RESNA
Working To Restore Nature

3315 Almaden Expressway, Suite 34
San Jose, CA 95118
Phone: (408) 264-7723
FAX: (408) 264-2435

TRANSMITTAL

CALIFORNIA REGIONAL WATER
JUL 16 1993
QUALITY CONTROL BOARD

TO: Mr. Eddy So
Regional Water Quality Control Board
San Francisco Bay Region
2101 Webster Street, Suite 500
Oakland, CA 94612

DATE: July 15, 1993
PROJECT NUMBER: 69028.09
SUBJECT: ARCO Station No. 6113

FROM: Valli Voruganti

WE ARE SENDING YOU:

COPIES	DATED	DESCRIPTION
1	7/15/93	Final Remedial Action Plan for Interim Soil and Groundwater Remediation at ARCO Station No. 6113, 785 E. Stanley Boulevard, Livermore, California.

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REMARKS:
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Valli Voruganti, Project Engineer

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San Jose, CA 95118
Phone: (408) 264-7723
FAX: (408) 264-2435

TRANSMITTAL

TO: Ms. Susan Hugo
Alameda County Health Care Services
80 Swan Way, Room 200
Oakland, CA 94621

DATE: July 15, 1993
PROJECT NUMBER: 69028.09
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REMEDIAL ACTION PLAN
for
INTERIM SOIL AND GROUNDWATER REMEDIATION
at
ARCO Station 6113
785 E. Stanley Boulevard
Livermore, California

69028.09 01-119

Report prepared for JUL 1993

ARCO Products Company
P.O. Box 5811
San Mateo, California 94402

by
RESNA Industries Inc.

Valli Voruganti
Project Engineer

John C. Young (SA)
Project Manager

Bruce Maeda, P.E.
Project Engineer

July 15, 1993

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FAX: (408) 264-2435

REMEDIAL ACTION PLAN
for
INTERIM SOIL AND GROUNDWATER REMEDIATION
at
ARCO Station 6113
785 E. Stanley Boulevard
Livermore, California

For ARCO Products Company

INTRODUCTION

As requested by ARCO Products Company (ARCO), RESNA Industries Inc. (RESNA) has prepared this Remedial Action Plan (RAP) for the interim remediation of onsite hydrocarbon-impacted soils and groundwater at ARCO Station 6113 located at 785 E. Stanley Boulevard in Livermore, California. This RAP includes a conceptual design for a combination vapor extraction system (VES) with either air sparging or groundwater extraction and treatment, and has been prepared for review, comment and approval by the California Regional Water Quality Control Board (CRWQCB) and the Alameda County Health Care Services Agency (ACHCSA), prior to installation and operation of the proposed systems. The subject site, ARCO Station 6113 is located at the southwestern corner of E. Stanley Boulevard and Murietta Boulevard in Livermore, California, as shown on the Site Vicinity Map, Plate 1. The location of the existing monitoring wells, vapor extraction wells, station building, underground storage tanks (USTs) and other pertinent features are shown on Plate 2, Generalized Site Plan.

The proposed scope of work under this RAP consists of the installation of one air sparging well, performance of an air sparging test, and the engineering design, permitting, construction, and start-up of a combination VES and groundwater remediation system at the subject site. The proposed remediation system is intended to serve as an interim remedial measure for onsite hydrocarbon-impacted soils and groundwater beneath the site.

SITE DESCRIPTION AND BACKGROUND

General

ARCO Service Station 6113 is an operating retail gasoline service station and mini-mart located at the southwestern corner of E. Stanley Boulevard and Mureitta Boulevard in Livermore, California, as shown on Plate 1, Site Vicinity Map. The site is located in an area of commercial and residential development, and is a predominantly asphalt- and concrete-covered lot at an elevation of approximately 457 feet above mean sea level. The site is bounded by E. Stanley Boulevard to the north, Murrieta Boulevard to the east, and the Arroyo Mocho Creek to the south and west. An operating Shell Service Station is located on the southeastern corner of E. Stanley Boulevard and Mureitta Boulevard.

Underground Storage Tanks

Two double-wall and one single wall 12,000-gallon gasoline USTs are present on the site. On January 26, 1989, prior to RESNA's involvement with the site, a 280 gallon waste-oil storage tank was excavated and removed from the site (Pacific Environmental Group, April 25, 1989). The former waste-oil tank location is covered by a large concrete utility-pad. From December 1992 through March 1993, Wilkey's Engineering (Wilkey) of Pleasant Grove, California, under the supervision of Roux Associates, removed and replaced existing product, vapor return and vent lines. In conjunction with this work, the abandoned pump island facing Murietta Boulevard was placed back into operation, and subgrade remediation piping for the interim VES and groundwater remediation system was installed (Roux Associates, May 7, 1993). The approximate locations of the existing USTs, former waste-oil tank, and pertinent station facilities are shown on Plate 2, Generalized Site Plan.

Regional Geology and Hydrogeology

The site is located in the Livermore Valley, which is an intermontane valley in the Coast Ranges Geomorphic Province. The valley is approximately 13 miles long in an east-west direction and is four miles wide. The valley is surrounded by hills of the Diablo Range (California Department of Water Resources, 1974). The valley floor slopes gently toward the west. The principal streams in the area are the Arroyo Valley and Arroyo Mocho, which flow toward the western end of the valley. Arroyo Mocho is located approximately 50 feet south-southwest of the site.

Livermore Valley is underlain by non-water-bearing rocks, water-bearing units, and sediments. The water-bearing units and sediments comprise the Livermore Valley groundwater basin. Water-bearing units include the Tassajara Formation, the Livermore Formation, and valley-fill materials (California Department of Water Resources, 1966, 1974). The Livermore Valley groundwater basin is divided into sub-basins on the basis of fault traces or other hydrologic discontinuities (California Department of Water Resources, 1974). The groundwater system in Livermore Valley is a multilayered system with an unconfined aquifer overlying a sequence of leaky or semiconfined aquifers. Groundwater in the basin flows downslope toward the east-west-trending axis of the valley and then flows generally to the west (Alameda County Flood Control and Water Conservation District - Zone 7, 1991).

PREVIOUS ENVIRONMENTAL WORK

The results of previous environmental investigations performed at this site are included in the reports listed in the references section at the end of this report.

Vapor Extraction Test

A one-day vapor extraction test (VET) was performed at the site on August 11, 1992 (RESNA, August 1992). The results of this test suggest that vapor extraction may be a practical and cost effective soil remediation alternative at this site. The VET was performed on vapor extraction wells VW-1 and VW-2, screened in the middle zone soils (26 to 45 feet below grade surface [bgs]) and monitoring well MW-5 screened in the deeper zone soils (43 feet bgs and below). Vapor extraction wells VW-1 and VW-2 were dry during the test, while monitoring well MW-5 had approximately 14 feet of exposed screen above the groundwater table. The shallower zone soils 26 ft bgs and above were not tested due to the lack of an extraction well in the vicinity of the USTs (Monitoring well MW-4 was not be accessible during the test).

Applied vacuums of 35 to 50 inches water column (W.C.) were required on VW-1 and VW-2 to remove hydrocarbon-bearing vapor from the middle vadose zone soils beneath the site. Based upon a wellhead vacuum of 50 inches W.C. and an air flow rate of 48 standard cubic feet per minute (scfm), an effective radius of influence (R.O.I) of 15 to 20 feet was projected for vapor extraction wells VW-1 and VW-2.

Applied vacuums of 20 to 30 inches water column (W.C.) were required to remove hydrocarbon-bearing vapor from MW-5 screened in the deeper zone subsurface soils 43 feet bgs and below at the site. Based upon a wellhead vacuum of 20 inches W.C. and an air flow rate of 28 scfm, an effective R.O.I of 75 feet was projected for vapor extraction well MW-5. This estimate assumes at least 10-feet of exposed screen above the water table.

Analytical results of air samples collected during the VET after 35 minutes from VW-1 indicated total petroleum hydrocarbons as gasoline (TPHg) concentrations of 45,000 milligrams per cubic meter (mg/m^3). Analytical results from VW-2 indicated that concentrations of TPHg in extracted vapor decreased from 52,000 mg/m^3 after 30 minutes of vapor extraction to 37,000 mg/m^3 after 120 minutes (a decrease of 28 percent). TPHg concentrations in extracted vapor from MW-5 during the VET averaged 130,000 mg/m^3. Comparing vapor-phase benzene concentration as a percent of TPHg for all the wells indicated that benzene on average comprised approximately 1.1 percent of the vapor-phase TPHg concentration. The results of field monitoring data, laboratory analysis of air samples, estimated R.O.I's and hydrocarbon extraction rates are summarized in Tables 1, 2 and 3.

Ongoing Additional Subsurface Investigation

In accordance with proposed work steps outlined in Addendum Two to Work Plan submitted to ACHCSA, RESNA has installed the proposed onsite monitoring well MW-10 and the offsite monitoring wells MW-11 and MW-12 in March 1993 (RESNA, December 1992). Plate 2 depicts the location of these wells. Proposed onsite vapor extraction wells VW-3 and VW-4 screened 15 to 24 feet bgs and 17 to 30 feet bgs, respectively, were installed in June 1993. Proposed vapor extraction well VW-5 was not installed in boring B-15 due to the lack of any visual evidence of permeable soils in the boring and the lack of measurable organic vapor concentrations in the soils as monitored with a photo-ionization detector (PID). A report on the initial offsite and additional onsite investigation detailed above is currently in progress and will be submitted for review and approval by August 15, 1993.

As agreed to in the May 19, 1993, meeting between ARCO, RESNA and ACHCSA personnel, in lieu of performing the proposed aquifer pump and recovery test presented in Addendum Two to Work Plan air sparging wells will be installed and an air sparging test will be performed (RESNA, June 7, 1993). A Work Plan for installation of the air sparging wells will be submitted for review and approval to ACHCSA by July 15, 1993, as agreed to at the May 19, 1993, meeting (RESNA, June 7, 1993).

SUMMARY OF SOIL AND GROUNDWATER CONTAMINATION

Extent of Hydrocarbon Impacted Soil

The presently interpreted extent of hydrocarbon impacted soil beneath the site is presented on the Geologic Cross Sections, Plates 3 through 8 and TPHg Concentrations in Soil Contours, Plates 9 through 11. Plate 3 shows the locations of geologic cross sections. Earth materials encountered at this site consist primarily of silty clay to gravelly silt interbedded with discontinuous layers of clayey to sandy gravel and clayey sand. These discontinuous layers extend across the site and divide the subsurface soils in the vicinity of the USTs into three approximate zones: a shallow zone occurring at approximate depths of 16 to 28 feet bgs; a middle zone at depths of 26 to 45 feet bgs; and a deeper zone occurring at approximate depths of 43 to 70 feet bgs.

The majority of gasoline hydrocarbons in the soil appear to be concentrated in the northeastern portion of the site in the immediate vicinity of the active gasoline UST pit at depths of 20 to 50 feet bgs. The highest concentrations in soils have been encountered at a depth of 20 feet in monitoring well MW-5 in the clayey to sandy gravel shallow vadoze zone soils. Small but measurable concentrations of TPHg ($\geq$ 100 parts per million [ppm]) have been encountered in middle zone at approximate depths of 40 feet bgs. The lateral extent of gasoline hydrocarbons in the soil at the site has been delineated to less than 1 ppm except west and northwest of the active gasoline-UST pit. The vertical extent of gasoline hydrocarbons in the soil at the site has been delineated to concentrations below 1 ppm TPHg at depths of approximately 50 feet bgs. Cumulative results of laboratory analyses of soil samples are included in Table 4.

Extent of Hydrocarbon Impacted Groundwater

The lateral extent of gasoline hydrocarbons in the groundwater has been delineated to nondetectable concentrations of TPHg (less than 50 ppb), except in the northeastern and northwestern vicinity of the site. The lateral extent of benzene in the groundwater has been delineated to nondetectable concentrations (less than 5 ppb) in the southern, eastern, northwest and southeast portions of the site. Plates 12 and 13, respectively, depict TPHg and benzene concentrations in groundwater based upon the most recent quarterly sampling event conducted on March 30, 1993 (Tables 5 and 6). The highest TPHg and BTEX concentrations in groundwater appear to be west and north of the active gasoline-storage tank pit (northeastern portion of the site). Free product sheen has been observed intermittently in monitoring well MW-6 since September 1992, although no floating product was observed in the sample collected from this well for the subjective analyses during the March monitoring event. No visual evidence of floating product or product sheen has been observed in other wells during first quarter 1993. The groundwater beneath the site appears not to be impacted by waste-oil related hydrocarbons, based on the analytical results from monitoring well MW-8, located next to the former waste oil tank (Table 6).

Groundwater Gradient

Cumulative depth to water (DTW) measurements, wellhead elevations, groundwater elevations, and subjective observations of floating product in the groundwater for this and previous quarterly monitoring events at the site are summarized in Table 7 Cumulative Groundwater Monitoring Data.

The interpreted groundwater gradient from the March 30, 1993 monitoring event is shown on the Groundwater Gradient Map, Plate 14. The average local groundwater gradient interpreted for the most recent quarter was approximately 0.1 ft/ft, with flow directions toward the northwest in January and February, and toward the north in March 1993.

Groundwater elevations in the shallow zone monitoring well MW-4 increased an average of 7 feet since fourth quarter 1992 (DTW decreased from 27 ft bgs to 20 ft bgs). Groundwater elevations in monitoring wells MW-1, MW-2, and MW-3 screened in the middle vadose zone soils (26 to 45 ft bgs) increased an average of 9 feet since the fourth quarter 1992 (DTW decreased from 30 ft bgs to 20 ft bgs). Groundwater elevations in monitoring wells MW-5 through MW-9 screened in the deeper capillary fringe soils (43 ft bgs and below) increased an average of 40 feet since the fourth quarter 1992 (DTW decreased from 62 ft bgs to 20 ft bgs). The significant increases in groundwater elevations since fourth quarter 1992 appear to be the result of heavy precipitation during first quarter 1993.

Water table rise to 20 feet bgs was observed in all onsite monitoring wells, irrespective of the zone they were screened indicating that the interbedded discontinuous layers of clayey to sandy gravel and clayey sands across the site at different depth may now be interconnected.

DESCRIPTION OF PROPOSED INTERIM SOIL AND GROUNDWATER REMEDIATION SYSTEMS

The proposed VES and groundwater remediation system will function as an interim remedial measure for onsite hydrocarbon-impacted soils and groundwater beneath the site. Future work will include the installation of one air sparging well and performance of an air sparging test to evaluate the feasibility of air sparging to enhance the removal of hydrocarbons from both the adsorbed-phase (saturated soils) and dissolved-phase (groundwater). As agreed to in the May 19, 1993 meeting, a Work Plan for installation of the sparge wells and performance of an air sparge test will be submitted on July 15, 1993, for review and approval (RESNA, June 7, 1993).

If the results of the sparge test indicate that air sparging is an effective remediation alternative, the proposed interim soil and groundwater remediation systems will consist of a combined vapor extraction and air sparging system. Alternatively, in the event the air sparge test indicates that sparging is not feasible, the interim soil and groundwater remediation systems will consist of a vapor extraction system and groundwater extraction and treatment system.

Upon installation and operation of the systems, the adequacy of the systems to remediate hydrocarbon-impacted soils and groundwater beneath the subject site to acceptable regulatory levels for closure will be reassessed. The installation of additional vapor extraction wells, air sparging wells, or groundwater recovery wells may be necessary in the future, depending on site-specific conditions.

Interim VES System

The proposed interim VES will utilize four existing vapor extraction wells (VW-1 through VW-4), two existing monitoring wells MW-5 and MW-6, a vacuum blower, and an off-gas abatement system to address the majority of gasoline-impacted soils in the northeastern portion of the site, which generally exist between the 20 to 50 foot depths.

Based upon VET data, an effective R.O.I for the vapor extraction wells screened in the middle vadose zone soils (26 to 45 feet bgs) has been estimated to be approximately 15 to 20 feet (RESNA, December 21, 1992). An effective R.O.I of 75 feet has been estimated for vapor extraction well MW-5, screened in the deeper capillary fringe and saturated zone soils (40 feet bgs and below), provided at least 10-feet of exposed screen interval is present above the water table (RESNA, December 21, 1992). These estimates were based upon interpreted VET data for wellhead air flow rates of 48 and 28 scfm, respectively, and applied wellhead vacuums of 50 and 20 inches WC, respectively, in the middle vadose and deeper capillary fringe soils. Although no VET was conducted in the shallow vadose zone soils, RESNA anticipates an effective R.O.I of 30 feet at applied vacuums and wellhead air flow rates of 35 to 50 inches WC and 20 to 50 scfm, respectively, based on VET results in other zones.

Groundwater elevations since fourth quarter 1992, have risen an average of 7, 9, and 20 feet, respectively in shallow, middle and deeper zone monitoring wells (Table 7). As a result of these rises in groundwater elevations, vapor extraction wells VW-1, VW-2, MW-5 and MW-6 are flooded and no exposed screen is available for vapor extraction. Groundwater in shallow vadose zone wells VW-3 and VW-4 was encountered at 24 and 27 feet bgs but rose to 20 feet bgs, leaving only 3 to 5 feet of exposed screen interval available for vapor extraction at the present time. As a result of the rise in water table elevations, operation of the interim VES will be initiated with only the shallow vadose zone wells VW-3 and VW-4, operational. The middle and deeper zone vapor extraction wells (VW-1, VW-2, MW-5 and MW-6) will be brought online as water levels decrease.

Air samples collected from the three vapor extraction wells (VW-1, VW-2 and MW-5) contained relatively high TPHg concentrations ranging from 45,000 mg/m^3 from well VW-1 to 130,000 mg/m^3 from well MW-5. RESNA anticipates that initial TPHg concentrations in extracted vapor from shallow vadose zone vapor extraction wells will fall within the range of concentrations seen from vapor extraction wells VW-1, VW-2, and MW-5. These relatively high concentrations will initially require the addition of fresh-air dilution to meet manufacturer requirements for off-gas abatement equipment.

The interim VES will be operated under similar conditions seen during the VET in order to achieve the same estimated radius of influence for each well. Due to the high water table, the high hydrocarbon concentrations, and the number of vapor extraction wells at the site, the VES may be operated using individual wells or sets of vapor wells in sequence, rather than operating all wells concurrently. This approach should minimize the size and inherent operating costs for the off-gas abatement unit while still allowing the air flow from individual wells to be maximized.

The actual radius of influence for the vapor extraction wells will vary depending on subsurface geologic conditions, the extent and distribution of hydrocarbon-impacted soil, and site-specific operating conditions of the VES. The effective radius of influence should be evaluated following long-term operation of the VES.

Vapor Wellheads

To minimize interruption of business activities, subgrade remediaiton piping was installed in conjunction with product line removal and replacement conducted by Wilkey's Engineering in first quarter 1993 (Roux Associates, May 1993). Subgrade remediaiton piping and conduits for vapor extraction, groundwater recovery, and air sparging were installed from each vapor extraction well the proposed remediation compound location (Plate 2). Each vapor extraction well was equipped with wellhead piping consisting of a vacuum gauge, a sample port, and a shut-off valve so that flow through each well can be adjusted to maximize the total pounds of petroleum hydrocarbons being extracted from the soil. Well vaults boxes with traffic rated covers were installed at each vapor extraction well and at junction boxes for protection. To allow for future expansion, a limited number of additional vapor, groundwater recovery, and air sparging pipe stub-out connections were installed subgrade to facilitate the connection of future vapor extraction, groundwater recovery and air-sparging wells, if needed. Brass monument markers flushed to grade were placed above these stubout connections for visual identification. Collection system piping will transmit extracted vapor from the wells to the remediation compound. Subgrade gas and sewer pipes, and electric conduit were also installed from their respective onsite service points to the remediation compound.

VES Treatment Processes

Subsurface piping will direct extracted vapor from the wells to an off-gas abatement unit located at the remediation compound. Components of the VES located in the remediation compound will include: a vapor extraction blower that will extract vapor from the wells through the subgrade piping; a flow indicator that measures extracted flow; a condensate separator to remove entrained droplets of moisture; the off-gas abatement unit; a set of associated piping, control valves, instrumentation and controls; a remote monitoring system to transmit the status of process variables and any alarm or upset conditions; and a fenced remediation compound to preclude public access. Plate 15 depicts a process flow schematic for the proposed VES.

A 100 or a 250 cfm thermal/catalytic oxidizer is proposed to initially abate hydrocarbon vapors extracted from the vapor wells based on the high flows and high concentrations observed during the vapor extraction test. The location of the six existing wells are shown on Plate 16 of the attached report. A catalytic oxidizer is also a possible abatement alternative, however, the high initial influent concentrations would require dilution in order to reduce the influent concentrations to approximately 25 percent of the lower explosive limit (LEL), or per the manufacturers specifications. An evaluation of the most viable off-gas abatement device will be performed during the preliminary design phase of the VES and after a more detailed life cycle cost comparison of viable off-gas abatement alternatives is conducted. The off-gas abatement device will be replaced with an activated carbon adsorption system (two or three 1,200 pound carbon canisters in series) in the future when influent hydrocarbon concentrations decrease to approximately 100 ppmv or when it becomes cost effective and safe.

A remote monitoring system will be installed in the remediation compound to report alarm or shut-down conditions. When any alarm conditions are triggered the remote monitoring system will notify RESNA's San Jose office personnel so the condition can be rectified prior to system restart. A fire extinguisher and no smoking signs will also be installed in the remediation compound.

<u>Interim Groundwater Remediation System</u>

The proposed interim groundwater remediation system will either consist of an air sparging system or a groundwater extraction and treatment system, if air sparging is not feasible at the site.

Air Sparging

Air sparging involves the injection of compressed air into groundwater through air sparging wells which contain a 1 to 2 foot section of slotted screen, installed near the bottom of the water-bearing zone of concern. The injected air forms both bubbles and transient air pockets which rise up through the saturated soils to enhance the volatilization of both dissolved-phase hydrocarbons [in groundwater] and adsorbed-phase hydrocarbons [in saturated soils]. The hydrocarbon-bearing vapors exit the groundwater surface and rise into the vadose zone and/or capillary fringe soils where they are captured by an operating VES.

The advantage of air-sparging systems is that air sparging can reduce dissolved-phase hydrocarbons in groundwater more effectively than "pump-and-treat" systems alone. This increased hydrocarbon removal results from air-sparging reducing dissolved-phase hydrocarbons by direct volatilization within the water-bearing zone itself. By contrast, pump and treat systems require dissolved hydrocarbons to be hydraulically drawn toward the well for removal. The hydraulically-induced migration of groundwater toward the recovery well is often slow (depending on subsurface geology and hydrogeology), and is compounded by the retardation of dissolved hydrocarbons as they flow through soil. In addition, extracted groundwater typically only contains dissolved hydrocarbons at the low parts per million (ppm) or parts per billion (ppb) level. Consequently, in pump and treat systems, the net mass removal of hydrocarbons is typically low relative to the volumes of water removed. An additional advantage of air sparging is that it can often target the removal of the source; i.e., adsorbed-phase hydrocarbons in the saturated soil zone more effectively than groundwater pumping alone. Finally, since air sparging systems do not generally create a hydraulic capture zone, potential off-site contaminants from a second source may be less likely to be drawn toward the site.

A general concern regarding air sparging systems is the potential for the migration of the dissolved contaminant plume. This migration could potentially occur from artificial changes in the groundwater gradient caused by local increases in groundwater elevation as air is injected into the water-bearing zone [mounding]. The presence of relatively impermeable soil zones above the water surface can also restrict the vertical movement of sparge air, which could potentially drive the dissolved plume in a horizontal direction. The potential for these effects to occur will be evaluated during the air sparging test.

Air Sparge Well Installation / Air Sparge Testing

In order the evaluate the applicability of air sparging at the site, an air sparging test will be performed to determine: (1) the air flow rates and pressures required to inject air within the saturated soil zone; (2) whether air sparging causes increased vapor-phase hydrocarbon concentrations within the vadose zone; (3) the radius of pressure impact within the vadose zone; (4) whether geologic conditions restrict the vertical movement of sparge air in the vadose zone; and (5) the effects of air sparging on groundwater surface elevations.

The installation of one air sparging well has been proposed at the site. The proposed locations of this well is shown on Plate 16. Following installation of the sparge points, an air sparging test will be conducted to evaluate the feasibility of air sparging to reduce dissolved hydrocarbon concentrations in groundwater at the subject site. If air sparging is feasible, the design of the interim VES will be modified to incorporate additional air sparging wells or vapor extraction wells, as needed.

Installation of the air sparge well and the performance of an air sparging test is contingent upon water levels decreasing enough (to 50 feet bgs) to allow for capture of the sparge off-gas by vapor extraction wells. At the present time, all middle and deeper vadose zone wells are flooded rendering the wells incapable of capturing sparge off-gas generated as a result of sparging the deeper water bearing zone (43 feet bgs and below).

Interim Groundwater Extraction and Treatment System [optional]

If air sparging is not feasible, a groundwater extraction and treatment system will be installed to begin migration control of the on-site dissolved hydrocarbon plume. A Work Plan for installation of a recovery well and performance of an aquifer pump and recovery test will then be submitted for review and approval to ARCO, ACHCSA and CRWQCB, prior to design of the groundwater extraction and treatment system. Based on results of the pump test, an Addendum to the RAP for design of the groundwater extraction and remediation system will be submitted to ARCO, ACHCSA and CRWQCB for review and approval. The groundwater extraction and remediation system will then be designed, permitted, and installed to begin migration control of the on-site dissolved hydrocarbon plume. Treated groundwater is proposed to be discharged to the sanitary sewer under a discharge permit from the City of Livermore.

PROPOSED SCOPE OF WORK

Based on the results of previous subsurface investigations, RESNA proposes the following project Tasks 1 through 9 listed below, for interim remedial measures for soil and groundwater. These tasks outlined below are described in detail in ensuing sections:

- Task 1. Interim Remedial Action Plan
- Task 2. Air Sparging Feasibility Evaluation

- Task 3. Design of Plans and Specifications
- Task 4. Building and Discharge Permits
- Task 5. Bid Package and Evaluation
- Task 6. Equipment Procurement
- Task 7. Construction and Construction Inspection
- Task 8. System Startup and Operation
- Task 9. System Performance Evaluation

Task 1. Interim Remedial Action Plan

As requested by ARCO, RESNA will submit this Interim Remedial Action Plan (RAP) for the preliminary design and implementation of a VES and groundwater remediation system at this site for review and approval to the CRWQCB and ACHCSA prior to design, permitting, installation, and operation of the proposed remediation system. This RAP describes interim remedial measures to be implemented for onsite hydrocarbon-impacted soil and groundwater at the site, including the design, construction, and proposed operation, maintenance and monitoring of the interim VES to be installed at this site. Task timelines agreed upon by ARCO and the ACHCSA in a meeting on November 19, 1992 are included on Plate 17 of the attached report (RESNA, November 30, 1992). **Revised time deadlines established and agreed to by ARCO and ACHCSA at the May 19, 1993 meeting include a July 15, 1993, date for submission of this RAP and startup of the interim VES with at least the shallow vadose zone wells operational by January 1994 (RESNA, June 7, 1993).**

Task 2. Air Sparging Feasibility Evaluation

RESNA proposes to install one air sparge well, AS-1 at the location shown on Plate 16. Following installation of the sparge well, an air sparging test will be conducted to evaluate the feasibility of air sparging to reduce dissolved hydrocarbon concentrations in groundwater at the subject site. If air sparging is feasible, the design of the interim VES will be modified to incorporate additional air sparging wells or vapor extraction wells, if needed.

Task timelines agreed upon by ARCO and the ACHCSA in the May 19, 1993, meeting include submission of a Work Plan for installation of the sparge wells and performance of

a sparge test by July 15, 1993 (RESNA, June 7, 1993). **Installation of air sparging wells and the performance of an air sparging test is contingent upon water levels decreasing enough to allow for capture of the sparge off-gas by vapor extraction wells.** At the present time, all middle and deeper vadose zone wells are flooded rendering the wells incapable of capturing sparge off-gas generated as a result of sparging the deeper water bearing zone (43 feet bgs and below). **Hence, no time deadlines were established for installation of the air sparging wells, performance of an air sparging test, and installation of an interim groundwater remediation system at this site during this meeting (RESNA, June 7, 1993).**

No task timeliness were established for performance of an aquifer pump and recovery test and design, permitting and installation of a groundwater extraction and treatment system, if sparging is determined not to be a viable groundwater remedial alternative.

Task 3. Design of Plans and Specifications

This phase of the proposed work will include: engineering calculations; list of equipment, materials and instrumentation; preparation of Plans and Specifications including site and remediation compound layout, remediation compound equipment pad and fence details, trench and section details, and a process and instrumentation diagram (P&ID); in-house plan check and review; one set of minor revisions to the Plans and Specifications by ARCO; and one by the City of Livermore Building Department. Also under this task, RESNA personnel will meet with City of Livermore personnel to discuss City requirements in location of remediation compound and take site measurements. Under this phase of the work, evaluation of the most viable off-gas abatement device for the VES will be performed. After determining the off-gas abatement unit to be used, the vapor extraction blower will be selected.

The remediation compound layout and size will be designed to allow for enough room in the compound to house a groundwater remediation system at a later date (i.e., an air compressor, an equalization tank, carbon canisters, etc).

Task 4. Building and Discharge Permits (Optional)

An Authority to Construct and Permit to Operate application will be completed and submitted to the Bay Area Air Quality Management District (BAAQMD) to allow for construction and installation of the proposed interim VES. The application will include a site history, VES specifications, and analytical results for known and suspected pollutants.

The complete set of Plans and Specifications will also be submitted to the City of Livermore Building, Planning and Fire Departments for review, comment and approval prior to construction and installation of the interim VES and in the future a groundwater remediation system, if applicable. One set of minor revisions to the permits to incorporate regulatory agency comments is also planned.

If results of the sparge test indicate that air sparging is not an effective remedial alternative, a sewer discharge permit application will be prepared and submitted to the City of Livermore for installation of a groundwater extraction and treatment system. Treated groundwater will be discharged to the sanitary sewer under a discharge permit from the City of Livermore.

Task 5. Bid Package and Bid Evaluation

After the design is completed, a bid package will be prepared for submittal to bid for installation of the proposed interim VES. A minimum of three pre-qualified contractors will receive the bid package. One meeting with each contractor is included in the scope of work, as well as time to answer contractor questions and assist them in preparation of their bids. This will not be a publicly advertised Bid Period with sealed bids. Contractor bids will be evaluated and recommendations made for Award of Contract.

Task 6. Equipment Procurement

After engineering design is completed, permits have been obtained, and a contractor selected, RESNA will then provide ARCO with a list of long-lead capital equipment (greater than 4 weeks) to be ordered. Either ARCO or RESNA will directly order the equipment from the vendor. Possible capital equipment to be ordered include a 100 or 250 scfm thermal/catalytic oxidizer or catalytic oxidizer, a vapor extraction blower, and vapor phase carbon. Other equipment (valves, pipes, etc), and instrumentation will be purchased by the contractor.

Equipment for the air sparging system will be purchased if results of the sparge well installation and test indicate that air sparging is a viable remedial alternative. If air sparging is not an effective remedial alternative, equipment procurement will commence on completion of design and permitting of the groundwater extraction and treatment system.

Task 7. Construction and Construction Inspection

Upon approval of the interim RAP, after having secured the City Building, Fire and Planning Department Permits, BAAQMD air permit to construct, after selection of a general contractor, and after equipment procurement, system installation in accordance with the approved Plans and Specifications will be initiated. Construction will include: completion of wellhead piping connections to vapor extraction wells VW-3 and VW-4; pressure testing of lines; construction of the remediation compound; above-grade electrical service and natural gas hookup; and installation and plumbing of all process equipment (blower and off-gas abatement system) related to the interim VES. **Completion of construction and startup of the interim VES will commence in January 1994 as agreed upon by ARCO and the ACHCSA in a meeting on May 19, 1993 (RESNA June 7, 1993). Construction of the groundwater remediation system is contingent upon the results of the air sparging test.**

Task 8. System Startup and Operation

This section and the ensuing sections detail a monitoring plan to verify the effectiveness of the proposed interim VES at this site.

System Monitoring

After completion of system installation, operation of the proposed interim VES and selected groundwater remediation system, will be initiated in compliance with all applicable regulatory agencies. Startup procedures will include system monitoring, maintenance and sampling within the first five days of operation. Operation and maintenance of the VES as described above typically includes daily site inspections for the first five days of operation, and site visits once every week for the first month. After the first month of operation, site visits will be typically performed once every two weeks, or as needed over the operating life of the remediation systems. Modifications to this typical schedule will be made if additional requirements are specified by the BAAQMD in the Authority to Construct/Permit to Operate for this site. Routine maintenance of the VES and groundwater system will be performed during these site visits and as needed.

Site inspections will typically include: monitoring and adjustment of system parameters to optimize VES and groundwater treatment system efficiency; periodic sampling and field monitoring of influent and effluent as required by the BAAQMD; and other periodic maintenance to promote continued operation of the remediation equipment. Parameters to be monitored and adjusted in the field will include: vapor extraction flow rates, induced vacuum responses at onsite wells if applicable, and hydrocarbon vapor concentrations with an organic vapor monitor approved by the BAAQMD.

System Sampling

Typical BAAQMD guidelines require that during the startup phase of the off-gas abatement unit, influent and effluent air samples to the VES be collected to evaluate destruction efficiency of the unit. To demonstrate compliance with BAAQMD regulations, the VES will likely be sampled at least once during the first week of operation, and once per month for the life of the remediation system. With the exception of influent and effluent air samples collected and analyzed as detailed above, during the first two days of operation and later on a biweekly and monthly basis, all other sampling of the VES will be conducted using a field organic vapor monitoring instrument approved by the BAAQMD. If at any time the results of laboratory analyses or field monitoring readings show emission limits to be exceeded, a confirmation air sample will be taken immediately and analyzed on a 24 hour turnaround basis. If emission limits are still exceeded, the system will be shut down and any necessary corrective action will be performed before repeating the startup sequence. BAAQMD will be notified that emission limits were exceeded within 24 hours of such indication.

The off-gas treatment system will be modified to an activated carbon adsorption system (two or three, in-series 1,200-pound vapor-phase activated carbon canisters) when the hydrocarbon concentrations of extracted vapor from subsurface soils approach 100 ppmv, or when it becomes cost-effective. Typical BAAQMD guidelines require that, extracted vapor influent to and effluent from the carbon system will be monitored with a field instrument approved by the BAAQMD on a daily basis until the frequency of carbon changeout can be determined. System monitoring frequency will likely be changed to once every two weeks, or monthly, with a field instrument and monthly verification with bag samples upon receiving BAAQMD approval.

If groundwater extraction is implemented, influent and effluent water samples will be collected for laboratory analysis during the first week of startup. All water compliance sampling will be conducted in accordance with the requirements set forth in a City of Livermore sewer discharge permit.

Task 9. System Performance Evaluation

Following continued operation of the interim VES and groundwater remediation system, a system performance evaluation will be conducted to monitor the effectiveness of the interim soil and groundwater remediation systems. This evaluation will be performed in conjunction with continued groundwater monitoring and sampling at the subject site, and will be submitted together with the regularly scheduled quarterly monitoring and sampling reports. This report may include the following: hours of operation collected; system influent and effluent field monitoring readings; laboratory results of influent and effluent air and water samples; total and individual vapor extraction well and groundwater extraction well flow rates; induced vacuum responses recorded in observation wells; all other relevant field data collected; and results obtained such as observed radius of influence, system destruction efficiency, groundwater treatment system efficiency, etc.

Recommendations will then be made to further optimize system performance and to further enhance remediation of subsurface impacted soils and groundwater. Recommendations may include tie-in of additional vapor extraction wells, air sparging wells, or groundwater extraction wells (if applicable) to the remediation system, upgrading of the off-gas abatement unit, etc.

SCHEDULE OF OPERATIONS

Plate 17 depicts the preliminary time schedules agreed upon during a November 19, 1992 meeting with ARCO, the ACHCSA, and RESNA to complete the above referenced tasks. These task timeliness do not include delays associated with the evaluation and installation of the air sparging technology, and permitting or equipment delivery delays. **At a subsequent meeting on May 19, 1993, ARCO and ACHCSA agreed to revise the preliminary time schedules as follows based on site-specific conditions (RESNA, June 7, 1993):**

- Submittal of a RAP for interim soil and groundwater remediation by July 15, 1993.

- **Installation of air sparging wells and performance of an air sparge test pending decreases in water table elevations in lieu of an aquifer pump and recovery test.** Submittal of a work plan detailing air sparge well locations and procedures to be followed during the test by July 15, 1993.

- **No time deadlines were established for installation of the air sparging wells, performance of an air sparging test, and installation of an interim groundwater remediation system at this site during this meeting (RESNA, June 7, 1993).**

- Startup by January 1994 of the interim VES using the shallow vapor extraction wells.

These revised time schedules take precedence over the preliminary time schedules depicted on Plate 17.

The time frames for the appropriate regulatory agencies to review and approve the RAP, permits, and construction Plans and Specifications are also estimated in the schedule (Plate 17). The permitting time frame is expected to take about as long as the engineering time frame. The hatched lines represent estimates of times which may be required to complete tasks should unforeseen delays occur. These unforeseen delays may include permitting issues, offsite access issues, or items discussed below.

The revised schedules agreed to at the May 19, 1993, meeting will be delayed if regulatory review of the interim RAP is delayed or, if after review of the RAP, the regulatory agencies involved have comments and require a submittal of a revised addendum; if delays are encountered in the installation of onsite vapor wells or air sparging wells; if delays associated with the BAAQMD air discharge permit, City of Livermore sewer discharge permit, or City of Livermore building or planning departments are encountered; if long-lead equipment cannot be delivered within the estimated timeframe; if system installation gets delayed due to inclement weather, negotiations with lessee, and delays in utility installation. The estimated schedule also assumes that results of the planned offsite investigation will not impact onsite soil and groundwater remediation.

The schedule assumes that soil remediation can be completed in about one year provided optimum soil and operating conditions exist for the VES, and that the hydrocarbons can be effectively desorbed from the soil by volatilization. The schedule also assumes that the groundwater remediation can be completed within three to six years based upon optimum site and operating conditions. The progress and expected duration of the soil and groundwater cleanup is dependent on physical factors such as: fluctuating groundwater levels both naturally and/or artificially induced (pumping of other wells near the site), adsorption and desorption effects, migration of off-site contaminants, and the correlation of data from specific points (wells and borings) with the actual conditions across the site. Fluctuating groundwater levels in onsite wells may decrease the effective screen available to vent from and hence reduce the effectiveness of the VES. Duration of cleanup can be more accurately predicated after a performance evaluation of the VES and groundwater remediation system has been completed.

The schedule assumes that the performance evaluation will show that the remediation system is effectively removing hydrocarbons from areas of impacted soil and groundwater onsite. It also assumes that no additional onsite or offsite vapor extraction wells, air sparging wells, groundwater extraction wells (if applicable), or other remedial technologies are required to effectively remediate impacted areas, once the treatment system is operational. Installation of additional wells will require submittal of a work plan to regulatory agencies, well permits to install wells, and installation and tie in of wells to the existing system.

To verify cleanup of previously impacted soil, verification borings will be drilled and samples collected and analyzed to show that the soil has been remediated below currently established State cleanup levels. Site closure for soils may be initiated in conjunction with closure for onsite groundwater; i.e., after completion of the installation and operation of the groundwater remediation system.

LIMITATIONS

This report was prepared in accordance with generally accepted standards of environmental geological and engineering practice in California at the time this investigation was performed. This assessment was conducted solely for the purpose of evaluating environmental conditions of the soil and groundwater with respect to gasoline and waste-oil related hydrocarbons at the site. No soil engineering or geotechnical references are implied or should be inferred. Groundwater monitoring procedures and acquisition of groundwater field data were performed under the direction of EMCON; evaluation and warrant of their field data and field protocols is beyond RESNA's scope of work. Evaluation of the geologic conditions at the site for the purpose of this assessment is made from a limited number of observation points. Subsurface conditions may vary away from the data points available. Additional work, including further subsurface investigation, can reduce the inherent uncertainties associated with this type of assessment. Also, this is to inform all interested parties that The Upjohn Company of Kalamazoo, Michigan is the Assignee for at least two

U.S. Patents (1984 and 1986) regarding soil vapor extraction systems and combined groundwater and vapor extraction wells. The legal implications of these patents to the conventional engineering practice of design and construction of these systems has not been determined.

DISTRIBUTION

RESNA recommends that copies of this report be sent to the following regulatory agencies:

Ms. Danielle Stefani
City of Livermore Fire Department
4550 East Avenue
Livermore, California 94550

Ms. Susan Hugo
Alameda County Health Care Services Agency
80 Swan Way, Room 200
Oakland, California 94621

Mr. Eddy So
Regional Water Quality Control Board
San Francisco Bay Region
2101 Webster Street, Suite 500
Oakland, California 94612

REFERENCES

Alameda County Flood Control and Water Conservation District - Zone 7, January 16, 1991. Fall 1990 Groundwater Level Report.

Applied GeoSystems. December 6, 1989. Limited Subsurface Environmental Investigation at ARCO Station 6113, 785 East Stanley Boulevard, Livermore, California. AGS Report 69028-2.

Applied GeoSystems. August 29, 1990. Letter Report, Quarterly Ground-Water Monitoring Second Quarter 1990 at ARCO Station 6113, 785 East Stanley Boulevard, Livermore, California. AGS Report 69028-3.

Applied GeoSystems. November 2, 1990. Letter Report, Quarterly Ground-Water Monitoring Third Quarter 1990 at ARCO Station 6113, 785 East Stanley Boulevard, Livermore, California. AGS Report 69028-3.

Applied GeoSystems. January 27, 1991. Letter Report, Quarterly Ground-Water Monitoring Fourth Quarter 1990 at ARCO Station 6113, 785 East Stanley Boulevard, Livermore, California. AGS Report 69028-3.

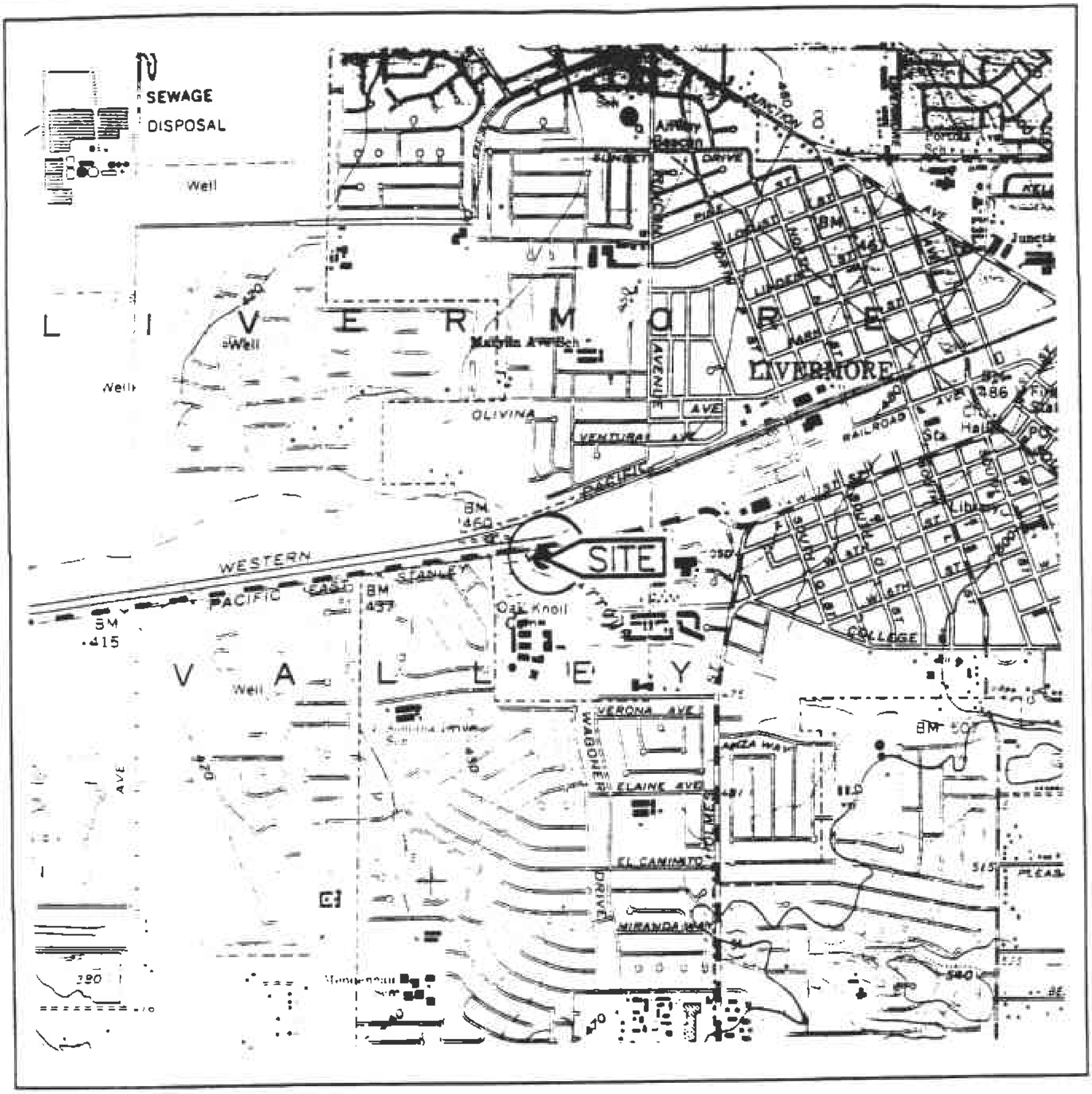
Applied GeoSystems. April 16, 1991. Limited Subsurface Environmental Investigation Related to the Former Waste-Oil Tank at ARCO Station 6113, 785 East Stanley Boulevard, Livermore, California. AGS Report 69028-4.

Applied GeoSystems. April 24, 1991. Letter Report, Quarterly Ground-Water Monitoring First Quarter 1991 at ARCO Station 6113, 785 East Stanley Boulevard, Livermore, California. AGS Report 69028-3.

Applied GeoSystems. July 11, 1991. Letter Report, Quarterly Ground-Water Monitoring Second Quarter 1991 at ARCO Station 6113, 785 East Stanley Boulevard, Livermore, California. AGS Report 69028-5.

California Department of Health Services, Office of Drinking Water, October 22, 1990, "Summary of California Drinking Water Standards", Berkeley, California.

California Department of Water Resources. 1966. Evaluation of Ground-Water Resources, Livermore and Sunol Valleys. California Department of Water Resources Bulletin 118-2, Appendix A.



Base: U.S. Geological Survey
7.5-Minute Quadrangle
Livermore, California
Photorevised 1980

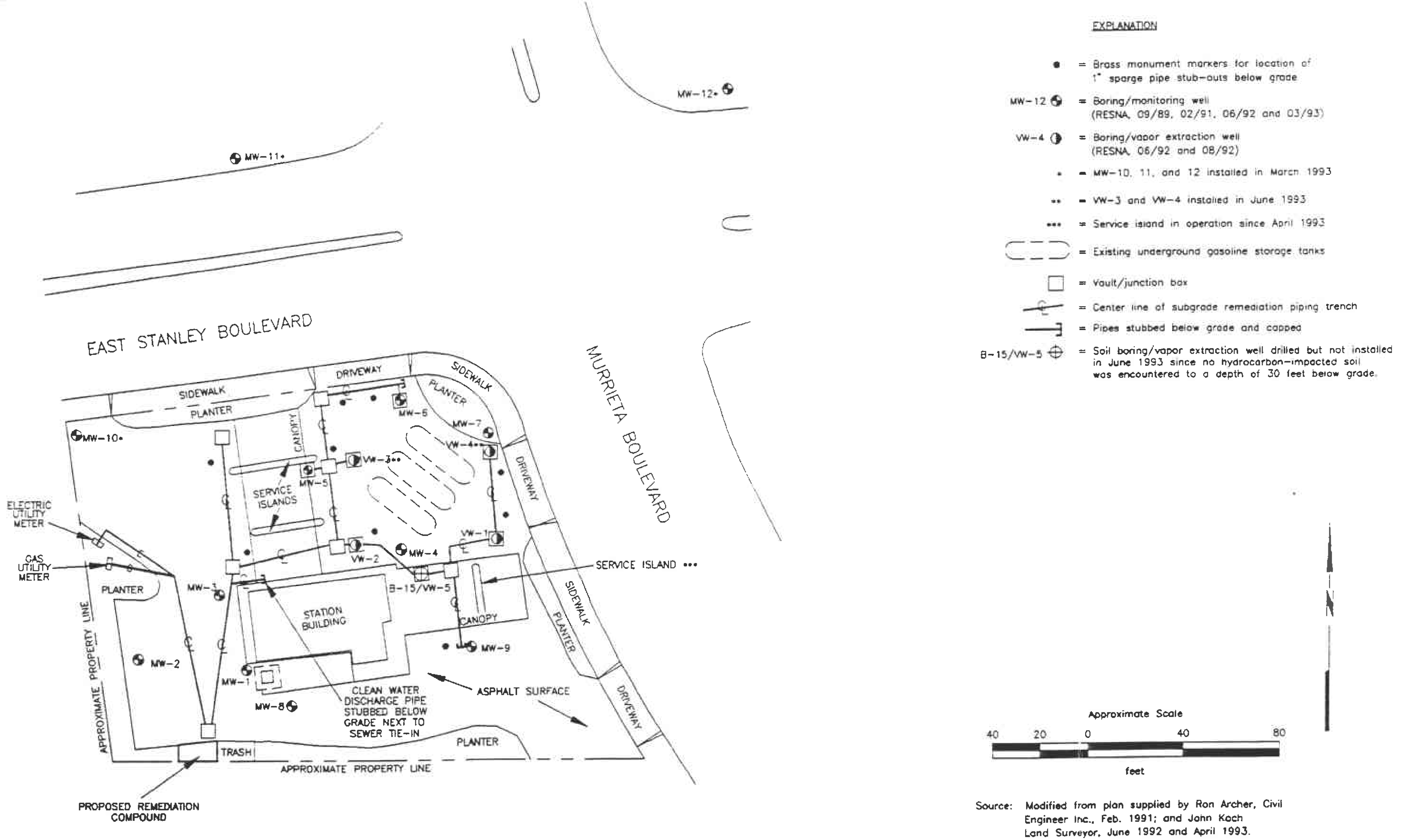
N

Approximate Scale

2000 1000 0 2000 4000

feet

RESNA *Working to Restore Nature*	**SITE VICINITY MAP** **ARCO Station 6113** **785 East Stanley Boulevard** **Livermore, California**	**PLATE** **1**
PROJECT **69028.09**		



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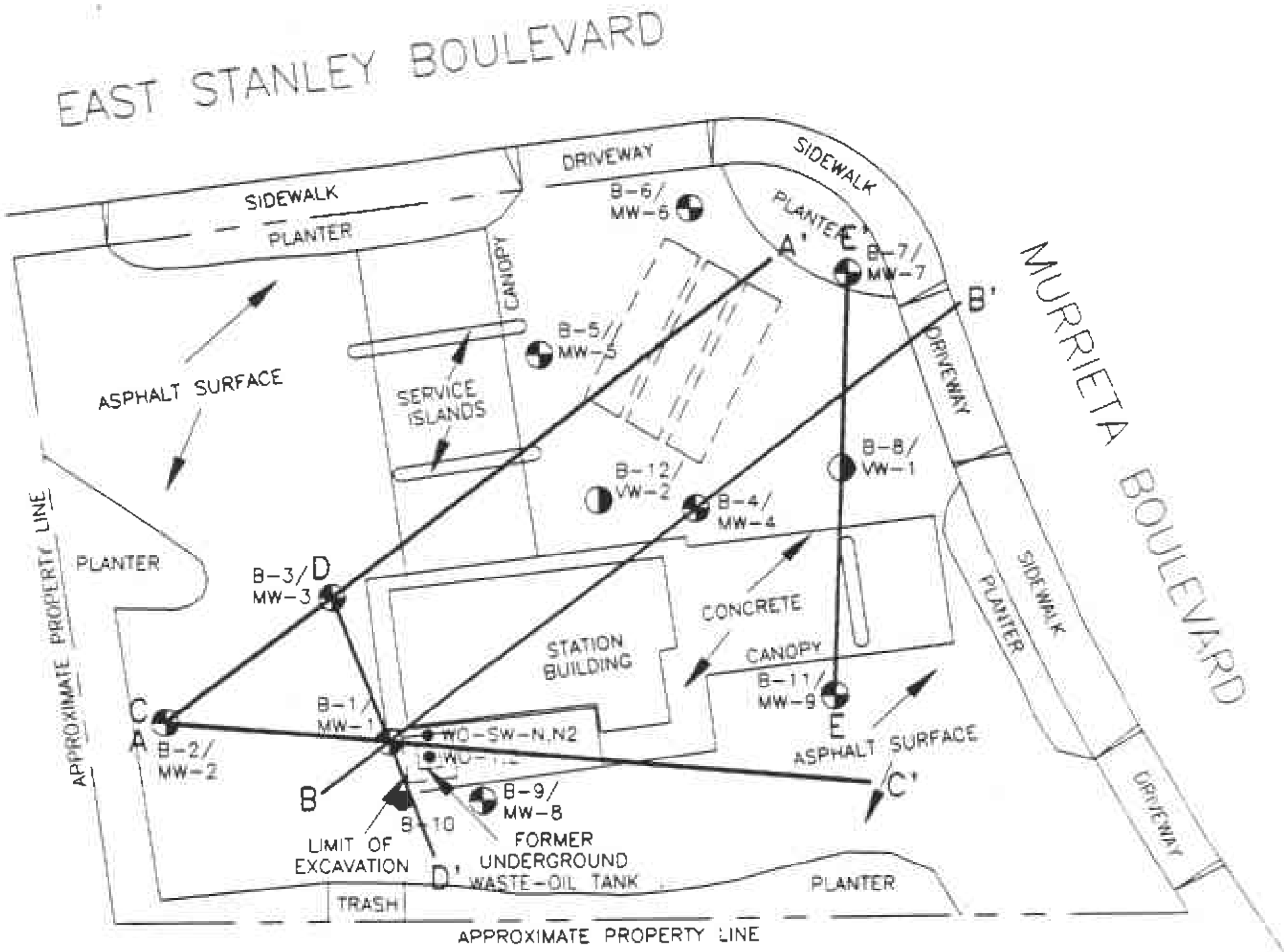
GENERALIZED SITE PLAN
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California

PLATE
2



EXPLANATION

B-11/ MW-9 = Boring/monitoring well (RESNA, 09/89, 02/91, and 06/92)

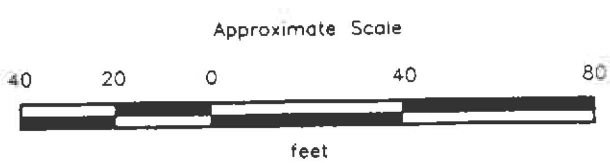
B-12/ VW-2 = Boring/vapor extraction well (RESNA, 06/92)

B-10 = Boring (RESNA, 06/92)

WO-SW-N,N2 = Soil sample collected by Pacific (1989)

E —— E' = Geologic cross section

= Existing gasoline-storage tanks



Source: Modified from plan supplied by Ron Archer, Civil Engineer Inc., October 1988

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GEOLOGICAL CROSS SECTIONS
ARCO Service Station 6113
785 East Stanley Boulevard
Livermore, California

PLATE 3

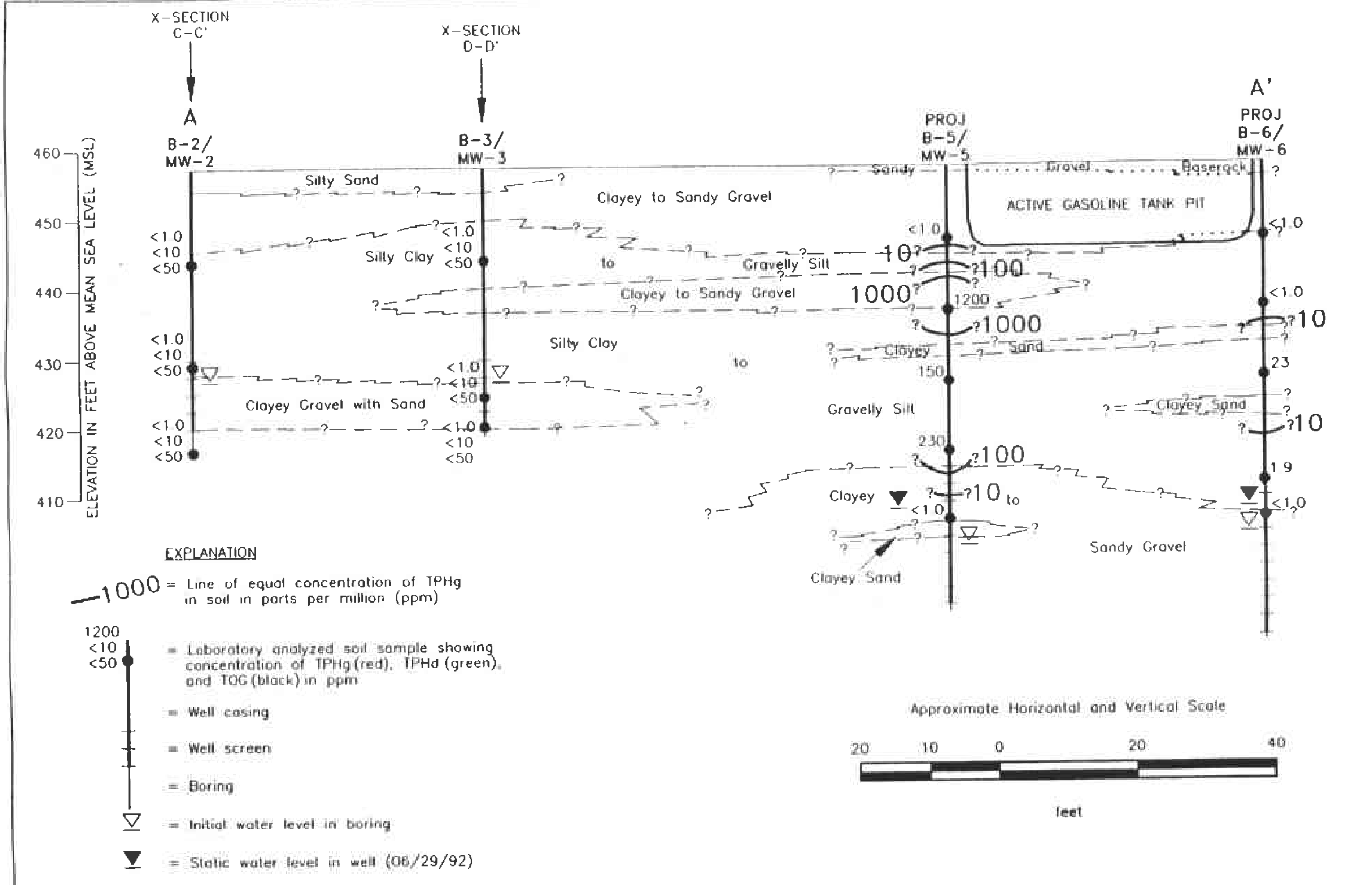

PLATE 4

GEOLOGIC CROSS SECTION A-A'
ARCO Service Station 6113
785 East Stanley Boulevard
Livermore, California

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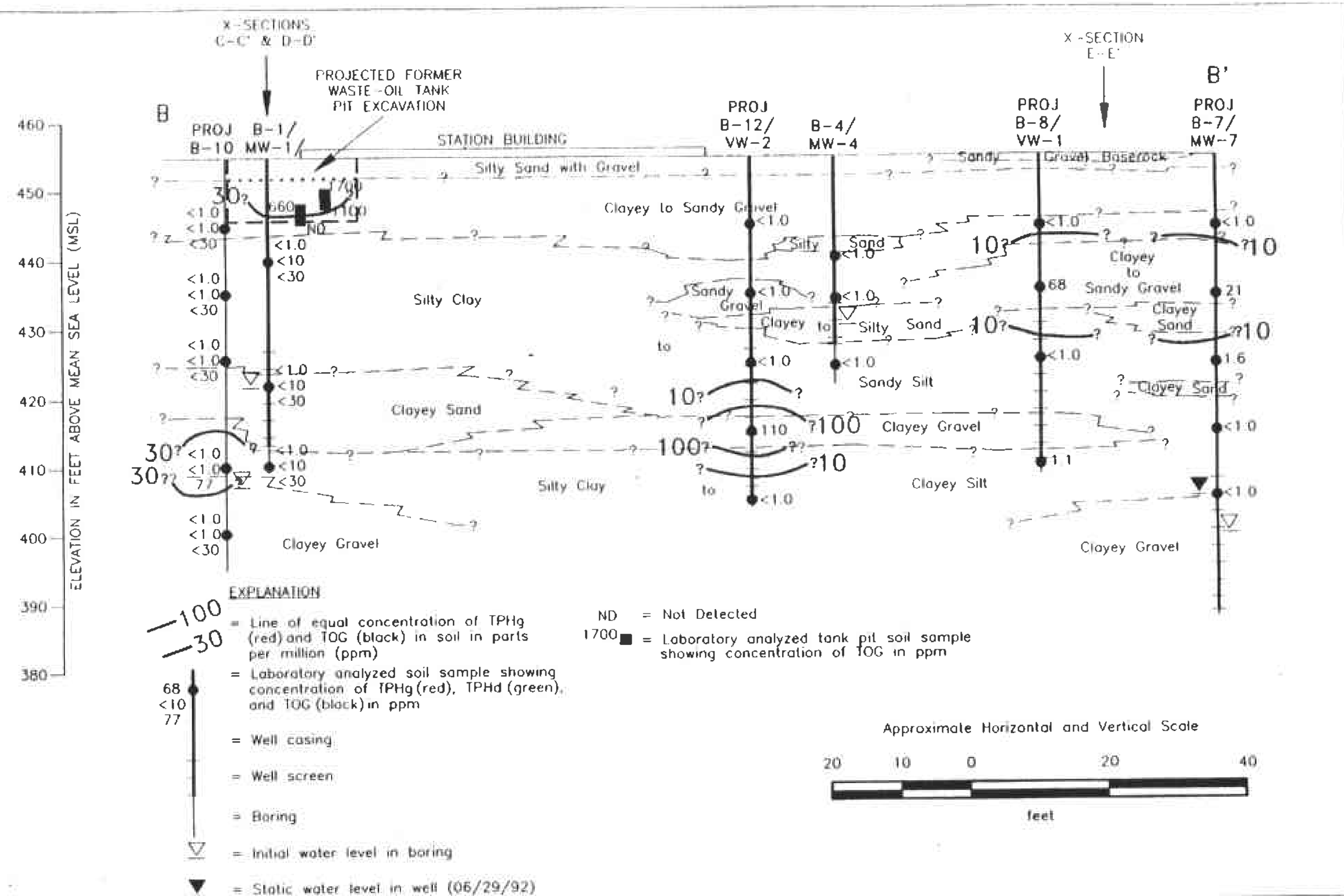

PLATE 5

GEOLOGIC CROSS SECTION B-B'
ARCO Service Station 6113
785 East Stanley Boulevard
Livermore, California

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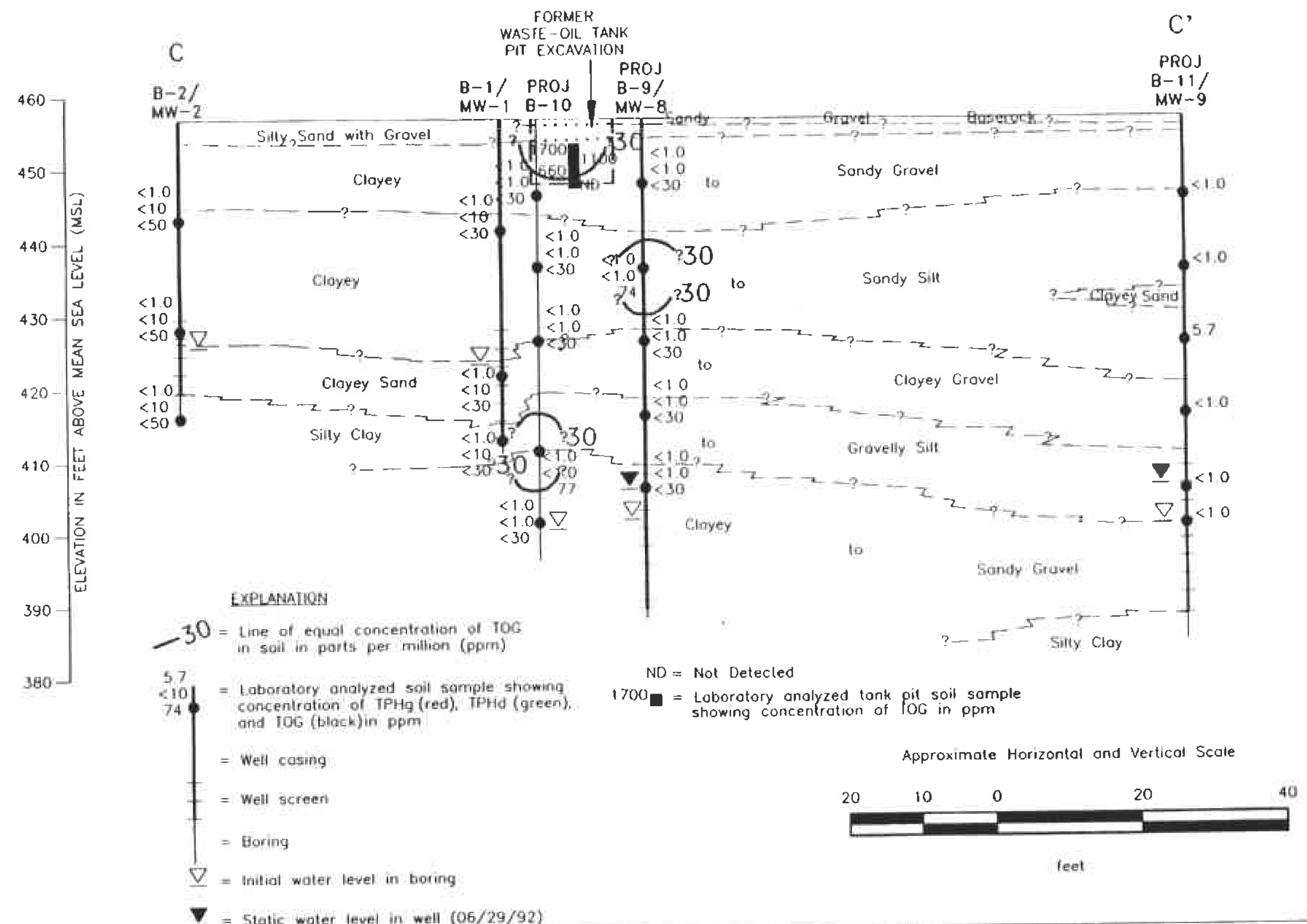

PLATE 6

GEOLOGIC CROSS SECTION C-C'
ARCO Service Station 6113
785 East Stanley Boulevard
Livermore, California

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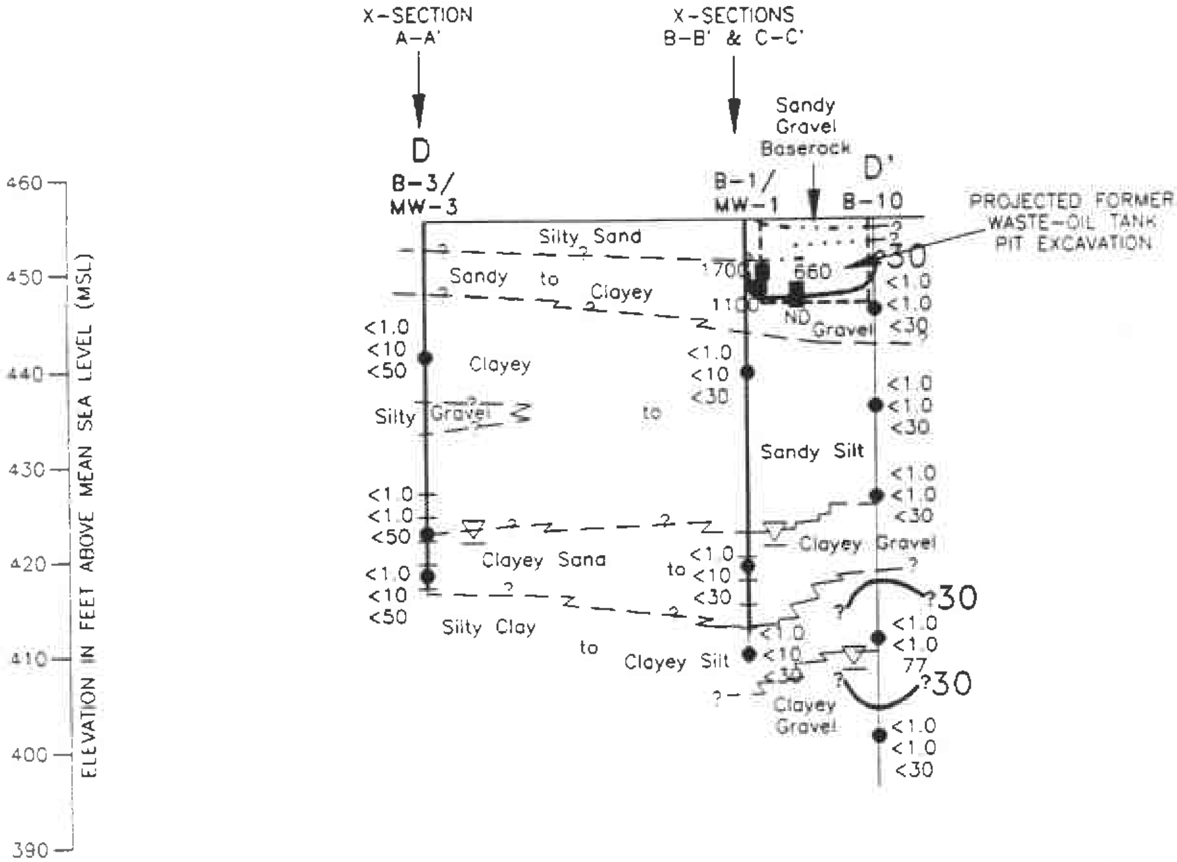


EXPLANATION

30 = Line of equal concentration of TOG in soil in parts per million (ppm)

<1.0 <10 77 = Laboratory analyzed soil sample showing concentration of TPHg (red), TPHd (green), and TOG (black) in ppm

= Well casing

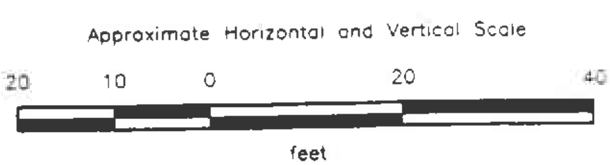
= Well screen

= Boring

= Initial water level in boring

ND = Not Detected

1100 ■ = Laboratory analyzed tank pit soi sample showing concentration of TOG in ppm



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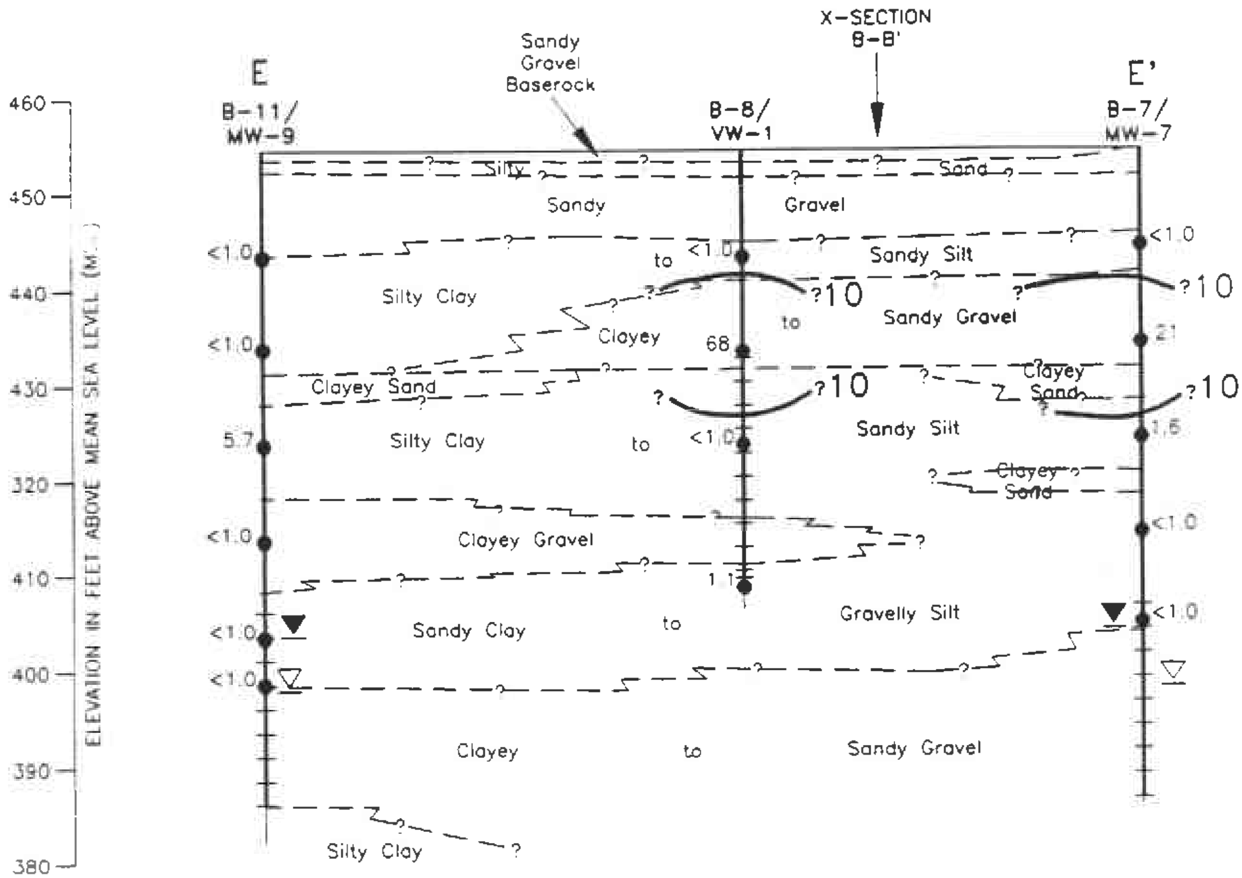
GEOLOGIC CROSS SECTION D-D'
ARCO Service Station 6113
785 East Stanley Boulevard
Livermore, California

PLATE
7



EXPLANATION

10 = Line of equal concentration of TPHg in soil in parts per million (ppm)

68 = Laboratory analyzed soil sample showing concentration of TPHg in ppm

= Well casing

= Well screen

= Boring

= Initial water level in boring

= Static water level in well (06/29/92)

Approximate Horizontal and Vertical Scale

20 10 0 20 40

feet

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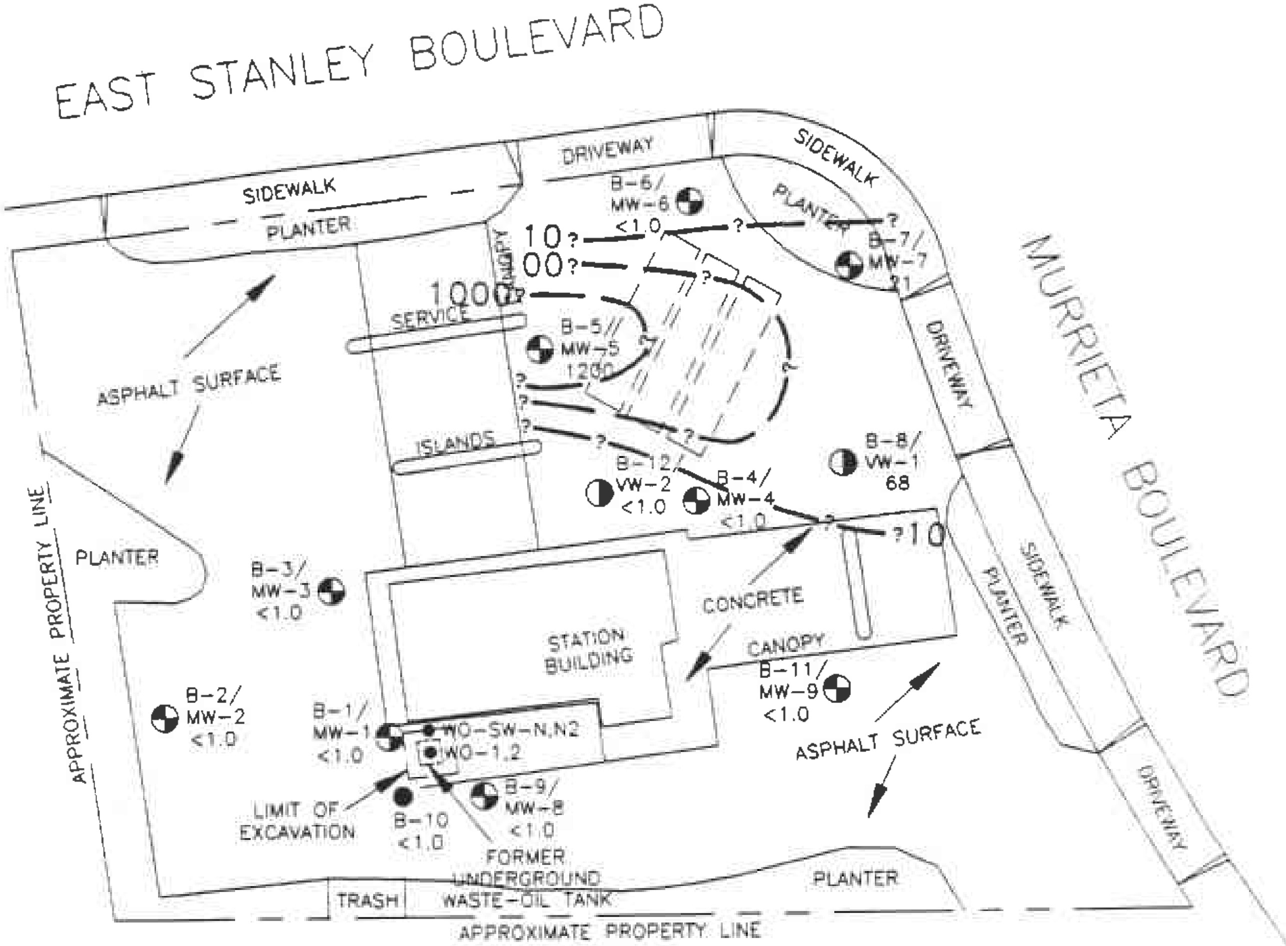
GEOLOGIC CROSS SECTION E-E'
ARCO Service Station 6113
785 East Stanley Boulevard
Livermore, California

PLATE

8



EXPLANATION

—1000 = Line of equal concentration of TPHg in soil in parts per million (ppm)

1200 = Concentration of TPHg in soil at depths between 14 and 20-1/2 feet, in ppm

B-11/ MW-9 = Boring/monitoring well (RESNA, 09/89, 02/91, and 06/92)

B-12/ VW-2 = Boring/vapor extraction well (RESNA, 06/92 and 08/92)

B-10 = Boring (RESNA, 06/92)

WO-SW-N,N2 = Soil sample collected by Pacific (1989)

= Existing underground gasoline storage tank

Approximate Scale

40 20 0 40 80

feet

Source: Modified from plan supplied by Ron Archer, Civil Engineer Inc., October 1988.

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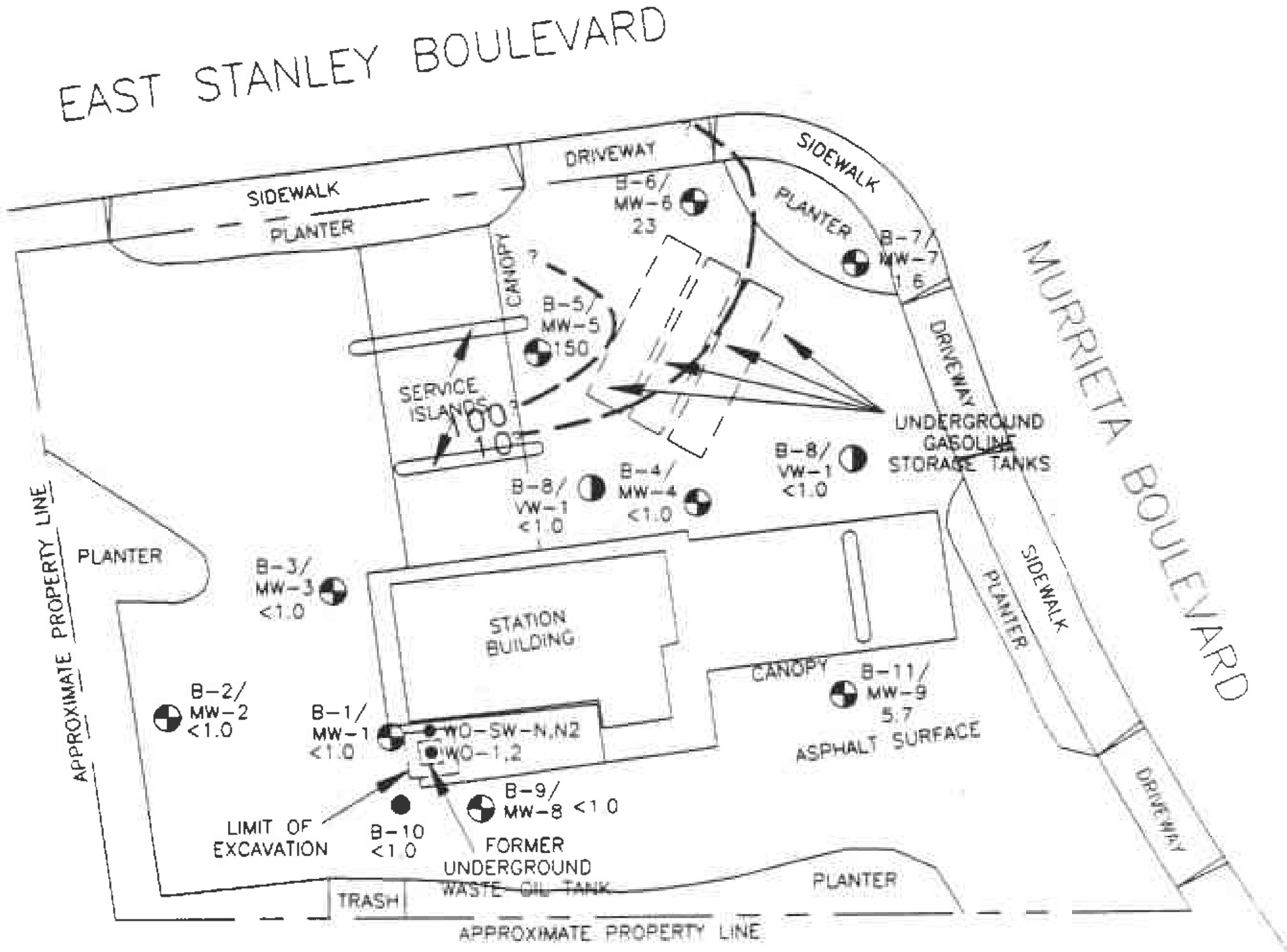
PROJECT: 69028.09

TPHg CONCENTRATIONS IN SOIL BETWEEN 14 AND 20-1/2 FEET
ARCO Service Station 6113
785 East Stanley Boulevard
Livermore, California

PLATE 9



EXPLANATION

100 = Line of equal concentration of TPHg in soil in parts per million (ppm)

150 = Concentration of TPHg in groundwater in parts per billion, June 29, 1992

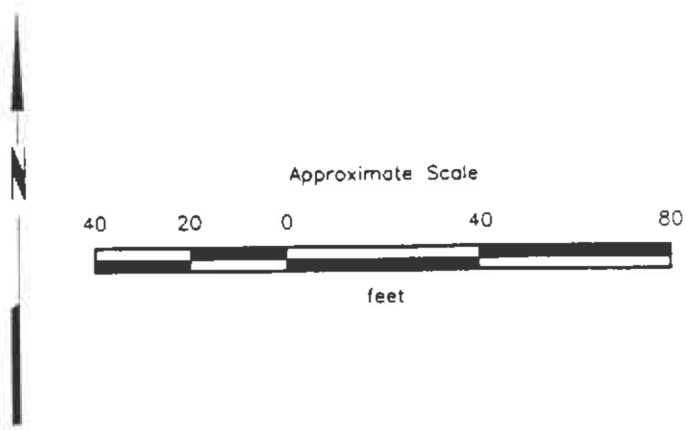
B-11/ MW-9 = Boring/monitoring well (RESNA, 09/89, 02/91, and 06/92)

B-8/ VW-2 = Boring/vapor extraction well (RESNA, 06/92 and 08/92))

B-10 = Boring (RESNA, 06/92)

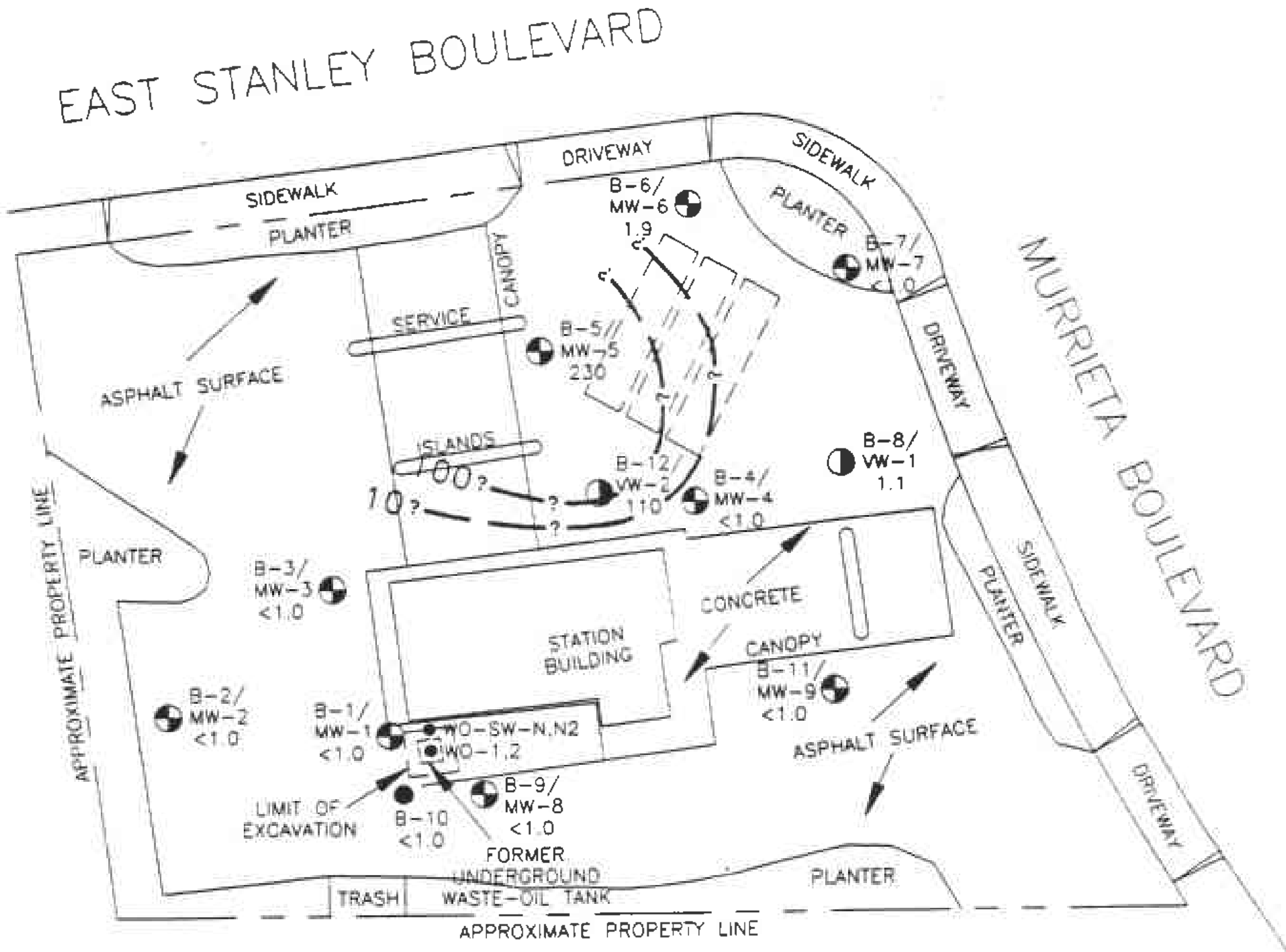
WO-SW-N,N2 = Soil sample collected by Pacific (1989)

= Underground gasoline storage tanks



Source: Modified from plan supplied by Ron Archer, Civil Engineer Inc., February 1991

RESNA *Working to Restore Nature*	TPHg CONCENTRATIONS IN SOIL BETWEEN 29 AND 34-1/2 FEET ARCO Station 6113 785 East Stanley Boulevard Livermore, California	PLATE 10
PROJECT: 69028.09		



EXPLANATION

—100 = Line of equal concentration of TPHg in soil in parts per million (ppm)

230 = Concentration of TPHg in soil at depths between 37-1/2 and 45-1/2 feet, in ppm

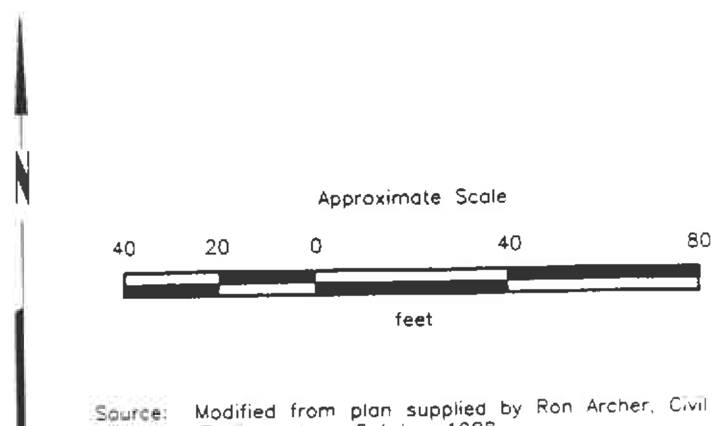
B-11/ MW-9 = Boring/monitoring well (RESNA, 09/89, 02/91, and 06/92)

B-12/ VW-2 = Boring/vapor extraction well (RESNA, 06/92 and 08/92)

B-10 = Boring (RESNA, 06/92)

WO-SW-N,N2 = Soil sample collected by Pacific (1989)

= Existing underground gasoline storage tank



Source: Modified from plan supplied by Ron Archer, Civil Engineer Inc., October 1988

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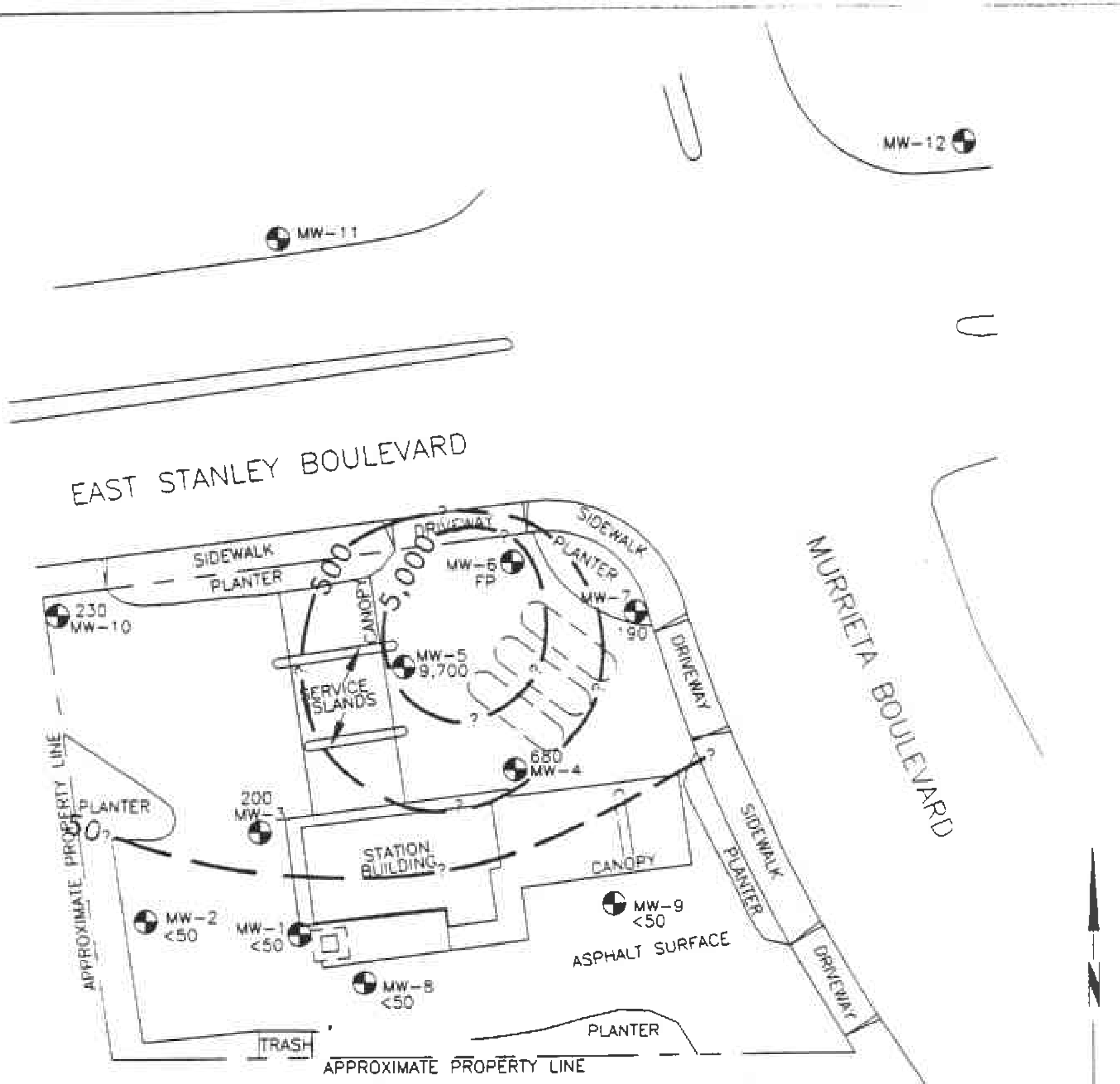
PROJECT: 69028.09

TPHg CONCENTRATIONS IN SOIL BETWEEN 37-1/2 AND 45-1/2 FEET
ARCO Service Station 6113
785 East Stanley Boulevard
Livermore, California

PLATE 11



EXPLANATION

MW-12 = Monitoring well (RESNA, 03/93)

5,000 = Line of equal concentration of TPHg in groundwater in parts per billion (ppb)

9,700 = Concentration of TPHg in groundwater in ppb, March 30 and 31, 1993

FP = Not sampled – floating product present

= Existing underground gasoline storage tanks

Approximate Scale

50 25 0 50 100

feet

Source: Modified from plan supplied by Ron Archer, Civil Engineer Inc., Feb. 1991; and John Koch Land Surveyor, June 1992 and April 1993.

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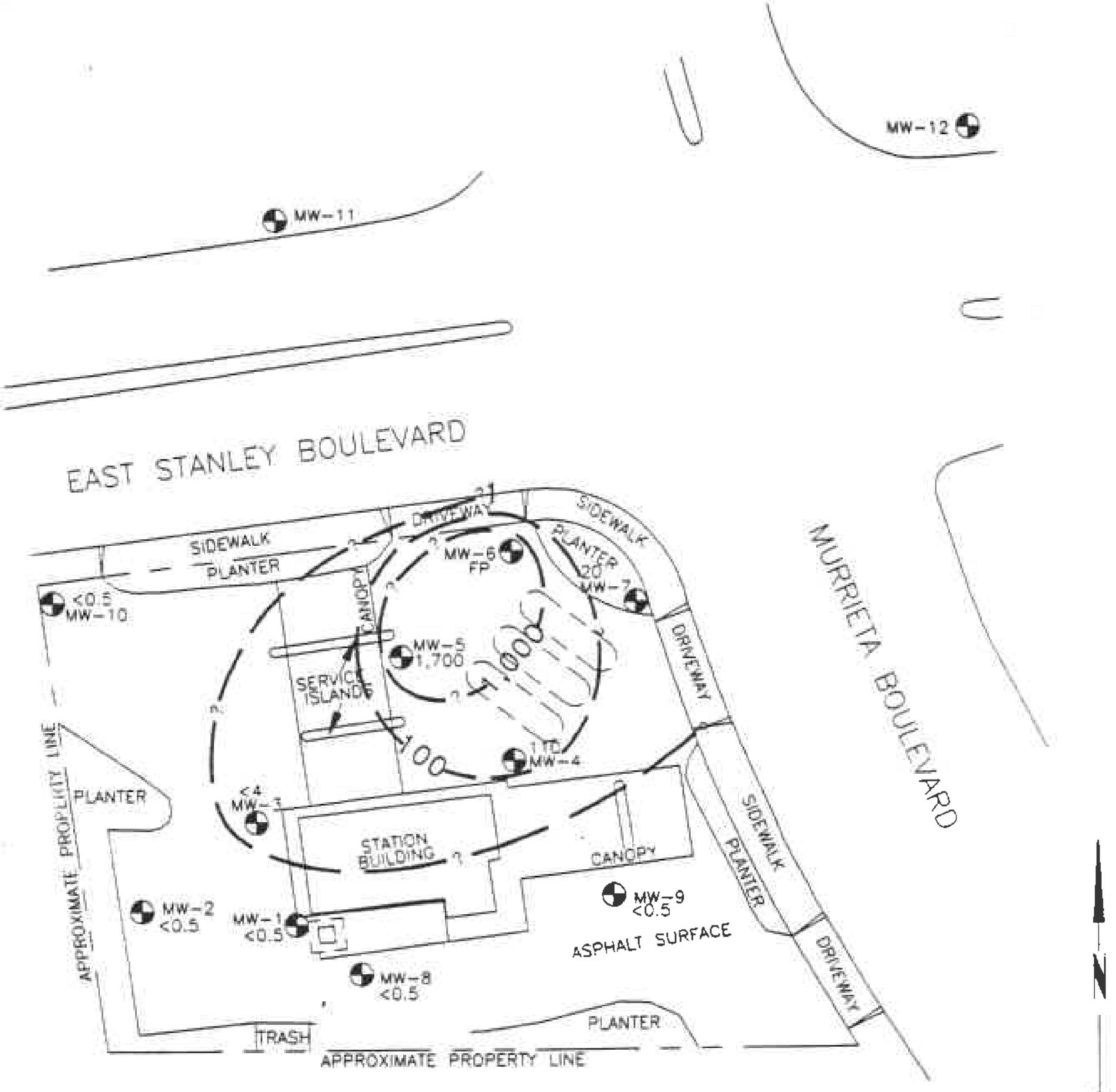
TPHg CONCENTRATIONS IN GROUNDWATER
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California

PLATE 12



EXPLANATION

MW-12 = Monitoring well (RESNA, 09/89, 02/91, 06/92 and 03/93)

1,000 = Line of equal concentration of benzene in groundwater in parts per billion (ppb)

1,700 = Concentration of benzene in groundwater in ppb, March 30 and 31, 1993

FP = Not sampled – floating product present

= Existing underground gasoline storage tanks

Approximate Scale

50 25 0 50 100

feet

Source: Modified from plan supplied by Ron Archer, Civil Engineer Inc., Feb. 1991; and John Koch Land Surveyor, June 1992 and April 1993.

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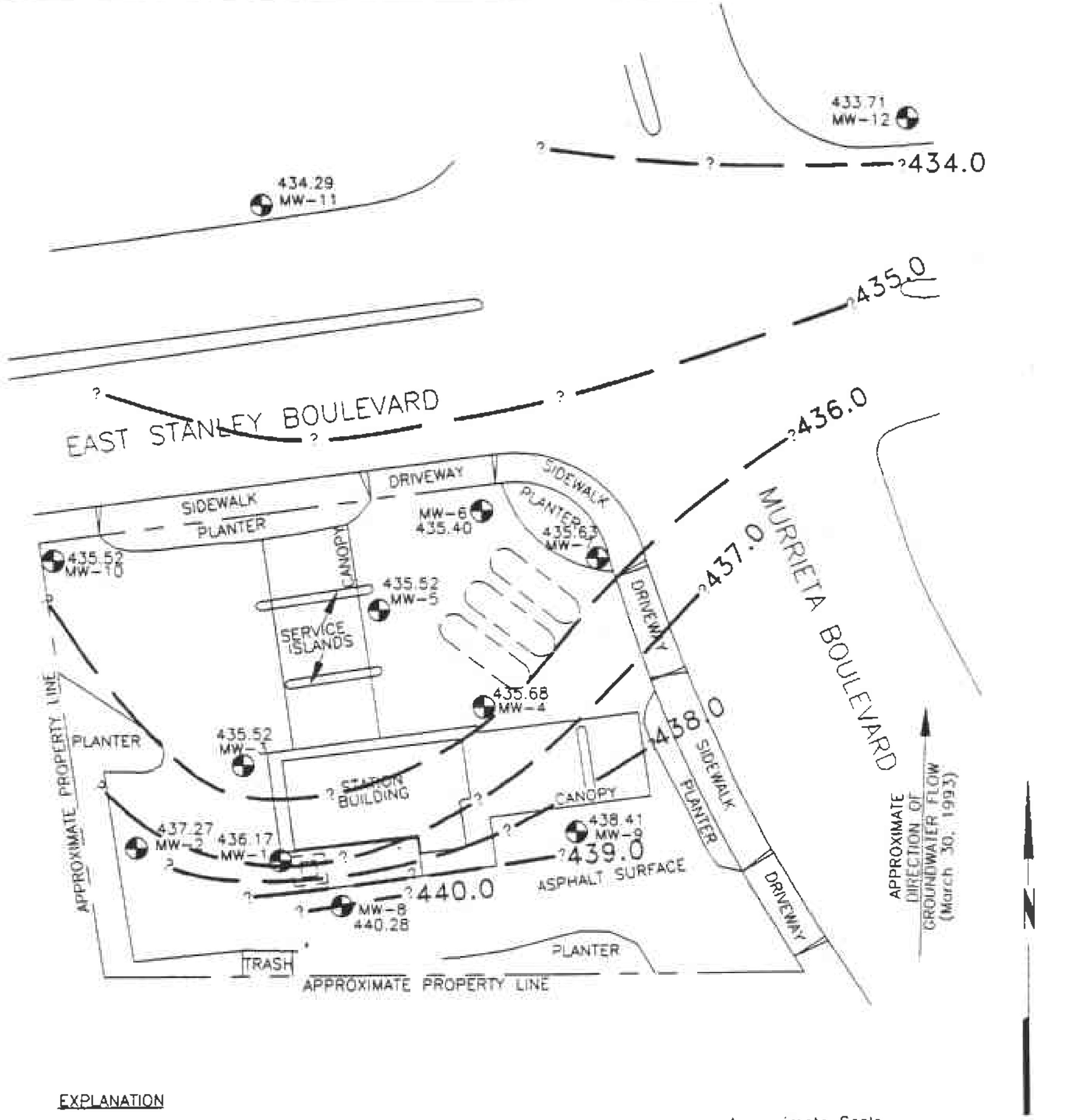
PROJECT: 69028.09

BENZENE CONCENTRATIONS IN GROUNDWATER
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California

PLATE 13



EXPLANATION

MW-12 = Monitoring well (RESNA, 09/89, 02/91, 06/92 and 03/93)

440.0 = Line of equal elevation of groundwater in feet above mean sea level (MSL)

440.28 = Elevation of groundwater in feet above MSL, March 30, 1993

= Existing underground gasoline storage tanks

Approximate Scale

50 25 0 50 100

feet

Source: Modified from plan supplied by Ron Archer, Civil Engineer Inc., Feb. 1991; and John Koch Land Surveyor, June 1992 and April 1993

RESNA
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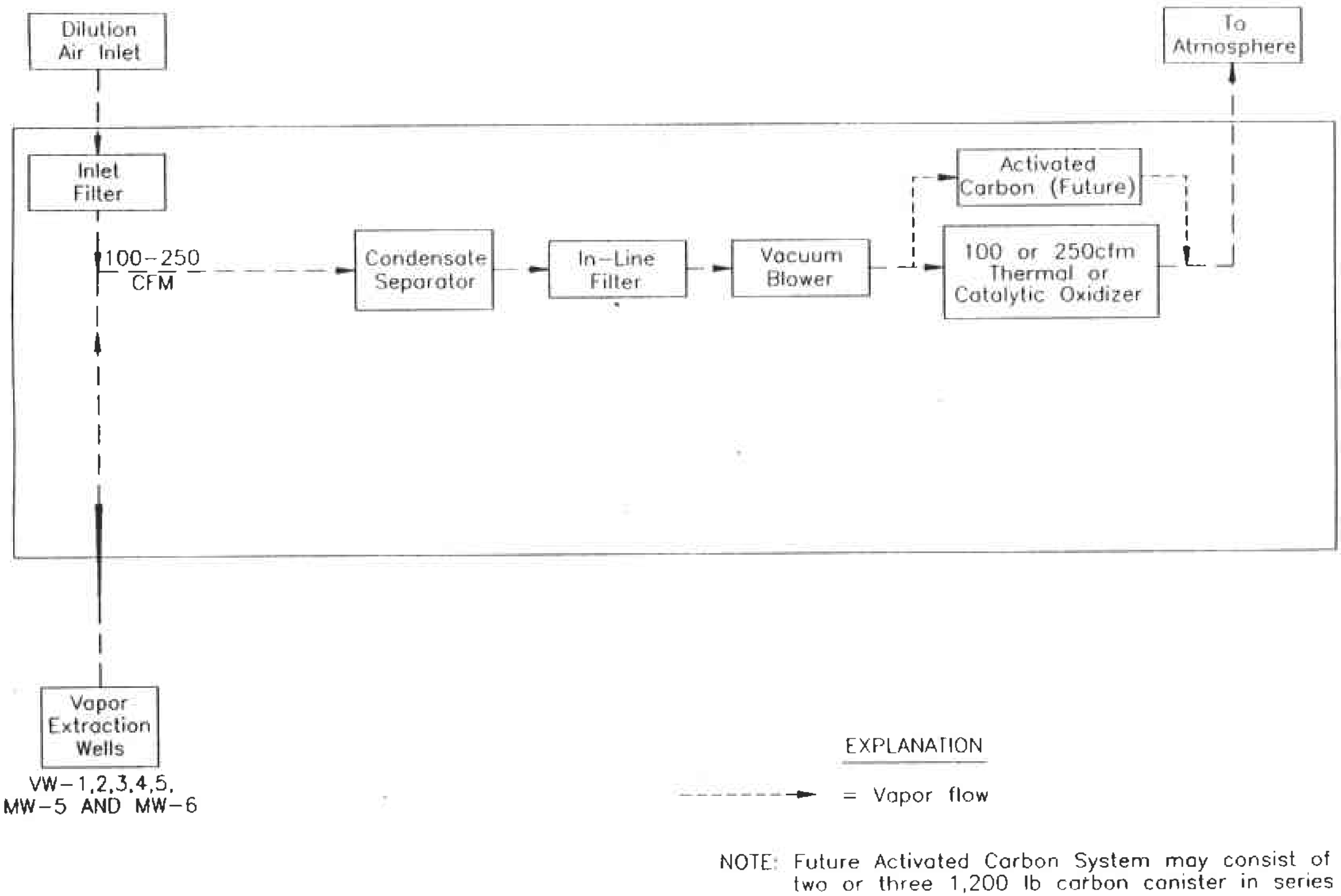
PROJECT: 69028.09

GROUNDWATER GRADIENT MAP
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California

PLATE
14



69028-PF

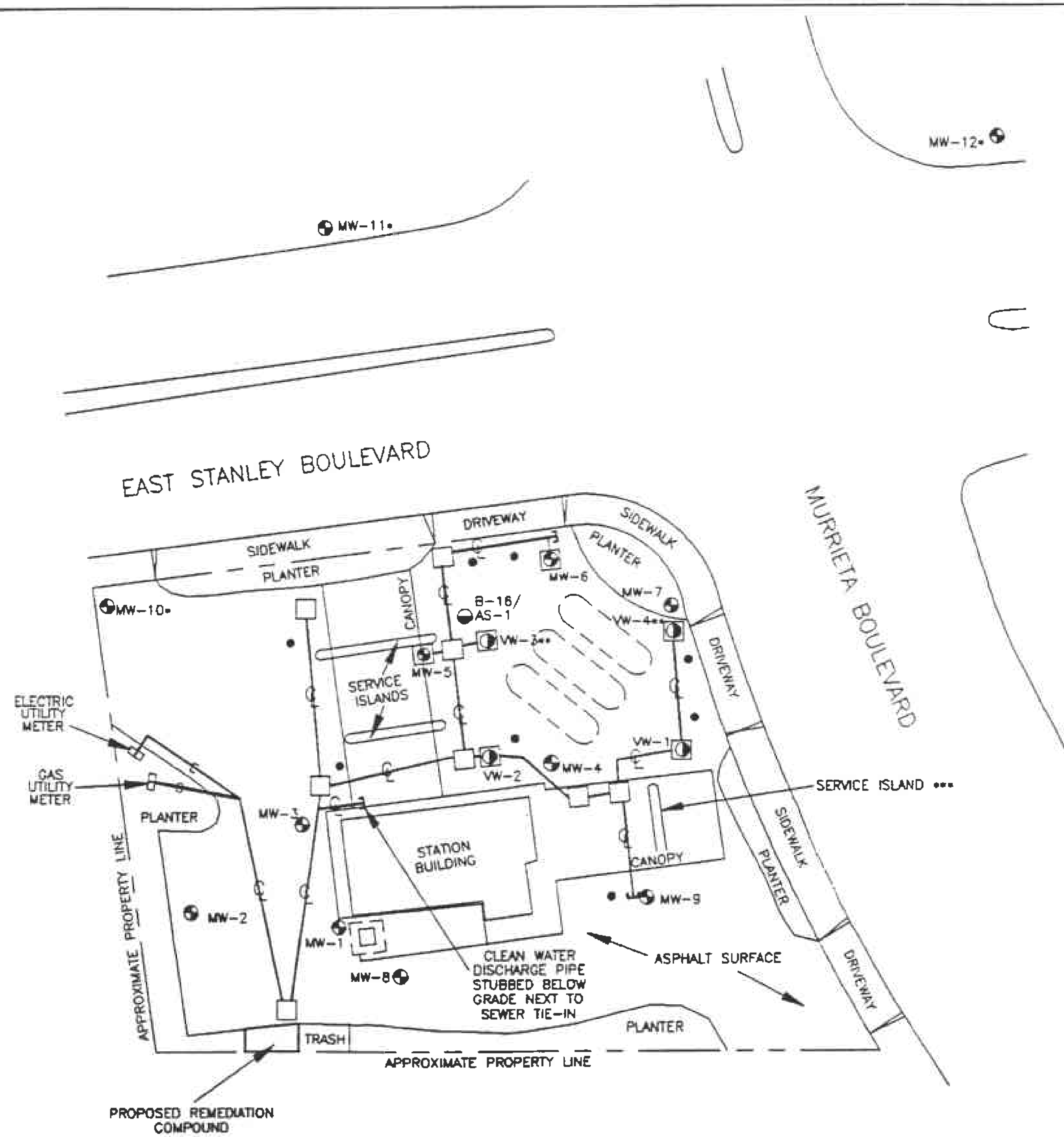
PLATE

15

PROCESS FLOW SCHEMATIC FOR INTERIM VES.
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California

RESNA
Working to Restore Nature

PROJECT **69028.09**



EXPLANATION

- ● = Brass monument markers for location of 1" sparge pipe stub-outs below grade
- MW-12 = Boring/monitoring well (RESNA, 09/89, 02/91, 06/92 and 03/93)
- VW-4 = Boring/vapor extraction well (RESNA, 06/92 and 08/92)
- • = MW-10, 11, and 12 installed in March 1993
- •• = VW-3 and VW-4 installed in June 1993
- ••• = Service island in operation since April 1993
- = Existing underground gasoline storage tanks
- = Vault/junction box
- = Center line of subgrade remediation piping trench
- = Pipes stubbed below grade and capped
- B-16/AS-1 = Proposed air-sparge well

Approximate Scale

40 20 0 40 80

feet

Source: Modified from plan supplied by Ron Archer, Civil Engineer Inc., Feb. 1991; and John Koch Land Surveyor, June 1992 and April 1993.

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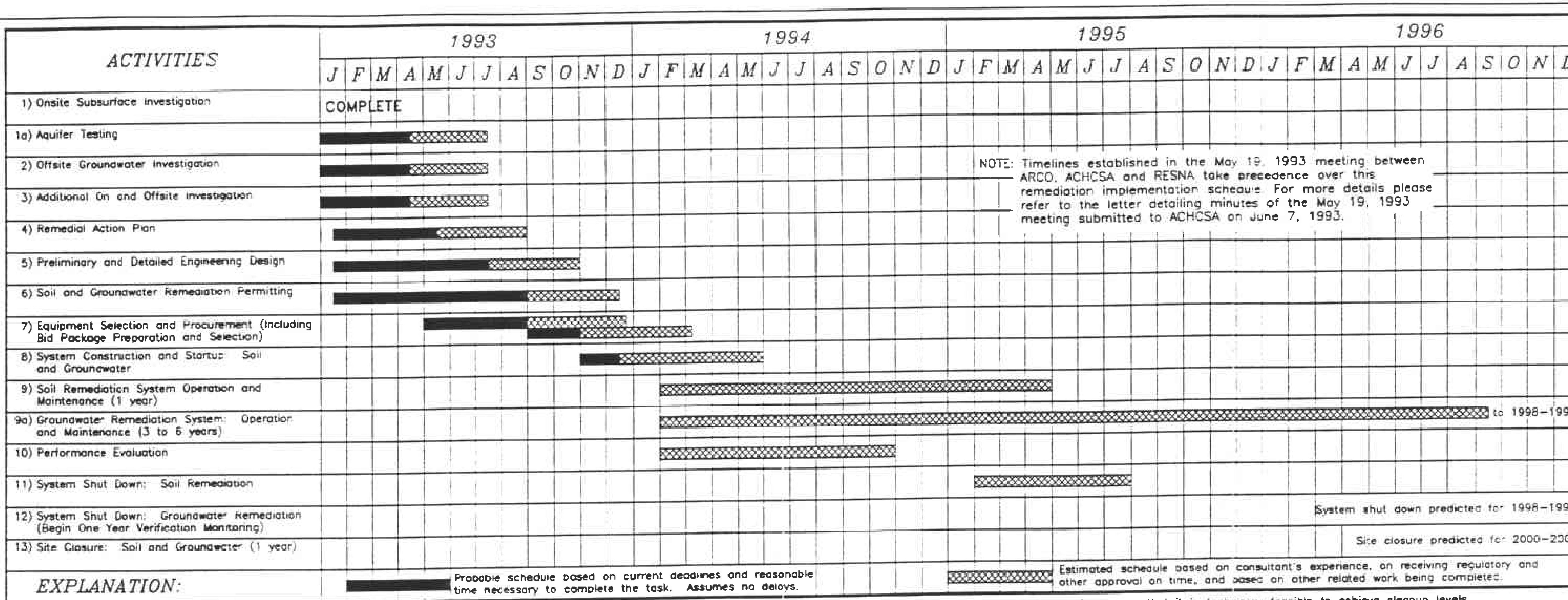
PROJECT 69028.09

PROPOSED BORING/WELL LOCATION
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California

PLATE
16



1) Onsite Subsurface Investigation:
- Two initial phases onsite investigation completed prior to 1992.

1a) Aquifer Testing:
- Work Plan including proposed aquifer testing to be submitted to ACHCSA and RWQCB by January 1, 1993.
- Report, including results of aquifer testing, additional onsite and initial offsite investigations due to ACHCSA and RWQCB by April 15, 1993.

2) Offsite Groundwater Investigation:
- Work Plan including initial offsite investigation to be submitted to ACHCSA and RWQCB by January 1, 1993.
- Assumes no delays in gaining offsite access or encroachment permits. Such delays are common and schedule may change.

3) Additional Onsite Investigation:
- Report of additional onsite investigation including vapor extraction test results to be submitted by Christmas 1992.
- Work plan for additional work at the site to be submitted to the ACHCSA and RWQCB by January 1, 1993.

4) Remedial Action Plan:
- Completion of offsite investigation will not affect remediation schedule.
- RAP due to ACHCSA by May 15, 1993.

5) Preliminary and Detailed Engineering Design:
- Assumes no RAP revisions are necessary.
- Assumes no changes to design after regulatory comments.
- Design to be completed by July 15, 1993.

6) Groundwater Remediation Permitting:
- Assumes no design changes will make additional permitting necessary, including modification of treatment system.
- Permitting completed by November 1, 1993.
- Also assumes no special regulatory agency, city committee, or other entity places special permitting requirements on this project.
- Assumptions concerning groundwater remediation are being made prior to performance of aquifer test at the site. Therefore, schedule pertaining to groundwater remediation may not reflect actual conditions and circumstances.

7) Equipment Selection and Procurement:
- Assumes all equipment is available from stock and can be obtained within 4 to 6 weeks.
- Assumes selected equipment will be approved by ACHCSA and other regulatory agencies in a timely manner.
- Bids will be evaluated and contract will be awarded by August 30, 1993.
- Equipment will be received by November 1, 1993.

8) System Construction and Startup:
- Assumes no delays due to weather.
- Assumes no delays due to negotiation with property owners.
- Assumes no delays due to other contractors performing work onsite.
- Assumes no delays due to utility installation.
- Assumes no delays due to special permitting requirements.
- Construction to begin by November 1, 1993.
- System startup to begin by February 1, 1994.

9 and 9a) Remediation Systems Operation and Maintenance:
- It is anticipated that soil remediation can be completed in 1 year.
- It is anticipated that groundwater remediation can be completed in 3 to 6 years.
- Assumes that it is technically feasible to achieve cleanup levels.
- Assumes no offsite remediation will be necessary.
- Assumes no significant equipment breakdowns.

10) Performance Evaluation:
- Evaluation shows that system will effectively remove hydrocarbons from soil and groundwater impacted areas and will reduce concentrations significantly over time.
- Evaluation shows that additional vapor and groundwater extraction wells are not required to effectively remediate impacted areas once the treatment system is operational.
- Performance evaluation to be completed by August to October 1994

11) System Shut Down: Soil Remediation System:
- Cleanup will be completed in approximately 1 year.
- Soil remediation system expected to be shut down by May to July 1995.

12) System Shut Down: Groundwater Remediation System:
- Cleanup will be completed approximately 3 to 6 years after startup.
- Only one year of verification groundwater monitoring will be required before site closure can be initiated.
- Groundwater remediation system expected to be shut down sometime in 1998 or 1999.

13) Site Closure: Soil and Groundwater:
- Requirements for soil closure involve only drilling of confirmation borings and performance evaluation at time of system shut down.
- Requirements for groundwater closure involve only groundwater monitoring and performance evaluation at system shutoff.
- Closure dependent on agency concurrence within 1 year following completion of verification monitoring.
- Assumes no risk assessment will be necessary.

RESNA
Working to Restore Nature

PROJECT 69028.09

ESTIMATED SOIL AND GROUNDWATER REMEDIATION IMPLEMENTATION SCHEDULE
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California

PLATE 17

TABLE 1
VAPOR EXTRACTION TEST FIELD MONITORING DATA
ARCO Station 6113, 785 East Stanley Boulevard
Livermore, California (Page 1 of 2)

Influent Air Stream from VW-1					Observation Wells					
Flow	% LEL-	Applied Vacuum	$\%O_2$	Elapsed Time (min)	VW-2 Induced Vacuum	MW-4 Induced Vacuum	MW-5 Induced Vacuum	MW-6 Induced Vacuum	MW-7 Induced Vacuum	MW-9 Induced Vacuum
10.9	NM	5	NM	0	NM	NM	NM	NM	NM	NM
21.3	NM	10	NM	10	0	0.04	0	0	0	0
29.4	NM	15	NM	15	NM	NM	NM	NM	NM	NM
40.9	NM	25	NM	20	NM	NM	NM	NM	NM	NM
43.8	24	35	3.5	25	0	0.04	0.01	0.01	0	0.01
46.0	54	50	5	35	0	0.05	0.01	0.01	0.01	0.01
49.6	54	51	5	40	0.01	0.05	0.01	0.01	0.01	0.02
50.2	NM	60	NM	50	NM	NM	NM	NM	NM	NM
Distance from well VW-1 (feet):					54.5	37.11	74.9	65.7	38.7	48
Screen Interval (feet):					28-49.5	21-27	43-63	48-68	48-68	48-68
Depth to Water (DTW, feet):					Dry	Dry	57.2	56.9	56.9	57.8

Vapor extraction well VW-1 screened from 26 to 45 feet. DTW - Dry

Influent Air Stream from MW-5					Observation Wells					
Flow	% LEL-	Applied Vacuum	$\%O_2$	Elapsed Time (min)	VW-1 Induced Vacuum	VW-2 Induced Vacuum	MW-4 Induced Vacuum	MW-6 Induced Vacuum	MW-7 Induced Vacuum	MW-9 Induced Vacuum
10.9	NM	5	NM	0	NM	NM	NM	NM	NM	NM
21.3	NM	10	NM	5	NM	NM	NM	NM	NM	NM
24.9	84	20	15	20	0.05	0.04	0.015	0.50	0.44	0.015
* 34.5	72	28	12	30	0.04	0.04	0.015	0.90	0.90	0.02
* 34.5	72	28	12	35	0.04	0.06	0.01	1.2	1.2	0.015
* 30.7	12	24	2.5	40	0.04	0.06	0.01	1.2	1.25	0.015
* 34.5	90	28	17	50	0.04	0.06	0.01	1.4	1.3	0.015
* 38.3	24	30	5	60	0.04	0.06	0.01	1.6	1.4	0.015
28.5	24	20	4	75	0.04	0.06	0.01	1.2	1.15	0.015
28.5	78	20	10.5	90	0.04	0.06	0.01	1.25	1.15	0.015
28.5	78	20	10	110	0.04	0.06	0.01	1.25	1.15	0.015
Distance from well MW-5 (feet):					74.9	31.5	45	47.1	74	88
Screen Interval (feet):					26-45	28-49.5	21-27	48-68	48-68	48-68
Depth to Water (DTW, feet):					Dry	Dry	Dry	56.9	56.9	57.8

Vapor extraction well MW-5 screened from 43 to 63 feet. DTW - 57.21 feet
*The I.C. engine operation sputtered at applied vacuums higher than 20" W.C. on MW-5 due to the low oxygen content in extracted vapor.

Notes: Flow measured in cubic feet per minute (CFM).
Concentration measured as percent Lower Explosive Limit (%LEL) by volume on Combustible Gas Meter.
Vacuum measured in inches of water column.
NM = Not Measured.

TABLE 1
VAPOR EXTRACTION TEST FIELD MONITORING DATA
ARCO Station 6113, 785 East Stanley Boulevard
Livermore, California (Page 2 of 2)

Influent Air Stream from VW-2					Observation Wells					
					VW-1	MW-3	MW-4	MW-5	MW-6	MW-7
Flow	% LEL-	Applied Vacuum	$\%O_2$	Elapsed Time (min)	Induced Vacuum	Induced Vacuum	Induced Vacuum	Induced Vacuum	Induced Vacuum	Induced Vacuum
22.9	NM	9	NM	0	NM	NM	NM	NM	NM	NM
37.4	NM	20	NM	2	NM	NM	NM	NM	NM	NM
44.4	NM	30	NM	4	NM	NM	NM	NM	NM	NM
46.1	NM	48	NM	6	NM	NM	NM	NM	NM	NM
* 43.5	NM	54	NM	8	NM	NM	NM	NM	NM	NM
* 48.5	NM	60	NM	10	NM	NM	NM	NM	NM	NM
47.8	36	50	17	15	0.07	0.05	0.09	0.07	0	0
53.5	48	50	16	30	0.08	0.04	0.1	0.08	0	0
49.7	42	50	12	45	0.07	0.05	0.09	0.07	0	0
47.8	36	50	17	60	0.09	0.04	0.1	0.07	0	0
47.8	54	50	7	75	0.09	0.04	0.105	0.06	0	0
47.8	72	48	11	90	0.095	0.04	0.12	0.06	0	0
53.6	60	49	13	110	0.095	0.04	0.12	0.06	0	0
48.4	48	49	15	120	0.095	0.04	0.12	0.06	0	0
45.2	NM	40	NM	130	0.08	0.04	0.1	0.06	0	0
36.4	NM	30	NM	140	0.06	0.04	0.075	0.04	0	0
27.0	NM	20	NM	150	0.06	0.02	0.06	0.04	0	0
10.7	NM	10	NM	170	0.04	0.02	0.04	0.03	0	0
Distance from well VW-2 (feet):					54.5	59.4	18.11	31.5	58.5	66.7
Screen Interval (feet):					26-45	25-40	21-27	43-63	48-68	48-68
Depth to Water (DTW, feet):					Dry	Dry	Dry	57.2	56.9	56.9

Vapor extraction well VW-2 screened from 28 to 49.5 feet. DTW - Dry
*The I.C. engine operation sputtered at applied vacuums higher than 50" W.C. on VW-2.

Flow measured in cubic feet per minute (CFM).
Concentration measured as percent Lower Explosive Limit (%LEL) by volume on Combustible Gas Meter.
Vacuum measured in inches of water column.
NM = Not Measured.

TABLE 2
LABORATORY ANALYSES OF AIR SAMPLES
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California

Sample ID	Sample Location	Elapsed Time of Sample	TPHg	B	T	E	X
AS-VW1-35	VW-1	35	45,000	900	89	27	68
AS-VW2-30	VW-2	30	52,000	510	58	15	35
AS-VW2-EFF	VW-2	35	630	33	5	2	6
AS-VW2-120	VW-2	120	37,000	350	34	10	21
AS-MW5-90	MW-5	90	130,000	530	120	17	39

Concentrations reported in milligrams per cubic meter (mg/m^3).
Effluent sample collected from stack of internal combustion engine.

TPHg: Total petroleum hydrocarbons as gasoline (analyzed by EPA Methods 8015 and 8020).
B: Benzene
T: Toluene
E: Ethylbenzene
X: Total Xylene Isomers
BTEX: Analyzed by EPA Methods 8015 and 8020

TABLE 3
ESTIMATED RADIUS OF INFLUENCE AND
PROJECTED INITIAL HYDROCARBON EXTRACTION RATES
DURING VAPOR EXTRACTION TEST
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California

Vapor Well	Elapsed Time	Applied Vacuum	Air Flowrate	Initial TPHg Vapor Concentration	Projected TPHg Removal Rate	Estimated ROI
VW-1	35 min	50	46 scfm	45,000 mg/m³	186 lb/day	15 to 20
VW-2	30 min	50	48 scfm	52,000 mg/m³	220 lb/day	15 to 20
VW-2	120 min	50	48 scfm	37,000 mg/m³	160 lb/day	15 to 20
MW-5	90 min	20	28 scfm	130,000 mg/m³	330 lb/day	75

Applied vacuum measured in inches of water column.
min = Elapsed time in minutes.
scfm = Air flowrate measured in standard cubic feet per minute.
mg/m^3 = Milligrams per cubic meter
TPHg = Total petroleum hydrocarbons as gasoline (analyzed by EPA Method 8015/8020).
ROI = Effective radius of influence in feet.
lb/day = Removal rate measured in pounds per hour.

$$\text{TPHg removal rate} = \text{air flowrate } (ft^3/min) \times \text{Air concentration } (mg/m^3) \times \frac{[1440 \text{ min/day}] \times [0.02832 \text{ } m^3/ft^3]}{454{,}000 \text{ mg/lb}}$$

TABLE 4
CUMULATIVE RESULTS OF LABORATORY ANALYSES OF SOIL SAMPLES
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California, (Page 1 of 3)

Sample	B	T	E	X	TPHg	TPHd	TOG
September 1989							
S-14½-B1	<0.005	<0.005	<0.005	<0.005	<1.0	<10	<30
S-34½-B1	<0.005	<0.005	<0.005	<0.005	<1.0	<10	<30
S-44½-B1	<0.005	<0.005	<0.005	<0.005	<1.0	<10	<30
S-19-B2	<0.005	<0.005	<0.005	<0.005	<1.0	<10	<50
S-34-B2	<0.005	<0.005	<0.005	<0.005	<1.0	<10	<50
S-41-B2	<0.005	<0.005	<0.005	<0.005	<1.0	<10	<50
S-14-B3	<0.005	<0.005	<0.005	<0.005	<1.0	<10	<50
S-34-B3	<0.005	<0.005	<0.005	<0.005	<1.0	<10	<50
S-37½-B3	<0.005	<0.005	<0.005	<0.005	<1.0	<10	<50
February 1991							
S-14½-B4	<0.005	<0.005	<0.005	<0.005	<1.0	<10	<50
S-19½-B4	<0.005	<0.005	<0.005	<0.005	<1.0	<10	<50
S-29-B4	0.008	<0.005	<0.005	<0.005	<1.0	<10	<50
S-0221-SP(A-D)	<0.005	<0.005	<0.005	<0.005	<1.0	<10	NA
June 1992							
S-10½-B5	<0.005	<0.005	<0.005	<0.005	<1.0	NA	NA
S-20½-B5	1.4	2.0	13	67	1,200	NA	NA
S-30½-B5	1.1	0.30	1.1	6.0	150	NA	NA
S-40½-B5	17	32	14	150	230	NA	NA
S-50½-B5	0.012	<0.005	<0.005	<0.005	<1.0	NA	NA
S-10½-B6	<0.005	<0.005	<0.005	<0.005	<1.0	NA	NA
S-20½-B6	<0.005	<0.005	<0.005	<0.005	<1.0	NA	NA
S-30½-B6	0.45	0.079	0.035	0.15	23	NA	NA
S-45½-B6	0.70	0.021	<0.005	<0.005	1.9	NA	NA
S-50½-B6	0.056	<0.005	<0.005	0.006	<1.0	NA	NA
S-10½-B7	<0.005	<0.005	<0.005	<0.005	<1.0	NA	NA
S-20½-B7	0.43	1.3	0.35	2.5	21	NA	NA
S-30½-B7	0.094	0.20	<0.005	0.023	1.6	NA	NA
S-40½-B7	0.009	<0.005	<0.005	<0.005	<1.0	NA	NA
S-50½-B7	<0.005	<0.005	<0.005	<0.005	<1.0	NA	NA
S-10½-B8	<0.005	<0.005	<0.005	<0.005	<1.0	NA	NA
S-20½-B8	<0.005	0.22	0.42	2.1	68	NA	NA
S-30½-B8	0.043	<0.005	<0.005	<0.005	<1.0	NA	NA
S-45½-B8	0.022	<0.005	<0.005	<0.005	1.1	NA	NA

See notes on Page 3 of 3.

TABLE 4
CUMULATIVE RESULTS OF LABORATORY ANALYSES OF SOIL SAMPLES
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California
(Page 2 of 3)

Sample	B	T	E	X	TPHg	TPHd	TOG
S-8½-B9	<0.005	<0.005	<0.005	<0.005	<1.0	<1.0	<30
S-20½-B9	<0.005	<0.005	<0.005	<0.005	<1.0	<1.0	74
S-30½-B9	<0.005	<0.005	<0.005	<0.005	<1.0	<1.0	<30
S-40½-B9	<0.005	<0.005	<0.005	<0.005	<1.0	<1.0	<30
S-50½-B9	<0.005	<0.005	<0.005	<0.005	<1.0	<1.0	<30
S-10-B10	<0.005	<0.005	<0.005	<0.005	<1.0	<1.0	<30
S-20-B10	<0.005	<0.005	<0.005	<0.005	<1.0	<1.0	<30
S-30-B10	<0.005	<0.005	<0.005	<0.005	<1.0	<1.0	<30
S-45-B10	<0.005	<0.005	<0.005	<0.005	<1.0	<1.0	77
S-55-B10	<0.005	<0.005	<0.005	<0.005	<1.0	<1.0	<30
S-10½-B11	<0.005	<0.005	<0.005	<0.005	<1.0	NA	NA
S-20½-B11	<0.005	<0.005	<0.005	<0.005	<1.0	NA	NA
S-30½-B11	<0.005	<0.005	<0.005	<0.005	5.7	NA	NA
S-40½-B11	<0.005	<0.005	<0.005	<0.005	<1.0	NA	NA
S-50½-B11	<0.005	<0.005	<0.005	<0.005	<1.0	NA	NA
S-55½-B11	<0.005	<0.005	<0.005	<0.005	<1.0	NA	NA
S-0615-SP1(A-D)	<0.005	<0.005	<0.005	<0.005	<1.0	NA	NA
S-0615-SP2(A-D)	0.014	0.037	0.054	0.45	24	NA	NA
August 1992							
S-10-B12	<0.005	<0.005	<0.005	<0.005	<1.0	NA	NA
S-20-B12	<0.005	<0.005	<0.005	<0.005	<1.0	NA	NA
S-30-B12	<0.005	<0.005	<0.005	<0.005	<1.0	NA	NA
S-40-B12	0.59	0.60	1.3	2.0	110	NA	NA
S-50-B12	<0.005	<0.005	<0.005	<0.005	<1.0	NA	NA
S-0804-SP(A-D)	<0.005	0.011	0.030	0.066	2.6	NA	NA

See notes on Page 3 of 3.

TABLE 4
CUMULATIVE RESULTS OF LABORATORY ANALYSES OF SOIL SAMPLES
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California
(Page 3 of 3)

Sample	Cadmium	Chromium	Lead	Nickel	Zinc	VOC
June 1992						
S-8½-B9	<0.010	<0.010	<0.0050	0.051	0.47	ND*
S-50½-B9	<0.010	<0.010	<0.0050	0.098	0.57	ND*
S-10-B10	<0.010	<0.010	<0.0050	0.13	0.44	ND*
S-55-B10	<0.010	<0.010	<0.0050	0.063	0.75	ND*
Background average concentrations in soil (ppm)[1,2]	0.06	100	11.5	74	50	–

Results in parts per million (ppm).
<: Results reported as less than the detection limit.
NA: Not Analyzed
TPHg: Total petroleum hydrocarbons as gasoline by EPA method 5030/8015/8020.
TPHd: Total petroleum hydrocarbons as diesel by EPA method 3550/8015.
B: Benzene, T: Toluene, E: Ethylbenzene, T: Total Xylene isomers
BTEX: Analyzed by EPA method 5030/8015/8020.
TOG: Total Oil and Grease by Standard Method 5520 E&F.
VOCs = Halogenated volatile organics.
NA = Compound not analyzed for.
ND = Compound not detected.
* = 37 compounds were tested
[1]Lindsay, W.L. 1979. Chemical Equilibria in Soil. John Wiley & Sons.
[2]Scot, L.M. December 1991. Background Metal Concentrations in Soils in Northern Santa Clara County, California". M.S. Thesis, University of San Francisco.
Composite soil sample S-0615-SP2(A-D) consists of four soil samples taken from stockpiled soil.
Sample designation:

S-55-B11
- Boring number
- Sample depth in feet below ground surface
- Soil sample

TABLE 4
CUMULATIVE RESULTS OF LABORATORY ANALYSES OF SOIL SAMPLES
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California
(Page 3 of 3)

Sample	Cadmium	Chromium	Lead	Nickel	Zinc	VOC
June 1992						
S-8½-B9	<0.010	<0.010	<0.0050	0.051	0.47	ND*
S-50½-B9	<0.010	<0.010	<0.0050	0.098	0.57	ND*
S-10-B10	<0.010	<0.010	<0.0050	0.13	0.44	ND*
S-55-B10	<0.010	<0.010	<0.0050	0.063	0.75	ND*
Background average concentrations in soil (ppm)[1,2]	0.06	100	11.5	74	50	--

Results in parts per million (ppm).
<: Results reported as less than the detection limit.
NA: Not Analyzed
TPHg: Total petroleum hydrocarbons as gasoline by EPA method 5030/8015/8020.
TPHd: Total petroleum hydrocarbons as diesel by EPA method 3550/8015.
B: Benzene, T: Toluene, E: Ethylbenzene, T: Total Xylene isomers
BTEX: Analyzed by EPA method 5030/8015/8020.
TOG: Total Oil and Grease by Standard Method 5520 E&F.
VOCs = Halogenated volatile organics.
NA = Compound not analyzed for.
ND = Compound not detected.
* = 37 compounds were tested
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Composite soil sample S-0615-SP2(A-D) consists of four soil samples taken from stockpiled soil.
Sample designation:

```
S-55-B11
| |  └──  Boring number
| └────  Sample depth in feet below ground surface
└──────  Soil sample
```

TABLE 5
CUMULATIVE RESULTS OF LABORATORY ANALYSES OF GROUNDWATER SAMPLES -- TPHg and BTEX
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California (Page 1 of 3)

Well Date	TPHg	Benzene	Toluene	Ethyl-benzene	Total Xylenes
MW-1					
09/20/89	80	3.0	1.0	0.7	1
06/21/90	<20	<0.50	0.66	<0.50	<0.50
09/20/90	<50	<0.5	1.0	<0.5	1.8
12/18/90	<50	<0.5	1.8	<0.5	1.7
02/21/91	<50	1.2	2.3	<0.5	2.2
05/20/91	<30	<0.30	<0.30	<0.30	<0.30
08/13/91	Not sampled--dry				
11/13/91	Not sampled--dry				
03/19/92	400	<3.5*	<1.2*	<0.8*	<1.0*
06/29/92	Not sampled--residual water only				
09/11/92	Not sampled--dry				
11/12/92	Not sampled--dry				
03/30/93	<50	<0.5	<0.5	<0.5	<0.5
MW-2					
09/20/89	<50	<0.5	<0.5	<0.5	<1
06/21/90	<20	<0.50	<0.50	<0.50	<0.50
09/20/90	<50	<0.5	0.7	<0.5	1.4
12/18/90	<50	0.6	1.5	<0.5	1.9
02/21/91	<50	<0.5	<0.5	<0.5	<0.5
05/20/91	<30	<0.30	<0.30	<0.30	<0.30
08/13/91	Not sampled--dry				
11/13/91	Not sampled--dry				
03/19/92	<50	<0.5	<0.5	<0.5	<0.5
06/29/92	<50	<0.5	<0.5	<0.5	<0.5
09/11/92	Not sampled--residual water only				
11/12/92	Not sampled--dry				
03/30/93	<50	<0.5	<0.5	<0.5	<0.5
MW-3					
09/20/89	170	8.9	0.6	1.1	<1
06/21/90	<20	<0.50	1.0	<0.50	<0.50
09/20/90	<50	<0.5	1.0	<0.5	1.9
12/18/90	<50	<0.5	1.7	<0.5	2.0
02/21/91	<50	<0.5	<0.5	<0.5	<0.5
05/20/91	97	1.3	1.1	6.2	8.4
08/13/91	Not sampled--dry				
11/13/91	Not sampled--dry				
03/19/92	220	<1.1*	<1.9	<0.6*	<0.8*
06/29/92	Not sampled --residual water only				
09/11/92	Not sampled --residual water only				

See notes on Page 3 of 3.

TABLE 5
CUMULATIVE RESULTS OF LABORATORY ANALYSES OF GROUNDWATER -- TPHg and BTEX
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California (Page 2 of 3)

Well Date	TPHg	Benzene	Toluene	Ethyl-benzene	Total Xylenes
MW-3 cont.					
11/12/92	Not sampled--dry				
03/30/93	200**	<4.0*	<0.5	<0.5	<0.5
MW-4					
02/21/91	3,500	410	7.6	30	47
05/20/91	1,400	150	6.0	4.4	3.1
08/13/91	Not sampled--dry				
11/13/91	Not sampled--dry				
03/19/92	Not sampled--dry				
06/29/92	Not sampled--dry				
09/11/92	Not sampled--dry				
11/12/92	Not sampled--dry				
03/31/93	680	110	5.2	3.0	7.4
MW-5					
06/29/92	8,900	1,700	640	310	1,100
09/11/92	13,000	2,200	1,500	130	930
11/12/92	Not sampled--residual water only				
03/31/93	9,700	1,700	430	220	880
MW-6					
06/29/92	8,600	1,800	460	52	450
09/11/92	Not sampled--floating product				
11/12/92	Not sampled--floating product				
03/31/93	Not sampled--floating product				
MW-7					
06/29/92	270	38	3.7	1.1	4.4
09/11/92	420	20	0.7	<0.5	<0.5
11/12/92	470	31	1.0	<0.5	0.8
03/31/93	190	20	1.0	<0.5	<0.5
MW-8					
06/29/92	<50	<0.5	<0.5	<0.5	<0.5
09/11/92	<50	<0.5	<0.5	<0.5	<0.5
11/12/92	<50	<0.5	<0.5	<0.5	<0.5
03/30/93	<50	<0.5	<0.5	<0.5	<0.5

See notes on Page 3 of 3.

TABLE 5
CUMULATIVE RESULTS OF LABORATORY ANALYSES OF GROUNDWATER SAMPLES – TPHg and BTEX
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California
(Page 3 of 3)

MW-9					
06/29/92	<50	<0.5	<0.5	<0.5	<0.5
09/11/92	<50	<0.5	<0.5	<0.5	<0.5
11/12/92	<50	<0.5	<0.5	<0.5	<0.5
03/31/93	<50	<0.5	<0.5	<0.5	<0.5
MW-10					
03/31/93	230**	<0.5	<0.5	<1.0*	0.6
MW-11					
03/31/93	<50	<0.5	<0.5	<0.5	<0.5
MW-12					
03/31/93	150	20	<0.5	<0.5	<0.5
MCLs	None	1.0	None	680	1,750
DWAL	None	None	100	None	None

Results in parts per billion (ppb). Benzene, toluene, ethylbenzene and total xylenes by EPA Method 5030/8020/DHS LUFT Method.
TPHg = Total petroleum hydrocarbons as gasoline by EPA Method 5030/8020/DHS LUFT Method.
< = Less than the detection limits shown.
MCLs = Adopted Maximum Contaminant Levels in Drinking Water, DHS (October 1990)
DWAL = Recommended Drinking Water Action Level, DHS (October 1990)
* = Laboratory reportedly raised detection limit due to matrix interference.
** = The sample contains components eluting in the gasoline range that were quantitated as gasoline. The chromatogram does not match the typical gasoline fingerprint.

TABLE 6
CUMULATIVE RESULTS OF LABORATORY ANALYSES OF GROUNDWATER SAMPLES – VOCs, TPHd, TOG, and Metals
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California
(Page 1 of 2)

Well Date	VOCs	TPHd	TOG	Cd	Cr	Pb	Zn	Ni
MW-1								
09/20/89	NA	<50	<5,000	NA	NA	NA	NA	NA
06/21/90	NA	<100	13,000	NA	NA	NA	NA	NA
09/20/90	NA	<50	<5,000	NA	NA	NA	NA	NA
12/18/90	NA		<5,000	NA	NA	NA	NA	NA
02/21/91	NA		<5,000	NA	NA	NA	NA	NA
05/20/91	NA		<75,000	NA	NA	NA	NA	NA
08/13/91	NS		NS	NS	NS	NS	NS	NS
11/13/91	NS		NS	NS	NS	NS	NS	NS
03/19/92	NA		NA	NA	NA	NA	NA	NA
06/29/92	NS		NS	NS	NS	NS	NS	NS
09/11/92	NS		NS	NS	NS	NS	NS	NS
11/12/92	NS		NS	NS	NS	NS	NS	NS
03/30/93	NA		NA	NA	NA	NA	NA	NA
MW-2								
09/20/89	NA	<50	<5,000	NA	NA	NA	NA	NA
06/21/90	NA	<100	<5,000	NA	NA	NA	NA	NA
09/20/90	NA	<50	<5,000	NA	NA	NA	NA	NA
12/18/90	NA		<5,000	NA	NA	NA	NA	NA
02/21/91	NA		<5,000	NA	NA	NA	NA	NA
05/20/91	NA		<75,000	NA	NA	NA	NA	NA
08/13/91	NS		NS	NS	NS	NS	NS	NS
11/13/91	NS		NS	NS	NS	NS	NS	NS
03/19/92	NA		NA	NA	NA	NA	NA	NA
06/29/92	NA		NA	NA	NA	NA	NA	NA
09/11/92	NS		NS	NS	NS	NS	NS	NS
11/12/92	NS		NS	NS	NS	NS	NS	NS
03/30/93	NA		NA	NA	NA	NA	NA	NA
MW-3								
09/20/89	NA	<50	<5,000	NA	NA	NA	NA	NA
06/21/90	NA	<100	10,000	NA	NA	NA	NA	NA
09/20/90	NA	<50	<5,000	NA	NA	NA	NA	NA
12/18/90	NA		<5,000	NA	NA	NA	NA	NA
02/21/91	NA		<5,000	NA	NA	NA	NA	NA
05/20/91	NA		<75,000	NA	NA	NA	NA	NA
08/13/91	NS		NS	NS	NS	NS	NS	NS
11/13/91	NS		NS	NS	NS	NS	NS	NS
03/19/92	NA	<50	<5,000	NA	NA	NA	NA	NA
06/29/92	NS		NS	NS	NS	NS	NS	NS
09/11/92	NS		NS	NS	NS	NS	NS	NS

See notes on Page 2 of 2.

TABLE 6
CUMULATIVE RESULTS OF LABORATORY ANALYSES OF GROUNDWATER SAMPLES – VOCs, TPHd, TOG, and Metals
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California
(Page 2 of 2)

Well Date	VOCs	TPHd	TOG	Cd	Cr	Pb	Zn	Ni
MW-3 cont.								
11/12/92	NS		NS	NS	NS	NS	NS	NS
03/30/93	NA		NA	NA	NA	NA	NA	NA
MW-4								
02/21/91	NA		<5,000	NA	NA	NA	NA	NA
05/20/91	NA		<75,000	NA	NA	NA	NA	NA
08/13/91	NS		NS	NS	NS	NS	NS	NS
11/13/91	NS		NS	NS	NS	NS	NS	NS
03/19/92	NS		NS	NS	NS	NS	NS	NS
06/29/92	NS		NS	NS	NS	NS	NS	NS
09/29/92	NS		NS	NS	NS	NS	NS	NS
11/12/92	NS		NS	NS	NS	NS	NS	NS
03/31/93	NA		NA	NA	NA	NA	NA	NA
MW-8								
06/29/92	ND*	<50	<500	<3	1,780	143	1,310	5,100
09/11/92	NA	<50	<500	13	3,580	308	2,620	10,300
11/12/92	NA		NA	28	3,440	221	2,550	9,840
03/31/93	NA		NA	NA	NA	NA	NA	NA
MW-9								
11/12/92	NA		NA	10	1,080	101	859	3,070
03/31/93	NA		NA	NA	NA	NA	NA	NA
MCL:	Varies	—	—	10	50	50	5,000	—

Results in micrograms per liter (ug/L) = parts per billion (ppb).

VOCs: Halogenated Volatile Organic Compounds by EPA Method 5030/601.
TPHd: Total petroleum hydrocarbons as diesel by EPA Methods 3510/California DHS LUFT Method.
TOG: Total oil and grease measured by EPA Method 5520C&F.
Cd: Cadmium by EPA Method 6010.
Cr: Chromium by EPA Method 6010.
Ni: Nickel by EPA Method 6010.
Zn: Zinc by EPA Method 6010.
Pb: Lead by EPA Method 7421.
NA: Not analyzed.
<: Results reported as less than the detection limit.
NS: Well not sampled.
ND: Not detected.
*: 31 compounds tested were nondetectable.
MCL: Adopted Maximum Contaminant Levels in Drinking Water (October 1990)

TABLE 7
CUMULATIVE GROUNDWATER MONITORING DATA
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California (Page 1 of 5)

Well Date	Elevation of Wellhead	Depth to Water	Elevation of Groundwater	Floating Product
MW-1				
09/20/89	457.04	21.03	436.01	None
10/12/89		19.64	437.40	None
06/21/90		21.72	435.32	None
09/20/90		19.79	437.25	None
12/18/90		19.28	437.76	None
02/21/91		22.45	434.59	None
03/20/91		19.87	437.17	None
04/10/91		19.42	437.62	None
05/20/91		25.95	431.09	None
06/20/91		32.55	424.49	None
07/25/91		38.22	418.82	None
08/13/91		40.74	416.30	None
09/12/91		43.16	413.88	None
10/22/91		Dry	Dry	None
11/13/91		Dry	Dry	None
12/21/91		Dry	Dry	None
01/18/92		Dry	Dry	None
02/21/92		Dry	Dry	None
03/19/92		36.16	420.88	None
04/24/92		38.14	418.90	None
05/20/92		40.74	416.30	None
06/29/92		43.80*	–	None
07/28/92		Dry	Dry	None
08/26/92		Dry	Dry	None
09/11/92		Dry	Dry	None
10/29/92		Dry	Dry	None
11/11/92		Dry	Dry	None
12/14/92	Not monitored due to construction activities			
01/27/93		30.10	426.94	None
02/26/93		24.72	432.32	None
03/30/93		20.87	436.17	None
MW-2				
09/20/89	457.74	20.67	437.07	None
10/12/89		18.98	438.76	None
06/21/90		21.88	435.86	None
09/20/90		19.90	437.84	None
12/18/90		19.32	438.42	None
02/21/91		23.02	434.72	None
03/20/91		20.01	437.73	None
04/10/91		19.81	437.93	None

See notes on Page 5 of 5.

TABLE 7
CUMULATIVE GROUNDWATER MONITORING DATA
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California
(Page 2 of 5)

Well Date	Elevation of Wellhead	Depth to Water	Elevation of Groundwater	Floating Product
MW-2 cont.				
05/20/91	457.74	26.62	431.12	None
06/20/91		33.15	424.59	None
07/25/91		37.10	420.64	None
08/13/91		37.20	420.54	None
09/12/91		37.44*	—	None
10/22/91		37.38*	—	None
11/13/91		37.39*	—	None
12/21/91		Dry	Dry	None
01/18/92		37.65*	—	None
02/21/92		37.75*	—	None
03/19/92		35.82	421.92	None
04/24/92		36.64	421.10	None
05/20/92		37.23	420.51	None
06/29/92		37.67*	—	None
07/28/92		38.36*	—	None
08/26/92		38.26*	—	None
09/11/92		38.37*	—	None
10/29/92		Dry	Dry	None
11/11/92		Dry	Dry	None
12/14/92	Not monitored due to construction activities			
01/27/93		32.87	424.87	None
02/26/93	Not monitored due to construction activities			
03/30/93		20.47	437.27	None
MW-3				
09/20/89	456.97	20.98	435.99	None
10/12/89		19.66	437.31	None
06/21/90		21.72	435.25	None
09/20/90		19.72	437.25	None
12/18/90		19.21	437.76	None
02/21/91		22.36	434.61	None
03/20/91		19.79	437.18	None
04/10/91		19.35	437.62	None
05/20/91		25.86	431.11	None
06/20/91		32.45	424.52	None
07/25/91		38.06	418.91	None
08/13/91		38.40	418.57	None
09/12/91		Dry	Dry	None
10/22/91		Dry	Dry	None
11/13/91		Dry	Dry	None
12/21/92		Dry	Dry	None

See notes on Page 5 of 5.

TABLE 7
CUMULATIVE GROUNDWATER MONITORING DATA
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California
(Page 3 of 5)

Well Date	Elevation of Wellhead	Depth to Water	Elevation of Groundwater	Floating Product
MW-3 cont.				
01/18/92	456.97	38.90*	—	None
02/21/92		38.88*	—	None
03/19/92		36.03	420.94	None
04/24/92		37.92	419.05	None
05/20/92		38.57*	—	None
06/29/92		38.70*	—	None
07/28/92		39.05*	—	None
08/26/92		39.03*	—	None
09/11/92		39.02*	—	None
10/29/92		Dry	Dry	None
11/11/92		Dry	Dry	None
12/14/92	Not monitored due to construction activities			
01/27/93		30.36	426.61	None
02/26/93		24.96	432.01	None
03/30/93		21.45	435.52	None
MW-4				
02/21/91	456.97	22.01	434.96	None
03/20/91		20.31	436.66	None
04/10/91		19.55	437.42	None
05/20/91		25.24	431.73	None
06/20/91		Dry	Dry	None
07/25/91		Dry	Dry	None
08/13/91		Dry	Dry	None
09/12/91		Dry	Dry	None
10/22/91		Dry	Dry	None
11/13/91		Dry	Dry	None
12/21/92		Dry	Dry	None
01/18/92		Dry	Dry	None
02/21/92		Dry	Dry	None
03/19/92		Dry	Dry	None
04/24/92		Dry	Dry	None
05/20/92		Dry	Dry	None
06/29/92	456.55	Dry	Dry	None
07/28/91		Dry	Dry	None
08/26/92		Dry	Dry	None
09/11/92		Dry	Dry	None
10/29/92		Dry	Dry	None
11/11/92		Dry	Dry	None
12/14/92	Not monitored due to construction activities			
01/27/93		Dry	Dry	None

See notes on Page 5 of 5.

TABLE 7
CUMULATIVE GROUNDWATER MONITORING DATA
ARCO Station 6113
785 East Stanley Boulevard
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Well Date	Elevation of Wellhead	Depth to Water	Elevation of Groundwater	Floating Product
MW-4 cont.				
02/26/93	456.55	23.60	432.95	None
03/30/93		20.87	435.68	None
MW-5				
06/29/92	455.84	50.53	405.31	Odor
07/28/92		54.92	400.92	None
08/26/92		59.58	396.26	None
09/11/92		60.88	394.96	None
10/29/92		61.86*	—	None
11/11/92		62.53*	—	None
12/14/92	Not monitored due to construction activities			
01/27/93		29.08	426.76	None
02/26/93		23.56	432.28	None
03/30/93		20.32	435.52	None
MW-6				
06/29/92	454.93	49.72	405.21	None
07/28/92		54.63	400.30	None
08/26/92		59.45	395.48	None
09/11/92		60.73**	394.20**	0.04
10/29/92		62.14	392.79	None
11/11/92		62.42**	392.51**	0.03
12/14/92	Not monitored due to construction activities			
01/27/93	Not monitored due to construction activities			
02/26/93		22.73	432.20	None
03/30/93		19.53	435.40	None
MW-7				
06/29/92	454.92	49.57	405.35	None
07/28/92		54.60	400.32	None
08/26/92		59.60	395.32	None
09/11/92		60.74	394.18	None
10/29/92		62.23	392.69	None
11/11/92		62.69	392.23	None
12/14/92	Not monitored due to construction activities			
01/27/93		27.97	426.95	None
02/26/93		22.57	432.35	None
03/30/93		19.29	435.63	None
MW-8				
06/29/92	456.97	50.40	406.57	None

See notes on Page 5 of 5.

TABLE 7
CUMULATIVE GROUNDWATER MONITORING DATA
ARCO Station 6113
785 East Stanley Boulevard
Livermore, California
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Well Date	Elevation of Wellhead	Depth to Water	Elevation of Groundwater	Floating Product
MW-8 cont.				
07/28/92	456.97	55.79	401.18	None
08/28/92		60.79	396.18	None
09/11/92		61.97	395.00	None
10/29/92		63.51	393.46	None
11/11/92		64.21	392.76	None
12/14/92	Not monitored due to construction activities			
01/27/93		25.57	431.40	None
02/26/93		19.86	437.11	None
03/30/93		16.69	440.28	None
MW-9				
06/29/92	456.18	50.29	405.89	None
07/28/92		55.53	400.65	None
08/26/92		60.62	395.56	None
09/11/92		61.67	394.51	None
10/29/92		63.17	393.01	None
11/11/92		63.68	392.50	None
12/14/92	Not monitored due to construction activities			
01/27/93		26.48	429.70	None
02/26/93	Not monitored due to construction activities			
03/30/93		17.77	438.41	None
MW-10				
03/30/93	456.85	21.33	435.52	None
MW-11				
03/30/93	455.07	20.78	434.29	None
MW-12				
03/30/93	455.04	21.33	433.71	None

For MW-1 through MW-3 (surveyed by Ron Archer in October 1988) and MW-4 (surveyed by Ron Archer in February 1991) wellhead elevation based on benchmark: Top of pin set in concrete in the most westerly monument at the intersection of East Stanley Boulevard and Fenton Avenue. Elevation taken as 455.896 mean sea level. City of Livermore Datum.
For MW-4 through MW-9 (surveyed by John Koch in June 1992) and MW-10 through MW-12 (surveyed by John Koch in April 1993) wellhead elevation based on benchmark: Top of pin in standard monument, at intersection of El Rancho Drive and Albatross Ave. Elevation taken as 448.218'. City of Livermore Datum.
Measurements in feet.
* Residual water.
**Adjusted water level due to product. The recorded thickness of the floating product was then multiplied by 0.80 to obtain an approximate value for the displacement of water by the floating product. This approximate displacement value was then subtracted from the measured depth to water to obtain a calculated depth to water. These calculated groundwater depths were subtracted from surveyed wellhead elevations to calculate the differences in groundwater elevations.