Texaco, Inc.

Universal City, California

ENSR

Final Texaco Fillmore Site Feasibility Study Report

ENSR Consulting and Engineering

February 1992

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1.0 INTRODUCTION

1.1 Purpose and Organization of Report

The purpose of this report is to present the development, screening, assembly of technologies, and detailed analysis of alternatives as part of the feasibility study (FS) process for the Texaco Fillmore facility. This report utilizes information and data generated during remedial investigation (RI) activities conducted at the Texaco Fillmore facility and documented in the *Texaco Fillmore RI/FS Final Remedial Investigation Report*, dated June 1991 (ENSR Final Document 6600-047-900). This FS report is also based on the *Draft Report: Remedial Alternative Development and Screening for the Texaco Fillmore Site*, dated June 1991 (ENSR Document 6600-047-995) and *Detailed Analysis of Alternatives* (ENSR Document No. 6600-063-100-R2). The report follows the FS outline that was presented to the U.S. Environmental Protection Agency (U.S. EPA) in Texaco's letter of May 29, 1991.

This FS report has been prepared in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and the National Contingency Plan. The report also incorporates pertinent requirements of the Resource Conservation and Recovery Act (RCRA), Safe Drinking Water Act (SDWA), and Clean Water Act (CWA).

The process used to develop remedial alternatives in this report is consistent with guidelines established in U.S. EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (U.S. EPA, 1988) and *Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites* (U.S. EPA, 1988a).

The development and screening of remedial alternatives and, ultimately, the detailed analysis of remedial alternatives in the FS will allow for selection of a final site remedy, if any is required under CERCLA, that fulfills the following criteria established in CERCLA Section 121:

- Protects human health and the environment (Section 121 (b)).
- Achieves applicable or relevant and appropriate requirements (ARARs) of Federal and State laws (Section 121 (d)(2)(A)).
- Incorporates a cost-effective solution (Section 121 (a)).

- Utilizes permanent solutions and treatment technologies or resource recovery technologies to the maximum extent practicable (Section 121 (b)).

- Satisfies the preference for remedies that employ treatment permanently and significantly reduce the mobility, toxicity, or volume of hazardous substances as a principal element (Section 121 (b)).

This report is organized into the following sections:

- Section 1.0 - Introduction
- Section 2.0 - Identification and Screening of Technologies
- Section 3.0 - Development of Remedial Alternatives
- Section 4.0 - Overview of Evaluation Criteria
- Section 5.0 - Detailed Evaluation of Alternatives
- Section 6.0 - Comparative Analysis of Alternatives
- Section 7.0 - Conclusions and Recommendations

This report was prepared under the guidance and oversight of U.S. EPA Region IX. Further discussion with U.S. EPA will be needed to determine whether any of the remedial alternatives discussed herein are allowed under CERCLA.

1.2 Site Background Information

1.2.1 Site Description

The Texaco Fillmore facility, also known as the Pacific Coast Pipelines site, is located at 67 East Telegraph Road, northeast of the intersection of Highway 126 and Pole Creek, in Ventura County, California. The facility is a former refinery that Texaco continues to operate as a crude oil pump station. The facility occupies approximately 20 acres and is surrounded by areas of mixed agricultural, industrial, and residential use. The Texaco Fillmore facility is located just east of the City of Fillmore. Adjacent to the facility to the north and east is primarily vacant land, some of which is used for agricultural purposes. Industrial and residential properties are located to the south, a gasoline service station operated by Ultramar is located to the southwest, and residences and a secondary school are located along the western boundary of the facility.

The facility lies between the Topa Topa mountains to the northeast and the Fillmore Groundwater Basin to the southwest, at elevations ranging from 480 to 625 feet above mean sea level. The property slopes generally to the south and west toward the Santa Clara River and is bordered on the west by Pole Creek, the only natural surface water drainage system in the immediate

vicinity of the facility. The Pole Creek Flood Control Channel was constructed in the 1970s, converting the creek to a concrete-lined channel.

Surface water runoff at the facility flows in a southerly direction; some of the runoff is channeled along graded roads for collection in bermed storage tank areas or the Main Waste Pit excavation, and some flows into Pole Creek directly via surface runoff or through drainage pipes. Pole Creek drains to the south from the Topa Topa Mountains into the Santa Clara River. Pole Creek's concrete-lined channel extends approximately 1,200 feet north (upstream) of Tank #8 and about 500 feet south (downstream) of Highway 126.

Figure 1-1 shows the location of the Texaco Fillmore facility; Figure 1-2 is a detailed site location map.

1.2.2 Site History

The earliest reference to refinery operations at the Fillmore site concerns the transportation of oil from the nearby Montebello oil field to the "Ventura Refinery" in 1917. The initial business of Ventura Consolidated Oil Fields was oil production, primarily in Ventura County. In 1928, Texaco purchased the refinery and operated it as the "Fillmore Works," where the primary products were gasoline (possibly leaded regular and super), diesel, and fuel oil. Texaco likely added or revamped the thermal cracking capacity shortly after acquisition. Texaco operated the refinery until February 1950, at which time it was shut down and a majority of the refinery was dismantled. Since closure of the refinery, the facility has operated only as a crude oil pumping station.

Over the years, miscellaneous refinery and hydrocarbon wastes believed to consist primarily of tank bottoms, filter clays, and sludge were disposed on-site in a large pit located on the western border of the property, and in eight smaller pits located throughout the facility. It is reported that the waste disposal areas on-site have not been used since 1950.

In November 1980, Texaco submitted a letter proposal to the Regional Water Quality Control Board (RWQCB) to remove waste material from the pits and apply it to site roads. RWQCB requested additional information, including chemical analysis of the waste.

During a pre-RI/FS investigation (Assessment 1 program) in February 1984, Radian studied the chemical composition of the landfilled refinery waste and identified a Main Waste Pit and eight other refinery waste disposal areas. Plate A-1 in Appendix A illustrates the locations of these waste pits. Based on the pH readings and laboratory analyses that Radian conducted on selected samples from these waste pits, the California Department of Health Services (DHS)

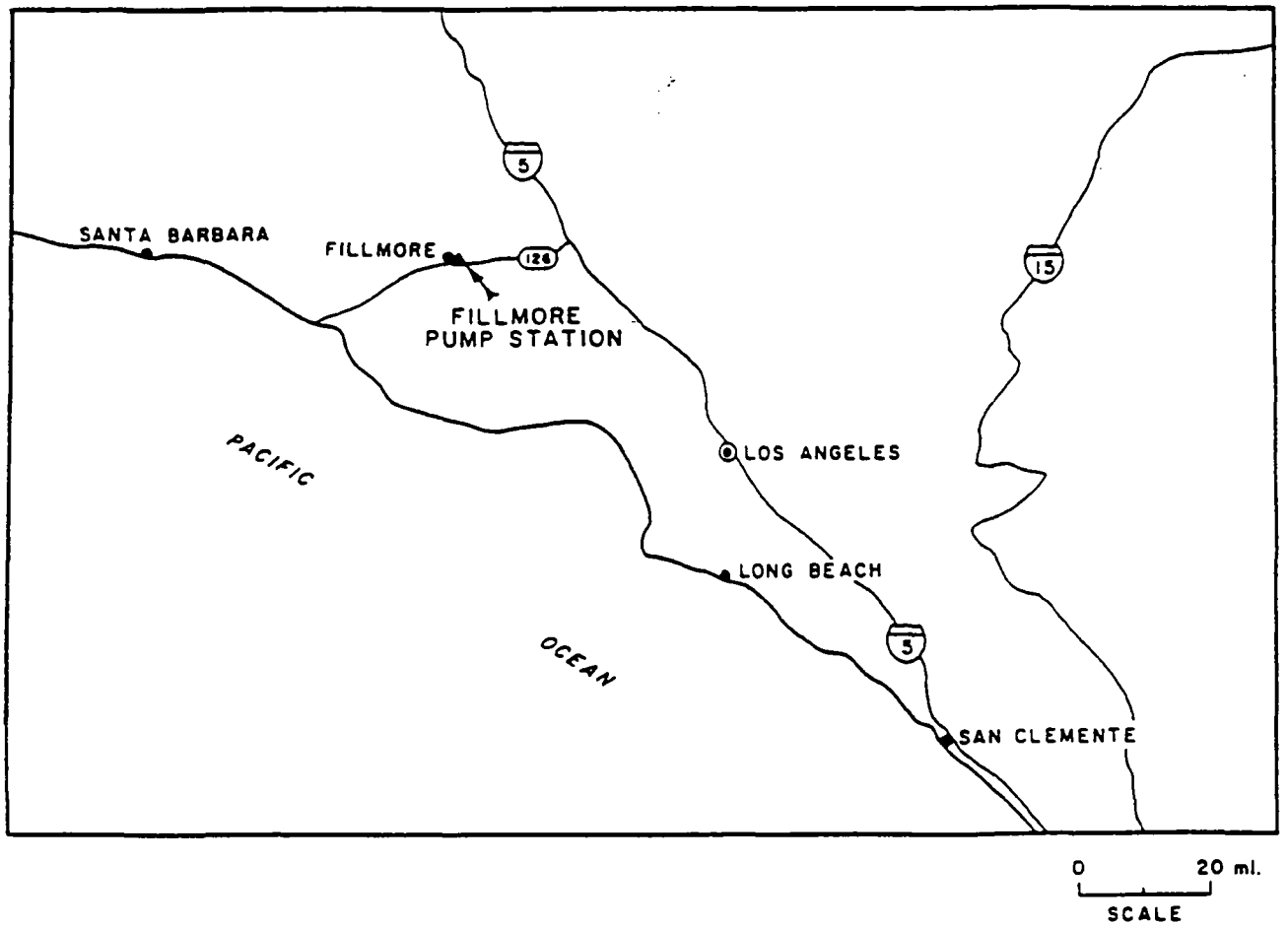

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FIGURE 1-1

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LOCATION MAP
FILLMORE FACILITY
TEXACO FILLMORE SITE

DRAWN:	JDG	DATE: 12/22/91	PROJECT NUMBER:	REV.
APPV'D:	GF	REVISED: X	6600-063	0

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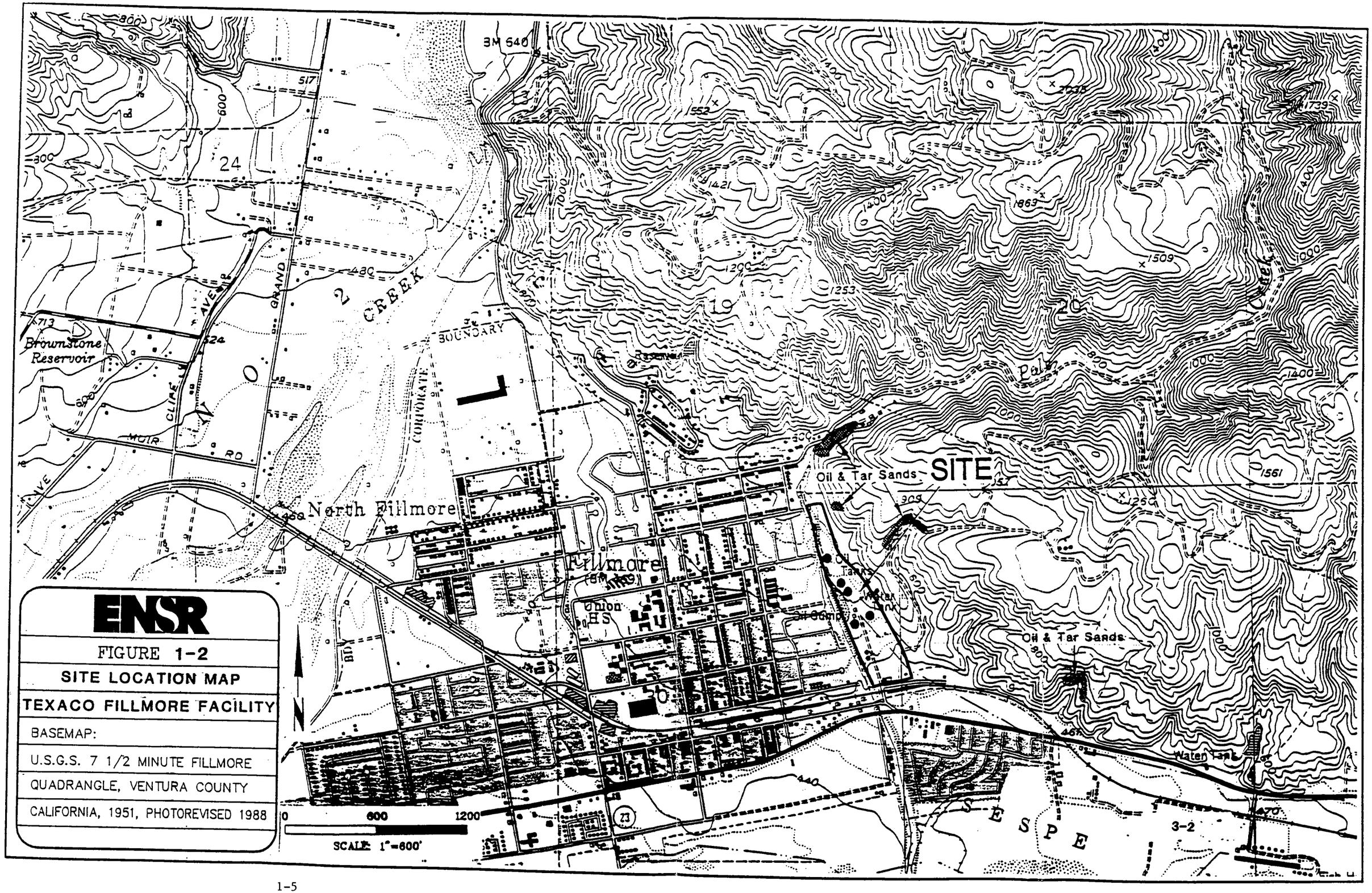
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FIGURE 1-2
SITE LOCATION MAP
TEXACO FILLMORE FACILITY
BASEMAP:
U.S.G.S. 7 1/2 MINUTE FILLMORE
QUADRANGLE, VENTURA COUNTY
CALIFORNIA, 1951, PHOTOREVISED 1988
SITE
Oil & Tar Sands
Oil & Tar Sands
Oil & Tar Sands
Brownstone Reservoir
North Fillmore
Fillmore
Union HS
Oil Tanks
Water Tank
Oil Camp
Water Tank
Palm Creek
Reservoir
BOUNDARY
CORDGATE
GRAND AVE
CLIFF AVE
MOIR RD
SESPE
3-2
0 600 1200
SCALE 1"=600'

determined that the refinery wastes and waste/soil mixtures were classified as hazardous waste. Following this determination and after review of remedial options, Texaco excavated and removed 38,000 tons of waste and contaminated soil from the Main Waste Pit and from the smaller waste disposal areas during January through September 1986.

From 1983 through 1989, Texaco voluntarily conducted groundwater and soils assessment programs and remediation activities at the Fillmore facility under the direction of DHS and the Los Angeles RWQCB. In October 1983 and June 1985, Radian installed a total of seven groundwater monitoring wells and two piezometers. In February 1986 and April 1987, TriHydro installed a total of 10 additional wells to provide more complete monitoring. Routine groundwater sampling and analysis were conducted up to and throughout the RI. Groundwater contamination was detected in the general area of the Main Waste Pit and at the southwestern corner of the facility; the source of the contamination was not clear.

In addition to the groundwater assessment programs, a study was performed to assess the impact of refinery waste on adjacent properties located downgradient of the Texaco Fillmore facility. A 1988 TriHydro study entitled *Environmental Assessment, Texaco Fillmore Facility and Adjacent Neighborhood Properties* identified no significant impacts to neighborhoods situated adjacent to and hydraulically downgradient from the site.

The Texaco Fillmore facility was listed on the U.S. EPA National Priorities List (NPL) on June 27, 1989 (CERCLIS August 9, 1989). While preserving its rights and without acknowledging the applicability of CERCLA to the site, Texaco entered into an agreement with U.S. EPA on November 15, 1989, whereby Texaco would conduct an RI/FS under U.S. EPA guidance to characterize the site and fully determine the nature and extent of remaining contamination at the Fillmore facility.

Texaco contracted with ENSR Consulting and Engineering to conduct the RI for the Texaco Fillmore facility. The RI report, released in draft form in January 1991 (ENSR Draft Document 6600-047-900) and finalized in June 1991 (ENSR Final Document 6600-047-900), describes the objectives, field methods, results, and conclusions of the RI.

1.2.3 Study Area Hydrogeology

1.2.3.1 Stratigraphy

The stratigraphic interpretation of the site is based on cored intervals and cuttings from 78 borings ranging in depth from 20 feet to 165 feet below grade, and from review of aerial photographs and topographic maps. Continuous core through a full penetration of the vadose

interval was obtained from two borings. Continuous core was obtained in the shallowest 20 feet below grade from 14 borings. Cores 2 feet in length were obtained during each 5 feet of penetration from 31 borings. Cores were collected at discrete depths from 11 borings for quality assurance/quality control of chemical analyses. Cores were not collected from 20 other borings, which were drilled solely for the purpose of installing groundwater monitoring wells.

The geomorphic expression of the depositional environments within alluvium was reviewed on the United States Geological Survey (USGS) 7.5 Minute Fillmore Quadrangle topographic map (1951, photorevised 1988), and on vertical aerial photographs taken in 1974 and 1986 (both photographs had an approximate scale of 1:2400).

The general interpretation of the depositional environment of alluvium at the site is that a portion of an alluvial fan was deposited in a semiarid climate, derived from sporadic discharge from Pole Creek Canyon onto an alluvial plain. The site lies on the most recent area of deposition of the fan (prior to stabilization of discharge via the installation of Pole Creek Flood Control Channel). During deposition in this area, stream discharge was approximately parallel to the foot of the San Cayetano Fault Line Escarpment, approximately 25 degrees east of south. Evidence of an alluvial fan is based on topographic contours that are convex away from the canyon mouth, extending through the town of Fillmore. Evidence of the most recent deposition is based on orientation of the current Pole Creek and parallel alignment of a reentrant, which is oriented parallel to this portion of the creek on a subsurface structural map (Structure Contours of Top of the Upper Fine-Grained Unit, ENSR Document No. 6600-047, Plate 3-15).

Lithologies encountered while drilling below grade include: a sequence of silty sand interbedded with gravels from 40 to 60 feet in thickness (Vadose Sequence with Perched Water); a sequence of clayey silt interbedded with silty sand from 10 to 30 feet in thickness (the Upper Fine-Grained Unit); a sequence of gravelly sands interbedded with silty sands from 60 to 80 feet in thickness (Aquifer 1); and a silty clay from less than 5 feet to 20 feet in thickness (the Lower Fine-Grained Unit). A sequence of gravels and silty sands (Aquifer 2) with a thickness of up to 30 feet was encountered beneath the Lower Fine-Grained Unit. However, this sequence was never fully penetrated.

1.2.3.2 Occurrence of Groundwater

Groundwater is encountered at the site in perched, unconfined, and confined conditions. Perched water is encountered on the upper surface of the Upper Fine-Grained Unit, at depths of approximately 60 feet below grade. A water table is encountered in Aquifer 1 at a depth of approximately 90 to 120 feet below grade, or an average subsurface elevation of 405 feet above sea level. Water from Aquifer 2 generates a potentiometric surface at approximately 125 feet

below grade and 10 feet above the base of the Lower Fine-Grained Unit, with an average subsurface elevation of 395 feet above sea level.

1.2.3.3 Hydraulic Parameters

Hydraulic parameters within Aquifer 1, including conductivity, transmissivity, and gradient, were estimated based on slug tests performed on six wells, and on hydraulic gradient maps that were based on quarterly well soundings. Conductivities were estimated to range from 9 to 1,360 feet per day. The average conductivity was 434 feet per day. Transmissivities were estimated to range from 0.45 to 61 sq. ft./day. Hydraulic gradients, estimated from May 1991, ranged from 0.5 to 1.5 ft per 100 ft, generally lowering toward the west. A hydraulic gradient was estimated for Aquifer 2 in May 1991 at approximately 0.5 ft per 100 ft, lowering toward the northwest.

1.2.3.4 Distribution of Benzene in Groundwater

Benzene in Aquifer 1 was found to be distributed in two plumes, according to quarterly groundwater sampling and analyses performed in May 1991. Plate A-2 in Appendix A shows the location of the two plumes based on the May 1991 data. Appendix A includes the benzene isoconcentration maps for the quarterly sampling. Based on May 1991 data, a northern plume, which covers an approximate area of 8 acres, is centered around the Main Waste Pit. A portion of the southern plume east of Pole Creek covers an area of approximately 10 acres and underlies pits 3, 4, and 9. The plume extends beneath the Ultramar service station located immediately south of the site on Ventura Avenue. Where benzene was detected, concentrations in wells located within both plumes ranged from 4 to 280 µg/L. Benzene was detected in Aquifer 2 in monitoring well MW-25D at 11 µg/L. It is important to note that the August 1991 sampling event resulted in a benzene range of 3 to 150 µg/L. Subsequent quarterly monitoring indicates that the extent of benzene in the northern plume is significantly reduced.

1.2.4 Nature and Extent of Impacts from Constituents of Interest

Chemical constituents identified in media investigations completed during the RI at the Texaco Fillmore facility are compounds typically associated with petroleum industry operations. The RI report provides a detailed representation of the distribution and concentration of identified organic constituents at the Texaco Fillmore facility.

As contractor to U.S. EPA Region IX, CH_2M Hill has developed a *Preliminary Discussion of Potential Contaminants and Related Standards* as a precursor to the baseline risk assessment being conducted for the Texaco Fillmore facility. The preliminary discussion is intended to allow for the development of remedial action alternatives prior to the release of the baseline risk

assessment by U.S. EPA. In its preliminary discussion, CH_2M Hill identified ten organic compounds in groundwater at the Texaco Fillmore facility. This listing was derived from the electronic data base of analytical data for the Texaco Fillmore RI. The ten compounds are:

Acetone	2-Methylnaphthalene
Benzene	4-Methyl-2-pentanone
1,2-Dichloroethane	Methylene chloride
Ethylbenzene	Toluene
Methyl ethyl ketone	Xylenes (total)

The preliminary discussion also identified fuel hydrocarbons as the constituents of interest. Fuel hydrocarbons are usually associated with benzene and other aromatic constituents.

Of these compounds, acetone and methylene chloride are believed to be laboratory contaminants. Because U.S. EPA developed this listing of constituents prior to completion of data validation, any flags to the data indicating that a constituent was a laboratory contaminant were not available at the time of the compilation of this list. In addition, because the focus of this feasibility study is Aquifer 1, it is notable that no methylene chloride was detected in the shallow aquifer (Aquifer 1) wells.

Of the remaining compounds, neither 4-methyl-2-pentanone nor methyl ethyl ketone were detected in Aquifer 1.

In addition to the above compounds identified by CH_2M Hill, quarterly groundwater monitoring analytical data show that naphthalene was detected at low levels in more than one well.

1.2.4.1 Characterization of Constituents of Interest

The physical and chemical characteristics of the constituents of interest play a large role in the fate and transport of the constituents and, especially pertinent to the feasibility study, in determining which treatment technologies will be effective in remediating the facility. The following paragraphs provide a discussion of the general chemical, physical, and biological parameters that govern the fate of these constituents in the environment. Table 1-1 presents a summary of data regarding these compounds.

Benzene - A review of the physical, chemical, and biological data for benzene indicates that it is a highly volatile solvent that is fairly soluble in water. Benzene is less dense than water; releases of this solvent to groundwater tend to accumulate at the surface of an aquifer. At the aquifer/vadose zone interface, benzene will volatilize, as reflected by its relatively high Henry's

TABLE 1-1

Physical and Chemical Characteristics of Constituents of Interest Identified at the Texaco Fillmore Facility

Compound	Boiling Point (°C)	Density (g/mL)	Solubility (mg/L)	Vapor Pressure (torr)	Log Octanol Water Partition Coefficient	Henry's Law Constant (atm m^3 mole)	Relative Biodegradation Rate	Major Natural Fate Process
1,2-Dichloro-ethane	83.5	1.23	8,690 (@ 20°C)	79 (@ 25°C)	1.45	1.10×10^{-3}	Slow	Volatilization
Benzene	80.1	0.88	1,000 (@ 20°C)	95 (@ 25°C)	2.13	5.55×10^{-3}	Slow	Volatilization
Ethylbenzene	136.2	0.87	152 (@ 20°C)	7 (@ 20°C)	3.15	6.44×10^{-1}	-	Volatilization
Toluene	110.6	0.87	534.8 (@ 25°C)	87.7 (@ 25°C)	2.69	5.92×10^{-3}	Fast	Volatilization
Xylene (mixed)	740.6	0.86	insoluble in water	6.7 (@ 21°C)	-	-	Fast	Volatilization
Naphthalene	218	1.0	30 (@ 25°C)	0.082 (@ 25°C)	3.37	4.83×10^{-4}	Fast	Sorption/Bio-degradation

law constant value. This organic constituent would not be expected to readily adsorb to subsurface soils because of its soluble nature, which is reflected by its relatively low log octanol-water partition coefficient. Compounds with log octanol-water partition coefficient values of less than three are considered to be environmentally soluble. The scientific literature states that benzene is biodegradable, primarily by aerobic metabolism. In some cases, however, anaerobic biodegradation may occur. Limited data are available concerning the chemical degradation of benzene in water, but it has not been demonstrated to play a significant role.

Based on the general physical and chemical parameters identified in Table 1-1, volatilization appears to be the major fate-governing mechanism for removal of benzene from the aquatic environment. Removal is also affected by microbial degradation. In groundwater, in-situ volatilization is limited by the solubility of benzene as well as by the lack of contact with air. Therefore, biodegradation is likely to represent a major in-situ fate-governing mechanism for benzene in groundwater. Once groundwater has been extracted from the subsurface, volatilization to the atmosphere is considered to be the primary transport process. Benzene volatilized to the atmosphere rapidly reacts with hydroxyl radicals, resulting in oxidation of the molecule. The half-life of benzene in the atmosphere is expected to be on the order of 2.4 to 24 hours.

Toluene - Physical, chemical, and biological data for toluene indicate that, like benzene, it is a very volatile and relatively soluble organic solvent. Toluene has a density of 0.87 g/mL, making it less dense than water. As is the case for benzene, groundwater plumes of toluene characteristically float near the water table surface of an aquifer. As indicated by its relatively high Henry's law constant, toluene will volatilize when present in the vadose zone above the water table. This organic solvent is fairly mobile in subsurface soils, but may be moderately retarded by subsurface soils rich in organic carbon content. In the atmosphere, toluene is readily oxidized by hydroxyl radicals; however, the rate of such degradation is very slow in aquatic systems. Rapid biodegradation of toluene has been known to occur in both shallow groundwater and in soil by aerobic microbial metabolism.

Based on the general physical and chemical parameters discussed above, volatilization of toluene to the atmosphere appears to be the major fate mechanism in aquatic environments. In groundwater, in-situ volatilization is limited by the availability of an air supply and the sorptive effects of any organically rich subsurface material that may be present. Once groundwater is removed from the subsurface, volatilization to the atmosphere is the primary transport process. In the atmosphere, toluene is readily oxidized by hydroxyl radicals. The half-life of toluene in the atmosphere is expected to be approximately 15 hours. Additional sources indicate that, in groundwater, toluene is degraded primarily by microbial action and not by chemical oxidation.

Xylene - A review of the physical, chemical, and biological data for mixed xylenes indicates that this solvent is volatile, but relatively insoluble in water. Xylene is less dense than water, and subsurface releases of this solvent tend to accumulate at the surface of an aquifer. A Henry's law constant and log octanol-water partition coefficient are not currently available in the literature for xylenes. It is expected, however that xylenes behave in a manner similar to benzene and toluene in terms of a primary environmental fate. Given this assumption, xylenes would be expected to volatilize into the vadose zone from the interface of the water table and the unsaturated zone in the subsurface. As is the case for toluene, soils with rich organic content tend to adsorb xylene and retard volatilization. Biodegradation of xylenes does occur in soils. Like toluene, xylene removed from the soil would be expected to undergo oxidation by hydroxyl radicals.

Definitive information concerning the primary environmental fate of xylene is not currently available in the literature. However, chemical, physical, and biological data indicate that volatilization is the primary removal mechanism in soils, with further removal being affected by biodegradation. In-situ volatilization is limited by the availability of air and may be further retarded by the presence of organically rich soils. Biodegradation, therefore, may be a major in-situ removal mechanism in soils. The rate of biodegradation of xylene in groundwater is not well documented in the literature. Once removed from groundwater, xylene would be expected to partition into the atmosphere and undergo oxidation.

Ethylbenzene - A review of the physical, chemical, and biological data for ethylbenzene indicates that the solvent is volatile and soluble in water. Ethylbenzene is less dense than water and releases of this solvent into groundwater tend to accumulate at the surface of an aquifer. The primary transport mechanism for ethylbenzene in aquatic systems is volatilization to the atmosphere. The Henry's law constant for ethylbenzene is even greater than that of benzene. Therefore, similarly to benzene, ethylbenzene would be expected to rapidly volatilize into soil pore spaces in the vadose zone groundwater. Data concerning the degree to which ethylbenzene adsorbs to soils and sediments are not available, but the log octanol water partition coefficient indicates that sorption may be significant. Soil bacteria have been shown to degrade ethylbenzene by aerobic metabolism. In the atmosphere, ethylbenzene is subject to photooxidation by hydroxyl radicals. Data are lacking concerning the oxidation of this solvent in aquatic systems, but oxidation has not been demonstrated be a significant removal mechanism.

Based on the general physical and chemical parameters mentioned above, volatilization appears to be the major transport mechanism for ethylbenzene in aquatic environments, with additional removal being affected by microbial degradation. In groundwater, volatilization to the unsaturated zone will be limited by the quantity of air available in soil pore spaces. Therefore,

biodegradation is likely to present a significant mechanism for the removal of this constituent from groundwater. Volatilization would be the primary transport process once groundwater has been extracted to the surface. Once ethylbenzene is transported to the atmosphere via volatilization, photooxidation is considered to be the ultimate environmental fate responsible for its degradation. The half-life of ethylbenzene in the atmosphere is expected to be on the order of 15 hours.

1,2-Dichloroethane - A review of the physical, chemical, and biological data for 1,2-dichloroethane (1,2-DCA) indicates that it is a highly volatile water-soluble solvent. When DCA is released to an aquatic system or to surface soils, the majority of the chemical rapidly partitions to the air by volatilization. Data are not currently available regarding the sorption of DCA in sediments or soils; however, substances with similar chemical makeup, such as trichloromethane and 1,1,1-trichloroethane, do not concentrate selectively on sediments or sandy soils with low organic content. This is to be expected given DCA's relatively low log octanol-water partition coefficient value. Because the log octanol coefficient provides a measure of a compound's hydrophobic partitioning (or propensity to become sorbed by organic matter), it also provides a measure of the ease of transport or mobility of the compound through an aquifer, and directly affects the ease of removal.

DCA is more dense than water, and quantities in excess of those that can be dissolved in water tend to accumulate at the bottom of surface water bodies. However, levels of DCA in Aquifer 1 during the most recent (May 1991) groundwater sampling event are significantly lower than the water saturation point for the compound, and the compound should be considered a dilute solution.

Little biodegradation of DCA occurs in groundwater, and processes other than volatilization do not play a significant role in the removal of DCA from aquatic systems. The lack of biodegradation is likely related to the toxicity associated with chlorinated compounds. Once this solvent has partitioned to the atmosphere, it undergoes photooxidation by hydroxyl radicals.

Based on the chemical characteristics of DCA discussed above, volatilization appears to be the major mechanism for removal of DCA from aquatic systems. In groundwater, in-situ volatilization is limited by this solvent's solubility and by the limited availability of air in the unsaturated zone. Because biodegradation and oxidation of DCA does not readily occur in groundwater, it has been estimated by U.S. EPA that residence time of this constituent in groundwater ranges from months to years. Once groundwater has been extracted from the subsurface, rapid partitioning to the atmosphere occurs via volatilization. The ultimate fate of DCA in the environment is photooxidation in the atmosphere.

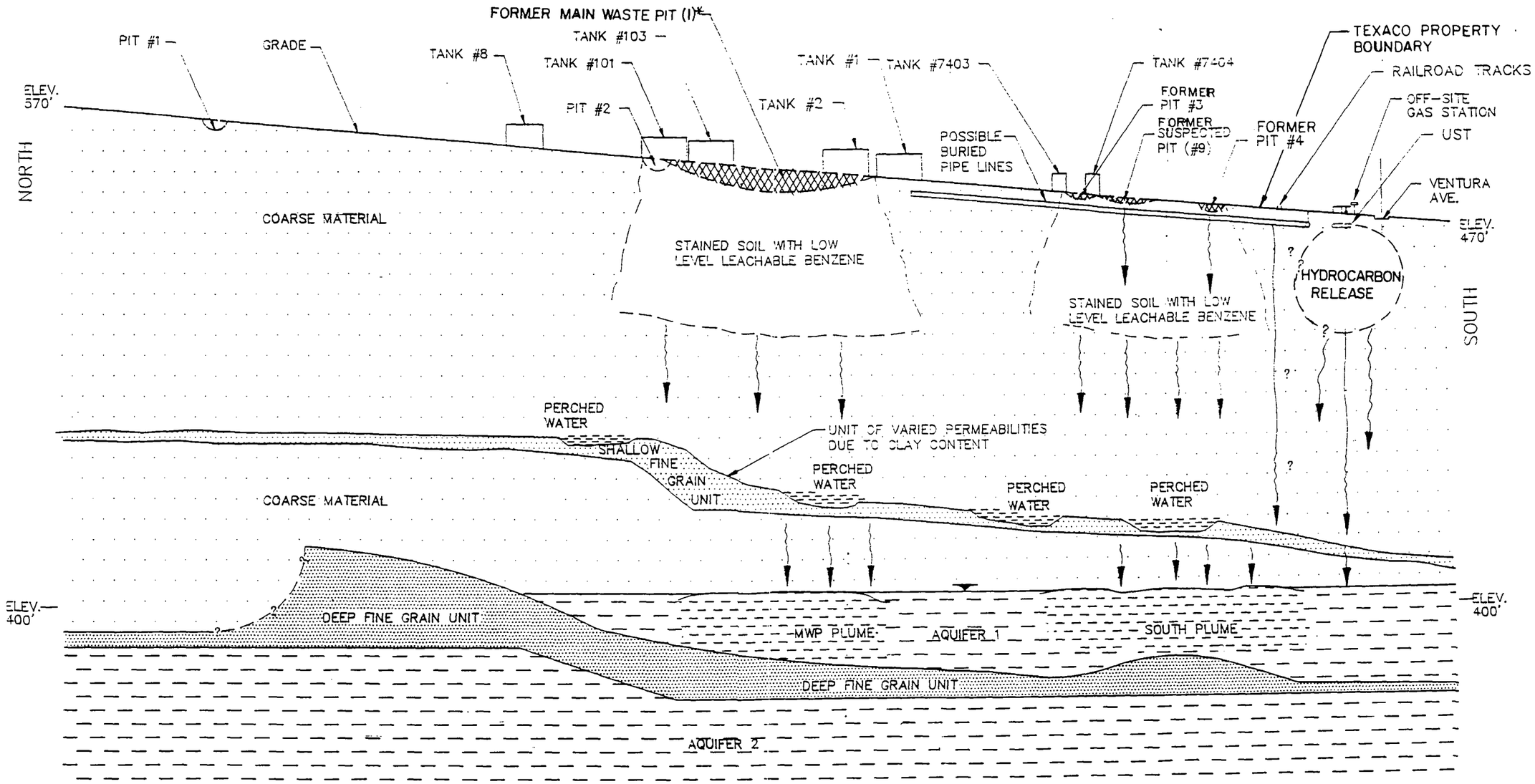
Naphthalene/2-Methylnaphthalene - A review of the physical, chemical, and biological data for naphthalene indicates that this compound is a polynuclear aromatic hydrocarbon (PAH) that contains two aromatic rings. Naphthalene is not highly volatile and is relatively insoluble in water. It is strongly adsorbed onto suspended particles, particularly those rich in organic carbon. This characteristic would be expected in compounds with log octanol water partition coefficients in excess of three. In groundwater systems, naphthalene is transported as absorbed matter on suspended particles. Volatilization of naphthalene does occur to some extent in aquatic systems, but is only significant in shallow, rapidly flowing streams. Rapid mixing of fluids is required to facilitate volatilization; therefore, volatilization is not expected to be a major transport mechanism for naphthalene in groundwater. Scientific literature reports that biodegradation of PAHs with two aromatic rings occurs rapidly in river sediments and soils and at a relatively slower rate in groundwater. Photolysis of dissolved PAHs in aquatic systems does occur, but the relative role compared to other environmental fates is still in question. The oxidation of PAHs by oxygen radicals is a slow process; therefore oxidation is not a significant environmental fate, particularly in groundwater, where the availability of oxygen may be limited.

Based on the parameters discussed above, biodegradation would be the ultimate environmental fate for naphthalene. Sorption also plays a major role in aquatic systems. The most important transport mechanism for this PAH in groundwater is as adsorbed material on suspended particles. In surface aquatic systems, photolysis of dissolved PAHs may occur.

1.2.4.2 Occurrence of Constituents of Interest

The FS report will evaluate the remedial alternatives and select the best overall solution with respect to the site conditions, the chemicals of interest, and the ARARs. To assist in this evaluation and selection process, three Action Areas were selected to address the two areas of the Fillmore site where impact on groundwater was identified. Figure 1-3 presents the conceptual site model developed in the RI summary. Figure 1-4 presents the locations of the two groundwater plumes and outlines the extent of Action Areas 1, 2A, and 2B.

Action Area 1 consists of the groundwater plume located in Aquifer 1 beneath the former main waste pit. A second plume of affected groundwater located near the southern portion of the site is divided into two Action Areas: 2A and 2B. Action Area 2A represents the majority of the groundwater plume. Action Area 2B consists of the portion of the southern groundwater plume which exists on or near the Ultramar service station. Soils containing low levels of the constituents of interest are present below the former disposal pits on-site in Action Areas 1 and 2A. Generally, however, constituents in soil were distributed over the site at low concentrations. For this FS, soils remediation will be focused on the mass beneath the Main Waste Pit as well as Waste Pits 3 and 4.



NOT TO SCALE

*(I) WASTES WERE REMOVED

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FIGURE 1-3
SCHEMATIC CONCEPTUAL MODEL
TEXACO FILLMORE
FEASIBILITY STUDY

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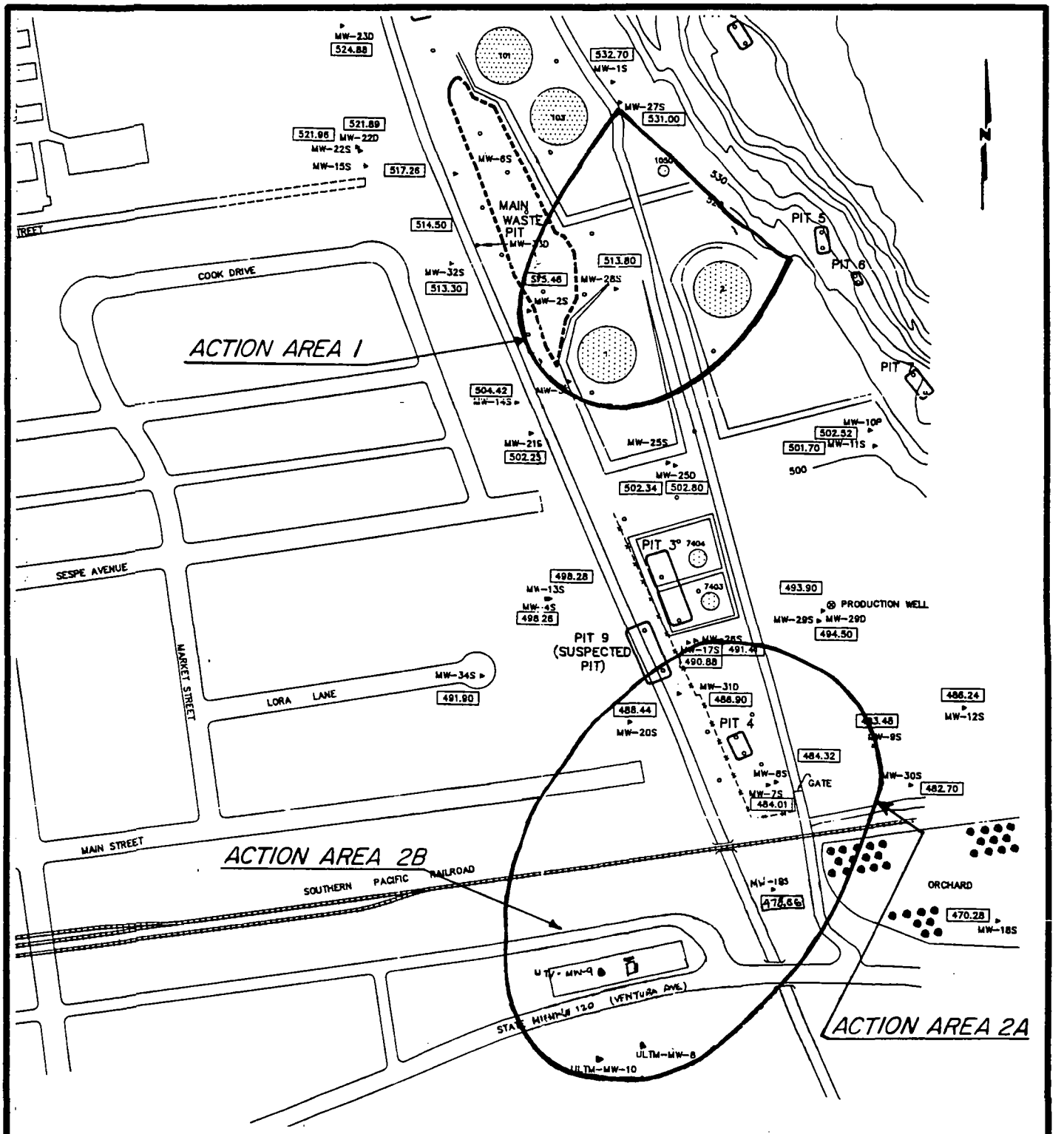
APPV'D:	REVISED:	6600-063	0



LEGEND

—— ESTIMATED BOUNDARIES OF REMEDIATION ACTION AREAS (BASED ON 10 ppb BENZENE CONTOURS OF SECOND, THIRD AND FOURTH QUARTER 1991 GROUNDWATER MONITORING SAMPLE DATA).

NOT TO SCALE

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FIGURE 1-4

DEFINITION OF ACTION AREAS TEXACO FILLMORE SITE

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APPV'D: JH	REVISED: 1/14/92	6600-063	0

During the RI, 785 subsurface samples were collected from 68 boreholes distributed throughout the Texaco facility. Soil sample data indicate that target metals concentrations detected in the samples were representative of background conditions for these constituents. Benzene was detected above the FSP characterization threshold level (11 µg/kg) in only four soil samples (at 38 µg/kg, 25 µg/kg, 22 µg/kg, and 12 µg/kg). Other target volatile and semivolatile compounds identified in soils analyzed by the Toxicity Characteristic Leaching Procedure (TCLP) were at or near reported limits of analytical detection. Xylene was detected above the FSP threshold of 620 µg/kg in only three samples (at 860 µg/kg, 810 µg/kg, and 640 µg/kg).

Based on the RI data, volatile organic compounds (VOCs) are the most common constituents identified in the Aquifer 1 groundwater adjacent to the Texaco Fillmore facility. During the four groundwater sampling events that occurred between August 1990 and May 1991, six VOCs were detected in Aquifer 1 underlying the facility: benzene, toluene, xylene (total), ethylbenzene, 1,2-dichloroethane, and acetone. Acetone is commonly associated with laboratory sample preparation and VOC analysis.

VOC concentrations were detected in two plumes within Aquifer 1: one near the main waste pit (Main Waste Pit Plume) and the other in the southern part of the facility (Southern Plume). Two semivolatile organic constituents, naphthalene and 2-methylnaphthalene, were detected in groundwater samples from the shallow aquifer at the Texaco Fillmore facility. The semivolatile organic compounds were encountered in Aquifer 1 in both the Main Waste Pit Plume and the Southern Plume. Table 1-2 presents a matrix of the constituents of interest that were detected for each plume.

Table 1-3 presents the range for the constituents found during each of the four groundwater sampling events and identifies the well in which the highest concentration of the constituent was detected during that event.

1.2.5 Contaminant Fate and Transport

The fate and transport of chemical constituents at the facility discussed in this report will focus specifically on benzene migration for the following reasons. Benzene in the groundwater is the only constituent that exceeded maximum contaminant levels (MCLs) established for drinking water. Moreover, most other constituents were at or near the reported limits of detection, and site characterization data reveal no identifiable spatial pattern of detection. Physical and chemical properties of benzene indicate that inter- and intra-phase movement of this compound is relatively uninhibited compared to other volatile aromatics identified in media investigations.

TABLE 1-2

Occurrence of Constituents of Interest in MWP Plume and Southern Plume

Constituent	Main Waste Pit Plume[1]	Southern Plume[2]
Benzene	X	X
Toluene	X	X
Xylenes (total)	X	X
Ethylbenzene	X	X
1,2-Dichloroethane	X	X
Naphthalene	X	X
2-Methylnaphthalene		X

[1]Wells located in the Main Waste Pit Plume are MW-6S, MW-21S, MW-22S, MW-27S, MW-28S, and MW-32S.
[2]Wells located in the Southern Plume are MW-18S, MW-19S, MW-20S, MW-26S, MW-29S, MW-30S, and MW-34S.

TABLE 1-3

Constituents of Interest Detected For Each Groundwater Sampling Event

Constituent	Concentration Range/High Well (August 1990)	Concentration Range/High Well (Sept-Oct 1990)	Concentration Range/High Well (January 1991)	Concentration Range/High Well (May 1991)	Concentration Range/High Well (August 1991)	Concentration Range/High Well (November 1991)[1]
Benzene	ND-720 µg/L MW-26S	5-540 µg/L MW-19S	2-320 µg/L MW-19S	4-280 µg/L MW-19S and ULTM-MW-9	ND-260 µg/L ULTM-MW-9	ND-390 µg/L MW-19S
Toluene	ND-73 µg/L MW-26S	4-110 µg/L MW-26S	6-52 µg/L MW-19S	4-82 µg/L ULT M-MW-9	ND-23 µg/L MW-28S and MW-24D	ND-78 µg/L ULTM-MW-9
Xylenes (total)	ND-28 µg/L MW-26S	1-70 µg/L MW-19S	3-30 µg/L MW-19S	2-55 µg/L MW-27S	ND-37 µg/L MW-28S	ND-28 µg/L ULTM-MW-9
Ethylbenzene	ND-14 µg/L MW-26S	1-15 µg/L MW-26S	2-39 µg/L MW-20S	4-150 µg/L MW-27S	ND-49 µg/L MW-20S	ND-14 µg/L ULTM-MW-9
1,2-Dichloroethane	ND	9 µg/L MW-26S	<1-6 µg/L MW-19S	1-5 µg/L ULT M-MW-9	MD-TR ULTM-MW-9	ND-TR ULTM-MW-9
Naphthalene	ND	33-84 µg/L MW-19S	TR-12 µg/L MW-20S	TR-54 µg/L MW-27S	ND-42 µg/L ULTM-MW-9	--
2-Methylnaph-thalene	ND	11 µg/L MW-19S	ND	ND	ND-TR MW-8S	--

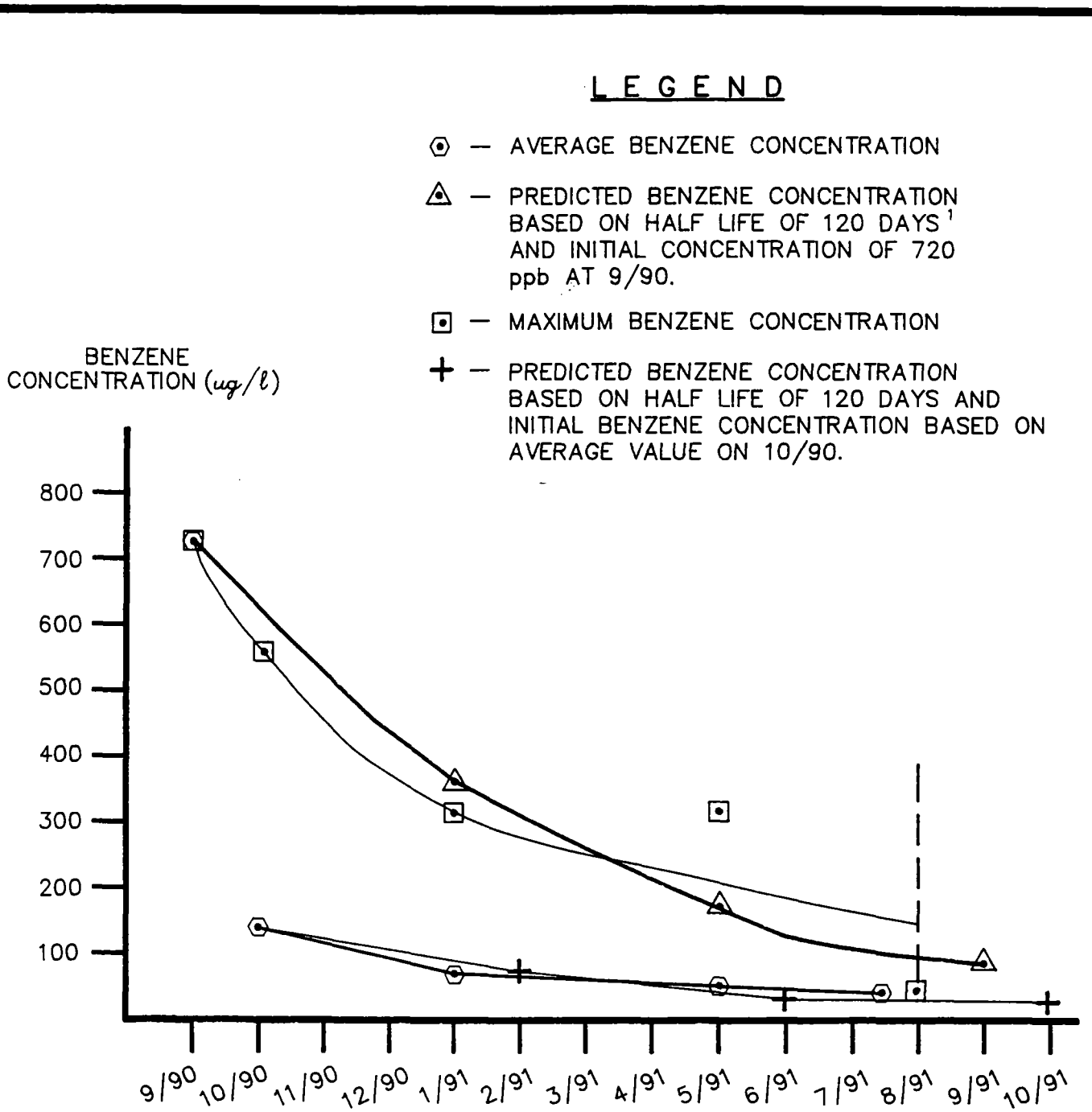
TR = Trace amount.
ND = Not detected.
-- = Not analyzed for this constituent.
[1]Data not validated.

In addition, attenuation of benzene via sorption processes or degradation is relatively low. Therefore, benzene possesses the greatest potential for off-site migration. Benzene will also be used as the primary driving force for soils remediation beneath the main waste pit.

With respect to the benzene, available site data suggest that natural degradation would achieve chemical-specific treatment standards for groundwater criteria over time. Benzene is present in groundwater at concentrations greater than its MCL and is one of the most mobile of the contaminants present. An estimate of time required for natural biodegradation of benzene in groundwater and soils to achieve the benzene MCL is calculated in Appendix D. Based on the aerobic biodegradation half-life of benzene (Ward and Thomas, 1986) and an initial benzene concentration of 720 μg/L, approximately 5 years would likely be required for aerobic biodegradation to achieve the MCL of 5 μg/L. Biodegradation constants for 1,2-DCA were not cited in the literature reviewed during report preparation; therefore, a degradation timeframe for achieving the maximum contaminant level (MCL) could not be specified. DCA, which was present slightly above the federal MCL at one location, is very soluble and would therefore be expected to dissipate over the long term due to natural groundwater flow. Groundwater monitoring data presented in Figure 1-5 indicate that significant biodegradation of benzene may have already occurred at the Fillmore site.

Figure 1-5 is a plot of the maximum and average detected concentrations of benzene in groundwater samples versus time. The plot of maximum benzene concentrations was estimated between January and August 1991. For comparison purposes, plots of the predicted degradation rates for maximum and average detected benzene concentrations are included in Figure 1-5. Both the maximum and average concentrations of benzene as graphed correlate well with the concentration curves predicted from its reported natural biodegradation half-life. Monitoring will be required to focus on this relationship to confirm whether natural biodegradation will continue to reduce benzene concentrations with time. The movement of constituents less soluble than benzene is expected to continue to be attenuated by sorption to soils and biodegradation. Thus, in the long-term, natural degradation and attenuation processes are likely to achieve standards.

A preliminary conceptual model has been developed to define and address potential routes of benzene migration in media underlying the Texaco Fillmore facility and the subsequent fate and transport mechanisms that act on this constituent. Currently, this model consists of the following elements.



[1] HALF LIFE FROM WARD & THOMAS, 1986, BIOTRANSFORMATION RATES OF SELECTED CHEMICALS.

FIGURE 1-5

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COMPARISON OF OBSERVED BENZENE CONCENTRATION WITH PREDICTED DEGRADATION RATE
TEXACO FILLMORE SITE

DRAWN: JDG	DATE: 12/12/91	PROJECT NUMBER:	REV.
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- Naturally occurring hydrocarbons are not likely to be a source for the amount of benzene dissolved in the groundwater of Aquifer 1. However, naturally occurring petroleum hydrocarbons may be contributing to the extent and concentrations of identified constituents.

- The Southern Plume appears to contain the highest benzene concentrations in Aquifer 1, based upon the May 1991 quarterly groundwater sampling results. During previous sampling episodes, however, the Main Waste Pit Plume contained the highest concentrations of benzene. The levels of benzene in the Main Waste Pit Plume have steadily declined since initial sampling of Aquifer 1.

- There may be several sources within the Texaco facility that contribute to benzene levels in the Southern Plume, also in Aquifer 1. For example, the Southern plume underlies Pits 3, 4 and 9, former pipelines, and a former bulk loading area. It is also possible that the gas station and salvage yard facilities on nearby properties are off-site sources of benzene in groundwater.

- Migration of the Main Waste Pit Plume is probably minimized by the limited extent of Aquifer 1 in the northern portion of the facility. The plume's source is likely to be low-level residual volatiles in soils beneath the extent of former Main Waste Pit excavations. However, other possible sources of chemical constituents, such as abandoned or former pipelines, remain.

1.2.6 Baseline Risk Assessment

A site-specific risk assessment of the Texaco Fillmore facility has not been performed by Texaco. CH_2M Hill completed the risk assessment on behalf of U.S. EPA Region IX, and provided this assessment as a separate document to Texaco in late December 1991. As such, the development and analysis of alternatives presented herein are based on the draft risk assessment document, the comments made by U.S. EPA and CH_2M Hill to the draft Detailed Analysis of Alternatives, and guidance provided to Texaco by U.S. EPA and CH_2M Hill.

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

2.1 Introduction

During this phase of the FS, the potentially feasible remedial technology types and process options identified in the *Draft Report: Remedial Alternative Development and Screening for the Texaco Fillmore Site* (ENSR Document 6600-047-995) will be screened with respect to technical implementability and feasibility to achieve the general response actions (GRAs) developed for groundwater in the Main Waste Pit and Southern Plumes of Aquifer 1. GRAs, consisting of medium-specific actions, will be developed to satisfy remedial action objectives (RAOs) for protecting human health and the environment from exposure to hazardous constituents identified in the groundwater plumes. During the development of GRAs, an initial determination will be made of the volume of contaminated groundwater in each of these plumes.

Both Section 121 of CERCLA and the National Contingency Plan (NCP) require that response actions attain a level or standard of control which complies with applicable or relevant and appropriate requirements (ARARs) of federal environmental laws and more stringent state environmental and federal siting laws.

- Chemical-specific ARARs - Usually health- or risk-based numerical values or methodologies, which when applied to site-specific conditions, establish the numerical site cleanup values.
- Location-specific ARARs - Usually technology- or activity-based requirements or limitations.
- Action-specific ARARs - Restrictions placed on the concentration of hazardous substances or the conduct of activities because they occur in special locations.

The ARARs identified in this report were established based on the specific characteristics of the Texaco Fillmore site, constituents identified in the groundwater, and potential alternatives available to remediate those constituents.

2.2 Remedial Action Objectives

RAOs are site-specific, quantitative goals that define the extent of cleanup required. They include the preliminary cleanup levels, the area of attainment, and the restoration timeframe. RAOs form the basis for developing detailed remedial action alternatives. In this section, RAOs for the

Texaco Fillmore facility will be developed based on the contaminants present in Aquifer 1, pertinent ARARs, and the classification and uses of groundwater at the facility.

2.2.1 Constituents of Interest

As described in Section 1.2.4, six VOCs and two semivolatile organic compounds were identified as being present in the shallow aquifer, Aquifer 1. Of the six VOCs (benzene, toluene, total xylenes, ethylbenzene, 1,2-dichloroethane, and acetone), benzene is the contaminant of primary interest, due to its status as a "chemical known to the state of California to cause cancer" (per Proposition 65), as well as to its mobility and behavior as an "indicator" compound. In Aquifer 1, benzene was found at levels above the state of California recommended MCL of 1.0 µg/L.

Usually associated with the benzene are fuel hydrocarbons and other aromatics such as toluene, ethylbenzene, and xylenes; this fact is supported by the analytical results of the groundwater investigation portion of the RI. Toluene, total xylenes, and ethylbenzene were detected in Aquifer 1 at levels below the state of California MCL and will be addressed in Section 2.2.3.1, "Chemical-Specific ARARs," along with benzene.

The presence of 1,2-dichloroethane in two monitoring wells is also of interest because of its inclusion on the list of "chemicals known to the state of California to cause cancer" (per Proposition 65). 1,2-Dichloroethane was found at levels above the state of California recommended MCL of 0.5 µg/L.

The presence of acetone in the groundwater sample taken from MW-20S during the May 1991 sampling events is believed to be a result of laboratory contamination; therefore, acetone is not a contaminant of interest.

The two semivolatile organic compounds detected in the Aquifer 1 groundwater samples are naphthalene and 2-methylnaphthalene. These compounds were detected at relatively low levels. As stated in Section 2.2.3.1, no published ARARs are available for these constituents. However, until the RI risk assessment is completed for the site, these two semivolatile compounds will be considered constituents of interest.

In the RI/FS Quality Assurance Project Plan (QAPP) prepared for the Texaco Fillmore facility prior to the initiation of field work, five VOCs were identified as being indicator parameters for the groundwater investigation: benzene, toluene, total xylenes, ethylbenzene, and ethylene dibromide. Of these five organic compounds, all but ethylene dibromide were detected in the groundwater samples from the facility. For all groundwater samples taken during the four sampling events (August 1990, September 1990, January 1991, and May 1991), ethylene

dibromide was consistently reported below the detection limit of the analytical instrument. Therefore, ethylene dibromide is not a constituent of interest.

No semivolatile organic compounds were specified as indicator parameters for the Texaco Fillmore groundwater investigation.

2.2.2 Selection of ARARs and Allowable Exposure Based on Risk Assessment

ARARs are used to evaluate the effectiveness of remedial alternatives under investigation in the feasibility study, as well as to develop allowable concentrations and target cleanup levels in the media requiring remediation. ARARs are supplemented by other criteria and guidelines to be considered (TBCs). If ARARs are not available or if they are found not to adequately protect human health in situations involving, for example, multiple contaminants, appropriate target cleanup levels may be established based on the risk assessment.

Until the risk assessment for the Texaco Fillmore facility is completed, only ARARs and TBCs under the following statutes or regulatory agencies will be addressed for the remediation of the groundwater in Aquifer 1.

2.2.2.1 Chemical-Specific ARARs and TBCs

The contaminant-specific ARARs for the site are Federal and State of California drinking water standards because the Fillmore Basin is a potential source of drinking water. The NCP requires that remedial actions attain the Maximum Contaminant Level Goals (MCLGs) established under the Safe Drinking Water Act that are set above zero for groundwater that is a current or potential source of drinking water. If an MCLG is set at zero or is not relevant and appropriate under the circumstances, the Maximum Contaminant Level (MCL) established under the Safe Drinking Water Act will be the ARAR. The MCLs and MCLGs for the constituents of concern are set forth in Table 2-1.

California has also promulgated MCLs for certain contaminants as shown in Table 2-1. Where the California MCLs are more stringent than the federal MCLs, it is appropriate for EPA to choose the more protective and stringent standard as the ARAR.

The California Department of Health Services has established drinking water applied action levels which are used to protect drinking water and are generally more stringent than MCLs. The drinking water applied action levels are not promulgated by the State and therefore cannot be ARARs. However, EPA can consider the action levels as To Be Considered Criteria (TBCs).

2.2.2.2 Action-Specific ARARs and TBCs

Several of the potential alternatives discussed in Chapter 3 involve groundwater extraction and treatment. The potential groundwater treatment technologies include carbon adsorption, air stripping or UV/ozone oxidation. The treated groundwater may be injected into the aquifer, discharged to the Publicly Owned Treatment Works (POTW), discharged to surface water, or reused. These potential actions require compliance with the following ARARs:

Injection of Treated Effluent into Aquifer

ARARs applicable to injection of treated effluent into the aquifer include:

1. The Los Angeles Regional Water Quality Control Board's Water Quality Control Plan, which incorporates State Water Resources Control Board (SWRCB) Resolution No. 68-16 "Statement of Policy with Respect to Maintaining High Quality of Waters in California." The Resolution requires maintenance of existing water quality unless it is demonstrated that a change will benefit the people of the State, will not unreasonably affect present or potential uses, and will not result in water quality less than that prescribed by other State Policies.

2. Section 3020 of the Resource Conservation and Recovery Act prohibits disposal of hazardous waste into a formation which contains a source of drinking water or above such a formation. This prohibition does not apply to treated contaminated groundwater into an aquifer if: (1) such injection is part of a response action under CERCLA, (2) the contaminated groundwater is treated to substantially reduce hazardous constituents prior to such injection, and (3) the response action will upon completion be adequate to protect human health and the environment.

3. The California Safe Drinking Water Act (Proposition 65) prohibits the discharge of chemicals known to the State to cause cancer or reproductive toxicity into groundwater or surface water drinking water sources or onto land which may pass into a drinking water source. Benzene has been identified by California as a carcinogen.

In order to comply with these ARARs, any water that is reinjected will have to be treated to below Federal or State MCLs, whichever is more stringent for all contaminants.

Discharge to the POTW

The Clean Water Act allows municipalities to determine pretreatment standards for discharges to POTWs. Discharge of treated groundwater to the local sanitary sewer system requires compliance with the local POTW's substantive discharge limitations and the Clean Water Act pretreatment standards.

Reuse of Treated Groundwater

If the treated groundwater is to be used in a public drinking water system, ARARs for providing the treated groundwater for reuse would include (1) the state or federal MCLs, whichever is more stringent, (2) the SWRCBs' Resolution No. 68-16, and (3) California's Proposition 65. These ARARs can be met by treating the contaminated groundwater to levels below the MCLs.

Discharge to Surface Water

Substantive National Pollutant Discharge Elimination System (NPDES) permit requirements are ARARs for treated effluent that is discharged on-site to surface waters. The Los Angeles RWQCB regulates NPDES discharges. The RWQCB establishes effluent limitations based on water quality standards set forth in the Los Angeles River Basin Plan.

Carbon Adsorption

Use of activated carbon for remediation of organics in the groundwater may trigger RCRA and California Hazardous Waste Control Act requirements for disposal of hazardous waste. If the used carbon is characteristic of hazardous waste under RCRA or the California Hazardous Waste Control Act, the requirements for generators of hazardous waste under RCRA and the California Hazardous Waste Control Act would be ARARs. In addition, the handlers must determine whether any hazardous waste generated during the remedial actions would be subject to RCRA and the California Hazardous Waste Control Act land disposal restrictions.

Air Stripping

In California, the authority to regulate stationary sources of emissions has been delegated to local air quality management districts. The Site is located within the jurisdiction of the Ventura County Air Pollution Control District (APCD). Therefore, the substantive APCD regulations applicable to emissions from air strippers constitute State ARARs.

2.2.2.3 Location-Specific ARARs

No location-specific ARARs are anticipated for the remediation of the Aquifer 1 groundwater at the Texaco-Fillmore Facility.

2.2.2.4 Soil ARARs

No chemical-specific ARARs have been identified for cleanup of the soil. The proposed EPA regulation for corrective action for RCRA solid waste management units may be a TBC. Under the proposed corrective action regulation, action levels are determined by EPA to protect human health and the environment. Contamination exceeding action levels indicates a potential threat to human health or the environment.

If soil vapor extraction is used at the Texaco Fillmore Facility for cleanup of the soil, action-specific ARARs would include the ACPD's substantive regulations.

2.2.3 Development of Remedial Action Objectives

During the FS process, the development of RAOs involves establishing preliminary cleanup levels based on ARARs and health-based risk information, determining the areas of attainment, and estimating the restoration timeframe. Preliminary cleanup levels for the Texaco Fillmore site will comprise predominantly chemical-specific ARARs and, to a lesser extent, action-specific and location-specific ARARs. Preliminary cleanup levels based on health-based risk information cannot be addressed in this report, because allowable exposure levels based on the Texaco Fillmore risk assessment have not been established.

The area of attainment is the area over which cleanup levels in the groundwater must be achieved. As agreed during the March 8, 1991, meeting between U.S. EPA and Texaco, the areas of attainment that will be addressed in this FS include only groundwater in the Main Waste Pit and Southern Plumes of Aquifer 1.

The restoration timeframe is defined as the period of time required to achieve selected cleanup levels in the groundwater within the areas of attainment. An estimate of the restoration timeframe will not be presented for the preliminary remediation alternatives in this report.

2.2.3.1 Chemical-Specific ARARs

Until the risk assessment for the Texaco Fillmore facility is completed, it will not be known whether published water quality standards and drinking water standards are protective of human health and the environment. For the purpose of proposing preliminary cleanup standards, however, we will rely upon the published water quality and drinking water standards for chemical-specific ARARs. After completion of the risk assessment, if it is determined that the published standards for a compound of concern are protective, these standards will become the chemical-specific cleanup goals.

Based on the analytical results of the groundwater samples collected during the four sampling events, seven chemical constituents should be addressed: benzene, toluene, total xylenes, ethylbenzene, 1,2-dichloroethane, naphthalene, and 2-methylnaphthalene (see Section 2.2.1, "Constituents of Interest"). Where a chemical constituent has more than one published standard, for example, a U.S. EPA MCL and a DHS action level, the more stringent of the standards was selected, as long as the value is enforceable and is not just a suggested value. Table 2-1 presents selected chemical-specific ARARs and TBCs for the seven constituents of interest.

2.2.3.2 Location-Specific ARARs

Location-specific requirements are those that involve restrictions on how remedial activities are to be conducted in particular locations. No location-specific ARARs are anticipated for the remediation of the Aquifer 1 groundwater at the Texaco Fillmore facility.

2.2.3.3 Action-Specific ARARs

Action-specific requirements anticipated for remediation of the groundwater at the Texaco Fillmore facility will primarily concern any discharges from the selected groundwater treatment system. These discharges could potentially be to the air, surface water, a POTW, or by reinjection to the groundwater. Any air or water discharges from the selected treatment system will be permitted as required. Permit requirements will typically dictate that the permitted stream meet certain discharge standards. Discharge standards commonly include chemical-specific concentration limits and flow rate limitations.

Another action-specific ARAR that may apply to remedial action alternatives being evaluated for the Texaco Fillmore facility is a grading permit, to be acquired from Ventura County.

As implied by the name, all action-specific ARARs cannot be fully identified until a remedial action alternative has been evaluated in detail. However, at the preliminary stage of treatment

TABLE 2-1

Potential Chemical-Specific ARARs and TBCs for Groundwater at the Texaco Fillmore Facility

Chemical	Standard (μg/L)	ARARs/TBCs
Benzene	1.0	MCL (Cal DHS)
	5.0	MCL (Federal)
	0.66[1]	WQC (Federal)
	235	HA[2] (Federal)
	0.66[1]	HA[3] (Federal)
	2.0	NSRL (Cal DHS)
Toluene	100[1]	AL (Cal DHS)
	10,000	AL (Federal)
	14,300	WQC (Federal)
	2000	MCLG (Federal)
	2420	HA (Federal)
Total Xylenes	70,000	AL (Federal)
	1750	MCL (Cal DHS)
	440	MCLG (Federal)
	400	HA (Federal)
Ethylbenzene	680	MCL (Cal DHS)
	4,000	AL (Federal)
	680	MCLG (Federal)
	1400	WQC (Federal)
	680	HA (Federal)
1,2-Dichloroethane	0.5[1]	MCL (Cal DHS)
	5.0	MCL (Federal)
	0.5	AL (Federal)
	0.9	NSRL (Cal DHS)
	740/2600[4]	HA[2] (Federal)
	0.38	HA[3] (Federal)
Naphthalene	No ARARs/TBCs identified	
2-Methylnaphthalene	No ARARs/TBCs identified	

[1]Value suggested to protect beneficial use.
[2]For carcinogens, health advisory value not considering any cancer risk.
[3]For carcinogens, health advisory as a 1-in-a-million incremental cancer risk.
[4]Child/Adult.
Additional Notes: AL = action level; HA = health advisory; MCL = maximum contaminant level; MCLG = maximum contaminant level goal; NSRL = no significant risk level; WQC = water quality criteria

technology identification (and ARAR identification), it can be stated that for the selected remedial action alternative. Texaco will comply with ARARs and administrative requirements, such as obtaining permits. Texaco will acquire all necessary permits for construction and/or operation of the alternative. These may include an NPDES permit, a permit to discharge to the local POTW, or an air permit from the Ventura County APCD.

2.2.3.4 Potential Use and Classification of Groundwater in Aquifer

Based on its vulnerability to contamination and its vertical proximity to existing agricultural, municipal, and private water wells producing from deeper aquifers, the groundwater within Aquifer 1 may be classified as Class IIA under guidelines established in U.S. EPA's *Groundwater Protection Guidelines* (U.S. EPA, 1986). Groundwater under this classification is described as "potential sources of drinking water and water having other beneficial uses" (*Groundwater Protection Strategy,* U.S. EPA, 1984).

Groundwater in Aquifer 1 may be described as vulnerable to contamination, based on results presented in the final RI report for the site (ENSR Final Document 6600-047-900). However, the aquifer is of higher subsurface elevation than the perforated intervals of surrounding agricultural, municipal, and private water wells. Therefore, it may be deduced that Aquifer 1 is not an irreplaceable source of potable groundwater. Evidence indicates that it is not a direct source. No evidence was found to indicate that waters from Aquifer 1 provide baseflow for local, ecologically sensitive systems, such as wetlands (ENSR Draft Document 6600-047-900).

No data currently exist regarding levels of total dissolved solids or nitrates in Aquifer 1. However, for the purposes of classification, it is currently assumed that total dissolved solids are present at levels below 10,000 mg/L, and nitrates are at levels that could potentially be remediated if necessary. It is also assumed that groundwater within Aquifer 1 may be hydraulically connected to aquifers from which local agricultural, municipal, and private wells produce.

The Texaco Fillmore facility lies within the drainage basin (watershed) of the Fillmore Basin. Contamination reaching producing aquifers could, for example, potentially affect areas lying to the west and southwest, based on a map of water levels (Ventura County Public Works Agency [VCPWA] Water Level Map, Fall 1984). Groundwater supply wells are located in the vicinity of the site. For example, a well used for agricultural purposes (04N19W30R01S) lies 1,000 feet to the south and contains a screened interval reportedly at 173 to 300 feet below grade (ENSR Draft Document 6600-047-900). The base of Aquifer 1 is at an approximate depth of 65 feet below grade in monitoring well MW-19, located near the southern boundary of the site. The subsurface elevation of the base of Aquifer 1 in monitoring well MW-19 is approximately 415 feet above sea level. Assuming the surface elevation at the agricultural well (04N19W30R01S) is approximately

440 feet above sea level (estimated from topographic map), the subsurface elevation of the top of the screened interval in the well would be 267 feet above sea level. Therefore, it is estimated that constituents of interest identified in Aquifer 1 at the Texaco Fillmore facility would have to migrate approximately 150 feet vertically to reach the top of the screened interval in this agricultural well.

2.2.3.5 Remedial Action Objectives for the Texaco Fillmore Facility

Based on the nature and extent of the impact from constituents of interest detected in the groundwater of Aquifer 1 at the Texaco Fillmore facility, and based upon the potential use and classification of groundwater in Aquifer 1, the following RAOs are proposed for use as the basis for developing remedial alternatives. The RAOs were established for the three action areas.

Action Area 1 (Main Waste Pit Area)

- Provide remedies that allow eventual achievement of groundwater standards that are appropriate for constituents of interest beneath the Fillmore site given the regional influence of naturally occurring petroleum.

- Prevent public from exposure to potentially hazardous substances present in groundwater and on-site subsurface soils near the Main Waste Pit Area.

Action Areas 2A and 2B (Southern Groundwater Plume)

- Provide remedies that allow eventual achievement of groundwater standards that are appropriate for constituents of interest located beneath adjacent properties given the regional influence of naturally occurring petroleum as well as the contribution of other off-site sources to the plume.

- Prevent public exposure to potentially hazardous substances contained in groundwater in and near the southern portion of the facility, and in on-site subsurface soils near the former waste pits at the south end of the facility.

These objectives formed the basis for the development of remedial alternatives that are analyzed in detail in this document and will be used to recommend a remedial life cycle approach for the site.

2.3 Development of General Response Actions

General response actions describe the actions that will satisfy the RAOs. The RAOs for the facility that were defined in Section 2.2.3.5 serve as the basis for developing general response actions. At this stage, the types and volumes of contaminated media to be addressed must be defined.

2.3.1 Identification of Attainment Areas

2.3.1.1 Groundwater

The areas of attainment within the groundwater in Aquifer 1 comprise an estimated total of approximately 15 acres in two plumes: Action Area 1 - Main Waste Pit Plume, with an average estimated area of 4.4 acres (192,000 ft^2) and Action Area 2 - Southern Plume, with an area of 10.7 acres (467,000 ft^2). These areal estimates are based on isopleth maps of benzene distribution derived from the May, August, and November 1991 quarterly groundwater sampling activities. The extent of the Action Area 1 and 2 plumes for each sampling date was estimated based on the distribution of benzene in groundwater. Benzene was selected as the most representative constituent due to its water solubility (see Plates A-1, A-2, A-3, and A-4). Three sampling dates were determined.

Comparison of the May 1991 area for Action Area 1, 360,000 ft^2, with the fourth quarter (November 1991) area of 15,625 ft^2 suggests that the plume is degrading under natural conditions.

In Action Area 2, the areas of the plume located on the Texaco Fillmore property have been reduced; however, the overall size of the plume has remained relatively constant. This trend suggests that natural degradation may be in a steady-state flux with residual benzene on soils. Mass transfer from the soils may be preventing the reduction of plume size in Action Area 2. For the purpose of the FS, however, an average area was selected to define the area of attainment. Appendix B presents the calculations used to determine the average areas.

Benzene concentrations detected in the Main Waste Pit Plume ranged from 4 to 73 µg/L. The highest concentrations were detected in monitoring wells MW-27S and MW-28S at 63 and 73 µg/L, respectively. The periphery of the Main Waste Pit Plume was identified by low concentrations of benzene, in samples collected from monitoring well MW-34S, in which 4 µg/L of benzene was detected, and monitoring wells MW-6S and MW-21S, in which only nondetect levels of benzene were found.

Benzene concentrations were detected in the on-site portion of the Southern Plume in monitoring wells MW-19S and MW-29S at concentrations of 280 and 40 µg/L, respectively. The periphery of this portion of the plume was defined by sparse control utilizing monitoring wells MW-18S, MW-25S, and MW-30S, in which nondetect levels of benzene were found.

2.3.1.2 Soils

Potential sources of constituents of interest detected in Aquifer 1 in the two attainment areas include subsurface soils underlying the waste pits. A potential source of the Main Waste Pit Plume is the main waste pit. Potential sources of the on-site portion of the Southern Plume may include Waste Pits 3, 4, and 9. A potential source of the portion of the Southern Plume that extends off-site to the south may be leaks from underground storage tanks or piping at the Ultramar service station, located immediately south of the site.

Although these sources have been identified as impacted soil areas, it is possible that undiscovered abandoned pipelines or other sources exist which may also have contributed to the plumes. However, in order to locate additional sources, geophysical surveys and/or other investigations must be performed.

2.3.1.3 Estimation of Impacted Groundwater Volume

The total volumes of groundwater contaminated with benzene within Aquifer 1 are approximately 13,600,000 gallons in the Main Waste Pit Plume (Action Area 1), and approximately 55,000,000 gallons in the Southern Plume (Action Area 2). These volumes, which represent the average pore volume in the saturated aquifer beneath each action area, were determined using the average area of the benzene plumes calculated from the May, August, and November 1991 monitoring data. Appendix A contains the benzene isoconcentration maps used to develop the volumes. Appendix B contains the groundwater volume calculations.

In general, the contour maps were constructed to estimate the distribution of benzene in groundwater in Aquifer 1. An initial map was partially constructed using a logarithmic contour interval (equal concentrations of 0, 5, 10, 50, 100 µg/L) and a linear (50 µg/L) contour interval at higher concentrations. This map was used as a template to construct the 1, 30, and 100 µg/L contours, parallel to contours of the map with the tighter contour interval.

Areas of impacted groundwater (based on the August and November 1991 data) were estimated by plotting the 10 µg/L contours on a grid and calculating the enclosed area. The impacted groundwater area (based on the May 1991 data) was estimated using on the 1 µg/L contour. The areas were then multiplied by average aquifer thicknesses based on the distance from the

static water level (measured in wells chosen based on their proximity to the plumes in August 1991) to the top of the lower fine-grained unit. The resulting volumes were multiplied by an assumed porosity of 0.35 to yield an estimate of the pore volume of impacted groundwater for the north and south plumes.

2.3.2 General Response Actions for the Texaco Fillmore Site

Based upon the RAOs for the Texaco Fillmore facility, as defined in Section 2.2.3.5, general response actions were developed and are presented in Table 2-2.

2.4 Identification and Screening of Technology Types and Process Options

2.4.1 Identification and Screening of Technologies

In the *Draft Report: Remedial Alternative Development and Screening for the Texaco Fillmore Site,* a qualitative evaluation was conducted of the array of potentially feasible technologies and process options for remediating hazardous constituents detected in the subsurface soil and groundwater at the site. During the qualitative evaluation process, the technologies and process options were ranked as high, moderate, or low applicability, feasibility, and cost-effectiveness according to the following criteria.

- The ability to control on-site releases or mitigate off-site impacts.
- The adverse environmental impacts of each technology.
- The feasibility, applicability, and reliability of the technology for locations and conditions of release.
- A preliminary cost estimate indicator for both capital and operating and maintenance (O&M) costs.

Based on the results of the evaluation, seven technology types and 19 associated process options were identified as having a high or moderate degree of feasibility for remediating constituents of interest detected in the groundwater of Aquifer 1 in the two attainment areas. Table 2-3 lists these technologies.

TABLE 2-2

General Response Actions for the Texaco Fillmore Site

Attainment Area	Medium	Remedial Action Objective	General Response Action
Main Waste Pit Plume	Groundwater	Prevent ingestion or further migration of Aquifer 1 groundwater and protect usable uncontaminated groundwater.	No action Institutional controls Containment actions
		Restore contaminated groundwater in Aquifer 1.	Removal and treatment In-situ treatment
	Soil	Prevent further contamination of Aquifer 1.	No action Containment In-situ treatment
Southern Plume	Groundwater	Prevent ingestion or further migration of groundwater in Aquifer 1 and protect usable uncontaminated groundwater.	No action Institutional controls Containment actions
		Restore contaminated groundwater in Aquifer 1.	Removal and treatment In-situ treatment
	Soil	Prevent further contamination of Aquifer 1.	No action Containment In-situ treatment

TABLE 2-3

Remedial Technologies for Texaco Fillmore Facility Attainment Areas 1 and 2

General Response Action	Remedial Technology	Process Option
No Action	None	None
Institutional controls	Access restrictions	Deed restrictions Fencing Groundwater use restrictions
	Monitoring	Groundwater monitoring
	Alternate water supply	State water supply
Containment	Vertical barriers	Slurry walls Hydraulic barriers
Groundwater removal	Groundwater extraction	Recovery wells
Surface groundwater treatment	Physical treatment	Carbon adsorption Air stripping Surface biotreatment UV/ozone oxidation
	In-situ treatment	In-situ bioremediation Air sparging
Disposal	Discharge to surface water	Discharge to Pole Creek Discharge to storm drain
	Reinjection	Reinjection through wells onsite
	Discharge to POTW	Discharge to Fillmore POTW
Leachate migration control	Capping	Clay or synthetic cap
Soil treatment	Soil vapor extraction and treatment	Extraction wells Carbon adsorption Catalytic oxidation Thermal oxidation
	Bioremediation	In-situ bioremediation infiltration

2.4.2 Evaluation of Technologies and Selection of Representative Technologies

In this section, the technology types and process options selected from the qualitative evaluation were screened in order to assemble a set of remedial alternatives that address the general response actions established for groundwater in the two attainment areas. Each of the technologies and associated process options were evaluated with respect to three broad CERCLA screening criteria: 1) implementability, 2) effectiveness, and 3) cost. The following paragraphs describe the focus of each of the three screening criteria.

Implementability

The implementability criterion focused on the technical and administrative feasibility of implementing each process at the site. Factors that were examined regarding the implementability of a technology or process option include:

- Ability to construct (process and site constraints)
- Ability to operate
- Permitting needs
- Availability of treatment, storage, and disposal services
- Availability of equipment and skilled workers

Effectiveness

The effectiveness criterion focused on the general effectiveness of the technology in treating the contaminants of concern and on site conditions. Factors that were examined regarding the effectiveness of a technology or process option include:

- Ability to meet cleanup objectives
- Ability to handle areas or volumes of media
- Potential impacts to human health and the environment during construction and implementation
- Level of development and reliability of process

Cost

Finally, costs associated with construction and implementation of a process at the site were estimated to rank the process in terms of high, moderate, and low costs. The estimated costs for each technology were based on engineering judgement and include:

- Capital cost
- O&M costs

The screening process for evaluating the technology types and process options involved the following.

- Review literature, including U.S. EPA reference sources, standard engineering texts, and other sources.

- Solicit vendor information on well-established and well-demonstrated technologies.

- Review case studies documenting the use and performance of these technologies at similar Superfund and other contaminated sites.

The technology types and associated process options selected from the qualitative evaluation process are, in general, composed of processes that are widely used throughout the industry for remediating VOCs in subsurface soil and groundwater at similar Superfund and other contaminated sites. The chemical and physical properties of the constituents of interest identified for the Texaco Fillmore site are also conducive to effective treatment by most of the processes.

The technology screening process has been summarized in tabular form to provide an effective means for evaluating and selecting the most appropriate technologies and process options for the site. The tables, entitled "Remedial Technology Evaluation Summary," were structured to address each component of the screening criteria outlined above.

In addition to the three screening criteria, each summary table identifies any additional site characterization or treatability study data that may be needed to further evaluate the implementability and/or effectiveness of a technology or process option. Based upon evaluation of each of the screening criteria, each summary table also incorporates a conclusion regarding the need to carry the particular technology or process option forward into the remedial alternative development and screening process. Essentially, those technologies and process options that

cannot be effectively implemented at the Texaco Fillmore site were eliminated from the FS process.

Geologic and hydrogeologic descriptions of subsurface conditions within the two attainment areas were presented in Section 1.2.3. Based on these discussions, it is estimated that geologic and hydrogeologic parameters of subsurface media, as well as the nature and extent of the constituents of interest, are much the same in both attainment areas. Because of this similarity, an evaluation of potentially feasible technologies is best presented on the basis of the two media involved: the groundwater plumes in Aquifer 1, and the impacted soil beneath the affected waste pits. Therefore, the remedial technology evaluation summary tables have been presented for each technology based on the medium to which the technology applies. The evaluation summaries are presented for groundwater in Tables 2-4A through 2-4P, and for soil in Tables 2-4Q through 2-4W.

It is important to note that this report focuses upon the attainment of cleanup objectives that address the constituents of interest detected in the groundwater of Aquifer 1 within the two attainment areas. As previously discussed, potential chemical-specific ARARs and TBCs have been identified to establish cleanup objectives for groundwater at the Texaco Fillmore site. Remediation of soils has not been focused on by this report since no chemical-specific ARARs were identified for cleanup of soils. The ultimate fate of constituents of interest within subsurface soils at the site is dependent upon the results of the RI risk assessment. However, because of the interrelationship between the constituents of interest in the groundwater and their occurrence in subsurface soils, it is important to identify and evaluate technologies that address the leachability of these constituents from impacted soils. This may have an effect on the treatment and ultimate quality of groundwater at the site.

As indicated in Tables 2-4A through 2-4W, technologies were either selected or rejected for the detailed analysis process based upon the evaluation of technologies. Table 2-5 presents each of the potentially feasible technologies, shows whether each was selected or rejected, and provides comments regarding the evaluation. Finally, Table 2-6 lists remaining technologies that underwent evaluation.

TABLE 2-4A
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Media: Groundwater and Soil
Technology: No Action

1) **EFFECTIVENESS**

   1.1) **Ability to meet cleanup objectives:** Would not meet cleanup objectives based on current VOC levels in groundwater. Final cleanup objectives dependent upon results of risk assessment.
   1.2) **Ability to handle areas or volumes of media:** Not applicable.
   1.3) **Potential impacts to human health and the environment during construction and implementation:** Not applicable.
   1.4) **Level of development and reliability of process:** Not applicable.

2) **IMPLEMENTABILITY**

   2.1) **Ability to construct (process and site constraints):** Not applicable.
   2.2) **Ability to operate:** Not applicable.
   2.3) **Permitting needs:** Not applicable.
   2.4) **Availability of treatment, storage, and disposal services:** Not applicable.
   2.5) **Availability of equipment and skilled workers:** Not applicable.

3) **COST**

   3.1) **Capital cost:** None.
   3.2) **O&M cost:** None.

4) **ADDITIONAL DATA REQUIREMENTS:** Evaluation of this technology is dependent upon health-risk exposure evaluation results of the RI Risk Assessment.

5) **CONCLUSIONS:** This technology is selected on the basis that conclusions regarding the health risk of this alternative cannot be made until completion of the RI Risk Assessment.

TABLE 2-4B
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Media: Groundwater and Soil
Technology: Groundwater Use Restrictions, Deed Restrictions and Fencing

1) **EFFECTIVENESS**

1.1) **Ability to meet cleanup objectives:** Could meet cleanup objectives through natural biodegradation over an extended period of time. Would prevent public exposure to constituents of interest in the groundwater. Effectiveness is dependent upon continued future use of access restrictions and results of RI Risk Assessment.
1.2) **Ability to handle areas or volumes of media:** Access restrictions could be implemented over the entire action area.
1.3) **Potential impacts to human health and the environment during construction and implementation:** Not applicable.
1.4) **Level of development and reliability of process:** Not applicable.

2) **IMPLEMENTABILITY**

2.1) **Ability to construct (process and site constraints):** Implementation of deed restrictions may be subject to legal requirements and local government authority. Site currently contains perimeter fencing.
2.2) **Ability to operate:** Would require nominal inspection and maintenance of perimeter fencing to insure security.
2.3) **Permitting needs:** None.
2.4) **Availability of treatment, storage, and disposal services:** Not applicable.
2.5) **Availability of equipment and skilled workers:** Not applicable.

3) **COST**

3.1) **Capital cost:** Negligible.
3.2) **O&M cost:** Negligible.

4) **ADDITIONAL DATA REQUIREMENTS:** Evaluation of this technology is dependent upon results of the RI Risk Assessment.

5) **CONCLUSIONS:** This technology would prevent public exposure to hazardous constituents in the groundwater through future use restrictions of a potential drinking water source. Therefore, this technology is selected for inclusion in the development and screening of remedial alternatives.

TABLE 2-4C
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Groundwater
Technology: Groundwater Monitoring

1) **EFFECTIVENESS**

1.1) **Ability to meet cleanup objectives:** Would not meet objectives based on current VOC levels in groundwater. Would be implemented as part of all alternatives to track progress in achieving cleanup objectives.
1.2) **Ability to handle areas or volumes of medium:** May require installation of additional monitoring wells to effectively monitor and evaluate contaminant plume.
1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts would be minimal.
1.4) **Level of development and reliability of process:** Conventional technology.

2) **IMPLEMENTABILITY**

2.1) **Ability to construct (process and site constraints):** Site currently contains groundwater monitoring wells. Construction of additional wells may be necessary, but is easily implementable.
2.2) **Ability to operate:** Would require quarterly groundwater sampling and analysis. May require nominal maintenance of monitoring wells.
2.3) **Permitting needs:** Permitting for installation of additional monitoring wells would be required by Ventura County Flood Control District .
2.4) **Availability of treatment, storage, and disposal services:** Disposal of contaminated groundwater generated during quarterly sampling episodes would be conducted at an offsite facility.
2.5) **Availability of equipment and skilled workers:** Both are readily available.

3) **COST**

3.1) **Capital cost:** Low.
3.2) **O&M cost:** Low.

4) **ADDITIONAL DATA REQUIREMENTS:** Additional hydrogeological data may be required to effectively define contaminant plume for continued monitoring.

5) **CONCLUSIONS:** Alone, this technology would not achieve current cleanup objectives as required under CERCLA Section 121 and may not be acceptable to local community and regulatory agencies. However, in concert with other technologies, it is effective in monitoring the quality of impacted groundwater and, therefore, is selected for inclusion in the development and screening of remedial alternatives.

TABLE 2-4D
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Groundwater
Technology: State Water Supply

1) **EFFECTIVENESS**

1.1) **Ability to meet cleanup objectives:** Would not meet cleanup objectives based on current VOC levels in groundwater. Final cleanup objectives are dependent upon results of the risk assessment.
1.2) **Ability to handle areas or volumes of medium:** New water supply could be established to handle entire action area.
1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts during construction would be limited to native soil and vegetation along aqueduct corridor, and would be addressed in an Environmental Impact Report.
1.4) **Level of development and reliability of process:** Would be an effective means of substituting for the contaminated groundwater.

2) **IMPLEMENTABILITY**

2.1) **Ability to construct (process and site constraints):** Construction is conventional and would be readily implementable. However, implementation would be subject to State and local government approval, and require procurement of extensive surface rights-of-way.
2.2) **Ability to operate:** Would require nominal maintenance of aqueduct.
2.3) **Permitting needs:** Would require extensive construction permitting.
2.4) **Availability of treatment, storage, and disposal services:** Not applicable.
2.5) **Availability of equipment and skilled workers:** Both are readily available.

3) **COST**

3.1) **Capital cost:** Very high.
3.2) **O&M cost:** Moderate.

4) **ADDITIONAL DATA REQUIREMENTS:** None.

5) **CONCLUSIONS:** The current classification of the impacted groundwater is believed to be Class IIA. The affected aquifer is not currently used as a drinking water source. This technology would not achieve current cleanup objectives and would require significant capital expenditure and governmental review to implement. Therefore, it is rejected for further evaluation.

TABLE 2-4E
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Groundwater
Technology: Groundwater Barrier with Slurry Wall

1) **EFFECTIVENESS**

1.1) **Ability to meet cleanup objectives:** Would be effective in preventing further migration of contaminated groundwater. Would contribute to, but not achieve all cleanup objectives based on current VOC levels in groundwater. Final cleanup objectives are dependent upon RI Risk Assessment.
1.2) **Ability to handle areas or volumes of medium:** Could be designed to handle areal extent of impacted plume as currently defined in Attainment Area 1. Areal extent of plume barrier in Attainment Area 2 may be too great to effectively control groundwater migration.
1.3) **Potential impacts to human health and the environment during construction and implementation:** Would be a potential for worker contact with constituents of interest during well installation for grout pumping.
1.4) **Level of development and reliability of process:** Common technology that is reliable in relatively shallow aquifers. The depth of Aquifer 1 may reduce the effectiveness of this technology.

2) **IMPLEMENTABILITY**

2.1) **Ability to construct (process and site constraints):** Construction would be accomplished via slurry injection. A large number of injection wells may be required. No major problems anticipated.
2.2) **Ability to operate:** No maintenance anticipated.
2.3) **Permitting needs:** Approval would be required from Ventura County Flood Control District.
2.4) **Availability of treatment, storage, and disposal services:** Not applicable.
2.5) **Availability of equipment and skilled workers:** Both are readily available.

3) **COST**

3.1) **Capital cost:** High.
3.2) **O&M cost:** Low.

4) **ADDITIONAL DATA REQUIREMENTS:** Additional hydrogeological data may be required to effectively define contaminant plume for design and installation of barriers.

5) **CONCLUSIONS:** Alone, this technology would not achieve current cleanup objectives as required under CERCLA Section 121. It may not be effective in preventing migration of the impacted groundwater plume due to the depth at which it must be applied. Also, it is more costly to implement than other equally effective technologies and, therefore, is rejected for further evaluation.

TABLE 2-4F
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Groundwater
Technology: Groundwater Barrier with Hydraulic Barriers

1) **EFFECTIVENESS**

   1.1) **Ability to meet cleanup objectives:** Would be effective in preventing further migration of constituents of interest. Would meet cleanup objectives when combined with treatment of extracted groundwater.
   1.2) **Ability to handle areas or volumes of medium:** Could be designed to handle areal extent of impacted plumes in both attainment areas.
   1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts would be limited to potential worker exposure during drilling of wells.
   1.4) **Level of development and reliability of process:** Conventional technology. Effectiveness and reliability would depend upon results of aquifer testing.

2) **IMPLEMENTABILITY**

   2.1) **Ability to construct (process and site constraints):** No major problems anticipated.
   2.2) **Ability to operate:** Would require regular maintenance of wells and pumps, and monitoring of flow rates. Would require treatment of extracted groundwater.
   2.3) **Permitting needs:** Well installation/operation permits would be required by Ventura County Flood Control District.
   2.4) **Availability of treatment, storage, and disposal services:** Treatment and disposal of extracted groundwater could be conducted on- or offsite.
   2.5) **Availability of equipment and skilled workers:** Both are readily available.

3) **COST**

   3.1) **Capital cost:** Moderate.
   3.2) **O&M cost:** Moderate.

4) **ADDITIONAL DATA REQUIREMENTS:** Aquifer testing would be required to effectively define well placement and required flow rates.

5) **CONCLUSIONS:** In conjunction with a groundwater treatment system, this technology is effective in preventing further migration of impacted groundwater and contributes to achieving the cleanup objectives. Therefore, it is selected for inclusion in the detailed analysis of remedial alternatives.

TABLE 2-4G
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Groundwater
Technology: Groundwater Extraction with Recovery Wells

1) **EFFECTIVENESS**

1.1) **Ability to meet cleanup objectives:** Would require aquifer testing to determine effectiveness. However, slug tests of groundwater monitoring wells indicate that extraction wells are a viable means of recovering contaminated plume. Would meet cleanup objectives when combined with a groundwater treatment system.
1.2) **Ability to handle areas or volumes of medium:** Could be designed to encompass impacted plume, but would require aquifer testing to determine number of extraction wells.
1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts would be limited to potential worker exposure during drilling of wells.
1.4) **Level of development and reliability of process:** Conventional technology. Effectiveness and reliability would depend upon results of aquifer testing.

2) **IMPLEMENTABILITY**

2.1) **Ability to construct (process and site constraints):** No major problems anticipated.
2.2) **Ability to operate:** Would require regular maintenance of wells and pumps. Would require treatment of extracted groundwater.
2.3) **Permitting needs:** Well installation permits would be required by Ventura County Flood Control District. Any treatment system implemented at the site may require permitting by the California DHS.
2.4) **Availability of treatment, storage, and disposal services:** Drill cuttings generated during well drilling activities would be disposed of at an offsite facility. Disposal of treated groundwater could be conducted onsite or at an offsite facility.
2.5) **Availability of equipment and skilled workers:** Both are readily available.

3) **COST**

3.1) **Capital cost:** Moderate.
3.2) **O&M cost:** Moderate.

4) **ADDITIONAL DATA REQUIREMENTS:** Aquifer testing and computer modeling would be required to better define hydrogeologic and hydraulic parameters of impacted aquifer. Data requirements include porosity, permeability, radius of influence, flow boundaries, hydraulic conductivity, transmissivity, and storativity.

5) **CONCLUSIONS:** Groundwater extraction would be a viable method for mitigating the impacted plume based on the extraction potential of existing monitoring wells as determined during slug tests. This technology is selected for inclusion in the development and screening of remedial alternatives with the recommendation that aquifer testing be conducted to determine its effectiveness and reliability.

TABLE 2-4H
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Groundwater
Technology: Surface Groundwater Treatment with Activated Carbon

1) **EFFECTIVENESS**

1.1) **Ability to meet cleanup objectives:** Would meet cleanup objectives when combined with a groundwater extraction system to recover the impacted plume.
1.2) **Ability to handle areas or volumes of medium:** Could be designed to handle required flow rate of groundwater and concentrations of constituents of interest.
1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts would be minimal.
1.4) **Level of development and reliability of process:** Conventional technology would be used. Would be reliable.

2) **IMPLEMENTABILITY**

2.1) **Ability to construct (process and site constraints):** No major problems anticipated. Prepackaged units available commercially from vendors.
2.2) **Ability to operate:** Would require a part-time operator and regular maintenance. Pretreatment to remove suspended solids may be necessary. Regeneration or disposal of spent carbon and disposal or discharge of treated water would be required.
2.3) **Permitting needs:** None.
2.4) **Availability of treatment, storage, and disposal services:** Carbon regeneration or disposal would be conducted at an offsite facility. Disposal of treated water could be conducted onsite or at an offsite facility.
2.5) **Availability of equipment and skilled workers:** Both are readily available.

3) **COST**

3.1) **Capital cost:** Moderate.
3.2) **O&M cost:** Moderate.

4) **ADDITIONAL DATA REQUIREMENTS:** None.

5) **CONCLUSIONS:** This is an effective and reliable, low-cost, conventional technology for removing VOCs from groundwater and is readily implementable. Therefore, it is selected for inclusion in the development and screening of remedial alternatives.

TABLE 2-4I
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Groundwater
Technology: Surface Groundwater Treatment with Air Stripping

1) **EFFECTIVENESS**

1.1) **Ability to meet cleanup objectives:** Would meet cleanup objectives when combined with a groundwater extraction system to recover the impacted plume.
1.2) **Ability to handle areas or volumes of medium:** Could be designed to handle required flow rate of groundwater and concentrations of contaminants of interest. May require post-treatment to meet effluent standards depending upon method of groundwater discharge.
1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts would be minimal.
1.4) **Level of development and reliability of process:** Conventional technology would be used. Would be reliable.

2) **IMPLEMENTABILITY**

2.1) **Ability to construct (process and site constraints):** No major problems anticipated. Treatment unit may require custom design and construction. However, prepackaged units available commercially from vendors.
2.2) **Ability to operate:** Would require a part-time operator and regular maintenance. Pretreatment to inhibit scaling and remove suspended solids may be required. Post-treatment of effluent vapor phase would be required to meet air quality standards. Disposal or discharge of treated water would be required. Post-treatment of water phase may be required depending upon discharge requirements.
2.3) **Permitting needs:** Permit would be required from the Ventura County Air Pollution Control District for air emissions.
2.4) **Availability of treatment, storage, and disposal services:** Disposal of treated water could be conducted onsite or at an offsite facility.
2.5) **Availability of equipment and skilled workers:** Equipment procurement may require relatively long lead time for design and construction. Skilled workers are readily available.

3) **COST**

3.1) **Capital cost:** Moderate.
3.2) **O&M cost:** Moderate.

4) **ADDITIONAL DATA REQUIREMENTS:** None.

5) **CONCLUSIONS:** This is an effective and reliable, conventional technology for removing VOCs from groundwater and is readily implementable requiring modest capital and O&M expenditures; therefore, it is selected for inclusion in the development and screening of remedial alternatives.

TABLE 2-4J
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Groundwater
Technology: Surface Groundwater Treatment with Biotreatment

1) **EFFECTIVENESS**

1.1) **Ability to meet cleanup objectives:** Could meet cleanup objectives when combined with a groundwater extraction system, but would require treatability testing to determine effectiveness. Must be combined with other technology (i.e., air stripping) to remove DCA.
1.2) **Ability to handle areas or volumes of medium:** Could be designed to handle required flow rate of groundwater and concentrations of contaminants of interest. Rate of treatment is relatively slow.
1.3) **Potential impacts to human health and the environment during construction and implementation:** Would be potential impacts from release of volatile compounds due to the use of aeration during treatment. However, this could be controlled.
1.4) **Level of development and reliability of process:** Innovative technology not widely used. Reliability would be dependent upon results of the treatability testing.

2) **IMPLEMENTABILITY**

2.1) **Ability to construct (process and site constraints):** No major problems anticipated. Mobile bioreactor treatment units are available commercially from vendors.
2.2) **Ability to operate:** Would require a part-time operator and regular maintenance. Primary operational concern is maintaining optimum reactor conditions, i.e., pH, temperature, nutrients, and oxygen. Contaminant levels in groundwater are low, which may require high nutrient additions. Disposal of biosludge residuals and disposal or discharge of treated water would be required.
2.3) **Permitting needs:** None.
2.4) **Availability of treatment, storage, and disposal services:** Disposal of biosludge residuals would be conducted offsite. Disposal of treated water could be conducted onsite or at an offsite facility.
2.5) **Availability of equipment and skilled workers:** Both are readily available.

3) **COST**

3.1) **Capital cost:** Moderate.
3.2) **O&M cost:** Moderate.

4) **ADDITIONAL DATA REQUIREMENTS:** Treatability testing would be required to determine appropriate microbial type, loading rate, and nutrient requirements.

5) **CONCLUSIONS:** This is an effective, reliable, and readily available conventional technology for removing VOCs from groundwater. Additional treatment would be required to remove DCA. O&M costs would depend upon results of treatability testing. It is selected for inclusion in the development and screening of remedial alternatives.

TABLE 2-4K
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Groundwater
Technology: Surface Groundwater Treatment with UV/Ozone Oxidation

1) **EFFECTIVENESS**

1.1) **Ability to meet cleanup objectives:** Could meet cleanup objectives when combined with a groundwater extraction system to recover the impacted plume.
1.2) **Ability to handle areas or volumes of medium:** Could be designed to handle required flow rate of groundwater and concentrations of contaminants of interest.
1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts would be minimal.
1.4) **Level of development and reliability of process:** Conventional technology would be used. Would be reliable.

2) **IMPLEMENTABILITY**

2.1) **Ability to construct (process and site constraints):** No major problems anticipated. Prepackaged units available commercially from vendors.
2.2) **Ability to operate:** Would require a part-time operator and regular maintenance. Disposal or discharge of treated water would be required.
2.3) **Permitting needs:** None.
2.4) **Availability of treatment, storage, and disposal services:** Disposal of treated water could be conducted onsite or at an offsite facility.
2.5) **Availability of equipment and skilled workers:** Procurement of equipment may require relatively long lead time. Skilled workers are readily available.

3) **COST**

3.1) **Capital cost:** High.
3.2) **O&M cost:** Moderate to high.

4) **ADDITIONAL DATA REQUIREMENTS:** None.

5) **CONCLUSIONS:** This is an effective, reliable, and readily available conventional technology for removing VOCs from groundwater. Capital and O&M costs are relatively higher than for other technologies evaluated. This technology is rejected from further evaluation on the basis that other equally effective and less costly technologies are available.

TABLE 2-4L
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Groundwater
Technology: Groundwater Disposal via Discharge to Fillmore POTW

1) **EFFECTIVENESS**

   1.1) **Ability to meet cleanup objectives:** Would meet cleanup objectives when combined with a groundwater extraction and treatment system to recover the impacted plume. Effective method for disposal of treated water.
   1.2) **Ability to handle areas or volumes of medium:** Pipeline could be designed to handle required flow rate of groundwater. Discharge rate would be dependent upon capacity of wastewater treatment plant at time of implementation.
   1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts would be minimal.
   1.4) **Level of development and reliability of process:** Reliable method of discharge for treated wastewater.

2) **IMPLEMENTABILITY**

   2.1) **Ability to construct (process and site constraints):** No major problems anticipated.
   2.2) **Ability to operate:** Would require pretreatment and periodic sampling and analysis of groundwater prior to disposal.
   2.3) **Permitting needs:** Would require a permit from City of Fillmore.
   2.4) **Availability of treatment, storage, and disposal services:** Not applicable.
   2.5) **Availability of equipment and skilled workers:** Both are readily available.

3) **COST**

   3.1) **Capital cost:** Low.
   3.2) **O&M cost:** Low.

4) **ADDITIONAL DATA REQUIREMENTS:** None.

5) **CONCLUSIONS:** This is an effective, reliable, and low-cost disposal method for treated wastewater; therefore, it is selected for inclusion in the development and screening of remedial alternatives.

TABLE 2-4M
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Groundwater
Technology: Groundwater Disposal via Reinjection

1) **EFFECTIVENESS**

1.1) **Ability to meet cleanup objectives:** Treated groundwater would meet cleanup objectives prior to injection.
1.2) **Ability to handle areas or volumes of medium:** Would require aquifer testing to determine the ability to handle the required flow rate of groundwater.
1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts would be limited to potential worker exposure during drilling of wells.
1.4) **Level of development and reliability of process:** Conventional technology for disposal of wastewater. Reliability would depend upon results of aquifer testing.

2) **IMPLEMENTABILITY**

2.1) **Ability to construct (process and site constraints):** No major problems anticipated.
2.2) **Ability to operate:** Level of maintenance may be high due to bacterial and scale deposits at injection well screens.
2.3) **Permitting needs:** A wastewater injection permit would be required from Ventura County Flood Control.
2.4) **Availability of treatment, storage, and disposal services:** Not applicable.
2.5) **Availability of equipment and skilled workers:** Both are readily available.

3) **COST**

3.1) **Capital cost:** Moderate.
3.2) **O&M cost:** Moderate.

4) **ADDITIONAL DATA REQUIREMENTS:** Aquifer testing would be required to better define hydraulic parameters of recharge aquifer. Data requirements would include porosity, permeability, hydraulic conductivity, transmissivity, and storativity.

5) **CONCLUSIONS:** Reinjection would be a viable method for disposing of treated groundwater based on the extraction potential of existing monitoring wells as determined during slug tests. This technology is selected for inclusion in the development and screening of remedial alternatives with the recommendation that aquifer testing be conducted to determine its effectiveness and reliability.

TABLE 2-4N
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Groundwater
Technology: Groundwater Disposal via Discharge to Pole Creek

1) **EFFECTIVENESS**

1.1) **Ability to meet cleanup objectives:** Treated water would meet cleanup objectives prior to discharge to Pole Creek.
1.2) **Ability to handle areas or volumes of medium:** May be limited by volume of treated water that Pole Creek could handle. Pipeline could be designed to handle required flow rate of groundwater.
1.3) **Potential impacts to human health and the environment during construction and implementation:** Because of Pole Creek's limited capacity, there is a potential to overflow during heavy rains and to impact the environment.
1.4) **Level of development and reliability of process:** Conventional and reliable method of discharge for treated wastewater.

2) **IMPLEMENTABILITY**

2.1) **Ability to construct (process and site constraints):** No major problems anticipated.
2.2) **Ability to operate:** Would require pretreatment and periodic sampling and analysis of groundwater prior to disposal. May be necessary to limit operation of a groundwater extraction and treatment system during flood events.
2.3) **Permitting needs:** Would require National Pollutant Discharge Elimination System (NPDES) permit from the Los Angeles Regional Water Quality Control Board and approval from Ventura County Flood Control.
2.4) **Availability of treatment, storage, and disposal services:** Not applicable.
2.5) **Availability of equipment and skilled workers:** Both are readily available.

3) **COST**

3.1) **Capital cost:** Low.
3.2) **O&M cost:** Moderate.

4) **ADDITIONAL DATA REQUIREMENTS:** None.

5) **CONCLUSIONS:** This is an effective, reliable, and low-cost method of disposal for treated groundwater; therefore, it is selected for inclusion in the development and screening of remedial alternatives.

TABLE 2-4O
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Groundwater
Technology: In-Situ Groundwater Treatment via Enhanced Biodegradation

1) **EFFECTIVENESS**

1.1) **Ability to meet cleanup objectives:** Could meet cleanup objectives, but would require laboratory screening and treatability testing to determine effectiveness. Must be combined with other technology (i.e., air stripping) to remove DCA.
1.2) **Ability to handle areas or volumes of medium:** Could be designed to handle required flow rates of groundwater and concentrations of constituents of interest. Would require laboratory screening and treatability testing to evaluate loading rates and nutrient requirements.
1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts would be minimal.
1.4) **Level of development and reliability of process:** Innovative technology not widely used. Reliability would be dependent upon results of treatability testing.

2) **IMPLEMENTABILITY**

2.1) **Ability to construct (process and site constraints):** No major problems anticipated.
2.2) **Ability to operate:** Would require a part-time operator and regular monitoring and maintenance. Primary operational concern is maintaining consistent nutrient addition to reinjected groundwater.
2.3) **Permitting needs:** None.
2.4) **Availability of treatment, storage, and disposal services:** Not applicable.
2.5) **Availability of equipment and skilled workers:** Both are readily available.

3) **COST**

3.1) **Capital cost:** Moderate.
3.2) **O&M cost:** Moderate.

4) **ADDITIONAL DATA REQUIREMENTS:** Laboratory screening would be required to identify appropriate microbial population and nutrient requirements. Treatability testing would be required to evaluate the effectiveness and reliability of the technology.

5) **CONCLUSIONS:** This is a potentially viable technology for conducting in-situ treatment of the impacted plume depending upon the results of laboratory screening and treatability testing; therefore, it is selected for inclusion in the development and screening of remedial alternatives.

TABLE 2-4P
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Groundwater
Technology: In-Situ Groundwater Treatment via Air Sparging

1) **EFFECTIVENESS**

   1.1) **Ability to meet cleanup objectives:** Could meet cleanup objectives, but would require treatability testing to determine effectiveness.
   1.2) **Ability to handle areas or volumes of medium:** Could be designed to handle constituents of interest, but has some limitations in providing necessary horizontal coverage. May be effective if combined with vapor extraction and groundwater recovery systems.
   1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts would be limited to potential worker exposure during drilling of wells.
   1.4) **Level of development and reliability of process:** Innovative technology not widely used. Reliability would be dependent upon results of treatability testing.

2) **IMPLEMENTABILITY**

   2.1) **Ability to construct (process and site constraints):** No major problems anticipated.
   2.2) **Ability to operate:** Would require regular monitoring and maintenance, and pretreatment of extracted vapors. Primary operational concerns would be air flow rates, extent of coverage, and effects on groundwater recovery and flowpaths.
   2.3) **Permitting needs:** None anticipated.
   2.4) **Availability of treatment, storage, and disposal services:** Not applicable.
   2.5) **Availability of equipment and skilled workers:** Both are readily available.

3) **COST**

   3.1) **Capital cost:** Low to moderate, depending upon the number of wells required.
   3.2) **O&M cost:** Moderate.

4) **ADDITIONAL DATA REQUIREMENTS:** Treatability testing would be required to define extent of coverage and constituent removal efficiency.

5) **CONCLUSIONS:** This is a potentially viable technology for conducting in-situ treatment of the impacted plume dependent upon the results of treatability testing; therefore, it is selected for inclusion in the development and screening of remedial alternatives.

TABLE 2-4Q
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Soil
Technology: Caps/Covers with Clay or Synthetic Liner

1) **EFFECTIVENESS**

   1.1) **Ability to meet cleanup objectives:** Would be effective in preventing leachate migration from subsurface soils to groundwater. Would contribute to, but not achieve all cleanup objectives based on current VOC levels in groundwater.
   1.2) **Ability to handle areas or volumes of medium:** Could be designed to cover impacted soils underlying waste pits.
   1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts would be limited to potential worker exposure during excavation and mixing of capping medium.
   1.4) **Level of development and reliability of process:** Common technology would be used. Would be reliable.

2) **IMPLEMENTABILITY**

   2.1) **Ability to construct (process and site constraints):** No major problems anticipated.
   2.2) **Ability to operate:** Would require nominal maintenance of surface drainage control. Could require periodic repair of surface cracks in clay caps caused by soil drying.
   2.3) **Permitting needs:** None.
   2.4) **Availability of treatment, storage, and disposal services:** Not applicable.
   2.5) **Availability of equipment and skilled workers:** Both are readily available.

3) **COST**

   3.1) **Capital cost:** Moderate.
   3.2) **O&M cost:** Low.

4) **ADDITIONAL DATA REQUIREMENTS:** None.

5) **CONCLUSIONS:** Alone, this technology would not achieve current cleanup objectives as required under CERCLA Section 121. However, in concert with other technologies, it is effective in preventing further contamination of the groundwater and, therefore, is selected for inclusion in the development and screening of remedial alternatives.

TABLE 2-4R
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Soil
Technology: In-Situ Vapor Extraction Using Extraction Wells

1) **EFFECTIVENESS**

1.1) **Ability to meet cleanup objectives:** Could contribute to achieving cleanup objectives by mitigating constituents of interest in the unsaturated soils that could be potential source of groundwater contamination. Would require treatability testing to determine effectiveness.
1.2) **Ability to handle areas or volumes of medium:** Could be designed to handle volumes and contaminants of interest. Could be designed to encompass impacted soils, but would require treatability testing to determine the number of extraction wells.
1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts would be limited to potential worker exposure during drilling of wells.
1.4) **Level of development and reliability of process:** Conventional technology would be used. Reliability would be dependent upon results of treatability testing.

2) **IMPLEMENTABILITY**

2.1) **Ability to construct (process and site constraints):** No major problems anticipated.
2.2) **Ability to operate:** Would require a part-time operator and regular maintenance. Would require treatment of extracted vapors.
2.3) **Permitting needs:** Permit required from the Ventura County Air Pollution Control District for emissions.
2.4) **Availability of treatment, storage, and disposal services:** Drill cuttings generated during well drilling activities would be disposed of at an offsite facility. Water produced during operation would be treated and discharged onsite or disposed of at an offsite facility.
2.5) **Availability of equipment and skilled workers:** Both are readily available.

3) **COST**

3.1) **Capital cost:** Low to moderate, depending upon the number of wells required.
3.2) **O&M cost:** Low.

4) **ADDITIONAL DATA REQUIREMENTS:** Treatability testing and computer modeling would be required to define the effectiveness of in-situ vapor extraction at mitigating VOCs and some SVOCs from impacted soils. Data requirements would include air permeability, extraction potential, radius of influence, and extractable VOC content.

5) **CONCLUSIONS:** In-situ vapor extraction could be a viable method for mitigating leachable contaminants in unsaturated soils beneath the Main Waste Pit. This technology is selected for inclusion in the development and screening of remedial alternatives with the recommendation that column and pilot testing be conducted to determine its effectiveness and reliability.

TABLE 2-4S
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Soil
Technology: Activated Carbon as Treatment Method for Vapor Extraction

1) **EFFECTIVENESS**

1.1) **Ability to meet cleanup objectives:** Would meet emission control requirements. Would contribute to achieving cleanup objectives by mitigating constituents of interest in the unsaturated soils that could be potential source of groundwater contamination.
1.2) **Ability to handle areas or volumes of medium:** Could be designed to handle required air flow rates and concentrations of constituents of interest.
1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts would be minimal.
1.4) **Level of development and reliability of process:** Conventional technology would be used. Best when used on vapor streams containing low VOC levels. Would be reliable.

2) **IMPLEMENTABILITY**

2.1) **Ability to construct (process and site constraints):** No major problems anticipated. Prepackaged units available commercially from vendors.
2.2) **Ability to operate:** Would require a part-time operator and minimal maintenance. Primary concerns are carbon loading rates and regeneration requirements.
2.3) **Permitting needs:** Permit would be required from the Ventura County Air Pollution Control District for air emissions.
2.4) **Availability of treatment, storage, and disposal services:** Carbon regeneration or disposal would be conducted at an offsite facility. Water produced during operation would be treated and discharged onsite or disposed of at an offsite facility.
2.5) **Availability of equipment and skilled workers:** Both are readily available.

3) **COST**

3.1) **Capital cost:** Low.
3.2) **O&M cost:** Low to moderate.

4) **ADDITIONAL DATA REQUIREMENTS:** None.

5) **CONCLUSIONS:** This is an effective and reliable, low-cost conventional technology for removing VOCs from unsaturated soils, and is readily available; therefore, it is selected for inclusion in the development and screening of remedial alternatives.

TABLE 2-4T
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Soil
Technology: Thermal Oxidation as Treatment Method for Vapor Extraction

1) **EFFECTIVENESS**

   1.1) **Ability to meet cleanup objectives:** Would meet emission control requirements. Would contribute to achieving cleanup objectives by mitigating constituents of interest in the unsaturated soils that could be a potential source of groundwater contamination.
   1.2) **Ability to handle areas or volumes of medium:** Could be designed to handle required air flow rates and concentrations of constituents of interest.
   1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts would be minimal.
   1.4) **Level of development and reliability of process:** Conventional technology would be used. Best when used on vapor streams containing high VOC levels. Would be reliable.

2) **IMPLEMENTABILITY**

   2.1) **Ability to construct (process and site constraints):** No major problems anticipated. Prepackaged units available commercially from vendors.
   2.2) **Ability to operate:** Would require a part-time operator and regular monitoring and maintenance. Primary concerns would be loading rates, operating temperatures, and utility costs.
   2.3) **Permitting needs:** Permit would be required from Ventura County Air Pollution Control District for air emissions.
   2.4) **Availability of treatment, storage, and disposal services:** Water produced during operation would be treated and discharged onsite or disposed of at an offsite facility.
   2.5) **Availability of equipment and skilled workers:** Equipment procurement may require relatively long lead times. Skilled workers are readily available.

3) **COST**

   3.1) **Capital cost:** Moderate.
   3.2) **O&M cost:** Moderate.

4) **ADDITIONAL DATA REQUIREMENTS:** None.

5) **CONCLUSIONS:** This an effective and reliable, conventional technology for removing VOCs from extracted vapors. However, this technology is best suited for treatment of vapor streams containing high VOC levels and would be relatively more costly to operate than other technologies evaluated. Therefore, it is rejected from further evaluation.

TABLE 2-4U
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Soil
Technology: Catalytic Oxidation as Treatment Method for Vapor Extraction

1) **EFFECTIVENESS**

1.1) **Ability to meet cleanup objectives:** Would meet emission control requirements. Would contribute to achieving cleanup objectives by mitigating constituents of interest in the unsaturated soils that could be potential source of groundwater contamination.
1.2) **Ability to handle areas or volumes of medium:** Could be designed to handle the required air flow rates and concentrations of contaminants of interest.
1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts would be minimal.
1.4) **Level of development and reliability of process:** Conventional technology would be used. Best when used on vapor streams containing moderate VOC levels.

2) **IMPLEMENTABILITY**

2.1) **Ability to construct (process and site constraints):** No major problems anticipated. Prepackaged units available commercially from vendors.
2.2) **Ability to operate:** Would require a part-time operator and regular monitoring and maintenance. Primary concerns would be loading rates and operating temperatures.
2.3) **Permitting needs:** Permit would be required from Ventura County Air Pollution Control District for air emissions.
2.4) **Availability of treatment, storage, and disposal services:** Water produced during operation would be treated and discharged onsite or disposed of at an offsite facility.
2.5) **Availability of equipment and skilled workers:** Equipment procurement may require relatively long lead time. Skilled workers are readily available.

3) **COST**

3.1) **Capital cost:** Moderate.
3.2) **O&M cost:** Low.

4) **ADDITIONAL DATA REQUIREMENTS:** None.

5) **CONCLUSIONS:** This is an effective and reliable, conventional technology for removing VOCs from extracted vapors and is readily implementable requiring modest capital and O&M expenditures. Therefore, it is selected for inclusion in the development and screening of remedial alternatives.

TABLE 2-4V
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Soil
Technology: In-Situ Soil Treatment via Enhanced Biodegradation

1) **EFFECTIVENESS**

1.1) **Ability to meet cleanup objectives:** Would contribute to achieving cleanup objectives by mitigating constituents of interest in the unsaturated soils that could be potential source of groundwater contamination. Would require laboratory screening and treatability testing to determine effectiveness. Must be combined with other technology (i.e., vapor extraction) to remove DCA.
1.2) **Ability to handle areas or volumes of medium:** Could be designed to handle required flow rates of infiltration water and concentrations of constituents of interest. Would require laboratory screening and treatability testing to evaluate loading rates and nutrient requirements.
1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts would be minimal.
1.4) **Level of development and reliability of process:** Innovative technology not widely used. Reliability would be dependent upon results of treatability testing.

2) **IMPLEMENTABILITY**

2.1) **Ability to construct (process and site constraints):** No major problems anticipated.
2.2) **Ability to operate:** Would require a part-time operator and regular monitoring and maintenance. Primary operational concern is maintaining consistent nutrient addition to infiltration water.
2.3) **Permitting needs:** None anticipated.
2.4) **Availability of treatment, storage, and disposal services:** Not applicable.
2.5) **Availability of equipment and skilled workers:** Both are readily available.

3) **COST**

3.1) **Capital cost:** Low.
3.2) **O&M cost:** Moderate.

4) **ADDITIONAL DATA REQUIREMENTS:** Laboratory screening would be required to identify appropriate microbial population and nutrient requirements. Treatability testing would be required to evaluate the effectiveness and reliability of the technology.

5) **CONCLUSIONS:** This is a potentially viable technology for conducting in-situ treatment of the unsaturated soils, depending upon the results of laboratory screening and treatability testing. Therefore, it is selected for inclusion in the development and screening of remedial alternatives.

TABLE 2-4W
REMEDIAL TECHNOLOGY EVALUATION SUMMARY

Medium: Soil
Technology: Infiltration

1) **EFFECTIVENESS**

   1.1) **Ability to meet cleanup objectives:** As part of in-situ soil treatment, would contribute to achieving cleanup objectives by mitigating constituents of interest in the unsaturated soils that could be a potential source of groundwater contamination. Would require treatability testing to determine effectiveness.
   1.2) **Ability to handle areas or volumes of medium:** Could be designed to encompass impacted soils, but would require treatability testing to determine the most effective system design.
   1.3) **Potential impacts to human health and the environment during construction and implementation:** Impacts would be limited to potential worker exposure during subsurface excavations (i.e., excavation or trenching).
   1.4) **Level of development and reliability of process:** Innovative technology not widely used. Reliability would depend upon results of treatability testing.

2) **IMPLEMENTABILITY**

   2.1) **Ability to construct (process and site constraints):** Conventional construction techniques would be used (i.e., well drilling, trenching, etc.). Final system design would depend upon results of treatability testing.
   2.2) **Ability to operate:** Level of maintenance would be dependent upon final system design. Primary operational problem would be bacterial or scale deposition.
   2.3) **Permitting needs:** Approval would be required from Ventura County Flood Control.
   2.4) **Availability of treatment, storage, and disposal services:** Not applicable.
   2.5) **Availability of equipment and skilled workers:** Both are readily available.

3) **COST**

   3.1) **Capital cost:** Low to moderate, depending upon the final system design.
   3.2) **O&M cost:** Moderate.

4) **ADDITIONAL DATA REQUIREMENTS:** Geotechnical and treatability testing would be required to better define hydrogeologic parameters of unsaturated soils. Data requirements would include porosity, permeability, and hydraulic conductivity.

5) **CONCLUSIONS:** Infiltration could be a viable method for introducing nutrient-rich groundwater. This technology is selected for inclusion in the development and screening of remedial alternatives with the recommendation that treatability testing be conducted to determine its effectiveness and reliability.

TABLE 2-5

Evaluation of Technologies for Achieving Groundwater Remediation Goals Attainment Areas 1 and 2

General Response Action	Remedial Technology	Process Option	Rejected	Selected for Screening	Comments
No action	None	None		X	Viable option depending upon risk assessment
Institutional controls	Access restrictions	Deed restrictions, fencing, and groundwater use restrictions		X	Potentially applicable
	Monitoring	Groundwater monitoring		X	Potentially applicable
	Alternate water supply	State water supply	X		Costs would be excessive
Containment	Vertical barriers	Slurry walls	X		More costly than other technologies
		Hydraulic barriers		X	Potentially applicable
Groundwater removal	Groundwater extraction	Recovery wells		X	Potentially applicable
Surface groundwater treatment	Physical treatment	Carbon adsorption		X	Potentially applicable
		Air stripping		X	
	Biological treatment	Surface biotreatment		X	Requires additional treatment for DCA
	Chemical treatment	UV/ozone oxidation	X		More costly than other technologies
In-situ groundwater treatment	Bioremediation	Enhanced biodegradation		X	Would require additional treatment for DCA
		Air sparging		X	Potentially applicable
Disposal	Discharge to surface water	Discharge to Pole Creek, Discharge to stormdrain		X	Potentially applicable
	Reinjection	Reinjection through onsite wells		X	Potentially applicable
	Discharge to POTW[1]	Discharge to City of Fillmore POTW		X	Potentially applicable
Leachate migration control	Capping	Clay or synthetic cap		X	Would inhibit migration of leachables

TABLE 2-5

Evaluation of Technologies for Achieving Groundwater Remediation Goals Attainment Areas 1 and 2

General Response Action	Remedial Technology	Process Option	Rejected	Selected for Screening	Comments
Soil treatment	Soil vapor extraction and treatment	Extraction wells		X	Potentially applicable
		Carbon adsorption		X	
		Catalytic oxidation		X	
		Thermal oxidation	X		More costly than other technologies
	Bioremediation	In-situ bioremediaton		X	Would require additional treatment for DCA
		Infiltration		X	Potentially applicable

[1]POTW - publicly owned treatment works.

TABLE 2-6

Technologies Surviving Evaluation Attainment Areas 1 and 2

General Response Action	Remedial Technology	Process Option
No action	None	None
Institutional controls	Use restrictions	Deed restrictions, fencing, groundwater use restrictions
	Monitoring	Groundwater monitoring
Containment	Vertical barriers	Hydraulic barriers
Groundwater removal	Groundwater removal	Recovery wells
Surface groundwater treatment	Physical treatment	Carbon adsorption; Air stripping; Surface biotreatment
	In-situ treatment	In-situ bioremediation; Air sparging
Disposal	Discharge to surface water	Discharge to Pole Creek, discharge to storm drain
	Reinjection	Reinjection through onsite wells
	Discharge to POTW	Discharge to Fillmore POTW
Leachate migration control	Capping	Clay or synthetic cap
Soil treatment	Soil vapor extraction and treatment	Extraction wells; Carbon adsorption; Catalytic oxidation
	Bioremediation	Infiltration In-situ bioremediation

3.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES

Based on the screening and evaluation of technology process options presented in Sections 2.4.1 and 2.4.2, respectively, the technologies determined to be most applicable to the Texaco Fillmore site were selected. In this section, the selected technologies are assembled into remedial alternatives that address the remedial action objectives established for the two attainment areas at the Texaco Fillmore site. Table 3-1 presents an assembly of remedial alternatives for groundwater and soil within the two attainment areas.

Typically, the technology evaluation process produces numerous waste management options which, when assembled into remedial alternatives, may require further screening to refine the alternatives for detailed analysis. However, due to the site characteristics and physical and chemical properties of the constituents of interest, the technology screening and evaluation process resulted in a limited array of remedial alternatives. Based on the types and quantity of selected technologies, further screening of the alternatives was deemed unnecessary in order to produce a workable range of alternatives for detailed analysis; therefore, this section will focus on:

1. Presenting the rationale by which selected technologies were assembled into remedial alternatives; and

2. Providing a description of each alternative.

Further definition of each alternative with respect to specific process options will be conducted during the detailed analysis of alternatives.

Although the hydrogeologic properties of the two impacted attainment areas differ slightly, the hydraulic parameters of the aquifer and nature and extent of the constituents of interest are somewhat analogous. In that regard, remedial alternatives have been developed to address the impacted groundwater for both attainment areas. Similarly, remedial alternatives have been developed to address leachable constituents of interest in subsurface soils beneath the waste pits of both areas. Thus, the rationale for developing remedial alternatives is presented on the basis of medium alone, and does not differentiate between attainment areas.

TABLE 3-1

Assembly of Alternatives - Texaco Fillmore Site

	REMEDIAL ALTERNATIVES[1]						
	1	2	3	4	5	6	7
General Response Action	No Action	Continued Operations	Caps/Covers	Groundwater Extraction and Surface Treatment	In-Situ Groundwater Treatment	Groundwater Extraction and Surface Treatment Plus Soil Treatment	In-Situ Groundwater Treatment With Soil Treatment
None	X	X					
Access[2] Restrictions		X	X	X	X	X	X
Groundwater Monitoring		X	X	X	X	X	X
Grading to Control Surface Runoff		X					
Cap/Cover			X				
Groundwater Barriers				X	X	X	X
Groundwater Extraction				X	X	X	X
Surface Groundwater Treatment				X		X	
In-situ Groundwater Treatment					X		X
Groundwater Discharge				X		X	
Groundwater Infiltration/ Reinjection				X	X	X	X
In-Situ Vapor Extraction						X	X
In-Situ Biotreatment of Soils					X		

[1]See Tables 3-2 through 3-8 for more detailed descriptions of alternatives.
[2]Includes deed and groundwater use restrictions while applicable.

3.1 Rationale For Developing Remedial Alternatives

Previous sections of this report have described the constituents of interest, the nature and extent of impact on groundwater from these constituents, and the remedial action objectives. Remedial technologies are generally selected based on a number of factors related to the type of constituents present and site conditions. Applicable factors regarding the physical and chemical properties of constituents include concentration, solubility, vapor pressure, Henry's Law constant, and natural biodegradability. Geophysical factors include hydraulic conductivity and permeability to air. Utilizing the above factors, the following presents the rationale for assembling technologies into remedial alternatives that address the impacted groundwater and soil at the Texaco Fillmore site.

Groundwater

As described in Section 1.2.3, Study Area Hydrogeology, Aquifer 1 is interpreted to be a fluvial deposit consisting of fine- to medium-grained sediments with hydraulic conductivities ranging from 9 to 1,360 feet per day. Areas of relatively low hydraulic conductivity are most likely restricted to sporadic interbedding of relatively fine-grained sediment, and areas of relatively high subsurface elevation at the base of the aquifer that locally reduce the thickness of the saturated interval. Based on an average estimated hydraulic conductivity of 435 feet per day, it is anticipated that sufficient overall hydraulic conductivity exists to justify groundwater extraction as a technically feasible remedial technology to restore Aquifer 1. Similarly, in-situ groundwater treatment and hydraulic barriers would be effective technologies in Aquifer 1.

As described in Section 1.2.4.1, the relative solubility in water for benzene, toluene, ethylbenzene, xylene (BTEX), and 1,2-dichloroethane (DCA) is greater than the chemicals' sorptive effects for organic materials in subsurface soils. For this reason, groundwater extraction would be a viable means of removing these constituents from the impacted plumes in Aquifer 1. The major transport mechanism for these constituents appears to be volatilization. This is due to relatively high Henry's Law constants for these constituents. Aerobic microbial degradation has also been shown to remove these constituents from water, with the exception of DCA. Little biodegradation of DCA occurs in groundwater, and processes other than volatilization do not play a significant role in the removal of DCA. Similarly, the sorptive property of DCA is such that physical adsorption techniques are inefficient at removing DCA from groundwater. Based on these physical properties, groundwater extraction, air stripping, activated carbon, and air sparging have been identified as potential treatment technologies for removing these constituents from impacted groundwater. In-situ enhanced biodegradation may also be an applicable technology, if combined with other technologies for the removal of DCA. However, specific process options cannot be identified without first conducting further treatability investigations.

The relationship between volatility and adsorptivity is reversed for naphthalene and 2-methylnaphthalene to that for the above constituents. Due to their sorptive properties, the most important transport mechanism for these constituents in groundwater is as adsorbed material on suspended particles. Aerobic microbial degradation, however, is an effective mechanism for removing these constituents from groundwater. In-situ enhanced or surface biodegradation would be applicable technologies for the removal of these constituents.

Soil

Little data are available regarding the leachability of the constituents of interest other than toxicity characteristic leaching potential (TCLP) laboratory analyses of soil samples collected from the impacted areas. Although the TCLP results indicate that the leachability of these constituents would have little impact on the groundwater, the impacted soils may be considered as a source of potential contamination for the underlying Aquifer 1. Surface capping has been identified as an effective technology for inhibiting leachate migration from the impacted soils to the groundwater. In-situ vapor extraction has also been identified as a potentially feasible technology for removing the leachable constituents.

Based upon the geologic description of subsurface soils presented in Section 1.2.3, the fine- to medium-grained soils underlying the subject waste pits in the two attainment areas may have sufficient permeability to air to allow effective remediation of unsaturated soils via in-situ vapor extraction. Although the vadose zone contains interbedded fine-grained sediments, further geotechnical characterization coupled with subsurface modeling would result in a vapor extraction system capable of remediating leachable constituents of interest from impacted soils.

Of the constituents of interest characterized in Section 1.2.4.1, benzene and other compounds are readily removed from soils via vapor extraction as a result of their high volatilities. Again, this is due to the relatively high Henry's Law constants of these constituents. Conversely, the low relative volatilities of naphthalene and 2-methylnaphthalene tend to inhibit removal via vapor extraction. However, design considerations, such as introducing heated air into the subsurface to enhance the volatilization of these constituents, may increase the effectiveness of the technology. Carbon adsorption and catalytic and thermal oxidation were identified as potentially feasible for treating extracted vapors containing the constituents of interest. Only thermal oxidation was rejected on the basis of cost due to the low levels of the constituents of interest detected in subsurface soils.

3.2 Descriptions of Remedial Alternatives

The paragraphs below and Tables 3-2 through 3-8 summarize the seven remedial alternatives developed for the Fillmore site.

3.2.1 No Action

Remedial Alternative No. 1: No Action

Remedial Alternative No. 1, No Action, assumes that no further action is required at the site. This alternative is included for continuity with the conditions presented in the Baseline Risk Assessment and is considered the basis for comparison of actions at the site. Table 3-2 summarizes Remedial Alternative No. 1.

3.2.2 Continued Operations

Remedial Alternative No. 2: Continued Operations

Remedial Alternative No. 2, Continued Operations, would involve continuing the access restrictions and groundwater monitoring presently performed at the Texaco Fillmore site. However, no action would be taken to remove the constituents of interest from the impacted groundwater or soils, to minimize the migration of leachable constituents from the subsurface soils beneath the waste pits to the groundwater, or to prevent migration of the groundwater plume. Table 3-3 summarizes Remedial Alternative No. 2.

Current operations at the Texaco Fillmore site include access restriction via perimeter fencing and quarterly groundwater monitoring via sampling and analysis of appropriate monitoring wells. These operations would be part of all alternatives, except Alternative 1. Results of the RI risk assessment, as well as the concentrations of constituents of interest in the groundwater that may be detected in the future, will determine whether this alternative is selected during the detailed analysis.

3.2.3 Leachate Migration

Remedial Alternative No. 3: Caps/Covers

Remedial Alternative No. 3, Caps/Covers, would involve continuing the access restrictions and groundwater monitoring presently performed at the Texaco Fillmore site plus installing caps or covers over existing waste pits in the two action areas to inhibit leachate migration from the

TABLE 3-2

Remedial Alternative Description: No. 1

Alternative No. 1: No Action

- **Institutional Actions**
  - None
- **Remedial Technology**
  - None

TABLE 3-3

Remedial Alternative Description: No. 2

Alternative No. 2: Continued Operations

- **Access Restrictions**
  - Fencing
  - Deed restrictions
  - Groundwater use restrictions
  - Grading to control surface runoff
- **Monitoring**
  - Groundwater monitoring

TABLE 3-4

Remedial Alternative Description: No. 3

Alternative No. 3: Continued Operations Plus Caps/Covers

- **Access Restrictions**
  - Fencing
  - Deed restrictions
  - Groundwater use restrictions
- **Monitoring**
  - Groundwater monitoring
- **Capping**
  - Clay plus native soil
  - Synthetic liners

Note: Selection of specific process options will be made during detailed analysis of alternatives.

TABLE 3-5

Remedial Alternative Description: No. 4

Alternative No. 4: Groundwater Extraction and Surface Treatment

- **Access Restrictions**
  - Fencing
  - Deed restrictions
  - Groundwater use restrictions
- **Monitoring**
  - Groundwater monitoring
- **Groundwater Extraction**
  - Recovery wells
- **Surface Groundwater Treatment**
  - Carbon adsorption
  - Air stripping
  - Surface biotreatment
- **Groundwater Disposal**
  - Discharge to Pole Creek
  - Discharge to storm drain
  - Reinjection through on-site wells
  - Discharge to City of Fillmore POTW
- **Vertical Barriers**
  - Hydraulic barriers

Note: Selection of specific process options will be made during detailed analysis of alternatives.

TABLE 3-6

Remedial Alternative Description: No. 5

Alternative No. 5: In-Situ Groundwater Treatment

- **Access Restrictions**
  - Fencing
  - Deed restrictions
  - Groundwater use restrictions
- **Monitoring**
  - Groundwater monitoring
- **Groundwater Extraction/Reinjection**
  - Recovery wells
  - Reinjection through on-site wells
- **In-situ Groundwater Treatment**
  - Enhanced biodegradation
- **Groundwater Disposal**
  - Air stripping (for removal of DCA)
- **Vertical Barriers**
  - Hydraulic barriers

Note: Selection of specific process options will be made during detailed analysis of alternatives.

TABLE 3-7

Remedial Alternative Description: No. 6

Alternative No. 6: Groundwater Extraction and Surface Treatment Plus Soil Treatment

- **Access Restrictions**
  - Fencing
  - Deed restrictions
  - Groundwater use restrictions
- **Monitoring**
  - Groundwater monitoring
- **Groundwater Extraction**
  - Recovery wells
- **Surface Groundwater Treatment**
  - Carbon adsorption
  - Air stripping
  - Surface biotreatment
- **Groundwater Disposal**
  - Discharge to Pole Creek
  - Discharge to storm drain
  - Reinjection through on-site wells
  - Discharge to City of Fillmore POTW
- **Vertical Barriers**
  - Hydraulic barriers
- **Soil Vapor Extraction and Treatment**
  - Extraction wells
  - Carbon adsorption
  - Catalytic oxidation

Note: Selection of specific process options will be made during detailed analysis of alternatives.

TABLE 3-8

Remedial Alternative Description: No. 7

Alternative No. 7: In-Situ Groundwater Treatment Plus Soil Treatment

- **Access Restrictions**
  - Fencing
  - Deed restrictions
  - Groundwater use restrictions
- **Monitoring**
  - Groundwater monitoring
- **Groundwater Extraction/Reinjection**
  - Recovery wells
  - Reinjection through on-site wells
  - Infiltration system
- **In-situ Groundwater Treatment**
  - Enhanced biodegradation
  - Air sparging
- **In-situ Soil Treatment**
  - Bioremediation
- **Soil Vapor Extraction and Treatment**
  - Extraction wells
  - Carbon adsorption
  - Catalytic oxidation
- **Vertical Barriers**
  - Hydraulic barriers

Note: Selection of specific process options will be made during detailed analysis of alternatives.

impacted soils to groundwater. However, no action would be taken to remove the constituents of interest from the impacted groundwater or soils or prevent migration of the groundwater plume. Table 3-4 summarizes Remedial Alternative No. 3.

Installation of caps/covers over existing waste pits would involve two technologies: 1) forming a mixture of clay and native soil; and 2) installing synthetic covers. Capping the Main Waste Pit would involve importing native fill from other locations at the site, combining the fill with clay, and covering the waste pit with the material. Capping the Main Waste Pit with a synthetic cover would involve installing the cover over the pit and capping it with imported fill from other locations at the site. Both scenarios would involve final surface grading and revegetation to control surface drainage. Capping the waste pits in Action Area 2 would involve excavation of topsoil covering the pits, combining clay with the soil, and re-covering the pits with the material. Capping the pits with synthetic covers would involve excavating topsoil from the pits, installing the cover, and capping the pits with the excavated soil. Both scenarios would involve final surface grading and revegetation to control surface drainage.

3.2.4 Groundwater Treatment

Remedial Alternative No. 4: Groundwater Extraction and Surface Treatment

Remedial Alternative No. 4 would involve continuing the access restrictions and quarterly groundwater monitoring that are currently conducted at the Texaco Fillmore site. In addition, a groundwater extraction and surface treatment system would be installed to restore the groundwater in Aquifer 1 in both action areas. No action would be taken to prevent or inhibit the migration of leachable contaminants from the subsurface soils beneath the waste pits to the groundwater. Table 3-5 summarizes Remedial Alternative No. 4.

The groundwater extraction system would consist of a set of recovery wells strategically situated within each impacted plume. Placement of the wells would be determined through aquifer testing and groundwater modeling. Depending upon the results of the aquifer testing and modeling, groundwater recovery wells may also be used as a hydraulic barrier to prevent further migration of the plume. Surface treatment of extracted groundwater would be conducted using one or more of the following technologies: activated carbon, air stripping, or surface biotreatment. Treated groundwater would be disposed of using one of the following technologies: discharge to Pole Creek, discharge to storm drain system, reinjection into on-site or off-site injection wells, or disposal at a POTW. Final selection of specific treatment and disposal technologies will be made during detailed analysis of alternatives.

Based on existing site conditions, it is anticipated that groundwater extraction and treatment would continue for 1 to 5 years to restore the groundwater in Aquifer 1. However, the duration of a groundwater extraction and treatment system would depend upon the results of aquifer testing and groundwater modeling.

Groundwater monitoring would be conducted during remediation in order to track progress of the removal of constituents of interest from the groundwater. Monitoring would be continued after remediation was complete to ensure that no constituents of interest remained in the groundwater.

Remedial Alternative No. 5: In-Situ Groundwater Treatment

Remedial Alternative No. 5 would involve continuing the access restrictions and quarterly groundwater monitoring that are currently conducted at the Texaco Fillmore site. In addition, an in-situ groundwater treatment system would be installed to restore the groundwater in Aquifer 1 in both action areas. No action would be pursued to prevent or inhibit the migration of leachable contaminants from the subsurface soils beneath the waste pits to the groundwater. Table 3-6 summarizes Remedial Alternative No. 5.

The in-situ groundwater treatment system would consist of a set of recovery and reinjection wells strategically situated within each impacted plume. Placement of the wells would be determined through aquifer testing and groundwater modeling. The recovery wells would be used to extract groundwater from the plumes in order to incorporate the oxygen and nutrients required for effective aerobic biodegradation. The nutrient-rich stream would then be returned to Aquifer 1 via reinjection wells. Nutrient and possibly additional microbial requirements would be determined through laboratory screening of the impacted groundwater. Groundwater flow rates as well as placement of recovery and reinjection wells would be designed to achieve bioremediation throughout the impacted plume. Depending upon the results of the aquifer testing and modeling, groundwater recovery wells may also be used as a hydraulic barrier to prevent further migration of the plume.

Surface treatment of extracted groundwater (i.e., air stripping) may be required to remove DCA, because this constituent is not amenable to biotreatment. Final selection of specific treatment technologies will be made during detailed analysis of alternatives. Based on existing site conditions, it is anticipated that in-situ groundwater treatment under ideal conditions would continue for 2 to 3 years to restore the groundwater in Aquifer 1. However, the duration of an in-situ groundwater treatment system would depend upon the results of laboratory screening, treatability studies, aquifer testing, and groundwater modeling.

Groundwater monitoring would be conducted during remediation in order to track progress of the removal of constituents of interest from the groundwater. Monitoring would be continued after remediation was complete to ensure that no constituents of interest remained in the groundwater.

3.2.5 Combined Groundwater and Soil Treatment

Remedial Alternative No. 6: Groundwater Extraction and Surface Treatment Plus Soil Treatment

Remedial Alternative No. 6 would involve continuing the access restrictions and quarterly groundwater monitoring that are currently conducted at the Texaco Fillmore site, plus installing a groundwater extraction and surface treatment system as described in Remedial Alternative No. 4 and conducting soil treatment to remove leachable constituents of interest from impacted soils beneath the waste pits in the two action areas. Table 3-7 summarizes Remedial Alternative No. 6.

Soil treatment would consist of in-situ vapor extraction and surface treatment of extracted vapors. The vapor extraction system would consist of a set of extraction and air infiltration wells strategically situated around the waste pit areas. Placement of the wells and selection of slotted intervals would be determined through geophysical characterization and vapor extraction modeling.

Surface treatment of extracted vapors would involve carbon adsorption or catalytic oxidation, due to the relatively low levels of volatile constituents anticipated in extracted vapors. Final selection of specific treatment technologies will be made during detailed analysis of alternatives. Based on existing site conditions, it is anticipated that in-situ vapor extraction would continue for 1 to 3 years to remove leachable constituents from the impacted soils. However, the duration of an in-situ vapor extraction system would depend upon the results of laboratory screening, treatability studies, and vapor extraction modeling.

Groundwater monitoring would be conducted during remediation in order to track progress of the removal of constituents of interest from the groundwater. Monitoring would be continued after remediation was complete to ensure that no constituents of interest remained in the groundwater.

Remedial Alternative No. 7: In-Situ Groundwater Treatment With Soil Treatment

Remedial Alternative No. 7 involves continuing the access restrictions and quarterly groundwater monitoring that are currently conducted at the Texaco Fillmore site, plus installing an in-situ groundwater treatment system as described in Remedial Alternative No. 5 and conducting soil treatment to remove leachable constituents of interest from impacted soils beneath the waste pits in the two action areas. Table 3-8 summarizes Remedial Alternative No. 7.

Soil treatment would consist of one of two technologies: 1) in-situ vapor extraction and surface treatment of extracted vapors, or 2) in-situ biotreatment of unsaturated soils. The in-situ vapor extraction system would be as described in Remedial Alternative No. 6. However, air sparging could be included as an additional groundwater treatment technology or as an aeration technique for in-situ groundwater treatment.

In-situ biotreatment of unsaturated soils would be conducted in conjunction with in-situ groundwater treatment. However, alterations would be made to the overall system design as presented in Remedial Alternative No. 5. Rather than reinjecting all of the nutrient-rich groundwater into Aquifer 1 via injection wells, some of the water would be allowed to percolate through the impacted unsaturated soils to affect biotreatment of the soil. The specific design for an infiltration system to introduce the water into the subsurface soil would require further geophysical characterization of the impacted soils.

Groundwater monitoring would be conducted during remediation in order to track the progress of the removal of constituents of interest from the groundwater. Monitoring would be continued after remediation was complete to ensure that no constituents of interest remained in the groundwater.

4.0 OVERVIEW OF EVALUATION CRITERIA

The detailed analysis of alternatives was performed in accordance with *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (U.S. EPA, 1988) and Section 300.430(e)(9) of the National Contingency Plan (NCP). The purpose of the detailed analysis of alternatives is to provide decisionmakers with sufficient information to adequately compare the alternatives and select an appropriate remedy for the site. As noted above, this report does not discuss the applicability of CERCLA to this site. The nine evaluation criteria for selection of a remedy that are outlined in Section 300.430(e)(9)(iii) of the NCP are categorized into three groups:

- **Threshold Criteria** - Overall protection of human health and the environment and compliance with ARARs [unless a specific ARAR is waived in accordance with Section 300.430(f)(1)(ii)(c)].

- **Primary Balancing Criteria** - Long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; cost.

- **Modifying Criteria** - State and community acceptance.

Any remedy selected must meet the threshold criteria and be cost effective. Cost effectiveness is determined by examining whether the costs are proportional to the remedy's overall effectiveness, as determined by evaluating the following three of the five primary balancing criteria listed above: long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; and short-term effectiveness. In addition, each remedial action selected must utilize permanent solutions to the maximum practicable extent.

The nine evaluation criteria outlined in the NCP serve as the basis for conducting the detailed analysis of alternatives and for subsequently selecting appropriate remedial action for the site. The nine evaluation criteria to be used in the detailed analysis of alternatives are listed in Table 4-1. The following paragraphs briefly describe the factors addressed by each evaluation criterion.

TABLE 4-1

Summary of Detailed Evaluation Criteria

Criterion	Issues
Overall Protection of Human Health and the Environment	- Protection of human health and the environment.
Compliance with ARARs	- Compliance with chemical-specific ARARs, location-specific ARARs, action-specific ARARs, and other to-be-considered guidance and criteria.
Long-Term Effectiveness and Permanence	- Magnitude of residual risk - Adequacy and reliability of controls
Reduction of Toxicity, Mobility, or Volume Through Treatment	- Treatment process used and materials treated - Amount of hazardous materials destroyed or treated - Degree of expected reductions in toxicity, mobility, or volume - Degree to which treatment is irreversible - Type and quantity of residuals remaining after treatment
Short-Term Effectiveness	- Protection of community during remedial actions - Protection of works during remedial actions - Environmental impacts - Time until remedial action objectives are achieved
Implementability	- Ability to construct and operate the technology - Reliability of the technology - Ease of undertaking additional remedial actions, if necessary - Ability to monitor effectiveness of remedy - Ability to obtain approval from other agencies - Coordination with other agencies - Availability of off-site treatment, storage, and disposal services and capacities - Availability of necessary equipment and specialists - Availability of prospective technologies
Cost	- Capital costs - Operating and maintenance cost - Present worth costs
State Acceptance*	- State acceptance of the preferred alternative
Community Acceptance*	- Community acceptance of the preferred alternative

*State and community acceptance criteria area addressed in the Record of Decision following public comment on the Feasibility Study.

4.1 Overall Protection of Human Health and the Environment

This criterion, which is a final assessment of whether the alternative adequately protects human health and the environment, encompasses assessments of other evaluation criteria, particularly long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. The criterion also includes a description of how site risks are eliminated, reduced, or controlled through treatment, engineering, or institutional controls. Potential cross-media impacts are also evaluated. This criterion will address the controls proposed with respect to risks determined in the site-specific risk assessment.

4.2 Compliance with ARARs

This criterion is used to determine whether all federal and state ARARs (as defined in the Screening document) will be met. A summary of which requirements are applicable or relevant and appropriate to an alternative is provided, as well as a description of how the alternative will meet the requirements. For any ARARs that are not met, justification using one of six allowable waivers is provided. The following are addressed for each alternative:

- Compliance with chemical-specific ARARs (such as maximum contaminant levels);
- Compliance with location-specific ARARs (such as impacts on regulated wetlands); and
- Compliance with action-specific ARARs (such as RCRA minimum technology standards).

An evaluation of ARARs was presented in Section 2.0 of the RAD document.

4.3 Long-Term Effectiveness and Permanence

This criterion considers the risk remaining at the site after remedial action objectives have been met. Two major factors are considered: magnitude of residual risk and adequacy and reliability of controls. Magnitude of residual risk refers to risk remaining from untreated waste or treatment residuals. Adequacy and reliability of controls refers to the controls, if any, that are used to manage the residual risk identified. Technical components and institutional controls are evaluated and the risk posed if a technical component (e.g., cap or extraction well) needs replacement is also considered.

4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The statutory preference for remedial alternatives that permanently and significantly reduce the toxicity, mobility, or volume of hazardous waste is addressed by this criterion. Questions are also considered concerning to what extent the risk can be reduced through treatment and whether the principal threats at the site are addressed by the selected alternative.

4.5 Short-Term Effectiveness

This evaluation criterion, unlike the long-term effectiveness criterion, considers the risk associated with the alternative during the construction and implementation phase, up to the point at which the remedial action objectives are met. Factors considered include protection from risks to the community, such as dust, air emissions, or transportation of hazardous materials; protection of workers on the site; potential environmental impacts; and time required for cleanup objectives to be met.

4.6 Implementability

The technical and administrative feasibility of implementing an alternative is addressed by this criterion. Technical feasibility factors include potential difficulties and uncertainties associated with construction and operation; reliability of the technology; feasibility of additional remedial action, if required; ability to monitor various pathways; and risks associated with insufficient monitoring. Administrative feasibility factors include coordination with other agencies; availability of treatment, storage, and disposal services and capabilities; availability of necessary equipment and specialists; and availability and level of development of required technologies.

4.7 Cost

The cost criterion includes capital costs and O&M costs. Capital costs include direct expenses, such as construction, equipment, and disposal costs; and indirect expenses, such as engineering and design, legal and permitting, mobilization and startup, and scope and bid contingency costs, as well as the costs of health and safety considerations and services during construction.

Scope contingencies cover changes that invariably occur during final design and implementation and is intended to adjust the estimate so it can be used for budgetary purposes. Bid contingencies may cover unknown expenses associated with constructing a given project scope such as adverse weather conditions, geotechnical unknowns, and unfavorable market conditions for a particular project scope. O&M costs, calculated on an annual basis, include expenses for

operating labor and materials, maintenance labor and parts, power requirements, sampling and analysis, administration, and periodic site reviews.

In order to allow costs to be compared, the net present value is also calculated. The net present value, or present worth, is calculated in order to evaluate expenditures that occur over different time periods. By discounting all costs to a common base year, the costs for different remedial action alternatives can be compared on the basis of a single figure for each alternative. This single figure, the net present value or present worth of a project, represents the amount of money in today's dollars needed to cover all the expenditures associated with a remedial action alternative. Cost data including the net present value for each alternative are presented in Appendix E.

The feasibility study costs presented in Section 5.0 have been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope, final project schedule, and other variable factors. As a result, the final project costs will vary from the estimates herein. Because of these factors, funding needs must be carefully reviewed prior to making specific financial decisions or establishing final budgets.

4.8 State Acceptance

Technical and administrative issues and concerns of the state pertaining to the alternatives will be evaluated. This criterion will be addressed in U.S. EPA's Record of Decision (ROD) once comments on the FS report have been received from the state.

4.9 Community Acceptance

Technical and administrative issues and concerns of the community pertaining to the alternatives will be evaluated. As with state acceptance, this criterion will be addressed in the ROD once comments on the FS report have been received from the community.

Because they are not considered until comments are received from the state and community, the latter two evaluation criteria, state acceptance and community acceptance, are not assessed in the following sections.

5.0 DETAILED EVALUATION OF ALTERNATIVES

The detailed evaluation of remedial alternatives follows development and screening of alternatives and precedes the final selection of a remedial alternative. The results of the detailed evaluation provide the basis for identification of a preferred alternative and for preparation of a proposed remediation plan. The detailed evaluation will include:

- A detailed description of each alternative, including the various technologies that make up the alternative, any performance requirements associated with those technologies, and the logic behind application of such an alternative.

- An evaluation of each alternative against the detailed set of nine evaluation criteria (as discussed in Section 4.0).

- A comparative analysis of the alternatives to assess the relative performance of each alternative with respect to the detailed evaluation criteria and the conditions at the Fillmore site (presented in Section 6.0).

Table 3-1 presents the alternatives developed in the RAD document for the soil and groundwater at the site. Each of these alternatives is described in detail and evaluated in the following sections.

5.1 Alternative No. 1: No Action

5.1.1 Detailed Description of Alternative No. 1

Alternative No. 1 is the No Action Alternative for the Fillmore site. No institutional or technology controls would be carried out under this alternative. The actions planned for Alternative No. 1 are not expected to impact the results of the baseline risk assessment in any way.

The no action alternative would rely upon natural degradation and attenuation processes to address potential sources impacting groundwater quality, although no groundwater monitoring would be conducted to document achievement of groundwater standards. A review of quarterly groundwater data for May, August, and November of 1991 indicates a noticeable reduction in both the maximum and average benzene concentrations detected in Aquifer 1.

During the sample period, the calculated area of impacted groundwater of the north plume decreased from 360,000 square feet to approximately 15,600 square feet. These data indicate that natural degradation processes may be removing benzene from vadose zone soils and groundwater in Aquifer 1.

A more detailed description of the database documenting and supporting the occurrence of natural degradation of the Fillmore site is provided in Section 1.2.5.

Currently there is little potential for the general public to be exposed to hazardous constituents that may be present in groundwater or subsurface soils beneath the Fillmore site. Groundwater is not used as a drinking water resource in the site vicinity and no private potable water wells are known to exist in the site area.

In terms of achievement of remedial objectives outlined in Section 2.0, the logic for considering a no action scenario is based on two factors: the lack of any concentrated source of constituents remaining at the site and the action of natural bioattenuation processes. The investigative record of the site indicates that waste materials were removed from the disposal areas (i.e., Main Waste Pit) in 1985-1986. The removal of the waste materials several years ago is significant in that no concentrated source of constituents remains on-site to further affect groundwater quality. Only soils with low levels of leachable constituents remain in the vadose zone. The movement of constituents less soluble than benzene is expected to be attenuated by sorption to soils and biodegradation.

The unknown factor in this alternative is the effect of the drought conditions on the transport of the relatively low level of leachable constituents from the vadose zone to the groundwater. The lack of precipitation coupled with the previous waste removal actions has likely decreased or eliminated completely any leaching of constituents from the soil to the aquifer, effectively removing the source of chemical constituents. Therefore, a potential source exists in the vadose zone soils that could possibly contribute a mass of constituents greater than the soil's attenuation capacity.

5.1.2 Detailed Evaluation of Alternative No. 1

Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment because the depth of the constituents would prevent direct contact with the constituents in soil, and constituents in soils currently do not pose an unacceptable risk to human health or the environment. Although no proactive containment or treatment of groundwater is included in this alternative, natural

degradation process would reduce the volume and toxicity of constituents. In addition, the levels of constituents detected in the aquifer present an estimated risk of 5×10^{-5}, a value that is currently within the 10^{-4} to 10^{-7} range of risk that is typically used by U.S. EPA as cleanup goals for similar sites.

Compliance with ARARs

Achievement of ARARs in Alternative 1 will not be measured and therefore cannot be quantified. Site data suggest that natural degradation could achieve chemical-specific ARARs for groundwater criteria over time (see description in Section 1.2.5), although these criteria would not immediately be met under this alternative for two of the constituents of concern, benzene and 1,2-dichloroethane (DCA).

Location- and action-specific ARARs are not applicable to this alternative.

Long-Term Effectiveness and Permanence

This criterion addresses the risk remaining at the site after remedial action objectives are achieved. As mentioned above, constituents in groundwater are currently within the range of risk (10^{-4} to 10^{-7}) that is typically used by U.S. EPA as cleanup goals for similar sites. Natural degradation, dispersion, and attenuation processes are expected to achieve the ARAR-based remedial action objectives for the compounds at the site over the long term. These processes are permanent, and once groundwater remediation objectives were achieved, they would not be exceeded again. The potential source of constituents in the vadose zone may lead to conditions where the capacity of soil for natural attenuation would be exceeded, resulting in a less rapid decrease in the concentration and/or extent of the groundwater plume than would be expected without this potential source. A full evaluation of the potential impacts of residual constituents is needed to determine residual risks; however, it is not likely that the mass of constituents in soil will substantially affect long-term risks. It is expected that the risks remaining at the site after remedial action objectives are achieved will remain within the U.S. EPA cleanup goal risk range for the site in the long term. However, since no groundwater monitoring will be conducted under this alternative, documentation of long-term effectiveness of this alternative would not be possible.

Reduction of Toxicity, Mobility or Volume Through Treatment

This alternative does not specifically include treatment, although the volumes of constituents at the site have been greatly reduced by the prior waste removal actions. Figure 1-5 (see Section 1.2.5) indicates that significant natural biodegradation of constituents at the site has already

occurred. The average benzene concentration detected in groundwater in October 1990 was approximately 138 µg/ml. In August 1991 the average benzene concentration was 45 µg/ml. This reduction is related to a removal of benzene mass by biodegradation. Benzene removal from groundwater will ultimately reduce the risk of exposure to public. Reduction in the toxicities, mobilities, and volumes of constituents in groundwater would occur over time due to natural biodegradation and dispersion.

Short-Term Effectiveness

Construction would not take place under this alternative, no exposure of constituents is involved, and potential risks to the community during construction is not an issue. There is some potential for public exposure for the site, because groundwater beneath the site is part of a regional system that could potentially be used for drinking water. However, the potential for public exposure to constituents in groundwater is slight. Data presented in the RAD report indicated that benzene and DCA were the only two constituents detected in groundwater at the site exceeding MCLs established for drinking water. Natural biodegradation and dilution would likely reduce benzene concentrations below the MCL before reaching regional groundwater sources off-site. There would be no exposure to site workers under this alternative.

Remedial action objectives associated with constituent concentrations in groundwater would be achieved by natural processes in the long run. The total time for natural processes to reduce levels of constituents in groundwater to below ARARs is difficult to predict, but is expected to be 5 to 30 years. A calculation of the 5-year biodegradation period to achieve the 5 µg/L MCL for benzene is presented in Appendix D. This calculation is based on aerobic biodegradation rates found in the literature (Ward and Thomas, 1986). As discussed previously, data presented in Section 1.2.5 indicate that an observed reduction of benzene in groundwater correlates well with the predicted biodegradation rate based on a benzene half-life of 120 days. The potential for migration of constituents from soil to groundwater has been greatly reduced by previous waste removal actions; however, this alternative would not prevent migration of constituents to groundwater. It should be noted that the groundwater is not considered to be a drinking water source and discussion of risk is hypothetical.

Implementability

This alternative is relatively easy to implement.

Cost

No costs are associated with this alternative.

5.2 Alternative No. 2: Continued Operations

5.2.1 Detailed Description of Alternative No. 2

Alternative No. 2 is similar to the no-action alternative for the Fillmore site with the exception that the alternative consists of maintaining Texaco's involvement in the project at the current level.

Continued-operations would include grading to control surface water runoff, maintaining access restrictions, and continuing groundwater monitoring presently performed at the Fillmore site. Access restrictions would include deed restrictions preventing any future drilling or installation of groundwater wells for drinking purposes, or other subsurface disturbances (note: access restrictions will be part of all alternatives while such action is required). Grading of surface soils on-site would be completed to minimize surface runoff to the former disposal pits, further reducing any potential for leaching of constituents from soils below the former waste pits to the aquifer. Current operations at the site include access restriction via perimeter fencing, and periodic (e.g., quarterly) monitoring via sampling and analysis of the monitoring wells. It is likely that long-term monitoring could be completed with a limited number of wells.

For the purpose of this evaluation, 10 wells will be selected for long-term monitoring. Samples would be analyzed for volatile organics (Method 8240) and other compounds and parameters as appropriate. Results of the monitoring would be used to determine migration and degradation of constituents in groundwater. In terms of achievement of remedial objectives outlined in Section 2.0, the continued operations alternative would continue to prevent public exposure to potentially hazardous substances in subsurface soils by preventing site access and intrusive activities in the vadose zone, would utilize natural degradation and attenuation processes to address potential sources impacting groundwater quality, and would allow for achievement of groundwater standards via the continuation of documented naturally occurring degradation processes.

Currently there is little potential for the general public to be exposed to hazardous constituents that may be present in groundwater or subsurface soils beneath the Fillmore site. Groundwater is not used as a drinking water resource in the site vicinity and no private potable water wells are known to exist in the site area. Any future installation of groundwater wells for potable use will be prevented by deed restrictions as part of the no-action alternative.

The logic for considering a continued operations scenario is supported by the investigative record at the site and activities already taken therein, including the removal of the waste from the disposal areas (i.e., Main Waste Pit) in 1985-1986. The removal of the waste materials several years ago is significant in that no concentrated source of constituents remains on-site to further

affect groundwater quality. Only soils with low levels of leachable constituents remain in the vadose zone. According to the *Literature Survey: Hydrocarbon Solubilities and Attenuation Mechanisms* by the American Petroleum Institute (API Publication No. 4414, August 1985), low levels of leachable constituents remaining in vadose zone soils may be subject to natural attenuation mechanisms, such as volatilization and biodegradation. In one field study cited in the literature survey, following the physical removal of most of the free product from a gasoline spill in a dolomite aquifer, the hydrocarbon-utilizing microbial populations indigenous to the systems degraded an estimated quantity of over 1,000 barrels of gasoline over 18 months. The area of groundwater affected by the gasoline spill was estimated at 180,000 sq. ft. Bacterial cultures were grown in the laboratory from groundwater samples collected from this site. Thirty-two species of hydrocarbon-utilizing bacteria were isolated from genera including *Flavobacterium, Micrococcus, Acinetobacter, Pseudomonas, and Nocardia*. During laboratory studies performed in 1975 by Jamison and Raymont (see literature survey), a mixed culture of bacteria readily grew on Sunoco 260 gasoline and degraded 55 hydrocarbons present in Sunoco 260. At the end of the 8-day laboratory culture study 100% of the benzene, toluene, ethylbenzene, and xylene (BTEX) initially present was degraded.

As discussed in Section 1.2.5, groundwater monitoring data collected at the Fillmore site between August 1990 and November 1991 suggest that natural biodegradation and attenuation processes are controlling the spread of constituents of interest at the site. As indicated in the RAD document and by data presented in the *Third Quarter 1991 Groundwater Sampling Report for the Texaco Fillmore Facility* (ENSR Document No. 6600-060-520, November 1991), both the average and maximum detected benzene concentrations have decreased significantly with each quarterly sampling event. Based on review of literature regarding degradation of benzene, a half-life approximately 120 days is expected (Ward and Thomas, 1986). Figure 1-5 provides a plot of the maximum and average detected concentrations

The unknown factor in this alternative is the effect of the drought conditions on the transport of the relatively low level of leachable constituents from the vadose zone to the groundwater. The lack of precipitation coupled with the previous waste removal actions has likely decreased or eliminated completely any leaching of constituents from the soil to the aquifer, effectively removing the source of chemical constituents. Therefore, a potential source exists in the vadose zone soils that could possibly contribute a mass of constituents greater than the soil's

attenuation capacity. Monitoring is included in this alternative to assess the mobility of benzene and the effects of the drought on the achievement of cleanup objectives.

5.2.2 Detailed Evaluation of Alternative No. 2

Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment because access restrictions and the depth of the constituents would prevent direct contact with the constituents in soil, and constituents in soils currently do not pose an unacceptable risk to human health or the environment. Although no proactive containment or treatment of groundwater is included in this alternative, natural degradation process would reduce the volume and toxicity of constituents. In addition, the levels of constituents detected in the aquifer present an estimated risk of 5×10^{-5}, a value that is currently within the 10^{-4} to 10^{-7} range of risk that is typically used by U.S. EPA as cleanup goals for similar sites. Grading of the site to divert surface runoff away from the former disposal pits would reduce the potential for leaching of remaining low levels of constituents from soil to groundwater.

Compliance with ARARs

Site data suggest that natural degradation would achieve chemical-specific ARARs for groundwater criteria over time, although these criteria would not immediately be met under this alternative for two of the constituents of concern, benzene and 1,2-dichloroethane (DCA). An estimate of time required for natural biodegradation of benzene in groundwater and soils to achieve the benzene MCL is calculated in Appendix D. Based on the aerobic biodegradation half-life of benzene (Ward and Thomas, 1986) and an initial benzene concentration of 720 µg/L, approximately 5 years would be required for aerobic biodegradation to achieve the MCL of 5 µg/L. However, site-specific conditions in the subsurface may vary from those encountered in the literature and 5 to 30 years may be required to achieve benzene ARARs. Biodegradation constants for 1,2-DCA were not cited in the literature reviewed during report preparation; therefore, a degradation timeframe for achieving the maximum contaminant level (MCL) could not be specified. Groundwater monitoring data presented in Figure 5-1 indicate that significant biodegradation of benzene may have already occurred at the Fillmore site; therefore, it is likely that natural biodegradation and attenuation mechanism would allow achievement of constituent MCL in 5 to 30 years. Thus, in the long-term, natural degradation and attenuation processes are likely to achieve standards. Benzene is present in groundwater at concentrations greater than its MCL and is one of the most mobile of the contaminants present. DCA, which was present slightly above the federal MCL at one location, is very soluble and would therefore be expected to dissipate over the long term due to natural groundwater flow.

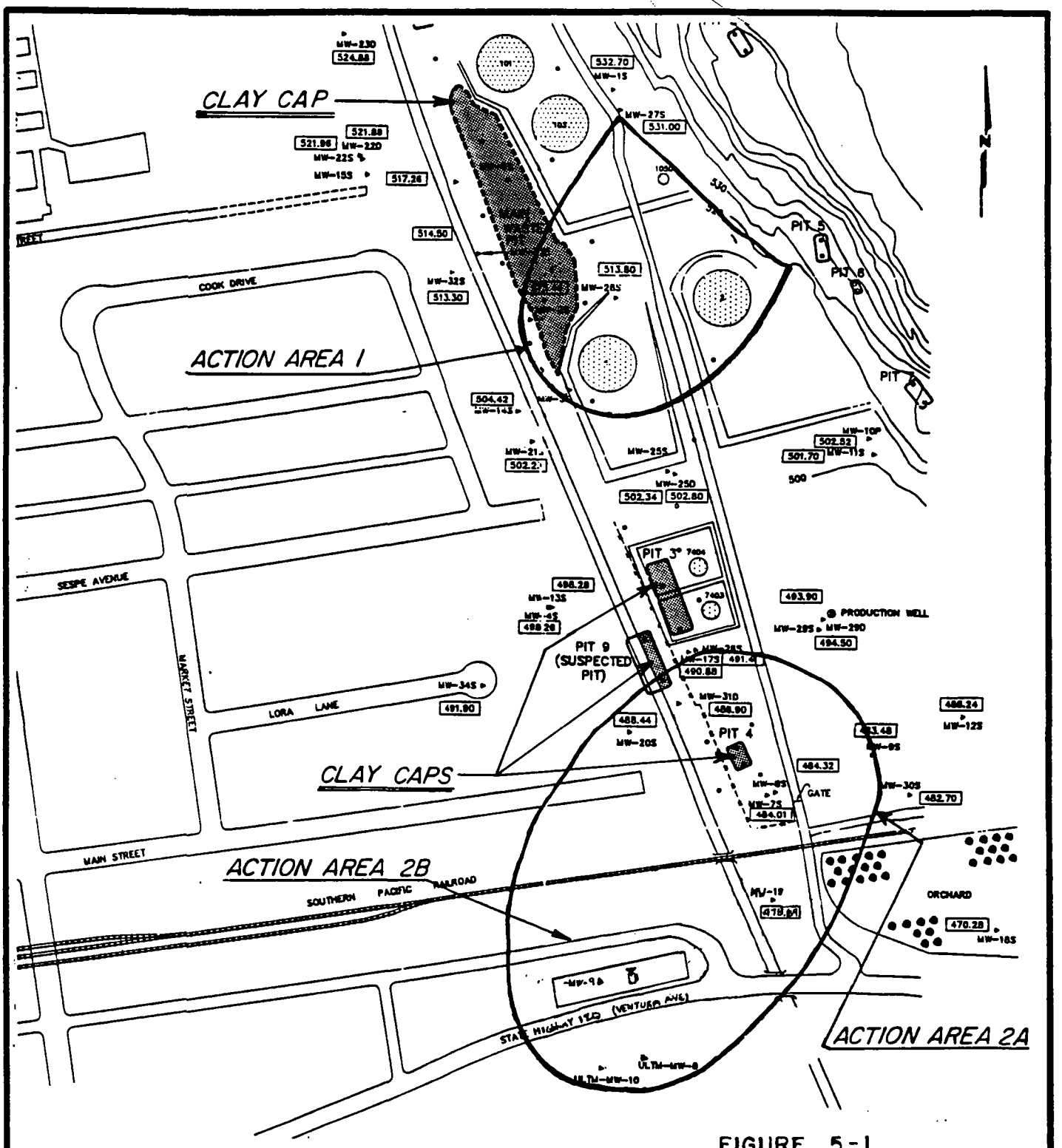

FIGURE 5-1

LEGEND

—— ESTIMATED BOUNDARIES OF REMEDIATION ACTION AREAS (BASED ON 10 ppb BENZENE CONTOURS OF SECOND, THIRD AND FOURTH QUARTER 1991 GROUNDWATER MONITORING SAMPLE DATA).

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PROPOSED LOCATIONS OF CLAY CAPS
TEXACO FILLMORE SITE

DRAWN: JDG	DATE: 10/2/91	PROJECT NUMBER:	REV.
APPV'D: GF	REVISED:	6600-063	0

6600A1

Location- and action-specific ARARs are not applicable to this alternative.

Long-Term Effectiveness and Permanence

This criterion addresses the risk remaining at the site after remedial action objectives are achieved. As mentioned above, constituents in groundwater are currently within the range of risk (10^{-4} to 10^{-7}) that is typically used by U.S. EPA as cleanup goals for similar sites. Natural degradation, dispersion, and attenuation processes are expected to achieve the ARAR-based remedial action objectives for the compounds at the site over the long term. These processes are permanent, and once groundwater remediation objectives were achieved, they would not be exceeded again. The potential source of constituents in the vadose zone may lead to conditions where the capacity of soil for natural attenuation would be exceeded, resulting in a less rapid decrease in the concentration and/or extent of the groundwater plume than would be expected without this potential source. A full evaluation of the potential impacts of residual constituents is needed to determine residual risks; however, it is not likely that the mass of constituents in soil will substantially affect long-term risks. Continued monitoring would be performed to determine the ongoing impact from the vadose zone soils and to track contact with or hypothetical use of groundwater. Thus, it is expected that the risks remaining at the site after remedial action objectives are achieved will remain within the U.S. EPA cleanup goal risk range for the site in the long term.

Reduction of Toxicity, Mobility or Volume Through Treatment

This alternative does not specifically include treatment, although the volumes of constituents at the site have been greatly reduced by the prior waste removal actions. Figure 5-1 indicates that significant natural biodegradation of constituents at the site has already occurred. The average benzene concentration detected in groundwater in October 1990 was approximately 138 µg/ml. In August 1991 the average benzene concentration was 45 µg/ml. This reduction is related to a removal of benzene mass by biodegradation. Benzene removal from groundwater will ultimately reduce the risk of exposure to public. Reduction in the toxicities, mobilities, and volumes of constituents in groundwater would occur over time due to natural biodegradation and dispersion.

Short-Term Effectiveness

Construction under this alternative would include grading to control surface runoff. As these activities would be conducted on-site and no exposure of constituents is involved, potential risks to the community during construction is not an issue. There is some potential for public exposure for the site, because groundwater beneath the site is part of a regional system that

could potentially be used for drinking water. However, the potential for public exposure to constituents in groundwater is slight. Data presented in the RAD report indicates that benzene was the only constituent detected in groundwater at the site exceeding MCLs established for drinking water. Natural biodegradation and dilution would likely reduce benzene concentrations below the MCL before reaching regional groundwater sources off-site. Potential risks to workers involved in the implementation of the alternative could be posed during grading, but are not anticipated to be significant. All workers on-site will undergo health and safety training, and will comply with safety procedures included in the Site-Specific Health and Safety Plan. All health and safety activities will comply with OSHA requirements for work at hazardous waste sites (29 CFR 1910.120).

Remedial action objectives associated with constituent concentrations in groundwater would be achieved by natural processes in the long run. The total time for natural processes to reduce levels of constituents in groundwater to below ARARs is difficult to predict, but is expected to be no more than 5 years. A calculation of the 5-year biodegradation period to achieve the 5 µg/L MCL for benzene is presented in Appendix D. This calculation is based on aerobic biodegradation rates found in the literature (Ward and Thomas, 1986). Site-specific conditions, however, may vary from the literature and 5 to 30 years is used as the time required to achieve ARARs. As discussed previously, data presented in Figure 1-5 indicate that an observed reduction of benzene in groundwater correlates well with the predicted biodegradation rate based on a benzene half-life of 120 days. The potential for migration of constituents from soil to groundwater has been greatly reduced by previous waste removal actions; however, grading to divert surface runoff would reduce the potential even further. It should be noted that the groundwater is not considered to be a drinking water source and discussion of risk is hypothetical.

Implementability

Grading of surface soils would be simple to complete using standard excavating equipment. Maintaining access restrictions and conducting a groundwater monitoring program would also be relatively easy to implement.

Cost

The costs associated with this alternative are for grading, preparation of a groundwater sampling plan, and quarterly groundwater sampling and analysis. The total capital cost for this alternative is $55,000. Annual O&M costs would be $120,000. The estimated net present values for different remediation time frames are presented in Section 6.0. Assumptions and detailed cost spreadsheets used to develop these costs are included in Appendix E.

5.3 Alternative No. 3: Continued Operations Plus Capping

5.3.1 Detailed Description of Alternative No. 3

This alternative would include placing caps over the former waste pits on-site. Installing the caps would ensure the continuation of the present lack of direct contact with, and minimize leaching of constituents from, soils under the former waste pits. Although the waste materials have been excavated from the pits, thereby removing the major sources of groundwater contamination, the underlying soils may be contributing to the presence of constituents in groundwater by percolating precipitation (although presumably at a decreasing degree). Areas to be capped include the Main Waste Pit and Waste Pits 3 and 4 (suspected Waste Pit 9 lies partially below the Pole Creek concrete channel and is therefore partially capped at present). The total area of the caps would be approximately 11,000 square yards. This alternative builds on the no-action alternative by providing a means of further minimizing the percolation of rainwater through those areas of the vadose zone where leaching of constituents of interest to groundwater may occur. This alternative assumes that the continued natural degradation, dispersion, and attenuation processes within the groundwater in Aquifer 1 will result in achievement of the remedial objectives for groundwater and that the capping will control movement of the constituents of interest from the vadose zone. This alternative would also continue to prevent public exposure to soils through access restrictions and capping.

Two types of caps were identified through the screening and evaluation of remedial technologies:

- A clay cap, which includes a 1-foot grading layer made of existing cover material, 2 feet of compacted clay, 1 foot of cover material, and 0.5 feet of top soil and vegetation. The clay cap would have a 2-foot-thick compacted clay layer with an in-place hydraulic conductivity of 10^{-7} cm/sec or less as recommended in U.S. EPA guidance documents (U.S. EPA, 1989). Hydraulic conductivities of 10^{-7} to 10^{-9} could easily be achieved for clay with proper compaction.

- A RCRA Subtitle C-type cap, which includes a 1-foot grading layer, 2 feet of compacted clay, a geomembrane liner, 1 foot of drainage material, a geosynthetic filter, 2 feet of cover soil, and 0.5 feet of top soil and vegetation (based on U.S. EPA recommendations for final covers for hazardous waste landfills, U.S. EPA, 1989).

Table 5-1 is a comparison of the constructions, permeabilities, percolation rates, relative risk reductions, and costs of the two caps. As the table shows, both caps would provide excellent protection from direct contact with the contaminated soils. The amount of precipitation percolating to the groundwater is essentially none for the RCRA Subtitle C-type cap and very small for the clay cap. The clay cap, however, is significantly less costly than the RCRA Subtitle C-type cap, while providing very good protection to groundwater.

The additional reduction in leaching provided by the Subtitle C-type cap is not that significant, thus does not justify the significant additional expense. Based on this evaluation, the clay cap will be retained for detailed analysis of Alternative No. 3 (see Figure 5-2).

Clay and topsoil would be imported to the site to construct the caps. The caps would have a final slope of 2% to 4% and the side slope would be at a maximum of 4:1. A grading plan would be developed to promote positive drainage of the cap surface, yet minimize erosion. In addition, the covers would be designed to prevent root intrusion and would be seeded to establish an erosion-resistant grass cover. Site monitoring would consist of grass cutting and regular inspections. Site maintenance would require inspection of the caps for signs of damage; any damage would be repaired.

Site access restriction by fencing would be maintained and periodic (e.g., quarterly) groundwater monitoring would be continued as part of this alternative.

5.3.2 Detailed Evaluation of Alternative No. 3

Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment as far as constituents in soil are concerned by continuing to prevent direct contact with residual constituents and by minimizing the leaching of constituents to the groundwater. Existing fencing of the site would help prevent deterioration of the cap by trespassers. Regular inspection and maintenance would ensure that the cap remained an effective barrier. Reduction of risks in groundwater (shown to be minimal in the draft risk assessment (CH_2M Hill, 1991) would rely on the continuing natural degradation processes over time as described for Alternative No. 2. Thus, the alternative would be protective over the long term.

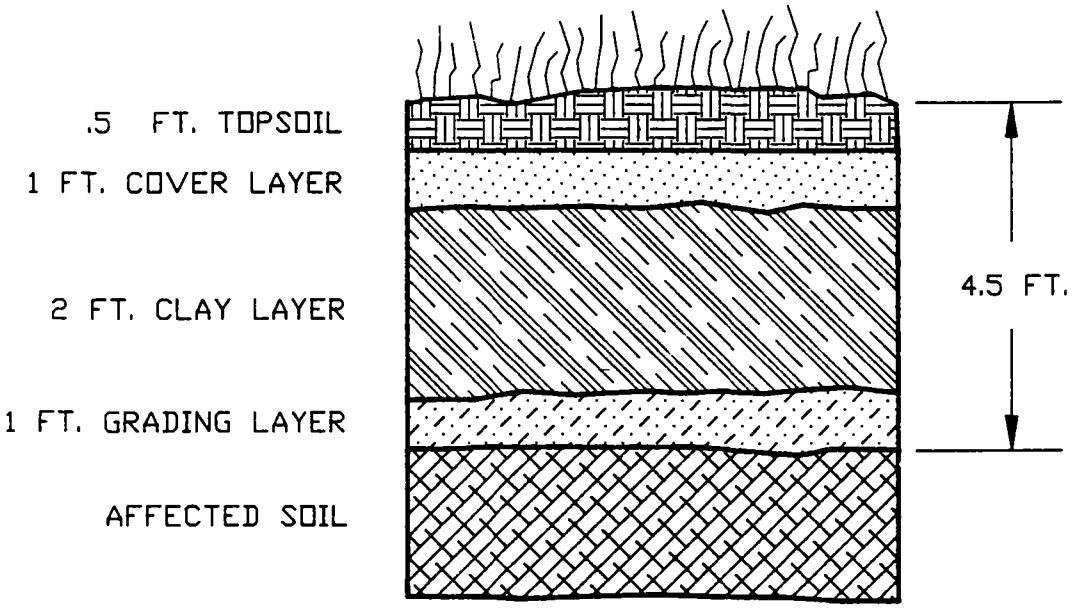
In addition to preventing direct contact with the soil under the former waste pits, the cap would significantly reduce infiltration of precipitation into the disposal area since the 2-foot clay layer would have a compacted permeability of 1×10^{-7} cm/sec or less. This would further reduce the currently minimal (or nonexistent) migration of constituents from soil to the groundwater. As with

TABLE 5-1

Comparison of Different Types of Caps

	TYPE OF CAP	
	Clay Cap	RCRA "C" Cap
Construction		
Topsoil/Vegetation	0.5 ft	0.5 ft
Cover Soil	1.0 ft	2 ft
Geosysthetic Filter	--	1 in
Drainage Material	--	1 ft
Geomembrane Liner	--	20 mil
Compacted Clay Liner	2 ft	2 ft
Existing Cover Soil/Grading Layer (Minimum[1])	1 ft	1 ft
Permeability of Least Permeable Layer (cm/sec)	1×10^{-7} to 1×10^{-9}	(impermeable)[2]
Relative Risk Reduction		
Direct Contact	Excellent	Excellent
Leaching to Groundwater	Very good	Very good
Cost		
Per Square Yard	$34	$90
Total[3]	$380,000	$990,000

[1]The volume of the existing soil cover may necessitate an increase in the depth of the grading layer.
[2]Assumes structural integrity of synthetic liner is maintained.
[3]Based on cap area of 11,000 square yards; does not include backfill costs.



CONCEPTUAL DESIGN ASSUMPTIONS (1)

- GRADING LAYER MADE OF EXISTING COVER
- COMPACTED CLAY WITH A HYDRAULIC CONDUCTIVITY OF 10-7 cm/sec. OR LESS.
- COVER MATERIAL MADE OF IMPORTED BACKFILL
- TOPSOIL WOULD BE IMPORTED
- FINAL SLOPE OF CAP WOULD BE 2% TO 4%
- SITE ACCESS WOULD BE RESTRICTED BY EXISTING FENCING

(1) FOR FS PURPOSES ONLY.

FIGURE 5-2

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TYPICAL CROSS-SECTION OF A CLAY CAP
TEXACO FILLMORE SITE

DRAWN: JDG	DATE: 2/13/92	PROJECT NUMBER:	REV
APPV'D: JA	REVISED: X	6600-063	0

NOT TO SCALE

6600063\TEX5-2

Alternative No. 2, it is anticipated that dispersion and transformation/attenuation processes, including natural biodegradation, would reduce the concentrations of the constituents in the aquifer to acceptable levels over time. Because the constituents of interest are volatile in nature, it is likely that vapor transport through diffusion may provide a mechanism for the constituents to migrate beyond the limit of the cap, but soil vapor levels are currently low in the proposed capping area. Movement of soil vapor plumes with subsequent readsorbtion to soils has been observed at other sites.

In the short term, there would be little risk to human health and the environment during cap and any required fence installation. The existing soil would be used as the grading layer. However, increased traffic and dust are likely as a result of delivery of capping materials to the site and construction of the cap.

The remedial action objective related to preventing contact with constituents in soil would be met; the groundwater cleanup objectives would be achieved in the long term through natural dispersion, adsorption, and biodegradation.

Compliance with ARARs

This alternative will meet chemical-specific ARARs for groundwater over the long term through natural degradation and dispersion processes. As with Alternatives No. 1 and 2, it is anticipated that groundwater ARARs would be achieved within 5 to 30 years at the current observed rate of benzene degradation (Appendix D). Since there is minimal observed transport of constituents in the vadose zone to groundwater, it is not expected that the mass within the vadose zone will significantly impact the timeframe.

Long-Term Effectiveness and Permanence

This criterion assesses the risk remaining at the site after remedial action objectives are achieved. As mentioned previously, constituents in groundwater and soils are currently within the range of risk that is typically used by U.S. EPA to set cleanup goals for similar sites. Significantly reducing the potential for leaching of constituents through the use of capping would reduce the risk to groundwater presented by the affected soils; however, a full evaluation of the potential impact of residual constituents is needed to determine actual residual risks. It is likely that the mass of constituents present will not substantially affect long-term risks.

Access restrictions and regular maintenance would further prevent direct contact with the soils. The risk from the need to replace or repair the cap would be minimal, because regular inspection of the cap would detect signs of deterioration, and repair could be completed as needed.

Transport of vapor plumes may reduce the long-term effectiveness of the cap. Natural degradation, dispersion, and attenuation processes would result in achievement of groundwater remediation goals over the long term. These processes are permanent, and levels of constituents in groundwater would not exceed cleanup goals once they were achieved. Groundwater would be monitored to track the constituents and assess the rate of natural attenuation. Thus, it is expected that the risks remaining at the site after remedial action objectives are achieved will remain within the risk range used by U.S. EPA to develop cleanup goals for the site in the long term.

Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative does not include treatment beyond the previous waste removal action, although reduction of toxicities, mobilities, and volumes of constituents in groundwater would occur over time due to natural biodegradation and dispersion. However, Texaco's prior waste removal action provided a significant reduction of material that could impact soil, groundwater, or other media at the site. The mobilities of residual constituents in soil would be reduced through capping, which would minimize leaching due to percolation of precipitation.

Short-Term Effectiveness

This evaluation criterion assesses the risk associated with construction and implementation of the alternative up to the point when remedial action objectives are achieved. The remedial time frame for this alternative includes time needed for construction, implementation, and installing the caps, and the time it will take (number of years) for the levels of constituents in groundwater to be reduced through natural processes to achieve remedial action objectives. The total time for natural processes to reduce levels of constituents in groundwater to below ARARs is difficult to predict, but is expected to be 5 to 30 years.

Risks to the community would be minimal. No waste materials remain in the waste pits and underlying soils in the vadose zone would be undisturbed. The only potential effects would result from the transportation to the site of clay, topsoil, and other materials to install the cap. Increased traffic through parts of the City of Fillmore may occur. Possible airborne dust from working with the soils on-site could also result, in areas closest to the caps.

Potential risks to workers involved in the implementation of the alternative could be posed while the caps are being installed, but are not anticipated to be significant. All workers on-site will undergo health and safety training, and will comply with safety procedures included in the Site-Specific Health and Safety Plan. All health and safety activities will comply with OSHA requirements for work at hazardous waste sites (29 CFR 1910.120).

Minimal impacts to the environment are expected during the implementation of this alternative. Soil erosion could occur during cap installation and result in increased sediment loads to any nearby surface water. Such erosion and runoff would be controlled by physical barriers commonly used at construction sites.

Implementability

In general, the installation of the clay cap would not involve any major technical constraints. The potential for vapor plume transport from beneath the cap may impact implementability. Standard construction techniques would be used to grade the site, spread and compact clay, spread cover and topsoil, and seed the surface. Investigation, design, and construction of the cap is expected to take 1 year. O&M activities, including inspection of the cap on a regular basis and repair when necessary, would also be relatively simple.

Cost

The total capital cost for this alternative would be approximately $967,000. The annual O&M cost would be $140,000. The estimated net present values for different remediation time frames are presented in Section 6.0. Assumptions and detailed cost spreadsheets used to develop these costs are included in Appendix E.

5.4 Alternative No. 4: Groundwater Extraction with Surface Treatment

5.4.1 Detailed Description of Alternative No. 4

Remedial Alternative No. 4 would involve a groundwater extraction and surface treatment system that would be installed to remediate the groundwater in Aquifer 1. Although no specific action would be taken to further minimize the leaching of constituents in subsurface soils beneath the waste pits to groundwater, any leached constituents would be captured and treated when they reached the groundwater. Access restrictions would be maintained and periodic (e.g., quarterly) groundwater monitoring that is currently being conducted at the Fillmore site would be continued. Thus, Alternative No. 4 would meet the remedial objectives outlined in Section 2.0 by preventing direct contact with the soils through access restriction, minimizing intrusive activities to the waste pit areas, extracting and treating groundwater until groundwater cleanup criteria are met, and containing, extracting, and treating any constituents that leach from the vadose zone soils. The following sections describe the different components of this alternative and select optimum technologies for addressing groundwater treatment needs.

5.4.1.1 Groundwater Recovery System

A groundwater recovery system would be required to pump groundwater to a surface treatment system. Groundwater recovery wells would be located downgradient of and within the two identified benzene plumes at the Fillmore site to recover affected groundwater. Based on a preliminary review of the RI data, estimations of well yields and zones of groundwater capture were performed to develop a conceptual layout of groundwater recovery wells (presented in Figure 5-3). It is anticipated that a single extraction well located near MW-2S, pumping at 10 gpm, should capture the north plume. However, two wells pumping 10 gpm each are proposed to enhance recovery of groundwater. Two recovery wells spaced approximately 500 feet apart, each pumping at 15 gpm for a combined flow rate of 30 gpm, would be capable of capturing the south plume. To enhance performance of the system, three recovery wells, pumping at 10 gpm each for a combined flow of 30 gpm, would be installed in the southern plume. Supporting calculations and assumptions for the proposed recovery system are located in Appendix B. The proposed recovery system is conceptual in nature. Groundwater modeling studies would need to be performed to optimize the groundwater recovery system to ensure plume containment and recovery in both areas. Groundwater modeling data is not currently available. For the purpose of this evaluation, the recovered groundwater was estimated to contain a total of 1.2 mg/L BTEX, DCA, and trace organics. This is the total of the maximum concentration of each chemical constituent detected through quarterly groundwater monitoring; actual total concentrations of constituents are expected to be much less.

The total volume of impacted groundwater is estimated to be 68,600,000 gallons. In order to remove the constituents to cleanup objectives, it is estimated that 10 to 20 pore volumes of water must be removed and treated (see calculations in Appendix B). It has been suggested in the literature that 30 pore volumes of groundwater may have to be pumped to remove 90 percent of organic constituents, such as benzene, present in an unconsolidated aquifer (Jackson and Patterson, 1989). However, there are conditions at the Fillmore site which are different from those typically cited in the literature. Waste material containing elevated levels of constituents above have already been removed from the site. Also, no floating free product or other concentrated source of constituents which could provide a continuing source of contaminants during pumping operations was identified at the Fillmore site during the RI. Constituents adsorbed to vadose zone soils provide the only continuing source of constituents during a pump and treat remedial action. These constituents, such as benzene, were detected in only four samples out of 785 subsurface soil samples collected during the RI at levels well above 11 µg/kg.

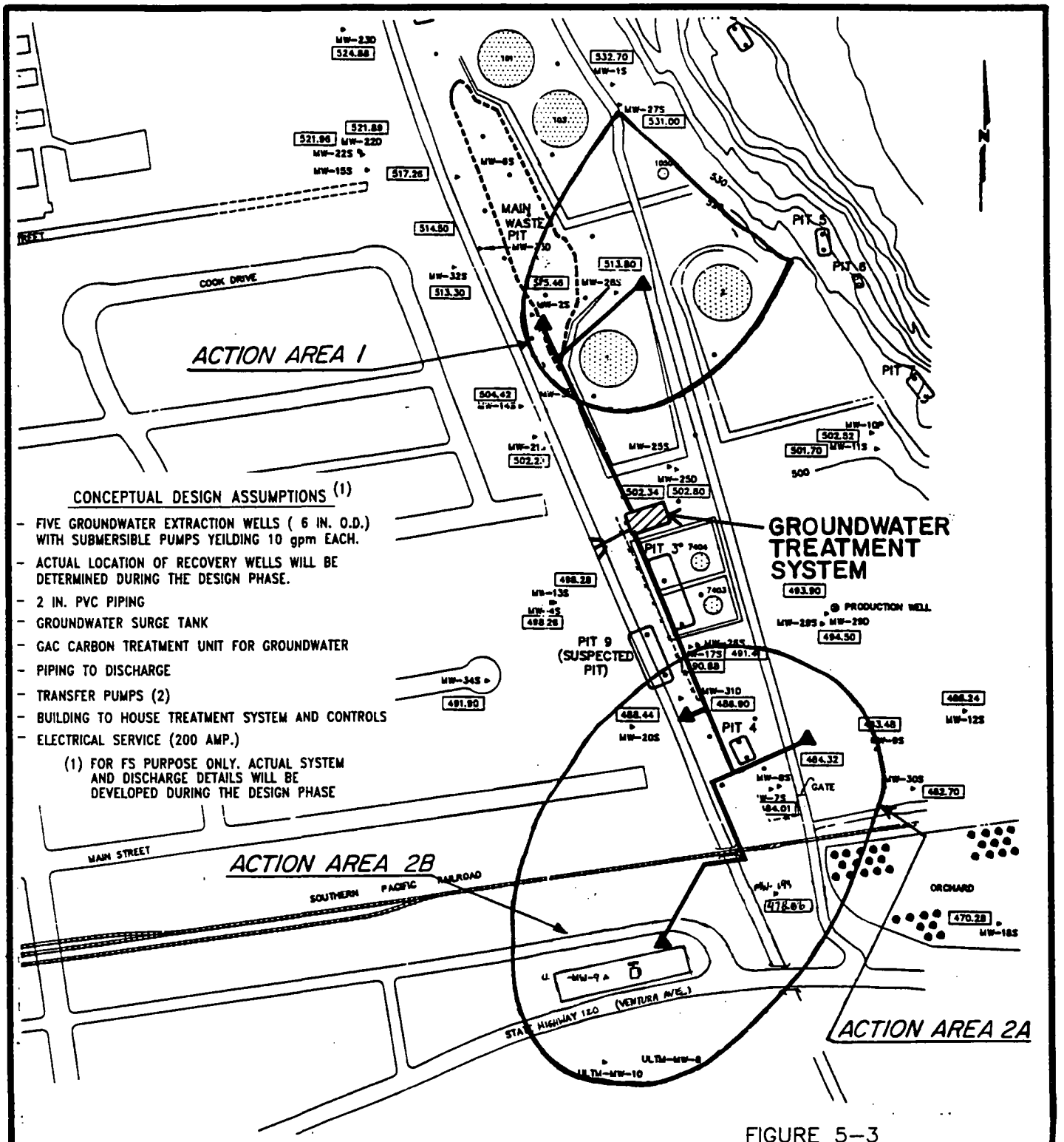

FIGURE 5-3

LEGEND

▲ RECOVERY WELLS

—— ESTIMATED BOUNDARIES OF REMEDIATION ACTION AREAS (BASED ON 10 ppb BENZENE CONTOURS OF SECOND, THIRD AND FOURTH QUARTER 1991 GROUNDWATER MONITORING SAMPLE DATA).

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PROPOSED LAYOUT OF GROUNDWATER RECOVERY SYSTEM
TEXACO FILLMORE SITE

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APPV'D: JA	REVISED: X		

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Therefore, based on these factors and ENSR's experience on similar projects, removal of 10 to 20 pore volumes at the Fillmore site should be sufficient to reduce constituent concentrations below applicable clean-up standards for groundwater.

Based on a flow rate of 20 gpm for the North Plume, a pore volume for groundwater of 13,600,000 gallons, and removal of 10 to 20 pore volumes, a timeframe ranging from 13 to 26 years will be required to achieve cleanup objectives. For the Southern Plume, given a calculated pore volume of 55,000,000 gallons, a flow rate of 30 gpm, and removal of 10 to 20 pore volumes, 35 to 70 years will be required to achieve cleanup objectives. These timeframes do not take into account the potential impact of natural biodegradation, which would act to reduce the remediation period. However, based on conversations with the U.S. EPA Remedial Project Manager (RPM) and for the purposes of comparative analysis between alternatives, natural biodegradation will not be considered as part of this alternative. As such, a remedial timeframe of 3 to 30 years will be utilized to assess pump and treat options.

The groundwater recovery system would serve as a vertical hydraulic barrier to migration of constituents of interest in groundwater, inhibiting migration of the plumes. However, groundwater modeling studies or other, more detailed hydrogeologic assessments would be required to optimize recovery performance and ensure achievement of a vertical hydraulic barrier.

The extraction wells from each plume would be connected to common headers, which would deliver the extracted groundwater to the treatment system. The treatment system would be located on-site between the two plumes.

5.4.1.2 Groundwater Treatment System

Three potentially applicable groundwater treatment technologies were identified through the screening and evaluation process in the RAD document: carbon adsorption, air stripping, and surface biotreatment. Each of these technologies is described in detail in the following sections.

Carbon Adsorption

Carbon adsorption is a physical process in which materials are transferred from the aqueous or vapor phase to the surface of a solid (carbon), where they are concentrated. The phase transfer occurs primarily as a result of a material's low affinity for the liquid or vapor phase and high affinity for the solid phase. Activated carbon is the most common adsorbent used in water and wastewater treatment. It is usually produced by crushing and heat activating selected grades of bituminous coal. The internal pore structure provides a large surface area for adsorption of different organic compounds. Activated carbon is supplied in either granular or powdered form.

The effectiveness and cost of adsorption depends on many factors, including the molecular weight, structure, solubility, and polarity of the compound. In general, the absorbability of a compound increases with increasing size and aromaticity, and decreases with solubility, polarity, and carbon-chain branching. The temperature and pH of aqueous-phase solutions can affect adsorption as well.

A typical liquid-phase carbon adsorption system consists of two or more vessels, in series or parallel, that are partially filled with activated carbon. Water to be treated enters the top of the unit, flows downward, and exits the bottom of the unit. A typical vapor-phase unit is similar, except the vapor stream to be treated typically enters the bottom and exits the top of the unit.

The adsorption capacity of granulated activated carbon (GAC) decreases with time until "breakthrough" occurs, when the compounds are no longer removed from the liquid or vapor phase. At this point, the carbon needs to be replaced or regenerated. Because adsorption capacities decrease with temperature, steam is commonly used to regenerate carbon. Carbon can be regenerated on-site with steam, or off-site by other methods such as thermal regeneration. Eventual treatment or disposal of carbon is required either way. Regeneration and/or replacement of carbon constitutes the majority of operation costs associated with carbon adsorption.

Air Stripping

Air stripping is a process in which VOCs dissolved in solution are transferred to the vapor phase (air). Generally, compounds with high vapor pressures and low solubilities (and therefore high Henry's Law constants) are removed most effectively by air stripping. In order to be effective, there must be good contact between the air and the liquid. The most efficient and common aeration method is the packed tower stripper. Water is sprayed into the top of the tower, which is partially filled with inert packing material. The water flows downward through the packing material and exits at the tower base. Air enters the bottom of the tower, strips the compounds, and exits from the top of the tower. The packing provides a large surface area for air/water contact.

The air stream exiting the air stripper often requires treatment to remove or destroy compounds transferred from the liquid phase. Vapor-phase carbon adsorption and catalytic oxidation are the most common vapor-control technologies used with air strippers. An air emission permit will be required. Air stripping equipment is generally moderately priced compared with the equipment for other treatment technologies. Operating and maintenance costs include electric power for the blower, vapor treatment, cleaning, and replacement of packing material.

For the Fillmore site, liquid-phase GAC adsorption may be required as a polishing step after air stripping, in order to remove highly soluble DCA to a level below National Pollutant Discharge Elimination System (NPDES) permit limits.

Surface Biological Treatment

Surface biological treatment has been demonstrated to be useful in treating groundwater containing petroleum constituents. The process uses microorganisms to degrade organic compounds dissolved in groundwater, creating carbon dioxide and water. Bioreactor size and, therefore, costs are influenced mainly by the flow rates and oxygen demand of the water to be treated. In addition to oxygen, nutrients would also be added to enhance microbial growth. The effluent would require polishing by carbon adsorption to meet NPDES permit limits, because surface bioremediation is estimated to be 90% efficient in removing BTEX and SVOCs, and DCA is not readily biodegradable and would not be removed to a great extent by this process.

This method has the advantage of being a destructive technology. Disadvantages to surface bioremediation result from the several weeks required for acclimation of the microorganisms; it cannot be used where a quick startup time is required, and it cannot be run in a discontinuous mode. Aeration of the groundwater to provide oxygen is likely to result in the release of VOCs to the air; therefore, vapor controls in the form of activated carbon would be necessary.

A sludge would be generated that may contain residual constituents and require handling and disposal as a hazardous waste. Treatability studies would be required to determine optimum nutrient and oxygen levels for metabolism of the constituents.

Selected Technology for Detailed Evaluation

Each of these three technologies has advantages and disadvantages related to its implementation at the Fillmore site. BTEX compounds would be removed by all three systems. DCA would not be removed by surface biotreatment and removal by air stripping would be very difficult at the low concentrations at the site. Removal of DCA by carbon adsorption is also difficult, but is the most effective of the three technologies. In addition, although carbon adsorption can be expensive for removal of large concentrations of organic contaminants, the total amount of constituents to be removed at this site are low. In addition, no air emission controls or air permits will be required with the carbon system. Carbon adsorption is therefore the most effective groundwater treatment technology for this site, and will be included in Alternative No. 4 (see Figure 5-4.

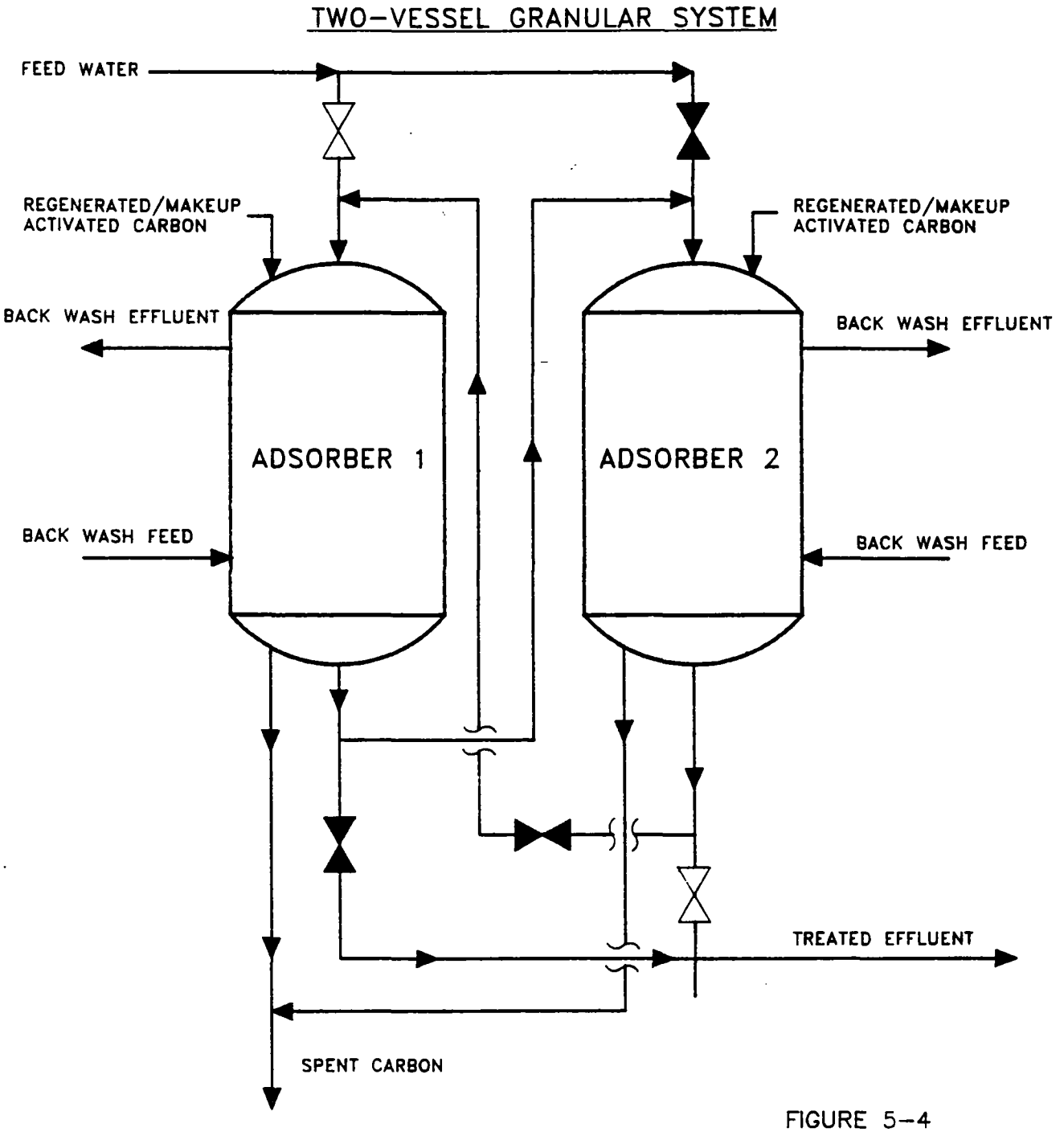

FIGURE 5-4

VALVE CLOSED

VALVE OPEN

SOURCE: USEPA, 1985

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TYPICAL CARBON ADSORPTION TREATMENT SYSTEM
TEXACO FILLMORE SITE

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5.4.1.3 Groundwater Disposal System

Four groundwater disposal options for treated groundwater were identified through the screening and evaluation process: discharge to Pole Creek, discharge to municipal storm drain system, reinjection through on-site wells, and discharge to the City of Fillmore POTW. Additional options include discharge to infiltration galleries on-site or reuse for irrigation. The most effective option will be selected during design activities; however, for the purpose of this FS, it is assumed that treated groundwater effluent would be discharged to Pole Creek. Such discharge would require an NPDES permit and approval from Ventura County Flood Control District. Discharge piping (approximately 6 inches in diameter) from the treatment system would run 200 feet underground to Pole Creek. Regular monitoring of the discharge would be conducted, as required by the NPDES permit.

5.4.2 Detailed Evaluation of Alternative No. 4

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment by removing constituents from the groundwater. The groundwater recovery wells would also act as hydraulic barriers to the flow of constituents in groundwater. Monitoring would be used to track constituents in groundwater and assess achievement of remedial action objectives. As with natural degradation of the constituents discussed in Alternatives No. 1 and 2, residual constituents in soil may leach to groundwater over time, thus impacting the length of time needed for groundwater recovery and treatment. Based on RI data, it is not anticipated that leaching of constituents will significantly impact the protectiveness of this alternative; however, a full evaluation of the potential impact of residual constituents is needed to determine the actual impact.

The groundwater recovery and treatment system would reduce constituents in groundwater to applicable standards, thereby meeting the remedial action objective. Any constituents leached from soil to groundwater would be collected and treated by the system. Direct contact with constituents in soil would be prevented by access restrictions. This alternative is therefore protective of human health and the environment.

Compliance with ARARs

The treatment system would be designed to collect and treat groundwater to concentrations below the ARARs. Discharge of the treated water to Pole Creek would meet NPDES permit discharge requirements. By proper design of the treatment systems, levels of compounds in the

discharged water would meet applicable criteria. If spent carbon shipped off-site for regeneration were determined to be a hazardous waste, RCRA regulations would be complied with. Based on calculations presented in Appendix B, it is estimated that ARARs would be achieved in an estimated timeframe of 3 to 30 years. Applicable chemical-specific ARARs for groundwater are federal MCLs, non-zero MCLGs, or state MCLs, whichever are more stringent for a particular constituent. Calculations presented in Appendix B are based on achieving the state benzene MCLs of 1 μg/l, which is the most stringent ARAR identified.

Long-Term Effectiveness and Permanence

This criterion assesses the risk remaining at the site after remedial action objectives are achieved. As mentioned previously, constituents in groundwater are currently within the range that is typically used by U.S. EPA to set cleanup goals for similar sites. Constituents would be removed from groundwater to meet remedial action objectives and treated to levels below discharge standards. Constituents removed through carbon adsorption would be destroyed thermally during carbon regeneration, an irreversible process. Although soils treatment is not included in this alternative, the leaching of constituents to groundwater would be monitored and groundwater treatment would continue until leaching was reduced to acceptable levels. Groundwater collection and treatment would also provide containment of groundwater affected by constituents. Over the long term, groundwater would be monitored to ensure that remedial action levels determined to be necessary were not exceeded, and access restriction by fencing would be continued. Thus, it is anticipated that the risks remaining at the site after the remedial action objectives are achieved will remain within the risk range used by U.S. EPA to develop cleanup goals for the site in the long term.

Reduction of Toxicity, Mobility, or Volume Through Treatment

The groundwater recovery system would remove the constituents from the groundwater and control migration, thereby reducing their mobilities. A graphical presentation of the anticipated reduction of risk from benzene is presented in Appendix F. The groundwater treatment system would be designed to reduce the concentrations of organic compounds in groundwater to below ARARs, thereby reducing the toxicity and volume of organic compounds present in groundwater. Eventual destruction of the constituents removed from groundwater would occur through thermal treatment during carbon regeneration. Soils would be treated through natural percolation and leaching; leached constituents would be collected and treated by the groundwater treatment system, and destroyed thermally during carbon regeneration. This alternative, therefore, meets the statutory preference for treatment.

Short-Term Effectiveness

This evaluation criterion assesses the risk associated with construction and implementation of the alternative up to the point at which remedial action objectives are achieved. For this alternative, construction and implementation includes installing the groundwater collection and treatment system and treating the groundwater until standards are achieved.

Hypothetical potential risks to the community would be minimal. No drinking water supply wells would be affected by groundwater pumping on-site.

Potential risks to remediation workers would be associated with normal subsurface work in installing groundwater wells. Potential risks to operating workers during remedial activities would be associated with normal process-type operations. These risks would likely include hazards associated with electrical and mechanical maintenance, and the potential exposure to various constituents. These risks could be addressed and minimized through good operating procedures specified in the Operation and Maintenance Plan. All workers at the site would be subject to OSHA health and safety requirements (29 CFR 1910.120).

Minimal impacts to the environment would be expected during the implementation of this alternative. It is estimated that approximately 10 to 20 pore volumes would be required to achieve decontamination of the aquifer if there were no continued source. The estimated pumping time to treat the plume in Action Area 1 to ARARs is 13 to 26 years. The time to treat the portion of the southern plume in Action Area 2A is 35 to 70 years. A timeframe of 3 to 30 years of pumping will be used to assess costs of the pump and treat alternatives. Additional investigation of Action Area 2B will determine plume characteristics and allow for an estimate of remediation time. Calculations of pumping time frames are included in Appendix B.

Implementability

No major difficulties would be anticipated with the construction and operation of the groundwater recovery and treatment system. Additional studies may be required to determine optimum pumping rates and recovery well arrangement and total treatment time for all three Action Areas. Carbon adsorption systems are readily available in prepackaged units from vendors. Based on data collected during pump test activities, it does not appear that substantial pretreatment would be required.

Discharge of treated water to Pole Creek would require an NPDES permit and approval from Ventura County Flood Control District. Availability of off-site treatment, storage capacity, and disposal services would not be a problem, because only small amounts of treatment residuals

would potentially be dealt with off-site, and carbon would be regenerated by the vendor. The necessary equipment and specialists are available as is the technology involved in installing the groundwater recovery and treatment system.

Cost

The total capital cost for this alternative is approximately $550,000. The annual O&M cost would be $240,000. The estimated net present values for different remediation time frames are presented Section 6.0. Assumptions and detailed cost spreadsheets used to develop these costs are included in Appendix E.

5.5 Alternative No. 5: In-Situ Bioremediation

5.5.1 Detailed Description of Alternative No. 5

Remedial Alternative No. 5 would include an in-situ groundwater bioremediation system to remediate the groundwater in all three Action Areas. Percolation of the constituents of interest in subsurface soils beneath the waste pits to groundwater would be integrated into the bioremediation scenario, and constituents leached from soils would be treated along with groundwater. It is assumed that groundwater extraction and infiltration rates will be equal. The conceptual layout of a bioremediation system would consist of: 1) extraction of groundwater from the affected areas in Aquifer 1; 2) surface treatment of the water to remove residual constituents and to enhance the oxygen and nutrient content of the water; and 3) reinfiltration of the water through the vadose zone soils and to the groundwater plumes. The system would require the use of extraction wells, infiltration galleries, and injection wells. Access restrictions would be maintained and quarterly groundwater monitoring would be continued.

Remedial Alternative No. 5 would prevent public exposure to soils through access restrictions, and would address leaching of constituents and achievement of groundwater standards through bioremediation.

A description of the bioremediation process and necessary equipment is provided in the following section.

Bioremediation Process

In-situ bioremediation consists of enhancing environmental conditions in the subsurface where constituents are present to optimize natural microbial metabolism of organic compounds. Figure 5-5 presents a conceptual cross-section of an in-situ bioremediation system. Generally, the

CONCEPTUAL DESIGN ASSUMPTIONS (1)

- GROUNDWATER RECOVERY SYSTEM (5 x 6 IN. EXTRACTION WELLS)
- 5 GROUNDWATER INJECTION WELLS (2 IN. O.D.)
- SURGE AND NUTRIENT MIX TANKS
- TRANSFER PUMPS AND EXTRACTION PIPING
- BUILDING TO HOUSE SYSTEM EQUIPMENT AND CONTROLS.
- GROUNDWATER TREATMENT UNIT FOR REMOVAL OF RESIDUAL CONTAMINANTS.
- INFILLTRATION GALLERY LOCATED OVER AFFECTED SOILS TO BE IDENTIFIED IN PRE-DESIGN PHASE.
- ASSUME INJECTION RATE OF TREATED GROUNDWATER IS EQUAL TO COMBINED GROUNDWATER EXTRACTION RATE OF 50 gpm.
- LABORATORY BIODEGRADATION TREATABILITY STUDY TO BE PREFORMED IN PRE-DESIGN PHASE.

(1) FOR FS PURPOSES ONLY. ACTUAL SYSTEM AND DISCHARGE DETAILS WILL BE DEVELOPED DURING THE DESIGN PHASE.

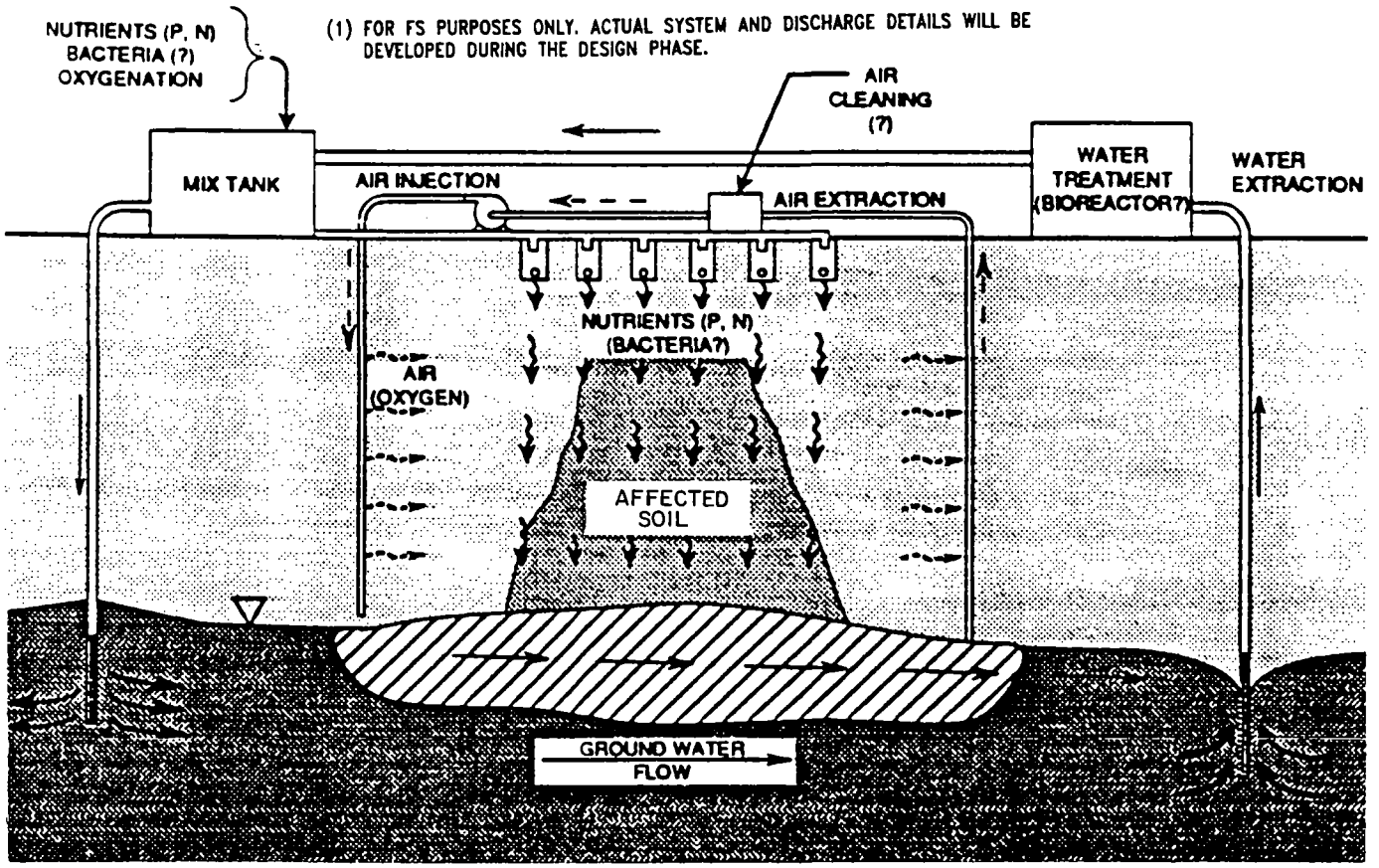

FIGURE 5-5

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CONCEPTUAL CROSS-SECTION OF IN-SITU BIOREMEDIATION SYSTEM
TEXACO FILLMORE SITE

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APPV'D:	REVISED:	6600-063	0

natural population of microorganisms present in the subsurface are acclimated to environmental conditions. In order to increase the rate of biodegradation that occurs naturally, oxygen and nutrients are added to the subsurface. Oxygen is usually the limiting factor. Oxygen can be added by introducing air into the subsurface, by injecting water that has been oxygen-enriched, or by addition of compounds such as hydrogen peroxide. For groundwater remediation, nutrients and oxygen are typically added to groundwater that has been pumped to the surface prior to recirculation to the subsurface. Groundwater recovery wells and reinjection wells and/or infiltration galleries are required, and must be located and constructed to control the flow of groundwater and treatment solutions. The hydraulic conductivity of the subsurface materials determines the amount and rate of circulation of groundwater and treatment solutions. In-situ bioremediation has the advantage of treating a large proportion of both dissolved and adsorbed compounds in the subsurface without removing them. Thus, the vadose zone soil could be treated using this process, by infiltrating water enriched with oxygen and nutrients from the surface. The water would travel through the vadose zone and be recovered from the underlying aquifer through groundwater extraction wells. Surface treatment of extracted water using GAC filters would also be included.

Laboratory or field treatability studies are usually required to determine biodegradation rates, oxygen and nutrient requirements, and effects of parameters such as pH and temperature on biodegradation. Usually, nitrogen and phosphorous are the major nutrients required, although other compounds and trace elements are also necessary. Other naturally occurring groundwater constituents such as iron and manganese can significantly impact the operation of an in-situ process and should be evaluated. Once implemented, bioremediation systems require significant operation efforts to monitor and maintain optimum conditions for microbial growth, and to prevent fouling or plugging that may render the system ineffective.

We can assume an oxygen requirement of 7.5 mg O_2/mg BTEX, which is a conservative value developed from laboratory testing at another site. During a laboratory biotreatment study performed by ENSR on soil containing TPH it was determined that 7.37 mg 0_2/mg TPH was consumed during biological treatment. The study was conducted on soil samples originally containing TPH concentrations ranging from 22,700 mg/L to 37.9 mg/L. The biodegradation evaluation was conducted on soil/nutrient buffer suspensions in sealed BOD bottles over a 3-week period. Dissolved oxygen levels were monitored daily and oxygen consumption was compared with mass of TPH degraded during the study to determine mg of O_2 consumed per mg of TPH.

Appendix D contains calculations of remedial timeframe for the in-situ bioremediation system. Based on a conservative estimate of benzene concentration in the subsurface, it is estimated that less than 3 years is required to actively bioremediate the mass of benzene found in the Action

Area 1 and 2 groundwater plumes. If the concentration of constituents on soil adds significantly to the mass, engineering solutions such as addition of hydrogen peroxide (H_2O_2) to the infiltration galleries, to increase O_2 concentration to the subsurface can be implemented to achieve a remedial timeframe of 3 years or less. For the purposes of this evaluation, a conservative approach will be taken. Therefore, it is anticipated that the required remedial timeframe to achieve benzene ARARs will be 2 to 30 years.

In-situ bioremediation has been used successfully for site cleanups, especially at sites where gasoline is the material to be removed and is being applied for groundwater remediation under the Superfund program. Hydrocarbon removal efficiency usually ranged from 70 to 80% (Wilson et al., 1986). DCA is, however, only slightly degradable using this technique and is likely to be unaffected by bioremediation efforts, except for incidental volatilization due to pumping and handling of groundwater. Carbon adsorption units would remove any DCA prior to reinjecting water to the subsurface.

Bioremediation Equipment

In order to deliver sufficient oxygen and nutrients to the subsurface, a system of groundwater recovery wells and infiltration galleries is required. Particle size analyses on soil samples confirmed that the aquifer material is primarily a medium- to fine-grained sand. The average hydraulic conductivity of this material is 434 ft./day. Transmissivity ranged from 0.45 to 61 sq. ft./day. These conditions make recirculation of the groundwater and delivery of oxygen and nutrients to the subsurface feasible.

Groundwater chemistry, including calcium, magnesium, and iron, would need to be evaluated to determine potential adverse effects on in-situ bioremediation. Current data on groundwater chemistry indicate that the water may be subject to $CaSO_4$ precipitation, which could result in operational difficulties. Groundwater would be added, from the subsurface, hydrogen peroxide or some other oxygen source and nutrients would be added, and the groundwater would be reinjected. Groundwater modeling studies would be required to select extraction well locations to ensure control of groundwater flow at the site. Five extraction wells would be installed within and downgradient of the plumes. The wells would be drilled to a depth of approximately 90 to 120 feet below the surface. Each well would pump 10 gpm for a combined flow of 50 gpm.

Groundwater would be treated through the use of GAC filtration and reinjected through infiltration galleries and wells constructed over the former waste pits. The infiltration galleries would consist of areas with dikes and berms to contain water until it infiltrates into soil. The injection wells would be installed to deliver oxygenated water directly to the plume.

Storage tanks for oxygen and nutrients, mixing tanks, pumps, carbon adsorption units, and piping would be located on the surface. Sampling ports in the piping system would be required to monitor oxygen and nutrient levels and concentrations of constituents in groundwater.

5.5.2 Detailed Evaluation of Alternative No. 5

Overall Protection of Human Health and the Environment

Overall, the Alternative No. 5 would be protective of human health and the environment, because it would destroy or remove constituents of interest from groundwater. The groundwater recovery wells would also act as hydraulic barriers to the flow of constituents in groundwater. Periodic (e.g., quarterly) groundwater monitoring would be used to track constituents in groundwater.

The groundwater recovery and treatment system would be designed to reduce constituents in groundwater to applicable standards, thereby meeting this remedial action objective. Direct contact with constituents in soil would be prevented by access restrictions and by the minimal amount of intrusive activities required. Leaching and subsequent biodegradation or extraction and treatment of the constituents in soil would be expected.

Compliance with ARARs

ARARs for constituents in groundwater would be met using in-situ bioremediation with GAC polishing. Any treatment residuals generated from pretreatment or carbon adsorption on the surface would be handled according to RCRA and other applicable regulations. Applicable chemical-specific ARARs for groundwater are federal MCLs, non-zero MCLGs, or state MCLs, whichever are more stringent for a particular constituent. For estimations of the timeframe to achieve ARARs, the 1 µg/l state MCL for benzene was used. This is the more stringent of the identified ARARs for benzene.

Permits to reinject groundwater, which are not ARARs, are substantive administrative requirements and, if required, will be obtained.

Long-Term Effectiveness and Permanence

This criterion assesses the risk remaining at the site after remedial action objectives are achieved. As mentioned previously, constituents in groundwater and soils are currently within the range of risk that is typically used by U.S. EPA to set cleanup goals for similar sites. Constituents would be treated through bioremediation to meet remedial action objectives. The extraction wells would also provide containment of groundwater. Few treatment residuals would

be generated by the groundwater treatment system, because treatment would take place in-situ; however, the water would be treated using carbon adsorption prior to reinjection, and spent carbon would require regeneration off-site. Soils would also be treated through bioremediation, thereby removing a potential source of constituents leaching to groundwater. Groundwater would be monitored to ensure that remedial action levels were not exceeded. Thus, it is expected that the risks remaining at the site after remedial action objectives are achieved will remain within the risk range used by U.S. EPA to develop cleanup goals for the site in the long term.

Reduction in Toxicity, Mobility, or Volume Through Treatment

The constituents of interest in both soil and groundwater would be destroyed in the subsurface through microbiological metabolism or removed and treated by carbon adsorption. The toxicities, mobilities, and volumes of the constituents would therefore be reduced. The process is irreversible and little or no treatment residuals are generated. The DCA removed by carbon adsorption would eventually be destroyed through carbon regeneration. This alternative, therefore, meets the preference for treatment to reduce the hazards posed by the constituents of interest in groundwater.

Short-Term Effectiveness

This evaluation criterion assesses the risk associated with construction and implementation of the alternative up to the point at which remedial action objectives are achieved. For this alternative, construction and implementation includes installing the groundwater and soil collection and treatment system, and treating the groundwater until treatment standards are achieved.

Because groundwater treatment would take place in-situ, risks to the community during construction and treatment would be minimal. Nutrients and oxygen would be added to the groundwater after it was pumped to the surface, however, and the H_2O_2 used as an oxygen source could be hazardous during handling.

Hypothetical risks to remedial workers would result primarily from the installation of the necessary recovery and injection wells and the potential for contact with constituents of interest in the subsurface. Once in place, the most significant risk to remedial workers would be the handling of treatment chemicals. Potential risks to operating workers during remedial activities would be associated with normal process-type operations. These risks are likely to include hazards associated with electrical and mechanical maintenance, hazards associated with treatment units, and potential exposure to various constituents. These risks will be addressed

and minimized through good operating procedures specified in the Operation and Maintenance Plan. All workers at the site will be subject to OSHA health and safety requirements (29 CFR 1910.120). Groundwater and injected treatment solutions would be closely controlled in the subsurface through groundwater gradient control wells; no risks to the environment are anticipated.

Approximately 2 to 30 years would be required to meet groundwater cleanup objectives.

Implementability

No major difficulties are anticipated with the construction of the technologies included in this alternative. More difficulties and uncertainties, however, are associated with operation of the system. The main factors affecting feasibility of in-situ bioremediation are environmental factors affecting microbial growth, site hydrogeology, and geochemistry. It is expected that all of the constituents of interest in the groundwater except DCA could be biodegraded; DCA would be removed by carbon adsorption. Some environmental factors, such as nutrient and oxygen concentration, can be enhanced to optimize growth conditions. Others, such as the presence of compounds toxic to the microorganisms or competition from other microorganisms, cannot be altered. The site hydrogeology appears to be amenable to efficient extraction and infiltration of groundwater. The natural chemistry of the groundwater may require pretreatment of the groundwater prior to treatment in the GAC units and may lead to precipitation of $CaSO_4$ or other materials in the subsurface.

Treatability studies would be required to determine the optimum conditions for bioremediation, the rate of biodegradation, the efficiency of the process, and pretreatment needs. Sufficient contact between the constituents of interest, the microorganisms, and the oxygen source and nutrients is required for effective bioremediation. Ability to maintain control over the treatment solutions is also important. The presence of iron in the groundwater could also impact the use of H_2O_2 as an oxygen source. While we anticipate that site conditions are amenable to bioremediation, there are many variables and uncertainties that could lead to schedule delays.

Groundwater monitoring would be used to track migration of constituents of interest in the groundwater. Little coordination with other agencies is expected to be necessary, although a permit to reinject groundwater may be required.

The availability of treatment, storage, and disposal sources is not a concern, because all treatment will be conducted on-site and carbon will be regenerated by the vendor. Although the technology is not as common as carbon adsorption or other conventional methods, the necessary specialists and equipment are available.

Reinjection of treated groundwater that has been enhanced with oxygen and nutrients would have to meet waste discharge requirements of the Los Angeles Regional Groundwater Quality Board. Permits have been issued for other in-situ bioremediation projects. Up to 120 days is required for approval.

Cost

The total capital cost associated with this alternative is approximately $790,000. The annual O&M costs are estimated at $300,000. The estimated net present values for different remediation time frames are presented in Section 6.0. Assumptions and detailed cost spreadsheets used to develop these costs are included in Appendix E.

5.6 Alternative No. 6: Groundwater Surface Treatment Plus Soil Treatment

5.6.1 Detailed Description of Alternative No. 6

Alternative No. 6 would consist of the groundwater extraction and carbon treatment and disposal system described for Alternative No. 4, plus soil treatment by soil vapor extraction (SVE). Access restrictions would be maintained and periodic (e.g., quarterly) groundwater monitoring would be continued. The groundwater extraction system would remove constituents from groundwater and the SVE system would remove constituents from soil, thereby eliminating a potential future source of groundwater contamination. The areas to be remediated by SVE include the former waste areas: the Main Waste Pit, Pit 3, and Pit 4. The SVE process and equipment are described in the following sections.

SVE Process

SVE consists of removing vapors from pore spaces in the unsaturated zone by drawing air through the subsurface. This is accomplished by installing and drawing a vacuum on vapor recovery wells (see Figure 5-6. The flow of air through the subsurface enhances the volatilization rate of constituents and therefore the removal from the soil phase. More volatile compounds are removed at first, followed by less volatile compounds. Significant increases in the subsurface biological degradation of many compounds has also been confirmed through the use of SVE. Air infiltration wells or open "passive" wells can be installed to allow for better air flow in the subsurface. An impermeable plastic liner is typically placed over the soil surface to assist in control of air flow. The main factors that affect the use of vapor extraction are the chemical composition of the constituents, the vapor flow paths through the unsaturated zone, and the flow path of the vapors relative to the location of the constituents (Johnson et al., 1990). Vapors

CONCEPTUAL DESIGN ASSUMPTIONS (1)

- PVC EXTRACTION WELL PIPING.
- SOIL VAPOR EXTRACTION WELLS SPACED 100 FT. APART IN ACTION AREAS 1 & 2.
- PASSIVE AIR INFILTRATION WELLS SPACED AT 50 FT. EQUIDISTANT INTERVALS BETWEEN EXTRACTION WELLS.
- AN IMPERMEABLE BARRIER WOULD BE PLACED ON THE SURFACE TO ENHANCE SUBSURFACE AIRFLOW.
- VACUUM PUMP EQUIPPED WITH A VAPOR MOISTURE TRAP.
- A CARBON UNIT FOR REMOVING VOCs FROM EXTRACTED AIR.
- BUILDING TO HOUSE SVE UNIT.
- GROUNDWATER RECOVERY AND TREATMENT SYSTEM DESCRIBED IN ALTERNATE 4.

(1) FOR FS PURPOSES ONLY. ACTUAL SYSTEM AND DISCHARGE DETAILS WIIL BE DEVELOPED DURING THE DESIGN PHASE.

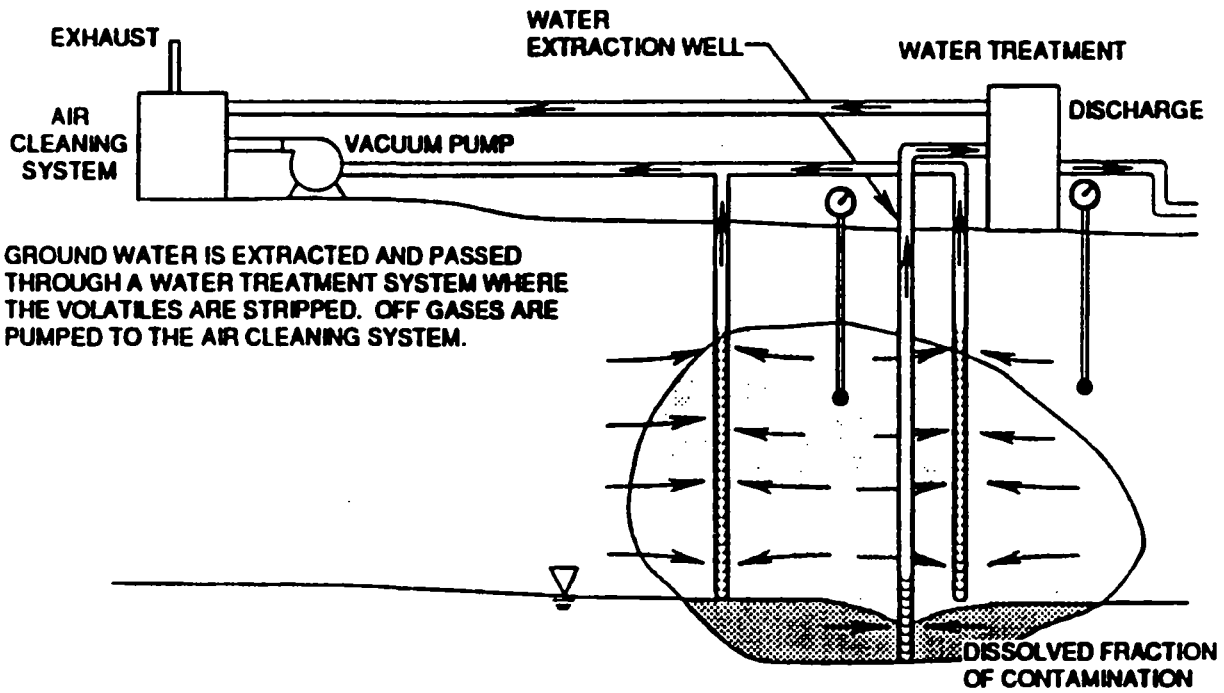

FIGURE 5-6

ENSR™
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TYPICAL CROSS-SECTION OF IN-SITU SVE COMBINED WITH GROUNDWATER TREATMENT
TEXACO FILLMORE SITE

DRAWN: JDG	DATE: 2/13/92	PROJECT NUMBER:	REV
APPV'D: JA	REVISED: X	6600-063	0

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removed to the surface will require treatment. For the purpose of this FS, treatment is assumed to be by vapor-phase carbon adsorption. Carbon regeneration would be conducted off-site.

Additional treatability studies would be required to determine well design, well spacing, flow rates, and removal rates. Based on data in the RI, the concentrations of leachable VOCs in the soils below the former waste pits are relatively low. Data on actual total concentration of VOCs in the affected soils need to be investigated. If, however, we estimate that the concentration of total benzene, for example, is 20 times greater than the leachable concentration, then a maximum benzene concentration of 440 µg/kg would be found in the former Main Waste Pit area and 760 µg/kg in the southern region. In addition, actual waste materials have been removed from the waste pits, and no free product layer has been identified. Because no concentrated source of the constituents of interest is present, SVE is expected to be an effective method for remediating the soil in a relatively short period of time. Actual remediation timeframes would be developed during evaluation of soils mass.

BTEX compounds and DCA could be readily removed using SVE. Naphthalene and methylnaphthalene would not be removed as readily, but are not as prevalent at the site as the more volatile compounds. Specific remediation goals have not been developed for soil. SVE would be used to remove constituents from soil to prevent their being a threat to groundwater.

Data on total concentrations of constituents in soil are not currently available. Without this information or treatability studies, a detailed technical evaluation cannot be completed.

SVE Equipment

Although treatability studies would be required to design the most effective SVE system, a possible system layout was selected based on available information, for the purpose of this study. SVE wells would be installed at approximately 100-foot intervals in areas where constituents are present in soils. The wells would be approximately 65 feet deep, and would draw constituent vapors from pore spaces in the soil. The 100-foot spacing of vapor extraction wells is based on system designs for other sites with similar constituents and geology. Passive air infiltration injection wells would be installed between the extraction wells (e.g. 50 feet away). The radius of influence of each well would therefore be approximately 50 feet. This is not uncommon well spacing for SVE systems. Studies by Crow et al. (1987) concluded that hydrocarbon vapor concentrations could be reduced by subsurface venting at distances greater than 100 feet. Without conducting treatability studies, an approximate system layout is the only way to define the alternative for evaluation and cost estimation. An impermeable barrier would be placed on the ground surface to enhance air flow through the vadose zone. The extraction wells would be connected by a header and a blower would induce a vacuum in the wells. The

blower would force vapors to a single collection point, where the air stream would pass through a vapor-phase carbon adsorption unit, to remove constituents of interest. Vapor extraction would continue until monitoring of extracted vapors and soil samples indicated that no constituents remained above levels that would represent a threat to groundwater.

5.6.2 Detailed Evaluation of Alternative No. 6

Overall Protection of Human Health and the Environment

Overall, this alternative would be protective of human health and the environment by removing constituents from both groundwater and soil.

The groundwater recovery and carbon adsorption system would remove the constituents of interest in groundwater to applicable standards, thereby meeting remedial action objectives. The groundwater recovery wells would also act as hydraulic barriers to the flow of constituents in groundwater. The SVE system would remove constituents of interest from the soil on-site, thereby eliminating a potential future source of groundwater contamination. While the potential for releases to air from the SVE system exists, these could be controlled using a vapor-phase carbon treatment system. Access restriction would prevent direct contact with the soil.

Compliance with ARARs

ARARs would be met for groundwater by the groundwater extraction and treatment system. Applicable chemical-specific ARARs for groundwater are federal MCLs, non-zero MCLGs, or state MCLs, whichever are more stringent for a particular constituent. For estimations of the timeframe to achieve ARARs, the 1 µg/l state MCL for benzene was used. This is the more stringent of the identified ARARs for benzene. This alternative is expected to achieve ARARs for benzene in groundwater in a timeframe of 3 to 30 years. Permits for discharge of treated groundwater and any other discharge will, if required, be obtained. Air emissions from the SVE system would be permitted through Ventura County APCD and controlled to meet emission standards through the use of vapor-phase carbon adsorption. Permitting requirements are not ARARs, but are substantive administrative requirements, which would be addressed during implementation of this alternative. Any treatment residuals and spent carbon from groundwater and soil treatment systems would be handled according to RCRA and other applicable regulations.

Long-Term Effectiveness and Permanence

This criterion addresses the risk remaining at the site after remedial action objectives are achieved. Constituents in groundwater and soils are currently within the range of risk that is

typically used by U.S. EPA to set cleanup objectives for similar sites. Compounds removed from groundwater through carbon adsorption and compounds removed from the soil through vapor extraction would be treated and eventually destroyed thermally during carbon regeneration, an unreversible process.

Long-term management would not be required once the cleanup objectives are achieved. It is anticipated, however, that access restriction by fencing would continue. Groundwater monitoring would also likely be continued over the long term, to ensure that no constituents of interest remained in the subsurface above remedial action objectives. The groundwater monitoring program would consist of sampling existing wells on a quarterly basis following the guidelines established for the current groundwater monitoring program. Specific locations for groundwater monitoring will include selected wells from Aquifer 1 and Aquifer 2. Potential wells to be used for groundwater monitoring are indicated on Figure A-1 in Appendix A. Groundwater samples will be analyzed for volatile compounds (Method 8240), semivolatiles (Method 8270) and selected total metals to include arsenic and lead. The current groundwater monitoring program would be modified according to changing site conditions.

Thus, it is expected that the risks remaining at the site after remedial action objectives are achieved will remain within the risk range used by U.S. EPA to develop cleanup goals for the site in the long term.

Reduction in Toxicity, Mobility, or Volume Through Treatment

Both of the treatment systems to be employed under this technology, liquid-phase carbon adsorption and SVE with vapor-phase carbon adsorption, are removal technologies. Constituents in both the groundwater and soil would be removed, thereby significantly reducing the volume of constituents in groundwater and soil. Constituents would be removed from soil and groundwater to levels necessary to meet cleanup objectives.

Because the compounds removed would be transferred to the solid phase, treated, and ultimately destroyed, there would be a reduction in the toxicity of the compounds. The process is irreversible, and few if any treatment residuals are generated. Therefore, this alternative meets the preference for treatment to remove the hazards posed by the constituents of interest in both the groundwater and soil.

Short-Term Effectiveness

This evaluation criterion assesses the risk associated with construction and implementation of the alternative up to the point when remedial action objectives are achieved. For Alternative No.

6 this includes installation of the groundwater and soil treatment systems and operation until remedial action objectives are achieved.

The major potential risk to the community posed by implementing this alternative is the release of constituents to the air by the SVE system. This risk could be controlled, however, by removing the constituents from air using a vapor-phase treatment system.

Potential risks to remediation workers are those associated with subsurface work in installing groundwater recovery wells, and vapor extraction and injection wells. Potential risks to operations workers during remedial activities would be associated with normal process-type operations. These risks are likely to include hazards associated with electrical and mechanical maintenance, hazards associated with vapor-phase treatment units, and the potential exposure to various constituents. These risks will be addressed and minimized through good operating procedures specified in the Operation and Maintenance Plan. All workers at this site will be subject to OSHA health and safety requirements (29 CFR 1910.120). No other environmental impacts are anticipated.

As with Alternative No. 4, it is estimated that 3 to 30 years would be required to meet groundwater cleanup objectives in Action Areas 1 and 2A. It is difficult to predict SVE remediation time frames; however, based on ENSR's experience in applying SVE to sites where no significant source of volatile constituents exists (e.g., free product), a conservative estimate of 2 years or less is required to remediate the soil. Because there would be overlap of these time frames, a total of 30 years is estimated to be required to complete remediation under this alternative.

Implementability

No major difficulties are anticipated with the construction and operation of the groundwater extraction and carbon adsorption system. Groundwater recovery wells are simple to install and carbon adsorption systems are available from vendors in prepackaged units. Additional studies may be necessary to determine optimum pumping rates, recovery well arrangements, and total treatment time for all three Action Areas. Based on data collected during pump test activities, it does not appear that substantial pretreatment would be required.

The installation of the SVE system involves common technology, materials, and labor. Possible site constraints exist, such as the location of tanks or other structures in areas where soil remediation is required. Uncertainties regarding the areal extent of constituents in the soil and localized subsurface conditions (heterogeneity) could affect the operation of the system.

Treatability studies would be required to determine to most effective well design, well spacing, flow rates, and removal rates, as well as carbon treatment requirements.

Discharge of treated water to Pole Creek would require an NPDES permit and approval from the Ventura County Flood Control District. An air emissions permit would be required for the SVE system. The SVE system and air pollution control equipment would require an operating permit from the Ventura County Air Pollution Control District. Approximately 2 to 4 months would be required to prepare the permit and obtain approval. The permitting process typically occurs during the vendor selection and equipment procuring stage, after the system has been designed, and would not be expected to adversely impact implementation of this alternative.

Availability of treatment, storage capacity, and disposal services would not be a problem because only small amounts of treatment residuals would potentially be dealt with off-site, and carbon would be regenerated by the vendor. The necessary equipment and specialists are also available. Carbon adsorption is a well demonstrated, readily available technology. SVE, while not as common, has been used at similar sites, and could be implemented using common technology.

Cost

The total capital cost for this alternative is $1,075,000. Annual O&M costs, including quarterly groundwater monitoring, would be $480,000. Net present values for different remediation time frames are presented in Section 6.0. Assumptions and detailed cost spreadsheets sued to develop these costs are included in Appendix E.

5.7 Alternative No. 7: In-Situ Groundwater Treatment Plus Soil Treatment

5.7.1 Detailed Description of Alternative No. 7

Alternative No. 7 would consist of the in-situ groundwater treatment system described for Alternative No. 5, plus soil treatment by SVE. Access restrictions would be maintained, and periodic (e.g., quarterly) groundwater monitoring would be continued. The in-situ soil bioremediation system would differ from that described for Alternative No. 5 in that groundwater enhanced with oxygen and nutrients would be reinjected into the subsurface only through the injection wells rather than through infiltration galleries (because the SVE system would eliminate the need for soil treatment by in-situ bioremediation). The SVE system would be the same as was discussed for Alternative No. 6.

While in-situ soil bioremediation is potentially applicable and works well in conjunction with an in-situ groundwater bioremediation system, SVE would still be a more efficient technology for remediation of soils at the Fillmore site for several reasons. DCA is not readily biodegradable, although it is volatile and therefore can be removed by SVE. Also, SVE will be easier to construct and operate than soil bioremediation, and will be less susceptible to the fouling and precipitation while infiltrating groundwater due to natural groundwater characteristics. SVE is also expected to stimulate biodegradation in the vadose zone.

5.7.2 Detailed Evaluation of Alternative No. 7

Overall Protection of Human Health and the Environment

Overall, this alternative would be protective of human health and the environment by removing constituents from groundwater and soil. The groundwater in-situ bioremediation system would address the constituents of interest in groundwater to applicable standards to meet this remedial action objective. The groundwater recovery wells would also act as hydraulic barriers to groundwater flow. The SVE system would remove constituents of interest from the soil on-site, thereby eliminating a potential future source of groundwater contamination. Access restrictions would prevent direct contact with the soils until the cleanup objectives were met. Potential releases to air from the SVE system would be controlled using a vapor-phase carbon treatment system.

Compliance with ARARs

ARARs for constituents in groundwater would be achieved using in-situ bioremediation with carbon polishing. Applicable chemical-specific ARARs for groundwater are federal MCLs, non-zero MCLGs, or state MCLs, whichever are more stringent for a particular constituent. For estimations of the timeframe to achieve ARARs, the 1 μg/l state MCL for benzene was used. This is the more stringent of the identified ARARs for benzene. This alternative is expected to achieve ARARs for benzene and DCE in a remedial timeframe of 1 to 30 years. Permits for discharge of treated groundwater any other discharge will, if required, be obtained. Air emissions from the SVE system would be permitted through Ventura County APCD and controlled to meet emission standards through the use of vapor-phase carbon adsorption. Permitting requirements are not ARARs, but are substantive administrative requirements, which would be addressed during implementation of this alternative. Any treatment residuals and spent carbon from groundwater and soil treatment systems would be handled according to RCRA and other applicable regulations.

Long-Term Effectiveness and Permanence

This criterion addresses the risk remaining at the site after remedial action objectives are achieved. Constituents in groundwater and soil are currently within the range of risk that is typically used by U.S. EPA to set cleanup goals for similar sites. Biodegradable compounds in groundwater would be destroyed in-situ; DCA and compounds removed from soil by SVE would be destroyed thermally during carbon regeneration, both irreversible processes.

Long-term management would not be required once the cleanup objectives were achieved. It is anticipated, however, that access restriction by fencing would continue. Groundwater monitoring would also likely continue over the long term to ensure that no constituents of interest remained in the subsurface above remedial action objectives. Thus, it is expected that the risks remaining at the site after remedial action objectives are achieved will remain within the risk range used by U.S. EPA to develop cleanup goals for the site in the long term.

Reduction in Toxicity, Mobility, or Volume Through Treatment

The bioremediation and SVE systems would remove the target constituents from soil and groundwater. The biodegradable constituents present in the groundwater would be destroyed through microbiological metabolism to carbon dioxide and water. The DCA removed through carbon adsorption would eventually be destroyed during carbon regeneration. The toxicities, mobilities, and volumes of the constituents would therefore be reduced.

The SVE system is a removal technology that would decrease the volume of constituents of interest in soil. The removed constituents would be transferred to the vapor phase, treated, and eventually destroyed thermally during carbon regeneration. Because the constituents are destroyed, there is a reduction in toxicity.

Both treatment processes are irreversible and generate few if any treatment residuals. This alternative meets the preference for treatment to remove the hazard posed by the constituents of interest in both the groundwater and soil.

Short-Term Effectiveness

This evaluation criterion assesses the risk associated with construction and implementation of the alternative up to the point at which remedial action objectives are achieved. For Alternative No. 7, this includes installation of the groundwater and soil treatment systems and operation until remedial action objectives are achieved.

Because groundwater treatment under this alternative would be conducted almost entirely in-situ, the risks to the community are minimal. Peroxide added to the groundwater is a potential hazard to remediation workers, however. The release of constituents to the air from the SVE system is also a potential hazard; however, the risks would be controlled by removing compounds from the air stream using a vapor-phase carbon treatment system.

Potential risks to workers are those associated with subsurface work in installing recovery, injection, and vapor extraction wells. Once in place, the major risk to workers would be the handling of treatment chemicals. Other potential risks are those associated with normal process-type operations. These include hazards associated with electrical and mechanical maintenance and potential exposure to various constituents. These risks will be addressed and minimized through good operating procedures specified in the Operation and Maintenance Plan. All workers at the site will be subject to OSHA health and safety requirements (29 CFR 1910.120).

Other potential risks to the environment are associated with the groundwater treatment system. Potential off-site migration of nutrients and peroxide injected into the surface could occur. This would be controlled by designing groundwater recovery wells to prevent off-site migration of treatment solutions. In addition, groundwater monitoring efforts to track remediation progress and site conditions would be able to detect such migration.

As discussed for Alternative No. 5, approximately 3 years would be required to meet groundwater cleanup objectives by in-situ bioremediation. The SVE system would require approximately 2 years to treat the soil. However, infiltration of air into the subsurface, induced by the SVE system, will provide an excess of oxygen and may increase the rate of natural biodegradation in soils and decrease the time required for in-situ groundwater bioremediation. It is anticipated that this alternative would achieve ARARs for benzene in 1 to 30 years.

Implementability

No major difficulties are anticipated in the construction of the groundwater in-situ bioremediation system. Common technology would be used to install components of the in-situ groundwater bioremediation system, including groundwater, recovery, and injection wells; carbon adsorption units; and surface equipment for the addition of nutrients and oxygen. More difficulties and uncertainties, however, are associated with operation of the system. The main factors affecting feasibility of in-situ bioremediation are the biodegradability of the constituents, environmental factors affecting microbial growth, and site hydrogeology. It is expected that all of the constituents of interest in the soil could be biodegraded. Some environmental factors, such as nutrient and oxygen concentration, can be enhanced to optimize growth conditions. Others, such as the presence of compounds toxic to the microorganisms or competition from other

microorganisms, cannot be altered. The site hydrogeology appears to be amendable to efficient extraction and infiltration of groundwater.

Treatability studies would be required to determine the optimum conditions for bioremediation, the rate of biodegradation, and efficiency of the process. Sufficient contact between the constituents of interest, the microorganisms, and treatment agents is required for effective bioremediation. Ability to maintain control over the treatment solutions is also important. The presence of iron in the groundwater could also impact the use of H_2O_2 as an oxygen source. While we anticipate that site conditions are amenable to bioremediation, there are many variables and uncertainties that could potentially lead to schedule delays.

The installation of the SVE system involves common technology, materials, and labor. Possible site constraints exist, such as the location of tanks or other structures in areas where soil remediation is required. Uncertainties about the areal extent of constituents in the soil and localized subsurface conditions could affect the operation of the system. Treatability studies would be required to determine the most effective well design, well spacing, flow rates, and removal rates, as well as carbon treatment requirements.

Reinjection of treated groundwater may require a permit. An air emissions permit would be required for the SVE system.

Availability of treatment, storage capacity, and disposal services would not pose a problem because treatment would be conducted on-site. The necessary equipment and specialists are also available. Both in-situ groundwater bioremediation and SVE are implemented using common technology with readily available equipment and labor.

Cost

The total capital cost for this alternative is $1,270,000. Annual O&M costs, including groundwater monitoring, would be $540,000. The estimated net present values for different remediation time frames are presented in Section 6.0. Assumptions and detailed cost spreadsheets used to develop these costs are included in Appendix E.

6.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

6.1 Comparison of Alternatives by Evaluation Criteria

Overall Protection of Human Health and the Environment

Overall, all seven alternatives are protective of human health and the environment. According to the draft risk assessment report for the site, constituents in groundwater and soil currently are within U.S. EPA acceptable risk ranges. Based on conservative exposure scenarios presented in the risk assessment (i.e., a person living on the site and consuming 2 liters of water every day for 30 years for calculation of drinking water risks), exposure to residual constituents present at the Fillmore site are within the range of risk (10^{-4} to 10^{-7}) used by U.S. EPA to set cleanup goals at similar sites. Calculation of site-specific risks does not take into account the observed natural degradation of constituents that are contributing to risks, and thus it is likely that current risks will diminish with time. In addition, groundwater is not used as a drinking water source and access restrictions and the depth of soils below the former waste pits would prevent any contact with constituents in soils. Based on FS evaluations, a difference does exist between the alternatives with respect to the rate of risk reduction.

The estimate of risk reduction is based on the estimated remedial timeframes and the graph in Appendix F. Based on these estimates, reduction of groundwater benzene concentrations to the federal MCL of 5 µg/l for benzene will result in an excess lifetime cancer risk of 2×1^{-6}; reduction to the California MCL of 1 µg/l for benzene will result in an excess lifetime cancer risk of 4×1^{-7}. Alternatives 1, 2, and 3 would rely on natural degradation and could be expected to reduce risk to below 10^{-6} in approximately 5 to 30 years. Alternatives 5 and 7, alternatives that rely on enhanced bioremediation, are expected to achieve a risk reduction to below 10^{-6} in less than 3 years. Alternatives 4 and 6, which employ pump and treat, will achieve the reduction to below 10^{-6} in 3 years or less if natural degradation is considered but may take 30 years if natural degradation is assumed to not be a significant removal mechanism for benzene.

Compliance With ARARs

Achievement of ARARs in Alternative 1 will not be measured and therefore cannot be quantified. All other alternatives are expected to achieve groundwater ARARs, although in different time frames. A range of timeframes has been developed for each alternative to achieve ARAR's. The purpose of this range is to reflect the uncertainty of achieving ARARs and to provide a basis for developing cost estimates for the site.

Achieving ARARs at this site may be significantly affected by natural degradation of benzene. Data currently available for the site indicates that an overall reduction in the volume of groundwater effected by benzene has occurred, presumably through natural degradation. Significant portions of the north plume area that were formerly affected by benzene are currently below ARARs. Site data also indicates that a mass of leachable benzene in soil was not encountered during RI activities. The lower end of the cleanup timeframe range assumes that natural degradation is significant and that little or no leachable benzene is present to impact the groundwater cleanup. As such, cleanup is estimated to be relatively rapid.

If natural degradation is not significant or leachable benzene is present in significant quantities, the upper end of the range of cleanup timeframes has been presented to account for delays in ARAR achievement. This upper end estimate takes into account effects of the drought, potential inadequacies in soil sampling and other unknowns. The cost table presented later in this section presents the estimated cleanup timeframes with respect to costs.

It should be noted that achievement of ARARs may be difficult based on recent experience with groundwater cleanup. Monitoring and progress evaluations will be required during implementation of any alternative to determine if actual achievement of ARARs is possible.

Action-specific ARARs are applicable only to Alternatives No. 4 through 7. Proper permitting, design, and operation of the remediation systems included in these alternatives would ensure compliance with ARARs.

Long-Term Effectiveness and Permanence

This criterion assesses the risk remaining after remedial action objectives are achieved. Groundwater ARARs would be achieved by alternatives 2 through 7, although through different remediation time frames. Alternative 1 could achieve ARARs groundwater, but would not be documented. The constituents in groundwater and soil currently are within the range of risk typically used by U.S. EPA to determine cleanup objectives at similar sites and would not be expected to present unacceptable risks to human health and the environment in the future, regardless of the time frame in which groundwater ARARs are achieved. Appendix F includes a graphic presentation of anticipated reduction of benzene risk. Based on the initial concentration of 71 μg/L (upper confidence level [UCL] for benzene), achievement of ARARs will reduce benzene risk in groundwater to the 10^{-6} to 10^{-7} range in less than approximately 5 years under natural degradation (Alternatives 1, 2, and 3) although 30 years may be required if natural degradation is not significant or leachable benzene in soils impacts the cleanup timeframe. Approximately 3 years or less under in-situ bioremediation or pump and treat scenarios that assume natural degradation, and may require 30 years or more under a scenario where pump

and treat is not assisted by natural degradation (Alternatives 4 through 7). Calculation of remedial timeframes presented in the FS report are based on a more conservative approach using a 720 µg/L or greater initial benzene concentration (maximum benzene concentration detected). Actual degradation rates in the field will depend on many factors and will require close monitoring to evaluate remedial progress and reduction of risk. However, the magnitude of residual risk is expected be reduced for all alternatives.

This criterion also considers adequacy and reliability of controls. Under Alternative 1, control or monitoring of natural degradation would not take place. Thus, Alternative 1 would be the least controllable alternative. Alternative 2 includes monitoring of constituent degradation and access restrictions that would prevent contact with the groundwater while risk reduction was occurring. This is estimated to be an adequate control of exposure to the public; in fact, monitoring and access restrictions will be part of all alternatives while risk reduction is being effected.

Alternatives 3 through 7 all add additional levels of control to that presented in Alternative 2. Alternative 3 considers capping to reduce leaching of constituents to groundwater. Since no concentrated mass of constituents in soil was identified during the RI, it is not likely that capping will significantly impact the long-term effectiveness of this alternative. Alternatives that include pump and treat (Alternatives 4 and 6) will provide groundwater controls such that an added safeguard to access restrictions will be in place while risk reduction is occurring. Bioremediation and soils treatment (Alternatives 5 and 7) may speed up the risk reduction and reduce the potential for leaching of constituents in soil to the groundwater. As with capping, since significant amounts of constituents were not identified in soils, it is not likely that the adequacy and reliability of controls will be increased greatly through soils treatment. There may be limited areas, however, where soils treatment is warranted.

Reduction of Toxicity, Mobility, or Volume Through Treatment

All alternatives are expected to reduce the toxicities, mobilities, and volumes of the constituents of interest although the mechanism for reduction varies for the different techniques, as follows:

Alternative	Natural Degradation of Soils and Groundwater	Direct Treatment of Groundwater	Direct Treatment of Groundwater and Soil
1 No Action	X		
2 Continued Operation	X		
3 Continued Operation Plus Capping	X		
4 Groundwater Extraction with Surface Treatment		X	
5 In-Situ Bioremediation		X	
6 Groundwater Surface Treatment Plus Soil Treatment			X
7 In-Situ Groundwater Treatment Plus Soil Treatment			X

Thus, reduction of toxicities, mobilities, and volumes of the constituents of interest through direct treatment is accomplished in Alternatives 4 through 7.

Under Alternatives No. 5, 6, and 7, constituents of interest would be irreversibly destroyed in-situ or removed from soil and groundwater and eventually destroyed during carbon regeneration, thereby reducing the toxicities, mobilities, and volumes of the constituents directly through treatment. Alternative No. 4 includes direct groundwater treatment, also reducing toxicities, mobilities, and volumes of the constituents of interest.

Under Alternatives No. 1, 2, and 3 the toxicities, mobilities, or volumes of constituents of interest could be expected to be reduced through natural degradation processes. The prior waste removal action significantly reduced the volume of constituents on-site, by removing a large volume of material containing the highest concentrations of constituents. Current site data suggest that natural degradation is likely to reduce the toxicities, mobilities, and volumes of the constituents of interest. As previously stated, Figure 5-1 depicts this reduction.

Since the cleanup of the site for all alternatives is basically measured as achievement of ARARs, there is no significant delineation of the degree of expected reduction of toxicity, or volume or the amount of constituents destroyed. All alternatives represent irreversible mechanisms for removal of the constituents of interest. Under natural degradation, the constituents of interest

are expected to be degraded to non-toxic byproducts of cellular metabolism. In-situ bioremediation will result in similar byproducts. Under active pump and treat or vapor extraction, the constituents of interest will be collected and destroyed in irreversible processes. Measurement of degradation will not be possible under Alternative 1 since monitoring is not included. There will be treatment residues (i.e., ash and spent regenerated carbon) under the pump and treat alternatives; however, these are expected to be non-hazardous in nature.

There are, however, differences with respect to control of mobility. Alternative 1 does not include monitoring of constituents, therefore, reduction of the mobility cannot be measured. The pump and treat alternatives (4 and 6) will include active control of groundwater through pumping and thus will be most effective at reduction of mobility of the constituents in groundwater. Alternatives 5 and 7 are expected to provide some measure of containment of groundwater, although pumping rates could be lower. Alternatives 2 and 3 rely on natural degradation to control mobility of constituents in groundwater.

Short-Term Effectiveness

This criterion assesses protection of the community and workers during remedial activities, environmental impacts, and the time until remedial action objectives are achieved. For the seven alternatives evaluated, protection of the community and workers would be impacted by the activities in Alternatives 3 through 7. Alternative 3, capping, would result in the normal hazards associated with construction of the cap and increased truck traffic required for this construction. Alternatives 4 through 7 would include impacts on the community and workers through two main areas: intrusive activities and air emissions from treatment equipment. Normal hazards of construction and equipment operations would also be present. If the bioremediation system were to use H_2O_2, for example, chemical hazards would be present to site workers. Overall, protection of the community and workers will be addressed through standard health and safety procedures and is not expected to be significantly negative for any alternative. No adverse environmental impacts are currently occurring or expected to occur.

Achievement of remedial action objectives (RAOs) are largely associated with the achievement of ARARs discussed previously.

In general, Alternatives 4, 5, 6, and 7 may achieve the RAOs in the most rapid timeframe (>3 years) with Alternatives 1, 2, and 3 estimated to achieve the RAOs in approximately 5 to 30 years. If natural degradation is found to not be significant, then all Alternatives 4 and 6 may require 30 years to achieve RAOs. All alternatives except No Action will prevent public exposure to potentially hazardous substances through access restrictions.

Implementability

Because Alternative No. 2 consists of continuing present operations and some limited surface grading, it would be the easiest to implement. Alternative No. 3, which includes cap construction, and Alternative No. 4, which includes a groundwater treatment system, would be about equally difficult to implement. Alternatives No. 5, 6, and 7 would be most complex and difficult to implement, because both soil and groundwater treatment systems are included. Site constraints and groundwater chemistry may affect alternatives that include infiltration of solutions or extraction of vapors.

Cost

A cost summary for each alternative, including total present-worth costs for different remediation time frames, is presented in Table 6-1. Although approximate remedial time frames were estimated for each alternative, many uncertainties exist that could affect these estimates. The different net present-worth values listed in Table 6-1 for each alternative allow comparison of total costs for different time frames.

TABLE 6-1

Summary of Costs for Remedial Alternatives
Texaco Fillmore Site

Alternative	Capital Cost ($)	Annual O&M Cost ($)	Years[1]	Net Present Value of O&M Costs ($)	Total Net[2] Present Value ($M)
1) No Action	$0	0	5	0	0
			30	0	0
2) Continued Operations	$55,000	120,000	5	500,000	0.5
			30	1,500,000	1.5
3) Clay Cap	970,000	140,000	5	580,000	1.6
			30	1,750,000	2.7
4) Groundwater Pump & Treat (Liquid GAC)	550,000	240,000	3	620,000	1.2
			30	2,940,000	3.5
5) Groundwater In-situ Bioremediation	790,000	300,000	2	540,000	1.3
			30	3,720,000	4.5
6) Groundwater Pump & Treat with Soil Vapor Extraction	1,075,000	480,000	3	1,260,000	2.3
			30	5,950,000	7.0
7) Groundwater In-situ Bioremediation with Soil Vapor Extraction	1,270,000	540,000	1	500,000	1.8
			30	6,720,000	8.0

[1]Presented to represent a range of remediation times. The upper end of the range considers assumptions based on the unknowns associated with the processes and site conditions.
[2]Presented as range of possible costs based on cleanup timeframe.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The evaluation of alternatives presented in Sections 5.0 and 6.0 was prepared to select the best techniques for achieving regulatory standards (ARARs) and for preventing the public from exposure to potentially hazardous substances present in groundwater and soils at the Fillmore site. Based on the relative timeframe required to achieve ARARs, comparative protection of human health and environment, and cost, Alternative No. 2 is likely to be an acceptable remediation strategy for the Fillmore site. However, a more conservative approach, that takes into account the uncertainty associated with remediation timeframes and the limitations of site data, would be Alternative 6. Because it is possible that natural biodegradation is occurring, Alternative 6 should be implemented at the site in a phased approach.

For evaluation purposes, the Fillmore site was divided into several action areas so that the final recommendation for an overall remediation strategy at the site would take into account differences in plume definition, soil characteristics, and locations of the various areas requiring remediation. The remedial life-cycle approach developed for the site is presented in this section.

The life-cycle approach considers the anticipated phases of the selected remedial action at the site and the timing of implementation of the phases. Data needed to plan for implementation of the selected alternative are identified and a preliminary program for collecting the required data is outlined. Recommendations are given for implementing the selected alternative in each action area.

7.1 Remedial Life-Cycle Approach

Development of the remedial life cycle approach for the Fillmore site is based on the investigation record, the *Draft Risk Assessment* for the site, and the physical nature of the compounds being remediated. The results of extensive investigation at the site indicate that limited areas of soils have been impacted by petroleum products and that groundwater contains low concentrations of VOCs. There is little or no evidence in the investigation record to indicate a major source of petroleum in the subsurface at the site. In fact, the recorded concentrations of VOCs suggest that a major source is not present. The maximum concentration of TCLP-leachable benzene in soils, for example, was 38 μg/kg (leachable benzene was identified in 23 out of 128 samples). Concentrations in the mg/kg (parts-per-million) range would be expected if a source were present as nonaqueous phase liquid (NAPL) in the soil pores. In addition, calculated risks for ingestion of surface soils is within the risk range typically used by U.S. EPA to set cleanup goals at similar sites.

Benzene was the most frequently detected VOC in groundwater, found in 29 of 66 samples. A maximum concentration of 720 µg/L benzene was found during the initial sampling round at the site. The concentration of benzene has steadily declined in each subsequent sampling event, with a maximum benzene concentration of 150 µg/L in the August 1991 sampling event. These concentrations, when compared with an aqueous solubility of 1,000 µg/L for benzene, also indicate that the source of benzene to Aquifer 1 is likely diffuse and not concentrated. They also reflect the biodegradable nature of benzene in the natural environment. Free-floating product was identified in only one monitoring well during the site investigation; it was not encountered in any other wells.

Groundwater at the site is not used as a drinking water source; however, a hypothetical drinking water scenario was developed for use in the *Draft Risk Assessment* for the site. Based on the risk assessment, the calculated risk for the site is 2.42×10^{-5} for benzene, 2.42×10^{-6} for DCA, and 2.35×10^{-6} for 1,1,2,2-tetrachloroethane. Thus, approximately 84% of the hypothetical potential risk from groundwater, if it were used as a drinking water source, is due to benzene. This potential risk, at approximately 3.07×10^{-5}, is within the U.S. EPA acceptable risk range of 10^{-4} to 10^{-7} that has typically been used by U.S. EPA to set cleanup goals for groundwater at similar sites. Thus, additional degradation expected to be occurring at the site will lead to overall lower risks with time.

Where the extent of impacted soils and groundwater is not clearly defined, additional data will be required prior to implementation of remedial action. The remedial life-cycle presented in Table 7-1 considers the need for additional information; firm recommendations for action are presented where enough information is available.

In Action Area 1, an area where natural degradation of constituents is reducing the extent of affected groundwater, Phase I will consist of two activities. For groundwater, the natural degradation will be monitored. Concurrently, the potential for affected soils to impact groundwater will be evaluated, current soils data will be reviewed, and groundwater conditions will be monitored and compared to rainwater infiltration and groundwater levels to determine whether the soils may impact the remediation timeframe.

During Phase 2 in Action Area 1, if monitoring data indicate that it is required, a groundwater pump and treat system for capture and collection of groundwater will be designed and installed.

In Action Area 2, Phase 1 will consist of monitoring of natural degradation. Investigative activities will be performed as necessary to confirm the significance of natural degradation and provide pre-design information. Design activities will also be conducted during Phase 1. These activities are expected to include design of the groundwater remediation system, preparation of plans and

TABLE 7-1

Fillmore Remedial Life-Cycle

Action Area	Media	Phase 1[1]	Phase 2
1	Groundwater	Monitor Natural Degradation	Design & Install Treatment[2]
	Soil	Evaluate Soil Impact on Natural Degradation of VOCs in Groundwater	
2	Groundwater	Evaluate/Monitor Natural Degradation	Continue Monitoring
		Design Activities	Installation/Operation of Pump & Treat System[2]
	Soil	Pre-Design/Design Activities	Installation/Operation of Soils Treatment System[3]

[1]Duration of Phase 1 expected to be 1 to 2 years.
[2]System will be designed to achieve benzene ARARs, if required and warranted, and will be adaptable to address the dynamic conditions observed through quarterly monitoring.
[3]If required and warranted.

specifications, and procurement of contractors to install and operate the equipment. Similar design activities will be performed for soils if investigative activities indicate that soils are significantly impacting the remediation timeframe. During Phase 2 for this area, groundwater monitoring will continue and, if monitoring data indicate that it is required, a groundwater recovery and treatment system will be installed to achieve benzene ARARs. This system will be adaptable to address the dynamic conditions observed through quarterly monitoring. Likewise, if required and warranted, a soils treatment system will be installed to address the potential impact of affected soils on achievement of groundwater ARARs.

Additional investigation is proposed in Action Area 2B to:

- Assess the potential downgradient extent of VOC movement though installation of additional monitoring wells. A program of downgradient monitoring is currently being implemented and may be completed prior to finalization of this FS.

- Confirm that the benzene plume is being naturally degraded and will therefore be limited with respect to downgradient travel. This activity would be performed through ongoing groundwater monitoring and evaluation of data using U.S. EPA models for developing trends in biodegradation. Quarterly reporting of trends in benzene degradation would continue. Significant increases in the benzene concentrations or downgradient extent of the plume would require corrective action.

- Address the relative contribution of potential sources to the plume.

7.2 Conclusions and Recommendations

Based on the evaluation presented in this FS report, the following activities should be implemented in a phased approach.

- **Drought Effects Assessment**. A review of climatological data, as well as data from the site, should be conducted to determine the effects, if any, that the drought has on the evaluation and recommendations presented herein.

- **Continued Groundwater Monitoring/Investigation**. Monitoring to assess the natural degradation of the constituents of interest and to assess the progress of remedial action at the site should continue. Groundwater monitoring data would be assessed using U.S. EPA models for determining biodegradation trends at

groundwater cleanup sites. This biodegradation assessment may include collection of field data to support the modeling effort.

- **Soil Impact Evaluation.** The mass and distribution of potentially leachable hydrocarbons should be assessed to determine whether residuals in soil will significantly impact the cost or remedial timeframe of the overall project. Of particular interest would be the soil vapor study area and the contribution of the Ultramar release.

- **Design Activities.** Pending the outcome of continued groundwater and the soil evaluations, design activities should be initiated for installation of groundwater and soils treatment systems in Action Area 2.

8.0 REFERENCES

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9.0 GLOSSARY OF TERMS

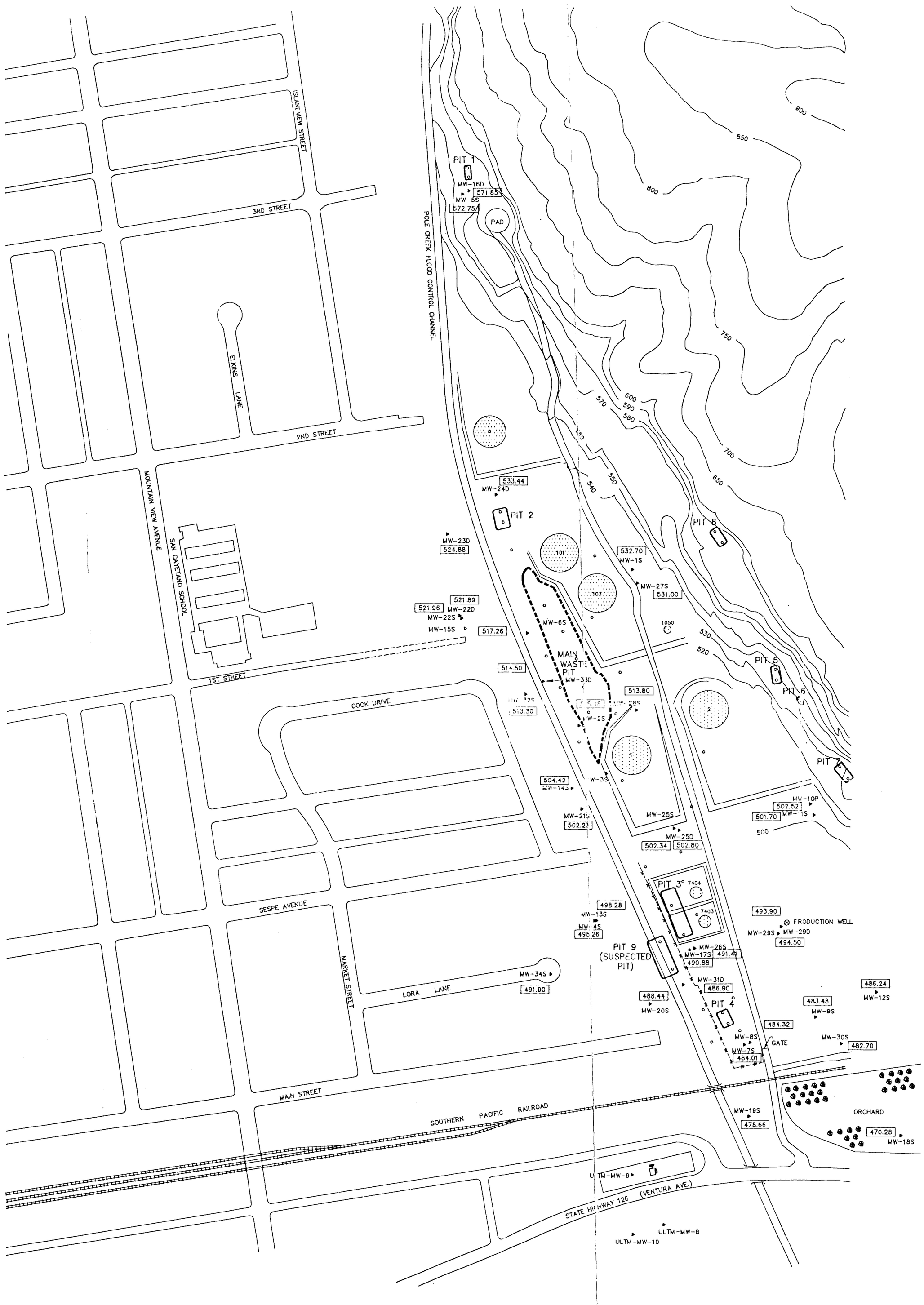
APCD	Air Pollution Control District
ARARs	Applicable or relevant and appropriate requirements
BATs	Best available technologies
BCTs	Best conventional technologies
BTEX	Benzene, toluene, ethylbenzene, and xylenes
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CWA	Clean Water Act
DCA	1,2-dichloroethane
DHS	California Department of Health Services
FS	Feasibility study
GRAs	General response actions
MCL	Maximum contaminant level
MCLGs	Maximum contaminant level goals
NAPL	Nonaqueous phase liquid
NCP	National Contingency Plan
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NSRLs	No-significant-risk levels
O&M	Operations and maintenance
PAH	Polynuclear aromatic hydrocarbons
POTW	Publicly owned treatment works
QAPP	Quality Assurance Project Plan
RAOs	Remedial action objectives
RCRA	Resource Conservation and Recovery Act
RI	Remedial investigation
RWQCB	Regional Water Quality Control Board
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
TBCs	To be considered
TCLP	Toxicity Characteristic Leaching Procedure
UCL	Upper Confidence Level
U.S. EPA	U.S. Environmental Protection Agency

USGS	United States Geological Survey
VCEHD	Ventura County Environmental Health Department
VCPWA	Ventura County Public Works Agency
VOC	Volatile organic compounds
WQL	Water quality criteria

APPENDIX A

FIGURES

A-1 MONITORING WELLS LOCATIONS AND ELEVATIONS
A-2 AQUIFER 1 BENZENE PLUME (SECOND QUARTER, MAY 1991)
A-3 AQUIFER 1 BENZENE PLUME (THIRD QUARTER, AUGUST 1991)
A-4 AQUIFER 1 BENZENE PLUME (FOURTH QUARTER, NOVEMBER 1991)



LEGEND

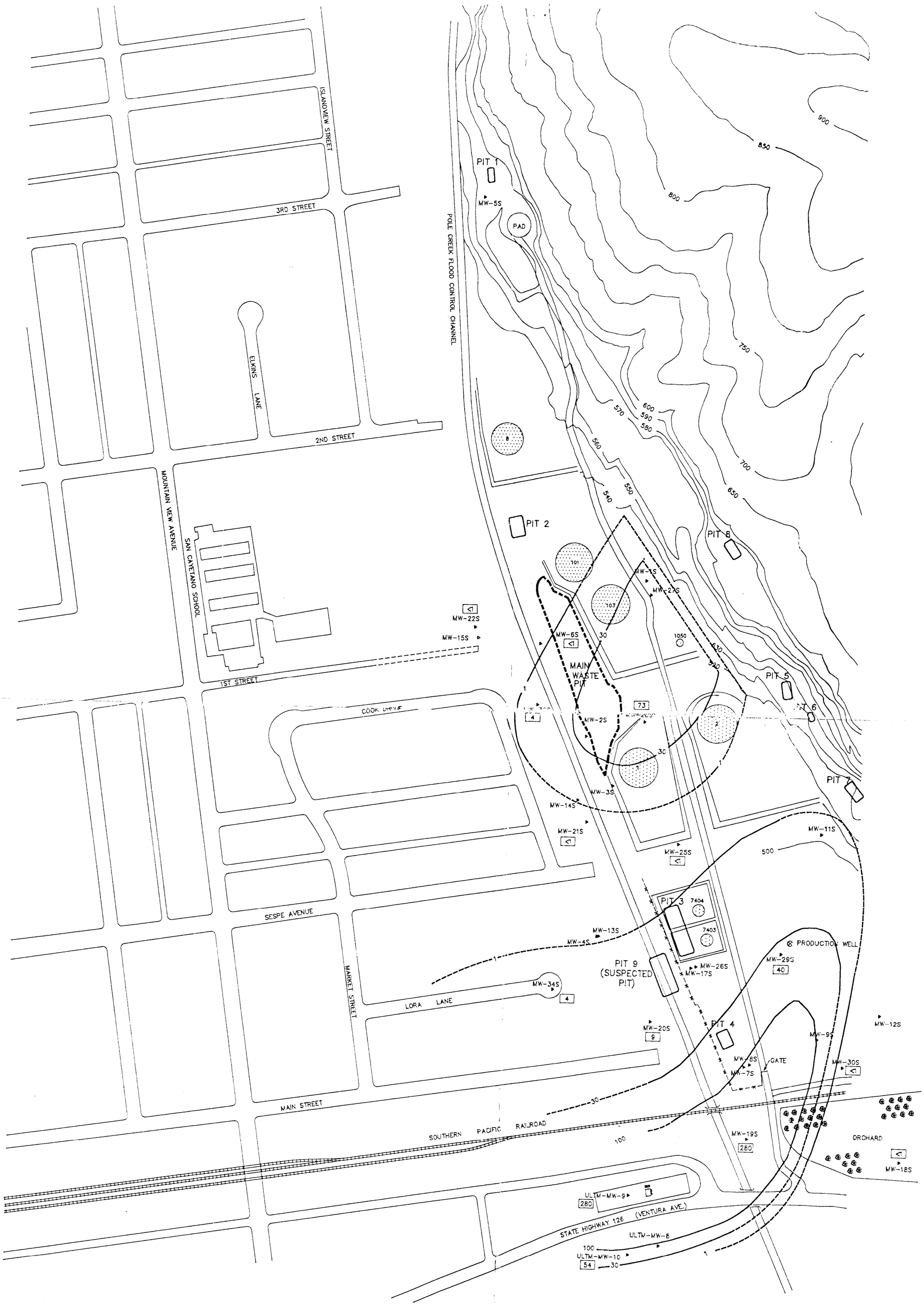
⊗	GROUNDWATER PRODUCTION WELL		ULTRAMAR GASOLINE STATION
▸	GROUNDWATER MONITORING WELL		ORCHARD
▸	GROUNDWATER MONITORING WELL (DECOMMISSIONED)		
∘	BOREHOLE		
500.00	GROUNDWATER ELEVATION (FEET) ABOVE MSL		FENCE (TEXACO FACILITY PROPERTY LINE)
	CRUDE OIL STORAGE TANKS		

ENSR

0 100 200
SCALE IN FEET

sdms 88111116 (1 of 3) A

PLATE: A-1	MONITORING WELLS LOCATION AND ELEVATION		
REPORT:	TEXACO FILLMORE REMEDIAL INVESTIGATION REPORT		
CLIENT:	TEXACO INC.	ENSR PROJECT NO. 6600-063	
DATE: 6/3/91	DRAWING FILE NAME: 6600-047.DWG	LAYERS USED: 0,1,2,2A,4,4A,5,5A,6*,13,15,16	
DRAFTED BY: M. SCOP	REVIEWED BY:	APPROVED BY:	



LEGEND			
⊗	GROUNDWATER PRODUCTION WELL		ULTRAMAR GASOLINE STATION
▸	GROUNDWATER MONITORING WELL	⊗	ORCHARD
▷	GROUNDWATER MONITORING WELL (DECOMMISSIONED)		
54	BENZENE ppb		
30	BENZENE CONCENTRATION CONTOUR		FENCE (TEXACO FACILITY PROPERTY LINE)
	CRUDE OIL STORAGE TANKS		

ENSR

0 100 200
SCALE IN FEET

SDMS 88111116 (2 of 3)

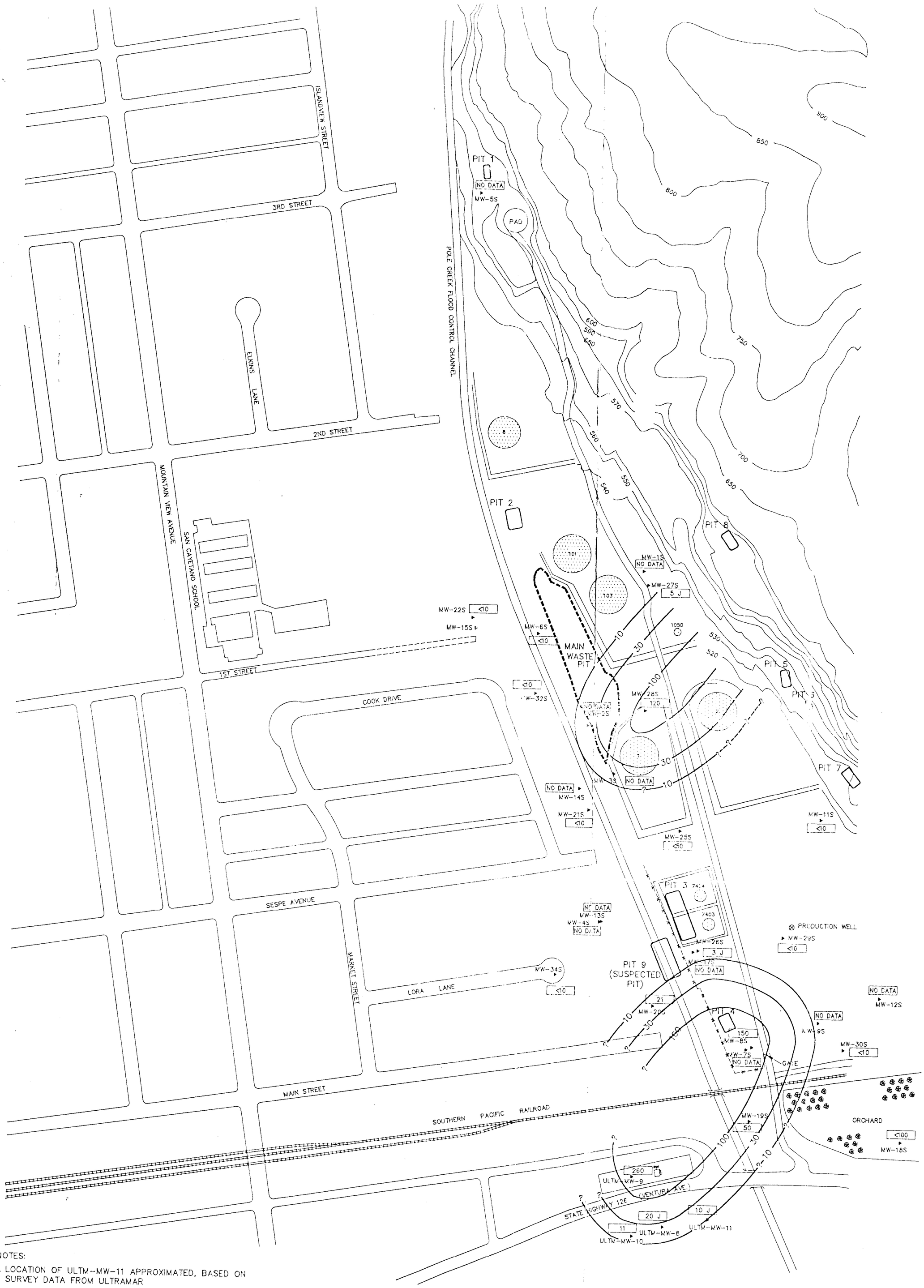
PLATE: A-2 SECOND QUARTER (MAY, 1991) AQUIFER I BENZENE PLUME

REPORT: TEXACO FILLMORE REMEDIAL INVESTIGATION REPORT

CLIENT: TEXACO INC. ENSR PROJECT NO. 6600-063

DATE: 6/13/91 | DRAWING FILE NAME: 6600-047.DWG | LAYERS USED: 0,1,2,2A,4,4A,5,5A,6,6A1,6T,6U,13,15,

DRAFTED BY: M. SCO | REVIEWED BY: | APPROVED BY:



NOTES:

1. LOCATION OF ULTM-MW-11 APPROXIMATED, BASED ON SURVEY DATA FROM ULTRAMAR
2. CONCENTRATIONS DENOTED "J" ASSUMED VALID FOR MAPPING PURPOSES.
3. CONCENTRATIONS DENOTED "<(n)" ASSUMED ≈ 0 FOR MAPPING PURPOSES.

LEGEND

⊗	GROUNDWATER PRODUCTION WELL		ULTRAMAR GASOLINE STATION
▸	GROUNDWATER MONITORING WELL	⊛	ORCHARD
▸	GROUNDWATER MONITORING WELL (DECOMMISSIONED)		
<10	BENZENE ppb		
30	BENZENE CONCENTRATION CONTOUR		FENCE (TEXACO FACILITY PROPERTY LINE)
	CRUDE OIL STORAGE TANKS		

0 100 200
SCALE IN FEET

SDMS 88111116 (3 of 3) A

PLATE: A-3 THIRD QUARTER (AUGUST) 1991 AQUIFER I BENZENE CONTOUR MAP

REPORT: TEXACO FILLMORE THIRD QUARTER 1991 GROUNDWATER MONITORING REPORT

CLIENT: TEXACO INC. ENSR PROJECT NO. 6600-063

DATE: 10/31/91 DRAWING FILE NAME: 6600-047.DWG LAYERS USED: 0,1,2,2A,4,4A,5,5A,6A1,6U,6T,13,15,16,56

DRAFTED BY: M. SCOP REVIEWED BY: APPROVED BY:

APPENDIX B

GROUNDWATER CALCULATIONS

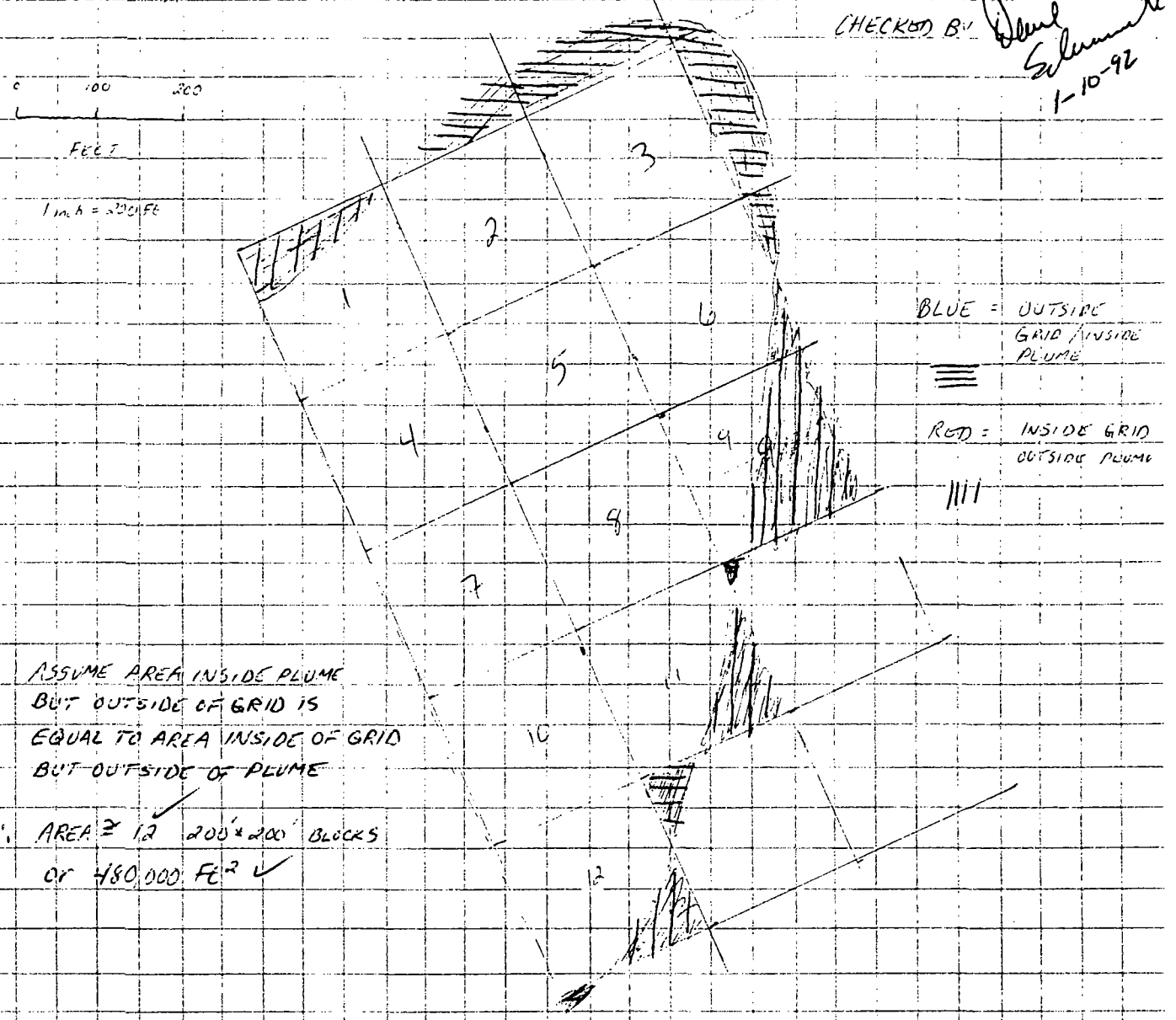
Title	Date	Dwg.	Project	Proposal
CALCULATION OF BENZENE PLUME	1/8/92	1	2660 060 400	

SOUTH PLUME - AQUIFER 1 AREA.
MAY 1991 DATA

TEXACO - FILLMORE FS

PREPARED BY: [illegible]

CHECKED BY: [illegible] 1-10-92



ASSUME AREA INSIDE PLUME BUT OUTSIDE OF GRID IS EQUAL TO AREA INSIDE OF GRID BUT OUTSIDE OF PLUME

∴ AREA ≅ 12 200' × 200' BLOCKS
or 480,000 FT^2

APPROXIMATE AREA OF PLUME DEFINED BY 1 PPB ISOPLETH - APPROXIMATED BY ASSUMING PLUME IS EQUAL TO 3" × 4" GRID USING SCALE 1" = 200'

A ≅ 800 FT × 600 FT
A ≅ 480,000 FT^2

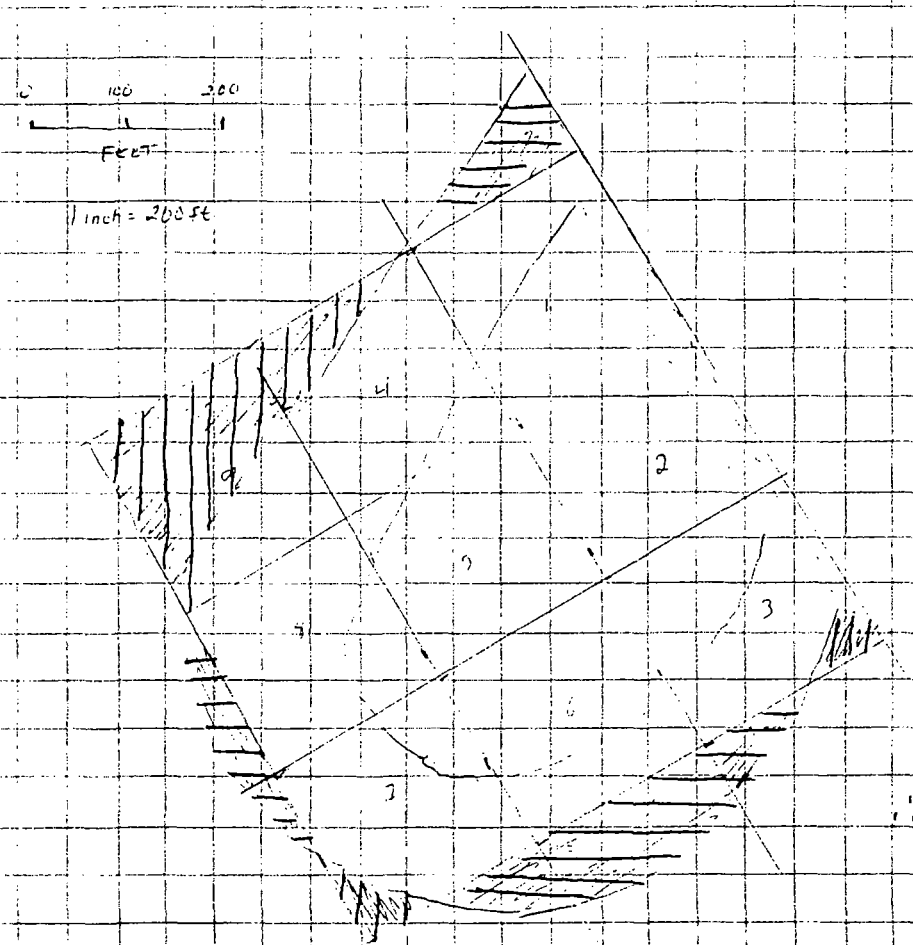
PLUME TRACED FROM 1:200 PLATE - MAY, 1991 DATA

Title	Date	Dwg.	Project	Proposal
CALCULATION OF BENZENE PLUME	1/8/92	2	6600 060 400	

NORTH AQUIFER 1' PLUME
MAY 1991 DATA

TEXACO - FILLMORE FS

PREPARED BY: [signature]
CHECKED BY: [signature] 1-10-92



BLUE = OUTSIDE GRID / IN PLUME

RED = INSIDE GRID / OUT PLUME

ASSUME AREA INSIDE PLUME BUT OUTSIDE OF GRID IS EQUAL TO AREA INSIDE OF GRID BUT OUTSIDE OF PLUME

∴ AREA ≅ 9 200' × 200' BLOCKS
or 360,000 ft^2

APPROXIMATE AREA OF PLUME DEFINED BY 1 PPB ISOPLETH - APPROXIMATED BY ASSUMING PLUME IS EQUAL TO 3" × 3" GRID USING SCALE 1" = 200'

A ≅ 600 ft × 600 ft
A ≅ 360,000 ft^2

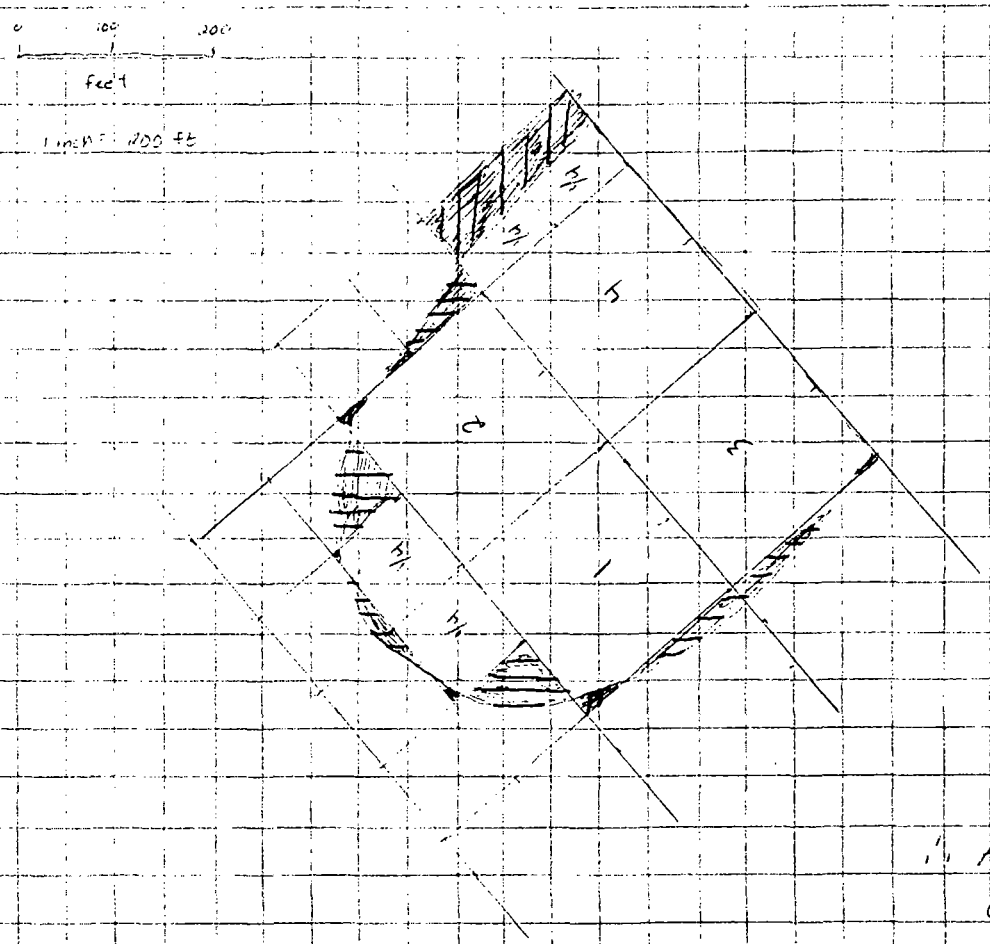
PLUME TRACED FROM 1:200 PLATE - MAY, 1991 DATA

Title	Date	Dwg.	Project	Proposal
CALCULATION OF BENZENE PLUME	1/8/92	4	6600 060 400	

NORTH AQUIFER 1 PLUME
AUGUST 1991 DATA

TEXACO - FILLMORE

PREPARED BY: [illegible]
CHECKED BY: [illegible] Schmacher 1-10-92



BLUE = OUTSIDE GRID / INSIDE PLUME

RED = INSIDE GRID / OUTSIDE PLUME

ASSUME AREA INSIDE PLUME BUT OUTSIDE OF GRID IS EQUAL TO AREA INSIDE OF GRID BUT OUTSIDE OF PLUME ✓

∴ AREA ≃ 5 200' * 200' BLOCKS OR 200,000 Ft² ✓

APPROXIMATE AREA OF PLUME DEFINED BY 10 PPB ISOPLETH - APPROXIMATED BY ASSUMING PLUME IS EQUAL TO 2" * 2.5" GRID USING SCALE 1" = 200'

A ≃ 400 Ft * 500 Ft ✓

A ≃ 200,000 Ft² ✓

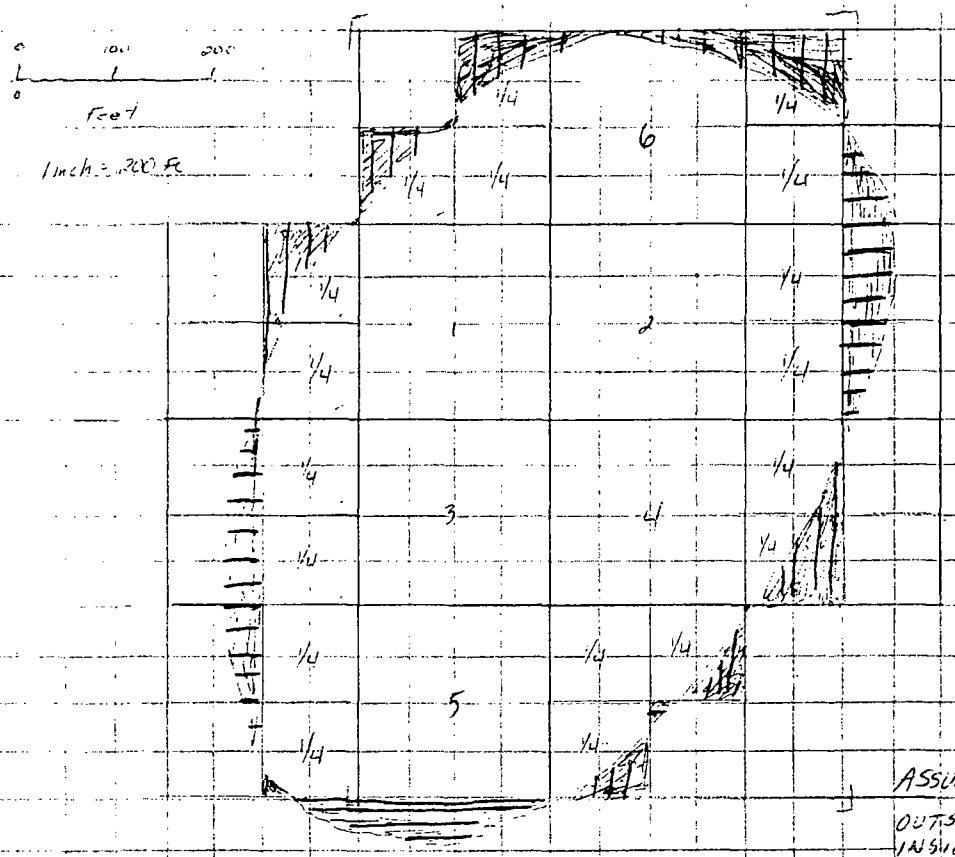
PLUME TRACED FROM 1:200 PLATE - AUGUST, 1991 DATA

Title	Date	Dwg.	Project	Proposal
CALCULATION OF BENZENE PLUME	1/8/92	3	6600 060 400	

SOUTH PLUME AQUIFER 1 AREA
AUGUST 1991 DATA

TEXACO - FILLMORE CS

PREPARED BY J Hydu
CHECKED BY Dave Schumacher 1-10-92



BLUE = OUTSIDE GRID / INSIDE PLUME

RED = INSIDE GRID / OUTSIDE PLUME

ASSUME AREA INSIDE PLUME BUT OUTSIDE OF GRID IS EQUAL TO AREA INSIDE OF GRID BUT OUTSIDE OF PLUME

∴ AREA ≅ 10.5 200' × 200' BLOCKS OR 420,000 ft^2

APPROXIMATE AREA OF PLUME DEFINED BY 10 PPB ISOPLETH - APPROXIMATED BY ASSUMING PLUME IS EQUAL TO A 2.5" × 4" GRID AND A 1" × 1/2" GRID USING A SCALE OF 1" = 200'

$A \cong (500\ ft \times 800\ ft) + (200\ ft \times 100\ ft)$

$A \cong 400{,}000\ ft^2 + 20{,}000\ ft^2$

$A \cong 420{,}000\ ft^2$

PLUME TRACED FROM 1:200 PLOT - AUGUST 1991 DATA

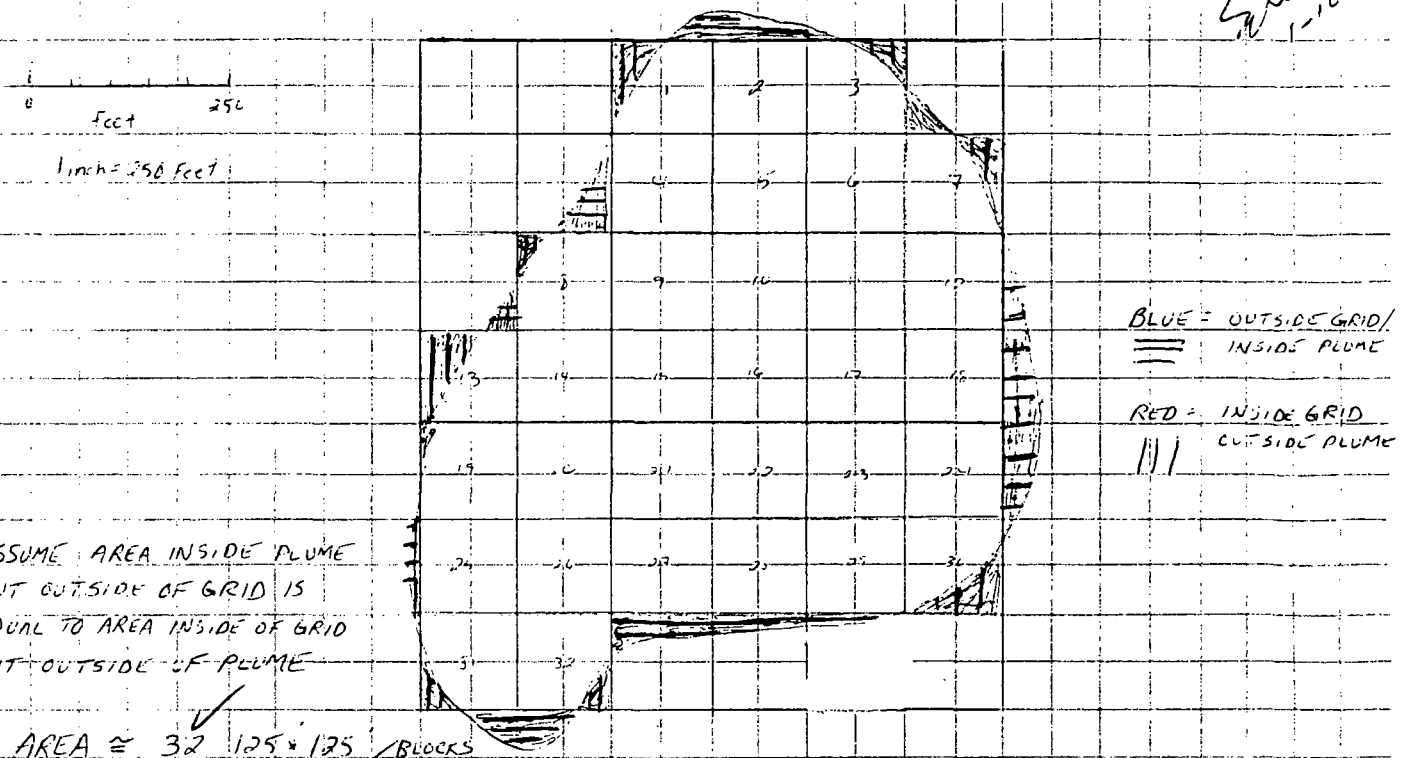
ENSR FORM 1052

Title	Date	Dwg.	Project	Proposal
CALCULATION OF BENZENE PLUME	1/10/92	5	6600 060 400	

SOUTH AQUIFER 1 PLUME
4th QTR DATA

TEXACO - FILLMORE

PREPARED BY:
CHECKED BY:



ASSUME AREA INSIDE PLUME BUT OUTSIDE OF GRID IS EQUAL TO AREA INSIDE OF GRID BUT OUTSIDE OF PLUME

∴ AREA ≅ 32 125' × 125' BLOCKS
or 500,000 ft²

APPROXIMATE AREA OF PLUME DEFINED BY 10 PPB ISOPLETH - APPROXIMATED BY ASSUMING PLUME IS EQUAL TO A 2" × 4" GRID USING A SCALE OF 1" = 250'

A ≅ 500 ft × 1000 ft
A ≅ 500,000 ft

PLUME TRACED FROM ATTACHED SHEET -

ENSR FORM 1052

Title	Date	Dwg.	Project	Proposal
CALCULATION OF BENZENE PLUME	1/10/92	6	6600 060 400	

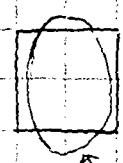
NORTH, AQUIFER 1 PLUME
~~4th QTR DATA~~

TEXACO - FILLMORE

PREPARED BY [illegible]
CHECKED BY [illegible] 1-10-92

SCALE

0 250
FT



TRACE OF PLUME

APPROXIMATE AREA OF PLUME DEFINED BY 10 PPB ISOPLETH - APPROXIMATED BY ASSUMING PLUME IS EQUAL TO A .5" x .5" GRID USING A SCALE OF 1" = 250'

A ≅ 125' x 125'
A ≅ 15625 feet

PLUME TRACED FROM ATTACHED SHEET

Title	Date	Dwg.	Project	Proposal
CHECK OF SCALE FOR	1/10/92		6600 060 400	

ATTACHED MAP - SHOWING FOURTH QTR PLUMES

TEXACO - FILLMORE

PREPARED BY: [illegible]
CHECKED BY: [illegible] 1-10-92

DISTANCE BETWEEN MW12S & MW30S ON MAP WITH KNOWN SCALE:

$$.925 \text{ inches} \times \frac{200 \text{ Ft}}{\text{inch}} = 185 \text{ Ft}$$

DISTANCE BETWEEN MW-12S & MW30S ON MAP WITH UNKNOWN SCALE

$$\frac{185 \text{ Ft}}{.75 \text{ inches}} = 247 \text{ ft/inch} \Rightarrow 250 \text{ Ft/inch}$$

ENSR FORM 1052

Title	Date	Dwg.	Project	Proposal
SATURATED AQUIFER 1 THICKNESS IN VICINITY OF NORTH BENZENE PLUME	1/10/92		6600 060 400	

TEXACO FILLMORE

PREPARED BY: [illegible]
CHECKED BY: [illegible] 1-10-92

DETERMINE SATURATED THICKNESS OF AQUIFER 1 IN VICINITY OF NORTH BENZENE PLUME

MONITORING WELL[1]	S.W.L.[2]	TOP OF LOWER FINE GRAINED UNIT[3]	AQUIFER THICKNESS[4]
MW-21S	410.73'	383'	27.7'
MW-25S	414.80'	377'	37.8'
MW-27S	409.05'	385'	24.1'
MW-28S	412.00'	384'	28.0'
MW-32S	409.3'	393'	16.3'

[1] WELLS WERE CHOSEN BASED ON THEIR PROXIMITY TO THE PLUME

[2] STATIC WATER LEVELS OBTAINED FROM AUGUST 1991 GROUNDWATER SURFACE ELEVATION MAP (PLATE) ⇒ ELEVATION AMSL

[3] EXTRAPOLATED FROM PLATE 3-2 - STRUCTURE CONTOURS OF TOP OF THE LOWER FINE GRAINED UNIT ⇒ ELEVATION AMSL

[4] TOP OF LOWER FINE GRAINED UNIT MINUS S.W.L

THICKNESS $_{\bar{x}}$ = 27.7 + 37.8 + 24.1 + 28.0 + 16.3 / 5

THICKNESS $_{\bar{y}}$ = 26.8 ft ⇒ SAY 27 Feet

NOTE: VALUE AGREES WITH VALUE PRESENTED ON PLATE 3-7 - AQUIFER 1 SATURATED THICKNESS MAP

ENSR FORM 1052

Title	Date	Dwg.	Project	Proposal
SATURATED AQUIFER 1 THICKNESS IN VICINITY OF SOUTH BENZENE PLUME	1/10/92		6600 060 400	

TEXACO - FILLMORE

PREPARED BY: [illegible]
CHECKED BY: [illegible] 1/10/92

DETERMINE SATURATED THICKNESS OF AQUIFER 1 IN VICINITY OF SOUTH BENZENE PLUME

MONITORING WELL [1]	S.W.L. [2]	TOP OF LOWER FINE GRAINED UNIT [3]	AQUIFER THICKNESS [4]
MW-8S	416.82	366'	50.8'
MW-9S	416.98	366'	51.0'
MW-19S	416.76	363'	53.8'
MW-20S	413.14	370'	43.1'
MW-26S	415.51	372'	43.5'
MW-27S	416.30	376.5'	39.8'
MW-30S	417.10	364'	53.1'
MW-34S	409.20	386'	23.2'

[1] WELLS WERE CHOSEN BASED ON PROXIMITY TO THE BENZENE PLUME

[2] STATIC WATER LEVELS OBTAINED FROM AUGUST 1991 GROUNDWATER SURFACE ELEVATION MAP (PLATE) → ELEVATION AMSL

[3] EXTRAPOLATED FROM PLATE 3-2 - STRUCTURE CONTOURS OF TOP OF THE LOWER FINE GRAINED UNIT → ELEVATION AMSL

[4] TOP OF LOWER FINE GRAINED UNIT MINUS SWL

$$THICKNESS_{\bar{x}} = \frac{50.8 + 51.0' + 53.8' + 43.1' + 43.5' + 39.8' + 53.1' + 23.2'}{8}$$

$$THICKNESS_{\bar{x}} = 44.8 \text{ Feet}$$

SAY 45 Feet

NOTE! VALUE AGREES WITH VALUE PRESENTED ON PLATE 3-7 - AQUIFER 1 SATURATED THICKNESS MAP (FROM RI REPORT)

Title	Date	Dwg.	Project	Proposal
CALCULATION OF AVERAGE SURFACE AREA OF AQUIFER 1 - BENZENE PLUMES	1/10/92		6600 060 400	

TEXACO - FILLMORE

PREPARED BY: [illegible]
CHECKED BY: Dave Schumacher 1-10-92

AVERAGE AREA OF NORTH PLUME - AQUIFER 1 FOR SECOND, THIRD, AND FOURTH QUARTER, 1991 DATA

SECOND QUARTER → 360,000 ft^2
THIRD QUARTER → 200,000 ft^2
FOURTH QUARTER → 15,625 ft^2
575,625 ft^2 ÷ 3 ⇒ 191,875 ft^2

SAY 192,000 ft^2

AVERAGE AREA OF SOUTH PLUME - AQUIFER 1 FOR SECOND, THIRD AND FOURTH QUARTER, 1991 DATA

SECOND QUARTER → 480,000 ft^2
THIRD QUARTER → 420,000 ft^2
FOURTH QUARTER(1) → 500,000 ft^2
1,400,000 ft^2 ÷ 3 ⇒ 466,667 ft^2

SAY 467,000 ft^2

(1) Based on preliminary review of 4th QTR Data (JMC.)

AVERAGE TOTAL (JMC.) –

(A) 192,000 ft^2
+ 467,000 ft^2
659,000 ft^2

(B) $\frac{659,000\ ft^2}{\cancel{43,600}\ 43,560\ ft^2/acre}$ = ~~15 acres~~ 15.13 acres (AZ 1-13-92) (G.F. 1-13-92)

Title	Date	Dwg.	Project	Proposal
CALCULATION OF PORE VOLUMES	1/10/92		6600 060 400	

FOR NORTH AND SOUTH AQUIFER TEXACO-FILLMORE
2 BENZENE PLUMES.

PREPARED BY: [illegible]
CHECKED BY: Paul Schumacher

PORE VOLUME OF NORTH PLUME (BASED ON AVERAGE PLUME AREAS FOR 2nd, 3rd, 4th QUARTER 1991 DATA AND SATURATED THICKNESS CALCULATIONS)

VOLUME PLUME = AVERAGE SURFACE AREA * SATURATED AQUIFER THICKNESS
VOLUME = 192,000 Ft^2 * 27 Ft
VOLUME = 5,184,000 Ft^3 ✓

ASSUME POROSITY = 35%

PORE VOLUME = 5,184,000 Ft^3 × 0.35 ✓
PORE VOLUME = 1,814,400 Ft^3 × $\frac{7.48 \text{ gal}}{Ft^3}$ = 13,571,712 gallons ✓

SAY ~~13,572,000~~ DS gallons
13,600,000

PORE VOLUME OF SOUTH PLUME (BASED ON AVERAGE PLUME AREAS FOR 2nd, 3rd, 4th QUARTER, 1991 DATA AND SATURATED THICKNESS CALCULATIONS)

VOLUME PLUME = AVERAGE SURFACE AREA × SATURATED AQUIFER THICKNESS
VOLUME = 467,000 Ft^2 × 45 Ft
VOLUME = 21,015,000 Ft^3 ✓

ASSUME POROSITY = 35%

PORE VOLUME = 21,015,000 Ft^3 × 0.35 ✓
PORE VOLUME = 7,355,250 Ft^3 × $\frac{7.48 \text{ gal}}{Ft^3}$ = 55,017,270 gallons ✓

SAY ~~55,018,000~~ DS gallons
55,000,000 gallons

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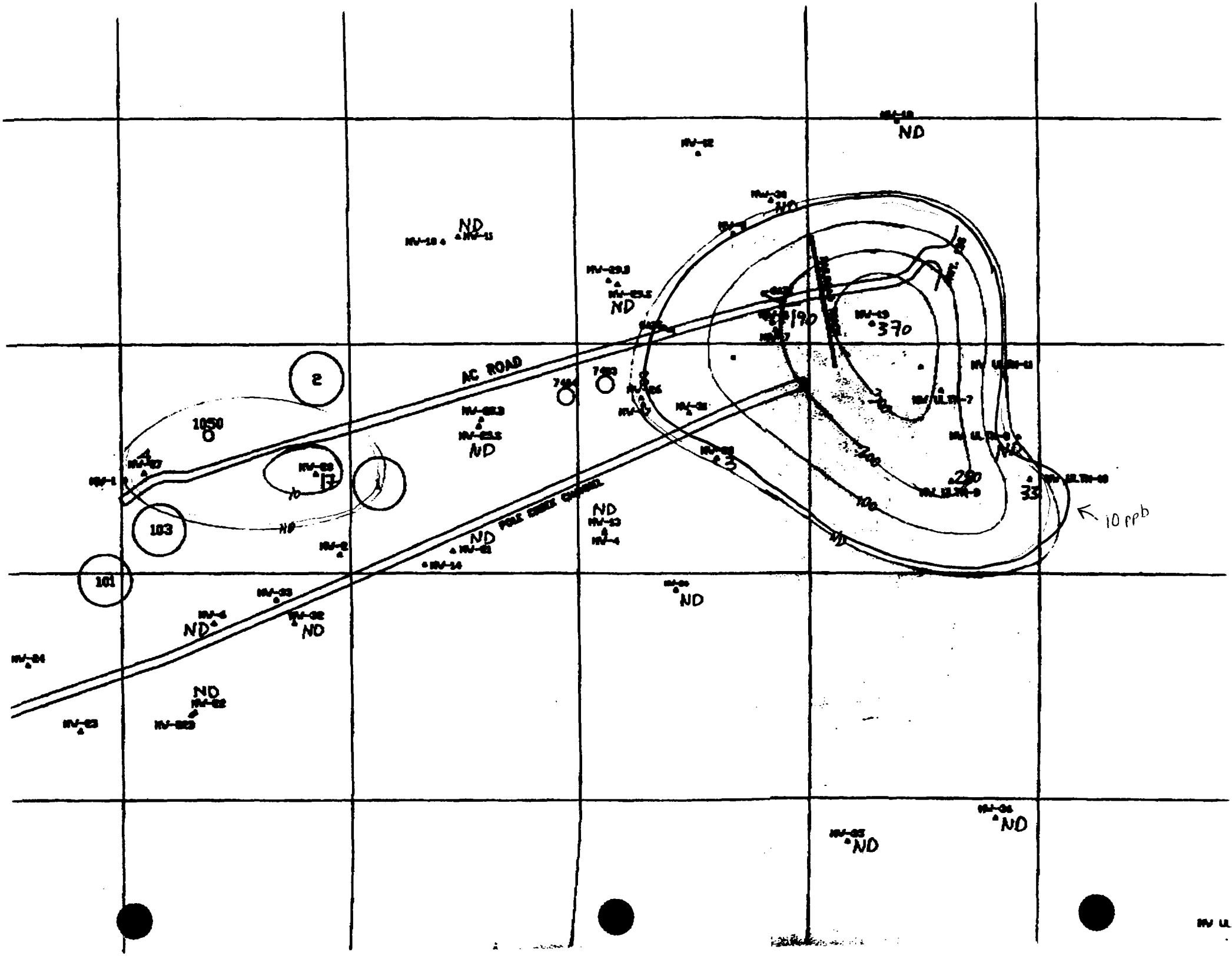
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
190
370
280
33
1050
2
103
101
AC ROAD
10 ppb

Title	Date	Dwg.	Project	Proposal
TEXACO - Fillmore	1-10-92	DAS	6600-060-400	

4/Hodi 1/10/92

Estimation of well yields and capture zones

Sichardt Equation:

$$R = 3000 \cdot s \cdot \sqrt{K}$$

where R = Radius of influence
s = Drawdown
k = Hydraulic Conductivity in m/s

Thiem Equation (See Driscoll, 1989, p. 213)

$$Q = \frac{K(H^2 - h^2)}{1{,}055 \log(R/r)}$$

where K = Hydraulic Conductivity in gpd/ft²
H = Aquifer Thickness (ft)
h = Pumping Water Column (ft)
R = Radius of Influence (ft)
r = Radius of well (ft)
H-h = Drawdown (ft)
Q = well yield (gpm)

Assumptions

North Region

1. Aquifer Thickness = Saturated Thickness Estimated from Plate 3-7 = 30 ft

2. Avg. = Hydraulic Conductivity = 20 ft/day = 7.1×10^{-5} m/s = 150 $\frac{gpd}{ft^2}$
(from slug test data - see page 3-36 of RI)

3. Drawdown = s = H-h = 40% of Aquifer thickness to compensate for well efficiency and equipment = (30)(0.4) = 12 ft = 3.7 meters

4. R = Radius of Influence Determined by Sichardt Equation

$$R = (3000)(3.7)\sqrt{7.1 \times 10^{-5}} = 94 \text{ meters} = 307 \text{ ft}$$

5. r = well radius = 6-inch well casing in a 12-inch borehole use r = 6 in = 0.5 ft

Title	Date	Dwg.	Project	Proposal
TEXACO - Fillmore	1-10-92	DAS	6600-060-400	

4 Hydro 1/10/92

Therefore

$$Q = \frac{(150)(30^2 - 18^2)}{1.055 \log(307/0.5)} = 29 \text{ gpm}$$

A single well will yield 29 gpm with a radius of influence of 307 ft. Wells must fully penetrate Aquifer 1 with screens extending from the water table to the top of the lower fine grained unit.

South Region

① Aquifer Thickness = Saturated thickness Estimated from Plate 3-7 = 40 ft

② Avg. Hydraulic Conductivity = 20 ft/day = 7.1×10^{-5} m/s = 150 gpd/ft^2 (from slug test data - see page 3-36 of RI)

③ Drawdown = s = H-h = 40% of Aquifer thickness to compensate for well efficiency and equipment = (40)(0.4) = 16 ft = 4.9 m

④ R = Radius of Influence Determined by Sichardt Equation

$$R = (3000)(4.9)\sqrt{7.1 \times 10^{-5}} = 124 \text{ m} = 406 \text{ ft}$$

⑤ r = well radius = 6-inch well casing in a 12-inch borehole; use r = 6 in = 0.5 ft

Title	Date	Dwg.	Project	Proposal
TEXACO - Fillmore	1-10-92	DAS	6600-060-400	

Hadley 1/10/92

Therefore

$$Q = \frac{(150)(40^2 - 24^2)}{1.055 \log(406/0.5)} = 50 \text{ gpm}$$

A single well will yield 50 gpm with a radius of influence of 406 ft. Wells must fully penetrate Aquifer 1.

Calculated Q and R agree reasonably well with results of pump tests. Lower Q for pump tests may be because wells were not fully penetrating aquifer or were in area with smaller saturated thickness.

Calculations do not consider (1) decreasing transmissivity to the north; (2) presence of impermable boundaries to the east and north; (3) varying hydraulic properties (heterogeneity) of the aquifer; and (4) drawdown interferences between recovery wells

Therefore, assume wells will yield 10 gpm in north and 15 gpm in south.

Based on caculated radius of influence, two wells spaced approximately 500 ft apart should capture south plume. One well located along east side of Palo Creek near MW-19S and the other 500 ft north also along east side of Palo Creek. Total flow ~ 30 gpm

One well located near MW-2S should capture the north plume. Total flow ~ 10 gpm

ADD → 1 well to each plume for a total of 50 GPM (10 GPM ea)

Title	Date	Dwg.	Project	Proposal
CALCULATION OF TIME TO PUMP FROM 1 PORE VOLUME FROM AQUIFER 1	1/10/92		600 060 400	

PREPARED BY: [illegible]

NORTH PLUME:

$$t = \frac{13{,}600{,}000 \text{ gallons}}{10 \text{ gal/min}} = 1{,}360{,}000 \text{ min} = 2.58 \text{ years}$$

SAY 2.6 years

SOUTH PLUME:

$$t = \frac{55{,}000{,}000 \text{ gallons}}{30 \text{ gal/min}} = 1{,}833{,}333 \text{ min} = 3.49 \text{ years}$$

SAY 3.5 years

Volumes from pore volume calculation for north and south plume

Checked [illegible] 1-10-92

[illegible] 1-13-91

$$T = \frac{13{,}600{,}000 \text{ Gal}}{20 \text{ GPM}} = 680000 \text{ min} = 1.29 \text{ years}$$

Say 1.3 years

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Title	Date	Dwg.	Project	Proposal
Texaco Fillmore	1-14-92	72	6600-060-400	

Prepared by: Gordon Ferguson

Estimated Pump & Treat Remediation Time

- Given 1.3 years to pump 1 pore volume of groundwater from the North Plume and 3.5 years to pump 1 pore volume of groundwater from the South Plume.
- Assume* that pumping 10 to 20 pore volumes will be required to reduce the concentration of benzene in groundwater from 28.0 ug/l to less than 1 ug/l.

North Plume

1.3 yrs/pore vol. x 10 pore volumes = 13 years ✓

1.3 yrs/pore vol. x 20 pore volumes = 26 years ✓

South Plume

3.5 yrs/pore vol. x 10 pore volumes = 35 years ✓

3.5 yrs/pore vol. x 20 pore volumes = 70 years ✓

Checked 1-15-92 Dave Schumacher

* Pore volume assumption based on lack of a concentrated constituent source at the Fillmore site, e.g. no floating free product or large concentrated mass of contaminated soil.

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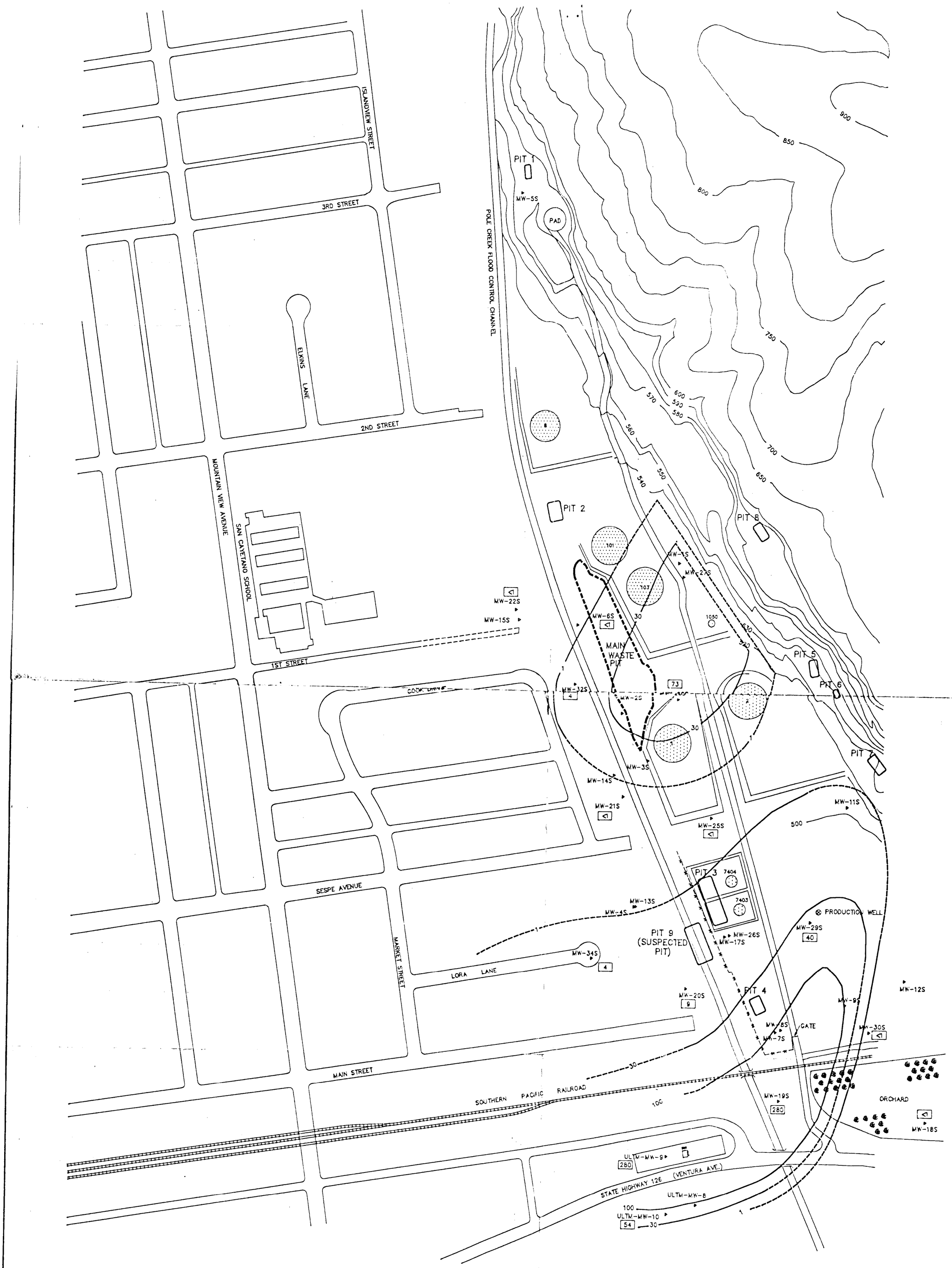


LEGEND			
⊗	GROUNDWATER PRODUCTION WELL		ULTRAMAR GASOLINE STATION
▸	GROUNDWATER MONITORING WELL	⊗	ORCHARD
▸	GROUNDWATER MONITORING WELL (DECOMMISSIONED)		
54	BENZENE ppb		
30	BENZENE CONCENTRATION CONTOUR		FENCE (TEXACO FACILITY PROPERTY LINE)
	CRUDE OIL STORAGE TANKS		

ENSR

0 100 200
SCALE IN FEET

SDMS 88111116

B (1 of 2)

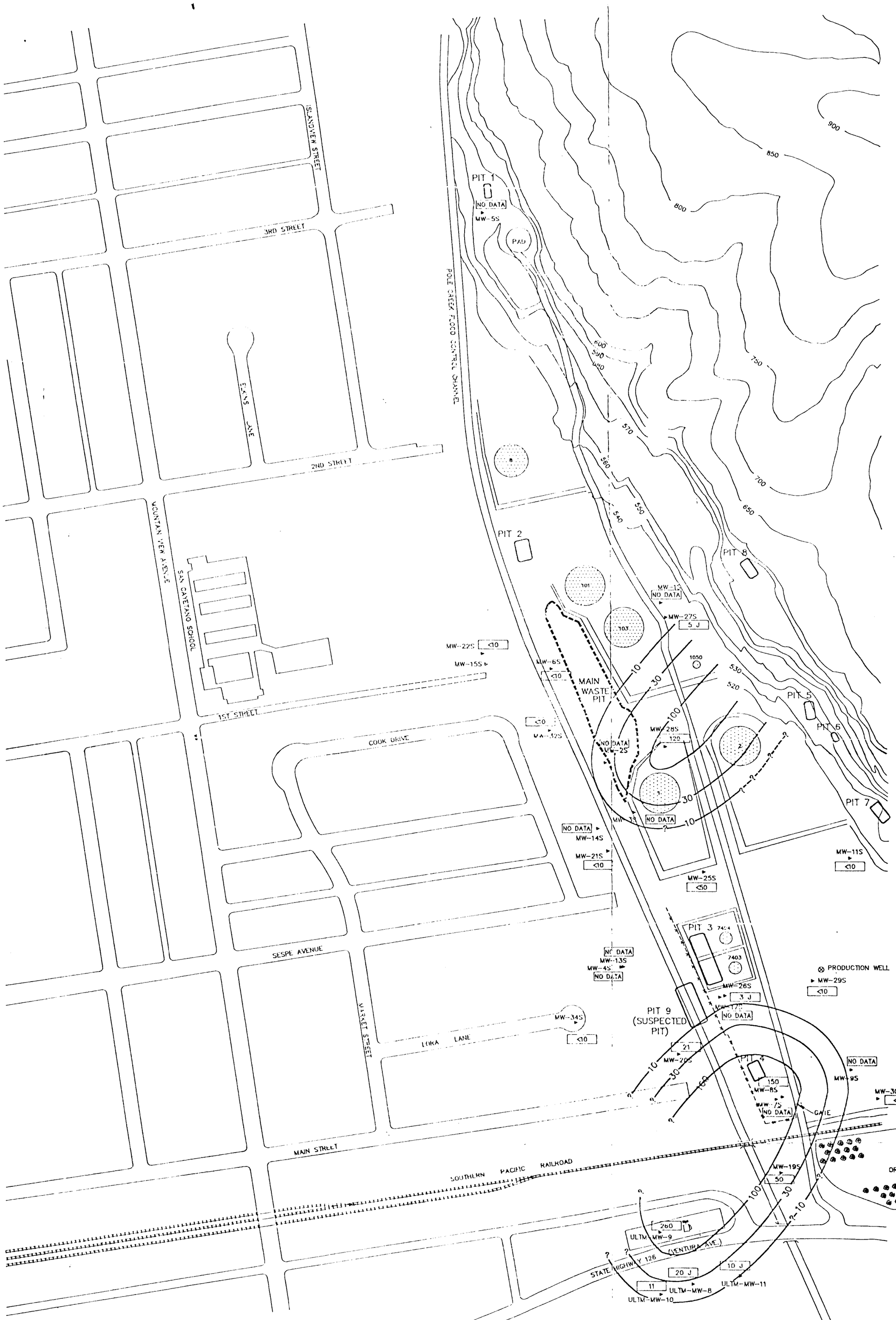
PLATE: A-2 SECOND QUARTER (MAY, 1991) AQUIFER I BENZENE PLUME

REPORT: TEXACO FILLMORE REMEDIAL INVESTIGATION REPORT

CLIENT: TEXACO INC. ENSR PROJECT NO. 6600-063

DATE: 6/13/91 | DRAWING FILE NAME: 6600-047.DWG | LAYERS USED: 0,1,2,2A,4,4A,5,5A,6,6A1,6T,6U,13,15,16,47

DRAFTED BY: M. SCO | REVIEWED BY: | APPROVED BY:



NOTES:

1. LOCATION OF ULTM-MW-11 APPROXIMATED, BASED ON SURVEY DATA FROM ULTRAMAR
2. CONCENTRATIONS DENOTED "J" ASSUMED VALID FOR MAPPING PURPOSES.
3. CONCENTRATIONS DENOTED "<(n)" ASSUMED ≈ 0 FOR MAPPING PURPOSES.

SDMS 88111116 (2 of 2) B

LEGEND

⊗	GROUNDWATER PRODUCTION WELL		ULTRAMAR GASOLINE STATION
▸	GROUNDWATER MONITORING WELL		ORCHARD
▸	GROUNDWATER MONITORING WELL (DECOMMISSIONED)		
<10	BENZENE ppb		
30	BENZENE CONCENTRATION CONTOUR		FENCE (TEXACO FACILITY PROPERTY LINE)
	CRUDE OIL STORAGE TANKS		

0 100 200
SCALE IN FEET

PLATE: A-3 THIRD QUARTER (AUGUST) 1991 AQUIFER I BENZENE CONTOUR MAP

REPORT: TEXACO FILLMORE THIRD QUARTER 1991 GROUNDWATER MONITORING REPORT

CLIENT: TEXACO INC. ENSR PROJECT NO. 6600-063

DATE: 10/31/91	DRAWING FILE NAME: 6600-047.DWG	LAYERS USED: 0,1,2,2A,4,4A,5,5A,6A1,8U,8T,13,15,16,58
DRAFTED BY: M. SCOP	REVIEWED BY:	APPROVED BY:

APPENDIX C

GROUNDWATER MONITORING DATA REVIEW

Title	Date	Dwg.	Project	Proposal
AQUIFER I DATA REVIEW	1-23-92	72	6600-063-200	

Prepared by:
G. Ferguson
Checked by:
J. Aiken

NO. PLUME BENZENE CONCENTRATION (µg/l)

Well ID No.	- 4th Qtr 9-90	4th Qtr 10-90	1st Qtr. 1-91	2nd Qtr 5-91	3rd Qtr. 8-91	4th Qtr 11-91
MW6S		20				<1 (1)
MW8S		230			150	190
MW10P		9	10	19	23J	9
MW19S		540	320	280	50	390
MW20S		5	11	4	15	3
MW25S					3J	<1
MW26S	720	21J	49	4	3J	8
MW27S				63	5J	4
MW28S			110	54	108	18
MW29S			2	40		<1
MW30S			3			<1
MW32S			58	4		<1
Total	720	825	563	468	357	624.5
N	1	6	8	8	8	12
$\bar{X}$	720	137.5	70.4	58.5	44.6	52

(1) For all values with < qualifier, half of the reported value was used to calculate average value.

ESTIMATED BENZENE HALFLIFE (1)

HALF LIFE	BENZENE (µg/l)	HALF LIFE	BENZENE (µg/l)	HALF LIFE	BENZENE (µg/l)
T0	720	T0	137.5	T0	71
H1 (1/91)	360	H1 (1/91)	68.8	H1	35
H2 (3/91)	180	H2 (3/91)	34.4	H2	17.5
H3 (9/91)	90	H3 (9/91)	17.2	H3	8.9
H4 (12/91)	45	H4 (12/91)	8.6	H4	4.5
				H5	2.2
				H6	1.1

(2) Calculated based on WARD & Thomas, 1985 ($K = 0.0006 d^{-1} \approx 120$ DAYS)

NON-DETECT WELLS (BENZENE)

MW11S	MW16D
MW18S	MW22D
MW21S	MW23D
MW22S	MW24D
MW35S	MW31D
MW36S	MW33D

ENSR FORM 1052

APPENDIX D

NATURAL DEGRADATION RATE CALCULATIONS

Title	Date	Dwg.	Project	Proposal
TERACO FILLMORE FS	12-11-91	72	6600-063-200	

CALCULATION OF NATURAL DEGRADATION RATES (BENZENE)

PREPARED BY: G. FERGUSON
CHECKED BY: J. AIKEN

① FIRST ORDER AEROBIC DEGRADATION IS DESCRIBED BY THE BELOW TRANSFORMATION EQUATION:

$$C_t = C_0 e^{-kt}$$

WHERE: C_t = CONSTITUENT CONCENTRATION AT TIME t
C_0 = INITIAL CONSTITUENT CONCENT.
$-k$ = DEGRADATION RATE CONSTANT
t = TIME

② BENZENE DEGRADATION

$C_t = 5\ \mu g/l$ (FED MCL)

$C_0 = 720\ \mu g/l$ (MAXIMUM RI OBSERVED BENZENE CONCENTRATION)

$k = 0.006\ (d^{-1})$

t = TIME TO ACHIEVE MCL

a) $5\ \mu g/l = 720\ \mu g/l\ e^{-kt}$

b) $\dfrac{5\ \mu g/l}{720\ \mu g/l} = e^{-kt}$

c) $0.00694 = e^{-0.006t}$

d) $\ln(0.00694) = \ln(e^{-0.006t})$

e) $-4.97 = -0.006t$

f) $t = \dfrac{-4.97}{-0.006} = 828$ DAYS

③ ESTIMATION OF REMEDIAL TIMEFRAME (BENZENE)

828 DAYS = 2.27 YEARS (SAY 2.5 YEARS)

2.5 YEARS × 2 (CONTINGENCY FACTOR) = 5 YEARS TO ACHIEVE BENZENE MCL

ENSR FORM 1052

Title	Date	Dwg.	Project	Proposal
TEXACO FILL	1-14-92	—	6600-063-400	—

Prepared by: E. Ferguson
Checked: [illegible]

I MASS OF BTEX IN GROUNDWATER (WITHOUT SOIL INPUT)

ASSUMPTIONS
A) AVG GROUNWATER BTEX CONCENTRATIONS OVERESTIMATED AT 1 ppm

Thus

North Plume

a) $1\ mg/l \times \frac{3.78\ l}{gal} \times 13{,}600{,}000\ gal = 51\ kg\ BTEX$

b) $51\ kg \times 7.5\ kg\ O_2/kg\ BTEX = 382.5\ kg\ O_2$ (required)

c) @ 10 ppm O_2
$\frac{382.5\ kg\ O_2}{10 \times 10^{-6}\ kg\ O_2/l} \times \frac{1\ gal}{3.78\ l} = 10{,}100{,}000\ gal$

d) $\frac{10{,}100{,}000\ gal}{20\ gpm} \times \frac{1\ yr}{525{,}600\ min} = 0.96\ yrs$

South Plume

a) $1\ mg/l \times \frac{3.78\ l}{gal} \times 55000000\ gal = 207{,}900{,}000 = 208\ kg$

b) $208\ kg \times 7.5\ kg\ O_2/kg\ BTEX = 1559\ kg\ O_2$

Title	Date	Dwg.	Project	Proposal

c) $\frac{1559 \text{ kg } O_2}{10 \times 10^{-6} \text{ kg } O_2/\ell} \times \frac{1 \text{ gal}}{3.78 \ell} = 41{,}200{,}000 \text{ gal}$

d) $\frac{41{,}200{,}000}{30 \text{ gpm}} \times 1 \text{ yr}/525{,}600 \text{ min} = 2.6 \text{ years}$

	@ GW CONC = 1 ppm	@ GW CONC = 11 ppm O_2 (10 mg/l O_2)	@ GW CONC = 11 ppm H_2O_2 (200 mg/l O_2)
NORTH PLUME	0.96 yrs	10.6 yrs	0.53
SOUTH PLUME	2.6 yrs	29.8 yrs	1.44
TOTAL TIME FOR SITE REMEDIATION =	> 3 yrs	> 30 yrs	> 2 yrs

SUMMARY OF PG 1A-5A

Title	Date	Dwg.	Project	Proposal
TEXACO FILLMORE	1-14-92	—	6600-063-400	—

Performed: G. Zeronian
Checked: JWR

I MASS OF BTEX IN GROUNDWATER (WITH ADDED MASS FROM SOILS)

(1) BASED ON SOIL AND GROUNDWATER ANALYTICAL DATA, A MAJOR MASS OF LEACHABLE BTEX COMPOUNDS WAS NOT FOUND AT THE FILLMORE SITE. TO DETERMINE THE REMEDIAL TIMEFRAME FOR IN-SITU BIOREMEDIATION, AN ESTIMATE OF TOTAL MASS OF BTEX, INCLUDING LEACHABLE BENZENE WAS PERFORMED.

ASSUMPTIONS: A) AVG. GROUNDWATER BTEX CONCENTRATION WAS OVERESTIMATED AT 1ppm (UEL CONCENTRATIONS FROM RISK ASSESSMENT TOTAL ≈ 10 mg/l BTEX)

B) AVG. POTENTIAL LEACHABLE MASS WILL BE APPROXIMATELY ~~[illegible]~~ 10 TIMES THE GROUNDWATER CONCENTRATION (AGAIN AN OVERESTIMATE BASED ON MINIMUM LEACHABLE BENZENE DETECTED DURING THE RI)

C) INFILTRATION = EXTRACTION VOLUME (20 gpm NORTH PLUME & 30 GPM SOUTH PLUME)

THUS:

NORTH PLUME

a) $1 \text{ mg/l} \times \frac{3.78 \text{ l}}{\text{Gal}} \times 13{,}600{,}000 \text{ gal} = 51{,}408{,}000 \text{ mg BTEX} \approx$

GROUNDWATER MASS – 51 Kg BTEX

Soil Mass — $51 \text{ kg} \times 10 = 510 \text{ Kg BTEX}$

TOTAL MASS = 510 kg + 51 kg = 561 kg BTEX

b) $561 \text{ Kg} \times 7.5 \text{ kg } O_2 / \text{Kg BTEX} = 4208 \text{ Kg } O_2$ (required)

Title	Date	Dwg.	Project	Proposal
Texaco Fillmore	1-14-92	—	6600-063 -400	—

@ 10 ppm O2

c) $\frac{4208 \text{ kg } O_2}{10 \times 10^{-6} \text{ kg } O_2/\ell} \times 1 \text{ gal}/3.78\ell = 111,322,751 \text{ gal}$

Say 111,000,000 gal

@ 200 ppm O2

$\frac{4208 \text{ kg } O_2}{200 \times 10^{-6} \text{ kg } O_2/\ell} \times 1 \text{ gal}/3.78\ell = 5,566,138$

Say 5,600,000 gal

d) $\frac{111,000,000 \text{ gal}}{20 \text{ gpm}} = 5550000 \text{ min}/1440 \text{ min/day}/365 \text{ day/yr} = 10.56 \text{ yrs}$

Say 10.6 yrs @ 10 ppm

$\frac{5,600,000 \text{ gal}}{20 \text{ gpm}} = 280,000 \text{ min}/1440 \text{ min/day}/365 \text{ day/yr} = 0.53 \text{ yrs}$

Say 0.5 yrs @ 200 ppm

Title	Date	Dwg.	Project	Proposal
TEXACO FILLMORE	1-14-92	—	6600-063-400	

SOUTH PLUME

a) $1\ mg/l \times \frac{3.78\ l}{gal} \times 55{,}000{,}000\ gal = 207{,}900{,}000\ mg$ BTEX

GROUNDWATER MASS - Say 208 Kg BTEX

SOIL mass - $208\ kg \times 10 = 2080\ kg$

TOTAL MASS = 2288 Kg ~~say 2300 Kg~~

b) $2288\ kg \times 7.5\ kg\ O_2/kg\ BTEX = 17{,}160\ kg\ O_2$ Required

c) @ 10 ppm

$$\frac{17{,}160\ kg\ O_2}{10 \times 10^{-6}\ kg\ O_2/l} \times 1\ gal/3.78\ l = 453{,}968{,}254\ gal\ H_2O$$

SAY 454,000,000 gal H_2O

@ 200 ppm

$$\frac{17{,}160\ kg\ O_2}{200 \times 10^{-6}\ kg\ O_2/l} \times 1\ gal/3.78\ l = 22{,}698{,}841\ gal$$

Say 22,700,000

d) $\frac{454{,}000{,}000}{30\ gpm} = 28.8$ years @ 10 ppm.

$\frac{22{,}700{,}000}{30} = 1.44$ years @ 200 ppm

Title	Date	Dwg.	Project	Proposal
TEXACO FILLMORE	1-14-97	—	6600-063-400	—

(4) @ 10 X Concentration

b) $\frac{5\ \mu g/l}{7200\ \mu g/l} = e^{-kt}$

c) $0.000694 = e^{-0.006t}$

d) $\ln(0.000694) = \ln(e^{-0.006t})$

e) $-7.27 = -0.006t$

f) $t = \frac{-7.27}{-0.006} = 1{,}212$ days $= 3.3$ years

3.3 < 5 years

Remediation within 5 years is likely

APPENDIX E

COST ESTIMATES

FILLMORE SITE

Capital Costs Estimate

Description	Unit Cost Method				Material and Labor Method								
Alternative 2 Continued Op.					Material				Labor				Capital Costs
	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	
Sampling Plan	1	ls	5000.00	5,000				0				0	5,000
Surface Grading	1	ls	50000.00	50,000				0				0	50,000
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
Subtotal				55,000				0				0	55,000
Contingency													
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
Total				55,000				0				0	55,000

TEXACO FILLMORE

Capital Cost and Present Worth Summary

Description	Capital Costs				Annual Operation Maintenance Cost	Present Worth of Operating Cost Over Project Life					
Alternative 2 Continued Operations	Quantity	Unit	Unit Price	Cost		n	7%	n	7%	n	7%
TOTAL CAPITAL COSTS	1	ls	55000.00	55000	0		0		0		0
TOTAL ANNUAL O&M COSTS				0	120000	5	492024	15	1092950	30	1489085
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
TOTAL				55000	120000		492024		1092950		1489085

TEXACO FILLMORE

Capital Costs Estimate

Description	Unit Cost Method				Material and Labor Method								
Alternative 3 Clay CAP					Material				Labor				Capital Costs
	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	
grading	11000	sy	2.00	22,000				0				0	22,000
2' clay cap	7407	cy	15.00	111,105				0				0	111,105
1' cover layer	3703	cy	10.00	37,030				0				0	37,030
6" topsoil	1851	cy	18.00	33,318				0				0	33,318
vegetation	11000	sy	0.35	3,850				0				0	3,850
fencing		lf	8.00	0				0				0	0
gate		ea	820.00	0				0				0	0
backfill(native)		cy	2.00	0				0				0	0
backfill(borrow)	50000	cy	7.00	350,000				0				0	350,000
land aquisition		ls	10000.00	0				0				0	0
monitoring wells		ea	8000.00	0				0				0	0
grading	11000	sy	2.00	22,000				0				0	22,000
				0				0				0	0
				0				0				0	0
				0				0				0	0
Subtotal				579,303				0				0	579,303
Contingency													
bid/scope	40%			231,721				0				0	231,721
health & safety	3%			17,379				0				0	17,379
Mobil/Demobil.	3%			17,379				0				0	17,379
legal/permits	5%			28,965				0				0	28,965
Constr. Admin/Su	10%			57,930				0				0	57,930
Engin & Design	6%			34,758				0				0	34,758
Total				967,436				0				0	967,436

TEXACO FILLMORE

Capital Cost and Present Worth Summary

Description	Capital Costs				Annual Operation Maintenance Cost	Present Worth of Operating Cost Over Project Life					
Alternative 3 Clay cap	Quantity	Unit	Unit Price	Cost		n	7%	n	7%	n	7%
TOTAL CAPITAL COSTS	1	ls	967436.00	967436	0		0		0		0
TOTAL ANNUAL O&M COSTS				0	140000	5	574028	15	1275108	30	1737266
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0		30	0	30	0	30	0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
TOTAL				967436	140000		574028		1275108		1737266

FILLMORE SITE

Capital Costs Estimate

Description	Unit Cost Method				Material and Labor Method								
					Material				Labor				
Alternative 4 PUMP & TREAT	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	Capital Costs
EXTRACTION WELLS	5	EA	30000.00	150,000				0				0	150,000
PIPING	3000	LF	5.00	15,000				0				0	15,000
SURGE TANK	1	LS	50000.00	50,000				0				0	50,000
CARBON UNITS	2	LS	40000.00	80,000				0				0	80,000
BUILDING	1	LS	50000.00	50,000				0				0	50,000
DISCHARGE PIPE	250	LF	7.00	1,750				0				0	1,750
PUMPS	2	LS	2500.00	5,000				0				0	5,000
CONTROLS/ELECTRI	1	LS	20000.00	20,000				0				0	20,000
				0				0				0	0
				0				0				0	0
NPDES PERMIT	1	LS	15000.00	15,000				0				0	15,000
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
Subtotal				386,750				0				0	386,750
Contingency													
BID/SCOPE	25%			96,688				0				0	96,688
MOB/DEMOB	5%			19,338				0				0	19,338
H&S	3%			11,603				0				0	11,603
ENG/DESIGN	10%			38,675				0				0	38,675
				0				0				0	0
				0				0				0	0
Total				553,053				0				0	553,053

FILLMORE SITE

Operations, Maintenance, and Replacement
Cost Estimate

Description	Unit Cost Method				Material and Labor Method								Annual Operation Maintanance Cost	Present Worth of Op. Cost Over Project Life	
					Material				Labor						
Alternative 4 PUMP & TREAT	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost		n	7%
ELECTRIC				0	12	MO	500.00	6000				0	6000		0
CARBON EXCHANGE				0	10000	3	1.00	10000				0	10000		0
O&M				0	12	MO	500.00	6000	400	HRS	40.00	16000	22000		0
SAMPLE/ANALITICA	4	QTR	30000.00	120000				0	12	MO	5000.00	60000	180000		0
NPDES SAMPLING	12	MO	1600.00	19200				0				0	19200		0
				0				0				0	0		0
				0				0				0	0		0
				0				0				0	0		0
				0				0				0	0		0
				0				0				0	0		0
				0				0				0	0		0
				0				0				0	0		0
				0				0				0	0		0
				0				0				0	0		0
				0				0				0	0		0
Subtotal				139200				22000				76000	237200		0

FILLMORE SITE

Capital Cost and Present Worth Summary

Description	Capital Costs				Annual Operation Maintenance Cost	Present Worth of Operating Cost Over Project Life					
Alternative 4 GW Extract. with GAC Adsorption	Quantity	Unit	Unit Price	Cost		n	7%	n	7%	n	7%
TOTAL CAPITAL COST	1	LS	553053.00	553053	0	2	0	2	0	2	0
TOTAL ANNUAL O&M COSTS				0	237200	3	622488	15	2160397	30	2943425
				0	0	2	0	2	0	2	0
				0	0	2	0	2	0	2	0
				0	0	2	0	2	0	2	0
				0	0	2	0	2	0	2	0
				0	0	2	0	2	0	2	0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
TOTAL				553053	237200		622488		2160397		2943425

FILLMORE SITE

Capital Costs Estimate

Description	Unit Cost Method				Material and Labor Method								
					Material				Labor				
Alternative 5 INSITUBIO W/ GAC	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	Capital Costs
EXTRACTION WELLS	5	LS	30000.00	150,000				0				0	150,000
EXTRACTIUON PIPI	3000	LF	5.00	15,000				0				0	15,000
MIX TANK	1	LS	5000.00	5,000				0				0	5,000
NUTRIENT FEED	1	LS	5000.00	5,000				0				0	5,000
PEROX FEED	1	LS	5000.00	5,000				0				0	5,000
BUILDING	1	LS	60000.00	60,000				0				0	60,000
DISCHARGE PIPE	3000	LF	5.00	15,000				0				0	15,000
DISCHARGE PUMP	1	LS	1500.00	1,500				0				0	1,500
INFIL GALLERIES	1	LS	50000.00	50,000				0				0	50,000
INJECTION WELS	5	LS	15000.00	75,000				0				0	75,000
CONTROLS/ELECT	1	LS	15000.00	15,000				0				0	15,000
CARBON UNITS	2	EA	40000.00	80,000				0				0	80,000
TREAT STUDY	1	LS	30000.00	30,000				0				0	30,000
INJECT PERMIT	1	LS	10000.00	10,000				0				0	10,000
				0				0				0	0
Subtotal				516,500				0				0	516,500
Contingency													
BID/SCOPE	25%			129,125				0				0	129,125
MOB/DEMOB	5%			25,825				0				0	25,825
H&S	3%			15,495				0				0	15,495
ENG/DESIGN	20%			103,300				0				0	103,300
				0				0				0	0
				0				0				0	0
Total				790,245				0				0	790,245

FILLMORE SITE

Operations, Maintenance, and Replacement
Cost Estimate

Description	Unit Cost Method				Material and Labor Method											
					Material				Labor				Annual Operation Maintanance Cost	Present Worth of Op. Cost Over Project Life	
Alternative 5 INSITUBIO W/ GAC	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost		n	7%
ELECTRIC				0	12	MO	800.00	9600				0	9600		0
NUTRIENTS/PEROXI				0	12	MO	1000.00	12000				0	12000		0
CARBON EXCHANGE				0	10000	MO	1.00	10000				0	10000		0
O&M				0	12	MO	500.00	6000	1000	HR	40.00	40000	46000		0
SYSTEM SAMPLING				0				0	12	MO	8500.00	102000	102000		0
SAMPLE/ANALYTICA				0				0	4	QTR	30000.00	120000	120000		0
				0				0				0	0		0
				0				0				0	0		0
				0				0				0	0		0
				0				0				0	0		0
				0				0				0	0		0
				0				0				0	0		0
				0				0				0	0		0
				0				0				0	0		0
				0				0				0	0		0
Subtotal				0				37600				262000	299600		0

FILLMORE SITE

Capital Cost and Present Worth Summary

Description	Capital Costs				Annual Operation Maintenance Cost	Present Worth of Operating Cost Over Project Life					
Alternative 5 IN-SITU BIO W/GAC	Quantity	Unit	Unit Price	Cost		n	7%	n	7%	n	7%
TOTAL CAPITAL COST	1	LS	790245.00	790245	0		0		0		0
TOTAL ANNUAL O&M COSTS				0	299600	2	541682	0	0	30	3717749
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
TOTAL				790245	299600		541682		0		3717749

FILLMORE SITE

Capital Costs Estimate

Description	Unit Cost Method				Material and Labor Method								
					Material				Labor				
Alternative 6 P&T W/ VAPOR EXT	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	Capital Costs
ALT3 P&T SYSTEM	1	LS	386750.00	386,750				0				0	386,750
				0				0				0	0
SVE WELLS	15	EA	8000.00	120,000				0				0	120,000
INDUCTION WELLS	15	EA	4000.00	60,000				0				0	60,000
PIPING	5000	FT	5.00	25,000				0				0	25,000
VACUUM PUMP	1	LS	50000.00	50,000				0				0	50,000
CARBON UNITS	2	EA	25000.00	50,000				0				0	50,000
VAPOR BARRIER	100000	SFT	0.10	10,000				0				0	10,000
				0				0				0	0
0													
AIR PERMIT	1	LS	20000.00	20,000				0				0	20,000
TREAT TEST	1	LS	30000.00	30,000				0				0	30,000
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
Subtotal				751,750				0				0	751,750
Contingency													
BID/SCOPE	25%			187,938				0				0	187,938
MOB/DEMOB	5%			37,588				0				0	37,588
H&S	3%			22,553				0				0	22,553
ENG/DESIGN	10%			75,175				0				0	75,175
				0				0				0	0
				0				0				0	0
Total				1,075,003				0				0	1,075,003

FILLMORE SITE

Operating and Maintenance Costs

Description	Unit Cost Method				Material and Labor Method								
Alternative 6 GW P&T W/ VAPOR EXTRACT.					Material				Labor				O & M Costs
	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	
GW P&T SYSTEM	1	LS	237200.00	237,200				0				0	237,200
				0				0				0	0
SVE SYSTEM:				0				0				0	0
electric				0	12	mo	1500.00	18,000				0	18,000
carbon exch.				0	50,000	lbs	1.00	50,000				0	50,000
O&M				0	12	mo	500.00	6,000	800	hr	30.00	24,000	30,000
air mon.				0	12	mo	2000.00	24,000				0	24,000
				0				0				0	0
GW Monitoring	4	QTR	30000.00	120,000				0				0	120,000
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
Subtotal				357,200				98,000				24,000	479,200

FILLMORE SITE

Capital Cost and Present Worth Summary

Description	Capital Costs				Annual Operation Maintenance Cost	Present Worth of Operating Cost Over Project Life					
Alternative 6 GW P&T W/ VAPOR EXTRACT.	Quantity	Unit	Unit Price	Cost		n	7%	n	7%	n	7%
TOTAL CAPITAL COST	1	LS	1075003.00	1075003	0		0		0		0
TOTAL ANNUAL O&M COSTS				0	479200	3	1257572	15	4364512	30	5946413
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
TOTAL				1075003	479200		1257572		4364512		5946413

FILLMORE SITE

Capital Costs Estimate

Description	Unit Cost Method				Material and Labor Method								
Alternative 7 GW In-situ Bio w/SVE					Material				Labor				Capital Costs
	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	
EXTRACTION WELLS	5	EA	30000.00	150,000				0				0	150,000
EXTRACTION PIP.	3000	LF	5.00	15,000				0				0	15,000
MIX TANK	1	LS	5000.00	5,000				0				0	5,000
NUTRIENT FEED	1	LS	5000.00	5,000				0				0	5,000
PEROX FEED	1	LS	5000.00	5,000				0				0	5,000
BUILDING	*1*	*LS*	*60000.00*	*60,000*				*0*				*0*	*60,000*
DISCHARGE PIPE	3000	LF	5.00	15,000				0				0	15,000
DISCHARGE PUMP	1	LS	1500.00	1,500				0				0	1,500
INFIL GALLERIES		LS		0				0				0	0
INJECTION WELLS	5	EA	15000.00	75,000				0				0	75,000
CONTROLS/ELEC	1	LS	15000.00	15,000				0				0	15,000
CARBON UNITS	2	EA	40000.00	80,000				0				0	80,000
TREAT. STUDY	1	LS	30000.00	30,000				0				0	30,000
INJECT PERMIT	1	LS	10000.00	10,000				0				0	10,000
SVE SYSTEM	1	LS	365000.00	365,000				0				0	365,000
Subtotal				831,500				0				0	831,500
Contingency													
BID/SCOPE	25%			207,875				0				0	207,875
MOB/DEMOB	5%			41,575				0				0	41,575
H&S	3%			24,945				0				0	24,945
ENG/DESIGN	20%			166,300				0				0	166,300
				0				0				0	0
				0				0				0	0
Total				1,272,195				0				0	1,272,195

FILLMORE SITE

Operating and Maintenance Costs

Description	Unit Cost Method				Material and Labor Method								
Alternative 7 GW IN-SITU BIO W/ SVE					Material				Labor				O & M Costs
	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	Quantity	Unit	Unit Price	Cost	
GW IN-SITU BIO	1	YR	299600.00	299,600				0				0	299,600
SVE SYSTEM	1	YR	122000.00	122,000				0				0	122,000
GW MONITORING	4	QTR	30000.00	120,000				0				0	120,000
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
				0				0				0	0
Subtotal				541,600				0				0	541,600

FILLMORE SITE

Capital Cost and Present Worth Summary

Description	Capital Costs				Annual Operation Maintenance Cost	Present Worth of Operating Cost Over Project Life					
Alternative 7 GW IN-SITU BIO W/ SVE	Quantity	Unit	Unit Price	Cost		n	7%	n	7%	n	7%
TOTAL CAPITAL COSTS	1	LS	1272195.00	1272195	0		0		0		0
TOTAL ANNUAL O&M COSTS				0	541600	1	506168	0	0	30	6720737
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
				0	0		0		0		0
TOTAL				1272195	541600		506168		0		6720737

APPENDIX F

ANTICIPATED REDUCTION OF RISK FROM BENZENE

Title: ESTIMATED REDUCTION OF RISK

Date: 1-15-92

Dwg.

Project: FILLMORE

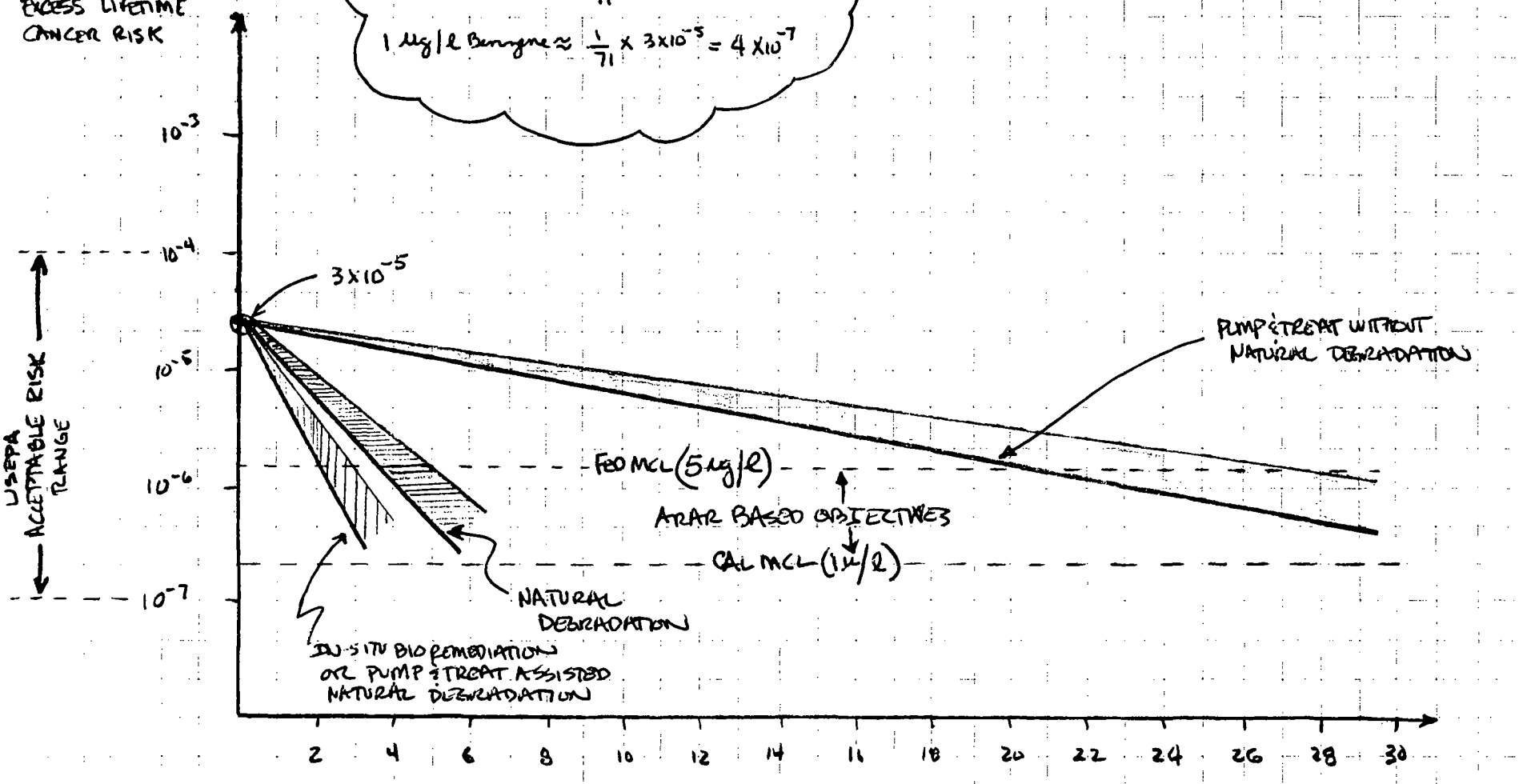
Proposal

ANTICIPATED REDUCTION OF RISK FROM BENZENE (1)

71 µg/l Benzene ≈ 3×10^{-5} risk (2)

5 µg/l Benzene ≈ $\frac{5}{71} \times 3 \times 10^{-5} = 2 \times 10^{-6}$

1 µg/l Benzene ≈ $\frac{1}{71} \times 3 \times 10^{-5} = 4 \times 10^{-7}$



(1) Based on estimated remedial timeframes to achieve ARARS for Benzene in groundwater

(2) Based on Baseline Risk Assessment

ESTIMATED TIME TO ACHIEVE ARARS

ALT 1 ..... 5 YRS
ALT 2 ..... 5 YRS
ALT 3 ..... 5 YRS
ALT 4 ..... 3 to 30 YRS
ALT 5 ..... 3 YRS
ALT 6 ..... 3 to 30 yrs
ALT 7 ..... 3 yrs

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