20-174

**URS**

SEP 30 2004

September 28, 2004

Mr. Robert W. Schultz, R.G.
Alameda County Environmental Health
1131 Harbor Bay Parkway
Alameda, CA 94502

**Re: Active Soil Gas Investigation Work Plan, Former ARCO Station # 5387, 20200 Hesperian Boulevard, Hayward, California, URS Project # 38486576**

Dear Mr. Schultz:

On behalf of the Atlantic Richfield Company (a BP affiliated Company), URS Corporation (URS) has prepared this sampling plan for soil vapor sampling at ARCO Station #5387 (the Site), located at 20200 Hesperian Boulevard, Hayward, California. This sampling plan was prepared in response to a letter from Alameda County Environmental Health (ACEH) to Atlantic Richfield Company (RM) dated August 30, 2004, requesting additional characterization at this site for case closure evaluation.

## 1.0 SITE FEATURES AND BACKGROUND

This non-operational Site is located in an area of mixed commercial and residential development at the southeastern corner of the Hesperian Boulevard and West Sunset Drive intersection. The site currently consists of a relatively flat asphalt and concrete covered lot, at an elevation of approximately 38 feet above mean seal level (Figures 1, 2 and 3).

In August 1986, Groundwater Technology Inc. (GTI) drilled four exploratory soil borings (SB-1 through SB-4) and installed three groundwater monitoring wells (MW-1 through MW-3). In October and December 1991, GeoStrategies, Inc (GSI) installed four additional groundwater monitoring wells (A-4 through A-7). In August 1992, GSI installed two offsite groundwater monitoring wells (A-8 and A-9) and one groundwater recovery well (AR-1) at the Site. One off-Site downgradient exploratory soil boring was drilled and completed as groundwater monitoring well A-10 on November 18, 1992. GSI drilled six on-Site exploratory soil borings and installed recovery well AR-2, vapor extraction/air sparging well AS-1, and air sparging well AS-2 in these borings on March 16 and 17, 1993.

An aquifer pumping and recovery test was performed at the site by GSI on October 13 and 14, 1992 utilizing recovery well AR-1. GSI evaluation of the step-drawdown test suggested that a pumping rate of 3 gallons per minute (gpm) would be the optimal discharge rate for the constant rate test. Maximum observed drawdown in the pumping well was 12.06 feet. Calculated hydraulic conductivity values from the field data plots ranged from 22.2 feet per day (ft/d) (7.85 x $10^{-3}$ centimeters per second [cm/s]) to 59.0 ft/d (2.08 x $10^{-2}$ cm/s). Storativity ranged between 1.09 x $10^{-4}$ and 9.92 x $10^{-2}$. Storativity values appear to represent an aquifer that is unconfined to

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semi-confined. The maximum observation well drawdown was seen in well A-7 at 0.55 feet below initial water-levels. Well A-7 is approximately 80 feet downgradient from the pumping well AR-1. Finally, the well efficiency was calculated to be 16.5% at a constant discharge rate of 3 gpm. Low well efficiency of well AR-1 may be a function of the fine-grained nature of the aquifer in the area around the well (GeoStrategies, 1993).

GSI performed two vapor extraction tests (VET) and one vapor extraction/air sparging test (VEAT) at the Site on March 24, 1993. A fourth test (VET) was performed on August 13, 1993. These tests were performed on four distinct groups of wells. The effective radius of influence was estimated to be 20 feet. The calculated hydrocarbon removal rates for these tests ranged from 11 pounds per day (lbs/day) to 60.7 lbs/day.

In December 1998 a leak was observed from the impact valve of dispenser No. 8 while overseeing the re-booting of the dispenser piping. Petroleum hydrocarbon constituents were detected in soil samples collected beneath dispenser No. 8. As a result, ACEH requested further assessment under dispenser No. 8.

On June 13, 2000, Delta Environmental Consultants, Inc (Delta) completed one hand auger soil boring (HA-1) to a total depth of approximately 13 feet bgs at an angle approximately 60° off horizontal. Soil samples were collected at 3-feet, 6-feet, 9-feet, and 12.5-feet bgs for chemical analysis. Based on the analytical results, it appeared that the soil beneath dispenser No. 8 was not significantly impacted. Benzene concentrations were not detected at or above the laboratory reporting limits and MTBE was reported at less than 1 milligram per kilogram (mg/kg).

In February 2002 Delta conducted soil sampling during the removal of four underground storage tanks (USTs), product distribution lines, and product dispenser islands at the site (Delta 2002). The recent (third quarter 2003) increase in MTBE concentrations at AR-1, MW-1, and MW-2 may be the result of constituents from the vadose zone being flushed into the groundwater by infiltration of precipitation through areas left exposed after the removal of the tanks. The site has since been paved over and is currently an empty lot.

URS conducted a Dual Phase Extraction (DPE) test between November 4 and November 9, 2002 for approximately 120 hours (the system was shut down for 17.8 hours on November 6 and 7, 2002) on three extraction points (MW-2, AR-2, and EP-1) (URS 2003). Test results indicated limited success using DPE on wells MW-2 and AR-1 to remove hydrocarbons and MTBE from soil and groundwater. On December 16, 2003, URS injected hydrogen peroxide in wells AR-1, AR-2, MW-1, MW-2, and A-7 and monitored baseline natural attenuation parameters for these wells on November 17, 2003 and on March 1, 2004. Peroxide injections were conducted under pressure for wells MW-1 and MW-2. The subsequent monitoring of hydrocarbon concentrations indicated that hydrogen peroxide injection did not have a uniform effect on hydrocarbon concentrations in the injection wells. Additionally, the natural attenuation parameters did not exhibit any conclusive trends.

## 2.0 ENVIRONMENTAL CONDITIONS

### 2.1 Site Hydrogeology

The following description of site hydrogeology comes from the *Site Assessment Investigation Report* (Groundwater Technology, Inc, 1986).

The site lies within the hydrogeologic feature known as the East Bay Plains Groundwater Basin. Groundwater occurs in mostly confined aquifers consisting of unconsolidated Tertiary to Quaternary age deposits. Some unconfined water bearing deposits of Quaternary age exist within this basin. The consolidated basement rocks underlying the Quaternary and Tertiary age deposits are considered to be non-water bearing due to their poor yields.

The water bearing deposits are composed of coalescing alluvial fans sloping westward from the Diablo Range to the east. These alluvial deposits are collectively known as the San Leandro Cone, a sub basin of the East Bay Plains Groundwater Basin. These water-bearing deposits are interfingered with tideland deposits that resulted from accumulations of flood stage silts and clays caused by marine inundations. Where these deposits are laterally extensive and/or thick enough, they can form confining layers that are impervious to the groundwater flow. These aquifers do not correlate at depths over any appreciable distance. They are analogous to the more studied Newark, Centerville, and Fremont aquifers located farther south in the adjacent Niles Cone Basin.

The near surface soils found in borings at the site are clays generally ranging from three to eight feet in thickness (except boring A-10, where no clay is present). The clays are underlain by silts and sandy silts ranging from 15 to 25 feet thick that are interbedded with occasional sand and clay lenses. The silts grade into sands and gravels at depths greater than 20 feet. These sand and gravel lenses pinch out towards the western edge of the site. Silts and clays were encountered at the bottom of several of the deeper wells and soil borings (A-4, AR-1, A-9, and A-8) and may indicate a confining layer below the water bearing sands and gravels. The cross sections illustrate the local geology underlying the site (Figures 4 and 5).

Groundwater occurs at a depth of approximately 10 feet below ground surface and groundwater flow direction is to the west, toward San Francisco Bay. Figure 2 shows the hydraulic gradient direction at the Site during the most recent second quarter 2004 monitoring event. A Rose diagram showing the historic groundwater flow direction is consistently to the west has also been included in Figure 2. The hydraulic gradient historically ranges from 0.003 to 0.008 feet per foot between the second quarter of 2002 and the first of 2004. Sulphur Creek, the most prominent surficial water feature, flows from east to west about 0.2 miles to the south.

### 2.2 Groundwater

A review of groundwater monitoring data for the Site indicates that the extent of the residual traces of the dissolved phase hydrocarbon plume has been defined (URS 2004). Wells A-4 through A-10 delineate the area of affected groundwater. Wells A-7 and A-10 located west across Hesperian Boulevard define the downgradient extent of the affected area, wells A-5, A-6, A-8, A-9, and MW-3 define the crossgradient extents, and well A-4 defines the upgradient extent. The well locations are shown in Figure 2. Groundwater analytical results are presented in Table 1 in comparison to Environmental Screening Levels (ESLs) for groundwater that is potential drinking (100 µg/L for TPH-g, 1.0 µg/L for benzene, and 5 µg/L for MTBE) and non drinking water sources (500 µg/L for TPH-g, 46 µg/L for benzene, and 1,800 µg/L for MTBE). The most recent second quarter 2004 analytical results are graphically presented in Figure 2. The groundwater monitoring analytical results from 2003 and 2004 of TPH-g, benzene and MTBE concentrations in source area indicate the following:

- Wells A-4 through A-10 that define the extent of the plume have consistently been below reporting limits for TPH-g/Gasoline range organics (GRO) and benzene, toluene, ethyl benzene, and xylenes (BTEX), with very low concentrations of MTBE ranging between non-detect to 1.1 µg/L (Table 1).
- Well MW-1 is located in the immediate vicinity of the primary source area (former UST complex location). BTEX concentrations in well MW-1 have consistently been at non-detect to relatively low levels. During the second quarter of 2004, MTBE concentrations were 250 µg/L. During the first and fourth quarters of 2003, TPH-g/GRO in MW-1 was present above ESL for potential drinking water sources but was below the ESL for non drinking water sources (Table 1).
- Wells AR-1 and A-7 are located immediately downgradient of MW-1 and the former UST complex location. TPH-g/GRO and BTEX concentrations in wells AR-1 and A-7 have consistently been at non-detect levels since the first quarter of 2003. In the second quarter of 2004, MTBE concentrations were at 3.6 µg/L in AR-1, below the ESLs for drinking and non drinking water sources. MTBE concentrations were at 0.92 µg/L in A-7 during the second quarter 2004, below ESLs for drinking and non drinking water sources (Table 1).
- Well MW-2 is located in the vicinity and immediately downgradient of the former pump island locations. BTEX concentrations in MW-2 have consistently been at low to non-detect levels, with concentrations being at non-detect levels during the second quarter of 2004. TPH-g/GRO and MTBE concentrations are at relatively low levels in MW-2 and have generally been declining. During the second quarter of 2004, TPH-g/GRO was detected at a concentration of 310 µg/L and MTBE was detected at 9.2 µg/L in MW-2 (Table 1).
- Well AR-2 is located in the vicinity and immediately downgradient of the former pump island locations. TPH-g/GRO and BTEX concentrations in AR-2 have consistently been at low to non-detect levels, with concentrations being at non-detect levels during the second quarter of 2004 (Table 1). During the second quarter of 2004, MTBE concentrations were detected at 4.30 µg/L in AR-2, which is below the ESLs for drinking and non drinking water sources.

## 2.3 Soil

A review of the analytical results of soil samples collected from the Site during 2000 and 2004 investigations (Delta 2000, 2004) indicates that the lateral and vertical extents of hydrocarbon impacts on onsite soils have been characterized and are limited to the source areas in the vicinity of sample locations OE-DP-1-12.3 (at 12.3 feet bgs) and UST-5-15 through UST-8-15 (at 15 feet bgs). The respective sample locations are shown on Figure 3 and the associated analytical results are presented in Table 2 (Figure 3 and Table 2).

Most of the hydrocarbon impacted soils in the source areas have been over-excavated. In the former pump island location, soil was excavated to depths of 12.3 feet bgs and in the former UST complex location to depths of 15 feet bgs (Figure 3). The maximum TPH-g, benzene and MTBE concentrations remaining in soils are 270 mg/kg (UST-6-15; at 15 feet bgs), 0.13 mg/kg (OE-DP-1-12.3; at 12.3 feet bgs), and 1.3 mg/kg (UST-8-15; at 15 feet bgs), respectively. However, it is to be noted that the respective residual hydrocarbon concentrations do not exceed applicable ESLs (Table 2).

## 2.4 Sensitive Receptors

In May/June 2001, a well survey was conducted within a one mile radius of the Site using records obtained from the Department of Water Resources (DWR) and Alameda County Public Works department (Figure 6, Attachment B). Approximately 59 wells were noted to be located within a one mile radius of the Site, of which, 9 were domestic, 38 were irrigation, 9 were unknown, and 3 were industrial (Figure 6, Attachment B). Approximately 8 wells were identified within a 2,000 feet radius of the Site, of which 6 were irrigation wells and 2 were of unknown usage. However, of the 8 wells identified within a 2,000 feet radius of the Site, only one irrigation well was identified to be located in the general downgradient and crossgradient direction of the Site, at an approximate distance of 500 feet northwest of the Site. Historic direction for groundwater flow at the Site is to the west. Considering the non-migratory residual concentrations of dissolved phase petroleum hydrocarbons in the groundwater that is confined to the primary source areas at the Site, no water wells, deeper drinking water aquifers, surface water or other sensitive receptors are likely to be impacted.

# 3.0 PROPOSED SAMPLING PLAN

The proposed sampling plan responds to ACEH's request for an active soil gas investigation workplan. Accordingly, this proposed sampling plan addresses the following:

- Soil Gas Sample Collection Plan and Procedure
- Data Analysis and Reporting

### 3.1 Prefield Activities

Before initiating field activities, URS will obtain a soil boring permit from Alameda County Public Works Agency , Water Resources Section, create a Site Health and Safety Plan (HASP) describing hazards associated with the proposed work, and conduct a subsurface utility clearance. The utility clearance will include notifying Underground Service Alert a minimum of 48 hours prior to initiating field activities and securing the services of a private utility-locating company to confirm the absence of underground utilities at each boring location. All borings will be cleared by air knifing the first 5 feet below grade.

The HASP, which will be prepared for URS personnel conducting field activities, will address the proposed soil boring and soil gas sampling protocol. A copy of the HASP will be available on-site at all times. The URS Site supervisor will hold a tailgate meeting covering aspects of the HASP before starting any work.

### 3.2 Soil Gas Sample Collection Plan

Based on historical soil sample results (Table 2), residual petroleum hydrocarbon concentrations in onsite soils do not exceed applicable ESLs. One sample result of potential concern (UST-2-14) collected at 14 feet bgs reported ND<0.50 mg/kg of benzene, where the laboratory reporting limit is greater than applicable residential ESL of 0.18 mg/kg for benzene. However, the area where sample UST-2-14 was collected was excavated to approximately 13 feet bgs and the depth to water in the respective area ranges between approximately 13 to 15 feet bgs. Therefore, the sample location UST-2-14 at 14 feet bgs generally falls within the capillary fringe/saturated zone. Additionally, samples UST-3-14, UST-5-14, and UST-5-15 that were collected in the immediate vicinity (Figure 3) and corresponding sample depth of sample UST-2-14, reported benzene concentrations ranging from ND<0.025 to ND<0.050 mg/kg (Table 2). Accordingly, the benzene concentration of ND<0.50 mg/kg at sample location UST-2-14 is unlikely to be of significant concern.

The proposed soil gas sampling plan will address ACEH's concerns with regards to petroleum hydrocarbon concentrations detected in the influent samples collected from wells MW-2, AR-2 and EP-1 during a dual phase extraction test conducted in November 2002 (Table 3). Accordingly, URS proposes collecting soil gas samples (SG-1 through SG-5) at five locations adjacent to but at least 5 feet from well locations MW-2, AR-2, EP-1, MW-1, and AR-1, and immediately adjacent and downgradient of the former UST complex and pump island locations (Figure 3). The soil gas borings will be located at least 5 feet from existing wells to minimize possible dilution caused by drawing surface air through a nearby screened well casing and filter pack.

- Soil gas sample location SG-1 will be located at least 5 feet from AR-2 and downgradient (west) of EP-1 and the former pump island location.

- SG-2 will be located at least 5 feet from MW-2 and directly downgradient of the former location of the southern pump islands, and also downgradient of the former UST complex location. Both SG-1 and SG-2 will be within approximately 13 to 15 feet of well location EP-1 and will characterize residual vadose zone hydrocarbon concentrations in the area of well locations of concern MW-2, AR-2 and EP-1, and also in the area directly downgradient of the former pump island and UST complex locations. Additionally, SG-1 and SG-2 will be located within native soil in close proximity to overexcavation soil sample location OE-DP-1.
- SG-3 will be located at least 5 feet from AR-1, which had MTBE concentrations of 3.6 µg/L during the second quarter of 2004, and downgradient (west) of the former location of the southern pump islands and the former UST complex locations.
- SG-4 will be located within native soil immediately adjacent to the former UST complex location, at the southern edge of the former UST complex overexcavation boundary, and west of tank basin soil sample UST-8.
- SG-5 will be located at least 5 feet from and downgradient of MW-1, which had MTBE concentrations of 250 µg/L during the second quarter of 2004, and will also be located in the vicinity of tank basin soil sample UST-7.

Accordingly, the proposed soil gas sampling plan will effectively characterize residual petroleum hydrocarbon concentrations in the vadose zone underlying the following three areas of concern:

- In the area where wells MW-2, AR-2 and EP-1 are located
- In the area where residual MTBE concentrations were detected in wells MW-1 and AR-1 during the second quarter of 2004, and
- In the area adjacent and downgradient of the former UST complex and pump island locations.

### 3.3 Soil Gas Sample Collection Procedure

Soil gas samples will be collected by drilling borings using direct push methods. Illustrations of typical soil gas sampling apparatus are provided in Attachment C. The borings will extend to maximum depths of approximately 10 to 12 feet bgs, determined by the depth to water, which typically ranges between approximately 10 to 12 feet bgs at the Site. Soil gas samples will be collected between 5 and 10 to 12 feet bgs, at which depths a relatively permeable silt lithologic strata exists in the area of the proposed soil gas sample locations. Soil vapor sample collection will be generally consistent with the guidelines published by DTSC and the RWQCB-LAR in the January 28, 2003 Advisory – Active Soil Gas Investigations, RWQCB-LAR "Interim Guidance for Active Soil Gas Investigation", February 25, 1997, and EPA Standard Operating Procedure (SOP) #1704, Summa Canister Sampling (Appendix D). Soil gas sampling procedures will include the following:

- Soil gas samples will be collected at least 7 days after any measurable precipitation event.
- The soil gas sampling probe will be pushed to the target depth; the sampling line will be installed; the sampling line will be capped with a vapor-tight valve; the valve will be closed; the probe will be raised six inches; and the line will be purged after 30 minutes have elapsed.
- Hydrated bentonite will be placed around the drill rod prior to sampling in order to inhibit surface air migration down the outer portion of the drill rod.
- A leak check will be performed prior to sampling by placing shaving cream with propellants containing isopropanol, isobutene, and/or propane on all sample line fittings and the top of the vapor probe tubing where the tubing exits the well.
- Three volumes of air will be purged from the sample tubing before sample collection using a vacuum pump connected to the sample tubing by a valve, T-fitting, and swage-lock couplings.
- A flow regulator will be used to collect vapor samples at a rate of 100 to 200 milliliters per minute (ml/min) to inhibit partitioning and short-circuiting.
- Summa canisters with vacuum gauges and a pre-sample vacuum of at least 29 inches of mercury (in. Hg) will be used to collect samples.
- Sampling will be terminated when at least 5 in. Hg vacuum remains in each summa canister.
- At least one duplicate sample will be collected from an area likely to have been impacted by hydrocarbons.
- Soil gas samples will not be chilled.

### 3.4 Soil Gas Sample Analysis

Soil and vapor samples will be submitted to a State of California Department of Health Services-certified laboratory and will be analyzed for GRO/TPH-g by EPA Method TO-3; and BTEX and MTBE by EPA Method TO-14A or TO-15. Soil vapor samples will also be analyzed for Oxygen ($O_2$), carbon dioxide ($CO_2$), methane, isopropanol, isobutene, and propane by appropriate methods.

## 4.0 DATA ANALYSIS AND REPORTING

Soil gas analytical data and a discussion of the results will be included in a soil gas investigation report. The report will include a discussion of field operations, any deviations from the approved work plan and sampling plan, and data inconsistencies; a drawing of the sampling apparatus; and findings, conclusions and recommendations.

## 5.0 LIMITATIONS

This report is based on data, site conditions and other information that is generally applicable as of the date of the report, and the conclusions and recommendations herein are therefore applicable only to that time frame. Background information including but not limited to previous field measurements, analytical results, site plans and other data have been furnished to URS by RM, their previous consultants, and/or third parties, which URS has used in preparing this report. URS has relied on this information as furnished, and is neither responsible for nor has confirmed the accuracy of this information.

Analytical data provided by RM approved laboratory has been reviewed and verified by the laboratory. URS has not performed an independent review of the data and is neither responsible for nor has confirmed the accuracy of this data. Field measurements have been supplied by a groundwater sampling subcontractor. URS has not performed an independent review of the field sampling data and is neither responsible for nor has confirmed the accuracy of this data.

If you have any questions regarding this submission, please call me at (510) 874-3280.

Sincerely,

**URS CORPORATION**

Scott Robinson,
Senior Geologist / Project Manager

Leonard P. Niles
Leonard P. Niles, R.G. #57[illegible], C.H.G. #357
Senior Geologist

CERTIFIED HYDROGEOLOGIST
LEONARD P. NILES
NO.HG357
EXP.3/31/06
STATE OF CALIFORNIA

### Figures

| | |
|---|---|
| Figure 1 | Site Vicinity Map |
| Figure 2 | Groundwater Elevation Contour and Analytical Summary Map – June 2, 2004 |
| Figure 3 | Site Plan with Historical Sample Locations and Proposed Soil Gas Sample locations |
| Figure 4 | Geologic Cross-section A-A' |
| Figure 5 | Geologic Cross-section B-B' |
| Figure 6 | Well Survey Map |

### Tables

| | |
|---|---|
| Table 1 | Comparison of Groundwater Analytical Data with Selected Groundwater ESLs |
| Table 2 | Soil Sample Analytical Results |
| Table 3 | Dual Phase Extraction Analytical Data |

### Attachments:

| | |
|---|---|
| Attachment A | ACEH's correspondence dated August 30, 2004 |
| Attachment B | Well Survey results. Including internal correspondence dated June 7, 2001 documenting performance of well survey. |
| Attachment C | Typical Soil Vapor Sampling Apparatus |
| Attachment D | EPA SOP #1704 - Summa Canister Sampling, DTSC/LARWQCB Advisory-Active Soil Gas Investigations, January 28, 2003 |

## REFERENCES

GTI 1986. *Site Assessment Investigation Report.* Groundwater Technology Inc.

GSI 1993. *Additional Remedial Investigation and Interim Remedial Action Plan.* GeoStrategies, Inc. December 13, 1993.

Delta 2000. *Hand Auger Boring Results Report.* Delta Environmental Consultants, Inc.

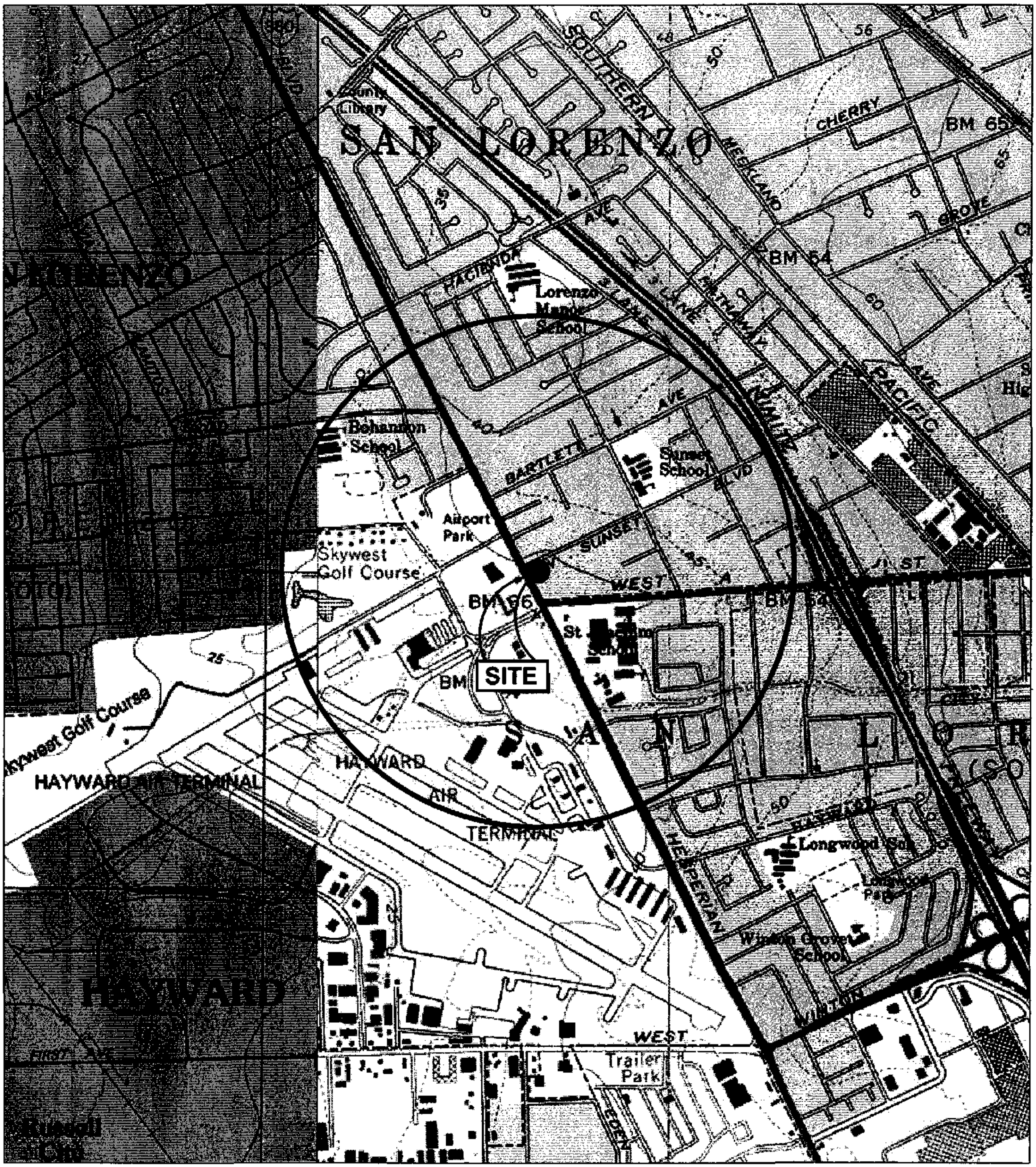
Delta 2002. *Tank Basin, Product Line and Dispenser Island Sampling.* Delta Environmental Consultants, Inc.

RWQCB 2003. *Screening for Environmental Concerns At Sites With Contaminated Soil and Groundwater. Volume 2: Background Documentation For The Development of Tier 1 Environmental Screening Levels.* Interim Final. California Regional Water Quality Control Board – San Francisco Bay. July.

URS 2003. *Results of a Dual Phase Extraction Test.* URS Corporation. April 02, 2003.

URS 2004. *First Quarter 2004 Groundwater Monitoring Report.* URS Corporation. April 06, 2004.

URS 2004. *Second Quarter 2004 Groundwater Monitoring Report.* URS Corporation. July 12, 2004.



REFERENCE:

BASE MAP FROM USGS TOPO!
NORTH REGION 7

7.5 MINUTE TOPOGRAPHIC
PHOTOREVISED 1998

QUADRANGLE LOCATION

NORTH

0 1400 2800

APPROXIMATE SCALE 1"= 1400'

| URS | Project No. 38486576 | | FIGURE |
|---|---|---|---|
| | ARCO Service Station #5387<br>20200 Hesperian Boulevard<br>Hayward, California | SITE LOCATION MAP | 1 |

Sep 17, 2004 - 12:11pm
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*Sep 22, 2004 - 4:11pm*
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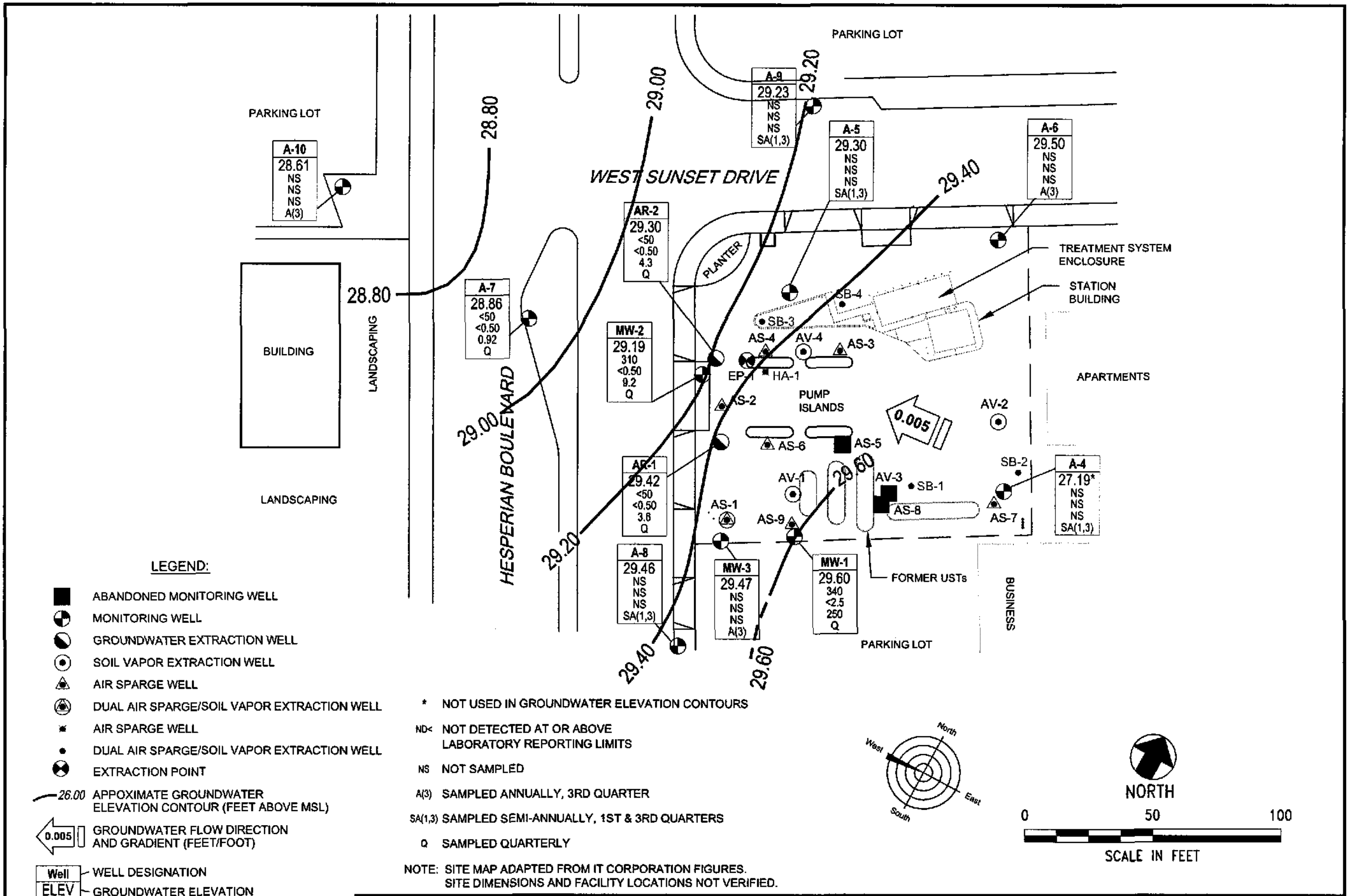


LEGEND:

- ■ ABANDONED MONITORING WELL
- ◐ MONITORING WELL
- ◑ GROUNDWATER EXTRACTION WELL
- ⊙ SOIL VAPOR EXTRACTION WELL
- ▲ AIR SPARGE WELL
- ◉ DUAL AIR SPARGE/SOIL VAPOR EXTRACTION WELL
- ✱ AIR SPARGE WELL
- • DUAL AIR SPARGE/SOIL VAPOR EXTRACTION WELL
- ⊗ EXTRACTION POINT
- —26.00 APPOXIMATE GROUNDWATER ELEVATION CONTOUR (FEET ABOVE MSL)
- ⇦ 0.005 GROUNDWATER FLOW DIRECTION AND GRADIENT (FEET/FOOT)

Well - WELL DESIGNATION
ELEV - GROUNDWATER ELEVATION
GRO / Benzene / MTBE - GRO, BENZENE & MTBE CONCENTRATIONS IN MICROGRAMS PER LITER (µg/L)
A/SA/Q - SAMPLING FREQUENCY

| | |
|---|---|
| * | NOT USED IN GROUNDWATER ELEVATION CONTOURS |
| ND< | NOT DETECTED AT OR ABOVE LABORATORY REPORTING LIMITS |
| NS | NOT SAMPLED |
| A(3) | SAMPLED ANNUALLY, 3RD QUARTER |
| SA(1,3) | SAMPLED SEMI-ANNUALLY, 1ST & 3RD QUARTERS |
| Q | SAMPLED QUARTERLY |

NOTE: SITE MAP ADAPTED FROM IT CORPORATION FIGURES.
SITE DIMENSIONS AND FACILITY LOCATIONS NOT VERIFIED.

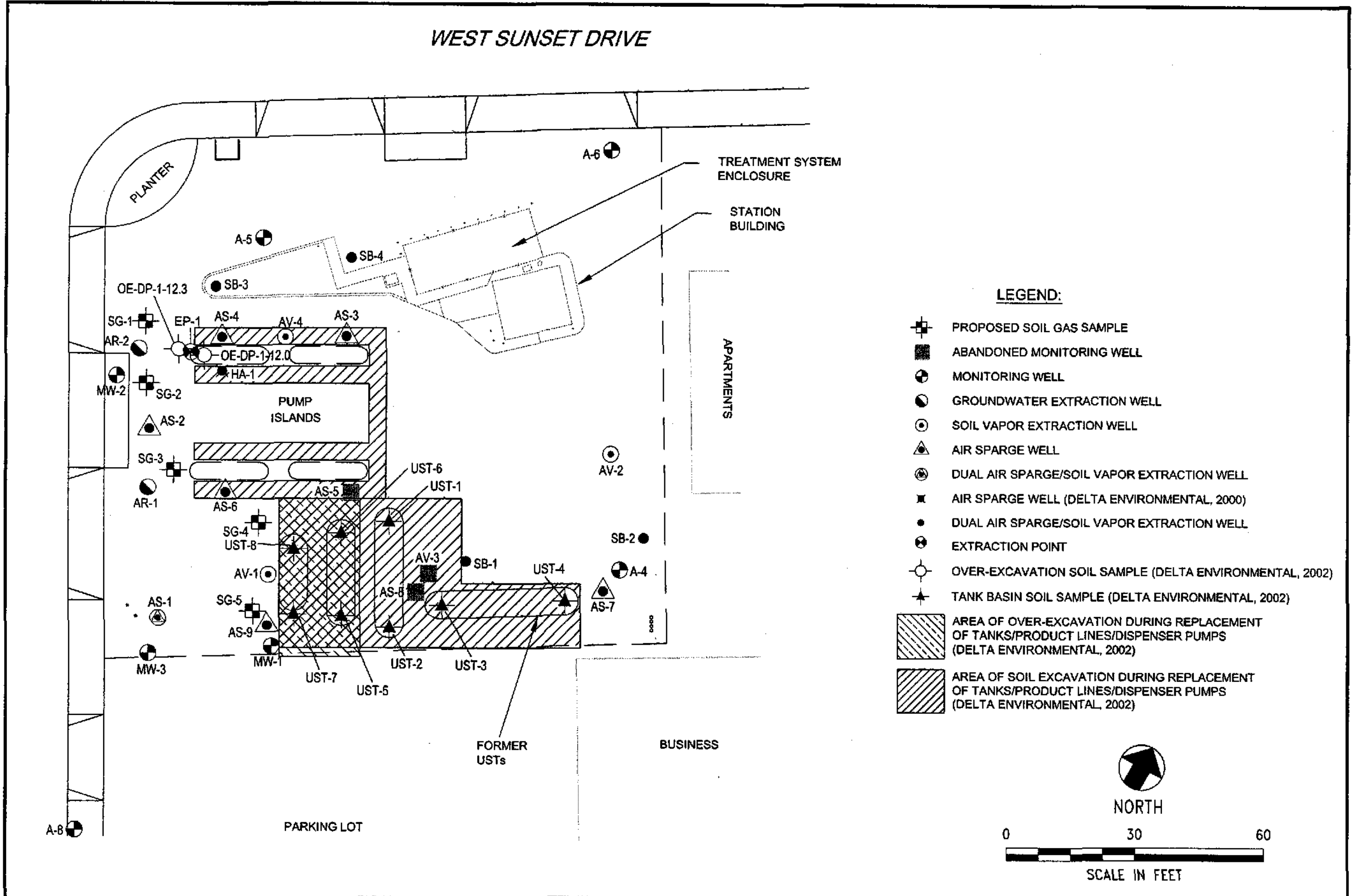
**URS**

**Project No. 38486726**
**Atlantic Richfield Company Station 5387**
**20200 Hesperian Boulevard**
**Hayward, California**

# GROUNDWATER ELEVATION CONTOUR AND ANALYTICAL SUMMARY MAP
## Second Quarter 2004 (June 2, 2004)

FIGURE
2

Sep 29, 2004 - 10:04am
X:\x_env_waste\BP GEM\Sites\Scott Robinson\Paul Supple\5387\SVS Investigation\Drawings\SAMPLE-GAS-POINTS.dwg



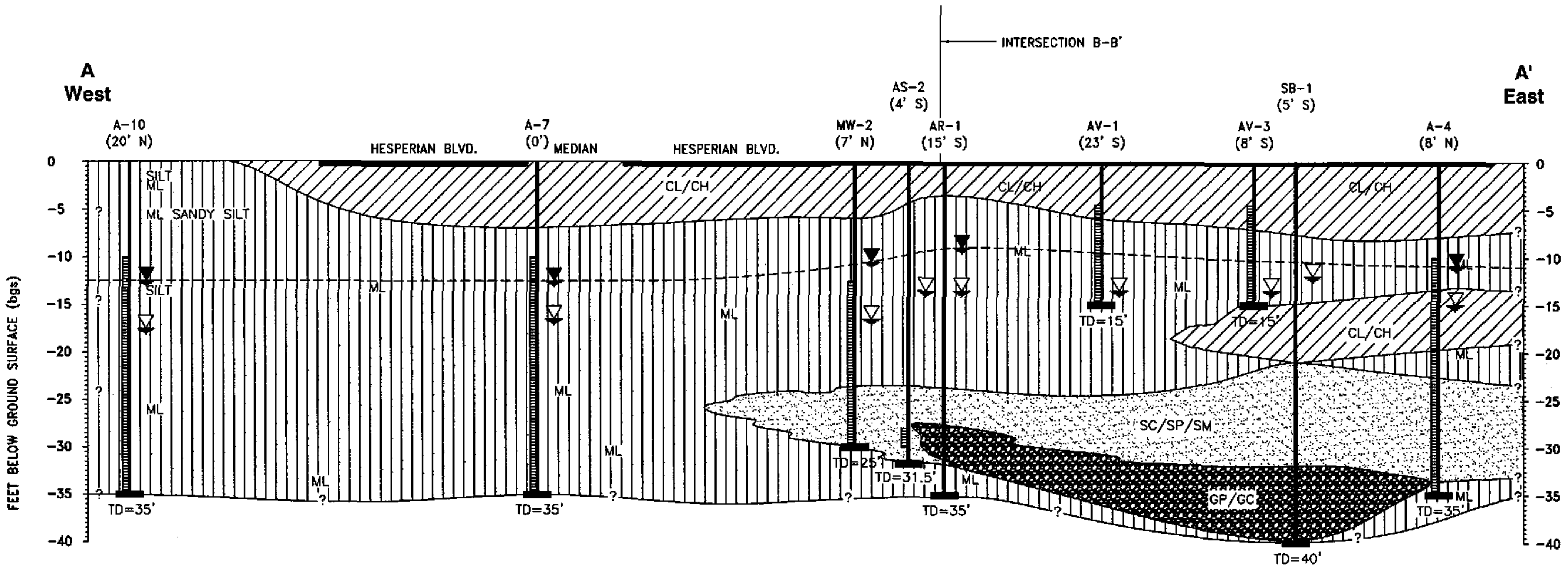
**URS**

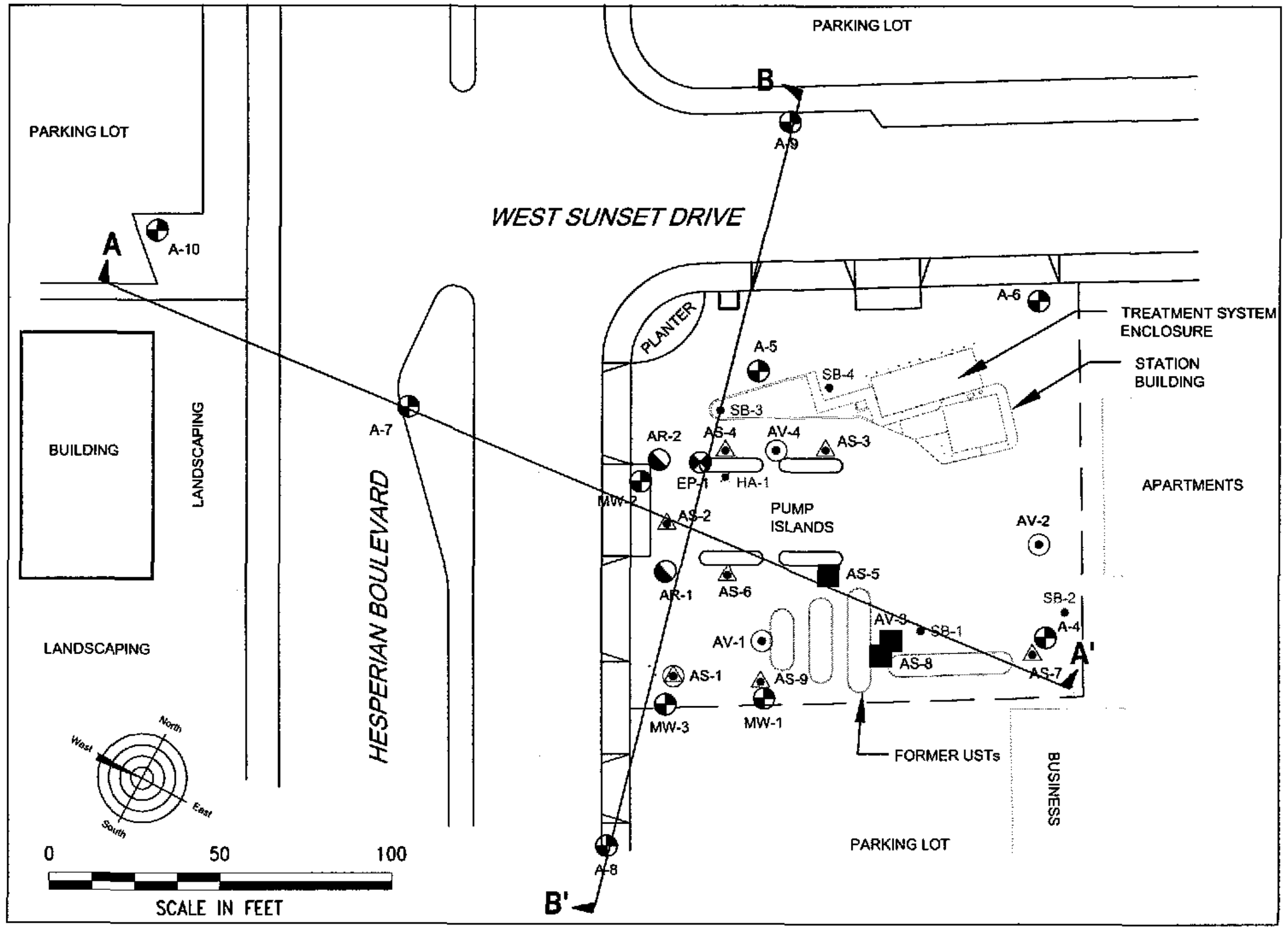
**Project No. 38486910**

**Former ARCO Service Station #5387**
**20200 Hesperian Boulevard**
**Hayward, California**

## SITE PLAN WITH HISTORIC SAMPLE LOCATIONS AND PROPOSED SOIL GAS SAMPLE LOCATIONS

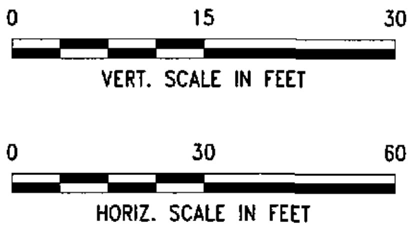
FIGURE
3





LEGEND:

| | |
|---|---|
| ▽ | FIRST ENCOUNTER GROUNDWATER LEVEL |
| ▼ | STATIC WATER LEVEL (3/1/04) |
| A' —— A' | GEOLOGICAL CROSS-SECTION LINE |
| ------- | ESTIMATED WATER TABLE |
| ▩ | GP/GC (GRAVELS) |
| ▒ | SC/SP/SM (SANDS) |
| ▥ | ML (SILTS) |
| ▨ | CL/CH (CLAYS) |
| ■ | ASPHALT/CONCRETE |
| MW-5<br>(X') | WELL OR SOIL BORING NUMBER<br>DISTANCE IN FEET AND DIRECTION OF PROJECTION |
| ▤ | MONITORING WELL SCREENED INTERVAL |
| TD=36' | TOTAL DEPTH (FEET BELOW GROUND SURFACE) |



URS

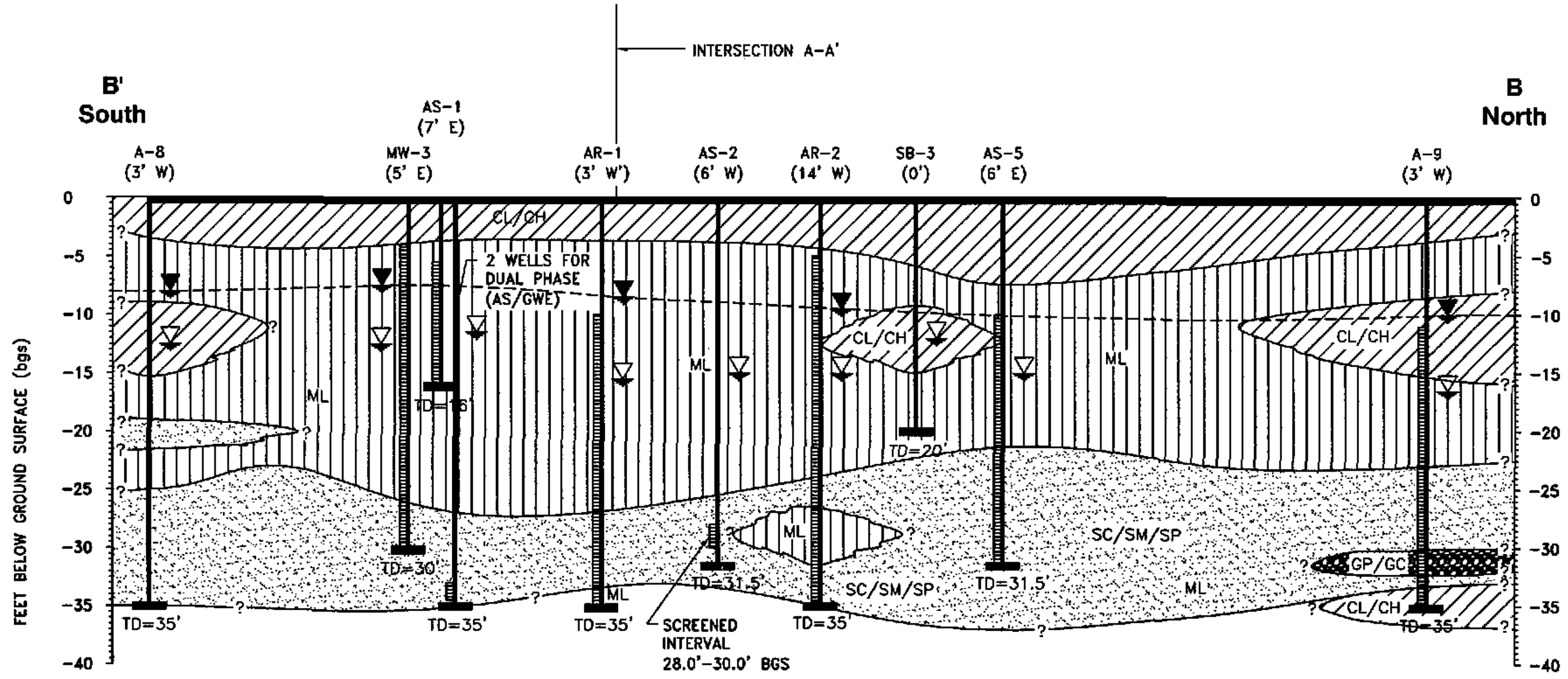
Project No. 38486910

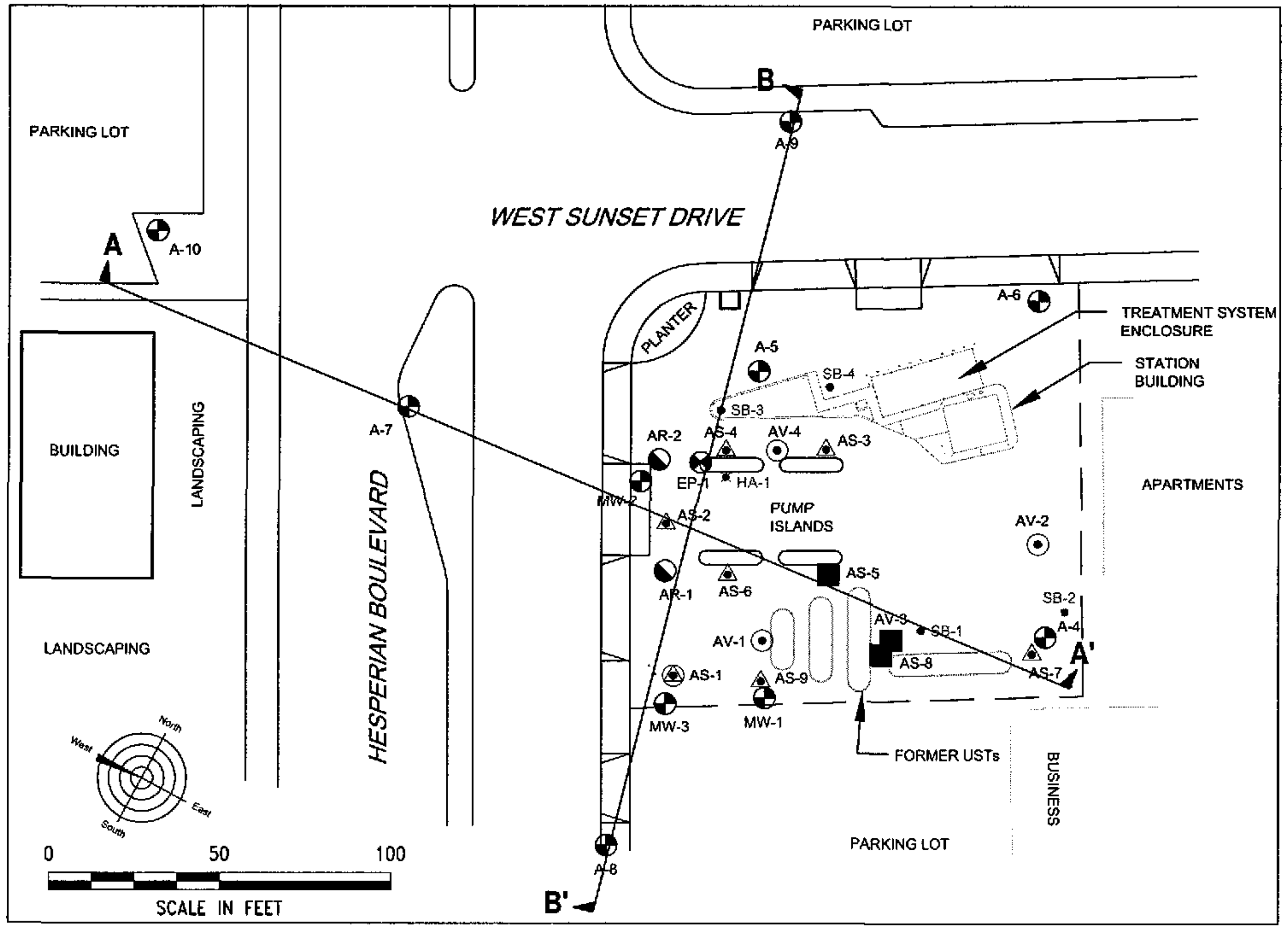
Former ARCO Service Station #5387
*20200 Hesperian Boulevard*
Hayward, California

**GEOLOGIC CROSS-SECTION A-A'**

FIGURE
4

Sep 22, 2004 - 4:14pm
X:\x_env_waste\BP GEM\Sites\Scott Robinson\Paul Supple\5387\SVS Investigation\Drawings\A-A_XSECTION.dwg





**LEGEND:**

| | |
|---|---|
| ▽ | FIRST ENCOUNTER GROUNDWATER LEVEL |
| ▼ | STATIC WATER LEVEL (3/1/04) |
| A'—— A' | GEOLOGICAL CROSS-SECTION LINE |
| ------- | ESTIMATED WATER TABLE |
| ▩ | GP/GC (GRAVELS) |
| ▒ | SC/SP/SM (SANDS) |
| ▥ | ML (SILTS) |
| ▨ | CL/CH (CLAYS) |
| ■ | ASPHALT/CONCRETE |
| MW-5<br>(X') | WELL OR SOIL BORING NUMBER<br>DISTANCE IN FEET AND DIRECTION OF PROJECTION |
| | MONITORING WELL SCREENED INTERVAL |
| TD=36' | TOTAL DEPTH (FEET BELOW GROUND SURFACE) |

0 15 30
VERT. SCALE IN FEET

0 30 60
HORIZ. SCALE IN FEET

URS

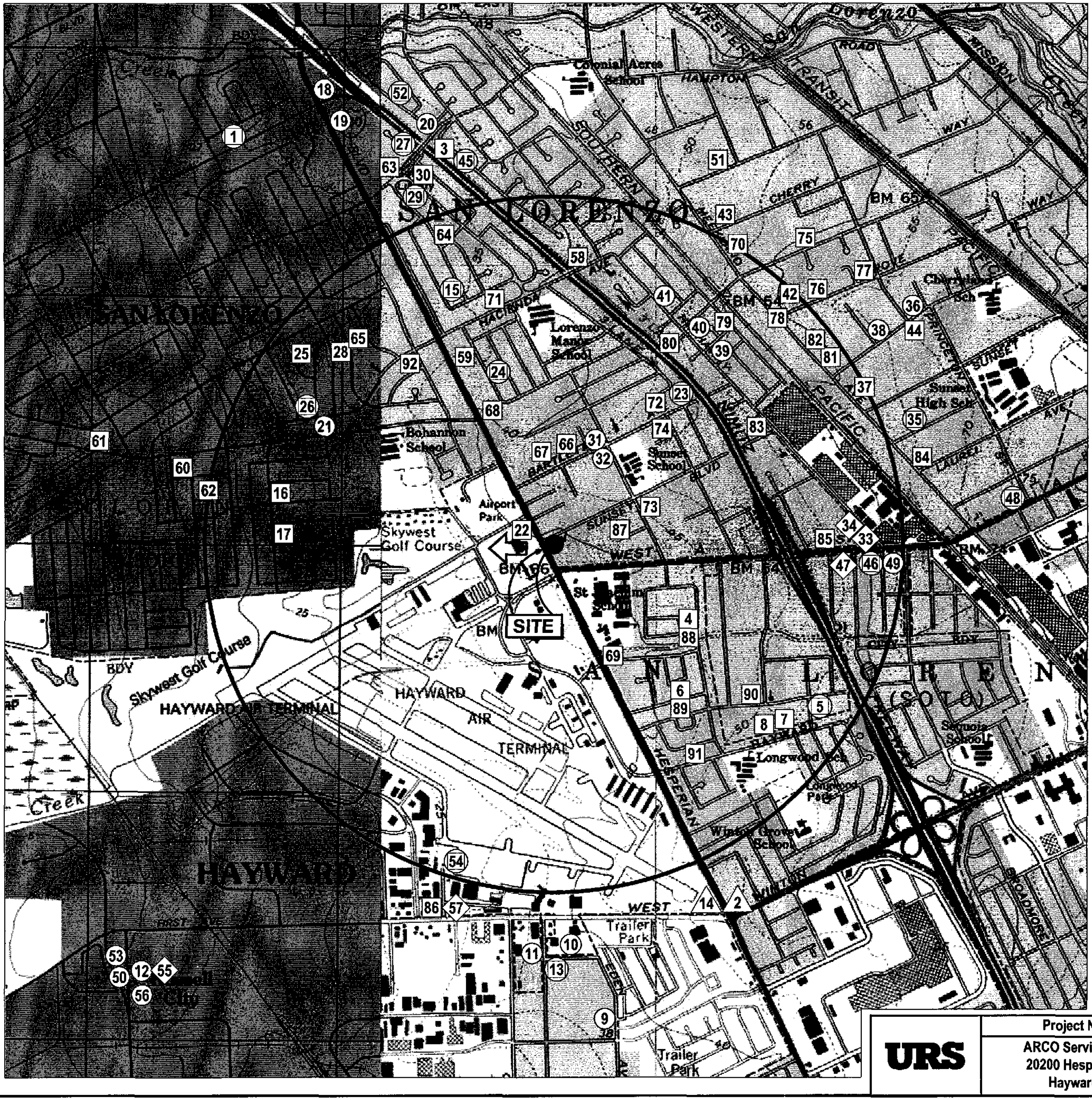
Project No. 38486910

Former ARCO Service Station #5387
20200 Hesperian Boulevard
Hayward, California

## GEOLOGIC CROSS-SECTION B-B'

FIGURE
5

Sep 22, 2004 - 4:14pm
X:\x_env_waste\BP GEM\Sites\Scott Robinson\Paul Supple\5387\SVS Investigation\Drawings\B-B_XSECTION.dwg



LEGEND

- Ⓧ Unknown well
- ☒ Irrigation well
- Ⓧ Domestic well
- ◇X Industrial well
- △X Other well
- ⇦ Site historic groundwater direction

NORTH

0 1400 2800

APPROXIMATE SCALE 1"= 1400'

| URS | Project No. 38486576<br>ARCO Service Station #5387<br>20200 Hesperian Boulevard<br>Hayward, California | WELL SURVEY MAP | FIGURE<br>6 |
|---|---|---|---|

Sep 29, 2004 - 1:41pm
X:\x_env_waste\BP GEM Sites\Scott Robinson\Paul Supple\5387\Drawings\SITEMAP-WELLS.dwg

# Table 1
# Comparison of Groundwater Analytical Data with Selected Groundwater ESLs

Former ARCO Service Station #5387
20200 Hesperian Blvd., Hayward, California

| | TPH-g /GRO (µg/L) | Benzene (µg/L) | Toluene (µg/L) | Ethyl-benzene (µg/L) | Total Xylenes (µg/L) | MTBE (µg/L) |
|---|---|---|---|---|---|---|
| **Groundwater ESLs for Potential Drinking Water Sources** | | | | | | |
| Direct Contact and Ingestion Residential ESLs (µg/L) | 100 | 1.0 | 40 | 30 | 13 | 5.0 |
| Inhalation Residential ESLs (µg/L) | NA | 530 | 500,000 | 14,000 | 150,000 | 24,000 |
| Inhalation Commercial ESLs (µg/L) | NA | 1,800 | 530,000 | 47,000 | 160,000 | 80,000 |
| **Groundwater ESLs for Non Drinking Water Sources** | | | | | | |
| Direct Contact Construction Worker ESLs (µg/L) | 500 | 46 | 130 | 290 | 13 | 1800 |
| Inhalation Residential ESLs (µg/L) | NA | 530 | 500,000 | 14,000 | 150,000 | 24,000 |
| Inhalation Commercial ESLs (µg/L) | NA | 1,800 | 530,000 | 47,000 | 160,000 | 80,000 |

| Well Number | Date Sampled | Top of Screen (ft, bgs) | Bottom of Screen (ft, bgs) | Depth to Groundwater (ft) | TPH-g /GRO (µg/L) | Benzene (µg/L) | Toluene (µg/L) | Ethyl-benzene (µg/L) | Total Xylenes (µg/L) | MTBE (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| AR-1 | 02/11/03 | | | 9.91 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 4.7 |
| | 06/27/03 | | | 10.30 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 1.6 |
| | 09/04/03 | | | --- | --- | --- | --- | --- | --- | --- |
| | 11/17/03 | | | 11.13 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 1.4 |
| | 03/01/04 | | | 9.00 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | **8.6** |
| | 06/02/04 | 10.0 | 35.0 | 10.40 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 3.6 |
| AR-2 | 02/11/03 | | | 10.80 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 0.75 |
| | 06/27/03 | | | 11.14 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | **6.0** |
| | 09/04/03 | | | --- | --- | --- | --- | --- | --- | --- |
| | 11/17/03 | | | 12.08 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 0.86 |
| | 03/01/04 | | | 10.01 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 |
| | 06/02/04 | 5.0 | 35.0 | 11.38 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 4.30 |
| MW-1 | 02/11/03 | | | 9.70 | **120** | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | **76** |
| | 06/27/03 | | | 10.10 | ND<500 | ND<5.0 | ND<5.0 | ND<5.0 | ND<5.0 | **170** |
| | 09/04/03 | | | --- | --- | --- | --- | --- | --- | --- |
| | 11/17/03 | | | 10.94 | **420** | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | **140** |
| | 03/01/04 | | | 8.85 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | **14** |
| | 06/02/04 | 5.0 | 30.0 | 10.20 | **340** | ND<2.5 | ND<2.5 | ND<2.5 | ND<2.5 | **250** |
| MW-2 | 02/11/03 | | | 10.79 | **1,100** | ND<0.50 | ND<0.50 | ND<0.50 | 0.53 | **71** |
| | 06/27/03 | | | 11.20 | **520** | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | **45** |
| | 09/04/03 | | | 11.84 | **500** | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | **28** |
| | 11/17/03 | | | 11.98 | **530** | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | **50** |
| | 03/01/04 | | | 10.05 | **890** | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | **36** |
| | 06/02/04 | 5.0 | 30.0 | 11.32 | **310** | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | **9.2** |
| MW-3 | 02/11/03 | | | 8.85 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 |
| | 06/27/03 | | | 9.12 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 0.61 |
| | 09/04/03 | | | 9.85 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 |
| | 11/17/03 | | | 9.93 | --- | --- | --- | --- | --- | --- |
| | 03/01/04 | | | 7.95 | --- | --- | --- | --- | --- | --- |
| | 06/02/04 | 5.0 | 30.0 | 9.25 | --- | --- | --- | --- | --- | --- |
| A-4 | 02/11/03 | | | 11.82 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 0.53 |
| | 06/27/03 | | | 12.12 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 |
| | 09/04/03 | | | --- | --- | --- | --- | --- | --- | --- |
| | 11/17/03 | | | 13.09 | --- | --- | --- | --- | --- | --- |
| | 03/01/04 | | | 10.95 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 |
| | 06/02/04 | 10.0 | 35.0 | 12.34 | --- | --- | --- | --- | --- | --- |

# Table 1
## Comparison of Groundwater Analytical Data with Selected Groundwater ESLs
Former ARCO Service Station #5387
20200 Hesperian Blvd., Hayward, California

| | TPH-g /GRO (µg/L) | Benzene (µg/L) | Toluene (µg/L) | Ethyl-benzene (µg/L) | Total Xylenes (µg/L) | MTBE (µg/L) |
|---|---|---|---|---|---|---|
| **Groundwater ESLs for Potential Drinking Water Sources** | | | | | | |
| Direct Contact and Ingestion Residential ESLs (µg/L) | 100 | 1.0 | 40 | 30 | 13 | 5.0 |
| Inhalation Residential ESLs (µg/L) | NA | 530 | 500,000 | 14,000 | 150,000 | 24,000 |
| Inhalation Commercial ESLs (µg/L) | NA | 1,800 | 530,000 | 47,000 | 160,000 | 80,000 |
| **Groundwater ESLs for Non Drinking Water Sources** | | | | | | |
| Direct Contact Construction Worker ESLs (µg/L) | 500 | 46 | 130 | 290 | 13 | 1800 |
| Inhalation Residential ESLs (µg/L) | NA | 530 | 500,000 | 14,000 | 150,000 | 24,000 |
| Inhalation Commercial ESLs (µg/L) | NA | 1,800 | 530,000 | 47,000 | 160,000 | 80,000 |

| Well Number | Date Sampled | Top of Screen (ft, bgs) | Bottom of Screen (ft, bgs) | Depth to Groundwater (ft) | TPH-g /GRO (µg/L) | Benzene (µg/L) | Toluene (µg/L) | Ethyl-benzene (µg/L) | Total Xylenes (µg/L) | MTBE (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| A-5 | 02/11/03 | | | 11.37 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 0.97 |
| | 06/27/03 | | | 11.55 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 0.98 |
| | 09/04/03 | | | 12.21 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 0.50 |
| | 11/17/03 | | | 12.37 | --- | --- | --- | --- | --- | --- |
| | 03/01/04 | | | 10.90 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 0.77 |
| | 06/02/04 | 10.0 | 31.5 | 11.70 | --- | --- | --- | --- | --- | --- |
| | | | | | | | | | | |
| A-6 | 02/11/03 | | | 11.21 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 |
| | 06/27/03 | | | 11.60 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 |
| | 09/04/03 | | | 12.29 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 |
| | 11/17/03 | | | 12.44 | --- | --- | --- | --- | --- | --- |
| | 03/01/04 | | | 10.45 | --- | --- | --- | --- | --- | --- |
| | 06/02/04 | - - | - - | 11.75 | --- | --- | --- | --- | --- | --- |
| | | | | | | | | | | |
| A-7 | 02/11/03 | | | 12.35 | 54 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | **21** |
| | 06/27/03 | | | 12.95 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | **9.4** |
| | 09/04/03 | | | 13.59 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 3.4 |
| | 11/17/03 | | | 13.84 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 1.4 |
| | 03/01/04 | | | 12.65 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 1.1 |
| | 06/02/04 | 10.0 | 35.0 | 13.08 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 0.92 |
| | | | | | | | | | | |
| A-8 | 02/11/03 | | | 9.90 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 |
| | 06/27/03 | | | 9.73 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 |
| | 09/04/03 | | | 10.32 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 |
| | 11/17/03 | | | 10.55 | --- | --- | --- | --- | --- | --- |
| | 03/01/04 | | | 8.51 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 0.76 |
| | 06/02/04 | 10.0 | 35.0 | 9.83 | --- | --- | --- | --- | --- | --- |
| | | | | | | | | | | |
| A-9 | 02/11/03 | | | 10.97 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 |
| | 06/27/03 | | | 11.41 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 |
| | 09/04/03 | | | 12.00 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 |
| | 11/17/03 | | | 12.18 | --- | --- | --- | --- | --- | --- |
| | 03/01/04 | | | 10.30 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 0.50 |
| | 06/02/04 | 10.0 | 35.0 | 11.50 | --- | --- | --- | --- | --- | --- |
| | | | | | | | | | | |
| A-10 | 02/11/03 | | | 12.21 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 1.9 |
| | 06/27/03 | | | 12.66 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 0.99 |
| | 09/04/03 | | | 13.31 | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 1.1 |
| | 11/17/03 | | | 13.27 | --- | --- | --- | --- | --- | --- |
| | 03/01/04 | | | 11.55 | --- | --- | --- | --- | --- | --- |
| | 06/02/04 | - - | - - | 12.61 | --- | --- | --- | --- | --- | --- |

# Table 1

## Comparison of Groundwater Analytical Data with Selected Groundwater ESLs

Former ARCO Service Station #5387
20200 Hesperian Blvd., Hayward, California

Notes:

**Bolded** analytical data indicates an exceedance of the residential direct exposure and ingestion groundwater ESLs. ESLs selected from Vol II of the ESL document (ESL 2003), Table F-1a *Groundwater Screening Levels - for groundwater that is a current or pot*

**Bolded and shaded** analytical data indicates an exceedance of the construction worker direct exposure groundwater ESLs. ESLs selected from Vol II of the ESL document (ESL 2003), Table F-1b *Groundwater Screening Levels - for groundwater that is not a curre*

bgs = Below ground surface
ESL = Environmental Screening Level
ft = Feet
MTBE = Methyl tertiary butyl ether
μg/L = Micrograms per liter
ND< = Not Detected at or above the reporting limit
TPH-g/GRO = Total Petroleum Hydrocarbons as gasoline/Gasoline Range Organics

# TABLE 2
## Soil Sample Analytical Results
Former ARCO Service Station # 5387
20200 Hesperian Blvd. Hayward,California

| Sample ID | Date | Depth (ft) | Benzene (mg/kg) | Toluene (mg/kg) | Ethyl-benzene (mg/kg) | Total Xylenes (mg/kg) | TPH-g/GRO (mg/kg) | MTBE (mg/kg) | Lead (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|
| **Residential ESL (mg/kg)** | | | 0.18 | 130 | 8.7 | 54 | 500 | 31 | 255 |
| **Construction Worker ESL (mg/kg)** | | | 17 | 650 | 400 | 420 | 2,300 | 2,800 | 750 |
| **Dispenser Island Samples** | | | | | | | | | |
| DP-1-3.5 | 02/01/02 | 3.5 | **0.19** | 1.6 | 0.47 | 2.8 | 16 | 0.27 | ND<10 |
| DP-1-7 | 02/01/02 | 7.0 | **ND<1.0** | 36 | **25** | **140** | **1,800** | 19 | ND<10 |
| DP-2-4 | 02/01/02 | 4.0 | ND<0.0050 | ND<0.0050 | ND<0.0050 | ND<0.0050 | ND<0.50 | ND<0.0050 | ND<10 |
| DP-3-3.5 | 02/01/02 | 3.5 | ND<0.0050 | ND<0.0050 | ND<0.0050 | ND<0.0050 | ND<0.50 | ND<0.0050 | ND<10 |
| DP-4-4 | 02/01/02 | 4.0 | ND<0.0050 | ND<0.0050 | ND<0.0050 | ND<0.0050 | ND<0.50 | ND<0.0050 | ND<10 |
| **Product Line Samples** | | | | | | | | | |
| PL-1-4.5 | 02/01/02 | 4.5 | ND<0.0050 | ND<0.0050 | ND<0.0050 | ND<0.0050 | ND<0.50 | ND<0.0050 | ND<10 |
| PL-2-5 | 02/01/02 | 5.0 | 0.0060 | 0.014 | ND<0.0050 | 0.0080 | ND<0.050 | 0.033 | 130 |
| **Tank Basin Samples** | | | | | | | | | |
| UST-1-14 | 02/01/02 | 14.0 | ND<0.025 | ND<0.025 | ND<0.025 | 0.029 | 8.1 | ND<0.0050 | ND<10 |
| UST-2-14 | 02/01/02 | 14.0 | **ND<0.50** | ND<0.0050 | ND<0.0050 | 0.025 | 1.4 | 0.50 | ND<12 |
| UST-3-14 | 02/01/02 | 14.0 | ND<0.025 | 0.041 | ND<0.025 | ND<0.025 | 0.76 | 0.67 | ND<12 |
| UST-4-14 | 02/01/02 | 14.0 | ND<0.0050 | ND<0.0050 | ND<0.0050 | ND<0.0050 | ND<0.50 | ND<0.0050 | ND<10 |
| UST-5-14 | 02/05/02 | 14.0 | ND<0.050 | 0.099 | 0.23 | 0.050 | 56 | 1.2 | ND<10 |
| UST-6-14 | 02/05/02 | 14.0 | ND<0.050 | 0.28 | 0.70 | 2.2 | 100 | 0.74 | 20 |
| UST-7-14 | 02/06/02 | 14.0 | ND<0.050 | ND<0.050 | 0.18 | ND<0.050 | 42 | 1.5 | ND<10 |
| UST-8-14 | 02/06/02 | 14.0 | ND<0.050 | 0.18 | 0.49 | 0.073 | 110 | 2.0 | ND<10 |
| **Over-excavation Results** | | | | | | | | | |
| OE-DP-1-12 | 12/06/02 | 12.0 | **ND<0.50** | 0.76 | 2.1 | 2.5 | 360 | 0.85 | ND<10 |
| OE-DP-1-12.3 | 12/06/02 | 12.3 | 0.13 | 0.42 | 0.15 | 0.12 | 16 | 0.59 | ND<12 |
| UST-5-15 | 02/07/02 | 15.0 | ND<0.050 | 0.080 | ND<0.050 | ND<0.050 | 45 | 0.47 | ND<10 |
| UST-6-15 | 02/07/02 | 15.0 | ND<0.050 | 0.87 | 0.80 | 0.70 | 270 | 0.22 | ND<10 |
| UST-7-15 | 02/07/02 | 15.0 | ND<0.050 | 0.065 | 0.23 | 0.12 | 50 | 0.53 | ND<10 |
| UST-8-15 | 02/07/02 | 15.0 | ND<0.050 | 0.081 | 0.086 | 0.28 | 43 | 1.3 | ND<10 |

Notes:

**Bolded** analytical data indicates an exceedance of the residential direct exposure to soil ESLs. Samples that were non detect but with reporting limits greater than ESLs selected from Vol II of the ESL document (ESL 2003), Table K-1, *Direct- Exposure Screening Levels - Residential Exposure Scenario*. Direct exposure ESLs protective of construction workers (Table K-3, ESL 2003) were not exceeded.

ESL = Environmental Screening Level
ft = Feet
MTBE = Methyl tertiary butyl ether
mg/kg = Milligrams per kilogram
ND< = Not Detected at or above the reporting limit
NA = Not analyzed
TPH-g/GRO = Total Petroleum Hydrocarbons as gasoline/Gasoline Range Organics
Reference: Delta Environmental Consultants, Inc., 2002. *Tank Basin, Product Line and Dispenser Island Sampling Results.*

# Table 3
# Dual Phase Extraction Analytical Data

Former ARCO Service Station #5387
20200 Hesperian Boulevard
Hayward, California

| Well Number | Date Sampled | Benzene (ppmv) | Benzene (ug/L) | Toluene (ppmv) | Toluene (ug/L) | Ethyl-benzene (ppmv) | Ethyl-benzene (ug/L) | Total Xylenes (ppmv) | Total Xylenes (ug/L) | Gasoline Range Organics* (ppmv) | Gasoline Range Organics* (ug/L) | MTBE (ppmv) | MTBE (ug/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Residential ESLs - groundwater screening levels for indoor air impacts (ug/L)** | | -- | 1,900 | -- | 530,000 | -- | 52,000 | -- | 160,000 | -- | NV | -- | 48,000 |
| **Commercial ESLs - groundwater screening levels for indoor air impacts (ug/L)** | | -- | 6,400 | -- | 530,000 | -- | 180,000 | -- | 160,000 | -- | NV | -- | 160,000 |
| MW-2 | 11/04/02 | ND<0.031 | ND<31 | ND<0.027 | ND<27 | ND<0.023 | ND<23 | 0.11 | 110 | ND<2.4 | ND<2400 | ND<0.14 | ND<140 |
| | 11/09/02 | ND<0.031 | ND<31 | ND<0.027 | ND<27 | ND<0.023 | ND<23 | 0.069 | 69 | ND<2.4 | ND<2400 | ND<0.14 | ND<140 |
| | | | | | | | | | | | | | |
| AR-2 | 11/04/02 | ND<0.031 | ND<31 | ND<0.027 | ND<27 | ND<0.023 | ND<23 | 0.17 | 170 | $2.9^{1}$ | $2900^{1}$ | 0.26 | 260 |
| | 11/09/02 | ND<0.031 | ND<31 | ND<0.027 | ND<27 | ND<0.023 | ND<23 | 0.13 | 130 | $20^{2}$ | $20,000^{2}$ | 0.28 | 280 |
| | | | | | | | | | | | | | |
| EP-1 | 11/04/02 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | 11/09/02 | 0.59 | 590 | 1.4 | 1,400 | 0.48 | 480 | 2.0 | 2,000 | $200^{2}$ | $200,000^{2}$ | 1.0 | 1000 |

Notes:

ESLs selected for the evaluation of indoor air impacts from groundwater **were not** exceeded. The ESLs selected for that comparison come from Vol II of the ESL document (ESL 2003), Table

* = Gasoline Range Organics (C6-C10). The molecular weight of gasoline (103 grams) calculated by averaging the molecular weight of benzene (C6) and napthalene (C10).

1 = Chromatogram Pattern: Gasoline C6-C10

2 = Hydrocarbon pattern is present in the requested fuel quantitation range but does not resemble the pattern of the requested fuel.

ESL = Environmental Screening Level

TPH = Total Petroleum Hydrocarbons

MTBE = Methyl tertiary butyl ether analyzed by EPA Method 8021B unless otherwise noted

$\mu g/m^3$ = Micrograms per cubic meter

NA = Not analyzed

ND< = Not Detected at or above the reporting limit

NV = No Value

**Reference:** URS., 2003. *Results of a Dual Phase Extraction Test.*

**Assumptions:** units of ppmv are approximately equal to units of mg/L

# Attachment A

## ACHCSA's correspondence dated August 30, 2004

ALAMEDA COUNTY
**HEALTH CARE SERVICES**
AGENCY
DAVID J. KEARS, Agency Director

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August 30, 2004

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P.O. Box 6549
Moraga, CA 94570

Subject: Fuel Leak Case No. RO0000174, Thrifty Oil #52/ARCO #5387, 20200 Hesperian Blvd., Hayward, California

Dear Mr. Supple:

Alameda County Environmental Health (ACEH) has reviewed your June 3, 2004, *Request For Site Closure Status* prepared by URS Corporation for the above-referenced site. Based upon our review, your site does not appear to be meet the minimum criteria for case closure at this time. To progress the case towards regulatory closure, we request that you address the following technical comments and submit a workplan for additional characterization by the due date specified below.

**TECHNICAL COMMENTS**

1. Source Area

During the November 2002 two-phase extraction (TPE) test, URS detected up to 859,928 ug/m$^3$ GRO and 1,920 ug/m$^3$ benzene in vapor influent from onsite well EP-1. In addition, URS states in Section 3.1.3 that "elevated [dissolved] concentrations of benzene and TPHg may have resulted from the constituents from the vadose zone flushing into the groundwater by increased infiltration of precipitation at that time." These findings suggest that residual hydrocarbons in vadose zone soil are not fully characterized by the analytical results presented in Table 2-2 of the subject report. Please propose additional tasks to further define the onsite subsurface impact in the workplan requested below. Your workplan should include rationale supporting proposed sampling locations including evaluation of historical investigation results.

2. Well Survey

URS states that no water wells are likely to be impacted; however, the August 21, 1986 *Site Assessment Investigation Report* prepared by Groundwater Technology, Inc. identified " a minimum of 20 permitted wells within a one mile radius of the site." The locations of these wells never appear to have been evaluated. We request that you perform an updated well survey to locate all wells (monitoring and production wells: active, inactive, standby, decommissioned, abandoned and dewatering, drainage and cathodic protection wells) within a 2,000 foot radius of the site. Submittal of maps showing the location of all wells identified in your study, and the use of tables to report the data collected as part of your survey are required. We recommend that you obtain well information from the State of California Department of Water Resources, at a minimum. Please include an analysis and interpretation of your findings, and report your results in the workplan requested below.

3. Risk To Human Health

URS states that an evaluation of potential impacts to human health should be formed if the site is developed for residential use. URS also states that human health can be safeguarded through appropriate precautions for potential future onsite construction activities. ACEH concurs with these recommendations. If residual pollution is to be left in place, a deed restriction could be placed on the property and a soil management plan filed with ACEH. In addition, we request you perform an onsite soil vapor assessment. This assessment may be used to simultaneously address Comment No. 1, above. Please perform your soil vapor survey following the guidelines published by DTSC and the RWQCB-LAR in the January 28, 2003 *Advisory – Active Soil Gas Investigations*. We also recommend that you evaluate your results using either the RWQCB-SFBR ESLs or the protocol detailed in ASTM E1739-95(2002) *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites.*

**REPORT REQUEST**

Please submit an *Acitve Soil Gas Investigation Workplan* and address the comments above by **September 30, 2004**. CCR, Title 23, Chapter 16 requires your compliance with this request. If it appears as though significant delays are occurring or reports are not submitted as requested we will consider referring your case to the County District Attorney or other appropriate agency, for enforcement. Under California Health and Safety Code, Section 25299.76, you may be subject to civil penalties of up to $10,000 per day for each day of violation.

Please call me at (510) 567-6719 with any questions regarding this case.

Sincerely,

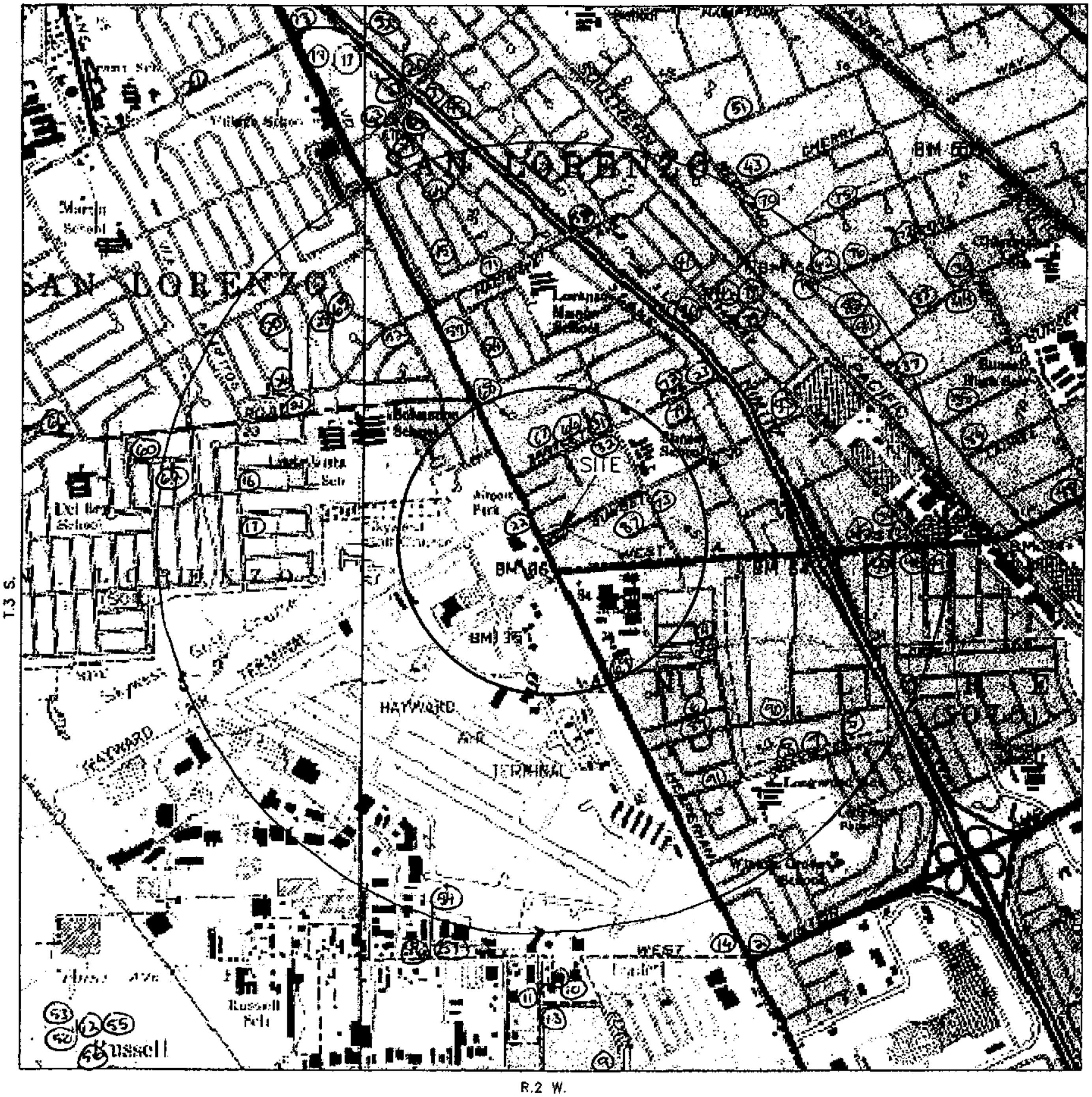
Robert W. Schultz

Robert W. Schultz, R.G.
Hazardous Materials Specialist

cc: Scott Robinson, URS Corporation, 500 12th St., Ste. 200, Oakland, CA 94607-4014
Chris Panaitescu, Thrifty Oil Co., 13116 Imperial Hwy., Santa Fe Springs, CA 90760
Donna Drogos, ACEH
Robert W. Schultz, ACEH

# Attachment B

Well Survey results. Including internal correspondence dated June 7, 2001 documenting performance of well survey.



GENERAL NOTES:
BASE MAP FROM U.S.G.S.
SAN LEANDRO & HAYWARD, CA.
7.5 MINUTE TOPOGRAPHIC
PHOTOREVISED 1980

QUADRANGLE LOCATION

SCALE 1:24,000

FIGURE 1

SITE TOPOGRAPHIC MAP

ARCO SERVICE STATION NO. 05387

20200 HESPERIAN BOULEVARD

HAYWARD, CA.

| | |
|---|---|
| PROJECT NO.<br>D000-318 | DRAWN BY<br>M.L. 8/8/00 |
| FILE NO.<br>D000318A | PREPARED BY<br>JWS |
| REVISION NO.<br>1 | REVIEWED BY |

**Delta**
Environmental
Consultants, Inc.

# TABLE 1

# INVENTORY OF WATER WELLS WITHIN 5,280 FEET OF SITE

Arco Service Station No. 05387
20200 Hesperian Boulevard
Hayward, California

| Site Map Location | State Well I.D. | Well Location | Date Drilled | Well Type | Total Depth (ft) | Screened Interval(s) (ft) | Notes |
|---|---|---|---|---|---|---|---|
| 1 | 3S/2W-7M3 | 754 Grant Avenue | 06/01/77 | Domestic | 31 | 10.5-30 | outside boundary |
| 2 | 3S/2W-20L | N of W Winton, E of Hesperian | 03/09/93 | Other | 670 | | outside boundary |
| 3 | 3S/2W-20C1 | 776 Barker Avenue | 05/05/77 | Irrigation | 29 | 20-29 | |
| 4 | 3S/2W-20B3 | 21979 Thelma Street | 07/11/77 | Irrigation | 28.5 | 20-28 | |
| 5 | 3S/2W | 622 Fifth Street | 05/23/53 | Domestic | 72 | 52-72 | |
| 6 | 3S/2W-20D | 849 Lester Avenue | 09/30/77 | Irrigation | 42 | 22-42 | |
| 7 | 3S/2W-20G1 | 22920 Lilla Road | 07/14/77 | Irrigation | 52 | 15-50 | |
| 8 | 3S/2W-20G2 | 22917 Lilla Road | 08/08/77 | Irrigation | 50 | 34-50 | |
| 9 | 3S/2W-19R1 | Eden Avenue | 03/01/49 | | 80 | | outside boundary |
| 10 | 3S/2W-19R2 | Saklin Road | | | 96 | 35-92 | outside boundary |
| 11 | 3S/2W-19R3 | Saklin Road | 09/14/38 | | 125 | | outside boundary |
| 12 | 3S/2W-19R4 | Russel City Road | | | 112 | | |
| 13 | 3S/2W-19R6 | 3431 Brookdale Blvd | 06/21/99 | Domestic | 148 | 128-144 | outside boundary |
| 14 | 3S/2W-19R | 1401 West Winton | 08/29/85 | Other | 848 | | outside boundary |
| 15 | 3S/2W-18M2 | 1304 Via Madera | 06/04/77 | Domestic | 27 | | |
| 16 | 3S/2W-18M3 | 17252 Via Estrella | 04/09/77 | Irrigation | 20 | | |
| 17 | 3S/2W-18N2 | 17356 Via-Alamitos | 06/11/77 | Irrigation | 25 | | |
| 18 | 3S/2W-18J2 | 21626 Hesperian | | | 91 | | outside boundary |
| 19 | 3S/2W-18J3 | Hesperian Blvd | | | 100 | 80-96 | outside boundary |
| 20 | 3S/2W-18J | Royal Avenue | 09/01/48 | | 69 | 60-65 | outside boundary |
| 21 | 3S/2W-18J8 | 1266 Bartlett Avenue | | | 75 | | |
| 22 | 3S/2W-18K3 | Kennedy park, Hesperian Blvd | 03/25/78 | Irrigation | 155 | 35-155 | |
| 23 | 3S/2W-18 | 1238 Bartlett Avenue | | Domestic | 202 | | |
| 24 | 3S/2W-18G1 | 18451 Robscott Avenue | 05/07/77 | Domestic | 26 | 15-25 | |
| 25 | 3S/2W-18F4 | 17061 Via Perdido | 05/01/89 | Irrigation | 25 | | |
| 26 | 3S/2W-18F3 | 840 Hacienda Avenue | 07/19/77 | Domestic | | 15-29.5 | |
| 27 | 3S/2W | 700 Hathaway | 02/26/53 | Domestic | 100 | 40-60, 80-100 | |
| 28 | 3S/2W-18C1 | 17127 Via Flores | 03/13/77 | Irrigation | 25 | 25-Dec | outside boundary |
| 29 | 3S/2W-18B6 | 19578 Via Primero | 06/24/89 | Domestic | 30 | 20-30 | outside boundary |
| 30 | 3S/2W-18B1 | 16138 Via Segundo | | Irrigation | 34 | | |

# TABLE 1

# INVENTORY OF WATER WELLS WITHIN 5,280 FEET OF SITE

Arco Service Station No. 05387
20200 Hesperian Boulevard
Hayward, California

| Site Map Location | State Well I.D. | Well Location | Date Drilled | Well Type | Total Depth (ft) | Screened Interval(s) (ft) | Notes |
|---|---|---|---|---|---|---|---|
| 31 | 3S/2W-17M1 | 1230 Barttlett Avenue | 10/01/48 | | | 66 | |
| 32 | 3S/2W/17M2 | 130 feet sw of Garden Avenue | | | 72 | 45-63 | |
| 33 | 3S/2W/-17K2 | Corner of West A St. and Hathaway | 07/01/65 | Industrial | 680 | 480-510 | |
| 34 | 3S/2W-17K3 | West A St. and Hathaway | 07/22/65 | Industrial | 680 | | |
| 35 | 3S/2W-17J2 | 746 Poplar Avenue | 03/08/54 | Domestic | 74 | 50-70 | outside boundary |
| 36 | 3S/2W-17H | Willow Avenue | 04/28/42 | | 128 | 105-107 | outside boundary |
| 37 | 3S/2W-17G3 | 21455 Meekland | 10/05/77 | Irrigation | 82 | 40-80 | outside boundary |
| 38 | 3S/2W-17G1 | Meekland and Willow | 05/15/35 | | 93 | 56-93 | outside boundary |
| 39 | 3S/2W-17F3 | Florence and Hathaway | 06/12/31 | | 201 | | |
| 40 | 3S/2W-17D3 | Highway 17 and Hathaway | | | 68 | 48-60 | |
| 41 | 3S/2W-17D1 | Highway 17 and Hathaway | | | 67 | 48-60 | |
| 42 | 3S/2W-17C4 | 21005 Meekland Avenue | 07/27/77 | Irrigation | 77 | 20-77 | |
| 43 | 3S/2W-17C3 | 163 Cherry Way | 05/17/77 | Irrigation | 63 | 25-66 | outside boundary |
| 44 | 3S/2W-17A3 | 21671 Haviland Avenue | 05/19/77 | Irrigation | 80 | 40-72 | outside boundary |
| 45 | | 1330 Solano | 04/11/53 | Domestic | 61 | 40-61 | |
| 46 | | 1338 Solano | 04/18/53 | Domestic | 61 | 41-61 | |
| 47 | 3S/2W-17R6 | West A St. and Hathaway | 07/16/65 | Industrial | 510 | | |
| 48 | 3S/2W-17Q5 | 2601 A Street | | Domestic | 63 | | outside boundary |
| 49 | 3S/2W-17Q2 | Hathaway and A Street | 07/15/58 | | 541 | 533-541 | |
| 50 | 3S/2W-17Q1 | Russel City Road | 03/03/38 | | 47 | 33-43 | |
| 51 | 3S/2W-8P3 | 219 Medford Avenue | 01/31/78 | Irrigation | 83 | 53-83 | outside boundary |
| 52 | | 15881 Via Granada | | Domestic | 70 | | outside boundary |
| 53 | 3S/2W-19Q1 | Russel City Road | 05/25/26 | | 81 | 70-80 | outside boundary |
| 54 | 3S/2W-19P5 | 1844 West Winton Avenue | 05/25/77 | Domestic | 100 | 57-96 | |
| 55 | 3S/2W-19N | Russell City | 04/17/53 | Industrial | 97 | 41-51 | outside boundary |
| 56 | 3S/2W-19N3 | Washington Avenue | 03/26/43 | | 89 | | outside boundary |
| 57 | 3S/2W-19L02 | 1900 West Winton Avenue | 04/23/92 | Industrial | 160 | 150-160 | outside boundary |
| 58 | 3S/2W-18 | 17061 Via Perdido | 07/01/77 | Irrigation | 29 | | |
| 59 | 3S/2W-18 | 840 Hacienda Avenue | 05/01/89 | Irrigation | 25 | | |

# TABLE 1

## INVENTORY OF WATER WELLS WITHIN 5,280 FEET OF SITE

Arco Service Station No. 05387
20200 Hesperian Boulevard
Hayward, California

| Site Map Location | State Well I.D. | Well Location | Date Drilled | Well Type | Total Depth (ft) | Screened Interval(s) (ft) | Notes |
|---|---|---|---|---|---|---|---|
| 60 | 3S/2W | 17166 Via Del Ray | | Irrigation | 30 | | outside boundary |
| 61 | 3S/2W | 1580 Bockman Road | 01/01/53 | Irrigation | 42 | | outside boundary |
| 62 | 3S/2W | 1316 Via Madera | 02/01/89 | Irrigation | 29 | | outside boundary |
| 63 | 3S/2W-18 | 16138 Via Segundo | 09/01/50 | Irrigation | 34 | | |
| 64 | 3S/22-18 | 17162 Via Primero | 02/01/78 | Irrigation | 40 | | |
| 65 | 3S/2W-18 | 17127 Via Flores | 03/01/77 | Irrigation | 25 | | |
| 66 | 3S/2W-18 | 657 Bartlett Avenue | 02/01/18 | Irrigation | 90 | | |
| 67 | 3S/2W-18 | 713 Bartlett Avenue | 01/01/46 | Irrigation | 95 | | |
| 68 | 3S/2W-18 | 18600 Hesperian Blvd | 01/01/29 | Irrigation | 65 | | |
| 69 | 3S/2W-18 | 21626 Hesperian Blvd | 12/01/41 | Irrigation | 91 | | |
| 70 | 3S/2W-17 | 19288 Medford Ct | 12/01/55 | Irrigation | 45 | | |
| 71 | 3S/2W-18 | 396 Hacienda Avenue | 11/01/77 | Irrigation | 31 | | |
| 72 | 3S/2W-17 | 421 Bartlett Street | 11/28/01 | Irrigation | 44 | | outside boundary |
| 73 | 3S/2W-17 | 20859 Royal Avenue | 11/01/53 | Irrigation | 45 | | |
| 74 | 3S/2W-17 | 20555 Garden Avenue | 11/01/60 | Irrigation | 44 | | outside boundary |
| 75 | 3S/2W-17 | 854 Blossom Way | 05/01/77 | Irrigation | 72 | | outside boundary |
| 76 | 3S/2W-17 | 204 Grove Way | 06/01/33 | Irrigation | 100 | | |
| 77 | 3S/2W-17 | 294 Grove Way | 06/01/86 | Irrigation | 23 | | |
| 78 | 3S/2W-17 | 21005 Meekland Avenue | 07/01/77 | Irrigation | 77 | | |
| 79 | 3S/2W-17 | 20161 Times Avenue | 12/01/52 | Irrigation | 55 | | |
| 80 | 3S/2W-17 | 20165 Hathaway | 06/01/31 | Irrigation | 200 | | |
| 81 | 3S/2W-17 | 21568 Meekland Avenue | 05/01/34 | Irrigation | 92 | | |
| 82 | 3S/2W-17 | 21455 Meekland | 10/01/77 | Irrigation | 80 | | |
| 83 | 3S/2W-17 | 21335 Hathaway Avenue | 10/01/51 | Irrigation | 70 | | |
| 84 | 3S/2W-17 | 193 Laurel Avenue | 10/01/54 | Irrigation | 85 | | outside boundary |
| 85 | 3S/2W-17 | 351 A Street | | Irrigation | 63 | | |
| 86 | 3S/2W-19 | 1655 West Winton Avenue | 06/01/46 | Irrigation | 65 | | outside boundary |
| 87 | 3S/2W | 21367 Garden Avenue | 09/18/01 | Irrigation | 85 | | |
| 88 | 3S/2W-20 | 776 Barker Avenue | 05/01/77 | Irrigation | 29 | | |

# TABLE 1

# INVENTORY OF WATER WELLS WITHIN 5,280 FEET OF SITE

Arco Service Station No. 05387
20200 Hesperian Boulevard
Hayward, California

| Site Map Location | State Well I.D. | Well Location | Date Drilled | Well Type | Total Depth (ft) | Screened Interval(s) (ft) | Notes |
|---|---|---|---|---|---|---|---|
| 89 | 3S/2W-20 | 849 Lester Avenue | 09/01/77 | Irrigation | 42 | | |
| 90 | 3S/2W-20 | 716 Marin Avenue | 08/01/35 | Irrigation | 60 | | |
| 91 | 3S/2W-20 | 22719 Corkwood Street | 07/01/77 | Irrigation | 40 | | |
| 92 | 3S/2W-20 | Via Arriba & Hacienda | 07/01/91 | Irrigation | 595 | | |

**"Supple, Paul V"**
**<SUPPLPV@bp.com>**
09/14/2004 10:41 AM

To: <scott_robinson@URSCorp.com>
cc:
Subject: FW: Well inventory from DWR and Alameda County Public Works Combined for ARCO 5387, Hayward CA

-----Original Message-----
From: smeeks@deltaenv.com [mailto:smeeks@deltaenv.com]
Sent: Thursday, June 07, 2001 9:57 AM
To: SUPPLPV@bp.com
Subject: Well inventory from DWR and Alameda County Public Works Combined for ARCO 5387, Hayward CA

Paul,
Here are the wells that were listed. As you can see some of the wells fell outside the one mile area after plotting them. However, there are still approximately 59 wells within the 1 mile radius of which 9 are domestic; 38 are irrigation; 9 are unknown; and 3 are industrial.

<<Well Inventory ARCO 5387.pdf>>

Thanks,
Steven Meeks, P.E.
Project Manager
Delta Environmental Consultants, Inc.
Phone: (916) 536-2613
Fax: (916) 638-8385

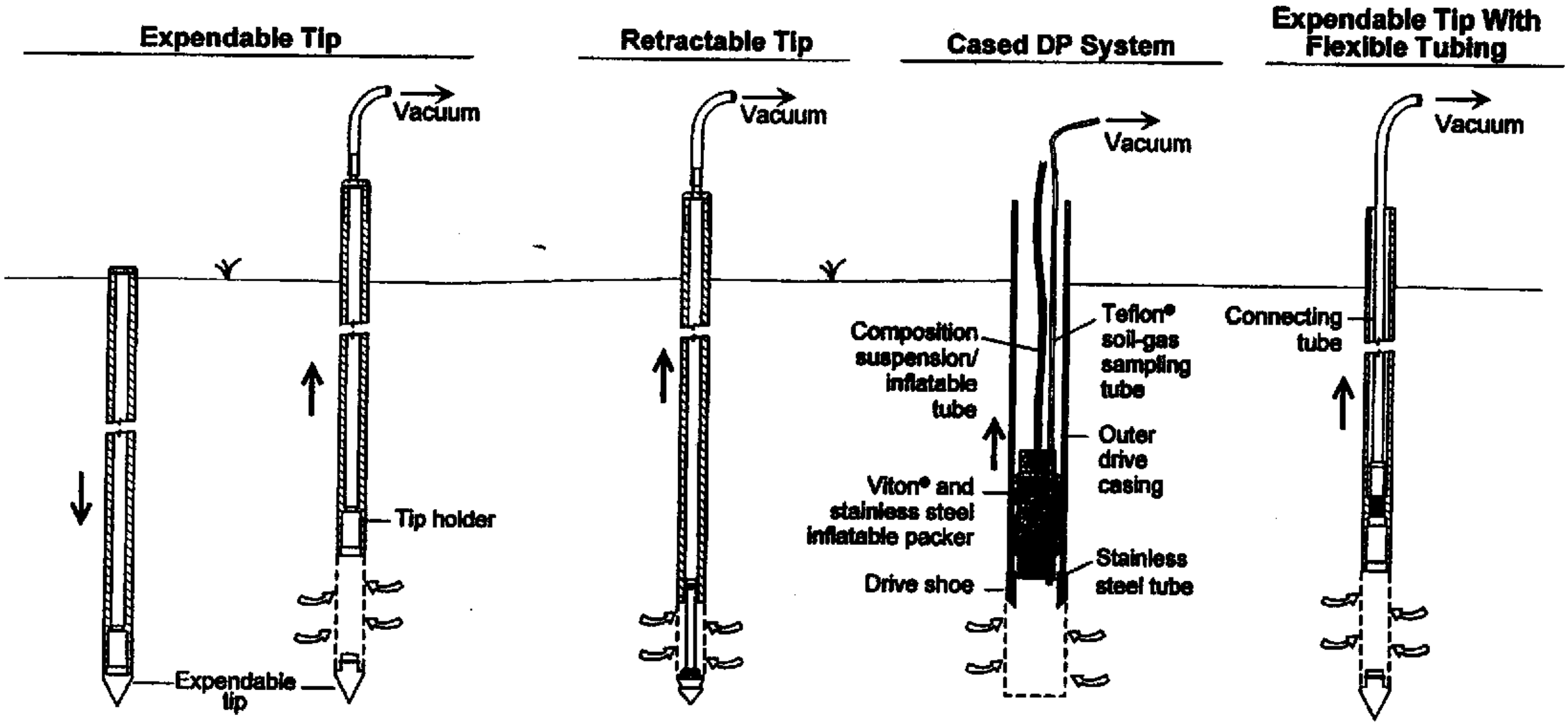
Well Inventory ARCO 5387.p

# Attachment C

## Typical Soil Vapor Sampling Apparatus

Source: http://www.Geoprobe.com/products/tools/sampling_tools/soil_gas_menu.htm

## Exhibit V-7
## Types Of Direct Push Soil Gas Sampling Tools



$a_1$) DP rods equipped with expendable tip pushed to target depth.

$a_2$) DP rods withdrawn to expose target interval. Soil-gas sample collected through probe rods.

b) Soil-gas samples are collected through probe rods. Tip is removed with probe rods.

c) Soil-gas samples are collected through small-diameter tubing.

d) Soil-gas samples are collected through inner tubing.

*Source: Geoprobe Systems and Precision Sampling, Inc.*

# Attachment D

## EPA SOP #1704 - Summa Canister Sampling

## DTSC/LARWQCB-Advisory-Active Soil Gas Investigations, January 28, 2003

# SUMMA CANISTER SAMPLING

SOP#: 1704
DATE: 07/27/95
REV. #: 0.1

## 1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to describe a procedure for sampling of volatile organic compounds (VOCs) in ambient air. The method is based on samples collected as whole air samples in Summa passivated stainless steel canisters. The VOCs are subsequently separated by gas chromatography (GC) and measured by mass-selective detector or multidetector techniques. This method presents procedures for sampling into canisters at final pressures both above and below atmospheric pressure (respectively referred to as pressurized and subatmospheric pressure sampling).

This method is applicable to specific VOCs that have been tested and determined to be stable when stored in pressurized and subatmospheric pressure canisters. The organic compounds that have been successfully collected in pressurized canisters by this method are listed in the Volatile Organic Compound Data Sheet (Appendix A). These compounds have been measured at the parts per billion by volume (ppbv) level.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure or other procedure limitations. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

## 2.0 METHOD SUMMARY

Both subatmospheric pressure and pressurized sampling modes use an initially evacuated canister. Both modes may also use a mass flow controller/vacuum pump arrangement to regulate flow. With the above configuration, a sample of ambient air is drawn through a sampling train comprised of components that regulate the rate and duration of sampling into a pre-evacuated Summa passivated canister. Alternatively, subatmospheric pressure sampling may be performed using a fixed orifice, capillary, or adjustable micrometering valve in lieu of the mass flow controller/vacuum pump arrangement for taking grab samples or short duration time-integrated samples. Usually, the alternative types of flow controllers are appropriate only in situations where screening samples are taken to assess for future sampling activities.

## 3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

After the air sample is collected, the canister valve is closed, an identification tag is attached to the canister, and the canister is transported to a laboratory for analysis. Upon receipt at the laboratory, the canister tag data is recorded. Sample holding times and expiration should be determined prior to initiating field activities.

## 4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Contamination may occur in the sampling system if canisters are not properly cleaned before use. Additionally, all other sampling equipment (e.g., pump and flow controllers) should be thoroughly cleaned.

## 5.0 EQUIPMENT/APPARATUS

The following equipment/apparatus (Figure 1, Appendix B) is required:

## 5.1 Subatmospheric Pressure Sampling Equipment

1. VOC canister sampler - whole air sampler capable of filling an initially evacuated canister by action of the flow controlled pump from vacuum to near atmospheric pressure. (Andersen Samplers Inc., Model 87-100 or equivalent).
2. Sampling inlet line - stainless steel tubing to connect the sampler to the sample inlet.
3. Sample canister - leak-free stainless steel pressure vessels of desired volume with valve and Summa passivated interior surfaces (Scientific Instrumentation Specialist, Inc., ID 83843, Andersen Samplers, Inc., or equivalent).
4. Particulate matter filter - 2-µm sintered stainless steel in-line filter (Nupro Co., Model SS-2F-K4-2, or equivalent).
5. Chromatographic grade stainless steel tubing and fittings - for interconnections (Alltech Associates, Cat. #8125, or equivalent). All materials in contact with sample, analyte, and support gases should be chromatographic grade stainless steel.
6. Fixed orifice, capillary, or adjustable micrometering valve - used in lieu of the electronic flow controller/vacuum pump for grab samples or short duration time-integrated samples.

## 5.2 Pressurized Sampling Equipment

1. VOC canister sampler - whole air sampler capable of filling an initially evacuated canister by action of the flow controlled pump from vacuum to near atmospheric pressure. (Andersen Samplers Inc., Model 87-100).
2. Sampling inlet line - stainless steel tubing to connect the sampler to the sample inlet.
3. Sample canister - leak-free stainless steel pressure vessels of desired volume with valve and Summa passivated interior surfaces (Scientific Instrumentation Specialist, Inc., ID 83843, Andersen Samplers, Inc., or equivalent).
4. Particulate matter filter - 2-µm sintered stainless steel in-line filter (Nupro Co., Model SS-2F-K4-2, or equivalent).
5. Chromatographic grade stainless steel tubing and fittings - for interconnections (Alltech Associates, Cat. #8125, or equivalent). All materials in contact with sample, analyte, and support gases should be chromatographic grade stainless steel.

## 6.0 REAGENTS

This section is not applicable to this SOP.

## 7.0 PROCEDURE

## 7.1 Subatmospheric Pressure Sampling

### 7.1.1 Sampling Using a Fixed Orifice, Capillary, or Adjustable Micrometering Valve

1. Prior to sample collection, the appropriate information is completed on the Canister Sampling Field Data Sheet (Appendix C).
2. A canister, which is evacuated to 0.05 mm Hg and fitted with a flow restricting device, is opened to the atmosphere containing the VOCs to be sampled.
3. The pressure differential causes the sample to flow into the canister.
4. This technique may be used to collect grab samples (duration of 10 to 30 seconds) or time-integrated samples (duration of 12 to 24 hours). The sampling duration depends on the degree to which the flow is restricted.
5. A critical orifice flow restrictor will have a decrease in the flow rate as the pressure approaches atmospheric.
6. Upon sample completion at the location, the appropriate information is recorded on the

Canister Sampling Field Data Sheet.

### 7.1.2 Sampling Using a Mass Flow Controller/Vacuum Pump Arrangement (Andersen Sampler Model 87-100)

1. Prior to sample collection the appropriate information is completed on the Canister Sampling Field Data Sheet (Appendix C).
2. A canister, which is evacuated to 0.05 mm Hg and connected in line with the sampler, is opened to the atmosphere containing the VOCs to be sampled.
3. A whole air sample is drawn into the system through a stainless steel inlet tube by a direct drive blower motor assembly.
4. A small portion of this whole air sample is pulled from the inlet tube by a specially modified inert vacuum pump in conjunction with a mass flow controller.
5. The initially evacuated canister is filled by action of the flow controlled pump to near atmospheric pressure.
6. A digital time-program is used to pre-select sample duration and start and stop times.
7. Upon sample completion at the location, the appropriate information is recorded on the Canister Sampling Field Data Sheet.

## 7.2 Pressurized Sampling

### 7.2.1 Sampling Using a Mass Flow Controller/Vacuum Pump Arrangement (Anderson Sampler Model 87-100)

1. Prior to sample commencement at the location, the appropriate information is completed on the Canister Sampling Field Data Sheet.
2. A canister, which is evacuated to 0.05 mm Hg and connected in line with the sampler, is opened to the atmosphere containing the VOCs to be sampled.
3. A whole air sample is drawn into the system through a stainless steel inlet tube by a direct drive blower motor assembly.
4. A small portion of this whole air sample is pulled from the inlet tube by a specially modified inert vacuum pump in conjunction with a mass flow controller.
5. The initially evacuated canister is filled by action of the flow controlled pump to a positive pressure not to exceed 25 psig.
6. A digital time-programmer is used to pre-select sample duration and start and stop times.
7. Upon sample completion at the location, the appropriate information is recorded on the Canister Sampling Field Data Sheet.

## 8.0 CALCULATIONS

1. A flow control device is chosen to maintain a constant flow into the canister over the desired sample period. This flow rate is determined so the canister is filled to about 88.1 kPa for subatmospheric pressure sampling or to about one atmosphere above ambient pressure for pressurized sampling over the desired sample period. The flow rate can be calculated by:

$$F = \frac{(P)(V)}{(T)(60)}$$

where:

F = flow rate (cm$^3$/min)

P = final canister pressure, atmospheres absolute

V = volume of the canister (cm$^3$)

T = sample period (hours)

For example, if a 6-L canister is to be filled to 202 kPa (two atmospheres) absolute pressure in 24 hours, the flow rate can be calculated by:

$$F = \frac{(2)(6000)}{(24)(60)} = 8.3 cm^3/min$$

2. If the canister pressure is increased, a dilution factor (DF) is calculated and recorded on the sampling data sheet.

$$DF = \frac{Ya}{Xa}$$

where:

Xa = canister pressure (kPa, psia) absolute before dilution.
Ya = canister pressure (kPa, psia) absolute after dilution.

After sample analysis, detected VOC concentrations are multiplied by the dilution factor to determine concentration in the sampled air.

## 9.0 QUALITY ASSURANCE/ QUALITY CONTROL

The following general quality assurance procedures apply:

1. All data must be documented on standard chain of custody records, field data sheets, or site logbooks.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

## 10.0 DATA VALIDATION

This section is not applicable to this SOP.

## 11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and corporate health and safety practices. Specifically, pressurizing of Summa canisters should be performed in a well ventilated room, or preferably under a fume hood. Care must be taken not to exceed 40 psi in the canisters. Canisters are under pressure, albeit only 20-30 psi, and should not be dented or punctured. They should be stored in a cool dry place and always be placed in their plastic shipping boxes during transport and storage.

## 12.0 REFERENCES

1. Ralph M. Riggin, Technical Assistance Document for Sampling and Analysis of Toxic Organic Compounds in Ambient Air, EPA-600/4-83-027 U. S. Environmental Protection Agency, Research Triangle Park, NC, 1983.

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# APPENDIX A

## Volatile Organic Compound Data Sheet

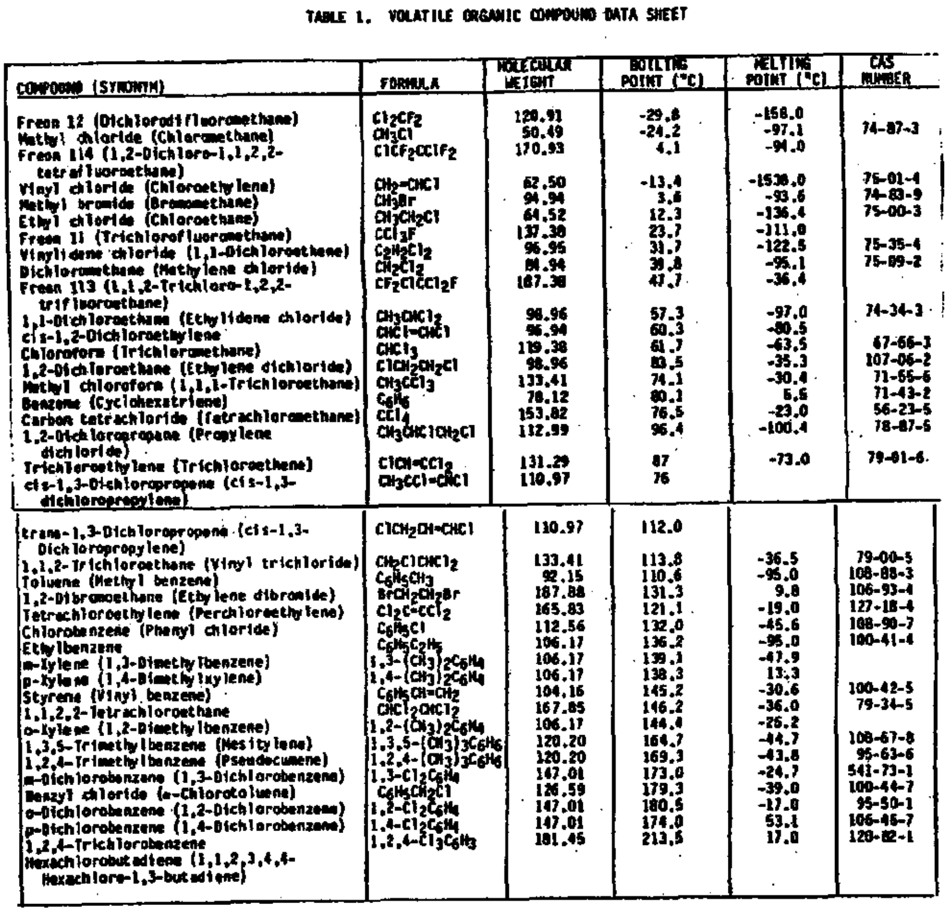

TABLE 1. VOLATILE ORGANIC COMPOUND DATA SHEET

| COMPOUND (SYNONYM) | FORMULA | MOLECULAR WEIGHT | BOILING POINT (°C) | MELTING POINT (°C) | CAS NUMBER |
|---|---|---|---|---|---|
| Freon 12 (Dichlorodifluoromethane) | $Cl_2CF_2$ | 120.91 | -29.8 | -158.0 | |
| Methyl chloride (Chloromethane) | $CH_3Cl$ | 50.49 | -24.2 | -97.1 | 74-87-3 |
| Freon 114 (1,2-Dichloro-1,1,2,2-tetrafluoroethane) | $ClCF_2CClF_2$ | 170.93 | 4.1 | -94.0 | |
| Vinyl chloride (Chloroethylene) | $CH_2{=}CHCl$ | 62.50 | -13.4 | -1538.0 | 75-01-4 |
| Methyl bromide (Bromomethane) | $CH_3Br$ | 94.94 | 3.6 | -93.6 | 74-83-9 |
| Ethyl chloride (Chloroethane) | $CH_3CH_2Cl$ | 64.52 | 12.3 | -136.4 | 75-00-3 |
| Freon 11 (Trichlorofluoromethane) | $CCl_3F$ | 137.38 | 23.7 | -111.0 | |
| Vinylidene chloride (1,1-Dichloroethene) | $C_2H_2Cl_2$ | 96.95 | 31.7 | -122.5 | 75-35-4 |
| Dichloromethane (Methylene chloride) | $CH_2Cl_2$ | 84.94 | 39.8 | -95.1 | 75-09-2 |
| Freon 113 (1,1,2-Trichloro-1,2,2-trifluoroethane) | $CF_2ClCCl_2F$ | 187.38 | 47.7 | -36.4 | |
| 1,1-Dichloroethane (Ethylidene chloride) | $CH_3CHCl_2$ | 98.96 | 57.3 | -97.0 | 74-34-3 |
| cis-1,2-Dichloroethylene | $CHCl{=}CHCl$ | 96.94 | 60.3 | -80.5 | |
| Chloroform (Trichloromethane) | $CHCl_3$ | 119.38 | 61.7 | -63.5 | 67-66-3 |
| 1,2-Dichloroethane (Ethylene dichloride) | $ClCH_2CH_2Cl$ | 98.96 | 83.5 | -35.3 | 107-06-2 |
| Methyl chloroform (1,1,1-Trichloroethane) | $CH_3CCl_3$ | 133.41 | 74.1 | -30.4 | 71-55-6 |
| Benzene (Cyclohexatriene) | $C_6H_6$ | 78.12 | 80.1 | 5.5 | 71-43-2 |
| Carbon tetrachloride (Tetrachloromethane) | $CCl_4$ | 153.82 | 76.5 | -23.0 | 56-23-5 |
| 1,2-Dichloropropane (Propylene dichloride) | $CH_3CHClCH_2Cl$ | 112.99 | 96.4 | -100.4 | 78-87-5 |
| Trichloroethylene (Trichloroethene) | $ClCH{=}CCl_2$ | 131.29 | 87 | -73.0 | 79-01-6 |
| cis-1,3-Dichloropropene (cis-1,3-dichloropropylene) | $CH_3CCl{=}CHCl$ | 110.97 | 76 | | |
| trans-1,3-Dichloropropene (cis-1,3-Dichloropropylene) | $ClCH_2CH{=}CHCl$ | 110.97 | 112.0 | | |
| 1,1,2-Trichloroethane (Vinyl trichloride) | $CH_2ClCHCl_2$ | 133.41 | 113.8 | -36.5 | 79-00-5 |
| Toluene (Methyl benzene) | $C_6H_5CH_3$ | 92.15 | 110.6 | -95.0 | 108-88-3 |
| 1,2-Dibromoethane (Ethylene dibromide) | $BrCH_2CH_2Br$ | 187.88 | 131.3 | 9.8 | 106-93-4 |
| Tetrachloroethylene (Perchloroethylene) | $Cl_2C{=}CCl_2$ | 165.83 | 121.1 | -19.0 | 127-18-4 |
| Chlorobenzene (Phenyl chloride) | $C_6H_5Cl$ | 112.56 | 132.0 | -45.6 | 108-90-7 |
| Ethylbenzene | $C_6H_5C_2H_5$ | 106.17 | 136.2 | -95.0 | 100-41-4 |
| m-Xylene (1,3-Dimethylbenzene) | $1,3\text{-}(CH_3)_2C_6H_4$ | 106.17 | 139.1 | -47.9 | |
| p-Xylene (1,4-Dimethylxylene) | $1,4\text{-}(CH_3)_2C_6H_4$ | 106.17 | 138.3 | 13.3 | |
| Styrene (Vinyl benzene) | $C_6H_5CH{=}CH_2$ | 104.16 | 145.2 | -30.6 | 100-42-5 |
| 1,1,2,2-Tetrachloroethane | $CHCl_2CHCl_2$ | 167.85 | 146.2 | -36.0 | 79-34-5 |
| o-Xylene (1,2-Dimethylbenzene) | $1,2\text{-}(CH_3)_2C_6H_4$ | 106.17 | 144.4 | -25.2 | |
| 1,3,5-Trimethylbenzene (Mesitylene) | $1,3,5\text{-}(CH_3)_3C_6H_6$ | 120.20 | 164.7 | -44.7 | 108-67-8 |
| 1,2,4-Trimethylbenzene (Pseudocumene) | $1,2,4\text{-}(CH_3)_3C_6H_6$ | 120.20 | 169.3 | -43.8 | 95-63-6 |
| m-Dichlorobenzene (1,3-Dichlorobenzene) | $1,3\text{-}Cl_2C_6H_4$ | 147.01 | 173.0 | -24.7 | 541-73-1 |
| Benzyl chloride (α-Chlorotoluene) | $C_6H_5CH_2Cl$ | 126.59 | 179.3 | -39.0 | 100-44-7 |
| o-Dichlorobenzene (1,2-Dichlorobenzene) | $1,2\text{-}Cl_2C_6H_4$ | 147.01 | 180.5 | -17.0 | 95-50-1 |
| p-Dichlorobenzene (1,4-Dichlorobenzene) | $1,4\text{-}Cl_2C_6H_4$ | 147.01 | 174.0 | 53.1 | 106-46-7 |
| 1,2,4-Trichlorobenzene | $1,2,4\text{-}Cl_3C_6H_3$ | 181.45 | 213.5 | 17.0 | 120-82-1 |
| Hexachlorobutadiene (1,1,2,3,4,4-Hexachloro-1,3-butadiene) | | | | | |

# APPENDIX B

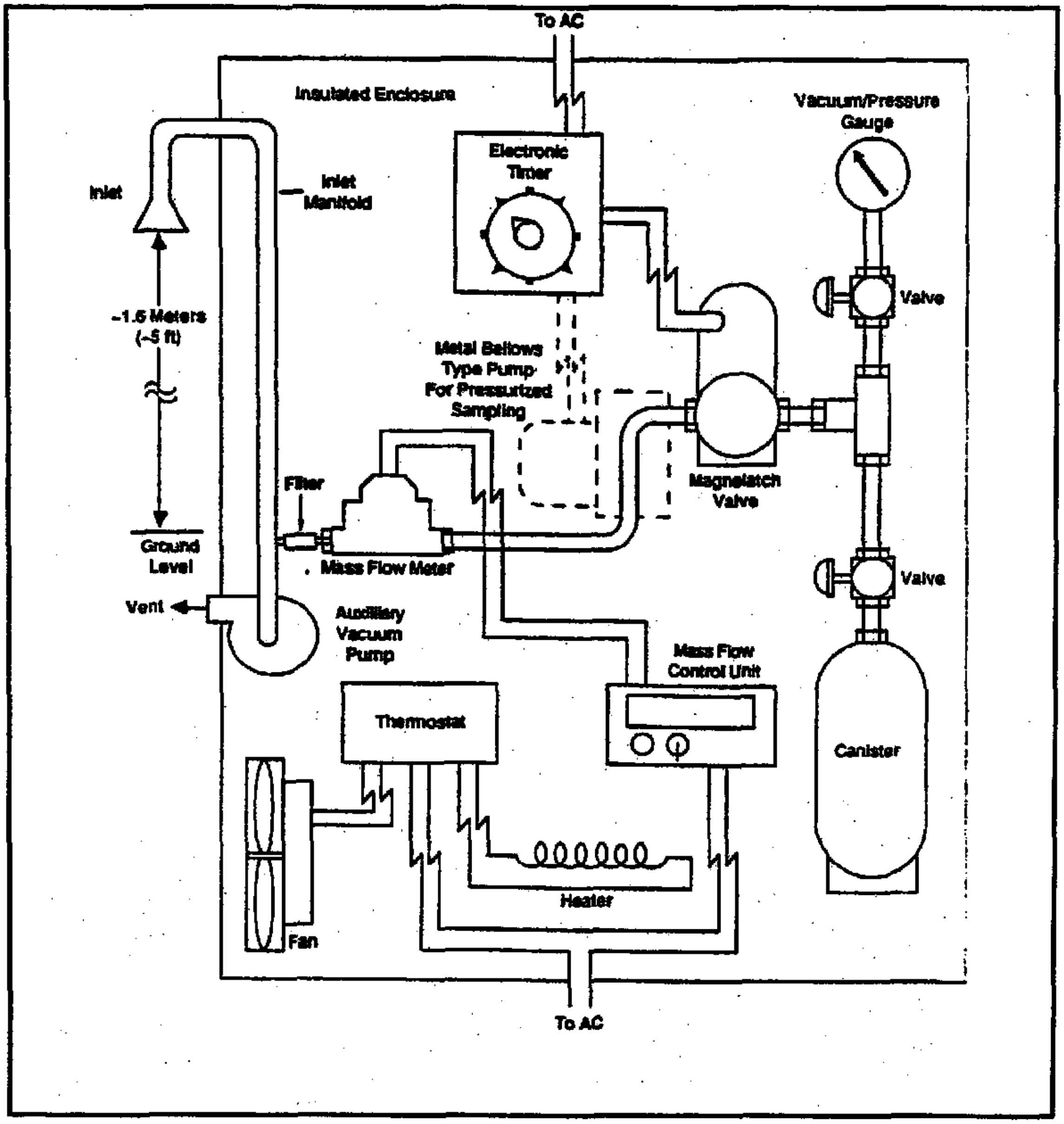

FIGURE 1. Subatmospheric/Pressurized Sampling Equipment

# APPENDIX C

## Canister Sampling Field Data Sheet

Page ___ of ___

### SUMMA AIR SAMPLING WORK SHEET

Site: ______________________________

Samplers: _______________

Date: ____________________________

Site#: __________________________

Work Assignment Manager: __________________________

Project Leader: __________________________

| | | | | | |
|---|---|---|---|---|---|
| Sample # | | | | | |
| Location | | | | | |
| SUMMA ID | | | | | |
| Orifice Used | | | | | |
| Analysis/Method | | | | | |
| Time (Start) | | | | | |
| Time (Stop) | | | | | |
| Total Time | | | | | |
| SUMMA WENT TO AMBIENT | YES/NO | YES/NO | YES/NO | YES/NO | YES/NO |
| Pressure Gauge | | | | | |
| Pressure Gauge | | | | | |
| Flow Rate (Pre) | | | | | |
| Flow Rate (Post) | | | | | |
| Flow Rate (Average) | | | | | |

MET Station On-site? Y / N

General Comments:

Gray Davis, Governor
Winston H. Hickox, Agency Secretary
California Environmental Protection Agency

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January 28, 2003

To: Interested Parties

ADVISORY – ACTIVE SOIL GAS INVESTIGATIONS

In a coordinated effort, the Department of Toxic Substances Control (DTSC) and the California Regional Water Quality Control Board – Los Angeles Region (LARWQCB) have jointly developed the "Advisory – Active Soil Gas Investigations" (see the attached). This document is to ensure that consistent methodologies are applied during active soil gas investigations to produce high quality data for regulatory decision-making. The document has been reviewed by other government organizations and by the soil gas consulting community. Their comments have been considered and, where appropriate, incorporated in the document. This is an on-going effort to streamline the characterization of gas phase contaminant sites. As additional knowledge and experience are obtained, this Advisory may be modified as appropriate.

This document is issued by DTSC and LARWQCB as an Advisory subject to review and revision as necessary. The information in this Advisory should not be considered as regulations. Mention of trade names or commercial products does not constitute the Agency's endorsement or recommendation.

If you have any questions regarding this document, please contact the joint-agency project coordinator Mr. Joe Hwong, of DTSC, at (714) 484-5406.

Sincerely,

Edwin F. Lowry

Edwin F. Lowry
Director
Department of Toxic Substances Control

Dennis A. Dickerson
Executive Officer
California Regional Water Quality Control Board
Los Angeles Region

Enclosure

# ADVISORY – ACTIVE SOIL GAS INVESTIGATIONS

**As a coordinated effort, this document is issued by the California Regional Water Quality Control Board – Los Angeles Region (LARWQCB) and Department of Toxic Substances Control (DTSC) as an Advisory subject to review and revision as necessary. Mention of trade names or commercial products does not constitute the Agency's endorsement or recommendation. The information in this Advisory should not be considered as regulations. In this Advisory, "Agency" should mean LARWQCB and/or DTSC.**

## 1.0 INTRODUCTION

Active soil gas investigations are useful to obtain vapor phase data at sites potentially affected by volatile organic compounds (VOCs), including chlorinated and aromatic hydrocarbons. Active soil gas investigations may also be used to investigate sites potentially affected by methane and hydrogen sulfide, and to measure fixed and biogenic gasses (e.g., oxygen, carbon dioxide, or carbon monoxide). Among other things, the data can be used to identify the source and determine the spatial distribution of VOC contamination at a site, or to estimate indoor air concentrations for risk assessment purposes.

For site characterization, the Agency encourages both soil gas and soil matrix sampling. Typically, soil gas data are more representative of actual site conditions in coarse-grained soil formations while soil matrix data are more representative of actual site conditions in fine-grained soil formations. For evaluating the risk associated with vapor intrusion to indoor air, soil gas data are the preferred contaminant data set, where practicable. Flux chamber and passive sampling methods are not discussed in this Advisory. Any sites where such sampling methods are necessary will be addressed separately.

On February 25, 1997, LARWQCB re-issued the "Interim Guidance for Active Soil Gas Investigation" (ASGI) as guidance for investigating sites with potential VOC contamination. Unless otherwise noted in this Advisory, the active soil gas investigation should be performed in accordance with the most current ASGI.

## 2.0 SUPPLEMENTAL RECOMMENDATIONS

The following sections supplement the ASGI in an effort to ensure that consistent methodologies are applied during soil gas investigations to produce reliable and defensible data of high quality. All sampling probe installation, sampling, and analytical procedures, whether or not discussed below, are subject to Agency review and approval.

2.1 Project Management
2.2 Soil Gas Sampling Probe Installation
2.3 Purge Volume Test
2.4 Leak Test
2.5 Purge/Sample Flow Rate
2.6 Soil Gas Sampling
2.7 Analysis of Soil Gas Samples

## 2.1 Project Management

2.1.1 Workplan: An appropriate workplan should be prepared and submitted to the Agency for review and approval at least 30 days prior to its implementation. Any variations or deviations from this Advisory should be specified in the workplan. The soil gas workplan can either be incorporated as part of a comprehensive site investigation workplan or as a stand-alone document, depending on site-specific circumstances.

2.1.2 Field Activities

A. The Agency should be notified 10 working days prior to implementation of field activities. All necessary permits and utility clearance(s) should be obtained prior to conducting any investigations described in this Advisory.

B. All engineering or geologic work (e.g., logging continuous soil cores, soil description) should be performed or supervised by a California Registered Professional in accordance with the Business and Professions Code, Chapters 7 and 12.5, and the California Code of Regulations, Title 16, Chapters 5 and 29.

In addition, for proposed school sites, all work performed should be under the direction and supervision of a project coordinator experienced in soil gas investigations [e.g., an Environmental Assessor as defined in Education Code Section 17210(b)].

C. Evaluation of raw data by Agency staff may occur either in the field or in the office.

1. Hard copies of the complete raw laboratory data, including handwritten data and field notes, should be provided to the Agency staff upon request.

2. Adjustments or modifications to the sampling program may be required by Agency staff to accommodate changes mandated by evaluation of the data set or unforeseen site conditions.

D. Investigation derived wastes (IDWs) should be managed as hazardous waste until proven otherwise or until specifically approved by the Agency as being non-hazardous waste. IDWs should be handled and disposed in accordance with federal, state and local requirements.

E. Field Variations

1. To expedite the completion of field activities and avoid potential project delays, contingencies should be proposed and included in the project workplan (e.g., soil matrix samples will also be collected if clayey soils [as defined in the *Unified Soil Classification System* (USCS)] are encountered during the proposed soil gas investigation).

2. The Agency field staff should be informed of any problems, unforeseen site conditions, or deviations from the approved workplan. When it becomes necessary to implement modifications to the approved workplan, the Agency should be notified and a verbal approval should be obtained before implementing changes.

F. Soil Matrix Sampling Requirements: Companion soil matrix sampling may be conducted concurrently with a soil gas investigation (in accordance with the ASGI, Section 5.0), except where extremely coarse-grained soils (as defined in USCS) are encountered or when specifically excluded by the Agency.

2.1.3 Soil Gas Investigation Reports: A soil gas investigation report including a discussion of field operations, deviations from the approved workplan, data inconsistencies, and other significant operational details should be prepared. The report may either be a stand-alone document in a format recommended by the Agency or be included within a site-specific assessment report. At a minimum, the report should contain the following:

A. Site plan map and probe location map at an appropriate scale as specified in the workplan (e.g., scale: one inch = 40 feet);

B. Final soil gas iso-concentration maps for contaminants of concern at the same scale as the site plan map;

C. Summary tables for analytical data, in micrograms per liter (µg/L), in accordance with the ASGI;

D. Legible copies of field and laboratory notes or logs;

E. All analytical results and Quality Assurance/Quality Control (QA/QC) information including tables and explanations of procedures, results, corrective actions and effect on the data, in the format specified by the Agency; and

F. Upon request, all raw data including chromatograms and calibration data should be submitted to the Agency.

## 2.2 Soil Gas Sampling Probe Installation

2.2.1 Lithology: Site soil or lithologic information should be used to select appropriate locations and depths for soil gas probes. If on-site lithologic information is not available prior to conducting the soil gas investigation, at least one (1) continuously cored boring to the proposed greatest depth of the soil gas investigation should be installed at the first sampling location, unless specifically waived or deferred by Agency. Depending on site conditions, additional continuously cored borings may be necessary.

A. Lithologic logs should be prepared for all borings (e.g., continuously cored borings, soil matrix sampling, geotechnical sampling, etc.). Note: This does not apply to direct-push soil gas probe installations.

B. Information gathered from the continuously cored borings may include soil physical parameters, geotechnical data and contaminant data.

C. If low-flow or no-flow conditions (e.g., fine-grained soil, clay, soil with vacuum readings that exceed approximately 10 inches of mercury or 136 inches of water) are encountered, soil matrix sampling using EPA Method 5035A should be conducted in these specific areas. Also see Section 4 of LARWQCB's "General Laboratory Testing Requirements for Petroleum Hydrocarbon Impacted Sites" on use of EPA Method 5035A.

D. If the bottom five (5) feet of a continuously cored boring is composed of clay or soil with a vacuum exceeding approximately 10 inches of mercury or 136 inches of water, the continuously cored boring should be extended an additional five (5) feet to identify permeable zones. If the extended boring is also composed entirely of clay, the boring may be terminated. Special consideration should always be given to advancing borings and ensuring that a contaminant pathway is not being created through a low permeability zone.

2.2.2 Sample Spacing: A scaled site plan depicting potential or known areas of concern (e.g., existing or former sumps, trenches, drains, sewer lines, clarifiers, septic systems, piping, underground storage tanks [USTs], chemical or waste management units) should be provided in the project workplan. Sample spacing should be in accordance with the most current ASGI and may be modified based on site-specific conditions with Agency approval. To optimize detecting and delineating VOCs, the grid spacing should be modified to include biased sampling locations.

2.2.3 <u>Sample Depth</u>: Sample depths should be chosen to minimize the effects of changes in barometric pressure, temperature, or breakthrough of ambient air from the surface; and to ensure that representative samples are collected. Consideration should be given to the types of chemicals of concern and the lithology encountered.

A. At each sample location, soil gas probes should be installed at a minimum of one sample depth, generally at five (5) feet below ground surface (bgs), in accordance with the most current ASGI.

B. Samples should be collected near lithologic interfaces or based on field instrument readings (e.g., Flame Ionization Detector [FID], Photo Ionization Detector [PID]) from soil cuttings and/or cores to determine the location of maximum analyte concentrations at the top or bottom of the interface depending upon the analyte.

C. Multi-depth sampling is appropriate for any of the following locations:

   1. Sites identified with subsurface structures (e.g., USTs, sumps, clarifiers, waste or chemical management units), subsurface sources (e.g., oil fields, artificial fill, buried animal waste), changes in lithology, and/or contaminated groundwater. Soil gas probes should be emplaced below the base of any subsurface structures, sources or backfilled materials in the vadose zone. Collection of deeper samples should be done in consultation with Agency staff;

   2. Areas with significantly elevated VOC concentrations detected during shallow or previous vapor sampling;

   3. Areas where elevated field instrument readings are encountered from soil matrix cuttings, cores or samples; or

   4. In the annular space of groundwater monitoring wells during construction, where an assessment of the vertical extent of soil gas contamination is necessary.

D. If no lithologic change or contamination is observed, default sampling depths may be selected for multi-depth sampling. For example, soil gas samples may be collected at 5, 15, 25, 40 feet bgs, etc., until either the groundwater is encountered or VOCs are not detected, whichever comes first.

   1. Additional samples may be necessary based on site conditions.

   2. For Preliminary Endangerment Assessments: When 40 feet bgs is reached, collection of deeper samples may be waived.

However, assessment and/or characterization of the deeper vadose zone may be required in the future to protect groundwater resources.

2.2.4 Sampling Tubes: Sampling tubes should be of a small diameter (1/8 to 1/4 inch) and made of material (e.g., nylon, polyethylene, copper or stainless steel) which will not react or interact with site contaminants. For example, metal tubes should not be used for collection of hydrogen sulfide samples.

A. Clean, dry tubing should be utilized at all times. If moisture, water, or an unknown material is present in the probe prior to insertion, the tubing should be decontaminated or replaced.

B. After use at each location:

1. Non-reusable (e.g., nylon or polyethylene) sampling tubes should be discarded; or

2. Reusable sampling tubes should be properly decontaminated as specified in Section 2.2.7.

C. A drawing of the proposed probe tip design and construction should be included in the project workplan.

2.2.5 Soil Gas Probe Emplacement Methods

A. Permanent or Semi-permanent Soil Gas Probe Methods: Permanent or semi-permanent soil gas probes may be installed, using a variety of drilling methods. Please note that the mud rotary drilling method is not acceptable for soil gas probe emplacement. Other drilling methods such as air rotary and rotosonic can adversely affect soil gas data during and after drilling and will require extensive equilibration times. Therefore, they are not recommended. Other soil gas probe designs and construction (e.g., soil gas wells or nested wells) may be appropriate and should be discussed with Agency staff prior to emplacement. When additional sampling is not anticipated per consultation with the Agency, such probes may be properly removed or decommissioned after completion of the soil gas investigation.

1. The probe tip should be emplaced midway within a minimum of one (1) foot of sand pack. The sand pack should be appropriately sized (e.g., no smaller than the adjacent formation) and installed to minimize disruption of airflow to the sampling tip. See Figure 1 for more information.

2. At least one (1) foot of dry granular bentonite should be emplaced on top of each sand pack to preclude the infiltration

of hydrated bentonite grout. The borehole should be grouted to the surface with hydrated bentonite. With respect to deep probe construction with multiple probe depths, the borehole should be grouted between probes. One (1) foot of dry granular bentonite should be emplaced between the filter pack and the grout at each probe location. See Figure 2 for more information.

3. The use of a downhole probe support may be required for deep probe construction (e.g., 40 feet bgs for direct push probes).

    a. Such probe support may be constructed from a one-inch diameter bentonite/cement grouted PVC pipe or other solid rod, or equivalent, allowing probes to be positioned at measured intervals.

    b. The support should be properly sealed or solid (internally or externally) to avoid possible cross-contamination or ambient air intrusion.

    c. The probes should be properly attached to the exterior of the support prior to placement downhole.

    d. Alternative probe support designs should be described in the project workplan. If probe support will not be used for deep probes, justification should be included in the project workplan.

4. Tubing should be properly marked at the surface to identify the probe location and depth.

5. As-built diagrams for probes or wells should be submitted with the soil gas investigation report detailing the well identification and corresponding probe depths. A typical probe construction diagram may be submitted for probes with common design and installation.

6. Unless soil gas probes are removed or decommissioned, probes should be properly secured, capped and completed to prevent infiltration of water or ambient air into the subsurface and to prevent accidental damage or vandalism. For surface completions, the following components may be installed:

    a. Gas-tight valve or fitting for capping the sampling tube;

    b. Utility vault or meter box with ventilation holes and lock;

    c. Surface seal; and

    d. Guard posts.

B. Temporary Soil Gas Probe Emplacement Method: In general, the drive rod is driven to a predetermined depth and then pulled back to expose the inlets of the soil gas probe. After sample collection, both the drive rod and tubing are removed.

  1. During installation of the probe, hydrated bentonite should be used to seal around the drive rod at ground surface to prevent ambient air intrusion from occurring.

  2. The inner soil gas pathway from probe tip to the surface should be continuously sealed (e.g., a sampling tube attached to a screw adapter fitted with an o-ring and connected to the probe tip) to prevent infiltration.

2.2.6 Equilibration Time: During probe emplacement, subsurface conditions are disturbed. To allow for subsurface conditions to equilibrate, the following equilibration times are recommended:

A. For probes installed with the direct push method where the drive rod remains in the ground, purge volume test, leak test, and soil gas sampling should not be conducted for at least 20 minutes following probe installation.

B. For probes installed with the direct push method where the drive rod does not remain in the ground, purge volume test, leak test, and soil gas sampling should not be conducted for at least 30 minutes following probe installation.

C. For probes installed with hollow stem drilling methods, purge volume test, leak test, and soil gas sampling should not be conducted for at least 48 hours (depending on site lithologic or drilling conditions) after the soil gas probe installation.

D. Probe installation time should be recorded in the field log book.

2.2.7 Decontamination: After each use, drive rods and other reusable components should be properly decontaminated to prevent cross contamination. These methods include:

A. 3-stage wash and rinse (e.g., wash equipment with a non-phosphate detergent, rinse with tap water, and finally rinse with distilled water); and/or

B. Steam cleaning process.

### 2.3 Purge Volume Test

To ensure stagnant or ambient air is removed from the sampling system and to assure samples collected are representative of subsurface conditions, a purge volume versus contaminant concentration test should be conducted as the first soil gas sampling activity at the selected purge test point. The purge volume test is conducted by collecting and analyzing a sample for target compounds after the removal of appropriate purge volumes.

2.3.1 Purge Test Locations: The purge test location should be selected as near as possible to the anticipated or confirmed contaminant source, and in an area where soil gas concentrations are expected to be greatest based on lithology (e.g., coarse-grained sediments). The first purge test location should be selected through the workplan approval process or as a field decision in conjunction with Agency staff.

2.3.2 Purge Volume: The purge volume or "dead space volume" can be estimated based on a summation of the volume of the sample container (e.g., glass bulbs), internal volume of tubing used, and annular space around the probe tip. Summa™ canisters, syringe, and Tedlar™ bags are not included in the dead space volume calculation. The Agency recommends step purge tests of one (1), three (3), and seven (7) purge volumes be conducted as a means to determine the purge volume to be applied at all sampling points.

A. The appropriate purge volume should be selected based on the highest concentration for the compound(s) of concern detected during the step purge tests. The purge volume should be optimized for the compound(s) of greatest concern in accordance with Section 2.2 of the ASGI.

B. If VOCs are not detected in any of the step purge tests, a default of three (3) purge volumes should be extracted prior to sampling.

C. The step purge tests and purging should be conducted at the same rate soil gas is to be sampled (see Section 2.5).

D. The purge test data (e.g., calculated purge volume, rate and duration of each purge step) should be included in the report to support the purge volume selection.

2.3.3 Additional Purge Volume Test

A. Additional purge volume tests should be performed to ensure appropriate purge volumes are extracted if:

1. Widely variable or different site soils are encountered; or

2. The default purge volume is used and a VOC is newly detected.

B. If a new purge volume is selected after additional step purge tests are conducted, the soil gas investigation should be continued as follows:

   1. In areas of the same or similar lithologic conditions:

      a. Re-sample 20 percent of the previously completed probes. This re-sampling requirement may be reduced or waived in consultation with Agency staff, depending on site conditions. If re-sampling indicates higher detections (e.g., more than 50 percent difference in samples detected at greater than or equal to 10 µg/L), all other previous probes should be re-sampled using the new purge volume.

      b. Continue the soil gas investigation with the newly selected purge volume in the remaining areas.

   2. In areas of different lithologic conditions: Continue the soil gas investigation with the newly selected purge volume in the remaining areas.

## 2.4 Leak Test

Leakage during soil gas sampling may dilute samples with ambient air and produce results that underestimate actual site concentrations or contaminate the sample with external contaminants. Leak tests should be conducted to determine whether leakage is present (e.g., the leak check compound is detected and confirmed in the test sample after its application).

2.4.1 Leak tests should be conducted at every soil gas probe.

2.4.2 <u>Leak Check Compounds</u>: Tracer compounds, such as pentane, isopropanol, isobutene, propane, and butane, may be used as leak check compounds, if a detection limit (DL) of 10 µg/L or less can be achieved. These compounds may be contained in common products such as shaving cream.

2.4.3 A leak check compound should be placed at any location where ambient air could enter the sampling system or where cross contamination may occur, immediately before sampling. Locations of potential ambient air intrusion include:

A. Sample system connections;

B. Surface bentonite seals (e.g., around rods and tubing); or

C. Top of the Temporary Soil Gas Probe (see Section 2.2.5.B).

2.4.4 The leak test should include an analysis of the leak check compound. If a leak check compound is detected in the sample, the following actions should be followed:

A. The cause of the leak should be evaluated, determined and corrected through confirmation sampling;

B. If the leak check compound is suspected or detected as a site-specific contaminant, a new leak check compound should be used;

C. If leakage is confirmed and the problem can not be corrected, the soil gas probe should be properly decommissioned;

D. A replacement probe should be installed at least five (5) feet from the original probe decommissioned due to confirmed leakage, or consult with Agency staff; and

E. The leak check compound concentration detected in the soil gas sample should be included and discussed in the report.

## 2.5 Purge/Sample Flow Rate

Sampling and purging flow rates should not enhance compound partitioning during soil gas sampling. Samples should not be collected if field conditions as specified in Section 2.6.4 exist.

2.5.1 The purging or sampling flow rate should be attainable in the lithology adjacent to the soil gas probe.

A. To evaluate lithologic conditions adjacent to the soil gas probe (e.g., where no-flow or low-flow conditions), a vacuum gauge or similar device should be used between the soil gas sample tubing and the soil gas extraction devices (e.g., vacuum pump, Summa™ canister).

B. Gas tight syringes may also be used to qualitatively determine if a high vacuum soil condition (e.g., suction is felt while the plunger is being withdrawn) is present.

2.5.2 The Agency recommends purging or sampling at rates between 100 to 200 milliliters per minute (ml/min) to limit stripping, prevent ambient air from diluting the soil gas samples, and to reduce the variability of purging rates. The low flow purge rate increases the likelihood that representative samples may be collected. The purge/sample rate may be modified based on conditions encountered in individual soil gas probes. These modified rates should be documented in the soil gas report.

## 2.6 Soil Gas Sampling

After the soil gas probe is adequately purged, samples should be collected by appropriate methodologies.

2.6.1 Sample Container: Samples should be collected in gas-tight, opaque/dark containers (e.g., syringes, glass bulbs wrapped in aluminum foil, Summa™ canisters), so that light-sensitive or halogenated VOCs (e.g., vinyl chloride) will not degrade.

A. If a syringe is used, it should be leak-checked before each use by closing the exit valve and attempting to force ambient air through the needle.

B. If syringe samples are analyzed within five (5) minutes of collection, aluminum foil wrapping may not be necessary.

C. EPA Method TO-14A, TO-15, or an equivalent air analysis method, requires samples be collected in Summa™ canisters.

D. If a Summa™ canister is used, a flow regulator should be placed between the probe and the Summa™ canister to ensure the Summa™ canister is filled at the flow rate as specified in Section 2.5.2.

E. Tedlar™ bags should not be used to collect VOC samples.

F. Specific requirements for methane and hydrogen sulfide sample containers are specified in Section 2.7.9.

2.6.2 Sample Collection

A. Vacuum Pump: When a vacuum pump is used, samples should be collected on the intake side of the vacuum pump to prevent potential contamination from the pump. Vacuum readings or qualitative evidence of a vacuum should be recorded on field data sheets for each sample.

B. Shallow Samples: Care needs to be observed when collecting shallow soil gas samples to avoid sample breakthrough from the surface. Extensive purging or use of large volume sample containers (e.g., Summa™ canisters) should be avoided for collection of near-surface samples [e.g., shallower than five (5) feet bgs].

### 2.6.3 Sample Container Cleanliness and Decontamination

A. Prior to its first use at a site, each sample container should be assured clean by the analytical laboratory as follows:

   1. New containers should be determined to be free of contaminants (e.g., lubricants) by either the supplier or the analytical laboratory; and

   2. Reused/recycled containers: Method blank(s), as specified in Section 2.7.1.A, should be used to verify sample container cleanliness.

B. After each use, reusable sample containers should be properly decontaminated.

   1. Glass syringes or bulbs should be disassembled and baked at 240° C for a minimum of 15 minutes or at 120° C for a minimum of 30 minutes, or be decontaminated by an equivalent method.

   2. Summa™ canisters should be properly decontaminated as specified by appropriate EPA analytical methods.

   3. During sampling activities using reused/recycled sampling containers (e.g., glass syringes, glass bulbs), at a minimum one (1) decontaminated sample container per 20 samples or per every 12 hours, whichever is more often, should be used as a method blank (as specified in Section 2.7.1.A) to verify and evaluate the effectiveness of decontamination procedures.

C. Plastic syringes should be used only once and then properly discarded.

2.6.4 Field Conditions: Field conditions, such as rainfall, irrigation, fine-grained sediments, or drilling conditions may affect the ability to collect soil gas samples.

A. Wet Conditions: If no-flow or low-flow conditions are caused by wet soils, the soil gas sampling should cease. In addition, the Agency recommends that the soil gas sampling should not be conducted during or immediately after a significant rain event (e.g., 1/2 inch or greater) or onsite watering.

B. If low flow conditions are determined to be from a specific lithology, a new probe should be installed at a greater depth or a new lateral location should be selected after evaluation of the site lithologic logs (See Section 2.2.1) or in consultation with Agency staff.

C. If moisture or unknown material is observed in the glass bulb or syringe, soil gas sampling should cease until the cause of the problem is determined and corrected.

D. If refusal occurs during drilling, soil gas samples should be collected as follows or in consultation with Agency staff.

   1. For sample depths less than five feet, collect a soil gas sample following the precautions outlined in Section 2.6.2.B.

   2. For sample depths greater than five feet, collect a soil gas sample at the depth of refusal.

   3. A replacement probe should be installed within five (5) feet laterally from the original probe decommissioned due to refusal. If refusal still occurs after three tries, the sampling location may be abandoned.

2.6.5 Chain of Custody Records: A chain of custody form should be completed to maintain the custodial integrity of a sample. Probe installation times and sample collection times should be included in the soil gas report.

## 2.7 Analysis of Soil Gas Samples

2.7.1 Quality Assurance/Quality Control (QA/QC): The soil gas analytical laboratory should comply with the project Quality Assurance Project Plan (QAPP) and follow the QA/QC requirements of the most current ASGI and the employed EPA Method. If there is any inconsistency, the most restrictive and specific requirements should prevail. The analytical data should be consistent with the Data Quality Objectives (DQOs) established for the project. The Agency staff may inspect the field and/or laboratory QA/QC procedures. Copies of the QA/QC plan and laboratory calibration data should be presented to the Agency field staff upon request

Field QC samples should be collected, stored, transported and analyzed in a manner consistent with site samples. The following QC samples should be collected to support the sampling activity:

A. Sample Blanks

   1. Method Blanks: Method blanks should be used to verify the effectiveness of decontamination procedures as specified in Section 2.6.3.B.3 and to detect any possible interference from ambient air.

   2. Trip Blanks for Off-site Shipments: Whenever VOC samples are shipped offsite for analysis, a minimum of one (1) trip blank

per day should be collected and analyzed for the target compounds. Trip blanks, consisting of laboratory grade ultra pure air, are prepared to evaluate if the shipping and handling procedures are introducing contaminants into the samples, and if cross contamination in the form of VOC migration has occurred between the collected VOC samples. Trip blank containers and media should be the same as site samples.

B. Duplicate Samples: At least one (1) duplicate sample per laboratory per day should be field duplicate(s). Duplicate samples should be collected from areas of concern.

   1. Duplicate samples should be collected in separate sample containers, at the same location and depth.

   2. Duplicate samples should be collected immediately after the original sample.

C. Laboratory Control Samples and Dilution Procedure Duplicates: Laboratory Control Samples (LCS) and Dilution Procedure Duplicates (DPD) should be done in accordance with the most recent ASGI (Sections 3.5.0 and 3.12.4, respectively).

D. Split Samples: The Agency staff may request that split samples be collected and analyzed by a separate laboratory.

2.7.2 Laboratory Certification: Although the California Department of Health Services, Environmental Laboratory Accreditation Program (ELAP) does not currently require certification for soil gas analytical laboratories, the Agency recommends laboratories utilizing EPA Methods 8260B, 8021B, and 8015B for analyses of soil gas samples obtain ELAP certifications for such EPA analytical methods accordingly. The Agency or DTSC's Hazardous Materials Laboratory (HML) staff may inspect the laboratory.

2.7.3 Detection Limits for Target Compounds: Analytical equipment calibration should be in accordance with the most current ASGI. Consideration and determination of appropriate DLs should be based on the DQOs of the investigation.

A. The DL for leak check compounds should be 10 µg/L or less (see Section 2.4.2). The DL for oxygen ($O_2$) and carbon dioxide ($CO_2$) should be one (1) percent or less. The DLs for methane and hydrogen sulfide are specified in Section 2.7.9.

B. If the investigation is being conducted to delineate the extent of contamination, a DL of 1 µg/L is appropriate for all targeted VOCs.

C. If the soil gas data are to be used to support risk assessment activities, a DL of 1 µg/L may be appropriate for the initial screening when evaluating all targeted VOCs. If the data are non-detect for all targeted VOCs, additional sampling with lower DLs is not required. If VOCs are detected, additional sampling, using a DL of 0.1 µg/L, may be required to confirm the non-detection of carcinogenic VOCs [see the Toxicity Criteria Database of the California Environmental Protection Agency, Office of Environmental Health Hazard (OEHHA), or the Integrated Risk Information System (IRIS) Database of the United States Environmental Protection Agency]. A DL of 0.1 µg/L may be proposed and used for all carcinogenic target VOCs from the beginning of the investigation.

D. Based on site-specific DQO needs, lower DLs may be required. Examples of sites requiring site-specifc DQO needs include, but are not limited to, chlorinated solvents sites, former industrial facilities and landfills. Several less common VOCs, not included on the ASGI-targeted compound list, may require lower detection limits [e.g., bis(chloromethyl)ether, DBCP (1,2-dibromo-3-chloropropane), or ethylene dibromide] when they are known or suspected to be present.

E. If the required DLs cannot be achieved by the proposed analytical method, additional sample analysis by a method achieving these DLs [e.g., EPA Method 8260B with selective ion method (SIM), TO-14A, TO-15] may be required. Use of these methods should comply with the QA/QC requirements as specified in Section 2.7.1.

F. For results with a high DL reported (e.g., due to matrix interference or dilution), the laboratory should provide a written explanation. Re-sampling and analyses may be required at the appropriate DL for a specific compound.

2.7.4 <u>Sample Handling</u>: Exposure to light, changes in temperature and pressure will accelerate sample degradation. To protect sample integrity:

A. Soil gas samples should not be chilled;

B. Soil gas samples should not be subjected to changes in ambient pressure. Shipping of sample containers by air should be avoided; and

C. If condensation is observed in the sample container, the sample should be discarded and a new sample should be collected.

2.7.5 Holding Time: All soil gas samples (e.g., samples of VOCs, methane, fixed gases, or biogenic gases), with the exception of hydrogen sulfide samples, should be analyzed within 30 minutes by an on-site mobile laboratory. Hydrogen sulfide samples should be analyzed as specified in Section 2.7.9.B.2. Under the following conditions, holding times may be extended and analyses performed off-site:

A. Soil gas samples collected in glass bulbs with surrogates added within 15 minutes of collection may be analyzed within 4 hours after collection;

B. Soil gas samples collected in Summa™ canisters may be analyzed within 72 hours after collection; and

C. Methane samples may be analyzed as specified in Section 2.7.9.A.2.

2.7.6 Analytical Methods

A. VOC Samples: All VOC samples should be analyzed using only a Gas Chromatograph/Mass Spectrometer (GC/MS) method (e.g., EPA Method 8260B, used for analysis of soil gas samples, EPA Method TO-14A or TO-15, or equivalent), except at well-characterized sites (e.g., VOCs are known to be present and confirmed based on previous GC/MS analyses). A non-GC/MS method (e.g., EPA Method 8021B, used for analysis of soil gas samples) may be used only for routine monitoring of VOC contamination at well-characterized sites.

If during routine monitoring, new VOC(s) were detected by a non-GC/MS method, then at least 10 percent of the samples with each newly identified VOC should be confirmed by a GC/MS method. Thereafter, routine monitoring can resume with the non-GC/MS method, including the new analyte(s).

B. Methane and Hydrogen Sulfide Samples: These gas samples should be analyzed using methods specified in Section 2.7.9.

2.7.7 Auto samplers may be used if:

A. One (1) sample is introduced at a time;

B. The sample vials are gas-tight and never opened after the sample is added;

C. Proper holding times are maintained (see Section 2.7.5); and

D. All samples are secured and under proper custody.

### 2.7.8 Target Compounds

A. VOCs

1. ASGI-Targeted Compounds: The ASGI (dated February 25, 1997) includes 23 primary and four (4) other target VOCs. All quantifiable results should be reported.

2. Others: The estimated results of all Tentatively Identified Compounds [TICs]) or non-AGSI-targeted compounds detected should be included in the report. If TICs or non-ASGI-targeted compounds are identified, contact the Agency to determine whether additional action is required (e.g., running additional standards to quantify TICs or non-ASGI compounds) and whether the use of these estimated data for risk evaluation is appropriate.

B. Leak Check Compounds: All quantifiable results should be reported as specified in Section 2.4.4.E.

C. Specific Compounds: Based on the site history and conditions, analyses for specific compounds may be required by the Agency staff. Examples include:

1. In areas where USTs or fuel pipelines are identified, soil gas samples should be analyzed for oxygenated compounds [e.g., methyl tertiary butyl ether (MTBE), ethyl tertiary butyl ether (ETBE), di-isopropyl ether (DIPE), tertiary amyl methyl ether (TAME), tertiary butyl alcohol (TBA), and ethanol];

2. At oilfield sites where semi-VOCs or Total Petroleum Hydrocarbons (TPHs) are detected in the soil gas samples, fixed and biogenic gas ($O_2$, $CO_2$, and $CH_4$) data should be obtained using a Thermal-Conductivity Detector (TCD) or a hand-held instrument;

3. At petroleum contaminated sites (including oilfields), dairies, wetlands, landfills or other sites where the presence of methane and/or hydrogen sulfide is suspected, soil gas samples should be analyzed for methane and/or hydrogen sulfide;

4. At sites where use of chlorinated solvents with 1,4-dioxane is suspected or known to exist, soil gas samples may be analyzed for 1,4-dioxane with a detection limit of 1 µg/L; or

5. See Section 2.7.9.A.4 below.

2.7.9 Methane and Hydrogen Sulfide Sampling Programs: If the presence of methane and/or hydrogen sulfide is suspected, they should also be included in the analytical plan. After evaluating the initial soil gas data, the Agency may recommend that testing for methane or hydrogen sulfide cease.

A. Methane Sampling Program: Methane samples may be analyzed by a GC using modified EPA Method 8015B, EPA Method TO-3, or ASTM 3416M (EPA 3C), or by an appropriate hand-held instrument (e.g., Land Tech Gas Analyzer GA-90, Gas Emissions Monitor GEM-500, GEM-2000).

1. Detection Limit: The DL for methane analysis should not exceed 500 parts per million by volume (ppmv).

2. Methane Sample Containers: In addition to the gas-tight sample containers previously specified in Section 2.6.1, Tedlar™ bags may be used for collection of methane samples with a holding time of no more than 24 hours.

3. Methane Screening Level: When methane is detected at 1,000 ppmv or more, additional sampling and/or further investigation is recommended to identify the source(s).

4. At sites where methane is investigated and detected at a level of 5,000 ppmv or more, fixed and biogenic gas ($O_2$, $CO_2$, and $CH_4$) data should be obtained using a Thermal-Conductivity Detector (TCD) or a hand-held instrument.

5. To determine that the area is pressurized by migration of gases, pressure readings of each sampling tube system should be recorded in the field logs and reported along with the methane concentration.

6. Special GC Requirements: The GC method requires calibration curves for analytes such as methane since it is not a normal target analyte for such an analytical method.

7. Special Hand-Held Instruments Requirements: Hand-held instruments should be calibrated in accordance with the manufacture's instructions. When a hand-held instrument is used to analyze methane samples, the Agency recommends that at least 10 percent of all positive methane samples (e.g., more than 5,000 ppmv), rounded to the nearest whole number, be confirmed by another hand-held instrument (different unit or brand) or by a GC method.

B. Hydrogen Sulfide Sampling Program: Hydrogen sulfide may be analyzed by a GC using the South Coast Air Quality Management District (SCAQMD) Method 307-91 or EPA Method 16, or by an appropriate hand-held instrument (e.g., LTX-310 calibrated for hydrogen sulfide or Jerome 631-X).

1. Detection Limit: The DL should be equal to or less than 0.5 ppmv or be sensitive enough to allow for a modeled ambient air concentration (at least one microgram per cubic meter) at the soil surface.

2. Holding Time: Hydrogen sulfide samples should be extracted directly into a hand-held analyzer within 30 minutes of collection to minimize the risk of losing the hydrogen sulfide due to reaction with active surfaces. If a hand-held instrument is not used, hydrogen sulfide samples should be analyzed as below:

   a. Within 30 minutes of collection, using the GC procedures; or

   b. Within 24 hours of collection, if a surrogate is added to the samples, or 100 percent duplicate samples are collected.

3. Sample Containers: The following sample containers are recommended:

   a. Minimum one (1) liter black Tedlar™ bag fitted with polypropylene valves or the equivalent;

   b. 100-ml gas-tight syringe fitted with an inert valve and wrapped in aluminum foil;

   c. Gas-tight glass bulb wrapped in aluminum foil; or

   d. Glass-lined or silicon coated Summa™ canister.

4. Precautions

   a. Since hydrogen sulfide is extremely unstable in the presence of oxygen and moisture, contact of hydrogen sulfide samples with them should be avoided.

   b. Due to the high reactivity of hydrogen sulfide gas, contact of hydrogen sulfide samples with metallic or other non-passive surfaces should be avoided during sample collection, storage and analysis.

   c. Care must be taken so that GC components do not react with the sample. Typically glass-lined injection ports and Teflon™ tube packed columns are used to avoid loss of hydrogen sulfide due to reaction with active surfaces.

## 3.0 SOIL PARAMETERS

If the soil gas data will be used in a health risk assessment, an estimation of the indoor air concentration should be performed using soil gas data with an Agency approved or modified predictable indoor air model. Default values of input parameters may be used in accordance with the approved indoor air modeling guidance and in consultation with Agency staff. If default values are not used, site-specific soil parameters should be obtained as discussed below.

To assess health risk, indoor air quality, the threat of groundwater contamination from VOCs, or to evaluate the effectiveness of a proposed remedial technology, the following soil matrix parameters should be obtained from a minimum of three (3) sample locations (at depths* corresponding to or associated with the detected VOCs) for each soil type in association with the soil gas investigation:

3.1 Soil description performed and presented in accordance with the Unified Soil Classification System (USCS);

3.2 Density;

3.3 Organic carbon content of the soil** (by the Walkee Black Method);

3.4 Soil moisture;

3.5 Effective permeability***;

3.6 Porosity; and

3.7 Grain size distribution analysis (curve) and evaluation of fine-grained soil content (by wet sieve analysis and any supplementary methods as necessary) to determine the percent clay, silt and sand. (The grain size distribution analysis will be used to classify the soil in accordance with the U. S. Soil Conservation Service [SCS] soil type, which is the same as the U. S. Department of Agriculture soil type.)

* Samples may be collected from proposed depths at the continuously cored boring.

** This input parameter is required for soil matrix VOC samples only. This parameter sample should not be collected from an impacted area.

*** As an alternative, the measurements of saturated hydraulic conductivity may be used to estimate vapor permeability.

## 4.0 REFERENCES

Additional information may be found in the following documents:

American Society for Testing and Materials (ASTM), "Standard Guide for Soil Gas Monitoring in the Vadose Zone, ASTM Standard D 5314-92," January 1993; Reapproved 2001; website http://www.astm.org

California Regional Water Quality Control Board, Los Angeles Region, "Interim Guidance for Active Soil Gas Investigation," February 25, 1997

California Regional Water Quality Control Board, Los Angeles Region, "General Laboratory Testing Requirements for Petroleum Hydrocarbon Impacted Sites," June 22, 2000

U.S. Environmental Protection Agency, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA Publication SW-846, Third Edition," November 1986, as amended by Updates I (Jul. 1992), II (Sep. 1994), IIA (August 1993), IIB (Jan. 1995), III (Dec. 1996), IIIA (Apr. 1998), IVA (Jan. 1998) and IVB (Nov. 2000); website http://www.epa.gov/SW-846/main.html

U.S. Environmental Protection Agency, "U.S. EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review, EPA 540/R-94/012," February 1994; website http://www.epa.gov/region09/qa/superfundclp.html

U.S. Environmental Protection Agency, "Soil Gas Sampling, SOP#: 2042, Revision #: 0.0," June 1, 1996; website http://www.ert.org/respns_resrcs/sops.asp

U.S. Environmental Protection Agency, "Summa Canister Cleaning Procedures, SOP #1703, Rev. #: 0.0," 09/01/94; website http://www.ert.org/respns_resrcs/sops.asp

California Environmental Protection Agency (Cal/EPA), Office of Environmental Health Hazard (OEHHA), Toxicity Criteria Database; website http://www.oehha.ca.gov/risk/ChemicalDB/index.asp

United States Environmental Protection Agency, Integrated Risk Information System (IRIS) Database; website http://www.epa.gov/iris/

## ACKNOWLEDGEMENTS

This Advisory was prepared under the direction of Sharon Fair, Branch Chief of DTSC's School Property Evaluation and Cleanup Division. Many Agency project supervisors, engineers, geologists, toxicologists, industrial hygienists, legal advisors, and Hazardous Material Laboratory staff provided support and consultation. In addition, the contents of this Advisory were greatly improved through discussions and comments received from consultants, school districts and numerous soil gas companies.

## FOR MORE INFORMATION

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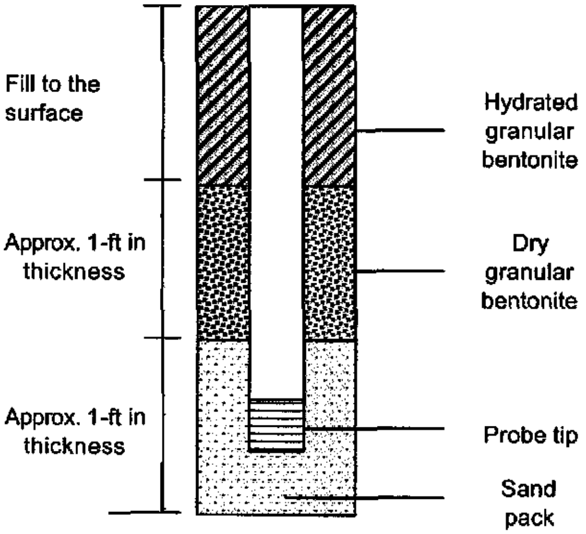
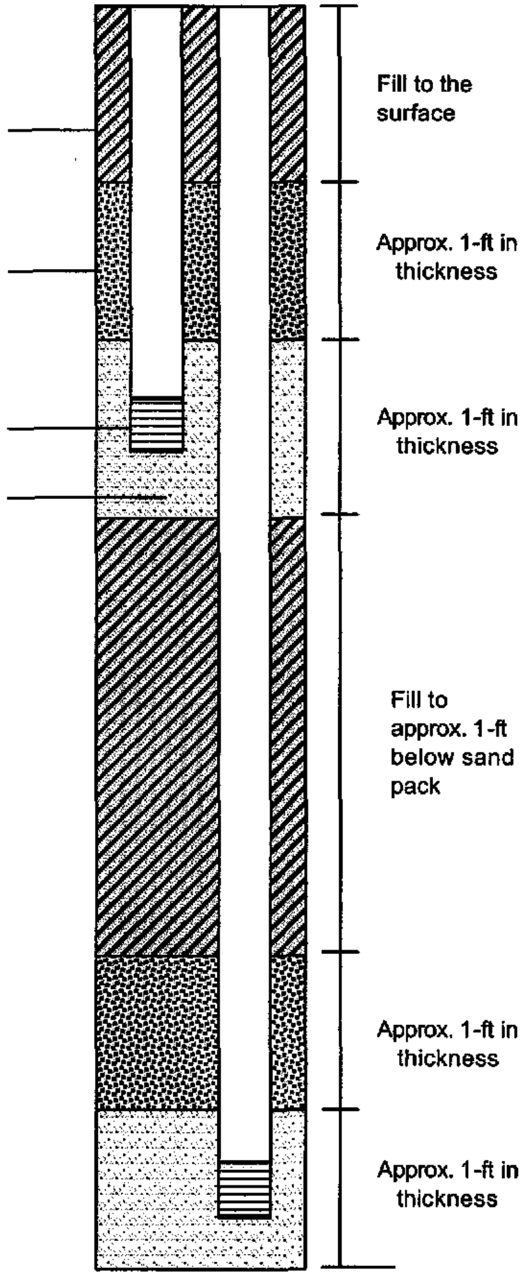
# Figures – Soil Gas Probe Emplacement Methods

**Figure 1 – Permanent/Semi-permanent Gas Probe Construction Diagram**

**Figure 2 – Multi-depth Gas Probe Construction Diagram**





**Temporary Gas Probe Method**