j; and Appendix E). Calculations using Santa Clara River flow at the 1993 (Figure 2-6; UWCD, 1994) low rate, the lowest upstream TDS concentration in the river, and a discharge of 1,600 mg/L TDS at 100,000 gallons per day, show the TDS concentration in the river would only increase by 1 mg/L which cannot be detected by normal analytical methods.

Based on this analysis, a written request was made to the Executive Officer at the RWQCB to allow continued operation of the Phase 1 system with an increased TDS limit. The RWQCB authorized continued operation of the Phase 1 system with a stipulation that the mass discharge rate of TDS in the effluent must not exceed the permitted daily maximum of 1,000 lbs/day and the discharge must not cause the water quality objectives in the Santa Clara River to be exceeded (both letters are included in Appendix E).

GWTS operation resumed on October 25, 1994 and continued through December 3, 1994 when the effluent concentration of sulfate from the November sampling exceeded the daily maximum discharge limit. A sample collected prior to system shut down on December 3 was analyzed for sulfate and the results were below the daily maximum limit. The RWQCB indicated that the system operation could continue as long as sulfate remains below the limit for four consecutive weeks. GWTS operation resumed on December 7, 1994.

Once approval of the final Phase 2 design is granted, an application for a new NPDES permit for the larger capacity Phase 2 system will be submitted.

6.0 ADDITIONAL REMEDIAL TESTING AND EVALUATION

6.1 Vapor Extraction Testing

As discussed in Addenda Nos. 1 and 2 to Technical Memorandum No. 6 (ESA, 1994a,d), vapor extraction tests were conducted at the site using a VR Systems Model V4. These tests were conducted to obtain additional information for the design of the Phase 2 remedial system.

Short-term Vapor Extraction Tests:

On March 14 through 18, 1994, five short-term vapor extraction tests were conducted at the PCPL site using a VR Systems Model V4 internal combustion engine (IC engine) unit. During each test, soil gas was extracted from one well while vacuum responses were observed in nearby wells and observation probes. Soil gas was extracted from wells PEW-1, PEW-2, PEW-3, SBB-1, and SBD-2. The duration of each test ranged from 1 to 48 hours. Test data and analytical results were presented to the EPA in Addendum No. 2 to Technical Memorandum No. 6 (ESA, 1994d).

Using the concentrations and flow rates achieved during the tests, hydrocarbon removal rates for each test were calculated. Air permeabilities were estimated from flow rate and pressure (vacuum) measurements. Table 6-1 summarizes the test results.

The following are concluded from the test:

- The vapor extraction tests revealed that satisfactory gas flow rates (17 to 103 scfm) may be achieved from the wells at relatively low vacuum levels (2.5 to 29 in. H_2O). Estimated gas permeabilities range from 8 to 80 darcies.

- Approximately 1,800 pounds of fuel hydrocarbons (hydrocarbons within C_6 to C_{15}) were removed and destroyed during the 5 days of vapor extraction tests. At the concentrations realized during the tests, total fuel hydrocarbons extracted from a single well at a flow rate of 100 scfm initially ranged from about 300 to 1,000 pounds per day.

- The tests were too short to determine how long the high levels of hydrocarbon removal will last. During the 48-hour test conducted on well PEW-2, no significant hydrocarbon concentration reduction was observed. A longer-term test, discussed below, was initiated to help in that determination.

- Laboratory analysis for fixed gases in extracted gas samples indicates low levels (2% to 4%) of oxygen. Typically, vapor extraction systems which utilize thermal oxidation as the vapor destruction mechanism require 15% to 18% oxygen to operate efficiently. Therefore, significant dilution of the extracted gas is required prior to oxidation. This required dilution will decrease the volume of gas which can be removed from the extracted wells.

Long-term Vapor Extraction Tests on PEW-2

A long-term vapor extraction test on well PEW-2 was started on June 10, 1994 using a VR Systems Model V4. The purpose of this test was to establish the hydrocarbon concentration decline curve and to evaluate the changes of oxygen, methane, and other gases as vapor extraction proceeded. Prior to the test, three vadose zone monitoring wells (PEW-4 through PEW-6) were installed near well PEW-2 to monitor the vacuum pressure changes. The newly installed vadose zone wells were also designed for potential vapor extraction. The well locations are shown in Figure 5-1.

Figures 6-1 and 6-2 show the time variation of concentrations of key components and cumulative mass of hydrocarbons removed. Through December 7, 1994, the following was concluded or achieved (Tables 6-2 and 6-3):

- Approximately 17,000,000 ft^3 of soil gas was extracted and treated in 180 days of system operation. Based on gas-filled porosity of the soil of 20 percent and an average thickness of the affected zone of 50 feet, that gas volume would have come from an area more than 700 feet in radius.

- Methane concentration decreased from 2.1% to 0.48%

- Oxygen concentration increased from 1.6% to as high as 4.4%. At this writing, it appears to have leveled off at slightly above 4 percent.

- Volatile fuel hydrocarbon concentration decreased from 22,000 ppmv to 13,000 ppmv, but has been as low as 12,000 ppmv.

- Carbon dioxide remained virtually unchanged at 14 percent by volume.

- In 180 days of system operation, approximately 70,000 lbs of total hydrocarbons and 400 lbs of benzene were removed. About 10 percent by weight of the hydrocarbons was methane.

- The slow change of oxygen concentration and lack of change of carbon dioxide concentration could indicate one or both of the following: (1) that little fresh air infiltration from the unpaved surface exists in the area influenced by this well; (2) most of the oxygen from infiltrated air is consumed by microbial action, producing carbon dioxide.

- Minimal vertical communication exists between the upper and lower vadose zones in the vicinity of well PEW-2. This is evidenced by the gas pressure measurement from extraction well PEW-2 and observation well MW-38S. Well MW-38S is located only 12 feet from well PEW-2. However, no vacuum pressure has been observed in this well. In fact, a positive pressure of 0.2 inches water was measured in MW-38S when a negative pressure of 4.4 inches was measured in PEW-2. This is attributed to the differences of the perforated intervals of the two wells, with MW-38S screened below a fine-grained layer of soil and PEW-2 screened above that layer. Well PEW-2 is screened from 20 to 45 feet bgs. Well MW-38S is screened from 56 to 86 feet bgs.

The decease in methane concentration in the extracted gas is expected to follow a first order exponential decay curve, if there is no replenishment of the extracted menthane. If there is a methane source, such as leakage from the deep earth, or microbial generation, the curve must be modified to account for the influx. As shown in Figure 6-3, the data fairly well fits a curve for exponential decay plus methane inflow at a constant rate. The development of the equation describing the process follows:

Assumptions:

- Methane concentration, c, is uniform within fixed soil gas volume, V_o.

- Soil gas is extracted at constant rate, Q.

- Methane mass in subsurface gas volume, V_o, changes by:

  1. Removal of methane by soil gas extraction (-cQ).

  2. Generation of methane or infiltration of deep earth methane at constant, R.

- Changing methane mass, m, within volume V_o is

$$dm/dt = -cQ + R \quad \text{(mass/time)}$$

and changing concentration is:

$$dc/dt = d(m/V_o) / dt = -cQ/V_o + R/V_o$$
(concentration/time)

- This integrates to:

$$\ln [(R - c_o Q) / (R - cQ)] = Qt/V_o$$
$$= V/V_o$$

where V is the volume extracted after time, t.

- This is rearranged to

$$c = R/Q + (c_o - R/Q) \exp(-V/V_o)$$

- Regression of the data gives

$$c = 4{,}040 + 7{,}800 \exp(-V/1.2) \text{ mg/m}^3$$

- For average Q = 0.0955 MMcf/d (66cfm), the parameters are

R = 24 lb/day

c_o = 12,000 mg/m^3 (18,000 ppmv)

V_o = 1.2 million cubic feet.

This means methane is being supplied to the zone of influence of the extraction well at a rate of 24 lb/day. The calculated methane concentration reached the asymptotic rate after about 4 months of extraction.

Vapor Concentration Tests

During August 9 through 12, 1994, vapor concentration tests were conducted at the site. A total of 35 vadose zone or ground water monitoring wells were tested. The purpose of these tests was to determine the subsurface vapor phase hydrocarbon and fixed gas distributions and air permeabilities at various locations of the site. A VR Systems Model V4 was used at each tested well head. A map showing all the wells tested, plus PEW-2

which is undergoing long-term testing (36 wells total), is presented as Figure 6-4. Laboratory analytical results and component distributions are discussed in Section 4.0, Subsurface Hydrocarbon Distribution and the laboratory data sheets are included in Appendix F.

Flow rates and well head vacuum applied during the tests are used for analyzing the permeabilities in the vicinities of the tested wells using the Johnson flow model. For wells which appear to have been affected by ground water upwelling when the vacuum was applied, a correction was made to account for less screened area available for gas flow. Wells with screen intervals that appeared to be completely submerged after applying a vacuum were not used for the calculations of air permeability. Calculated permeability values are presented in Table 6-4. The permeability values were used in modeling of the vadose zone gas movement described in Section 7.2, Vapor Extraction Modeling.

6.2 Vapor Condensation

As described in Section 4.1.3.2, Gas Condensate, hydrocarbon condensates were found in the vapor lines and knock out drum of the RETOX vapor extraction system during extraction from well PEW-3. Hydrocarbon distributions from six wells show a significant portion of the VOCs in the gases from these wells in the carbon number range C5 to C11. These are condensable under moderate conditions of temperature and pressure. Therefore, an alternative based on partial condensation of hydrocarbons has been considered. Methane and other light hydrocarbons (and probably even some of the C5 and C6 hydrocarbons) are apparently from natural sources and could be burned in a flare under Ventura County Air Pollution Control District Rules.

Preliminary calculations were made to determine if a significant portion of hydrocarbons could be recovered by condensation. Calculations were based on the hydrocarbon distributions presented in Table 4-5, for the five onsite wells listed on that table (MW-39S is offsite). The concept considered is:

- compression of the soil gas to 150 psia,
- partial condensation at 80°F,
- partial condensation at -25°F using refrigeration,
- flaring of the uncondensed hydrocarbons, and
- combining condensed liquids with crude oil to recover these as a beneficial product.

Results are summarized as follows:

Carbon No.	C3	C4	C5	C6	C7+
Percent Condensed	5 - 36	23 - 77	67 - 97	93 - 99.7	> 99

The preliminary calculations indicate the concept is technically feasible. However, there is considerable uncertainty about the length of time that the wells would continue to produce significant quantities of condensable hydrocarbons. Also, the EPA may not accept flaring of the non-condensible gas from a Superfund site without concrete evidence that all the uncondensed hydrocarbons are from natural sources. Therefore, this alternative has not been considered further.

6.3 Biotechnical Evaluation

Numerous empirical and field studies have established that the most significant factor in the time-dependent decrease of BTEX compounds in aquifers is degradation by soil microbes (Barker, et al., 1987; Chiang, et al., 1989, Gilham, et al., 1990; Kemblowski, et al., 1987; Thomas, et al., 1990). To evaluate the potential for intrinsic and engineered bioremediation of hydrocarbon impacted soil and ground water at the PCPL site, a three phase biotechnical investigation was undertaken. The first phase of the investigation was directed at characterizing the native physicochemical and microbiological parameters of the site. Subsequent phases of study focussed on evaluating the feasibility of manipulating the physicochemical parameters to enhance bioremediation.

The biotechnical investigation was performed by an expert independent consultant in the field of environmental biotechnology -- Mr. A. Keith Kaufman. Following is a synopsis of the results of the study. The entire report is attached as Appendix G and the reader should refer to this document for additional information.

6.3.1 Baseline Physicochemistry and Microbiology

Representative soil and ground water samples were tested to establish the baseline microbiological conditions at the site. Baseline conditions include qualifying the presence of indigenous microorganisms, establishing the proportion of indigenous microorganisms capable of degrading petroleum hydrocarbons (biodegraders), and evaluating the environmental physicochemical parameters for biodegrader compatibility.

6.3.1.1 Sample Collection

Representative, contaminated soil and ground water samples from various areas of the PCPL site were collected for biotechnical evaluation. The following three visibly

contaminated soil samples collected from monitoring and extraction well borings drilled in early to mid-May 1994 were selected for biotechnical evaluation:

- the 45 foot sample from boring MW-47D;
- the 60 foot sample from boring EW-4; and
- the 85 foot sample from boring EW-2.

Similarly, three ground water samples from three of the most contaminated monitoring/extraction wells were submitted for testing. Samples from wells MW-17S, MW-19S and P2 were collected using standard purging protocols during the second quarter 1994 ground water monitoring event.

6.3.1.2 Laboratory Testing

Physicochemical Testing

The above-described soil and ground water samples were evaluated for baseline physicochemical parameters (pH, nitrate, ammonium, phosphorous, and potassium) to determine the physicochemical "health" of the respective environments. The significant findings of the physicochemical tests indicate no apparent biotoxicity associated with the ambient environmental conditions. The tests did, however, indicate a deficiency of both reduced and oxidized forms of nitrogen. Furthermore, in situ measurements of dissolved oxygen in monitoring wells indicate that dissolved oxygen concentrations in ground water (0.64 mg/l, average of 46 data points) are very close to the critical concentration (0.5 mg/l) required for the promotion of aerobic activity (Riser-Roberts, 1992). In order to stimulate optimal biodegradative efficiency within the impacted matrices, supplemental nitrogen components in the form of ammonium nitrate and dissolved oxygen will be required.

Microbial Enumeration

Microbial enumeration of cultures developed from the soil and ground water samples reveals that a viable population of heterotrophic (def., the ability to derive energy and carbon for survival and growth from decomposition of organic materials) microorganisms exists within the saturated and vadose media underlying the site. Of the heterotrophic microorganisms present, a significant proportion (mean 25%, median 13%) of these possess the ability to degrade petroleum hydrocarbon. The presence of a significant population of indigenous hydrocarbon degraders supports the prospective use of biostimulation methods (optimization of the environmental conditions to encourage indigenous biodegrader growth) as opposed to bioaugmentation (the introduction of exogenous biodegrading microorganisms).

6.3.2 Biotreatability Studies

Soil and combined soil and ground water laboratory pilot studies were performed to evaluate the feasibility of manipulating the subsurface environmental conditions to optimize biodegrader performance (biostimulation). The tests were performed in two phases. The first phase involved treatment (nutrient and oxygen supplementation) of ground water only. The second phase included treatment of an integrated soil and ground water system.

6.3.2.1 Pilot Bioremedial Treatment of Ground Water

The test method involved the equal distribution of 3.7 liters of composited site-specific ground water to each of three one-gallon glass vessels. Each water sample was spiked with equal volumes of gasoline and diesel fuel (approximately 1,000 ppm total spike concentration). The first vessel was the control system and no nutrients or oxygen supplements were added. The second vessel received nutrients in the form of ammonium nitrate, but no supplemental oxygen and the third vessel received both nutrients and hydrogen peroxide as a source of dissolved oxygen. Each vessel was periodically mixed, loosely capped to allow for gas exchange, and maintained at room temperature under aerobic conditions for a total treatment period of 14 days. A second application of nutrients and hydrogen peroxide was performed on the seventh day. The systems were tested for physicochemistry and microbiology at t=0 (baseline), t=7 and t=14 days. The systems were also tested for hydrocarbon constituents (TRPH, TPH [as diesel and gasoline] and BTEX) at t=0, t=2, t=7, and t=14 days.

The results of the pilot study indicate that although a significant proportion of the contaminant reduction may be attributed to volatilization, the nutrient amended sample evidenced more efficient reduction of gasoline and specific BTEX components than either the control or hydrogen peroxide supplemented test systems. The observed increased efficiency of hydrocarbon reduction in the nutrient-amended test sample can be attributed to biological activity since a substantial increase in both heterotrophic and selective degrader populations was observed. Hydrogen peroxide (0.01%) proved detrimental (biotoxic) to microbial activity. Because of the improved efficiency of contaminant reduction noted for the nutrient amended system, this method was utilized for the integrated soil-ground water biotreatment study.

6.3.2.2 Pilot Bioremedial Treatment of Soil and Ground Water

This phase was conducted to evaluate the feasibility of using biostimulation for the in situ treatment of soil and ground water via an integrated closed-loop system. The test method involved the percolation of nutrient-amended (100 ppm nitrate), hydrocarbon-spiked (1,000

ppm diesel/gasoline mix), site-specific ground water through a 3-ft long vertical column packed with a composite of soil from the three samples. A ground water reservoir (2.5 liter flask) was connected, via Tygon tubing and a peristaltic pump, to the top of the soil column such that a continuous closed-loop flow from the reservoir through the soil column would be accomplished. A recirculating tube connected the distal end of the soil column to the influent port of the flask. To the extent possible, a continuous flow of water to the top of the soil column was maintained for a period of 14 days (average flow 2.34 ml/hr). Soil and ground water samples from the closed loop system were tested for physicochemistry, microbiology, and hydrocarbon constituents at t=0 and t= 14 days.

Analytical testing of ground water samples after the 14 day treatment period indicates a greater than 99.9% reduction in diesel and gasoline/BTEX concentrations. Although a portion of the hydrocarbon reduction may be attributed to adsorption of hydrocarbon onto soil particles, the vast majority of the reduction is believed to be the result of biologically-mediated degradation. This contention is supported by the results of microbiological and physicochemical analyses. Microbiologically, both soil and ground water samples showed substantial increases in both heterotrophic and selective degrader populations. The growth of the selective population (40-216% increase) could only have occurred if the hydrocarbon constituents were being utilized for microbial growth.

Physicochemically, the pilot test confirmed nutrient delivery to the soil column. The more efficient loss of nitrate within the soil matrix correlates well with the differential microbial enumeration findings, again indicating a rapidly metabolizing population of biodegraders. Interestingly, in spite of the presence of a significant proportion of fine-grained matrix in the soil samples, no evidence of biofouling (soil plugging developed as a result of bacterial growth) was observed during the treatment period.

Of significance is the fact that, although these experiments were performed within a closed loop system and opportunity for aeration of the water after process initiation was limited, the water was likely much more highly oxygenated during the tests than under actual in situ field conditions. As was pointed out earlier, dissolved oxygen in ground water at the PCPL site borders on the minimum critical concentration required to promote aerobic activity. Therefore, in addition to nitrate, supplemental dissolved oxygen will be required for successful implementation of in situ bioremedial treatment of soil and ground water.

6.3.3 Conclusions

The cumulative results of the biotreatability study support the prospective use of enhanced bioremedial treatment for expedited in situ cleanup of soil and ground water. However, scaling up the optimal laboratory treatment conditions to full scale field applications

presents many difficulties. For instance, the extreme heterogeneity of the site soils precludes the efficient delivery of nutrients and supplemental oxygen to the soil column. Furthermore, the site ground water contains relatively high levels of reduced iron and other dissolved solids which precipitate when the water is aerated. This observation causes concern that introduction of oxygen to the saturated zone will cause precipitation of iron and other solids within the aquifer eventually resulting in fouling of the saturated media surrounding a sparge point or injection well. Until a method can be engineered which will result in the efficient delivery of nutrients and dissolved oxygen to the saturated zone without precipitating unwanted solids, we do not recommend implementation of enhanced in situ bioremediation for cleanup of soil and ground water.

The results of the biotechnical evaluation indicate that hydrocarbon biodegradation is taking place at the site, although at a relatively slow pace that is limited by the availability of oxygen and nutrients. Long-term vapor extraction operation at the site may increase the oxygen content of the soil gas and improve the biodegradation rates. Dissolved hydrocarbons in ground water moving away from areas of residual hydrocarbon in soil (sources) will continue to biodegrade, effectively limiting further plume migration.

6.4 In-Situ Treatment Study

In-situ methods of ground water remediation were investigated for technical feasibility at the project site. The methods researched included air sparging (conventional, density-driven convection, and Underdruck-Verdampfer-Brunnen [UVB]) and bioventing (conventional and pure oxygen-enhanced).

6.4.1 Process Descriptions

6.4.1.1 Air Sparging

Conventional air sparging involves the introduction of pressurized air into contaminated ground water through the use of vertical or horizontal injection wells. Dissolved volatile contaminants in the ground water are then volatilized and stripped by the passage of air. Soil gas containing the removed contaminants is typically collected through a soil vapor extraction (SVE) system operated in conjunction with the sparging system.

Variations on this theme include "density driven convection," where water in a wellbore is aerated through the injection of air at the base of the well. The air bubbles strip contaminants from the ground water, while the aerated water rises in the wellbore, thereby drawing additional contaminated ground water in at the base of the well screen (Schrauf, et al., 1994). In the UVB Method, air injection and vapor extraction are conducted in

separate screened well sections in the same borehole. This method reportedly provides increased control over ground water circulation (Schrauf, et al., 1994). Again, the method relies upon the stripping action of rising air bubbles to removed dissolve contaminants.

6.4.1.2 Bioventing

Bioventing, as applied to ground water contamination, is similar in execution to air sparging, and the two methods share basic mechanical similarities. The physical processes governing the methods are quite different, however, in that air sparging is founded on the premise that the physical volatility of the dissolved contaminants will transfer the contaminants from one medium (water) to another (air). Bioventing relies upon the ability of microorganisms to metabolize the contaminants, resulting in the in-situ destruction of the contaminants.

Bioventing typically involves the injection of air into contaminated ground water, with physical methods similar to those involved in air sparging. The primary purpose, however, is to increase the dissolved oxygen (DO) content in the contaminated water, consequently enhancing the ability of indigenous or introduced microorganisms to metabolize the contaminants.

Conventional bioventing involves the injection of clean ambient air; pure oxygen or hydrogen peroxide injection may also be effective in specific circumstances. (However, hydrogen peroxide has proven to be toxic to the microorganisms in samples from the project site.)

6.4.2 Summary of Applicability of these Methods to the Subject Site

Dissolved bicarbonate, iron, manganese, calcium, and magnesium are present in high concentrations in ground water at the site (over 1,600 ppm total dissolved solids in some wells). Treatability studies conducted on ground water samples from the site (Section 6.5 below) indicate that agitation and aeration result in the evolution and release of carbon dioxide gas from the ground water. This results in an increase in pH and causes calcium to precipitate as calcium carbonate; iron and manganese are likewise precipitated as their oxidation states are changed and insoluble oxides are formed. The chemical equations for these reactions are as follow:

Calcium Carbonate Precipitation

$$C_a^{++} + 2\,HCO_3^- = CaCO_3\downarrow + CO_2\uparrow + H_2O$$

Iron Oxide Precipitation

$$2\ Fe^{++} + 1.5\ O_2 = Fe_2O_3\downarrow$$

The techniques discussed above (air sparging and bioventing) require the introduction of significant amounts of air and/or supplemental oxygen into ground water. In light of the treatability studies conducted to date, it is apparent that any such injection of air at the project site will likely result in the precipitation and formation of total hardness minerals in the ground water aquifer in the vicinity of the sparging/injection wells. It is conceivable that mineral deposition could significantly impact the overall ground water permeability in affected areas, thereby resulting in reduced yields to extraction wells. Furthermore, once mineralization occurs, it would be exceedingly difficult to mitigate or reverse.

It is concluded that airsparging and bioventing are not appropriate technologies for treatment of ground water at the PCPL site. However, bioventing may aid in remediation of the vadose zone.

6.5 Evaluation of Ground Water Solids Removal Alternatives

This section summarizes the results of testing solids removal technologies. A more detailed description of testing activities will be presented in the upcoming Third Quarter 1994 Quarterly Status Report.

As was discussed in previous sections of this report, suspended solids have fouled the activated carbon inside the GAC vessels, causing premature breakthrough of benzene. In order to select a suspended solids treatment system, pilot studies, bench scale tests, and technical evaluations were completed during Phase 1 operation. The following methods were evaluated:

Methods Evaluated

- Dissolved Air Flotation (DAF)
- Centrifuge
- Aeration
- Lime Treatment
- Sand Filter
- Bag Filter
- Settling Tank
- Chemical Addition

A comparison of methods evaluated is presented in Table 6-5.

Results

Fouling of the GAC vessels was initially attributed to high suspended solids in the extracted ground water, but bench scale testing and pilot studies indicate that suspended solids form as minerals in the ground water precipitate. Extracted ground water contains high concentrations of calcium, magnesium, manganese, iron and dissolved carbon dioxide (bicarbonate). As the water is exposed to air or agitated by pumping action, the solids precipitate in two steps: (1) oxidation of the iron and manganese produces insoluble oxides of these minerals, and (2) stripping of carbon dioxide converts soluble calcium bicarbonate into insoluble calcium carbonate and raises the pH of the water. The following summarizes key results and observations:

- DAF was not effective in removing suspended solids. Injection of air actually increased the total suspended solids (TSS) by promoting precipitation of minerals.
- Lime treatment would be effective in removing dissolved solids which tend to precipitate, but would require addition of large amounts of lime and would result in large volumes of oil-contaminated lime sludge requiring further treatment or disposal as a hazardous waste.
- No significant reduction in suspended solids was obtained with most of the tested methods.
- Solids continue to precipitate downstream of all tested physical separation methods.
- Chemical addition of a sequestering agent resulted in a 50 percent reduction in suspended solids by keeping most dissolved solids in solution.

Conclusion

Chemical addition of a sequestering agent is effective because it reduces precipitation. However, it is relatively expensive (approximately 60 pounds of chemical at a cost of $150 per 100,000 gallons of water treated). Its long-term effects on the activated carbon in unknown.

Periodic carbon backwash, with no pretreatment of the raw water appears to be the most cost effective approach, even if one additional changeout per year is required.

Design

No pretreatment will be used. Tanks and a high flow pump will be added to backwash the carbon when back pressure reaches about 40 psi, indicating significant solids buildup in the GAC vessels. If backwashing of the GAC vessels becomes too frequent, chemical addition may be incorporated. In addition, provision is made in the design for addition of multiple bag filters upstream of the carbon. These filters will be installed, but may be bypassed most of the time if backwashing effectiveness is demonstrated. Design of the backwashing system is addressed in Section 9.3, Ground Water Extraction and Treatment System.

6.6 Geophysical Logging

Eleven new and existing boreholes were geophysically logged to provide quantitative correlation between geologic logs that had been produced by a variety of geologists over the years. COLOG of Golden, Colorado was selected as the geophysical contractor for the task. Logging criteria included:

- location and depth of boreholes;
- maximum hole depth of 150 ft.; and
- logs generated in both 2-inch and 4-inch diameter PVC casing with no drilling fluid.

Based on these criteria, (the controlling factor being the existing well construction), eleven boreholes were selected for logging (Table 6-6). A gamma log and EM-39 log were generated for each of the selected boreholes. The gamma log measures the naturally occurring gamma emissions from the formation surrounding the borehole. The EM-39 log (induction log) measures electrical properties of the adjacent formation by inducing a current into the formation and measuring the electromagnetic response within the borehole to that current. From this information a conductivity/resistivity log of the borehole can be produced. The logs are included in Appendix H.

Interpretation

Extraction wells EW-2, EW-4 and EW-5 were selected for geophysical logging, because continuous core and soil boring log data had been previously generated for these borings. The gamma ray and induction log responses were correlated with the continuous soil data in order to calibrate the geophysical response to known soil lithologies or "marker beds." Since geophysical logs provide continuous information, subsurface lithologic correlations could be made based on a characteristic geophysical response or signature in those areas where continuous lithologic information was previously unavailable.

Attempts to match continuous core and boring log data to characteristic geophysical response indicates that a strong correlation appears to exist between fining upward and coarsening upward gradational soil lithologic sequences. Based on this characteristic geophysical signature, marker horizons mapped between borings MW-11S, MW-33D and MW-25D show an apparent vertical offset of strata that may be attributed to either very recent fault movement, the presence of a landslide, or simply depositional changes produced by stream bottom scour (erosional surface) or lateral changes associated with the shifting of Pole Creek. The data generated from the geophysical logs was used to supplement geologic information presented in the cross sections included in this report.

6.7 Ground Water Pumping Tests

Ground water pumping tests have been conducted at the PCPL site to characterize hydrologic properties of the aquifer 1 materials. The information obtained from those analyses has been incorporated into a series of permeability distribution maps for the site which were used for predictive modeling of ground water flow and subsequent capture zone analyses. Ground water pumping tests have been conducted since the inception of exploration activities at the site. During the Phase 1 program, three new extraction wells and six new monitoring wells were tested. The data were incorporated with previous information to generate a permeability distribution map of aquifer 1 (Figure 7-5). Table 6-7 is a list of wells where ground water pumping tests were recently conducted.

6.7.1 Phase 1 Aquifer Testing Summary

During Phase 1 activities three new extraction wells and six monitoring wells were selected for aquifer testing. A variety of testing techniques were used to:

- evaluate well efficiency and establish safe pumping rate for the planned forty- eight hour constant-rate tests;
- calculate aquifer properties for flow and capture zone modeling; and
- estimate permeabilities west of the site in the terrace deposits.

Methodology

The full aquifer test methodology and results are described in the forthcoming Third Quarter, 1994 Quarterly Status Report. Only a summary of methodology is presented here.

The step drawdown tests were conducted by pumping the extraction wells (EW-2, EW-4 and EW-5) individually at three different rates up to the full production capacity of the pump or until the automatic pump shut off in the well activated. The total length of each pumping test was less than four hours. Water levels were monitored in the pumped well using a pressure transducer and data logging system. Flow rates were measured both with the in-line flow meters on the treatment pad and with a totalizing flow meter on the discharge. Water levels were measured both prior to pumping and during well recovery.

Constant rate tests were conducted in a similar fashion except that a single pumping rate was maintained for a 48-hour period. Additional observation wells were selected for monitoring drawdown with a pressure transducer/data logger system. A background monitoring well and a barometric station were maintained onsite prior to, during and after each test.

Slug tests were conducted by inserting into, or removing a slug of known volume out of the well and monitoring the water level response using a pressure transducer and data logging system. In most wells, at least two tests were conducted for comparison purposes.

All aquifer test data were analyzed using the AQUIX4-S software package.

Results

Well efficiency is defined as the ratio of actual drawdown in the well to theoretical drawdown, expressed as a percentage. Calculation of the well efficiency for the newly installed extraction wells (as shown in the chart below) indicates that the wells are not operating at peak or expected efficiency. This is probably a direct result of the well design which was selected to minimize the movement of fines from the formation into the well. The resulting design influences the skin Factor (Kruseman & De Ridder, 1990).

Well Efficiency - Phase 2 Extraction Wells

Well	Calculated Well Efficiency
EW-2	0.69
EW-4	0.75
EW-5	0.74

Hydrologic property evaluation at PCPL is hampered by the lithologic variability of the site. There are no continuous, well defined aquicludes and the depth to the aquifer bottom and

top is problematic in most areas of the site. Review of drilling data, historic water level information and pumping test results all indicate that the wells are partially penetrating in unconfined to semi-confined zones. The magnitude of the barometric response measured during long term water level monitoring indicates however, that EW-4 at least may be more semi-confined than EW-2 and EW-5. Consequently, selection of an appropriate aquifer test evaluation methodology is hampered by a lack of a clearly defined aquifer definition. For the PCPL site, the evaluation methodology selected was driven by review of the aforementioned site characteristics and more importantly, the shape of the aquifer response curves.

Summary

The Phase 1 aquifer property evaluation indicates that the aquifer 1 hydrologic properties appear to follow trends discussed in earlier documents. The aquifer permeability decreases to the west and north of the PCPL site. The highest permeabilities appear to follow a linear trend from the vicinity of MW-28S south-southwesterly to EW-4 and MW-39S.

6.8 Evaluation of Treated Water Disposal Alternative

Beneficial reuse of treated water is the preferred treated water disposal option outlined in the record of decision (ROD) for the site. Current reuse options include:

- Recharge to ground water by reinjection wells or infiltration basins,
- Reuse as local irrigation water, and
- Reintroduction to the Fillmore Ground Water Basin by discharge at Pole Creek

Reinjection or Infiltration Basins

Extensive investigations associated with ground water solids removal during Phase 1 indicate that the site water is extremely hard and precipitates of calcium, magnesium, and iron would clog reinjection wells or infiltration basins. Therefore, reinjection or infiltration is not recommended.

Reuse as Local Irrigation Water

Water samples extracted from the site were analyzed for a variety of parameters to determine suitability as irrigation water for local crops. Montgomery Watson evaluated the analytical results based on a guide developed by the University of California Cooperative Extension Service for identifying potential areas of concern with irrigation waters. A letter

report by Montgomery Watson is included in Appendix H. The water analysis used for this evaluation was for combined extraction from wells EW-1 and MW-19S. Table 6-8 shows general minerals results for that sample and for the newer wells EW-2, EW-4, and EW-5. The water is of similarly poor quality in all of these wells.

Montgomery Watson concludes the use of effluent water from the granular activated carbon treatment system for irrigation is not a viable reuse option for the following reasons:

- Increasing problems with salinity and soil permeability may be expected from use of the treated ground water for irrigation, based on specific conductivity of 1,600 μmho/cm.

- Specific ion toxicity via root absorption may be an increasing problem owing to a boron concentration of 0.69 mg/l.

- Severe problems may be anticipated as a result of high sodium concentrations (10 meq/l).

- Use of this water can be expected to increase soil pH as a result of the high bicarbonate concentration (960 mg/l as equivalent $CaCO_3$ = 19 meq/l). Bicarbonate should not exceed 6 meq/l in irrigation water. The high bicarbonate concentration would likely result in adverse impacts to soil structure and affect the availability to crops of trace nutrients such as iron, zinc and magnesium.

- For spray or drip systems, the high hardness will result in precipitation of minerals which tend to clog these systems.. Because calcium and magnesium carbonates have different solubilities, the formation of these salts could adversely affect the ratio of calcium to magnesium remaining in solution and their availability to crops.

Reintroduction to the Basin by Discharge at Pole Creek

The reuse option implemented in Phase 1 was discharge of the treated water to Pole Creek under a NPDES permit. Pole Creek is concrete-lined at the discharge point, but is unlined approximately 1,300 feet to the south. The primary source of recharge in the Fillmore Basin is by percolation of streamflows. Therefore, there is substantial recharge of the water by reintroducing it to the Fillmore Ground Water Basin.

7.0 SITE SIMULATIONS

7.1 Stick Model

A three dimensional subsurface lithologic model was constructed from data reported on boring logs from over one hundred borings and wells installed at or near the site. The model was generated with a horizontal scale of one inch to forty feet in the horizontal dimension and one inch to twenty feet in the vertical dimension (2 times vertical exaggeration). Wooden dowels (sticks) were used to represent borings/wells originating at a datum elevation lower than the minimum elevation encountered during drilling of the borings. The sticks are attached to a board which has a map of the site superimposed. The sticks were colored to reflect the Unified Soil Classification System (USCS) soil type reported on the logs. Certain USCS soil types were grouped as follows and all red clay or red silt units were colored red:

- Clean Gravels (GW-GP)
- Clean Sands (SW-SP)
- Dirty Sands and Gravels (SM-SC-GM-GC)
- Silt (ML)
- Clay (CL-CH-MH)
- Red Clay or Red Silt

The sticks were colored in this manner to the total depth of each boring and were uncolored below, down to the datum. The tops of the sticks were cut to reflect surface elevation. For borings that were completed as wells, the perforated zones are shown on the sticks with horizontal lines and the ground water levels are represented by rubber "O" rings fitted around each stick at the appropriate elevation. Photographs of the model are included in Figure 7-1.

The stick model confirms the extreme lateral variability of subsurface soil types discussed previously in Section 2.0, Site Description and Refined Site Hypothesis. A large portion of the site subsurface contains dirty sands and gravels (orange) with discontinuous interlayered silts, clays, and clean sands. There is very little clean gravel at the site.

7.2 Vapor Extraction Modeling

Vapor extraction modeling was conducted to estimate pressure declines within the unsaturated zone beneath the site resulting from extracting gas at various rates from several onsite locations.

7.2.1 Methodology

A three dimensional, steady state, finite difference model of the expected vacuum in and around the PCPL site was constructed using the available data and MODFLOW computer code by McDonald and Harbaugh. The evaluation technique follows a suggestion presented by Parker, et al., 1989.

After review of the site geometry in relation to the planned vapor extraction system, the finite difference grid used for the ground water flow modeling (Section 7.3.3, Grid Generation and Data Input) was modified to accommodate the vapor extraction modeling. The ground water model was expanded into a two layer finite difference model with implicit no-flow boundaries at the base of the model and along all of the model sides. The finite difference grid was established using 49 rows and 25 columns representing a 4,200 x 2,200 ft area (Figure 7-2). A very low vertical permeability was assigned since the vapor extraction testing indicates little or no flow of atmospheric gas into the subsurface. Vertical permeability was set equal to one percent of horizontal permeability inside the site boundaries and ten percent of horizontal permeability outside the site. A constant head boundary of zero inches (atmospheric pressure) was assigned to all nodes. No gas generation was simulated. The thickness of the zone permeable to gas flow has been assumed constant at 50 feet.

Approximate intrinsic horizontal permeabilities of the unsaturated zone were calculated from vapor extraction testing conducted during the Phase 1 investigations. The vapor extraction testing and data analysis results are presented in Section 6.1, Vapor Extraction Testing. Based on the gas permeability values presented in Table 6-4, a value for each grid node was estimated using a minimum curvature method. Since the majority of the data was concentrated in the center of the site, the estimation process is not valid at the northern and southern portion of the site where there is no data control. In these areas, the gas conductivity was estimated extending the calculated gas conductivities for the model. The resulting permeability distribution overlain on the model grid is shown on Figure 7-3.

Three vapor extraction wells were selected based on the vadose zone target areas for the Phase 2 remediation (Section 8.1.1, Vadose Zone). Extraction wells were modeled as constant head nodes.

A vacuum of 40 inches of water was established at nodes where EW-4 and SBD-3 were located. Similarly, a vacuum of 30 inches H_2O was assigned to PEW-1. Note that these wells are all within the lower vadose zone. Figure 7-4 is a map representing calculated pressure drops within the vadose zone at the PCPL site using the parameters previously described.

The vapor extraction modeling estimates that the extraction of three wells (EW-4, SBD-3 and PEW-1) will effectively capture hydrocarbon vapors within the lower vadose zone target areas. As remediation proceeds, vapor flow from the extraction wells may increase or additional vapor extraction wells may be incorporated into the system. Extraction from well PEW-3 was not modeled. Based on extraction from well PEW-2 and modeling of extraction from the lower vadose zone, it is expected that extraction from well PEW-3 will effectively capture the upper vadose target area.

7.3 Ground Water Modeling

A numerical ground water flow model of aquifer I at the PCPL site was constructed to (1) provide information on flow direction and velocity, (2) assist in identifying recharge/ discharge volumes and locations, and (3) provide base information for performing capture zone analyses. After establishing an acceptable match of the modeled ground water elevations with the observed elevations, an advective transport model was superimposed on the data to calculate and display capture zones for a variety of proposed pump and treat options at the site.

Capture zone analyses are performed to assess the movement of ground water particles due to the advective properties of the medium and the fluid in question. At the PCPL site, it provides a measure of the potential for ground water moving across the site to carry hydrocarbons beyond the site boundary. More importantly, it delineates a zone where hydrocarbons already existing in the ground water will be pulled back to a pumping well for eventual extraction and treatment.

7.3.1 Conceptual Model

The conceptual hydrogeologic model of the PCPL site was developed in Section 2.5, Local Geology and Hydrogeology, of this report. A summary of the model follows.

The PCPL site is underlain by a semi-confined aquifer composed of fluvial and reworked landslide deposits. The material below the water table is composed of predominately silt and silty sand with local zones of clean sand and gravel. Recharge to the aquifer is primarily from infiltration due to precipitation with minor inflow from the east and additional minor inflow along the hills. Discharge from the site is primarily to the west-northwest where the water surface eventually flows below Sespe Creek which is a recharging stream. There is additional discharge to the south and southwest of the site where a small volume of water contributes to the flow originating from the Santa Clara River which eventually flows westward out of the basin.

7.3.2 Model Selection

The ground water simulation was conducted using the U. S. Geological Survey finite-difference model MODFLOW (McDonald, M.G. and Harbaugh, A. W., 1988). The capture zone evaluation was conducted using the MODPATH package (Pollack, 1989). MODPATH is a post processor package that uses data generated from the MODFLOW program as an input to a particle tracking algorithm. By generating a backward series of particle flow paths originating at a pumping well, the capture zone of the well can be modeled.

7.3.3 Grid Generation and Data Input

The aquifer system was simulated using a north-south oriented, block-centered, finite-difference grid (Figure 7-2). The grid consists of 49 rows and 25 columns representing a 4,200 ft x 2,200 ft area with varying row and cell widths. The MODFLOW standard of row and column numbering begins in the upper left corner of the grid.

The aquifer was modeled as an unconfined unit. Constant head boundaries were assigned to the northern model boundary. The western, southern and eastern boundaries were designated as general head boundaries in the computer runs used to generate the capture zone analyses.

The permeability at each model node was assigned a value based on aquifer test data described in Section 6.7, Ground Water Pumping Tests. Estimation was performed using a minimum curvature algorithm. The aquifer was assumed to be isotropic in all three dimensions. Initial heads for each node were estimated from ground water elevations measured during third quarter of 1993. Model calibration was performed using both those heads and the heads measured during the third quarter, 1994 values. Areal recharge to the system was initially set at a constant value of 1.5 inches per year. The value was modified during calibration to refine the fit between modeled heads and known heads.

The semi-analytical method that MODPATH employs to generate pathlines requires input information regarding cell by cell fluxes as generated from the MODFLOW model. Wells become sinks within the input data set. For the purpose of the simulation, all particles that encounter a sink, such as a well, terminate their movement at that point.

7.3.4 Calibration

Model calibration consisted of modifying the areal recharge rate and the conductivity values of the general head boundaries. A satisfactory calibration was obtained when the average difference between the modeled water levels and the observed water levels within the wells

was less than four feet. During development of the conceptual model, the northeastern nodes; like all of the boundary nodes has been assigned as a general head boundary. However, the modeled water levels in this area were not accurately simulating observed water levels. To obtain a better model fit, the general head boundary was removed from the area in question which decreased inflow to the model from the adjacent aquifer. Once the inflow was removed, modeled downgradient water levels had to be increased approximately uniformly. To accomplish this, eight nodes on the northeastern side of the model, two along the northern boundary and two rows of four along the southeasterly trending boundary were assigned recharge rates of 1.85 in/yr. all other nodes were assigned a recharge rate of 1.7 in/yr.

7.3.5 Application

A series of steady-state runs were made to evaluate the capture zones for various pumping scenarios. Three of the results have been included in this document. Capture zone well extraction scenarios were initially constructed to completely capture the MCL (1 ppb) benzene concentrations as mapped for third quarter 1994. However, after several application runs were made, it became evident that because of the low permeability terrace material west of the site, a large number of extraction wells (Figure 7-8) would be needed. Well and discharge piping construction would be a major impact on the residential area.

A second series of capture zone analyses were constructed to simulate a phased ground water extraction scheme. In this scheme, all of the Phase 1 extraction wells and associated facilities are located east of Pole Creek. The scenario was constructed to form a zone of zero flux along the western boundary of the site to stop migration of benzene westward beneath Pole Creek. Extraction wells were sited to optimize the capture of the plume that has traveled beneath Pole Creek. Figure 7-7 is a map showing the recommended extraction system and the generated capture zones.

Based on the results of aquifer testing and modeling, a series of new wells were added to the system to allow evaluation of different capture zones. Wells EW-1 and MW-28S are existing wells that will be included in the Phase 2 operation. Wells numbered EW-6 and higher are at locations of proposed new wells.

The corresponding capture zones for the pumping scenarios presented in Table 7-1 are shown in Figures 7-6, 7-7 and 7-8, respectively.

Since the capture zone boundary represents a ground water flux of zero, it follows that in the zones immediately beyond the capture zone boundaries, ground water fluxes are going to be relatively slow when compared to steady-state, non-pumping conditions. Figure 7-9 shows a contour map of the relative velocities with the recommended extraction system in operation.

8.0 EVALUATION OF REMEDIAL OPTIONS

8.1 Approach to Meeting Cleanup Criteria and Goals

The cleanup criteria and goals as set forth in the ROD and SOW are presented in Sections 1.3 and 1.4. The approach to meeting those criteria and goals is described below.

8.1.1 Vadose Zone

The selected remedy described in the ROD calls for "Soil Vapor Extraction for those areas that threaten to contaminate ground water at levels above Site cleanup standards..." Section 4.4, Benzene Fate and Transport, includes a discussion of migration potential of benzene vapor in the vadose zone. Figure 4-6 shows the areas in the vadose zone in which benzene vapor concentrations are significantly higher than concentrations which would be in equilibrium with benzene in the ground water immediately below that zone, i.e., where there is a concentration driving force for migration of benzene vapor from the vadose zone to ground water. These areas are considered preliminary target areas for vapor extraction. Other factors are taken into account to narrow down the target areas.

As discussed in Sections 4.1 and 4.4, there is evidence that soil layers of low gas permeability separate the upper vadose zone from the lower zone immediately adjacent to the ground water table. Benzene in the upper zone may not have a direct pathway to the ground water. The portions of the vadose zone representing the greatest threat are those with high concentrations of benzene in close proximity to the ground water. Next, are those higher zones with relatively direct pathways to the ground water.

Target zones for soil vapor extraction are shown in Figure 8-1. The southern target area and the northern half of the northern target area are in the lower vadose zone. The southern half of the northern target area is in the upper vadose zone, but, based on Cross Section D-D' (Figure 2-12), there appears to be a vertical pathway near wells MW-25D and MW-47D. Therefore, a large portion of the upper zone is included as a target area. Ground water is flowing from the east, so relatively low concentrations of benzene in ground water wells MW-37S and MW-38S indicate that there is no significant migration pathway from the upper zone to the lower zone in the eastern portion of the vapor plumes. Therefore, the upper zone target area does not encompass the entire area with elevated benzene vapor concentrations.

Wells selected to address these target areas are as follows:

- Well PEW-1 This is in an area with historically highest benzene concentrations in the ground water and among the highest benzene vapor concentrations in the vadose zone. Vertical permeability between the screened interval of lower zone well PEW-1 and that of adjacent upper vadose well SBB-1 appears to be extremely low (Section 4.1.3, Soil Gas). Therefore, flow to this well is expected to be virtually all horizontal from within the lower vadose zone. Based on horizontal flow, the area affected by extraction from this well is expected to extend hundreds of feet from the well after several months of operation.

- Wells SBD-3 and EW-4 These are in portions of the southern target area which appear to be close to sources of benzene, based on high benzene concentrations in the ground water and soil gas and the presence of free LNAPL containing benzene in well EW-4. The SBD-3 screen interval (32 ft to 55 ft bgs) provides coverage closer to ground surface than that for EW-4 (49.5 ft bgs to water table). Ground water extraction from EW-4 will result in drawdown of several feet near the well enabling deeper soil gas flow near that well. Also, soil gas extraction from EW-4 will result in evaporation of the light fraction of hydrocarbons (including benzene) from the LNAPL.

- Well PEW-3 This is an upper vadose zone well in the southern end of the northern target area. It is close to the identified potential vertical pathway to ground water and is in an area of high benzene concentrations in the soil and soil gas. Based on four months of extraction from well PEW-2, it is expected that flow to PEW-3 will be largely horizontal and its influence should extend several hundred feet from the well.

- Other wells Several other wells are already connected to the vapor extraction piping system. These include SBD-2 and EW-1 in the southern target area, MW-28S, AEW-1 and PEW-2 in the northern area. If significant amounts of benzene are found in the upper or lower vadose zones, well EW-7 will be connected when it is installed. Wells PEW-6 and EW-5 may be connected in the future if evaluation of data indicates these are needed. These wells are not designated as target wells, but one or more may be used if the ongoing evaluation of vapor extraction indicate the need. For example, since the bottom of PEW-1 is 10 or more feet above the water table, vapor extraction from nearby ground water well MW-28S may be needed to aid in the removal of soil gas next to the water table. The screen in this well is normally submerged, but with ground water extraction, several feet of screen may be available for soil gas extraction.

8.1.2 Ground Water

The selected remedy in the ROD calls for ". . . a ground water extraction and treatment system to treat extracted ground water to levels that meet the cleanup standard . . ." and, "Ground water monitoring to demonstrate that the extraction system is effectively capturing the contaminant plume and ultimately, to demonstrate achievement of the cleanup standards throughout the aquifer . . ." The SOW describes how achievement of the standards shall be measured, for example, by average of water quality data from wells within the former plume, or other approach recommended by EPA guidance or policy (Section 1.4, Cleanup Goals).

Based on information presented in Section 4.4.3, Natural Degradation of Benzene, benzene is continually being removed by natural degradation. Benzene is non-detectable in ground water a relatively short distance downgradient of the site. If the sources of benzene ("hot spots") were captured by ground water extraction, that benzene which would have moved beyond the capture zone would continue to degrade, and without a supply of additional benzene, would eventually disappear.

An additional objective is to minimize disruption of the residential neighborhoods to the west of the site. To the extent possible, all extraction wells are to be installed on the east side of Pole Creek.

Therefore, the approach to ground water remediation is to (1) extract from wells located such that the hot spots are within the capture zones, and (2) rely on natural forces to degrade benzene to its cleanup standard in areas beyond the capture zones. Quarterly monitoring will be used to evaluate effectiveness of the capture zones and reduction of benzene concentrations throughout the area.

Ground water target areas are shown on Figure 8-2. Selection of the north and south target areas are based primarily on high benzene concentrations in the ground water, but are also influenced by areas of high benzene concentrations in the soil and soil gas. The central target area is tentative, based on soil data which indicate high benzene concentrations at or near the water table.

Ground water extraction wells selected to address these target areas are based on results of ground water pumping tests and ground water modeling, discussed in Sections 6.0 and 7.0. These are as follows:

Northern Target Area: Wells MW-28S, EW-2 and EW-6 pumping at the rates indicated on Figure 8-2 are estimated to adequately capture ground water with the highest

concentrations of benzene. The first two wells are existing wells, EW-6 will be installed as part of Phase 2 construction.

Southern Target Area: Capture of ground water in this area is to be accomplished by extraction from wells EW-1, EW-4 and EW-5.

Central Target Area: Well EW-7 will be installed at the approximate location shown on Figure 8-2. Water from this well will be sampled and analyzed to determine whether the well will be used as an extraction well or a monitoring well. If concentrations indicate an upgradient benzene source the well will be converted to an extraction well. Otherwise, it will remain a monitoring well.

8.2 Vadose Zone Remedial Options

As set forth in the ROD, vadose zone remediation shall be achieved by soil vapor extraction. Soil vapor extraction removes contaminants in the vapor phase from pore spaces in the vadose zone by creating a vacuum in the extraction wells and drawing soil gas through the subsurface. The gas flow through the subsurface will also enhance the volatilization rate of contaminants. The vadose zone remedial design options to be evaluated under Phase 2 design are selections of above ground vapor treatment technologies.

Based on the design parameters, ROD requirements and treatment capacities, the following treatment alternatives were considered for treating extracted soil gas containing petroleum hydrocarbons:

Internal Combustion Engines

The internal combustion engine (IC engine) is used to both extract and treat the vapor. The hydrocarbons in the soil gas are the primary source of fuel for the IC engine. As the soil gas is drawn from the wells and passes through the engine's carburetor, the air to fuel ratio is monitored. An auxiliary fuel (natural gas or propane) is injected, when necessary, to maintain efficient combustion. Air must be added to increase oxygen content to the proper level for combustion and/or to dilute the hydrocarbons to stay within the optimum range.

This alternative has been successfully demonstrated at the PCPL site, with four months of continuous extraction from well PEW-2. It is more portable and more readily installed than thermal and catalytic oxidizers in that no electrical supply is needed. However, IC engines have high maintenance requirements and are sensitive to changes in extraction conditions. Based on experience with PEW-2, supplemental fuel consumption can be fairly high. Fuel costs have been about $2,000 per month.

Thermal/Catalytic Oxidation

Thermal oxidation occurs when gas containing volatile organic compounds (VOCs), is heated to high temperatures in the presence of oxygen. At approximately 1,800 degrees Fahrenheit, the VOCs are oxidized producing carbon dioxide and water vapor. Due to the high temperatures required for complete oxidation, this process needs a significant amount of energy when VOC concentrations are low in the influent vapor stream. A catalytic oxidizer is used for low VOC concentrations. The catalyst allows for oxidation of VOCs at a lower temperature (i.e., 600 degrees Fahrenheit), thus resulting in lower operating costs. A catalytic oxidizer cannot be used for VOC concentrations higher than 2,000 to 3,000 ppmv, because the heat of combustion from oxidizing greater concentrations would result in temperatures high enough to destroy the catalyst.

A thermal oxidizer could be an attractive alternative for vapor destruction. Dilution air would be required to get the oxygen content into the proper range for combustion. The added air would also dilute the hydrocarbon vapors to below the lower flammability limit and, thus, require the use of supplemental fuel. Catalytic oxidation may have an application in the later stages of remediation when VOC concentrations are low. Thermal and catalytic oxidizers have lower maintenance requirements than IC engines.

Carbon Adsorption

Adsorption is a natural process in which molecules of gas phase hydrocarbons are attracted to and then held at the surface of the carbon solids by weak chemical bonds. Carbon adsorption will continue until the carbon is saturated with hydrocarbons. When carbon saturation occurs, the spent carbon must be replaced and regenerated or disposed.

While carbon adsorption has proven to be an effective method of treating a vapor stream, changing out spent carbon is an expensive process. Because of the high change out cost, carbon is usually used for sites with low vapor concentrations, short-term tests, or final polishing used in conjunction with other treatment systems.

The soil gas at the PCPL site includes a significant amount of methane and other light hydrocarbons from oil and gas deposits deep below the site. These would not be removed using carbon and would have to be dealt with by some other means, such as burning in a flare.

Carbon adsorption is not an acceptable alternative for the PCPL site because (1) concentrations of adsorbable VOCs are too high for this to be cost effective, and (2) the non-adsorbable light hydrocarbons must be treated by other means.

Condensation and Flaring

During operation of the Phase 1 vapor extraction system, liquid phase hydrocarbons condensed and accumulated in the system's knockout pot. As discussed in Section 6.2, Vapor Condensation, preliminary calculations indicate that 85 percent to 93 percent of non-methane hydrocarbons can be removed from the vapor stream as liquid phase hydrocarbons using compression and cooling of the gas. Liquid hydrocarbons generated from this process could be mixed onsite with the crude oil and thus, be recovered for beneficial use. The residual light hydrocarbon vapors could be treated by burning in a flare.

This option becomes less attractive as remediation proceeds and the portion of condensable hydrocarbons decreases.

8.3 Perched and Ground Water Remedial Options

Of the 14 perched water wells, 10 have been dry since the first quarter of 1994 and the other four contain 1 to 6 feet of water. One of the Phase 1 remediation goals was to determine the feasibility of extracting water from perched water wells. Due to the absence of water in most of these wells, perched water extraction has not been implemented. Incorporation of selected perched water wells into the Ground Water Treatment System (GWTS) will be considered if water in the wells rise to levels high enough for sustainable extraction. Until that time, the wells will be monitored and sampled on a quarterly basis. At least three of the perched water wells will be used as vapor extraction wells for Phase 2 remediation. Currently, vapor extraction is being performed on well PEW-2.

Ground water extraction and surface treatment using activated carbon has been selected in the ROD as the final remedy for ground water remediation at the site. The extraction well field design, secondary treatment to increase system performance, and discharge options, have been evaluated during Phase 2 design and are discussed as follows:

Extraction Well Field Design

The selection of ground water extraction wells was based on ground water modeling to determine capture zones and estimated pumping rates (Section 7.3, Ground Water Modeling). The extraction well field, with well EW-7 included, consists of seven extraction wells with a total estimated flow rate of 113 gpm.

Secondary Treatment

Activated carbon is a primary method for treating ground water at this site. Secondary treatment has been an option for the treatment of suspended and dissolved solids present in the ground water. Solids treatment methods are detailed in Sections 5.2.2 and 6.7 of this design report.

Discharge Options

The discharge options presented in the ROD for treated ground water are beneficial reuse for irrigation or reinjection. Studies to determine the feasibility of these options are currently in progress. Preliminary results indicate that (1) treated ground water is not suitable for agricultural use, and (2) high hardness and iron levels in the ground water may cause fouling and scaling in the reinjection wells. These studies will be presented to the EPA in a technical memorandum. The Phase 1 remediation system discharges directly into Pole Creek under the NPDES permit. This method is still the most feasible and can be categorized as beneficial reuse, since the creek is unlined approximately 1,300 feet downstream of the current discharge point.

8.4 Recommended Remediation Approach

The recommended remediation approach is consistent with the ROD and includes ground water extraction and surface treatment using activated carbon treatment, in conjunction with soil vapor extraction, perimeter fencing and ground water monitoring.

8.4.1 Soil Vapor Extraction

Final selection of hydrocarbon vapor abatement equipment is based on the following criteria:

- System availability and portability;
- hydrocarbon destruction capacity;
- previous testing experience at the site; and
- capital and operating costs.

The VR Systems Model V4, using internal combustion engines, meets the criteria and is the recommended alternative for soil gas extraction and treatment. However, the gas composition varies considerably from one well to another and a thermal oxidizer may be a better match for some wells. The design will be sufficiently flexible to accommodate a thermal oxidizer in place of, or in combination with, IC engines. Ongoing evaluation will

be conducted to determine if modifications are needed to the extraction and treatment system and/or well field. As remediation proceeds and VOC concentrations decrease, it may be appropriate to replace one or more systems with a catalytic oxidizer system.

Soil gas will initially be extracted from wells PEW-1, SBD-3 and EW-4. Well PEW-3 will be added to the network later, and other wells may be added as needed. This is discussed in more detail in Section 9.1, Soil Vapor Extraction System.

8.4.2 Ground Water Extraction and Treatment

Phase 2 ground water extraction and treatment will consist of pumping aquifer I ground water from either six or seven wells as shown in Figure 8-2, activated carbon treatment of the extracted water, and discharge of the treated water to Pole Creek under a new NPDES permit. Quarterly monitoring data will be used to determine the effectiveness of capture and downgradient degradation of benzene. Based on a continuing evaluation, the well field or extraction rates may be modified. The design concept and operating strategy are described in more detail in Section 9.3, Ground Water Extraction and Treatment System.

9.0 PHASE 2 DESIGN OUTLINE

9.1 Soil Vapor Extraction System

To achieve the cleanup goals in the vadose zone and ground water, target areas for vadose zone remediation have been defined based on the distributions of hydrocarbons in the vadose zone and ground water, and the potential impact of vapor phase hydrocarbons to the ground water (Section 8.1, Approach to Meeting Cleanup Criteria and Goals). Within the vadose zone target areas, extraction will initially be limited to wells SBD-3 and EW-4 in the south and PEW-1 in the north. Well PEW-3 will be added to the extraction system later. As hydrocarbon concentrations decrease in these wells, additional vapor extraction wells will be connected as needed. Wells will be disconnected from the system when major component concentrations indicate an approach to asymptotic values that appears to match natural emissions. A Decision Tree is presented in Figure 9-1 that outlines the process for modifying or shutting down the vapor extraction system.

Three vapor extraction systems using internal combustion engines (IC engines) or equivalent technology, which have capacities similar to the VR Systems Model V4, will be operated at the site. The vapor extraction systems will be located greater than 1,000 feet from the San Cayetano School.

It is estimated that the extraction rate from PEW-1 will be limited to about 20 cfm from a single V4 unit, because the gas has high concentrations of hydrocarbons which must be diluted with air. Initially, two units will operate on PEW-1 to attain a flow rate of about 40 cfm. It is expected that the hydrocarbon concentrations will decrease within a few months, allowing higher flow rates from the well. When the well flow rate for a single unit approaches 40 cfm, then one V4 unit will be disconnected from well PEW-1 and will be connected to well PEW-3. One V4 unit will be connected to both wells SBD-3 and EW-4. An extraction rate of 50 cfm is predicted for each.

As indicated in the decision tree, ongoing evaluations will be conducted to guide the operation of the vapor extraction system. If a given extraction well shows several months of essentially constant removal rate of key components, such as methane, this indicates that the removal rate may be matching the rate at which that component is entering the capture area from natural emissions from the deep earth or seeps.

When benzene vapor concentration has been non-detectable for three consecutive months or benzene removal rate has been essentially constant for that period, it will be assumed that the natural emissions rate has been reached and extraction from that well will be stopped. At that time, system modifications will be made as necessary.

The vapor extraction system will be shut down when monitoring results indicate the goals have been met, or that all significant benzene vapors are entering the vadose zone from natural sources.

9.2 Perched Water Extraction and Treatment System

As discussed in Section 8.3, Perched and Ground Water Remedial Options, 10 of 14 perched water wells are dry. If water reappears in the perched ground water wells, extraction of perched water may be incorporated into the ground water treatment system. Perched ground water would then be treated above ground in the same manner as ground water from the deeper aquifer.

9.3 Ground Water Extraction and Treatment System

The chosen remedial method for ground water is extraction using submersible pumps and activated carbon treatment. The conceptual design of the ground water extraction and treatment system is described in this section. The detailed design is presented in Section 10.2, New Extraction Well Installation.

Except for treatment capacity, the design for the Phase 2 remediation system is similar to that for Phase 1. The system consists of six (or seven, if EW-7 is used for extraction) ground water extraction wells using electric submersible pumps for extraction, and two activated carbon vessels installed in series for ground water treatment. The extraction wells will consist of two of the three original Phase 1 extraction wells (EW-1 and MW-28S), three replacement extraction wells installed after Phase 1 remediation activities commenced (EW-2, EW-4 and EW-5), and one or two proposed ground water extraction wells (EW-6 and possibly EW-7). Locations for EW-6 and EW-7 are immediately east of Pole Creek, approximately 200 feet north of EW-2, and approximately 200 feet north of MW-17S, respectively. The combined flow rates from the extraction wells is expected to be between 100 and 120 gpm; the treatment system design capacity will be approximately 150 gpm.

LNAPL has been detected in extraction wells EW-1 and EW-4 and may appear in the proposed extraction wells. In wells where LNAPL is detected, LNAPL absorbers will be installed. In addition, pump shutoff sensors will be installed at sufficient distances above the pump to prevent the introduction of LNAPL into the pumps and the GWTS. As secondary protection in preventing LNAPL from entering the GAC vessels and causing premature breakthrough, the existing 4,000-gallon holding tank shall be piped to act as a LNAPL separation tank, if needed. Note that the separator tank is only needed in the unlikely event of simultaneous failure of both the absorber and the pump controller. The surge tank may also provide some minor LNAPL separation since the water level for pump

activation is approximately 6 inches higher than the pump discharge point. The 4,000-gallon holding tank will provide greater protection for LNAPL separation.

In order to remove suspended solids that may accumulate on the top layers of the GAC vessels, the vessels will be backwashed periodically. This will be performed by reversing the flow of the lead GAC vessel and backwashing with clean water at 300 gpm for 30 minutes. The process will require a portable high flow transfer pump powered by an IC engine, two 10,000-gallon polytanks (clean and dirty water), and 4-inch diameter flexible pipe with cam-lock fittings.

Backwashing will be performed manually when backpressure reaches 40 psi through the lead vessel, (refer to Appendix J for backwashing procedures and schematic). Pressure readings on the inlet of the lead vessel will be monitored continuously via remote monitoring system. Pressure readings between vessels, on the inlet of the lead vessel, and the outlet of the lag vessel will be monitored and recorded on a weekly basis as part of the operation and maintenance visits.

Initially, the backwash tanks will be temporarily located on the unpaved ground surface directly east of the GWTS equipment pad. If backwashing proves to be effective for the long term, then the existing equipment pad will be expanded in the eastern direction to accommodate both tanks. At that time a backwash system with automatic control would be considered. It is important to understand that implementation of backwashing does not require major modifications to the existing system. The existing GAC vessel distribution manifold is designed for manual backwashing. The only new equipment required will be two 10,000 gallon rented polyethylene tanks, trailer mounted diesel engine driven centrifugal transfer pump, flow meter, connection hoses and couplings.

Well EW-7 is proposed for a location not presently covered by ground water monitoring wells and may not be needed for extraction. Should initial sampling from this well indicate benzene concentrations are low, the well will be used as a monitoring well. If concentrations indicate a possible upgradient source which is not within the capture zones of other extraction wells, EW-7 will be added to the ground water extraction system network.

The necessary modifications to the Phase 1 system will consist of installing additional piping to new and existing extraction wells, upgrading the piping in the equipment area for higher flow capacity, installation of additional extraction wells, and upgrading the electrical controls for additional pumps. See the P&ID, Design Drawing M-2 for a basic process flow diagram. Components of the Phase 1 system will be incorporated into the Phase 2 system whenever possible, although some components may be require modification. The major components of the Phase 2 system are:

- Six (6) or seven (7) extraction wells (5 existing, 2 proposed).
- Six (6) or seven (7) electric submersible pumps
- One (1) free product gravity separation tank (existing 4,000 gallon holding tank)
- One (1) 1,000-gallon surge tank. (existing)
- One (1) high flow centrifugal transfer pump: 150 gpm @ 30 psi (5 hp)
- Two (2) 10,000-pound granular activated carbon (GAC) vessels. (existing)
- IC engine powered high-flow transfer pump (backwash)
- Two (2) 10,000-gallon polyethylene tanks (backwash)

The length of system operation will depend on how quickly cleanup goals are met. If operating data show inadequacies in the capture zone, system capacities, etc., the system may require modification. The decision tree (Figure 9-2) presents criteria for modifications and operating time. As stated in the ROD, "Because this remedy will not result in hazardous substances remaining on the site above health-based levels, the five-year review will not apply to this action. The selected remedy will undergo periodic performance evaluations at a frequency to be determined in the Remedial Design Workplan."

10.0 PHASE 2 DESIGN SPECIFICATIONS AND REMEDIAL PROGRAM

10.1 Objectives and Scope

This section provides the detailed design and specifications of the Phase 2 remedial system to be installed at the PCPL Superfund site to achieve the remediation goals described in Sections 1.4 and 8.1. The Phase 2 remediation system consists of the following major components:

Soil Vapor Extraction

- Three vapor extraction units, each with a capacity similar to that of VR Systems Model V4, will be installed.

- Three vadose zone extraction wells (PEW-1, SBD-3 and EW-4) will initially be connected to the system. Well PEW-3 will be added to the extraction system after the initial few months of operation. Additional wells may be incorporated into the system if concentrations of the initial extraction wells decrease to allow additional hydrocarbon destruction.

LNAPL Removal System

- LNAPL collection devices will be installed in ground water extraction wells EW-1 and EW-4 and any other extraction wells that accumulate a significant amount of LNAPL.

- LNAPL collection will be continued in ground water monitoring wells containing LNAPL (MW-9S, MW-17S, and MW-20S).

Ground Water Pump-and-Treat

- Six or seven ground water extraction wells (EW-1, -2, -4, -5, -6, MW-28S, and possibly EW-7) will be connected to the extraction network with dedicated electrical pumps in each extraction well.

- Extracted ground water will be treated with two 10,000-pound activated carbon canisters in series.

Design details for the Phase 2 remediation system are shown in Design Drawings M-1 through M-8, E-1 and E-2. These are:

- M-1 Site Location Map and General Notes
- M-2 Ground Water Treatment System Piping & Instrumentation Diagram
- M-3 Ground Water Treatment System Equipment Layout
- M-4 Ground Water Treatment System Piping Layout
- M-5 Vapor Extraction System Piping & Instrumentation Diagram
- M-6 Vapor Extraction Piping Layout
- M-7 Vapor Extraction System and Piping Details
- M-8 Extraction Well Details
- E-1 Single-Line Diagram, Load Schedule, and General Notes
- E-2 Schematic Wiring Diagram

All work specified in this project will conform to the construction, electrical, and instrumentation codes and standards, as applicable, as listed below:

American Society for Testing and Materials (ASTM)

American National Standards Institute (ANSI)

American Society of Mechanical Engineers (ASME)

American Water Works Association (AWWA)

Instrument Society of America (ISA)

National Electrical Manufacturers Association (NEMA)

Occupational Health and Safety Administration (OSHA)

10.2 New Extraction Well Installation

Two new extraction wells are to be installed and incorporated into the ground water extraction system (EW-6 and EW-7). (As discussed in Section 8.1.2, Ground Water, EW-7 may not be incorporated into the extraction system, depending on sample analyses.) The proposed locations are immediately east of Pole Creek, approximately 200 feet north of EW-2, and approximately 200 feet north of MW-17S, respectively. See Figure 7-7 for proposed locations.

The wells will be constructed of 6-inch Schedule 40 PVC casings and 0.012-inch manufactured PVC screen. The proposed screen intervals in EW-6 will be from approximately 97 ft to 117 ft and 128 ft to 133 ft bgs. The proposed screen interval in EW-7 will be from 80 ft to 100 ft bgs. Actual completion zones will be selected in the field during drilling. The annular space surrounding the screened intervals will be backfilled with a 20-40 silica sand filter to a minimum of one foot above the screen. The sand pack will be sealed to the surface with hydrated bentonite chips (to 3 ft above sand pack) and bentonite. Upon completion, the wells will be developed by surging with a surge block; at least three to five well volumes will be removed with a bailer. Based on ground water modeling, the expected maximum flow rates from the wells are 10 gpm for EW-6 and 11 gpm for EW-7. Proposed well construction details are shown in Design Drawing M-8, Extraction Well Details.

In addition, well EW-7 may also be screened for potential use of vapor extraction.

10.3 Soil Vapor Extraction System

10.3.1 System Outline

As suggested in Sections 8.2 and 9.1, three vapor extraction units (VR Systems Model V4 or equivalent) will be used for site remediation. All three units will be trailer mounted and centrally located near well MW-10P, more than 1,000 feet from San Cayetano School (Design Drawing M-1, Site Location Map). A temporary chain-link fence with slats will be installed around the vapor extraction systems to reduce noise levels produced by the units. A natural gas line will be installed to the system area to provide auxiliary fuel required for system operation.

Ten (10) vadose zone extraction wells (AEW-1, EW-1, -4, -7, MW-28S, PEW-1, -2, -3, SBD-2, and SBD-3) will be connected to the extraction systems. Initially, only three wells will be used for vapor extraction. As hydrocarbon and methane concentrations decline, additional extraction wells will be put into operation. On-going evaluation of this system setup will be conducted to ensure optimum performance of the systems and the best extraction well field for the ultimate site remediation goal.

10.3.2 Equipment Specification

Treatment System

Three trailer-mounted vapor extraction units, VR Systems Model V4, will be provided for the Phase 2 remediation. Each VR Systems unit utilizes two 460-cubic inch displacement

IC engines to oxidize the hydrocarbons. The exhaust gases from the IC engines are further treated catalytically prior to emission.

The unit is controlled by an internal computer system. The air/fuel ratio is automatically adjusted based on influent vapor changes. System performance is continuously monitored and recorded.

Each system is equipped with a 55-gallon knockout pot for the influent gas stream. The knockout pots will be periodically monitored and manually drained as needed. The liquid drained from the pots will be properly treated or disposed of.

Supplemental Fuel

A 1-1/2 inch low-pressure natural gas line will be connected to the system using a flexible connector. The gas line will be painted yellow. The natural gas requirement is 300,000 BTUs per hour with a minimum pressure of 10 inches of water at the system.

Well-Head Construction

Each vapor extraction well will be connected to the system piping using 2- or 4-inch Schedule 40 PVC fittings as shown on the wellhead detail drawing (Design Drawings M-6 through M-8). Extraction wells with casing diameters of 4 inches or larger will be connected with 4-inch fittings and extraction wells with less than 4-inch diameter casing will be connected with 2-inch fittings.

System Piping

Four-inch Schedule 40 PVC piping will be installed connecting the vapor extraction wells to the treatment systems as indicated in Design Drawings M-6 and M-7, Vapor Extraction Piping Layout and Vapor Extraction System and Piping Details. Separate piping will be used for each individual vapor extraction system for ease of operation and adjustment. All above ground PVC piping shall be painted to provide UV protection. New piping shall be installed in a manner to eliminate accumulation of condensed liquid by keeping pipes even and sloped toward the wells. The section of piping passing under the asphalt road and unpaved road near the fence gate will be equipped with a separate condensate collection trap for each line. The trap will be constructed of 12-inch diameter PVC pipe. Each trap will be double contained using a 16-inch diameter corrugated metal pipe filled with a minimum of 3 inches of concrete at the bottom. Liquid level in the collection trap will be checked during each site visit and manually evacuated as needed. The underground piping

passing under the asphalt road shall be extended a minimum distance of 15 feet from the edge of the road before coming above ground. Existing above ground pipe will be supported in sections that may sag.

Valves and Sampling Ports

Schedule 40 PVC ball valves will be installed near each extraction wellhead. A wellhead vapor sampling port will be installed between each extraction well and the ball valve. The sampling port shall be 1/4-inch MNPT x Barbed end PVC cock valve.

10.3.3 Operating Plan and Schedule

The vapor extraction and treatment system procurement and installation will require 3 to 6 months to complete, depending largely on availability of the extraction equipment. System startup will be performed in conjunction with the engineers provided by the system manufacturer. During the startup period, vapor samples will be collected from the influent and effluent of each system to evaluate its performance. System adjustments will be made as necessary based on the evaluations. After initial startup, systems will be operated continuously following the criteria outlined in the SVE Decision Tree (Figure 9-1).

As indicated in Sections 8.1 and 9.1, three wells (PEW-1, SBD-3, and EW-4) will initially be used for vapor extraction. On-going evaluations will be conducted to ensure optimum system utilization and performance. Well PEW-3 will be added as described in Section 9.1, Soil Vapor Extraction System, and well field design will be modified as needed. Other vapor extraction wells may be added to the system as hydrocarbon concentration decreases in the wells connected. Potential vapor extraction wells include, but are not limited to, wells AEW-1, EW-1, -7, MW-28S, PEW-2, and SBD-2, which are already connected or will be connected as part of the Phase 2 construction, and wells EW-5 and PEW-6 which may be connected, if needed.

10.3.4 Monitoring and Sampling Schedule

Monitoring and sampling activities associated with the soil vapor extraction system operation will be conducted during the Phase 2 remediation to evaluate remediation performance and meet the air emission regulation requirements.

The vapor extraction system will be monitored twice weekly during the first month of system operation following the completion of system startup. Weekly system monitoring will be conducted thereafter. Vapor samples initially will be collected from each extraction well and

analyzed for TPH and BTEX on a weekly basis. Carbon distribution and fixed gases may also be analyzed based on the need for evaluation. Hydrocarbon concentrations of extracted soil gas will be conducted using a flame ionization detector (FID) with and without a carbon filter to provide methane concentrations. Extracted soil gas flow rates, vacuum pressures at extraction well heads and at the extraction systems, and other system performance data will be collected during each site visit. Collected data and laboratory analytical results will be used for evaluating remediation progress and system performance. Modifications will be made as needed.

We expect that after three months operation, the changes of vapor concentrations in the extraction wells will be greatly reduced and a less frequent sampling schedule will be necessary. Therefore, a monthly vapor sampling schedule will be used after three months of system operation. When new extraction wells are brought on line, weekly sampling will be conducted for the new extraction well for a period of three months.

10.4 Perched and Ground Water Extraction and Treatment System

10.4.1 Equipment Specifications

Listed below are equipment specifications for the GWTS. Since the majority of the Phase 1 components will be used in the Phase 2 System, equipment specifications are listed only for new equipment, or equipment that has been modified since the original Phase 1 design.

10.4.1.1 Major Equipment Components

Electric Submersible Pumps: The pumps shall be electric submersible pumps meeting the specifications listed in Table 10-1. All pumps shall have 3-phase 460-volt motors manufactured by Franklin (or equivalent). Electrical wire shall be 4 wire, all weather cable, and resistant to hydrocarbons. Down hole piping shall be MNPT threaded Schedule 80 PVC. Pump shall be supported by down hole piping.

LNAPL Skimmers: Passive LNAPL skimmers shall be installed in extraction wells EW-1 and EW-4, and any other wells where LNAPL is present. The skimmer shall consist of an oleophilic absorption material housed in 304 stainless steel screened 2-inch diameter housing. The well cap for EW-1 currently will not accept a 2-inch diameter skimmer, but it will be modified to accommodate the skimmer. The skimmer will be supported by a steel cable and shall be SoakEase™ brand or equivalent.

Separator/Holding Tank (existing): The existing 4,000-gallon polyethylene holding tank will be piped to serve as either an oily water gravity separation tank (in-line) or multipurpose holding tank (off-line) for storing well purge water, well development water, and sump water. Piping will be sufficient in size to allow for full flow through the tank when valved for separation. Water will flow from the separator tank to the surge tank by gravity. The outlet pipe of the tank shall be installed internally, terminating approximately 6-inches from the bottom to ensure that floating product does not enter the surge tank. This use would be strictly a backup measure. LNAPL skimmers in the extraction wells will remove free oil to a sheen. So there would have to be a simultaneous failure of the low-level shutoff on the well pump and failure of the skimmer, before free oil could be pumped out of the well.

Surge Tank (existing): The surge tank is a 1,000-gallon rectangular tank (dimensions: 106"l x 56"w x 50"h) and is constructed of polypropylene. The tank is equipped with 4-inch and 2-inch female fittings to be used for inlet/outlet level sensor connections. There is a 2' x 2' wide manway. The surge tank is equipped with slotted PVC inlet piping to reduce turbulence.

Transfer Pump -- Surge Tank: The transfer pump shall be a centrifugal close-coupled pump capable of 150 gpm @ 30 psi. The pump shall have a 5-1/2-inch diameter impeller and shall be a model 1-1/2x2x7L,LA with a 3-phase 460 volt 5-hp motor or equivalent manufactured by Carver. See Appendix J for specifications and pump curve.

Bag Filtration System: The existing bag filter housing will be removed. A larger filter housing may be installed at later date, if necessary. An area will be left open on the equipment pad for a large capacity bag filter housing. The optional filter housing shall be constructed of 304 stainless steel and rated to 150 psi. The filter housing will hold a minimum of twenty-four (24) 6 ft^2 polypropylene filter bags with a minimum flow capacity of 200 gpm. The approximate dimensions of the housing are 68" h x 24" d.

GAC Vessels (existing): The existing GAC vessels will be used in the Phase 2 GWTS with modifications as discussed in Section 5.2.2, Solids Removal. The vessels are Westates model HP-10, rated for a maximum flow rate of 250 gpm and pressure of 75 psi. The existing manifold is designed for alternating lead/lag vessels and reverse flow capabilities for backwashing. When the pressure drop across either bed reaches a predetermined value, the vessels will be backwashed for 30 minutes at 300 gpm. A wheel mounted high-flow internal combustion powered transfer pump will be used. Two 10,000-gallon rental Baker tanks will be used for clean supply water and discharge water. A pump specification sheet for the backwash pump is included in Appendix J.

Transfer Pump -- Holding Tank (existing): The holding tank transfer pump is a Pacer model 2CL capable of 150 gpm at 17 ft of head. The pump will be operated manually without any level control.

10.4.1.2 Instrumentation and Controls Specifications

Flow Sensors and Meters: Individual extraction wells, total inlet flow from the extraction wells, and a total outlet flow from the GAC vessels will be monitored using paddle wheel type flow sensors with analog display flow meters and digital totalizers. The flow meter converts a pulse signal to a 4-20 ma signal. Signet or equivalent flow instrumentation will be used. If paddle wheels become clogged with suspended solids after operation of the system begins, magnetic inductive flow meters will be considered. Magnetic inductive flow meters have no ports or paddlewheels to clog, but costs are substantially higher. The paddle wheel flow sensors will be installed with unions on both ends of the sensor assemblies to allow for easy removal for cleaning and maintenance.

Pressure Indicators: Pressure indicators shall be installed at locations specified on the design drawings. Pressure gauges shall be Omega type S or equivalent.

Pressure Transmitters: The existing pressure transmitters on the individual extraction well lines will be removed and replaced with pressure indicators. Only the pressure transmitter on the inlet to the GAC vessel will remain. If the bag filtration system is installed at a future date, a pressure transmitter will be installed just prior to the bag filter. The pressure transmitter is manufactured by Signet, or equivalent.

Down Hole Level Sensors: High-low level sensors shall be Series 3Y (or equivalent) corrosion - resistant electrodes manufactured by Warrick. There shall be three sensors per well: high, low, and ground or reference. Sensors shall be used for pump activation with intrinsically safe level controls located in the main control panel. Suspension wire shall be PVC coated with an additional PVC heat shrink jacket used as protection from hydrocarbons.

Down Hole Pressure Transducers: Pressure transducers shall be installed in all extraction wells and monitoring wells MW-39S and MW-14S for continuous monitoring of ground water levels. Pressure transducers shall be Model PX 161D manufactured by In-Situ™, or equivalent. The transducers shall be linked to Hermit model 1000S or equivalent data loggers manufactured by In-Situ™. At monitoring wells MW-39S and MW-14S, the data loggers will be located inside the well boxes and data will be manually down loaded, as needed. At the extraction wells, the data will be transmitted to the control panel at the

equipment area via electrical sensor wire from the extraction wells to the pad. Down hole transducer wire shall be PVC coated with a secondary PVC heat shrink jacket as protection from hydrocarbons.

Flow Protection for Extraction Pumps: In the Phase 1 remediation system, Omega PSW series pressure switches were used to send a signal to the motor control center in the event of a high or low pressure condition to shut the pump off. Examples would be a break in the recovery piping (low) or blockage in recovery piping (high). Since operating line pressures are almost as low as static pressures, the pressure switches cannot be set to detect any difference. The signal from the individual well flow meters will be used to detect low flow in the recovery lines. The PLC will have programmed setpoints so if the pump is not operating at or above minimum flow in conjunction with a low or high pressure situation, the pump motors will shut off.

Telemetry System: The Telemetry system shall consist of two Microtel or equivalent telemetry units for data recovery and an IBM equivalent PC for data storage and transmission to a host site via modem. Each unit will be equipped with eight analog inputs for a total of sixteen. Data can be monitored continuously or down loaded via the modem. System monitoring will include instantaneous and cumulative flow for each well, and/or the GAC vessels, inlet pressure and total inlet and outlet instantaneous and cumulative flow.

Float Switches: Float switches installed in the surge tank serve as on-off control for the 5 hp transfer pump and overfill protection to shut the system off. There are three level sensors (L-H-HH) installed in the surge tank. The separator/holding tank has one flow switch used as overfill protection. The containment pad has a stainless steel ball type float switch to shut the system off, if the containment pad fills with water. This would most likely occur in the event of a failure in the sump pump. All float switches installed in tanks are the hanging mercury tilt type manufactured by Warrick or equivalent.

Motor Control Center (MCC): The motor control center contains main disconnects, motor starters, 240-volt breaker panel, level control relays, 480/240-volt transformer, and a Programmable Logic Controller (PLC). The MCC is a series 2100 manufactured by Westinghouse. Modifications to the MCC shall consist of additional motor starters and disconnect switches to be used for the additional submersible pumps and the 5 hp transfer pump. The addition of a PLC with digital and analog inputs manufactured by Square D or equivalent will be used to serve as a safety shutoff controller. The PLC will be programmed to shut extraction pumps off in the event of a low flow situation and to shut off the system if any of the high level float switches in the tanks or containment area are activated. Warning lights will be installed in the MCC to identify the appropriate alarm. In the event

of a low flow situation, a manual reset will need to be activated to restart the corresponding submersible pump; or to restart the GWTS in the event of an overfill situation.

10.4.1.3 Minor Equipment Specifications

Butterfly Valves: Butterfly valves will be used as flow control valves on individual recovery lines from the extraction wells in the equipment pad, and as flow control on the transfer pump between the surge tank and GAC vessels. Seat rings and valve seals shall be constructed of viton or Teflon.

Ball Valves: All ball valves in equipment areas shall be Schedule 80 true union type. Ball valves for vapor return control inside well boxes shall be molded-in-place slip to slip type. All valves shall have O-rings constructed of Viton or Teflon.

Check Valves: Check valves shall be spring or swing type with PVC bodies and Buna-N seals.

Piping and Fittings: Schedule 40 PVC pipe will be used for subsurface fluid and vapor recovery piping. Schedule 40 PVC piping will conform to ASTM-D-1785, and commercial standard CS-207-60. Pipe shall bear labelling from manufacturer stating conformance to the standards listed above. Pipe shall be slip connected and glued using PVC cement conforming to ASTM D2564.

Schedule 80 PVC piping shall be used for all fluid piping in equipment areas and as down hole recovery pipe for submersible pumps. Schedule 80 PVC pipe will conform to ASTM-D-1785 and CS-207-60. Pipe must be labelled accordingly and also bear labeling of pressure rating. Pipe shall be slip connected and glued using PVC cement conforming to ASTM D2564, except for down hole pipe which will be MNPT threaded. PVC pipe fittings shall meet or exceed the requirements of ASTM-2466-73 for socket type PVC pipe fittings.

Pipe Support: All piping supports shall be constructed from 1-5/8-inch wide unistrut or equivalent steel channel. The unistrut is to be secured to appropriate bases and fastened to the concrete using 3/8-inch red-head anchors or equal.

Trenching and subsurface pipe installation: All subsurface pipe and conduit shall be installed with a minimum burial of 24 inches. Fluid return piping shall be pressure tested at three times the working pressure for a minimum of one hour. Trenches shall be backfilled with native soil at maximum lifts of 8-inches.

Unions: Schedule 80 PVC Unions shall be installed at the inlet and outlets of all components that may need to be serviced, removed or require maintenance including flow sensor assemblies, pressure sensor assemblies, particulate filter housings (if used) and transfer pumps. Schedule 80 PVC unions shall meet or exceed the requirements of ASTM D-2467.

Sample Ports: Sample ports shall be installed at locations shown on the design plans. Samples shall have 1/4-inch MNPT x Barbed end with Teflon or Viton seals and seats, and shall be constructed of PVC.

Well Seals: Well seals on extraction wells shall be a sanitary type constructed of 304 stainless steel with Buna-N gaskets secured with steel tightening bolts. Holes will be drilled on top for power supply wiring, control wiring, SoakEase™ access and fluid return piping with INPT (2-inch hole for SoakEase™ access, (2) - 3/4-inch for electrical, 1-1/2-inch for fluid return).

Well Boxes: Well boxes for proposed wells EW-6 and EW-7 shall be 36-inch square traffic rated, rain tight steel well boxes.

10.4.1.4 Electrical Specifications

Hazardous Location Classification: From the ground to 18 inches above grade in the equipment enclosures, inside the extraction well boxes, and 18 inches in all directions of any tank where free phase product may be present shall be classified as a Class I, Division II, Group D Area as specified in NEC. All conduit, fitting, junction boxes, seal offs, and any other materials necessary for the installation of the remediation system located in hazardous areas shall meet the requirements of that area.

Electrical Conduit: Subsurface conduit shall be Type 40 PVC conduit with rigid coated sweeps at transitions to grade. Connections to transfer pump motors, float switches, etc., may use flexible liquid tight conduit for short transitions. All above grade conduit shall be rigid steel conduit, except for phone line conduit which shall be intermediate metal conduit (IMT). Conduits shall be supported in accordance with Article 346-12 of NEC.

Electrical Conductors: All conductors or wire shall be type THHN stranded copper wire with PVC insulation and nylon jackets.

Seal-Offs: EYS sealing unilets (Seal-Offs) shall be installed on conduit when leaving or entering a hazardous area.

Fittings and Junction Boxes: Fittings and junction boxes shall be constructed of cast malleable iron or cast gray iron alloy and shall be approved for the location in which they are installed.

10.4.2 Operating Plan and Schedule

Prior to system startup, base line data on all ground water extraction wells will be obtained (including water levels, TPH and BTEX levels). TPH and BTEX analysis may be taken from a quarterly ground water monitoring event, if it coincides with a system startup. The ground water levels will be monitored continuously for a minimum of one month prior to system startup. Pressure transducers will be used in the extraction wells and Hermit pressure transducers and dataloggers, or equivalent, in selected remote monitoring wells. Constant rate and step rate aquifer testing will be performed on the two additional extraction wells at system startup. The new extraction wells will be analyzed for general mineral analysis, TDS and TSS after development to compare water quality and solids content to those of existing extraction wells.

10.4.3 Monitoring and Sampling Schedule

Continuous Monitoring with Telemetry System

- Individual well flow rates and cumulative volumes.
- Water levels in extraction wells and selected monitoring wells.
- Combined well flow rate (system inlet and outlet) and cumulative volume.
- Inlet pressure to GAC vessels.

Weekly Monitoring by Technician

- Individual well flow rates and cumulative volumes.
- Combined well flow rate (system inlet and outlet) and cumulative volume.
- Individual well pressures at well head and equipment pad.
- Inlet, intermediate, and outlet pressure of GAC vessels.

Monthly Monitoring and Sampling

- Sample individual wells and analyze for TPH and benzene.
- NPDES sampling requirements.

11.0 PHASE 2 REMEDIAL ACTION IMPLEMENTATION

11.1 Introduction

The remedial action implementation will follow EPA approval of the Final Design. This section summarizes the major activities which will be included.

11.2 Remedial Action Work Plan

The Statement of Work (SOW) requires that Texaco shall submit a Remedial Action Work Plan 60 days following EPA approval of the Final Phase 2 Design. The Work Plan shall include the following: (1) a tentative formulation of the Remedial Action Team, (2) the method for selection of a remedial action contractor, (3) a schedule for developing and submitting Remedial Action deliverables set forth in Task 3 of the SOW and for completing the remedial action, (4) revised cost estimates, (5) contingency plan implementation, and (6) construction QA implementation and requirements for completion.

11.3 Construction and System Permitting

Permitting for the installation and operation of the Phase 2 Ground Water Treatment System (GWTS) and Soil Vapor Extraction (SVE) System will be initiated following approval of the Remediation Work Plan by the EPA. The final design plans will be submitted to the appropriate agencies and permits or addenda to the existing permits will be obtained. The following outline summarizes permitting requirements for both the GWTS and SVE.

A. Ground Water Treatment System

1. County of Ventura Planning Department
   a. CUP Amendment

2. County of Ventura Building Department (Plan Check)
   a. Building
   b. Electrical

3. Ventura County Flood Control District
   a. Encroachment permit: Installation of proposed extraction wells and remediation piping in the flood control district's easement.

4. Regional Water Quality Control Board
   a. New NPDES permit

B. Vapor Extraction System

1. County of Ventura Planning Department
   a. CUP Amendment

2. County of Ventura Building Department (Plan Check)
   a. Building
   b. Electrical

3. City of Fillmore Fire Department

4. Ventura County Air Pollution Control District (VCAPCD)

11.4 Remediation System Installation and Startup

The Final design specifications and plans will be submitted for plan check and the appropriate permits will be obtained. After the permitting process is complete, a general contractor will be selected by Texaco to perform the work. The general contractor will select subcontractors to perform specific tasks and all subcontractors must be approved by Texaco.

The estimated schedule for installation is summarized as follows:

- The permitting process will take approximately six weeks.
- Trenching and pipe installation will take approximately two weeks.
- The modifications to the GWTS will take approximately three weeks and the modifications to the SVE approximately one week. GWTS and SVE modifications may be completed simultaneously.
- One week is estimated for final inspections and any required corrections.

Therefore, the total time for system completion after plans are finalized is approximately 12 weeks.

Startup of the GWTS and SVE will commence immediately after system modifications are completed. The Phase 1 system will operate until construction commences to obtain performance data and continue the recovery of hydrocarbons.

11.5 Remediation System Operation and Maintenance

Operation and maintenance (O&M) of the Phase 2 remediation system will consist of recording pertinent data and performing recommended system maintenance.

As with the Phase 1 remediation system, data will be monitored on a weekly basis by an O&M technician and on a continuous basis by the data logger and telemetry system. An O&M manual will be prepared prior to system startup that will include a maintenance checklist for system components, field data sheets, and manufacturers' specification sheets for system components.

Particular attention will be paid to pressure drop across the individual GAC vessels. When the pressure drop exceeds a predetermined value (40 psi), backwashing of the GAC vessels will be performed. If the pressure drop increases rapidly after backwashing, or backwashing proves ineffective in removing suspended solids from the vessels, then a high capacity bag filtration unit or chemical addition (sequestering agent) system may be installed.

11.6 Project Management

Implementation of the Phase 2 construction will be managed by Texaco Environmental Services (TES). As the supervising contractor, England, Shahin and Associates will provide technical oversight and remedial system construction management services. Specialist subcontractors will be used for well drilling and installation, providing remediation equipment and electrical services. All equipment required for the Phase 2 construction will be provided by TES to the extent possible within their inventory or purchased from a qualified vender according to the specifications included in Section 10.

11.7 Quality Assurance/Quality Control

A Quality Assurance/Quality Control Plan (QA/QC Plan) will be prepared and submitted to the EPA with the Phase 2 Remedial Action Work Plan. All field activities including equipment installation, well installation, soil, vapor and water sampling (and the analysis) will be conducted as specified in the QA/QC Plan. Daily field reports, as-built drawings, construction reports, and testing results will be assembled in a file and made available for review by the EPA.

12.0 REFERENCES

AAPG. See American Association of Petroleum Geologists.

American Association of Petroleum Geologists (AAPG), 1977. *San Cayetano Fault - Field Trip (with Apologies to the San Andreas) - June 3, 1977.* Pacific Section of the American Association of Petroleum Geologists. June 3, 1977.

Barker, J.G.; Patrick, G.C.; and Major, D., 1987. *Natural Attenuation of Aromatic Hydrocarbons in a Shallow Sand Aquifer, Ground Water Monitoring Review.*

California Division of Oil and Gas (CDOG), 1960. *California Oil and Gas Fields - Southern, Central and Offshore California, Volume No. 2.* (Revised 1991).

California Division of Oil and Gas (CDOG), 1988. *Seventy-third Annual Report of the State Oil and Gas Supervisor - 1987: Publication No. PR06.*

California Division of Water Resources (CDWR), 1933. *Ventura County Investigation: Bulletin No. 46.*

California Division of Water Resources (CDWR), 1953. *Geology and Ground Water of Ventura County, California: Bulletin No. 12 -- Appendix B.*

California Regional Water Quality Control Board (CRWQCB), 1993. *Waste Discharge Requirements - Pacific Coast Pipeline Site, Fillmore (NPSDES No. CA 0063240). Letter dated December 10, 1993 to Glenn R. Anderson from Joshua M. Workman.* December 10, 1993.

CDOG. See California Division of Oil and Gas.

CDWR. See California Division of Water Resources.

CGS. See Coast Geologic Society.

Chapelle, F.H., 1993. *Ground Water Microbiology & Geochemistry*, John Wiley & Sons.

Chiang, C.Y.; Salanitro, J.P.; Chai, E.Y.; Colthart, J.D.; and Klein, C.L., 1989. *Aerobic Biodegradation of Benzene, Toluene, and Xylene in a Sandy Aquifer- Data Analysis and Computer Modeling. Groundwater.*

Coast Geologic Society (CGS), 1982. *Geologic Guide of the Central Santa Clara Valley, Sespe and Oak Ridge Trend Oil Fields - Ventura County, California: Coast Geologic Society Guidebook No. 53.*

CRWQCB. See California Regional Water Quality Control Board.

Dibblee, T.W., Jr., 1990. *Geologic Map of the Fillmore Quadrangle - Ventura County, California: Dibblee Geologic Foundation Map No. DF-27.*

Earthinfo Inc., 1994a. *NCDC Summary of the Day.* 1994.

Earthinfo Inc., 1994b. *USGS Daily Values.* 1994.

England, Shahin & Associates, 1993. *Second Quarter 1993, Ground Water Monitoring Report.* July 29, 1993.

England, Shahin & Associates, 1994a. *Addendum No. 1 to Technical Memorandum No. 6, dated February 25, 1994. Title: Additional Vapor Extraction System Installation Phase 1 Remediation Activities.* February 25, 1994.

England, Shahin & Associates, 1994b. *Technical Memorandum No. 7, dated February 25, 1994. Title: Revisions to Data Collection Program Phase 1 Remediation Activities.* February 25, 1994.

England, Shahin & Associates, 1994c. *Technical Memorandum No. 8, dated March 14, 1994. Title: Modification of Phase 1 Ground Water Remediation Program.* March 14, 1994.

England, Shahin & Associates, 1994d. *Addendum No. 2 to Technical Memorandum No. 6, dated May 4, 1994. Title: Results of Short-Term Vapor Extraction Tests and Recommendations for Supplemental Vapor Extraction Unit Phase 1 Remedial Activities.* May 4, 1994.

England, Shahin & Associates, 1994e. *Addendum No. 1 to Technical Memorandum No. 8, dated May 18, 1994. Title: Modifications of Phase 1 Ground Water Remediation Program.* May 18, 1994.

England, Shahin & Associates, 1994f. *Second Quarter 1994 NPDES Monitoring Report, Pacific Coast Pipeline Superfund Site, Fillmore, California.* July 15, 1994.

England, Shahin & Associates, 1994g. *Second Quarter 1994 Quarterly Status Report*. July 20, 1994.

England, Shahin & Associates, 1994h. *Technical Memorandum No. 9, dated July 27, 1994. Title: Biofeasibility/Biotreatability Study*. July 27, 1994.

England, Shahin & Associates, 1994i. *Second Quarter 1994, Ground Water Monitoring Report*. August 19, 1994.

England, Shahin & Associates, 1994j. *Third Quarter 1994, Ground Water Monitoring Report*. October 15, 1994.

ENSR Consulting and Engineering, 1990a. *Remedial Investigation/Site Background Summary for the Texaco Facility, Fillmore, California (Document No. 6600-035-110)*. March 1990.

ENSR Consulting and Engineering, 1990b. *Remedial Investigation/Feasibility Study (RI/FS), Texaco Facility, Fillmore, California (Document No. 660-035-130)*. July 1990.

ENSR Consulting and Engineering, 1991a. *Final Remediation Investigation Report - Texaco Fillmore Facility (Document No. 6600-047-900)*. June 1991.

ENSR Consulting and Engineering, 1991b. *Aquifer Testing Report - Texaco Fillmore Facility (Document No. 6600-060-510)*. October 1991.

Envirotools Ltd., 1993. *AQUIX-4S v 1.11 Aquifer Test Analysis Tools*.

Environmental Solutions, Inc. (ESI), 1992. *Preliminary Design Work Plan (PDW) - Pacific Coast Pipeline Superfund site, Fillmore, California*. December 1992.

Environmental Solutions, Inc. (ESI), 1993a. *Technical Memorandum No. 2 dated April 30, 1993, Title: NAPL Monitoring Program*. April 30, 1993.

Environmental Solutions, Inc. (ESI), 1993b. *Technical Memorandum No. 3, dated June 9, 1993. Title: Evaluation of Extracted Ground Water Disposal Options*. June 9, 1993.

Environmental Solutions, Inc. (ESI), 1993c. *Final (100%) Phase 1 Design Report - Pacific Coast Pipeline Superfund Site, Fillmore*, California. September 1993.

Environmental Solutions, Inc. (ESI), 1993d. *Technical Memorandum No. 6, dated December 30, 1993. Title: Refinement to SVE Testing Program, Phase 1 Remediation Activities.* December 30, 1993.

Environmental Solutions, Inc. (ESI), 1994. *Third Quarter 1994 NPDES Monitoring Report, Pacific Coast Pipeline Superfund Site, Fillmore, California.* October 15, 1994.

ESA. See England, Shahin & Associates.

Eschner, S., 1957. *Geology of the Central Part of the Fillmore Quadrangle - Ventura County, California: Unpublished M.S. thesis - University of California at Los Angeles.*

Eschner, S., 1969. *Geology of the central part of the Fillmore Quadrangle - Ventura County, California: American Association of Petroleum Geologists - 1969 Field Trip, Fillmore Area.*

ESI. See Environmental Solutions, Inc.

Fetter, C.W., 1993. *Contaminant Hydrogeology, Macmillan Publishing Co.*

Fine, S. F., 1954, *Geology and Occurrences of Oil in the Ojai-Santa Paula Area, Ventura County*, California Division of Mines Bulletin 170, map sheet No. 28.

Freeze, R.A. and Cherry, J.A., 1979. *Groundwater, Prentice-Hall, Inc.*

Gilham, R.W., Starr, R.C.; and Miller, D.J., 1990. *A Device for In Situ Determination of Geochemical Transport Parameters: 2. Biochemical Reactions. Groundwater*

Hengstebeck, R. J., 1959. *Petroleum Processing, Principals and Applications, McGraw-Hill Book Company.*

Hester, R.L., 1977. *The San Cayetano Thrust Fault: Pacific Section of the American Association of Petroleum Geologists - June 3, 1977 Field Trip.* June 3, 1977.

Jennings, C.W. and Troxel, B.W., 1954. *Geology of Southern California: California Division of Mines and Geology Bulletin No. 170 - Geologic Guide No. 2, Ventura Basin.*

Kaplan, Isaac R., 1994. *Formation Mechanisms and Differentiation of Methane and Hydrogen Sulfide in Various Environments.* Presentation to SWANA.

Kemblowski, M.W., Salanitro, J.P.; Deerly, G.M.; and Stanley, C.C., 1987. *Fate and Transport of Residual Hydrocarbons in Ground Water - A Case Study. Pp. 207-231 in Proceedings of the Petroleum Hydrocarbons and Organic Chemicals in Ground Water Conference. Houston: National Water Well Association and American Petroleum Institute.*

Krusemann, G.P. and DeRidder, N.A., 1991. *Analysis and Evaluation of Pumping Test Data, Second Edition, International Institute for Land Reclamation and Improvement.*

Mann, J.F., Jr., 1958. *A plan for ground water management - United Conservation Water District.*

Mann & Associates, 1959. [Ref pg 2-4]

McDonald, M.G., and Harbaugh, A.W., 1988. *A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model, U.S. Geological Survey - Techniques of Water Resources Investigations, Book 6, Chapter A1.*

Nagle, H.E. and Parker, E.S., 1971. *Future oil and gas potential of Onshore Ventura Basin, California: American Association of Petroleum Geologists Memoir No. 15.*

Osiecki, Patti and Dirth, Lisa, 1994. *1994 Study Manual for the California Geology Registration Exam.* February 1994.

Pollack, David W., 1989. *Documentation of Computer Programs to Compute and Display Pathlines Using Results from the U.S. Geological Survey Modular Three-Dimensional Finite-Difference Ground-Water Flow Model, U.S. Geological Survey Open File Report 89-381.*

Quinlan, Barbara J.; Korreck, William M.; Armstrong, John M., 1992. *Pure Oxygen-enhanced Biodegradation for Contaminated Groundwater, in Remediation, Autumn 1992.*

Radian, 1984. *Environmental Evaluation, Pacific Coast Pine Lines Facility.* February 1984.

Riser-Roberts, E., 1992. *Bioremediation of Petroleum Contaminated Sites. C.K. Smoley, c/o CRC Press, Inc., Boca Raton, Florida.*

SCG. See Southern California Gas Company.

Schrauf, Todd W.; Sheehan, Patrick J.; Pennington, Leslie H., 1994. *Alternative Method of Groundwater Sparging for Petroleum Hydrocarbon Remediation, in Remediation, Winter 1993/1994.*

Schultz, C.H., 1959. *Fillmore Oil Field: California Division of Oil and Gas (CDOG) Summary of Operations - California Oil Fields, Volume 45, No. 1.*

Southern California Gas Company, 1994. *Personal communication between Mario Alcazar, Southern California Gas Company and Michael Higuchi, England, Shahin & Associates.* August 16, 1994.

Sylvester, A.G. and Brown, G.C., 1988. *Santa Barbara and Ventura Basins - Tectonics, Structure, Sedimentation, Oilfields Along an East-west Transect: Coast Geological Society Field Guide No. 64.*

TES. See Texaco Environmental Services.

Testa, S.M. and Winegardner, D.L., 1991. *Restoration of Petroleum Contaminated Aquifer, Lewis Publishers.*

Texaco Environmental Services (TES), 1990. *Private Well Investigation, Fillmore RI/FS, (Document No. 620-002-020).* December 1990.

Texaco, Inc., 1994a. *Letter from Glenn R. Anderson to Mr. Robert P. Ghirelli, Regional Water Quality Control Board, dated March 10, 1994, regarding NPDES Permit for PCPL Site.* March 10, 1994.

Texaco, Inc., 1994b. *Letter from Glenn R. Anderson to Mr. Joshua M. Workman, Regional Water Quality Control Board dated May 31, 1994 regarding Update on Ground Water Treatment Project Status and Discussion of Future Activities and Concerns.* May 31, 1994.

Thomas, J.M.; Gordy, V. R.; Fiorenza, S.; and Ward, C.H., 1990. *Biodegradation of BTEX in Subsurface Materials Contaminated with Gasoline. Water Science Technology*

TriHydro Corporation, 1988. *Ground Water and Soils Assessment Progress Report, Texaco Fillmore Facility (Draft).* June 27, 1988.

TriHydro Corporation, 1990. *Soil Gas RI/FS Investigation, Texaco Facility, Fillmore, California.* September 7, 1990.

United States Geological Services, 1988. *7.5 minute United States Geological Services (USGS) Topographic Map of Fillmore, California -- dated 1951, photorevised 1988.*

United Water Conservation District, 1994. *Personal Communication with Jayne Laber and copies of flow records for drainages in Santa Clara River Basin.*

US Environmental Protection Agency (USEPA), 1992a. *A technology assessment of soil vapor extraction and air sparging: Risk Reduction Engineering Laboratory, Office of Research and Development. EPA/600/R-92/173.* 1992.

US Environmental Protection Agency (USEPA), 1992b. *Record of Decision (ROD) - Pacific Coast Pipeline, Texaco Fillmore Facility.* April 2, 1992.

US Environmental Protection Agency (USEPA), 1992c. *Statement of Work for the Preliminary Remedial Design at the Pacific Coast Pipeline Site. Fillmore, Ventura County, California.* August 1992.

US Environmental Protection Agency (USEPA), 1993a. *Consent Decree (CD) - Pacific Coast Pipeline Site.* February 1993, entered August 1993.

US Environmental Protection Agency (USEPA), 1993b. *Letter dated December 9 1993 from Tom Dunkelman to Fred Nunnery at Ventura County APCD regarding CERCLA Permitting Exemption for Texaco Fillmore Remedial Action.* December 9, 1993.

USGS. See United States Geological Services.

UWCD. See United Water Conservation District.

VCPDW. See Ventura County Department of Public Works.

Ventura County Department of Public Works, 1994. *Personal Communication with Glenn Luscombe and electronic copies of water level and water quality data for Santa Clara River Basin.*

WWI. See W. W. Irwin, Inc.

Weber, F.H., Jr.; Cleveland, G.B.; Kahle, J.E.; Kiessling, E.F.; Miller, R.V.; Mills, M.F. and Morton, D.M., 1973. *Geology and Mineral Resources Study of Southern Ventura County, California: California Division of Mines and Resources Preliminary Report No. 4.*

W.W. Irwin, Inc., 1994. *NPDES Monitoring Report - First Quarter 1994, Texaco Pacific Coast Pipeline Superfund Site.*

Zheng, C. Path3D, 1992. *A Ground-Water Path and Travel-Time Simulator, International Ground Water Modeling Center, TPS-08.*

TABLES

Table 2-1
Mean Monthly Flow in Pole Creek Upgradient of PCPL Site
Water Year October 1992 to September 1993

Year	Month	Mean Monthly Flow (cfs)
1992	October	1.89
	November	0.37
	December	1.24
1993	January	27.4
	February	17.2
	March	12.8
	April	7.84
	May	3.83
	June	1.56
	July	0.60
	August	0.82
	September	0.91

Table 4-1
Free Oil Noted on Soil

BORING OR WELL	ZONE	APPROXIMATE DEPTH TO HIGH GROUND WATER	DEPTH IN FEET	DESCRIPTION
MW-17S	Shallow	53	24-28	Trace of free liquid hydrocarbon (crude).
			34-38	Trace of liquid product; heavy oil stained and strong heavy crude oil odor.
			42-44	Heavy oil staining and odor.
MW-26S	Shallow	55	20-23	Very powerful petroleum odor, black contaminant visible.
			45-48	Black, oily
MW-37S	Shallow	73	40	Local brown and black product observed.
MW-38S	Shallow	68	18-28	Locally product saturated.
			35-42	Product saturated.
MW-40S	Shallow	41	35-40	Sheen on shale surfaces, black staining locally.
MW-47D	Shallow	66	45	Free product sheen visible in samples.
			50-52	Visible product; product aureoles around pores.
EW-1	Shallow	54	37-48	Locally product saturated; brown product on sample rings.
			48	Locally product saturated, brown product on sample rings.
EW-4	Shallow and Deep	47	40-63	Free hydrocarbon; locally saturated with oil; abundant beads of oil in saturated section; abundant oil in soil
EW-5	Shallow and Deep	41	38	Apparent free oil saturation.
			45	Oily.
			60-63	Apparent free oil saturation.
AEW-1	Shallow	70	26	Brown oil sheen on grains
PEW-1 (Cont.)	Shallow	80	38-45	Locally product saturated.

ENGLAND SHAHIN & ASSOCIATES

Table 4-1
Free Oil Noted On Soil (Cont.)

BORING OR WELL	ZONE	APPROXIMATE DEPTH TO HIGH GROUND WATER	DEPTH IN FEET	DESCRIPTION
PEW-1 (Cont.)	Shallow	80	55	Locally product saturated.
PEW-2	Shallow	67	40	Black staining.
PEW-3	Shallow	67	20	Locally product saturated.
PEW-5	Shallow	67	43	Saturated zones have free NAPL (speckled brown).
SBB-1	Shallow	80	35	Trace brown product on shale cleavage/fracture surface.
			40	Shale fragments locally product saturated; sheen on rusty weathered fragment surfaces..
			48	Shale fragments product saturated.
SBC-1	Shallow and Deep	45	30	Shale fragments, sheen on fractured surfaces.
			32	Shale fragments, locally product saturated.
			48	Locally product saturated (shale fragments).
SBD-2	Shallow	53	20	Local free product.
			30	Product saturated; brown product observed locally on shale bedding surfaces.
			34	Product saturated.
SBD-3	Shallow	52	39	(Sand) Product on surface of grains.
SBD-4	Deep	53	60	Product saturated.
SBE-1	Shallow	47	33	Locally product saturated; sheen observed on gravel surfaces.
SBF-1	Shallow and Deep	33	30	Locally product saturated (sheen on surface of gravel size shale fragments).
			35	Locally product saturated (sheen on surface of gravel size shale fragments).
SBG-2 (Cont.)	Shallow	41	30-36	Gray oil shale saturated with fuel.

Table 4-1
Free Oil Noted On Soil (Cont.)

BORING OR WELL	ZONE	APPROXIMATE DEPTH TO HIGH GROUND WATER	DEPTH IN FEET	DESCRIPTION
SBG-2 (Cont.)			36	Fuel saturated (gasoline odor).
FSB-1	Shallow	70	16-18	Visible product on shaly layers.
			24-26	Dark brown product in shale fractures.
			30-32	Oily.
			34-36	Shale has liquid hydrocarbon when broken.
			40-42	Oil on sampler and in shale fractures.
			42-44	Shale with free product in fractures.
FSB-3	Shallow	57	40-45	Hydrocarbon product visible on water in sampler.
FSB-4	Shallow	50	26-31	Hydrocarbon product visible on gravel.
FSB-6	Shallow	54	27-32	Liquid hydrocarbon in bedding layers.
P3-BH-1	Shallow	55	25-30	Moisture due to water or contamination.
P3-BH-2	Shallow	58 to high water	25-30	Moisture due to product.
			35-40	Moisture due to product.
			40-45	Moisture due to product.
P4-BH-6	Shallow and Deep	47	5-20	Very oily.
			49.5	Ground water and free product.

ENGLAND SHAHIN & ASSOCIATES

Table 4-2
Summary of LNAPL Removal

Well Number	Inclusive Dates	LNAPL Removed (gal)
MW-9S	2/8/94 -- 9/30/94	0.57
MW-17S	1/25/94 -- 9/30/94	0.06
MW-20S	1/25/94 -- 9/30/94	0.06
EW-1	1/25/94 -- 9/30/94	3.1
EW-4	6/16/94 -- 9/30/94	1.0
TOTAL		4.79

Table 4-3
BTEX and Volatile Fuel Hydrocarbons in Soil
Concentrations in ppmv

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Total Xylenes	Vol. Fuel Hydrocarb.	Perforated Depth
MW-10P	08/10/94	31	61	32	67	13,000	38-48
MW-13P	08/10/94	<11	13	<8.1	14	11,000	47-67
SBB-1	05/12/93	<0.31	2.6	0.75	4.8	NA	30-50
	03/17/94	180	74	<23	39	20,000	30-50
	08/09/94	18	80	30	35	12,000	30-50
SBC-1	05/12/93	<1.5	<1.3	<1.1	5.7	NA	25-45
	08/12/94	<31	37	<23	32	28,000	25-45
SBD-2	05/12/93	<0.31	1.7	<0.23	2.7	NA	15-50
	12/27/93	2.8	1.5	<1.2	<1.2	340	15-50
	01/04/94	5.6	<1.3	<1.2	<1.2	450	15-50
	03/18/94	110	27	<8.1	9.7	9,100	15-50
	08/11/94	100	26	9.0	8.5	5,700	15-50
SBD-3	05/12/93	<0.31	1.7	<0.23	2.5	NA	32-55
	08/11/94	150	37	<8.1	18	9,100	32-55
SBE-1	05/12/93	<0.31	1.8	<0.23	4.3	NA	25-50
	08/11/94	53	24	10	<8.1	8,000	25-50
PEW-1	12/27/93	190	<27	<23	<23	13,000	49-74
	01/04/94	180	18	<12	19	13,000	49-74
	03/18/94	470	45	<23	<23	34,000	49-74
	08/09/94	380	42	18	15	16,000	49-74
PEW-2	01/14/94	280	53	32	<23	28,000	20-45
	03/15/94	280	72	<23	53	27,000	20-45
	03/17/94	260	72	12	46	26,000	20-45
	06/10/94	300	88	<12	<12	22,000	20-45
	06/14/94	200	66	<12	<12	17,000	20-45
	06/17/94	190	69	<12	<12	17,000	20-45
	06/21/94	210	77	<12	<12	20,000	20-45
	06/23/94	<31	69	<23	<23	20,000	20-45
	06/27/94	<16	110	67	69	21,000	20-45
	06/30/94	<16	61	<12	<12	20,000	20-45
	07/06/94	<31	69	<23	<23	22,000	20-45
	07/14/94	180	42	<23	<23	20,000	20-45
	07/20/94	170	72	<12	<12	16,000	20-45
	07/28/94	180	80	37	85	13,000	20-45
	08/10/94	160	66	35	53	12,000	20-45
	08/15/94	180	72	22	25	15,000	20-45
	08/24/94	120	56	28	51	14,000	20-45
	09/01/94	120	61	21	20	14,000	20-45
	09/07/94	<16	69	21	53	14,000	20-45
	09/13/94	170	74	22	51	16,000	20-45
	09/20/94	140	61	19	18	15,000	20-45
	09/27/94	130	69	28	23	17,000	20-45

Table 4-3 (Cont.)
BTEX and Volatile Fuel Hydrocarbons in Soil
Concentrations in ppmv

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Total Xylenes	Vol. Fuel Hydrocarb.	Perforated Depth
PEW-3	12/27/93	630	85	110	100	48,000	10-45
	01/04/94	410	45	83	81	37,000	10-45
	03/14/94	590	180	94	97	45,000	10-45
	08/09/94	500	110	39	60	25,000	10-45
PEW-4	08/10/94	100	69	74	81	14,000	20-45
PEW-5	08/09/94	220	82	25	32	15,000	20-45
PEW-6	08/09/94	380	98	39	60	21,000	20-45
AEW-1	12/27/93	280	48	44	60	20,000	47.5-52.5
	01/04/94	280	40	32	39	18,000	47.5-52.5
	08/09/94	380	61	41	58	15,000	47.5-52.5
MW-2S	08/11/94	7.5	3.2	<1.2	<1.2	970	82.5-92.5
MW-3S	08/09/94	<6.3	6.6	4.8	7.6	6,300	72.5-82.5
MW-5S	08/12/94	<1.6	<1.3	<1.2	<1.2	<2.8	155-165
MW-8S	08/11/94	220	58	30	<12	23,000	45-71
MW-9S	08/12/94	<1.6	<1.3	<1.2	<1.2	200	48-68.5
MW-11S	08/10/94	<1.6	<1.3	<1.2	<1.2	12	65-86.5
MW-12S	08/12/94	<1.6	<1.3	<1.2	<1.2	5.4	45-65
MW-14S	08/11/94	9.4	2.0	<1.2	1.2	650	70-90
MW-17S	08/12/94	23	4.2	<1.2	1.7	1,300	53-73
MW-37S	08/09/94	660	100	39	23	21,000	65-95
MW-38S	08/10/94	41	13	7.4	14	4,800	56-86
MW-39S	12/09/93	170	<53	<46	<46	13,000	53-73
	01/04/94	100	15	12	15	9,400	53-73
	08/10/94	13	2.6	1.2	1.8	630	53-73
MW-40S	08/11/94	11	21	25	12	11,000	32-62
MW-41S	08/10/94	<1.6	<1.3	<1.2	<1.2	31	65-85
MW-42S	08/11/94	<1.6	3.2	<1.2	1.2	850	75-105
MW-43S	08/10/94	<3.1	<2.7	<2.3	<2.3	2,600	65-105
MW-44S	08/11/94	<1.6	<1.3	<1.2	<1.2	37	57-107
MW-45S	08/10/94	<7.8	20	8.1	12	7,700	45-95
MW-46S	08/10/94	<1.6	1.8	<1.2	6.9	740	60-105
EW-2	08/12/94	25	19	9.2	20	6,000	80.3-95.3
EW-4	08/12/94	470	110	<23	<23	8,500	49.5-67.5
EW-5	08/12/94	<1.6	<1.3	<1.2	<1.2	100	45-50

NA = Not Analyzed

Table 4-4
Fixed Gas Concentrations in Soil Gas
Results in %v

Well Number	Date Sampled	Carbon Dioxide	Carbon Monoxide	Methane	Nitrogen	Oxygen	Perforated Depth
MW-10P	05/13/93	0.3	NA	<0.1	NA	NA	38-48
	08/10/94	14	<0.10	2.1	78	5.6	38-48
MW-13P	05/12/93	0.2	NA	<0.1	NA	NA	47-67
	08/10/94	4.8	<0.10	7.8	82	5.4	47-67
SBB-1	05/12/93	13	NA	1.8	NA	NA	30-50
	03/17/94	16	<0.20	2.3	80	1.8	30-50
	08/09/94	15	<0.10	2.4	81	1.9	30-50
SBC-1	05/12/93	13	NA	2.6	NA	NA	25-45
	08/12/94	15	<0.10	2.6	80	1.9	25-45
SBD-2	05/12/93	10	NA	2.6	NA	NA	15-50
	01/04/94	0.66	<0.10	0.44	78	21	15-50
	03/18/94	16	<0.20	4.7	77	1.8	15-50
	08/11/94	15	<0.10	4.7	78	2.8	15-50
SBD-3	05/12/93	11	NA	2.2	NA	NA	32-55
	08/11/94	12	<0.10	7.5	75	5.5	32-55
SBE-1	05/12/93	14	NA	0.4	NA	NA	25-50
	08/11/94	17	<0.10	2.5	79	1.8	25-50
PEW-1	01/04/94	3.0	<0.10	25	70	2.3	49-74
	03/18/94	8.5	<0.40	56	34	1.4	49-74
	08/09/94	7.3	<0.40	48	41	3.0	49-74
PEW-2	01/14/94	10	<0.10	2.8	84	2.3	20-45
	03/15/94	14	<0.10	2.2	81	1.9	20-45
	03/17/94	14	<0.20	2.2	82	1.9	20-45
	06/10/94	14	<0.10	2.1	83	1.6	20-45
	06/14/94	14	<0.10	1.7	83	1.6	20-45
	06/17/94	13	<0.10	1.3	83	2.1	20-45
	06/21/94	14	<0.10	1.1	82	2.5	20-45
	06/23/94	14	<0.10	1	82	2.3	20-45
	06/27/94	14	<0.10	0.95	82	2.6	20-45
	06/30/94	14	<0.10	0.88	82	2.7	20-45
	07/06/94	14	<0.10	0.81	82	2.9	20-45
	07/14/94	15	<0.10	0.72	82	3.2	20-45
	07/20/94	14	<0.10	0.70	82	3.2	20-45
	07/28/94	14	<0.10	0.64	82	3.7	20-45
	08/10/94	14	<0.10	0.60	82	3.4	20-45
	08/15/94	15	<0.10	0.61	81	3.5	20-45
	08/24/94	15	<0.10	0.62	82	2.7	20-45
	09/01/94	14	<0.10	0.59	81	4.1	20-45
	09/07/94	14	<0.10	0.58	81	4.3	20-45

Table 4-4 (Cont.)
Fixed Gas Concentrations in Soil Gas
Results in %v

Well Number	Date Sampled	Carbon Dioxide	Carbon Monoxide	Methane	Nitrogen	Oxygen	Perforated Depth
PEW-2	09/13/94	14	<0.10	0.58	81	4.1	20-45
(cont.)	09/20/94	14	<0.10	0.56	82	4.2	20-45
	09/27/94	14	<0.10	0.60	82	3.1	20-45
PEW-3	01/04/94	7.9	<0.10	5.5	82	4.3	10-45
	03/14/94	13	<0.10	1.9	83	2.2	10-45
	08/09/94	12	<0.10	2.7	83	2.0	10-45
PEW-4	08/10/94	16	<0.10	0.46	81	2.2	20-45
PEW-5	08/09/94	13	<0.10	1.8	83	2.8	20-45
PEW-6	08/09/94	12	<0.10	3.2	82	2.1	20-45
AEW-1	01/04/94	11	<0.10	9.7	77	1.6	47.5-52.5
	08/09/94	15	<0.10	5.5	78	2.3	47.5-52.5
MW-1S	05/12/93	<0.1	NA	<0.1	NA	NA	104-114
MW-2S	08/11/94	13	<0.10	11	73	3.0	82.5-92.5
MW-3S	08/09/94	8.4	<0.20	40	49	2.0	72.5-82.5
MW-5S	08/12/94	1.1	<0.10	<0.10	80	19	155-165
MW-7S	05/13/93	0.2	NA	<0.1	NA	NA	63-73
MW-8S	05/13/93	12	NA	14	NA	NA	45-71
	08/11/94	13	<0.10	5.6	77	4.6	45-71
MW-9S	05/13/93	0.3	NA	<0.1	NA	NA	48-68.5
	08/12/94	0.31	<0.10	<0.10	78	21	48-68.5
MW-11S	08/10/94	<0.10	<0.10	<0.10	78	22	65-86.5
MW-12S	08/12/94	0.90	<0.10	<0.10	79	20	45-65
MW-14S	08/11/94	7.5	<0.10	7.9	78	6.4	70-90
MW-17S	05/12/93	4.8	NA	2.8	NA	NA	53-73
	08/12/94	0.93	<0.10	5.5	74	20	53-73
MW-19S	05/12/93	1.7	NA	<0.1	NA	NA	58-78
MW-20S	05/13/93	0.7	NA	<0.1	NA	NA	73-93
MW-26S	05/13/93	<0.1	NA	<0.1	NA	NA	70-90
MW-27S	05/12/93	<0.1	NA	<0.1	NA	NA	115-135
MW-28S	05/12/93	0.2	NA	<0.1	NA	NA	98-118
MW-30S	05/13/93	<0.1	NA	<0.1	NA	NA	65-85
MW-37S	05/13/93	1.0	NA	12	NA	NA	65-95
	08/09/94	3.8	<0.40	48	44	4.8	65-95
MW-38S	05/13/93	0.5	NA	1.0	NA	NA	56-86
	08/10/94	5.9	<0.20	35	58	2.0	56-86
MW-39S	12/09/93	2.5	<0.10	46	41	10	53-73
	01/04/94	1.1	<0.10	19	63	17	53-73
	08/10/94	0.24	<0.10	2.2	76	21	53-73
MW-40S	08/11/94	14	<0.10	0.97	83	2.0	32-62

Table 4-4 (Cont.)
Fixed Gas Concentrations in Soil Gas
Results in %v

Well Number	Date Sampled	Carbon Dioxide	Carbon Monoxide	Methane	Nitrogen	Oxygen	Perforated Depth
MW-41S	08/10/94	<0.10	<0.10	<0.10	78	22	65-85
MW-42S	08/11/94	6.8	<0.10	10	80	3.1	75-105
MW-43S	08/10/94	1.5	<0.13	29	68	2.2	65-105
MW-44S	08/11/94	3.8	<0.10	10	84	2.2	57-107
MW-45S	08/10/94	5.5	<0.13	27	65	2.3	45-95
MW-46S	08/10/94	3.3	<0.10	1.7	93	2.1	60-105
EW-1	05/12/93	1.9	NA	1.8	NA	NA	65-90
EW-2	08/12/94	4.9	<0.10	21	69	4.3	80.3-95.3
EW-4	08/12/94	10	<0.20	28	55	5.9	49.5-67.5
EW-5	08/12/94	0.23	<0.10	<0.10	78	22	45-50
ULTM-MW-9	05/14/93	1.4	NA	14	NA	NA	60-80

NA = Not Analyzed

Table 4-5
Soil Gas Hydrocarbon Distributions

CARBON NO.	Molecular Weight	Well MW-39S 12/9/93		Well PEW-1 3/18/94		Well PEW-2 3/15/94		Well PEW-3 3/14/94		Well SBB-1 3/17/94		Well SBD-2 3/18/94	
		mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv
C1-C2 (as C1)	16	230,000 (1)	348,000	120,000	181,000	24,000	36,000	20,000	30,000	27,000	41,000	30,000	45,000
C3	44	35,000 (2)	19,300	28,000	15,000	3,000	1,700	2,100	1,200	2,700	1,500	3,100	1,700
C4	58			110,000	46,000	1,000	400	3,600	1,500	2,100	900	8,800	3,700
C5	72	37,000	12,500	150,000	51,000	10,000	3,400	27,000	9,100	3,800	1,300	22,000	7,400
C6	86	25,000	7,000	75,000	21,000	39,000	11,000	69,000	19,000	22,000	6,200	17,000	4,800
C7	100	13,000	3,000	27,000	7,000	34,000	8,200	58,000	14,000	29,000	7,000	9,000	2,200
C8	114	5,500	1,000	11,000	2,300	18,000	3,800	27,000	5,700	15,000	3,200	4,500	1,000
C9	128	1,300	200	3,200	600	4,500	900	6,400	1,200	4,000	800	1,300	200
C10	142	ND		800	100	880	200	1,300	200	800	100	440	100
C11	156	ND		ND		ND		ND		ND		99	20
TOTAL		347,800	391,000	525,000	324,000	134,400	65,600	214,400	81,900	106,400	62,000	96,200	66,100
Average Hydrocarbon Molecular Weight			22		39		50		63		42		35
Average non-methane Hydrocarbon Molecular Wt			66		69		90		91		92		76
ppmv of non-methane Hydrocarbons			43,000		143,000		29,600		51,900		21,000		21,100

(1) Methane only
(2) C2 to C4

ENGLAND SHAHIN & ASSOCIATES

Table 4-6
Comparison of Benzene Content of Samples From Various Sources

Site Hydrocarbon Liquids

Sample Description	Sample Collection Date	Benzene Concentration (mg/l)
PEW-3 Condensate condensed at wellhead using ice water	4/26/94	2600
PEW-3 Condensate condensed at knock-out drum using ice water	4/26/94	2790
Condensate from RETOX knock-out drum condensed at ambient conditions	4/1/94	<0.5
Oil skimmed from well EW-4	9/13/94	490

Natural Oils

Sample Description	Sample Collection Date	Benzene Concentration (mg/l)
RS-01 Seep from beside Pole Creek, north of site	8/24/92	220
RS-02 Seep from beside Pole Creek, north of site	8/24/92	250
RS-03 Seep from	8/24/92	900
Crude oil from Rossi Lease about 3 miles northeast of site	NA	795

Natural Gas Condensates

Sample Description	Sample Collection Date	Benzene Concentration (mg/l)
Condensate from Shiells Canyon, condensed with dry ice	9/1/94	7130
Combined condensate from several Ventura County gas fields	8/30/94	8250
Natural Condensate B- a laboratory standard used by GGC	NA	2770

Refined Products

Sample Description	Sample Collection Date	Benzene Concentration (mg/l)
White Gas	NA	98
Unleaded Gasoline	NA	5960
Super Unleaded Gasoline	NA	4700

Gases

Sample Description	Sample Collection Date	Benzene Concentration (ppmv)
Gas from PEW-3	3/14/94	590
Gas from PEW-1	3/18/94	470
Natural Gas from Shiells Canyon	8/30/94	89

Table 4-7
Benzene Equilibrium
Concentrations and Mass Distribution Among Phases

Equilibrium calculation assumptions:

Activity coefficient for benzene in oil = 1.15, average oil MW = 140 100 lb/cu ft dry soil density Equilibria calculated at 20 C

Vadose zone 30% pore volume, 1/3 water filled, 2/3 gas filled pores, 6 2 lb water/cu ft soil.

Saturated zone 30 % pore volume filled with water 19 lb water/cu ft soil

Calculations based on measured TPH and benzene concentrations in soil samples

Percentages of total benzene mass in excess of 50 % are shown in boldface

WELL/ BORING NO.	SAMPLE DEPTH (feet)	MEASURED TPH CONCEN-TRATION IN SOIL (mg/kg)	MEASURED BENZENE CONCEN-TRATION IN SOIL (mg/kg)	CALCULATED EQUILIBRIUM BENZENE CONCENTRATIONS			BENZENE EQUILIBRIUM MASS DISTRIBUTION		
				in TPH (mg/kg)	in WATER (mg/L)	in GAS (ppmv)	in TPH %	in WATER %	in GAS %
VADOSE ZONE									
FSB-5 *	29	84,000	94	1,100	4.1	230	**99.7**	0 3	0.1
FSB-1	19	41	0 005	20	0 05	3	12 4	**64.1**	23 5
FSB-4	30	4,100	3 9	890	3.2	180	**93.4**	4 8	1 8
FSB-6	31	74	0 056	150	0 56	31	20 3	**58.3**	21 4
FSB-7	30	150	0 026	60	0.21	12	34.1	48.2	17.7
SBB-1	50	1,900	0.13	60	0 22	12	**86.8**	9 7	3.5
	55	3,900	1	240	0 87	40	**93.1**	5 1	1.9
SBO-3	50	1,100	0 13	93	0.34	19	**79.1**	15 3	5 6
SBE-1	45	590	0 056	48	0.17	10	**67.0**	24.1	8.8
SBG-2	65	540	0 033	40	0 14	8	**85.1**	25 6	9.4
MW-37S	50	1,100	0.554	400	1 4	81	**79.1**	15.3	5.6
	60	2	0 11	380	1.4	75	0 7	72.7	26 6
MW-38S	45	1,400	0 41	240	0 88	49	**82.8**	12 6	4 6
	50	120	0 29	710	2.6	140	29 3	**51.8**	19.0
MW-43S	50	180	0.36	760	2 8	160	38 3	45 2	16.5
MW-47D	5	1,800	0 24	110	0 42	23	**86.1**	10.2	3 7
	15	1,900	0.89	410	1 5	83	**86.8**	9 7	3 5
	57 5	1,100	0 3	220	0 78	44	**79.1**	15 3	5.6
EW-1	40	890	0.27	230	0 83	47	**75.4**	18.0	6 6
	50	2,000	0 11	48	0.17	10	**87.3**	9.3	3 4
EW-2	45	1,500	0.89	500	1 8	100	**83.8**	11.9	4.3
	50	1,200	1 1	740	2 7	150	**80.5**	14.2	5 2
EW-5	35	770	0 21	200	0.72	40	**72.6**	20 0	7.3
AEW-1	45	80	1	2,700	9 8	550	21 6	**57.4**	21.0
	50	170	0 23	500	1.8	100	37 0	46.2	16.9
	55	18	0 28	910	3 3	190	5.2	**69.4**	25 4
PEW-1	35	66	0 43	1,200	4 4	250	18 5	**59.6**	21 8
	45	130	0.079	190	0 68	40	30 9	**60.5**	18.5
	46	8,200	24	2,800	10 3	580	**96.6**	2.5	0.9
	50	3,600	1 4	360	1.3	70	**92.5**	5 5	2 0
	60	780	0.19	180	0 65	40	**72.9**	19 8	7.3
	75	2,200	1 1	440	1 6	90	**88.4**	8 5	3.1
PEW-2	20	100	0 16	410	1.5	80	25 6	**54.4**	19.9
	25	3,100	0 33	100	0 35	20	**91.4**	6 3	2 3
	35	2,100	0 11	50	0.17	10	**87.9**	8 9	3 3
	45	1	0 2	680	2 5	140	0.4	**72.9**	26 7

ENGLAND SHAHIN & ASSOCIATES

Table 4-7 (Cont.)
Benzene Equilibrium
Concentrations and Mass Distribution Among Phases

WELL/ BORING NO	SAMPLE DEPTH (feet)	MEASURED TPH CONCEN-TRATION IN SOIL (mg/kg)	MEASURED BENZENE CONCEN-TRATION IN SOIL (mg/kg)	CALCULATED EQUILIBRIUM BENZENE CONCENTRATIONS			BENZENE EQUILIBRIUM MASS DISTRIBUTION		
				in TPH (mg/kg)	in WATER (mg/L)	in GAS (ppmv)	in TPH %	in WATER %	in GAS %
VADOSE ZONE. continued									
PEW-3	5	7,500	18	2,300	8.4	470	96.3	2.7	1.0
	10	1,100	0.12	90	0.31	20	79.1	15.3	5.6
	20	1,700	0.51	260	0.93	50	86.4	10.7	3.9
	30	3,500	2.1	550	2.0	110	92.3	5.6	2.1
	40 **	6,700	*0.02*	*3*	*0.01*	*1*	96.9	3.0	1.1
	45	420	1.8	2,500	9.2	520	59.1	29.9	10.9
PEW-4	40	1,900	4.6	2,100	7.6	430	86.8	9.7	3.5
PEW-5	45	51	0.033	97	0.35	20	15.0	62.3	22.8
PEW-6	30	1,600	0.75	400	1.4	81	84.7	11.2	4.1
	40	1,700	2.2	1,100	4.0	230	85.4	10.7	3.9
ARITHMETIC AVERAGE		1,600	1.6	590	2.1	120			
WEIGHTED AVERAGE		3,900	5.4	860	3.1	180	89	8	3
MEDIAN		1,100	0.30	370	1.3	73	79	15	6

* Results from FSB-5 were not included in the averages

** No benzene detected at detection limits of 0.02 mg/kg

SATURATED ZONE	(Below Historic High Water Elevation)								
SBB-1	80	4,700	0.85	160	0.59	33	89.1	10.9	0.0
	90	4,000	1.8	390	1.4	80	87.4	12.6	0.0
SBC-1	40	4,000	0.013	3	0.01	1	87.4	12.6	0.0
	75	100	0.002	3	0.01	1	14.8	85.2	0.0
SBD-3	55.5	2,500	0.14	45	0.17	9	81.3	18.7	0.0
SBE-1	70	8,100	0.31	36	0.13	7	93.4	6.6	0.0
MW-40S	85	9.7	0.16	270	0.98	60	1.7	98.3	0.0
MW-47D	67.5	1,200	0.22	120	0.45	25	67.6	32.4	0.0
	77.5	590	1.3	1,100	4.0	230	50.6	49.4	0.0
EW-1	59.5	170	0.043	57	0.21	12	22.8	77.2	0.0
EW-5	60	450	1.6	1,600	5.6	320	43.9	56.1	0.0
ARITHMETIC AVERAGE		2,300	0.6	340	1.2	71			
WEIGHTED AVERAGE		5,000	0.6	160	0.6	30	86	14	0
MEDIAN		1,200	0.22	120	0.45	25	68	32	0

ENGLAND SHAHIN & ASSOCIATES

Table 4-8
Comparison of Equilibrium and Measured Benzene Concentrations in Water

Equilibrium water concentrations are calculated from measured gas phase concentrations.
Measured water concentration shown in parentheses are interpolated from August 1994 water data.

* Migration Potential	Gas			Water			
	Well No. for Gas Sample	Gas Sample Date	Benzene in Gas (ppmv)	Benzene in Water		Water Sample Date	Well No. for Water Sample
				Equilibrium (mg/L)	Measured (mg/L)		
↓	MW-10P	8/10/94	31	0.6	0.024	2/10/94	MW-10P
✓	MW-13P	8/10/94	<11	<0.2	<0.0003	2/9/94	MW-13P
✓	SBB-1	3/17/94	180	3.2	2.2	2/11/94	P2
↓		8/9/94	18	0.3	1.8	8/12/94	P2
✓	SBC-1	8/12/94	<31	<0.6	<0.019	5/21/93	SBC-1
↑	SBD-2	12/27/93	2.8	0.05	0.35	5/21/93	SBD-2
✓		1/4/94	5.6	0.1			
↓		3/18/94	110	2.0			
↓		8/11/94	100	1.8	0.38	8/12/94	EW-1
↓	SBD-3	8/11/94	150	2.7	0.24	5/20/93	SBD-3
↓	SBE-1	8/11/94	53	0.9	0.16	8/11/94	SBE-1
✓	PEW-1	12/27/93	190	3.4	1.5	11/16/93	P2
✓		1/4/94	180	3.2	2.2	2/11/94	P2
↓		3/18/94	470	8.4	2.2	2/11/94	P2
↓		8/9/94	380	6.8	1.8	8/12/94	P2
	PEW-2	1/14/94	280	5.0			
		3/15/94	280	5.0			
		3/17/94	260	4.6			
		6/10/94	300	5.4			
		6/14/94	200	3.6			
		6/17/94	190	3.4			
		6/21/94	210	3.8			
		6/23/94	<31	<0.6			
		6/27/94	<16	<0.3			
		6/30/94	<16	<0.3			
		7/6/94	<31	<0.6			
		7/14/94	180	3.2			
		7/20/94	170	3.0			
		7/28/94	180	3.2			
↓		8/10/94	160	2.9	(<0.001)	8/94	Interpolated

ENGLAND SHAHIN & ASSOCIATES

Table 4-8 (Cont.)
Comparison of Equilibrium and Measured Benzene Concentration in Water

* Migration Potential	Gas			Water			
	Well No. for Gas Sample	Gas Sample Date	Benzene in Gas (ppmv)	Benzene in Water: Equilibrium (mg/L)	Benzene in Water: Measured (mg/L)	Water Sample Date	Well No. for Water Sample
↓	PEW-3	12/27/93	630	11.3	<0.01	11/11/91	MW-25S
		1/4/94	410	7.3			
		3/14/94	590	10.5			
↓		8/9/94	500	8.9	(<0.001)	8/94	Interpolated
↓	PEW-4	8/10/94	100	1.8	(<0.001)	8/94	Interpolated
↓	PEW-5	8/9/94	220	3.9	(<0.001)	8/94	Interpolated
↓	PEW-6	8/9/94	380	6.8	(<0.001)	8/94	Interpolated
↓	AEW-1	12/27/93	280	5.0	(<0.001)	8/94	Interpolated
		1/4/94	280	5.0			
		8/9/94	380	6.8			
✓	MW-2S	8/11/94	7.5	0.1	0.15	8/12/94	MW-2S
✓	MW-3S	8/9/94	<6.3	<0.1	0.05	8/10/94	MW-3S
	MW-5S	8/12/94	<1.6	<0.03			N/A
↓	MW-8S	8/11/94	220	3.9	0.49	8/11/94	MW-8S
✓	MW-9S	8/12/94	<1.6	<0.03	0.042	8/11/94	MW-9S
✓	MW-11S	8/10/94	<1.6	<0.03	<0.0003	11/11/93	MW-11S
✓	MW-12S	8/12/94	<1.6	<0.03	<0.0003	11/11/93	MW-12S
✓	MW-14S	8/11/94	9.4	0.2	0.22	8/11/94	MW-14S
✓	MW-17S	8/12/94	23	0.4	0.72	8/12/94	MW-17S
↓	MW-37S	8/9/94	660	11.8	0.0029	8/10/94	MW-37S
↓	MW-38S	8/10/94	41	0.7	<0.0003	8/9/94	MW-38S
↓	MW-39S	12/9/93	170	3.0	0.27	11/15/93	MW-39S
↓		1/4/94	100	1.8	0.52	2/11/94	MW-39S
✓		8/10/94	13	0.2	0.35	8/11/94	MW-39S
↓	MW-40S	8/11/94	11	0.2	0.011	8/9/94	MW-40S
↑	MW-41S	8/10/94	<1.6	<0.03	0.33	8/11/94	MW-41S

Table 4-8 (Cont.)
Comparison of Equilibrium and Measured Benzene Concentration in Water

* Migration Potential	Gas			Water			
	Well No. for Gas Sample	Gas Sample Date	Benzene in Gas (ppmv)	Benzene in Water		Water Sample Date	Well No. for Water Sample
				Equilibrium (mg/L)	Measured (mg/L)		
↑	MW-42S	8/11/94	<1.6	<0.03	0.3	8/11/94	MW-42S
↑	MW-43S	8/10/94	<3.1	<0.06	0.2	8/11/94	MW-43S
✓	MW-44S	8/11/94	<1.6	<0.03	<0.0003	8/10/94	MW-44S
✓	MW-45S	8/10/94	<7.8	<0.1	0.17	8/11/94	MW-45S
✓	MW-46S	8/10/94	<1.6	<0.03	0.0024	8/10/94	MW-46S
↓	EW-2	8/12/94	25	0.4	0.055	8/12/94	EW-2
↓	EW-4	8/12/94	470	8.4	0.2	8/12/94	EW-4
✓	EW-5	34558	<1.6	<0.03	0.052	8/12/94	EW-5

* ↓ Calculated equilibrium concentration much greater than measured, (benzene migration driving force is from gas to water).

↑ Calculated equilibrium concentration much less than measured, (benzene migration driving force is from water to gas).

✓ Order of magnitude agreement - little or no migration potential.

Table 5-1
Phase 1 Vapor Extraction System Operation

Operation Duration	Extraction Wells	Average Flow Rates (scfm)	Concentrations (ppmv)		Mass Removal (pounds)	
			TPH	Benzene	TPH	Benzene
RETOX System Operation (January - May 1994)						
1/12-1/17 (1)	SBD-2, PEW-3	NA	800-1,700 (2)	NA	NA	NA
2/7-2/14	SBD-2, PEW-3	500(3)	1,100	NA	1,300	13(4)
2/15-2/24	PEW-3	400(3)	1,300	NA	1,600	16(4)
2/25-3/9	PEW-3	400(3)	1,100	NA	1,700	17(4)
4/7-5/11	PEW-3	550(3)	1,300	NA	7,500	75(4)
Subtotal	-	-	-	-	12,100	121
5-Day Vapor Extraction Tests - VR System Model V4 (March 1994)						
3/14, 8 hrs	PEW-3	82	44,000	560	390	4.4
3/15-3/17, 48 hrs	PEW-2	70	27,000	270	1,200	10.9
3/17, 8 hrs	SBB-1	66	20,000	170	140	1.1
3/18, 1 hr	PEW-1	17	34,000	470	8	0.1
3/18, 8 hrs	SBD-2	70	9,300	110	72	0.7
Subtotal	-	-	-	-	1,810	17
Long-Term Vapor Extraction Test - VR System Model V4 (June - December 1994)						
6/10 - 6/30	PEW-2	62	20,000	130	8,500	47
6/30 - 7/28	PEW-2	62	16,000	140	11,300	57
7/28 - 8/24	PEW-2	62	14,000	160	7,400	76
8/24 - 9/20	PEW-2	69	15,000	110	9,100	56
9/20 - 10/19	PEW-2	70	16,000	130	10,500	73
10/19 - 11/16	PEW-2	70	14,000	110	9,400	58
11/16 - 12/7	PEW-2	71	13,000	70	7,000	32
Subtotal	-	-	-	-	63,200	399
TOTAL:	-	-	-	-	77,100	540

Notes:

(1) System startup period.

(2) Concentrations were measured with FID meter in the field during RETOX system operation.

(3) Flow rates for RETOX include dilution air. Flow rate from wells was a small fraction of the total.

(4) Estimated based on assumption of 1 lb. benzene per 100 lbs TPH. Benzene has averaged approximately one percent of the TPH in the gas from these wells.

ENGLAND SHAHIN & ASSOCIATES

Table 5-2
Phase 1 Ground Water Treatment System Operation

Operation Duration	Extraction Wells Connected	Volume of Water Treated (gallons)	Concentrations (µg/l)		Mass Removal (pounds)	
			TPH	Benzene	TPH	Benzene
Initial Operation						
Dec 93	EW-1, MW-19S, MW-28S	687,960	3,700	340	21	2
Jan 94	EW-1, MW-19S, MW-28S	1,671,880	3,900	370	54	5
Feb 94	EW-1, MW-19S, MW-28S	1,067,190	4,600	440	41	4
Solids Removal Testing Period						
July 94	EW-2, EW-4, EW-5	105,320	1,300	130	1	0.1
Aug 94	EW-2, EW-4, EW-5	435,280	1,700	140	6	0.5
Sept 94	EW-2, EW-4, EW-5	206,350	2,000	100	3	0.2
Oct 94	EW-4	71,070	3,700	140	2	0.1
Nov 94	EW-4, EW-5, MW-28S (2)	672,230	2,500	120	14	0.7
TOTAL(1)	--	4,913,300	---	---	142	12.6

Notes:
(1) Totals are rounded off.
(2) MW-28 was connected on November 30.

ENGLAND SHAHIN & ASSOCIATES

Table 5-3
NPDES Monitoring and Sampling Schedule

Monitoring Points	Frequency	Monitoring Parameter
Effluent	Monthly	• total flow • temperature • pH • residual chlorine (if used) • turbidity • settleable solids • suspended solids • oil & grease • sulfides • chloride • TDS • TPH/BTEX (plus a duplicate)
	Quarterly (during the months of February, May, August and November)	• BOD_5 20°F • sulfate • nitrate and nitrite (as N) • boron (plus a duplicate) • ethylene dibromide • halogenated volatiles [1] • phenolic compounds (chlorinated) • phenols • priority pollutant metals [2]
	Annual (in February)	• toxicity acute
Receiving Water Monitoring R-1 and R-2 [3]	Monthly	• pH • temperature • dissolved oxygen • residual chlorine (if used) • chloride • total dissolved solids • TPH/BTEX

Notes:

(1) Carbon tetrachloride, tetrachloroethene, trichloroethene, 1,4-dichlorobenzene, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, and vinyl chloride.

(2) Arsenic, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc.

(3) Receiving water monitoring on Santa Clara River. R-1 is located 100 feet upstream of the confluence of Pole Creek and the Santa Clara River and R-2 is located 300 feet downstream of the confluence.

Table 5-4
NPDES Discharge Limits

Constituent	Discharge Limits		
	30-Day Average	Daily Maximum	Units
total flow		100,000	gallons
temperature	-	100	deg F
pH	-	<9 and >6	pH units
turbidity	50	75	NTU
total settleable solids	0.1	0.2	ml/l
total suspended solids	50	75	mg/l
oil & grease	10	15	mg/l
sulfides	-	1.0	mg/l
chloride	-	160	mg/l
total dissolved solids	-	1,200	mg/l
TPH	-	100	ug/l
benzene	-	1.0	ug/l
toluene	-	10	ug/l
ethyl benzene	-	10	ug/l
xylenes	-	10	ug/l
BOD, 20°F	20	30	mg/l
sulfate	-	550	mg/l
nitrate+nitrite (as N)	-	5.0	mg/l
boron	-	1.5	mg/l
ethylene dibromide	-	0.02	ug/l
carbon tetrachloride	-	0.5	ug/l
tetrachloroethene	-	5.0	ug/l
trichloroethene	-	5.0	ug/l
vinyl chloride	-	0.5	ug/l
1,4-dichlorobenzene	-	5.0	ug/l
1,1-dichloroethane	-	5.0	ug/l
1,2-dichloroethane	-	5.0	ug/l
1,1-dichloroethene	-	6.0	ug/l
phenolic compounds chlorinated	-	1.0	ug/l
phenols	-	1.0	mg/l
arsenic	-	50	ug/l
cadmium	-	10	ug/l
chromium	-	50	ug/l
copper	-	1.0	mg/l
lead	-	50	ug/l
mercury	-	2.0	ug/l
selenium	-	10	ug/l
silver	-	50	ug/l
zinc	-	5.0	mg/l
Toxicity - Acute	-	90% avg., none <70%	survival

ENGLAND SHAHIN & ASSOCIATES

Table 6-1
Results of Vapor Extraction Data Analysis (Short-term Test)

Extraction Well	Flow Rate (scfm)	Wellhead Vacuum (in. H_2O)	Screen Intervals (ft bgs)	Air Permeability (darcy)	Initial VFH Removal Rate (lbs/hr)	Initial Total[1] Hydrocarbon Removal Rate (lbs/hr)
PEW-3	82	3.8	10 - 45	70	49	64
PEW-2	70	3.9	20 - 45	82	25	33
SBB-1	66	21	30 - 50	15	18	25
PEW-1	17	2.5	49 - 74	30	8	33
SBD-2	70	29	15 - 50	8.3	9	26

Notes:
(1) Includes methane and other light hydrocarbons.

Table 6-2
Soil Gas Analytical Results
Well PEW-2

Analyte	Molecular Weight	1/14/94		SVE Test Sample A 3/15/94		SVE Test Sample B 3/17/94		SVE Test 6/10/94		SVE Test 6/14/94		SVE Test 6/17/94	
Vol. Fuel Hydrocarbons & BTEX		mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv
Benzene	78.11	880	280	890	280	840	260	970	300	640	200	610	190
Toluene	92.14	200	53	270	72	270	72	330	88	250	66	260	69
Ethylbenzene	106.17	140	32	<100	<23	54	12	<50	<12	<50	<12	<50	<12
Xylenes	106.17	<100	<23	230	53	200	46	<50	<12	<50	<12	<50	<12
Vol. Fuel Hydrocarbons	86.00	100,000	28,000	97,000	27,000	91,000	26,000	78,000	22,000	61,000	17,000	60,000	17,000
Fixed Gases		%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total
Carbon Dioxide	44.01	10	89,000	14	135,000	14	134,000	14	135,000	14	137,000	13	128,000
Carbon Monoxide	28.01	<0.10	<1000	<0.10	<1,000	<0.20	<2,000	<0.10	<1,000	<0.10	<1,000	<0.10	<1,000
Methane	16.04	2.8	*24,900*	2.2	*21,200*	2.2	*21,100*	2.1	*20,200*	1.7	*16,600*	1.3	*12,800*
Nitrogen	28.01	84	747,000	81	781,000	82	786,000	83	800,000	83	810,000	83	816,000
Oxygen	32.00	2.3	20,000	1.9	18,000	1.9	18,000	1.6	15,000	1.6	16,000	2.1	21,000
Hydrocarbon Distribution		mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv
C1+C2 (as C1)	16	75,000	113,300	24,000	36,300	22,000	33,200	18,000	27,200	13,000	19,600	12,000	18,100
C3	44	<200	<100	3,000	1,700	2,300	1,300	<10	0	<10	0	<1	0
C4	58	1,200	500	1,000	400	1,400	600	1,000	400	1,000	400	1,100	500
C5	72	13,000	4,400	10,000	3,400	10,000	3,400	5,800	2,000	6,900	2,300	7,300	2,500
C6	86	42,000	11,800	39,000	11,000	36,000	10,100	31,000	8,700	23,000	6,500	24,000	6,800
C7	100	36,000	8,700	34,000	8,200	32,000	7,800	27,000	6,500	21,000	5,100	21,000	5,100
C8	114	15,000	3,200	18,000	3,800	18,000	3,800	17,000	3,600	12,000	2,600	11,000	2,300
C9	128	6,700	1,300	4,500	900	4,700	900	3,500	700	3,500	700	3,000	600
C10	142	1,300	200	880	200	910	200	1,200	200	930	200	700	100
C11	156	<200	0	<10	0	<100	0	260	40	210	30	210	30
C12	170	<200	0	<10	0	<100	0	<10	0	51	10	<1.0	0
C13	184	<200	0	<10	0	<100	0	<10	0	<10	0	<1.0	0
TOTAL		190,200	143,400	134,400	65,900	127,300	61,300	104,800	49,300	81,600	37,400	80,300	36,000
Avg. Hydrocarbon Molecular Weight			32		49		50		52		53		54
Avg. non-methane Hydrocarbon Molec. Wt			93		90		91		95		93		92
ppmv of non-methane Hydrocarbons			30,100		29,600		28,100		22,100		17,800		17,900
FID Measurement									ppmv		ppmv		ppmv
Total ppmv									45,000		46,000		40,000
Methane ppmv									15,000		19,000		15,000

ENGLAND SHAHIN & ASSOCIATES

Table 6-2 (Cont.)
Soil Gas Analytical Results
Well PEW-2

Analyte	Molecular Weight	SVE Test 6/21/94		SVE Test 6/23/94		SVE Test 6/27/94		SVE Test 6/30/94		SVE Test 7/6/94		SVE Test 7/14/94	
Vol. Fuel Hydrocarbons & BTEX		mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv
Benzene	78.11	670	210	<100	<31	<50	<16	<50	<16	<100	<31	570	180
Toluene	92.14	290	77	260	69	420	110	230	61	260	69	160	42
Ethylbenzene	106.17	<50	<12	<100	<23	290	67	<50	<12	<100	<23	<100	<23
Xylenes	106.17	<50	<12	<100	<23	300	69	<50	<12	<100	<23	<100	<23
Vol. Fuel Hydrocarbons	86.00	72,000	20,000	71,000	20,000	74,000	21,000	70,000	20,000	79,000	22,000	70,000	20,000
Fixed Gases		%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total
Carbon Dioxide	44.01	14	137,000	14	137,000	14	137,000	14	137,000	14	136,000	15	145,000
Carbon Monoxide	28.01	<0.10	<1,000	<0.10	<1,000	<0.10	<1,000	<0.10	<1000	<0.10	<1000	<0.10	<1000
Methane	16.04	1.1	*10,800*	1	*9,800*	0.95	*9,300*	0.88	*8,600*	0.81	*7,900*	0.72	*7,000*
Nitrogen	28.01	82	803,000	82	803,000	82	802,000	82	802,000	82	799,000	82	792,000
Oxygen	32.00	2.5	24,000	2.3	23,000	2.6	25,000	2.7	26,000	2.9	28,000	3.2	31,000
Hydrocarbon Distribution		mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv
C1-C2 (as C1)	16	10,000	15,100	10,000	15,100	9,700	14,700	9,100	13,700	8,900	13,400	8,000	12,100
C3	44	<10	0	<20	0	<10	0	<10	0	<20	0	<20	0
C4	58	1,100	500	1,200	500	1,200	500	1,200	500	1,200	500	1,100	500
C5	72	7,500	2,500	7,800	2,600	7,900	2,700	7,600	2,600	8,100	2,700	7,500	2,500
C6	86	25,000	7,000	26,000	7,300	26,000	7,300	26,000	7,300	28,000	7,900	26,000	7,300
C7	100	24,000	5,800	24,000	5,800	26,000	6,300	24,000	5,800	27,000	6,500	25,000	6,100
C8	114	15,000	3,200	14,000	3,000	15,000	3,200	16,000	3,400	18,000	3,800	15,000	3,200
C9	128	5,100	1,000	4,500	900	4,900	900	3,400	600	4,100	800	3,200	600
C10	142	1,500	300	1,300	200	1,500	300	1,200	200	1,500	300	1,100	200
C11	156	370	60	340	50	420	70	290	50	430	70	280	40
C12	170	130	20	81	10	120	20	100	10	75	10	55	10
C13	184	15	2	<20	0	19	3	<10	0	<20	0	<20	0
TOTAL		89,700	35,500	89,200	35,500	92,700	36,000	88,900	34,200	97,300	36,000	87,200	32,600
Avg. Hydrocarbon Molecular Weight			61		61		62		63		66		65
Avg. non-methane Hydrocarbon Molec. Wt			95		94		94		94		95		94
ppmv of non-methane Hydrocarbons			20,400		20,400		21,300		20,500		22,600		20,500
FID Measurement			ppmv		ppmv		ppmv		ppmv		ppmv		ppmv
Total ppmv			26,000		31,000		27,500		31,000		26,000		28,000
Methane ppmv			9,500		12,000		9,500		11,000		9,000		9,000

ENGLAND SHAHIN & ASSOCIATES

Table 6-2 (Cont.)
Soil Gas Analytical Results
Well PEW-2

Analyte	Molecular Weight	SVE Test 7/20/94		SVE Test 7/28/94		SVE Test 8/3/94		SVE Test 8/10/94		SVE Test 8/15/94		SVE Test 8/24/94	
Vol. Fuel Hydrocarbons & BTEX		mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv
Benzene	78.11	550	170	590	180	550	170	520	160	560	180	390	120
Toluene	92.14	270	72	300	80	280	74	250	66	270	72	210	56
Ethylbenzene	106.17	<50	<12	160	37	100	23	150	35	97	22	120	28
Xylenes	106.17	<50	<12	370	85	220	51	230	53	110	25	220	51
Vol. Fuel Hydrocarbons	86.00	58,000	16,000	44,000	13,000	45,000	13,000	41,000	12,000	52,000	15,000	49,000	14,000
		%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total
Fixed Gases													
Carbon Dioxide	44.01	14	137,000	14	138,000	14	139,000	14	138,000	15	147,000	15	147,000
Carbon Monoxide	28.01	<0.10	<1000	<0.10	<1000	<0.10	<1000	<0.10	<1000	<0.10	<1000	<0.10	<1000
Methane	16.04	0.70	6,900	0.64	6,300	0.61	6,100	0.60	5,900	0.61	6,000	0.62	6,100
Nitrogen	28.01	82	805,000	82	806,000	81	805,000	82	810,000	81	796,000	82	805,000
Oxygen	32.00	3.2	31,000	3.7	36,000	3.8	38,000	3.4	34,000	3.5	34,000	2.7	26,000
Hydrocarbon Distribution		mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv
C1-C2 (as C1)	16	6,300	9,500	4,800	7,300	4,200	6,300	4,100	6,200	5,000	7,600	5,300	8,000
C3	44	<10	0	180	100	200	100	200	100	210	100	<1	0
C4	58	800	300	600	300	540	200	510	200	580	200	570	200
C5	72	5,800	2,000	4,400	1,500	3,100	1,000	3,800	1,300	4,500	1,500	4,200	1,400
C6	86	20,000	5,600	15,000	4,200	16,000	4,500	14,000	3,900	17,000	4,800	16,000	4,500
C7	100	20,000	4,800	15,000	3,600	15,000	3,600	14,000	3,400	18,000	4,400	17,000	4,100
C8	114	12,000	2,600	10,000	2,100	10,000	2,100	9,200	2,000	12,000	2,600	12,000	2,600
C9	128	4,000	800	2,400	500	3,300	600	2,900	500	4,200	800	2,900	500
C10	142	1,100	200	910	200	1,000	200	870	100	1,300	200	1,100	200
C11	156	290	50	260	40	260	40	240	40	340	50	330	50
C12	170	61	10	75	10	63	10	59	10	110	20	54	10
C13	184	<10	0	<1	0	<1	0	<1	0	19	3	<1	0
TOTAL		70,400	25,900	53,600	19,900	53,700	18,700	49,900	17,800	63,200	22,300	59,500	21,600
Avg. Hydrocarbon Molecular Weight			66		65		70		68		69		67
Avg. non-methane Hydrocarbon Molec. Wt			95		94		97		96		96		97
ppmv of non-methane Hydrocarbons			16,400		12,600		12,400		11,600		14,700		13,600
FID Measurement			ppmv		ppmv		ppmv		ppmv		ppmv		ppmv
Total ppmv			27,000		24,000		23,000		30,000		37,000		36,000
Methane ppmv			9,000		8,500		7,500		12,000		18,000		17,500

ENGLAND SHAHIN & ASSOCIATES

Table 6-2 (Cont.)
Soil Gas Analytical Results
Well PEW-2

Analyte	Molecular Weight	SVE Test 9/1/94		SVE Test 9/7/94		SVE Test 9/13/94		SVE Test 9/20/94		SVE Test 9/27/94		SVE Test 10/6/94	
Vol. Fuel Hydrocarbons & BTEX		mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv
Benzene	78.11	380	120	<50	<16	530	170	440	140	430	130	400	130
Toluene	92.14	230	61	260	69	280	74	230	61	260	69	220	58
Ethylbenzene	106.17	91	21	93	21	95	22	83	19	120	28	77	18
Xylenes	106.17	85	20	230	53	220	51	76	18	99	23	71	16
Vol. Fuel Hydrocarbons	86.00	48,000	14,000	49,000	14,000	58,000	16,000	52,000	15,000	60,000	17,000	50,000	14,000
		%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total
Fixed Gases													
Carbon Dioxide	44.01	14	138,000	14	138,000	14	138,000	14	136,000	14	138,000	13	129,000
Carbon Monoxide	28.01	<0.10	<1000	<0.10	<1000	<0.10	<1000	<0.10	<1000	<0.10	<1000	<0.10	<1000
Methane	16.04	0.59	5,800	0.58	5,700	0.58	5,700	0.56	5,500	0.60	5,900	0.78	7,700
Nitrogen	28.01	81	800,000	81	798,000	81	797,000	82	798,000	82	806,000	81	802,000
Oxygen	32.00	4.1	41,000	4.3	42,000	4.1	40,000	4.2	41,000	3.1	30,000	4.3	43,000
Hydrocarbon Distribution		mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv
C1-C2 (as C1)	16	5,100	7,700	5,100	7,700	5,900	8,900	6,200	9,400	6,300	9,500	8,500	12,800
C3	44	<8	0	<10	0	<1	0	<1	0	<1	0	<1	0
C4	58	540	200	540	200	680	300	670	300	710	300	750	300
C5	72	4,200	1,400	4,100	1,400	4,800	1,600	4,900	1,600	4,900	1,600	4,600	1,500
C6	86	15,000	4,200	13,000	3,700	18,000	5,100	18,000	5,100	18,000	5,100	16,000	4,500
C7	100	17,000	4,100	19,000	4,600	20,000	4,800	19,000	4,600	21,000	5,100	18,000	4,400
C8	114	11,000	2,300	12,000	2,600	14,000	3,000	12,000	2,600	15,000	3,200	12,000	2,600
C9	128	3,400	600	3,000	600	3,400	600	3,200	600	3,700	700	2,700	500
C10	142	1,100	200	1,200	200	1,300	200	930	200	1,400	200	940	200
C11	156	300	50	360	60	370	60	280	40	430	70	330	50
C12	170	64	10	67	10	<1	0	<1	0	<1	0	52	10
C13	184	<1	0	<10	<1	<1	0	<1	0	<1	0	<1	0
TOTAL		57,700	20,800	58,400	21,100	68,500	24,600	65,200	24,400	71,400	25,800	63,900	26,900
Avg. Hydrocarbon Molecular Weight			67		67		67		65		67		58
Avg. non-methane Hydrocarbon Molec. Wt			97		96		97		95		97		95
ppmv of non-methane Hydrocarbons			13,100		13,400		15,700		15,000		16,300		14,100
FID Measurement			ppmv		ppmv		ppmv		ppmv		ppmv		ppmv
Total ppmv			34,000		25,000		20,000		20,000		17,000		20,000
Methane ppmv			16,500		9,000		7,500		7,000		6,500		8,000

ENGLAND SHAHIN & ASSOCIATES

Table 6-2 (Cont.)
Soil Gas Analytical Results
Well PEW-2

Analyte	Molecular Weight	SVE Test 10/12/94		SVE Test 10/19/94		SVE Test 10/26/94		SVE Test 11/1/94		SVE Test 11/9/94		SVE Test 11/16/94	
Vol. Fuel Hydrocarbons & BTEX		mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv
Benzene	78.11	450	140	340	110	340	110	370	120	350	110	290	91
Toluene	92.14	240	64	240	64	220	58	270	72	210	56	240	64
Ethylbenzene	106.17	140	32	94	22	57	13	86	20	64	15	74	17
Xylenes	106.17	110	25	86	20	93	21	96	22	86	20	120	28
Vol. Fuel Hydrocarbons	86.00	56,000	16,000	54,000	15,000	50,000	14,000	53,000	16,000	51,000	14,000	45,000	13,000
		%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total	%v on fixed	ppmv on total
Fixed Gases													
Carbon Dioxide	44.01	13	128,000	14	136,000	14	137,000	14	136,000	14	137,000	14	137,000
Carbon Monoxide	28.01	<0.10	<1000	<0.10	<1000	<0.10	<1000	<0.10	<1000	<0.10	<1000	<0.10	<1000
Methane	16.04	*0.72*	*7,100*	*0.75*	*7,300*	*0.71*	*6,900*	*0.58*	*5,700*	*0.59*	*5,800*	*0.61*	*6,000*
Nitrogen	28.01	81	800,000	82	798,000	82	801,000	82	799,000	82	802,000	82	803,000
Oxygen	32.00	4.5	44,000	4	39,000	3.8	37,000	4.1	40,000	3.9	38,000	4.2	41,000
Hydrocarbon Distribution		mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv
C1-C2 (as C1)	16	7,600	11,500	7,600	11,500	7,200	10,900	6,300	9,500	6,000	9,100	4,600	7,000
C3	44	<1	0	<1	0	<1	0	<1	0	<1	0	<1	0
C4	58	840	400	820	300	720	300	640	300	630	300	440	200
C5	72	4,700	1,600	4,300	1,400	4,000	1,300	4,100	1,400	3,800	1,300	2,800	900
C6	86	17,000	4,800	16,000	4,500	15,000	4,200	15,000	4,200	14,000	3,900	11,000	3,100
C7	100	20,000	4,800	19,000	4,600	18,000	4,400	19,000	4,600	18,000	4,400	15,000	3,600
C8	114	14,000	3,000	14,000	3,000	13,000	2,800	15,000	3,200	13,000	2,800	13,000	2,800
C9	128	3,600	700	3,700	700	3,100	600	4,200	800	4,200	800	4,100	800
C10	142	1,100	200	1,300	200	970	200	1,400	200	1,100	200	1,500	300
C11	156	360	60	420	70	300	50	440	70	320	50	480	70
C12	170	<1	0	<1	0	<1	0	<1	0	<1	0	58	10
C13	184	<1	0	<1	0	<1	0	<1	0	<1	0	<1	0
TOTAL		69,200	27,100	67,100	26,300	62,300	24,800	66,100	24,300	61,100	22,900	53,000	18,800
Avg Hydrocarbon Molecular Weight			62		62		61		66		65		68
Avg non-methane Hydrocarbon Molec Wt			96		97		96		98		97		99
ppmv of non-methane Hydrocarbons			15,600		14,800		13,900		14,800		13,800		11,800
FID Measurement			ppmv		ppmv		ppmv		ppmv		ppmv		ppmv
Total ppmv			22,000		19,000		18,000		18,000		19,000		22,000
Methane ppmv			9,000		8,000		8,000		7,500		8,000		9,500

ENGLAND SHAHIN & ASSOCIATES

Table 6-2 (Cont.)
Soil Gas Analytical Results
Well PEW-2

Analyte	Molecular Weight	SVE Test 11/21/94		SVE Test 12/1/94		SVE Test 12/7/94	
Vol. Fuel Hydrocarbons & BTEX		mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv
Benzene	78.11	310	97	<50	<16	320	100
Toluene	92.14	260	69	270	72	250	66
Ethylbenzene	106.17	75	17	140	32	66	15
Xylenes	106.17	100	23	230	53	220	51
Vol. Fuel Hydrocarbons	86.00	47,000	13,000	50,000	14,000	44,000	13,000
		%v	ppmv	%v	ppmv	%v	ppmv
Fixed Gases		on fixed	on total	on fixed	on total	on fixed	on total
Carbon Dioxide	44.01	13	128,000	13	128,000	13	128,000
Carbon Monoxide	28.01	<0.10	<1000	<0.10	<1000	<0.10	<1000
Methane	16.04	0.56	5,500	0.49	4,800	0.48	4,700
Nitrogen	28.01	82	807,000	82	810,000	82	809,000
Oxygen	32.00	4.5	44,000	4.2	41,000	4.4	43,000
Hydrocarbon Distribution		mg/m3	ppmv	mg/m3	ppmv	mg/m3	ppmv
C1-C2 (as C1)	16	5,200	7,900	5,000	7,600	4,800	7,300
C3	44	<1	0	<1	0	<1	0
C4	58	510	200	440	200	420	200
C5	72	3,100	1,000	3,400	1,100	3,300	1,100
C6	86	12,000	3,400	11,000	3,100	11,000	3,100
C7	100	16,000	3,900	19,000	4,600	17,000	4,100
C8	114	13,000	2,800	13,000	2,800	11,000	2,300
C9	128	4,500	900	4,900	900	3,800	700
C10	142	1,500	300	1,600	300	970	200
C11	156	410	60	590	90	220	30
C12	170	<1	0	53	10	<1	0
C13	184	<1	0	<1	0	<1	0
TOTAL		56,200	20,500	59,000	20,700	52,500	19,000
Avg. Hydrocarbon Molecular Weight			66		69		67
Avg. non-methane Hydrocarbon Molec. Wt			98		100		99
ppmv of non-methane Hydrocarbons			12,600		13,100		11,700
FID Measurement			ppmv		ppmv		ppmv
Total ppmv			21,000		22,000		21,000
Methane ppmv			9,000		9,000		9,000

ENGLAND SHAHIN & ASSOCIATES

Table 6-3
Vapor Extraction Mass Balance
Well PEW-2

	SVE Test 6/10/94		SVE Test 6/14/94	SVE Test 6/17/94	SVE Test 6/21/94	SVE Test 6/23/94	SVE Test 6/27/94	SVE Test 6/30/94
Time of day	9:30	14:10	15:35	16:05	16:00	18:53	12:00	19:15
scfm		58	61	61	61	62	62	62
Engine 1 Downtime		0	0	0	0	0	8.33	0
Engine 2 Downtime		0	0	0	0	0	8.83	0
Incremental hours**	0	4.7	97.4	72.5	95.9	50.9	80.5	79.3
Cumulative hours	0	4.7	102.1	174.6	270.5	321.4	401.9	481.2
Incremental air volume (cu. ft.)	0	16,200	347,800	265,400	351,100	187,800	299,600	294,800
Cumulative air volume (cu. ft.)	0	16,200	364,000	629,400	980,500	1.17E+06	1.47E+06	1.76E+06
Incremental lbs of hydrocarbons								
lbs total hydrocarbons	0	106	2026	1343	1865	1050	1703	1673
lbs methane (C1-C2)	0	18	337	207	241	117	184	173
lbs non-methane hydrocarbons	0	88	1689	1135	1624	933	1519	1500
lbs benzene	0	1	17	10	14	4 *	0	0
Cumulative lbs of hydrocarbons								
lbs total hydrocarbons	0	106	2132	3475	5340	6390	8093	9766
lbs methane (C1-C2)	0	18	355	563	804	921	1106	1279
lbs non-methane hydrocarbons	0	88	1777	2912	4536	5469	6987	8487
lbs benzene	0	1	18	29	43	47	47	47
Average Daily Rates								
scfd soil gas		83,300	85,700	87,800	87,800	88,600	89,300	89,300
lbs/day total hydrocarbons		546	499	444	467	495	508	507
lbs/day methane (C1-C2)		94	83	69	60	55	55	52
lbs/day non-methane hydrocarbons		452	416	376	406	440	453	454
lbs/day benzene		5	4	3	4	2	0	0

* Estimated from average of benzene concentration of previous sample and half the detection limit of benzene for this sample.

** Incremental hours is time both engines have been running. It is total elapsed time in this period minus one-half the downtime of each engine.

ENGLAND SHAHIN & ASSOCIATES

Table 6-3 (Cont.)
Vapor Extraction Mass Balance
Well PEW-2

	SVE Test 7/6/94	SVE Test 7/14/94	SVE Test 7/20/94	SVE Test 7/28/94	SVE Test 8/3/94	SVE Test 8/10/94	SVE Test 8/15/94
Time of day	13:45	11:30	12:40	15:15	19:55	15:20	19:30
scfm	63	62	63	62	63	62	62
Engine 1 Downtime	0	3.83	0	6.33	0	2.13	0
Engine 2 Downtime	0	3.83	0	6.33	0	16.83	0
Incremental hours**	138.5	185.9	145.2	188.3	148.7	153.9	124.2
Cumulative hours	619.7	805.6	950.8	1139.0	1287.7	1441.6	1565.8
Incremental air volume (cu. ft.)	519,400	697,200	545,200	709,400	560,200	580,100	465,000
Cumulative air volume (cu. ft.)	2.28E+06	2.98E+06	3.52E+06	4.23E+06	4.79E+06	5.37E+06	5.84E+06
Incremental lbs of hydrocarbons							
lbs total hydrocarbons	3022	4020	2685	2749	1878	1878	1643
lbs methane (C1-C2)	292	368	244	246	158	150	132
lbs non-methane hydrocarbons	2730	3652	2441	2503	1721	1728	1511
lbs benzene	0	12	19	25	20	19	16
Cumulative lbs of hydrocarbons							
lbs total hydrocarbons	12,788	16,808	19,493	22,242	24,120	25,999	27,642
lbs methane (C1-C2)	1571	1939	2183	2429	2587	2737	2869
lbs non-methane hydrocarbons	11,217	14,869	17,310	19,813	21,534	23,262	24,773
lbs benzene	47	60	79	104	124	143	159
Average Daily Rates							
scfd soil gas	90,000	90,000	90,100	90,400	90,400	90,400	89,900
lbs/day total hydrocarbons	524	519	444	350	303	293	318
lbs/day methane (C1-C2)	51	48	40	31	25	23	26
lbs/day non-methane hydrocarbons	473	471	404	319	278	269	292
lbs/day benzene	0	2	3	3	3	3	3

* Estimated from average of benzene concentration of previous sample and half the detection limit of benzene for this sample.

** Incremental hours is time both engines have been running. It is total elapsed time in this period minus one-half the downtime of each engine.

ENGLAND SHAHIN & ASSOCIATES

Table 6-3 (Cont.)
Vapor Extraction Mass Balance
Well PEW-2

	SVE Test 8/24/94	SVE Test 9/1/94	SVE Test 9/7/94	SVE Test 9/13/94	SVE Test 9/20/94	SVE Test 9/27/94	SVE Test 10/6/94
Time of day	14:07	14:00	14:55	10:50	12:25	17:30	17:30
scfm	62	70	70	69	68	70	70
Engine 1 Downtime	24	2	0	7.50	0	4.58	0
Engine 2 Downtime	24	2	0	7.50	0	25.82	17.83
Incremental hours**	186.6	189.9	144.9	132.4	169.6	157.9	207.1
Cumulative hours	1752.4	1942.3	2087.2	2219.6	2389.2	2547.1	2754.2
Incremental air volume (cu. ft.)	698,800	751,500	604,500	549,200	695,300	653,400	866,800
Cumulative air volume (cu. ft.)	6.54E+06	7.29E+06	7.89E+06	8.44E+06	9.14E+06	9.79E+06	1.07E+07
Incremental lbs of hydrocarbons							
lbs total hydrocarbons	2679	2752	2193	2178	2905	2789	3665
lbs methane (C1-C2)	225	244	193	189	263	255	401
lbs non-methane hydrocarbons	2455	2508	2001	1989	2642	2534	3264
lbs benzene	21	18	8 *	10	21	18	22
Cumulative lbs of hydrocarbons							
lbs total hydrocarbons	30,321	33,074	35,267	37,445	40,350	43,139	46,804
lbs methane (C1-C2)	3094	3338	3531	3720	3983	4238	4639
lbs non-methane hydrocarbons	27,227	29,735	31,736	33,725	36,367	38,901	42,165
lbs benzene	180	198	205	215	236	254	277
Average Daily Rates							
scfd soil gas	89,900	95,000	100,100	99,500	98,400	99,300	100,500
lbs/day total hydrocarbons	345	348	363	395	411	424	425
lbs/day methane (C1-C2)	29	31	32	34	37	39	46
lbs/day non-methane hydrocarbons	316	317	331	361	374	385	378
lbs/day benzene	3	2	1	2	3	3	3

* Estimated from average of benzene concentration of previous sample and half the detection limit of benzene for this sample.

** Incremental hours is time both engines have been running. It is total elapsed time in this period minus one-half the downtime of each engine.

ENGLAND SHAHIN & ASSOCIATES

Table 6-3 (Cont.)
Vapor Extraction Mass Balance
Well PEW-2

	SVE Test 10/12/94	SVE Test 10/19/94	SVE Test 10/26/94	SVE Test 11/1/94	SVE Test 11/9/94	SVE Test 11/16/94	SVE Test 11/21/94
Time of day	9:30	16:30	8:10	17:40	14:40	14:50	14:35
scfm	70	70	69	70	70	70	72
Engine 1 Downtime	0	6.90	44.18	0	3.25	0	0
Engine 2 Downtime	0	6.90	1.50	0	3.25	0	0
Incremental hours**	136.0	168.1	136.8	153.5	185.7	168.2	119.8
Cumulative hours	2890.2	3058.3	3195.1	3348.6	3534.3	3702.5	3822.3
Incremental air volume (cu. ft.)	567,300	705,200	570,700	636,600	774,800	705,400	510,900
Cumulative air volume (cu. ft.)	1.12E+07	1.19E+07	1.25E+07	1.31E+07	1.39E+07	1.46E+07	1.51E+07
Incremental lbs of hydrocarbons							
lbs total hydrocarbons	2360	3004	2308	2554	3080	2515	1743
lbs methane (C1-C2)	285	335	264	269	298	234	156
lbs non-methane hydrocarbons	2074	2669	2044	2286	2782	2282	1587
lbs benzene	15	17	12	14	17	14	10
Cumulative lbs of hydrocarbons							
lbs total hydrocarbons	49,164	52,168	54,475	57,030	60,109	62,625	64,368
lbs methane (C1-C2)	4924	5259	5523	5792	6090	6323	6480
lbs non-methane hydrocarbons	44,239	46,908	48,952	51,238	54,020	56,301	57,888
lbs benzene	292	309	321	335	353	367	377
Average Daily Rates							
scfd soil gas	100,100	100,700	100,100	99,500	100,100	100,700	102,400
lbs/day total hydrocarbons	416	429	405	399	398	359	349
lbs/day methane (C1-C2)	50	48	46	42	38	33	31
lbs/day non-methane hydrocarbons	366	381	358	357	359	326	318
lbs/day benzene	3	2	2	2	2	2	2

* Estimated from average of benzene concentration of previous sample and half the detection limit of benzene for this sample.

** Incremental hours is time both engines have been running. It is total elapsed time in this period minus one-half the downtime of each engine.

ENGLAND SHAHIN & ASSOCIATES

Table 6-3 (Cont.)
Vapor Extraction Mass Balance
Well PEW-2

	SVE Test 12/1/94	SVE Test 12/7/94
Time of day	12:00	12:55
scfm	71	72
Engine 1 Downtime	0	3.75
Engine 2 Downtime	0	3.75
Incremental hours**	237.4	141.2
Cumulative hours	4059.7	4200.8
Incremental air volume (cu. ft.)	1,018,400	605,600
Cumulative air volume (cu. ft.)	1.61E+07	1.68E+07
Incremental lbs of hydrocarbons		
lbs total hydrocarbons	3666	2110
lbs methane (C1-C2)	325	185
lbs non-methane hydrocarbons	3342	1925
lbs benzene	11 *	7
Cumulative lbs of hydrocarbons		
lbs total hydrocarbons	68,034	70,144
lbs methane (C1-C2)	6804	6990
lbs non-methane hydrocarbons	61,230	63,155
lbs benzene	387	394
Average Daily Rates		
scfd soil gas	103,000	103,000
lbs/day total hydrocarbons	371	359
lbs/day methane (C1-C2)	33	32
lbs/day non-methane hydrocarbons	338	327
lbs/day benzene	1	1

* Estimated from average of benzene concentration of previous sample and half the detection limit of benzene for this sample.

** Incremental hours is time both engines have been running. It is total elapsed time in this period minus one-half the downtime of each engine.

ENGLAND SHAHIN & ASSOCIATES

Table 6-4
Results of Vapor Extraction Data Analysis
35-Wells Test

Extraction Well	Flow Rate (scfm)	Wellhead Vacuum (in.H_2O)	Screen Interval[1] (ft)	Air Permeability (darcy)	Initial VOH Removal Rate (lbs/day)	Initial Benzene Removal Rate (lbs/day)
MW-10P	74	16	5.7	85	290	0.7
MW-13P	80	37	8.9	25	270	0
SBB-1	62	20.5	20	18	230	0.3
SBC-1	79	42	20	11	710	0
SBD-2	32	13.5	35	7	60	0.9
SBD-3	33	15	23	11	90	1.4
SBE-1	32	12.5	20	15	80	0.5
PEW-1	21	6	24	15	100	2.3
PEW-3	32	1.8	36	52	260	4.6
PEW-4	45	9	24	22	200	1.3
PEW-5	40	26	25	7	190	2.6
PEW-6	33	8.1	24	18	220	3.6
AEW-1	34	7	30	17	170	3.7
MW-2S	31	42	2.5	30	10	0.1
MW-3S	22	55	3.4	12	40	0
MW-5S	52	26	NA	NA	0	0
MW-8S	26	90	NA	NA	190	1.6
MW-9S	59	161	NA	NA	4	0
MW-11S	26	111	NA	NA	0.1	0
MW-12S	55	159	NA	NA	0.1	0
MW-14S	70	102	NA	NA	10	0.2
MW-17S	42	110	NA	NA	20	0.3
MW-37S	16	90	4.5	4	110	3.0
MW-38S	26	58	10.2	4	40	0.3

Table 6-4 (Cont.)
Results of Vapor Extraction Data Analysis
35-Wells Test

Extraction Well	Flow Rate (scfm)	Wellhead Vacuum (in.H$_2$O)	Screen Interval[1] (ft)	Air Permeability (darcy)	Initial VEH Removal Rate (lbs/day)	Initial Benzene Removal Rate (lbs/day)
MW-39S	8	193	NA	NA	2	0
MW-40S	32	12	10	28	110	0.1
MW-41S	6	134	NA	NA	0.1	0
MW-42S	75	25	12.9	24	20	0
MW-43S	53	44	2.3	53	40	0
MW-44S	33	27	9.75	13	0.4	0
MW-45S	46	23	14.1	15	110	0
MW-46S	69	47	28	5	20	0
EW-2	41	37	NA	NA	80	0.3
EW-4	55	85	NA	NA	150	7.4
EW-5	69	155	NA	NA	2	0

Notes:

(1) "Screen Interval" represents the effective screened length, after the effects of water level rise are subtracted.

NA In cases where the expected water level rise is greater than the total screened length, the corrected screen interval and air permeability values are not calculated.

Table 6-5
Comparative Analysis of Solids Removal Technologies

Technology	Advantages	Disadvantages
Dissolved Air Flotation with Coagulation and Flocculation	• Proven technology in suspended solids treatment. • Effective in removing oil coated suspended solids. • Effective in removing small size solids (less than 5 micron).	• Limited effectiveness for low TSS concentrations (<50 ppm). • Costly chemical addition. • Limited effectiveness for dissolved solids. • Converts some of the TDS to TSS. • Requires off gas treatment. • Aerated water may promote bacteria growth in carbon. • Tests showed inadequate TSS removal.
Reverse Flow Centrifuge	• Low O&M costs: no chemical addition and minimal labor. • Low moisture content of solids produced (45% solids).	• Technology not proven for ground water with suspended concentrations as low as PCPL. • Not effective for dissolved solids. • Tests showed only 50 percent removal of TSS.
Aeration	• Low capital and O&M costs. • No chemical addition. • Effective in converting dissolved solids to suspended solids. • Oxidation of manganese and iron.	• Increases TSS by factor of ten. • Requires additional system for suspended solids removal. • Requires off gas treatment. • Aerated water may promote bacteria growth in carbon.
Lime Softening	• More effective than aeration for converting calcium and magnesium from TDS to TSS.	• High volume of lime addition required. • May not reduce iron or manganese. • Increases TSS by a factor of 50 to 100. • Additional system required for suspended solids removal. • Large volume of oily sludge which may be hazardous.
Granular Media Filter with Automatic Backwash	• Wide selection of systems and filter media. • Low O&M costs.	• Not effective in removing dissolved solids. • Oil coated solids may foul filter media. • May not remove fine solids (less than 1 micron). • Tests showed inadequate TSS removal.

Table 6-5 (Cont.)
Comparative Analysis of Solids Removal Technologies

Technology	Advantages	Disadvantages
Pump directly to Granular Activated Carbon without exposure to air via Bag Filter.	• Low Cost. • No chemical additives needed. • Eliminating the introduction of air should eliminate conversion of TDS to TSS.	• Not effective in removing dissolved solids. • Frequent carbon vessel backwash may be required, with treatment and disposal of solids in the backwash water. • Bag filters will continue to clog.
Settling Tank	• Proven effective in settling medium to large particles. • Increase separation of free phase product, if present. • Simple process.	• Precipitation of TSS from TDS, increases with longer residence time. • Particles smaller than 5 microns may require coagulation to settle. • Tests showed inadequate TSS removal.
Chemical Addition (sequestering agent: acrylic acid polymer)	• Effective in keeping TDS in solution. • Eliminates need for any additional suspended solids treatment. • Simple implementation.	• High cost for chemicals. • Chemical is 30% organic, may contribute to activated carbon loading. • TDS levels remain high. • Only 50 percent reduction in TSS.

Table 6-6
Boreholes Selected for Geophysical Logging

Well	Date Drilled	Logged Depth (feet)
EW-2	May 3, 1994	127.80
EW-4	May 2, 1994	102.79
EW-5	May 5, 1994	93.5
MW-11S	February 21, 1986	87.1
MW-20S	August 27, 1990	90
MW-25D	August 3, 1990	134.6
MW-29D	November 29, 1990	129.6
MW-31D	December 12, 1990	134.5
MW-33D	December 13, 1990	148
MW-34S	December 17, 1990	113.04
MW-41S	October 22, 1993	84.42

Table 6-7
Aquifer Test Summary

Well	Test Type	Pumping or Observation Well	Permeability (ft/day)
EW-2	Step Drawdown	Pumping	10
	Constant Rate	Pumping	
MW-2S	Constant Rate	Observation	13
MW-14S	Constant Rate	Observation	10
EW-4	Step Drawdown	Pumping	14
	Constant Rate	Pumping	
MW-8S	Constant Rate	Observation	9
EW-5	Step Drawdown	Pumping	13
	Constant Rate	Pumping	
MW-19S	Constant Rate	Observation	16
MW-40S	Constant Rate	Observation	16
MW-20S	Slug	Pumping	6
MW-39S	Slug	Pumping	27
MW-41S	Slug	Pumping	1
MW-44S	Slug	Pumping	3
MW-45S	Slug	Pumping	5
MW-46S	Slug	Pumping	.5
MW-17S	Constant Rate	Observation	6
P-2	Constant Rate	Observation	13
MW-37S	Constant Rate	Pumping	10
EW-1	Constant Rate	Pumping	8
MW-18S	Slug	Pumping	30
MW-21S	Slug	Pumping	9
MW-22S	Slug	Pumping	29
MW-25S	Slug	Pumping	61
MW-26S	Slug	Pumping	7

Table 6-8
General Minerals Summary

	EW-1 & MW-19S Combined 4/20/94		Well EW-2 6/20/94		Well EW-4 6/20/94		Well EW-5 6/20/94	
General								
pH	7.0		7.1		7.0		6.9	
Specific Conductance	1,600	umhos/cm	1,800	umhos/cm	1,900	umhos/cm	2,000	umhos/cm
	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L
Bicarbonate Alkalinity as CaCO3	960	19.2	770	15.4	1,000	20.0	850	17.0
Hardness as CaCO3	440 *	8.8	750	15.0	650	13.0	920	18.4
Total Dissolved Solids (TDS)	1,100	-	1,200	-	1,100	-	1,300	-
TDS by adding anions + cations	1,700		1,700		1,800		2,000	
Total Suspended Solids	NA	-	23	-	30	-	26	-
Surfactants	NA	-	0.93	-	1.3	-	1.1	-
Cations								
Calcium	80	4.0	140	7.0	130	6.5	190	9.5
Magnesium	58	4.8	97	8.0	79	6.5	110	9.1
Sodium	220	9.6	140	6.1	200	8.7	160	7.0
Potassium	4.3	0.11						
Iron	0.56	0.02	8.9	0.32	10.0	0.36	5.5	0.20
Manganese	0.076	0.003	0.094	0.003	0.11	0.004	0.54	0.019
Zinc	<0.05	<0.0015	<0.05	<0.0015	0.072	0.002	0.072	0.002
Total	363	18.5	386	21.4	419	22.1	466	25.7
Anions								
Bicarbonate	1,171	19.2	939	15.4	1,220	20.0	1,037	17.0
Chloride	130	3.7	74	2.1	100	2.8	83	2.3
Sulfate	29	0.3	320	3.3	110	1.1	370	3.9
Total	1,330	23.2	1,333	20.8	1,430	24.0	1,490	23.2

* Calculated from Ca + Mg

Table 7-1
Capture Zone Scenarios

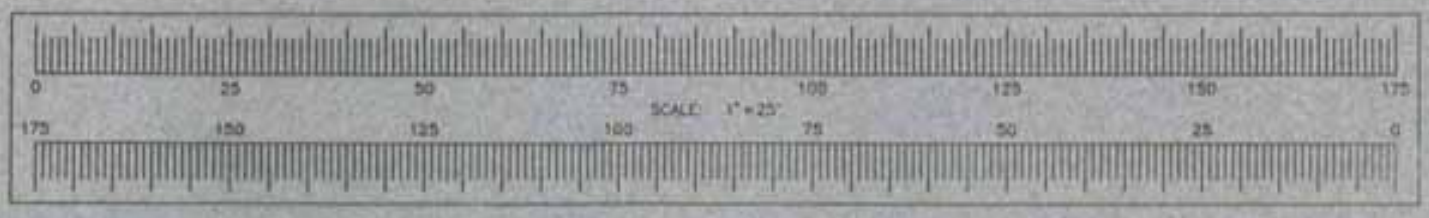
Well	Approximate Pumping Rate (gpm)		
	Existing Phase 1 System	Recommended Extraction System	Maximum Capture System
EW-1		10	
EW-2	6	6	
EW-4	12	20	
EW-5	10	16	16
EW-6		10	
EW-7		11[1]	
MW-28S		40	
EW-8			10
EW-9			10
EW-10			10
EW-11			10
EW-12			5
EW-14			7
TOTAL	28	102 to 113[1]	68

Notes:

(1) If necessary.

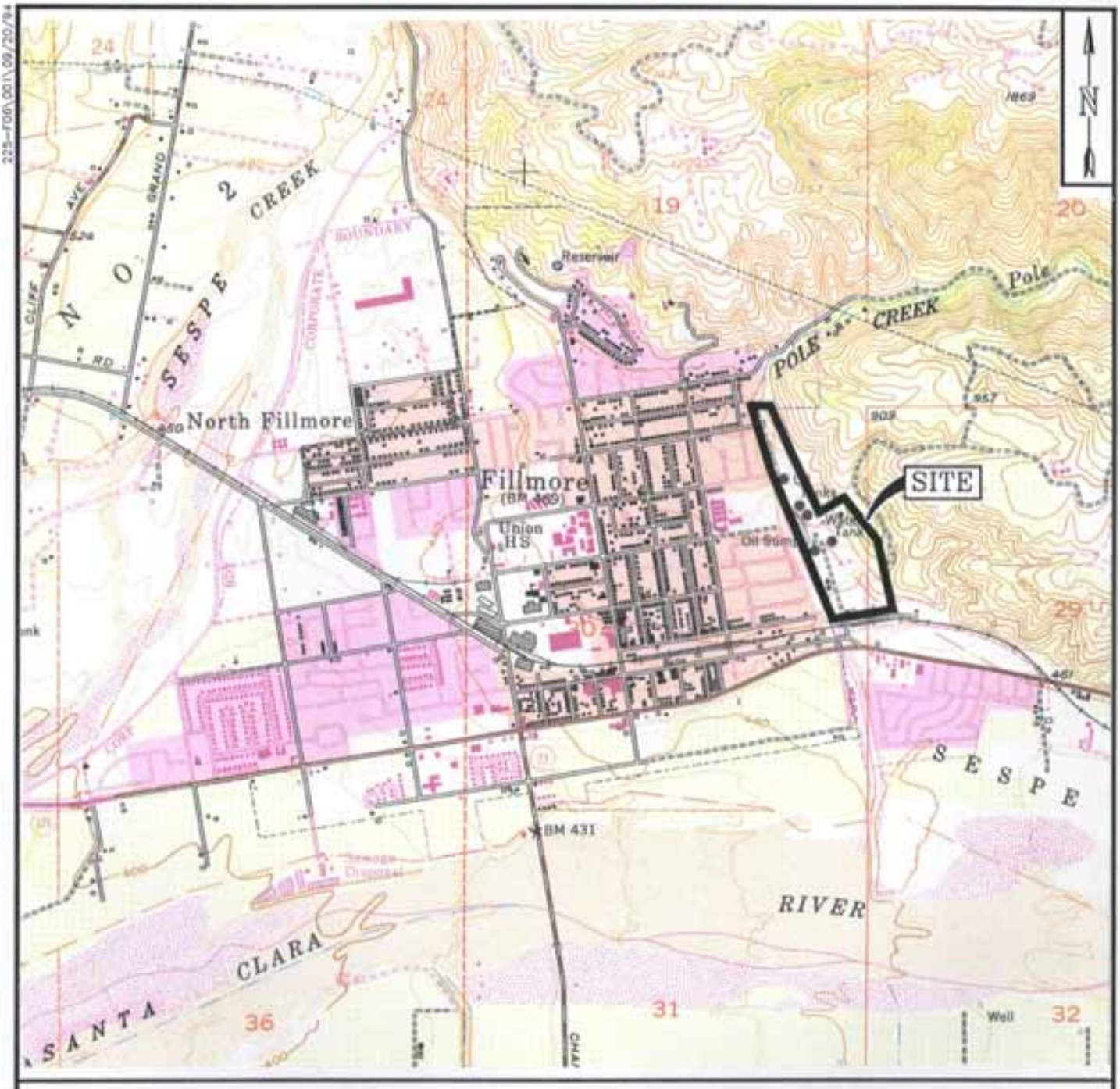
Table 10-1
Well Pump Specifications

Extraction Well	Maximum Expected Flow Rate	Grundfos Model Number	Pump Motor Horsepower
EW-1	10	10S05-9	1/2
EW-2	6	10S05-9	1/2
EW-4	20	25S10-7	1
EW-5	16	16S07-8	3/4
EW-6	10	10S10-15	1
EW-7	11	16S07-8	3/4
MW-28S	40	60S50-9	5



1" = 25'
SCALE

FOR USE WITH 1:250 SCALE MAPS
AND 1:25 CROSS SECTIONS



0 2000 4000 FEET

APPROXIMATE SCALE

FIGURE 1-1

SITE LOCATION MAP

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

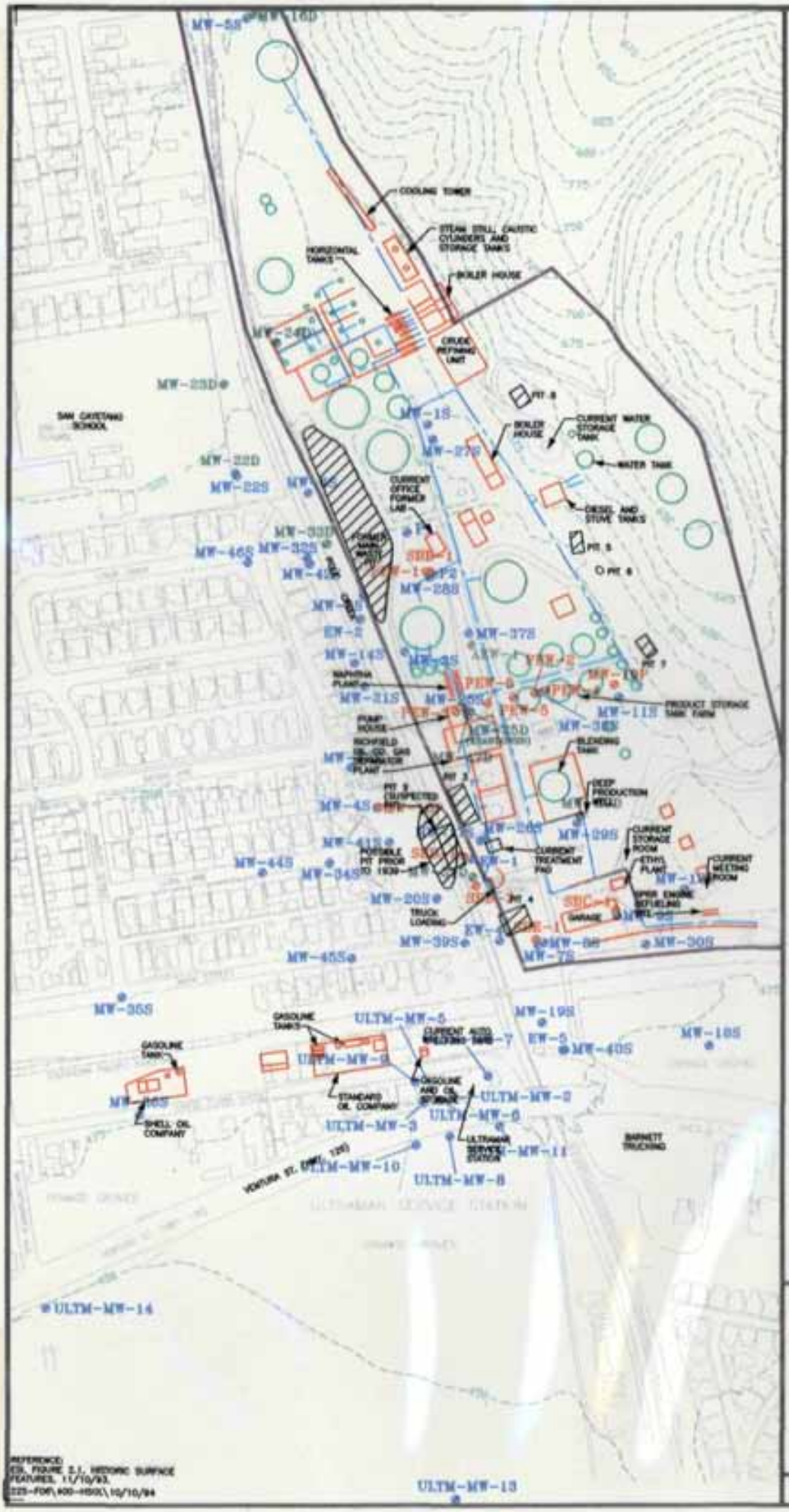
PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

REFERENCE:
7.5 MINUTE U.S.G.S. TOPOGRAPHIC
MAP OF FILLMORE, CALIFORNIA
DATED: 1951
PHOTOREVISED: 1988

225-T06.001\09/20/94



N

EXPLANATION

- CRUDE OIL OR PRODUCT STORAGE TANKS
- PITS
- BUILDINGS
- ESTIMATED PIPELINE ALIGNMENT

LEGEND

MW-10P	PERCHED AQUIFER WELL LOCATION AND WELL ID.
MW-12S	AQUIFER I WELL LOCATION AND WELL ID.
MW-29D	AQUIFER II WELL LOCATION AND WELL ID.
AEW-1	AIR EXTRACTION WELL LOCATION AND WELL ID.
475	GROUND SURFACE ELEVATION CONTOUR (IN FEET ABOVE MEAN SEA LEVEL). CONTOUR INTERVAL 25 FEET.
	PROJECT AREA

NOTES

WELL ID PREFIX DESCRIPTIONS:

MW	MONITORING WELL
P	2-INCH DIAMETER PIEZOMETER
SB	SOIL BORING CONVERTED TO PERCHED ZONE WELL
EW	AQUIFER I EXTRACTION WELL
PEW	PERCHED EXTRACTION WELL
AEW	AIR EXTRACTION WELL
ULTM	ULTRAMAR MONITORING WELL

0 200 400 600 800

FEET

FIGURE 1-2

SITE PLAN

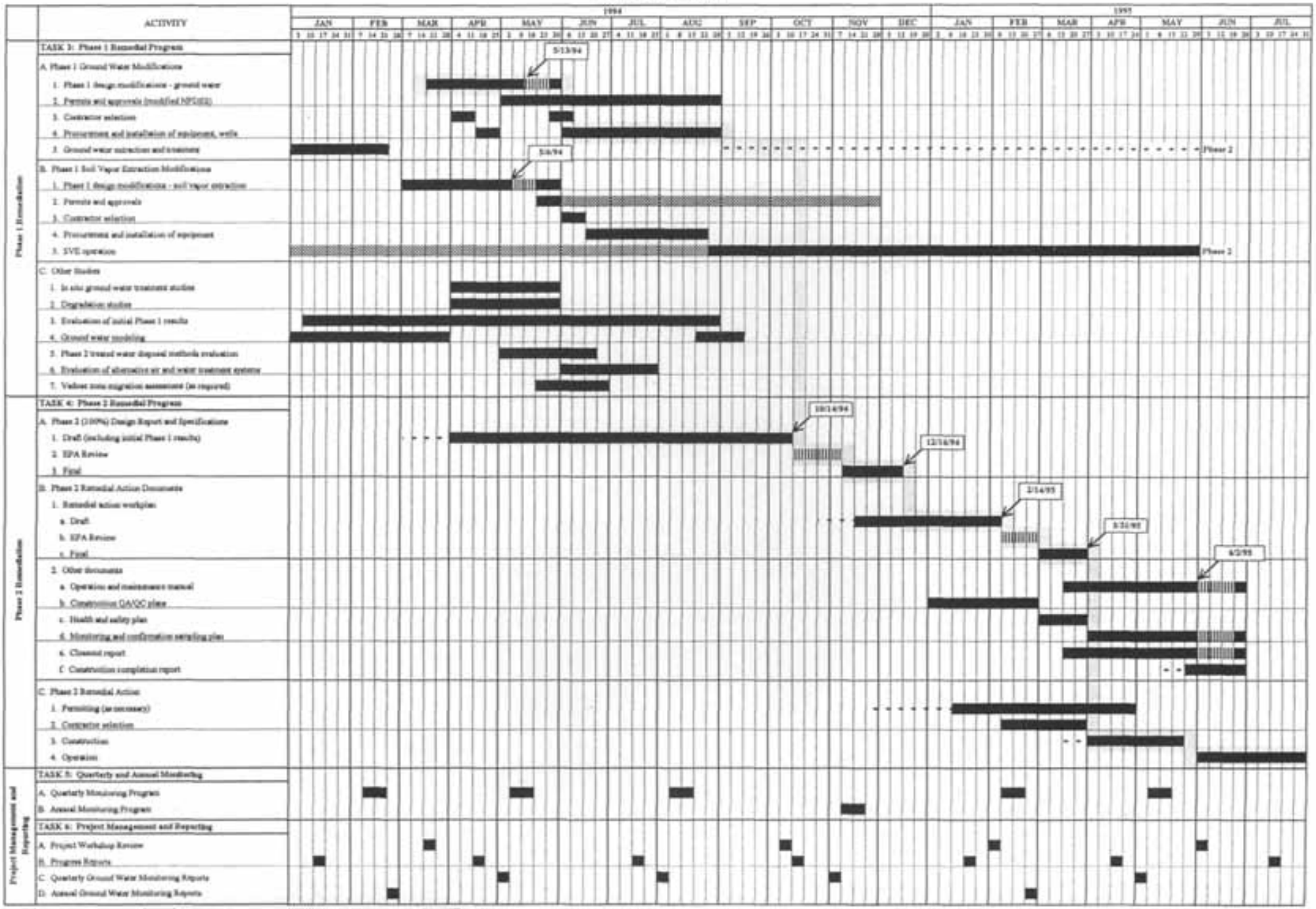
PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

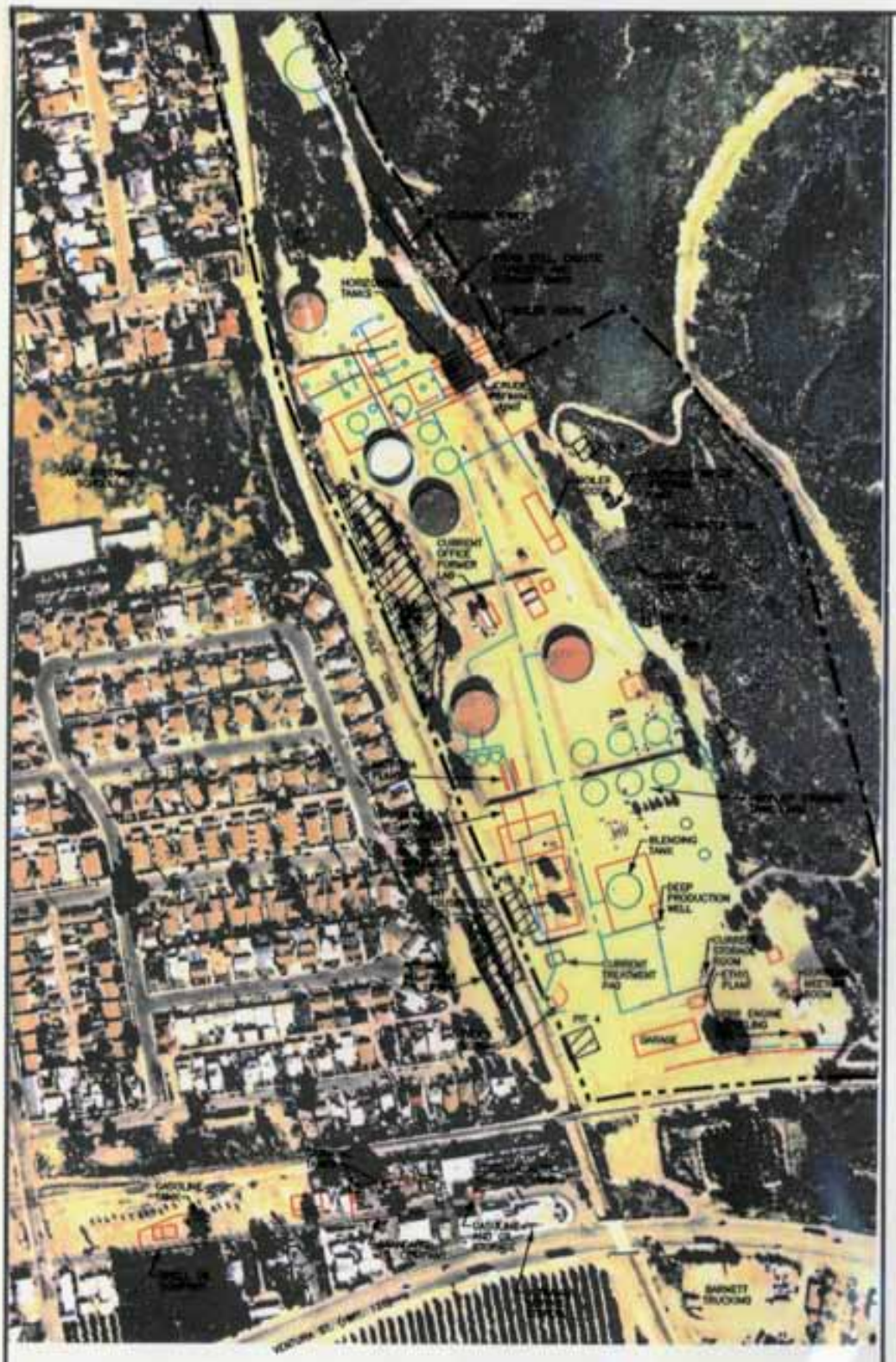
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

Figure 1-3
Site Remedial Design/Remedial Action Schedule
Pacific Coast Pipeline



As approved by Katherine Moore of the EPA, in a letter to Texaco dated March 31, 1994.



N

EXPLANATION

- PROJECT AREA
- CRUDE OIL OR PRODUCT STORAGE TANKS
- PITS
- BUILDINGS
- ESTIMATED PIPELINE ALIGNMENT

0 200 400 600 800 FEET

APPROXIMATE SCALE

SOURCE:
GOLDEN STATE AERIAL SURVEYS,
NEGATIVE NO. GS 204-1-1 02/04/93
REFERENCE:
ESL FIGURE 2.1, HISTORIC SURFACE FEATURES, 11/10/93.
225-F06,H07,08/07/94

FIGURE 2-1

AERIAL PHOTO WITH HISTORIC FACILITIES

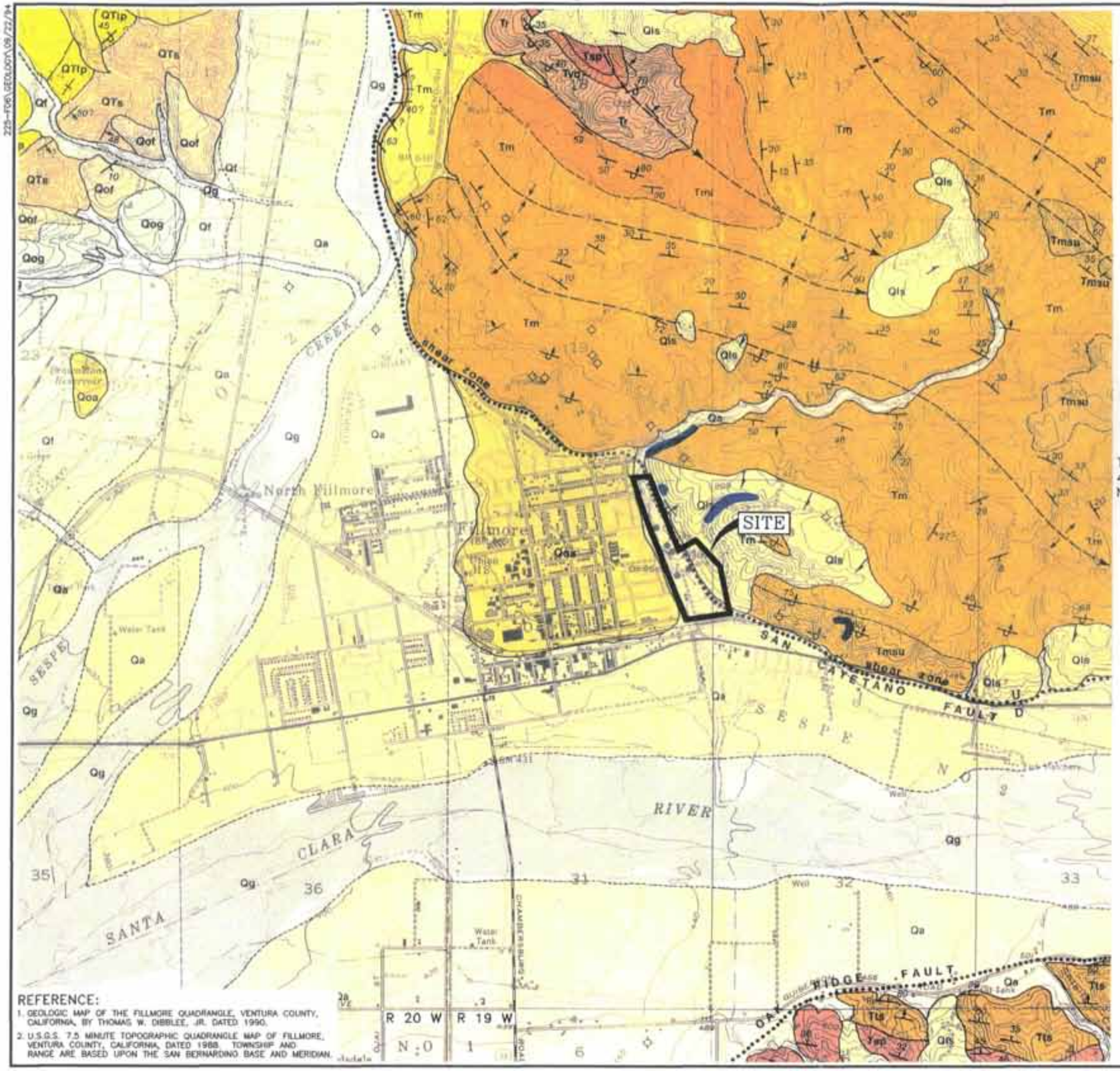
PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

225-F06\GEOLOGY\09/22/94



EXPLANATION

SURFICAL SEDIMENTS	Qg / Qf / Qa	Qg... Stream channel deposits, mostly gravel and sand Qf... Alluvial fan boulder-cobble gravel Qa... Alluvium: unconsolidated floodplain deposits of silt, sand and gravel
LANDSLIDE AND TALUS DEBRIS	Qls	Qls... Landslide and Talus Debris, includes slopewash of sandstone detritus
OLDER DISSECTED SURFICIAL SEDIMENTS	Qoa / Qog / Qof	Qoa... Youngest, lowest gravel terraces Qog... Intermediate, higher gravel terraces Qof... Oldest, highest, gravel terraces
SAUGUS FORMATION	QTs	QTs... Weakly consolidated brown alluvial cobble-boulder conglomerate of poorly sorted detritus
LOS POSAS SAND	QTlp	QTlp... Friable fine grained sandstone and sandy siltstone, commonly with shell fragments
MONTEREY FORMATION	Tmsu / Tm / Tml / Tmss	Tmsu... Upper sandstone, thick bedded arkosic sandstone Tm... Upper shale unit, Mohnian stage Tmss... Lower sandstone member, similar to Tmsu Tml... Lower shale unit, Luisian to uppermost saucesian stage
RINCON SHALE	Tr	Tr... Clay shale and siltstone, contains occasional gray dolomitic concretions
TOPANGA SANDSTONE	Tts	Tts... Semi-friable, vaguely bedded arkosic sandstone; exposed south of Oak Ridge Fault
VAQUEROS SANDSTONE	Tvq	Tvq... Fine grained sandstone, locally calcareous
SESPE FORMATION	Tsp	Tsp... In northern area, mostly hard bedded sandstone, lowest part is thick bedded hard sandstone and conglomerate with pebbles of granitic rocks, andesitic porphyries and quartzite

Naturally occurring Monterey Formation oil and tar sands in outcrop near the site location

0 2000 4000 FEET
APPROXIMATE SCALE

REFERENCE:
1. GEOLOGIC MAP OF THE FILLMORE QUADRANGLE, VENTURA COUNTY, CALIFORNIA, BY THOMAS W. DIBBLEE, JR. DATED 1990.
2. U.S.G.S. 7.5 MINUTE TOPOGRAPHIC QUADRANGLE MAP OF FILLMORE, VENTURA COUNTY, CALIFORNIA, DATED 1988. TOWNSHIP AND RANGE ARE BASED UPON THE SAN BERNARDINO BASE AND MERIDIAN.

FIGURE 2-2

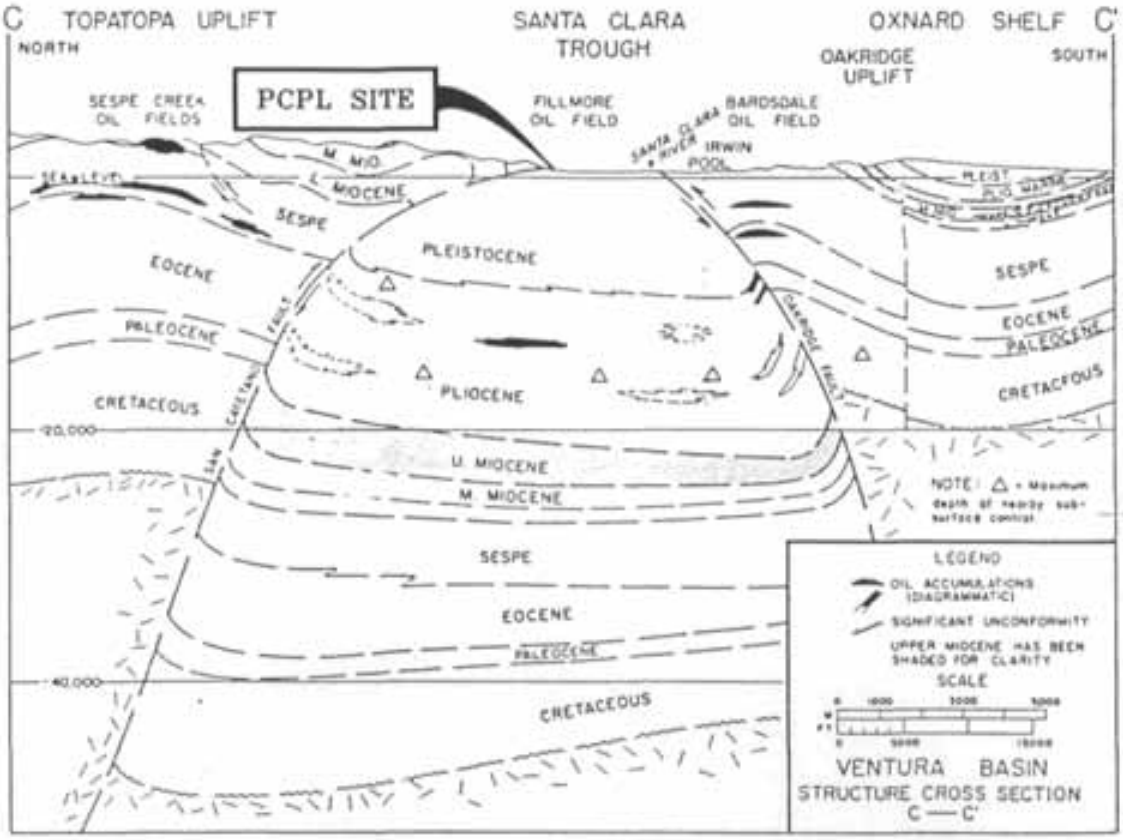
REGIONAL GEOLOGY

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



CROSS SECTION LOCATION

FIGURE 2-3

STRUCTURAL CROSS SECTION

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

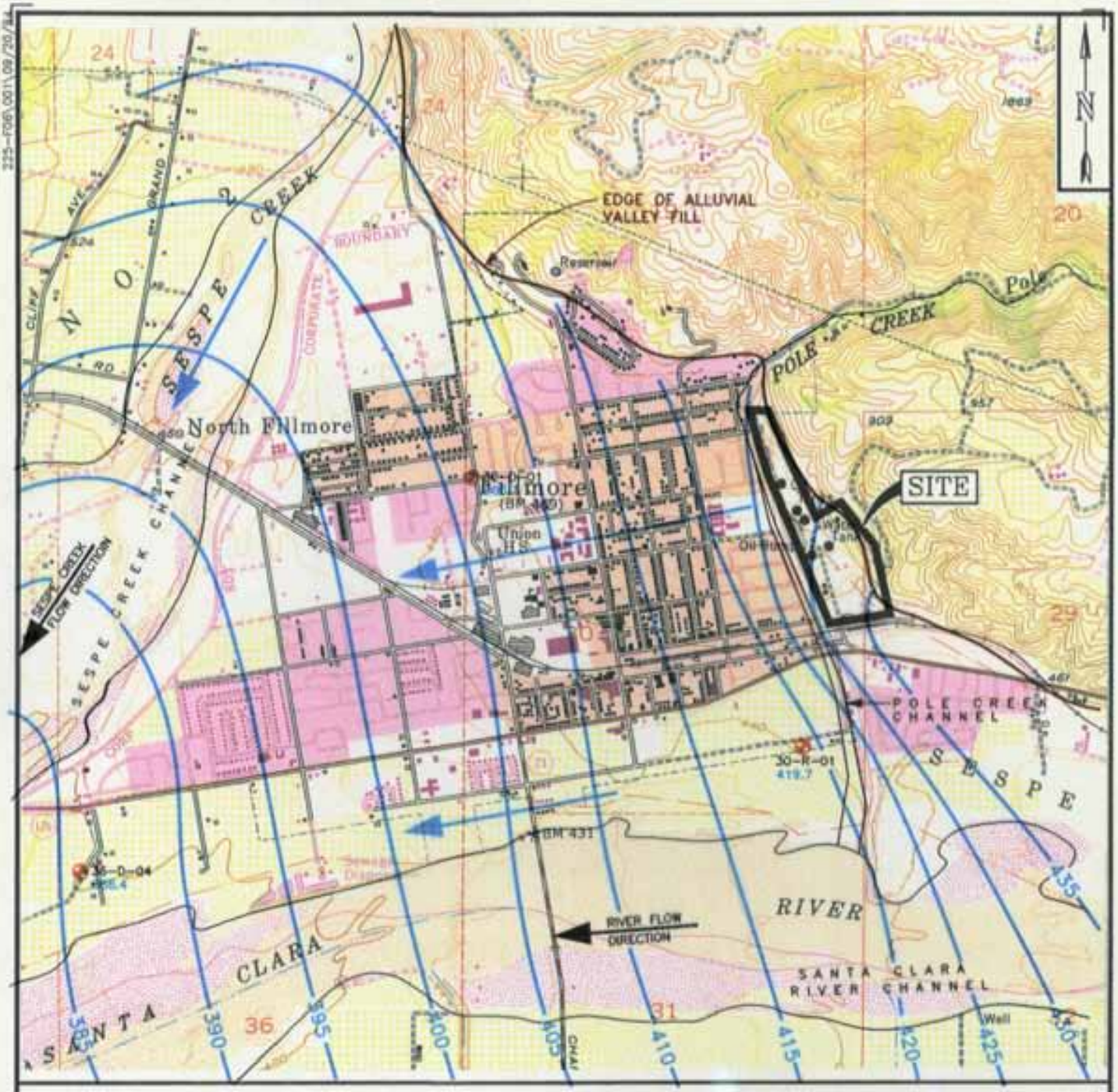
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

REFERENCE:

NAGLE, H.E. AND PARKER, E.S., 1971, FUTURE OIL AND GAS POTENTIAL OF ONSHORE VENTURA BASIN, CALIFORNIA: AMERICAN ASSOCIATION OF PETROLEUM GEOLOGIST MEMOIR NO. 15, P. 254-297.

225/06\005\10/04/94



0 2000 4000 FEET

APPROXIMATE SCALE

EXPLANATION

30-R-01 419.7	APPROXIMATE LOCATION OF GROUND WATER MONITORING WELL WITH GROUND WATER ELEVATION IN FEET AMSL
385	GROUND WATER CONTOUR IN FEET AMSL MEASURED DECEMBER 1993
←	GROUND WATER FLOW DIRECTION

REFERENCE:
7.5 MINUTE U.S.G.S. TOPOGRAPHIC MAP OF FILLMORE, CALIFORNIA
DATED: 1951
PHOTOREVISED: 1988

FIGURE 2-4

REGIONAL GROUND WATER CONTOUR MAP

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

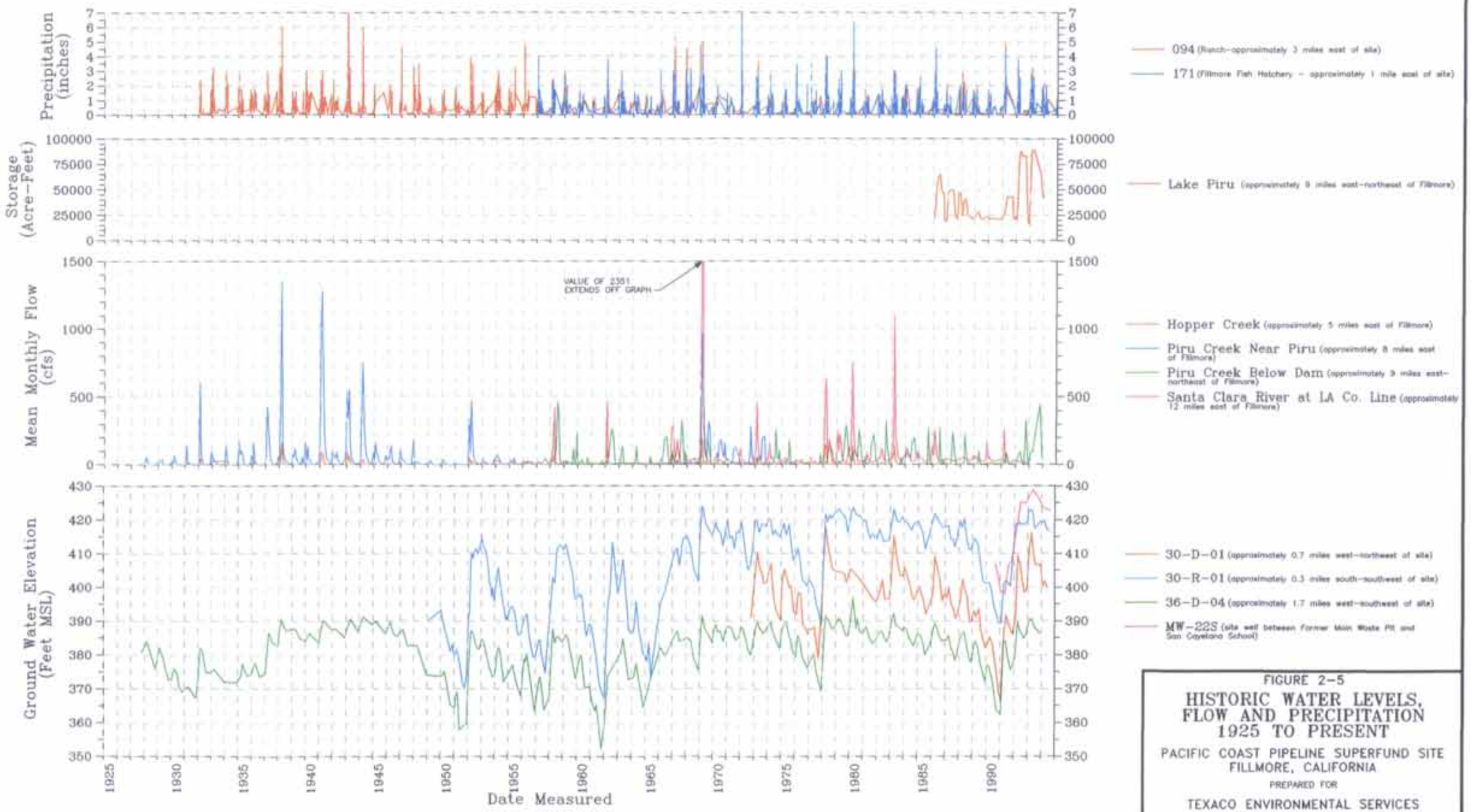


FIGURE 2–5

HISTORIC WATER LEVELS, FLOW AND PRECIPITATION 1925 TO PRESENT

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

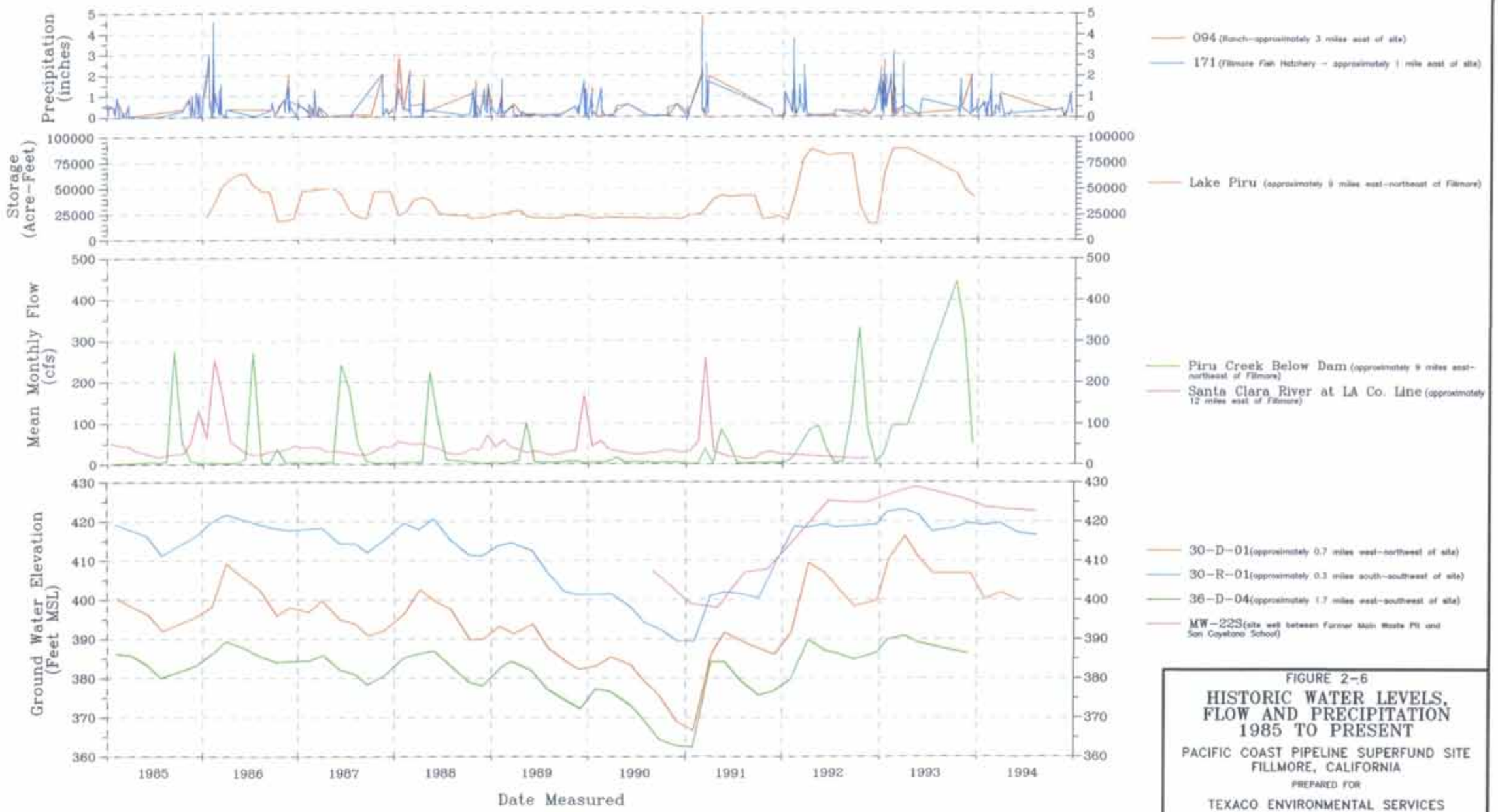


FIGURE 2-6

HISTORIC WATER LEVELS, FLOW AND PRECIPITATION 1985 TO PRESENT

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

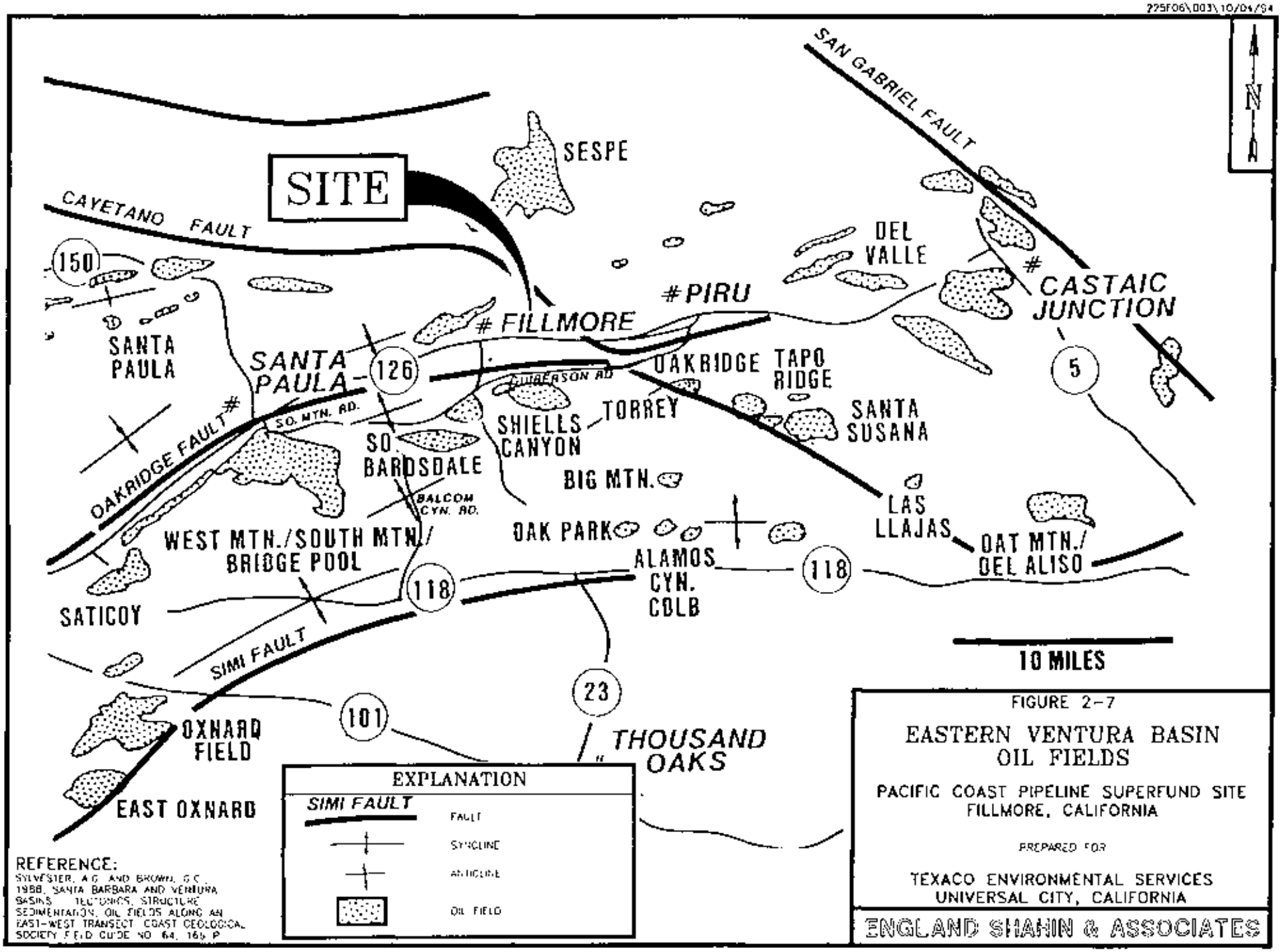


FIGURE 2-7

EASTERN VENTURA BASIN OIL FIELDS

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

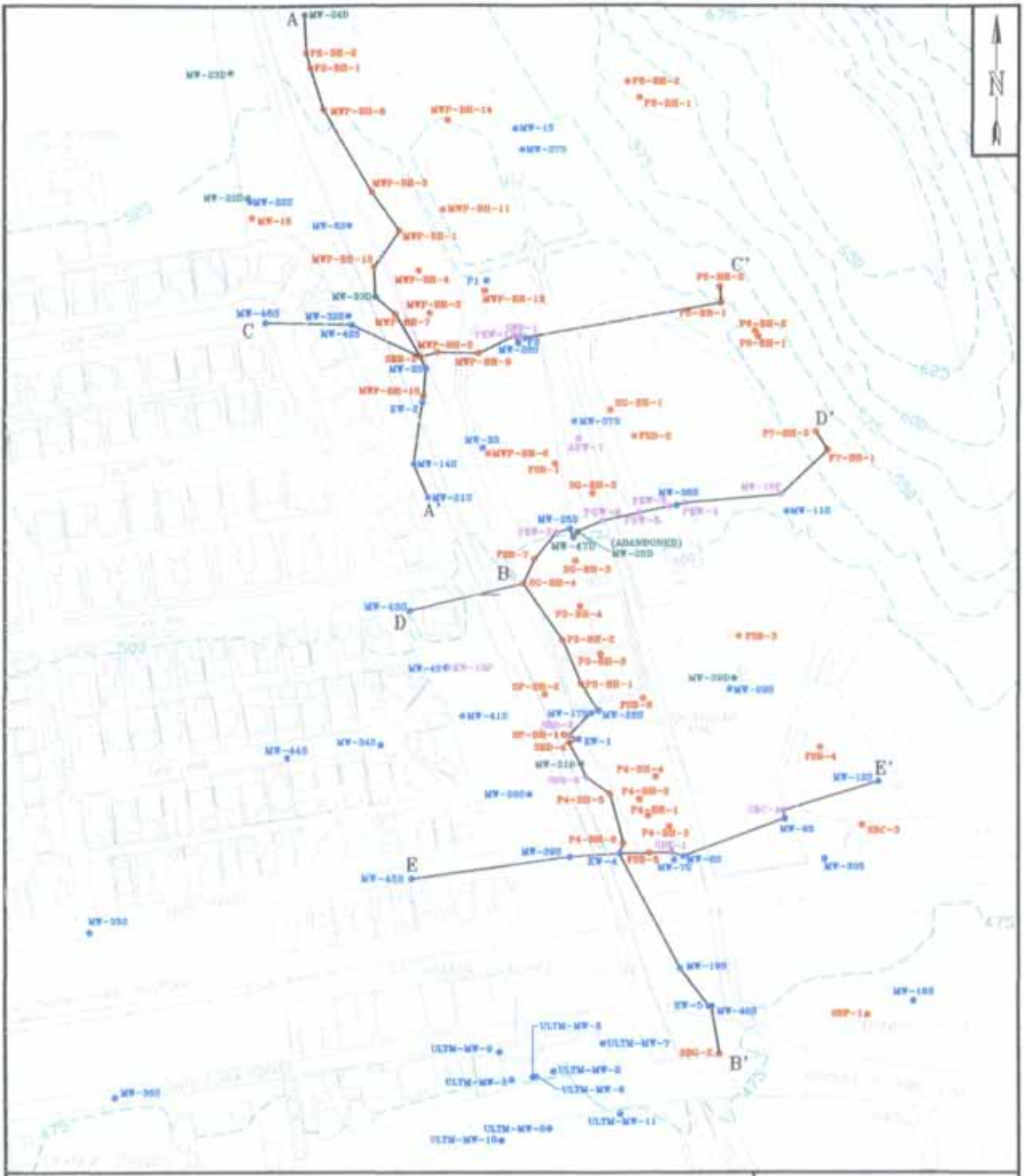
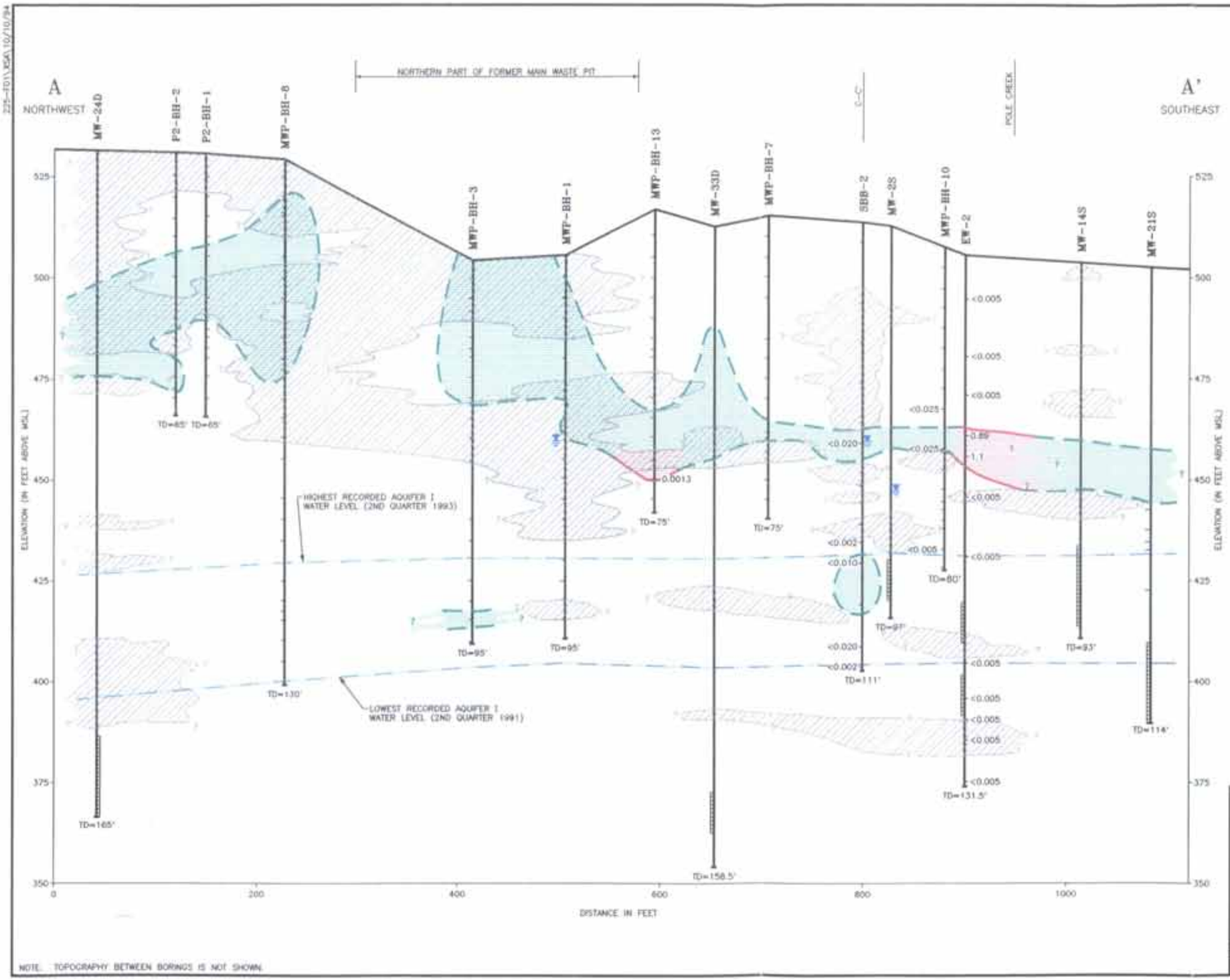


FIGURE 2-8

LOCATION OF BORINGS AND CROSS SECTIONS

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA
PREPARED FOR
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



NOTE: TOPOGRAPHY BETWEEN BORINGS IS NOT SHOWN.

CROSS SECTION LOCATION

EXPLANATION

- <0.005 — TD=131.5' — EXPLORATORY BORING WITH BENZENE CONCENTRATIONS IN mg/kg. TICKS INDICATE ANALYSIS FOR TPHg (EPA 8015M). WELL SCREEN INTERVALS WHERE INDICATED. TD INDICATES TOTAL DEPTH IN FEET.
- PERCHED GROUND WATER ENCOUNTERED IN BORING
- APPROXIMATE EXTENTS OF CONFIRMED BENZENE IN SOIL
- APPROXIMATE EXTENTS OF POTENTIAL BENZENE IN SOIL BASED ON TPHG ANALYTICAL AND BORING LOG COMMENTS
- FINE-GRAINED LITHOLOGY (SILT/CLAY)

0 25 50 FEET
APPROXIMATE VERTICAL SCALE
(4X VERTICAL EXAGGERATION)

0 100 200 FEET
APPROXIMATE HORIZONTAL SCALE

FIGURE 2-9

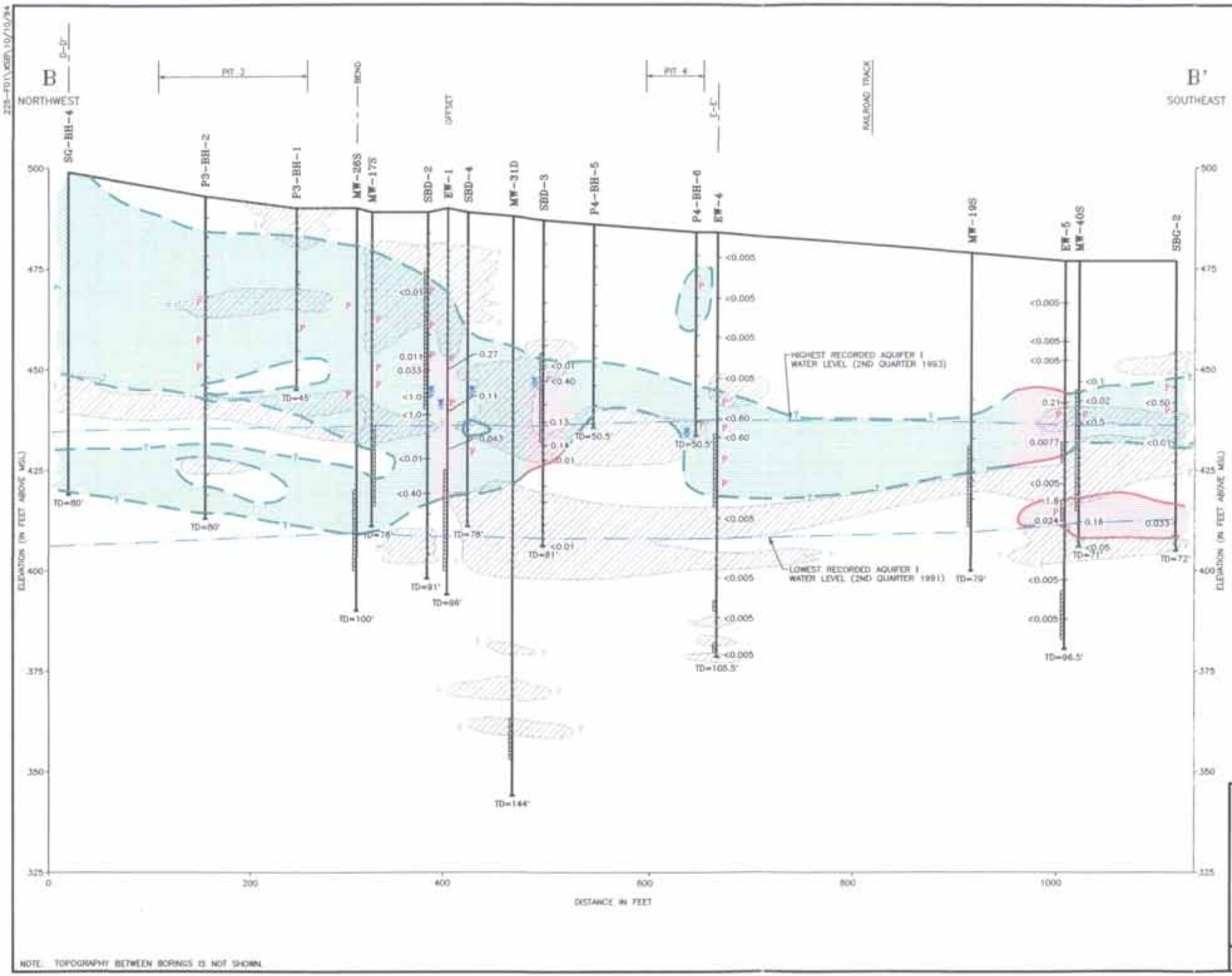
CROSS SECTION A-A'

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



CROSS SECTION LOCATION

EXPLANATION

- EXPLORATORY BORING WITH BENZENE CONCENTRATIONS IN mg/kg. TICKS INDICATE ANALYSIS FOR TPHg (EPA 8015M). WELL SCREEN INTERVALS WHERE INDICATED. TD INDICATES TOTAL DEPTH IN FEET.
- PERCHED GROUND WATER ENCOUNTERED IN BORING
- APPROXIMATE EXTENTS OF CONFIRMED BENZENE IN SOIL
- APPROXIMATE EXTENTS OF POTENTIAL BENZENE IN SOIL BASED ON TPHG ANALYTICAL AND BORING LOG COMMENTS
- FINE-GRAINED LITHOLOGY (SILT/CLAY)
- FREE OIL NOTED ON BORING LOG

0 25 50 FEET
APPROXIMATE VERTICAL SCALE
(4X VERTICAL EXAGGERATION)

0 100 200 FEET
APPROXIMATE HORIZONTAL SCALE

FIGURE 2-10

CROSS SECTION B-B'

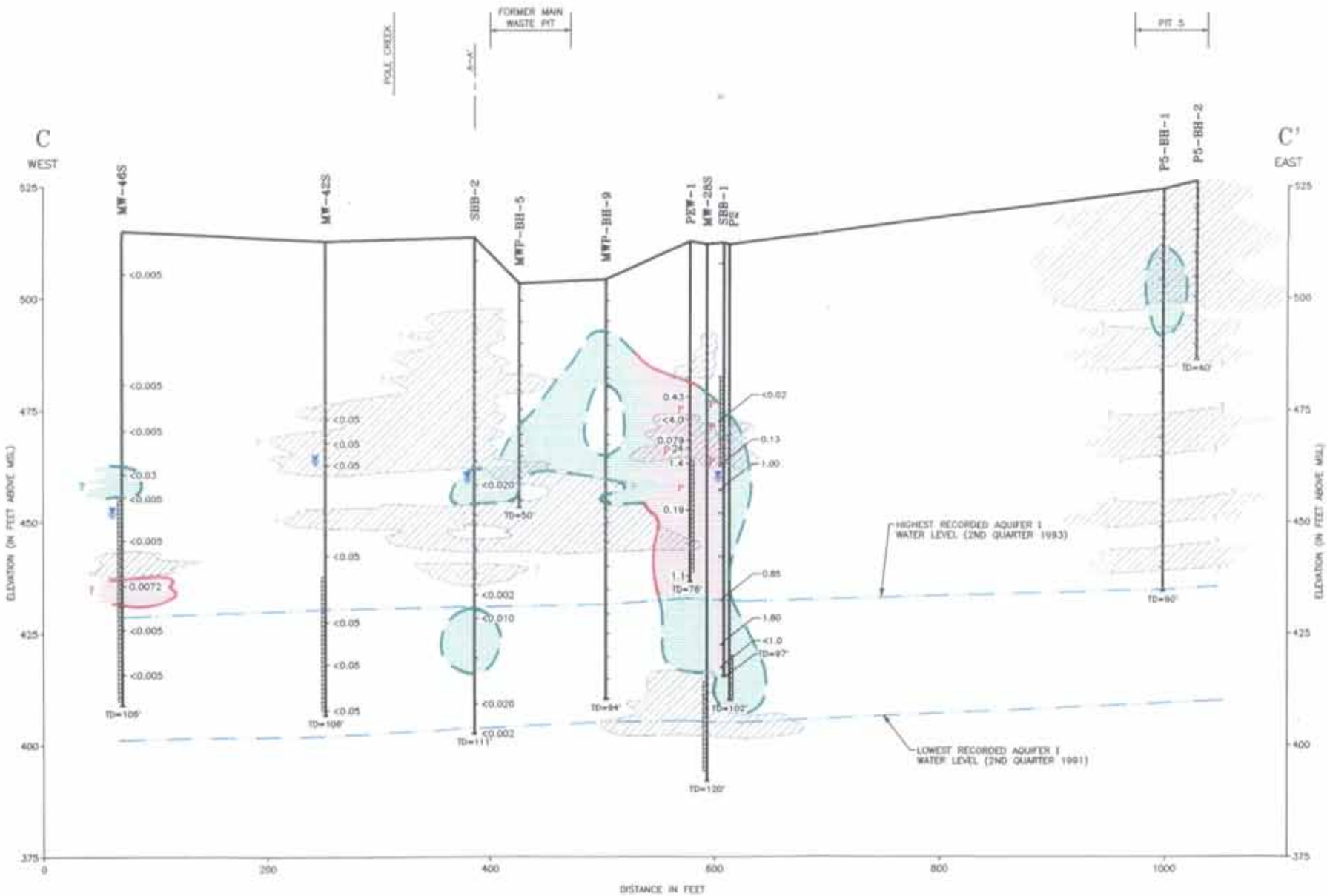
PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

225-F01\DSC\10/10/94



CROSS SECTION LOCATION

EXPLANATION

- EXPLORATORY BORING WITH BENZENE CONCENTRATIONS IN mg/kg. TICKS INDICATE ANALYSIS FOR TPHg (EPA 8015M). WELL SCREEN INTERVALS WHERE INDICATED. TD INDICATES TOTAL DEPTH IN FEET.
- PERCHED GROUND WATER ENCOUNTERED IN BORING
- APPROXIMATE EXTENTS OF CONFIRMED BENZENE IN SOIL
- APPROXIMATE EXTENTS OF POTENTIAL BENZENE IN SOIL BASED ON TPHG ANALYTICAL AND BORING LOG COMMENTS
- FINE-GRAINED LITHOLOGY (SILT/CLAY)
- FREE OIL NOTED ON BORING LOG

0 25 50 FEET
APPROXIMATE VERTICAL SCALE
(4X VERTICAL EXAGGERATION)

0 100 200 FEET
APPROXIMATE HORIZONTAL SCALE

NOTE: TOPOGRAPHY BETWEEN BORINGS IS NOT SHOWN.

FIGURE 2-11

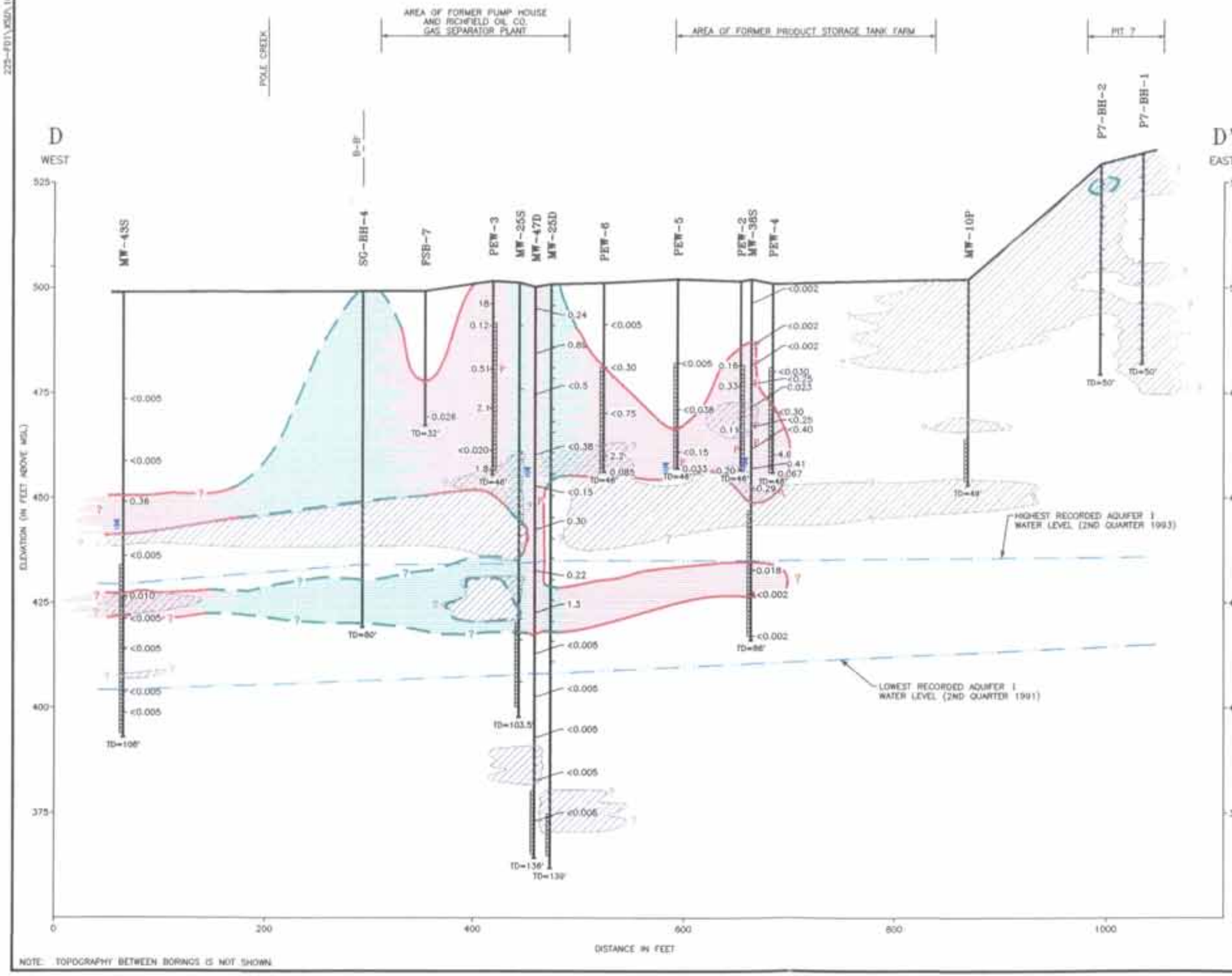
CROSS SECTION C-C'

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



CROSS SECTION LOCATION

EXPLANATION

- EXPLORATORY BORING WITH BENZENE CONCENTRATIONS IN mg/kg. TICKS INDICATE ANALYSIS FOR TPHg (EPA 8015M). WELL SCREEN INTERVALS WHERE INDICATED. TD INDICATES TOTAL DEPTH IN FEET.
- PERCHED GROUND WATER ENCOUNTERED IN BORING
- APPROXIMATE EXTENTS OF CONFIRMED BENZENE IN SOIL
- APPROXIMATE EXTENTS OF POTENTIAL BENZENE IN SOIL BASED ON TPHG ANALYTICAL AND BORING LOG COMMENTS
- FINE-GRAINED LITHOLOGY (SILT/CLAY)
- FREE OIL NOTED ON BORING LOG

0 25 50 FEET
APPROXIMATE VERTICAL SCALE
(4X VERTICAL EXAGGERATION)

0 100 200 FEET
APPROXIMATE HORIZONTAL SCALE

FIGURE 2-12

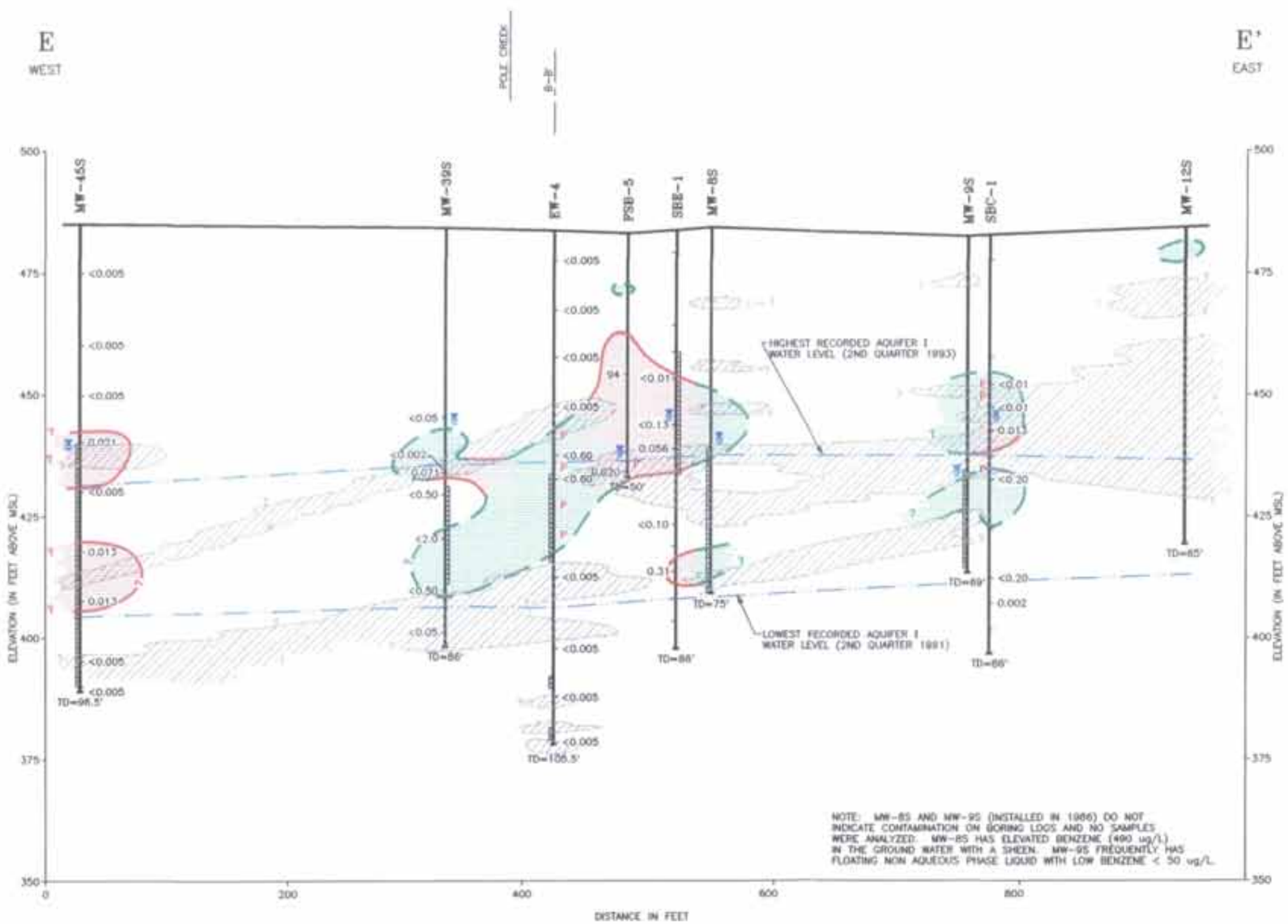
CROSS SECTION D-D'

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



CROSS SECTION LOCATION

EXPLANATION

- EXPLORATORY BORING WITH BENZENE CONCENTRATIONS IN mg/kg. TICKS INDICATE ANALYSIS FOR TPHg (EPA 8015M). WELL SCREEN INTERVALS WHERE INDICATED. TD INDICATES TOTAL DEPTH IN FEET.
- PERCHED GROUND WATER ENCOUNTERED IN BORING
- APPROXIMATE EXTENTS OF CONFIRMED BENZENE IN SOIL
- APPROXIMATE EXTENTS OF POTENTIAL BENZENE IN SOIL BASED ON TPHG ANALYTICAL AND BORING LOG COMMENTS
- FINE-GRAINED LITHOLOGY (SILT/CLAY)
- FREE OIL NOTED ON BORING LOG

0 25 50 FEET
APPROXIMATE VERTICAL SCALE
(4X VERTICAL EXAGGERATION)

0 100 200 FEET
APPROXIMATE HORIZONTAL SCALE

FIGURE 2-13

CROSS SECTION E-E'

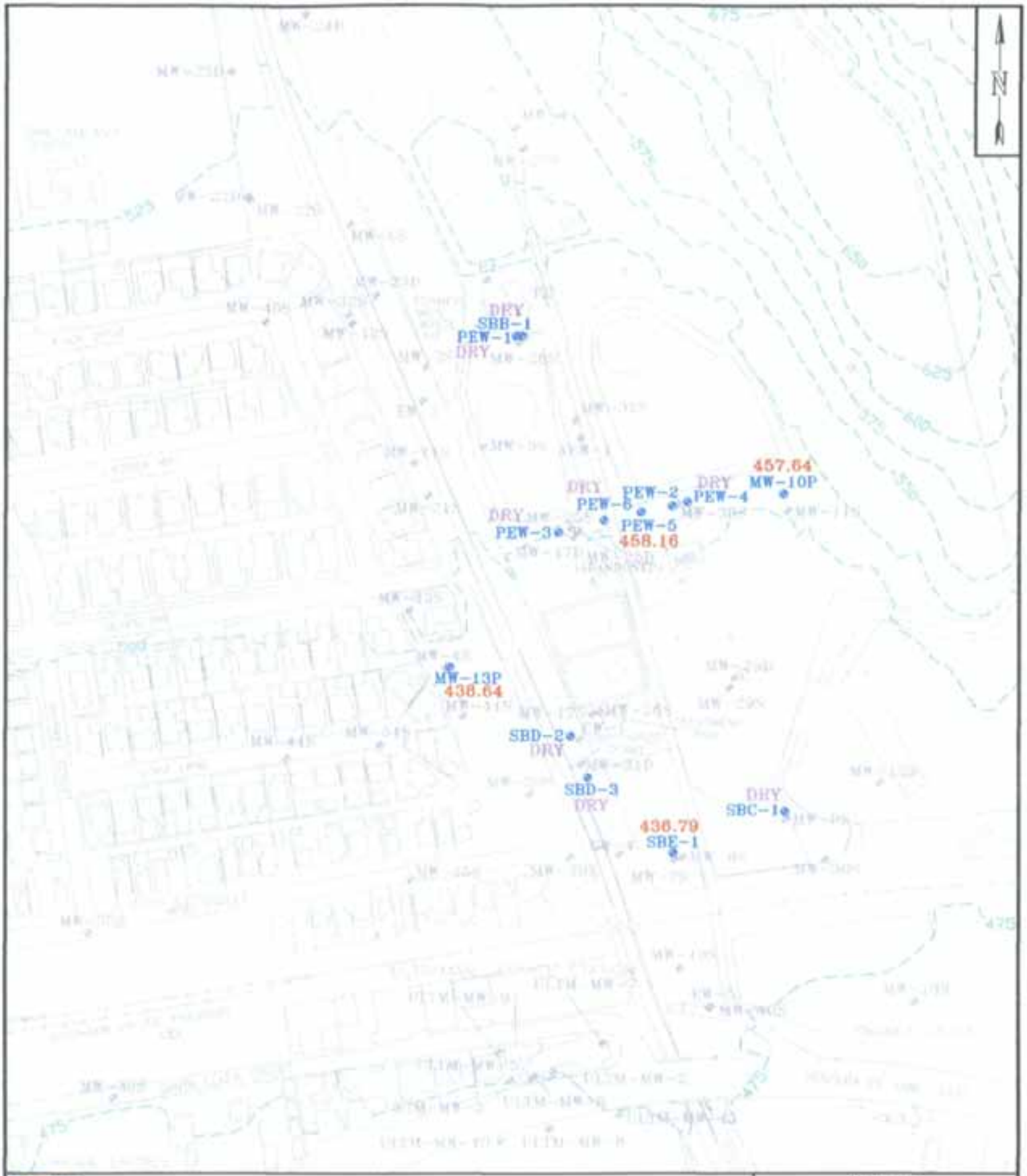
PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

NOTE: TOPOGRAPHY BETWEEN BORINGS IS NOT SHOWN.



MW-13P 438.64 PERCHED ZONE WELL LOCATION WITH WELL NUMBER AND GROUND WATER ELEVATION IN FEET ABOVE MSL.

GROUND SURFACE ELEVATION CONTOUR CONTOUR INTERVAL 25 FEET.

0 250 500 FEET

NOTE: 1. PEW-2 WAS HOOKED UP TO THE VAPOR EXTRACTION SYSTEM AND MEASUREMENT COULD NOT BE COULD NOT BE TAKEN.

FIGURE 2-14

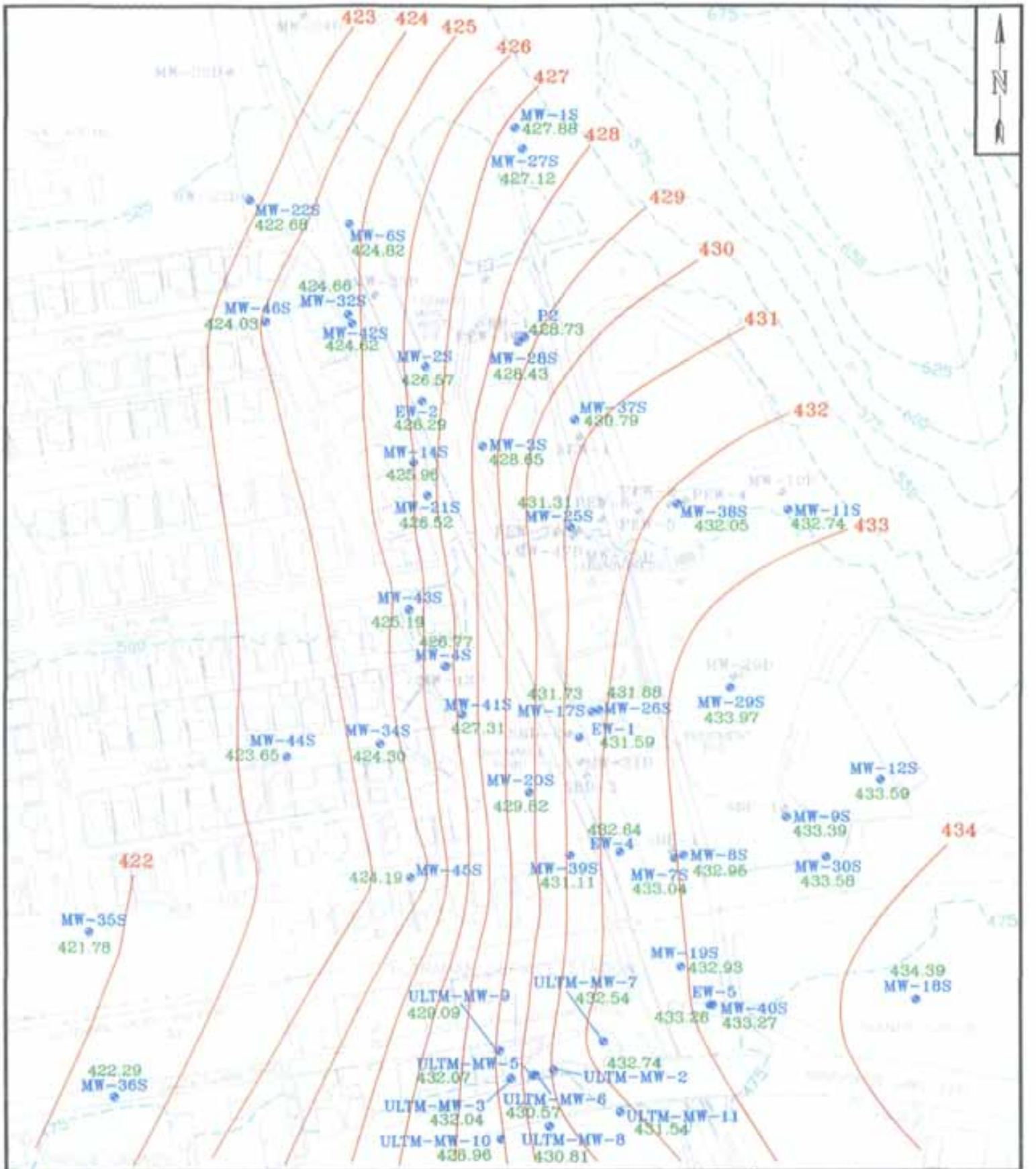
PERCHED ZONE GROUND WATER ELEVATION MAP THIRD QUARTER 1994

PACIFIC COAST PIPELINE SUPERFUND SITE FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



MW-35S 421.78 MONITORING WELL LOCATION WITH WELL NUMBER AND GROUND WATER ELEVATION IN FEET ABOVE MSL

430 AQUIFER I GROUND WATER SURFACE ELEVATION CONTOUR MEASURED AUGUST 1994. CONTOUR INTERVAL 1 FOOT.

GROUND SURFACE ELEVATION CONTOUR. CONTOUR INTERVAL 25 FEET

0 250 500 FEET

NOTES:

1. ELEVATIONS AT MW-1S & MW-27S, MW-7S & MW-8S WERE AVERAGED FOR CONTOURING.
2. ELEVATIONS AT ULTM-MW-2, ULTM-MW-3, AND ULTM-MW-5 WERE NOT USED IN CONTOURING AS THEY ARE ANOMALOUSLY HIGHER THAN THE SURROUNDING WELLS.

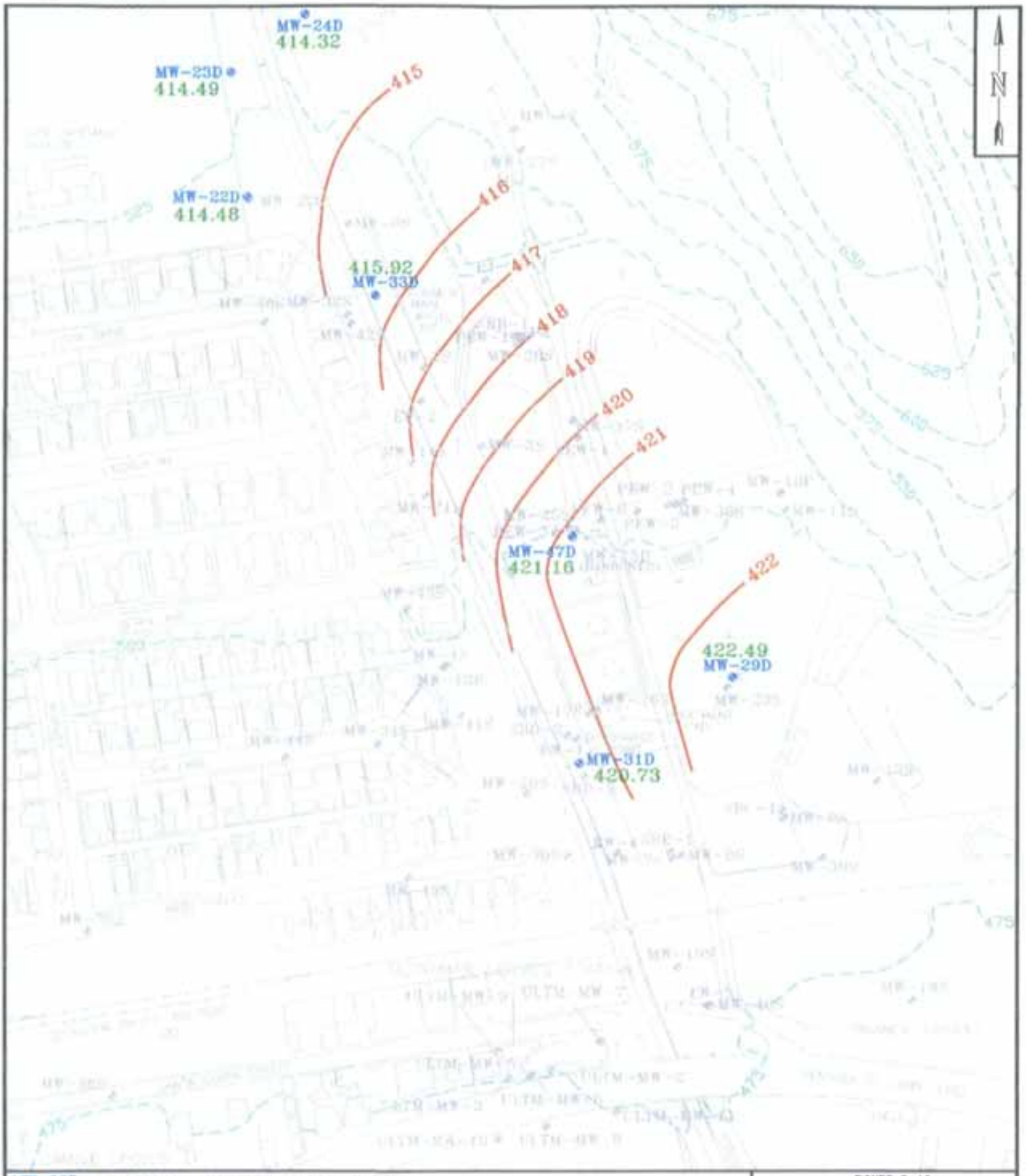
FIGURE 2-15

AQUIFER I GROUND WATER ELEVATION MAP THIRD QUARTER 1994

PACIFIC COAST PIPELINE SUPERFUND SITE FILLMORE, CALIFORNIA

PREPARED FOR TEXACO ENVIRONMENTAL SERVICES UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



MW-23D 414.49 MONITORING WELL LOCATION WITH WELL NUMBER AND GROUND WATER ELEVATION IN FEET ABOVE MSL.

420 AQUIFER II GROUND WATER SURFACE ELEVATION CONTOUR MEASURED AUGUST 1994. CONTOUR INTERVAL 1 FOOT.

GROUND SURFACE ELEVATION CONTOUR. CONTOUR INTERVAL 25 FEET.

0 250 500 FEET

FIGURE 2-16

AQUIFER II POTENTIOMETRIC SURFACE ELEVATION MAP THIRD QUARTER 1994

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

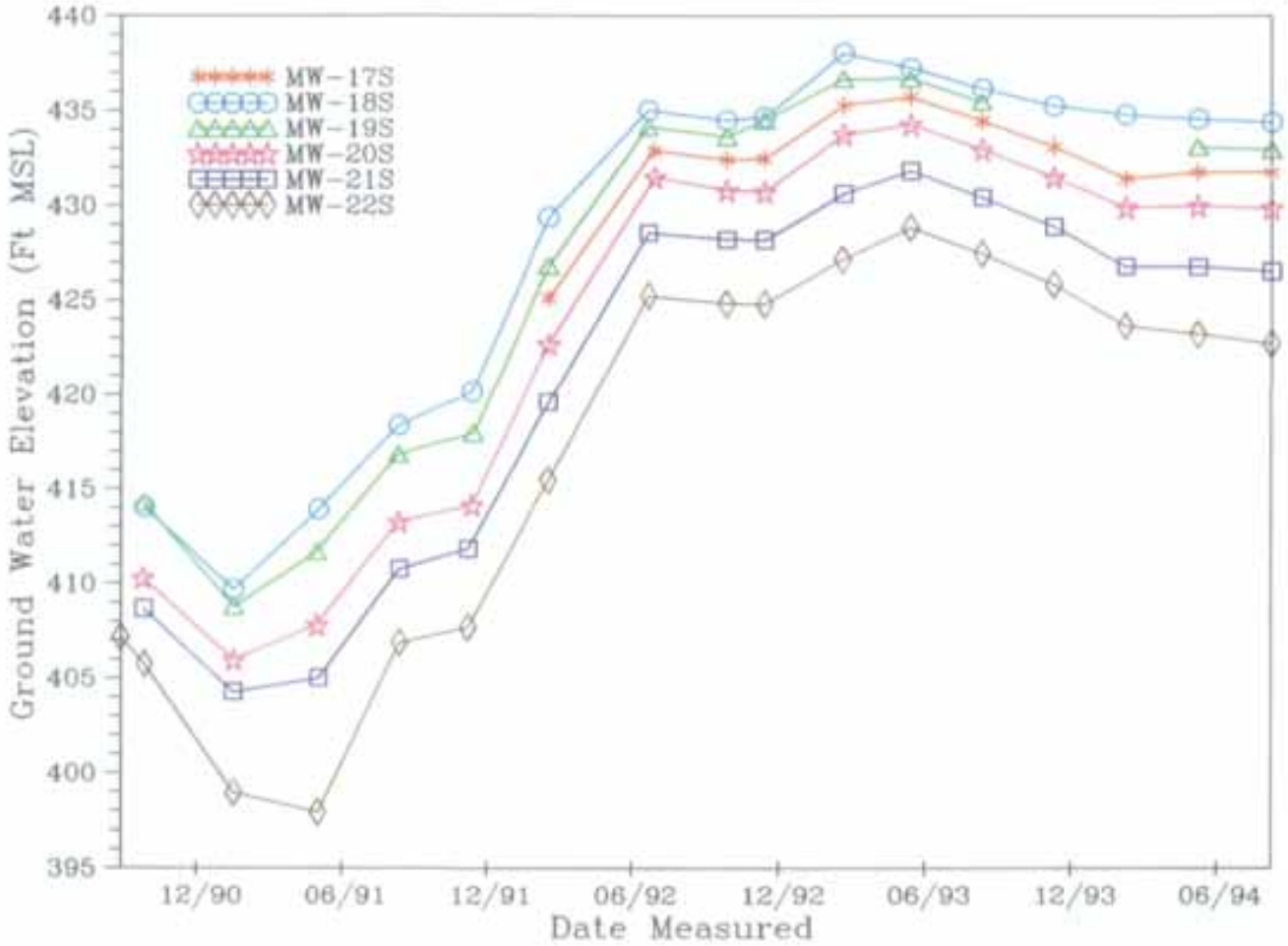


FIGURE 2-17

REPRESENTATIVE AQUIFER I HYDROGRAPH

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

N

LEGEND

- PERCHED AQUIFER WELL LOCATION AND WELL ID.
- AQUIFER I WELL LOCATION AND WELL ID.
- AQUIFER II WELL LOCATION AND WELL ID.
- AIR EXTRACTION WELL LOCATION AND WELL ID.
- EW-5 — NEW EXTRACTION WELL LOCATION AND WELL ID.
- MW-46S — NEW MONITORING WELL LOCATION AND WELL ID.
- PEW-4 — NEW VAPOR EXTRACTION WELL LOCATION AND WELL ID.
- MW-25D (ABANDONED) — LOCATION OF ABANDONED WELL.
- GROUND SURFACE ELEVATION CONTOUR (IN FEET ABOVE MEAN SEA LEVEL). CONTOUR INTERVAL 25 FEET.
- PROJECT AREA

NOTES

WELL ID PREFIX DESCRIPTIONS:

MW	MONITORING WELL
P	2-INCH DIAMETER PIEZOMETER
SB	SOIL BORING CONVERTED TO PERCHED ZONE WELL
EW	AQUIFER I EXTRACTION WELL
PEW	PERCHED EXTRACTION WELL
AEW	AIR EXTRACTION WELL
ULTM	ULTRAMAR MONITORING WELL

0 200 400 600 800

FEET

FIGURE 3-1

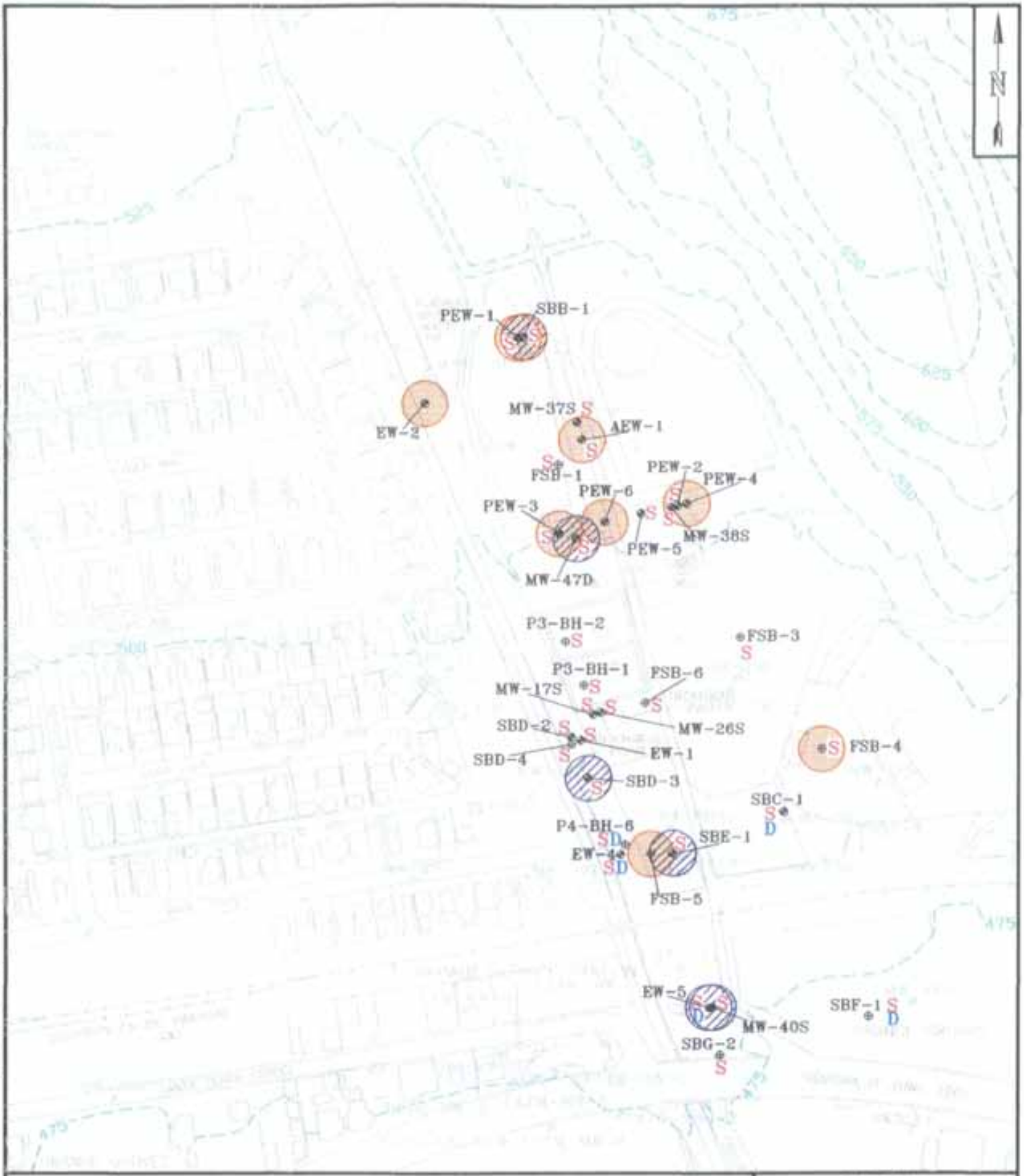
MAP SHOWING LOCATION OF NEW WELLS

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



MONITORING WELL LOCATION.
BORING LOCATION.
S FREE OIL NOTED ON SOIL ABOVE HIGH WATER.
D FREE OIL NOTED ON SOIL BELOW HIGH WATER.
GROUND SURFACE ELEVATION CONTOUR. CONTOUR INTERVAL 25 FEET.

0 250 500 FEET

CONFIRMED BENZENE IN SOIL ≥ 1 MG/KG ABOVE HIGH WATER.

CONFIRMED BENZENE IN SOIL ≥ 0.1 MG/KG BELOW HIGH WATER.

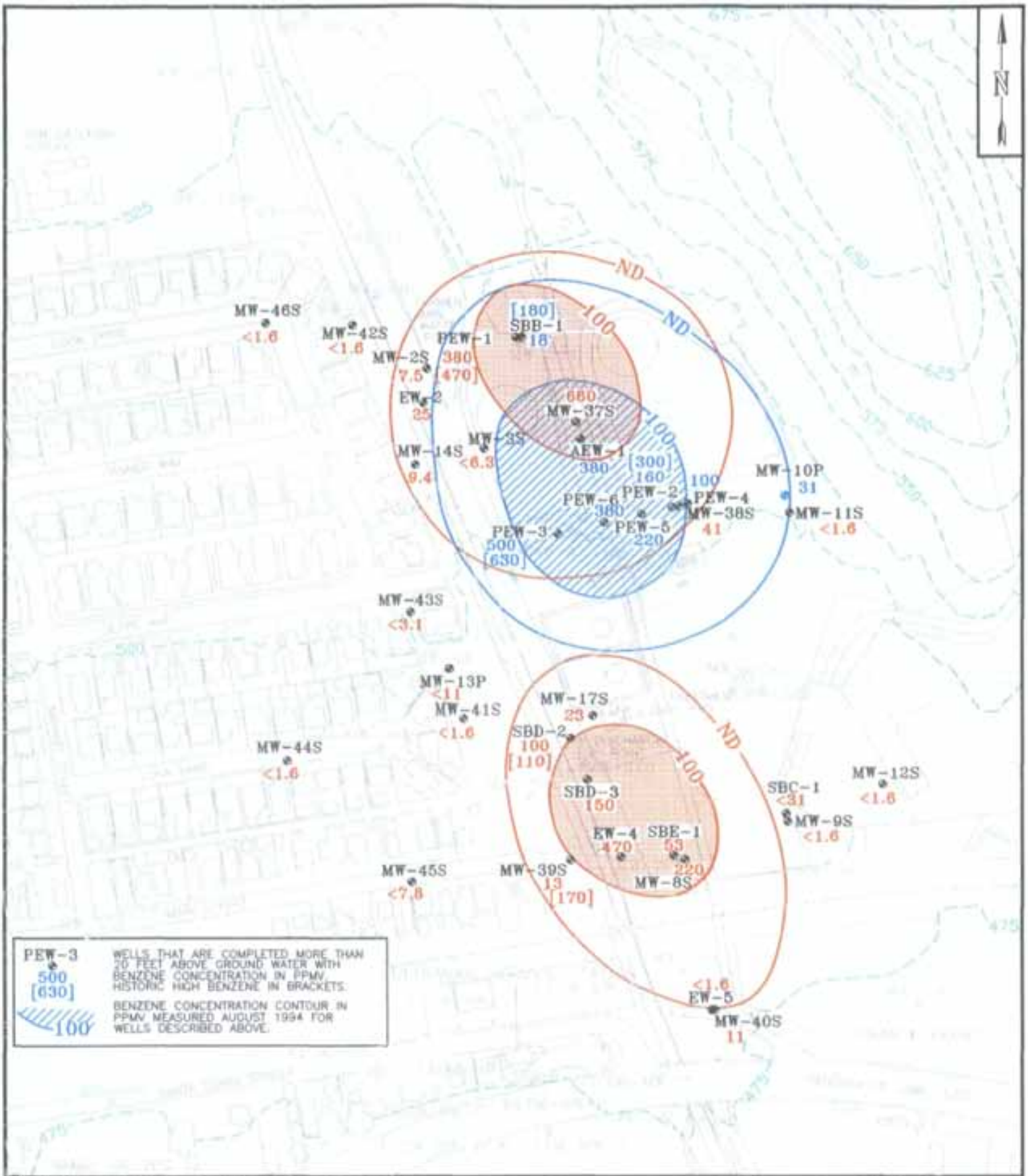
FIGURE 4-1

CONFIRMED BENZENE IN SOIL AND LOCATIONS OF OILY SOIL

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



NOTES:

1. BENZENE ANALYZED BY EPA METHOD 8020.
2. SAMPLES COLLECTED IN A TEDLAR BAG AFTER EXTRACTING WITH A VR SYSTEMS MODEL V4 FOR AT LEAST 30 MINUTES.
3. INCLUDES MW-5S, <1.6 WHICH IS LOCATED APPROXIMATELY 800 FEET NORTH OF MW-24D.

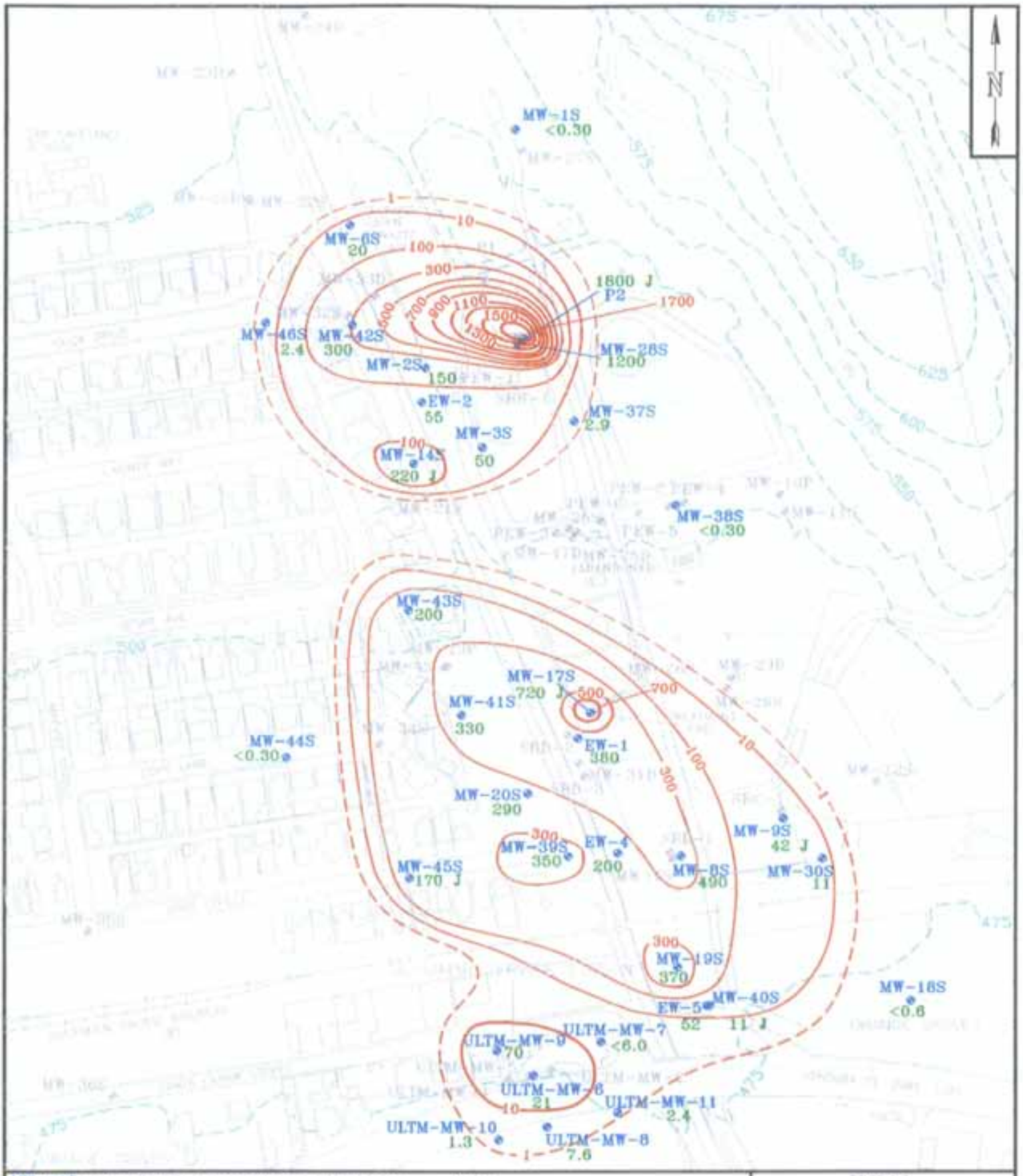
FIGURE 4-2

BENZENE DISTRIBUTION IN SOIL GAS

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



MW-44S MONITORING WELL LOCATION WITH WELL NUMBER AND BENZENE CONCENTRATION IN UG/L.
<0.30

100 AQUIFER I BENZENE CONCENTRATION CONTOUR IN UG/L MEASURED AUGUST 1994. CONTOUR INTERVAL VARIABLE.

GROUND SURFACE ELEVATION CONTOUR. CONTOUR INTERVAL 25 FEET.

0 250 500 FEET

NOTES:

1. A "J" QUALIFIER NEXT TO THE BENZENE VALUE INDICATES THE VALUE IS ESTIMATED.
2. P2 DATA USED INSTEAD OF MW-28S IN CONTOURING.

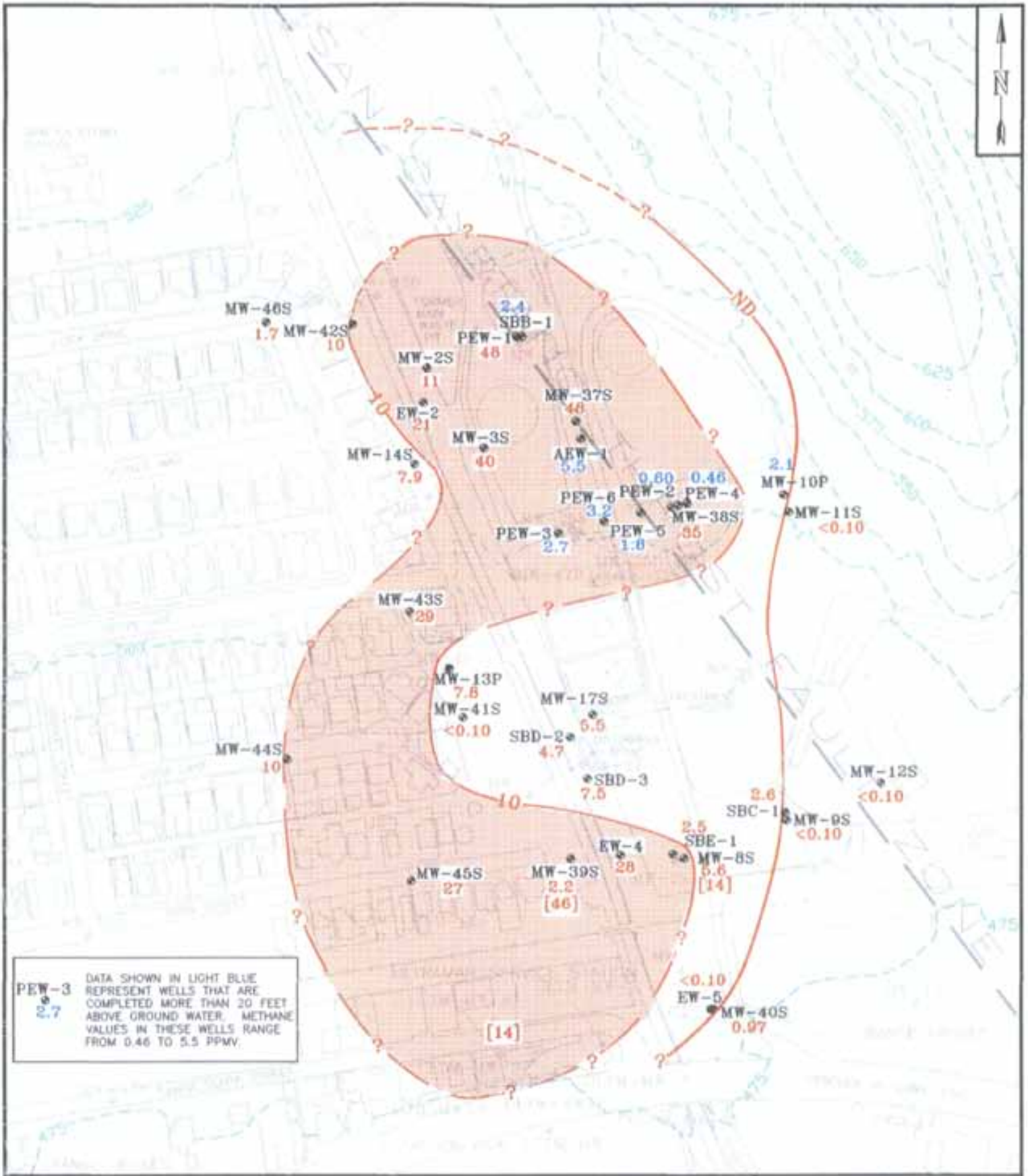
FIGURE 4-3

BENZENE DISTRIBUTION IN AQUIFER I WELLS THIRD QUARTER 1994

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



MW-44S
10
[14]

WELLS COMPLETED WITHIN OR UP TO 10 FEET ABOVE AQUIFER I. HISTORIC HIGH SHOWN IN BRACKETS.

10 METHANE %V CONTOUR MEASURED AUGUST 1994 FOR WELLS DESCRIBED ABOVE.

GROUND SURFACE ELEVATION CONTOUR. CONTOUR INTERVAL 25 FEET.

0 250 500 FEET

NOTE:
1. METHANE ANALYZED BY EPA METHOD GC/TCD.
2. SAMPLES COLLECTED IN A TEDLAR BAG AFTER EXTRACTING WITH A VR SYSTEMS MODEL V4 FOR AT LEAST 30 MINUTES.
3. INCLUDES MW-55, <0.10 WHICH IS LOCATED APPROXIMATELY 800 FEET NORTH OF MW-24D.

FIGURE 4-4

METHANE DISTRIBUTION IN SOIL GAS

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

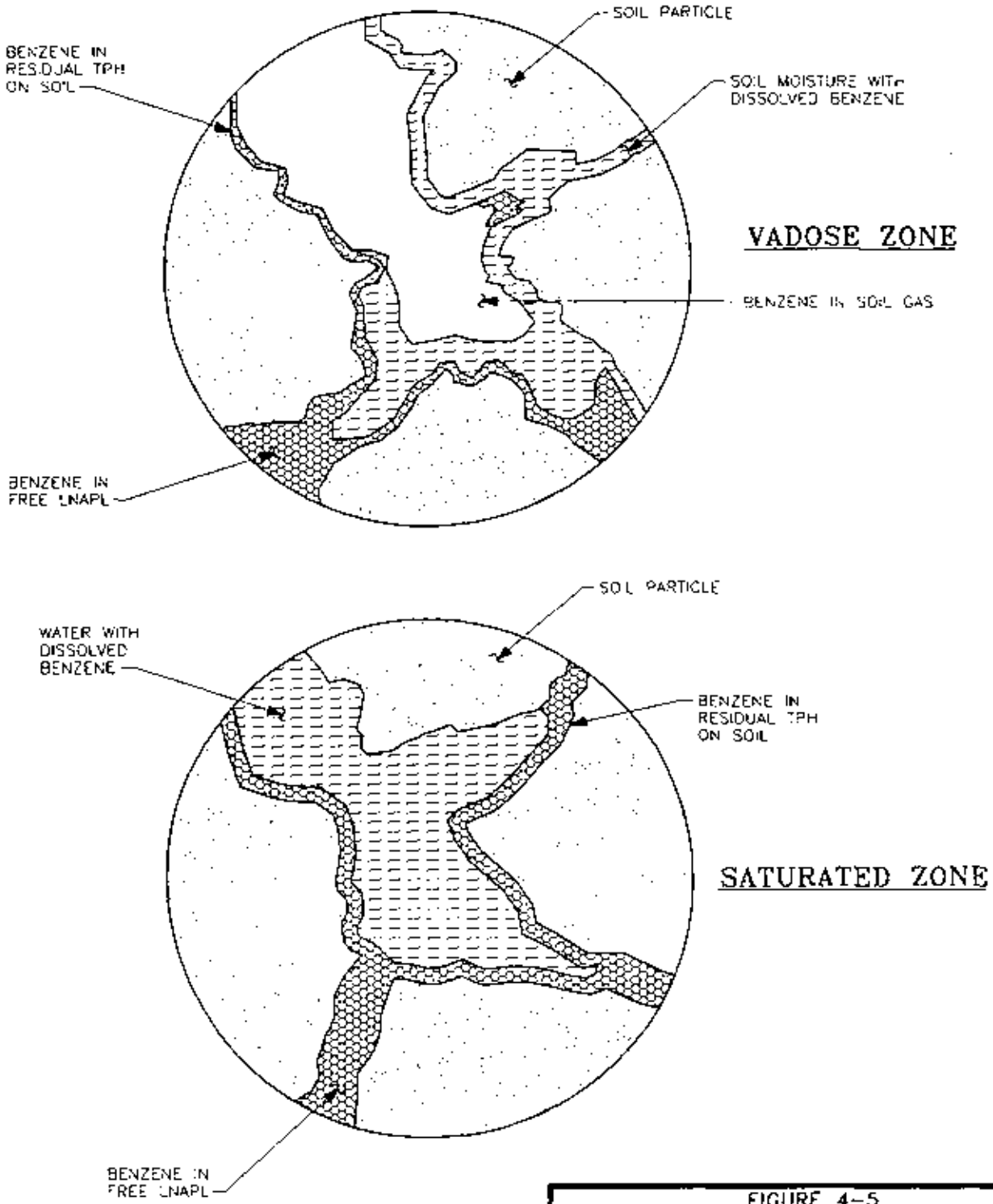


FIGURE 4-5

CONCEPTUAL MODEL OF BENZENE IN SOIL

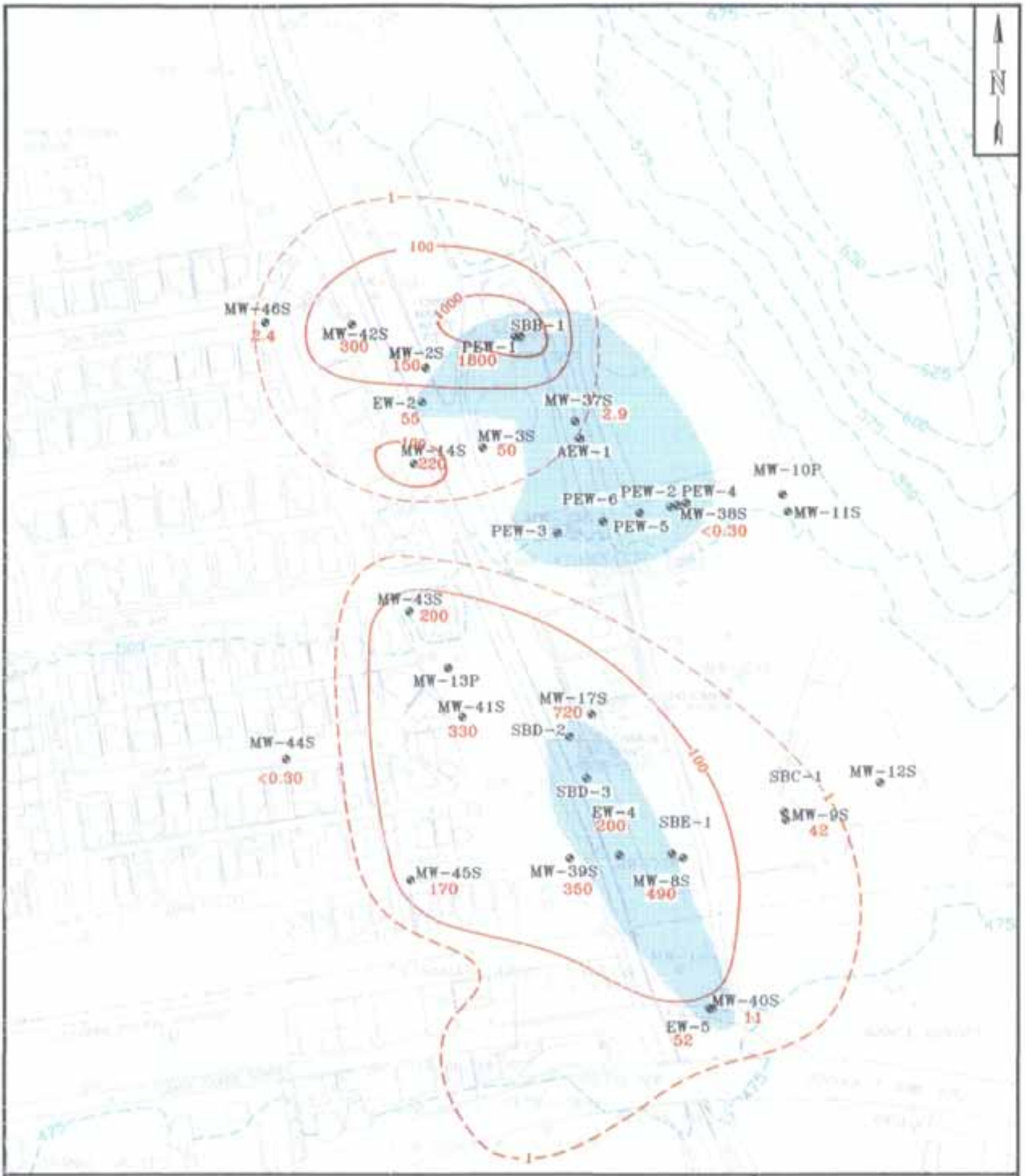
PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

226\06\4-5\10/03/94



MW-44S <0.30 MONITORING WELL LOCATION WITH WELL NUMBER AND BENZENE CONCENTRATION IN UG/L.

100 BENZENE CONCENTRATION CONTOUR IN UG/L, AUGUST 1994.

GROUND SURFACE ELEVATION CONTOUR. CONTOUR INTERVAL 25 FEET.

0 250 500 FEET

APPROXIMATE AREA WHERE BENZENE CONCENTRATION IN GAS IS HIGHER THAN CALCULATED EQUILIBRIUM CONCENTRATION WITH UNDERLYING WATER.

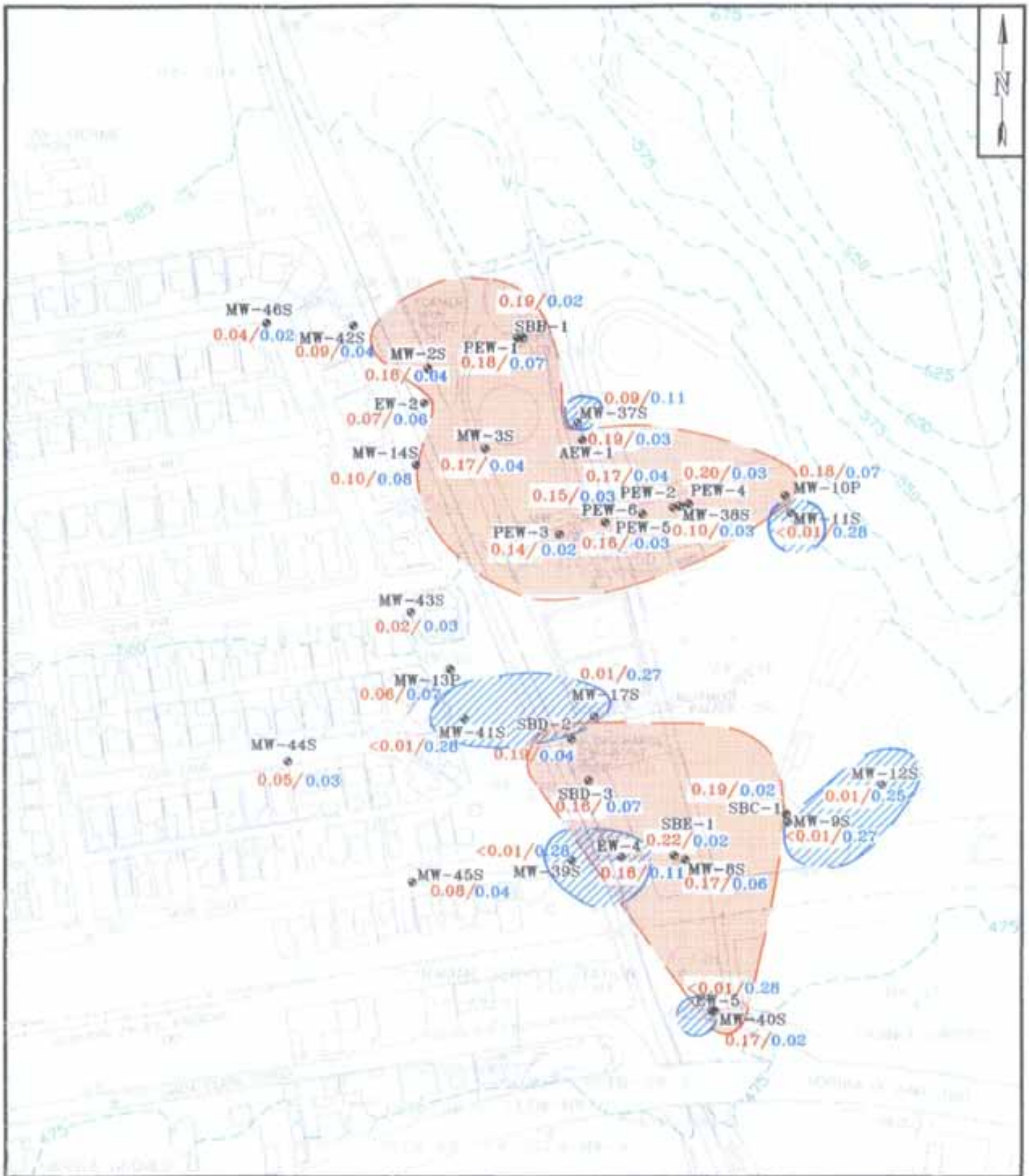
FIGURE 4-6

AREAS WITH BENZENE VAPOR CONCENTRATIONS GREATER THAN EQUILIBRIUM

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



MW-44S MONITORING WELL LOCATION WITH WELL NUMBER.
0.05/0.03 RATIO OF CARBON DIOXIDE TO NITROGEN IN RED AND RATIOS OF OXYGEN TO NITROGEN IN BLUE.

GROUND SURFACE ELEVATION CONTOUR. CONTOUR INTERVAL 25 FEET.

0 250 500 FEET

NOTE: INCLUDES MW-5S 0.01/0.24 WHICH IS LOCATED APPROXIMATELY 800 FEET NORTH OF MW-24D.

$O_2/N_2 \geq 0.1$

$CO_2/N_2 \geq 0.1$

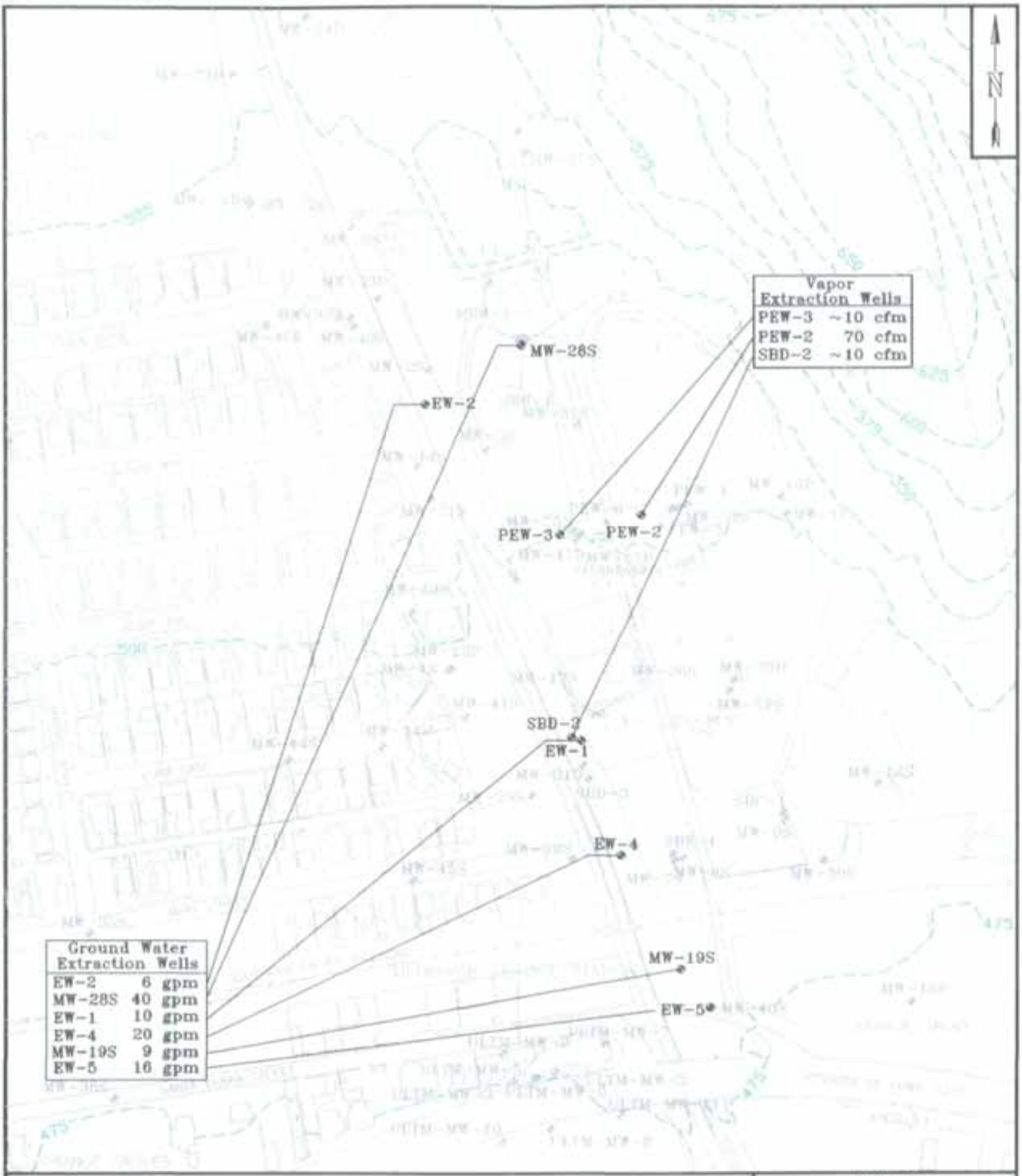
FIGURE 4-7

CO_2/N_2 AND O_2/N_2 DISTRIBUTION IN SOIL GAS

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



MW-44S WELL LOCATION AND WELL NUMBER.

FLOW RATES APPROXIMATE. ALL WELLS WERE NOT IN OPERATION AT THE SAME TIME.

0 250 500 FEET

FIGURE 5-1

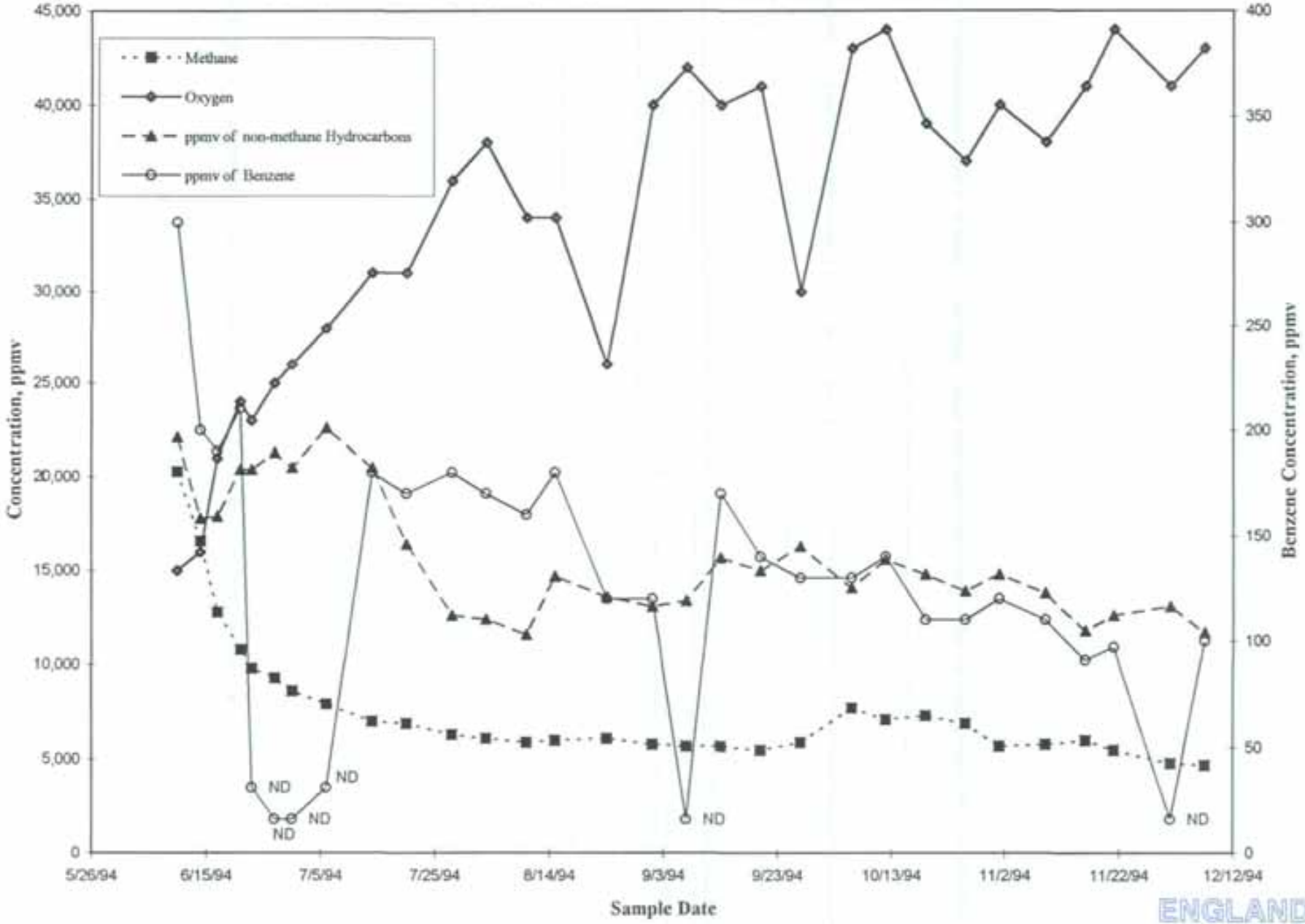
LOCATIONS OF PHASE 1 VAPOR EXTRACTION AND GROUND WATER PUMPING WELLS

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

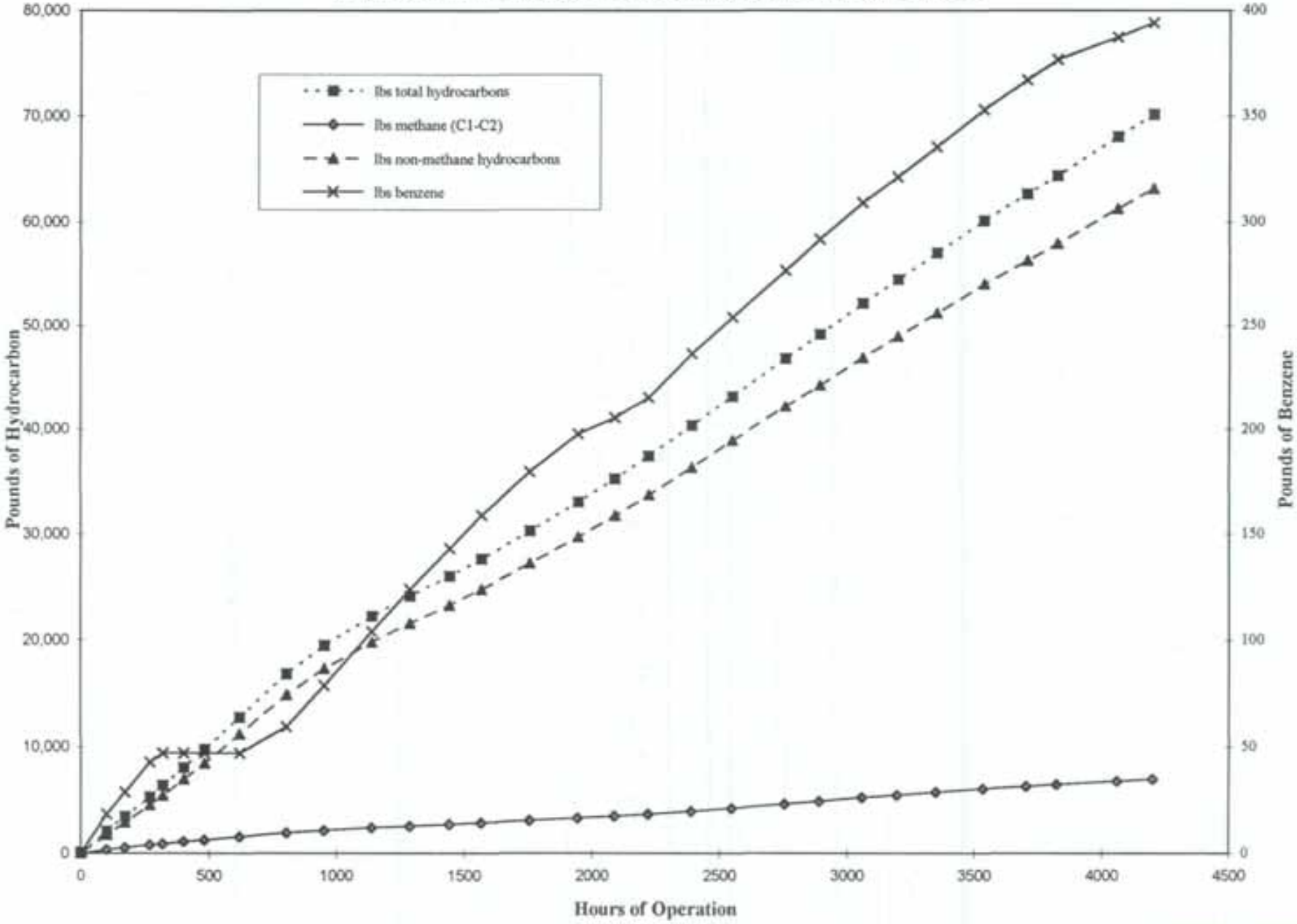
ENGLAND SHAHIN & ASSOCIATES

Figure 6-1
CONCENTRATIONS OF OXYGEN AND HYDROCARBONS FROM PEW-2



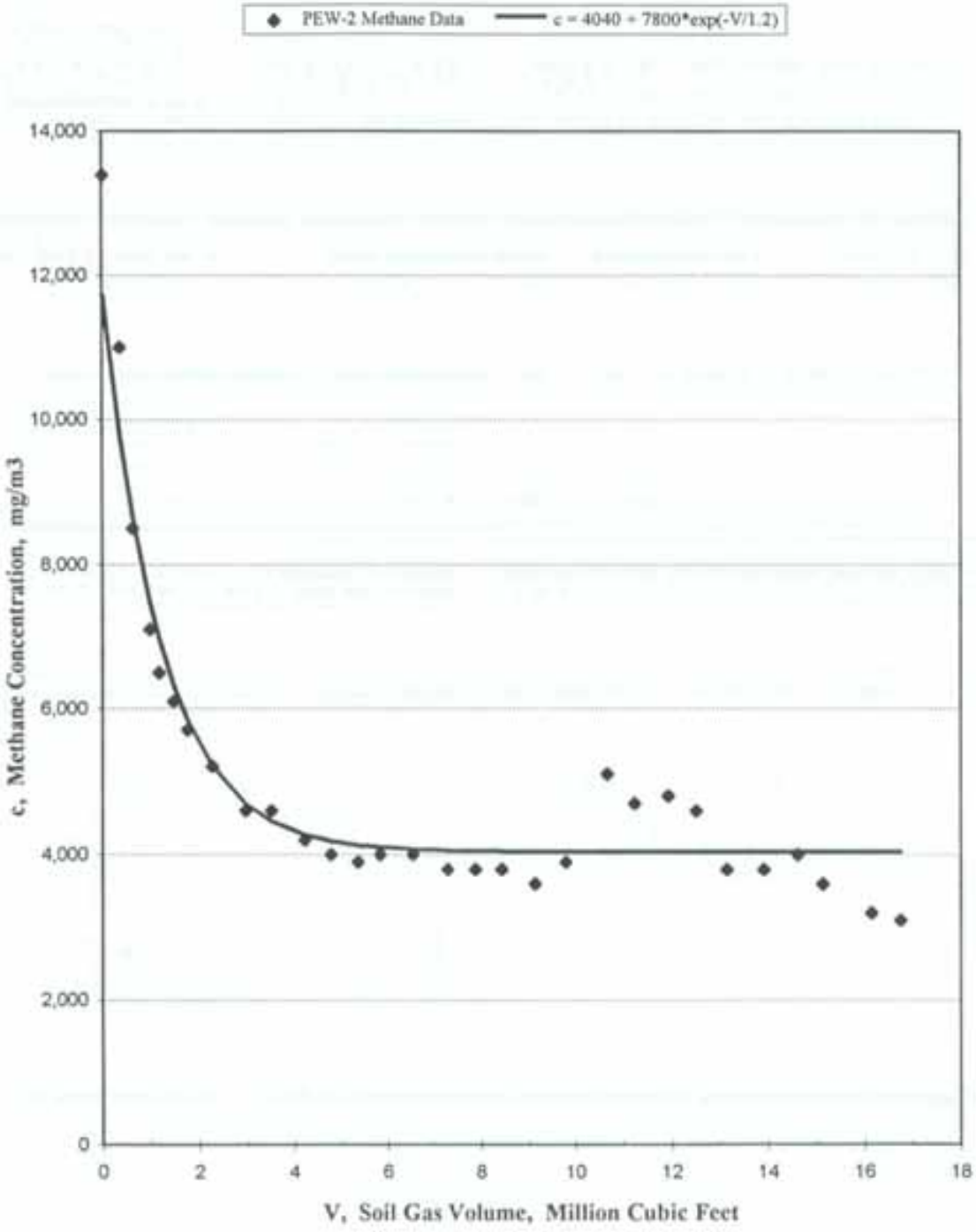
ENGLAND
SHAHIN &
ASSOCIATES

Figure 6-2
CUMULATIVE HYDROCARBON REMOVAL FROM PEW-2

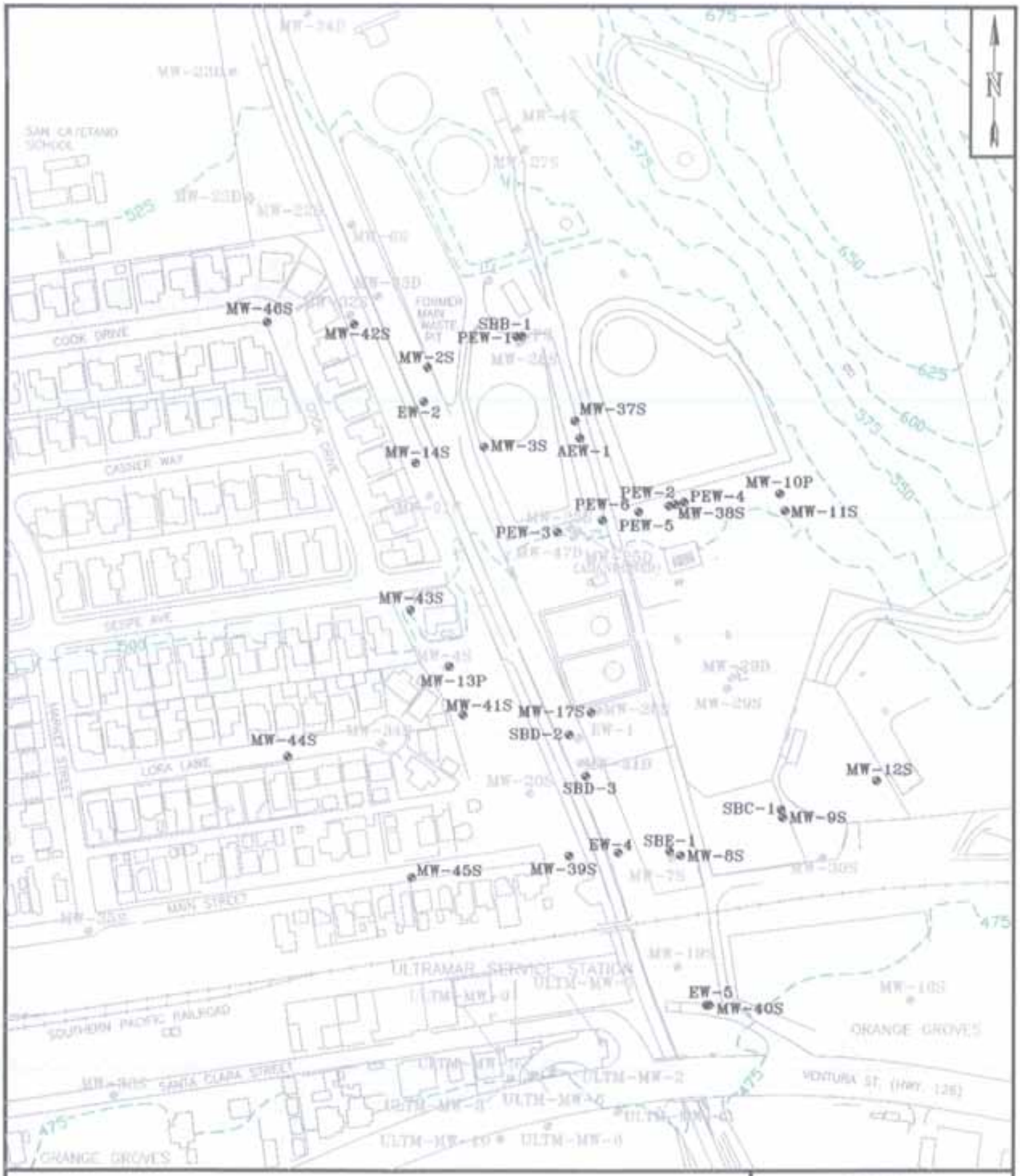


ENGLAND
SHAHIN &
ASSOCIATES

Figure 6-3
Methane Concentration in PEW-2



ENGLAND
SHAHIN &
ASSOCIATES



MW-44S VAPOR EXTRACTION TEST WELL LOCATION AND NUMBER.

NOTE: INCLUDES MW-5S WHICH IS LOCATED APPROXIMATELY 800 FEET NORTH OF MW-24D.

0 250 500 FEET

FIGURE 6-4

LOCATIONS OF VAPOR EXTRACTION TEST WELLS

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA
PREPARED FOR
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

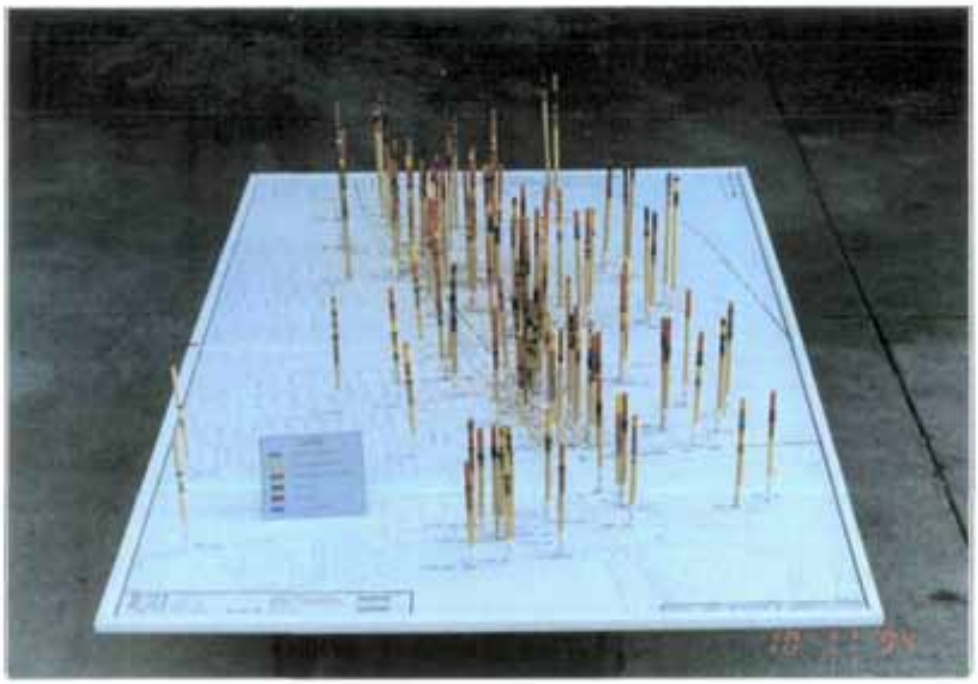


FIGURE 7-1

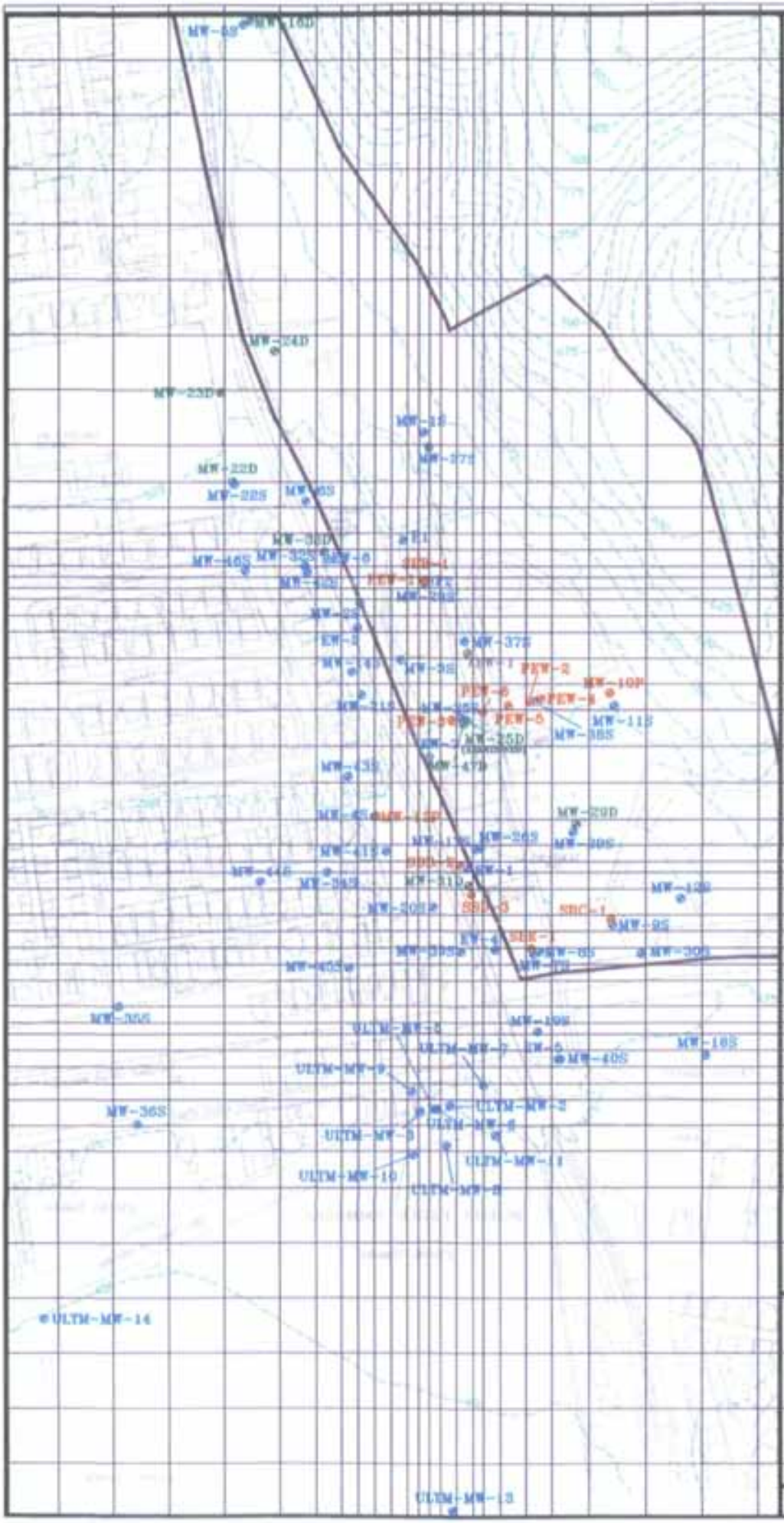
STICK MODEL

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



LEGEND

MW-10P	PERCHED AQUIFER WELL LOCATION AND WELL ID.
MW-12S	AQUIFER I WELL LOCATION AND WELL ID.
MW-20D	AQUIFER II WELL LOCATION AND WELL ID.
AEW-1	AIR EXTRACTION WELL LOCATION AND WELL ID.
	GROUND SURFACE ELEVATION CONTOUR (IN FEET ABOVE MEAN SEA LEVEL). CONTOUR INTERVAL 25 FEET.
	PROJECT AREA

NOTES

WELL ID PREFIX DESCRIPTIONS:

MW	MONITORING WELL
P	2-INCH DIAMETER PIEZOMETER
SB	SOIL BORING CONVERTED TO PERCHED ZONE WELL
EW	AQUIFER I EXTRACTION WELL
PEW	PERCHED EXTRACTION WELL
AEW	AIR EXTRACTION WELL
ULTM	ULTRAMAR MONITORING WELL

0 200 400 600 800

FEET

FIGURE 7-2

MODEL GRID

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

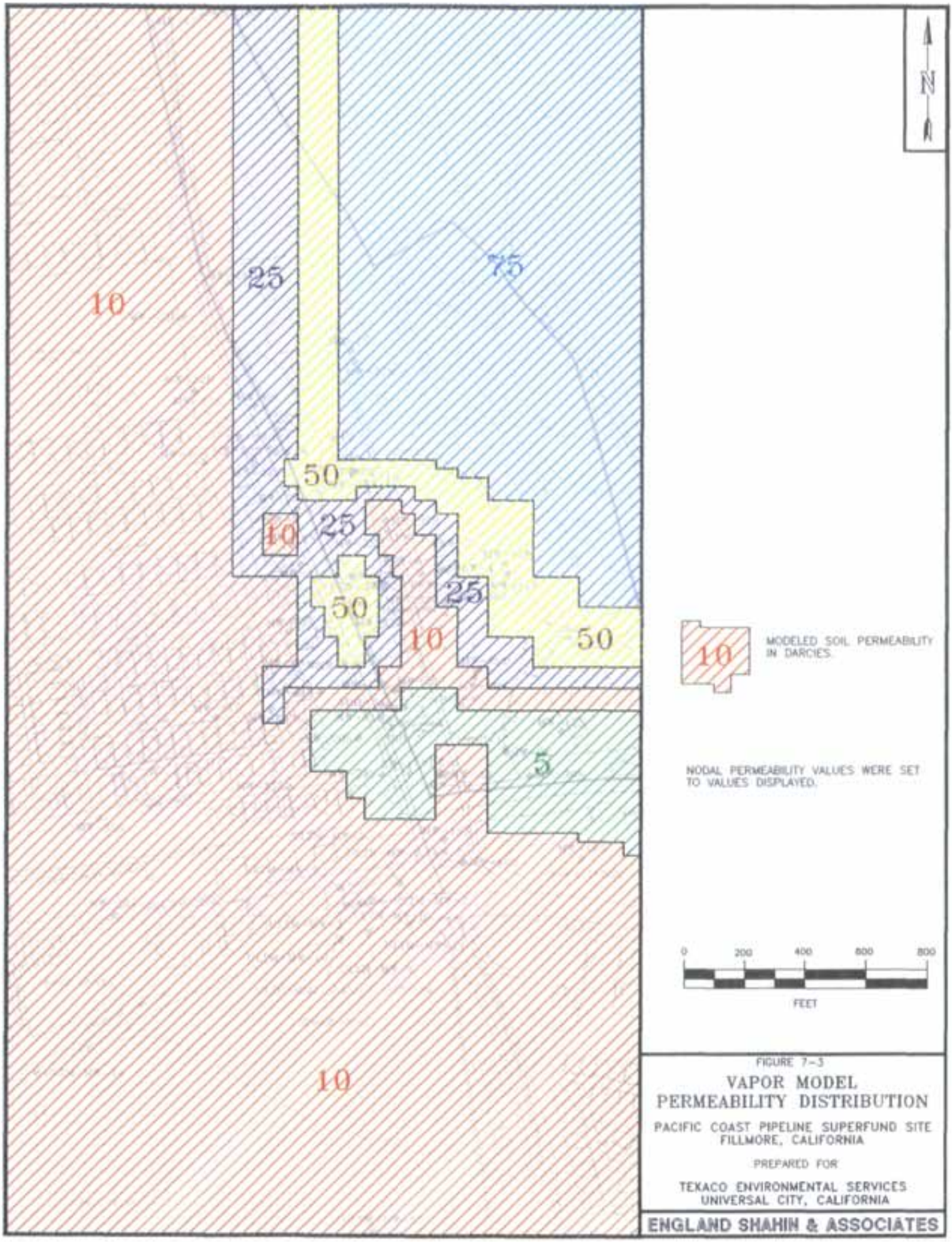


FIGURE 7-3

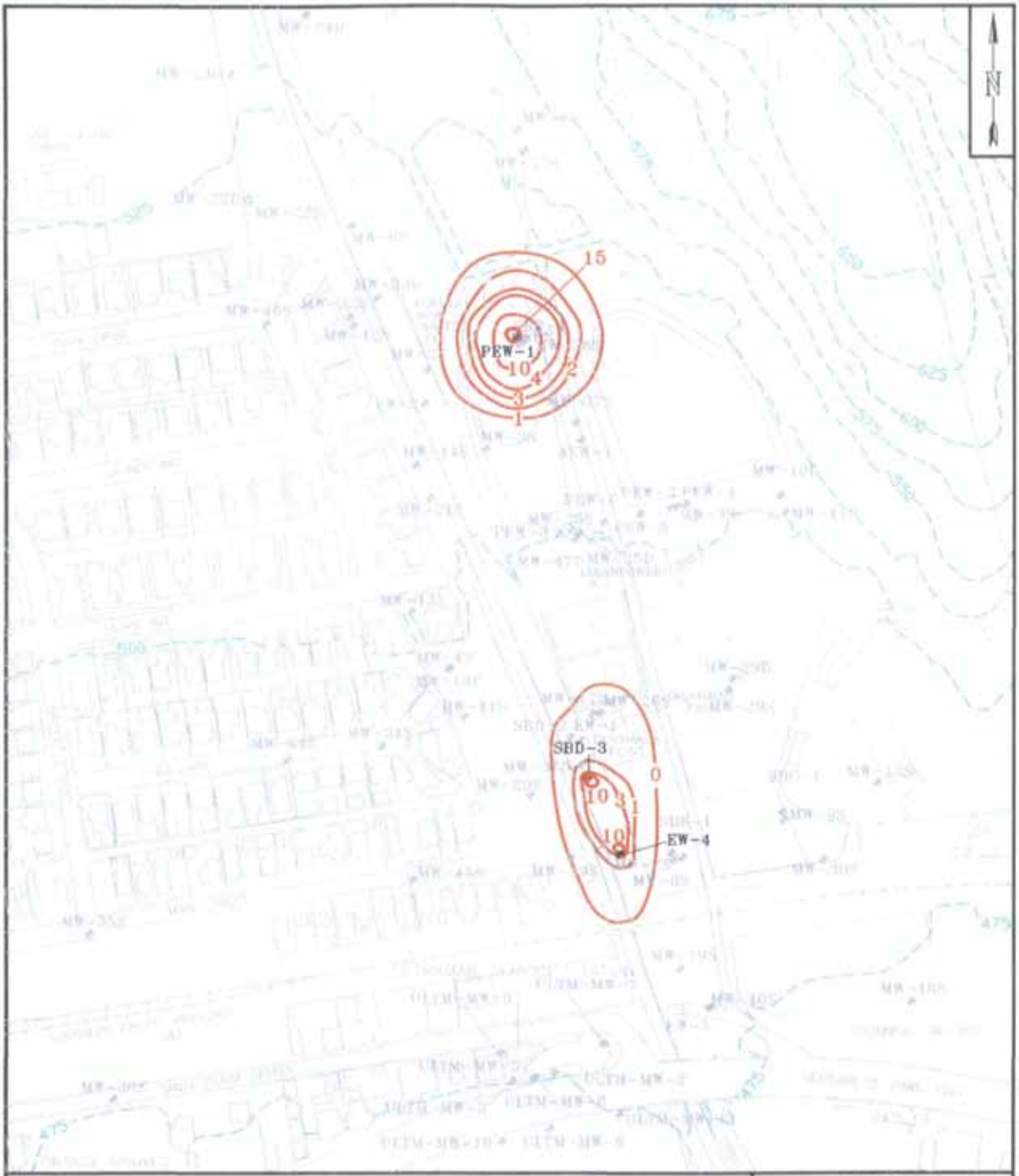
VAPOR MODEL
PERMEABILITY DISTRIBUTION

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



EW-4 MONITORING WELL LOCATION WITH WELL NUMBER.

—1— CONTOUR OF STEADY STATE SOIL GAS PRESSURE DECLINE IN INCHES OF WATER.

GROUND SURFACE ELEVATION CONTOUR. CONTOUR INTERVAL 25 FEET.

0 250 500 FEET

FLOW RATES:

SBD-3	50 cfm
EW-4	50 cfm
PEW-1	40 cfm

K_v = VERTICAL PERMEABILITY

K_h = HORIZONTAL PERMEABILITY

K_v = $0.01 K_h$ INSIDE SITE BOUNDARY

K_v = $0.1 K_h$ OUTSIDE SITE BOUNDARY

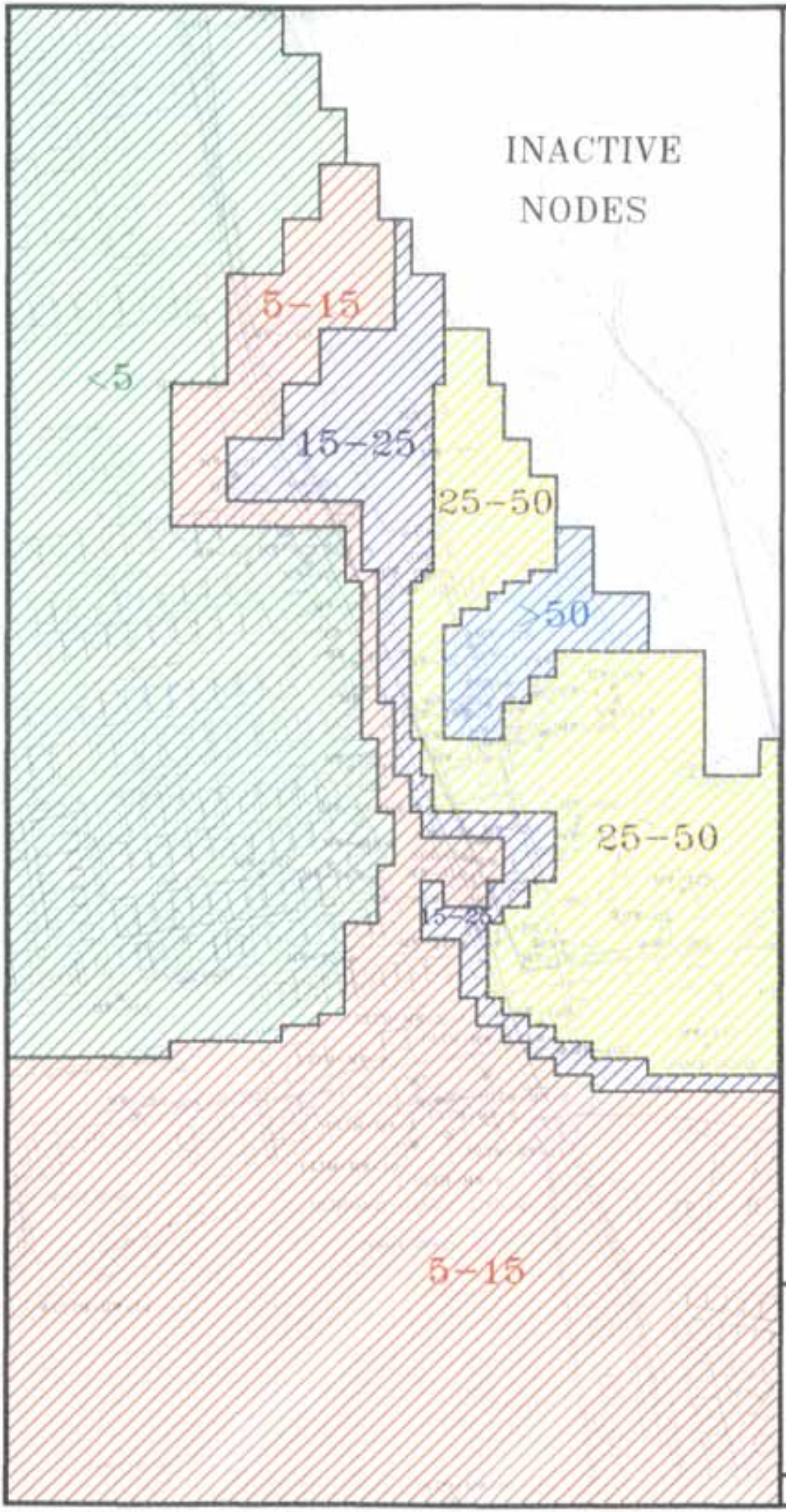
FIGURE 7-4

MODELED SOIL GAS PRESSURE DECLINE

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



MODELED PERMEABILITY RANGE DISTRIBUTION IN FT/DAY.

VALUES FOR PERMEABILITY USED IN MODEL VARIED ON INDIVIDUAL NODAL BASIS WITHIN RANGES SHOWN.

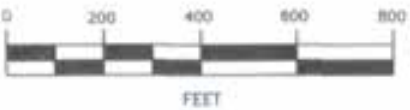


FIGURE 7-5

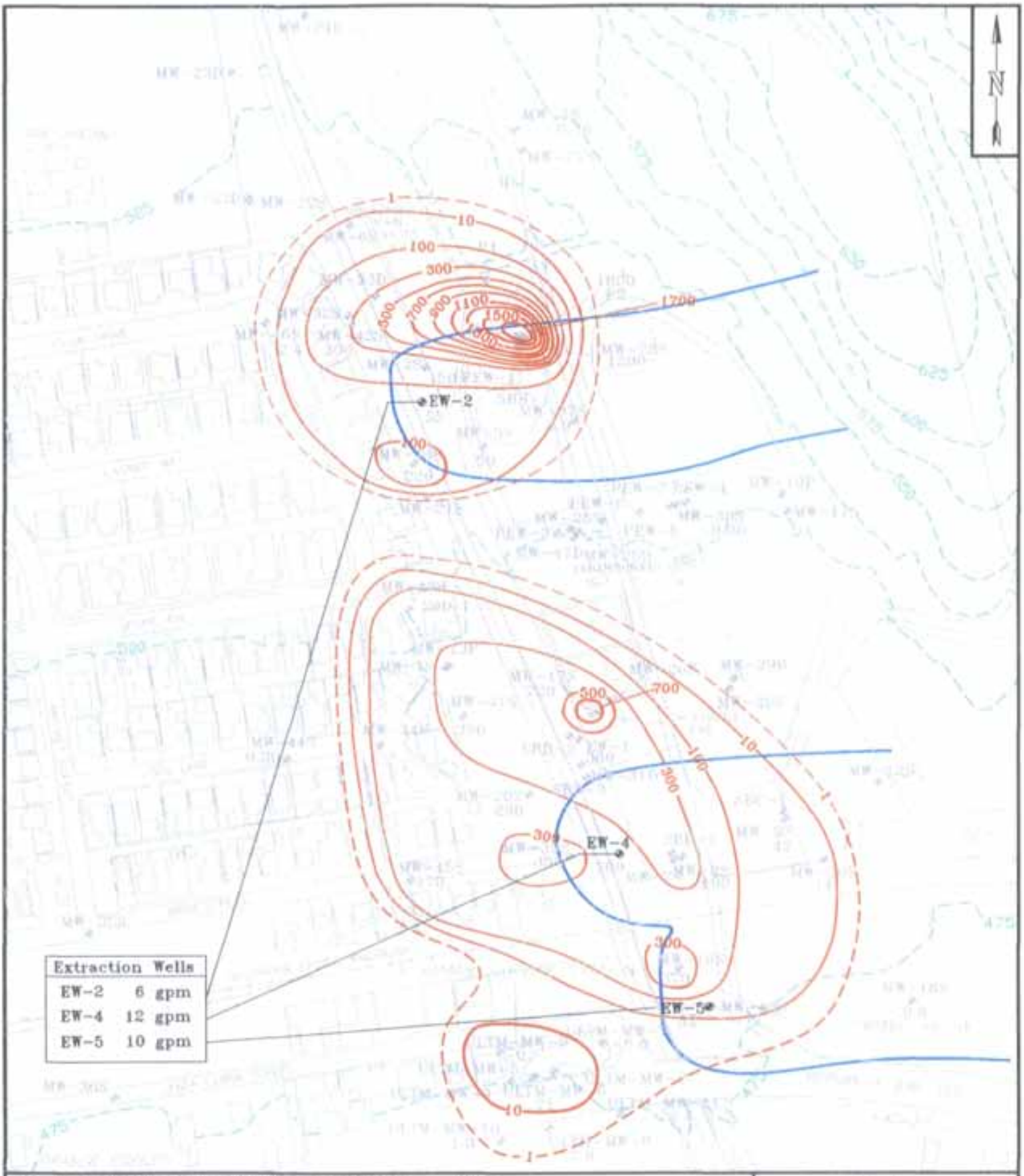
GROUND WATER MODEL PERMEABILITY DISTRIBUTION

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



MONITORING WELL LOCATION WITH WELL NUMBER AND BENZENE CONCENTRATION IN UG/L.

100 AQUIFER I BENZENE CONCENTRATION CONTOUR IN UG/L MEASURED AUGUST 1994. CONTOUR INTERVAL VARIABLE.

STEADY STATE CAPTURE ZONE.

0 250 500 FEET

NOTES:

1. THE CAPTURE ZONE REPRESENTS A BOUNDARY OF ZERO FLUX TOWARDS THE EXTRACTION WELL.

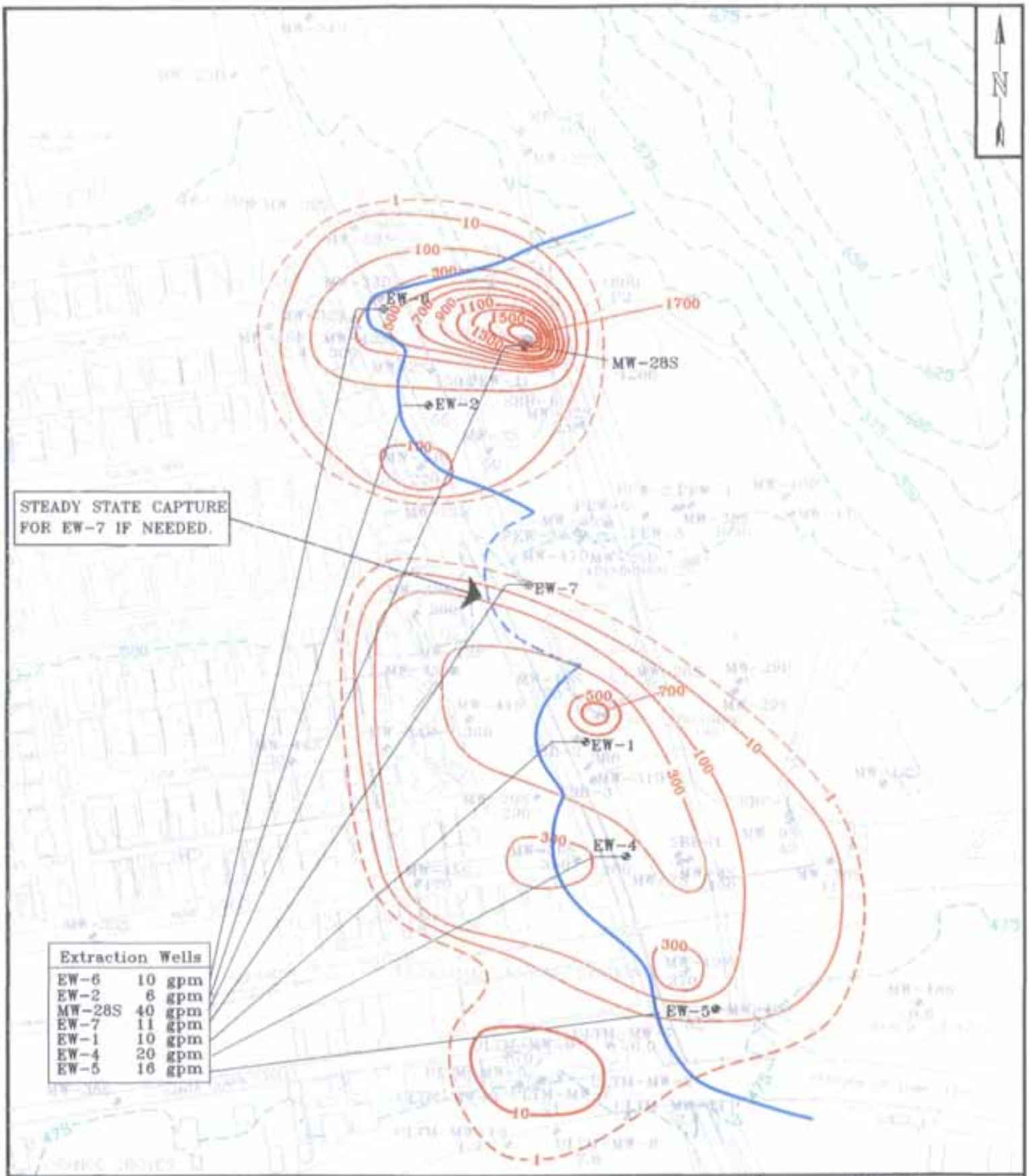
FIGURE 7-6

EXISTING PHASE 1 SYSTEM CAPTURE ZONE

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



MONITORING WELL LOCATION WITH WELL NUMBER AND BENZENE CONCENTRATION IN UG/L.

100 AQUIFER I BENZENE CONCENTRATION CONTOUR IN UG/L MEASURED AUGUST 1994. CONTOUR INTERVAL VARIABLE.

STEADY STATE CAPTURE ZONE

0 250 500 FEET

NOTES:

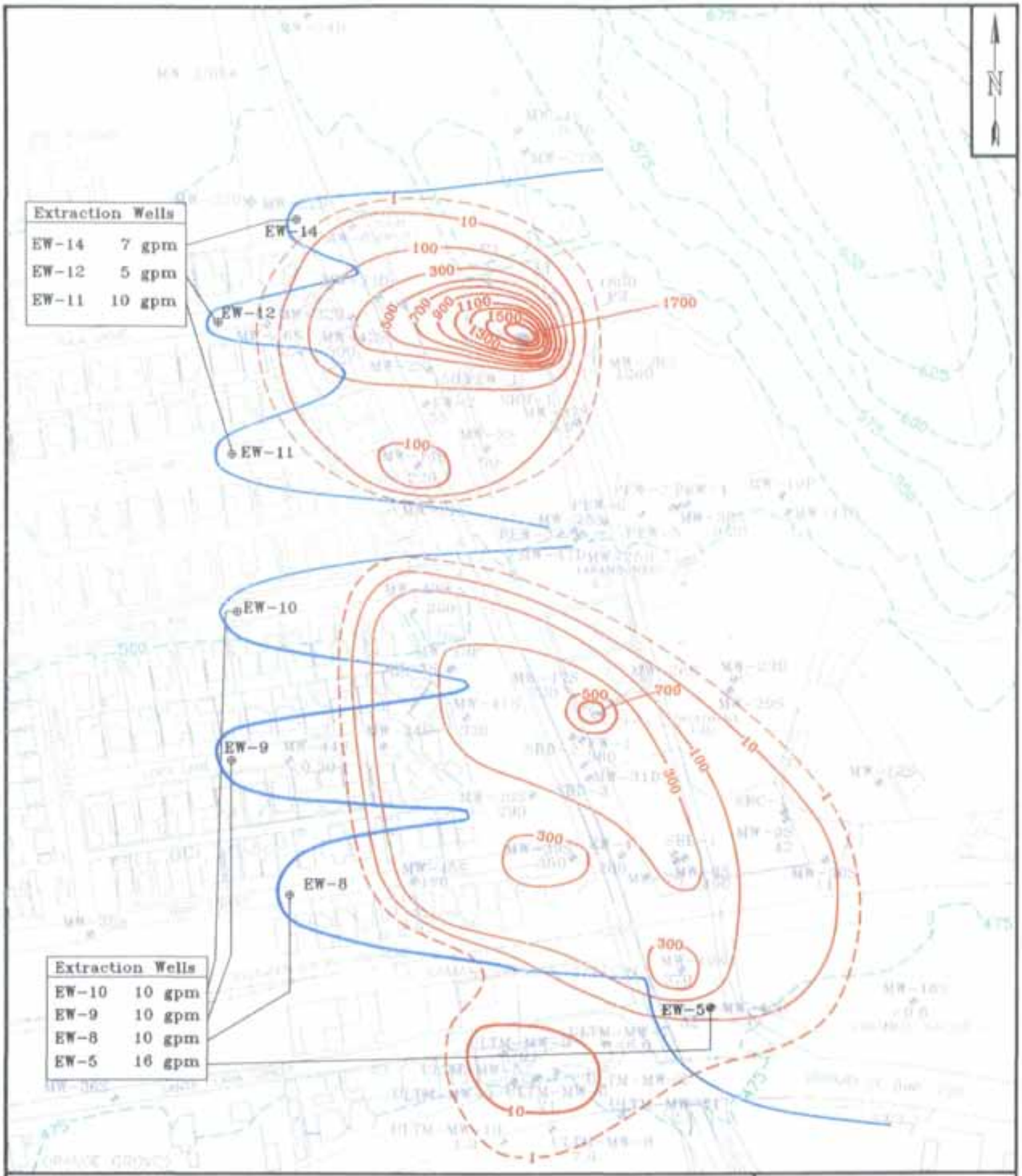
1. THE CAPTURE ZONE REPRESENTS A BOUNDARY OF ZERO FLUX TOWARDS THE EXTRACTION WELL.

FIGURE 7-7

RECOMMENDED SCENARIO CAPTURE ZONE

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA
PREPARED FOR
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



MONITORING WELL LOCATION WITH WELL NUMBER AND BENZENE CONCENTRATION IN UG/L.

100 AQUIFER I BENZENE CONCENTRATION CONTOUR IN UG/L MEASURED AUGUST 1994. CONTOUR INTERVAL VARIABLE.

STEADY STATE CAPTURE ZONE

0 250 500 FEET

NOTES:

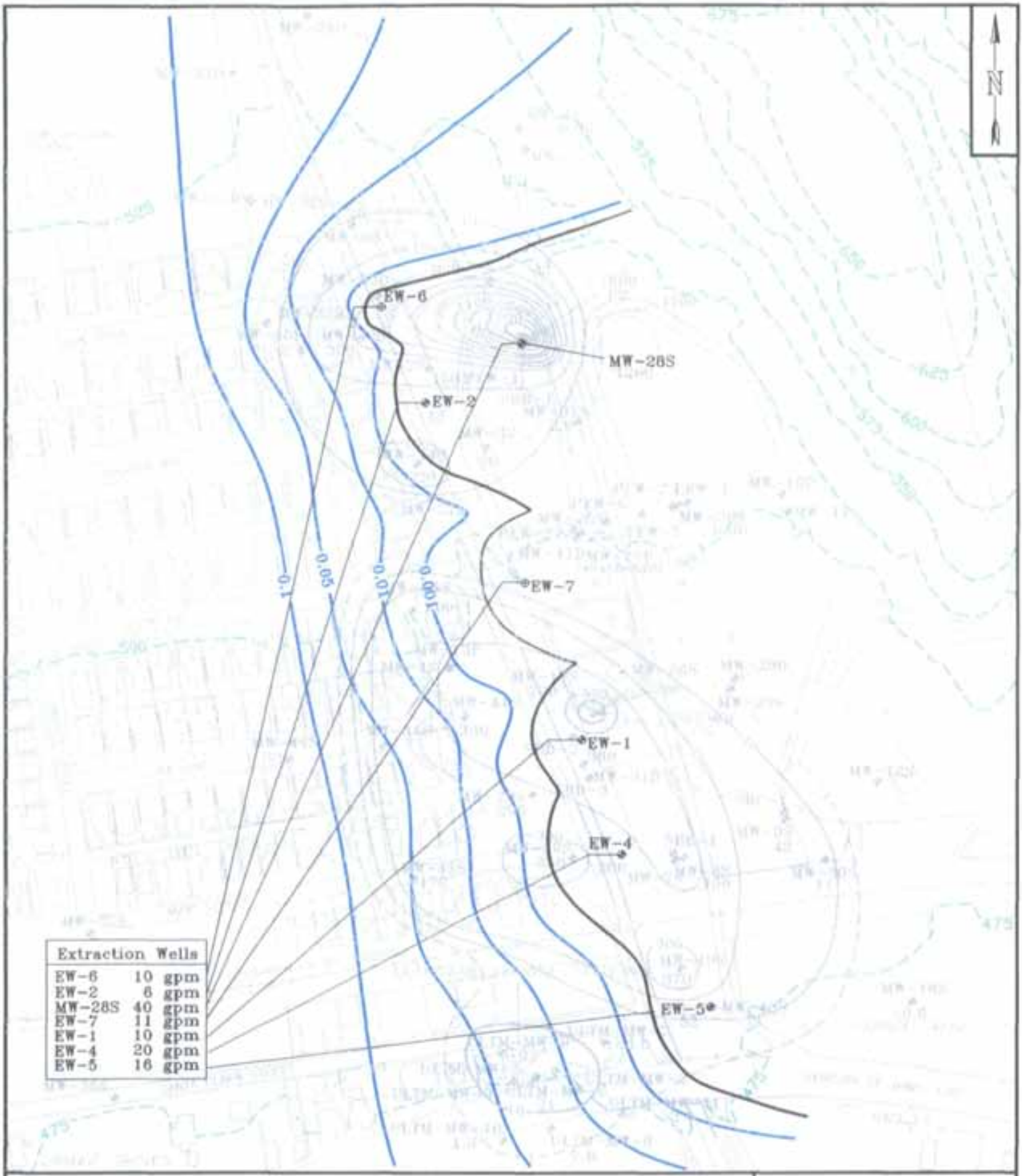
1. THE CAPTURE ZONE REPRESENTS A BOUNDARY OF ZERO FLUX TOWARDS THE EXTRACTION WELL.

FIGURE 7-8

MAXIMUM CAPTURE SCENARIO

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA
PREPARED FOR
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



MONITORING WELL LOCATION WITH WELL NUMBER AND BENZENE CONCENTRATION IN UG/L.

AQUIFER 1 BENZENE CONCENTRATION CONTOUR IN UG/L MEASURED AUGUST 1994. CONTOUR INTERVAL VARIABLE.

STEADY STATE CAPTURE ZONE

0.1 GROUND WATER VELOCITY IN FT/DAY.

0 250 500 FEET

NOTES:

1. THE CAPTURE ZONE REPRESENTS A BOUNDARY OF ZERO FLUX TOWARDS THE EXTRACTION WELL.

2. AVERAGE PRE-EXTRACTION GROUND WATER VELOCITIES RANGE FROM 0.07 TO 0.8 FT/DAY.

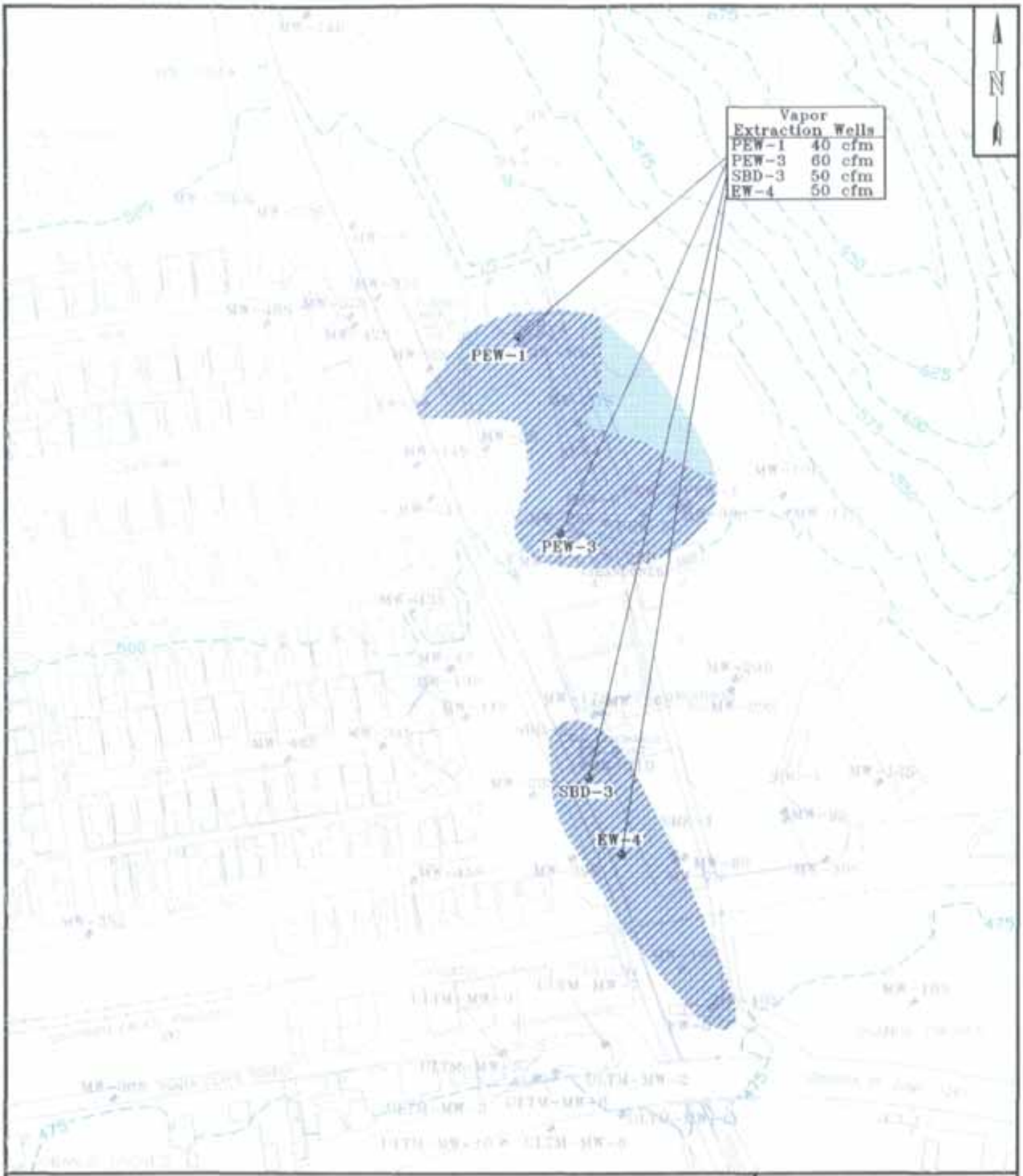
FIGURE 7-9

MODELED VELOCITIES DOWNGRADIENT OF THE CAPTURE ZONE

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



EW-4 VAPOR EXTRACTION WELL LOCATION WITH WELL NUMBER

GROUND SURFACE ELEVATION CONTOUR. CONTOUR INTERVAL 25 FEET.

0 250 500 FEET

APPROXIMATE AREA WHERE BENZENE CONCENTRATION IN GAS IS HIGHER THAN CALCULATED EQUILIBRIUM CONCENTRATION WITH UNDERLYING WATER.

VAPOR EXTRACTION TARGET AREA

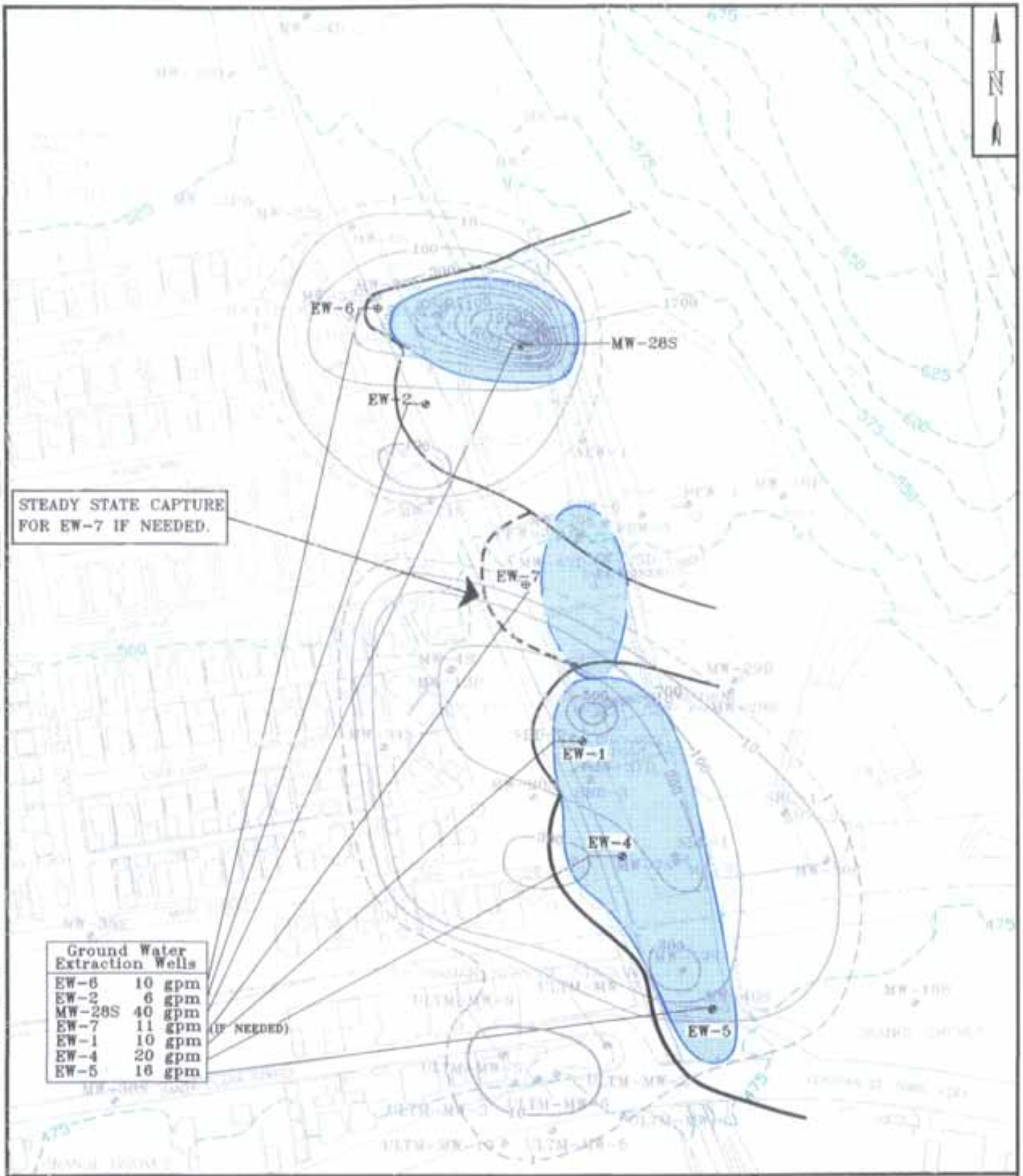
FIGURE 8-1

VAPOR EXTRACTION TARGET AREAS

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES



100 AQUIFER 1 BENZENE CONCENTRATION CONTOUR IN UG/L MEASURED AUGUST 1994. CONTOUR INTERVAL VARIABLE.

STEADY STATE CAPTURE ZONE

GROUND SURFACE ELEVATION CONTOUR. CONTOUR INTERVAL 25 FEET.

0 250 500 FEET

NOTES:

1. THE CAPTURE ZONE REPRESENTS A BOUNDARY OF ZERO FLUX TOWARDS THE EXTRACTION WELL.

GROUND WATER TARGET AREA

FIGURE 8-2

GROUND WATER REMEDIATION TARGET AREAS AND CAPTURE ZONES

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR
TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

DECISION TREE FOR MODIFYING OR SHUTTING OFF SOIL VAPOR EXTRACTION SYSTEM

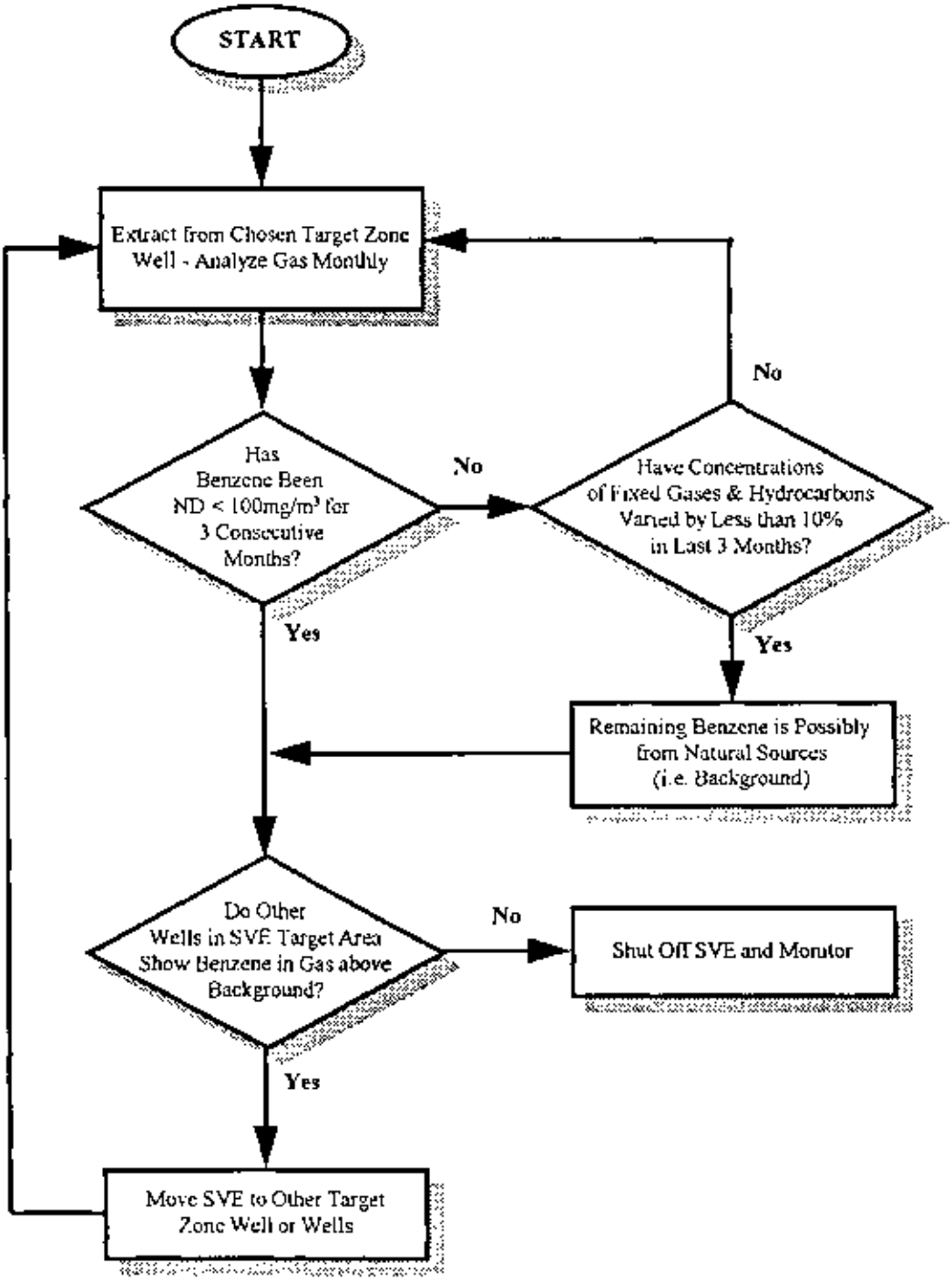
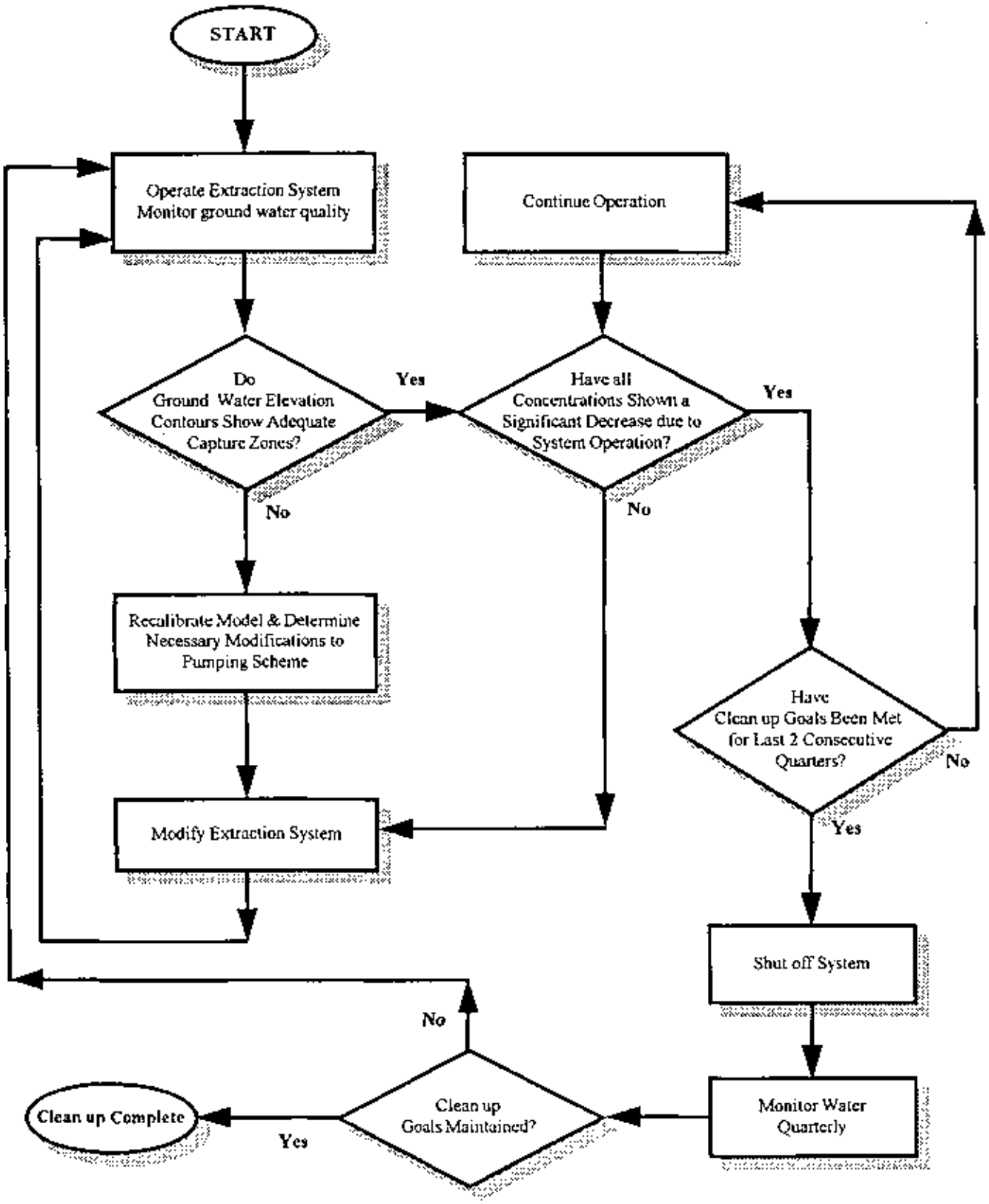


FIGURE 9-1

DECISION TREE FOR MODIFYING OR SHUTTING OFF GROUND WATER TREATMENT SYSTEM



NOTE NCP and ROD indicate a 5 year review will be conducted after start up of operation

FIGURE 9-2

DRAWINGS

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

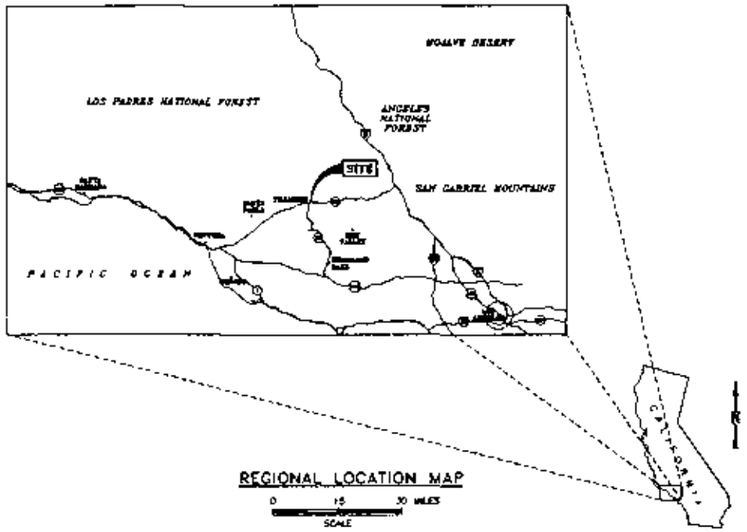
PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

INDEX OF DRAWINGS

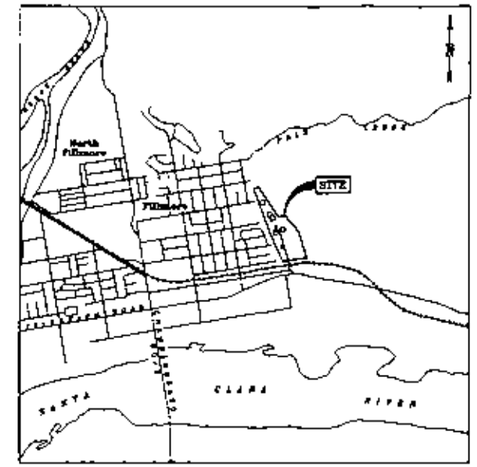
SHEET NO.	TITLE
M-1	SITE LOCATION MAP AND GENERAL NOTES
M-2	GROUND WATER TREATMENT SYSTEM PIPING AND INSTRUMENTATION DIAGRAM
M-3	GROUND WATER TREATMENT SYSTEM EQUIPMENT LAYOUT
M-4	GROUND WATER TREATMENT SYSTEM PIPING LAYOUT
M-5	VAPOR EXTRACTION SYSTEM PIPING AND INSTRUMENTATION DIAGRAM
M-6	VAPOR EXTRACTION PIPING LAYOUT
M-7	VAPOR EXTRACTION SYSTEM AND PIPING DETAILS
M-8	EXTRACTION WELL DETAILS
E-1	SINGLE-LINE DIAGRAM, LOAD SCHEDULE, AND GENERAL NOTES
E-2	SCHEMATIC WIRING DIAGRAM

ENGLAND SHAHIN & ASSOCIATES



REGIONAL LOCATION MAP

0 15 30 MILES
SCALE



SITE LOCATION MAP

0 1000 2000 FEET
SCALE

LEGEND

LINE AND PIPING IDENTIFICATION

- PROCESS PIPING LINE AND STREAM NUMBER
- DOUBLE WALL PIPING
- PROCESS INSTRUMENT LINE
- INSTRUMENT AIR LINE
- INSTRUMENT AND/OR ELECTRICAL LEAD
- CONTROL/OPERATION LOGIC

PIPING SYMBOLS

- TIE-IN NUMBER
- Y-TYPE STRAINER
- FLEX HOSE
- ROTAMETER OR POSITIVE DISPLACEMENT TYPE FLOW INDICATOR
- REDUCTION IN LINE SIZE
- BLIND FLANGE
- QUICK CONNECT OR HOSE FITTING
- CAPPED LINE

MANUALLY OPERATED VALVES

- GLOBE VALVE
- GATE VALVE
- CHECK VALVE
- BALL VALVE
- THREE-WAY VALVE (BALL)
- BUTTERFLY VALVE

CONTROL VALVES

- PNEUMATIC CONTROL VALVE
- SOLENOID VALVE
- PRESSURE REGULATOR
- MOTOR (ELECTRIC) OPERATED CONTROL VALVE
- PRESSURE SAFETY VALVE
- AIR VENT
- VACUUM BREAKER

EQUIPMENT IDENTIFICATION SYMBOLS

AS	AIR STRIPPER
B	BLOWER
C	COLUMN
EW	EXTRACTION WELL
F	FILTER
FB	FLUIDIZED BIOTOWER
M	MOTOR
MS	MIXER
P	PUMP
T	TANK
WP	WELL PUMP

ELECTRICAL SYMBOLS
(SEE SHEET E-1 FOR ADDITIONAL SYMBOLS)

- MOTOR START/STOP STATION (AUTO/OFF/MANUAL)
- MOTOR START/STOP STATION (OFF/MANUAL)
- MOTOR OPERATION INDICATOR LIGHT
- MOTOR

INSTRUMENT IDENTIFICATION SYMBOLS

AAH	ANALYZER ALARM HIGH
AE	ANALYZER ELEMENT
AT	ANALYZER (POTASSIUM PERMANGANATE)
BFR	BACK FLOW (PREVENTOR) REGULATOR
DL	DATA LOGGER
FAL	FLOW ALARM LOW
FCV	FLOW CONTROL VALVE
FE	FLOW ELEMENT
FQI	FLOW TOTALIZER/INDICATOR
FRC	FLOW RECORDER/CONTROLLER
FRQ	FLOW RECORDER/TOTALIZER
FSL	FLOW SWITCH LOW
FT	FLOW TRANSMITTER
LAH	LEVEL ALARM HIGH
LAL	LEVEL ALARM LOW
LCV	LEVEL CONTROL VALVE
LE	LEVEL ELEMENT
LG	LIGHT GREEN
LI	LEVEL INDICATOR
LIC	LEVEL INDICATOR/CONTROLLER
LPU	LOCAL PROCESSING UNIT
LSH	LEVEL SWITCH HIGH
LSHH	LEVEL SWITCH HIGH HIGH
LSL	LEVEL SWITCH LOW
LT	LEVEL TRANSMITTER
PAH	PRESSURE ALARM HIGH
PAL	PRESSURE ALARM LOW
PE	PRESSURE ELEMENT
PI	PRESSURE INDICATOR
PIT	PRESSURE INDICATOR TRANSMITTER
PSH	PRESSURE SWITCH HIGH
PSL	PRESSURE SWITCH LOW
PSV	PRESSURE SAFETY VALVE
PT	PRESSURE TRANSMITTER
PTD	PRESSURE TRANSDUCER

ABBREVIATIONS

AC	ASPHALTIC CONCRETE	PS	PIPE SUPPORT
AEW	AIR EXTRACTION WELL	PVC	POLYVINYL CHLORIDE (PIPE)
AG	ABOVEGROUND	REF	REFERENCE
BOP	BOTTOM OF PIPE	REQ'D	REQUIRED
CS	CARBON STEEL	RS	RESET
CI	CAST IRON	SBD	SOIL BORING (AREA 2)
CL	CENTER LINE	SCH	SCHEDULE
DI	DUCTILE IRON	SP	SAMPLE POINT
DIA	DIAMETER	SS	STAINLESS STEEL
DISCH	DISCHARGE	SS/EW	SAFETY SHOWER/EYE WASH
DRN	DRAIN	SCRD	SCREWED
DW	DOUBLE WALL	STD	STANDARD
EL	ELEVATION	SUPT	SUPPORT
ELL	ELBOW	TC	TOP OF CURB
EW	EXTRACTION WELL	THRD	THREADED
EXIST	EXISTING	THK	THICK
FDN	FOUNDATION	TOS	TOP OF STEEL
FL	FLOW LINE	TPH	TOTAL PETROLEUM HYDROCARBONS
FRP	FIBERGLASS REINFORCED PLASTIC	TYP	TYPICAL
FS	FINISHED SURFACE	UBC	UNIFORM BUILDING CODE
FT	FOOT	UG	UNDERGROUND
GAL	GALLON(S)	UL	ULTRAMAR
GPM	GALLONS PER MINUTE	VERT	VERTICAL
GV	GALVANIZED	WT	WEIGHT
HDPE	HIGH DENSITY POLYETHYLENE		
HLL	HIGH LIQUID LEVEL		
HORIZ	HORIZONTAL		
HP	HORSE POWER		
HP	HIGH POINT		
IAS	INSTRUMENT AIR SUPPLY		
IE	INVERT ELEVATION		
LBS	POUNDS		
LLL	LOW LIQUID LEVEL		
LP	LOW POINT		
MW	MONITORING WELL		
NIP	NIPPLE		
NLL	NORMAL LIQUID LEVEL		
NO	NUMBER		
NPT	NATIONAL PIPE THREAD		
NTS	NOT TO SCALE		
PE	POLYETHYLENE		
PEW	PERCHED WATER EXTRACTION WELL		

REV	DATE	BY	DESCRIPTION

SCALE: AS NOTED

DESIGNED DATE
DRAWN DATE
CHECKED DATE

SUBMITTED
PROJECT ENGINEER R.C.E. NO. DATE
ENGLAND SHAHIN & ASSOCIATES R.C.E. NO. DATE

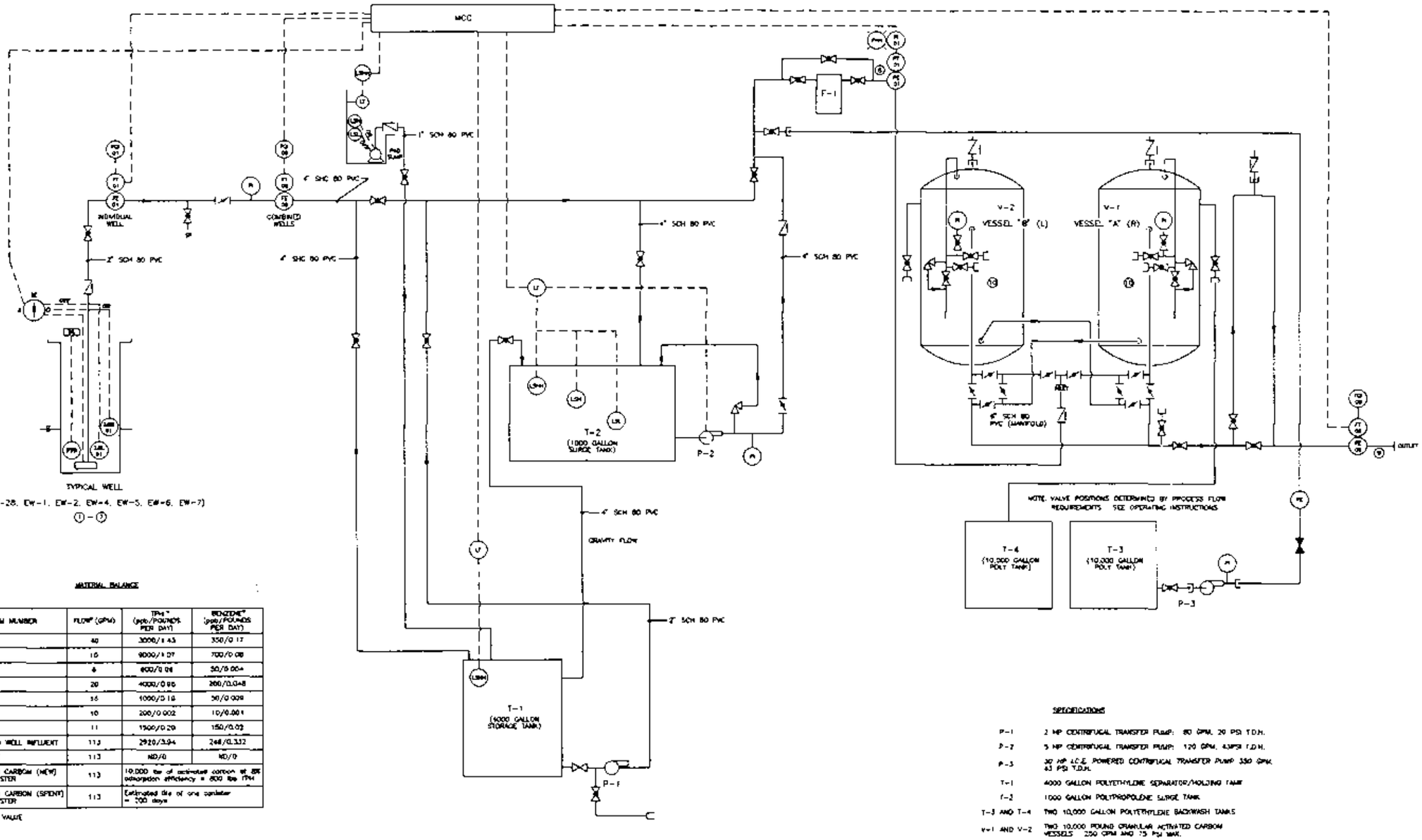
ENGLAND SHAHIN & ASSOCIATES

APPROVED DATE
APPROVED DATE

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

SITE LOCATION MAP AND GENERAL NOTES

SHEET M-1



MATERIAL BALANCE

STREAM NUMBER	FLOW* (GPM)	TPH* (ppb/POUNDS PER DAY)	BENZENE* (ppb/POUNDS PER DAY)
① MW-2BS	40	3000/1.43	350/0.17
② EW-1	16	9000/1.07	700/0.08
③ EW-2	6	800/0.06	50/0.004
④ EW-4	20	4000/0.96	200/0.048
⑤ EW-5	16	1000/0.16	50/0.009
⑥ EW-6	10	200/0.002	10/0.001
⑦ EW-7	11	1500/0.20	150/0.02
⑧ COMBINED WELL INFLUENT	113	2920/3.94	248/0.332
⑨ EFFLUENT	113	ND/0	ND/0
⑩ ACTIVATED CARBON (NEW) ONE CANISTER	113	10,000 lbs of activated carbon at 8% adsorption efficiency = 800 lbs TPH	
⑩ ACTIVATED CARBON (SPENT) ONE CANISTER	113	Estimated life of one canister = 200 days	

* ESTIMATED VALUE

SPECIFICATIONS

P-1	2 HP CENTRIFUGAL TRANSFER PUMP: 80 GPM, 20 PSI T.D.H.
P-2	5 HP CENTRIFUGAL TRANSFER PUMP: 120 GPM, 43PSI T.D.H.
P-3	30 HP I.C.E. POWERED CENTRIFUGAL TRANSFER PUMP 330 GPM, 43 PSI T.D.H.
T-1	4000 GALLON POLYETHYLENE SEPARATOR/HOLDING TANK
T-2	1000 GALLON POLYPROPOLENE SURGE TANK
T-3 AND T-4	TWO 10,000 GALLON POLYETHYLENE BACKWASH TANKS
V-1 AND V-2	TWO 10,000 POUND GRANULAR ACTIVATED CARBON VESSELS 250 GPM AND 75 PSI MAX.
F-1	HIGH FLOW BAG FILTRATION SYSTEM. STAINLESS STEEL FILTER HOUSING. 24 - BAG CAPACITY. 200 GPM AND 150 PSI MAX.

REV	DATE	BY	DESCRIPTION

SCALE: AS NOTED

SUBMITTED
PROJECT ENGINEER — P.E. NO. — DATE
ENGLAND SHAHIN & ASSOCIATES — P.E. NO. — DATE

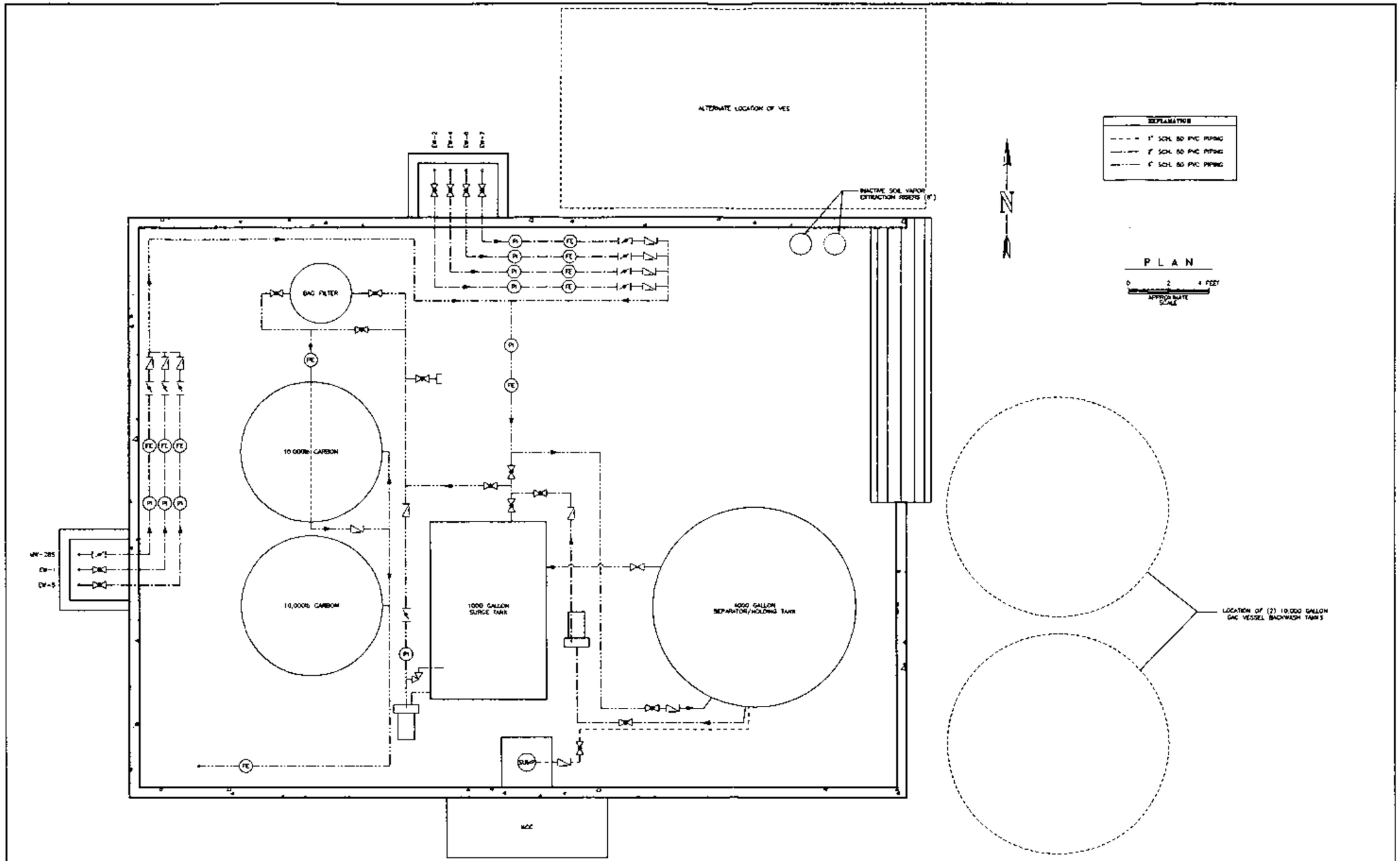
SCRIBED — DATE
DRAWN — DATE
CHECKED — DATE

ENGLAND SHAHIN & ASSOCIATES

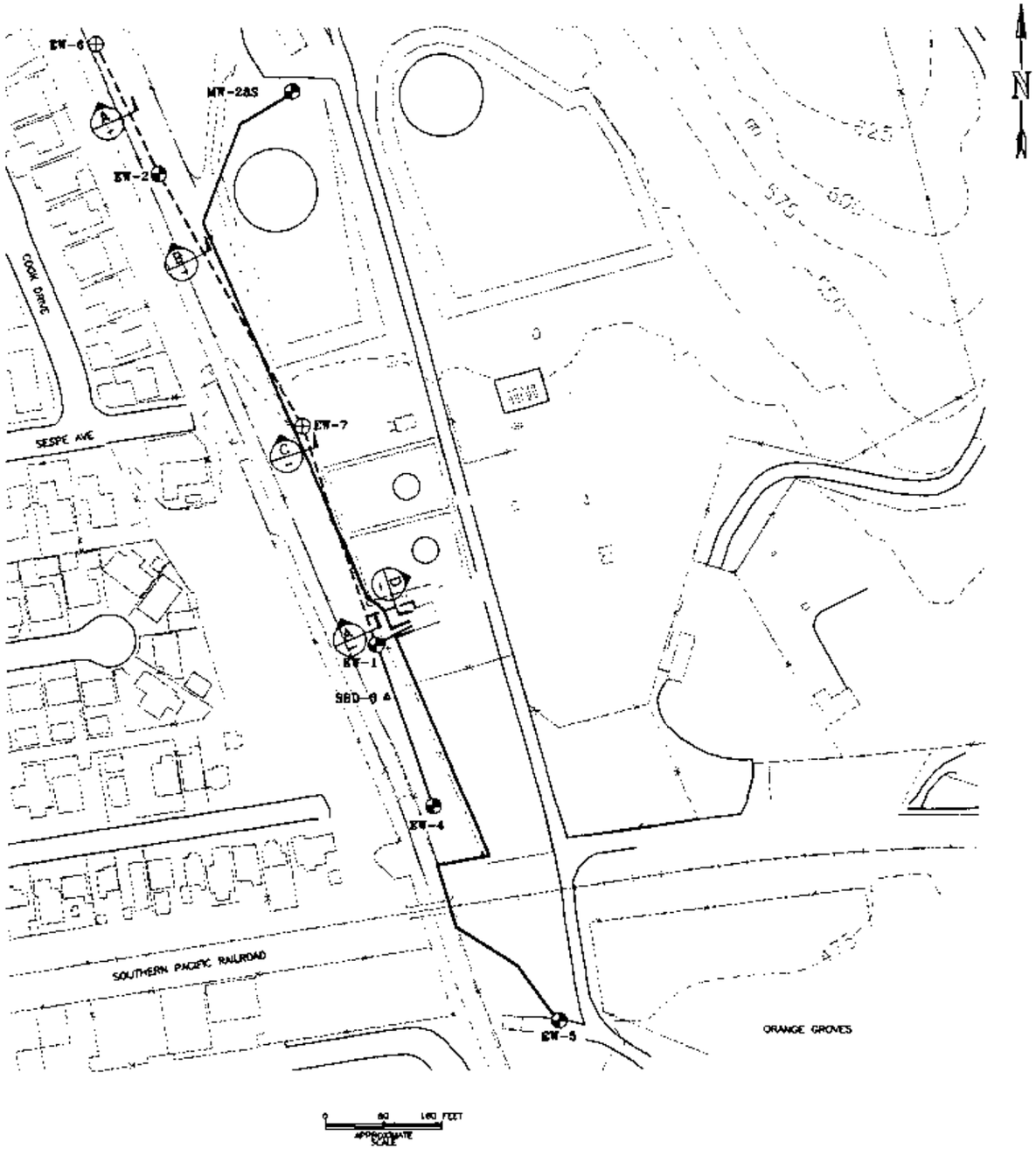
APPROVED — DATE
APPROVED — DATE

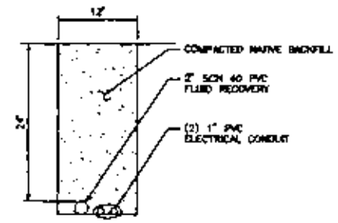
PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA
GROUND WATER TREATMENT SYSTEM
PIPING AND INSTRUMENTATION DIAGRAM

SHEET M-2



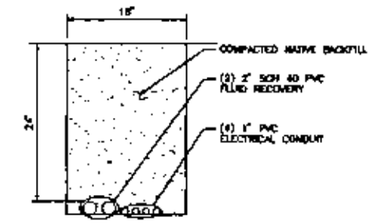
				AS NOTED			ENGLAND SHAHIN & ASSOCIATES	PACIFIC COAST PIPELINE SUPERFUND SITE FILLMORE, CALIFORNIA GROUND WATER TREATMENT SYSTEM EQUIPMENT LAYOUT	M-3





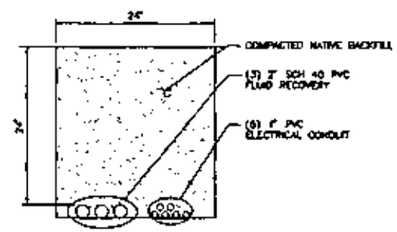
SECTION A

NTS



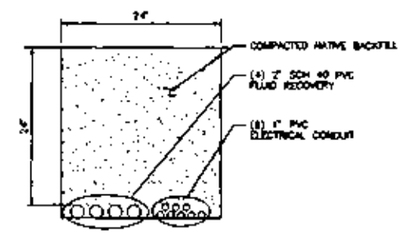
SECTION B

NTS



SECTION C

NTS

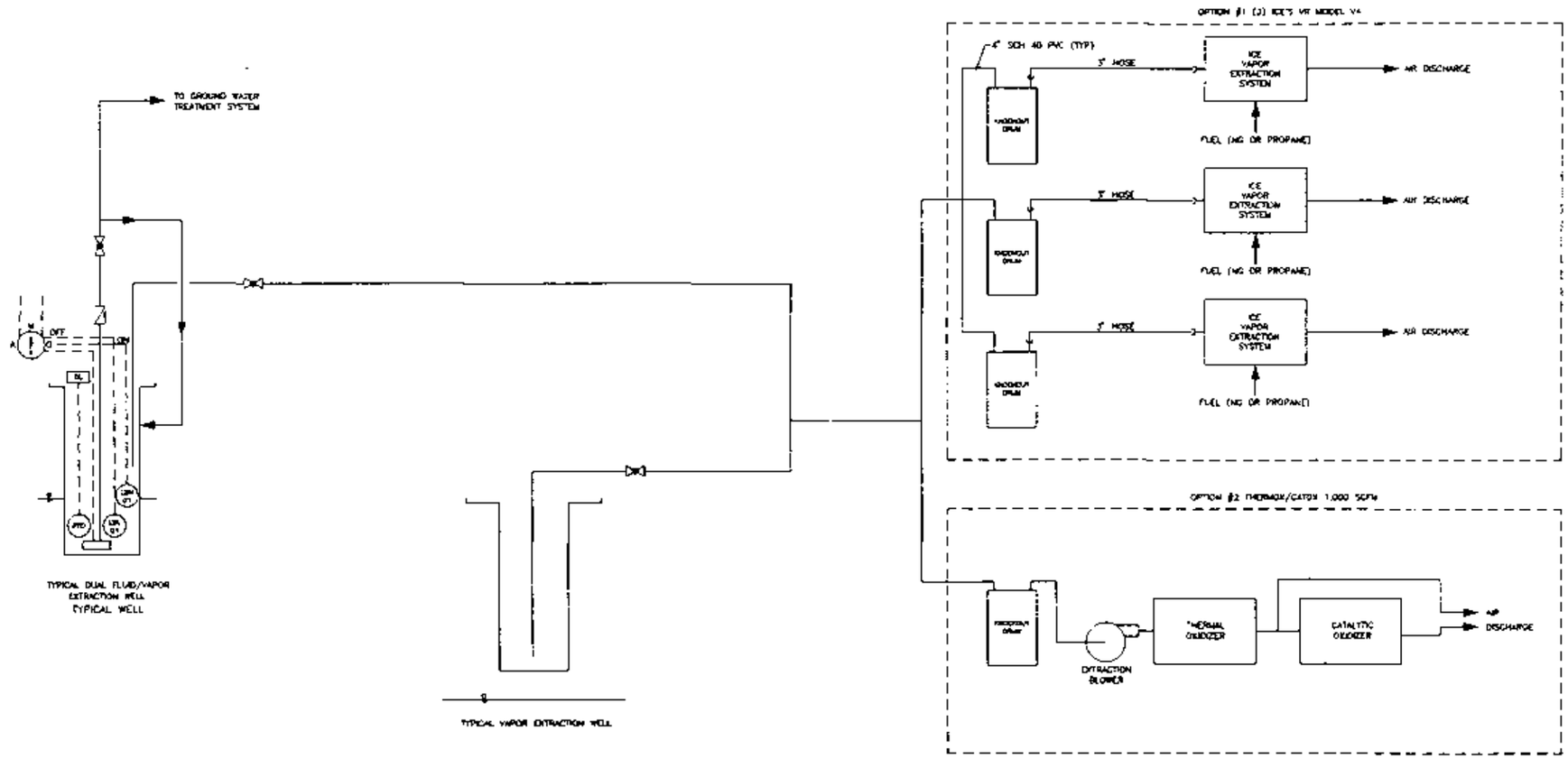


SECTION D

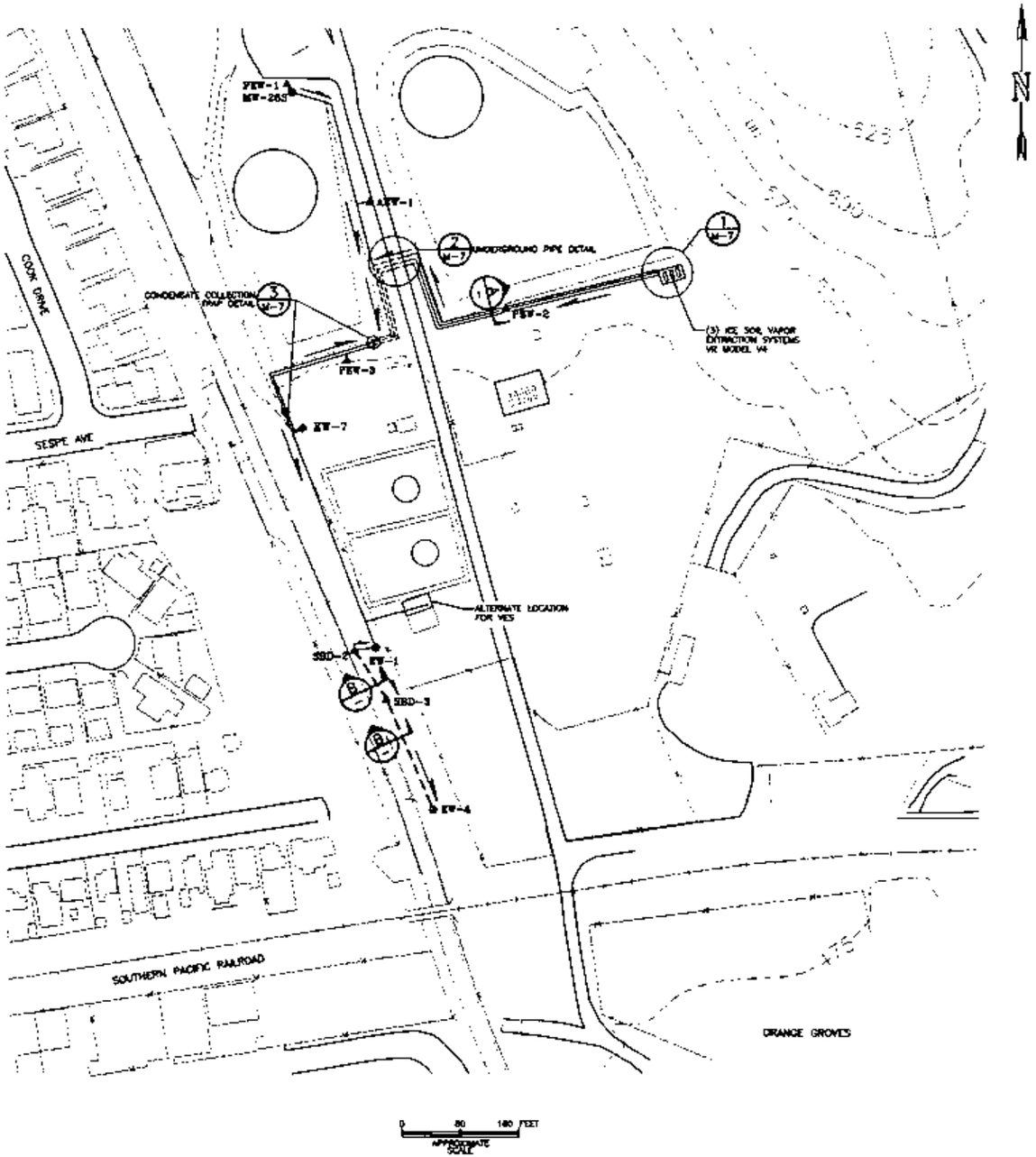
NTS

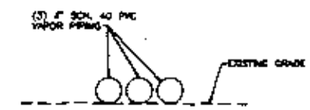
EXPLANATION	
———	EXISTING PIPING
- - - -	PROPOSED PIPING
EW-7 ⊕	NEW EXTRACTION WELLS

REV	DATE	BY	DESCRIPTION	SCALE	DESIGNED	DATE	SUBMITTED		ENGLAND SHAHIN & ASSOCIATES	APPROVED	DATE	PACIFIC COAST PIPELINE SUPERFUND SITE	SHEET
				AS NOTED	DRAWN	DATE	PROJECT ENGINEER	R.C.E. NO. DATE				FILLMORE, CALIFORNIA	M-4
					CHECKED	DATE	ENGLAND, SHAHIN & ASSOCIATES	R.C.E. NO. DATE		APPROVED	DATE	GROUND WATER TREATMENT SYSTEM PIPING LAYOUT	



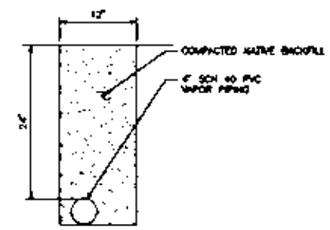
REV	DATE	BY	DESCRIPTION	SCALE	DESIGNED	DATE	SUBMITTED		ENGLAND SMAKIN & ASSOCIATES	APPROVED	DATE	PACIFIC COAST PIPELINE SUPERFUND SITE	SHEET
				AS NOTED	DRAWN	DATE	PROJECT ENGINEER	P.E. NO. DATE				FILLMORE, CALIFORNIA	M-5
					CHECKED	DATE	ENGLAND SMAKIN & ASSOCIATES	P.E. NO. DATE		APPROVED	DATE	VAPOR EXTRACTION SYSTEM PIPING AND INSTRUMENTATION	





SECTION A

NTS

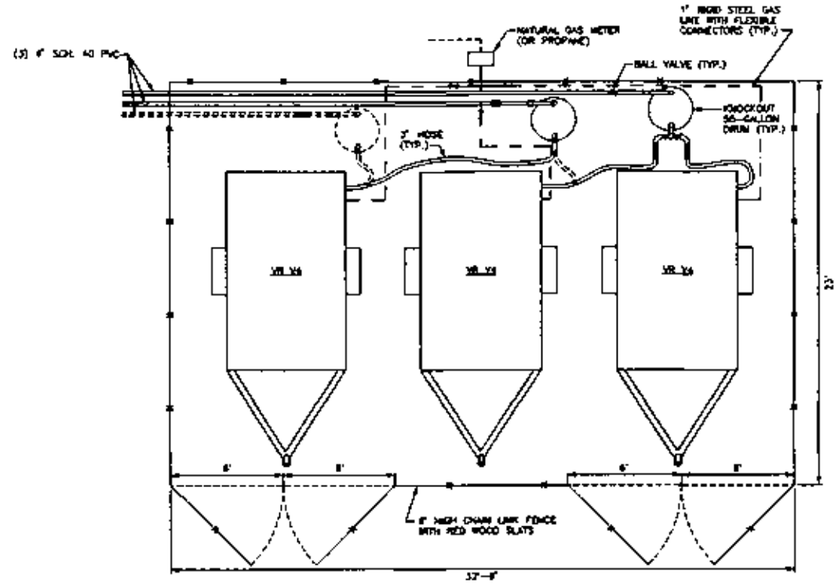


SECTION B

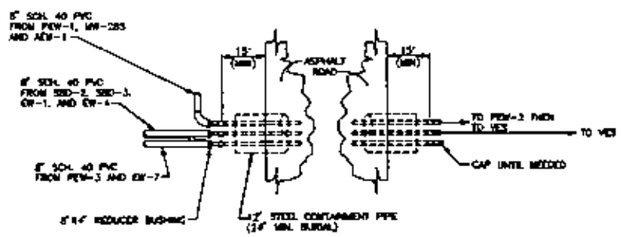
NTS

EXPLANATION	
	SLOPE DIRECTION
	EXISTING ABOVE GROUND PIPING
	PROPOSED BURIED PIPING

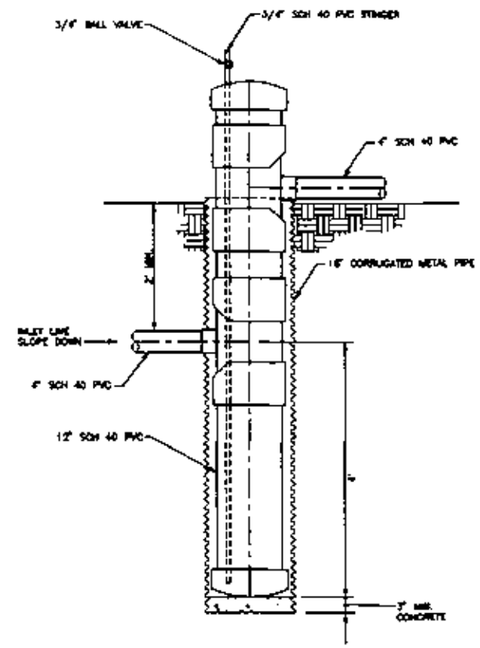
REV	DATE	BY	DESCRIPTION	SCALE AS NOTED	DESIGNED / DRAWN / CHECKED	SUBMITTED PROJECT ENGINEER / ENGLAND SHAHIN & ASSOCIATES	ENGLAND SHAHIN & ASSOCIATES	APPROVED / APPROVED	PACIFIC COAST PIPELINE SUPERFUND SITE FILLMORE, CALIFORNIA VAPOR EXTRACTION PIPING LAYOUT	SHEET M-6



DETAIL 1 (M-6)
VAPOR EXTRACTION SYSTEM (VES)
N T S



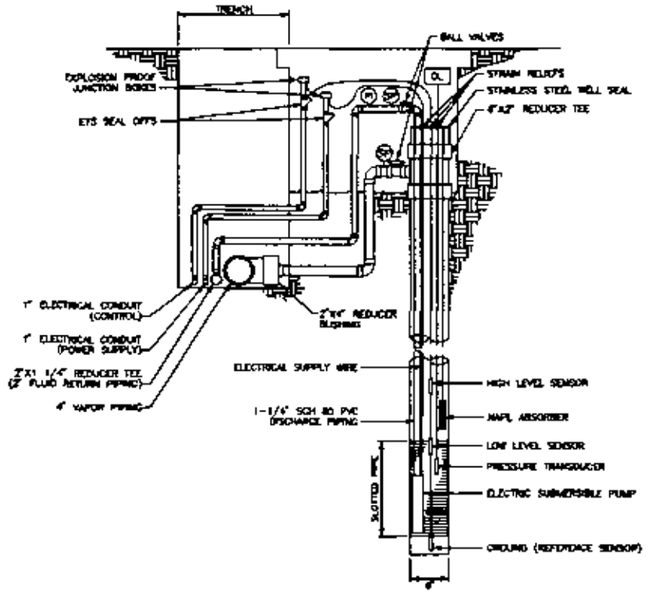
DETAIL 2 (M-6)
N T S



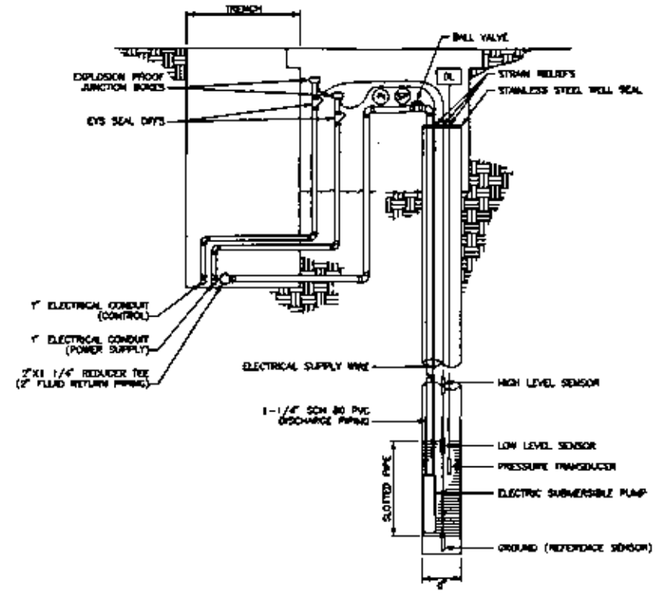
DETAIL 3 (M-6)
CONDENSATE COLLECTION TRAP
N T S

REV	DATE	BY	DESCRIPTION	SCALE N T S	REVIEWED DATE	SUBMITTED PROJECT ENGINEER E.E.I. NO. DATE	ENGLAND SHAHIN & ASSOCIATES	APPROVED DATE	PACIFIC COAST PIPELINE SUPERFUND SITE
					DRAWN DATE	ENGLAND SHAHIN & ASSOCIATES E.S.A. NO. DATE			FILLMORE, CALIFORNIA
					CHECKED DATE			APPROVED DATE	VAPOR EXTRACTION SYSTEM AND PIPING DETAILS

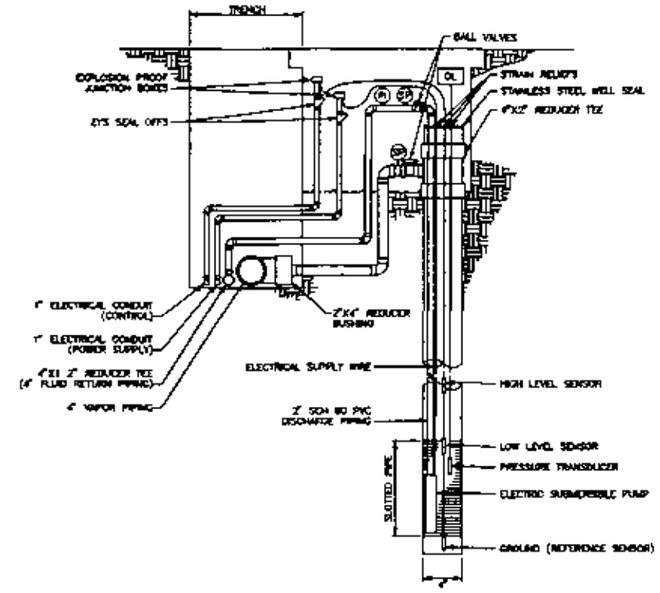
SHEET M-7



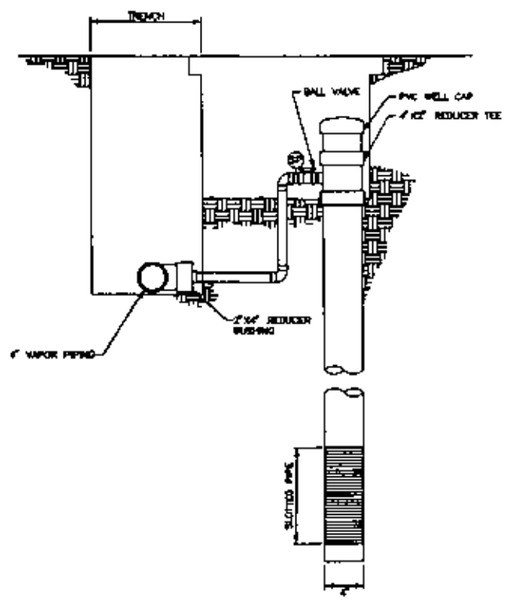
FLUID/VAPOR EXTRACTION WELL
EW-1, EW-4 AND EW-7
N T S



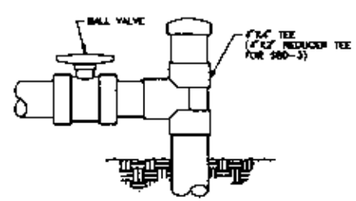
FLUID EXTRACTION WELL
EW-2, EW-5 AND EW-6
N T S



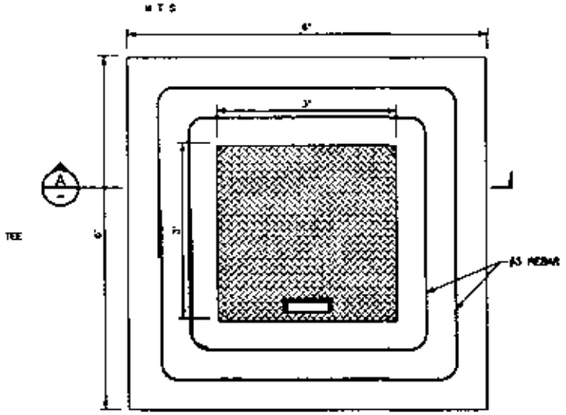
FLUID/VAPOR EXTRACTION WELL
MW-28S
N T S



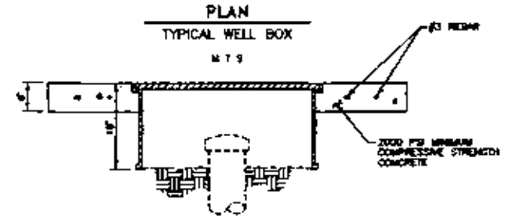
VAPOR EXTRACTION WELL
SBD-2, AEW-1 AND PEW-1
N T S



VAPOR EXTRACTION WELL
PEW-2, PEW-3 AND SBD-3
N T S



PLAN
TYPICAL WELL BOX
N T S



SECTION A
TYPICAL WELL BOX
N T S

Extraction Well	Total Depth in Feet (bgs)	Depth to Pump Inlet	Casing Diameter in Inches	Screen Interval	Fluid and or Vapor
EW-1	95	88	6	65–90	Fluid/Vapor
EW-2	116	100	6	30–65, 105–113	Fluid
EW-4	107.5	95	6	46.5–87, 91.5–94 102–106.5	Fluid/Vapor
EW-5	87	81	6	45–80, 82–94	Fluid
EW-6*	136	130	6	87–117, 126–133	Fluid
EW-7*	105	98	6	80–100	Fluid/Vapor
MW28S	120	110	6	98–118	Fluid/Vapor
PEW-1	74.5	–	6	40–74	Vapor
PEW-2	48.1	–	4	20–45	Vapor
PEW-3	43.8	–	4	10–45	Vapor
AEW-1	43	–	4	12–42	Vapor
SBD-2	48.4	–	4	15–50	Vapor
SBD-3	30.2	–	2	32–85	Vapor

* PROPOSED WELL

REV	DATE	BY	DESCRIPTION

SCALE: AS NOTED

REVIEWED DATE
DRAWN DATE
CHECKED DATE

SUBMITTED
PROJECT ENGINEER R.C.E. NO. DATE
ENGLAND SHAHIN & ASSOCIATES R.C.E. NO. DATE

ENGLAND SHAHIN & ASSOCIATES

APPROVED DATE
APPROVED DATE

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

EXTRACTION WELL DETAILS

SHEET M-8

PANEL SCHEDULE

MOUNTING MCC — PANEL "LA" — MAIN 25A

120/208 VOLTS — 3 PHASE — 4 WIRE — A.I.C. RATING 10,000 — BUS 100A

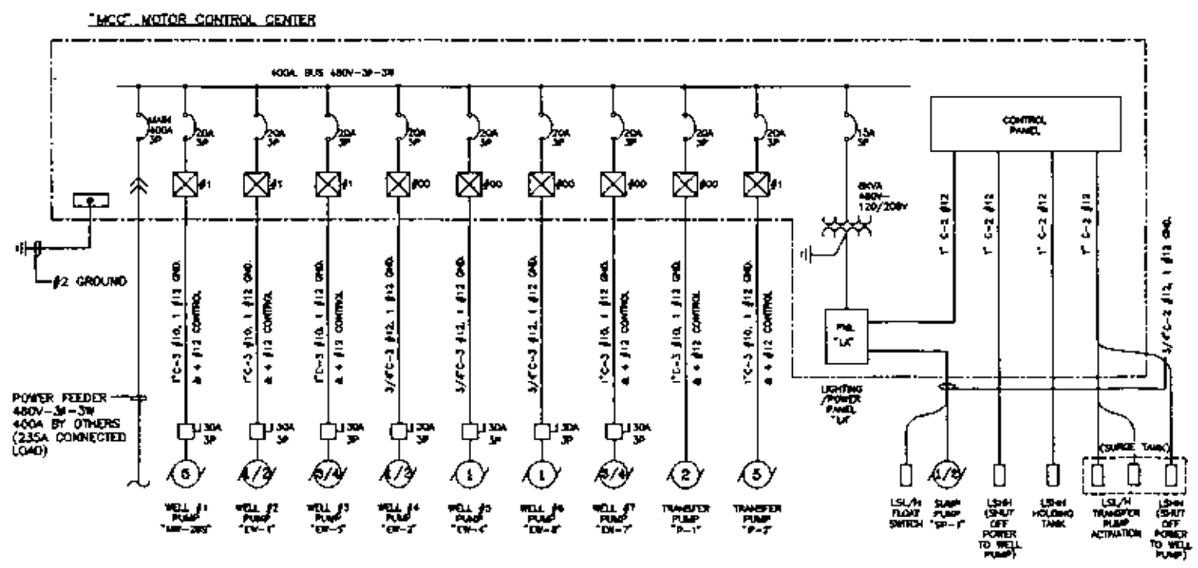
LOCATION	WATTAGE #A	WATTAGE #B	WATTAGE #C	LTG	RECP	MISC	BKR	CIRC			CIRC	BKR	MISC	RECP	LTG	WATTAGE #A	WATTAGE #B	WATTAGE #C	LOCATION
SUMP PUMP	1035			–	–	1	20/1	1			2	20/1	–	–	–				SPARE
CONTROL PANEL		500		–	–	1	20/1	3			4	20/1	–	2	–		350		DSRV. RECPT.
FLOW INSTRUMENT			100	–	–	5	20/1	5			6	20/1	–	2	–			400	AREA LIGHTING
SPARE	–	–	–	–	–	–	–	7			8	20/1	2	–	–	40			PRESSURE, INST.
SPARE	–	–	–	–	–	–	–	9			10	20/1	–	–	–		–		SPARE
SPARE	–	–	–	–	–	–	–	11			12	20/1	–	–	–			–	SPARE
–	–			–	–	–	–	13			14	15/1	–	–	–	–			SPARE
–		–		–	–	–	–	15			16	–	–	–	–		–		SPACE
–			–	–	–	–	–	17			18	–	–	–	–			–	SPACE

WATTS #A = 1075 — #B = 560 — #C = 500

TOTAL WATTS = 2435 — LCL = 2535 — AMPS = 7.0 — LCL = 400 + .25 = 100

HIGH # WATTS = 1075 — HIGH # AMPS = 9.0 — HIGH # LCL = –

SINGLE-LINE DIAGRAM



SOURCE:
CMB ELECTRICAL ENGINEERS, INC.
DWG. 318100

ELECTRICAL SYMBOLS LIST

- POLE MOUNTED H.I.D. AREA LIGHTING FIXTURE.
- STANDARD 20A, 120/277V-1Ø SPST TOGGLE SWITCH MOUNTED AT +48" A.F.F.-U.O.N.
- STANDARD 20A, 120V-1Ø GROUNDED FIRE DAMPER RECEPTACLE MOUNTED AT +24" A.F.F. - U.O.N.
- THERMOMAGNETIC SWITCH, AMPS – VOLTS & POLES AND FUSED OR NON-FUSED AS INDICATED.
- MAGNETIC MOTOR STARTER, NEMA SIZE – VOLTS & POLES AS INDICATED. PROVIDE COMPLETE WITH THERMAL OVERLOAD PROTECTION AND MOTOR NAMEPLATE DATA AND COIL VOLTAGE PER EQUIPMENT CONTROL REQUIREMENTS.
- JUNCTION BOX, SIZED BY THE CONTRACTOR PER ACTUAL NUMBER OF CONDUITS AND / OR CONDUCTORS PASSING THRU.
- MOTOR P.U. OR F.L.A. – VOLTS & PHASE AS INDICATED. VERIFY ELECTRICAL CHARACTERISTICS AND CONNECTION REQUIREMENTS WITH INSTALLED EQUIPMENT MANUFACTURER PRIOR TO ANY ROUGH-IN WORK.
- BRANCH CIRCUIT PANELBOARD, FLUSH OR SURFACE MOUNTED AS INDICATED.
- TRANSFORMER AS SPECIFIED.
- CONDUIT ROUTED EXPOSED ABOVE GRADE, TICK MARKS INDICATE QUANTITY OF #12 THHN / THWN CONDUCTORS – U.O.N. CONDUIT SHOWN WITH NO TICK MARKS INDICATE 3 #12 THHN / THWN CONDUCTORS – U.O.N. CONDUIT SHALL BE 3/4" MINIMUM – U.O.N. INCLUDE CODE SIZED COPPER BOND CONDUCTOR (NOT SHOWN ON PLAN) IN ALL NON-METALLIC CONDUIT RUNS.
- CONDUIT ROUTED UNDERGROUND BELOW FINISHED GRADE, TICK MARKS INDICATE QUANTITY OF #12 THHN / THWN CONDUCTORS – U.O.N. CONDUITS SHOWN WITH NO TICK MARKS INDICATE 3 #12 THHN / THWN CONDUCTORS – U.O.N. CONDUIT SHALL BE 3/4" MINIMUM – U.O.N. INCLUDE CODE SIZED COPPER BOND CONDUCTOR (NOT SHOWN ON PLAN) IN ALL NON-METALLIC CONDUIT RUNS.
- HOMERUN TO DESTINATION AS INDICATED. REFER TO CONDUIT SYMBOL ABOVE.

SCHEMATIC LEGEND

- CIRCUIT BREAKER (AMPERE TRIP RATING AND NUMBER OF POLES)
- POWER TRANSFORMER, RATING AS NOTED.
- GROUND
- HAND-OFF-AUTO SELECTOR SWITCH
- MOMENTARY PUSH BUTTON, NORMALLY OPEN OR CLOSED AS INDICATED.
- CONTROL RELAY COIL
- CONTROL RELAY NORMALLY OPEN CONTACT
- CONTROL RELAY NORMALLY CLOSED CONTACT
- LEVEL SWITCH
- PRESSURE SWITCH
- PILOT LIGHT, LENS COLOR INDICATED BY LETTER IN CENTER. G = GREEN, R = RED.
- TERMINAL IN STARTER CUBICLE, MOTOR CONTROL CENTER.
- LIQUID LEVEL CONTROLLER TERMINAL
- PANEL WIRING
- FIELD WIRING
- CONTROL PANEL TERMINAL BLOCK

GENERAL NOTES & SPECS.

1. PROVIDE ALL MATERIALS AND LABOR AS REQUIRED TO ACHIEVE A COMPLETE AND OPERATING SYSTEM.
2. INSTALL RACEWAY SYSTEMS AS FOLLOWS:
   a. USE ROOD GALVANIZED STEEL IN ALL AREAS EXPOSED TO WEATHER OR PHYSICAL DAMAGE.
   b. USE FLEXIBLE METALLIC CONDUIT, SEAL-TIGHT WHERE INDICATED OR DRAWINGS.
   c. USE P.V.C. CONDUIT UNDERGROUND WITH CODE SIZED GROUND. CONDUIT RISERS AND STUBS ABOVE GRADE SHALL BE E.M.C. WITH HALF-LAPPED TAPE CONSISTING OF P.V.C. COATING.
3. ALL NEW WIRING SHALL BE COPPER WITH TYPE "THWN/THWN" INSULATION – U.O.N.
4. ALL FIXTURE, DEVICE, ETC., LOCATIONS SHALL BE VERIFIED WITH MECHANICAL AND PIPING DRAWINGS AS WELL AS EQUIPMENT SUPPLIER'S REQUIREMENTS PRIOR TO ANY ROUGH-IN WORK.
5. ALL LIGHTING FIXTURES SHALL BE MOUNTED AND SUPPORTED IN ACCORDANCE WITH CBMA STANDARDS AND ALL NATIONAL AND LOCAL ELECTRICAL CODES.
6. THESE DRAWINGS ARE DIAGRAMMATIC AND REPRESENT THE INTENT OF EQUIPMENT, DEVICES, ETC., TO BE CONNECTED AND THE CIRCUITS TO WHICH THEY ARE TO BE CONNECTED. CONTRACTOR SHALL INSTALL ALL CONDUIT, J-BOXES, ETC., AS REQUIRED FOR A COMPLETE AND OPERATING SYSTEM.
7. ALL EXTERIOR EQUIPMENT SHALL BE WEATHERPROOF.
8. CONTRACTOR SHALL PERFORM ALL WORK IN STRICT ACCORDANCE WITH ALL LOCAL AND NATIONAL CONDUIT CODES.
9. ALL EQUIPMENT SHALL BE NEW AND BEAR A "UL" LABEL – U.O.N.
10. ALL EQUIPMENT ELECTRICAL CHARACTERISTICS, LOCATIONS, AND CONNECTION REQUIREMENTS SHALL BE VERIFIED PRIOR TO ANY ROUGH-IN WORK.
11. ELECTRICAL CONTRACTOR SHALL FURNISH THE FOLLOWING SHOP DRAWINGS FOR PRIOR APPROVAL:
    a. LIGHT FIXTURES.
    b. ALL ELECTRICAL MOTOR CONTROL CENTER, CONTROL PANELS AND PANELBOARDS.
    c. OTHER ITEMS AS SPECIFICALLY INDICATED.

    THESE ITEMS SHALL BE APPROVED BY THE OFFICE PRIOR TO ANY COMMENCEMENT OF PLACING ORDERS OR PERFORMING ANY ROUGH-IN WORK.
12. COMPLETE ELECTRICAL SYSTEM SHALL BE GROUNDED IN ACCORDANCE WITH THE PRESENTLY ADOPTED EDITION OF THE N.E.C. ART. 250.
13. PROVIDE ENGRAVED PLASTIC NAMEPLATES FOR ALL MAJOR ELECTRICAL EQUIPMENT.
14. PROVIDE THE OWNER AND THE ENGINEER WITH ONE SET OF ELECTRICAL "AS-BUILT DRAWINGS" AT THE COMPLETION OF JOB.

REFERENCES & ABBREVIATIONS

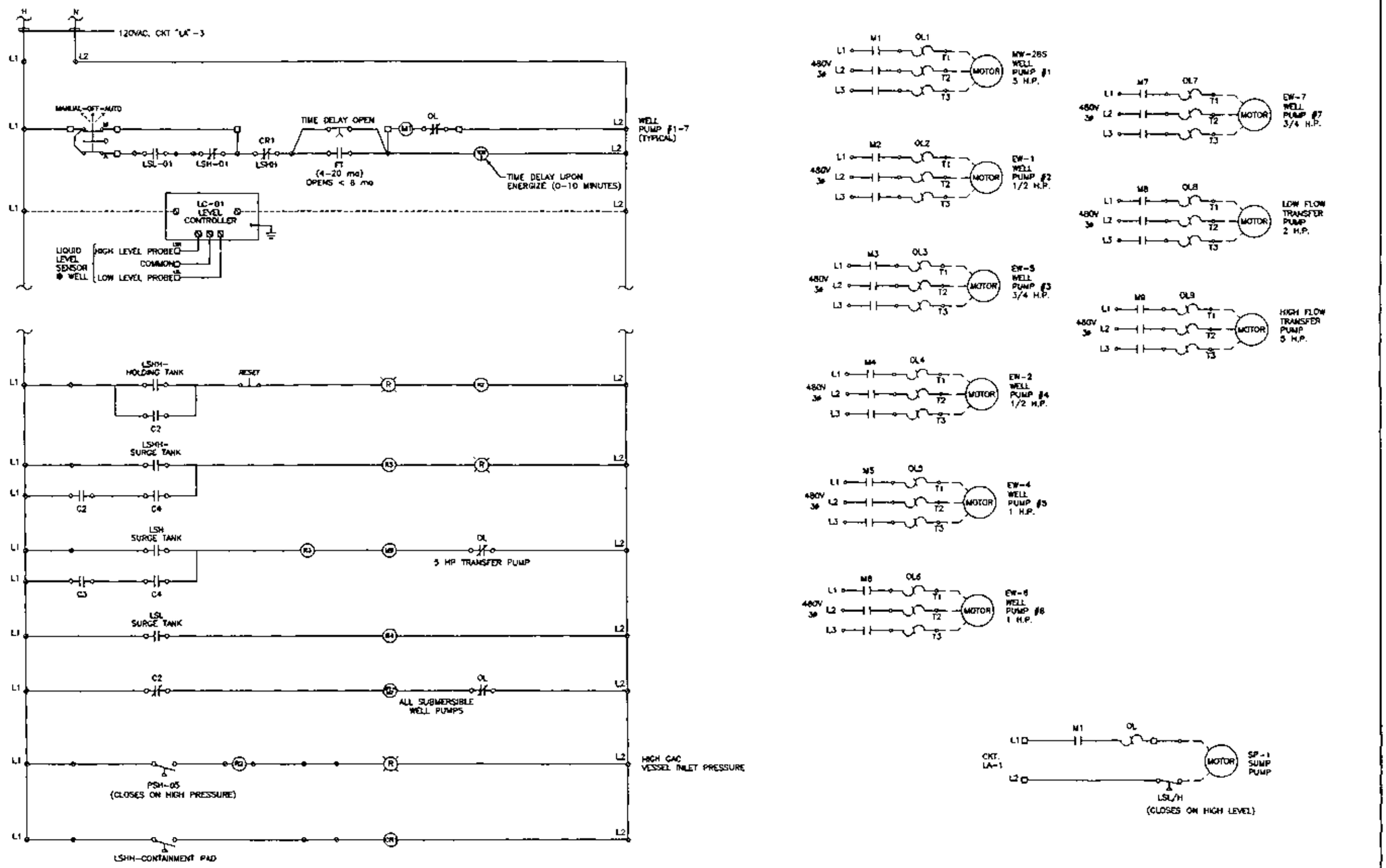
- LIGHTING FIXTURE DESIGNATION
- DETAIL REFERENCE
- REMOTE REFERENCE
- MECHANICAL EQUIPMENT DESIGNATION
- A. AMPERES
- A.I.C. AMPERES INTERRUPTING CAPACITY
- A.F.G. ABOVE FINISH GRADE
- BKR BREAKER
- U.O.N. UNLESS OTHERWISE NOTED
- CIRC CIRCUIT
- C.O. CONDUIT ONLY W/PULL ROPE
- W.P. WEATHER PROOF
- C.U. COPPER
- LCL LONG CONTINUOUS LOAD
- LTG LIGHTING
- M.L.O. MAIN LUGS ONLY
- REC RECEPTACLE
- RGS ROOD GALVANIZED STEEL
- XFMR TRANSFORMER
- M.C.B. MAIN CIRCUIT BREAKER
- F.L.A. FULL LOAD AMPS
- C. CONDUIT
- V. VOLTS
- G.F.I. GROUND FAULT INTERRUPTER
- V.L. VERIFY LOCATION
- A.C. ABOVE COUNTER
- N.L. NIGHT LIGHT
- EM. EMERGENCY
- 2/C 2 CONDUCTOR INSTRUMENT CABLE
- (#) NUMBER INDICATE QUANTITY
- P POLE
- N.F. NON-FUSED
- MCC MOTOR CONTROL CENTER
- TYP TYPICAL
- INSTR. INSTRUMENT
- O.L. OVERLOAD
- TDR TIME DELAY RELAY

REV.	DATE	BY	DESCRIPTION	SCALE AS NOTED	DESIGNED / DRAWN / CHECKED	SUBMITTED / PROJECT ENGINEER / ENGLAND SHAHIN & ASSOCIATES	ENGLAND SHAHIN & ASSOCIATES

APPROVED / APPROVED

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA
SINGLE LINE DIAGRAM, LOAD SCHEDULE AND GENERAL NOTES

SHEET E-1



SOURCE:
OWB ELECTRICAL ENGINEERS, INC.
DWG. 318100

				AS NOTED			ENGLAND SHAHIN & ASSOCIATES	PACIFIC COAST PIPELINE SUPERFUND SITE FILLMORE, CALIFORNIA SCHEMATIC WIRING DIAGRAM	E-2

APPENDIX A

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
AEW-1	10/28/93	10	250	<0.50	<0.50	<0.50	1.4
	10/28/93	20	360	<0.002	0.002	<0.002	0.003
	10/28/93	35	730	<0.004	0.06	<0.004	0.024
	10/28/93	45	80	1.0	0.32	1.0	0.75
	10/28/93	50	170	0.23	0.21	0.50	0.30
	10/28/93	55	16	0.28	<0.10	0.22	0.30
EW-1	04/26/93	40	890	0.27	0.38	0.26	0.71
	04/26/93	50	2000	0.11	0.34	<0.01	0.54
	04/26/93	59.5	170	0.043	0.029	<0.01	0.037
EW-2	05/03/94	11	<1.0	<0.0050	0.0062	<0.0050	<0.015
	05/03/94	25	<1.0	<0.0050	0.0082	<0.0050	<0.015
	05/03/94	35	<1.0	<0.0050	0.0078	<0.0050	<0.015
	05/03/94	45	1500	0.89 J	<0.12	9.1 J	4.7 J
	05/03/94	50	1200	1.1	<0.10	6.0	4.9
	05/03/94	60	<1.0	<0.0050	<0.0050	<0.0050	<0.015
	05/03/94	75	2.0	<0.0050	0.0095	<0.0050	0.018
	05/03/94	100	<1.0	<0.0050	<0.0050	<0.0050	<0.015
	05/03/94	110	<1.0	<0.0050	<0.0050	<0.0050	<0.015
	05/03/94	115	<1.0	<0.0050	<0.0050	<0.0050	<0.015
	05/03/94	120	<1.0	<0.0050	<0.0050	<0.0050	<0.015
	05/03/94	130	<1.0	<0.0050	<0.0050	<0.0050	<0.015
EW-4	05/02/94	5	<1.0	<0.0050	0.0052	<0.0050	<0.015
	05/02/94	15	<1.0	<0.0050	<0.0050	<0.0050	<0.015
	05/02/94	25	1.5 J	<0.0050	0.010	0.0064	<0.015
	05/02/94	35	1.6 J	<0.0050	0.0051	0.0073	<0.015
	05/02/94	45	2800 J	<0.60	<0.60	11	13
	05/02/94	50	4000 J	<0.60	<0.60	21	16
	05/02/94	70	<1.0	<0.0050	<0.0050	<0.0050	<0.015
	05/02/94	85	<1.0	<0.0050	0.0073	<0.0050	<0.015
	05/02/94	95	<1.0	<0.0050	<0.0050	<0.0050	<0.015
	05/02/94	105	<1.0	<0.0050	<0.0050	<0.0050	<0.015
EW-5	05/03/94	10	<1.0	<0.0050	0.012	<0.0050	<0.015
	05/03/94	20	<1.0	<0.0050	0.012	<0.0050	<0.015
	05/03/94	25	1.0 J	<0.0050	<0.0050	<0.0050	<0.015
	05/03/94	35	770 J	0.21 J	0.64 J	2.2 J	1.8 J
	05/03/94	45	<1.0	0.0077	<0.0050	<0.0050	<0.015
	05/03/94	55	1.0	<0.0050	<0.0050	<0.0050	<0.015
	05/03/94	60	450	1.6	<0.10	0.81	4.2
	05/03/94	65	1.7	0.024	<0.0050	0.0091	<0.015
	05/03/94	80	<1.0	<0.0050	0.0084	<0.0050	<0.015
	05/03/94	90	<1.0	<0.0050	<0.0050	<0.0050	<0.015
FSB-1	03/29/88	19	41	0.005	0.012	0.0025	0.0097
FSB-2	03/29/88	36	9500	ND	3.3	14	21
FSB-3	03/30/88	34	2700	ND	2.3	6.1	6.0
FSB-4	03/30/88	30	4100	3.9	ND	12	13
FSB-5	03/31/88	29	84000	94	140	130	580
	03/31/88	49	58	0.020	0.016	0.014	0.037
FSB-6	03/31/88	31	74	0.056	0.073	0.018	0.058

ENGLAND
SHAHIN &
ASSOCIATES

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
FSB-7	03/31/88	30	150	0.026	0.035	0.007	0.042
MW-18S	09/06/90	45	1500	NA	NA	NA	NA
	09/06/90	50	860	NA	NA	NA	NA
MW-19S	08/20/90	35	200	NA	NA	NA	NA
	08/20/90	38	190	NA	NA	NA	NA
	08/20/90	40	740	NA	NA	NA	NA
	08/20/90	45	40	NA	NA	NA	NA
	08/20/90	50	2500	NA	NA	NA	NA
	08/20/90	55	290	NA	NA	NA	NA
	08/20/90	60	140	NA	NA	NA	NA
MW-20S	08/27/90	60	270	NA	NA	NA	NA
	08/27/90	65	<10	NA	NA	NA	NA
	08/27/90	70	130	NA	NA	NA	NA
	08/27/90	73	340	NA	NA	NA	NA
	08/27/90	75	<10	NA	NA	NA	NA
	08/27/90	80	<10	NA	NA	NA	NA
	08/27/90	85	<10	NA	NA	NA	NA
MW-21S	09/04/90	60	<10	NA	NA	NA	NA
	09/04/90	65	<10	NA	NA	NA	NA
	09/04/90	68	<10	NA	NA	NA	NA
	09/04/90	70	<10	NA	NA	NA	NA
	09/04/90	80	<10	NA	NA	NA	NA
MW-22S	07/27/90	40	<10	NA	NA	NA	NA
	07/27/90	50	<10	NA	NA	NA	NA
	07/27/90	65	<10	NA	NA	NA	NA
	07/27/90	70	<10	NA	NA	NA	NA
	07/27/90	75	<10	NA	NA	NA	NA
	07/27/90	80	<10	NA	NA	NA	NA
	07/27/90	85	<10	NA	NA	NA	NA
	07/27/90	90	<10	NA	NA	NA	NA
	07/27/90	95	<10	NA	NA	NA	NA
	07/27/90	100	<10	NA	NA	NA	NA
	07/27/90	105	<10	NA	NA	NA	NA
	07/27/90	110	<10	NA	NA	NA	NA
	07/27/90	115	<10	NA	NA	NA	NA
	07/27/90	118	<10	NA	NA	NA	NA
	07/27/90	120	<10	NA	NA	NA	NA
	07/27/90	125	<10	NA	NA	NA	NA
	07/27/90	128	<10	NA	NA	NA	NA
MW-23D	07/27/90	63	<10	NA	NA	NA	NA
	07/27/90	65	<10	NA	NA	NA	NA
	07/27/90	75	<10	NA	NA	NA	NA
	07/27/90	80	<10	NA	NA	NA	NA
	07/27/90	85	<10	NA	NA	NA	NA
	07/27/90	90	<10	NA	NA	NA	NA
	07/27/90	93	<10	NA	NA	NA	NA
	07/27/90	95	<10	NA	NA	NA	NA
	07/27/90	100	<10	NA	NA	NA	NA
	07/27/90	110	<10	NA	NA	NA	NA
	07/27/90	115	<10	NA	NA	NA	NA
	07/27/90	130	<10	NA	NA	NA	NA

ENGLAND
SHAHIN &
ASSOCIATES

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
MW-23D (Cont'd)							
	07/30/90	40	<10	NA	NA	NA	NA
	07/30/90	45	<10	NA	NA	NA	NA
	07/30/90	55	30	NA	NA	NA	NA
	07/30/90	60	<10	NA	NA	NA	NA
MW-24D	07/23/90	30	<10	NA	NA	NA	NA
MW-25D	08/02/90	5	2000	NA	NA	NA	NA
	08/02/90	10	2600	NA	NA	NA	NA
	08/02/90	15	2500	NA	NA	NA	NA
	08/02/90	20	1100	NA	NA	NA	NA
	08/02/90	23	1900	NA	NA	NA	NA
	08/02/90	25	1400	NA	NA	NA	NA
	08/02/90	30	1600	NA	NA	NA	NA
	08/02/90	33	2400	NA	NA	NA	NA
	08/02/90	35	2500	NA	NA	NA	NA
	08/02/90	40	1400	NA	NA	NA	NA
	08/02/90	45	440	NA	NA	NA	NA
	08/02/90	50	180	NA	NA	NA	NA
	08/02/90	55	60	NA	NA	NA	NA
	08/02/90	60	110	NA	NA	NA	NA
	08/02/90	65	80	NA	NA	NA	NA
	08/02/90	70	44	NA	NA	NA	NA
	08/02/90	75	1600	NA	NA	NA	NA
	08/02/90	80	160	NA	NA	NA	NA
	08/02/90	85	<10	NA	NA	NA	NA
	08/02/90	90	<10	NA	NA	NA	NA
MW-25S	07/30/90	10	1700	NA	NA	NA	NA
	07/30/90	25	3000	NA	NA	NA	NA
	07/30/90	40	180	NA	NA	NA	NA
	07/30/90	55	840	NA	NA	NA	NA
	07/30/90	58	720	NA	NA	NA	NA
	07/30/90	60	<10	NA	NA	NA	NA
	07/30/90	70	490	NA	NA	NA	NA
	07/30/90	80	<10	NA	NA	NA	NA
	07/30/90	85	11	NA	NA	NA	NA
	07/30/90	95	<10	NA	NA	NA	NA
MW-37S	04/15/93	5	<1	NA	NA	NA	NA
	04/15/93	25	3.1	NA	NA	NA	NA
	04/15/93	30	<1	NA	NA	NA	NA
	04/15/93	35	3900	<0.02	<0.02	<0.02	<0.02
	04/15/93	45	890	0.027	0.049	<0.01	0.073
	04/15/93	45D	480	NA	NA	NA	NA
	04/15/93	46	7.2	NA	NA	NA	NA
	04/15/93	50	1100	0.54	0.63	2.0	2.1
	04/15/93	60	2.0	0.11	0.017	0.12	0.07
	04/15/93	70	7.7	NA	NA	NA	NA
	04/15/93	75	8.3	NA	NA	NA	NA
	04/15/93	80	190	NA	NA	NA	NA
	04/15/93	85	1500	<0.01	<0.01	<0.01	0.028
	04/15/93	90	730	NA	NA	NA	NA
	04/15/93	95	490	<0.10	<0.10	<0.10	<0.10
	04/15/93	95D	250	NA	NA	NA	NA
MW-38S	04/29/93	5	<1	<0.002	<0.002	<0.002	<0.002

ENGLAND SHAHIN & ASSOCIATES

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
MW-38S (Cont'd)							
	04/29/93	15	74	NA	NA	NA	NA
	04/29/93	20	190	NA	NA	NA	NA
	04/29/93	25	3500	NA	NA	NA	NA
	04/29/93	30	830	0.023	0.15	0.12	0.11
	04/29/93	300	2500	NA	NA	NA	NA
	04/29/93	35	3200	<0.25	<0.25	<0.25	2.10
	04/29/93	40	5800	<0.40	<0.40	<0.40	12.0
	04/29/93	45	1400	0.41	4.00	<0.40	<0.40
	04/29/93	50	120	0.29	0.044	0.087	0.029
	04/29/93	65	25	NA	NA	NA	NA
	04/29/93	70	1.1	0.018	0.007	0.005	0.023
	04/29/93	75	4.0	NA	NA	NA	NA
	04/29/93	85	<1	<0.002	<0.002	<0.002	<0.002
MW-39S	10/19/93	40	2.6	<0.050	<0.050	<0.050	<0.050
	10/19/93	50	3.3	<0.002	<0.002	<0.002	<0.002
	10/19/93	51	3.9	0.071	0.12	<0.050	<0.050
	10/19/93	55	10	<0.5	<0.5	<0.5	<0.5
	10/19/93	65	3200	<2.0	<2.0	<2.0	<2.0
	10/19/93	75	410	<0.5	<0.5	<0.5	<0.5
	10/19/93	85	<1.0	<0.050	<.0.050	<0.050	<0.050
MW-40S	10/18/93	30	160	<0.10	0.18	0.36	0.54
	10/18/93	35	810	<0.02	<0.02	<0.02	<0.02
	10/18/93	40	1600	<0.5	<0.5	<0.5	<0.5
	10/18/93	45	780	NA	NA	NA	NA
	10/18/93	65	9.7	0.16	<0.02	<0.02	<0.02
	10/18/93	70	<1.0	<0.050	<0.050	<0.050	<0.050
MW-41S	10/20/93	40	<1.0	<0.050	<0.050	<0.050	<0.050
	10/20/93	45	2.2	<0.050	<0.050	<0.050	<0.050
	10/20/93	50	580	<0.02	<0.02	<0.02	0.045
	10/20/93	55	850	<0.02	<0.02	<0.02	<0.02
	10/20/93	63	2.0	<0.050	<0.050	<0.050	<0.050
	10/20/93	75	<1.0	<0.050	<0.050	<0.050	<0.050
	10/20/93	85	1.2	<0.050	<0.050	<0.050	<0.050
MW-42S	10/22/93	40	<1.0	<0.050	<0.050	<0.050	<0.050
	10/22/93	45	<1.0	<0.050	<0.050	<0.050	<0.050
	10/22/93	50	<1.0	<0.050	<0.050	<0.050	<0.050
	10/22/93	70	<1.0	<0.050	<0.050	<0.050	<0.050
	10/22/93	85	<1.0	<0.050	<0.050	<0.050	<0.050
	10/22/93	95	6.1	<0.050	<0.050	<0.050	<0.050
	10/22/93	105	<1.0	<0.050	<0.050	<0.050	<0.050
MW-43S	05/10/94	25	<1.0	<0.005	0.0055	<0.005	<0.015
	05/10/94	40	<1.0	<0.005	<0.005	<0.005	<0.015
	05/10/94	50	180 J	0.36	0.29	0.46	0.73
	05/10/94	62.5	<1.0	<0.005	0.0081	<0.005	<0.015
	05/10/94	72.5	<1.0	0.010	<0.005	<0.005	<0.015
	05/10/94	77.5	<1.0	<0.005	0.0057	<0.005	<0.15
	05/10/94	85	<1.0	<0.005	<0.005	<0.005	<0.015
	05/10/94	95	<1.0	<0.005	<0.005	<0.005	<0.015
	05/10/94	100	<1.0	<0.005	<0.005	<0.005	<0.015
MW-44S	05/17/94	70	<1.0	<0.0050	<0.0050	<0.0050	<0.015

ENGLAND
SHAHM &
ASSOCIATES

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
MW-45S	05/09/94	10	<1.0	<0.0050	0.092	<0.0050	<0.015
	05/09/94	25	<1.0	<0.0050	0.010	<0.0050	<0.015
	05/09/94	35	<1.0	<0.0050	0.0099	<0.0050	<0.015
	05/09/94	45	1.2	0.021	<0.0050	<0.0050	<0.015
	05/09/94	55	1.8	<0.0050	0.013	0.0076	<0.015
	05/09/94	67.5	<1.0	0.013	0.013	<0.0050	<0.015
	05/09/94	77.5	1.6	0.013	0.012	0.0089	<0.015
	05/09/94	90	<1.0	<0.0050	<0.0050	<0.0050	<0.015
	05/09/94	95	<1.0	<0.0050	0.0072	<0.0050	<0.015
MW-46S	05/11/94	10	<1.0	<0.005	0.073	<0.005	<0.015
	05/11/94	35	<1.0	<0.005	0.024	<0.005	<0.015
	05/11/94	45	2.1	<0.005	0.0077	0.023	0.041
	05/11/94	55	94	<0.030	0.084	0.23	0.74
	05/11/94	60	<1.0	<0.005	<0.005	<0.005	<0.015
	05/11/94	70	<1.0	<0.005	<0.005	<0.005	<0.015
	05/11/94	80	<1.0	0.0072	<0.005	<0.005	<0.015
	05/11/94	90	<1.0	<0.005	<0.005	<0.005	<0.015
	05/11/94	100	<1.0	<0.005	0.013	<0.005	<0.015
MW-47D	05/12/94	5	1800	0.24	3.1	17	16
	05/12/94	15	1900	0.89 J	7.9 J	18 J	18 J
	05/12/94	25	2900	<0.50	6.2 J	25 J	12 J
	05/12/94	40	1800	<0.38	5.2	8.4	9.3
	05/12/94	47.5	460	<0.15	0.29	1.8	1.8
	05/12/94	57.5	1100	0.30 J	0.84 J	0.63 J	3.5 J
	05/12/94	67.5	1200	0.22 J	0.90 J	1.3 J	15 J
	05/12/94	77.5	590	1.3 J	0.43 J	<0.15	<0.45
	05/12/94	87.5	<1.0	<0.0050	<0.0050	<0.0050	<0.015
	05/12/94	97.5	<1.0	<0.0050	<0.0050	<0.0050	<0.015
	05/12/94	107.5	1.2	<0.0050	<0.0050	<0.0050	<0.015
	05/12/94	117.5	<1.0	<0.0050	<0.0050	<0.0050	<0.015
	05/12/94	127.5	<1.0	<0.0050	<0.0050	<0.0050	<0.015
MWP-BH-1	07/23/90	10	320	NA	NA	NA	NA
	07/23/90	15	780	NA	NA	NA	NA
	07/23/90	20	2100	NA	NA	NA	NA
	07/23/90	25	1900	NA	NA	NA	NA
	07/23/90	30	3800	NA	NA	NA	NA
	07/23/90	33	1300	NA	NA	NA	NA
	07/23/90	35	430	NA	NA	NA	NA
	07/23/90	40	1800	NA	NA	NA	NA
	07/23/90	43	2700	NA	NA	NA	NA
	07/23/90	45	670	NA	NA	NA	NA
	07/23/90	50	<10	NA	NA	NA	NA
	07/23/90	55	<10	NA	NA	NA	NA
	07/23/90	60	<10	NA	NA	NA	NA
	07/23/90	65	<10	NA	NA	NA	NA
	07/23/90	70	<10	NA	NA	NA	NA
	07/23/90	75	<10	NA	NA	NA	NA
	07/23/90	80	<10	NA	NA	NA	NA
	07/23/90	85	120	NA	NA	NA	NA
	07/23/90	90	40	NA	NA	NA	NA
MWP-BH-10	08/17/90	5	<10	NA	NA	NA	NA
	08/17/90	10	<10	NA	NA	NA	NA
	08/17/90	15	<10	NA	NA	NA	NA

ENGLAND
SHAHIN &
ASSOCIATES

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
MWP-BH-10 (Cont'd)							
	08/17/90	20	<10	NA	NA	NA	NA
	08/17/90	25	<10	NA	NA	NA	NA
	08/17/90	30	<10	NA	NA	NA	NA
	08/17/90	35	<10	NA	NA	NA	NA
	08/17/90	40	<10	<0.025	0.019	<0.025	<0.025
	08/17/90	45	12	NA	NA	NA	NA
	08/17/90	50	42	<0.025	0.0085	<0.025	<0.025
	08/17/90	55	34	NA	NA	NA	NA
	08/17/90	60	<10	NA	NA	NA	NA
	08/17/90	63	<10	NA	NA	NA	NA
	08/17/90	65	<10	NA	NA	NA	NA
	08/17/90	68	<10	NA	NA	NA	NA
	08/17/90	70	<10	NA	NA	NA	NA
	08/17/90	75	<10	<0.005	0.022	0.0012	<0.015
	08/17/90	80	<10	NA	NA	NA	NA
MWP-BH-11	08/08/90	5	<10	NA	NA	NA	NA
	08/08/90	10	<10	NA	NA	NA	NA
	08/08/90	15	<10	NA	NA	NA	NA
	08/08/90	20	<10	NA	NA	NA	NA
	08/08/90	25	<10	NA	NA	NA	NA
	08/08/90	30	<10	NA	NA	NA	NA
	08/08/90	35	63	NA	NA	NA	NA
	08/08/90	40	150	NA	NA	NA	NA
	08/08/90	45	300	NA	NA	NA	NA
	08/08/90	48	87	NA	NA	NA	NA
	08/08/90	50	1000	NA	NA	NA	NA
	08/08/90	55	170	NA	NA	NA	NA
	08/08/90	58	130	NA	NA	NA	NA
	08/08/90	60	<10	NA	NA	NA	NA
	08/08/90	65	<10	NA	NA	NA	NA
	08/08/90	70	13	NA	NA	NA	NA
	08/08/90	75	<10	NA	NA	NA	NA
	08/08/90	80	<10	NA	NA	NA	NA
	08/08/90	85	<10	NA	NA	NA	NA
	08/08/90	90	<10	NA	NA	NA	NA
MWP-BH-12	08/23/90	5	<10	NA	NA	NA	NA
	08/23/90	10	<10	NA	NA	NA	NA
	08/23/90	15	380	NA	NA	NA	NA
	08/23/90	20	2300	NA	NA	NA	NA
	08/23/90	25	710	NA	NA	NA	NA
	08/23/90	30	5000	NA	NA	NA	NA
	08/23/90	35	2100	NA	NA	NA	NA
	08/23/90	38	3100	NA	NA	NA	NA
	08/23/90	40	490	NA	NA	NA	NA
	08/23/90	45	130	NA	NA	NA	NA
	08/23/90	50	170	NA	NA	NA	NA
	08/23/90	53	1400	NA	NA	NA	NA
	08/23/90	55	1200	NA	NA	NA	NA
	08/23/90	60	<10	NA	NA	NA	NA
	08/23/90	65	<10	NA	NA	NA	NA
	08/23/90	70	13	NA	NA	NA	NA
	08/23/90	75	<10	NA	NA	NA	NA
	08/23/90	80	<10	NA	NA	NA	NA
	08/23/90	85	53	NA	NA	NA	NA

ENGLAND
SHAHIN &
ASSOCIATES

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
MWP-BH-12 (Cont'd)							
	08/23/90	88	51	NA	NA	NA	NA
	08/23/90	90	750	NA	NA	NA	NA
	08/23/90	95	180	NA	NA	NA	NA
	08/23/90	100	610	NA	NA	NA	NA
	08/23/90	105	<10	NA	NA	NA	NA
MWP-BH-13	08/29/90	5	<10	NA	NA	NA	NA
	08/29/90	10	<10	NA	NA	NA	NA
	08/29/90	15	<10	NA	NA	NA	NA
	08/29/90	20	<10	NA	NA	NA	NA
	08/29/90	25	<10	NA	NA	NA	NA
	08/29/90	30	<10	NA	NA	NA	NA
	08/29/90	33	<10	NA	NA	NA	NA
	08/29/90	35	<10	NA	NA	NA	NA
	08/29/90	40	<10	NA	NA	NA	NA
	08/29/90	45	95	NA	NA	NA	NA
	08/29/90	50	<10	NA	NA	NA	NA
	08/29/90	55	<10	NA	NA	NA	NA
	08/29/90	58	<30	NA	NA	NA	NA
	08/29/90	60	<10	NA	NA	NA	NA
	08/29/90	65	<10	0.0013	0.016	0.052	0.080
	08/29/90	70	<10	NA	NA	NA	NA
MWP-BH-14	09/06/90	5	<10	NA	NA	NA	NA
	09/06/90	10	<10	NA	NA	NA	NA
	09/06/90	15	<10	NA	NA	NA	NA
	09/06/90	20	1000	NA	NA	NA	NA
	09/06/90	25	670	NA	NA	NA	NA
	09/06/90	30	960	NA	NA	NA	NA
	09/06/90	33	840	NA	NA	NA	NA
	09/06/90	35	250	NA	NA	NA	NA
	09/06/90	40	380	NA	NA	NA	NA
	09/06/90	45	460	NA	NA	NA	NA
	09/06/90	50	<10	NA	NA	NA	NA
	09/06/90	55	1200	NA	NA	NA	NA
	09/06/90	60	410	<0.025	0.0094	0.079	0.081
	09/06/90	65	<10	NA	NA	NA	NA
	09/06/90	68	<10	NA	NA	NA	NA
	09/06/90	70	<10	NA	NA	NA	NA
	09/06/90	75	<10	NA	NA	NA	NA
	09/06/90	80	<10	NA	NA	NA	NA
	09/06/90	85	<10	NA	NA	NA	NA
MWP-BH-2	07/31/90	5	13000	NA	NA	NA	NA
	07/31/90	10	2800	NA	NA	NA	NA
	07/31/90	15	7300	NA	NA	NA	NA
	07/31/90	20	6100	NA	NA	NA	NA
	07/31/90	25	4400	NA	NA	NA	NA
	07/31/90	30	250	NA	NA	NA	NA
	07/31/90	38	420	NA	NA	NA	NA
	07/31/90	40	1900	NA	NA	NA	NA
	07/31/90	45	1500	NA	NA	NA	NA
	07/31/90	50	5300	NA	NA	NA	NA
MWP-BH-3	07/30/90	5	3500	NA	NA	NA	NA
	07/30/90	10	3800	NA	NA	NA	NA

ENGLAND SHAHIN & ASSOCIATES

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
MWP-BH-3 (Cont'd)							
	07/30/90	13	4100	NA	NA	NA	NA
	07/30/90	15	80	NA	NA	NA	NA
	07/30/90	20	520	NA	NA	NA	NA
	07/30/90	23	120	NA	NA	NA	NA
	07/30/90	25	3900	NA	NA	NA	NA
	07/30/90	30	3100	NA	NA	NA	NA
	07/30/90	35	5100	NA	NA	NA	NA
	07/30/90	40	<10	NA	NA	NA	NA
	07/30/90	45	<10	NA	NA	NA	NA
	07/30/90	50	<10	NA	NA	NA	NA
	07/30/90	65	<10	NA	NA	NA	NA
	07/30/90	70	<10	NA	NA	NA	NA
	07/30/90	75	<10	NA	NA	NA	NA
	07/30/90	80	<10	NA	NA	NA	NA
	07/30/90	85	<10	NA	NA	NA	NA
	07/30/90	90	380	NA	NA	NA	NA
	07/30/90	95	<10	NA	NA	NA	NA
MWP-BH-4	07/26/90	10	990	NA	NA	NA	NA
	07/26/90	15	1900	NA	NA	NA	NA
	07/26/90	20	2100	NA	NA	NA	NA
	07/26/90	23	1200	NA	NA	NA	NA
	07/26/90	25	<10	NA	NA	NA	NA
	07/26/90	30	1800	NA	NA	NA	NA
	07/26/90	35	500	NA	NA	NA	NA
	07/26/90	40	320	NA	NA	NA	NA
	07/26/90	45	<10	NA	NA	NA	NA
	07/26/90	50	<10	NA	NA	NA	NA
	07/26/90	48	7100	NA	NA	NA	NA
	07/26/90	55	<10	NA	NA	NA	NA
	07/26/90	60	<10	NA	NA	NA	NA
	07/26/90	65	<10	NA	NA	NA	NA
	07/26/90	70	<10	NA	NA	NA	NA
	07/26/90	75	<10	NA	NA	NA	NA
	07/26/90	80	<10	NA	NA	NA	NA
	07/26/90	85	60	NA	NA	NA	NA
	07/26/90	90	30	NA	NA	NA	NA
	07/26/90	95	<10	NA	NA	NA	NA
MWP-BH-5	08/07/90	5	<10	NA	NA	NA	NA
	08/07/90	10	690	NA	NA	NA	NA
	08/07/90	15	<10	NA	NA	NA	NA
	08/07/90	20	<10	NA	NA	NA	NA
	08/07/90	25	<10	NA	NA	NA	NA
	08/07/90	30	<10	NA	NA	NA	NA
	08/07/90	35	2300	NA	NA	NA	NA
	08/07/90	38	91	NA	NA	NA	NA
	08/07/90	40	2400	NA	NA	NA	NA
	08/07/90	45	2100	NA	NA	NA	NA
	08/07/90	50	<10	NA	NA	NA	NA
MWP-BH-6	08/21/90	10	<10	NA	NA	NA	NA
	08/21/90	15	1700	NA	NA	NA	NA
	08/21/90	20	360	NA	NA	NA	NA
	08/21/90	25	<10	NA	NA	NA	NA
	08/21/90	30	<10	NA	NA	NA	NA

ENGLAND SHAHIN & ASSOCIATES

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
MWP-BH-6 (Cont'd)							
	08/21/90	35	1300	NA	NA	NA	NA
	08/21/90	38	94	NA	NA	NA	NA
	08/21/90	40	1300	NA	NA	NA	NA
	08/21/90	45	<10	NA	NA	NA	NA
	08/21/90	50	670	NA	NA	NA	NA
	08/21/90	55	<10	NA	NA	NA	NA
	08/21/90	58	<10	NA	NA	NA	NA
	08/21/90	60	<10	NA	NA	NA	NA
	08/21/90	65	<10	NA	NA	NA	NA
	08/21/90	70	<10	NA	NA	NA	NA
	08/21/90	75	150	NA	NA	NA	NA
	08/21/90	80	25	NA	NA	NA	NA
	08/21/90	85	47	NA	NA	NA	NA
	08/21/90	90	85	NA	NA	NA	NA
	08/21/90	95	<10	NA	NA	NA	NA
MWP-BH-7	08/16/90	5	<10	NA	NA	NA	NA
	08/16/90	10	<20	NA	NA	NA	NA
	08/16/90	15	<10	NA	NA	NA	NA
	08/16/90	20	<10	NA	NA	NA	NA
	08/16/90	30	<10	NA	NA	NA	NA
	08/16/90	35	<10	NA	NA	NA	NA
	08/16/90	40	<10	NA	NA	NA	NA
	08/16/90	45	<10	NA	NA	NA	NA
	08/16/90	50	99	NA	NA	NA	NA
	08/16/90	53	3400	NA	NA	NA	NA
	08/16/90	55	<10	NA	NA	NA	NA
	08/16/90	58	<10	NA	NA	NA	NA
	08/16/90	60	<10	NA	NA	NA	NA
	08/16/90	65	<10	NA	NA	NA	NA
	08/16/90	70	<10	NA	NA	NA	NA
	08/16/90	75	<10	NA	NA	NA	NA
MWP-BH-8	08/01/90	5	<10	NA	NA	NA	NA
	08/01/90	10	1000	NA	NA	NA	NA
	08/01/90	13	5100	NA	NA	NA	NA
	08/01/90	15	4700	NA	NA	NA	NA
	08/01/90	20	2500	NA	NA	NA	NA
	08/01/90	25	2000	NA	NA	NA	NA
	08/01/90	30	1200	NA	NA	NA	NA
	08/01/90	35	41	NA	NA	NA	NA
	08/01/90	40	610	NA	NA	NA	NA
	08/01/90	45	690	NA	NA	NA	NA
	08/01/90	50	400	NA	NA	NA	NA
	08/01/90	53	410	NA	NA	NA	NA
	08/01/90	55	620	NA	NA	NA	NA
	08/01/90	60	260	NA	NA	NA	NA
	08/01/90	65	<10	NA	NA	NA	NA
	08/01/90	70	<10	NA	NA	NA	NA
	08/01/90	75	<10	NA	NA	NA	NA
	08/01/90	85	<10	NA	NA	NA	NA
	08/01/90	90	<10	NA	NA	NA	NA
	08/01/90	95	<10	NA	NA	NA	NA
	08/01/90	105	<10	NA	NA	NA	NA
	08/01/90	110	<10	NA	NA	NA	NA
	08/01/90	113	<10	NA	NA	NA	NA

ENGLAND
SHAHIN &
ASSOCIATES

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
MWP-BH-8 (Cont'd)							
	08/01/90	115	<10	NA	NA	NA	NA
	08/01/90	120	<10	NA	NA	NA	NA
	08/01/90	125	<10	NA	NA	NA	NA
MWP-BH-9	08/09/90	5	<10	NA	NA	NA	NA
	08/09/90	10	<20	NA	NA	NA	NA
	08/09/90	15	1000	NA	NA	NA	NA
	08/09/90	20	430	NA	NA	NA	NA
	08/09/90	23	1100	NA	NA	NA	NA
	08/09/90	25	<10	NA	NA	NA	NA
	08/09/90	30	20	NA	NA	NA	NA
	08/09/90	35	230	NA	NA	NA	NA
	08/09/90	38	<10	NA	NA	NA	NA
	08/09/90	40	1400	NA	NA	NA	NA
	08/09/90	45	68	NA	NA	NA	NA
	08/09/90	50	2000	NA	NA	NA	NA
	08/09/90	55	240	NA	NA	NA	NA
	08/09/90	60	<10	NA	NA	NA	NA
	08/09/90	65	<10	NA	NA	NA	NA
	08/09/90	70	<10	NA	NA	NA	NA
	08/09/90	75	<10	NA	NA	NA	NA
	08/09/90	80	<10	NA	NA	NA	NA
	08/09/90	85	<10	NA	NA	NA	NA
	08/09/90	90	<10	NA	NA	NA	NA
P1-BH-1	08/01/90	5	40	NA	NA	NA	NA
	08/01/90	10	44	NA	NA	NA	NA
	08/01/90	15	<10	NA	NA	NA	NA
	08/01/90	20	<10	NA	NA	NA	NA
	08/01/90	25	<10	NA	NA	NA	NA
	08/01/90	28	<10	NA	NA	NA	NA
	08/01/90	30	<10	NA	NA	NA	NA
	08/01/90	35	<10	NA	NA	NA	NA
	08/01/90	40	<10	NA	NA	NA	NA
P1-BH-2	08/01/90	5	<10	NA	NA	NA	NA
	08/01/90	10	<10	NA	NA	NA	NA
	08/01/90	13	<10	NA	NA	NA	NA
	08/01/90	15	<10	NA	NA	NA	NA
	08/01/90	20	<10	NA	NA	NA	NA
	08/01/90	25	<10	NA	NA	NA	NA
	08/01/90	30	<10	NA	NA	NA	NA
	08/01/90	35	<10	NA	NA	NA	NA
	08/01/90	40	<10	NA	NA	NA	NA
P2-BH-1	08/13/90	5	17	NA	NA	NA	NA
	08/13/90	10	<10	NA	NA	NA	NA
	08/13/90	15	<10	NA	NA	NA	NA
	08/13/90	20	<10	NA	NA	NA	NA
	08/13/90	25	740	NA	NA	NA	NA
	08/13/90	30	960	NA	NA	NA	NA
	08/13/90	35	1500	NA	NA	NA	NA
	08/13/90	40	240	NA	NA	NA	NA
	08/13/90	43	91	NA	NA	NA	NA
	08/13/90	45	<10	NA	NA	NA	NA
	08/13/90	48	<10	NA	NA	NA	NA

ENGLAND
SHAHIN &
ASSOCIATES

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
P2-BH-1 (Cont'd)							
	08/13/90	50	70	NA	NA	NA	NA
	08/13/90	55	28	NA	NA	NA	NA
	08/13/90	60	<10	NA	NA	NA	NA
	08/13/90	65	<10	NA	NA	NA	NA
P2-BH-2	08/14/90	5	<10	NA	NA	NA	NA
	08/14/90	10	<10	NA	NA	NA	NA
	08/14/90	15	<10	NA	NA	NA	NA
	08/14/90	20	100	NA	NA	NA	NA
	08/14/90	25	7100	NA	NA	NA	NA
	08/14/90	30	2400	NA	NA	NA	NA
	08/14/90	35	2200	NA	NA	NA	NA
	08/14/90	40	510	NA	NA	NA	NA
	08/14/90	43	1400	NA	NA	NA	NA
	08/14/90	45	<10	NA	NA	NA	NA
	08/14/90	50	860	NA	NA	NA	NA
	08/14/90	55	620	NA	NA	NA	NA
	08/14/90	58	410	NA	NA	NA	NA
	08/14/90	60	160	NA	NA	NA	NA
	08/14/90	65	<10	NA	NA	NA	NA
P3-BH-1	08/14/90	5	<10	NA	NA	NA	NA
	08/14/90	10	3200	NA	NA	NA	NA
	08/14/90	15	5300	NA	NA	NA	NA
	08/14/90	18	4900	NA	NA	NA	NA
	08/14/90	20	3500	NA	NA	NA	NA
	08/14/90	25	2900	NA	NA	NA	NA
	08/14/90	30	11000	NA	NA	NA	NA
	08/14/90	35	410	NA	NA	NA	NA
	08/14/90	40	52	NA	NA	NA	NA
	08/14/90	45	410	NA	NA	NA	NA
P3-BH-2	08/17/90	5	300	NA	NA	NA	NA
	08/17/90	10	2100	NA	NA	NA	NA
	08/17/90	15	680	NA	NA	NA	NA
	08/17/90	18	6500	NA	NA	NA	NA
	08/17/90	20	1400	NA	NA	NA	NA
	08/17/90	25	2000	NA	NA	NA	NA
	08/17/90	30	70	NA	NA	NA	NA
	08/17/90	35	2700	NA	NA	NA	NA
	08/17/90	40	1100	NA	NA	NA	NA
	08/17/90	45	1900	NA	NA	NA	NA
	08/17/90	48	40	NA	NA	NA	NA
	08/17/90	50	1500	NA	NA	NA	NA
	08/17/90	55	12	NA	NA	NA	NA
	08/17/90	65	13000	NA	NA	NA	NA
	08/17/90	70	29	NA	NA	NA	NA
	08/17/90	75	400	NA	NA	NA	NA
	08/17/90	80	320	NA	NA	NA	NA
P3-BH-3	08/01/90	5	1300	NA	NA	NA	NA
	08/01/90	10	<10	NA	NA	NA	NA
	08/01/90	15	<10	NA	NA	NA	NA
	08/01/90	20	580	NA	NA	NA	NA
	08/01/90	25	2500	NA	NA	NA	NA
	08/01/90	28	910	NA	NA	NA	NA

ENGLAND
SHAHIN &
ASSOCIATES

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
P3-BH-3 (Cont'd)							
	08/01/90	30	4600	NA	NA	NA	NA
	08/01/90	35	1900	NA	NA	NA	NA
	08/01/90	40	<10	NA	NA	NA	NA
	08/01/90	43	<10	NA	NA	NA	NA
	08/01/90	45	120	NA	NA	NA	NA
	08/01/90	50	24	NA	NA	NA	NA
	08/01/90	55	2000	NA	NA	NA	NA
	08/01/90	60	1800	NA	NA	NA	NA
P3-BH-4	08/01/90	5	<10	NA	NA	NA	NA
	08/01/90	10	<10	NA	NA	NA	NA
	08/01/90	15	<10	NA	NA	NA	NA
	08/01/90	20	<10	NA	NA	NA	NA
	08/01/90	25	430	NA	NA	NA	NA
	08/01/90	30	12	NA	NA	NA	NA
	08/01/90	33	<10	NA	NA	NA	NA
	08/01/90	35	2200	NA	NA	NA	NA
	08/01/90	40	3100	NA	NA	NA	NA
P4-BH-1	07/25/90	5	80	NA	NA	NA	NA
	07/25/90	10	4700	NA	NA	NA	NA
	07/25/90	15	1900	NA	NA	NA	NA
	07/25/90	20	<10	NA	NA	NA	NA
	07/25/90	25	<10	NA	NA	NA	NA
	07/25/90	30	<10	NA	NA	NA	NA
	07/25/90	35	50	NA	NA	NA	NA
	07/25/90	40	1300	NA	NA	NA	NA
	07/25/90	45	<10	NA	NA	NA	NA
	07/25/90	48	<10	NA	NA	NA	NA
P4-BH-2	07/26/90	45	14	NA	NA	NA	NA
	07/26/90	5	50	NA	NA	NA	NA
	07/26/90	10	3000	NA	NA	NA	NA
	07/26/90	15	3000	NA	NA	NA	NA
	07/26/90	20	7300	NA	NA	NA	NA
	07/26/90	25	10000	NA	NA	NA	NA
	07/26/90	30	3500	NA	NA	NA	NA
	07/26/90	33	5200	NA	NA	NA	NA
	07/26/90	35	1400	NA	NA	NA	NA
	07/26/90	40	1600	NA	NA	NA	NA
	07/26/90	50	<10	NA	NA	NA	NA
P4-BH-3	08/01/90	5	560	NA	NA	NA	NA
	08/01/90	10	1100	NA	NA	NA	NA
	08/01/90	15	870	NA	NA	NA	NA
	08/01/90	20	60	NA	NA	NA	NA
	08/01/90	25	14	NA	NA	NA	NA
	08/01/90	30	460	NA	NA	NA	NA
	08/01/90	35	3000	NA	NA	NA	NA
	08/01/90	40	1600	NA	NA	NA	NA
	08/01/90	43	2500	NA	NA	NA	NA
	08/01/90	45	760	NA	NA	NA	NA
	08/01/90	50	<10	NA	NA	NA	NA
P4-BH-4	08/01/90	5	<10	NA	NA	NA	NA
	08/01/90	10	<10	NA	NA	NA	NA

ENGLAND
SHAHIN &
ASSOCIATES

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
P4-BH-4 (Cont'd)							
	08/01/90	15	<10	NA	NA	NA	NA
	08/01/90	20	13	NA	NA	NA	NA
	08/01/90	25	29	NA	NA	NA	NA
	08/01/90	30	1400	NA	NA	NA	NA
	08/01/90	33	1600	NA	NA	NA	NA
	08/01/90	35	2100	NA	NA	NA	NA
	08/01/90	40	<10	NA	NA	NA	NA
	08/01/90	45	1300	NA	NA	NA	NA
	08/01/90	50	<10	NA	NA	NA	NA
P4-BH-5	09/04/90	5	<10	NA	NA	NA	NA
	09/04/90	10	<10	NA	NA	NA	NA
	09/04/90	15	<10	NA	NA	NA	NA
	09/04/90	20	<10	NA	NA	NA	NA
	09/04/90	25	<10	NA	NA	NA	NA
	09/04/90	30	<10	NA	NA	NA	NA
	09/04/90	33	<10	NA	NA	NA	NA
	09/04/90	35	1900	NA	NA	NA	NA
	09/04/90	40	110	NA	NA	NA	NA
	09/04/90	45	5200	NA	NA	NA	NA
	09/04/90	50	13	NA	NA	NA	NA
P4-BH-6	09/05/90	5	<10	NA	NA	NA	NA
	09/05/90	10	10000	NA	NA	NA	NA
	09/05/90	15	2900	NA	NA	NA	NA
	09/05/90	20	3400	NA	NA	NA	NA
	09/05/90	25	68	NA	NA	NA	NA
	09/05/90	30	12	NA	NA	NA	NA
	09/05/90	35	<10	NA	NA	NA	NA
	09/05/90	40	3100	NA	NA	NA	NA
	09/05/90	43	2200	NA	NA	NA	NA
	09/05/90	45	2300	NA	NA	NA	NA
	09/05/90	50	41	NA	NA	NA	NA
P5-BH-1	07/27/90	5	<10	NA	NA	NA	NA
	07/27/90	10	460	NA	NA	NA	NA
	07/27/90	12	340	NA	NA	NA	NA
	07/27/90	15	670	NA	NA	NA	NA
	07/27/90	20	6900	NA	NA	NA	NA
	07/27/90	25	770	NA	NA	NA	NA
	07/27/90	30	550	NA	NA	NA	NA
	07/27/90	35	430	NA	NA	NA	NA
	07/27/90	40	<10	NA	NA	NA	NA
	07/27/90	45	<10	NA	NA	NA	NA
	07/27/90	50	<10	NA	NA	NA	NA
	07/27/90	55	<10	NA	NA	NA	NA
	07/27/90	60	<10	NA	NA	NA	NA
	07/27/90	63	<10	NA	NA	NA	NA
	07/27/90	65	<10	NA	NA	NA	NA
	07/27/90	70	<10	NA	NA	NA	NA
	07/27/90	75	<10	NA	NA	NA	NA
	07/27/90	80	<10	NA	NA	NA	NA
	07/27/90	85	29	NA	NA	NA	NA
	07/27/90	90	<10	NA	NA	NA	NA
P5-BH-2	07/27/90	5	<10	NA	NA	NA	NA

ENGLAND
SHAHIN &
ASSOCIATES

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
P5-BH-2 (Cont'd)							
	07/27/90	10	<10	NA	NA	NA	NA
	07/27/90	15	<10	NA	NA	NA	NA
	07/27/90	20	<10	NA	NA	NA	NA
	07/27/90	25	<10	NA	NA	NA	NA
	07/27/90	30	<10	NA	NA	NA	NA
	07/27/90	33	<10	NA	NA	NA	NA
	07/27/90	35	<10	NA	NA	NA	NA
	07/27/90	40	<10	NA	NA	NA	NA
P6-BH-1	07/31/90	5	<10	NA	NA	NA	NA
	07/31/90	10	<10	NA	NA	NA	NA
	07/31/90	15	<10	NA	NA	NA	NA
	07/31/90	20	<10	NA	NA	NA	NA
	07/31/90	23	<10	NA	NA	NA	NA
	07/31/90	25	<10	NA	NA	NA	NA
P6-BH-2	08/01/90	5	<10	NA	NA	NA	NA
	08/01/90	10	<10	NA	NA	NA	NA
	08/01/90	15	<10	NA	NA	NA	NA
	08/01/90	20	<10	NA	NA	NA	NA
	08/01/90	25	<10	NA	NA	NA	NA
	08/01/90	30	<10	NA	NA	NA	NA
	08/01/90	35	<10	NA	NA	NA	NA
	08/01/90	40	<10	NA	NA	NA	NA
	08/01/90	45	<10	NA	NA	NA	NA
	08/01/90	48	<10	NA	NA	NA	NA
	08/01/90	50	51	NA	NA	NA	NA
	08/01/90	55	<10	NA	NA	NA	NA
	08/01/90	58	<10	NA	NA	NA	NA
	08/01/90	60	<10	NA	NA	NA	NA
	08/01/90	65	<10	NA	NA	NA	NA
	08/01/90	70	<10	NA	NA	NA	NA
	08/01/90	75	<10	NA	NA	NA	NA
	08/01/90	80	<10	NA	NA	NA	NA
	08/01/90	85	<10	NA	NA	NA	NA
P7-BH-1	08/06/90	5	<10	NA	NA	NA	NA
	08/06/90	8	29	NA	NA	NA	NA
	08/06/90	15	<10	NA	NA	NA	NA
	08/06/90	20	<10	NA	NA	NA	NA
	08/06/90	25	<10	NA	NA	NA	NA
	08/06/90	30	32	NA	NA	NA	NA
	08/06/90	35	<10	NA	NA	NA	NA
	08/06/90	40	<10	NA	NA	NA	NA
	08/06/90	45	<10	NA	NA	NA	NA
	08/06/90	50	<10	NA	NA	NA	NA
P7-BH-2	08/07/90	5	2900	NA	NA	NA	NA
	08/07/90	10	<10	NA	NA	NA	NA
	08/07/90	13	44	NA	NA	NA	NA
	08/07/90	15	<10	NA	NA	NA	NA
	08/07/90	20	<10	NA	NA	NA	NA
	08/07/90	25	<10	NA	NA	NA	NA
	08/07/90	30	<10	NA	NA	NA	NA
	08/07/90	35	<10	NA	NA	NA	NA
	08/07/90	40	<10	NA	NA	NA	NA

ENGLAND
SHAHIN &
ASSOCIATES

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
P7-BH-2 (Cont'd)							
	08/07/90	50	<10	NA	NA	NA	NA
P8-BH-1	08/13/90	5	18	NA	NA	NA	NA
	08/13/90	10	760	NA	NA	NA	NA
	08/13/90	15	<10	NA	NA	NA	NA
	08/13/90	20	<10	NA	NA	NA	NA
	08/13/90	25	78	NA	NA	NA	NA
	08/13/90	30	15	NA	NA	NA	NA
	08/13/90	40	21	NA	NA	NA	NA
	08/13/90	45	<10	NA	NA	NA	NA
	08/13/90	50	<10	NA	NA	NA	NA
	08/13/90	55	<10	NA	NA	NA	NA
	08/13/90	60	<10	NA	NA	NA	NA
	08/13/90	65	<10	NA	NA	NA	NA
	08/13/90	68	<10	NA	NA	NA	NA
	08/13/90	70	<10	NA	NA	NA	NA
	08/13/90	75	<10	NA	NA	NA	NA
	08/13/90	80	<10	NA	NA	NA	NA
	08/13/90	85	<10	NA	NA	NA	NA
	08/13/90	90	<10	NA	NA	NA	NA
	08/13/90	93	<10	NA	NA	NA	NA
	08/13/90	95	<10	NA	NA	NA	NA
	08/13/90	100	<10	NA	NA	NA	NA
	08/13/90	105	<10	NA	NA	NA	NA
P8-BH-2	08/09/90	10	<10	NA	NA	NA	NA
	08/09/90	15	<10	NA	NA	NA	NA
	08/09/90	20	<10	NA	NA	NA	NA
	08/09/90	5	<10	NA	NA	NA	NA
	08/09/90	25	<10	NA	NA	NA	NA
	08/09/90	28	<10	NA	NA	NA	NA
	08/09/90	30	<10	NA	NA	NA	NA
	08/09/90	35	<10	NA	NA	NA	NA
	08/09/90	40	<10	NA	NA	NA	NA
	08/09/90	45	<10	NA	NA	NA	NA
	08/09/90	50	<10	NA	NA	NA	NA
	08/09/90	55	<10	NA	NA	NA	NA
	08/09/90	58	<10	NA	NA	NA	NA
	08/09/90	60	<10	NA	NA	NA	NA
PEW-1	10/29/93	35	66	0.43	0.12	0.39	0.86
	10/29/93	40	1900	<4.0	9.6	11	11
	10/29/93	45	130	0.079	0.045	0.097	0.084
	10/29/93	46	8200	24	51	43	74
	10/29/93	50	3600	1.4	2.9	13	11
	10/29/93	60	780	0.19	0.43	1.3	0.83
	10/29/93	75	2200	1.1	1.0	1.9	0.98
PEW-2	10/26/93	20	100	0.16	0.22	0.38	0.47
	10/26/93	25	3100	0.33	<0.02	<0.02	0.15
	10/26/93	35	2100	0.11	<0.02	0.38	0.36
	10/26/93	45	1.3	0.20	<0.050	0.050	0.070
PEW-3	10/26/93	5	7500	18	20	89	110
	10/26/93	10	1100	0.12	<0.02	1.8	3.9
	10/26/93	20	1700	0.51	<0.13	10	3.5

ENGLAND
SHAHIN &
ASSOCIATES

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
PEW-3 (Cont'd)							
	10/26/93	30	3500	2.1	<0.25	<0.25	4.2
	10/26/93	40	6700	<0.02	<0.02	<0.02	0.66
	10/26/93	45	420	1.8	1.2	3.4	2.9
PEW-4	06/01/94	20	56	<0.030	0.20	0.39	0.40
	06/01/94	30	1400	<0.30	2.9	5.8	4.0
	06/01/94	40	1900	4.6	5.5	8.4	18
	06/01/94	45	<1.0	0.067	0.0080	0.020	0.028
PEW-5	06/01/94	20	3.3	<0.0050	0.011	0.021	0.025
	06/01/94	30	140	<0.038	0.089	0.34	0.38
	06/01/94	40	710	<0.15	1.0	0.46	2.7
	06/01/94	45	51	0.033	0.24	0.50	0.53
PEW-6	06/01/94	10	5.4	<0.0050	<0.0050	0.030	0.023
	06/01/94	20	2000	<0.30	2.4	7.9	8.9
	06/01/94	30	1600	<0.75	1.8	7.0	10
	06/01/94	40	1700	2.2	4.7	5.6	6.8
	06/01/94	45	<1.0	0.085	0.018	0.036	0.030
SBB-1	04/12/93	5	<1	NA	NA	NA	NA
	04/12/93	30	6.1	NA	NA	NA	NA
	04/12/93	40	1900	<0.02	<0.02	<0.02	<0.02
	04/12/93	40D	860	NA	NA	NA	NA
	04/12/93	45	6.1	NA	NA	NA	NA
	04/12/93	50	1900	0.13	0.19	0.48	0.31
	04/12/93	55	3900	1.00	1.50	5.80	3.40
	04/12/93	60	18	NA	NA	NA	NA
	04/12/93	70	60	NA	NA	NA	NA
	04/12/93	80	4700	0.85	0.41	3.50	1.40
	04/12/93	90	4000	1.80	0.23	3.80	0.67
	04/12/93	90D	1300	NA	NA	NA	NA
	04/12/93	95	700	<1.0	<1.0	2.60	<2.0
SBB-2	04/13/90	50	<3.3	NA	NA	NA	NA
	04/13/93	5	<1	NA	NA	NA	NA
	04/13/93	20	3.7	NA	NA	NA	NA
	04/13/93	30	2.5	NA	NA	NA	NA
	04/13/93	40	<1	NA	NA	NA	NA
	04/13/93	55	5800	<0.02	<0.02	0.47	0.94
	04/13/93	62	5.6	NA	NA	NA	NA
	04/13/93	65	12	NA	NA	NA	NA
	04/13/93	70	14	NA	NA	NA	NA
	04/13/93	75	3.2	NA	NA	NA	NA
	04/13/93	80	15	<0.002	<0.002	<0.002	<0.002
	04/13/93	80D	<1	NA	NA	NA	NA
	04/13/93	85	3200	<0.01	0.057	0.071	0.130
	04/13/93	95	970	NA	NA	NA	NA
	04/13/93	95D	480	NA	NA	NA	NA
	04/13/93	105	570	<0.02	<0.02	<0.02	<0.02
	04/13/93	110	670	<0.002	<0.002	<0.002	<0.002
SBC-1	04/08/93	5	<1.0	NA	NA	NA	NA
	04/08/93	25	250	NA	NA	NA	NA
	04/08/93	30	2300	<0.01	0.026	<0.01	0.028
	04/08/93	35	9400	<0.01	<0.01	<0.01	0.01

ENGLAND
SHAHIN &
ASSOCIATES

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
SBC-1 (Cont'd)							
	04/08/93	40	4000	0.013	0.063	<0.01	0.038
	04/08/93	40D	37	NA	NA	NA	NA
	04/08/93	45	1.9	NA	NA	NA	NA
	04/08/93	50	3100	<0.20	<0.20	<0.20	<0.20
	04/08/93	55	TBC	NA	NA	NA	NA
	04/08/93	60	60	NA	NA	NA	NA
	04/08/93	70	220	<0.20	<0.20	<0.20	<0.20
	04/08/93	75	100	0.002	0.003	<0.002	0.003
	04/08/93	80	140	NA	NA	NA	NA
	04/08/93	85	75	NA	NA	NA	NA
SBC-3	04/14/93	5	<1	NA	NA	NA	NA
	04/14/93	30	<1	NA	NA	NA	NA
	04/14/93	45	<1	NA	NA	NA	NA
	04/14/93	55	<1	NA	NA	NA	NA
	04/14/93	60	<1	NA	NA	NA	NA
	04/14/93	60D	<1	NA	NA	NA	NA
SBD-2	04/20/93	5	<1	NA	NA	NA	NA
	04/20/93	10	790	NA	NA	NA	NA
	04/20/93	20	4600	<0.01	0.02	<0.01	0.035
	04/20/93	25	800	NA	NA	NA	NA
	04/20/93	30	1400	NA	NA	NA	NA
	04/20/93	35	NA	0.011	0.031	<0.01	0.027
	04/20/93	40	2300	0.033	0.077	<0.01	0.065
	04/20/93	40D	930	NA	NA	NA	NA
	04/20/93	45	4400	<1.0	1.5	1.5	1.8
	04/20/93	50	5500	<1.0	<1.1	<1.0	<1.3
	04/20/93	55	28	NA	NA	NA	NA
	04/20/93	60	680	<0.01	<0.01	<0.01	<0.01
	04/20/93	60D	320	NA	NA	NA	NA
	04/20/93	70	1000	<0.4	<0.4	<0.4	<0.4
	04/20/93	75	220	NA	NA	NA	NA
	04/20/93	80	9.7	NA	NA	NA	NA
	04/20/93	85	1.1	NA	NA	NA	NA
	04/20/93	90	6.7	NA	NA	NA	NA
SBD-3	04/21/93	6	<1	NA	NA	NA	NA
	04/21/93	11	<1	NA	NA	NA	NA
	04/21/93	20	<1	NA	NA	NA	NA
	04/21/93	25.5	<1	NA	NA	NA	NA
	04/21/93	31	<1	NA	NA	NA	NA
	04/21/93	36	4600	<0.01	<0.01	<0.01	<0.01
	04/21/93	40	6000	<0.40	<0.40	1.1	0.96
	04/21/93	46	2700	NA	NA	NA	NA
	04/21/93	50	1100	0.13	0.16	0.092	0.15
	04/21/93	55.5	2500	0.14	0.19	<0.01	0.29
	04/21/93	60	410	<0.01	<0.01	<0.01	<0.01
	04/21/93	60D	190	NA	NA	NA	NA
	04/21/93	65.5	1.7	NA	NA	NA	NA
	04/21/93	70	2.5	NA	NA	NA	NA
	04/21/93	76	<2	NA	NA	NA	NA
	04/21/93	81	14	<0.01	<0.01	<0.01	<0.01
SBE-1	04/06/93	5	<1.0	NA	NA	NA	NA
	04/06/93	20	5.7	NA	NA	NA	NA

ENGLAND
SHAHIN &
ASSOCIATES

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
SBE-1 (Cont'd)							
	04/06/93	25	67	NA	NA	NA	NA
	04/06/93	30	670	<0.01	<0.01	<0.01	0.046
	04/06/93	35	1400	<0.13	<0.13	<0.13	<0.13
	04/06/93	40	3400	NA	NA	NA	NA
	04/06/93	45	590	0.056	0.065	<0.01	0.069
	04/06/93	60	180	<0.10	<0.10	<0.10	<0.10
	04/06/93	65	200	NA	NA	NA	NA
	04/06/93	70	8100	0.31	0.48	<0.30	0.57
	04/06/93	700	1800	NA	NA	NA	NA
	04/06/93	75	5.7	NA	NA	NA	NA
	04/06/93	80	2.3	NA	NA	NA	NA
SBF-1	04/23/93	5	<1	NA	NA	NA	NA
	04/23/93	25	560	NA	NA	NA	NA
	04/23/93	30	600	NA	NA	NA	NA
	04/23/93	300	21	NA	NA	NA	NA
	04/23/93	35	860	<0.004	<0.004	<0.004	<0.004
	04/23/93	40	4300	<0.01	<0.01	<0.01	<0.01
	04/23/93	45	590	<0.40	<0.40	<0.40	<0.40
	04/23/93	50	3800	<0.40	<0.40	<0.40	<0.40
	04/23/93	55	550	<0.01	<0.01	<0.01	<0.01
	04/23/93	60	26	NA	NA	NA	NA
	04/23/93	65	95	NA	NA	NA	NA
	04/23/93	70	3.4	NA	NA	NA	NA
	04/23/93	75	5.7	NA	NA	NA	NA
	04/23/93	80	5.7	<0.002	<0.002	<0.002	<0.002
SBG-2	04/09/93	30	760	NA	NA	NA	NA
	04/09/93	35	1300	<0.50	<0.50	<0.50	<0.50
	04/09/93	40	96	NA	NA	NA	NA
	04/09/93	45	3700	<0.01	<0.01	<0.01	<0.01
	04/09/93	50	<1	NA	NA	NA	NA
	04/09/93	55	30	NA	NA	NA	NA
	04/09/93	60	410	NA	NA	NA	NA
	04/09/93	65	540	0.033	<0.01	<0.01	0.012
	04/09/93	650	90	NA	NA	NA	NA
	04/09/93	70	<1	NA	NA	NA	NA
SG-BH-1	08/22/90	5	NA	<0.005	0.020	<0.005	<0.015
	08/22/90	10	NA	<0.005	0.021	<0.005	<0.015
	08/22/90	15	NA	<0.005	0.009	<0.005	<0.015
	08/22/90	20	NA	<0.005	0.0059	<0.005	<0.015
	08/22/90	25	NA	<0.005	0.042	<0.005	<0.015
	08/22/90	30	NA	<0.005	0.0046	<0.005	<0.015
	08/22/90	35	NA	<0.005	0.0067	<0.005	<0.015
	08/22/90	40	NA	<0.005	0.0029	<0.005	<0.015
	08/22/90	45	NA	0.060	0.027	0.097	0.036
	08/22/90	50	NA	<0.50	<0.50	0.37	<0.50
	08/22/90	55	NA	<0.50	0.63	1.8	8.9
	08/22/90	60	NA	<0.50	<0.50	0.11	0.49
	08/22/90	65	NA	<1.0	<1.0	0.22	2.7
	08/22/90	70	NA	<0.50	0.16	0.62	2.5
	08/22/90	75	NA	<0.50	<0.50	0.21	0.63
	08/22/90	80	NA	<0.50	<0.50	<0.50	0.35
	08/22/90	85	NA	<0.50	<0.50	0.40	0.71
	08/22/90	90	NA	<0.50	<0.50	0.44	0.79

Appendix A
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of TPH, Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Soil
Concentrations in mg/kg

Well Number	Date Sampled	Depth (Ft.)	TPHG	Benzene	Toluene	Ethyl Benzene	Total Xylenes
SG-BH-1 (Cont'd)							
	08/22/90	95	NA	<0.50	0.25	0.48	0.66
SG-BH-3	08/22/90	5	NA	<2.5	<2.5	1.2	0.60
	08/22/90	10	NA	<2.5	0.58	2.3	1.6
	08/22/90	15	NA	<2.5	0.56	1.7	1.8
	08/22/90	20	NA	0.62	0.72	0.86	1.7
	08/22/90	25	NA	<2.5	0.56	<2.5	0.62
	08/22/90	35	NA	<2.5	0.60	3.0	1.7
	08/22/90	45	NA	<2.5	<2.5	1.4	<2.5

NA = Not Analyzed

APPENDIX B

Appendix B
Summary of LNAPL Monitoring and Removal

Well Number	Date Measured	LNAPL Thickness Feet	Ground Water Elev.	Perforated Zone Elev.	Comments	LNAPL Removed (gallons) *
MW-9S	02/08/94	0.61	433.55	434-414	-	0
	02/15/94	0.13	433.40		-	0
	02/22/94	0.16	433.34		-	0
	03/01/94	0.13	433.53		SoakEase installed, initial weight of 4.5 lbs	0
	03/08/94	Sheen	433.50		SoakEase weighs 6.5 lbs	0.24
	03/14/94	Sheen	433.69		SoakEase weighs 6.5 lbs	0
	03/22/94	Sheen	433.66		SoakEase weighs 6.5 lbs	0
	03/29/94	Sheen	433.75		SoakEase weighs 6.5 lbs	0
	04/05/94	Sheen	433.63		SoakEase weighs 6.5 lbs	0
	04/12/94	0.00	433.60		SoakEase weighs 6.5 lbs	0
	04/20/94	Sheen	433.75		SoakEase weighs 6.5 lbs	0
	04/26/94	Sheen	433.54		SoakEase weighs 6 75 lbs	0.03
	05/03/94	Sheen	433.40		SoakEase weighs 6.75 lbs	0
	05/09/94	Sheen	433.38		SoakEase weighs 6.75 lbs	0
	05/17/94	Sheen	433.35		SoakEase weighs 6.75 lbs	0
	05/24/94	Sheen	433.41		SoakEase weighs 7.0 lbs	0 03
	05/31/94	0.02	433.21		Replaced absorbent material due to presence of measurable LNAPL, new SoakEase weighs 4.5 lbs	0
	06/08/94	Sheen	433.35		SoakEase weighs 4.75 lbs	0.03
	06/30/94	Sheen	433 52		SoakEase weighs 5.0 lbs	0.03
	07/07/94	Sheen	433.66		SoakEase weighs 5.0 lbs	0
	07/14/94	Sheen	433.65		SoakEase weighs 5.0 lbs	0
	07/20/94	Sheen	433.31		SoakEase weighs 5.5 lbs	0.06
	07/27/94	Sheen	433.49		SoakEase weighs 6.0 lbs	0.06
	08/03/94	Sheen	433.40		SoakEase weighs 6.0 lbs	0
	08/08/94	Sheen	433.39		SoakEase weighs 6.0 lbs	0
	08/19/94	Sheen	433.31		SoakEase weighs 6.25 lbs	0.03
	08/27/94	0.00	433 26		SoakEase weighs 6.75 lbs	0.06
	09/01/94	Sheen	433.43		SoakEase weighs 6.75 lbs	0
	09/07/94	Sheen	433.41		SoakEase weighs 6.75 lbs	0
	09/12/94	Sheen	433.59		SoakEase weighs 6.75 lbs	0
	09/20/94	Sheen	433.75		SoakEase weighs 6 75 lbs	0
	09/27/94	Sheen	434.01		SoakEase weighs 6 75 lbs	0
Total LNAPL removed from MW-9S						*0.57*

ENGLAND SHAHIN & ASSOCIATES

Appendix B
Summary of LNAPL Monitoring and Removal

Well Number	Date Measured	LNAPL Thickness Feet	Ground Water Elev.	Perforated Zone Elev.	Comments	LNAPL Removed (gallons) *
MW-17S	01/25/94	0.13	431.96	437-417	-	0
	02/01/94	0.11	431.57		-	0
	02/08/94	0.08	431.43		-	0
	02/15/94	0.01	431.39		-	0
	02/22/94	0.01	430.94		-	0
	03/01/94	Sheen	431.57		SoakEase installed, initial weight 4.5 lbs	0
	03/08/94	Sheen	431.67		SoakEase weighs 4.5 lbs	0
	03/14/94	Sheen	431.95		SoakEase weighs 4.5 lbs	0
	03/22/94	Sheen	431.97		SoakEase weighs 4.5 lbs	0
	03/29/94	Sheen	432.01		SoakEase weighs 4.5 lbs	0
	04/05/94	Sheen	431.92		SoakEase weighs 4.75 lbs	0.03
	04/12/94	Sheen	431.90		SoakEase weighs 4.75 lbs	0
	04/20/94	Sheen	432.12		SoakEase weighs 5.0 lbs	0.03
	04/26/94	Sheen	431.88		SoakEase weighs 5.0 lbs	0
	05/03/94	Sheen	431.75		SoakEase weighs 5.0 lbs	0
	05/09/94	Sheen	431.75		SoakEase weighs 5.0 lbs	0
	05/17/94	Sheen	431.73		SoakEase weighs 5.0 lbs	0
	05/24/94	Sheen	431.79		SoakEase weighs 5.0 lbs	0
	05/31/94	Sheen	431.54		SoakEase weighs 5.0 lbs	0
	06/08/94	Sheen	431.66		SoakEase weighs 5.0 lbs	0
	06/30/94	Sheen	431.71		SoakEase weighs 5.0 lbs	0
	07/07/94	Sheen	431.97		SoakEase weighs 5.0 lbs	0
	07/14/94	Sheen	431.95		SoakEase weighs 5.0 lbs	0
	07/20/94	Sheen	431.69		SoakEase weighs 5.0 lbs	0
	07/27/94	Sheen	431.71		SoakEase weighs 5.0 lbs	0
	08/03/94	Sheen	431.65		SoakEase weighs 5.0 lbs	0
	08/08/94	Sheen	431.73		SoakEase weighs 5.0 lbs	0
	08/19/94	0.00	431.48		SoakEase weighs 5.0 lbs	0
	08/27/94	Sheen	431.54		SoakEase weighs 5.0 lbs	0
	09/01/94	Sheen	431.61		SoakEase weighs 5.0 lbs	0
	09/07/94	Sheen	431.57		SoakEase weighs 5.0 lbs	0
	09/12/94	Sheen	431.74		SoakEase weighs 5.0 lbs	0
	09/20/94	Sheen	431.87		SoakEase weighs 5.0 lbs	0
	09/27/94	Sheen	432.21		SoakEase weighs 5.0 lbs	0
Total LNAPL Removed from MW-17S						*0.06*

ENGLAND SHAHIN & ASSOCIATES

Appendix B
Summary of LNAPL Monitoring and Removal

Well Number	Date Measured	LNAPL Thickness Feet	Ground Water Elev.	Perforated Zone Elev.	Comments	LNAPL Removed (gallons) *
MW-20S	01/25/94	Sheen	430.41	417-397	-	0
	02/01/94	Sheen	429.88		-	0
	02/08/94	Sheen	429.89		-	0
	02/15/94	Sheen	429.74		-	0
	02/22/94	Sheen	429.36		-	0
	03/01/94	Sheen	429.80		SoakEase installed, initial weight 4.5 lbs	0
	03/08/94	Sheen	429.87		SoakEase weighs 4.5 lbs	0
	03/14/94	Sheen	430.14		SoakEase weighs 4.5 lbs	0
	03/22/94	Sheen	430.20		SoakEase weighs 4.5 lbs	0
	03/29/94	Sheen	430.18		SoakEase weighs 4.5 lbs	0
	04/05/94	0.00	430.15		SoakEase weighs 4.75 lbs	0.03
	04/12/94	Sheen	430.07		SoakEase weighs 4.75 lbs	0
	04/20/94	Sheen	430.27		SoakEase weighs 5.0 lbs	0.03
	04/26/94	Sheen	430.11		SoakEase weighs 5.0 lbs	0
	05/03/94	Sheen	430.00		SoakEase weighs 5.0 lbs	0
	05/09/94	Sheen	429.98		SoakEase weighs 5.0 lbs	0
	05/17/94	Sheen	429.95		SoakEase weighs 5.0 lbs	0
	05/24/94	Sheen	430.03		SoakEase weighs 5.0 lbs	0
	05/31/94	Sheen	429.75		SoakEase weighs 5.0 lbs	0
	06/08/94	Sheen	429.88		SoakEase weighs 5.0 lbs	0
	06/30/94	Sheen	429.75		SoakEase weighs 5.0 lbs	0
	07/07/94	Sheen	430.04		SoakEase weighs 5.0 lbs	0
	07/14/94	Sheen	430.03		SoakEase weighs 5.0 lbs	0
	07/20/94	Sheen	429.80		SoakEase weighs 5.0 lbs	0
	07/27/94	Sheen	429.86		SoakEase weighs 5.0 lbs	0
	08/02/94	Sheen	429.78		SoakEase weighs 5.0 lbs	0
	08/08/94	Sheen	429.82		SoakEase weighs 5.0 lbs	0
	08/19/94	0.00	429.46		SoakEase weighs 5.0 lbs	0
	08/27/94	Sheen	429.60		SoakEase weighs 5.0 lbs	0
	09/01/94	Sheen	429.59		SoakEase weighs 5.0 lbs	0
	09/07/94	Sheen	429.57		SoakEase weighs 5.0 lbs	0
	09/12/94	Sheen	429.76		SoakEase weighs 5.0 lbs	0
	09/20/94	Sheen	429.92		SoakEase weighs 5.0 lbs	0
	09/27/94	Sheen	430.26		SoakEase weighs 5.0 lbs	0
Total LNAPL Removed from MW-20S						*0.06*

Appendix B
Summary of LNAPL Monitoring and Removal

Well Number	Date Measured	LNAPL Thickness Feet	Ground Water Elev.	Perforated Zone Elev.	Comments	LNAPL Removed (gallons) *
EW-1	01/25/94	0.31	431.72	426-401	-	0
	02/01/94	0.33	430.87		-	0
	02/07/94	0.60	429.21		-	0
	02/15/94	0.69	430.22		-	0
	02/22/94	1.45	428.31		-	0
	03/01/94	2.00	431.44		Bailed to a thickness of 0.6 feet	1.82
	03/08/94	0.67	431.54		Bailed to a thickness of 0.23 feet	0.73
	03/14/94	0.29	431.86		Bailed to a thickness of 0.05 feet	0.44
	03/22/94	0.05	431.90		-	0
	03/29/94	0.05	431.67		-	0
	04/05/94	0.06	431.85		-	0
	04/12/94	0.06	431.86		-	0
	04/20/94	0.06	431.99		-	0
	04/26/94	0.06	431.81		-	0
	05/03/94	0.06	431.69		-	0
	05/09/94	0.06	431.64		-	0
	05/17/94	0.06	431.66		-	0
	05/24/94	0.06	431.69		-	0
	05/31/94	0.06	431.46		-	0
	06/08/94	0.06	431.55		-	0
	06/30/94	0.06	431.56		-	0
	07/07/94	0.06	431.84		-	0
	07/14/94	0.06	431.82		-	0
	07/20/94	0.05	431.61		-	0
	07/27/94	0.06	431.64		-	0
	08/03/94	0.06	431.63		-	0
	08/08/94	0.06	431.59		-	0
	08/12/94	0.06	431.51		Used SoakEase, increased by 0.5 lbs.	0.06
	08/19/94	0.04	431.24		Bailed to a thickness of 0.01 feet	0.05
	08/27/94	Sheen	431.33		-	0
	09/01/94	Sheen	431.34		-	0
	09/07/94	Sheen	431.29		-	0
	09/12/94	0.00	431.56		-	0
	09/20/94	Sheen	431.75		-	0
	09/27/94	0.00	432.04		-	0
Total LNAPL Removed from EW-1						*3.1*

ENGLAND SHAHIN & ASSOCIATES

Appendix B
Summary of LNAPL Monitoring and Removal

Well Number	Date Measured	LNAPL Thickness Feet	Ground Water Elev.	Perforated Zone Elev.	Comments	LNAPL Removed (gallons) *
EW-4	06/16/94	0.00	432.69	435-417	After well installed prior to pumping	0
	06/30/94	0.36	428.71		Well pumping	0
	07/07/94	0.01	432.78		-	0
	07/14/94	0.01	432.76		-	0
	07/20/94	0.20	432.52		-	0
	07/27/94	0.22	433.63		-	0
	08/03/94	0.25	430.26		Well pumping	0
	08/08/94	0.45	432.64		-	0
	08/19/94	0.44	427.97		Bailed	0.25
	08/27/94	0.32	430.39		Bailed to a thickness of 0.11	0.75
	09/01/94	0.41	428.88		Well pumping	0
	09/07/94	0.35	428.97		Well pumping	0
	09/12/94	0.07	429.55		-	0
	09/20/94	0.01	432.64		-	0
	9/27/94	0.00	432.95		-	0
Total LNAPL Removed from EW-4						*1.00*
Total LNAPL Removed from all Wells						*4.79*

Note: All depths in feet; all elevations in feet above mean sea level. Ground water elevations corrected for LNAPL when present (assumes an LNAPL density of 0.9) The gallons of LNAPL removed with the SoakEase were calculated using the assumption that 90% of the weight gain on the SoakEase was due to LNAPL.

APPENDIX C

Report to:

TEXACO ENVIRONMENTAL SERVICES
10 Universal City Plaza
Universal City, California 91608

For:

ANALYSIS OF FOUR GAS SAMPLES FOR CHEMICAL AND ISOTOPIC COMPOSITION

by:

ISAAC R. KAPLAN

January 31, 1994

Global Geochemistry Corporation
6919 Eton Avenue
Canoga Park, California 91303
(818) 992-4103 FAX (818) 992-8940

Report to:

TEXACO ENVIRONMENTAL SERVICES
10 Universal City Plaza
Universal City, California 91608

For:

ANALYSIS OF FOUR GAS SAMPLES FOR CHEMICAL AND ISOTOPIC COMPOSITION

by:

ISAAC R. KAPLAN

January 31, 1994

INTRODUCTION

Four gas samples were submitted for identification of their constituents and to measure the $^{13}C/^{12}C$ ($\delta^{13}C$) isotope ratio of the hydrocarbon gases and carbon dioxide. Due to the very small content of hydrocarbon gases other than methane, $\delta^{13}C$ could only be measured on methane and carbon dioxide.

RESULTS

The data shown in Table 1 illustrate that the samples submitted are largely composed of air, with small contents of hydrocarbon gas. Only sample MW-39S contains a significant content of hydrocarbon gases (25%) compared to a range of 2.8-7.7% for the other three. Methane dominates the hydrocarbon content and is present in amounts greater than 95%. Significantly, ethane (C_2) and propane (C_3) are absent in all samples and CO_2 is dominant in AEW-1 and PEW-3, with concentrations of 12.1% and 9.33% respectively.

The carbon isotope ratios are shown in Table 2. The $\delta^{13}C$ values for PEW-1, AEW-1 and MW-39S fall in a range between thermogenic (deep earth generated) and biogenic (bacterial generated). Only sample PEW-3 gave a measured value of -42.96 which is in the range of oil associated gases.

Those three gases which fall in the range intermediate between thermogenic and biogenic origin also have carbon dioxide associated with them which are highly enriched in ^{12}C (i.e. more negative $\delta^{13}C$ values). It is very probable that these isotopically light values derive from the oxidation of methane, ethane and propane. In so doing, the bacteria have depleted ^{12}C from the hydrocarbon gases, leaving then enriched in ^{13}C. For that reason, their original values could have been significantly more enriched in ^{12}C and these hydrocarbons could have had values which are in the biogenic range. This would especially apply to samples AEW-1 and PEW-3, where in each sample the CO_2 content exceeds the methane content by a factor of approximately two. Further evidence for the hydrocarbon oxidation is the disappearance of ethane and propane, both of which are removed more rapidly than methane.

CONCLUSIONS

The analytical study shows the following:

1. Methane is the major hydrocarbon gas in the samples.
2. Ethane and propane are absent.
3. Carbon dioxide is present in amounts approximately twice that of methane in samples AEW-1 and PEW-3.
4. The carbon isotope values for the methane indicate that sample PEW-3 falls in the range of thermogenic methane, whereas the other three gas samples, PEW-1, AEW-1 and MW-39S are in between the range of thermogenic and biogenic methane.
5. The carbon dioxide in the gas samples are enriched in ^{12}C.
6. Further enrichment of ^{12}C in the CO_2 indicates that oxidation of the light hydrocarbon gases has occurred in which the ^{12}C has been preferentially removed, leaving them relatively enriched in ^{13}C with delta ^{13}C values approaching those of thermogenic methane.
7. It is probable that the gas source in the samples provided for analysis are a mixture of both thermogenic and biogenic gases, with the possible exception of sample PEW-3, which may be predominately thermogenic.

January 21, 1994

Table 1
Gas concentrations in samples submitted for Texaco Environmental Services.

	PEW-1 2217-1	PEW-1 (duplicate)	AEW-1 2217-2	PEW-3 2217-3	MW-39S 2217-4
C_1	2.67	2.68	6.75	4.10	23.9
C_2	ND	ND	ND	ND	ND
C_3	ND	ND	ND	ND	ND
i-C_4	ND	0.002	0.004	ND	0.022
n-C_4	0.028	0.028	0.061	0.006	0.25
i-C_5	0.046	0.047	0.15	0.069	0.32
n-C_5	0.051	0.051	0.18	0.11	0.30
CO_2	0.40		12.1	9.33	1.64
O_2+Ar	20.0		*	*	15.0
N_2	76.8		80.8	86.4	58.6

ND = Not Detected
The Detection Limit is 0.002%

* The O_2+Ar peak was not separated from the N_2 peak. For these samples the N_2, O_2 and Ar concentrations are combined.

Laboratory Supervisor

Isotope data for samples submitted for Texaco Environmental Services

Global Geochemistry Corporation 01-27-1994
Data file: WO2217 Page 1

Sample	GGCID	Methane d13C	Methane d13C Dup	CO2 d13C
PEW-1	2217-1	-50.12	-50.37	-27.52
AEW-1	2217-2	-52.57		-17.38
PEW-3	2217-3	-42.96		-15.29
MW-39S	2217-4	-54.19		-21.37
STANDARD				
2217-STD-1		-31.29		
2217-STD-2		-31.29		

ESTABLISHED STANDARD VALUE

STANDARD	$\delta^{13}C$
STD	-31.26

Values are reported in $^{o}/oo$ relative to PDB

Analyst

Supervisor

GLOBAL GEOCHEMISTRY CORPORATION
CHAIN OF CUSTODY RECORD

GGC W.O. # A2217

Client Name (WW TREWEN) TEXACO - FILLMORE

P.O./Project

Address: 2750 SIGNAL PARKWAY, LONG BEACH, CA 90806-2270

Phone # 800-834-4475 PROJECT CONTACT JOHN RIPLY

STA. No.	DATE	TIME	COMP.	GRAB.	*Type of sample	Station Location	Pre-servative	No. of Con-tainers	C1-C5	FIXED GAS	C12 C6-C1					REMARKS
-1	1-10-94	12:00			AIR	PEW-1			X	X	X					
-2	"	"				AEW-1			X	X	X					
-3	"	"				PEW-3			X	X	X					
-4	"	"				MW-395			X	X	X					

Relinquished by (Print Name & Signature):	Date	Time	Received by (Print Name & Signature):	Date	Time
Bert Caldwell	1-10-94	15:00			
Relinquished by (Print Name & Signature):	Date	Time	Received by (Print Name & Signature):	Date	Time
Relinquished by (Print Name & Signature):	Date	Time	Received by (Print Name & Signature):	Date	Time
Received by GGC:	Date 1-14-94	Time 1500	Remarks:		

Samples are discarded 30 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at CLIENTS expense.

* Sample type W: water S: Soil Sl: Sludge O: Other

APPENDIX D

JAN
CORPORATION
REFERENCE

THE TEXAS CORPORATION

AND SUBSIDIARY COMPANIES

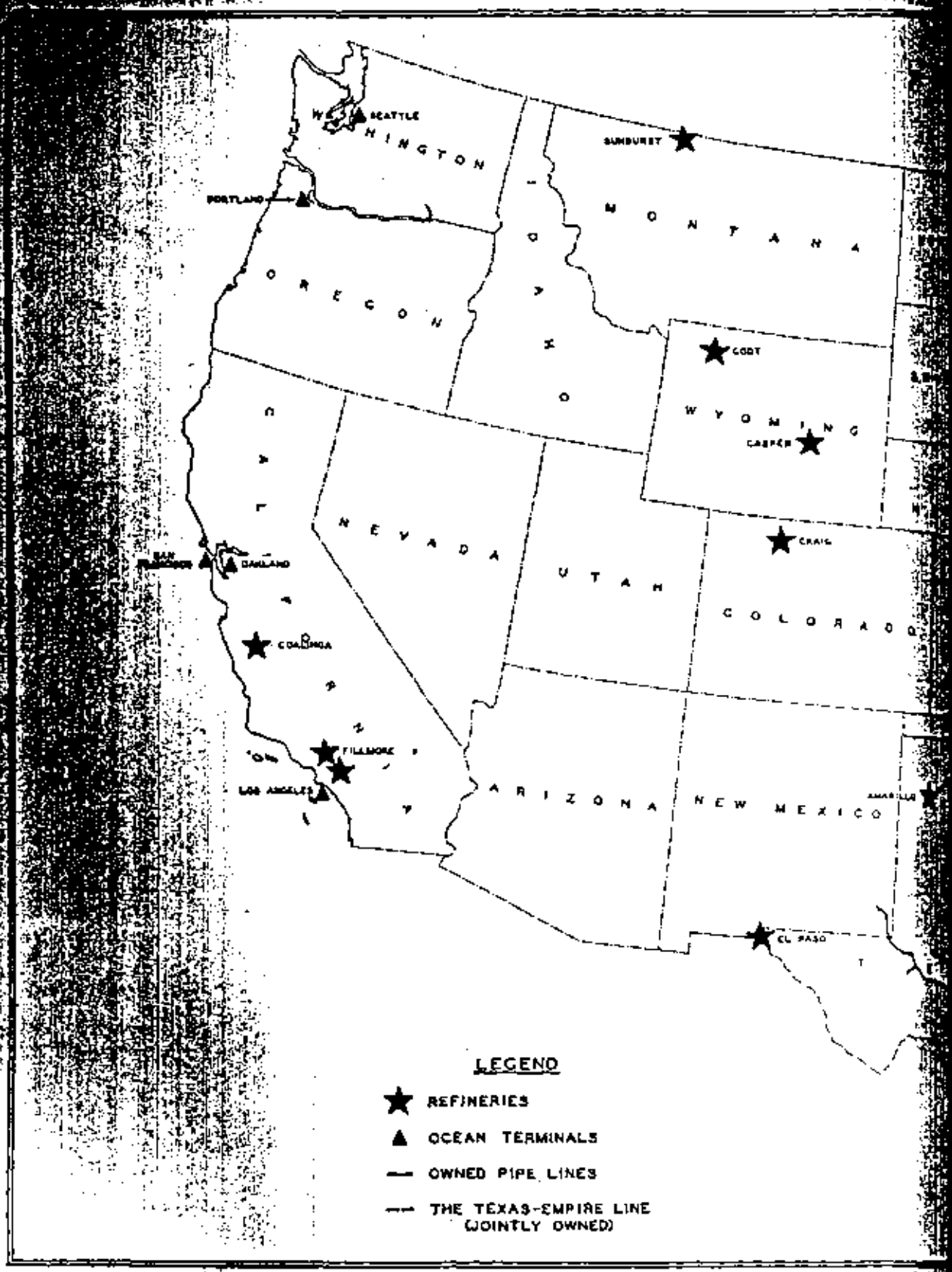
R 338.78 T355 1928-1940

Annual Report
for the year
1928

Location and Capacity of Refineries

	Normal Daily Crude Capacity (Barrels)
REFINERIES	
Port Arthur, Texas	60,000
Port Neches, Texas	20,000
West Dallas, Texas	16,000
Amarillo, Texas	3,000
Houston, Texas	20,000
San Antonio, Texas	3,000
El Paso, Texas	1,500
West Tulsa, Oklahoma	14,000
Lockport, Illinois	12,000
Pryse, Kentucky	2,000
Craig, Colorado	1,000
Casper, Wyoming	7,000
Cody, Wyoming	3,000
Sunburst, Montana	4,500
Los Angeles, California	30,000
Torrance, California	4,000
Total	201,000
CRACKING PLANTS	
Shreveport, Louisiana	6,500
Coalinga, California	500
Lusbeck, Wyoming	300
Total	7,300
ASPHALT PLANTS	
Norfolk, Virginia	1,500
Marcus Hook, Pennsylvania	1,500
Providence, Rhode Island	1,500
Total	4,500
Total Capacity	212,800

The Company has an asphalt plant in connection with the Port Neches refinery, the total crude capacity of which is given in the above table.


SEATTLE
PORTLAND
SUNBURST
MONTANA
OREGON
COD
WYOMING
CASPER
NEVADA
UTAH
CRAIG
COLORADO
OAKLAND
COALINGA
FILLMORE
LOS ANGELES
ARIZONA
NEW MEXICO
EL PASO
LEGEND
REFINERIES
OCEAN TERMINALS
OWNED PIPE LINES
THE TEXAS-EMPIRE LINE (JOINTLY OWNED)

(Burmah Oil and Gas Company)

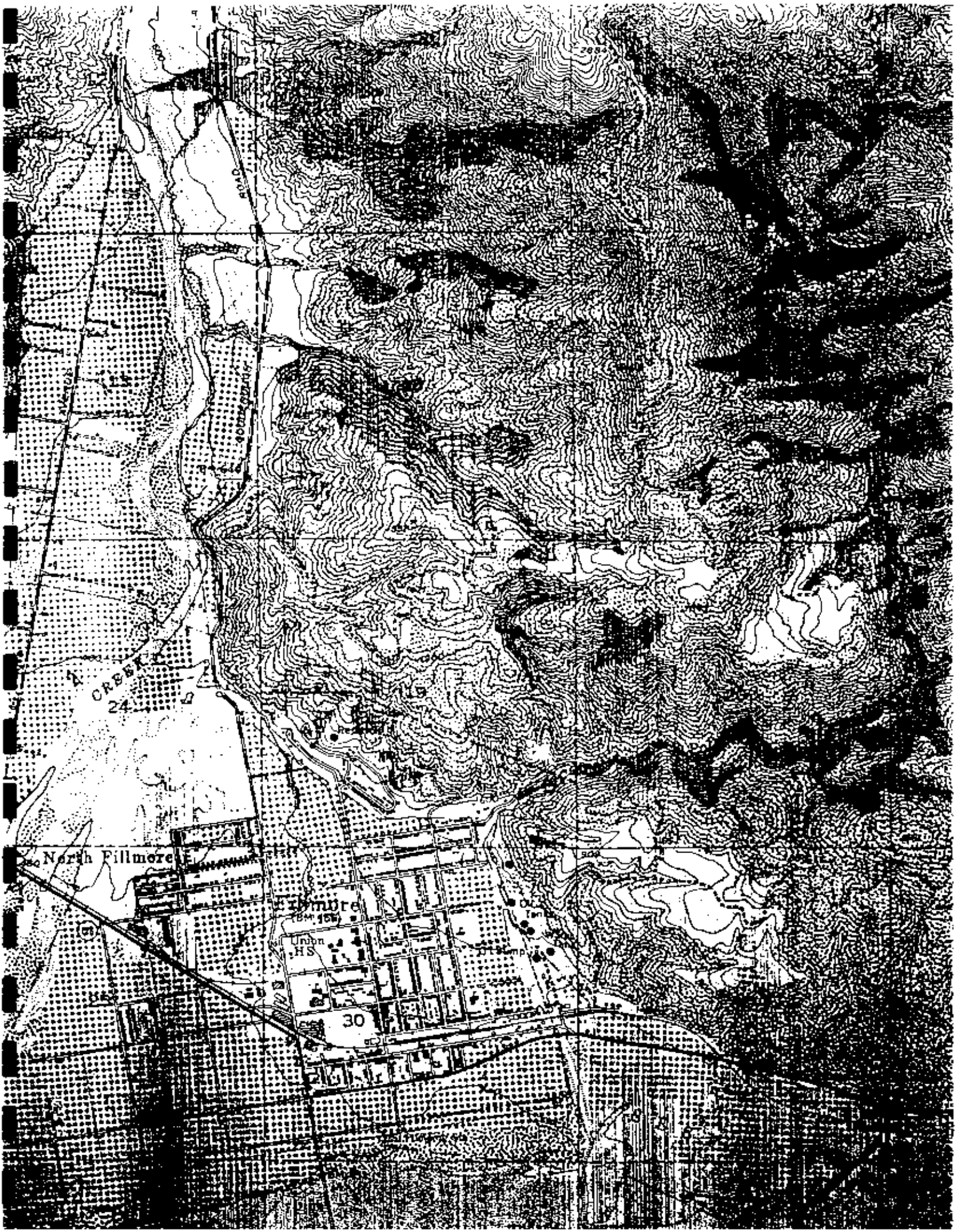
imately 100 boilers being fed by this dry line. When the oil hit the boilers, we had the first 'smoke in' in oil history. We knew at once what had happened, but several hours elapsed and a lot more smoke was produced before the source of the oil could be pinpointed."

If some helped themselves to gas, others helped themselves to automobile fuel. Natural gas is an elastic substance of which a large volume can be compressed into a very small space and when it is compressed at reasonably low temperature, the heavier components are liquefied. Because of this, lines carrying gas from the separator traps in the field to the gas plants were equipped with drip boxes, or pots, in which the condensate might gather.

The condensate had various uses. Carlton L. (Cop) Case recalled that, while working on the White Star lease in the Little Sespe Creek area near Fillmore, he gathered drips from gas fuel lines during the winter for use in starting the Fairbanks engine powering the jacklines on the lease.

"After pouring some of the volatile drips in the power cylinder," he recalled, "we turned it over several times by hand and set it in firing position on the compression stroke. We then ignited it with a 22-blank cartridge or the head of a big kitchen match in the firing pin device that protruded through the cylinder head. It was almost like serving in the artillery."

The condensate was found to be excellent blending material for aviation or automotive gasoline. In 1919, after the war, Case worked in Ventura Oil's gasoline plant on the Shiells lease at Fillmore. "The liquefied petroleum gas from the accumulator," Case recalled, "was blended with the water white distillate from a steam stove operating on the lease to make a fluid of approximately 72°-gravity. This was run through fuller's earth filters to improve color and remove moisture. The filters were made from twelve-inch pipe, and the fuller's earth was rejuvenated by the application of heat. The only trouble with the process was that the product had an end point of about 550° Fahrenheit due to the presence of heavy distillate. This blend, however, sold from ten to twenty cents a gallon. We furnished the fuel for most of the race cars at twenty cents a gallon in drums, after the old board track in Beverly Hills was started

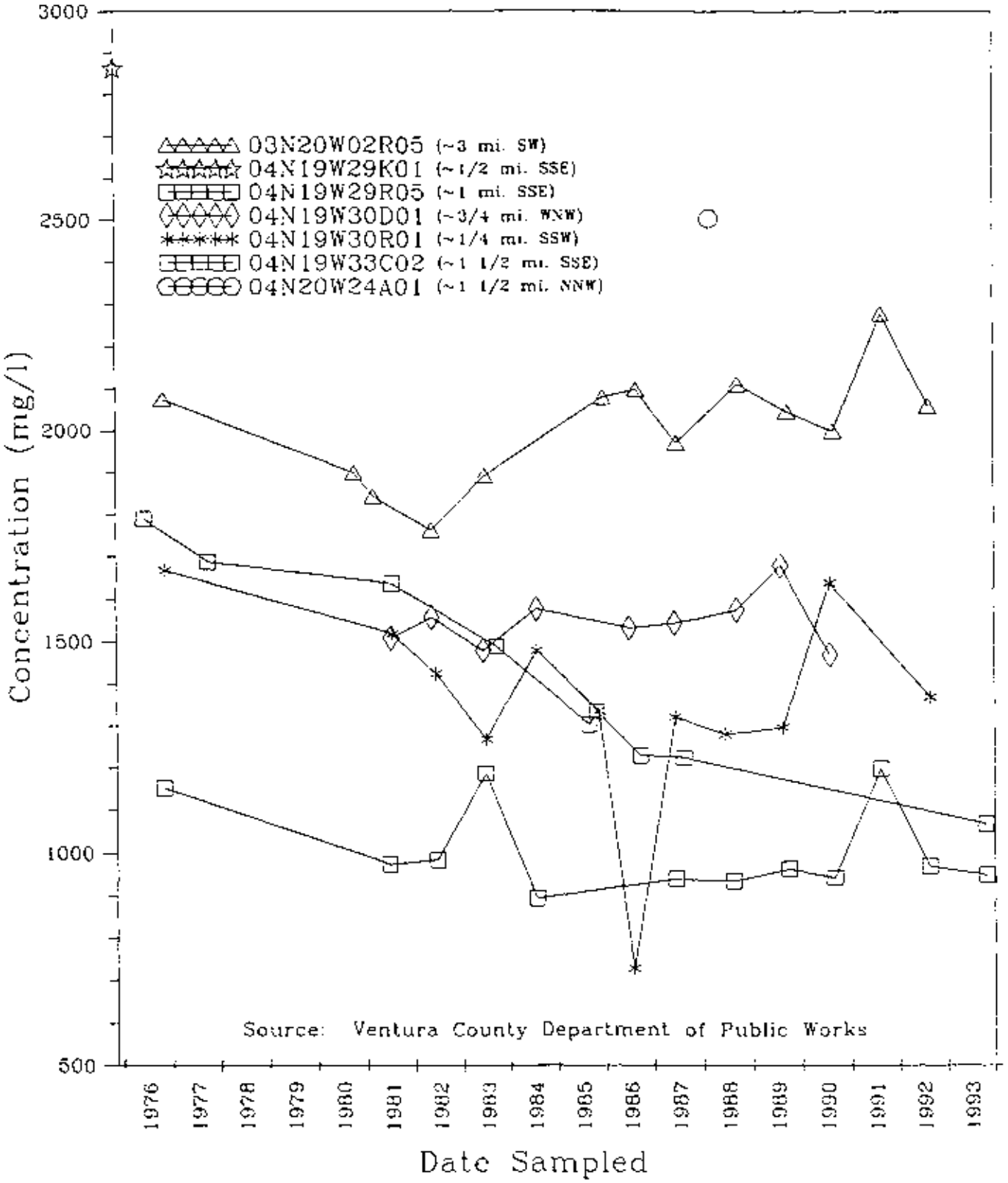

North Fillmore
Union
HS
30
24
CREEK

APPENDIX E

Table E-I
Summary of Total Dissolved Solids Concentrations From
From Pacific Coast Pipeline (PCPL) Site Wells

Aquifer	Well	Date Sampled	Total Dissolved Solids (TDS) mg/L
Aquifer I	MW-7S	March 18, 1993	1,200
	MW-8S	March 18, 1993	1,300
	MW-8S	May 9, 1993	1,300
	MW-17S	March 18, 1993	1,100
	MW-19S	December 20, 1993	1,100
	MW-19S	February 10, 1994	1,000
	MW-19S	February 17, 1994	1,100
	MW-26S	March 18, 1993	1,000
	MW-28S	August 21, 1991	1,180
	MW-28S	May 9, 1993	830
	MW-28S	December 20, 1993	1,300
	MW-28S	February 10, 1994	1,300
	MW-28S	February 17, 1994	1,300
	MW-29S	August 23, 1991	2,390
	MW-29S	March 18, 1993	2,700
	MW-40S	October 21, 1993	1,200
	EW-1	May 9, 1993	1,400
	EW-1	December 20, 1993	1,300
	EW-1	February 10, 1994	1,200
	EW-1	February 17, 1994	1,200
	EW-2	June 20, 1994	1,200
	EW-2	August 15, 1994	1,200
	EW-4	June 20, 1994	1,100
	EW-4	August 15, 1994	1,400
	EW-5	June 20, 1994	1,300
	EW-5	August 15, 1994	1,600

Figure E-1
Total Dissolved Solids Concentrations From Offsite Wells Near the PCPL Site



ENGLAND SHAHIN & ASSOCIATES

Texaco Refining
and Marketing Inc

10 Universal City Plaza
Universal City CA 91608

September 27, 1994

Mr. Robert P. Ghirelli
Executive Officer
California Regional Water Quality Control Board
Los Angeles Region
101 Centre Plaza Drive
Monterey Park, CA 91754-2156

SUBJECT: Notification of Discharge Excursion from NPDES Limit and Request for Increase in Limit
Pacific Coast Pipeline Superfund Site, Fillmore, California
Compliance File No. 7346, Order No. 93-072
NPDES No. CA0063240

Dear Mr. Ghirelli:

Texaco Inc. is submitting this letter, pursuant to the California Regional Water Quality Control Board's (RWQCB) Standard Provisions and Reporting Requirements, to notify you of an excursion from the requirements of the subject NPDES permit. In addition, Texaco is requesting a modification of the limit which was exceeded. The excursion is the result of naturally occurring ground water components, rather than from system upsets or contamination resulting from activities at the site.

TDS Limit

The permit is for discharge of treated ground water from the Pacific Coast Pipeline (PCPL) Superfund Site in Fillmore, California, into Pole Creek which is a tributary of the Santa Clara River. In our September 1994 effluent sample, total dissolved solids (TDS) concentration exceeded the permit limit. Upon receipt of the test results, the treatment plant was shut down on September 14, 1994.

An effluent sample collected on September 12, 1994 showed 1,400 mg/l TDS, which is 200 mg/l over the permit limit of 1,200 mg/l. A duplicate sample collected the same day tested at 980 mg/l. Additional samples were collected on September 14, just before shutdown. At 1,400 mg/l and 1,300 mg/l for a duplicate, these were also over the limit.

The mass discharge rate of TDS in the effluent has been less than 350 lb/day, well below the permitted daily maximum of 1,000 lb/day. The reason for this is that the treated ground water discharge has been less than 30,000 gallons per day, even though the permit allows up to 100,000 gallons per day.

The present treatment system will be upgraded to a larger capacity system in 1995, and we will apply for a new NPDES permit for the upgraded system. In the meantime, we would like to continue operation of the present system since we have already made a significant impact on ground water benzene concentrations in zones surrounding the pumping wells, and have contained a significant portion of the benzene plume.

We request that the limit for TDS in the present permit be increased to 1,600 mg/l and that we be allowed to continue operation until a new permit has been obtained and a new ground water treatment system is operable. We will apply for the new permit as soon as the Phase 2 design is final (currently estimated to be early 1995). The following items are offered for your consideration:

- The TDS is natural in the ground water and is not related to the benzene contamination we are working to remediate.

- The TDS is about two-thirds bicarbonates of calcium and magnesium. General minerals test results for the September 14, 1994 samples are attached. Note that, not only are chloride and sulfate concentrations well below the permit limits, but they are not significant contributors to TDS.

- Samples from the Santa Clara River have consistently shown high TDS. Sample concentrations range from 940 mg/l to 1,200 mg/l 100 ft upstream of the Pole Creek confluence (sample R-1) and 910 mg/l to 1,700 mg/l 300 ft downstream of that point (sample R-2). The September 1994 TDS values are 1,100 mg/l for R-1 and 820 mg/l for R-2. (NPDES Monitoring Reports - First Quarter 1994, and Third Quarter 1994 (latter in preparation)).

- The TDS of samples from Pole Creek upstream of our discharge point was higher than our present discharge limit; 1,300 mg/L on September 12, 1994.

- In the 1993 water year, the mean flow of the Santa Clara River near Fillmore ranged from about 53 million gallons per day in July to over 600 million gallons per day in February. The effluent covered by our NPDES permit is limited to 100,000 gallons per day. Therefore, at most, the effluent amounts to less than 0.2 percent of the river flow. Based on (1) a low river flow rate of 50 million gallons per day, (2) our lowest measured upstream TDS concentration in the river, 940 mg/l, (3) 1,600 mg/l TDS in our effluent and (4) 100,000 gallons per day effluent, the river concentration would change from 940 mg/l to 941 mg/l. The change is only 0.14 percent which is not even discernable by normal analytical methods.

- We have made considerable progress in containing and reducing the size of the benzene plume in ground water at the site. The following table summarizes observed benzene concentrations in extraction wells EW-2, EW-4 and EW-5 and nearby monitoring wells MW-2S, MW-39S and MW-40S before and after pumping for a few months.

Benzene Concentrations, ug/l

Well Number	May 1994	August 1994
EW-2	330	55
EW-4	610	200
EW-5	200	52
MW-2S	1300	150
MW-39S	510	350
MW-40S	19	11

Shutdown of the treatment system is a setback to our remediation efforts. Texaco and the U.S. EPA are very interested in keeping the remediation active. Ms. Katherine Moore, Project Officer for the EPA for this project has offered her support in efforts to get the system back in operation as quickly as possible.

Therefore, we request that you grant Texaco permission to restart the ground water system with an increase in allowable TDS to 1,600 mg/l. We will be pleased to meet with you or your staff to discuss this further, if this would be useful.

If you have any questions, please call Dennis England at (714) 453-8085, or me at (818) 505-2680.

Sincerely,

Glenn R. Anderson
Project Coordinator

Attachment: General Minerals Analysis for Effluent

cc: Ms. Katherine L. Moore, EPA
Mr. Shawn Haddad, DTSC
Mr. John R. Kirtley, Bechtel Corp.
Ms. Judith A. Wenker, Texaco
Mr. Mark J. Passarini, Texaco
Dr. Dennis C. England, England Shahin & Associates

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225-101
PCPL
Sample Descript: Water, Effluent
Lab Number: DI04411

Sampled: Sep 14, 1994
Received: Sep 15, 1994
Analyzed: Sep 15-21, 1994
Reported: Sep 21, 1994

GENERAL MINERAL ANALYSIS

Analyte	Detection Limit mg/L (ppm)	Sample Result mg/L (ppm)
Bicarbonate Alkalinity	2.0	850
Calcium	2.0	160
Carbonate Alkalinity	2.0	N.D.
Chloride	10	52
Copper	0.050	N.D.
Hardness	2.0	810
Hydroxide Alkalinity	2.0	N.D.
Iron	0.050	0.055
Magnesium	0.050	100
Manganese	0.050	0.37
pH (pH units)	N.A.	7.1
Sodium	0.50	170
Specific Conductance (µmhos/cm)	1.0	2,000
Sulfate	10	270
Surfactants	0.50	N.D
Zinc	0.050	N.D.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Gary Steube
Laboratory Director

STATE OF CALIFORNIA—ENVIRONMENTAL PROTECTION AGENCY

PETE WILSON, Governor

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION
101 CENTRE PLAZA DRIVE
MONTEREY PARK, CA 91754-2156
(213) 266-7500
FAX: (213) 266-7600

RECEIVED
OCT 26 1994
Ans'd.....

October 24, 1994

Mr. Glenn R. Anderson
Project Coordinator
Texaco Refining and Marketing Inc.
10 Universal City Plaza
Universal City, CA 91608

PACIFIC COAST PIPELINE SUPERFUND SITE, FILLMORE
(ORDER NO. 93-072, CA-0063240, CI-7346)

The subject facility currently discharges treated ground water under Order No. 93-072. In your September 27, 1994, letter, you notified the Board that a total dissolved solids (TDS) excursion occurred on September 12, 1994 with a concentration of 1,400 mg/l. The discharge limit is 1,200 mg/l. You stated that because of the high TDS in the discharge, the groundwater treatment system has been shut down and cleanup activities discontinued. You also stated that the excursion is the result of naturally occurring groundwater components, not from system upset or contamination resulting from activities at the site. Because the ground water has high TDS, you requested that the TDS effluent limit be increased from 1,200 mg/l to 1,600 mg/l. You further stated that under the worst case scenario, the increase of TDS effluent limitation from 1,200 to 1,600 mg/l would only increase TDS concentration in the Santa Clara River by 0.11 percent.

We have evaluated your report and concluded that the cleanup should continue.

The present treatment system will be upgraded in 1995 and you will be required to apply for a new NPDES permit. Therefore, we have no objection to your continual operation of the present system. However, the mass discharge rate of TDS in the effluent must not exceed the permitted daily maximum of 1,000 lbs/day and your discharge must not cause the water quality objectives in the Santa Clara River to be exceeded.

If you have any questions, please contact Harry Nguyen at (213) 266-7618 or Josh Workman at (213) 266-7615.

Robert P. Ghirelli

ROBERT P. GHIRELLI, D.Env.
Executive Officer

cc: John Youngerman, SWRCB, Division of Water Quality
Jorge Leon, SWRCB, Office of Chief Counsel
Shawn Haddad, DTSC, Region 3
Katherine Moore, EPA
Dennis England, England Shahin & Associates
15375 Barranca Pkwy, Suite F-106
Irvine, CA 92718

/hdn

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225-HO3-1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, PEW-1
Lab Number: DH02500

Sampled: Aug 9, 1994
Received: Aug 9, 1994
Analyzed: Aug 10, 1994
Reported: Aug 12, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	50	1,200	16	380
Toluene	50	160	13	42
Ethyl Benzene	50	78	12	18
Total Xylenes	50	67	12	15
Volatile Fuel Hydrocarbons	100	55,000	28	16,000

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 10.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225-HO3-1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, SB8-1
Lab Number: DH02501

Sampled: Aug 9, 1994
Received: Aug 9, 1994
Analyzed: Aug 10, 1994
Reported: Aug 12, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	50	56	16	18
Toluene	50	300	13	80
Ethyl Benzene	50	130	12	30
Total Xylenes	50	150	12	35
Volatile Fuel Hydrocarbons	100	41,000	28	12,000

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 10.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1558

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225-HO3-1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-3S
Lab Number: DH02502

Sampled: Aug 9, 1994
Received: Aug 9, 1994
Analyzed: Aug 10, 1994
Reported: Aug 12, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	20	N.D.	6.3	N.D.
Toluene	20	25	5.3	6.6
Ethyl Benzene	20	21	4.6	4.8
Total Xylenes	20	33	4.6	7.6
Volatile Fuel Hydrocarbons	40	22,000	11	6,300

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 4.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Rance for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8772 FAX (602) 968-1338

England Shahin & Associates	Client Project ID: 225-HO3-1O3	Sampled:	Aug 9, 1994
15375 Barranca Pkwy., Ste. F-106	Texaco PCPL-Vapor	Received:	Aug 9, 1994
Irvine, CA 92718	Sample Descript: Air Sample in Tedlar Bag, MW-37S	Analyzed:	Aug 10, 1994
Attention: Joni Fisher	Lab Number: DH02503	Reported:	Aug 12, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	50	2,100	16	660
Toluene	50	390	13	100
Ethyl Benzene	50	170	12	39
Total Xylenes	50	100	12	23
Volatile Fuel Hydrocarbons	100	73,000	28	21,000

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 10.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-17, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates	Client Project ID:	225-HO3-1O3	Sampled: Aug 9, 1994
15375 Barranca Pkwy., Ste. F-106		Texaco PCPL-Vapor	Received: Aug 9, 1994
Irvine, CA 92718	Sample Descript:	Air Sample in Tedlar Bag, PEW-1	Analyzed: Aug 10, 1994
Attention: Joni Fisher	Lab Number:	DH02500	Reported: Aug 12, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.40	7.3
Carbon Monoxide	0.40	N.D.
Methane	0.40	48
Nitrogen	0.40	41
Oxygen	0.40	3.0

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 4.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225-H03-1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, SBB-1
Lab Number: DH02501

Sampled: Aug 9, 1994
Received: Aug 9, 1994
Analyzed: Aug 10, 1994
Reported: Aug 12, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	15
Carbon Monoxide	0.10	N.D.
Methane	0.10	2.4
Nitrogen	0.10	81
Oxygen	0.10	1.9

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1845
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225-HO3-1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-3S
Lab Number: DH02502

Sampled: Aug 9, 1994
Received: Aug 9, 1994
Analyzed: Aug 10, 1994
Reported: Aug 12, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.20	8.4
Carbon Monoxide	0.20	N.D.
Methane	0.20	40
Nitrogen	0.20	49
Oxygen	0.20	2.0

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 2.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates	Client Project ID:	225-HO3-1O3	Sampled: Aug 9, 1994
15375 Barranca Pkwy., Ste. F-106		Texaco PCPL-Vapor	Received: Aug 9, 1994
Irvine, CA 92718	Sample Descript:	Air Sample in Tedlar Bag, MW-37S	Analyzed: Aug 10, 1994
Attention: Joni Fisher	Lab Number:	DH02503	Reported: Aug 12, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.40	3.8
Carbon Monoxide	0.40	N.D.
Methane	0.40	48
Nitrogen	0.40	44
Oxygen	0.40	4.8

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 4.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Franck for

Gary Steube
Laboratory Director

CHAIN OF CUSTODY

DATE 8/9/94 PAGE 1 OF 1

PROJECT MANAGER: J. Fisher
COMPANY: ENGLAND SHAHIN & ASSOCIATES
ADDRESS: 15375 Barranca Parkway, Suite F-106
Irvine, California 92718
Phone: 714-453-8085 Fax: 714-453-0733

BILL TO: Mark Pesserini
COMPANY: Texaco Refining & Mktg
ADDRESS:

SAMPLERS SIGNATURE: [signature]
PHONE NUMBER: 714-453-8085

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	Petroleum Hydrocarbons 418.1 (1L (H2SO4)/100g)	Oil and Grease 413.2 (1L (H2SO4)/100g)	Gasoline (WOD 8015/DOHS) (4 oz (HCL)/50g)	Diesel (WOD 8015/DOHS) (4 oz (HCL)/50g)	Gasoline/BTXE (WOD 8015/8020) (4 oz (HCL)/50g)	Petroleum Distillates (C6-C25) (4 oz (HCL)/50g)	BTXE (8020) (2x40ml (HCL)/50g)	Chlorinated Hydrocarbons (8010) (2x40ml (HCL)/50g)	Aromatic Hydrocarbons (2x40ml (HCL)/50g)	Chlorinated/Aromatic Hydrocarbons (8010/8020) (2x40ml (HCL)/50g)	Organic Pb (500ml/50g)		Pesticides/PCB (8080) (1L/50g)	Base/NEU/Acid Cmpds GC/MS (8270) (1L/100g)	Volatile Cmpds GC/MS (8240) (2x40ml (HCL)/50g)	Polynuclear Aromatic (8310) (1L/100g)	CCR Metals (500ml/100g)	Priority Pollutant Metals (500ml/100g)		8015/8020	Fixed Gases					Number of Containers
PEW-1	8/9/94	0218	Gas																					X	X					1
SBG-1	↓	1014	↓																					X	X					1
MW-3S	↓	1215	↓																					X	X					1
MW-3D	8/9/94	1497	Gas																					X	X					1

PROJECT INFORMATION	SAMPLE RECEIPT	MH
PROJECT NUMBER: 225-H03/103	TOTAL NUMBER OF CONTAINERS	4
PROJECT NAME: Texaco PCPL - Vapor	CHAIN OF CUSTODY SEALS Y/N/NA	N/A
PURCHASE ORDER NUMBER:	INTACT? Y/N/NA	Y
VIA	RECEIVED GOOD COND./COLD	Y AIR
TAT:	LAB NUMBER	TEMP

SAMPLE DISPOSAL INSTRUCTIONS

COMMENTS:

RELINQUISHED BY: 1.	RELINQUISHED BY: 2.	RELINQUISHED BY: 3.
Signature [signature] Time 14:58	Signature [signature] Time	Signature [signature] Time 3:55
Printed Name Mike Hayashi Date 8/9/94	Printed Name Lonnie Kubita Date	Printed Name L. DeLacy Date 8/10/94
Company ENGLAND SHAHIN & ASSOCIATES	Company Del Mar	Company DELMAR
RECEIVED BY: 1.	**RECEIVED BY: 2.**	**RECEIVED BY: 3.**
Signature [signature] Time 14:58	Signature [signature] Time 2:15	Signature [signature] Time 3:55p
Printed Name LONNIE KUBITA Date 8/9/94	Printed Name L. DeLacy Date 8/10/94	Printed Name D Adamson Date 8-10-94
Company Del Mar	Company DELMAR	Company DEL MAR ANALYTICAL

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr. Suite A Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St. Suite 1 Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, AEW-1
Lab Number: DH02538

Sampled: Aug 9, 1994
Received: Aug 10, 1994
Analyzed: Aug 10, 1994
Reported: Aug 12, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	50	1,200	16	380
Toluene	50	230	13	61
Ethyl Benzene	50	180	12	41
Total Xylenes	50	250	12	58
Volatile Fuel Hydrocarbons	100	54,000	28	15,000

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 10.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, PEW-6
Lab Number: DH02539

Sampled: Aug 9, 1994
Received: Aug 10, 1994
Analyzed: Aug 10, 1994
Reported: Aug 12, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	50	1,200	16	380
Toluene	50	370	13	98
Ethyl Benzene	50	170	12	39
Total Xylenes	50	260	12	60
Volatile Fuel Hydrocarbons	100	75,000	28	21,000

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 10.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370 1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1538

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, PEW-3
Lab Number: DH02540

Sampled: Aug 9, 1994
Received: Aug 10, 1994
Analyzed: Aug 10, 1994
Reported: Aug 12, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	100	1,600	31	500
Toluene	100	400	27	110
Ethyl Benzene	100	170	23	39
Total Xylenes	100	260	23	60
Volatile Fuel Hydrocarbons	200	89,000	57	25,000

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 20.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Rancl for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, PEW-5
Lab Number: DH02541

Sampled: Aug 9, 1994
Received: Aug 10, 1994
Analyzed: Aug 10, 1994
Reported: Aug 12, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	50	710	16	220
Toluene	50	310	13	82
Ethyl Benzene	50	110	12	25
Total Xylenes	50	140	12	32
Volatile Fuel Hydrocarbons	100	53,000	28	15,000

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 10

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-38S
Lab Number: DH02542

Sampled: Aug 10, 1994
Received: Aug 10, 1994
Analyzed: Aug 11, 1994
Reported: Aug 12, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	20	130	6.3	41
Toluene	20	50	5.3	13
Ethyl Benzene	20	32	4.6	7.4
Total Xylenes	20	62	4.6	14
Volatile Fuel Hydrocarbons	40	17,000	11	4,800

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 4.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, PEW-4
Lab Number: DH02543

Sampled: Aug 10, 1994
Received: Aug 10, 1994
Analyzed: Aug 11, 1994
Reported: Aug 12, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	50	320	16	100
Toluene	50	260	13	69
Ethyl Benzene	50	320	12	74
Total Xylenes	50	350	12	81
Volatile Fuel Hydrocarbons	100	50,000	28	14,000

Hydrocarbons detected by this method range from C6 - C15
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 10.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1558

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-10P
Lab Number: DH02544

Sampled: Aug 10, 1994
Received: Aug 10, 1994
Analyzed: Aug 11, 1994
Reported: Aug 12, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	50	98	16	31
Toluene	50	230	13	61
Ethyl Benzene	50	140	12	32
Total Xylenes	50	290	12	67
Volatile Fuel Hydrocarbons	100	44,000	28	13,000

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 10.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-11S
Lab Number: DH02545

Sampled: Aug 10, 1994
Received: Aug 10, 1994
Analyzed: Aug 11, 1994
Reported: Aug 12, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	5.0	N.D.	1.6	N.D.
Toluene	5.0	N.D.	1.3	N.D.
Ethyl Benzene	5.0	N.D.	1.2	N.D.
Total Xylenes	5.0	N.D.	1.2	N.D.
Volatile Fuel Hydrocarbons	10	41	2.8	12

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-46S
Lab Number: DH02546

Sampled: Aug 10, 1994
Received: Aug 10, 1994
Analyzed: Aug 11, 1994
Reported: Aug 12, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	5.0	N.D.	1.6	N.D.
Toluene	5.0	6.6	1.3	1.8
Ethyl Benzene	5.0	N.D.	1.2	N.D.
Total Xylenes	5.0	30	1.2	6.9
Volatile Fuel Hydrocarbons	10	2,600	2.8	740

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranek for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-43S
Lab Number: DH02547

Sampled: Aug 10, 1994
Received: Aug 10, 1994
Analyzed: Aug 11, 1994
Reported: Aug 12, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	10	N.D.	3.1	N.D.
Toluene	10	N.D.	2.7	N.D.
Ethyl Benzene	10	N.D.	2.3	N.D.
Total Xylenes	10	N.D.	2.3	N.D.
Volatile Fuel Hydrocarbons	20	9,200	5.7	2,600

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 2.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-45S
Lab Number: DH02548

Sampled: Aug 10, 1994
Received: Aug 10, 1994
Analyzed: Aug 11, 1994
Reported: Aug 12, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	25	N.D.	7.8	N.D.
Toluene	25	75	6.6	20
Ethyl Benzene	25	35	5.8	8.1
Total Xylenes	25	53	5.8	12
Volatile Fuel Hydrocarbons	50	27,000	14	7,700

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 5.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Rauck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave. Irvine, CA 92714 (714) 261-1022 FAX (714) 261-2228
1014 E. Cooley Dr., Suite A, Colton CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe AZ 85281 (602) 968-8272 FAX (602) 968-1558

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, AEW-1
Lab Number: DH02538

Sampled: Aug 9, 1994
Received: Aug 10, 1994
Analyzed: Aug 10, 1994
Reported: Aug 12, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	15
Carbon Monoxide	0.10	N.D.
Methane	0.10	5.5
Nitrogen	0.10	78
Oxygen	0.10	2.3

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Rance for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8772 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, PEW-6
Lab Number: DH02539

Sampled: Aug 9, 1994
Received: Aug 10, 1994
Analyzed: Aug 10, 1994
Reported: Aug 12, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	12
Carbon Monoxide	0.10	N.D.
Methane	0.10	3.2
Nitrogen	0.10	82
Oxygen	0.10	2.1

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranch for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, PEW-3
Lab Number: DH02540

Sampled: Aug 9, 1994
Received: Aug 10, 1994
Analyzed: Aug 10, 1994
Reported: Aug 12, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	12
Carbon Monoxide	0.10	N.D.
Methane	0.10	2.7
Nitrogen	0.10	83
Oxygen	0.10	2.0

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, PEW-5
Lab Number: DH02541

Sampled: Aug 9, 1994
Received: Aug 10, 1994
Analyzed: Aug 10, 1994
Reported: Aug 12, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	13
Carbon Monoxide	0.10	N.D.
Methane	0.10	1.8
Nitrogen	0.10	83
Oxygen	0.10	2.8

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Rance for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1538

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-38S
Lab Number: DH02542

Sampled: Aug 10, 1994
Received: Aug 10, 1994
Analyzed: Aug 11, 1994
Reported: Aug 12, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.20	5.9
Carbon Monoxide	0.20	N.D.
Methane	0.20	35
Nitrogen	0.20	58
Oxygen	0.20	2.0

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 2.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, PEW-4
Lab Number: DH02543

Sampled: Aug 10, 1994
Received: Aug 10, 1994
Analyzed: Aug 10, 1994
Reported: Aug 12, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	16
Carbon Monoxide	0.10	N.D.
Methane	0.10	0.46
Nitrogen	0.10	81
Oxygen	0.10	2.2

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

England Shahin & Associates	Client Project ID:	225 HO3/1O3	Sampled: Aug 10, 1994
15375 Barranca Pkwy., Ste. F-106		Texaco PCPL-Vapor	Received: Aug 10, 1994
Irvine, CA 92718	Sample Descript:	Air Sample in Tedlar Bag, MW-10P	Analyzed: Aug 10, 1994
Attention: Joni Fisher	Lab Number:	DH02544	Reported: Aug 12, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	14
Carbon Monoxide	0.10	N.D.
Methane	0.10	2.1
Nitrogen	0.10	78
Oxygen	0.10	5.6

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-11S
Lab Number: DH02545

Sampled: Aug 10, 1994
Received: Aug 10, 1994
Analyzed: Aug 10, 1994
Reported: Aug 12, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	N.D.
Carbon Monoxide	0.10	N.D.
Methane	0.10	N.D.
Nitrogen	0.10	78
Oxygen	0.10	22

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16535 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-46S
Lab Number: DH02546

Sampled: Aug 10, 1994
Received: Aug 10, 1994
Analyzed: Aug 11, 1994
Reported: Aug 12, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	3.3
Carbon Monoxide	0.10	N.D.
Methane	0.10	1.7
Nitrogen	0.10	93
Oxygen	0.10	2.1

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-43S
Lab Number: DH02547

Sampled: Aug 10, 1994
Received: Aug 10, 1994
Analyzed: Aug 11, 1994
Reported: Aug 12, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.13	1.5
Carbon Monoxide	0.13	N.D.
Methane	0.13	29
Nitrogen	0.13	68
Oxygen	0.13	2.2

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 1.3.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates	Client Project ID:	225 HO3/1O3	Sampled: Aug 10, 1994
15375 Barranca Pkwy., Ste. F-106		Texaco PCPL-Vapor	Received: Aug 10, 1994
Irvine, CA 92718	Sample Descript:	Air Sample in Tedlar Bag, MW-45S	Analyzed: Aug 11, 1994
Attention: Joni Fisher	Lab Number:	DH02548	Reported: Aug 12, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.13	5.5
Carbon Monoxide	0.13	N.D.
Methane	0.13	27
Nitrogen	0.13	65
Oxygen	0.13	2.3

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 1.3

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for

Gary Steube
Laboratory Director

CHAIN OF CUSTODY

DATE 8/10/94 PAGE 1 OF 1

PROJECT MANAGER: J. Fisher
COMPANY: ENGLAND SHAHIN & ASSOCIATES
ADDRESS: 15375 Barranca Parkway, Suite F-106
Irvine, California 92718
Phone: 714-453-8085 Fax: 714-453-0733

BILL TO: Mark Pescarini
COMPANY: Texaco Refin. & Mktg
ADDRESS:

SAMPLER SIGNATURE: [signature] PHONE NUMBER: 714-453-8085

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	Petroleum Hydrocarbons 418.1 (1L H_2SO_4 /100g)	Oil and Grease 413.2 (1L H_2SO_4 /100g)	Gasoline (MOD 8015/DOHS) (4 oz (HCL)/50g)	Diesel (MOD 8015/DOHS) (4 oz (HCL)/50g)	Gasoline/BTXE (MOD 8015/8020) (4 oz (HCL)/50g)	Petroleum Distillates (C6-C25) (4 oz (HCL)/50g)	BTXE (8020) (2x40ml (HCL)/50g)	Chlorinated Hydrocarbons (8010) (2x40ml (HCL)/50g)	Aromatic Hydrocarbons (2x40ml (HCL)/50g)	Chlorinated/Aromatic Hydrocarbons (8010/8020) (2x40ml (HCL)/50g)	Organic Pb (1500ml /50g)	Pesticides/PCB (8080) (1L/50g)	Base/NEU/Acid Cmpds GC/MS (8270) (1L/100g)	Volatile Cmpds GC/MS (8240) (2x40ml (HCL)/100g)	Polynuclear Aromatic (8310) (1L/100g)	CCP Metals (500ml /100g)	Priority Pollutant Metals (500ml /100g)	8015 /8020	Fixed Gases	Number of Containers
AEW-1	8/9/94	1540	Gas																			X	X	1
PEW-6		1625																				X	X	1
PEW-3		1705																				X	X	1
PEW-5		1755																				X	X	2
MW-38S	8/10/94	0810																				X	X	2
PEW-4		0900																				X	X	2
MW-10P		0955																				X	X	2
MW-11S		1110																				X	X	2
MW-46S		1240																				X	X	2
MW-43S		1335																				X	X	2
MW-45S		1435																				X	X	2

PROJECT INFORMATION	SAMPLE RECEIPT	
PROJECT NUMBER: 275 H03 /103	TOTAL NUMBER OF CONTAINERS	19
PROJECT NAME: Texaco PCPL - Vapor	CHAIN OF CUSTODY SEALS Y/N/NA	—
PURCHASE ORDER NUMBER:	INTACT? Y/N/NA	Y
VIA	RECEIVED GOOD COND/COLD	Y
TAT: NORMAL	LAB NUMBER	

SAMPLE DISPOSAL INSTRUCTIONS

COMMENTS:

RELINQUISHED BY: 1.	RELINQUISHED BY: 2.	RELINQUISHED BY: 3.
Signature [signature] Time 1500	Signature Lonnie Kukita Time 9:45	Signature [signature] Time 9:15 pm
Printed Name Michael Hagedorn Date 8/10/94	Printed Name Lonnie Kukita Date 8/10/94	Printed Name Javier Ruiz Date 8/10/94
Company ENGLAND SHAHIN & ASSOCIATES	Company Del Mar	Company Golden West
RECEIVED BY: 1.	**RECEIVED BY: 2.**	**RECEIVED BY: 3.**
Signature Lonnie Kukita Time 1500	Signature [signature] Time 9:45	Signature [signature] Time 9:15
Printed Name Lonnie Kukita Date 8/10/94	Printed Name Javier Ruiz Date 8/10/94	Printed Name D. Williams Date 8/10/94
Company Del Mar	Company Golden West	DEL MAR ANALYTICAL

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225-IO1
Texaco PCPL
Sample Descript: Air Sample in Tedlar Bag, PEW-2
Lab Number: DH02549

Sampled: Aug 10, 1994
Received: Aug 10, 1994
Analyzed: Aug 11, 1994
Reported: Aug 12, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	35	520	11	160
Toluene	35	250	9.3	66
Ethyl Benzene	35	150	8.1	35
Total Xylenes	35	230	8.1	53
Volatile Fuel Hydrocarbons	70	41,000	20	12,000

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 7.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Rauch for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16535 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1558

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225-IO1
Texaco PCPL
Sample Descript: Air Sample in Tedlar Bag, PEW-2
Lab Number: DH02549

Sampled: Aug 10, 1994
Received: Aug 10, 1994
Analyzed: Aug 11, 1994
Reported: Aug 12, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	14
Carbon Monoxide	0.10	N.D.
Methane	0.10	0.60
Nitrogen	0.10	82
Oxygen	0.10	3.4

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225-IO1
Texaco PCPL
Sample Descript: Air Sample in Tedlar Bag, PEW-2
Lab Number: DH02549

Sampled: Aug 10, 1994
Received: Aug 10, 1994
Analyzed: Aug 11, 1994
Reported: Aug 12, 1994

HYDROCARBON DISTRIBUTION

Laboratory Number	Hydrocarbon Type	Sample Results mg/m3	Percentage of Total %
DH02549	C1 - C2	4,100	8.2
	C3	200	0.40
	C4	510	1.0
	C5	3,800	7.6
	C6	14,000	28
	C7	14,000	28
	C8	9,200	18
	C9	2,900	5.8
	C10	870	1.7
	C11	240	0.48
	C12	59	0.12
	C13	N.D.	N.D.
	C14	N.D.	N.D.
	C15	N.D.	N.D.

Detection Limit	**1.0**

Hydrocarbons detected by this method range from C1 to C15

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Rancl for
Gary Steube
Laboratory Director

CHAIN OF CUSTODY

DATE 8/10/94 PAGE 1 OF 1

PROJECT MANAGER: JONI FISHER
COMPANY: ENGLAND SHAHIN & ASSOCIATES
ADDRESS: 15375 Barranca Parkway, Suite F-106
Irvine, California 92718
Phone: 714-453-8085 Fax: 714-453-0733

BILL TO: MARK PASSARINI
COMPANY: TEXACO Refining & Marketing
ADDRESS: 10 Universal City Plaza
Universal City, CA.
(818) 505-2741
SAMPLERS SIGNATURE: [signature] PHONE NUMBER: (714) 453-8085

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	Petroleum Hydrocarbons 418.1 (1L H_2SO_4/100g)	Oil and Grease 413.2 (1L H_2SO_4/100g)	Gasoline (MOD 8015/OOHS) (4 oz (HCL)/50g)	Diesel (MOD 8015/OOHS) (4 oz (HCL)/50g)	Gasoline/BTXE (MOD 8015/8020) (4 oz (HCL)/50g)	Petroleum Distillates (C6-C25) (4 oz (HCL)/50g)	BTXE (8020) (2X40m (HCL)/50g)	Chlorinated Hydrocarbons (8010) (2X40ml (HCL)/50g)	Aromatic Hydrocarbons (2X40ml (HCL)/50g)	Chlorinated/Aromatic Hydrocarbons (8010/8020) (2X40ml (HCL)/50g)	Organic Pb (500ml/50g)		Pesticides/PCB (8080) (1L/50g)	Base/NEU/Acid Cmpds GC/MS (8270) (1L/100g)	Volatile Cmpds GC/MS (8240) (2X40m (HCL)/100g)	Polynuclear Aromatic (8310) (1L/100g)	CCR Metals (500ml/100g)	Priority Pollutant Metals (500ml/100g)	8015/8020		Fixed Gases	Hydrocarbon Dist.				Number of Containers
PEW-2	8/10/94	15:20	AIR																					X		X	X			2

PROJECT INFORMATION	SAMPLE RECEIPT	
PROJECT NUMBER: 225-101	TOTAL NUMBER OF CONTAINERS	2
PROJECT NAME: TEXACO PCPL	CHAIN OF CUSTODY SEALS Y/N/NA	—
PURCHASE ORDER NUMBER:	INTACT? Y/N/NA	Y
VIA	RECEIVED GOOD COND./COLD	Y
TAT: NORMAL	LAB NUMBER	

SAMPLE DISPOSAL INSTRUCTIONS

COMMENTS:

RELINQUISHED BY: 1.	RELINQUISHED BY: 2.	RELINQUISHED BY: 3.
Signature: [signature] Time: 15:20	Signature: [signature] Time: 4:45	Signature: [signature] Time: 7:15
Printed Name: BOB DADAR Date: 8/10/94	Printed Name: Lonnie Kukita Date: 8/10/94	Printed Name: Javier Ruiz Date: 8/10/94
Company: ENGLAND SHAHIN & ASSOCIATES	Company: Del Mar	Company: Golden West
RECEIVED BY: 1.	**RECEIVED BY: 2.**	**RECEIVED BY: 3.**
Signature: [signature] Time: 15:30	Signature: [signature] Time: 4:45	Signature: [signature] Time: 7:15
Printed Name: Lonnie Kukita Date: 8/10/94	Printed Name: Javier Ruiz Date: 8/10/94	Printed Name: [illegible] Date: 8/10/94
Company: Del Mar	Company: Golden West Express	Company: DEL MAR ANALYTICAL

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-13P
Lab Number: DH02763

Sampled: Aug 10, 1994
Received: Aug 11, 1994
Analyzed: Aug 13, 1994
Reported: Aug 15, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	35	N.D.	11	N.D.
Toluene	35	49	9.3	13
Ethyl Benzene	35	N.D.	8.1	N.D.
Total Xylenes	35	59	8.1	14
Volatile Fuel Hydrocarbons	70	37,000	20	11,000

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 7.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates	Client Project ID: 225 HO3/1O3	Sampled:	Aug 10, 1994
15375 Barranca Pkwy., Ste. F-106	Texaco PCPL-Vapor	Received:	Aug 11, 1994
Irvine, CA 92718	Sample Descript: Air Sample in Tedlar Bag, MW-41S	Analyzed:	Aug 13, 1994
Attention: Joni Fisher	Lab Number: DH02764	Reported:	Aug 15, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	5.0	N.D.	1.6	N.D.
Toluene	5.0	N.D.	1.3	N.D.
Ethyl Benzene	5.0	N.D.	1.2	N.D.
Total Xylenes	5.0	N.D.	1.2	N.D.
Volatile Fuel Hydrocarbons	10	110	2.8	31

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Rancl for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Taxaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-39S
Lab Number: DH02765

Sampled: Aug 10, 1994
Received: Aug 11, 1994
Analyzed: Aug 13, 1994
Reported: Aug 15, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	5.0	41	1.6	13
Toluene	5.0	9.8	1.3	2.6
Ethyl Benzene	5.0	5.2	1.2	1.2
Total Xylenes	5.0	7.7	1.2	1.8
Volatile Fuel Hydrocarbons	10	2,200	2.8	630

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for

Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-42S
Lab Number: DH02766

Sampled: Aug 11, 1994
Received: Aug 11, 1994
Analyzed: Aug 13, 1994
Reported: Aug 15, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	5.0	N.D.	1.6	N.D.
Toluene	5.0	12	1.3	3.2
Ethyl Benzene	5.0	N.D.	1.2	N.D.
Total Xylenes	5.0	5.3	1.2	1.2
Volatile Fuel Hydrocarbons	10	3,000	2.8	850

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8772 FAX (602) 968-1558

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-14S
Lab Number: DH02767

Sampled: Aug 11, 1994
Received: Aug 11, 1994
Analyzed: Aug 13, 1994
Reported: Aug 15, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	5.0	30	1.6	9.4
Toluene	5.0	7.7	1.3	2.0
Ethyl Benzene	5.0	N.D.	1.2	N.D.
Total Xylenes	5.0	5.3	1.2	1.2
Volatile Fuel Hydrocarbons	10	2,300	2.8	650

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
10525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe AZ 85281 (602) 968-8272 FAX (602) 968-1558

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-44S
Lab Number: DH02768

Sampled: Aug 11, 1994
Received: Aug 11, 1994
Analyzed: Aug 13, 1994
Reported: Aug 15, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	5.0	N.D.	1.6	N.D.
Toluene	5.0	N.D.	1.3	N.D.
Ethyl Benzene	5.0	N.D	1.2	N.D
Total Xylenes	5.0	N.D.	1.2	N.D.
Volatile Fuel Hydrocarbons	10	130	2.8	37

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Runck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-2S
Lab Number: DH02769

Sampled: Aug 11, 1994
Received: Aug 11, 1994
Analyzed: Aug 13, 1994
Reported: Aug 15, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	5.0	24	1.6	7.5
Toluene	5.0	12	1.3	3.2
Ethyl Benzene	5.0	N.D.	1.2	N.D.
Total Xylenes	5.0	N.D.	1.2	N.D.
Volatile Fuel Hydrocarbons	10	3,400	2.8	970

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8277 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, SBD-2
Lab Number: DH02770

Sampled: Aug 11, 1994
Received: Aug 11, 1994
Analyzed: Aug 13, 1994
Reported: Aug 15, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	20	330	6.3	100
Toluene	20	99	5.3	26
Ethyl Benzene	20	39	4.6	9.0
Total Xylenes	20	37	4.6	8.5
Volatile Fuel Hydrocarbons	40	20,000	11	5,700

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 4.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-17, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-13P
Lab Number: DH02763

Sampled: Aug 10, 1994
Received: Aug 11, 1994
Analyzed: Aug 12, 1994
Reported: Aug 15, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	4.8
Carbon Monoxide	0.10	N.D.
Methane	0.10	7.8
Nitrogen	0.10	82
Oxygen	0.10	5.4

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

England Shahin & Associates	Client Project ID:	225 HO3/1O3	Sampled: Aug 10, 1994
15375 Barranca Pkwy., Ste. F-106		Texaco PCPL-Vapor	Received: Aug 11, 1994
Irvine, CA 92718	Sample Descript:	Air Sample in Tedlar Bag, MW-41S	Analyzed: Aug 12, 1994
Attention: Joni Fisher	Lab Number:	DH02764	Reported: Aug 15, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	N.D.
Carbon Monoxide	0.10	N.D.
Methane	0.10	N.D.
Nitrogen	0.10	78
Oxygen	0.10	22

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1558

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-39S
Lab Number: DH02765

Sampled: Aug 10, 1994
Received: Aug 11, 1994
Analyzed: Aug 12, 1994
Reported: Aug 15, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	0.24
Carbon Monoxide	0.10	N.D.
Methane	0.10	2.2
Nitrogen	0.10	76
Oxygen	0.10	21

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370 1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968 8272 FAX (602) 968 1358

England Shahin & Associates	Client Project ID:	225 HO3/1O3	Sampled: Aug 11, 1994
15375 Barranca Pkwy., Ste. F-106		Texaco PCPL-Vapor	Received: Aug 11, 1994
Irvine, CA 92718	Sample Descript:	Air Sample in Tedlar Bag, MW-42S	Analyzed: Aug 12, 1994
Attention: Joni Fisher	Lab Number:	DH02766	Reported: Aug 15, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	6.8
Carbon Monoxide	0.10	N.D.
Methane	0.10	10
Nitrogen	0.10	80
Oxygen	0.10	3.1

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-14S
Lab Number: DH02767

Sampled: Aug 11, 1994
Received: Aug 11, 1994
Analyzed: Aug 12, 1994
Reported: Aug 15, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	7.5
Carbon Monoxide	0.10	N.D.
Methane	0.10	7.9
Nitrogen	0.10	78
Oxygen	0.10	6.4

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
10525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8772 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-44S
Lab Number: DH02768

Sampled: Aug 11, 1994
Received: Aug 11, 1994
Analyzed: Aug 12, 1994
Reported: Aug 15, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	3.8
Carbon Monoxide	0.10	N.D.
Methane	0.10	10
Nitrogen	0.10	84
Oxygen	0.10	2.2

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/1O3
Texaco PCPL-Vapor
Sample Descript: Air Sample in Tedlar Bag, MW-2S
Lab Number: DH02769

Sampled: Aug 11, 1994
Received: Aug 11, 1994
Analyzed: Aug 12, 1994
Reported: Aug 15, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	13
Carbon Monoxide	0.10	N.D.
Methane	0.10	11
Nitrogen	0.10	73
Oxygen	0.10	3.0

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

England Shahin & Associates	Client Project ID: 225 HO3/1O3	Sampled:	Aug 11, 1994
15375 Barranca Pkwy., Ste. F-106	Texaco PCPL-Vapor	Received:	Aug 11, 1994
Irvine, CA 92718	Sample Descript: Air Sample in Tedlar Bag, SBD-2	Analyzed:	Aug 12, 1994
Attention: Joni Fisher	Lab Number: DH02770	Reported:	Aug 15, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	15
Carbon Monoxide	0.10	N.D.
Methane	0.10	4.7
Nitrogen	0.10	78
Oxygen	0.10	2.8

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for
Gary Steube
Laboratory Director

CHAIN OF CUSTODY

DATE 8/1/94 PAGE 1 OF 1

PROJECT MANAGER: J. Fisher
COMPANY: ENGLAND SHAHIN & ASSOCIATES
ADDRESS: 15375 Barranca Parkway, Suite F-106
Irvine, California 92718
Phone: 714-453-8085 Fax: 714-453-0733

BILL TO: Mark Pescarini
COMPANY: Texaco Refin. & Mktg
ADDRESS:

SAMPLER SIGNATURE: [signature] PHONE NUMBER: 714-453-8085

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	Petroleum Hydrocarbons 418.1 (1L H_2SO_4/100g)	Oil and Grease 413.2 (1L H_2SO_4/100g)	Gasoline (MOD 8015/DOHS) (4 oz (HCL)/50g)	Diesel (MOD 8015/DOHS) (4 oz (HCL)/50g)	Gasoline/BTXE (MOD 8015/8020) (4 oz (HCL)/50g)	Petroleum Distillates (C6-C25) (4 oz (HCL)/50g)	BTXE (8020) (2x40ml (HCL)/50g)	Chlorinated Hydrocarbons (8010) (2x40ml (HCL)/50g)	Aromatic Hydrocarbons (2x40ml (HCL)/50g)	Chlorinated/Aromatic Hydrocarbons (8010/8020) (2x40ml (HCL)/50g)	Organic Pb (500ml/50g)		Pesticides/PCB (8080) (1L/50g)	Base/NEU/Acid Cmpds GC/MS (8270) (1L/100g)	Volatile Cmpds GC/MS (8240) (2x40ml (HCL)/100g)	Polynuclear Aromatic (8310) (1L/100g)	CCR Metals (500ml/50g)	Priority Pollutant Metals (500ml/50g)		8015/8020	Fixed Gases					Number of Containers
MW-13P	8/10/94	1620	Gas																					X	X					2
MW-41S	↓	1700	↓																					X	X					2
MW-32S	↓	1805	↓																					X	X					2
MW-42S	8/11/94	0850	↓																					X	X					2
MW-14S	↓	0940	↓																					X	X					2
MW-44S	↓	1040	↓																					X	X					2
~~MW-2P~~ MW-2S	↓	~~1315~~	↓																					X	X					2
SBD-2	8/11/94	1420	Gas																					X	X					2

PROJECT INFORMATION	SAMPLE RECEIPT	
PROJECT NUMBER: 225H03/103	TOTAL NUMBER OF CONTAINERS	16
PROJECT NAME: Texaco PCPL-Vapor	CHAIN OF CUSTODY SEALS Y/N/NA	—
PURCHASE ORDER NUMBER:	INTACT? Y/N/NA	Y Y
VIA	RECEIVED GOOD COND./COLD?	Y Y
TAT: Normal	LAB NUMBER	

SAMPLE DISPOSAL INSTRUCTIONS

COMMENTS:

RELINQUISHED BY: 1.	RELINQUISHED BY: 2.	RELINQUISHED BY: 3.
Signature [signature] Time	Signature [signature] Time 4:30	Signature [signature] Time 6:40
Printed Name Michael Higuchi Date 8/11/94	Printed Name Lorrie Kubitz Date 8/11/94	Printed Name L. DeCloy Date 8/11/94
Company ENGLAND SHAHIN & ASSOCIATES	Company Del Mar	Company DELMAR
RECEIVED BY: 1.	**RECEIVED BY: 2.**	**RECEIVED BY: 3.**
Signature [signature] Time 3:18P	Signature [signature] Time 4:30	Signature [signature] Time 6:40
Printed Name Lorrie Kubitz Date 8/11/94	Printed Name L. DeCloy Date 8/11/94	Printed Name D. Gonzalez Date 8/11/
Company Del Mar	Company DELMAR	Company DEL MAR ANALYTICAL

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/IO3
PCPL, Fillmore
Sample Descript: Air Sample in Tedlar Bag, SBD-3
Lab Number: DH03068

Sampled: Aug 11, 1994
Received: Aug 12, 1994
Analyzed: Aug 13, 1994
Reported: Aug 16, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	35	480	11	150
Toluene	35	140	9.3	37
Ethyl Benzene	35	N.D.	8.1	N.D.
Total Xylenes	35	78	8.1	18
Volatile Fuel Hydrocarbons	70	32,000	20	9,100

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 7.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Rancr for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-12, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1558

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/IO3
PCPL, Fillmore
Sample Descript: Air Sample in Tedlar Bag, SBC-1
Lab Number: DH03072

Sampled: Aug 12, 1994
Received: Aug 12, 1994
Analyzed: Aug 13, 1994
Reported: Aug 16, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	100	N.D.	31	N.D.
Toluene	100	140	27	37
Ethyl Benzene	100	N.D.	23	N.D.
Total Xylenes	100	140	23	32
Volatile Fuel Hydrocarbons	200	100,000	57	28,000

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 20.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave. Irvine CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates	Client Project ID:	225 HO3/IO3	Sampled: Aug 11, 1994
15375 Barranca Pkwy., Ste. F-106		PCPL, Fillmore	Received: Aug 12, 1994
Irvine, CA 92718	Sample Descript:	Air Sample in Tedlar Bag, MW-40S	Analyzed: Aug 13, 1994
Attention: Joni Fisher	Lab Number:	DH03069	Reported: Aug 16, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	35	36	11	11
Toluene	35	78	9.3	21
Ethyl Benzene	35	110	8.1	25
Total Xylenes	35	51	8.1	12
Volatile Fuel Hydrocarbons	70	38,000	20	11,000

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 7.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-13, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1538

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/IO3
PCPL, Fillmore
Sample Descript: Air Sample in Tedlar Bag, SBE-1
Lab Number: DH03070

Sampled: Aug 11, 1994
Received: Aug 12, 1994
Analyzed: Aug 13, 1994
Reported: Aug 16, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	35	170	11	53
Toluene	35	89	9.3	24
Ethyl Benzene	35	44	8.1	10
Total Xylenes	35	N.D.	8.1	N.D.
Volatile Fuel Hydrocarbons	70	28,000	20	8,000

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 7.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/IO3
PCPL, Fillmore
Sample Descript: Air Sample in Tedlar Bag, MW-8S
Lab Number: DH03071

Sampled: Aug 11, 1994
Received: Aug 12, 1994
Analyzed: Aug 13, 1994
Reported: Aug 16, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	50	700	16	220
Toluene	50	220	13	58
Ethyl Benzene	50	130	12	30
Total Xylenes	50	N.D.	12	N.D.
Volatile Fuel Hydrocarbons	100	80,000	28	23,000

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 10.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates	Client Project ID:	225 HO3/IO3	Sampled: Aug 12, 1994
15375 Barranca Pkwy., Ste. F-106		PCPL, Fillmore	Received: Aug 12, 1994
Irvine, CA 92718	Sample Descript:	Air Sample in Tedlar Bag, MW-9S	Analyzed: Aug 13, 1994
Attention: Joni Fisher	Lab Number:	DH03073	Reported: Aug 16, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	5.0	N.D.	1.6	N.D
Toluene	5.0	N.D.	1.3	N.D.
Ethyl Benzene	5.0	N.D.	1.2	N.D.
Total Xylenes	5.0	N.D.	1.2	N.D.
Volatile Fuel Hydrocarbons	10	720	2.8	200

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1538

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/IO3
PCPL, Fillmore
Sample Descript: Air Sample in Tedlar Bag, MW-12S
Lab Number: DH03074

Sampled: Aug 12, 1994
Received: Aug 12, 1994
Analyzed: Aug 13, 1994
Reported: Aug 16, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	5.0	N.D.	1.6	N.D.
Toluene	5.0	N.D.	1.3	N.D.
Ethyl Benzene	5.0	N.D.	1.2	N.D.
Total Xylenes	5.0	N.D.	1.2	N.D.
Volatile Fuel Hydrocarbons	10	19	2.8	5.4

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Rance for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1558

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/IO3
PCPL, Fillmore
Sample Descript: Air Sample in Tedlar Bag, MW-5S
Lab Number: DH03075

Sampled: Aug 12, 1994
Received: Aug 12, 1994
Analyzed: Aug 13, 1994
Reported: Aug 16, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	5.0	N.D.	1.6	N.D.
Toluene	5.0	N.D.	1.3	N.D.
Ethyl Benzene	5.0	N.D.	1.2	N.D.
Total Xylenes	5.0	N.D.	1.2	N.D.
Volatile Fuel Hydrocarbons	10	N.D.	2.8	N.D.

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Rancil for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1538

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/IO3
PCPL, Fillmore
Sample Descript: Air Sample in Tedlar Bag, EW-5
Lab Number: DH03076

Sampled: Aug 12, 1994
Received: Aug 12, 1994
Analyzed: Aug 13, 1994
Reported: Aug 16, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	5.0	N.D.	1.6	N.D.
Toluene	5.0	N.D.	1.3	N.D.
Ethyl Benzene	5.0	N.D.	1.2	N.D.
Total Xylenes	5.0	N.D.	1.2	N.D.
Volatile Fuel Hydrocarbons	10	360	2.8	100

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr. Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite F, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/IO3
PCPL, Fillmore
Sample Descript: Air Sample in Tedlar Bag, EW-4
Lab Number: DH03077

Sampled: Aug 12, 1994
Received: Aug 12, 1994
Analyzed: Aug 15, 1994
Reported: Aug 16, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	100	1,500	31	470
Toluene	100	400	27	110
Ethyl Benzene	100	N.D.	23	N.D.
Total Xylenes	100	N.D.	23	N.D.
Volatile Fuel Hydrocarbons	200	30,000	57	8,500

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 20.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Rancl for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/IO3
PCPL, Fillmore
Sample Descript: Air Sample in Tedlar Bag, EW-2
Lab Number: DH03078

Sampled: Aug 12, 1994
Received: Aug 12, 1994
Analyzed: Aug 15, 1994
Reported: Aug 16, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	20	81	6.3	25
Toluene	20	71	5.3	19
Ethyl Benzene	20	40	4.6	9.2
Total Xylenes	20	86	4.6	20
Volatile Fuel Hydrocarbons	40	21,000	11	6,000

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 4.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranick for

Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates	Client Project ID:	225 HO3/IO3	Sampled: Aug 12, 1994
15375 Barranca Pkwy., Ste. F-106		PCPL, Fillmore	Received: Aug 12, 1994
Irvine, CA 92718	Sample Descript:	Air Sample in Tedlar Bag, MW-17S	Analyzed: Aug 15, 1994
Attention: Joni Fisher	Lab Number:	DH03079	Reported: Aug 16, 1994

VOLATILE FUEL HYDROCARBONS with BTEX DISTINCTION

Analyte	Detection Limit mg/m3	Sample Result mg/m3	Detection Limit ppm/vol	Sample Result ppm/vol
Benzene	5.0	73	1.6	23
Toluene	5.0	16	1.3	4.2
Ethyl Benzene	5.0	N.D.	1.2	N.D.
Total Xylenes	5.0	7.5	1.2	1.7
Volatile Fuel Hydrocarbons	10	4,700	2.8	1,300

Hydrocarbons detected by this method range from C6 - C15.
The molecular weight of 86 was used to convert Volatile Fuel Hydrocarbons from mg/m3 to ppm by volume.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-7022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates	Client Project ID: 225 HO3/IO3	Sampled:	Aug 11, 1994
15375 Barranca Pkwy., Ste. F-106	PCPL, Fillmore	Received:	Aug 12, 1994
Irvine, CA 92718	Sample Descript: Air Sample in Tedlar Bag, SBD-3	Analyzed:	Aug 13, 1994
Attention: Joni Fisher	Lab Number: DH03068	Reported:	Aug 16, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	12
Carbon Monoxide	0.10	N.D.
Methane	0.10	7.5
Nitrogen	0.10	75
Oxygen	0.10	5.5

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for

Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1538

England Shahin & Associates	Client Project ID:	225 HO3/IO3	Sampled: Aug 11, 1994
15375 Barranca Pkwy., Ste. F-106		PCPL, Fillmore	Received: Aug 12, 1994
Irvine, CA 92718	Sample Descript:	Air Sample in Tedlar Bag, MW-40S	Analyzed: Aug 13, 1994
Attention: Joni Fisher	Lab Number:	DH03069	Reported: Aug 16, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	14
Carbon Monoxide	0.10	N.D.
Methane	0.10	0.97
Nitrogen	0.10	83
Oxygen	0.10	2.0

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for

Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370 1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite F, Tempe, AZ 85281 (602) 968 8272 FAX (602) 968 1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/IO3
PCPL, Fillmore
Sample Descript: Air Sample in Tedlar Bag, SBE-1
Lab Number: DH03070

Sampled: Aug 11, 1994
Received: Aug 12, 1994
Analyzed: Aug 13, 1994
Reported: Aug 16, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	17
Carbon Monoxide	0.10	N.D.
Methane	0.10	2.5
Nitrogen	0.10	79
Oxygen	0.10	1.8

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/IO3
PCPL, Fillmore
Sample Descript: Air Sample in Tedlar Bag, MW-8S
Lab Number: DH03071

Sampled: Aug 11, 1994
Received: Aug 12, 1994
Analyzed: Aug 13, 1994
Reported: Aug 16, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	13
Carbon Monoxide	0.10	N.D.
Methane	0.10	5.6
Nitrogen	0.10	77
Oxygen	0.10	4.6

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-13, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1558

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/IO3
PCPL, Fillmore
Sample Descript: Air Sample in Tedlar Bag, SBC-1
Lab Number: DH03072

Sampled: Aug 12, 1994
Received: Aug 12, 1994
Analyzed: Aug 13, 1994
Reported: Aug 16, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	15
Carbon Monoxide	0.10	N.D.
Methane	0.10	2.6
Nitrogen	0.10	80
Oxygen	0.10	1.9

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Rance for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite F, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/IO3
PCPL, Fillmore
Sample Descript: Air Sample in Tedlar Bag, MW-9S
Lab Number: DH03073

Sampled: Aug 12, 1994
Received: Aug 12, 1994
Analyzed: Aug 13, 1994
Reported: Aug 16, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	0.31
Carbon Monoxide	0.10	N.D.
Methane	0.10	N.D.
Nitrogen	0.10	78
Oxygen	0.10	21

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Rance for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1845
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/IO3
PCPL, Fillmore
Sample Descript: Air Sample in Tedlar Bag, MW-12S
Lab Number: DH03074

Sampled: Aug 12, 1994
Received: Aug 12, 1994
Analyzed: Aug 13, 1994
Reported: Aug 16, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	0.90
Carbon Monoxide	0.10	N.D.
Methane	0.10	N.D.
Nitrogen	0.10	79
Oxygen	0.10	20

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Rance for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/IO3
PCPL, Fillmore
Sample Descript: Air Sample in Tedlar Bag, MW-5S
Lab Number: DH03075

Sampled: Aug 12, 1994
Received: Aug 12, 1994
Analyzed: Aug 13, 1994
Reported: Aug 16, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	1.1
Carbon Monoxide	0.10	N.D.
Methane	0.10	N.D.
Nitrogen	0.10	80
Oxygen	0.10	19

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbi Rance for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates	Client Project ID:	225 HO3/IO3	Sampled: Aug 12, 1994
15375 Barranca Pkwy., Ste. F-106		PCPL, Fillmore	Received: Aug 12, 1994
Irvine, CA 92718	Sample Descript:	Air Sample in Tedlar Bag, EW-5	Analyzed: Aug 13, 1994
Attention: Joni Fisher	Lab Number:	DH03076	Reported: Aug 16, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	0.23
Carbon Monoxide	0.10	N.D.
Methane	0.10	N.D.
Nitrogen	0.10	78
Oxygen	0.10	22

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Rance for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1558

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225 HO3/IO3
PCPL, Fillmore
Sample Descript: Air Sample in Tedlar Bag, EW-4
Lab Number: DH03077

Sampled: Aug 12, 1994
Received: Aug 12, 1994
Analyzed: Aug 14, 1994
Reported: Aug 16, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.20	10
Carbon Monoxide	0.20	N.D.
Methane	0.20	28
Nitrogen	0.20	55
Oxygen	0.20	5.9

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 2.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for

Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
3014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates	Client Project ID:	225 HO3/IO3	Sampled: Aug 12, 1994
15375 Barranca Pkwy., Ste. F-106		PCPL, Fillmore	Received: Aug 12, 1994
Irvine, CA 92718	Sample Descript:	Air Sample in Tedlar Bag, EW-2	Analyzed: Aug 14, 1994
Attention: Joni Fisher	Lab Number:	DH03078	Reported: Aug 16, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	4.9
Carbon Monoxide	0.10	N.D.
Methane	0.10	21
Nitrogen	0.10	69
Oxygen	0.10	4.3

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debori Ranck for
Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates	Client Project ID:	225 HO3/IO3	Sampled: Aug 12, 1994
15375 Barranca Pkwy., Ste. F-106		PCPL, Fillmore	Received: Aug 12, 1994
Irvine, CA 92718	Sample Descript:	Air Sample in Tedlar Bag, MW-17S	Analyzed: Aug 14, 1994
Attention: Joni Fisher	Lab Number:	DH03079	Reported: Aug 16, 1994

FIXED GASES by METHOD GC/TCD

Analyte	Detection Limit %	Sample Result %
Carbon Dioxide	0.10	0.93
Carbon Monoxide	0.10	N.D.
Methane	0.10	5.5
Nitrogen	0.10	74
Oxygen	0.10	20

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Debbie Ranck for
Gary Steube
Laboratory Director

CHAIN OF CUSTODY

DATE 8/11/94 PAGE 1 OF 1

PROJECT MANAGER: J. Fashir
COMPANY: ENGLAND SHAHIN & ASSOCIATES
ADDRESS: 15375 Barranca Parkway, Suite F-106
Irvine, California 92718
Phone: 714-453-8085 Fax: 714-453-0733

BILL TO:
COMPANY: Texaco Refining + Marketing
ADDRESS:

SAMPLERS SIGNATURE: [signature] PHONE NUMBER: 714-453-8085

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	Petroleum Hydrocarbons 418.1 (1L (H_2SO_4)/1000g)	Oil and Grease 413.2 (1L (H_2SO_4)/1000g)	Gasoline (MOD 8015/DOHS) (4 oz (HCL)/50g)	Diesel (MOD 8015/DOHS) (4 oz (HCL)/50g)	Gasoline/BTXE (MOD 8015/8020) (4 oz (HCL)/50g)	Petroleum Distillates (C6-C25): BTXE (8020) (2x40ml (HCL)/50g)	Chlorinated Hydrocarbons (8010) (2x40ml (HCL)/50g)	Aromatic Hydrocarbons (2x40ml (HCL)/50g)	Chlorinated/Aromatic Hydrocarbons (8010/8020) (2x40ml (HCL)/50g)	Organic Pb (500ml/50g)		Pesticides/PCB (8080) (1L/50g)	Base/NEU/Acid Cmpds GC/MS (8270) (1L/100g)	Volatile Cmpds GC/MS (8240) (2x40ml (HCL)/100g)	Polynuclear Aromatic (8310) (1L/100g)	CCR Metals (500ml/100g)	Priority Pollutant Metals (500ml/100g)	TPH/BTEX	Fixed Gases							Number of Containers
SBD-3	8/11/94	15:50	Air																					✓	✓					2
MW-40S	"	16:45																						✓	✓					2
SBE-1	"	17:05																						✓	✓					2
MW-8S	"	17:45																						✓	✓					2
SBC-1	8/12/94	7:40																						✓	✓					2
MW-9S	"	8:47																						✓	✓					2
MW-12S	8/12/94	9:33																						✓	✓					2
MW-5S	"	10:53																						✓	✓					2
EW-5	"	11:43																						✓	✓					2
EW-4	"	12:35																						✓	✓					2
EW-2	"	13:27																						✓	✓					2
MW-17S	"	14:17																						✓	✓					2

PROJECT INFORMATION	SAMPLE RECEIPT	
PROJECT NUMBER: 225 H03/103	TOTAL NUMBER OF CONTAINERS	24
PROJECT NAME: PCPL Fillmore	CHAIN OF CUSTODY SEALS Y/N/NA	—
PURCHASE ORDER NUMBER:	INTACT? Y/N/NA	Y
VIA	RECEIVED GOOD COND/COLD	Y
TAT: NORMAL	LAB NUMBER	

SAMPLE DISPOSAL INSTRUCTIONS

COMMENTS:

RELINQUISHED BY: 1.	RELINQUISHED BY: 2.	RELINQUISHED BY: 3.
Signature [signature] Time 3:00	Signature Lonnie Kukita Time 4:20	Signature [signature] Time 1855
Printed Name Ricardo Sumar Date 8/12	Printed Name Lonnie Kukita Date 8/12/94	Printed Name [signature] Date 8-12-94
Company ENGLAND SHAHIN & ASSOCIATES	Company Del Mar	Company DMA
RECEIVED BY: 1.	**RECEIVED BY: 2.**	**RECEIVED BY: 3.**
Signature [signature] Time 3:00	Signature [signature] Time 16:30	Signature Libby Vanglo Time 6:55
Printed Name Lonnie Kukita Date 8/12/94	Printed Name [signature] Date 8/12	Printed Name Libby Vanglo Date 8/12/94
Company Del Mar	Company Del Mar	Company DEL MAR ANALYTICAL

APPENDIX G

A. Keith Kaufman, M.S.

Consultant in Environmental Biotechnology
Serving Industry, Government, Academia and the Legal Profession

SUMMARY REPORT

Biotreatability and Pilot-scale Evaluations of TPH-impacted Soil & Groundwater for Prospective Bioremedial Treatment

Pacific Coast Pipeline Superfund Project
Fillmore, CA

PRESENTED TO

ENGLAND, SHAHIN, & ASSOCIATES
15375 Barranca Parkway, #F-106
Irvine, CA 92718

Respectfully submitted:

x_____
A. Keith Kaufman, M.S.
Consultant in Environmental Biotechnology

August 9, 1994

6245 Bristol Parkway #249 *Culver City, CA 90230* *(310) 822-9385 [Voice/FAX]*

TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	1
METHODS AND RESULTS	
Phase 1 - Baseline Physicochemistry, Microbiology, & Biotreatability	2
Phase 2 - Pilot Bioremedial Treatment of Groundwater Via an *in Situ* Model System	4
Phase 3 - Pilot Bioremedial Treatment of Soil and Groundwater Via an Integrated Closed-loop System	8
CONCLUSION	12
APPENDIX	
- Analytical Reports	

EXECUTIVE SUMMARY

This report summarizes the methods used and results obtained from a three-phase investigation evaluating the biofeasibility and prospective biotreatability of petroleum hydrocarbon-impacted soils and groundwater at the Pacific Coast Pipeline Superfund Project in Fillmore, CA. The scope of work was performed in accordance with a Work Agreement dated 5/3/94 between England, Shahin, and Associates (Client) and A. Keith Kaufman, M.S., Consultant in Environmental Biotechnology.

The project discussed within this report was conducted in order to determine whether and to what degree biotreatment could be utilized for the remediation of groundwater (*in situ*) and/or soil and groundwater *(in situ)* at the subject site. The first phase of the investigation was directed at addressing the native physicochemical and microbiological parameters of site-specific soil and groundwater pursuant to prospective biotreatability. The second phase evaluated the efficacy and efficiency of bioremedial treatment (in accordance with Phase 1 information) for impacted groundwater via an *in situ* model system. Subsequently, the third phase was conducted to assess the feasibility and potential effectiveness of implementing a system for the bioremediation of both soil and groundwater via integrated *in situ* methodology.

The results obtained from these investigations support the use of *biostimulation* methodology for the biologically-based cleanup of both soil and groundwater matrices via an integrated *in situ* approach. For groundwater, pilot bioremedial treatment resulted in a 97.2 % cleanup efficiency (over a two week treatment period) for all parameters, as compared to an 87.5 % control efficiency for the same period. Efficiency of groundwater cleanup for the integrated soil/groundwater treatment system was greater than 99.9%; however, the soils increased in hydrocarbon concentration over a two week treatment period (due to hydrocarbon adsorption by soils). Although volatilization and contaminant adsorption by soil particles influenced observed results, evidence of substantial bioremedial activity within groundwater and soil/groundwater systems was obtained, primarily from stoichiometric variances and observations of substantially increased levels of contaminant-specific biodegraders (not evidenced in controls). The latter can only occur as a result of contaminant use as metabolic substrates.

Other findings of note include the fact that significant biofouling of soil during integrated treatment was not observed. Such a finding supports the feasibility of performing field *in situ* treatment. The use of hydrogen peroxide for subsurface oxygen supplementation was contraindicated by the results of these investigations, suggesting a high degree of biotoxicity (at 0.01%) for specific hydrocarbon biodegraders within the native microbial population.

Based on the overall results of this investigation, we believe that *in situ bioremedial treatment* is feasible for mitigation of the subject facility, and would recommend that both infiltration gallery and direct injection and recovery be considered for field implementation of the bioremedial process. Observed microbial growth dynamics, degradation kinetics, and related field experience suggest the likelihood that site cleanup can be completed within two to three years post-implementation, under the conditions described within this report.

METHODS AND RESULTS

PHASE I - Baseline Physicochemistry, Microbiology, & Biotreatability

Site-specific soil and groundwater samples were evaluated for baseline physicochemical parameters (pH, nitrate, ammonium, phosphorous, and potassium concentrations) to determine the physicochemical "health" of the respective environments, and determine whether and to what degree nutrient supplementation will be required for pilot-scale and prospective full-scale treatment. The HACH Spectrophotometric process and ion-specific probes were utilized for these analyses in accordance with manufacturers' specifications.

As noted in Table 1, the results indicate that there is considerable heterogeneity among the soil and water samples tested, especially with respect to physicochemistry. For example, soil and groundwater pH differed, in some cases, by nearly two pH units. Additionally, there appeared to be major differences associated with potassium concentrations, especially among the water samples analyzed. As there appeared to be little, if any, biotoxicity associated with these variances, however, we do not expect to encounter negative impacts upon or disruption to microbiological activity, especially for *in situ* treatment of soil and groundwater via an integrated loop system. The physicochemical findings also indicate a need for both reduced and oxidized forms of nitrogen. In order to facilitate optimal biodegradative efficiency within the impacted matrices, supplemental nitrogen components in the form of ammonium nitrate will be required for treatment.

While considerable heterogeneity associated with microbial population dynamics also exists among the samples tested, we believe the proportion of indigenous hydrocarbon degraders (as a percentage of the overall heterotrophic population) supports the prospective use of biostimulation methods (as opposed to bioaugmentation. As a matter of routine however, representative hydrocarbon-biodegraders were subcultured and stored in our frozen stock supply in the event bioaugmentation is required at one or more points during the field implementation process. Such events could occur at the initiation of the process in order to establish an active "seed" population to minimize lag time for natural population development (would likely be necessary in the area around EW-2, since the proportion of specific degraders is only 0.3%) and/or during such times when contaminant concentrations drop to a point where alternative carbon sources, possibly present in the soils/groundwater, begin to play a more dominant role in microbial metabolic processes. These events, where present, are detected and managed via periodic bioprocess monitoring.

In general, there were no findings in the phase which would contraindicate the use of bioremediation for this site.

Table 1. Results of physicochemical and microbial analyses of site-specific soil and water samples from England Shahin & Assoc. as of 5/13/94.

Parameter	EW-2 (soil)	EW-4 (soil)	MW-47D (soil)	P2 (water)	MW-19S (water)	MW-17S (water)
pH	8.9	9.1	8.9	7.2	7.3	7.2
Nitrate	5	5	5	ND	ND	ND
Nitrite	-	-	-	ND	ND	ND
Ammonium	18	13	24	0.05	0.06	0.40
Phosphate	49	77	126	52	45	20
Potassium	46	81	58	5	700	13
% Moisture	13	16	18	-	-	-
General Count (CFU x 10^4)	80.0	6.4	0.6	13.4	1.7	26.2
Selective Count (CFU x 10^4)	0.24	0.78	0.54	2.0	0.56	1.2
% Degraders	0.3	12.2	90	14.6	32.9	4.7

* CFU = colony-forming units (number of organisms) per gram/milliliter soil/water
General count - General microbial population; cultured on 25% Trypticase Soy Agar
Selective count - Biodegrader population; cultured on TPH-supplemented Bushnell-Haas medium

Inorganic nutrient concentrations are expressed in ppm

ND = not detected at or above detection levels

PHASE 2 - Pilot Bioremedial Treatment of Groundwater Via an *In Situ* Model System

This phase was conducted in order to determine the efficacy and prospective efficiency of biostimulation methodology for the *in situ* cleanup of site-specific groundwater, with and without the addition of hydrogen peroxide (for oxygen supplementation).

Approximately 3.7 liters of composited site-specific groundwater sample were equally distributed to each of three one-gallon glass vessels. Each water sample was spiked with equal volumes of gasoline and diesel fuel (approx. 1000 ppm total spike concentration) to ensure adequate baseline hydrocarbon levels. The three treatment systems were designated, respectively, as 1: Untreated Control, 2: Nutrient-supplemented Test, and 3: Nutrient/Hydrogen Peroxide-supplemented Test. Prior to treatment initiation, baseline (t=0) analytical and bioprocess monitoring samples were collected from each vessel and evaluated. Biotreatment was initiated by the application of inorganic nutrients to the test systems in accordance with Phase 1 protocol. Hydrogen peroxide was added to one of the test systems to yield a final concentration of 0.01% (100 ppm). Each vessel was mixed and the tops loosely capped to provide for gas exchange. Each system was gently mixed on a 24-48 hour basis to simulate groundwater movement. All systems were maintained at room temperature under aerobic conditions for a total treatment period of 14 days. A second application of nutrients and hydrogen peroxide was performed for appropriate test systems at t=7 days.

Analytical monitoring of test and control systems via EPA Methods 418.1, 8015 modified for diesel fuel, and 8015/8020 (for gasoline and BTEX components) was performed at t=0 (baseline), t=2 days, t=7 days (except 418.1), and t=14 days. Bioprocess monitoring analyses (physicochemistry and microbiology) were performed at t=0 (baseline), t=7 days, and t=14 days.

The results of Phase 2 are presented in Tables 2 (analytical) and 3 (physicochemical/ microbiological) on the following pages.

Analytical results indicate that substantial contaminant reduction occurred within both control and test systems. Presumably, a significant portion of the observed loss could be attributable to volatilization, especially within the control system. The nutrient-amended system generally showed more efficient reduction of gasoline and specific BTEX components than did the control or hydrogen peroxide supplemented test system. The observed increased efficiency of hydrocarbon reduction in the nutrient-amended test system (nearly 50% greater for gasoline) can be attributable to biological activity, since a substantial increase in both heterotrophic and selective degrader populations were observed concurrently over time for this system.

Hydrogen peroxide appeared detrimental to microbial activity, and loss of contaminant observed in this system can thus be attributable to a combination of both volatilization and hydrogen peroxide-induced hydrocarbon oxidation. While hydrogen peroxide was utilized at a very low

concentration (0.01%), many microorganisms (especially those which do not possess the enzyme "catalase") are extremely sensitive to the highly oxidative nature of the compound. Since biotoxicity was clearly observed for the microbial population developed in the site-specific water, we do not recommend hydrogen peroxide for supplemental oxygenation purposes.

It is recognized that laboratory model systems, such as that used for this phase, inherently have limitations associated particularly with management of volatilization. Clearly, the results obtained here strongly indicate that volatilization played a strong role in reducing contaminant concentration over time (although it is unclear why the diesel fraction appeared more impacted by such action than the gasoline fraction). It should be noted however, that the role of volatilization for actual field *in situ* application will likely be minimal. Under such circumstances therefore, methods to facilitate exclusive biologically-mediated contaminant reduction should be implemented and maintained. Because of the improved efficiency of contaminant reduction noted for the nutrient only-amended system, this method was utilized for Phase 3 of the investigation, and is anticipated for full-scale implementation purposes, as well.

Table 2. Cumulative analytical results for bench-scale pilot treatment of TPH-impacted groundwater from England Shahin & Assoc. (TEXACO, Fillmore, CA site)

Time (t=days)	TPH	TPHd	TPHg	Benz-ene	Tolu-ene	Ethyl Benz	Xylene
Control							
0	6200	810	150	4 8	17	2 1	21
2	NA	400	350	2.6	8 7	1 4	20
7	NA	200	1200	1.6	5.1	0 93	22
14	100	72	90	0.15	0.74	ND	1 9
% Redctn	98.4	91 1	40 0	96 7	95.6	100	91.0
Nutrients only							
0	7800	940	200	4.8	20	3.0	33
2	NA	200	67	1 5	3.2	0.28	8.7
7	NA	230	1400	ND	ND	ND	6 8
14	66	76	21	ND	ND	ND	0 009
% Redctn	99 2	91 9	89.5	100	100	100	99 97
Nutrients + H_2O_2							
0	220	91	170	3.8	17	2 8	26
2	NA	110	290	2.0	7.0	1.8	20
7	NA	200	660	1 3	3 4	0 78	6 0
14	81	82	32	0.24	0 75	0 13	1 7
% Redctn	63 2	9 9	81 2	93 7	95 6	95 4	93 5

TPH = Total Petroleum Hydrocarbon (oils) analysis (EPA Method 418 1)
TPHd = Diesel analysis (EPA Method 8015 diesel)
TPHg = Gasoline analysis (EPA Method 8015 gasoline)
BTEX = Benzene, toluene , ethylbenzene, xylenes analysis (EPA Method 8020)
ND = Not detected at or above detection limits
NA = Analyses not performed
Analytical concentrations expressed in parts per million (ppm)

Table 3. Cumulative results of physicochemical and microbiological analyses for bench pilot-scale treatment of TPH-impacted groundwater from England Shahin & Assoc. (TEXACO, Fillmore, CA site)

Time (t=days)	pH	NO_3	NO_2	NH_4	PO_4	K	Gen	Sel	% Deg
Control									
0	7.5	ND	ND	0.9	6.1	17.5	1.4	1.0	71
2	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	8.0	9.7	4.8	0.5	ND	19	3.9	3.6	92
14	8.5	12.3	3.0	0.4	ND	18	3.9	3.5	89.7
Nutrients only									
0	7.5	ND	ND	0.9	6.1	17.5	1.4	1.0	71
2	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	8.1	120	4.5	91.6	ND	14.0	35.0	7.8	22.2
14	8.3	129	2.1	142	ND	7.0	76.0	12.8	16.8
Nutrients + H_2O_2									
0	7.5	ND	ND	0.9	6.1	17.5	1.4	1.0	71
2	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	8.2	112	3.6	86.8	ND	11.5	2.4	ND	----
14	8.5	147	ND	91.6	4.0	6.0	0.06	ND	----

* Gen = General (heterotrophic) microbial population, expressed as CFU x 10^5
Sel = Selective biodegrader (gasoline/diesel) microbial population, expressed as CFU x 10^5
CFU = Colony-forming units (number of microorganisms) per milliliter water

ND = Not detected at or above detection limits
NA = Analyses not performed
Inorganic nutrient concentrations expressed in parts per million (ppm)

PHASE 3 - Pilot Bioremedial Treatment of Soil and Groundwater Via an Integrated Closed-loop System

This phase was conducted in order to evaluate the efficacy and prospective efficiency of utilizing biostimulation methodology for the *in situ* treatment of soil and groundwater via an integrated closed-loop system.

The *in situ* pilot-scale model system was composed of a soil-packed 3-foot vertical column (1" inner diameter) and a 2.5 liter double side arm Erlenmeyer flask which functioned as a reservoir for groundwater. The column was packed with site-specific soil in a manner which was consistent with site stratigraphy, as represented by depth of collection (45', 60', and 85'). Approximately 200 grams of each soil type was utilized during column packing. An equal volume of composited soil (untreated) was utilized as a t=0 baseline control. For the groundwater reservoir, a total volume of 2,500 ml of hydrocarbon-spiked (1000 ppm diesel/gasoline mix) site-specific groundwater was used. Baseline samples for analytical and bioprocess monitoring (t=0) were collected as previously described. Water within the flask was then supplemented with inorganic nutrients (27N-0P-1K) in accordance with previous findings (100 ppm nitrate). The flask was connected, via Tygon tubing, such that a continuous closed-loop flow from the reactor through the soil column would be accomplished. A peristaltic pump was utilized to pump water from the reservoir into the top of the column. A recirculating tube connected the distal (bottom) end of the column to a second pump which, in turn, was connected to the influent port of the flask. Subsequent attempts were made to establish a continuous delivery rate of water to the top of the column; however, due to the clay-like composition of soil portions, continuous flow rates were unable to be sustained. As a result, frequent monitoring of the column was necessary to facilitate maximum flow without allowing water backup.

The recirculating process was maintained for a period of fourteen (14) days. Following completion, the soil column was dismantled and the soils composited and submitted, along with treated water, to a state-certified analytical testing laboratory for analysis via EPA Methods 418.1 (soil), 8015 gasoline/diesel (soil and groundwater), and 8020 BTEX (soil and groundwater). Aliquots of all soil and groundwater samples were retained for physicochemical and microbiological analyses over time. Analyses were performed at t=0 (baseline) and t=14 days.

As noted, difficulties were encountered in maintaining a continuous flow rate of water through the soil column. The recirculating pump however, remained on during the entire treatment period. The rate of flow ranged from 0.22 cm (1.98 ml)/hr to 0.32 cm (2.88 ml)/hr (average = 0.26 cm (2.34 ml)/hr. Although a continuous rate could not be established, it is important to note that some degree of flow was able to be maintained for the entire treatment duration. This observation indicates that significant biofouling did not occur, in spite of the presence of clays within the soil matrix. The presence or absence of biofouling (soil "plugging" developed as a result of bacterial growth and resultant biomass) is a significant factor in evaluating the feasibility

of performing *in situ* biotreatment for soils. Accordingly, the absence of biofouling noted for these analyses supports prospective *in situ* implementation.

Analytical and physicochemical/microbiological results for this phase are noted in Tables 4 and 5, respectively. Analytical results indicate that greater than 99.9% reduction in diesel and gasoline/BTEX concentrations occurred for water. Soil samples however, showed a marked increase in TPH concentrations. Such a result suggests that, in the process of recirculating spiked water through the soil column, the soil matrix adsorbed significant portions of the hydrocarbon fractions. This finding is rather unusual, since water passage through an impacted soil column (both in laboratory and field projects) typically produce "flushing" effects, resulting in leachate passage of contaminants into groundwater. In fact, such flushing is generally what facilitates rapid remedial effectiveness of the *in situ* process (bioremedial activity is generally more effective in aqueous environments due to solubility effects and enhanced bioavailability of carbon substrates). As a result of this finding, it would initially appear that the significant loss of hydrocarbon observed for water samples could be, in part, attributable to adsorption of hydrocarbon onto soil particles. While clearly playing a role, it is important to note that the concentrations noted for soil do not reflect additive levels. Therefore, non-adsorptive loss could be demonstrated. Since this was a closed-loop system, and efforts were taken to preclude volatilization, we do not believe that VOC emissions played a significant role in hydrocarbon reduction. Furthermore, data from microbiological and physicochemical analyses support biologically-mediated reduction of hydrocarbons within both soil and groundwater matrices. Microbiologically, both soil and groundwater samples showed substantial increases in both heterotrophic and selective degrader populations. The relative percentage of selective hydrocarbon degraders increased by 28% in water, and 68% in soil, likely reflecting differential hydrocarbon concentrations between the two matrices. It is important to note that the growth of the selective population could only have occurred if the hydrocarbon constituents were being utilized for microbial growth. Therefore, the microbiological observations confirm that significant biodegradation had occurred within both soil and groundwater. Given the particularly large concentrations of degraders within soil, we would anticipate relatively rapid and efficient reduction of hydrocarbons over time. Physicochemically, confirmation of nutrient delivery to the soil column was obtained. Stoichiometrically added amounts of nutrient (nitrate index concentration of 100 ppm) were also efficiently utilized by noting significant nitrate depletion in both soil and water environments. The more efficient loss of nitrate within the soil matrix correlates well with the differential microbial enumeration findings, again indicating a rapidly metabolizing population of biodegraders.

Table 4 Summary of analytical results from *in situ* (closed loop) pilot-scale biotreatment of TPH-impacted soil and water from England & Shahin (Texaco site, Fillmore, CA)

Time (T=days)	TRPH	TPHD	TPHG	Benzene	Toluene	Ethyl Benzene	Xylene
Water							
0	NA	550	760	1 6	7 0	2 9	27 0
14	NA	5.7	0.12	0 0006	0 007	ND	0.011
Soil							
0	430	390	320	0.054	0 091	0 60	1.3
14	1000	1300	510	0.30	0 16	1 1	1.7

* ND = analytes are not detected at or above method detection limit
NA = analysis not performed
TPH concentrations expressed in parts per million (ppm)

TRPH = Total Recoverable Petroleum Hydrocarbons (EPA 418.1)
TPHD = analysis for diesel concentrations (EPA Modified 8015)
TPHG = analysis for gasoline (EPA 8015)
BTEX = analysis via EPA 8020

Table 5. Summary of physicochemical and microbiological results from *in situ* pilot-scale biotreatment of TPH-impacted soil and water from England & Shahin (Texaco site, Fillmore, CA)

Time (T=days)	pH	NO_3	NO_2	NH_4	PO_4	K	Gen (x 10^5)	Sel (x 10^5)	% Deg
Water									
0	8 0	ND	ND	1 1	5 7	16 5	1 2	0 47	39 2
14	8 2	65	ND	84	5.2	15 3	16 8	9.2	54.8
Soil									
0	9 0	7	NA	12	50	110	76 8	12 6	16 4
14	9.1	20	NA	96	27	96	274	142	51.8

ND = analyte not detected at or above detection limit

Gen = general microbial population count; expressed as CFU x 10^5 per milliliter (ml) water/gram (g) soil

Sel = selective (biodegrader) microbial population count, expressed as CFU x 10^5 per ml water/g soil

CFU = colony-forming units (number of organisms) per milliliter water or gram soil

Inorganic nutrient concentrations are expressed in parts per million (ppm) Some values have been rounded off to the nearest whole number

CONCLUSION

The cumulative results from this investigation support the prospective use of bioremedial treatment for *in situ* cleanup of groundwater and/or soil and groundwater. Where feasible and appropriate, such approaches have been utilized in the past for projects of a similar nature with exceptional results. Although it is difficult to project a cleanup time for this project, we believe a two to three year completion is attainable. This estimation is based upon observed kinetics, coupled with the cumulative microbiological findings which suggest rapid remedial initiation and efficient biodegradative metabolism maintenance. It is important to note however, that many factors will directly or indirectly influence the actual rate of contaminant degradation and cleanup time requirements in the field. Most notably, these factors include final cleanup criteria, temperature, degree of maintenance of hydrodynamic flow of bionutrients and water, oxygenation, and continued bioavailability of carbon substrates. Additionally, as with any *in situ* bioremedial project involving soils (especially those containing clays and other minimally impermeable lithologies, isolated biofouling must always be considered a possible development. Reduced aqueous flow rates and/or odors generated as a result of the development of anaerobic conditions are strongly suggestive of biofouling development. Because of the potential influence of these factors on bioremedial effectiveness and efficiency, it is recommended that a comprehensive bioprocess monitoring program be maintained throughout the duration of the field implementation phase. Such action allows for the rapid response to physicochemical and microbiological changes which may occur during the course of treatment, thereby minimizing the potential for problem development.

We would anticipate that field implementation would involve the use of infiltration galleries for delivery of bionutrients with the possible use of direct injection, as well. The latter would be especially useful for initiation of bioactivity within groundwater as well as more efficient delivery of materials to those areas within the soil column that are particularly inundated with clays and/or minimally permeable lithologies. While the use of hydrogen peroxide for oxygen supplementation is not supported by this investigation, air sparging (and/or modified bioventing) should be considered as a method to facilitate subsurface oxygenation and enhancement of aerobic microbial metabolism. While we do not believe this is essential (as long as hydrodynamic flow of materials from the surface into and through the soil matrix can be maintained), air sparging would likely enable more efficient (and therefore more rapid) contaminant reduction. The decision as to whether or not to utilize air sparging however, should, in part, be dictated by regulatory constraints and concerns associated with contaminant spread/migration potentially induced as a result of such sparging.

APPENDIX

Analytical Reports

Del Mar Analytical

2852 Alton Ave. Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
945 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 418.1 (I.R. with clean-up)
First Sample #: V4061048

Sampled: Jun 16, 1994
Received: Jun 20, 1994
Analyzed: Jun 27, 1994
Reported: Jun 29, 1994

TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (EPA 418.1)

Laboratory Number	Sample Description Water	Petroleum Hydrocarbons mg/L (ppm)
V4061048	ES1-0A	6,200
V4061051	ES2-0A	7,800
V4061054	ES3-0A	220

Detection Limit:	1.0

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas

Wendy Thomas
Laboratory Manager

V4061048.RES <1>

Del Mar Analytical

2852 Alton Ave. Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way Suite C-11 Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1845
943 South 48th St., Suite 114 Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1538

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 5030/CA DHS Mod. 8015/8020
First Sample #: V4061050

Sampled: Jun 16, 1994
Received: Jun 20, 1994
Analyzed: Jun 27, 1994
Reported: Jun 29, 1994

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Number	Sample Description Water	Volatile Fuel Hydrocarbons µg/L (ppb)	Benzene µg/L (ppb)	Toluene µg/L (ppb)	Ethyl Benzene µg/L (ppb)	Total Xylenes µg/L (ppb)
V4061050	ES1-0C	150,000	4,800	17,000	2,100	21,000
V4061053	ES2-OC	200,000	4,800	20,000	3,000	33,000
V4061056	ES3-0C	170,000	3,800	17,000	2,800	26,000
Detection Limit:		**100,000**	**600**	**600**	**600**	**1,200**

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 2000

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas.
Wendy Thomas
Laboratory Manager

V4061C48.RES <2>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1034 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16575 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 5030/CA DHS Mod. 8015/8020
First Sample #: V4061058

Sampled: Jun 18, 1994
Received: Jun 20, 1994
Analyzed: Jun 27, 1994
Reported: Jun 29, 1994

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Number	Sample Description Water	Volatile Fuel Hydrocarbons µg/L (ppb)	Benzene µg/L (ppb)	Toluene µg/L (ppb)	Ethyl Benzene µg/L (ppb)	Total Xylenes µg/L (ppb)
V4061058	ES1-2C	350,000	2,600	8,700	1,400	20,000
Detection Limit:		100,000	600	600	600	1,200

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 2000

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas

Wendy Thomas
Laboratory Manager

V4061048.RES <3>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16535 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
945 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 5030/CA DHS Mod. 8015/8020
First Sample #: V4061060

Sampled: Jun 18, 1994
Received: Jun 20, 1994
Analyzed: Jun 28, 1994
Reported: Jun 29, 1994

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Number	Sample Description Water	Volatile Fuel Hydrocarbons µg/L (ppb)	Benzene µg/L (ppb)	Toluene µg/L (ppb)	Ethyl Benzene µg/L (ppb)	Total Xylenes µg/L (ppb)
V4061060	ES2-2C	67,000	1,500	3,200	280	8,700
Detection Limit:		**40,000**	**240**	**240**	**240**	**480**

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 800.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas

Wendy Thomas
Laboratory Manager

V4061048.RES <4>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16535 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
944 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1558

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 5030/CA DHS Mod. 8015/8020
First Sample #: V4061062

Sampled: Jun 18, 1994
Received: Jun 20, 1994
Analyzed: Jun 27, 1994
Reported: Jun 29, 1994

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Number	Sample Description Water	Volatile Fuel Hydrocarbons µg/L (ppb)	Benzene µg/L (ppb)	Toluene µg/L (ppb)	Ethyl Benzene µg/L (ppb)	Total Xylenes µg/L (ppb)
V4061062	ES3-2C	290,000	2,000	7,000	1,800	20,000
Detection Limit:		**130,000**	**750**	**750**	**750**	**1,500**

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 2500

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas

Wendy Thomas
Laboratory Manager

V4061048.RES <5>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-6272 FAX (602) 968-1538

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 3510/CA DHS Mod. 8015
First Sample #: V4061049

Sampled: Jun 16, 1994
Received: Jun 20, 1994
Analyzed: Jun 22, 1994
Reported: Jun 29, 1994

EXTRACTABLE FUEL HYDROCARBONS (CA DHS Mod. EPA 8015)

Laboratory Number	Sample Description Water	Extractable Hydrocarbons mg/L (ppm)	Hydrocarbon Type
V4061049	ES1-0B	810	Gas & Diesel
V4061052	ES2-0B	940	Gas & Diesel
V4061055	ES3-0B	91	Gas & Diesel

Detection Limit:	0.50

Extractable Hydrocarbons are quantitated against a diesel fuel standard. Hydrocarbons detected by this method range from C8 to C40.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

Wendy Thomas
Laboratory Manager

V4061048 RES <G>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 3510/CA DHS Mod. 8015
First Sample #: V4061057

Sampled: Jun 18, 1994
Received: Jun 20, 1994
Analyzed: Jun 22, 1994
Reported: Jun 29, 1994

EXTRACTABLE FUEL HYDROCARBONS (CA DHS Mod. EPA 8015)

Laboratory Number	Sample Description Water	Extractable Hydrocarbons mg/L (ppm)	Hydrocarbon Type
V4061057	ES1-2B	400	Gas & Diesel
V4061059	ES2-2B	200	Gas & Diesel
V4061061	ES3-2B	110	Gas & Diesel

Detection Limit:	0.50

Extractable Hydrocarbons are quantitated against a diesel fuel standard. Hydrocarbons detected by this method range from C8 to C40.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas

Wendy Thomas
Laboratory Manager

V4061048 RES <7>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Method Blank

Analyzed: Jun 27, 1994
Reported: Jun 29, 1994
Matrix: Water

TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (EPA 418.1)

Laboratory Description	Petroleum Hydrocarbons mg/L (ppm)
Method Blank	N.D.

Detection Limit:	**1.0**

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

Wendy Thomas
Laboratory Manager

V4061048.RES <8>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
10525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Method Blank

Analyzed: Jun 27, 1994
Reported: Jun 29, 1994
Matrix: Water

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Description	Volatile Fuel Hydrocarbons µg/L (ppb)	Benzene µg/L (ppb)	Toluene µg/L (ppb)	Ethyl Benzene µg/L (ppb)	Total Xylenes µg/L (ppb)
Method Blank	N.D.	N.D.	N.D.	N.D.	N.D.
Detection Limit:	50	0.30	0.30	0.30	0.60

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas

Wendy Thomas
Laboratory Manager

V4061048 RES <9>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Method Blank

Analyzed: Jun 22, 1994
Reported: Jun 29, 1994
Matrix: Water

EXTRACTABLE FUEL HYDROCARBONS (CA DHS Mod. EPA 8015)

Laboratory Description	Extractable Hydrocarbons mg/L (ppm)	Hydrocarbon Type
Method Blank	N.D.	N.A.

Detection Limit:	0.50

Extractable Hydrocarbons are quantitated against a diesel fuel standard. Hydrocarbons detected by this method range from C8 to C40.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas

Wendy Thomas
Laboratory Manager

V4061048 RES <10>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

QC DATA REPORT

EPA METHOD: 8015 by extraction
matrix: water

DATE: 6/22/94

SAMPLE # Blank

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppm	ppm	ppm	ppm	%	%	%	%
Hydrocarbons	0	5.0	4.5	4.4	90%	88%	2.2%	89%

Definition of Terms:

R1 ..... Result of Sample Analysis

Sp. ..... Spike Concentration Added to Sample

MS. ..... Matrix Spike Result

MSD. ..... Matrix Spike Duplicate Result

PR1 ..... Percent Recovery of MS: (MS-R1) / SP X 100

PR2 ..... Percent Recovery of MSD: ((MSD-R1) / SP X 100

RPD. ..... Relative Percent Difference: ((MS-MSD)/(MS + MSD)/2)) X 100

Del Mar Analytical

Del Mar Analytical

2852 Alton Ave., Irvine CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr. Suite A, Colton CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114 Tempe, AZ 85283 (602) 968-8272 FAX (602) 968-1338

QC DATA REPORT

EPA METHOD: 418.1
matrix: water

DATE: 6/27/94

SAMPLE # Blank

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppm	ppm	ppm	ppm	%	%	%	%
Hydrocarbons	0	5.0	4.9	5.0	98%	100%	2.0%	99%

Definition of Terms:

R1..... Result of Sample Analysis

Sp..... Spike Concentration Added to Sample

MS..... Matrix Spike Result

MSD..... Matrix Spike Duplicate Result

PR1..... Percent Recovery of MS; ((MS-R1) / SP) X 100

PR2..... Percent Recovery of MSD; ((MSD-R1) / SP) X 100

RPD..... Relative Percent Difference; ((MS-MSD)/(MS+MSD)/2)) X 100

Del Mar Analytical

Del Mar Analytical

2852 Alton Ave. Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr. Suite A Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114 Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

QC DATA REPORT

EPA METHOD: 8020
matrix: water

DATE: 6/28/94

SAMPLE # V4061270

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppb	ppb	ppb	ppb	%	%	%	%
Benzene	0.054	10	8.5	8.2	84%	81%	3.6%	83%
Toluene	0.079	10	8.0	9.2	79%	91%	14.0%	85%
Ethylbenzene	0	10	8.5	12	85%	120%	34.1%	103%
Xylenes	0.042	30	26	38	87%	127%	37.5%	107%

Definition of Terms:

R1. . . . . Result of Sample Analysis

Sp. . . . . Spike Concentration Added to Sample

MS. . . . . Matrix Spike Result

MSD. . . . . Matrix Spike Duplicate Result

PR1. . . . . Percent Recovery of MS; ((MS-R1) / SP) X 100

PR2. . . . . Percent Recovery of MSD; ((MSD-R1) / SP) X 100

RPD. . . . . Relative Percent Difference; ((MS-MSD)/(MS+MSD)/2)) X 100

Del Mar Analytical

Del Mar Analytical

2852 Alton Ave. Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16529 Sherman Way, Suite C-13, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

QC DATA REPORT

EPA METHOD: 8015 volatile
matrix: water

DATE: 6/28/94

SAMPLE # V4061270

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppb	ppb	ppb	ppb	%	%	%	%
Hydrocarbons	18	110	127	109	99%	83%	9.0%	91%

Definition of Terms:

R1 ..... Result of Sample Analysis

Sp ..... Spike Concentration Added to Sample

MS ..... Matrix Spike Result

MSD ..... Matrix Spike Duplicate Result

PR1 ..... Percent Recovery of MS, ((MS-R1) / SP) X 100

PR2 ..... Percent Recovery of MSD, ((MSD-R1) / SP) X 100

RPD ..... Relative Percent Difference, ((MS-MSD)/(MS + MSD)/2)) X 100

Del Mar Analytical

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8772 FAX (602) 968-1358

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 3510/CA DHS Mod. 8015
First Sample #: V4061259

Sampled: Jun 23, 1994
Received: Jun 23, 1994
Analyzed: Jun 29, 1994
Reported: Jun 30, 1994

EXTRACTABLE FUEL HYDROCARBONS (CA DHS Mod. EPA 8015)

Laboratory Number	Sample Description Water	Extractable Hydrocarbons mg/L (ppm)	Hydrocarbon Type
V4061259	ES1-7B	200	C9-C27
V4061261	ES2-7B	230	C9-C27
V4061263	ES3-7B	200	C9-C27

Detection Limit:	*0.50*

Extractable Hydrocarbons are quantitated against a diesel fuel standard. Hydrocarbons detected by this method range from C8 to C40.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas

Wendy Thomas
Laboratory Manager

V4061259.RES <1>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370 1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779 1843
945 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968 1358

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 5030/CA DHS Mod. 8015/8020
First Sample #: V4061260

Sampled: Jun 23, 1994
Received: Jun 23, 1994
Analyzed: Jun 29-30, 1994
Reported: Jun 30, 1994

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Number	Sample Description Water	Volatile Fuel Hydrocarbons µg/L (ppb)	Benzene µg/L (ppb)	Toluene µg/L (ppb)	Ethyl Benzene µg/L (ppb)	Total Xylenes µg/L (ppb)
V4061260	ES1-7C	1,200,000	1,600	5,100	930	22,000
V4061264	ES3-7C	860,000	1,300	3,400	780	6,000
Detection Limit:		50,000	300	300	300	600

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 1000

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas.
Wendy Thomas
Laboratory Manager

V4061259 RES <2>

Del Mar Analytical

2852 Alton Ave. Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11 Van Nuys CA 91406 (818) 779-1844 FAX (818) 779-1843
945 South 48th St. Suite 114 Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 5030/CA DHS Mod. 8015/8020
First Sample #: V4061262

Sampled: Jun 23, 1994
Received: Jun 23, 1994
Analyzed: Jun 29-30, 1994
Reported: Jun 30, 1994

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Number	Sample Description Water	Volatile Fuel Hydrocarbons µg/L (ppb)	Benzene µg/L (ppb)	Toluene µg/L (ppb)	Ethyl Benzene µg/L (ppb)	Total Xylenes µg/L (ppb)
V4061262	ES2-7C	1,400,000	N.D.	N.D.	N.D.	6,800
Detection Limit:		**100,000**	**600**	**600**	**600**	**1,200**

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 2000.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas

Wendy Thomas
Laboratory Manager

V4061259 RES <3>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 418.1 (I.R. with clean-up)
First Sample #: V4061611

Sampled: Jun 30, 1994
Received: Jun 30, 1994
Analyzed: Jul 8, 1994
Reported: Jul 8, 1994

TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (EPA 418.1)

Laboratory Number	Sample Description Water	Petroleum Hydrocarbons mg/L (ppm)
V4061611	ES1-14A	100
V4061612	ES2-14A	66
V4061613	ES3-14A	81

Detection Limit:	1.0

Analytes reported as N.D. were not present above the stated limit of detection

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas.
Wendy Thomas
Laboratory Manager

Del Mar Analytical

2852 Alton Ave., Irvine CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-14, Van Nuys CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 174, Tempe, AZ 85281 (602) 968-8777 FAX (602) 968-1338

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Method Blank

Analyzed: Jun 29, 1994
Reported: Jun 30, 1994
Matrix: Water

EXTRACTABLE FUEL HYDROCARBONS (CA DHS Mod. EPA 8015)

Laboratory Description	Extractable Hydrocarbons mg/L (ppm)	Hydrocarbon Type
Method Blank	N.D.	N.A.

Detection Limit:	**0.50**

Extractable Hydrocarbons are quantitated against a diesel fuel standard. Hydrocarbons detected by this method range from C8 to C40.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas
Wendy Thomas
Laboratory Manager

V4061259.RES <4>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
945 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1558

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Method Blank

Analyzed: Jun 29, 1994
Reported: Jun 30, 1994
Matrix: Water

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Description	Volatile Fuel Hydrocarbons µg/L (ppb)	Benzene µg/L (ppb)	Toluene µg/L (ppb)	Ethyl Benzene µg/L (ppb)	Total Xylenes µg/L (ppb)
Method Blank	N.D.	N.D.	N.D.	N.D	N.D.
Detection Limit:	**50**	**0.30**	**0.30**	**0.30**	**0.60**

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15

Analytes reported as N.D. were not present above the stated limit of detection

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas
Wendy Thomas
Laboratory Manager

V4061259 RES <5>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
945 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 418.1 (I.R. with clean-up)
First Sample #: V4061611

Sampled: Jun 30, 1994
Received: Jun 30, 1994
Analyzed: Jul 8, 1994
Reported: Jul 8, 1994

TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (EPA 418.1)

Laboratory Number	Sample Description Water	Petroleum Hydrocarbons mg/L (ppm)
V4061611	ES1-14A	100
V4061612	ES2-14A	66
V4061613	ES3-14A	81

Detection Limit:	1.0

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas.
Wendy Thomas
Laboratory Manager

V4061611 RES <1>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-13, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

QC DATA REPORT

EPA METHOD: 8015 by extraction
matrix: water

DATE: 6/29/94

SAMPLE # Blank

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppm	ppm	ppm	ppm	%	%	%	%
Hydrocarbons	0	5.0	5.7	5.9	114%	118%	3.4%	116%

Definition of Terms:

R1. . . . . Result of Sample Analysis

Sp. . . . . Spike Concentration Added to Sample

MS. . . . . Matrix Spike Result

MSD. . . . . Matrix Spike Duplicate Result

PR1. . . . . Percent Recovery of MS; (MS-R1) / SP X 100

PR2. . . . . Percent Recovery of MSD; ((MSD-R1) / SP X 100

RPD. . . . . Relative Percent Difference; ((MS-MSD)/(MS+MSD)/2)) X 100

Del Mar Analytical

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
945 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1558

QC DATA REPORT

EPA METHOD: 8020
matrix: water

DATE: 6/30/94

SAMPLE # V4061540

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppb	ppb	ppb	ppb	%	%	%	%
Benzene	0.073	10	11	11	109%	109%	0.0%	109%
Toluene	0.10	10	11	11.0	109%	109%	0.0%	109%
Ethylbenzene	0	10	12	12	120%	120%	0.0%	120%
Xylenes	0.064	30	35	36	116%	120%	2.8%	118%

Definition of Terms:

R1. . . . . Result of Sample Analysis

Sp. . . . . Spike Concentration Added to Sample

MS. . . . . Matrix Spike Result

MSD. . . . . Matrix Spike Duplicate Result

PR1. . . . . Percent Recovery of MS; ((MS-R1) / SP) X 100

PR2. . . . . Percent Recovery of MSD; ((MSD-R1) / SP) X 100

RPD. . . . . Relative Percent Difference; ((MS-MSD)/(MS+MSD)/2)) X 100

Del Mar Analytical

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr. Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

QC DATA REPORT

EPA METHOD: 8015 volatile
matrix: water

DATE: 6/30/94

SAMPLE # V4061540

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppb	ppb	ppb	ppb	%	%	%	%
Hydrocarbons	43	110	167	170	113%	115%	9.0%	114%

Definition of Terms:

R1 . . . . . Result of Sample Analysis

Sp . . . . . Spike Concentration Added to Sample

MS . . . . . Matrix Spike Result

MSD . . . . . Matrix Spike Duplicate Result

PR1 . . . . . Percent Recovery of MS; ((MS-R1) / SP) X 100

PR2 . . . . . Percent Recovery of MSD; ((MSD-R1) / SP) X 100

RPD . . . . . Relative Percent Difference; ((MS-MSD)/(MS+MSD)/2)) X 100

Del Mar Analytical

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 5030/CA DHS Mod. 8015/8020
First Sample #: V4061611

Sampled: Jun 30, 1994
Received: Jun 30, 1994
Analyzed: Jul 7, 1994
Reported: Jul 8, 1994

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Number	Sample Description Water	Volatile Fuel Hydrocarbons µg/L (ppb)	Benzene µg/L (ppb)	Toluene µg/L (ppb)	Ethyl Benzene µg/L (ppb)	Total Xylenes µg/L (ppb)
V4061611	ES1-14C	90,000	150	740	N.D.	1,900
Detection Limit:		6,300	38	38	38	75

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 125.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas
Wendy Thomas
Laboratory Manager

V4061611.RES <2>

Del Mar Analytical

2852 Alton Ave. Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 5030/CA DHS Mod. 8015/8020
First Sample #: V4061612

Sampled: Jun 30, 1994
Received: Jun 30, 1994
Analyzed: Jul 7, 1994
Reported: Jul 8, 1994

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Number	Sample Description Water	Volatile Fuel Hydrocarbons µg/L (ppb)	Benzene µg/L (ppb)	Toluene µg/L (ppb)	Ethyl Benzene µg/L (ppb)	Total Xylenes µg/L (ppb)
V4061612	ES2-14C	21,000	N.D.	N.D.	N.D.	9.1
Detection Limit:		500	3.0	3.0	3.0	6.0

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 10.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas
Wendy Thomas
Laboratory Manager

V4061611.RES <3>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 5030/CA DHS Mod. 8015/8020
First Sample #: V4061613

Sampled: Jun 30, 1994
Received: Jun 30, 1994
Analyzed: Jul 7, 1994
Reported: Jul 8, 1994

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Number	Sample Description Water	Volatile Fuel Hydrocarbons µg/L (ppb)	Benzene µg/L (ppb)	Toluene µg/L (ppb)	Ethyl Benzene µg/L (ppb)	Total Xylenes µg/L (ppb)
V4061613	ES3-14C	32,000	240	750	130	1,700
Detection Limit:		5,000	30	30	30	60

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 100.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas
Wendy Thomas
Laboratory Manager

V4061611.RES <4>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
5014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 3510/CA DHS Mod. 8015
First Sample #: V4061611

Sampled: Jun 30, 1994
Received: Jun 30, 1994
Analyzed: Jul 6, 1994
Reported: Jul 8, 1994

EXTRACTABLE FUEL HYDROCARBONS (CA DHS Mod. EPA 8015)

Laboratory Number	Sample Description Water	Extractable Hydrocarbons mg/L (ppm)	Hydrocarbon Type
V4061611	ES1-14B	72	C9-C34
V4061612	ES2-14B	76	C9-C34
V4061613	ES3-14B	82	C9-C34

Detection Limit:	0.50

Extractable Hydrocarbons are quantitated against a diesel fuel standard. Hydrocarbons detected by this method range from C8 to C40.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas

Wendy Thomas
Laboratory Manager

V4061611 RES <5>

Del Mar Analytical

2852 Alton Ave., Irvine CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-4046
16525 Sherman Way, Suite C-11, Van Nuys CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe AZ 85281 (602) 968-8272 FAX (602) 968-1358

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Method Blank

Analyzed: Jul 8, 1994
Reported: Jul 8, 1994
Matrix: Water

TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (EPA 418.1)

Laboratory Description	Petroleum Hydrocarbons mg/L (ppm)
Method Blank	N.D.

Detection Limit:	1.0

Analytes reported as N.D. were not present above the stated limit of detection

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas.
Wendy Thomas
Laboratory Manager

V4061611 RES <6>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1054 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Method Blank

Analyzed: Jul 7, 1994
Reported: Jul 8, 1994
Matrix: Water

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Description	Volatile Fuel Hydrocarbons µg/L (ppb)	Benzene µg/L (ppb)	Toluene µg/L (ppb)	Ethyl Benzene µg/L (ppb)	Total Xylenes µg/L (ppb)
Method Blank	N.D.	N.D.	N.D.	N.D.	N.D.
Detection Limit:	**50**	**0.30**	**0.30**	**0.30**	**0.60**

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas

Wendy Thomas
Laboratory Manager

V4061611.RES <7>

Del Mar Analytical

2852 Alton Ave. Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

Resna Industries
5301 Beethoven St., Ste. 290
Los Angeles, CA 90066
Attention: Cheryl Krueger

Method Blank

Analyzed: Jul 6, 1994
Reported: Jul 8, 1994
Matrix: Water

EXTRACTABLE FUEL HYDROCARBONS (CA DHS Mod. EPA 8015)

Laboratory Description	Extractable Hydrocarbons mg/L (ppm)	Hydrocarbon Type
Method Blank	N.D.	N.A.

Detection Limit:	0.50

Extractable Hydrocarbons are quantitated against a diesel fuel standard. Hydrocarbons detected by this method range from C8 to C40.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas
Wendy Thomas
Laboratory Manager

V4061611 RES <8>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114 Tempe, AZ 85281 (602) 968-8772 FAX (602) 968-1538

QC DATA REPORT

EPA METHOD: 8015 by extraction
matrix: water

DATE: 7/6/94

SAMPLE # Blank

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppm	ppm	ppm	ppm	%	%	%	%
Hydrocarbons	0	5.0	5.1	5.3	102%	106%	3.8%	104%

Definition of Terms:

R1 . . . . . Result of Sample Analysis

Sp . . . . . Spike Concentration Added to Sample

MS . . . . . Matrix Spike Result

MSD . . . . . Matrix Spike Duplicate Result

PR1 . . . . . Percent Recovery of MS; (MS-R1) / SP X 100

PR2 . . . . . Percent Recovery of MSD; ((MSD-R1) / SP X 100

RPD . . . . . Relative Percent Difference; ((MS-MSD)/(MS+MSD)/2)) X 100

Del Mar Analytical

Del Mar Analytical

2853 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

QC DATA REPORT

EPA METHOD: 8020
matrix: water

DATE: 7/7/94

SAMPLE # V4070129

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppb	ppb	ppb	ppb	%	%	%	%
Benzene	0	10	11	10	110%	100%	9.5%	105%
Toluene	0.064	10	10	10	99%	99%	0.0%	99%
Ethylbenzene	0	10	11	12	110%	120%	8.7%	115%
Xylenes	0.027	30	35	35	117%	117%	0.0%	117%

Definition of Terms:

R1. . . . . Result of Sample Analysis

Sp. . . . . Spike Concentration Added to Sample

MS. . . . . Matrix Spike Result

MSD. . . . . Matrix Spike Duplicate Result

PR1. . . . . Percent Recovery of MS; ((MS-R1) / SP) X 100

PR2. . . . . Percent Recovery of MSD, ((MSD-R1) / SP) X 100

RPD. . . . . Relative Percent Difference; ((MS-MSD)/(MS+MSD)/2)) X 100

Del Mar Analytical

Del Mar Analytical

2852 Alton Ave. Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr. Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
945 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

QC DATA REPORT

EPA METHOD: 8015 volatile
matrix: water

DATE: 7/7/94

SAMPLE # V4070129

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppb	ppb	ppb	ppb	%	%	%	%
Hydrocarbons	10	110	120	120	100%	100%	9.0%	100%

Definition of Terms:

R1 ..... Result of Sample Analysis

Sp ..... Spike Concentration Added to Sample

MS ..... Matrix Spike Result

MSD ..... Matrix Spike Duplicate Result

PR1 ..... Percent Recovery of MS; ((MS-R1) / SP) X 100

PR2 ..... Percent Recovery of MSD; ((MSD-R1) / SP) X 100

RPD ..... Relative Percent Difference; ((MS-MSD)/(MS + MSD)/2)) X 100

Del Mar Analytical

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr. Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

A. Keith Kaufman, M.S.
6245 Bristol Parkway #249
Culver City, CA 90230
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 418.1 (I.R. with clean-up)
First Sample #: V4070794

Sampled: Jul 8, 1994
Received: Jul 25, 1994
Analyzed: Jul 26, 1994
Reported: Jul 27, 1994

TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (EPA 418.1)

Laboratory Number	Sample Description Soil	Petroleum Hydrocarbons mg/Kg (ppm)
V4070794	ES-0B	430

Detection Limit:	5.0

Analytes reported as N.D. were not present above the stated limit of detection

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas
Wendy Thomas
Laboratory Manager

V4070793 AKK <1>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr. Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
945 South 48th St. Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

A. Keith Kaufman, M.S.
6245 Bristol Parkway #249
Culver City, CA 90230
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 418.1 (I.R. with clean-up)
First Sample #: V4070796

Sampled: Jul 22, 1994
Received: Jul 25, 1994
Analyzed: Jul 25, 1994
Reported: Jul 27, 1994

TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (EPA 418.1)

Laboratory Number	Sample Description Soil	Petroleum Hydrocarbons mg/Kg (ppm)
V4070796	ES-148	1,000

Detection Limit:	5.0

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas

Wendy Thomas
Laboratory Manager

V4070793 AKK <2>

Del Mar Analytical

2852 Alton Ave. Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
945 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

QC DATA REPORT

EPA METHOD: 418.1
matrix water

DATE: 7/8/94

SAMPLE # Blank

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppm	ppm	ppm	ppm	%	%	%	%
Hydrocarbons	0	5.0	5.1	5.0	102%	100%	2.0%	101%

Definition of Terms:

R1. . . . . Result of Sample Analysis

Sp. . . . . Spike Concentration Added to Sample

MS. . . . . Matrix Spike Result

MSD. . . . . Matrix Spike Duplicate Result

PR1. . . . . Percent Recovery of MS: ((MS-R1) / SP) X 100

PR2. . . . . Percent Recovery of MSD: ((MSD-R1) / SP) X 100

RPD. . . . . Relative Percent Difference: ((MS-MSD)/(MS + MSD)/2)) X 100

Del Mar Analytical

Del Mar Analytical

2852 Alton Ave. Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
945 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

A. Keith Kaufman, M.S.
6245 Bristol Parkway #249
Culver City, CA 90230
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 5030/CA DHS Mod. 8015/8020
First Sample #: V4070793

Sampled: Jul 8, 1994
Received: Jul 25, 1994
Analyzed: Jul 25, 1994
Reported: Jul 27, 1994

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Number	Sample Description Water	Volatile Fuel Hydrocarbons µg/L (ppb)	Benzene µg/L (ppb)	Toluene µg/L (ppb)	Ethyl Benzene µg/L (ppb)	Total Xylenes µg/L (ppb)
V4070793	ES-0A	760,000	1,600	7,000	2,900	27,000
Detection Limit:		25,000	150	150	150	300

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 500.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas
Wendy Thomas
Laboratory Manager

V4070793 AKK <3>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1538

A. Keith Kaufman, M.S.
6245 Bristol Parkway #249
Culver City, CA 90230
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 5030/CA DHS Mod. 8015/8020
First Sample #: V4070795

Sampled: Jul 22, 1994
Received: Jul 25, 1994
Analyzed: Jul 27, 1994
Reported: Jul 27, 1994

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Number	Sample Description Water	Volatile Fuel Hydrocarbons µg/L (ppb)	Benzene µg/L (ppb)	Toluene µg/L (ppb)	Ethyl Benzene µg/L (ppb)	Total Xylenes µg/L (ppb)
V4070795	ES-14A	120	0.56	7.1	N.D.	11
Detection Limit:		50	0.30	0.30	0.30	0.60

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas

Wendy Thomas
Laboratory Manager

V4070793 AKK <4>

Del Mar Analytical

2852 Alton Ave. Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8277 FAX (602) 968-1338

A. Keith Kaufman, M.S.
6245 Bristol Parkway #249
Culver City, CA 90230
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 5030/CA DHS Mod. 8015/8020
First Sample #: V4070794

Sampled: Jul 8, 1994
Received: Jul 25, 1994
Analyzed: Jul 26, 1994
Reported: Jul 27, 1994

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Number	Sample Description Soil	Volatile Fuel Hydrocarbons mg/Kg (ppm)	Benzene mg/Kg (ppm)	Toluene mg/Kg (ppm)	Ethyl Benzene mg/Kg (ppm)	Total Xylenes mg/Kg (ppm)
V4070794	ES-0B	320	0.054	0.091	0.60	1.3
Detection Limit:		8.0	0.040	0.040	0.040	0.12

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 8

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas
Wendy Thomas
Laboratory Manager

V4070793 AKK <5>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

A. Keith Kaufman, M.S.
6245 Bristol Parkway #249
Culver City, CA 90230
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 5030/CA DHS Mod. 8015/8020
First Sample #: V4070796

Sampled: Jul 22, 1994
Received: Jul 25, 1994
Analyzed: Jul 26, 1994
Reported: Jul 27, 1994

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Number	Sample Description Soil	Volatile Fuel Hydrocarbons mg/Kg (ppm)	Benzene mg/Kg (ppm)	Toluene mg/Kg (ppm)	Ethyl Benzene mg/Kg (ppm)	Total Xylenes mg/Kg (ppm)
V4070796	ES-14B	510	0.30	0.16	1.1	1.7
Detection Limit:		12	0.060	0.060	0.060	0.18

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15.

Analytes reported as N.D. were not present above the stated limit of detection. Due to matrix effects and/or other factors, the sample required dilution. Detection limits for this sample have been raised by a factor of 12.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas
Wendy Thomas
Laboratory Manager

V4070793 AKK <6>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

A. Keith Kaufman, M.S.
6245 Bristol Parkway #249
Culver City, CA 90230
Attention: Cheryl Krueger

Client Project ID: England Shabin

Analysis Method: EPA 3510/CA DHS Mod. 8015
First Sample #: V4070793

Sampled: Jul 8, 1994
Received: Jul 25, 1994
Analyzed: Jul 26, 1994
Reported: Jul 27, 1994

EXTRACTABLE FUEL HYDROCARBONS (CA DHS Mod. EPA 8015)

Laboratory Number	Sample Description Water	Extractable Hydrocarbons mg/L (ppm)	Hydrocarbon Type
V4070793	ES-0A	550	C9-C30

Detection Limit:	0.50

Extractable Hydrocarbons are quantitated against a diesel fuel standard. Hydrocarbons detected by this method range from C8 to C40.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas
Wendy Thomas
Laboratory Manager

V4070793 AKK <7>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

A. Keith Kaufman, M.S.
6245 Bristol Parkway #249
Culver City, CA 90230
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 3510/CA DHS Mod. 8015
First Sample #: V4070795

Sampled: Jul 22, 1994
Received: Jul 25, 1994
Analyzed: Jul 26, 1994
Reported: Jul 27, 1994

EXTRACTABLE FUEL HYDROCARBONS (CA DHS Mod. EPA 8015)

Laboratory Number	Sample Description Water	Extractable Hydrocarbons mg/L (ppm)	Hydrocarbon Type
V4070795	ES-14A	5.7	C9-C38

Detection Limit:	0.50

Extractable Hydrocarbons are quantitated against a diesel fuel standard. Hydrocarbons detected by this method range from C8 to C40.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas

Wendy Thomas
Laboratory Manager

V4070793.AKK <8>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

A. Keith Kaufman, M.S.
6245 Bristol Parkway #249
Culver City, CA 90230
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 3550/CA DHS Mod. 8015
First Sample #: V4070794

Sampled: Jul 8, 1994
Received: Jul 25, 1994
Analyzed: Jul 25, 1994
Reported: Jul 27, 1994

EXTRACTABLE FUEL HYDROCARBONS (CA DHS Mod. EPA 8015)

Laboratory Number	Sample Description Soil	Extractable Hydrocarbons mg/Kg (ppm)	Hydrocarbon Type
V4070794	ES-0B	390	C6-C39

Detection Limit:	**5.0**

Extractable hydrocarbons are quantitated against a diesel fuel standard. Hydrocarbons detected by this method range from C8 to C40.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas
Wendy Thomas
Laboratory Manager

V4070793 AKK <9>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1358

A. Keith Kaufman, M.S.
6245 Bristol Parkway #249
Culver City, CA 90230
Attention: Cheryl Krueger

Client Project ID: England Shahin

Analysis Method: EPA 3550/CA DHS Mod. 8015
First Sample #: V4070796

Sampled: Jul 22, 1994
Received: Jul 25, 1994
Analyzed: Jul 26, 1994
Reported: Jul 27, 1994

EXTRACTABLE FUEL HYDROCARBONS (CA DHS Mod. EPA 8015)

Laboratory Number	Sample Description Soil	Extractable Hydrocarbons mg/Kg (ppm)	Hydrocarbon Type
V4070796	ES-14B	1,300	C9-C38

Detection Limit:	5.0

Extractable Hydrocarbons are quantitated against a diesel fuel standard. Hydrocarbons detected by this method range from C8 to C40.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas
Wendy Thomas
Laboratory Manager

V4070793.AKK <10>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-3338

A. Keith Kaufman, M.S.
6245 Bristol Parkway #249
Culver City, CA 90230
Attention: Cheryl Krueger

Method Blank

Analyzed: Jul 26, 1994
Reported: Jul 27, 1994
Matrix: Water

EXTRACTABLE FUEL HYDROCARBONS (CA DHS Mod. EPA 8015)

Laboratory Description	Extractable Hydrocarbons mg/L (ppm)	Hydrocarbon Type
Method Blank	N.D.	N.A.

Detection Limit:	**0.50**

Extractable Hydrocarbons are quantitated against a diesel fuel standard. Hydrocarbons detected by this method range from C8 to C40.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

Wendy Thomas
Laboratory Manager

V4070793.AKK <14>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
945 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

A. Keith Kaufman, M.S.
6245 Bristol Parkway #249
Culver City, CA 90230
Attention Cheryl Krueger

Method Blank

Analyzed: Jul 25, 1994
Reported: Jul 27, 1994
Matrix: Soil

EXTRACTABLE FUEL HYDROCARBONS (CA DHS Mod. EPA 8015)

Laboratory Description	Extractable Hydrocarbons mg/Kg (ppm)	Hydrocarbon Type
Method Blank	N.D.	N.A.

Detection Limit:	**5.0**

Extractable Hydrocarbons are quantitated against a diesel fuel standard. Hydrocarbons detected by this method range from C8 to C40.

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

W. Thomas

Wendy Thomas
Laboratory Manager

V4070793 AKK <15>

Del Mar Analytical

2852 Alton Ave. Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
10575 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St. Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1558

A. Keith Kaufman, M.S.
6245 Bristol Parkway #249
Culver City, CA 90230
Attention: Cheryl Krueger

Method Blank

Analyzed: Jul 26, 1994
Reported: Jul 27, 1994
Matrix: Soil

TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (EPA 418.1)

Laboratory Description	Petroleum Hydrocarbons mg/Kg (ppm)
Method Blank	N.D.

Detection Limit:	5.0

Analytes reported as N.D. were not present above the stated limit of detection.

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

Wendy Thomas
Laboratory Manager

V4070793 AKK <11>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1914 E. Cooley Dr., Suite A, Colton CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
945 South 48th St., Suite 114, Tempe AZ 85281 (602) 968-8272 FAX (602) 968-1338

A. Keith Kaufman, M.S.
6245 Bristol Parkway #249
Culver City, CA 90230
Attention: Cheryl Krueger

Method Blank

Analyzed: Jul 25, 1994
Reported: Jul 27, 1994
Matrix: Water

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Description	Volatile Fuel Hydrocarbons µg/L (ppb)	Benzene µg/L (ppb)	Toluene µg/L (ppb)	Ethyl Benzene µg/L (ppb)	Total Xylenes µg/L (ppb)
Method Blank	N.D.	N.D	N.D.	N.D.	N.D.
Detection Limit:	50	0.30	0.30	0.30	0.60

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15

Analytes reported as N.D. were not present above the stated limit of detection

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1865)

W. Thomas
Wendy Thomas
Laboratory Manager

V4070793 AKK <12>

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-12, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1538

A. Keith Kaufman, M.S.
6245 Bristol Parkway #249
Culver City, CA 90230
Attention Cheryl Krueger

Method Blank

Analyzed: Jul 26, 1994
Reported: Jul 27, 1994
Matrix: Soil

VOLATILE FUEL HYDROCARBONS/BTEX DISTINCTION (CA DHS Mod. EPA 8015/8020)

Laboratory Description	Volatile Fuel Hydrocarbons mg/Kg (ppm)	Benzene mg/Kg (ppm)	Toluene mg/Kg (ppm)	Ethyl Benzene mg/Kg (ppm)	Total Xylenes mg/Kg (ppm)
Method Blank	N.D	N.D.	N.D.	N.D.	N.D.
Detection Limit:	1.0	0.0050	0.0050	0.0050	0.015

Volatile Fuel Hydrocarbons are quantitated against a gasoline standard. Hydrocarbons detected by this method range from C6 to C15

Analytes reported as N.D. were not present above the stated limit of detection

DEL MAR ANALYTICAL, VAN NUYS (ELAP #1855)

Wendy Thomas
Laboratory Manager

V4070793 AKK <13>

Del Mar Analytical

2852 Alton Ave. Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 124, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

QC DATA REPORT

EPA METHOD: 8020
matrix: water

DATE: 7/25/94

SAMPLE # V4070619

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppb	ppb	ppb	ppb	%	%	%	%
Benzene	0.059	10	9.6	9.6	95%	95%	0.0%	95%
Toluene	0.084	10	10	9.3	99%	92%	7.3%	96%
Ethylbenzene	0	10	9.5	10	95%	100%	5.1%	98%
Xylenes	0.053	30	33	30	110%	100%	9.5%	105%

Definition of Terms:

R1 ..... Result of Sample Analysis

Sp ..... Spike Concentration Added to Sample

MS ..... Matrix Spike Result

MSD ..... Matrix Spike Duplicate Result

PR1 ..... Percent Recovery of MS; ((MS-R1) / SP) X 100

PR2 ..... Percent Recovery of MSD; ((MSD-R1) / SP) X 100

RPD ..... Relative Percent Difference; ((MS-MSD)/(MS+MSD)/2)) X 100

Del Mar Analytical

Del Mar Analytical

2852 Alton Ave. Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1538

QC DATA REPORT

EPA METHOD: 8015 volatile
matrix: water

DATE: 7/25/94

SAMPLE # V4070619

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppb	ppb	ppb	ppb	%	%	%	%
Hydrocarbons	7.9	110	120	130	102%	111%	9.0%	106%

Definition of Terms:

R1. . . . . Result of Sample Analysis

Sp. . . . . Spike Concentration Added to Sample

MS. . . . . Matrix Spike Result

MSD. . . . . Matrix Spike Duplicate Result

PR1. . . . . Percent Recovery of MS; ((MS-R1) / SP) X 100

PR2. . . . . Percent Recovery of MSD; ((MSD-R1) / SP) X 100

RPD. . . . . Relative Percent Difference; ((MS-MSD)/(MS+MSD)/2)) X 100

Del Mar Analytical

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr. Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St. Suite F14, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

QC DATA REPORT

EPA METHOD: 8015 by extraction
matrix: water

DATE: 7/26/94

SAMPLE # Blank

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppm	ppm	ppm	ppm	%	%	%	%
Hydrocarbons	0	5.0	4.4	4.7	88%	94%	6.6%	91%

Definition of Terms:

R1. . . . . Result of Sample Analysis

Sp. . . . . Spike Concentration Added to Sample

MS. . . . . Matrix Spike Result

MSD. . . . . Matrix Spike Duplicate Result

PR1. . . . . Percent Recovery of MS; (MS-R1) / SP X 100

PR2. . . . . Percent Recovery of MSD; ((MSD-R1) / SP X 100

RPD. . . . . Relative Percent Difference. ((MS-MSD)/(MS + MSD)/2)) X 100

Del Mar Analytical

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

QC DATA REPORT

EPA METHOD: 8015 by extraction
matrix: soil

DATE: 7/25/94

SAMPLE # Blank

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppm	ppm	ppm	ppm	%	%	%	%
Hydrocarbons	0	200	180	160	90%	80%	11.8%	85%

Definition of Terms:

R1. . . . . Result of Sample Analysis

Sp. . . . . Spike Concentration Added to Sample

MS. . . . . Matrix Spike Result

MSD. . . . . Matrix Spike Duplicate Result

PR1. . . . . Percent Recovery of MS; ((MS-R1) / SP) X 100

PR2. . . . . Percent Recovery of MSD; ((MSD-R1) / SP) X 100

RPD. . . . . Relative Percent Difference, ((MS-MSD)/(MS + MSD)/2)) X 100

Del Mar Analytical

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370 4667 FAX (909) 370 1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779 1844 FAX (818) 779 1843
945 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968 1338

QC DATA REPORT

EPA METHOD: 418.1
matrix: soil

DATE: 7/26/94

SAMPLE # BLANK

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppm	ppm	ppm	ppm	%	%	%	%
Hydrocarbons	0	60	53	56	88%	93%	5.5%	91%

Definition of Terms:

R1 ..... Result of Sample Analysis

Sp ..... Spike Concentration Added to Sample

MS ..... Matrix Spike Result

MSD ..... Matrix Spike Duplicate Result

PR1 ..... Percent Recovery of MS, ((MS-R1) / SP) X 100

PR2 ..... Percent Recovery of MSD; ((MSD-R1) / SP) X 100

RPD ..... Relative Percent Difference: ((MS-MSD)/(MS + MSD)/2)) X 100

Del Mar Analytical

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

QC DATA REPORT

EPA METHOD: 8015 volatile
matrix: soil

DATE: 7/26/94

SAMPLE # BLANK

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppm	ppm	ppm	ppm	%	%	%	%
Hydrocarbons	0	1.1	1.2	1.2	109%	109%	0.0%	109%

Definition of Terms:

R1 ..... Result of Sample Analysis

Sp ..... Spike Concentration Added to Sample

MS ..... Matrix Spike Result

MSD ..... Matrix Spike Duplicate Result

PR1 ..... Percent Recovery of MS; ((MS-R1) / SP) X 100

PR2 ..... Percent Recovery of MSD; ((MSD-R1) / SP) X 100

RPD ..... Relative Percent Difference; ((MS-MSD)/(MS+MSD)/2)) X 100

Del Mar Analytical

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Copley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
943 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

QC DATA REPORT

EPA METHOD: 8020
matrix: soil

DATE: 7/26/94

SAMPLE # BLANK

Analyte	R1	Sp	MS	MSD	PR1	PR2	RPD	MEAN PR
	ppm	ppm	ppm	ppm	%	%	%	%
Benzene	0	0.10	0.098	0.091	98%	91%	7.4%	95%
Toluene	0	0.10	0.096	0.085	96%	85%	12.2%	91%
Ethylbenzene	0	0.10	0.10	0.095	100%	95%	5.1%	98%
Xylenes	0	0.30	0.31	0.28	103%	93%	10.2%	98%

Definition of Terms:

R1. . . . . Result of Sample Analysis

Sp. . . . . Spike Concentration Added to Sample

MS. . . . . Matrix Spike Result

MSD. . . . . Matrix Spike Duplicate Result

PR1. . . . . Percent Recovery of MS; ((MS-R1) / SP) X 100

PR2. . . . . Percent Recovery of MSD; ((MSD-R1) / SP) X 100

RPD. . . . . Relative Percent Difference; ((MS-MSD)/(MS + MSD)/2)) X 100

Del Mar Analytical

A. Keith Kaufman, M.S.

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

PROJECT NO.:

PROJECT NAME/SITE: ENGLAND SHAFT'N

SAMPLERS (SIGN): Cheryl Krueger (PRINT): CHERYL KRUEGER

ANALYSIS REQUESTED: BTEX (602/8020), TPHg (8015), TPHd (8015), TOG 418.1/5520, 601/8010, 624/8240, 625/8270

P.O. #:

	SAMPLE IDENTIFICATION	DATE	TIME	COMP	GRAB	PRES. USED	ICED	NO CONTAINERS	SAMPLE TYPE	BTEX (602/8020)	TPHg (8015)	TPHd (8015)	TOG 418.1/5520	601/8010	624/8240	625/8270	REMARKS
793	ES-OA	7/8/94		✓				2	W	✓	✓	✓	✓				Please fax
794	ES-OB	"		✓				1	S	)	)	)	)				results to
795	ES-14A	7/22/94		✓				2	W	)	)	)	)				me at
796	ES-14B *	"		✓				1	S	)	)	)	)				(805) 352-6315
	* (HEAD SPACE)																(CALL FIRST)

RELINQUISHED BY:	DATE	TIME	RECEIVED BY:
Cheryl Krueger	7/25/94	10:20	[illegible]
RELINQUISHED BY:	DATE	TIME	RECEIVED BY
RELINQUISHED BY:	DATE	TIME	RECEIVED BY:
RELINQUISHED BY:	DATE	TIME	RECEIVED BY LABORATORY:

LABORATORY: DEL MAR ANALYTICAL, 16525 SHERMAN WAY, VAN NUYS, CA

REQUESTED TURNAROUND TIME: 72 HRS.

RECEIPT CONDITION:

PLEASE SEND RESULTS TO: CHERYL KRUEGER, KEITH KAUFMAN, 6245 BRISTOL PKWY #249, CULVER CITY, CA 90230

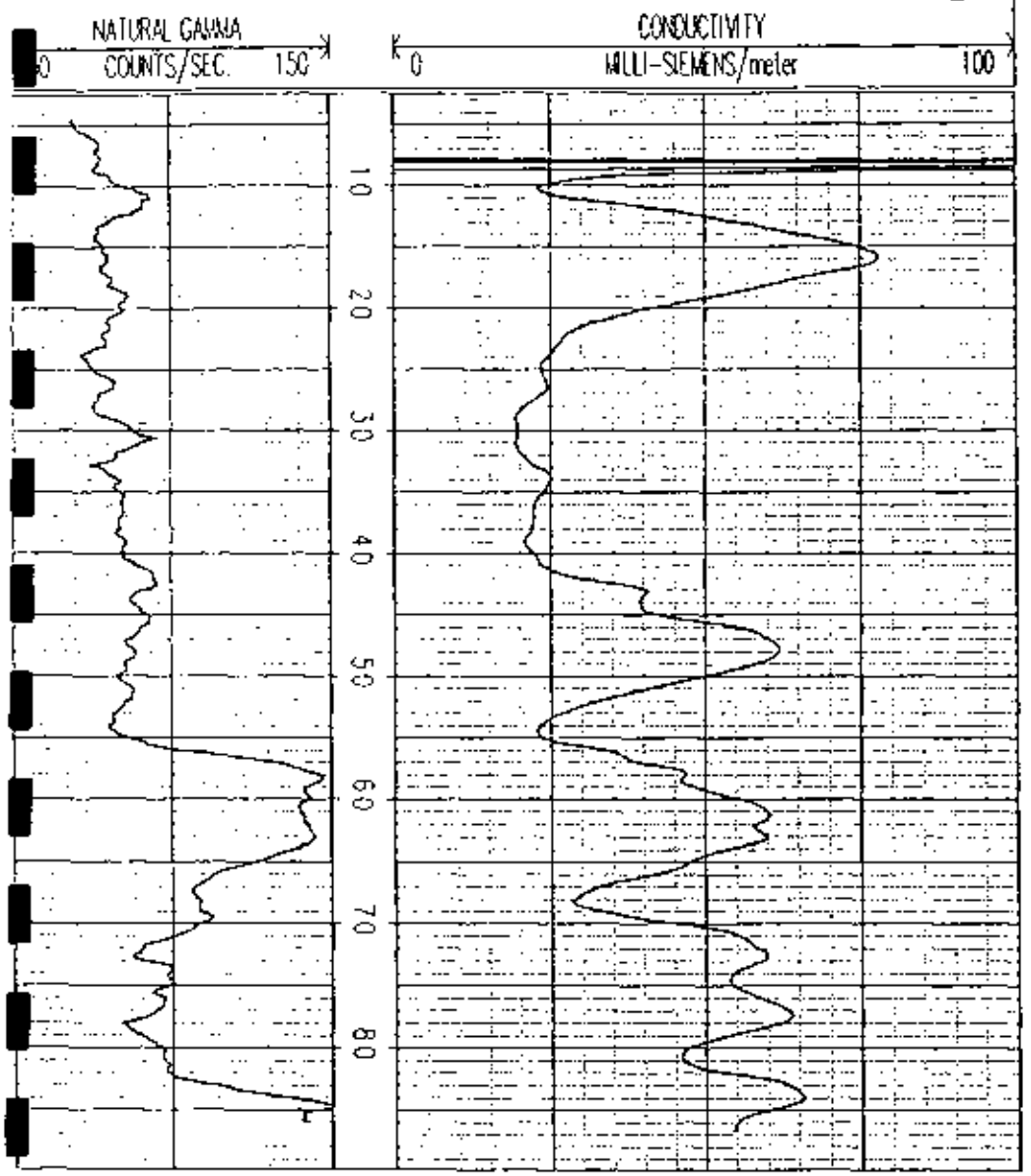
PROJECT MANAGER: KEITH KAUFMAN

6245 Bristol Parkway #249 Culver City CA 90230 (310) 822-9385 (Voice/FAX)

APPENDIX H

TEXACO PCPL MAY 05, 1994 WELL MW-11S

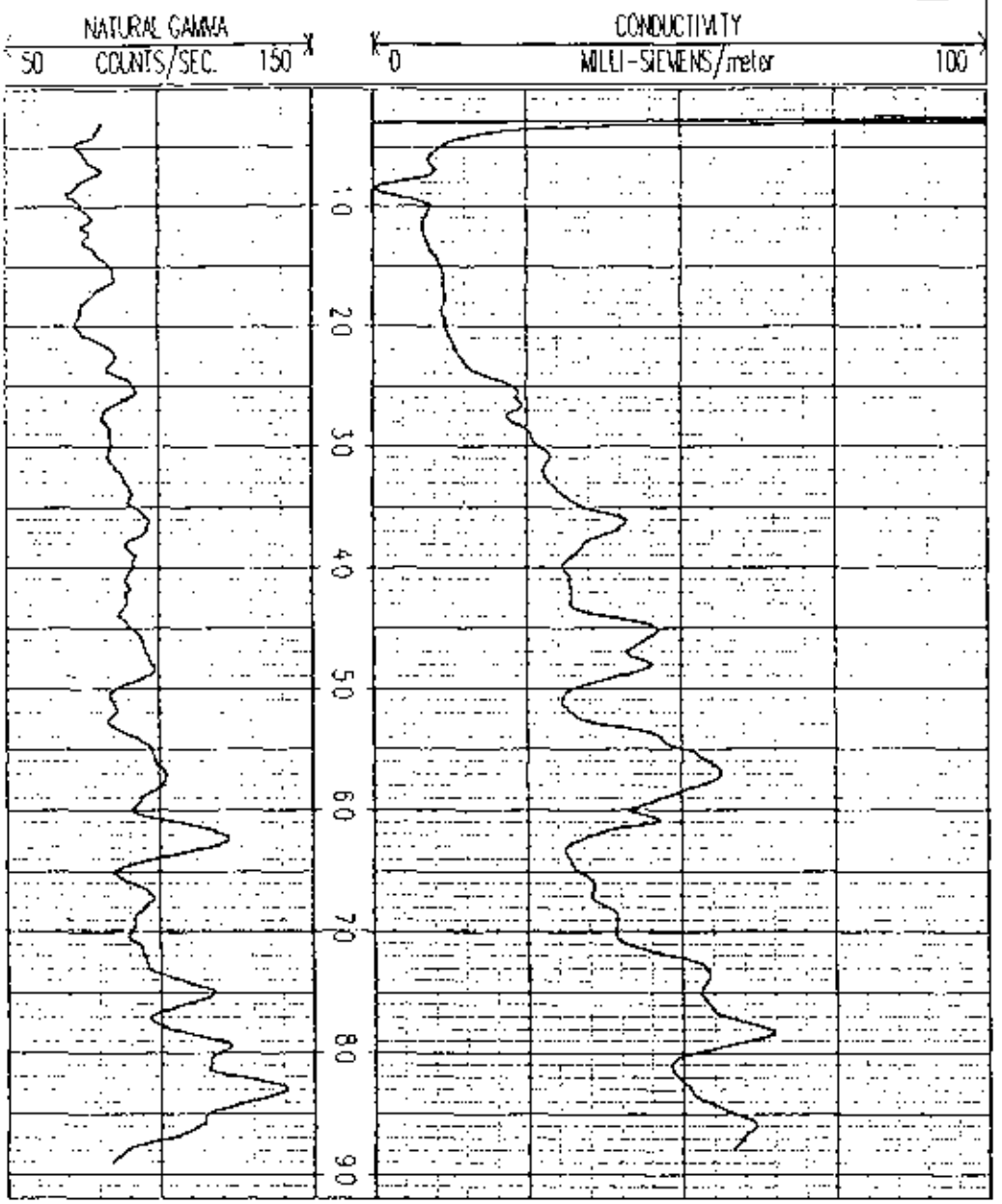
COLOG



NATURAL GAMMA
50 COUNTS/SEC. 150
CONDUCTIVITY
0 MILLI-SIEMENS/meter 100
TEXACO PCPL MAY 05, 1994 WELL MW-11S
COLOG

TEXACO PCPL MAY 05, 1994 WELL MW-20s

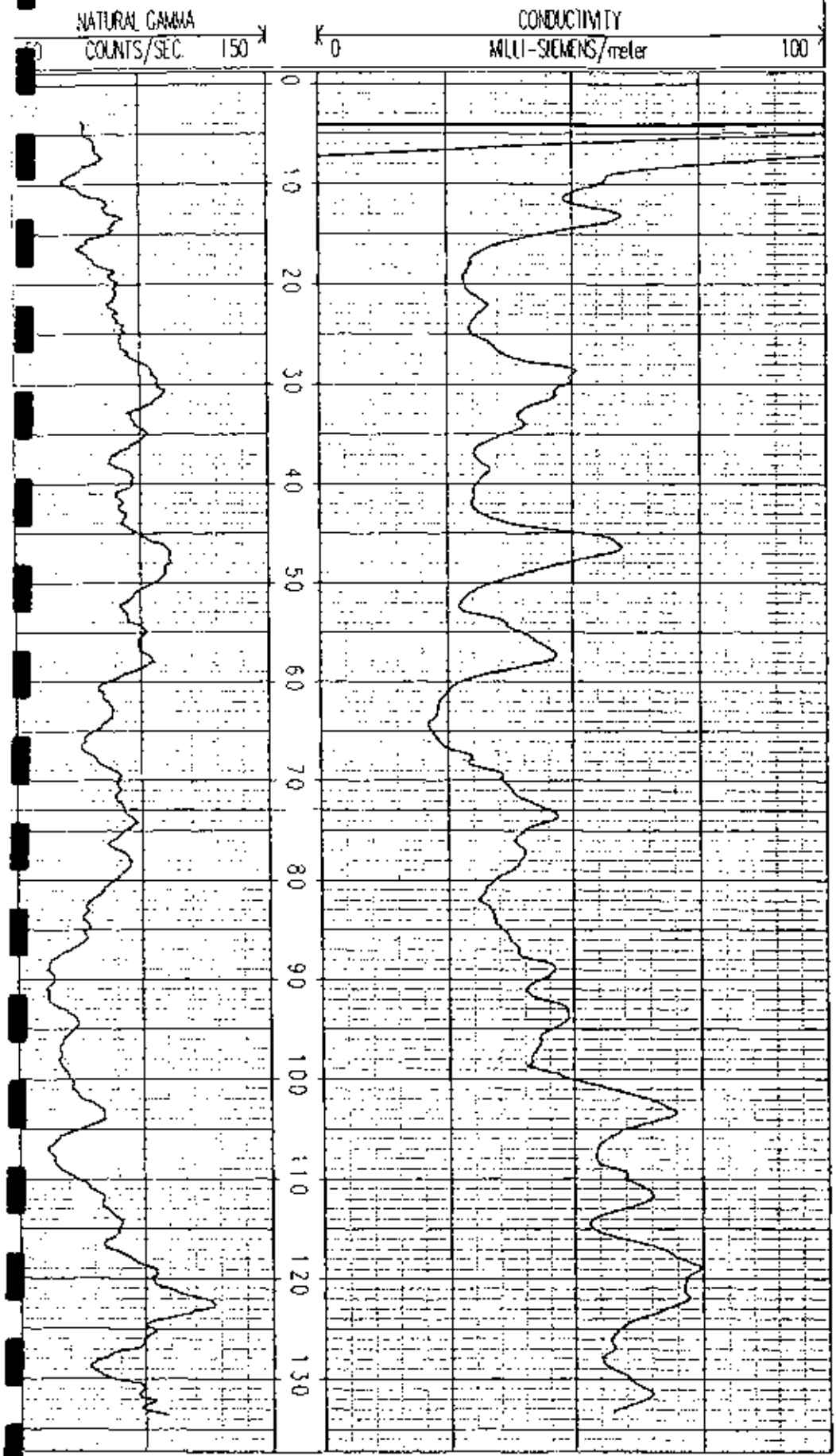
COLOG



NATURAL GAMMA
50 COUNTS/SEC. 150
CONDUCTIVITY
0 MILLI-SIEMENS/meter 100
TEXACO PCPL MAY 05, 1994 WELL MW-20s
COLOG

TEXACO PCPL MAY 04, 1994 WELL MW-25D

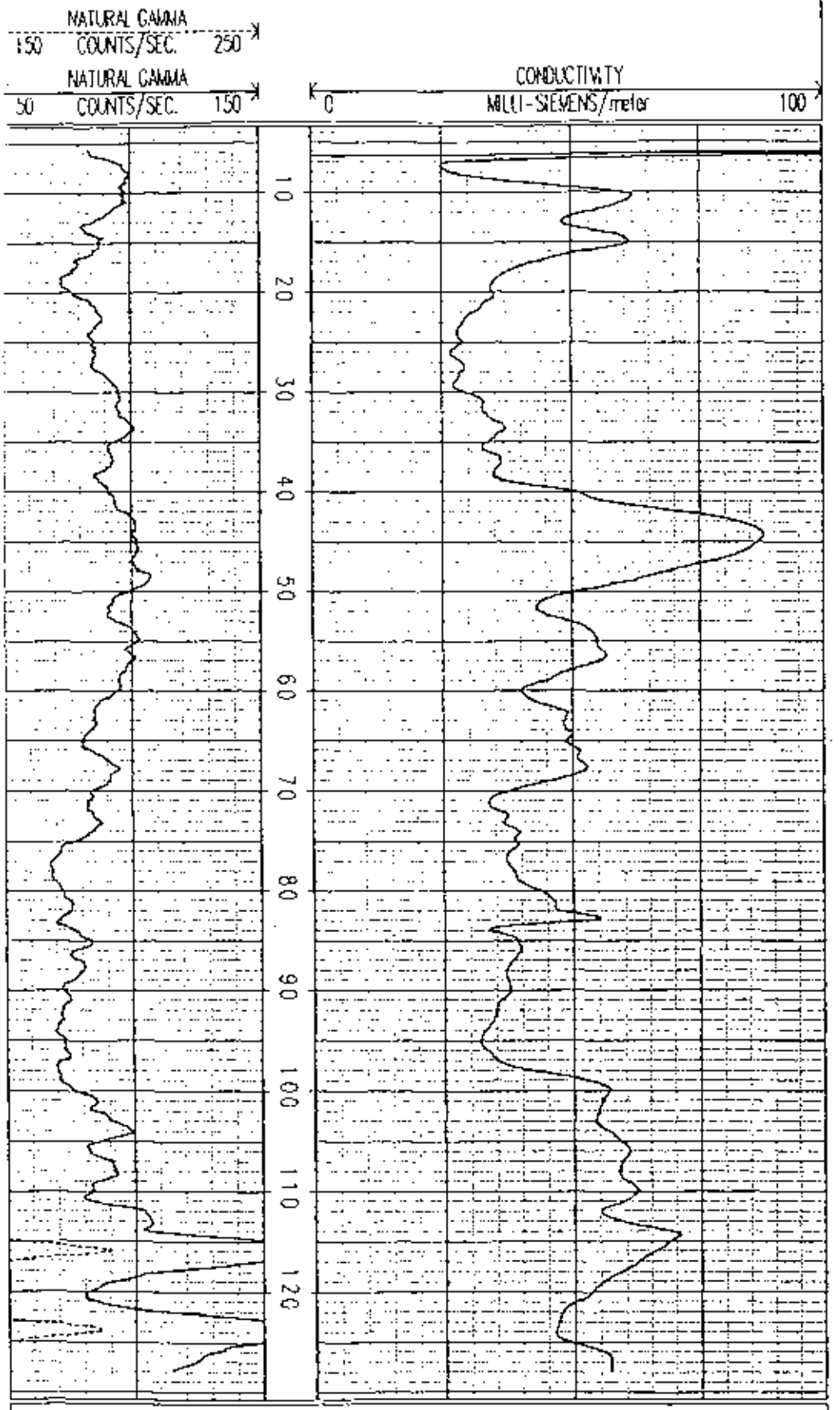
COLOG



NATURAL GAMMA
50 COUNTS/SEC. 150
CONDUCTIVITY
0 MILLI-SIEMENS/meter 100
TEXACO PCPL MAY 04, 1994 WELL MW-25D
COLOG

TEXACO PCPL MAY 05, 1994 WELL MW-29D

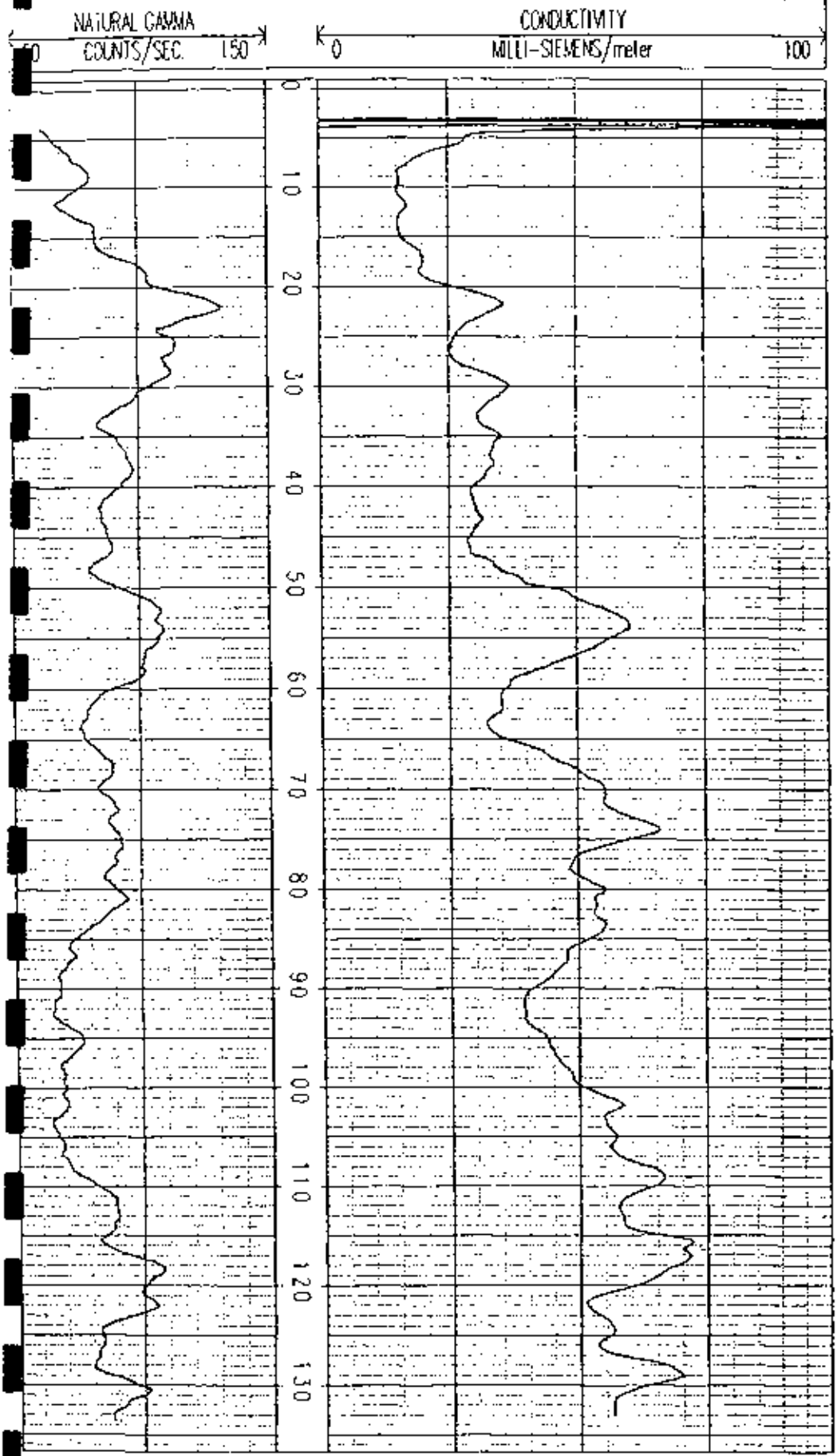
COLOG



TEXACO PCPL MAY 05, 1994 WELL MW-29D

COLOG

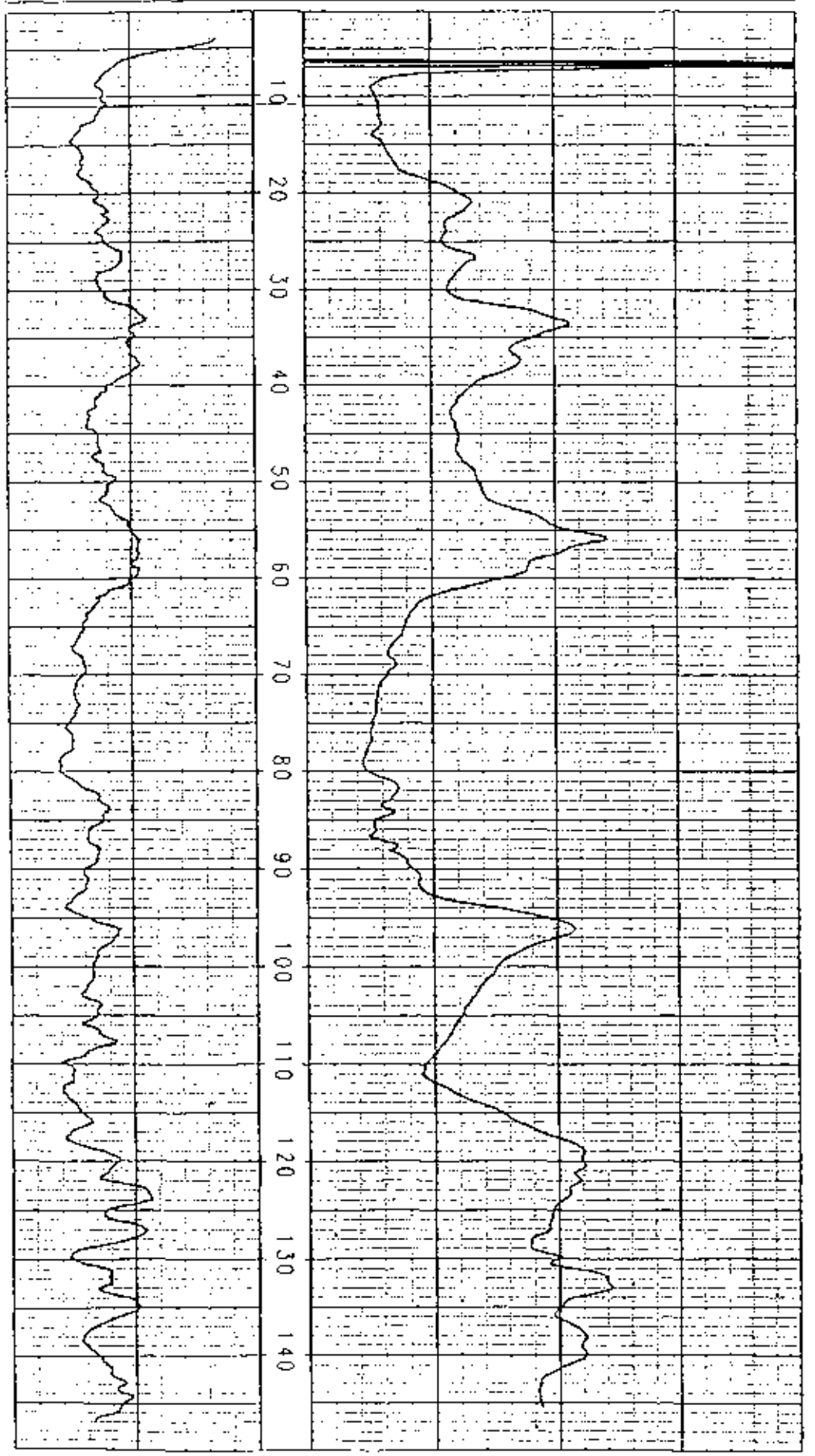
TEXACO PCPL MAY 04, 1994 WELL MW-31D



NATURAL GAMMA
50 COUNTS/SEC. 150
CONDUCTIVITY
0 MILLI-SIEMENS/meter 100
TEXACO PCPL MAY 04, 1994 WELL MW-31D
COLOG

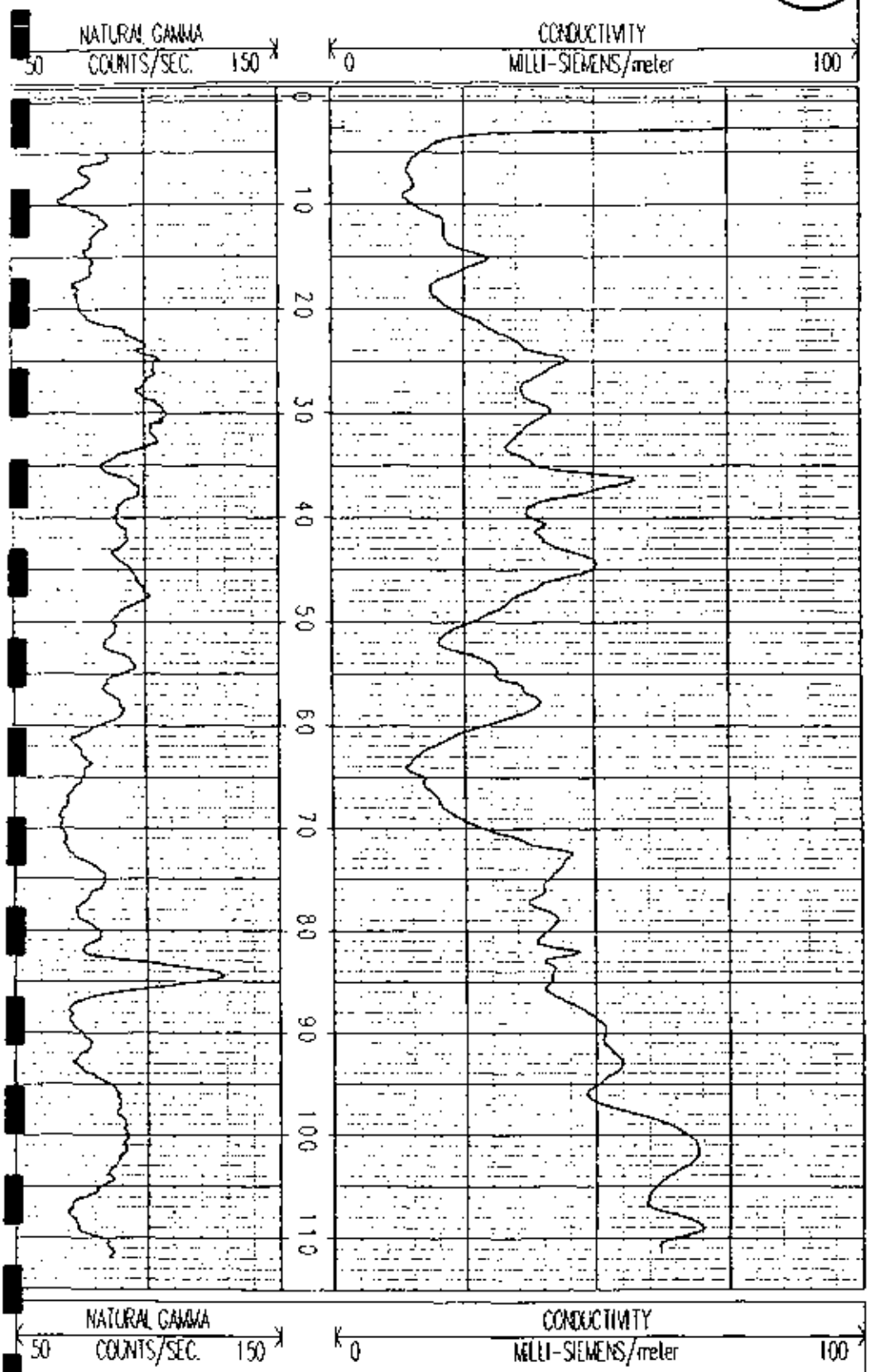
TEXACO PCPC MAY 04, 1994 WELL MW-330

COLOG



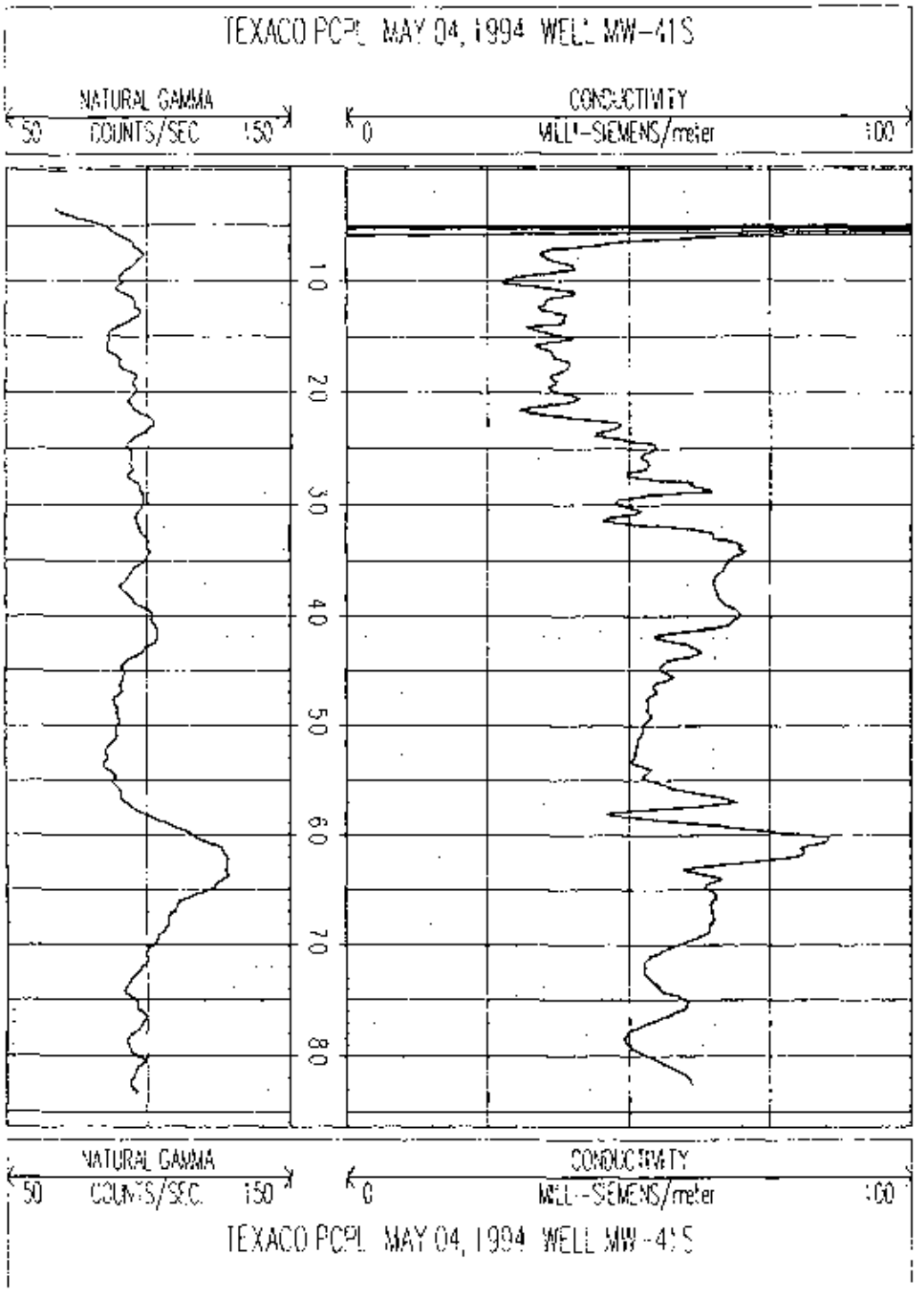
TEXACO PCPC MAY 05, 1994 WELL MW-34S

COLOG



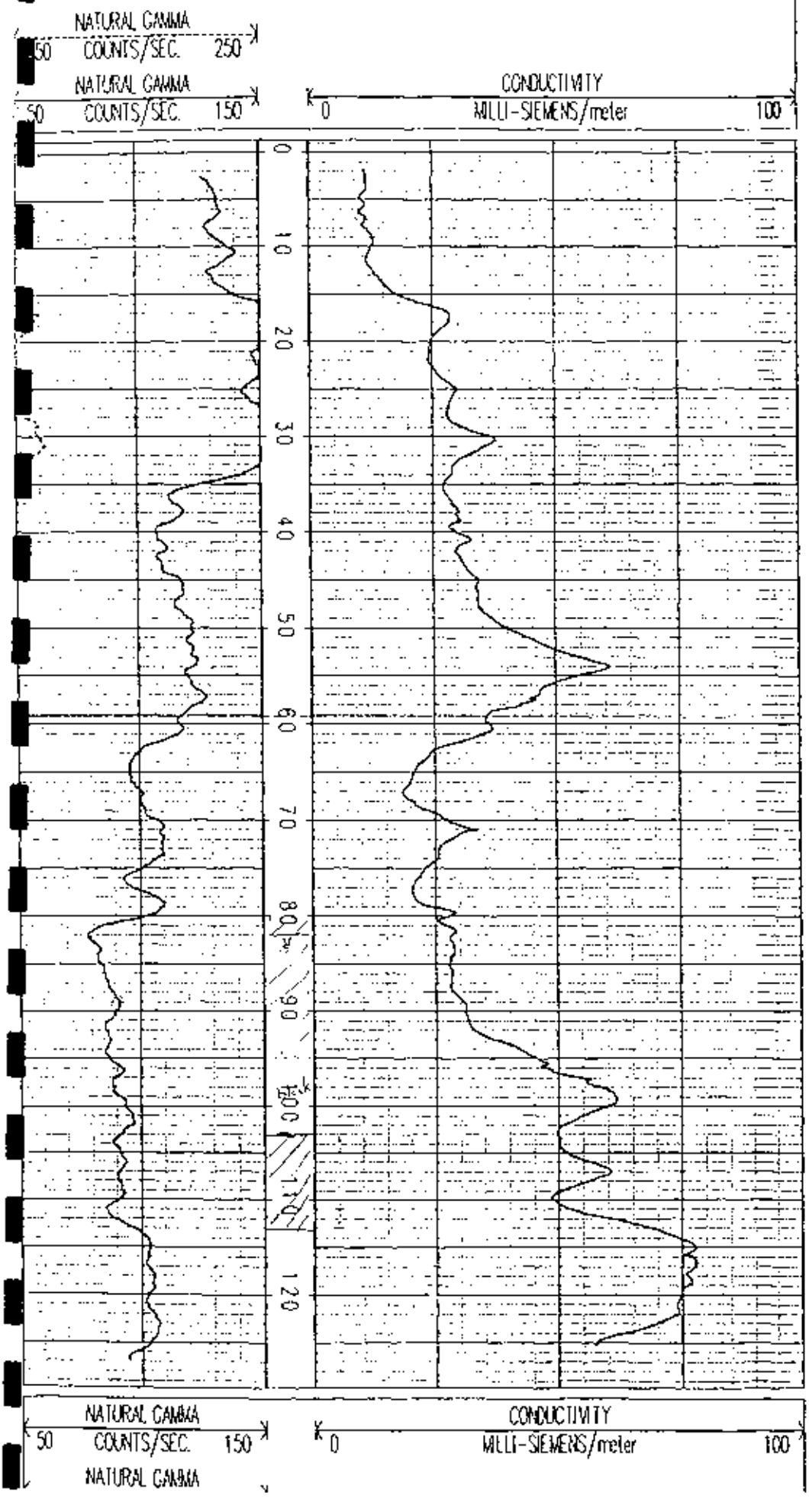
TEXACO PCPC MAY 05, 1994 WELL MW-34S

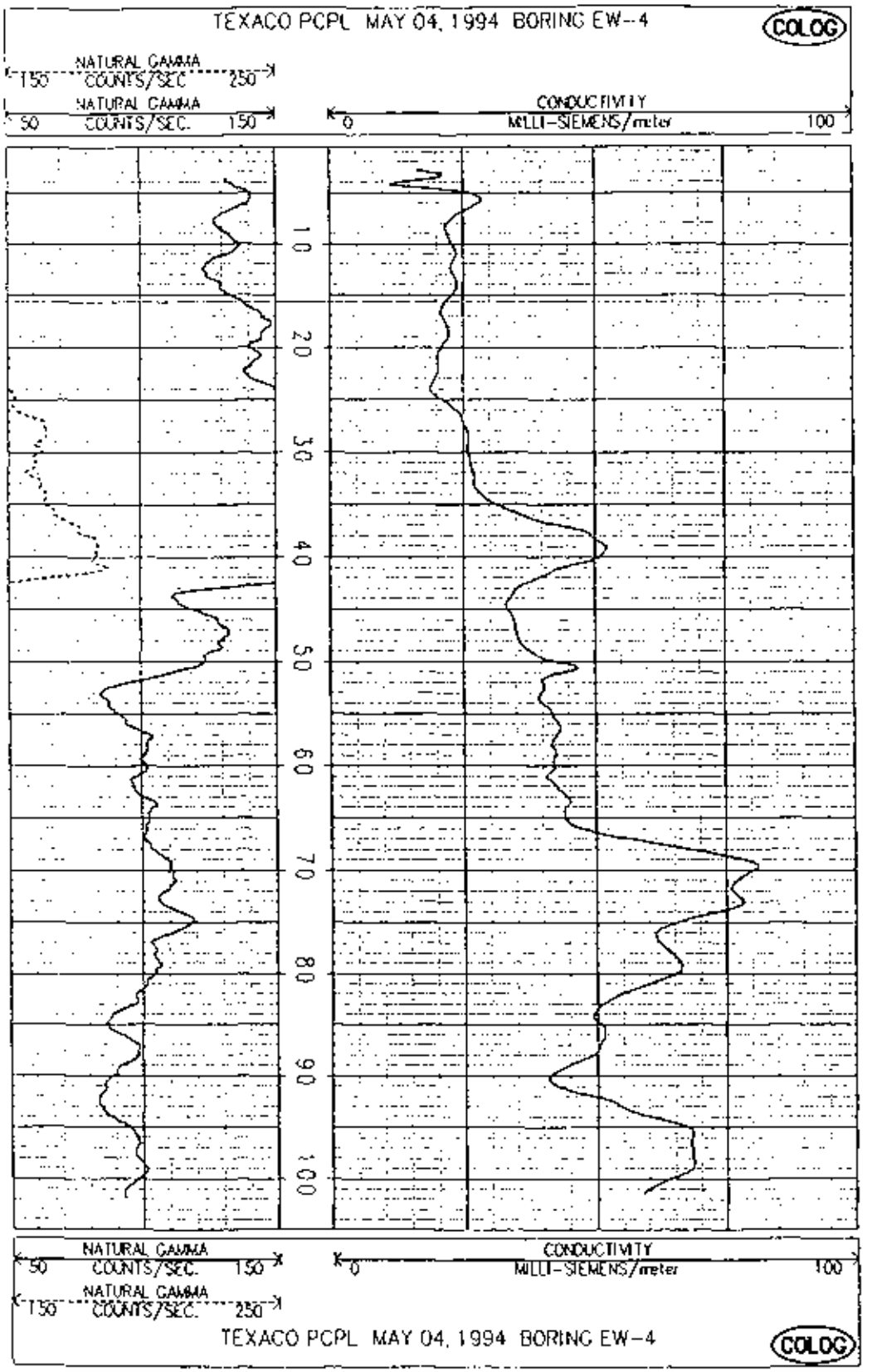
COLOG


TEXACO PCPL MAY 04, 1994 WELL MW-41S
NATURAL GAMMA
50 COUNTS/SEC 150
CONDUCTIVITY
0 MILLI-SIEMENS/meter 100
10
20
30
40
50
60
70
80
NATURAL GAMMA
50 COUNTS/SEC 150
CONDUCTIVITY
0 MILLI-SIEMENS/meter 100
TEXACO PCPL MAY 04, 1994 WELL MW-41S

TEXACO PCPL MAY 04, 1994 BORING EW-2

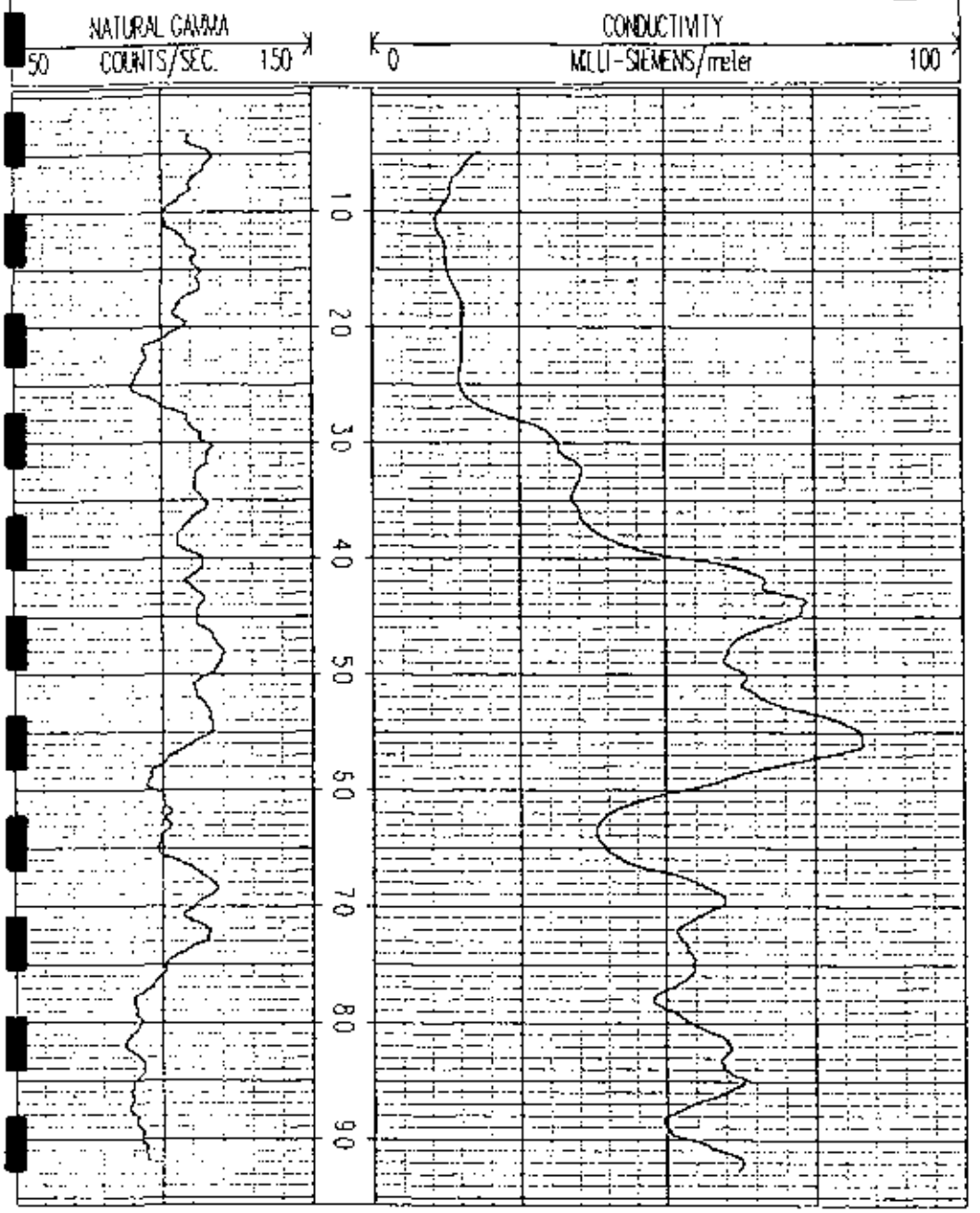
COLOG




TEXACO PCPL MAY 04, 1994 BORING EW-4
COLOG
NATURAL GAMMA
150 COUNTS/SEC 250
NATURAL GAMMA
50 COUNTS/SEC. 150
CONDUCTIVITY
0 MILLI-SIEMENS/meter 100
10
20
30
40
50
60
70
80
90
100
NATURAL GAMMA
50 COUNTS/SEC. 150
CONDUCTIVITY
0 MILLI-SIEMENS/meter 100
NATURAL GAMMA
150 COUNTS/SEC. 250
TEXACO PCPL MAY 04, 1994 BORING EW-4
COLOG

TEXACO PCPL MAY 05, 1994 boring EW-5

COLOG



NATURAL GAMMA
50 COUNTS/SEC. 150
CONDUCTIVITY
0 MILLI-SIEMENS/meter 100
TEXACO PCPL MAY 05, 1994 boring EW-5
COLOG

APPENDIX J

MONTGOMERY WATSON

October 12, 1994

Texaco Refining and Marketing, Inc.
10 Universal City Plaza
Universal City, CA 91608

Attention: Mr. Mark Passarini

Subject: Suitability of Treatment System Effluent for Irrigation, Pacific Coast Pipeline (PCPL) Superfund Site, 67 Telegraph Road, Fillmore, California

Dear Mark:

Per your request, this letter presents the results of Montgomery Watson's evaluation of the groundwater treatment system effluent for use as irrigation water. This evaluation is based primarily upon our review of analytical data from one treatment system effluent sample, which you provided. We understand that this sample is typical of previous and anticipated future treated groundwater quality. The sample was analyzed by Del Mar Analytical and the results presented in their report dated May 4, 1994. The sample lab number is DD0387. A copy of the laboratory report is attached.

It is our understanding that the Record of Decision (ROD) for the site (Pacific Coast Pipeline Superfund Site, Record of Decision, U.S. EPA, March 31, 1992) lists beneficial reuse as the preferred disposal option for treated water generated during site remediation. Additionally, Technical Memorandum No. 3, Evaluation of Extracted Ground Water Disposal Options (Environmental Solutions, Inc., June 9, 1993), states that irrigation is the most beneficial reuse option and that irrigation in conjunction with other options is considered to be the most appropriate long-term solution. Our evaluation is intended to determine the feasibility of irrigation as a viable disposal option for treated ground water.

Factors affecting the suitability of the extracted, treated ground water for irrigation purposes include the following: type of crops to be irrigated, chemical parameters of the water that affect plant growth and survival, soil conditions, and the underlying groundwater. The chemical parameters of major importance are salinity, sodium adsorption ration (SAR), concentrations of specific ions known to have toxic effects on plants, and trace constituents (Montgomery, 1985). This evaluation will focus on these four parameters.

The University of California Cooperative Extension Service (UCCES) has developed a widely accepted guide for identifying potential areas of concern with irrigation waters. This guide is presented in the attached Table 14-6. From this table and the available water quality data, increasing problems with salinity and permeability may be expected from use

350 N. Madison Ave
Pasadena, California
91101

Tel. 818 796 9141
Fax: 818 568 6515

of the treated ground water for irrigation, based on the effluent's electrical conductivity of 1,600 µmho/cm. Specific ion toxicity via root absorption may also be an increasing problem, owing to a boron concentration of 0.69 mg/l. Severe problems may be anticipated as a result of high sodium concentrations (10 meq/l).

In addition to the above factors, use of the treated ground water for irrigation can be expected to increase the soil pH as a result of the high bicarbonate concentration (960 mg/l = 19 milliequivalents per liter). Bicarbonate should not exceed a maximum of 6 milliequivalents in irrigation water (Dr. Don Suarez, U.S. Salinity Laboratory, Personal Communication, September 27, 1994). This high bicarbonate concentration would likely result in adverse impacts to soil structure and affect the availability to crops of trace nutrients such as iron, zinc and magnesium. To overcome these problems, these nutrients may have to be applied directly on leaves via foliar spray. For drip irrigation systems, it is likely that the emitters would become clogged by precipitated salts. Because calcium and magnesium carbonates have different solubilities, the formation of these salts could adversely affect the ratio of calcium to magnesium remaining in solution and their availability to crops. Mitigation of high bicarbonate concentrations would require substantial, costly treatment of the treated ground water with acid prior to use for irrigation purposes.

Based on these factors, it is our opinion that the use of treated ground water for irrigation is not a viable reuse option without substantial, additional and costly treatment. Should you have any questions or require additional information, please contact David Ebersold at (818) 568-6508 or Janet Fahey at (818) 568-6286.

Sincerely,

MONTGOMERY WATSON

David B. Ebersold, R.G., C.E.G.
Senior Geologist

Janet L. Fahey, D.Env., P.E.
Principal Environmental Scientist

cc: Dennis England

TABLE 14-6. UC Cooperative Extension Guidelines for Irrigation Water Quality (UCCES)

Problems and Related Constituent	Water Quality Guidelines[a]		
	No Problems	Increasing Problems	Severe
Salinity[b]			
EC of irrigation water (mho/cm)	<750	750–3000	>3000
Permeability			
EC of irrigation water (mho/cm)	<500	500–2000	>2000
SAR[c]	<6.0	6.0–9.0	>9.0
Specific ion toxicity[d]			
From root adsorption			
Sodium (meq/L)	<3	3–9	>9
Chloride			
(meq/L)	<4	4–10	>10
(mg/L)	<142	142–355	>355
Boron (mg/L)	<0.5	0.5–2.0	>2.0–10.0
From foliar adsorption[e] (Sprinklers)			
Sodium			
(meq/L)	<3.0	>3.0	—
(mg/L)	<70	>70	—
Chloride			
(meq/L)	<3.0	>3.0	—
(mg/L)	<106	>106	—
Miscellaneous[f]			
NH_4 as N (mg/L) for sensitive crops	<5	5–30	>30
NO_3 (only with overhead sprinklers)			
(meq/L)	<1.5	1.5–8.5	>8.5
(mg/L)	<90	90–520	>520
pH (units)	Normal range	6.5–8.4	—

[a] Interpretations are based on possible effects of constituents on crops and/or soils. Guidelines are flexible and should be modified when warranted by local experience or special conditions of crop, soil, and method of irrigation.

[b] Assumes water for crop plus water for leaching requirement (LR) will be applied. Crops vary in tolerance to salinity. Refer to tables for crop tolerance and LR. Mho/cm × 0.64 = total dissolved solids (TDS) in mg/L or ppm.

[c] SAR (sodium adsorption ratio) is calculated from a modified equation developed by U. S. Salinity Laboratory to include added effects of precipitation and dissolution of calcium and is related to CO_3 + HCO_3 concentrations.

[d] Most tree crops and woody ornamentals are sensitive to sodium and chloride (use values shown). Most annual crops are not sensitive (use salinity tolerance tables). For boron sensitivity, refer to boron tolerance tables.

[e] Leaf areas wet by sprinklers (rotating heads) may show a leaf burn caused by sodium or chloride adsorption under low-humidity/high-evaporation conditions. (Evaporation increases ion concentration in water films on leaves between rotations of sprinkler heads).

[f] Excess N may affect production or quality of certain crops; e.g., sugar beets, citrus, avocados, apricots, etc. Water containing HCO_3 distributed by overhead sprinklers may cause a white carbonate deposit to form on fruit and leaves.

Del Mar Analytical

2852 Alton Ave. Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16525 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
2465 W. 12th St., Suite 1, Tempe, AZ 85281 (602) 968-8772 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Joni Fisher

Client Project ID: 225-F02
TEXACO, PCPL
Sample Descript.: Water, IRRIG-EVAL
Lab Number: DD03807

Sampled: Apr 20, 1994
Received: Apr 21, 1994
Analyzed: 4/21-5/2, 1994
Reported: May 4, 1994

LABORATORY ANALYSIS: GENERAL PARAMETERS

Analyte	EPA Method	Detection Limit mg/L (ppm)	Sample Result mg/L (ppm)
Ammonia-N*	350.3	0.10	N.D.
Bicarbonate	SM 403	2.0	960
Carbonate	SM 403	2.0	N.D.
Chloride	300	25	130
Electrical Conductivity (µmhos/c	120.1	1.0	1,600
Fluoride	340.2	1.0	N.D.
Hydrogen Sulfide	SM 4500	0.50	N.D.
Nitrate-N*	300	0.33	N.D.
Organic Nitrogen*	300	0.10	0.54
Ortho-phosphate phosphorus	300	2.5	N.D.
pH (pH units)	150.1	N.A.	7.0
Residual Chlorine	330.5	0.10	N.D.
SAR (mEq/L)	6010	0.050	4.6
Salinity (g/L)	SM 2520B	1.0	N.D.
Sulfate	300	2.5	29
Total Dissolved Solids	160.1	5.0	1,100
Total Nitrogen*	300	0.10	0.58
Total Phosphorus	365.3	0.050	0.49

* This analysis was performed at a subcontracted laboratory

Analytes reported as N.D. were not present above the stated limit of detection

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Gary Steube
Laboratory Director

Del Mar Analytical

2852 Alton Ave., Irvine, CA 92714 (714) 261-1022 FAX (714) 261-1228
1014 E. Cooley Dr., Suite A, Colton, CA 92324 (909) 370-4667 FAX (909) 370-1046
16535 Sherman Way, Suite C-11, Van Nuys, CA 91406 (818) 779-1844 FAX (818) 779-1843
945 South 48th St., Suite 114, Tempe, AZ 85281 (602) 968-8272 FAX (602) 968-1338

England Shahin & Associates
15375 Barranca Pkwy., Ste. F-106
Irvine, CA 92718
Attention: Mark Passarini

Client Project ID: 225-F02
TEXACO, PCPL
Sample Descript: Water, IRRIG-EVAL
Lab Number: DD03807

Sampled: Apr 20, 1994
Received: Apr 21, 1994
Analyzed: 4/28-5/4, 1994
Reported: May 4, 1994

LABORATORY ANALYSIS: METALS

Analyte	EPA Method	Detection Limit mg/L (ppm)	Sample Result mg/L (ppm)
Aluminum	6010	0.50	N.D.
Arsenic	7060	0.010	0.016
Barium	6010	0.050	1.7
Boron	6010	0.050	0.69
Cadmium	6010	0.0050	N.D.
Calcium	6010	2.0	80
Chromium (Total)	7191	0.0050	N.D.
Copper	6010	0.050	N.D.
Iron	6010	0.050	0.56
Lead	7421	0.0050	N.D.
Lithium	6010	0.050	N.D.
Magnesium	6010	0.050	58
Manganese	6010	0.050	0.076
Mercury	7470	0.0020	N.D.
Nickel	6010	0.050	N.D.
Potassium	6010	0.50	4.3
Selenium	7740	0.010	N.D.
Silver	6010	0.050	N.D.
Sodium	6010	0.50	220
Vanadium	6010	0.050	N.D.
Zinc	6010	0.050	N.D.

Analytes reported as N.D. were not present above the stated limit of detection

DEL MAR ANALYTICAL, IRVINE (ELAP #1197)

Gary Steube
Laboratory Director

CHAIN OF CUSTODY

DATE 4/20/94 PAGE 1 OF 1

PROJECT MANAGER: JONI FISHER
COMPANY: ENGLAND SHAKIN & ASSOCIATES
ADDRESS: 15375 Barranca Parkway, Suite F-106
Irvine, California 92718
Phone: 714-453-8085 Fax: 714-453-0733

BILL TO: MARK PASSARINI
COMPANY: TEXACO Refining & Marketing
ADDRESS: 10 Universal City Plaza
Universal City, Ca.

Bob Dadkar — SAMPLERS SIGNATURE
(714) 453-8085 — PHONE NUMBER

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	Petroleum Hydrocarbons 418.1 (1L/50g)	Oil and Grease 413.2 (1L/50g)	Gasoline (MOD 8015/DOHS) (4 oz (HCL)/50g)	Diesel (MOD 8015/DOHS) (4 oz (HCL)/50g)	Gasoline/BTXE (MOD 8015/8020) (4 oz (HCL)/50g)	Petroleum Distillates (C6-C25) (4 oz (HCL)/50g)	BTXE (8020) (2x40ml (HCL)/50g)	Chlorinated Hydrocarbons (8010) (2x40ml (HCL)/50g)	Aromatic Hydrocarbons (2x40ml (HCL)/50g)	Chlorinated/Aromatic Hydrocarbons (8010/8020) (2x40ml (HCL)/50g)	Organic Pb (500ml/50g)		Pesticides/PCB (8080) (1L/50g)	Base/NEU/Acid Cmpcs GC/MS (8270) (1L/100g)	Volatile Cmpds GC/MS (8240) (2x40ml (HCL)/100g)	Polynuclear Aromatic (8310) (1L/100g)	CCR Metals (500ml/100g)	Priority Pollutant Metals (500ml/100g)		ANALYZE FOR PARAMETERS STATED ON ATTACHED SHEETS						Number of Containers
IRRIG-EVAL	4/20/94	17:30	Water																					X						4

PROJECT INFORMATION	SAMPLE RECEIPT	
PROJECT NUMBER: 2245-FC2	TOTAL NUMBER OF CONTAINERS	4
PROJECT NAME: TEXACO PCPL	CHAIN OF CUSTODY SEALS Y/N/NA	
PURCHASE ORDER NUMBER	INTACT? Y/N/NA	
VIA	RECEIVED GOOD COND./COLD	
TAT:	LAB NUMBER	

SAMPLE DISPOSAL INSTRUCTIONS

COMMENTS:

RELINQUISHED BY: 1.	RELINQUISHED BY: 2.	RELINQUISHED BY: 3.
Signature: Bob Dadkar — Time:	Signature: [illegible] — Time:	Signature: — Time:
Printed Name: BOB DADKAR — Date: 4/4/94	Printed Name: [illegible] — Date: 4-4-94	Printed Name: — Date:
Company: ENGLAND SHAKIN & ASSOCIATES	Company: [illegible]	Company:
RECEIVED BY: 1.	**RECEIVED BY: 2.**	**RECEIVED BY: 3.**
Signature: [illegible] — Time: 11:45	Signature: [illegible] — Time: 12:10	Signature: — Time:
Printed Name: Dan Hendricks — Date: 4-4	Printed Name: Lily Sinogeo — Date: 4-4-94	Printed Name: — Date:
Company: Del Mar	Company: Del Mar Analytical	Company:

APPENDIX J

Appendix J
GAC Vessel Backwash Procedure

1. Treated discharge water is diverted to the clean water backwash tank by attaching the backwash hose to the cam lock fitting above valve #15 and connecting to the top of the clean water backwash tank. The system is in normal series operation.

2. Valve #15 is opened and Valve #16 is closed in that order.

3. When the supply water backwash tank has approximately 9,000 gallons, valve #16 is opened and valve #15 is closed, in that order. This process is completed while the system is in normal operation. The water in this tank will be used to backwash the "A" GAC vessel.

4. The system is then shut down and the valves on the carbon manifold are set for backwash as shown on the manifold schedule on the attached drawing J-1.

5. The supply water hose is connected from the bottom discharge connection of the supply water tank to the inlet of the backwash pump. From the outlet of the backwash pump, the supply water hose is connected to the cam lock fitting attached to valve #13.

6. The backwash hose is then attached to cam lock fitting below valve #11 and connected to the top of "dirty" water backwash water tank.

7. The backwash pump is started. A gate valve installed on the outlet of the pump is used to control the flow rate at approximately 300 gpm. An inline flow meter is used to verify the flow rate.

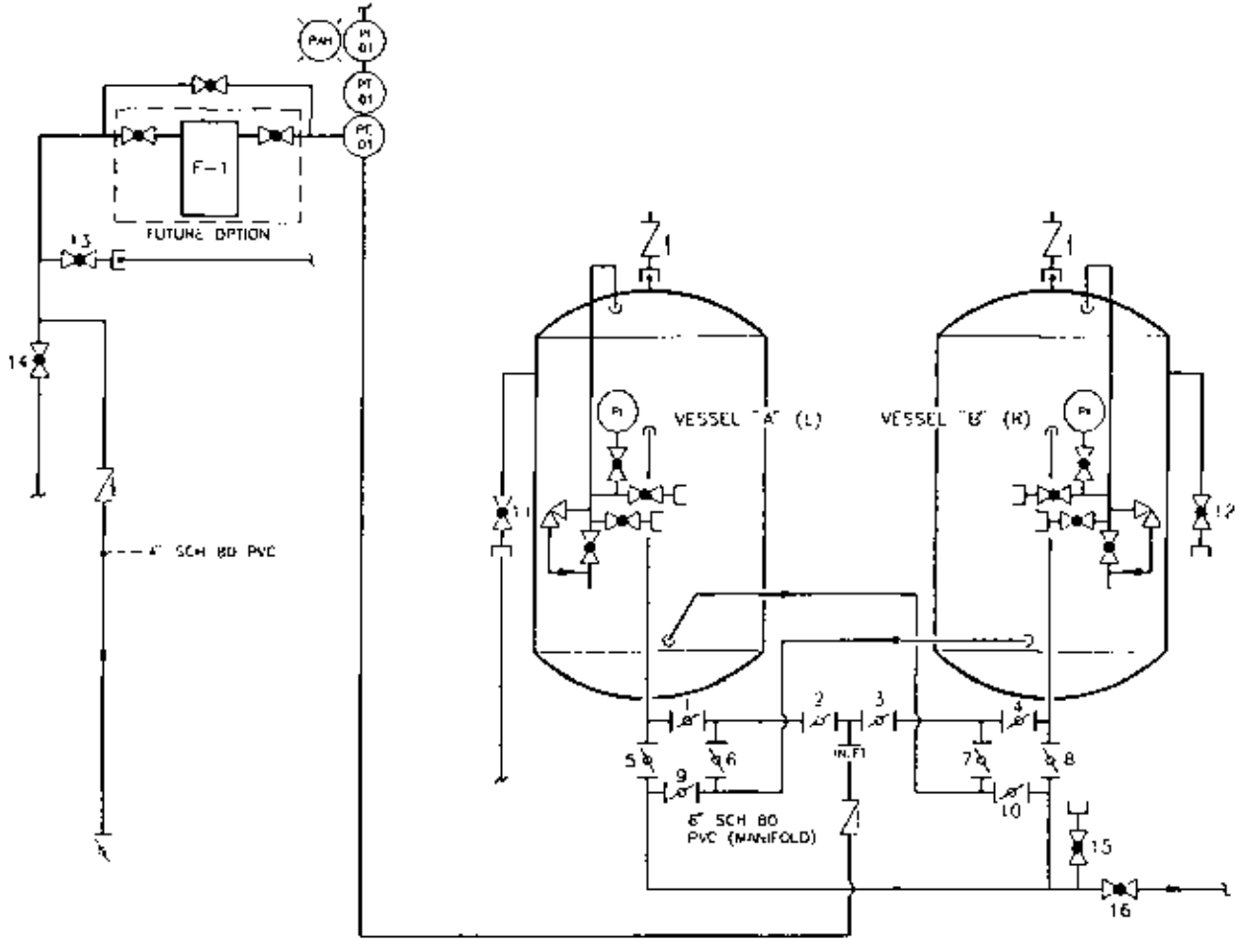
8. After 30 minutes, the pump is shut off and the system is returned to normal operation. The valves are set for normal series operation.

9. Pressure readings are taken to verify the effectiveness of the backwash treatment. If the pressure drop is high across the "B" vessel, this vessel should also be backwashed.

10. The solids are allowed to settle to the bottom of the used water tank. The decanted water is then pumped from the top of the tank into the surge tank or 4,000 gallon tank to be treated in the GWTS.

11. The settled solids are removed by vacuum truck for disposal or temporarily stored on site.

225-F06\AL\12/15/94



GAC VESSEL MANIFOLD SCHEDULE

OPERATION TYPE	VALVE NUMBER															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SERIES FLOW "A" THEN "B"	O	O	C	O	C	C	O	C	O	C	C	C	C	O	C	O
SERIES FLOW "B" THEN "A"	O	C	O	O	C	O	C	C	C	O	C	C	C	O	C	O
BACKWASH "A" ONLY	C	C	O	C	C	C	O	C	C	C	O	C	O	C	C	C
BACKWASH "B" ONLY	C	O	C	C	C	C	C	C	C	C	C	O	O	C	C	C

FIGURE J-1

GAC VESSEL BACKWASH SCHEMATIC

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

TEXACO ENVIRONMENTAL SERVICES
UNIVERSAL CITY, CALIFORNIA

ENGLAND SHAHIN & ASSOCIATES

Electric Submersible Pumps

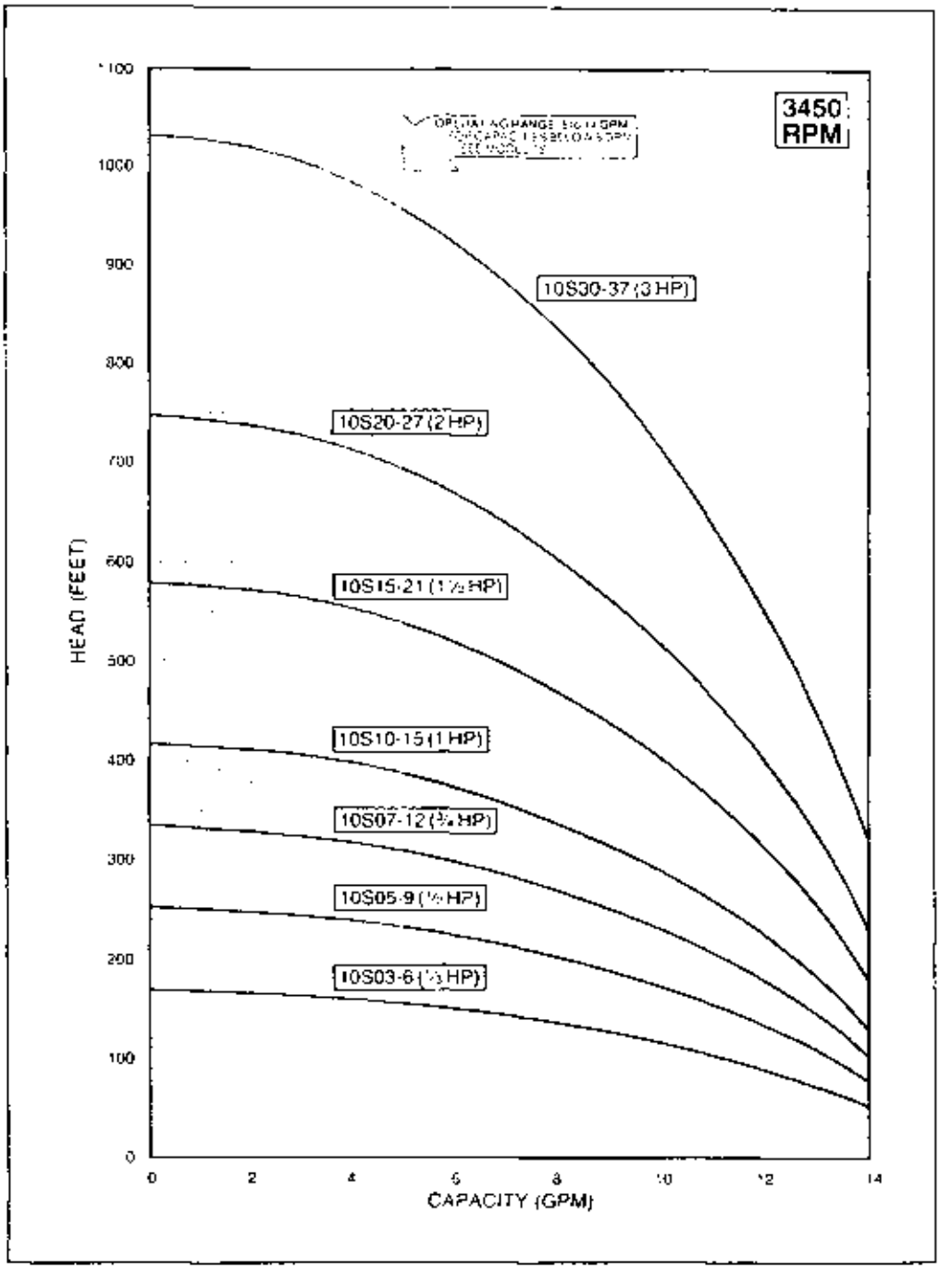
MODEL 10S

10 GPM

GRUNDFOS

FLOW RANGE
5 to 14 GPM

PUMP OUTLET
1¼" NPT



DIMENSIONS AND WEIGHTS

MODEL NO.	HP	LENGTH (INCHES)	WIDTH (INCHES)	APPROX. UNIT SHIPPING WT. (LBS.)
10S03-6	⅓	22	3¾	26
10S05-9	½	25⅛	3¾	29
10S07-12	¾	28¼	3¾	32
10S10-15	1	31¼	3¾	34
10S15-21	1½	37⅞	3¾	44
10S20-27	2	42	3¾	49
10S30-37	3	57⅜	3¾	83

Specifications are subject to change without notice.

GRUNDFOS 10 GPM MODEL 10S

SELECTION CHARTS

(Ratings are in GALLONS PER HOUR – GPH)

FLOW RANGE
5 to 14 GPM

PUMP OUTLET
1¼" NPT

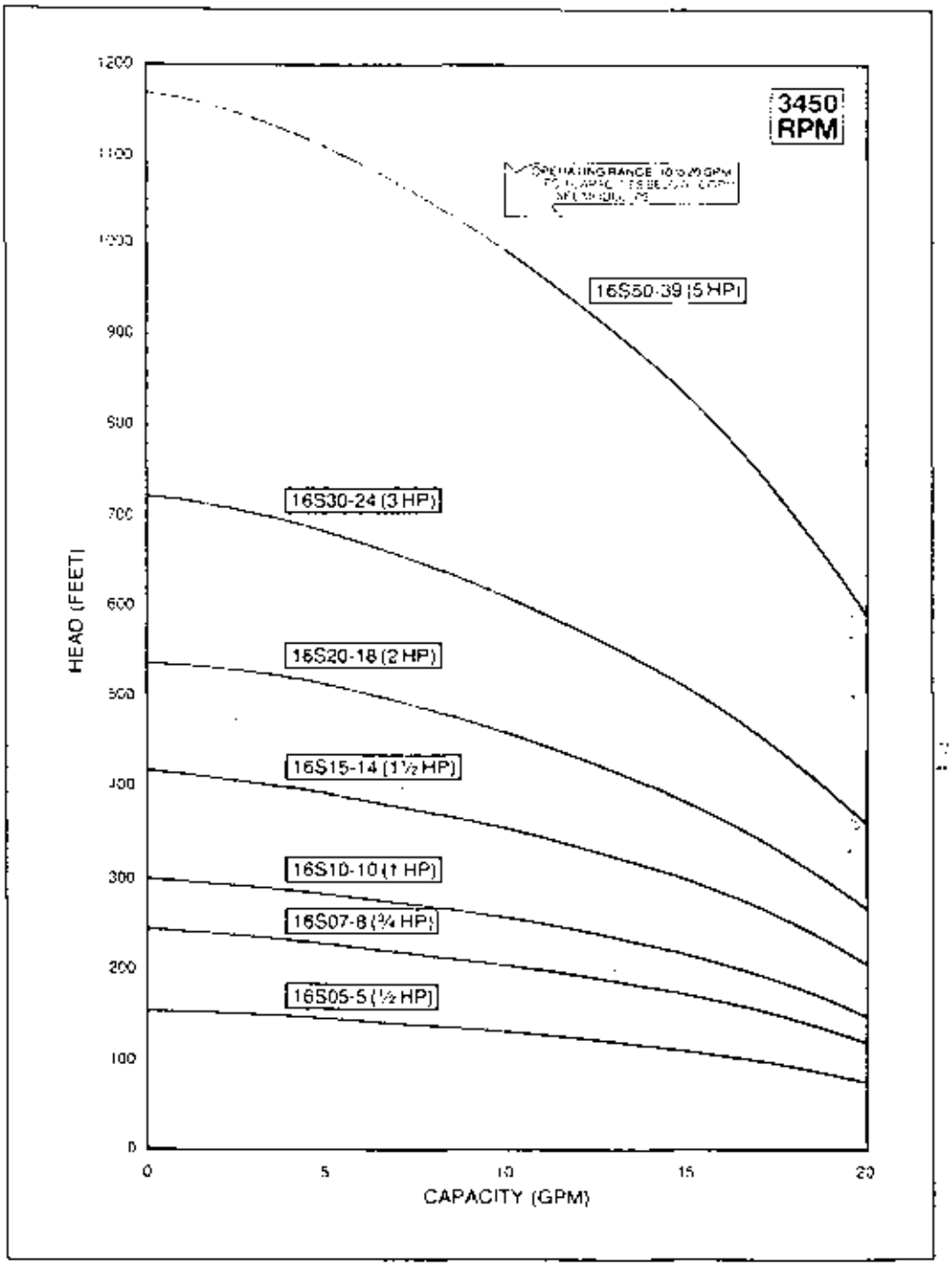
PUMP MODEL	HP	PSI	DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET																								
			20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	340	400	460	520	600	700	800	900	1000	1100
10S03-6	⅓	0		856	811	766	666	564	398	233																	
		20	840	790	741	636	532	315	98																		
		30	790	706	621	501	380	190																			
		40	712	606	500	250																					
		50	588	447	306	153																					
		60	464	232																							
Shut-off PSI:			64	55	47	38	29	21	12	3																	
[illegible]	½	0				847	802	746	685	626	568	499	393	207													
		20		835	765	727	667	608	549	472	347	122															
		30	828	777	718	658	600	538	457	320	73																
		40	768	708	649	590	528	440	290																		
		50	699	639	581	516	422	258																			
		60	630	572	504	403	220																				
Shut-off PSI:			100	92	83	74	66	57	48	40	31	23	14	5													
10S07-[illegible]	¾	0					857	828	791	748	703	658	614	570	521	457	362										
		20			849	817	778	734	689	644	601	556	503	432	323	155											
		30		845	812	771	727	682	637	594	549	494	418	302	121												
		40	840	806	765	720	675	631	587	541	484	403	279	85													
		50	800	758	713	658	624	580	533	473	387	254															
		60	751	706	661	617	573	525	462	370	228																
Shut-off PSI:			137	129	120	111	103	94	85	77	68	59	51	42	33	25	16										
[illegible]	1	0							843	816	785	750	714	678	643	608	573	489	225								
		20					835	807	774	739	703	667	632	598	562	522	472	312									
		30				831	802	769	734	698	662	627	592	556	515	463	393	153									
		40		851	827	797	764	728	692	656	621	587	550	508	454	380	276										
		50	848	823	792	758	723	686	651	616	581	544	500	444	366	256	99										
		60	818	787	753	717	681	645	611	576	538	493	434	352	235												
Shut-off PSI:			174	165	157	148	139	131	122	113	105	96	87	79	70	61	53	35	10								
[illegible]	1½	0									853	836	817	795	772	747	721	669	594	511	375						
		20							848	831	811	788	764	739	713	687	661	611	533	415	176						
		30						845	828	807	784	760	735	709	683	657	632	583	495	344							
		40					843	825	804	781	756	731	705	679	653	628	604	552	449	248							
		50				840	822	800	777	752	727	701	675	650	625	600	575	519	389	120							
		60		854	837	818	797	773	748	723	697	671	646	621	596	571	544	478	308								
Shut-off PSI:				237	229	220	211	203	194	185	177	168	159	151	142	133	125	107	81	55	29						
[illegible]	2	0												847	834	819	803	766	707	647	589	500	284				
		20										844	830	814	797	779	760	720	660	602	541	425	87				
		30									842	827	812	795	776	757	737	697	636	580	514	373					
		40							852	839	825	809	792	773	754	734	714	674	615	556	483	309					
		50						850	837	823	807	789	770	751	731	711	691	651	593	531	445	228					
		60					848	835	820	804	786	767	748	728	708	688	668	629	570	502	398	126					
Shut-off PSI:							285	276	268	259	250	242	233	224	215	207	198	181	155	129	103	68	25				
[illegible]	3	0																841	808	759	725	587	596	519	389		
		20														847	838	816	778	736	691	634	562	472	309		
		30													846	836	826	802	762	719	675	617	545	444	252		
		40												845	835	824	813	787	746	702	658	601	525	411	185		
		50											843	833	822	811	798	772	729	685	641	585	504	372	105		
		60										842	832	821	809	796	783	756	712	666	625	568	481	326			
Shut-off PSI:												362	354	345	336	328	319	302	276	250	224	189	146	103	59		

MODEL 16S

GRUNDFOS

FLOW RANGE
10 to 20 GPM

PUMP OUTLET
1¼" NPT



DIMENSIONS AND WEIGHTS

MODEL NO.	HP	LENGTH (INCHES)	WIDTH (INCHES)	APPROX. UNIT SHIPPING WT. (LBS.)
16S05-5	½	21 ⅞	3 ¾	27
16S07-8	¾	25	3 ¾	29
16S10-10	1	27 ⅛	3 ¾	32
16S15-14	1 ½	32	3 ¾	36
16S20-18	2	34 ⅝	3 ¾	40
16S30-24	3	46 ⅝	3 ¾	64
16S50-39	5	63 ⅝	3 ¾	94

Specifications are subject to change without notice.

GRUNDFOS 16 GPM MODEL 16S

SELECTION CHARTS

(Ratings are in GALLONS PER HOUR – GPH)

FLOW RANGE
10 to 20 GPM

PUMP OUTLET
1¼" NPT

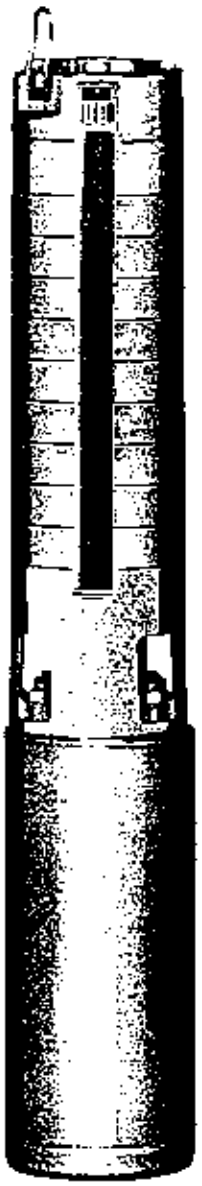
PUMP MODEL	HP	PSI	DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET																								
			20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	340	400	460	520	600	700	800	900	1000	11
16S05-5	½	0			1260	1135	920	710																			
		20	1215	1090	845	600	300																				
		30	1035	865	480	95																					
		40	760	480	240																						
		50	390																								
		60	175																								
Shut-off PSI:			58	49	40	32	23	14																			
	¾	0					1230	1150	1050	950	770	585	310														
		20			1205	1130	1015	910	710	510	255																
		30	1270	1195	1105	1015	860	705	450	190	95																
		40	1160	1100	980	860	645	430	215																		
		50	1075	980	810	640	370	100																			
		60	940	810	576	350	175																				
Shut-off PSI:			97	88	80	71	62	54	45	36	28	19	10														
	1	0						1250	1165	1125	1040	955	820	685	480	280											
		20				1230	1165	1100	1010	920	775	630	420	210	105												
		30			1220	1160	1085	1010	890	770	585	400	200														
		40		1210	1145	1080	985	885	730	575	355	135															
		50	1200	1140	1060	980	850	720	530	335	170																
		60	1125	1055	950	845	680	515	290																		
Shut-off PSI:			123	115	106	97	89	80	71	63	54	45	37	28	19	11											
	1½	0								1260	1215	1175	1125	1080	1015	950	860	640	200								
		20							1205	1160	1110	1060	995	925	825	730	600	305									
		30					1240	1200	1150	1105	1045	990	905	820	705	590	440	145									
		40				1235	1190	1145	1095	1045	960	900	800	695	560	420	255										
		50			1225	1185	1135	1090	1030	965	880	790	670	545	390	235	120										
		60		1220	1175	1130	1080	1025	950	870	765	660	515	375	205												
Shut-off PSI:				167	158	149	141	132	123	115	106	97	89	80	71	63	54	37	28								
	2	0										1270	1235	1200	1170	1135	1090	1000	810	525	160						
		20									1225	1190	1160	1120	1080	1040	985	880	600	250							
		30								1220	1185	1150	1115	1075	1030	980	915	770	475	115							
		40							1215	1180	1145	1110	1065	1025	965	910	835	665	340								
		50						1210	1175	1140	1100	1060	1010	960	895	830	740	550	190								
		60					1205	1170	1135	1100	1050	1010	950	890	810	735	635	420									
Shut-off PSI:							194	186	177	168	160	151	142	134	125	116	108	90	65	39	13						
	3	0																1175	1095	990	850	585	125				
		20													1220	1195	1170	1115	1020	885	710	390					
		30												1215	1190	1165	1140	1080	975	820	625	280					
		40											1210	1190	1160	1135	1105	1040	920	750	535	170					
		50										1210	1185	1160	1130	1100	1070	1000	860	675	440						
		60									1205	1180	1150	1125	1100	1070	1030	950	800	590	330						
Shut-off PSI:											239	230	221	213	204	195	187	169	143	117	91	52	13				
	5	0																			1205	1140	1060	925	755	530	
		20																			1170	1100	1000	855	660	410	
		30																		1200	1150	1080	970	815	605	345	
		40																		1180	1135	1060	940	770	550	280	
		50																	1210	1165	1115	1035	905	725	540	210	
		60																	1190	1145	1090	1010	865	680	430	140	
Shut-off PSI:																			342	316	290	256	213	169	125	83	

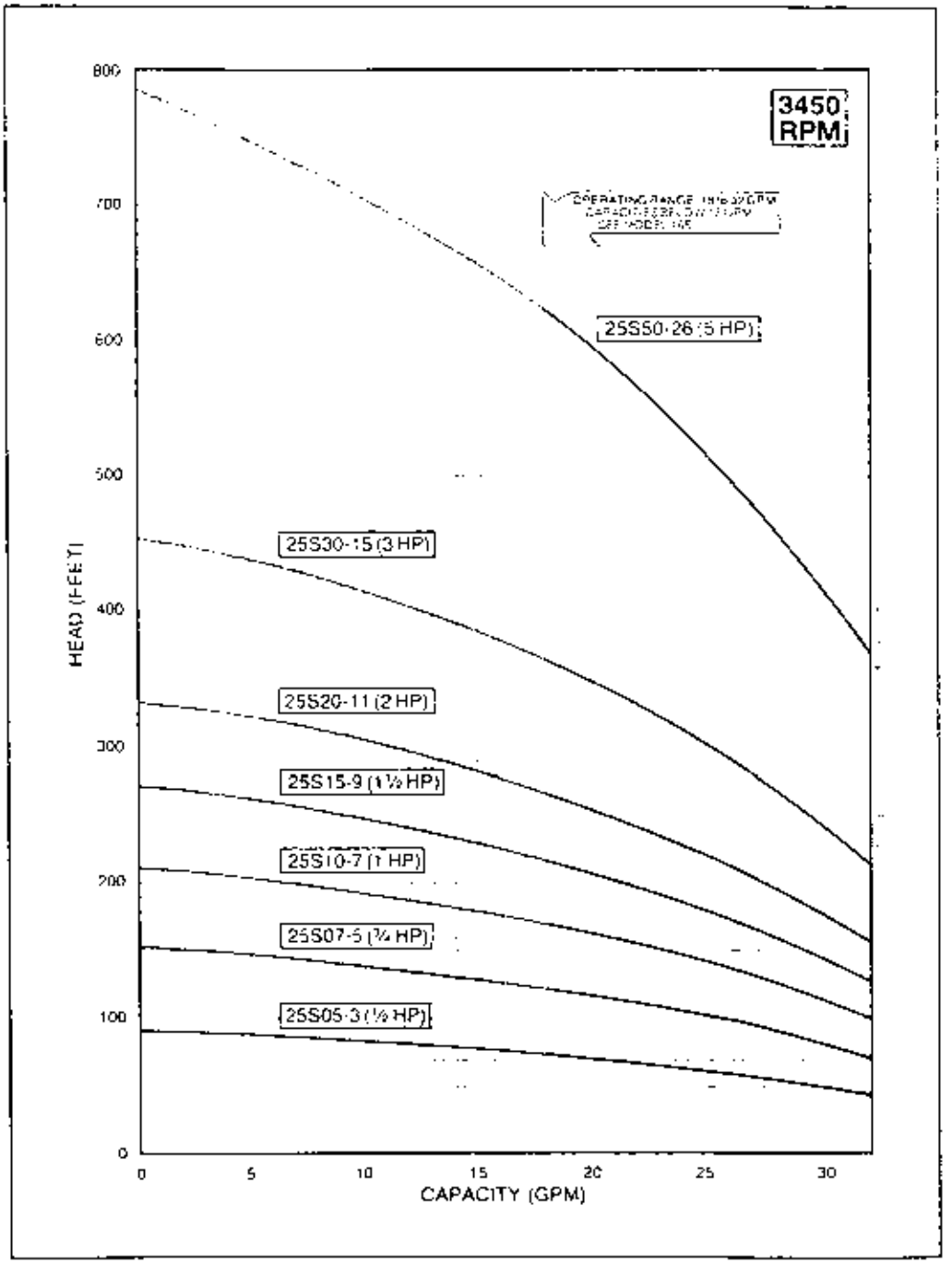
MODEL 25S

GRUNDFOS

FLOW RANGE
18 to 32 GPM

PUMP OUTLET
1½" NPT





DIMENSIONS AND WEIGHTS

MODEL NO.	HP	LENGTH (INCHES)	WIDTH (INCHES)	APPROX. UNIT SHIPPING WT. (LBS.)
25S05-3	½	20 ¼	3 ¾	26
25S07-5	¾	22 ⅜	3 ¾	28
25S10-7	1	24 ⅞	3 ¾	29
25S15-9	1 ½	28	3 ¾	34
25S20-11	2	28 ⅞	3 ¾	37
25S30-15	3	39 ⅛	3 ¾	59
25S50-26	5	51 ⅛	3 ¾	76

Specifications are subject to change without notice.

GRUNDFOS 25 GPM MODEL 25S

SELECTION CHARTS
(Ratings are in GALLONS PER HOUR – GPH)

FLOW RANGE
18 to 32 GPM

PUMP OUTLET
1½" NPT

PUMP MODEL	HP	PSI	DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET																								
			20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	340	400	460	520	600	700	800	900	1000	1100
25S0F-G	½	0		1960	1350	740																					
		20	1115	390	195																						
		30	630																								
		40																									
		50																									
		60																									
Shut-off PSI:			31	22	13	5																					
	¾	0			2070	1785	1435	1085																			
		20	1975	1715	1310	905	450																				
		30	1625	1350	735	120																					
		40	1170	705	350																						
		50	605																								
		60	245																								
Shut-off PSI:			57	48	39	31	22	13																			
	1	0					1880	1710	1460	1210	760	305															
		20		1990	1820	1655	1375	1100	625	150	80																
		30	1980	1795	1590	1385	780	575	290																		
		40	1765	1595	1280	970	490																				
		50	1520	1290	855	420	210																				
		60	1180	835	420																						
Shut-off PSI:			83	74	65	57	48	39	31	22	13	5															
	1½	0						1930	1800	1675	1485	1295	975	650													
		20				1890	1760	1630	1420	1215	870	530	265														
		30			1875	1745	1585	1420	1135	850	470	90															
		40		1850	1715	1580	1355	1125	770	410	205																
		50	1835	1705	1530	1350	1045	735	370																		
		60	1670	1530	1280	1030	660	290	145																		
Shut-off PSI:			109	100	91	83	74	55	57	48	39	31	22	13													
	2	0						1985	1865	1760	1655	1505	1350	1110	870	560											
		20					1950	1835	1725	1620	1455	1290	1035	780	465	150											
		30				1920	1820	1720	1585	1450	1235	1015	720	420	210												
		40			1910	1805	1690	1580	1400	1225	955	585	375														
		50		1690	1785	1685	1540	1395	1165	935	625	320	160														
		60	1880	1775	1655	1535	1345	1155	870	590	295																
Shut-off PSI:			135	126	118	109	100	92	83	74	66	57	48	40	31	23											
	3	0										1935	1860	1785	1705	1625	1510	1240									
		20								1910	1835	1760	1680	1595	1475	1360	1190	810									
		30						1980	1900	1825	1750	1670	1570	1470	1325	1180	985	560									
		40					1970	1890	1815	1740	1650	1560	1440	1315	1140	965	745	295									
		50				1955	1880	1800	1720	1645	1540	1430	1280	1125	920	720	490	130									
		60			1945	1865	1790	1715	1620	1530	1400	1270	1085	900	660	455	230										
Shut-off PSI:					170	161	152	144	135	126	118	109	100	92	83	74	66	48									
	5	0																1950	1815	1660	1515	1195	610				
		20															1935	1845	1755	1555	1350	950	300				
		30														1925	1880	1795	1660	1480	1250	810	150				
		40													1920	1875	1830	1745	1600	1400	1135	660					
		50											1960	1910	1870	1825	1780	1690	1530	1305	1010	510					
		60										1950	1905	1860	1815	1775	1730	1635	1455	1200	875	350					
Shut-off PSI:												253	245	236	227	219	210	193	167	141	115	80	37				

Separator/Holding Tank

TANK SPECIFICATIONS

(1) OUR **PREMIUM** WEIGHT TANKS ARE RATED FOR MATERIALS WEIGHING UP TO 14 LBS. PER GALLON.

(2) OUR **HEAVY** WEIGHT TANKS ARE RATED FOR MATERIALS WEIGHING UP TO 16.5 LBS PER GALLON

(3) OUR RATINGS ON CAPACITY IN GALLONS AND WEIGHT PER GALLON ARE CONSERVATIVE COMPARE OUR TANK WEIGHTS (GROSS EMPTY WEIGHT). COMPARE THE QUALITY — WE OFFER MAXIMUM VALUE IN COST PER GALLON COMPARED TO **ANYONE** IN THE INDUSTRY

(4) OUR STANDARD COLORS ARE:
- ★ PREMIUM WEIGHT TANKS – TRANSLUCENT WHITE
- ★ HEAVY WEIGHT TANKS – TRANSLUCENT BLUE
  (HEAVY WEIGHTS CAN BE ORDERED IN TRANSLUCENT WHITE AT **NO** EXTRA CHARGE IF YOU WILL GIVE US AN APPROXIMATE 3 WEEKS LEAD TIME)
- ★ OTHER COLOR VARIATIONS ARE A 10% UPCHARGE AND APPROXIMATE 3 WEEKS LEAD TIME

(5) OUR STANDARD WARRANTIES:
- ★ PREMIUM WEIGHT — 3 YEARS
- ★ HEAVY WEIGHT (TRANSLUCENT WHITE) -- 3 YEARS
- ★ HEAVY WEIGHT (TRANSLUCENT BLUE) — 5 YEARS
- ★ THE REASON FOR THE DIFFERENCE IN HEAVY WEIGHT WARRANTIES IS THAT THE FACTORY KEEPS TRACK OF WARRANTIES BY COLOR CODE: THEREFORE TRANSLUCENT WHITE HEAVY WEIGHT TANKS CANNOT BE DISTINGUISHED FROM A PREMIUM WEIGHT TANK.
- ★ COMPLETE WARRANTY INFORMATION IS AVAILABLE UPON REQUEST

(6) ALL TANKS HAVE MOLDED-IN CALIBRATION

(7) OUR TANKS ARE CONSTRUCTED WITH DUPONT'S SCLAIR #8504 MEDIUM DENSITY, FOOD GRADE RESIN

(8) ALL TANKS HAVE U.V. STABILIZERS

(9) ALL TANKS HAVE EXCELLENT RESISTANCE TO EXTREMELY HOT AND COLD CLIMATES

OUTLET SPECIFICATIONS

A	16" FILL OPENING, 2" POLYPROPYLENE FITTING
B & H	8" FILL OPENING, 2" POLYPROPYLENE FITTING
C & E	16" FILL OPENING, 3" POLYPROPYLENE FITTING
D	5" FILL OPENING, 1½" POLYPROPYLENE FITTING
J	7" FILL OPENING, ¾" POLYPROPYLENE FITTING
K	7" FILL OPENING, 1¼" & ¾" POLYPROPYLENE FITTING
L	5" FILL OPENING, ¾" POLYPROPYLENE FITTING
M	7" FILL OPENING, 1½" POLYPROPYLENE FITTING

ADDITIONAL FITTING INFORMATION:

(1) B, D, H, J, K, L & M TYPE TANKS COME WITH THE ABOVE STANDARD OUTLET AND CANNOT BE ORDERED WITHOUT THEM.

(2) A, C & E TYPE TANKS CAN BE ORDERED WITH FILL OPENINGS ONLY (NO OTHER OUTLETS). HOWEVER THERE IS **NO** PRICE REDUCTION FOR LEAVING OUT THE STANDARD FITTING STANDARD FITTING

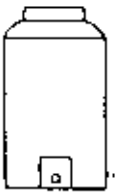
(3) FOR ADDITIONAL FITTINGS, PLEASE REFER TO OUR BULKHEAD FITTING PRICE SHEET

POLYETHYLENE
VERTICAL TANKS

PRODUCT NUMBER	SIZE (GALS.)	DIMENSIONS (DIA. X HT.)	PREMIUM WT. (LBS.)	$ PRICE (PREM. WT.)	HEAVY WT. (LBS.)	$ PRICE (HVY. WT.)	STANDARD OUTLETS
60000-0065	65	23" x 38"	25	$ 110.00	–	$ –	M
60000-0120	120	38" x 29"	30	196.00	–	–	B
60000-0125	125	30" x 48"	30	238.00	–	–	A
60000-0200	200	36" x 50"	50	265.00	–	–	A
60000-0220	220	42" x 41"	70	248.00	–	–	B
60000-0300	300	35" x 74"	80	351.00	–	–	A
60000-0301	300	45" x 50"	80	279.00	–	–	A
60000-0325	325*	66" x 33"	95	352.00	–	–	B
60000-0425	425*	67" x 35"	110	378.00	–	–	B
60000-0500	500	48" x 70"	110	474.00	125	558.00	A
60000-0550	550	67" x 42"	110	427.00	–	–	A
60000-0780	780	46" x 119"	–	–	185	1080.00	A
60000-1000	1000	64" x 85"	195	845.00	225	986.00	A
60000-1100	1100	87" x 49"	185	698.00	215	–	A
60000-1300	1300	87" x 58"	220	835.00	255	982.00	A
60000-1500	1500	64" x 126"	320	1258.00	370	1446.00	A
60000-1550	1550	87" x 64"	240	928.00	–	–	A
60000-1700	1700	87" x 70"	260	1010.00	300	1188.00	A
60000-2100	2100	87" x 87"	320	1246.00	300	1466.00	A
60000-2500	2500	95" x 89"	395	1604.00	455	1887.00	A
60000-3000	3000	95" x 105"	470	1953.00	540	2298.00	C
60000-4000	4000	95" x 142"	835	3010.00	960	3541.00	C
60000-5000	5000	102" x 151"	1010	3812.00	1160	4485.00	C
60000-5800	5800	141" x 98"	1150	4288.00	1320	5044.00	C
60000-6000	6000	102" x 180"	1275	4370.00	1465	5141.00	C
60000-6500	6500	120" x 144"	1350	4599.00	1550	5290.00	C
60000-9000	9000	141" x 144"	–	–	1895	7261.00	C

TO ORDER A HEAVY WEIGHT TANK, ADD AN "H" TO THE END OF THE PART NUMBER (Example: 1000 GAL. HEAVY DUTY VERTICAL WOULD BE PART #60000-1000H).

*MAY BE USED AS PICK-UP TANK (DESIGNED TO FIT BETWEEN WHEEL WELLS).



PEABODY

Fluid Handling Systems P.O. Box 1245 Gardena California 90249 • Phone (213) 321-6636 (714) 971-2215 • FAX 1-213-324-7247 • Toll Free in California (800) 992-6251

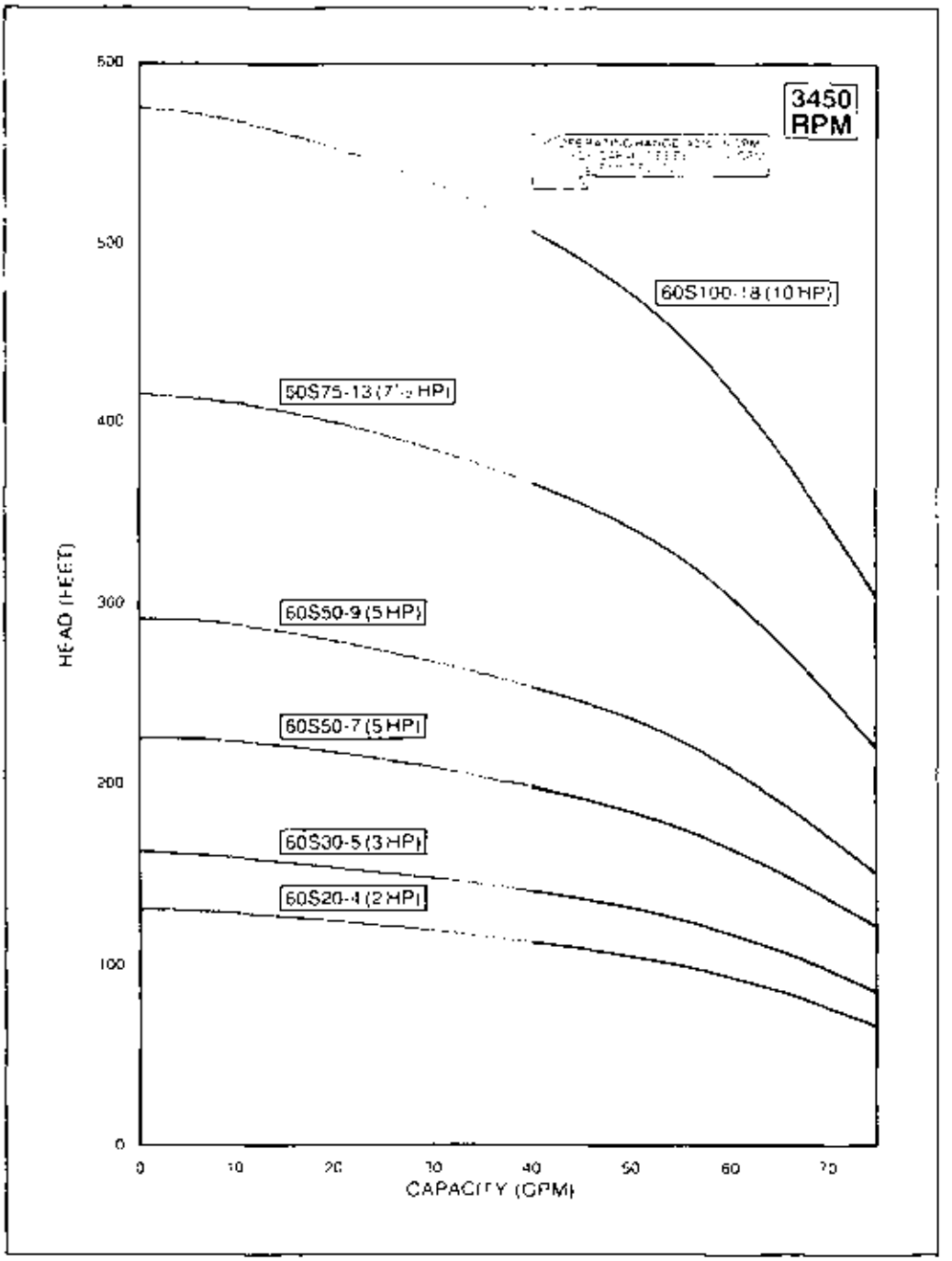
LNAPL Absorbers

MODEL 60S

GRUNDFOS

FLOW RANGE
40 to 75 GPM

PUMP OUTLET
2" NPT



MODEL NO.	HP	LENGTH (INCHES)	WIDTH (INCHES)	APPROX. UNIT SHIPPING WT. (LBS.)
60S20-4	2	31 ¼	3¾	39
60S30-5	3	40 ¾	3¾	64
60S50-7	5	48 ⅝	3¾	75
60S50-9	5	53 ¾	3¾	80
60S75-13	7½	70	3¾	105
60S100-18	10	97 ¼	3¾	160

Specifications are subject to change without notice

GRUNDFOS 60 GPM MODEL 60S

SELECTION CHARTS

(Ratings are in GALLONS PER HOUR – GPH)

FLOW RANGE
40 to 75 GPM

PUMP OUTLET
2" NPT

PUMP MODEL	HP	PSI	DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET																								
			20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	340	400	450	520	600	700	800	900	1000	1100
60S20-4	2	0			4480	4060	2845	1630																			
		20	4335	3870	2315	760	380																				
		30	3515	2695	1345																						
		40	1825																								
		50	1075																								
		60																									
Shut-off PSI:			46	37	29	20	11	3																			
60S30-5	3	0				4485	4005	3530	2060																		
		20	4685	4375	3830	3265	1645																				
		30	4560	3860	2835	1800	900																				
		40	3625	2995	1500																						
		50	2425	1165	585																						
		60	1320																								
Shut-off PSI:			60	51	42	34	25	16	8																		
60S50-7	5	0					4650	4430	4105	3785	3130	2480															
		20			4580	4345	3995	3665	2900	2150	1075																
		30		4560	4275	3990	3470	2950	1475																		
		40	4505	4260	3875	3490	2630	1765	885																		
		50	4180	3875	3285	2695	1350																				
		60	3740	3320	2320	1320	660																				
Shut-off PSI:			88	80	71	62	54	45	36	28	19	10															
60S50-9	5	0							4490	4300	4040	3780	3335	2890	1965	1040											
		20					4430	4230	3955	3680	3180	2690	1650	610	305												
		30			4590	4410	4175	3940	3565	3190	2440	1685	840														
		40		4570	4365	4160	3660	3565	3015	2460	1230																
		50	4530	4350	4100	3850	3440	3025	2180	1330	665																
		60	4300	4085	3760	3440	2825	2205	1105																		
Shut-off PSI:			115	106	98	89	81	72	63	55	46	37	29	20	11	3											
60S75-10	7½	0									4640	4525	4385	4240	4065	3890	3640	3000	1290								
		20							4610	4485	4340	4195	4010	3825	3560	3300	2875	1735									
		30						4595	4460	4325	4160	3995	3770	3550	3200	2860	2290	860									
		40					4570	4445	4295	4145	3950	3760	3475	3195	2735	2275	1500	360									
		50				4555	4415	4280	4105	3935	3700	3460	3095	2725	2100	1480	740										
		60			4530	4400	4245	4090	3890	3685	3380	3080	2585	2085	1245	405											
Shut-off PSI:					152	143	134	126	117	108	100	91	82	74	65	56	48	30	4								
60S1[illegible]	10	0													4590	4500	4400	4185	3785	3155	2150						
		20											4565	4475	4370	4270	4150	3880	3330	2400	850						
		30										4555	4455	4360	4250	4135	4000	3695	3055	1890							
		40									4540	4445	4340	4235	4110	3990	3835	3480	2700	1240							
		50								4525	4425	4325	4210	4100	3960	3820	3640	3215	2250	600							
		60							4510	4415	4305	4200	4070	3945	3785	3630	3410	2890	1700								
Shut-off PSI:									186	177	169	160	152	143	134	126	117	100	74	48	22						

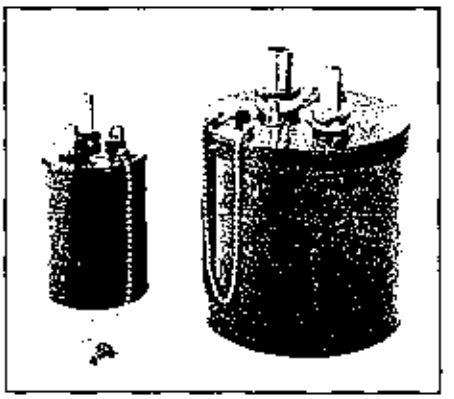
SOAKEASE™ OIL ABSORBENT KIT

When a "think-fast" solution is necessary to safely and effectively remove petroleum hydrocarbons from groundwater monitoring wells, the pro-active answer is a SOAKEASE™ Oil Absorbent Kit. When placed into the well, SOAKEASE™ reacts instantly to absorb and contain petroleum-based contaminants. It repels water, resists chemicals and helps reduce weight and disposal costs. After having "bailed" the excess floating product in low yielding formations, SOAKEASE™ may be left in the well to absorb free product over a length of time. Its 3 ft length will easily accommodate changes in the water table. SOAKEASE™ kits are easy to use and available for 2 in. and 4 in. wells.

A SOAKEASE™ kit includes a stainless steel refillable canister and disposable absorbent tubes. It is as easy to use as a bailer and acts as a passive selective skimmer. It will absorb and help remove a sheen.

MODELS

TB2-100	2 in. SOAKEASE™ Kit. Contains: (1) 2 in. stainless steel canister with a 2 in. disposable absorbent tube, (15) 2 in. disposable absorbent refill tubes. Case dimensions: 7 x 7 x 42 in. (178 x 178 x 1069 mm). Shipping weight: 7 lb (3.2 kg)
TB2-110	2 in. SOAKEASE™ refill case. Contains: (12) 2 in. absorbent refill tubes per case. Case dimensions: 4 x 15 x 15 in. (102 x 102 x 381 mm). Shipping weight: 4 lb (1.8 kg)
TB4-100	4 in. SOAKEASE™ Kit. Contains: (1) 4 in. stainless steel canister with a 4 in. disposable absorbent tube, (4) 4 in. disposable absorbent refill tubes. Case dimensions: 7 x 7 x 42 in. (178 x 178 x 1069 mm). Shipping weight: 8 lb (3.6 kg)
TB4-110	4 in. SOAKEASE™ refill case. Contains: (12) 4 in. absorbent refill tubes per case. Case dimensions: 4 x 15 x 15 in. (102 x 102 x 381 mm). Shipping weight: 7 lb (3.2 kg)



WELL CLINCHERS

Brainard•Kilman™ Well Clinchers are designed to facilitate the installation of recovery pumps. A stainless steel eye hook is provided for the attachment of the pump support cable and brass bulkhead fittings are provided for hose connections. Well Clinchers feature an "O" ring seal which provides water resistance and allow use in vacuum applications.

- Precision machined PVC with brass fittings.
- Access hole for water level measurements.
- "O" ring seal for use in vacuum applications
- SST eye bolt for pump support cable attachment
- Available for various well configurations

MODELS

300070	2 in. (51 mm) Well Clincher for FAP™ Pump installation
300087	2 in. (51 mm) Well Clincher for Evacuator Pump installation
300071	4 in. (102 mm) Well Clincher for FAP™ Pump installation
300088	4 in. (102 mm) Well Clincher for Evacuator Pump installation
300089	6 in. (152 mm) Well Clincher for FAP™ Pump installation
300090	6 in. (152 mm) Well Clincher for Evacuator Pump installation

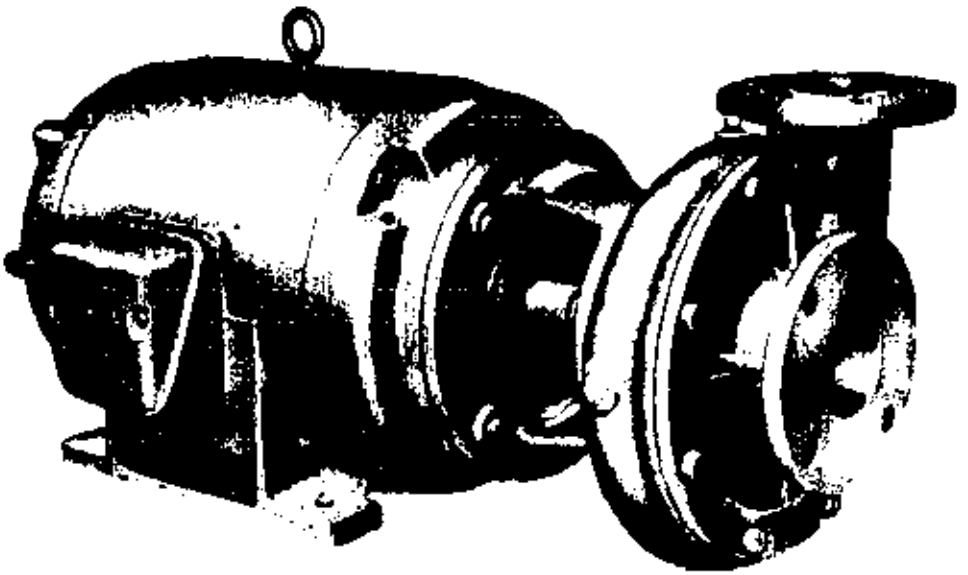
Transfer Pump

Bulletin 14(

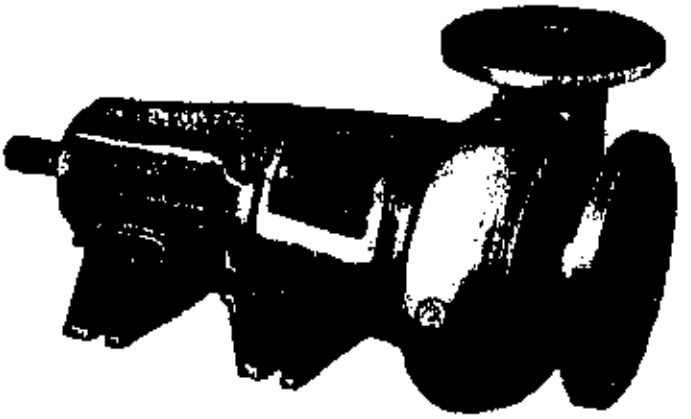
GARVER

end suction straight centrifugal

The General Purpose Pumps with a Thousand Uses



Capacities to 3000 G.P.M. Heads to 390 feet.

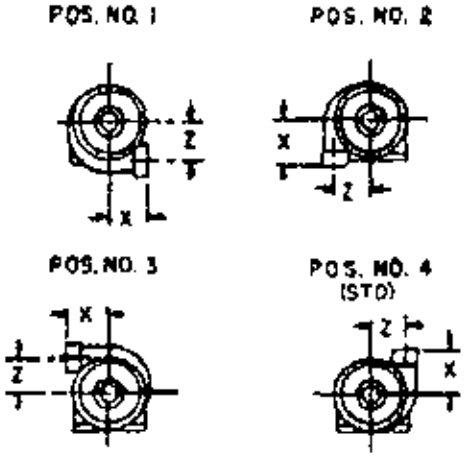


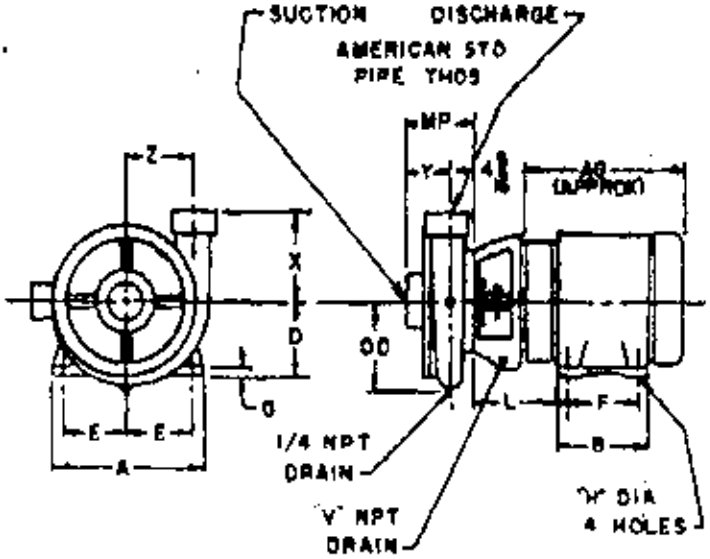
- Close coupled — industry standard C-face
- Frame mounted coupled—NEMA standard
- Open or Enclosed Impeller

GARVER PUMP CO.

MUSCATINE, IOWA

TYPE L, LA, H, HA (THREADED)
CLOSE COUPLED





PUMP DIMENSIONS

MODEL DISCH X SUCT X TYPE	X	Y	Z	OD	MP WITH MOTOR FRAME 143 TCZ THRU 215 TCZ	MP WITH MOTOR FRAME 254 TCZ THRU 326 TCZ
1 X 1-1/4 X 6L	3-3/4	3-3/16	3-7/16	4-3/4	5-13/16	
1 X 1-1/4 X 6LA	3-3/4	3-1/8	3-7/16	4-3/4	5-3/4	
1 X 1-1/4 X 7L	4-1/4	2-11/16	3-13/16	4-15/16	5-3/4	
1-1/4 X 1-1/2 X 7L, LA	4	3-3/8	3-3/4	5-1/8	5-15/16	
1-1/2 X 2 X 7L, LA	5	3-7/16	4-1/8	5-3/8	6-1/16	
2 X 2-1/2 X 7L, LA	5	3-11/16	4-1/8	5-3/4	6-5/16	
1-1/4 X 1-1/2 X 9H, 9HA	5	3-7/16	4-23/32	6-1/8	6	6-3/4
1-1/2 X 2 X 10H	6	4-7/16	5-7/16	6-15/16	7	7-3/4
1-1/2 X 2 X 10HA	6	3-9/16	5-7/16	6-15/16	6-1/8	
2 X 2-1/2 X 10H	6-1/4	4-9/16	5-1/2	7-1/8	7-3/16	7-15/16
2 X 2-1/2 X 10HA	6-1/4	4-1/16	5-1/2	7-1/8	6-11/16	

MOTOR DIMENSIONS

FRAME NO.	A (MAX)	AG	B (MAX)	D	E	F	G	H	L	V
143 TCZ	7	10-1/2	6	3-1/2	2-3/4	4	7/16	11/32	7-7/16	3/8
145 TCZ	7	11-1/2	6	3-1/2	2-3/4	5	7/16	11/32	7-7/16	3/8
182 TCZ	9	12-5/8	6-3/4	4-1/2	3-3/4	4-1/2	9/16	13/32	8-3/16	3/8
184 TCZ	9	13-5/8	6-3/4	4-1/2	3-3/4	5-1/2	9/16	13/32	8-3/16	3/8
213 TCZ	10-1/2	15-1/4	7	5-1/4	4-1/4	5-1/2	5/8	13/32	9-1/16	3/8
215 TCZ	10-1/2	16-3/4	8-1/2	5-1/4	4-1/4	7	5/8	13/32	9-1/16	3/8
254 TCZ	12-1/2	19-1/8	10-1/2	6-1/4	5	8-1/4	5/8	17/32	9-9/16	3/8
256 TCZ	12-1/2	20-7/8	12-1/4	6-1/4	5	10	5/8	17/32	9-9/16	3/8
284 TCZ	13-7/8	20-15/16	12-1/4	7	5-1/2	9-1/2	3/4	17/32	9-9/16	1/2
286 TCZ	13-7/8	22-7/16	13-3/4	7	5-1/2	11	3/4	17/32	9-9/16	1/2
324 TCZ	15-7/8	23-1/8	13-3/4	8	6-1/4	10-1/2	13/16	21/32	10-1/16	1/2
326 TCZ	15-7/8	24-5/8	15-1/4	8	6-1/4	12	13/16	21/32	10-1/16	1/2

MODEL _____
GPM _____ TDH _____ RPM _____
HP _____ VOLTS _____ PH ____ HZ ____ AC

CUSTOMER _____
CUST. NO. _____
DATE: _____

CARVER PUMP COMPANY
1088 HERSHY AVE.
MUSCATINE, IOWA 52761
PH (319) 263-3410

ENGLAND SHAHIN + ASSOC

FAX (714)453-0733

ATTENTION: RICH JOLOMAN

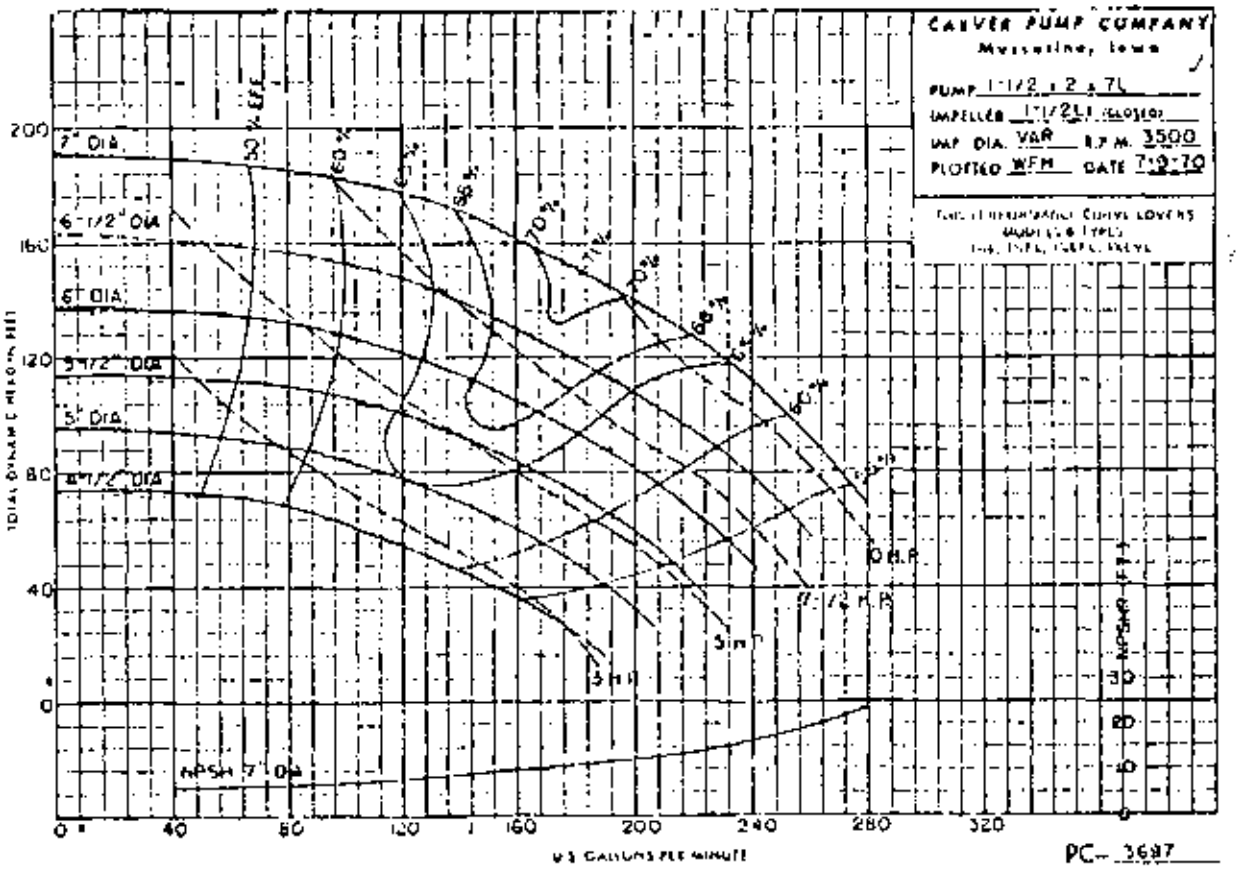
SHAW PUMP & SUPPLY

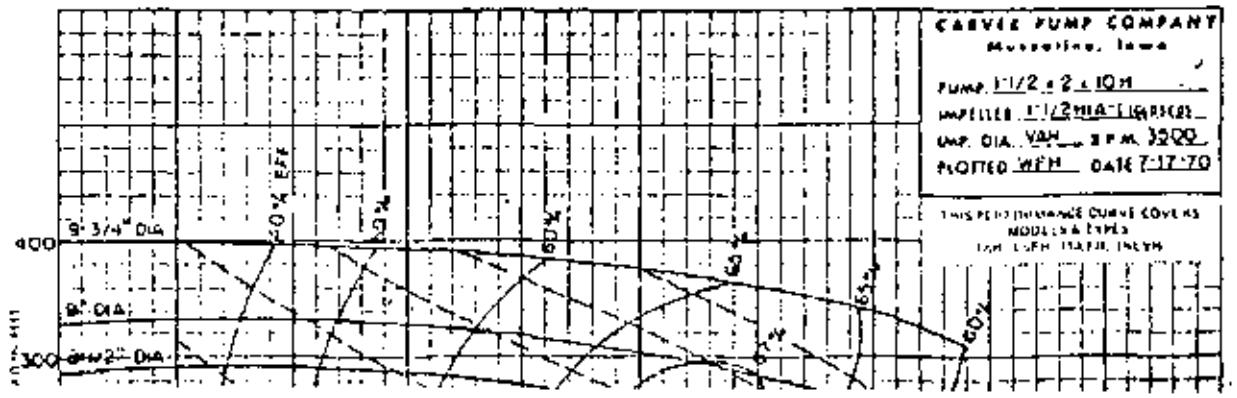
800/242-4639 818/962-8985

15854 BUSINESS CENTER DR., IRWINDALE, CA 91706

Carver Curves

FRAME = 182JP

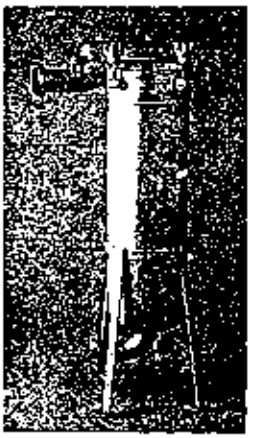




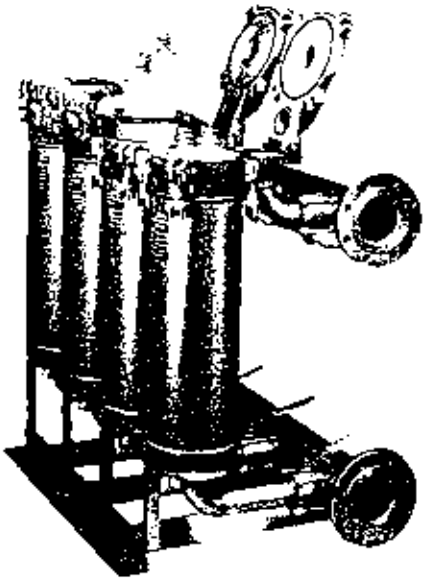
BAG Filtration System

3M BRAND HIGH PERFORMANCE FILTER HOUSINGS

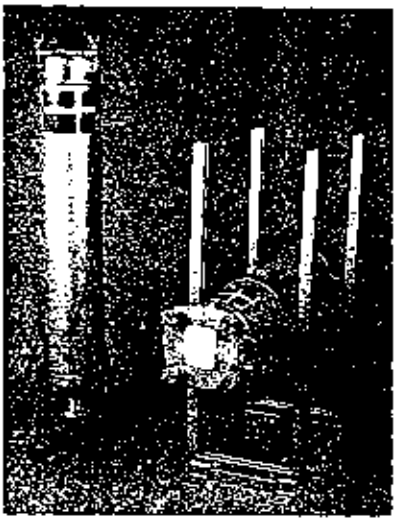
3M offers a complete line of Carbon Steel and Stainless Steel filter housings to meet your critical filtration requirements. These vessels are all ASME Code rated and guarantee no particle by-pass when used with 3M filter bags or cartridges. Whether your flow requirement is as little as 20 gpm or as high as 2,000 gpm., 3M has the proper vessels for your critical filtration needs.



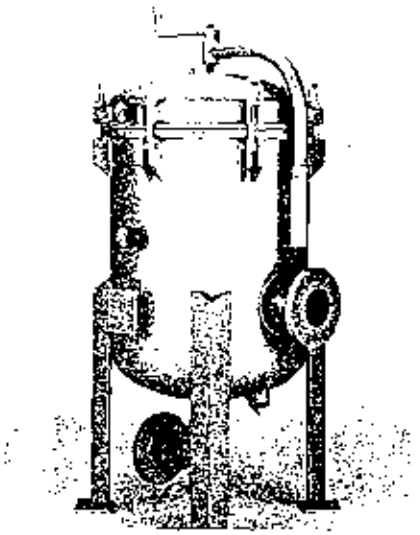
SINGLE VESSELS
For 100 or 500 Series Bags & 700 Series Cartridges



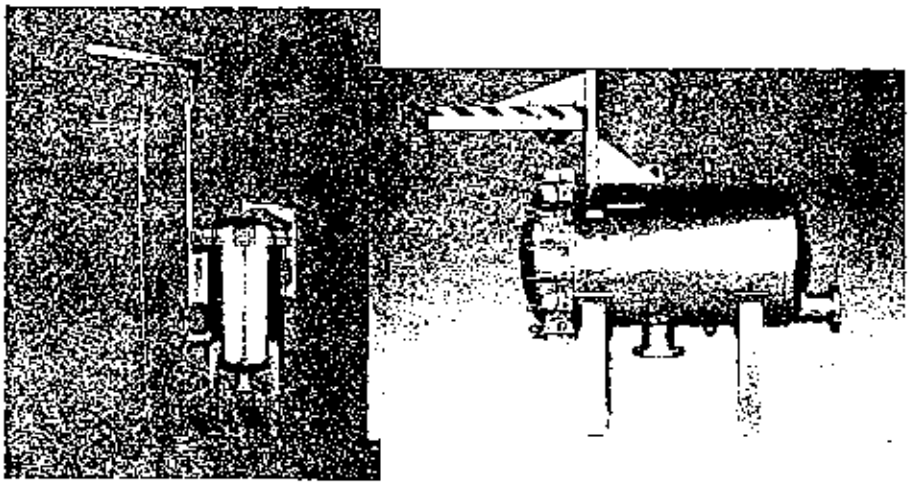
PLEX VESSELS
For 100 or 500 Series Bags & 700 Series Cartridges



HORIZONTAL OR VERTICAL SINGLE OR PLEX VESSELS
For 740B Series Cartridges



MULTI-BAG VESSELS
FOR THE 500 SERIES BAGS



MULTI-CARTRIDGE VESSELS IN BOTH VERTICAL AND HORIZONTAL DESIGNS
FOR THE 740B SERIES CARTRIDGES

LET US SHOW YOU HOW TO CUT YOUR TOTAL FILTATION COST BY SELECTING THE 3M BRAND SYSTEM TO MEET YOUR NEEDS. PLEASE CALL YOUR LOCAL HARRINGTON SERVICE CENTER FOR COMPLETE APPLICATION ENGINEERING ASSISTANCE.

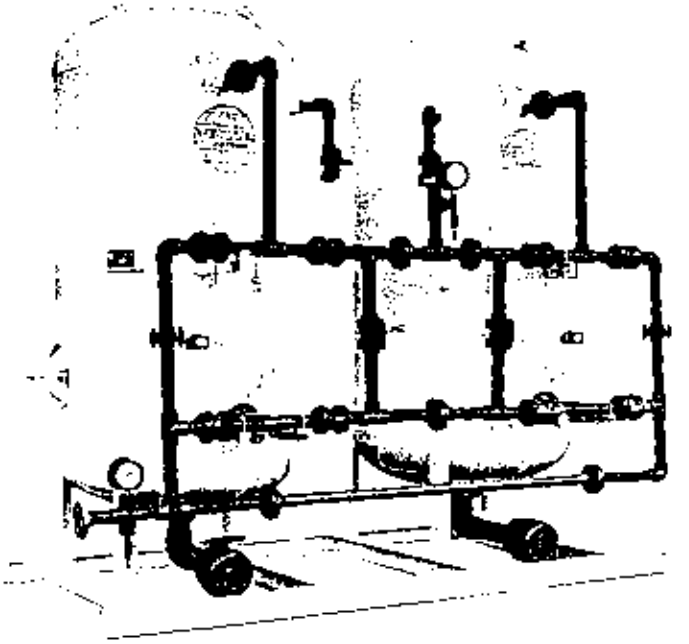
A Member of the Crystal Brand of a 3M group of companies

GAC Vessels

Water Purification Systems

HIGH PRESSURE

HP-2 HP-10 HP-20



DESCRIPTION

Westates' High Pressure Activated Carbon Adsorption Systems are designed to efficiently remove dissolved organic contaminants from drinking water, groundwater and wastewater. The systems are ideally suited for both industrial and municipal applications with high flow rates and low level concentrations of organics. The systems are pre-engineered, skid-mounted, and complete with piping for series lead/lag or parallel flow configurations, carbon transfer and venting, and water and air utilities. Westates' High Pressure Systems are supported by a state-of-the-art laboratory, system engineering and performance modeling capabilities, and nationwide carbon change out services.

FEATURES

- Down-flow fixed bed with backwash capability.
- Carbon steel vessel designed and manufactured according to ASME Code Section VIII Div. 1.
- Proven internal distribution and collection system designed to maximize utilization of activated carbon, and minimize channeling.
- Face piping options, sized for the required flow rate.
- Internal lining options, including FDA approved epoxies and vinyl esters.
- Access manways for easy maintenance.
- Designed for cost-effective bulk carbon fill and removal.
- Built-in pressure-relief valve.

WESTATES CAPABILITIES

Westates has more than 20 years of experience in the design and development of complete activated carbon adsorption systems utilizing AQUA-Carb™ and other Certified Activated Carbons. Our technical staff provides complete guidance in the selection of the appropriate high pressure carbon system to meet your needs. Our in-house laboratory is fully equipped to provide complete quality control and continuing analysis of your carbon–using ASTM procedures–to maintain maximum adsorption efficiency. Westates has a convenient lease program, and the service personnel to supply and exchange carbon nationwide.

WESTATES carbon ACTIVATED CARBON SYSTEMS

WESTATES CARBON, INC.
2130 Leo Ave. Los Angeles, CA 90040
PHONE (213) 722-7500
FAX (213) 722-9207 Telex 910-321-2355

Water Purification Systems

HIGH PRESSURE

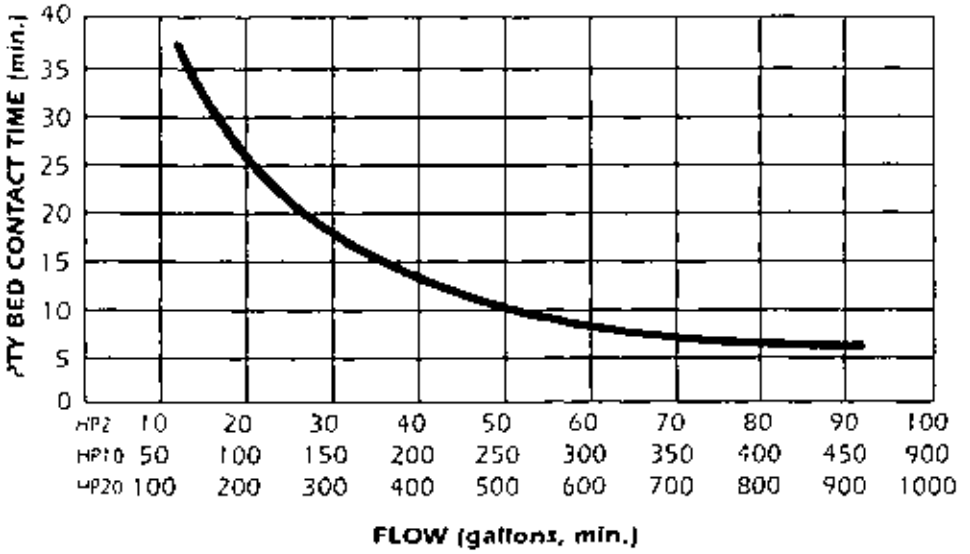
SPECIFICATIONS

	HP2	HP10	HP20
Design Flow - GPM			
Series @ 8-10 PSID	50	250	500
Parallel @ 4-5 PSID	100	500	1000
Surface Velocity GPM/Ft²	4.0	6.5	6.4
Backwash Rate GPM	175	525	1100
Quantity of Carbon per vessel lbs.	2,000	10,000	20,000
Vessel Diameter inches	48	84	120
Service Connection 150 lbs. FL.	2"	4"	6"
Shipping Weight lbs.	8,350	37,500	72,050
Operating Weight lbs.	15,430	68,500	139,600
Dimensions L x D x H inches	120 x 68 x 138	192 x 113 x 194	276 x 168 x 240

NOTES:

1. Design Flows are based on an empty bed contact time (EBCT) of ten minutes per vessel and a carbon density of 28 lbs/Ft³.
2. All models are designed and fabricated according to ASME code from carbon steel, 75 psi @ 150°F. Other pressure ratings are available
3. Internal surfaces finish options include 12-15 mil phenolic epoxy, vinyl ester, and FDA approved epoxy linings.
4. External coating: epoxy.
5. Service connection piping options include carbon steel and PVC.
6. Vessel supports: structural steel legs and skid.
7. Access openings: 14" x18" manway and 4" carbon removal and fill connection.
8. Manual backwash capabilities available, if required.

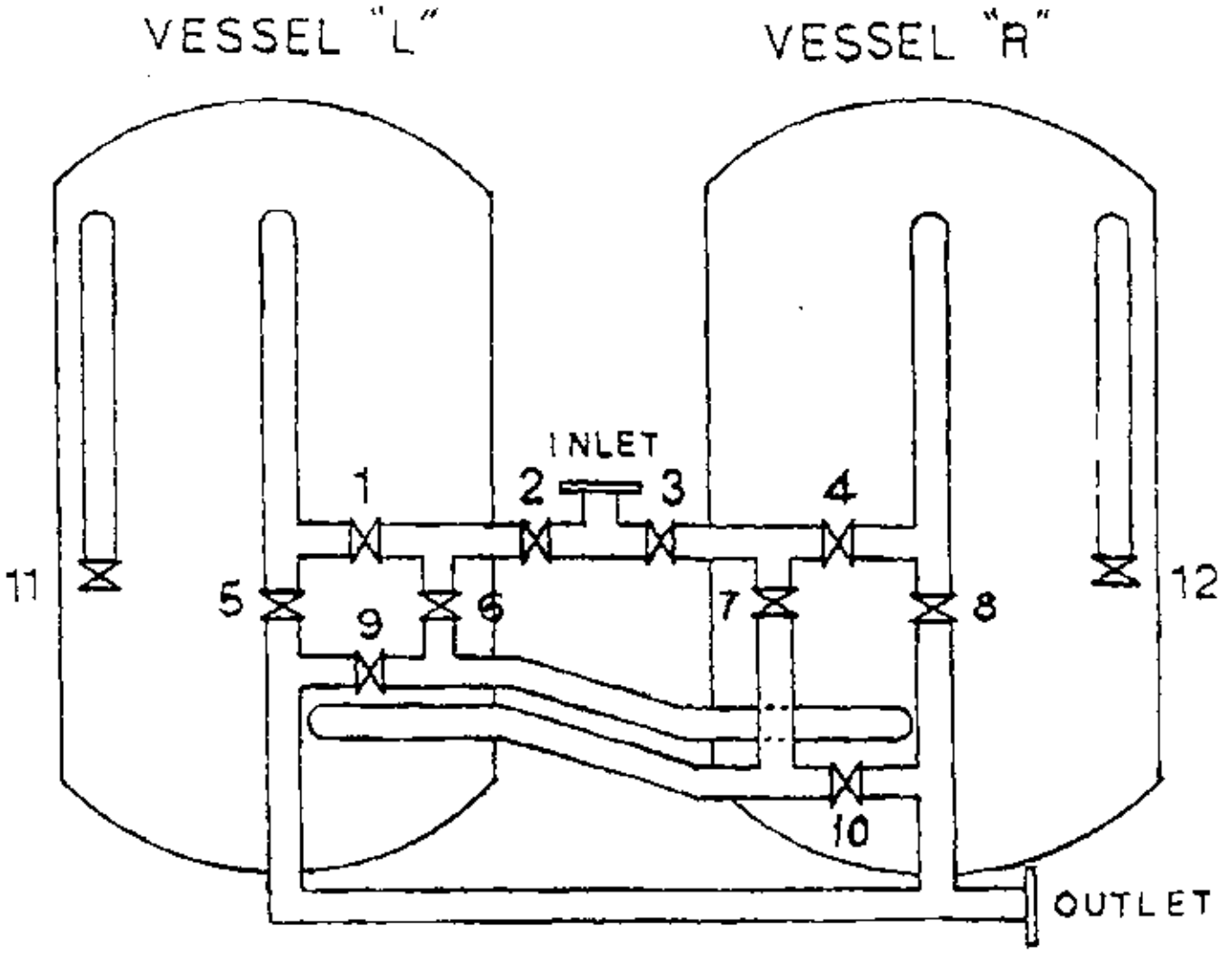
EBCT vs. FLOW



Westates Carbon, Inc. reserves the right to change specifications, without prior notification.

WESTATES carbon ACTIVATED CARBON SYSTEMS
A Westates Carbon Company
WESTATES CARBON, INC.
2130 Leo Ave., Los Angeles, CA 90040
PHONE (213) 722-7500
FAX (213) 722-8207 TWX 910-321-2355

Sheet No. 1 of 2 Project No. 015775 Date JAN 10 1996 By RWG



FLOW SEQUENCE/VALVING

OPERATION TYPE	VALVE NUMBER									
	1	2	3	4	5	6	7	8	9	10
PARALLEL FLOW	O	O	O	O	C	C	C	C	O	O
VESSEL "L" ONLY	O	O	C	C	C	C	C	C	C	O
VESSEL "R" ONLY	C	C	O	O	C	C	C	C	O	C
SERIES FLOW "L", THEN "R"	O	O	C	O	C	C	O	C	C	C
SERIES FLOW "R", THEN "L"	O	C	O	O	C	O	C	C	C	O
BACKWASH "L" & "R" (NOTE 1)	C	O	O	C	C	O	O	C	C	C
BACKWASH "L" ONLY (NOTE 2)	C	C	O	C	C	C	O	C	C	C
BACKWASH "R" ONLY (NOTE 3)	C	O	C	C	C	O	C	C	C	C

NOTE 1: ALSO OPEN THE CARBON FILL PIPE VALVES, 11 AND 12
NOTE 2: ALSO OPEN CARBON FILL PIPE VALVE, 11
NOTE 3: ALSO OPEN CARBON FILL PIPE VALVE, 12

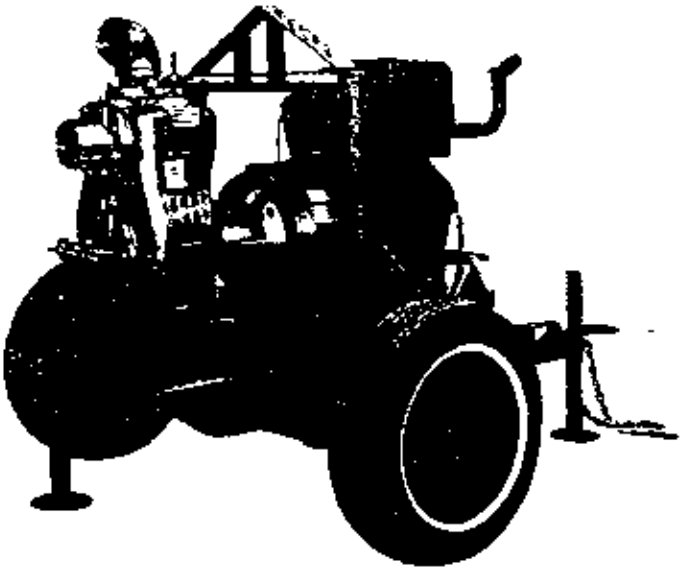
Backwash Pump

A,C,D,I

Self Priming Centrifugal
Diesel Engine Driven
Model 14C2-F2L
Size 4" x 4"

35MT

Total Head		CAPACITY OF PUMP IN U.S. GALLONS PER MINUTE AT CONTINUOUS PERFORMANCE				
P.S.I.	Feet					
48	110	140	140	140	140	140
43	100	275	350	350	350	350
39	90	310	420	505	575	575
35	80	320	440	530	605	650
30	70	320	450	540	623	685
Suction Lift		25'	20'	15'	10'	5'



PUMP SPECIFICATIONS

Size: 4" x 4" NPT - Female
Casing: Gray Iron No. 30
(Maximum Operating Pressure 80 lbs.)
Impeller: Open Type, Two Vanes Ductile Iron 60-40-18
(Handles 3" Dia. Spherical Solids)
Impeller Shaft: Steel No. 1045
Wear Plate; Replaceable: Steel No.1018
Cover Plate; Removable: Gray Iron No. 30 – Wt. 26 lbs.
Intermediate Bracket: Gray Iron No. 30
Seal Plate: Gray Iron No.30
Seal: Double Grease Lubricated with Spring Loaded Grease Cup. Sintered Bronze Stationary Seal Seats. Rotating Faces are Steel. Maximum Temperature of Liquid Pumped, 110°F. Maximum Suction Pressure 10 lbs. per square inch.
Seal Liner: Brass No. 70-30
Flap Valve: Neoprene with Steel Reinforcement
Radial Bearing: Roller Type
Thrust Bearing: Roller Type
Bearing Lubrication: Grease
Flanges: Gray Iron No. 30
Gaskets: Vegetable Fiber, Asbestos, Rubber
Standard Equipment:
Hoisting Bail
Skid Base
90° Elbow
Strainer
Optional Equipment:
2 Wheel Truck Assembly with Pneumatic Tires, 7.75" x 15"

ENGINE SPECIFICATIONS

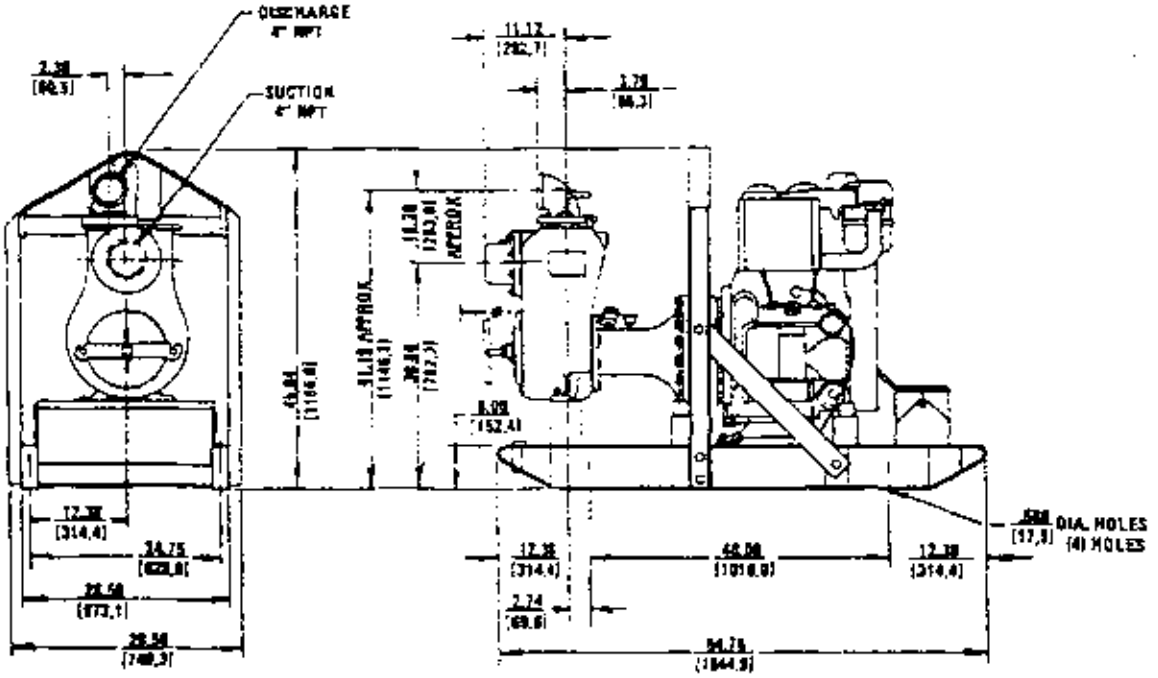
Model: Deutz F2L 912
Type: Two Cylinder, Four Cycle, Air Cooled Diesel Engine
Displacement: 115.3 Cu. In.
Governor: Mechanical
Lubrication: Forced Circulation
Air Cleaner: Oil Bath
Oil Reservoir: 6 U. S. Quarts
Fuel Tank: 13.3 U. S. Gallons
Operating Time; Full Load: 10.2 Hours
Starter: 12 Volt Electric
Amp Light, Exhaust Muffler, Fan Belt Failure Engine Shut Down

DEUTZ PUBLISHED PERFORMANCE:

Max. Cont. B.H.P. 27.5 @ 2300 RPM
Max. Dyn. B.H.P. 32 @ 2500 RPM

WARNING
DO NOT USE IN EXPLOSIVE ATMOSPHERE OR FOR PUMPING VOLATILE FLAMMABLE LIQUIDS

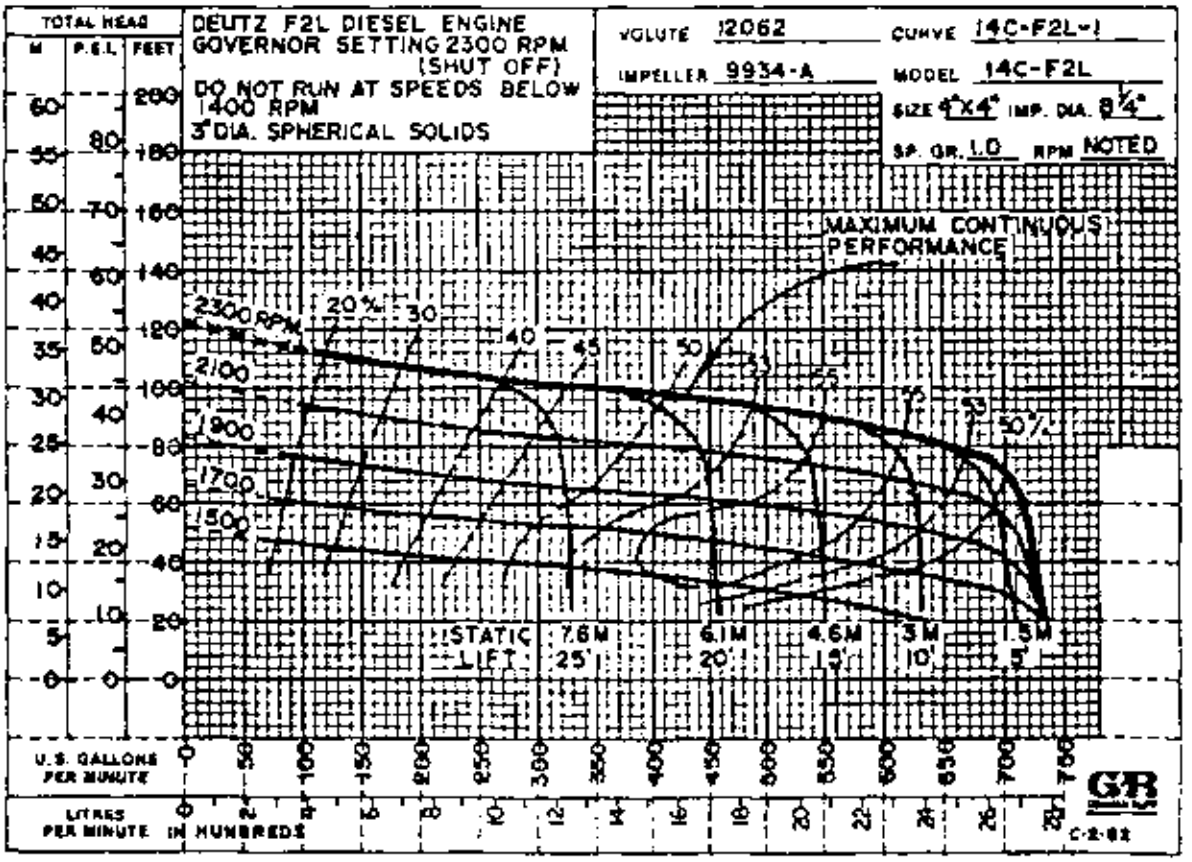
Specification Data	OVERALL DIMENSIONS and WEIGHTS APPROXIMATE		SKID BASE	2-WHEEL
SECTION 45, PAGE 1205		NET WEIGHT	1460 LBS.	1690 LBS.
		SHIPPING WEIGHT	1660 LBS.	1790 LBS.
		EXPORT CRATE SIZE	75 CU. FT.	93 CU. FT.



DIMENSIONS: INCHES [MILLIMETERS]

* 18.00 [457.2] REQUIRED FOR REMOVAL OF SACK COVER PLATE

POWERED BY DEUTZ DIESEL ENGINE F2L/912



Copyright by The Gorman-Rupp Company

Flow Sensors and Meters

SIGNET ELECTRONIC FLOW AND PROCESS CONTROL INSTRUMENTATION

NET IS 1-2-3 EASY!

Building your liquid flow-measurement system is easy with Signet's simple, three-component design. Simply choose (1) a flow sensor, (2) a sensor installation fitting and (3) a flow-rate indicator or controller. Your Ryan Herco specialist will be glad to help select the right system for your requirements.

(1) Flow sensor: Signet sensors' ±0.5% repeatability assures high accuracy, plus the convenience of quick installation and reduced maintenance. Available for installation in line sizes 1/2" - 36", the insertion flow sensors can easily be installed by one person in a matter of minutes, using only simple hand tools. In addition, the wide choice of sensor materials offers compatibility with virtually any corrosive or ultrapure liquid, including housing materials of polypropylene, PVDF, stainless steel or brass. Low flows in small-diameter systems (1/4" and 3/8") are handled by any of three microflow sensor units, which combine sensor and installation fitting into one unit. Flow velocity (measured in FPS) must be known in order to select the flow sensor right for your system.

(3) →

(1)

(2)

(2) Installation fittings: Using a matched Signet installation fitting and flow sensor assures correct positioning in the flow stream. Insertion sensors measure flow at a specific local velocity of the pipe. It is, therefore, critical that the sensor be oriented properly, inserted to an exact depth, and exist in a pipe that is always full. The range of sensor installation fittings accommodates almost any pipe size or material, including PVC, PVDF, CPVC, stainless steel, carbon steel, polypropylene, copper and bronze.

(3) Flow indicators and controllers: Whether you desire local, remote, analog or digital flow-rate indication, control or totalization, Signet has a meter to match your system needs. Power options include self-powered, battery-operated and 115VAC powered units. Signet instruments are calibrated by our factory-trained technicians to any pipe size and volumetric unit. They may be recalibrated, should your system design change. All can be located up to 200 feet from sensors without signal amplification. Additionally, many units offer a pulse output, which makes integrated computer-controlled automation easy.

Flow alarms indicate the flow rate and actuate a relay if the user-selectable alarm set point is exceeded as well as flow rate and totalizer.

Electric-actuated ball valve

Signal conditioners change the flow-sensor output to one necessary for process control, i.e., 0-5 Vdc or 4-20mA.

Strip chart recorder

Flowmeters indicate flow rate

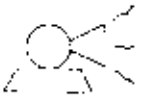
Pump pulsers externally pace an electronic chemical metering pump proportional to the main flow volume.

Externally pulsed metering pumps (pages 165-168)

Batch controllers activate the relays to allow for dispensation of predetermined quantities of solution.

Electric solenoid valves (pages 108 to 111)

Accumulators totalize flow and indicate the flow rate.



Audible alarm

Dual-alarm Flo-limit detectors will activate the relays if the flow rate drops below or exceeds setpoint limits.

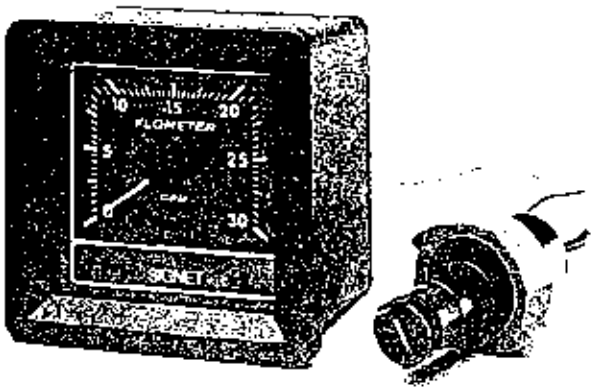
All types of pumps (pages 137-176)

RyanHerco
FLUID FLOW SOLUTIONS

Call 1-800-848-11-41

SIGNET ELECTRONIC FLOWMETERS

SELF-POWERED FLOW INDICATOR—Intrinsically Safe



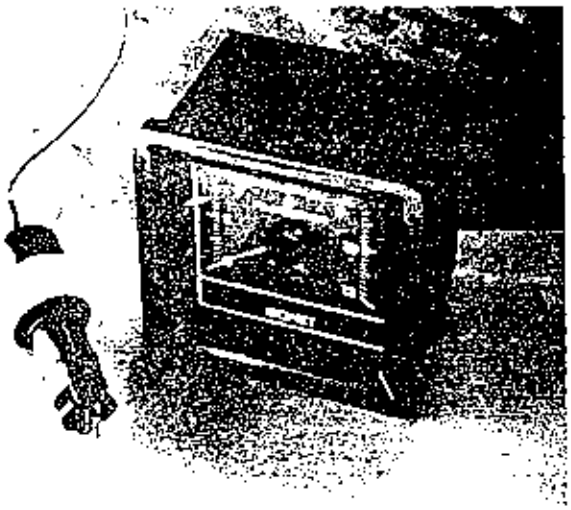
Self-powered flowmeter. Flow sensor sold seperately.

You can combine this self-powered Flowmeter with a Rotor-X flow sensor and the appropriate installation fitting for a completely self-contained, affordable flow-monitoring system. Because no external power or battery is needed, you can mount it anywhere—up to 200 feet from the sensor. The simple hookup involves only three flow-sensor wires to the terminal strip.

The flowmeter's easy-to-read 5.5" dial is activated by a 250° damped meter movement for smooth linear readings and accurate flow rate indication (±2% of full scale, with a repeatability of ±1% of full scale). It's also protected by a waterproof face to withstand wash-downs. Note: Not recommended for a vibration environment.

Intrinsically safe. Factory Mutual rating of Class 1, Div. 1, Group A, B, C, D.

ORDER: 5930-941 FLOWMETER, SELF-POWERED
(509) $225.00

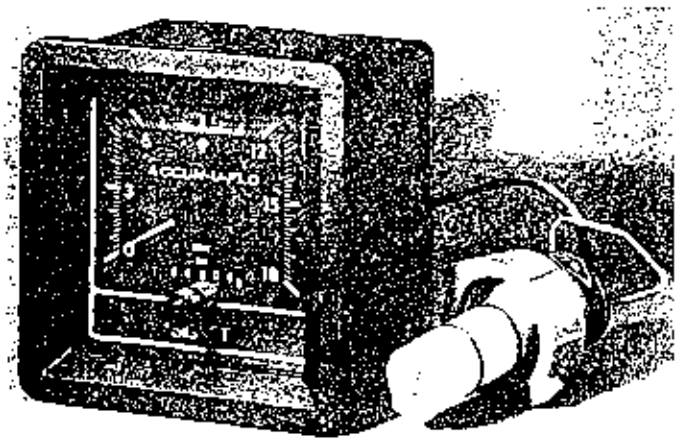


Powered analog flowmeter. Flow sensor sold seperately.

POWERED ANALOG FLOWMETER

Powered flow indicators are recommended for use with all flow sensors—they withstand high vibration levels when mounted on operating equipment. This product features a TTL-compatible pulse output for easy interface to external computation and control instrumentation, and is accurate to ±1% of full scale. A 117Vac-12Vdc power converter is included.

ORDER: 5938-401 ANALOG FLOWMETER *(584)* $385.00



Accum-u-flo meter. Flow sensor sold seperately.

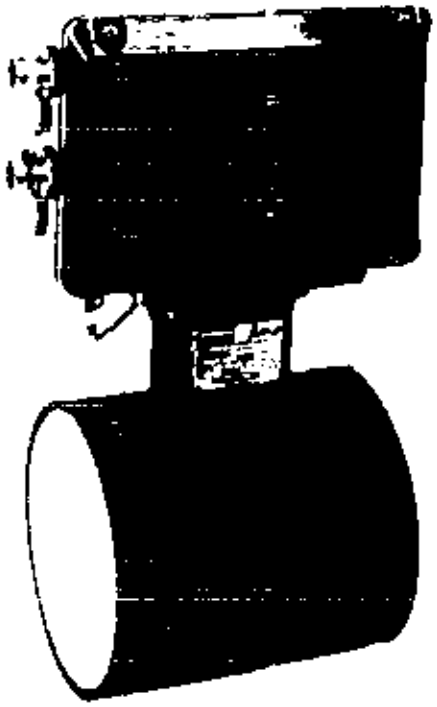
ACCUM-U-FLO

A quick glance at the Accum-U-Flo gives an accurate fluid flow rate and totalized flow volume readings. It combines both essential flow functions in one convenient unit, saves space and eliminates extra expense.

The flow rate is displayed on an easy-to-read 5.5" analog dial; the totalized volume on an electromechanical counter. Choose from a seven-digit non-resettable counter for continuous totalizing, or a five-digit front-resettable counter for periodic totalizing.

The unit's 245° high-torque meter gives greater resolution in high-vibration areas. The resulting flow rate accuracy is ±1% of the standard scale, and totalized volume accuracy is ±2% of the calibrated flow rate. The Accum-u-flo is easily interfaced with other TTL-compatible equipment and includes a 117Vac-12Vdc power converter.

ORDER: ACCUM-U-FLO FLOW METER
5937-501 Non-resettable 7-digit counter *(575)* $520.00
5937-502 Front-resettable 5-digit counter *(575R)* 520.00



FLUMAG is described the best affordable among many.

The Schlumberger FLUMAG is a new generation of magnetic inductive flowmeters providing excellent flow measurement accuracy and flexible operating characteristics.

FLUMAG flowmeters take exception to what you might expect in magnetic inductive flowmeters this affordable measuring the flow of electrical conductive liquids with high solids content, FLUMAG offers excellent performance in every area that counts most towards quality and productivity **ACCURACY, COST EFFECTIVENESS and MAINTENANCE FREE.**

Every component in FLUMAG'S design and manufacture is designed specifically to be as **DEPENDABLE, RELIABLE,** and **EFFICIENT** as possible. And aren't these the same qualities you demand in a full bore magnetic flowmeter?

A g the many special performance characteristics is the ability of FLUMAG to resist the attack of abrasive or corrosive liquids processed at extreme temperatures. Surrounded by cast iron, the cylindrical-shaped measuring tube is lined with fused aluminum oxide for corrosion resistance and better performance value long term.

The most beneficial and unique characteristic of FLUMAG is its selectable current modulation feature The microprocessor-based electronics allows the user to choose between three different operating modes, Slow — Fast — Dual, depending on the type of liquid and flow conditions.

Foremost among the choices is the dual modulation selection. Combining five fast modulation cycles and one slow modulation cycle in a single measuring cycle, dual modulation optimizes response time, accuracy and noise filteration characteristics

In addition, the operating mode can be selected on-site and while in service without disrupting the flow or productivity of the flowmeter

The Schlumberger FLUMAG is the right choice in electromagnetic flowmeters for your operation. We're sure you will be pleased with its performance characteristics

MEASURING PRINCIPLE

The Schlumberger FLUMAG is a magnetic inductive flowmeter which measures volume flow of electrically conductive liquids

The basic FLUMAG operating principle utilizes Faraday's law i.e., the voltage induced in a conductive fluid which moves perpendicularly to a magnetic field is directly proportional to the velocity of the conductive fluid.

In the FLUMAG, a pair of coils defined as B1 and B2 (see illustration in Figure 1), is located transversely to the measuring tube While conveying a pulsed DC current, B1 and B2 produce an alternating magnetic field B. Continuous control of the intensity of the DC current ensures a stable and reproductive magnetic field.

The two diametrically opposed electrodes E1 and E2, separated by distance d and located transversely with respect to the axis of the pipe and perpendicularly with respect to the axis of the coils, pick up a voltage e when an electrically conductive fluid flows through the pipe at an average velocity V. Since the volumetric flow is related to the average velocity,

$e = kV$ (k is constant for a given flowmeter)

$k = a \times B \times d$ (where a is a geometrical factor, depending on the shape and the geometry of the measuring tube)

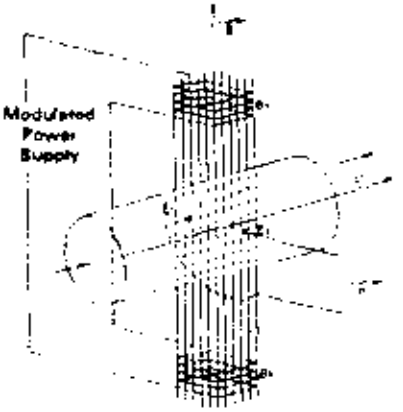


Figure 1

F. ,MAG'S features add . performance value

- Automatic zero operating principle
- Microprocessor-based electronics
- Built-in digital indicator
- Parameters configurable on-site while in service
- Low energy consumption
- Bi-directional flowmeter
- Built-in or remote electronics
- Displays flow rate or total
- ;lput signal proportional to rate of flow
- Flow measurement is independent of changes in pressure, temperature and viscosity
- Obstructionless ceramic flow tube
- CENELEC Approved-option —
  Transducer rating CENELEC EEx ia IIB T4 to T6 (Intrinsically Safe)
  Electronics must remain in safe area and contains an intrinsically safety barrier rated CENELEC [EEx ia] IIB
- 3-A Sanitary Standards Symbol Authorization for milk and milk products

Typical applications for FLUMAG

The Schlumberger FLUMAG is best used for the measurement of conductive liquids for batching, process control, totalization or volumetric counting.

Known for its application versatility the FLUMAG is adaptable for installation in numerous industries. A partial list of industries using FLUMAG includes:

- Chemicals and allied products
- Water processing and distribution
- Blast furnaces and steel mills
- Pharmaceutical preparations
- Mining
- Food preparations
- Sugar preparations and refineries
- Battery manufacturing

Typical applications for FLUMAG are liquids which are generally difficult to handle: slurries, abrasive or corrosive as well as liquids with extreme temperatures. Examples of these are waste water, sludge, slurries, pulp, pastes, juices, acids, alkalis, food products and many others.

PROGRAMMABLE OPERATING PARAMETERS

Engineering Units
LPH, CMPH, USGM, or IGPM

Modulation
Slow — Fast — Dual

Outputs
4-20 mA and scaled pulse

Multifunctional Electronic Display
(Four-Digit LCD)
Rate (percent of fullscale or engineering units)
Pulse integration
Error messages
Program parameters

Pulse Amplitude
5 volts with a minimum load of 2 k ohm or 24 volt, 0.2 Amps

Pulse Scaling
From 0.001 to 9999 unit per pulse

Full Scale Spaning
Minimum — 3.3 ft/s (1 m/s)
Maximum — 33 ft/s (10 m/s)

Alarms
High or low alarm setting: For a flow higher or lower than the alarm flow, a contact is triggered. One threshold is available at a time

Relay rating is either 48 volts 1 Amp or 220 volts 500 mA on resistive load.

Bidirectional
Plus (+) or minus (-) signal on the display for normal or inverted flow (relay contact open (+) or relay contact closed (-)). An alarm is not available in this case.

Flow Threshold
Threshold adjustable from 0 to 50 percent of full scale. For a flow lower than the threshold flow, the output signal is equivalent to 0 percent.

Response Time
Time Constant at 63%
Adjustable from 0.5 to 100 seconds

FLUMAG SPECIFICATIONS

Minimum Electrical Conductivity*	5 micro Siemens/cm
Accuracy*	±1.0% of rate [standard] ±0.5% of rate [optional] (N/A for 5/32", 1/4" & 3/8")
Repeatability	±0.1% of rate
Maximum Fluid Pressure	580.15 psi (40 bar)
Maximum Fluid Temperature	176°F (80°C) [built-in electronics] 302°F (150°C) [remote electronics]
Maximum Temperature Change (Ceramic)	113°F (45°C) per minute [fluid]
Velocity Range	.66-33 ft/s (.2-10 m/s) [lower velocities can be measured**]
Electronics Operating Temperature	-15°F (-25°C) to 131°F (55°C)
Power Supply Voltage	115 volts AC 60 Hz [standard] 220 volts AC 60 Hz [optional] 20-53 volts DC [optional] 220 volts AC 50 Hz [optional]
Power Consumption	11-13 volt amps
Outputs	4-20 mA and scaled pulse
High or Low Alarm	48 volts at 1 Amp or 220 volts at 1 mA
Electronics	Built-in or remote. NEMA IV enclosure.
Assembly Type	Wafer body type, assembled between either 150# or 300# ANSI flang
Materials of Construction	
Measurement Tube	Ceramic [fused aluminum oxide]
Electrodes	Platinum point
Tube Housing	Cast iron with polyurethane coating
Electronic Housing	Aluminum alloy with polyurethane coating

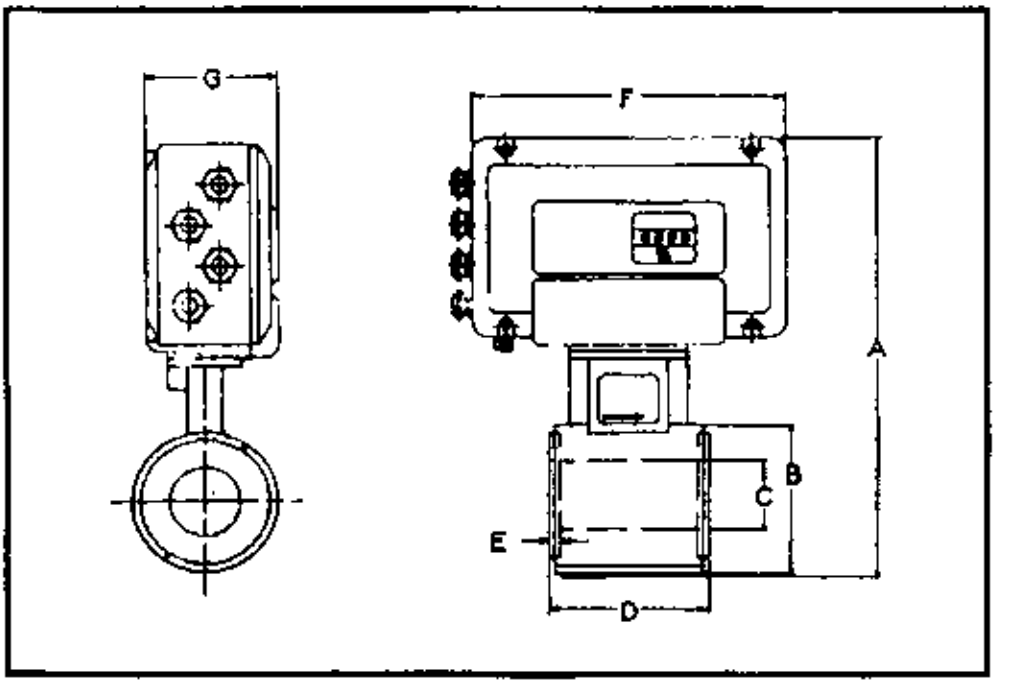
FLOW RATE

**For velocities less than .66 ft/s (.2 m/s) Accuracy = ±.2% fsc (±.1 fsc optional)

Model	Diameter	Minimum Full Scale @ 3.3 ft/s (1 m/s)	Maximum Full Scale @ 33 ft/s (10 m/s)
FM020*	5/32"	.04 to .20 gpm (1.5 to 75 lpm) [fsc]	.20 to 2.0 gpm (.75 to 7.5 lpm) [fsc]
FM025*	1/4"	.09 to .45 gpm (.33 to 1.7 lpm) [fsc]	45 to 4.4 gpm (1.7 to 16.7 lpm) [fsc]
FM040*	3/8"	.26 to 1.3 gpm (1 to 5 lpm) [fsc]	1.3 to 13.2 gpm (5 to 50 lpm) [fsc]
FM050*	1/2"	.44 to 2.2 gpm [fsc] (1.7 to 8.3 lpm) [fsc]	2.2 to 22 gpm [fsc] (8.3 to 83 lpm) [fsc]
FM100*	1"	1.3 to 6.5 gpm [fsc] (4.9 to 24.6 lpm) [fsc]	6.5 to 65 gpm [fsc] (24.6 to 246 lpm) [fsc]
FM150	1 1/2"	4.0 to 20 gpm [fsc] (15 to 76 lpm) [fsc]	20 to 200 gpm [fsc] (76 to 760 lpm) [fsc]
FM200	2"	5.4 to 27 gpm [fsc] (20 to 102 lpm) [fsc]	27 to 270 gpm [fsc] (102 to 1020 lpm) [fsc
FM300	3"	14.4 to 72 gpm [fsc] (54 to 272.5 lpm) [fsc]	72 to 720 gpm [fsc] (272.5 to 2725 lpm) [fs
FM400	4"	23.4 to 117 gpm [fsc] (89 to 443 lpm) [fsc]	117 to 1,170 gpm [fsc] (443 to 4430 lpm) [fs
FM600	6"	47 to 237 gpm [fsc] (178 to 897.1 lpm) [fsc]	237 to 2,370 gpm [fsc] (897.1 to 8971 lpm) [f

* 5/32" - 1" require 10 micro siemens/cm, otherwise multiply accuracy by 2.

PHYSICAL DIMENSIONS



Model	DIMENSIONS*							Weight*
	A	B	C	D	E	F	G	
FM020	10.12 (257)	1.97 (50)	.16 (4)	1.80 (46)	.16 (4)	8.3 (210)	3.5 (88)	10.4 (4.7)
FM025	10.12 (257)	1.97 (50)	.24 (6)	1.80 (46)	.16 (4)	8.3 (210)	3.5 (88)	10.4 (4.7)
FM040	10.12 (257)	1.97 (50)	.39 (10)	1.80 (46)	.16 (4)	8.3 (210)	3.5 (88)	10.4 (4.7)
FM050	10.4 (264)	2.2 (56)	.50 (13)	3.6 (92)	.16 (4)	8.3 (210)	3.5 (88)	10.4 (4.7)
FM100	10.9 (277)	2.9 (74)	.85 (22)	3.6 (92)	.16 (4)	8.3 (210)	3.5 (88)	11.0 (5)
FM150	11.9 (302)	3.6 (91)	1.5 (38)	3.9 (99)	.16 (4)	8.3 (210)	3.5 (88)	12.8 (5.8)
FM200	12.3 (312)	4.1 (104)	1.9 (48)	4.2 (107)	.16 (4)	8.3 (210)	3.5 (88)	14.3 (6.5)
FM300	13.8 (350)	5.6 (142)	3.0 (76)	6.4 (163)	.16 (4)	8.3 (210)	3.5 (88)	20.1 (9.1)
FM400	15.4 (391)	6.7 (170)	3.8 (97)	7.0 (178)	.16 (4)	8.3 (210)	3.5 (88)	26.4 (12)
FM600	18.6 (472)	8.7 (221)	5.5 (140)	9.9 (252)	.16 (4)	8.3 (210)	3.5 (88)	56.0 (25.4)

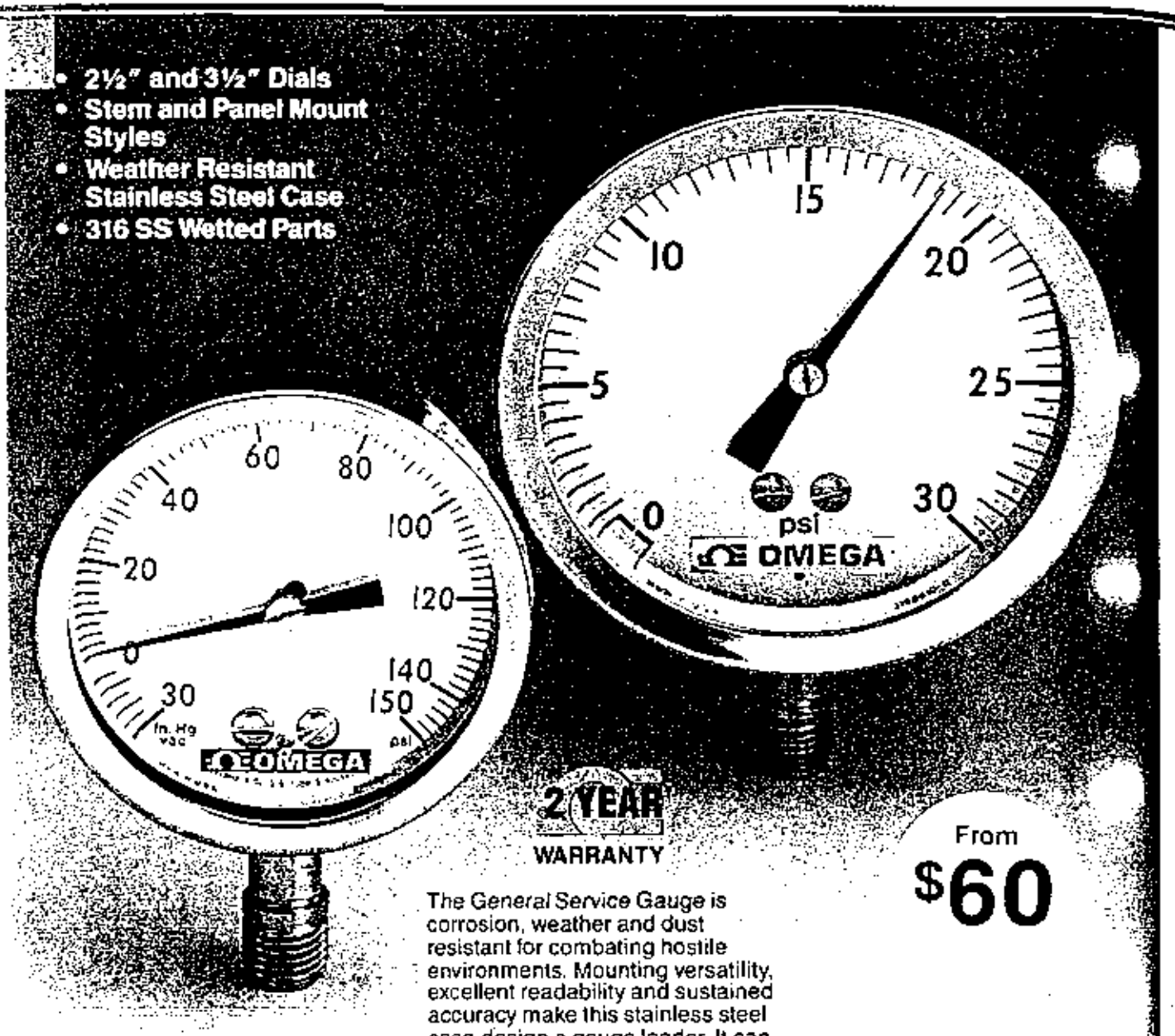
*Dimensions: inches (millimeters); Weight: pounds (kilograms)

Pressure Indicators

OMEGA GENERAL SERVICE GAUGES TYPE S

MADE IN USA

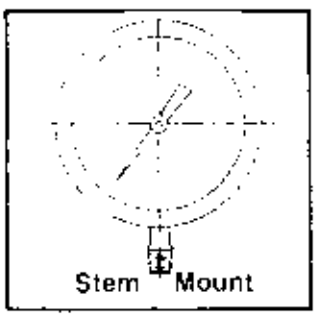
- 2½" and 3½" Dials
- Stem and Panel Mount Styles
- Weather Resistant Stainless Steel Case
- 316 SS Wetted Parts



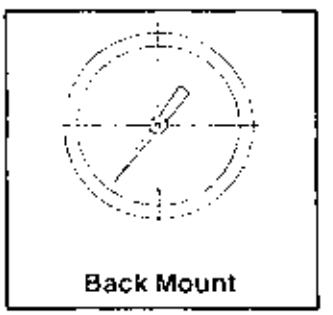
2 YEAR WARRANTY

From $60

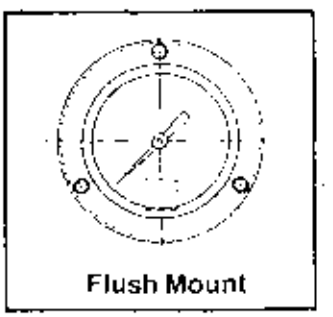
The General Service Gauge is corrosion, weather and dust resistant for combating hostile environments. Mounting versatility, excellent readability and sustained accuracy make this stainless steel case-design a gauge leader. It can be stem, surface or flush mounted.



STYLE L

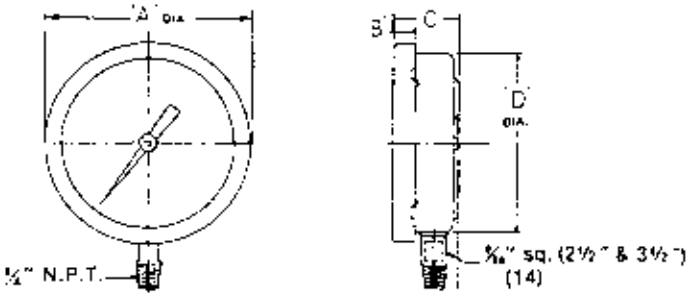


STYLE B

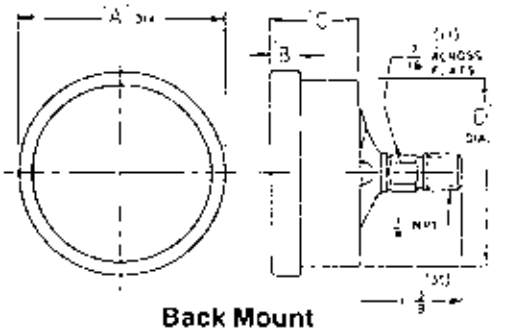


STYLE B
With Flange Mtg Kit shown on Page G-14.

GENERAL SERVICE GAUGES TYPE S



Stem Mount
STYLE L



Back Mount
STYLE B

SIZE (in.)	A	B	C	D
2½	2⅞ (73)	⅜ (10)	1 5/32 (29)	2 7/32 (67)
3½	3 11/32 (101)	15/32 (12)	1 7/32 (31)	3 19/32 (91)

Sustained accuracy and excellent readability are important user features of the OMEGA General Service Gauge line.

Meeting the requirements of many industrial applications, General Service Gauges may be used on steam boilers or other pressurized vessels; on pumps and compressors; on many types of industrial machinery; in the chemical, petrochemical and allied process industries, in power plants; in pulp and paper mills, plus in an unlimited number of low pressure applications using gauges with a bellows pressure element design.

The pressure gauge actuation systems that comprise the OMEGA General Service Gauge line is the standard 316 SS Bourdon tube system which is engineered to precise tolerances for consistent repeatability and response to pressure fluctuations.

SPECIFICATIONS

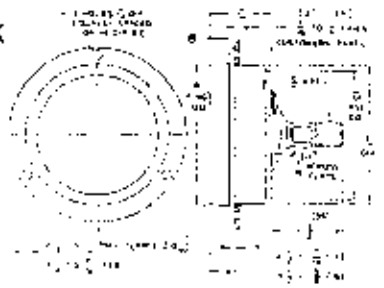
Max. Operating Temp: 150°F
Case: Polished Stainless Steel
Window: Polycarbonate Plastic with Neoprene Sealing Gasket
Bourdon Tube: 316 Stainless Steel
Connection: Back or Lower
Fitting: 316 SS, ¼" NPT
Dial Size: 2½" and 3½"
Mounting: Stem, Flange or "U" Bracket
Accuracy: 1% full scale

Warning: All gauge components should be selected considering media and ambient operating conditions to prevent misapplication. Improper application can be detrimental to the gauge, cause failure, and possible personal injury or property damage.

Accessories for Type S Gauges

MODEL NO.	DESCRIPTION	PRICE
UBK-25	U-Bracket Kit for 2½" Gage	$10
UBK-35	U-Bracket Kit for 3½" Gage	10
FMK-25	Flange Mount Kit for 2½" Gage	10
FMK-35	Flange Mount Kit for 3½" Gage	15

Model FMK
Flange Kit



For a Complete Listing of Stocked General Service Gauges, Refer to pg. G-15

Model UBK
U-Bracket

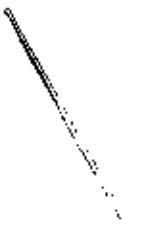
2½	2⅞ (73)	⅜ (10)	1 5/32 (29)	2 7/32 (67)	2 23/32 (69)	1/16 (2)	1/8 (4)	3 1/8 (79)
3½	3 11/32 (101)	15/32 (12)	1 7/32 (31)	3 19/32 (91)	3 11/16 (94)	1/32 (1)	1/32 (6)	4 9/16 (116)

2½	2⅞ (73)	1 1/8 (29)	2 11/16 (68)	2 7/32 (67)	1 1/32 (26)	2 1/16 (52)	1 7/32 (45)	⅜ (10)
3½	3 11/32 (101)	1 1/8 (27)	3 7/32 (93)	3 19/32 (91)	1 1/32 (31)	2 13/32 (61)	1 3/4 (44)	15/32 (12)

Down Hole Level Sensors

Electrodes.

General application electrodes.



Series 3R. These electrodes are metallic rods with one end threaded so they can be screwed into the couplings on electrode fittings to extend vertically down into the liquid. They are available in a variety of materials to satisfy the requirements of water and many corrosive solutions. Series 3T, tapered electrode, used in conjunction with fitting 3G.

Series 3W. Series 3W electrodes are metallic bars contained within a protective plastic shield. They are suspended above the liquid by the use of PVC-insulated wires. ⅞" dia. x 3¾" in length.

Table 23-1 General Application Electrodes

Series	Style	Material	Sheathing	Ordering Information (Page)
3RXXXX 3TXXXX	¼" rod (threaded) ¼" rod (tapered)	Brass 303 SS 316 SS Carp. 20 Hast. B Hast. C Monel Titanium	PVC (200°F) Teflon (500°F) Slip-on/ Heat Shrink	31
3WXX*	Wire Suspended	Brass 303 SS	Polyethylene Shield PVC coated wire (150°F)	31

*Material: Brass 30, 303 SS 31, 316 SS 32, Carp. 20 33, Hast. B 34, Hast. C 35, Monel 36, Titanium 37. Ordering required at time of purchase.

Corrosion-resistant electrode.

Series 3Y. Corrosion-resistant metallic bars within a protective plastic shield designed for use in corrosive liquid applications. Suspension wire is PVC-jacketed and is attached to the electrode at the factory. ⅞" dia. x 3½" in length.

Table 23-2 Corrosion-Resistant Electrode

Series	Style	Tip Material	Shield Material	Ordering Information (Page)
3YXXX	Wire Suspended	Carp. 20 Hast. B Hast. C 316 SS	PVC (150°F)	31

Chart 23-3 Sensitivity-Material Selection

Liquid Or Material	Sensitivity-Conductivity Ohms/cm	Sensitivity-Conductivity Micro-Mhos/cm	Electrode Material Good*	Electrode Material Better**
†Acids	Consult Factory		Consult Factory	
Aluminum Hydroxide	2.2K	450	316 SS	Titan
Aluminum Sulfate	2.2K	450	303 SS	Hast. C
Ammonia	5K	200	316 SS	N.A.
Ammonium Chloride	1K	1K	316 SS	Titan
Ammonium Hydroxide	10K	100	316 SS	Titan
Ammonium Nitrate	18K	50	303 SS	316 SS
Ammonium Sulfate	10K	100	316 SS	Titan
Baby Foods	5K	1K	303 SS	316 SS
Barium Chloride	1K	1K	Carp. 20	N.A.
Barium Nitrate	1K	1K	316 SS	N.A.
Beer	2.2K	450	303 SS	316 SS
Black Liquor	1K	1K	Consult Factory	
Borax - Aqueous	10K	100	Brass	303 SS
Bourbon	200K	5	N.A.	316 SS
Brine	1K	1K	N.A.	Hast. C
Buttermilk	1K	1K	N.A.	316 SS
Cadmium Chloride	1K	1K	316 SS	N.A.
Cadmium Nitrate	1K	1K	316 SS	N.A.
Cake Batter	5K	200	303 SS	316 SS
Calcium Chloride	1K	1K	Carp. 20	Hast. C
Calcium Hydroxide	10K	100	316 SS	Titan
Catsup	2.2K	450	303 SS	316 SS
Caustic Soda	1K	1K	316 SS	Hast. B
Cement Slurry	5K	200	303 SS	316 SS
Coffee	2.2K	450	303 SS	316 SS
Corn Syrup	45K	21	303 SS	316 SS
Corn—Cream Style	2.2K	450	303 SS	316 SS
Ferric Chloride	10K	100	N.A.	Titan
Ferrous Sulfate	10K	100	Carp. 20	Titan
Ink (Water Base)	2.2K	450	N.A.	316 SS
Jams/Jellies	45K	21	303 SS	316 SS
Juices—Fruit/Vegetable	1K	1K	303 SS	316 SS
Lithium Chloride	1K	1K	N.A.	Carp. 20
Magnesium Chloride	1K	1K	316 SS	Carp. 20
Magnesium Hydroxide	2.2K	450	316 SS	N.A.
Mayonnaise	5K	200	303 SS	316 SS
Mercuric Chloride	90K	11	N.A.	Titan
Milk	1K	1K	303 SS	316 SS
Molasses	10K	100	303 SS	316 SS
Mustard	1K	1K	303 SS	316 SS
Oil—Soluble	10K	100	N.A.	303 SS
Paper Stock	5K	200	Titan	N.A.
Photographic Solutions	1K	1K	316 SS	Hast. C
Plating Solutions	2.2K	450	N.A.	316 SS
Potassium Chloride	1K	1K	316 SS	Titan
Salts—Chemical	2.2K	450	Monel	N.A.
Sewage	5K	200	303 SS	316 SS
Silver Nitrate	1K	1K	316 SS	Carp. 20
Soap Foam	18K	50	303 SS	316 SS
Sodium Carbonate	2.2K	450	316 SS	Monel
Sodium Hydroxide	1K	1K	316 SS	Hast. B
Soups	1K	1K	303 SS	316 SS
Starch Solutions	5K	200	303 SS	316 SS
Sugar Solutions	90K	11	303 SS	316 SS
Vinegar—Aqueous	2.2K	450	316 SS	Carp. 20
Water—Carbonated	3K	330	303 SS	316 SS
Water—Condensate	18K	50	Brass	303 SS
Water—Chlorinated	5K	200	316 SS	Mone
Water—Distilled	450K	2	Brass	303 SS
Water—Deionized	2.0M	5	Brass	303 SS
Water—Hard/Natural	5K	200	Brass	303 SS
Water—Salt	2.2K	450	Mone	N.A.
Wine	2.2K	450	303 SS	316 SS
Zinc Chloride	1K	1K	Carp. 20	Titan
Zinc Sulfate	2.2K	450	316 SS	Titan

*Less than .020" erosion per year

**Less than .002" erosion per year

†Note: Liquid concentration and temperature will affect conductivity and material erosion rate. Contact factory for detailed information.

N.A. —No material available with this erosion rate

Series 3U Electrode Fittings

ORDER BY COMPONENT NUMBER ---------- 3UXX

3RD PLACE SYMBOL

	Conduit Size and No. of Electrodes
1	½", 1-5
2	¾", 1-7
3	1", 1-10

4TH PLACE SYMBOL

	Body Material
A	PVC
B	Cast Iron

Series 3W Electrodes

ORDER BY COMPONENT NUMBER ---------- 3WX

Component Number 3Z1A—Suspension Wire

Component Number 3Z1B—Adapter Kit

3RD PLACE SYMBOL

	Electrode Material
1	Brass
2	303 SS

Series 3R or 3T Electrodes

ORDER BY COMPONENT NUMBER ---------- 3RXXXX* or 3TXXXX*

3RD PLACE SYMBOL

	Length (Feet)
1	One
2	Two
3	Three
4	Four
5	Five
6	Six
	et cetera

4TH PLACE SYMBOL

	Electrode Material
A	Brass
B	303 SS
C	316 SS
D	Carp 20
E	Hast B
F	Hast C
G	Monel
H	Titanium

5TH PLACE SYMBOL

	Sheathing Slip-On
0	None
1	PVC
2	Teflon
	Sheathing Heat Shrink
4	PVC
5	Teflon

Use only when tips are required

6TH PLACE SYMBOL

	Electrode Tip
A	303 SS
B	316 SS

* Specify exact length of electrode

Series 3Y Electrodes

ORDER BY COMPONENT NUMBER ---------- 3YXXX

3RD PLACE SYMBOL

	Shield Material
1	PVC

4TH PLACE SYMBOL

	Electrode Tip Material
C	316 SS
D	Carp 20
E	Hast B
F	Hast C

5TH PLACE SYMBOL

	Length of Wire
1	10 feet
2	20 feet
3	30 feet
	et cetera

Component Number 3Z1B—Adapter Kit

Limited Warranty and Remedy

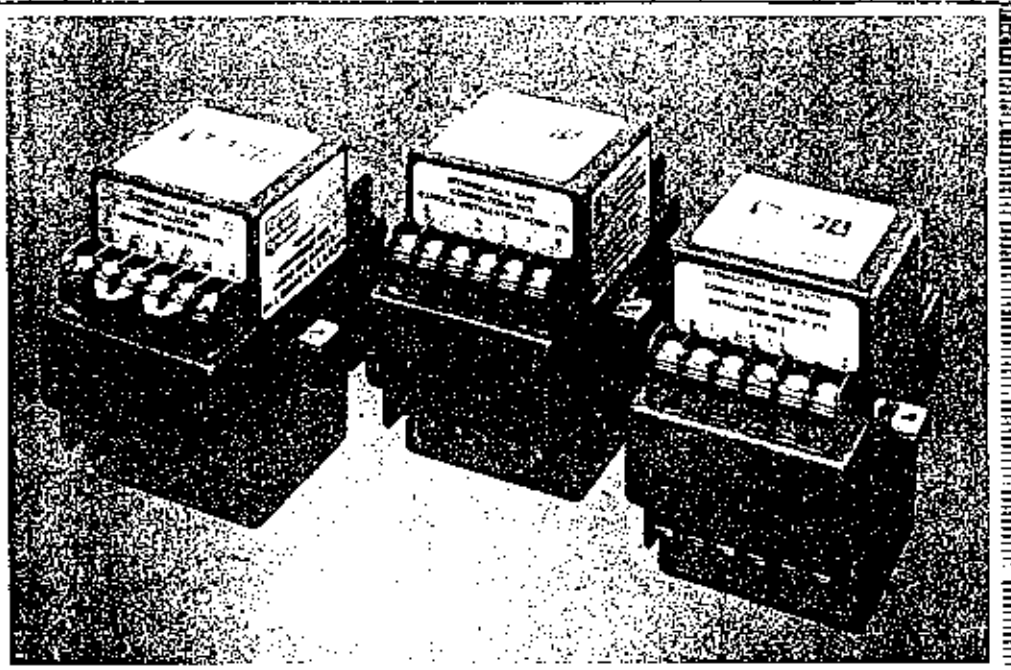
Warrick Controls, Inc. warrants to the original user that those products supplied by it and used in the service and in the manner for which they are intended shall be free from defects in materials and workmanship for a period of one (1) year after installation, or fifteen (15) months from date of shipment. Except as may be expressly provided for in a written agreement between WARRICK and the user, WARRICK DOES NOT MAKE ANY OTHER REPRESENTATIONS OR WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OR MERCHANTABILITY AND ANY IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE.

The sole and exclusive remedy with respect to the above limited warranty or with respect to any other claim relating to defects or any other condition or use of the products supplied by Warrick, however caused, and whether such claim is based upon warranty, contract, negligence, strict liability or any other theory, is limited to the repair or replacement of the part or product, excluding any labor or any other cost to remove or install said part or product or, at Warrick's option, to repayment of the purchase price. Notice of any such claim must be given, in writing, to Warrick Controls, Inc., Royal Oak, Michigan 48073, within fifteen months after the first installation or use of the products. In no event shall Warrick be liable for special, direct, indirect or consequential damages, including, but not limited to, loss of use or profits or to interruption of business activity.

Level Controllers

WARRICK CONTROLS

Now, three Warrick options for Intrinsically Safe Interface Controls... FM, CSA and UL approved



The Warrick Series 17, Series 27 and Series 37 Intrinsically Safe Interface Controls.

You depend on the FM-approved Warrick Series 17, and the UL-approved Series 27 control for safety and reliability in intrinsically safe (I.S.) circuits. Now, the Warrick Series 37 provides the same peace of mind for applications requiring CSA approval.

Two isolated SPST contacts (1 N.O. and 1 N.C.) on the Series 17 permit the handling of two loads of different voltages. The Series 27/37 has one set of SPDT contacts for handling loads of the same voltage.

Different features for different needs. But the Series 17, Series 27 and the Series 37 come with Warrick built-in reliability.

Operation/applications.

Warrick's Series 17/27/37 controls provide an intrinsically safe interface for applications where the control equipment and/or associated wiring are exposed to Class I and II, Division I, Groups A, B, C, D, E, F or G hazardous locations. The Series 27/37 are approved for Class III locations.

Series 17/27/37 controls may serve as an interface between a float, a push-button, a temperature switch or any non-powered switch installed in a hazardous area to provide an intrinsically safe circuit to that switch. In addition, they can be used as level controls in probe-type systems to provide a switch closure to turn on lights, control a pump, etc., for liquids, semi-solid and solid materials of less than 470,000 ohm-centimeters specific resistance.

Warrick's Series 17/27/37 controls are the ideal solution to your liquid level problems in the sewage industry as an interface to mercury floats or conductance-type probe systems.

They also can be used for interfacing to alarm/pump sensors in oil/water separators, air strippers and other groundwater remediation equipment.

You can depend on them, too, for versatility, convenience and security in providing intrinsically safe circuits in chemical plants and industrial sites with high dust levels. Here's why.

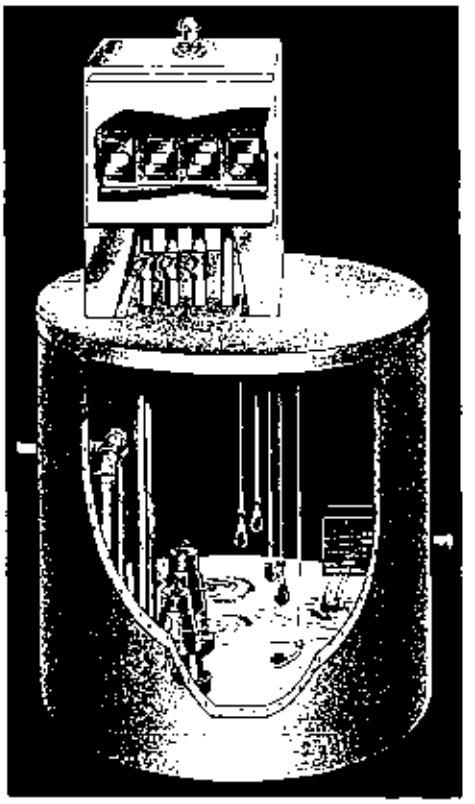
Intrinsically safe.
The intrinsically safe circuit is incapable of releasing sufficient energy to ignite flammable gases or dust found in hazardous areas.

Reliability.
All three controls are designed to virtually eliminate false triggering through dependable circuitry and relay outputs. Internal surge suppression eliminates spikes and transients, thus protecting the control.

Stability.
Variable sensitivity allows you to match the sensitivity of the control to your specific application, thus reducing the probability of false triggering (Sensitivity is field adjustable on Series 17, factory set on Series 27/37.)

Capacity.
An 8 amp rating permits handling of larger loads without the expense of extra equipment such as slave relays. All controls can handle up to a size "3" motor starter.

Lift station installation.



Versatility.
Latching and non-latching service are standard in the same unit. No separate latching relay is necessary. This means that for typical five-float systems, only four Warrick intrinsically safe controls are necessary. Normally open and normally closed load contacts permit simultaneous handling of two loads. Inverse mode is available for failsafe operation.

Safety. Efficiency. Reliability. We've built them into Warrick's Series 17/27/37. So you can build in peace of mind.

Intrinsic Safety — Why and How

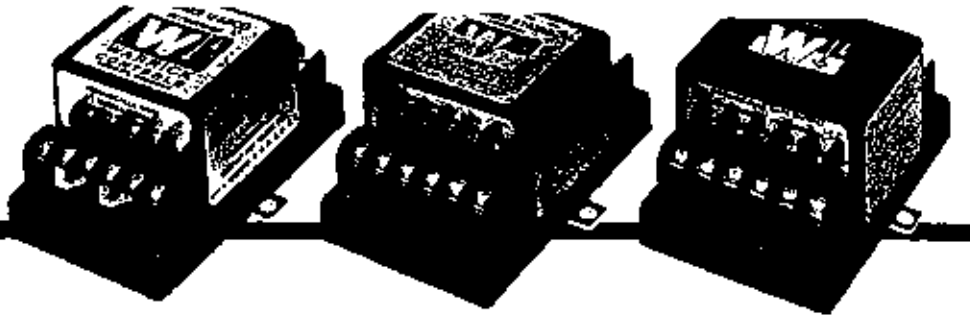
Compared to an Explosion-Proof (E.P.) electrical system, an Intrinsically Safe (I.S.) system has several important advantages.

1. Safety. No explosion can occur in an intrinsically safe system under any operating condition. In explosion-proof systems, explosions may occur, but will be confined within an explosion-proof enclosure.

2. Reliability. The components of I.S. circuits are tested for reliability before they are certified as intrinsically safe. E.P. system components are not tested for reliability. Instead, their enclosures are tested for their ability to contain an explosion.

3. Easier Installation. In an I.S. system, rigid metallic conduit or explosion-proof enclosures do not have to be installed in the hazardous area. The interface controls can be mounted in standard enclosures when installed in the safe area.

4. Economy. I.S. systems do not require expensive enclosures. I.S. certification implies that, when the system is properly installed, an explosion is an impossibility. Therefore, insurance rates also tend to be lower.



Series 17 Specifications

Contact Design: (1 Form A, 1 Form B): one normally open (N.O.) and one normally closed (N.C.)

Contact Ratings: 8 amperes resistive load at 250 volts A.C. and 5 amperes at 30 volts D.C.

Contact Life: Electrical at rated load = 100,000 cycles min
Mechanical = 10,000,000 cycles min

Electronics Module: Solid state components epoxy encapsulated in nylon shell

Primary (A.C. Supply Line):
(a) Voltage: 24 volt, 120 volt, 240 volt A.C., plus 10% minus 15%
(b) Frequency: 50/60 Hertz
(c) Power: Relay-energized: 8 watts

Secondary: Nominal voltage 12 VAC, 3 milliamps

Sensitivity: Operates from: 0-470,000 ohm maximum specific resistance

Temperature: -40 to +120 degrees F ambient

Terminals: Size 6 pan head screws with captivated wire clamping plate

Approval: Factory Mutual

Series 27, Series 37 Specifications

Contact Design: SPDT (1 Form C): one normally open (N.O.) and one normally closed (N.C.).

Contact Ratings: 8 amperes resistive load at 120 VAC, 250 volts A.C. and at 30 volts D.C.

Contact Life: Electrical at rated load = 100,000 cycles min
Mechanical = 10,000,000 cycles min

Electronics Module: Solid state components epoxy encapsulated in nylon shell

Primary (A.C. Supply Line):
(a) Voltage: 120 volt, 240 volt A.C., plus 10% minus 15%
(b) Frequency: 50/60 Hertz
(c) Power: Relay-energized: 7.2 watts

Secondary: Nominal voltage 11.3 VAC, 2.3 milliamps

Sensitivity: Operates from 0-100,000 ohm maximum specific resistance

Temperature: -40 to +150 degrees F ambient

Terminals: Size 6 pan head screws with captivated wire clamping plate

Approval: Series 27 — Underwriters Laboratory, Series 37 — CSA

Options and how to order.

SERIES 17 X X X X

17 X X X X

- **Enclosure:** 0 — open (no enclosure); 1 — Nema 1 enclosure
- **Sensitivity (ohms):** C — 3,300; D — 4,700; E — 10,000; F — 22,000; G — 47,000; H — 100,000; J — 220,000; K — 470,000
- **Power Supply:** 1 — 120 VAC, 50/60 Hz; 2 — 240 VAC, 50/60 Hz; 3 — 24 VAC, 50/60 Hz
- **Mode of Operation:** A — Direct; B — Inverse
- ***Control Series***

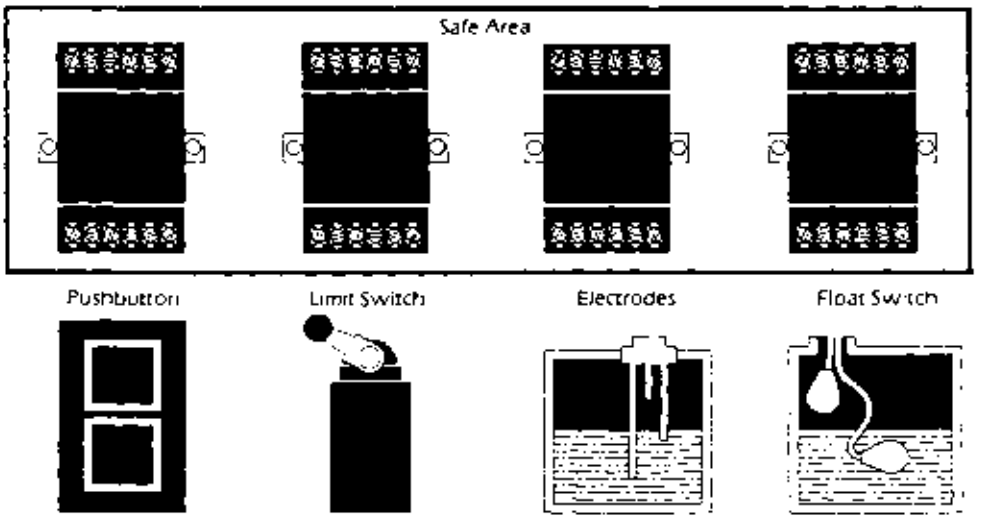
SERIES 27-37 X X X X

27 X X X X
37 X X X X

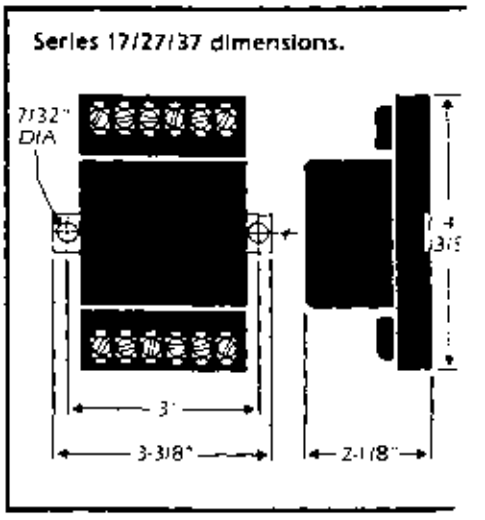
- **Enclosure:** 0 — open (no enclosure); 1 — Nema 1 enclosure
- **Sensitivity (ohms):** D — 3,000; E — 10,000; G — 100,000
- ***Primary AC Supply:*** 1 — 120 VAC; 2 — *240 VAC (50/60 Hz)
- ***Mode of Operation:*** A — Direct; B — Inverse
- **Control Series**

*Series 37 not available in 240 VAC

Series 17/27/37 Instrinsically safe systems. Locating the Series 17/27/37 control in a "safe" area and wiring it through an approved seal into "hazardous" areas provides an intrinsically safe circuit for a variety of applications.



Series 17/27/37 dimensions.



Hazardous Locations and the National Electrical Code*

Articles 500-516 of the National Electric Code* cover installations in hazardous locations. The following material is reprinted with permission from NFPA 500-1984, National Electric Code*, Copyright © 1984, National Fire Protection Association, Quincy, MA 02269. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety.

500-4. Class I Locations. Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitible mixtures. Class I locations shall include those specified in (a) and (b) below.

(a) Class I, Division 1. A Class I, Division 1 location is a location: (1) in which ignitible concentrations of flammable gases or vapors can exist under normal operating conditions, or (2) in which ignitible concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage, or (3) in which breakdown or faulty operation of equipment or processes might release ignitible concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment.

(b) Class I, Division 2. A Class I, Division 2 location is a location: (1) in which volatile flammable liquids or flammable gases are handled, processed or used, but in which the liquids, vapors or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment; or (2) in which ignitible concentrations of gases or vapors are normally prevented by positive mechanical ventilation, and which might become hazardous through failure or abnormal operation of the ventilating equipment, or (3) that is adjacent to a Class I, Division 1 location, and to which ignitible concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

500-5. Class II Locations. Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations shall include those specified in (a) and (b) below.

(a) Class II, Division 1. A Class II, Division 1 location is a location: (1) in which combustible dust is in the air under normal operating conditions in quantities sufficient to produce explosive or ignitible mixtures, or (2) where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitible mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, operation of protection devices, or from other causes; or (3) in which combustible dusts of an electrically conductive nature may be present in hazardous quantities.

(b) Class II, Division 2. A Class II, Division 2 location is a location where combustible dust is not normally in the air in quantities sufficient to produce explosive or ignitible mixtures, and dust accumulations are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus, but combustible dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment and where combustible dust accumulations on, in or in the vicinity of the electrical equipment may be sufficient to interfere with the safe dissipation of heat from electrical equipment or may be ignitible by abnormal operation or failure of electrical equipment.

500-6. Class III Locations. Class III locations are those that are hazardous because of the presence of easily ignitible fibers or flyings, but in which such fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitible mixtures. Class III locations shall include those specified in (a) and (b) below.

(a) Class III, Division 1. A Class III, Division 1 location is a location in which easily ignitible fibers or materials producing combustible flyings are handled, manufactured or used.

(b) Class III, Division 2. A Class III, Division 2 location is a location in which easily ignitible fibers are stored or handled.

National Electric Code* and NEC* are Registered Trade marks of the National Fire Protection Association, Inc. Quincy, MA

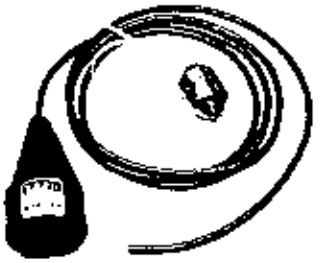
Other Warrick Products

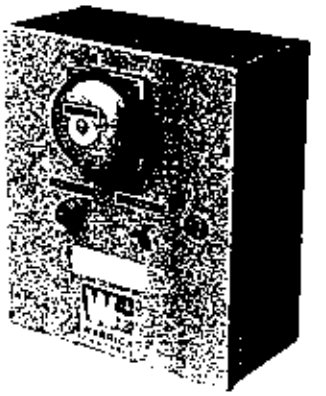
Series F—Mercury Tilt Float Switch

Features of the Warrick Mercury Tilt Float Switch include a completely potted mercury switch and electrical connections, oil resistant cable, polypropylene outer shell, various contact ratings and configurations, and polyurethane foam filling.

These floats are ideal for use in sewage lift stations, slurries, municipal drainage sumps, waste treatment facilities, holding tanks, etc.

Request form #230.





Level Control Systems

Warrick's system control panels range from simple, single-function devices to multiple-function systems with multiple-level controls, peripheral equipment such as lights, solid state horns and motor controls. Systems can be built into a single enclosure of Nema Types 1, 3R, 4, 7, 9 or 12. Warrick engineers can assist you in evaluating your application and will recommend a system to meet your individual requirements.

When control is absolutely essential.

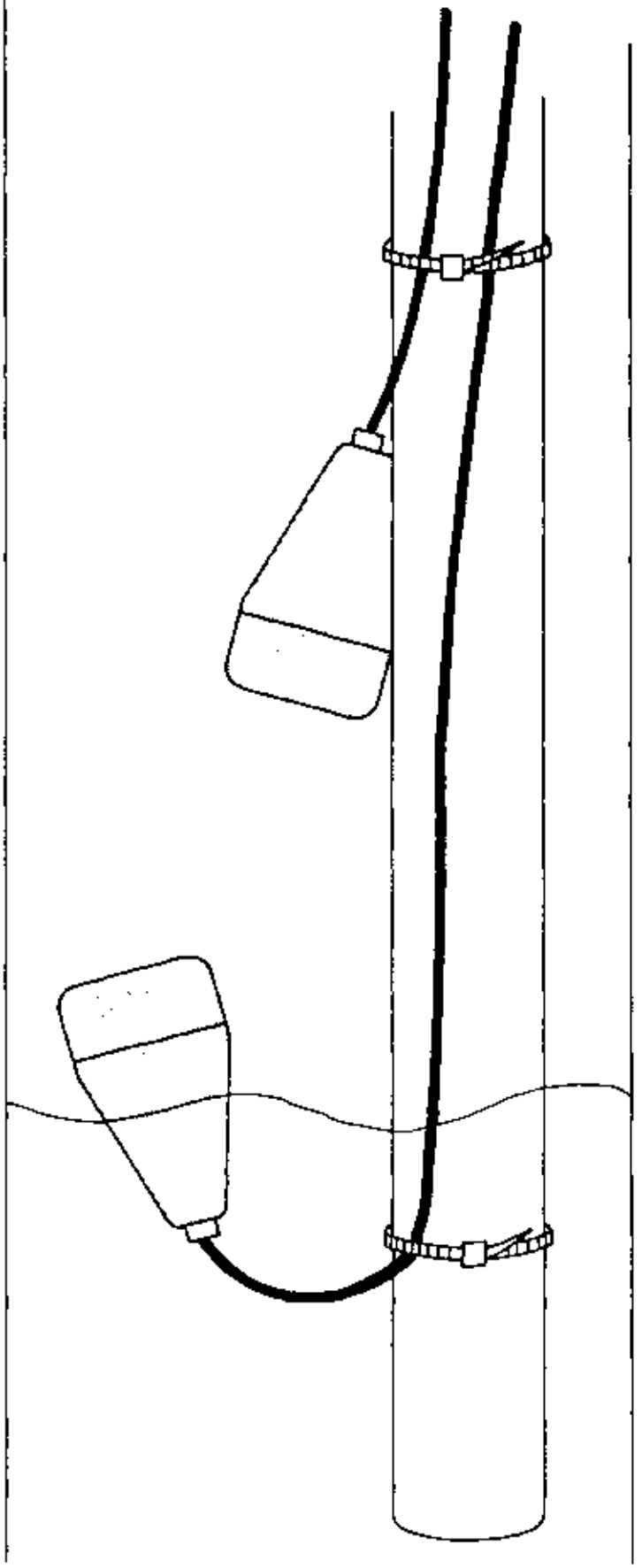
WARRICK CONTROLS

Warrick Controls, Inc.
4237 Normandy Court
Royal Oak, MI 48073
Telephone: 313/545-2512
Telex: 23-0454
Fax: 313/549-4904

A Subsidiary of Armstrong International, Inc.

Float Switches

WARRICK CONTROLS
SERIES F
MERCURY TILT FLOAT SWITCH



Applications

Warrick's Mercury Tilt Float Switch is ideal for use in difficult liquids such as in sewage lift stations, slurries, municipal drainage sumps, waste treatment facilities, holding tanks, etc.

Reliability

Our Mercury Tilt Float Switch consists of oil resistant cable securely soldered to a stainless steel mercury capsule which is housed in a durable polypropylene outer shell. The mercury capsule and electrical connections are epoxy potted internally protecting the critical parts from moisture and vibration. The remaining inside of the float is foam filled adding strength and buoyancy under severe conditions.

Flexibility

Warrick offers the Series F for virtually any application. Whether connected to an intrinsically safe control or directly to a pump motor starter, Series F Mercury Tilt Float Switches can be used for level control as well as alarms. Models are available in either normally open or normally closed contacts, with various contact ratings, and cable lengths.

For further information, contact your Warrick Controls representative.

NOTE: If application requires an intrinsically safe circuit, request Bulletin 271.

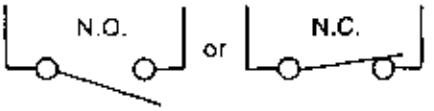
WARRICK CONTROLS

Specifications

Contact Rating*: Models F-BLK-XX-X and F-RED-XX-X, 1 AMP @ 240 VAC or 2 AMP @ 120 VAC. Models F-BLU-XX-X and F-YEL-XX-X, 1/3 HP @ 120 VAC, 20 AMP @ 120 VAC and 10 AMP @ 240 VAC.

Temperature- 0-140° F Ambient

Switch Design- Single pole single throw stainless steel mercury switch.



Cable Type: #16 A.W.G., 2 conductor type SJTO, oil resistant PVC.

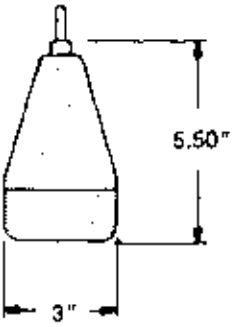
Outer Shell: Impact resistant and corrosion resistant polypropylene.

Internal: Polyurethane foam filled. Chemical resistant hysol epoxy

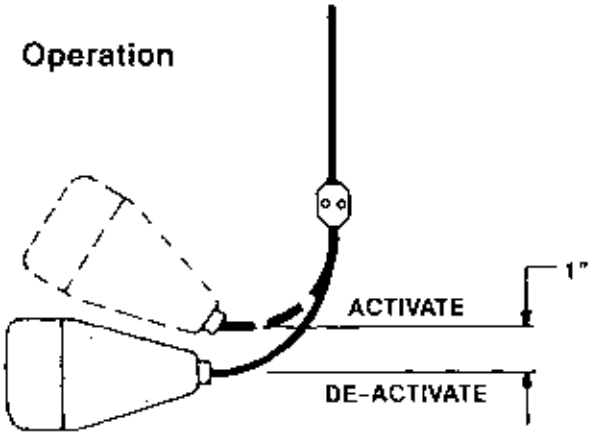
Overall Weight: (Without lead weight)- 2.5 lbs.

*Contact ratings are for resistive loads.

Dimensions



Operation

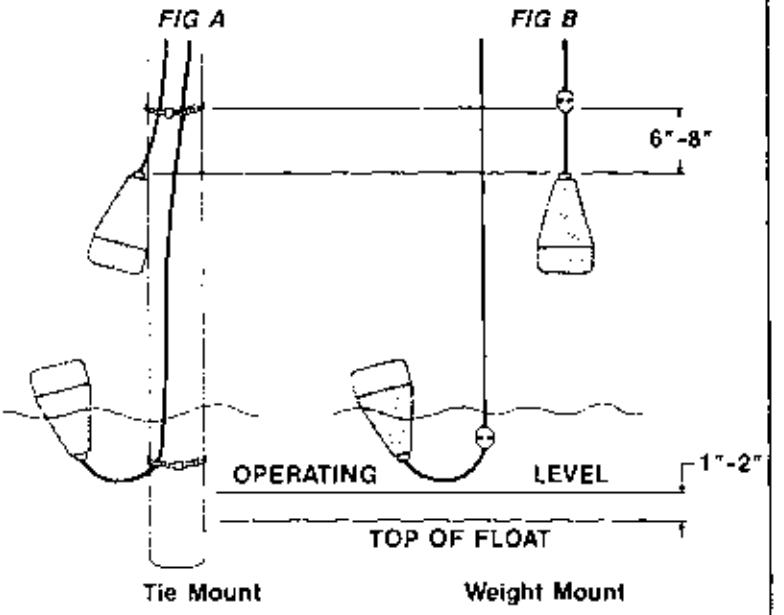


WARRICK CONTROLS, INC.

4237 Normandy Court (48073)
P.O. Box 460
Royal Oak, Michigan 48068-0460
313/545-2512 • Telex. 230454

A Subsidiary of Armstrong International

Installation of Warrick Series F Mercury Tilt Float Switch



Tie Mount (Fig A)

1) To install float using support pipe, locate top of float 1 - 2 inches below desired operating level.
2) Attach float cable to pipe 6 - 8 inches above top of float using enclosed wire tie. Be sure the serrations on the tie are on the inside.

Weight Mount (Fig B)

1) For weight mount installation, slip slotted tubing over float cable 6 - 8 inches above float.
2) Assemble two halves of lead weight around tubing and securely tighten using two self tapping screws. A slight gap may exist between the two halves.
3) Hang float from above with top of float 1 - 2 inches below desired operating level.

How To Order

Series F -XXX-XX- X

Mounting

T	Wire Tie
W	Weight

Length

20	20 Feet
40	40 Feet

Contact Design

BLK	1 AMP Normally Open
RED	1 AMP Normally Closed
BLU	10 AMP Normally Open
YEL	10 AMP Normally Closed

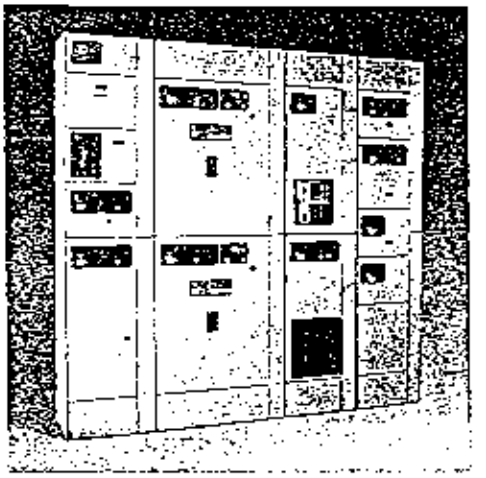
Warrick Mercury Tilt Float Switch

When level control is absolutely essential.

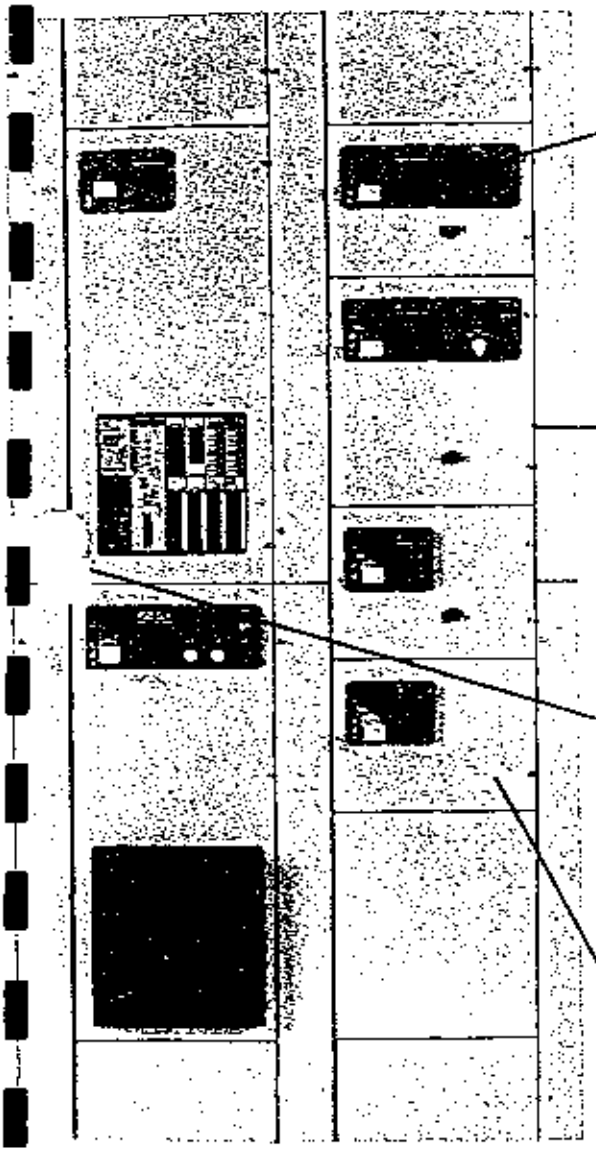
Motor Control Center

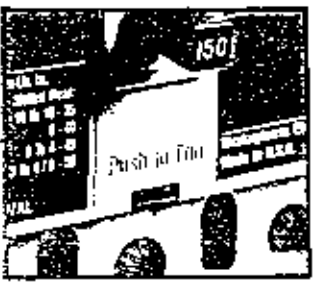
Our newest Motor Control Center has 23,000-plus improvements.

Introducing the Series 2100 from Westinghouse.



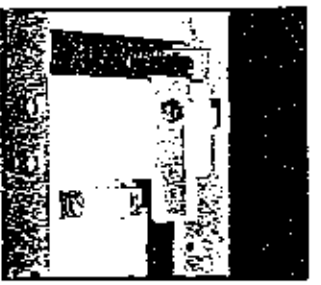
so many ways
hillion-plus needs.





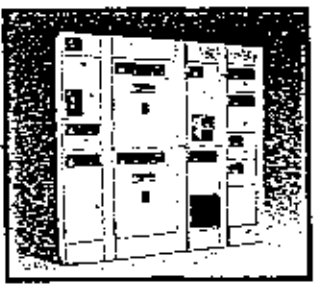
Improvement 23,000 Plus Four: Standard Push To Trip.

Simply by pressing a button, the trip unit and related mechanical parts can be dependably, economically and quickly tested.



Improvement 23,000 Plus Five: Standard Double Grounding.

All plug-in units are grounded through a metal-to-metal connection, and by a ground clip, ensuring a positive unit to structure ground for personnel safety.



Improvement 23,000 Plus Six: Standard Smaller Overall Size.

Depending on its rating, a Series 2100 Motor Control Center has a smaller configuration than others in the industry.

Yet, it will match and line up with a Five Star Motor Control Center without transition sections or modifications of any kind.

Improvement 23,000 Plus Seven: Standard J Interlock.

A newly designed electrical interlock is standard. It improves conductivity and increases electrical life

But, we didn't stop there. We added other standard improvements, then included one of the widest ranges of options available, including IQ Data Plus solid state digital metering, Accutrol adjustable frequency drives, Numa Logic* programmable controllers, vacuum starters, Easy Start solid state reduced voltage [illegible]ers and more. All backed by our Quick Ship accelerated delivery programs.

[illegible]oday, you can specify, and we can build, a Series 2100 Motor Control Center in a million-plus ways and deliver it where and when you need it.

Series 2100.
Innovation in Motor Control Centers.

The Series 2100 Motor Control Center is in production and available now. It is being manufactured at our main manufacturing center in Fayetteville, NC and at our five Service Centers. So you are within 700 miles of the answer to your Motor Control Center needs.

For more information on the Series 2100 Motor Control Center, contact your local distributor or any of these locations:

Fayetteville, NC
2900 Doc Bennett Road
Fayetteville, NC 28306
Phone: (919) 483-2222

Houston, TX
4650 South Pinemont Avenue
Suite 125
Houston, TX 77041
Phone: (713) 939-9696

Los Angeles, CA
12810 East Florence Avenue
Sante Fe Springs, CA 90670
Phone: (213) 944-6413

Chicago, IL
500 East Touhy Avenue
Des Plaines, IL 60018
Phone: (312) 299-1911

Portland, OR
6024 S. W. Jean Road
Building C-8
Lake Oswego, OR 97034
Phone: (503) 221-4446

Hartford, CT
16 International Drive
Building 16
East Granby, CT 06026
Phone: (203) 653-5061

Experience

You can be sure...
if it's Westinghouse

SA-11494 Printed in U.S.A. 20M 2/87

It's innovative that it can meet a

Improvements One through 23,000: 23,000 higher interrupting capacity... standard.

By using the Series C̄ Circuit Breaker, even the most basic Series 2100 Motor Control Center has an interrupting capacity of 65,000 amperes. By increasing the standard withstand rating, the Series 2100 Motor Control Center meets more needs now and more requirements in the future.

Improvement 23,000 Plus One: IQ Data Plus solid state digital metering.

When instrumentation to monitor incoming power is required, the IQ Data Plus uses digital readouts to display voltage, current, watts, VARS, power factor, demand and frequency with switchboard instrument accuracy.

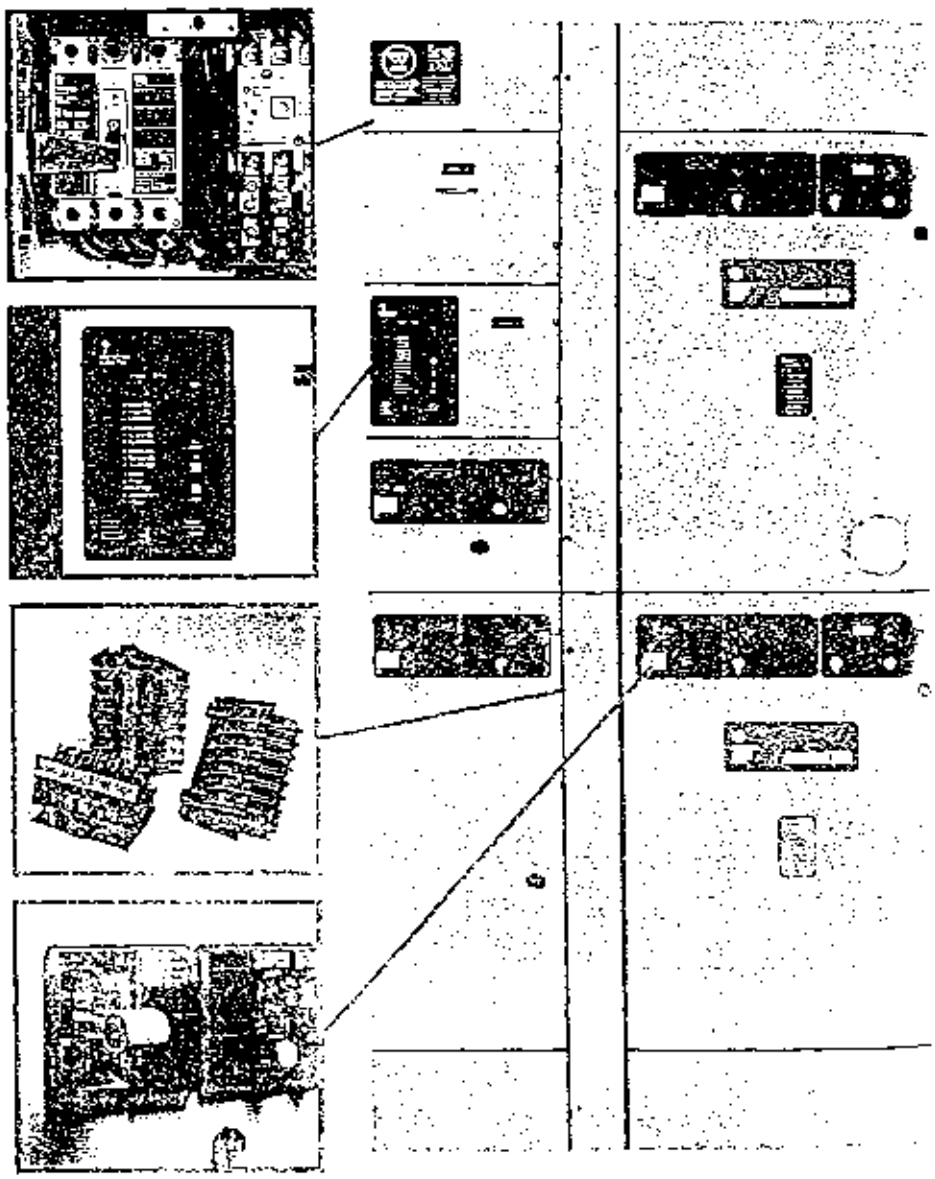
(When required, analog instrumentation can be specified.)

Improvement 23,000 Plus Two: Standard Pull-Apart Terminal Blocks.

Patented pull-apart terminal blocks speed installation and startup. They also reduce maintenance downtime and help to ensure that wiring is reconnected correctly.

Improvement 23,000 Plus Three: Standard Visual Tripped Indication.

Just by glancing, you can tell if a starter is on, off or in a tripped condition.

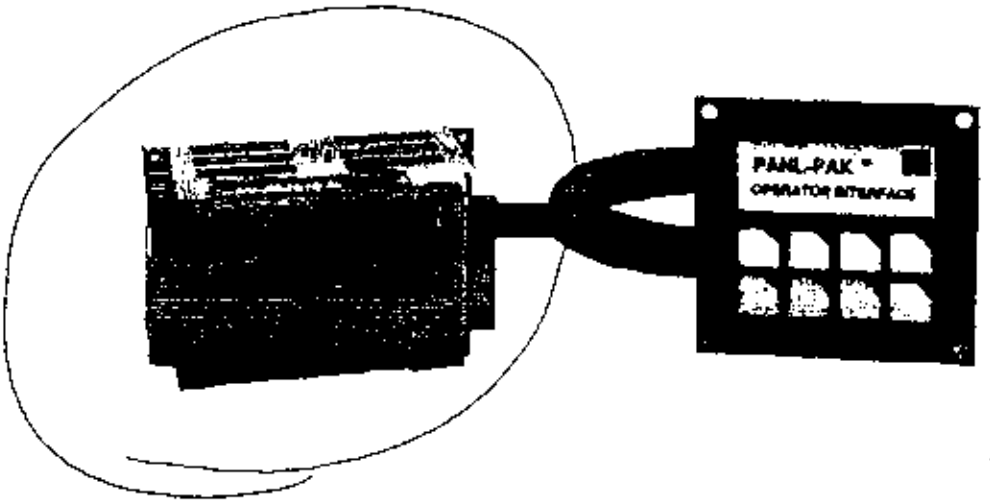


When Westinghouse created our Series 2100 Motor Control Center, we used one component that instantly improved it 23,000 ways. That component is our Series C̄ Circuit Breaker.

The result is a Motor Control Center with a standard withstand rating of 65,000 amperes. That's 23,000 amperes higher than the previous standard of 42,000 and one reason the Series 2100 Motor Control Center is the most flexible ever offered by Westinghouse.

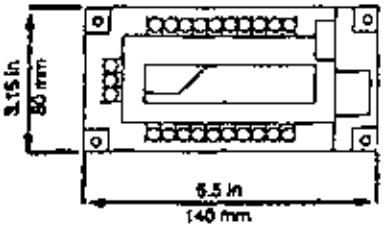
Order Information

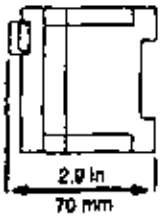
Class 8003



Input Specifications

Number of Inputs	8 points (M3 screw terminal)
Input Signals	NPN open collector
Source Type	transistor input; No-voltage mechanical contact input
	PNP open collector
Sink Type	transistor input; No-voltage mechanical contact input
Voltage Rating	24 VDC
Isolation Method	Photocoupler
Input Current	5 mA
Input Impedance	4.3 KΩ
Turn ON Time	7 msec. maximum
Turn OFF Time	11 msec. maximum
Must Turn On Current	3 mA minimum (15 V minimum)
Must Turn OFF Current	1.5 mA maximum (6 V maximum)





Relay Output Specifications

Number of Outputs	6 points, base or expansion unit (M3 screw terminal)
Output Device	Electromechanical relay contact
Contact Configuration	3 N.O. contacts with a shared common connection and 3 discrete N.O. contacts
Switching Capacity	220 VAC, 2A (resistive; inductive: cos q=0.4) (120 VAC, 2 A maximum) 30 VDC, 2A resistive; inductive: L/R=7 msec.)
Discrete Contacts: (203-205, 213-215)	220 VAC, 2 A; 30 VDC, 2 A
Shared Common Connection Contacts: (200-202, 210-212)	220 VAC, 2 A total (resistive load) 30 VDC, 2 A total (resistive load)
Minimum Applicable Load	5 VDC, 1 mA (reference value)
Contact Resistance	30 mΩ maximum (initial value)
Mechanical Life (without load)	20,000,000 operations (at 1,800 operations/hr.)
Electrical Life (rated load)	100,000 operations (at 1,800 operations/hr.)

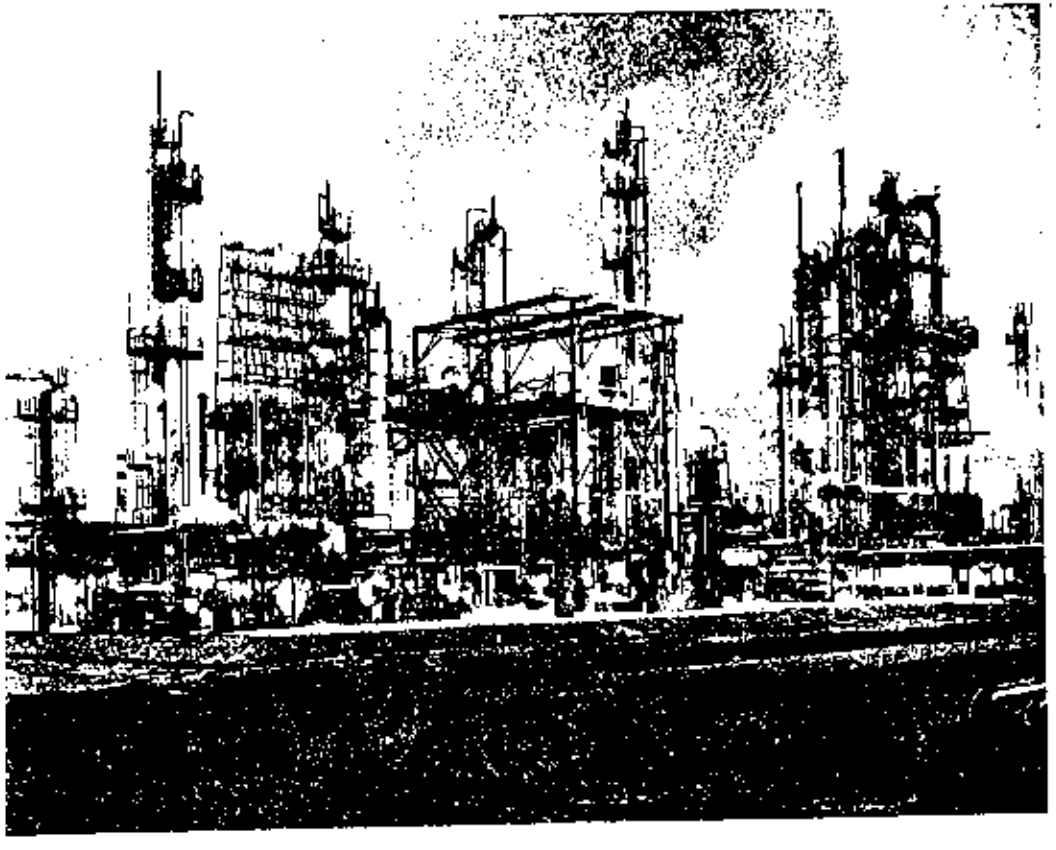
Transistor Output Specifications

Number of Outputs	6 points, base or expansion unit (M3 screw terminal)
Output Device	Transistor output (Sink or source)
Isolation Method	Photocoupler
Rated Load Voltage	12 to 24 VDC, ±10%
Max. Load Current	0.4 A/point (2.4 A/common)
Inrush Current	5 A maximum
Leakage Current	100 µA maximum
Turn ON Time	1 msec. maximum
Turn OFF Time	1 msec. maximum
On Voltage	
Sink Output	1.5 V maximum
Source Output	(+V (Rated load voltage) -1.5V maximum)
External Current Draw	12 to 24 VDC, 40 mA/unit

How To Order:

To Order Specify:	Catalog Number	
	Class	Type
▲ Class Number ▲ Type Number	8003	CP30

APPENDIX K



PETROLEUM PROCESSING

Principles and Applications

R. J. HENGSTEBECK

Research and Development Department, Standard Oil Company (Indiana)

McGRAW-HILL BOOK COMPANY

New York *Toronto* *London* 1959

CHAPTER 9

POLYMERIZATION AND ALKYLATION

With the introduction of cracking, the production of light gases increased greatly—and a new opportunity was created. Cracked gases are rich in olefins, which are chemically reactive, and technologists were challenged to convert them into something more valuable than fuel gas. Research took two paths: thermal conversions and catalytic conversions. The thermal work bore the earliest fruit, and a semicommercial plant went into operation in 1931 to make gasoline by polymerization.* When a full-scale plant was built in 1934,† thermal polymerization appeared to have great promise. However, the picture changed suddenly when catalytic processes were perfected a short time later.‡ For a brief period, there were sharp disagreements as to the merits of the two polymerization routes; however, the arguments were soon resolved in favor of the catalytic processes.

Polymerization causes olefins to combine with each other. In the late 1930s, alkylation processes were developed that cause olefins to react with isoparaffins. Thus twice as much gasoline is made from a given quantity of olefins. The gasoline products are of exceptionally high octane quality, and 60 plants were built to make "alkylates" for aviation gasoline during World War II.

Alkylation units are much more costly to build and to operate than are polymerization units. Consequently, polymerization was favored initially for the production of motor gasoline, even though it produces

* At the Toledo refinery of the Pure Oil Co. (17).

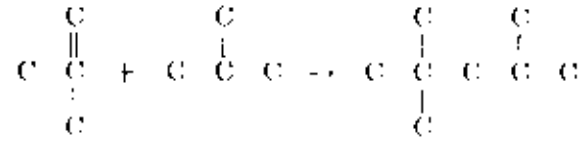
† At the Alamo refinery of the Phillips Petroleum Co. Cooperating companies included Standard Oil Co. (Indiana), Standard Oil Co. (New Jersey), The Texas Company, and M. W. Kellogg Co. (17).

‡ By Shell Oil Company (sulfuric acid catalyst) and by Universal Oil Products Co. (phosphoric acid on kieselguhr). Three additional processes were perfected later—one by Polymerization Process Corp. (copper pyrophosphate catalyst) and two by California Research Corp. (phosphoric acid on quartz and liquid phosphoric acid). Polymerization Process Corp. utilizes patents of Phillips Petroleum Co., Standard Oil Co. (Indiana), Standard Oil Co. (New Jersey), The Texas Company, and M. W. Kellogg Co.

less gasoline and the gasoline has a lower octane rating. Rising octane requirements brought alkylation into the motor-gasoline picture about 1955.

POLYMERIZATION

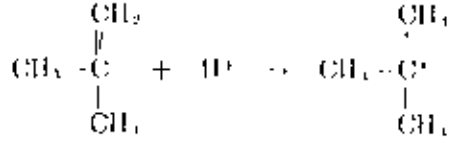
Although the term is sometimes used more broadly, "polymerization" usually means the combining of two or more olefinic molecules to yield a larger molecule. For example,



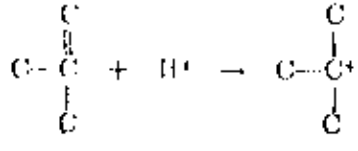
When a mixture of olefins is polymerized, the operation is called "copolymerization." Under some conditions, reactants rearrange during reaction, and complex products are made. This type of polymerization is called "conjunct polymerization" (39). Conjunct products are not necessarily multiples of the original molecules, and they may contain paraffinic, naphthenic, and aromatic compounds as well as olefins. Operations in which the olefins do not rearrange are called "true" polymerization. Thermal polymerization is conjunct polymerization. Under the conditions used commercially, catalytic polymerization is true polymerization.

Reaction Mechanisms

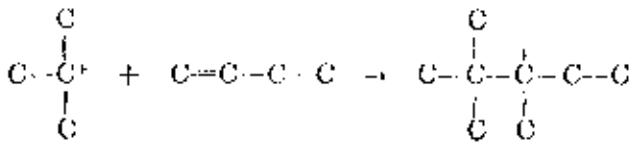
As discussed in Chap. 6, thermal polymerization is believed to proceed by way of a free-radical mechanism. Catalytic polymerization, on the other hand, is explained by a carbonium-ion theory (39). A carbonium ion is formed by combination of an olefin with a proton furnished by the acid catalyst. With isobutene,



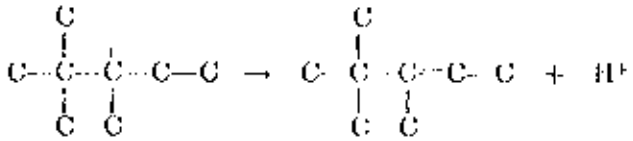
which is also written:



The carbonium ion so formed may add to another olefin to form a larger carbonium ion. For example,



The larger carbonium ion may add another olefin to form a still larger ion, and a mixture of carbonium ions of various sizes results. Any of the carbonium ions may lose a proton to form an olefin. For example,



Thus, the original proton is regenerated, and the cycle is repeated many times, a chain reaction resulting. Because carbonium ions may isomerize (especially when they contain tertiary carbon atoms), most products contain mixtures of isomers.

Thermal Polymerization

Like all pyrolytic processes, thermal polymerization is a complex process involving cracking, dehydrogenation, and cyclization reactions, as well as polymerization. Accordingly it can be performed with any light feed stock, whether olefinic or paraffinic. Although gasoline can be produced from any hydrocarbon, very severe conditions are required for paraffinic gases lighter than butane, and the lighter gases are seldom processed (21).

In any given situation, it is not necessary to convert all the butanes and butenes produced in a refinery, because they can be blended into gasoline up to a concentration of about 10 per cent. So long as the excess C_4 production does not exceed the production of butenes, the excess can be converted to gasoline by catalytic polymerization. In this situation, thermal polymerization cannot compete. Where excess C_4's exceed the butene production, alkylation can be used, since alkylation converts one mole of isobutane with every mole of butene. The field for thermal polymerization is limited, therefore, to situations where olefins are not available. Thermal-polymerization operations are discussed in Chap. 6.

Sulfuric Acid Polymerization

The first catalytic polymerization process employed sulfuric acid as the catalyst. Now known as the "cold acid" process, it polymerizes

i-butene selectively (18). A later modification, the "hot acid" process, copolymerizes all the butenes. The cold-acid process was important during World War II (and still is) in preparing feed stocks for the manufacture of butadiene. *i*-Butene, which interferes with the production of butadiene, is removed from butanes-butenes via the cold-acid route.

Schematic flow sheets for the sulfuric acid processes are shown in Fig. 9-1. The cold-acid process consists of two steps: extraction of *i*-butene, followed by polymerization (49). As discussed in Chap. 4,

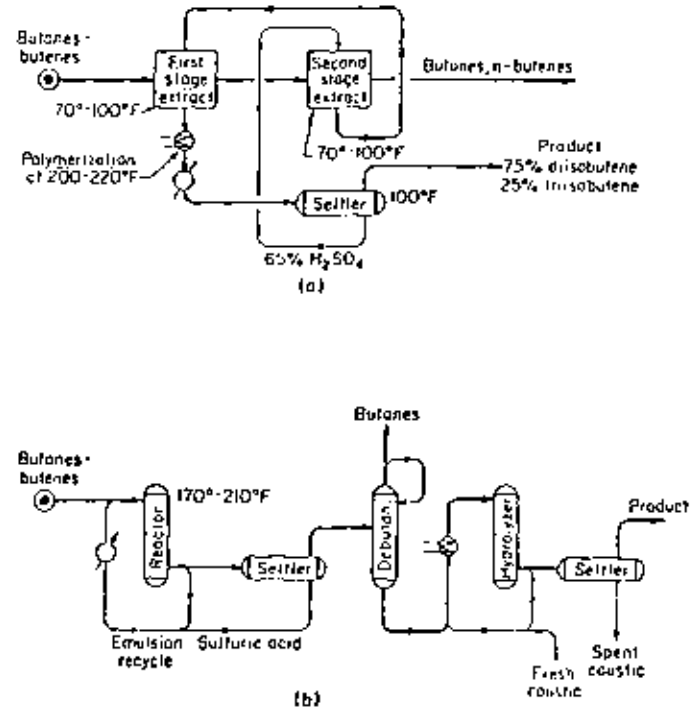


FIG. 9-1. Sulfuric acid polymerization processes. (*a*) Cold-acid process. (*b*) Hot-acid process.

extraction is accomplished with 65 per cent sulfuric acid at 70 to 100°F, usually in two stages. The extract phase is separated and heated to about 210°F for about 1 min to effect polymerization. It is then cooled to about 100°F and the product is separated from the acid catalyst by settling. Conversion of *i*-butene is generally about 90 per cent. The product is 75 per cent dimer; the rest is trimer.

In hot-acid plants, extraction and polymerization are carried out in a single step at about 200°F (49). A hydrocarbon-acid emulsion is circulated through the reactor to reduce the concentration of isobutene in the feed; circulation promotes copolymerization of the more-reactive *i*-butene with the less-reactive *n*-butenes and thereby improves yields.

Reactor effluent is settled to separate product from the catalyst, which is recycled. The product is fractionated to eliminate butanes and then hydrolyzed with caustic to break down any acidic materials. At contact times of 10 to 15 min, all the *i*-butene and an equal amount of *n*-butenes are converted. The product contains 90 to 95 per cent octenes.

During World War II, products from sulfuric acid plants were fractionated to separate the dimers, which were then hydrogenated to produce aviation-gasoline components (50). Except for those plants which prepared feed stock for butadiene production, cold-acid plants were converted to hot-acid plants during the war, because of the higher production from the latter.

Polymerization with Phosphorus-containing Catalysts

Four polymerization processes employ catalysts containing phosphorus. Three of them use solid catalysts; the fourth employs liquid

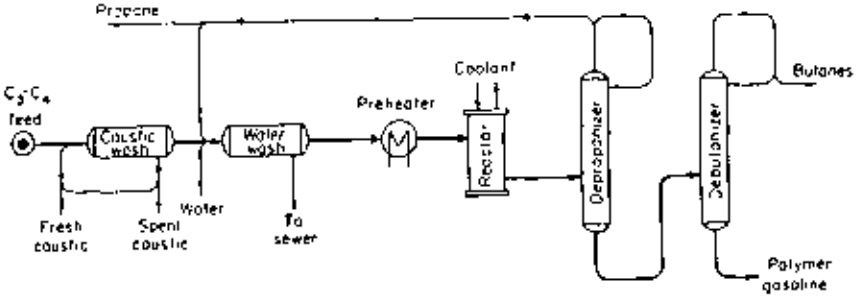


FIG. 9-2. Phosphoric acid polymerization unit.

phosphoric acid. As shown schematically in Fig. 9-2, an olefin-containing feed is first pretreated to remove sulfur compounds and poisons. It is then passed over a bed of catalyst at a temperature in the range of 300 to 425°F and a pressure in the range of 150 to 1,200 psi. Olefin conversions to gasoline are 85 per cent or better. There is a large exothermic heat of reaction—about 400 Btu per lb of butene reacted, about 670 Btu per lb of propene (13)—and olefin-lean streams are often recycled to act as heat absorbers and thus to help control the reaction temperature.

Most units employ solid catalysts. The earliest operated at about 200 psi and at inlet temperatures of 450°F, rising to 500°F at the outlet. Under these conditions, coke is deposited on the catalyst, necessitating periodic shutdowns to burn it off.* Subsequently, it was found that coke production is greatly reduced at higher pressures, presumably

* Combustion was carried out at temperatures controlled between 650 and 950°F. The catalyst was then steamed at 500°F for 6 to 16 hr to restore its normal water content (1,21,49).

because the denser reactants dissolve trace materials that would otherwise remain on the catalyst to be converted to coke (13,17). Most later units employ this principle, and catalyst-regeneration facilities are not provided.

The use of liquid phosphoric acid as catalyst necessitates the use of special materials of construction to withstand corrosion (34). Use of a liquid catalyst permits temperature control by circulating the catalyst through a cooler. Consequently, recycle of olefin-lean streams is not needed to control reaction temperatures.

Catalysts. Commercial catalysts include phosphoric acid on kieselguhr, copper pyrophosphate on charcoal, phosphoric acid on quartz chips (13), and liquid phosphoric acid (34). The acid-on-kieselguhr catalyst was developed first, and it is the most active (13). Copper pyrophosphate has the disadvantage of requiring an induction period of one to two days; it is usually diluted with charcoal to reabsorb any phosphoric acid leached from it. Phosphoric acid on quartz (28-35 mesh) is the least active of the catalysts because of its small surface area. However, the catalyst is rugged and it is "replaced" simply by washing with water and then recoating with 75 per cent phosphoric acid (39). Occasionally, accumulated tarry deposits must be burned off the quartz support (13). To avoid corrosion difficulties, alloys must be used for all equipment that contacts hot phosphoric acid.

Catalyst life ranges between 100 and 200 gal of polymer per pound for phosphoric acid on kieselguhr and between 100 and 150 gal per lb for copper pyrophosphate (39). In a semicommercial unit, catalyst life in a liquid phosphoric acid operation exceeded 45 gal of polymer per pound of acid (34).

Feed Pretreatment. Feeds are pretreated to remove hydrogen sulfide and mercaptans, which would otherwise enter the product and thus reduce its octane rating (13). Any basic materials must also be excluded because they are catalyst poisons. Typically, a feed is washed with caustic to remove hydrogen sulfide and mercaptans, and then is washed with water to remove any organic bases and any carry-over of caustic as well. Because oxygen promotes the deposition of tarry materials on the catalyst (13,21), both the feed stock and the wash water should be free of oxygen. Steam condensate is often used.

If a feed contains large amounts of hydrogen sulfide or mercaptans, the use of a regenerative absorbent may be more economic than caustic washing; regenerative absorbents for hydrogen sulfide include ethanolamines and tripotassium phosphate (20). Caustic solutions containing "solutizers" are regenerative absorbents for mercaptans (28); they are discussed in Chap. 14.

With phosphoric acid-on-kieselguhr catalyst, the water content of

the feed must be closely controlled. If the feed is too wet, the catalyst softens and the reactor may plug. If the feed is too dry, coke deposits on the catalyst, reducing its activity and increasing the pressure drop (17). Because the distribution of water between the catalyst and the reactants is a function of temperature and pressure, which vary from unit to unit, different water concentrations are required in the feeds to different units (21). Sometimes the liquid feed is saturated with water at a controlled temperature. In other cases, saturation water is insufficient, and additional water is injected into the feed (2,13).

Reaction Conditions. Conversions of olefins to polymers depend upon temperature, pressure, reaction time, catalyst activity, and the composition of the feed.

Reaction rates increase with temperature, but the magnitude of the effect depends on the catalyst. With liquid phosphoric acid, an increase of 100°F is required to double the rate (4). With phosphoric acid on kieselguhr, the reaction rate appears to double for an increase of 20°F (21). Higher temperatures also increase the rate at which tarry deposits accumulate on solid catalysts, and thus they shorten catalyst life. Temperatures between 300 and 425°F are usually employed (30,39).

Increasing pressure increases conversion, primarily by increasing contact time (4). Pressures are usually in the range of 400 to 1,500 psi although pressures as low as 150 psi are sometimes used with phosphoric acid-on-quartz catalyst (13,17,30). Higher pressures permit the use of lower temperatures and thus reduce the formation of heavy polymers and coke (17).

Reaction times must be long enough to give satisfactory conversions, but not so long as to cause the production of polymer chains too long to be included in gasoline (42). Reaction times are usually expressed reciprocally as space velocity; the usual range is 0.12 to 0.46 gal of total feed per hour per pound of catalyst (13,17).

Reaction rates differ for the several olefins. *i*-Butene is the most reactive, followed by butene-1, butene-2, and propene, in that order (13). *i*-Butene accelerates the polymerization of *n*-butenes, and butenes accelerate the polymerization of propene.

Reactors. In the design of polymerization reactors, the principal problem is temperature control; provision must be made to remove the large exothermic heat of reaction. Some of this heat is absorbed by the reactants, which are permitted to rise 15 to 100°F, depending upon the reaction system. However, only a part of the heat can be removed in this way, and other means must be used to dissipate the rest. To achieve this end, two types of reactors are employed with solid catalysts: chamber and tubular. With liquid phosphoric acid, packed columns are used as reactors, and the catalyst is circulated through an external cooler to remove the heat of reaction.

Chamber reactors are vertical cylindrical vessels containing several beds of catalyst 2 to 8 ft deep (30), with provisions for injecting a quench liquid between them. Quench liquid usually consists of recycled light ends, which are largely unreactive paraffins. If the fresh feed contains more than 25 per cent olefins, it may be diluted to that concentration with recycled light ends (17); in such cases only part of the combined feed may be heated to reaction temperatures and charged to the first bed, the rest being charged cold as quench liquid between the beds (30).

Tubular reactors are single-pass heat exchangers, with the catalyst contained in the tubes, which are 2 to 6 in. in diameter (17). When water is used as the coolant, it is converted to steam, and temperature is controlled by controlling the steam pressure. Because tubular reactors provide closer control of temperatures than do chamber reactors, they can tolerate higher olefin contents in the feed stocks, the maximum concentration depending upon the particular design. For any given operation, the catalyst lasts longer in a tubular unit (39). On the other hand, tubular reactors are more expensive to build, and charging and discharging of catalyst is more difficult. The catalyst is often removed by sluicing the tubes with water (36).

Chamber reactors usually operate at about 500 psi; tubular reactors operate at 700 to 1,200 psi (17).

Feed Stocks. Presumably, any olefin can be polymerized. For the production of motor gasoline, however, only butene and lighter materials are of interest; heavier olefins (up to about C_{10} or C_{11}) can be incorporated directly into gasoline. With sulfuric acid as the catalyst, butenes are the only light stocks that can be polymerized satisfactorily, although a conjunct polymer can be made from propene (13). With phosphoric acid catalysts, propene also is a satisfactory feed stock, and a conjunct polymer can be made from ethylene. Butadiene is undesirable in a feed because it tends to make long-chain polymers and because it accelerates the deposition of coke on the catalyst. Nevertheless, units have been designed to handle up to 3 per cent butadiene (13).

In most circumstances, feed stocks to polymerization are limited to olefins made as by-products of cracking operations. However, butanes have been cracked to make olefinic feeds as primary products (15), and during World War II *n*-butene was made in England by dehydrogenation of *i*-butene (13).

Operations. Most polymerization units operate to produce motor gasoline from olefin-containing C_3, C_4, or mixed C_3-C_4 streams. Since World War II, most units are operated for maximum conversion of

olefins. To distinguish such operations from a wartime practice, they are called "nonselective."

Wartime "selective" polymerization was aimed at producing highly branched isooctenes for subsequent hydrogenation to aviation gasoline.*

Table 9-1

Olefinic feed stock	Polymerization	Reactor	Psi	Temperature In	Temperature Out
C_4	Selective	Tubular	600	350	365
C_3, C_4, or C_3-C_4	Nonselective	Tubular	1,000	400	415
C_3, C_4, or C_3-C_4	Nonselective	Chamber	500	350	450
C_3, C_4, or C_3-C_4	Nonselective	Chamber	500	400	475

Highly branched isooctenes are made by reaction of *i*-butene with itself or with *n*-butenes (39). Conversions were carried only to the point where most of the *i*-butene—the most reactive olefin had reacted. Selective polymerization may still be practiced in refineries that have both a polymerization unit and an alkylation unit, especially if the available olefins exceed the capacity of the alkylation unit (45). Butene-2, which polymerizes least readily, is the preferred stock for alkylation (12).

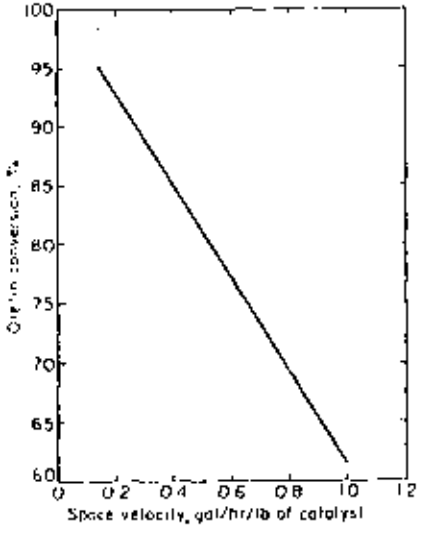


FIG. 9-3. Olefin conversions for chamber-type unit with phosphoric-acid-on-kieselguhr catalyst (31).

Reaction conditions differ with the feed stock, the type of reactor, and the type of reaction. Typical conditions are given in Table 9-1 (17,30,49). In Fig. 9-3, space velocity requirements are related to olefin conversions when a mixed C_3-C_4 feed is charged to a chamber-type unit employing a phosphoric acid-on-kieselguhr catalyst. In Fig. 9-4, olefin conversions are related to all the operating variables for a tubular-type unit employing copper pyrophosphate catalyst (43).

Products. Polymer gasolines are chemically stable, clean-burning fuels of high-octane quality. They are usually mixtures of polymers, principally dimers and trimers. With a propene feed, trimers pre-

* The hydrogenated product has a clear motor octane rating of about 95 (17,30).

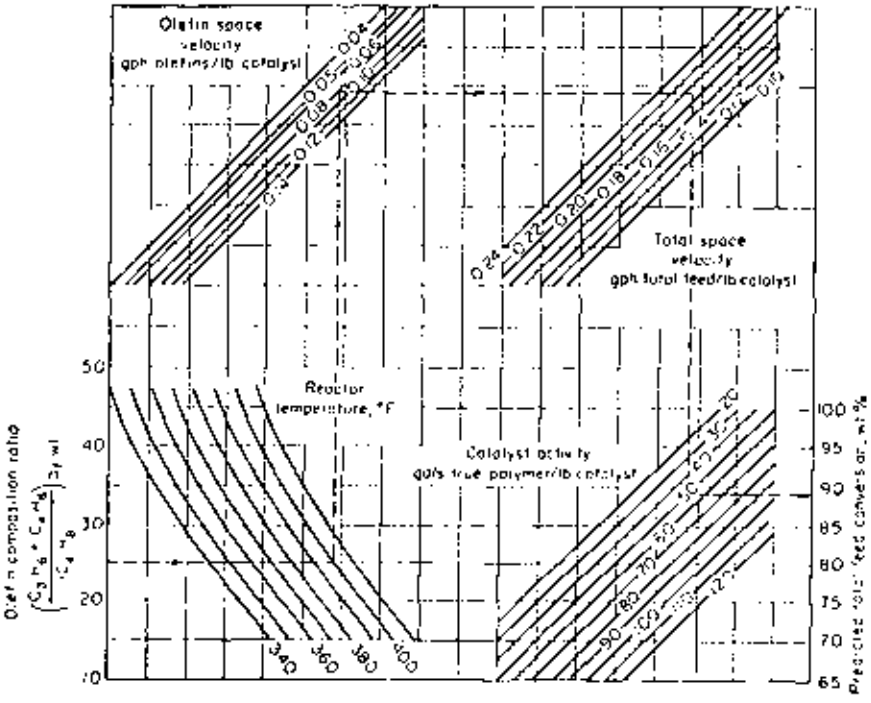


FIG. 9-4. Polymerization with copper pyrophosphate catalyst (43).

Table 9-2. Inspections of Polymer Gasolines (13,17,49)

	Propene polymer*	Butene polymer	Mixed polymer
Octane ratings:			
Research, clear	93	99	97
Research, 3 cc TEL	99	100+	101
Motor, clear	80	81	83
Motor, 3 cc TEL	86	84	86
ASTM distillation, °F:			
IBP	222	140	132
10%	267	211	206
50%	311	242	271
90%	381	361	372
EP	408	443	439
Reid vapor pressure, lb	0.5	2.0	

* Five per cent bottoms were fractionated from this polymer.

dominate. With a butene feed, dimers are the major constituents. Typical product inspections are listed in Table 9-2.

Utilities Requirements. Utilities requirements for polymerization are modest. For a typical chamber unit charging mixed C_3-C_4's, utilities may be about as in Table 9-3 (38).

Table 9-3

Utility	*Per bbl of polymer*
Steam	620 lb
Power	0.8 kwhr
Cooling water	4,300 gal
Fuel gas	15 lb

Related Operations

Olefinic polymers are important raw materials for the manufacture of chemicals (13). To provide feed stocks for the manufacture of oxo alcohols, heptenes are fractionated from propene-butene polymer and nonenes are separated from propene polymer. Also, propene tetramer is used in the manufacture of detergents. When tetramer is made, lighter polymer is recycled for further conversion.

Because the operation can be carried out in the same equipment, alkylation of aromatics is related to phosphoric acid polymerization (13). In this operation, a large excess of the aromatic—usually benzene—is used to promote alkylation and to minimize polymerization.

ALKYLATION

Alkylation is any reaction in which an alkyl group is added to a compound; in petroleum refining, it normally means reaction of an olefin with an *i*-paraffin to produce a larger *i*-paraffin.

i-Paraffins can be alkylated without catalysts, but high temperatures and high pressures are required (12,22,47). Commercially, acid catalysts are employed.* Sulfuric acid and hydrogen fluoride—the two most important catalysts—are used to alkylate *i*-butane with propene and butenes, and sometimes with pentenes. Aluminum chloride is used to alkylate *i*-butane with ethylene.

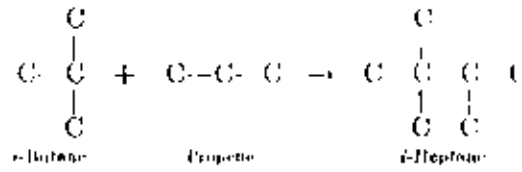
Like polymerization, alkylation is highly exothermic; the theoretical reaction liberates 630 to 700 Btu per lb of *i*-butane reacting (19).

Alkylation Reactions

The principal reaction in alkylation is the coupling of an *i*-paraffin, customarily *i*-butane, with an olefin, such as propene or a butene.

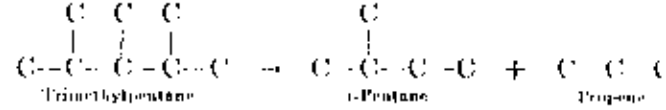
* One plant was built during World War II to alkylate ethylene with *i*-butane thermally to produce neohexane (20,22,47).

For example,

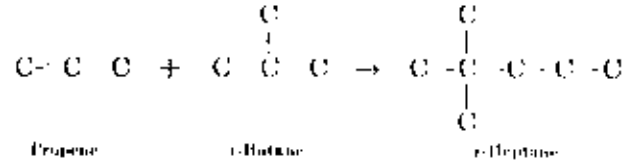


In such an operation, the alkylation reaction competes with polymerization of the olefins. Inasmuch as trimers are formed in alkylation (19), some polymerization apparently takes place, followed by alkylation of the dimer.

Polymerization reduces the consumption of *i*-butane. Other side reactions increase it, and some of them lead to the production of materials lighter than the theoretical products (12). For example, an alkylation product (or a reaction intermediate) may break down to form a smaller olefin and paraffin. With a butene feed the primary product may break down as follows:

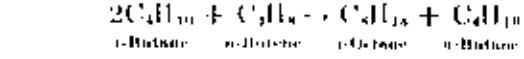


The olefin so formed may then alkylate another molecule of *i*-butane:



In the example cited, one mole of *i*-pentane and one of *i*-heptane result from the reaction of two moles of *i*-butane and one of butene.

Hydrogen transfer may also occur in alkylation, through a series of complicated reactions (12). With butene as the hydrogen acceptor, the over-all reaction may be represented as:



Although the major product is the same as from the theoretical reaction, twice as much *i*-butane is used to make it.

To some extent, hydrogen may transfer from one olefin to another, yielding a paraffin and a diolefin that associates with the acid catalyst. Further loss of hydrogen from diolefins results in highly unsaturated compounds that form "sludge" in the catalyst phase. Because sludge deactivates the catalyst, its concentration must be controlled. Accord-

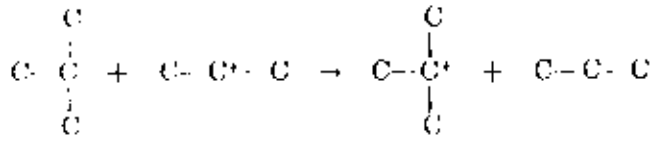
ingly, catalyst is withdrawn continuously and replaced with fresh or with regenerated material.

Although the chemical formula for the major product is the sum of the formulas of the reactants, the reaction is not simply the joining of the two molecules. The molecular structures of the products show clearly that isomerization must also occur.

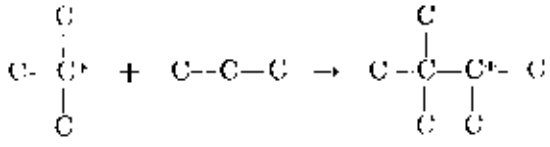
Mechanism of Reaction

A number of theories have been advanced to explain catalytic alkylation (12). Probably the most popular is one involving carbonium ions. Carbonium ions result from unions of olefins with protons furnished by the acid catalyst:

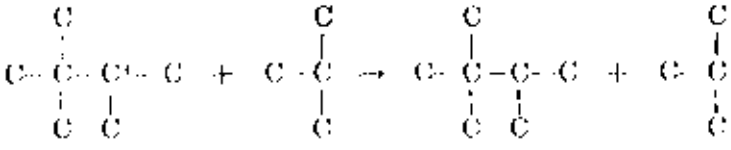
Carbonium ions react with *i*-butane to form *i*-butyl carbonium ions:



i-Butyl carbonium ions combine with olefins to form larger carbonium ions:



The larger carbonium ions react with isobutane to yield *i*-paraffins:



Thus, the *i*-butyl carbonium ion is regenerated, and a chain reaction commences.

The reaction intermediates—the larger carbonium ions—isomerize readily to other skeletal structures. This phenomenon explains the mixtures of isomers usually found in alkylation products.

Alkylation Catalysts

A large number of acidic materials have been used experimentally as catalysts for alkylation of *i*-paraffins (12). However, only sulfuric acid, hydrogen fluoride, and aluminum chloride have been used commercially.

Sulfuric Acid.* Sulfuric acid may be used with propene and higher-boiling olefins. (It reacts with ethylene to form ethyl hydrogen sulfate.) Commercially, the catalyst phase includes some water and some complex hydrocarbons, which are by-products of the reaction. A satisfactory catalyst contains at least 85 per cent titratable acidity, and a higher acidity is desirable (11,12). Below 85 per cent titratable acidity, acid usage increases sharply and product quality is lowered. Acidity is maintained at the desired level by withdrawing a part of the circulating stream and replacing it with fresh acid of about 98 per cent concentration. Replacement may be continuous, in which case the circulating acid is held at a desired acidity, usually 88 to 90 per cent. When batchwise replacement is used, acidity varies between that of the fresh and of the spent acids, usually between 98 and 88 per cent. Because the average acid strength is higher, somewhat better results are obtained with batchwise replacement, but more equipment is required.

Sulfuric acid catalyst is circulated as an emulsion with the reactants. Best results are obtained when the reactants are emulsified in the acid; such an emulsion results when the acid makes up at least 40 per cent of the mixture (19). Normally, the emulsion is held at about 50 per cent acid (12,45); higher proportions increase the difficulty of breaking the emulsion to recover the alkylation product.

The rate at which the catalyst deactivates depends mostly on the type of feed and the *i*-butane charge rate. Reported consumptions of acid have ranged from 0.3 to 2 lb per gal of product (19,30,32,45). Butene feeds have the lowest requirement; propene have the highest (30). For an operation with a butene feed and an *i*-butane:olefin ratio of 5:1, 0.9 lb of 98 per cent acid were consumed per gallon of product (19). For an operation on an effluent from a selective-polymerization unit and with an *i*-butane:olefin ratio of 12:1, an acid consumption of 0.3 lb per gal is claimed (32,45).

Hydrogen Fluoride.† Like sulfuric acid, hydrogen fluoride is used for the alkylation of *i*-butane with propene and higher-boiling olefins. High acidity is used to maintain high conversions and high antiknock quality (9). Unlike sulfuric acid, hydrogen fluoride is readily separated from water and sludge by distillation, and the optimum acidity is a function of fractionation costs. Typically, the circulating catalyst contains 85 to 92 per cent titratable acid and about 1.5 per cent water; the remainder is hydrocarbon sludge (12,26). If the catalyst contains

* Sulfuric acid alkylation was developed by the Anglo-Iranian Oil Co. (now British Petroleum), in cooperation with Humble Oil Co., Shell Development Co., Standard Oil Development Co., and The Texas Company (47).

† Hydrogen fluoride alkylation was pioneered by Phillips Petroleum Co. Universal Oil Products Co. have also developed an HF process (26).

as much as 5 per cent water, the quality of the alkylate deteriorates and the conversion decreases (9).

Hydrogen fluoride consumptions have been reported at from 0.2 to 0.8 lb per bbl of product (19,26).

Aluminum Chloride.* One plant was built during World War II to produce diisopropyl (for aviation gasoline) from *i*-butane and ethylene; it employs aluminum chloride–hydrocarbon complex as a catalyst (3,19). Hydrogen chloride is used as a promoter to increase and maintain catalyst activity (3). Because sludge gradually accumulates in the catalyst, some catalyst is withdrawn continuously and aluminum chloride is added to the remainder to hold the composition constant. The optimum aluminum chloride concentration in the catalyst is between 63 and 84 per cent (12).

Aluminum chloride requirements are about 1.4 to 3 lb per bbl of product (3), although laboratory experiments have required as little as 0.5 lb per bbl (12,46).

Process Variables

Important process variables in alkylation are the *i*-butane:olefin charge ratio, the *i*-butane content of the reactor effluent, temperature, and space velocity. Both product yields and product quality are affected by changes in these variables.

***i*-Butane-to-olefin Ratio.** Because the conditions which favor alkylation also favor polymerization of olefins, an excess of *i*-butane is employed to promote the desired reaction. Commercially, the ratios of *i*-butane to olefins charged to the reactors have ranged between about 4:1 and 12:1 (30,47), and ratios as high as 33:1 have been used experimentally (12). The usual commercial range is 5:1 to 10:1. Inasmuch as side reactions are reduced by increasing the *i*-butane charge rate, the octane rating of the product is improved, the end point is lowered, and the consumption of catalyst is reduced as the *i*-butane rate is increased.

Because alkylation reactions are rapid, internal circulation of the reactants may be used to augment the external *i*-butane-to-olefin ratio. Internal circulation consists of circulating the reactor contents rapidly and introducing the fresh feed into the circulating stream. Internal *i*-butane-to-olefin ratios may be as high as 1,000:1 (26).

***i*-Butane in Effluent.** Increasing the *i*-butane concentration in the reactor effluent has the same effect as increasing the *i*-butane:olefin ratio (19). *i*-Butane concentration may be increased by reducing the amount of *n*-butane charged to the reactors in the fresh feed and in the *i*-butane-recycle stream. Thus, there is an economic balance between

* Aluminum-chloride alkylation is licensed by Phillips Petroleum Co. (26).

increasing the volume of the *i*-butane-recycle stream and increasing its purity.

Temperature. Low temperatures are used in all catalytic alkylations. Refrigeration is required with sulfuric acid, atmospheric temperatures are used with hydrogen fluoride, and slightly higher temperatures are employed with aluminum chloride.

With sulfuric acid, temperature is an important variable. From the standpoint of product quality, low temperatures are preferred; however, the catalyst is viscous at low temperatures and contacting it with the reactants is difficult (12). If temperatures are too low, yields are adversely affected (47); the lowest practical limit is about 30°F, and preferred temperatures are 40 to 50°F (19). The upper practical limit is about 70°F; at higher temperatures, the acid attacks olefins (12).

Hydrogen fluoride catalysis is less sensitive to temperature. In the laboratory, essentially the same results are obtained at −10°F and at 135°F (12). Reaction temperatures in the neighborhood of 75 to 100°F are convenient; consequently such temperatures are usually used (19). However, refrigeration has been used in at least two units, and improved octane ratings are claimed (9,25).

With the aluminum chloride catalyst, commercial operating temperatures are 110 to 140°F (12,46).

Olefin Space-velocity. Olefin space-velocity may be defined as the volume of olefin charged per hour divided by the volume of acid in the reactor. Reducing the olefin space-velocity improves the octane quality of the product, reduces the production of heavy materials, and lowers the consumption of acid (19).

Contact Time. Contact time is defined as the residence time of the fresh feed and externally recycled *i*-butane in the reactor. For sulfuric acid alkylation, the normal range is 5 to 40 min; for HF alkylation, it is 5 to 25 min. Long contact times in the absence of *i*-butane are undesirable, presumably because olefins, which are soluble in the catalyst, undergo side reactions. To minimize such reactions in the product settler (where catalyst is settled from the hydrocarbon product), an *i*-butane-rich stream may be bubbled through the acid phase, which, being heavier, is the lower phase (37).

Feed Stocks for Alkylation

Any olefin-containing hydrocarbon stream may be used to alkylate *i*-butane. Butenes are the usual alkylating agents, propenes are also used, and ethylene and pentenes are employed to a limited extent. Butenes-*i*-butene copolymers have also been charged to alkylation, especially during World War II. Inasmuch as they react about as do butenes themselves (9), they must depolymerize before reacting.

The chief sources of olefins are cracking operations, especially catalytic cracking. However, olefins can be produced by the dehydrogenation of paraffins (8,27,33), and butanes are dehydrogenated commercially to provide feeds to alkylation (5,35). Butane is also isomerized to *i*-butane, which is cracked thermally to produce an alkylation feed (33). The production of ethylene is discussed in Chap. 6. In the commercial operation with aluminum chloride, an ethane-propane mixture is cracked, and the ethylene and propene are recovered by absorption in cold *i*-butane (3).

i-Butane is obtained from crude oils, from cracking operations, from catalytic reformers, and from natural gas fields. To supplement these sources, *n*-butane is sometimes isomerized. Isomerization is discussed in Chap. 10.

Alkylation feeds should be free of hydrogen sulfide and mercaptans (19). Both materials form free sulfur, which makes the product corrosive. They also lower leaded octane ratings of products and increase consumptions of catalyst.

Only small concentrations of diolefins are permissible in feeds to alkylation, with sulfuric acid catalyst at least. Diolefins increase the consumption of the catalyst (47).

Alkylation Products

Alkylation products—"alkylates"—are branched paraffins with high octane ratings. Butene alkylates produced with a sulfuric acid catalyst

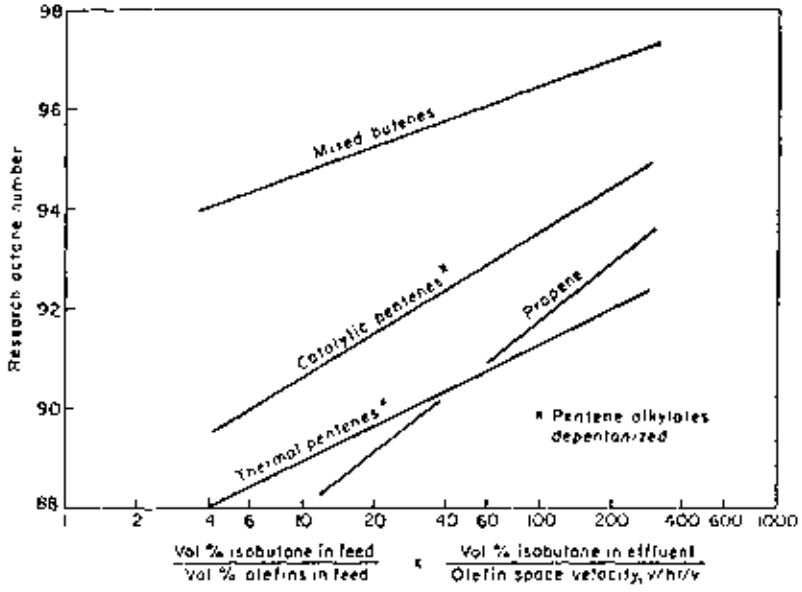


FIG. 9-5. Alkylate octane ratings (19.)

Table 9-4. Composition of a Typical Butene Alkylate (7,19)

Component	*Vol per cent*
Pentanes and lighter	8.9
2,3-Dimethylbutane	4.7
2-Methylpentane	1.1
3-Methylpentane	0.1
2,2-Dimethylpentane	0.2
2,4-Dimethylpentane	3.4
2,2,3-Trimethylbutane	0.2
2,3-Dimethylpentane	2.3
2-Methylhexane / 3-Methylhexane	0.3
2,2,4-Trimethylpentane	24.3
2,2-Dimethylhexane	0.2
2,5-Dimethylhexane / 2,4-Dimethylhexane	6.6
2,2,3-Trimethylpentane	1.2
2,3,4-Trimethylpentane	13.0
2,3,3-Trimethylpentane	12.3
2,3-Dimethylhexane	3.0
3,4-Dimethylhexane	0.1
2,2,5-Trimethylhexane	4.5
2,3,5-Trimethylhexane	0.9
High-boiling *i*-paraffins	12.1
	100.0

Table 9-5. Typical Inspections of Alkylates (19,27,30,45)

	H_2SO_4 Alkylates				HF Alkylates	
	Butene alkylate*	Propene alkylate*	Pentene alkylate*	Aviation alkylate*	Butene alkylate	Aviation alkylate
Gravity, °API	69	72	67	71	69	70
ASTM distillation °F:						
10%	197	179	227	164	199	200
50%	224	196	247	212	224	220
90%	261	241	281	230	264	239
End point	360	360	360	314	362	327
Octane ratings:						
Research, clear	95	89	99	...	93.1	91.6
Motor, clear	.	.	.	.		89.8
F-4 (4.0 cc TEL)	151	122	127	165		
RVP, lb	3.5	4.0	1.5	4.6	.	2.3

* Run to 360° end point; pentene alkylate is depentanized. Yields are 90 to 95 per cent of total alkylate.

† Produced from the effluent from a selective-polymerization plant (45).

usually rate 93 to 95 on a clear research basis, although ratings of 92 to 97 have been reported (30,31,45). With hydrogen fluoride catalyst, butene alkylates rate about 91 to 93 research octane clear (27,30). Addition of 3 cc TEL raises octane ratings by 10 to 12 units.

As shown in Fig. 9-5, variations in octane ratings in sulfuric acid alkylation can be related to variations in process conditions (19,51).

Table 9-6

Olefin	Alkylate, vol %	*i*-Butane, vol %
Ethylene	188	139
Propene	181	128
Butenes (mixed)	172	112
Pentenes (mixed)	165	96

Also, octane ratings of propene and pentene alkylates are somewhat lower than for butene alkylates.

When butene is the alkylating agent, the major components of the product are trimethylpentanes (12). With propene, the major components are dimethylpentanes, and with ethylene the principal product is diisopropyl (2,3-dimethylbutane). In all cases both lighter and heavier materials are also made. A typical composition of a butene alkylate is shown in Table 9-4. Some typical product inspections are given in Table 9-5.

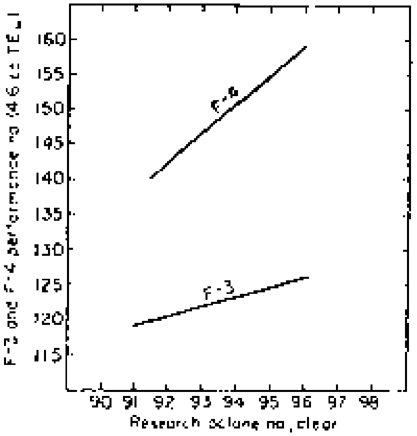


Fig. 9-6. Octane relationships for butene alkylates (19).

Because an alkylate is denser than the reactants that form it, volumetric yields are not additive. The theoretical yields of alkylates and the theoretical isobutane requirements are given in Table 9-6 (based on olefin reacting). Theoretical yields are approximated commercially, even though reactions occur that consume more and less than the theoretical *i*-butane. Apparently, such reactions usually offset each other.

When alkylate is to be used as a blending stock for aviation gasoline, 5 to 10 per cent of heavy ends must first be separated to meet boiling-range specifications. Removing the heavy ends raises the octane rating inasmuch as the heavy ends have research octane ratings of about 80 [redacted] 85 [redacted]

used. How aviation ratings of alkylates relate to research ratings is shown in Fig. 9-6.

Reaction Systems for Alkylation

Because *i*-butane is almost insoluble in the acid catalysts and because the olefins are relatively soluble, alkylation reaction systems must be designed for thorough mixing of the hydrocarbon and catalyst phases if polymerization is to be minimized (9). Also, provisions must be made for removing the high exothermic heat of reaction and the heat of mixing. Reactors in use include time-tank, jet, cascade, impeller, and tubular types. Heat is removed through cooling coils, which may be external

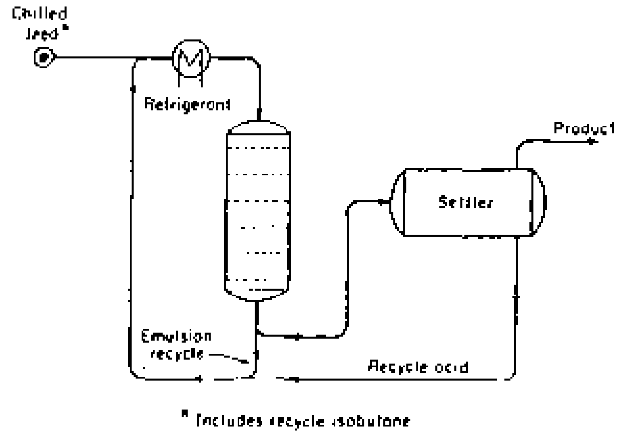


Fig. 9-7. Time-tank reactor system.

or internal to the reactor, or by permitting part of the reactants to vaporize. The latter operation is called "autorefrigeration." Autorefrigeration is not used in hydrogen fluoride units because hydrogen fluoride is itself very volatile.

Time-tank and Jet Reactors. Time-tank and jet reactors were used in early sulfuric acid units. The time-tank system is illustrated in Fig. 9-7. Chilled feed is mixed with a recycle catalyst phase and pumped through a cooler and a cylindrical reactor fitted with internal perforated plates. As it leaves the reactor, the hydrocarbon is emulsified in the acid. Sufficient emulsion is circulated through a cooler to control the reaction temperature as desired. The remainder of the emulsion passes to a settler, where hydrocarbon product separates from the acid, which is recycled.

The jet reactor, illustrated in Fig. 9-8, operates on the same principle, except that jet devices provide the energy of mixing, and internal baffles are not used.

Cascade Reactor. The cascade system is also used in sulfuric acid plants. As shown in Fig. 9-9, a cascade reactor is divided into several