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December 31, 1996

Mr. Steve Chrissanthos
Alameda Cellars
1709 Otis Drive
Alameda, California 94501

RE: Tier 1 Risk Assessment
2425 Encinal Avenue, Alameda, California
ACC Project No. 96-6039-2.5

Dear Mr. Chrissanthos:

ACC Environmental Consultants, Inc., (ACC) has enclosed the Tier 1 Risk Assessment Report for the property located at 2425 Encinal Avenue, Alameda, California.

ACC outlined parameters for the Risk Assessment in our letters dated August 15, 1996, and September 4, 1996, which were subsequently approved by Alameda County Health Care Services Agency. ACC incorporated these parameters into the Tier 1 evaluation and calculated the excess lifetime cancer risk for the site.

If you have any questions regarding this report or the project, please call me at (510) 638-8400.

Sincerely,

Misty C. Kaltreider

Misty C. Kaltreider
Project Geologist

sps/mcr:mck

cc: Ms. Juliet Shin, Alameda County Health Care Services Agency

7977 Capwell Drive, Suite 100 • Oakland, CA 94621 • (510) 638-8400 • FAX (510) 638-8404
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TIER 1
RISK ASSESSMENT REPORT

December 31, 1996

Alameda Cellars
2425 Encinal Avenue
Alameda, California

Prepared For:
Mr. Steve Chrissanthos
Alameda Cellars

OAKLAND ▪ SACRAMENTO
SEATTLE ▪ LOS ANGELES

ACC Project No. 96-6039-2.5

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TIER I RISK ASSESSMENT REPORT
2425 Encinal Avenue
Alameda, California

ACC Project No. 96-6039-2.5

Prepared for:

Mr. Steve Chrissanthos
Alameda Cellars
1709 Otis Drive
Alameda, California 94501

December 31, 1996

Prepared by: Stephen Southern, REA #06524
Risk Analyst

REGISTERED ENVIRONMENTAL ASSESSOR
STEPHEN P. SOUTHERN
No. 06524
Expires: 6/97
STATE OF CALIFORNIA

Prepared by: Martha Rindfleisch
Martha Rindfleisch
Technical Writer

Reviewed by:
Misty Kaltreider
Project Geologist

Reviewed by: Susan Bayne Churchill 6/97
Susan Bayne Churchill, REA #668
President

REGISTERED ENVIRONMENTAL ASSESSOR
SUSAN BAYNE CHURCHILL
No. 00668
STATE OF CALIFORNIA

7977 Capwell Drive, Suite 100 • Oakland, CA 94621 • (510) 638-8400 • FAX (510) 638-8404
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2425 Encinal Avenue
Alameda, California

1.0 INTRODUCTION

ACC Environmental Consultants, Inc., (ACC) conducted a Tier 1 Risk Assessment on the property located at 2425 Encinal Avenue, Alameda, California, on behalf of Mr. Steve Chrissanthos, property owner. The Risk Assessment was performed to evaluate potential human health and environmental risk of impacted soil and groundwater on site and to document the rationale for requesting case closure of the site from the Alameda County Health Care Services Agency (ACHCSA) and Regional Water Quality Control Board (RWQCB). This Risk Assessment was performed according to the American Society for Testing and Materials (ASTM) *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (E 1739-95) and the United States Environmental Protection Agency's (USEPA) *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual* (USEPA, 1989a).

1.1 Background

The site is currently occupied by Alameda Cellars, a commercial liquor store. The site is located on the northwestern corner of Park Avenue and Encinal Avenue (Figure 1). Previously, the subject property was owned by Texaco. In March 1990, two 10,000-gallon gasoline tanks (reportedly installed by Texaco) were removed from this site.

Site investigations and remedial activities are under the jurisdiction of the ACHCSA and RWQCB, San Francisco Bay Region. Site investigation and interim remedial activities have been conducted since 1992.

1.2 Purpose

The purpose of this Risk Assessment is to:

- identify the constituents of concern;
- identify release mechanisms such as wind erosion/vaporization, leaching/percolation;
- identify receptor/exposure routes for both onsite workers, offsite residents, and trespassers;
- determine what concentrations of constituents are appropriate to remain onsite and still be protective of human health; and
- provide required documentation for site regulatory closure that will satisfy the requirements of the ACHCSA and RWQCB.

1.3 Scope

This Risk Assessment provides an evaluation of the potential human health risks associated with exposure to residual petroleum hydrocarbon compounds detected in subsurface soil and groundwater at the subject property. The scope is limited to an assessment of complete exposure pathways for Tier 1 Risk-Based Corrective Action (RBCA) using simple analytical models provided in ASTM (1995) and risk assessment techniques outlined by the USEPA (1989a) and using reasonable maximum exposure (RME) default assumptions provided in the ASTM Standard (E 1739-95) and the USEPA document (1989a).

2.0 SITE BACKGROUND

2.1 Site Description

The subject property is located within an irregularly shaped lot located on the northwestern corner of Park Avenue and Encinal Avenue (Figure 2). The lot is developed with a building, which occupies approximately 30 percent of the site. Based on ACC's review of original building plans at the City of Alameda Planning Department, the concrete slab for the building is approximately 4 inches thick and is covered with vinyl floor covering. Most of the site is used for parking and is capped with asphalt. Approximately 436 square feet of the site is comprised of three small planters.

2.2 Regional Geology and Hydrology

The subject property is located within the Bay Plain. The Bay Plain is geomorphic terrain which is the gently bayward sloping alluvial plain of Alameda County adjacent to the eastern shore of San Francisco Bay. The Bay Plain is situated on the eastern side of the San Francisco Bay depression. This depression is an irregular warpage of the earth's crust resulting principally from downward movement along the northwest trending faults at its edge (California Department of Water Resources, 1963).

During various drilling activities, the site was observed to be covered with a baserock/asphalt cap. Beneath the cap, subsurface soils consisted of fine-grained sand to a depth of 18 feet. The sand is part of the Merritt Sand Formation, which has a thickness of approximately 65 feet below ground surface (bgs). A report by the Alameda County Flood Control and Water Conservation District (FCWCD) dated June 1988 describes Merritt Sand as loose, well-sorted, fine-grained to medium-grained sand and silt, with lenses of sandy clay and clay. The sand was part of a wind and water deposited beach and near-shore deposit and is exposed only in the Alameda and Oakland areas. For the purpose of this Risk Assessment, the subsurface soil across the site will be considered homogenous, consisting of silty sand.

Discharge from groundwater aquifers consists of natural and artificial discharge. Natural discharge includes evapotranspiration, groundwater discharge to streams, and underflow to San Francisco Bay. Artificial discharge is from pumping wells. Water pumped from wells is used for irrigation and industrial use. Domestic water to the site is supplied by the East Bay Municipal Utility District from surface water sources. The sources are from outside the Alameda area and include the Hetch-Hetchy Reservoir system.

The regional topography slopes toward the west-southwest, which is the interpreted direction of regional groundwater movement. The groundwater flow direction underneath the subject site has been documented to be toward the west and southwest with an average groundwater gradient of 0.01 foot/foot. Depth to groundwater underneath the subject site is approximately 5 to 9 feet bgs in Merritt Sand. The shallow aquifer in the area is the Merritt Sand (FCWCD, dated June 1988). Wells drilled within the Merritt Sand have the lowest groundwater specific capacity of all wells installed throughout Alameda County. The FCWCD report states that saltwater intrusion has occurred on a limited basis within the Merritt Sand in Alameda. The nearest marine water is approximately 0.66 mile southwest of the site. The Merritt Sand has a maximum thickness of approximately 65 feet and it contains some groundwater, but is not considered a primary source of domestic supply because of its limited areal distribution and thickness (FCWCD, June 1988). Wells drilled in the Merritt Sand produce enough water for domestic use, but should not be used except for non-potable use because Merritt Sand is composed of relatively thin, permeable, near-surface deposits that are susceptible to impacts from sewer systems, street runoff, etc. (FCWCD, June 1988).

In 1994, ACC conducted a well inventory within a 1-mile radius of the subject property. Of the 61 wells identified, only one was identified as a domestic well. This well was located on the Alameda Historical High School campus. According to Alameda Unified School District personnel, the well has been abandoned. There are 15 wells in the area that are listed as irrigation wells. Many of the irrigation wells were drilled during the 1976 and 1977 drought and are believed to be relatively shallow. It is unknown how many of the wells are still in use today. No wells located within 1 mile of the subject property are used for municipal purposes. There are 32 wells located within 1 mile of the subject property that are reportedly used for monitoring. Total depths of the wells in the area range from 15 feet to 325 feet bgs.

Precipitation either infiltrates into the subsurface via two small planter areas onsite or leaves the site through runoff.

2.3 Site Investigation History

In March 1990, two 10,000-gallon gasoline underground storage tanks (USTs) (reportedly installed by Texaco) were removed from the site by Zaccor. According to an ACHCSA letter dated October 7, 1992, analysis of the soil samples collected from beneath the two former gasoline USTs indicated concentrations of total petroleum hydrocarbons as gasoline (TPHg) up to 1,500 parts per million (ppm). Groundwater was observed in the pit during tank excavation, but no groundwater samples were collected. Results of UST removal indicated impact from leaking USTs on site. No other source was observed. Soil from the excavation was removed and disposed off site. No further overexcavation was performed.

On December 23, 1992, ACC drilled five soil borings at the subject property to evaluate the lateral extent of impact (Figure 3). Soil samples were collected and analyzed for TPHg, benzene, toluene, ethylbenzene, and total xylenes (BTEX), and total lead (from nondetect to 22 ppm). Analytical results of soil samples are presented in Table 2-1. Elevated concentrations of TPHg and benzene were detected in soil samples collected from borings located around the perimeter of the former tank pit (B-1, B-2, B-3, and B-4). Soil borings B-1, B-3, and B-4 were converted into groundwater monitoring wells MW-1, MW-2, and MW-3, respectively. The casing of well MW-2 was damaged and a replacement well, MW-2a, was installed adjacent to former well MW-2. Elevated concentrations of constituents were detected in groundwater samples collected from wells MW-1 and MW-2a upon installation. Analytical results of grab groundwater samples are presented in Table 2-2.

On May 11, 1993, ACC drilled nine additional soil borings at the site (S-1 through S-9). Soil samples were collected from the soil/groundwater interface and were analyzed for TPHg and BTEX. Soil sample analytical results indicated no concentrations above laboratory detection limits for all samples, with the exception of minor concentrations in boring S-6. Analytical results for soil samples are presented in Table 2-1. Findings of the additional investigation indicated the lateral extent of petroleum hydrocarbon impacted soil did not appear to extend beyond the property boundaries along the northern, western, and eastern sides. Minor concentrations were detected in the soil boring drilled along the southern boundary, into Park Avenue and Encinal Avenue.

Field observations made during the additional investigation and soil sample analysis indicated impacted soil existed primarily around the former tank excavation and the former dispenser island. The vertical extent of petroleum hydrocarbons in the soil occurs at the soil/groundwater interface (at a depth of between 5.5 to 10 feet bgs). Analysis of groundwater samples collected from the borings indicated offsite migration of minor concentrations of petroleum hydrocarbons via groundwater.

At the direction of ACHCSA, three additional groundwater monitoring wells, MW-4, MW-5, and MW-6, were installed at the site in December 1993 to further evaluate the extent of petroleum hydrocarbon impact to groundwater. Two of the wells (MW-5 and MW-6) were installed within the property boundaries. Well MW-4 was installed outside the property boundary in Park Avenue, south of the former UST excavation. Groundwater samples collected from these wells were analyzed for TPHg and BTEX. Concentrations of constituents were not detected above laboratory reporting limits in groundwater samples collected from wells MW-5 and MW-6. Analytical results of groundwater samples collected from well MW-4 indicated elevated concentrations of TPHg and slightly elevated concentrations of benzene. Further investigation could not be performed within Encinal Avenue due to CalTrans restriction of access on its property (Highway 61).

In January 1993, ACC initiated a quarterly monitoring program at the subject site. Concentrations of TPHg ranged from not detected above laboratory reporting limits to 14,000 ppb. Concentrations of benzene range from not detected above laboratory reporting limits to 470 ppb. The highest concentrations of benzene have been detected in groundwater samples collected from well MW-2a, adjacent to the former UST pit. Consistently, no concentrations of constituents have been detected in wells MW-5 and MW-6, which are downgradient and upgradient, respectively, of the former UST excavation. Table 2-2 summarizes the historic groundwater concentrations detected in samples collected from all the wells. Boring and well locations are illustrated on Figure 3.

3.0 CHEMICALS OF POTENTIAL CONCERN

Subsurface soil and groundwater investigations have been conducted at this subject property since December 1992. This Risk Assessment assumes that the most recent site investigation data provided the most accurate representation of current conditions at the subject property. Data regarding subsurface soil conditions will be based on soil boring activity conducted at the site since December 1992. The groundwater conditions at the subject property will be based on groundwater sampling results from the past four quarters (from September 1995 through June 1996). These are based on parameters as detailed in ACC's letter dated August 15, 1996, and approved by ACHCSA.

The conceptual site model (SCM) established in our letter dated August 15, 1996, identifies potentially complete exposure/receptor pathways at the subject property (Figure 4). Historically, soil and groundwater samples collected at the site have been analyzed for TPHg and BTEX. Of these constituents, only benzene is identified as a Class A carcinogen by the USEPA; therefore, the chemical of potential concern (COPC) has been identified as benzene. In addition, according to the ASTM E1739-95, "in general, TPH should not be used for 'individual constituent' risk assessments because the general measure of TPH provides insufficient information about the amounts of individual compounds present" (Appendix X1.5.4).

Lead is not addressed on the SCM because only low concentrations of metals were reported in samples collected in 1992. The concentrations of metals were compared with the Department of Health Services Criteria for Inorganic Constituents of Hazardous Wastes, June 1989, and were determined to be below California Code of Regulation, Title 26, Division 22 total threshold limit concentrations for hazardous waste, and within 10 times the soluble threshold limit concentration. Based on the reported metal results, the concentrations of metals reported in the soil samples are within acceptable guidelines and appear representative of natural geologic conditions. Because only low concentrations of metals were reported, lead does not appear to pose a human health or environmental concern for worker safety.

3.1 Soil Investigation Results

Based on site investigations conducted since 1992 and because no constituents of concern have been detected in borings drilled since 1992, the extent of hydrocarbon-impacted soil appears to be primarily limited to the vicinity of the former UST pit. The area of soil impact is estimated to occur between a depth of 5.5 and 10 feet bgs and includes an area extending from the former UST pit to the former dispensers. Migration of petroleum hydrocarbons in soil from the known source area is assumed to have impacted soil to approximately 5 feet beyond the sidewalls of the UST pit, dispenser, and product-line trenches.

The estimation of a site specific representative benzene concentration is difficult due to spatial variability and the lack of sufficient data to quantify this variability. To evaluate the representative benzene concentrations, ACC used the Thiessen Polygon Method (Figure 5). The selected polygon areas were based on the groundwater flow direction. Concentrations of benzene in soil samples collected during drilling soil borings and installing wells were used to evaluate the mean benzene concentrations for soil on site (Table 3-1).

3.2 Groundwater Investigation Results

To evaluate the representative benzene concentrations in groundwater, ACC used the Thiessen Polygon Method. The selected polygon areas were based on the groundwater flow direction (Figure 5). The average benzene concentration in groundwater was calculated using the analytical results from all six wells for the four quarters between September 1995 through June 1996. The average benzene concentrations for groundwater as used in this Risk Assessment and calculated using the Thiessen Polygon Method are included in Table 3-2.

3.3 Identification of Chemicals of Potential Concern

The purpose of identifying a COPC is to focus the Risk Assessment on chemicals that contribute most significantly to potential risks existing at the subject property. The COPC for the subject property has been identified as benzene. Concentrations of benzene at the subject property are compared with risk based screening levels (RBSLs) to determine whether the risk posed at the subject property is due to the presence of this chemical that exceeds acceptable levels of risk. This Risk Assessment assumes a level of risk equal to 1×10^{-5} (equivalent to one death per 100,000 exposed).

Tier 1 RBSLs represent chemical concentrations in source media that are not expected to pose a health risk, even under long-term exposure. Tier 1 RBSLs are developed based on an acceptable target risk level and standard exposure scenarios, USEPA RME default exposure assumptions, and current toxicological parameters recommended by the USEPA. For direct exposure pathways, standard exposure assumptions are used to derive RBSLs. For indirect exposure pathways, fate and transport models are used with standard assumptions to derive RBSLs. ACC's SCM identifies potentially complete exposure/receptor pathways at the subject property (Figure 4).

3.3.1 *Subsurface Soil Chemicals of Potential Concern*

Tier 1 soil RBSLs have been calculated by ASTM for the following potential single and/or combined routes of exposure from chemicals in subsurface soil:

- indoor inhalation of vapor originating from soil beneath the building;
- outdoor inhalation of vapor originating from soil; and
- ingestion of soil (which also considers dermal contact with soil and inhalation of airborne particulates).

Table 3-3 presents a comparison of the average benzene concentrations in vadose zone subsurface soil with Tier 1 soil RBSLs for the identified exposure pathways.

3.3.2 *Groundwater Chemicals of Potential Concern*

Tier 1 groundwater RBSLs have been calculated by ASTM for the following potential routes of exposure from chemicals in groundwater:

- indoor inhalation of vapor originating from groundwater; and
- outdoor inhalation of vapor originating from groundwater.

Table 3-4 presents a comparison of the averaged benzene concentrations in groundwater against Tier 1 RBSLs for these exposure pathways.

4.0 EXPOSURE ASSESSMENT

The purpose of the exposure assessment is to estimate the type and magnitude of exposures to current and potential receptors from the COPCs that are present at the site and those COPCs that may be migrating from the site, if any. The results of the exposure assessment are combined with chemical specific toxicity information (Section 5.0) to characterize potential risks (Section 6.0).

The exposure assessment consists of the following three components:

- characterize potentially exposed human populations (receptors) under expected land use conditions;
- identify actual or potential exposure pathways; and
- quantitatively estimate relevant receptor point concentration using data, models or combination and estimate the uptake of each chemical by each receptor for each route of exposure.

4.1 Characterization of Potentially Exposed Human Receptors

Potentially exposed human receptors are selected for evaluation under current and hypothetical future land use conditions. Land use surrounding the subject property is commercial/service and residential. The current use of the subject property is commercial. There is no anticipated change in the current use of the subject property; therefore, commercial land use is considered representative of future conditions.

Because of current and anticipated land use conditions, onsite exposures will be limited to onsite worker exposures. The most conservative Tier 1 approach assumes the onsite worker will work indoors at the same location for 8 hours per day (time), 5 days per week, 50 weeks per year (frequency), for a total of 30 years (duration). ✓

The property is capped except for the planter areas. The three small planters on the subject property have an estimated total area of 436 square feet. Groundskeeping activities are not expected to disturb existing soil in the planters or any subsurface soil, but they may involve watering, pruning, and mowing. For the purpose of this Risk Assessment, the landscape worker/groundskeeper will be considered the onsite construction worker. The landscape worker is not expected to be exposed to benzene through dermal contact with the exposed surface soil.

Potential risks to the onsite indoor and outdoor worker are conservatively estimated assuming current detected concentrations of benzene remain steady. Although biodegradation should occur, it will not be considered in this Risk Assessment.

4.2 Identification of Exposure Pathways

An exposure pathway describes a specific environmental pathway by which a receptor can be exposed to COPCs present at the subject property. Elements that comprise the pathway consist of:

- a primary chemical source (e.g., surface, subsurface soils);
- a secondary chemical source (e.g., groundwater, air vapors);
- an environmental transport medium (e.g., air, groundwater) for the released chemical;
- a release mechanism (e.g., leaching, wind erosion/vaporization); and
- receptors and exposure routes (e.g., onsite worker, offsite resident and inhalation, ingestion, respectively).

Information concerning sources, release and transport mechanisms, locations of potential receptors, and potential exposure routes was used to develop a SCM of the subject property. The schematic model is Figure 4. The purpose of the SCM is to provide a framework for problem definition, identify exposure pathways that may result in human health risks, aid in identifying data gaps, and aid in identifying effective cleanup methodologies that target specific contaminant sources. The SCM was included in ACC's letter dated August 15, 1996, which was approved by ACHCSA.

4.2.1 *Potentially Complete and Significant Exposure Pathways*

The SCM indicates the following exposure pathways are potentially complete and significant for the onsite commercial worker, onsite construction worker, the offsite resident, and the trespasser. These pathways are evaluated in this Risk Assessment.

4.2.1.1 Identified Exposure Pathways for the Onsite Indoor Commercial Worker

The SCM indicates the onsite indoor commercial worker may be exposed to benzene via the following exposure pathways:

- Inhalation of benzene concentrations that emanate from subsurface soil to indoor air. Volatilization of benzene from subsurface soils to indoor air is quantitatively evaluated.
- Inhalation of volatile organic compounds (VOCs) that emanate from groundwater to indoor air. Volatile COPCs (benzene) are present in groundwater, which may volatilize and the vapor could potentially migrate upward through the foundation of the onsite building to enclosed space air. Exposure via this pathway is quantitatively evaluated in this Risk Assessment.

4.2.1.2 Identified Exposure Pathways for the Onsite Construction Worker &

Although there is no anticipated land use changes currently in place, ~~inges~~ inhalation & dermal scenarios should be considered if construction work is ever conducted where excavation is involved.

The SCM indicates the onsite construction worker may be exposed to benzene via the following exposure pathways:

- Incidental ingestion of soil. Because there is no anticipated change in the use of the subject property that might significantly disturb existing soil conditions at the subject property and there is no evidence of benzene in surface soils, ingestion of benzene impacted soil is not expected, and this pathway is not quantitatively evaluated.

- Dermal contact with soil. Because there is no anticipated change in the use of the subject property that might significantly disturb existing soil conditions at the subject property, and because there is no evidence of benzene in surface soils, ingestion of benzene impacted soil is not expected, and this pathway is not quantitatively evaluated.

- Inhalation of airborne soil particulates. Because there is no anticipated change in the use of the subject property that might significantly disturb existing soil conditions at the subject property, and because there is no evidence of benzene in surface soils, ingestion of benzene impacted soil is not expected, and this pathway is not quantitatively evaluated.

- Inhalation of VOCs that emanate from subsurface soils to ambient air. Volatilization of benzene from subsurface soils to ambient air may occur; therefore, this pathway is quantitatively evaluated.

- Dermal contact with groundwater. Dermal contact with groundwater may occur during quarterly groundwater sampling events; however, precautions are taken that preclude excess exposure to constituents of concern. Exposure via this pathway is not quantitatively evaluated.

- Inhalation of VOCs that emanate from groundwater to ambient air. Volatile COPCs (benzene) are present in groundwater. These may volatilize and the vapor could potentially migrate upward through the soil/air interface to ambient air. Exposure via this pathway is quantitatively evaluated in this Risk Assessment.

4.2.1.3 Identified Exposure Pathway for the Offsite Resident

The SCM indicates the offsite resident may be exposed to benzene via the following exposure pathways:

- Ingestion of benzene via contact with groundwater. Although this pathway was identified in the SCM as a potential complete pathway, no offsite residential receptors have been identified. Offsite residential contact with groundwater is not expected and this pathway is not quantitatively evaluated.

4.2.1.4 Incomplete Exposure Pathways

The SCM indicates the following exposure pathways are incomplete. These incomplete pathways are not addressed in the Risk Assessment.

Ingestion of and dermal contact with soil for the onsite worker. It is assumed that the onsite commercial worker is engaged in indoor activities; therefore, exposure via this pathway is not expected. ?

No downgradient, offsite receptors are identified because the area immediately downgradient of the subject property is Encinal Avenue (Highway 61). Jackson Park is across Encinal Avenue; however, due to numerous utility lines located in Encinal Avenue, it is probable that constituents originating at the subject property would follow the preferential pathway of least resistance and migrate downgradient following utility trenches. For this reason and because no concentrations have been detected in downgradient well MW-5, it is considered to be unlikely that constituents would cross Encinal Avenue and impact Jackson Park.

4.3 Quantification of Exposure

This section presents the mechanism to quantify exposure by estimating constituent concentrations at the exposure point and the magnitude of exposure or intake for each receptor. Tables 4-1 through 4-4 contain diffusion coefficient calculations and Tables 4-5 through 4-8 contain volatilization factor calculations based on ASTM 1995. Appendix 1 includes ASTM parameter definitions and values.

4.3.1 *Estimation of Exposure Point Concentrations*

The exposure point concentration (EPC) is the estimated concentration of each constituent in each medium at the location of potential contact with a receptor. Development of EPCs includes an underlying assumption about the representativeness of the monitoring data. No physical, chemical, or biological processes that could result in the reduction of constituent concentrations over time were included in the estimation of EPCs. The EPC generally used in an intake calculation is the arithmetic average concentration for a constituent in the medium being evaluated. Because this average is derived from a limited data set, it is uncertain how accurately it represents the true average concentration at the subject property. ACC estimated the EPCs by the Thiessen Polygon Method (Section 3.0).

EPCs for COPCs in groundwater are used in vapor-phase migration models to estimate the concentration of site specific COPCs in enclosed space air and ambient air.

4.3.1.1 Enclosed Space Air Exposure Point Concentrations - Groundwater

To estimate the concentration of benzene in enclosed space air, the vapor-phase migration model presented in ASTM E1739-95 is used. The model uses closed form analytical solutions for connective and diffusive transport of vapor phase chemicals in groundwater. The calculation of enclosed space air concentrations is performed in two steps: 1) deriving a site-specific and chemical specific volatilization factor; and 2) estimating enclosed space air concentrations from the calculated volatilization factor and groundwater concentrations.

Volatilization Factor Derivation

$$VF_{wesp}\left[\frac{(mg/m^3-air)}{mg/L-H_2O}\right]=\frac{H\times\left[\dfrac{D_{ws}^{eff}/L_{GW}}{ER\times L_B}\right]}{1+\left[\dfrac{D_{ws}^{eff}/L_{GW}}{ER\times L_B}\right]+\left[\dfrac{D_{ws}^{eff}/L_{GW}}{\left(D_{cracks}^{eff}/L_{crack}\right)n}\right]}\times 10^3\,\frac{L}{m^3}$$

Where:

VF_{wesp} = volatilization factor for groundwater to enclosed space vapors [(mg/m^3-air)/(mg/L-H_2O)]
H = Henry's law constant (unitless)
D_{ws}^{eff} = effective diffusion coefficient between groundwater and soil surface
L_{GW} = depth to groundwater (cm)
ER = enclosed space air exchange rate (1/s)
L_B = enclosed space volume/infiltration area ratio (cm)
D_{cracks}^{eff} = effective diffusion coefficient through foundation cracks
L_{crack} = enclosed space foundation or wall thickness (cm)
n = areal fraction of cracks in foundation/wall (cm^2-cracks/cm^2 -total area)

This model is based on the following assumptions:

- a constant dissolved chemical concentration in groundwater;
- equilibrium partitioning between dissolved chemicals in groundwater and chemical vapors at the groundwater table;
- steady-state vapor and liquid phase diffusion through the capillary fringe, vadose zone, and foundation cracks;
- no loss of chemical as it diffused toward ground surface (i.e., no biodegradation); and
- steady, well-mixed atmospheric dispersion of the emanating vapors within the enclosed space.

Enclosed Space Air Concentrations - Groundwater

Using the calculated volatilization factor for benzene, enclosed space air concentrations are estimated with the following algorithm:

$$C_{\text{enclosed space air}} = C_{\text{groundwater}} \text{ X } VF_{wesp}$$

Where:

$C_{\text{enclosed space air}}$ = chemical concentration in enclosed space air (mg/m^3)
$C_{\text{groundwater}}$ = chemical concentration in groundwater (mg/L)

VF_{wesp} = chemical specific groundwater to enclosed space air volatilization factor $[(mg/m^3\text{-air})/mg/L\text{-}H_2O)]$

Calculated enclosed space air concentrations of benzene from groundwater for average exposure sitewide and for the building interior are presented in Table 4-9.

4.3.1.2 Ambient Air Exposure Point Concentration - Groundwater

To estimate the concentration of benzene in ambient air, the vapor phase migration model presented in ASTM E 1739-95 is used. The model uses closed-form analytical solutions for connective and diffusive transport of vapor phase chemicals in groundwater. The calculation of ambient air concentrations is performed in two steps: 1) deriving a site and chemical specific volatilization factor that describes the relationship between air and groundwater concentrations; and 2) estimating ambient air concentrations from the calculated volatilization factor and groundwater concentrations.

Volatilization Factor Derivation - Groundwater

Chemical specific volatilization factors are determined using the following model:

$$VF_{wamb}\left[\frac{(mg/m^3 - air)}{mg/L - H_2O}\right] = \frac{H}{1+\left[\frac{U_{air}\times\delta_{air}\times L_{GW}}{W\times D_{ws}^{eff}}\right]}\times 10^3\frac{L}{m^3}$$

Where:

VF_{wamb} = volatilization factor for groundwater to enclosed space vapors $[(mg/m^3\text{-air})/(mg/l\text{-}H_2O)]$
H = Henry's law constant (unitless)
U_{air} = wind speed above ground surface in ambient mixing zone (cm/s)
δ_{air} = ambient air mixing zone height (cm)
L_{GW} = depth to groundwater (cm)
W = width of source area parallel to wind, or groundwater flow direction (cm)
D_{ws}^{eff} = effective diffusion coefficient between groundwater and soil surface

This model makes the following assumptions:

- a constant dissolved chemical concentration in groundwater;
- linear equilibrium partitioning within the soil matrix between dissolved chemicals in groundwater and chemical vapor at the groundwater table;
- steady-state vapor and liquid phase diffusion through the capillary fringe and vadose zones to ground surface;
- no loss of chemical as is diffuses toward ground surface (i.e., biodegradation); and

- stead well-mixed atmospheric dispersion of the emanating vapors within the breathing zone as modeled by a "box model" for air dispersion.

Ambient Air Concentrations

Using the calculated volatilization factors for benzene, ambient air concentrations are estimated with the following algorithm:

$$C_{\text{ambient air}} = C_{\text{groundwater}} \times VF_{\text{wamb}}$$

Where:

$C_{\text{ambient air}}$ = chemical concentration in ambient air (mg/m^3)

$C_{\text{groundwater}}$ = chemical concentration in groundwater (mg/L)

VF_{wamb} = chemical specific groundwater to ambient air volatilization factor [(mg/m^3-air)/(mg/L-H_2O)]

Calculated ambient air concentrations of benzene from groundwater for average sitewide exposure and for the building interior are presented in Table 4-9.

4.3.1.3 Enclosed Space Air Exposure Point Concentration - Soil

To estimate the concentration of benzene in enclosed space air, the vapor phase migration model presented in ASTM E1739-95 is used. The model uses closed form analytical solutions for connective and diffusive transport of vapor phase chemicals in subsurface soil. The calculation of enclosed space air concentrations is performed in two steps: 1) deriving a site-specific and chemical specific volatilization factor, and 2) estimating enclosed space air concentrations from the calculated volatilization factor and subsurface soil concentrations.

Volatilization Factor Derivation - Soil

$$VF_{sesp}\left[\frac{mg/m^3 - air}{mg/kg - soil}\right] = \frac{\dfrac{H\rho_s}{\left[\theta_{ws} + k_s\rho_s + H\theta_{as}\right]}\left[\dfrac{D_s^{eff}/L_s}{ERL_B}\right]}{1 + \left[\dfrac{D_s^{eff}/L_s}{ERL_B}\right] + \left[\dfrac{D_s^{eff}/L_s}{\left(D_{crack}^{eff}/L_{crack}\right)\eta}\right]} \times 10^3 \frac{cm^3 - kg}{m^3 - g}$$

Where:

VF_{sesp} = volatilization factor for groundwater to enclosed space vapors [(mg/m^3-air)/(mg/kg-soil)]

H = Henry's law constant (unitless)

ρ_s = soil bulk density (g-soil/cm^3 -soil)

θ_{ws} = volumetric water content in vadose zone soils (cm^3-H_20/cm^3-soil)

k_s = soil-water sorption coefficient (cm^3-H_20/g -soil)
θ_{as} = volumetric air content in vadose zone soils (cm^3-air/cm^3-soil)
D_s^{eff} = effective diffusion coefficient in soil based on vapor-phase concentration (cm^2/soil)
L_s = depth to subsurface soil surfaces (cm)
ER = enclosed space air exchange rate (1/s)
L_B = enclosed space volume/infiltration area ratio (cm)
D_{cracks}^{eff} = effective diffusion coefficient through foundation cracks
L_{crack} = enclosed space foundation or wall thickness (cm)
η = areal fraction of cracks in foundation/wall (cm^2-cracks/cm^2 -total area)

This model is based on the following assumptions:

- a constant dissolved chemical concentration in groundwater;
- equilibrium partitioning between dissolved chemicals in groundwater and chemical vapors at the groundwater table;
- steady-state vapor and liquid phase diffusion through the capillary fringe, vadose zone, and foundation cracks;
- no loss of chemical as it diffused toward ground surface (i.e., no biodegradation); and
- steady, well-mixed atmospheric dispersion of the emanating vapors within the enclosed space.

Soil-water sorption coefficient:

$$K_s = f_{oc} \times k_{oc}$$

K_s = soil-water sorption coefficient (cm^3-H_20/g -soil)
f_{oc} = fraction of organic carbon in soil (g-C/g-soil) = 0.01
k_{oc} = carbon/water sorption coefficient (cm^3-H_20/g -C)

Calculated ambient air concentrations of benzene from soil for average sitewide exposure and for the building interior are presented in Table 4-10.

4.3.1.4 Ambient Air Exposure Point Concentration - Soil

To estimate the concentration of benzene in ambient air, the vapor phase migration model presented in ASTM E1739-95 is used. The model uses closed form analytical solutions for connective and diffusive transport of vapor phase chemicals in subsurface soil. The calculation of enclosed space air concentrations is performed in two steps: 1) deriving a site-specific and chemical specific volatilization factor, and 2) estimating ambient air concentrations from the calculated volatilization factor and subsurface soil concentrations.

$$VF_{samb}\left[\frac{(mg/m^3-air)}{mg/kg-soil}\right]=\frac{H\rho_s}{\left[\theta_{ws}+k_s\rho_s+H\theta_{as}\right]\left(1+\frac{U_{air}\delta_{air}L_s}{D_s^{eff}W}\right)}\times10^3\,\frac{cm^3-kg}{m^3-g}$$

where:

VF_{samb} = volatilization factor for groundwater to ambient vapors [(mg/m^3-air)/(mg/kg-soil)]
H = Henry's law constant (unitless)
ρ_s = soil bulk density (g-soil/cm^3 -soil)
θ_{ws} = volumetric water content in vadose zone soils (cm^3-H$_2$0/cm^3-soil)
k_s = soil-water sorption coefficient (cm^3-H$_2$0/g -soil)
θ_{as} = volumetric air content in vadose zone soils (cm^3-air/cm^3-soil)
U_{air} = wind speed above ground surface in ambient mixing zone, cm/s
δ_{air} = ambient air mixing zone height, cm
L_s = depth to surface soils, cm
D_s^{eff} = effective diffusion coefficient in soil based on vapor-phase concentration (cm^2/soil)
W = width of source area parallel to wind or groundwater flow direction

- a constant dissolved chemical concentration in groundwater;
- linear equilibrium partitioning within the soil matrix between dissolved chemicals in groundwater and chemical vapor at the groundwater table;
- steady-state vapor and liquid phase diffusion through the capillary fringe and vadose zones to ground surface;
- no loss of chemical as is diffuses toward ground surface (i.e., biodegradation); and
- stead well-mixed atmospheric dispersion of the emanating vapors within the breathing zone as modeled by a "box model" for air dispersion.
-

Calculated ambient air concentrations of benzene from soil for average sitewide exposure and for the building interior are presented in Table 4-10.

4.3.2 *Estimation of Chemical Intakes*

To assess the potential adverse health effects associated with benzene exposure at the subject property, the potential level of human exposure to benzene must be determined. The USEPA has published exposure algorithms for the calculation of chemical intake (USEPA, 1989a). In these algorithms, chemical intake is a function of the EPC of the target chemical, the receptor specific contact rate, exposure frequency, exposure duration, body weight, and averaging time. Chemical intakes are conservatively estimated using upper bound default exposure assumptions recommended by the USEPA. Upper bound exposure assumptions are chosen for these parameters so that the combination of all exposure variables results in a RME for the exposure pathway evaluated. The goal of the RME is to quantify the maximum exposure which is reasonably expected to occur at the subject property, not necessarily the worst possible exposure (USEPA, 1989a).

4.3.2.1 Inhalation of Benzene (Enclosed Space Air) Emanating from Groundwater

Chemical intake of benzene via inhalation of enclosed space air is a function of the enclosed space air concentration, the inhalation rate, the time, frequency and duration of exposure. Intake of benzene via this exposure pathway is evaluated for the onsite commercial worker and is estimated with the following algorithm.

$$Intake(mg/kg-day) = \frac{C_A \times IR \times ET \times EF \times ED}{BW \times AT}$$

✓

where:

C_A = Chemical concentration in indoor air (mg/m^3)
IR = Inhalation rate (m^3/hour)
ET = Exposure time (hour/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

Enclosed space air concentrations for benzene are derived in Section 4.3.1.1. For the onsite, indoor commercial worker, the inhalation rate is assumed to be 0.83 m^3/hr (USEPA and ASTM). ok It is conservatively assumed that exposure to the onsite construction worker occurs 8 hours per day, 250 days per year, ok for 25 years. ok The averaging time for exposure to carcinogens is equivalent to the average lifetime (i.e., 70 years) expressed in days (25,550 days) regardless of the age of the receptor evaluated. ok

These exposure assumptions and the calculated chemical intake for the onsite construction worker via inhalation of benzene in ambient air are presented in Table 4-11.

4.3.2.2 Inhalation of Benzene (Ambient Air) Emanating from Groundwater

Chemical intake of benzene via inhalation of ambient air is a function of the ambient air concentration, the inhalation rate, the time, frequency and duration of exposure. Intake of benzene via this exposure pathway is evaluated for the onsite construction worker and is estimated with the following algorithm.

$$Intake(mg/kg-day) = \frac{C_A \times IR \times ET \times EF \times ED}{BW \times AT}$$

✓

Ambient air concentrations for benzene are derived in Section 4.3.1.2. For the onsite construction worker, the inhalation rate is assumed to be 0.83 m^3/hr (USEPA and ASTM). It is assumed that exposure to the onsite construction worker occurs 8 hours per day, 12 days per year (once per month), for one year. The averaging time for exposure to carcinogens is equivalent to the average lifetime (i.e., 70 years) expressed in days (25,550 days) regardless of the age of the receptor evaluated.

→ Should b
250 day

These exposure assumptions and the calculated chemical intake for the onsite construction worker via inhalation of benzene in ambient air are presented in Table 4-12.

4.3.2.3 Inhalation of Benzene (Enclosed Space Air) Emanating from Subsurface Soil

Chemical intake of benzene via inhalation of enclosed space air is a function of the enclosed space air concentration, the inhalation rate, the time, frequency and duration of exposure. Intake of benzene via this exposure pathway is evaluated for the onsite commercial worker and is estimated with the following algorithm.

$$Intake(mg/kg-day) = \frac{C_A \times IR \times ET \times EF \times ED}{BW \times AT} \quad \checkmark$$

Enclosed space air concentrations for benzene in soil are derived in Section 4.3.1.1. For the onsite, indoor commercial worker, the inhalation rate is assumed to be 0.83 m^3/hr (USEPA and ASTM). It is conservatively assumed that exposure to the onsite construction worker occurs 8 hours per day, 250 days per year, for 25 years. The averaging time for exposure to carcinogens is equivalent to the average lifetime (i.e., 70 years) expressed in days (25,550 days) regardless of the age of the receptor evaluated.

These exposure assumptions and the calculated chemical intake for the onsite construction worker via inhalation of benzene from groundwater in ambient air are presented in Table 4-13.

4.3.2.4 Inhalation of Benzene (Ambient Air) Emanating from Soil

Chemical intake of benzene via inhalation of ambient air is a function of the ambient air concentration, the inhalation rate, the time, frequency and duration of exposure. Intake of benzene via this exposure pathway is evaluated for the onsite construction worker and is estimated with the following algorithm.

$$Intake(mg/kg-day) = \frac{C_A \times IR \times ET \times EF \times ED}{BW \times AT} \quad \checkmark$$

Ambient air concentrations for benzene are derived in Section 4.3.1.2. For the onsite construction worker, the inhalation rate is assumed to be 0.83 m^3/hr (USEPA and ASTM). It is assumed that exposure to the onsite construction worker occurs 8 hours per day, 12 days per year (once per month), for one year. The averaging time for exposure to carcinogens is equivalent to the average

→ Should
be 250 da

lifetime (i.e., 70 years) expressed in days (25,550 days) regardless of the age of the receptor evaluated.

These exposure assumptions and the calculated chemical intake for the onsite construction worker via inhalation of benzene from groundwater in ambient air are presented in Table 4-14.

5.0 TOXICOLOGICAL ASSESSMENT

This section presents an assessment of the potential for COPCs at the site to cause adverse effects in exposed individuals. The means of quantifying toxicity is discussed below and toxicity profiles are presented in Appendix 1. Several numerical values can be used to describe the toxicity of a specific compound. As a broad first step, the effects of exposure to a specific compound are divided into two categories, carcinogenic and noncarcinogenic. No noncarcinogenic constituents identified at the subject property are evaluated in this Risk Assessment.

5.1 Toxicity Information for Carcinogenic Effects

Carcinogens are constituents that cause or induce cancer. The USEPA Human Health Assessment Group uses a weight-of-evidence classification system to identity compounds as carcinogens. Information used in developing the classification includes: 1) evaluating the quality of data from human studies of the association between cancer incidence and exposure; 2) evaluating long-term animal studies; 3) combining the two types of studies to obtain an overall human carcinogenic weight-of-evidence; and 4) assessing all other types of information such as short-term tests for genotoxicity, metabolic and pharmacokinetic properties, and structure activity relationships to determine whether a modification of the weight-of-evidence is necessary. Five categories of carcinogens are used:

- Group A, Human Carcinogen. Sufficient information exists from human epidemiological studies to support a causal association between exposure and cancer.

- Group B, Probable Human Carcinogen. This includes compounds for which limited evidence of carcinogenicity in humans exists based on epidemiological studies and those compounds for which sufficient evidence of carcinogenicity in animals exists, but adequate evidence of carcinogenicity in humans is not available.

- Group C, Possible Human Carcinogen. This includes those compounds for which there is limited evidence of carcinogenicity in animals.

- Group D, Not Classifiable as to Human Carcinogenicity. This includes those compounds for which there is inadequate animal evidence of carcinogenicity.

- Group E, Evidence of Noncarcinogenicity in Humans. This includes compounds for which there is no evidence for carcinogenicity in at least two adequate animal tests in different species or in both adequate epidemiological and animal studies (USEPA, 1986a).

The toxicity value used to describe the dose/response relationship for carcinogenic effects is called the cancer slope factor (CSF). The slope factor is a plausible upper-bound estimate of the probability of a carcinogenic response per unit intake of a chemical during a lifetime. Slope factors are expressed as the inverse of milligrams of chemical per kilogram of body weight per day $(\text{mg/kg-day})^{-1}$. As discussed, evidence of chemical carcinogenicity originates primarily from two sources: lifetime studies with animals and human (epidemiological) studies. Assumptions arise from the necessity of extrapolating experimental results across species (i.e., from laboratory animals to humans); from high-dose regions (i.e., levels to which laboratory animals are exposed) to low-dose regions (i.e., levels to which humans are likely to be exposed); and across routes of administration (e.g., inhalation versus ingestion).

For chemical carcinogens, the USEPA assumes a small number of molecular events can evoke changes in a single cell that can lead to uncontrolled cellular proliferation and tumor induction. This mechanism for carcinogenesis is referred to as stochastic, which means that there is theoretically no level of exposure to a given chemical that does not pose a small, but finite probability of generating a carcinogenic response. Since risk at low exposure levels cannot be measured directly either in laboratory animals or human epidemiology studies, various mathematical models have been proposed to extrapolate from high to low dose (i.e., to estimate the dose/response relationship at low doses).

Regulatory decisions are based on the output of the linearized multistage model (USEPA, 1989a). The basis of the model is that multiple events may be needed to yield tumor induction (Crump, et al., 1977). The linearized model reflects the biological variability in tumor frequencies observed in animal or human studies. The dose/response relationship predicted by this model at low doses is usually linear. It should be noted that the slope factors calculated for chemical carcinogens using the multistage model represent the 95th percentile UCL on the probability of a carcinogenic response. Consequently, risk estimates based on these slope factors are conservative estimates representing upper bound estimates of risk where there is only a 5 percent probability that the actual risk is greater than the estimated risk.

5.2 Toxicity of Benzene

Benzene is highly toxic and exposure to acute levels can irritate mucous membranes, cause restlessness, convulsions, excitement, depression and even death from respiratory failure. Chronic levels of benzene can cause bone marrow depression or leukemia.

The lighter fractions of gasoline (BTEX constituents) are more mobile than other fractions. Benzene can therefore migrate or dissipate away from the main hydrocarbon plume; however, little migration away from the UST excavation has been noted at the subject site.

6.0 RISK CHARACTERIZATION

Risk characterization combines the toxicity and exposure assessments to allow for an estimate of the risk at a specific site. Two methods are used to characterize risk. The first method evaluates chemicals with carcinogenic effects by estimating excess lifetime cancer risk. The second method evaluates chemicals with noncarcinogenic effects (USEPA 1989a). In accordance with the approved SCM for the subject property, noncarcinogenic are not evaluated in this Risk Assessment.

6.1 Estimated Lifetime Excess Cancer Risk

Risks are estimated as probabilities for constituents which elicit a carcinogenic response. The excess lifetime cancer risk is the incremental increase in the probability of getting cancer compared with the background probability or that with no exposure to site constituents. A risk of 1×10^{-5} for example, represents the probability that one person in 100,000 persons exposed to a carcinogen over a lifetime (70 years) will develop cancer. Estimates of risk using the slope factors developed by the USEPA are generally upper bound estimates. Actual risks at a specific site would not be greater than the risks estimated in this assessment and are likely to be much lower, even zero.

Risk from chemicals with potential carcinogenic effects are estimated using the following equation:

$$R = 1\text{-exp}^{(SF \times LDCI)}$$

Where:

R = Excess lifetime cancer risk (probability)
exp = Base of natural logarithm (2.71828)
SF = Slope factor $(\text{mg/kg/day})^{-1}$ from linearized model
LDCI = Lifetime daily chemical intake (mg/kg/day)

For low intakes where the estimated cancer risk is lower than 1×10^{-2}, it can be assumed that the dose/response relationship will be linear, and the equation becomes:

$$R = SF \times LDCI$$

CSFs are used to determine the potential risk associated with exposure to individual COPCs. The CSF is multiplied by the chronic daily intake averaged over 70 years to estimate the excess lifetime cancer risk incidence.

Based on regulatory guidelines, it is appropriate to combine risk estimated across exposure pathways if the exposure to a particular pathway is not exclusive of other pathways. Excess lifetime cancer risks are summed by exposure pathway. In addition, the total excess lifetime cancer risk is estimated by summing all the risks from all exposure pathways (USEPA, 1989a).

6.2 Summary of Potential Cancer Risk

This section summarizes the cancer risk estimates for the onsite commercial worker, and onsite construction worker.

6.2.1 *Onsite Commercial Worker*

Tables 6-1 and 6-3 present the excess cancer risks estimated for the onsite commercial worker from groundwater and subsurface soil, respectively, in the building at the subject site. The total excess cancer risk for the onsite commercial worker is 3.9E-06 (Table 6-5). This risk level is below the excess cancer risk of 1E-05 as accepted in ACC's parameter letter dated August 15, 1996.

6.2.2 *Onsite Construction Worker*

Tables 6-2 and 6-4 present the excess cancer risks estimated for the hypothetical onsite construction worker from groundwater and soil, respectively, at the subject site. The total excess cancer risk for the onsite construction worker is 1.4E-08 (Table 6-6). This risk level is below the excess cancer risk of 1E-05 as accepted in ACC's parameter letter dated August 15, 1996. This risk level is also below the USEPA and California EPA acceptable excess cancer risk range of 1E-06 to 1E-04.

7.0 UNCERTAINTIES

Quantitative risk estimates derived in this assessment are conditional estimates that include assumptions about land use, exposures and toxicity. None of the risk estimates can be separated from these assumptions or the uncertainties inherent in the numerical values of the parameters used to calculate them. The calculated cancer risks are contingent on the assumptions and parameter assignments made in deriving them and should not be interpreted as "true" risks. Uncertainties associated with each step in the Risk Assessment process and their potential effect on the numerical risk estimates are discussed below.

7.1 Uncertainties Associated with Data Evaluation

Uncertainties are associated with the collection, analysis and evaluation of environmental data. Environmental sampling may not have accurately characterized chemical concentrations. Sampling at discrete locations and at discrete times may not be fully representative of potential exposures. Sample locations were selected because the area was likely to be impacted. This would result in overestimates of risk from using these data as representative of the entire site. For environmental media with time varying chemical concentrations (i.e., organic concentrations in soil), long-term exposure conditions may not be characterized accurately by a single point-in-time measurement. Estimated EPCs are subject to temporal variability and uncertainty. Risk calculated from these data could be overestimated or underestimated.

The procedures used to analyze chemicals in environmental media may have introduced errors. A series of samples (e.g., laboratory blanks, system blanks) are designed to detect errors introduced in this manner. These data were not reviewed for this assessment. This assessment assumes all data are of acceptable quality. This assumption can introduce uncertainty into the resulting risk estimates.

7.2 Uncertainties Associated with Exposure Assessment

A number of uncertainties are associated with the exposure assessment, such as EPCs and the assumptions used to estimate chemical intake in the exposure assessment.

7.2.1 *Vapor Transport Model*

The vapor transport model assumes that the groundwater concentration of benzene beneath the building is uniform. The model further assumes that vapors enter a structure primarily through cracks and openings in the foundation floor. The model assumes that the indoor air exchange mechanism is the only means of dilution of chemicals in air. Chemical biodegradation is not considered in this model. Default values presented in ASTM E-1739-95 were used to determine vapor transport model inputs for building floor area and ventilation rates. This default may not be representative of actual building characteristics at the subject property.

7.2.2 *Chemical Intake*

For estimating chemical intake, there are uncertainties associated with standard exposure assumptions such as body weight, period exposed, life expectancy, population characteristics, and lifestyle. Assumptions made for these exposure parameters may not be representative of actual exposure scenarios associated with the subject property. It is assumed that the period of chemical intake is constant and representative of the exposed population. This assumption has the potential for overestimating exposure, as does the assumption that exposure occurs on a daily basis.

The data from the subject property were grouped to evaluate average sitewide exposure conditions. Assumptions made for this grouping of data may not be representative of any actual exposure situation associated with the subject property.

7.3 Uncertainties Associated with Toxicity Assessment

Use of reference doses and CSFs are subject to several types of uncertainties. Typically the studies from which these values are derived involve conditions that are not identical to the type of exposures of interest involving chemicals in the environment. Extrapolations from animal experiments are frequently required to derive a toxicity value for use in risk assessments. These extrapolations can include the following uncertainties:

- from high experimental doses to low doses for environmental exposures;
- from animals used in experimental studies to humans;
- from short-term exposure to long-term exposure;
- from relatively homogenous experimental populations to individuals who can vary substantially in their individual dose/response reactions; and
- from continuous experimental doses to intermittent human exposures (e.g., through the use of calculated lifetime average exposure).

The methods used to derive slope factors and reference doses are intended to be conservative in recognition of these types of uncertainties. For carcinogens, a slope factor at the estimated 95 percent UCL is used. Carcinogenic slope factors assume no threshold for effects. If there are in fact thresholds for carcinogenicity, the slope factor could be altered considerably.

The overall quality of the toxicology database contains numerous uncertainties including:

- lack of consistency between different experimental studies;
- small numbers of studies;
- lack of available information on multiple species and multiple routes of administration;
- lack of a demonstration of clear dose/response relationship;
- lack of plausible biological mechanism of action; and
- lack of direct evidence of effects in humans.

7.4 Uncertainties Associated with Risk Characterization

Potential risks were based on an assumed sitewide average exposure. A number of limitations are associated with the risk characterization approach for carcinogens. For estimating potential excess cancer risk, the slope factor used to convert chemical intake averaged over a lifetime to incremental risk is often a 95 percentile UCL of the probability of response. In addition, slope factors derived from animal data will be given the same weight as slope factors derived from human data. These factors may contribute to an overestimate of risk.

7.5 Summary of Risk Assessment Uncertainties

An analysis of the uncertainties associated with the Risk Assessment indicates that cancer health risk estimates are likely to overestimate actual risks posed by benzene at the subject property. Although many factors can contribute to the potential for overestimating or underestimating risk, a mixture of conservative and upper bound input values were selected to estimate potential exposures. Compounding conservative and upper bound input values in the risk calculations result in reasonable, maximum, health-protective risk estimates. Actual risks are likely to be less.

8.0 SUMMARY AND CONCLUSIONS

The Tier 1 structure is the most conservative approach to estimating risk to human health and environment. Only the cleanup levels for inhalation of indoor air exceed the target RBSL; however, the estimated excess cancer risk (3.9E-06) to the onsite commercial worker is less than target risk levels (1E-05). All other cleanup level estimates at 2425 Encinal Avenue are well below allowable RBSLs for soil and groundwater. ACC believes that the risk to human health and environment is minimal to nonexistent because of the following:

- No concentrations of constituents of concern have been detected in soil samples since 1992 indicating that the source was removed with tank removal and therefore defining the area of impact. No concentrations of constituents in soil have been detected migrating off site in any direction.

- Due to the relatively flat gradient on site, the potential for plume migration is limited. Impacted groundwater will likely degrade before any substantial downgradient migration occurs. To date no groundwater concentrations have migrated offsite to the north, east or west. But significantly to south.

- The findings from recent groundwater monitoring and analysis really? indicate that natural biodegradation is occurring within the impacted groundwater plume; however, because of the relatively slow rate of anaerobic biodegradation, petroleum hydrocarbon concentrations in the groundwater will continue to illustrate fluctuations as a result of fluctuating water levels, but the overall concentrations will decrease with time. This slow decrease has been illustrated in the groundwater sampling and analysis performed at the site since 1993. ← really?

- After evaluation, the only complete exposure pathways for benzene were from soil and groundwater to enclosed space (indoor) air and ambient (outdoor) air.

- The conservatively calculated excess cancer risk to onsite commercial and construction workers is significantly less than target risk levels.

9.0 REFERENCES

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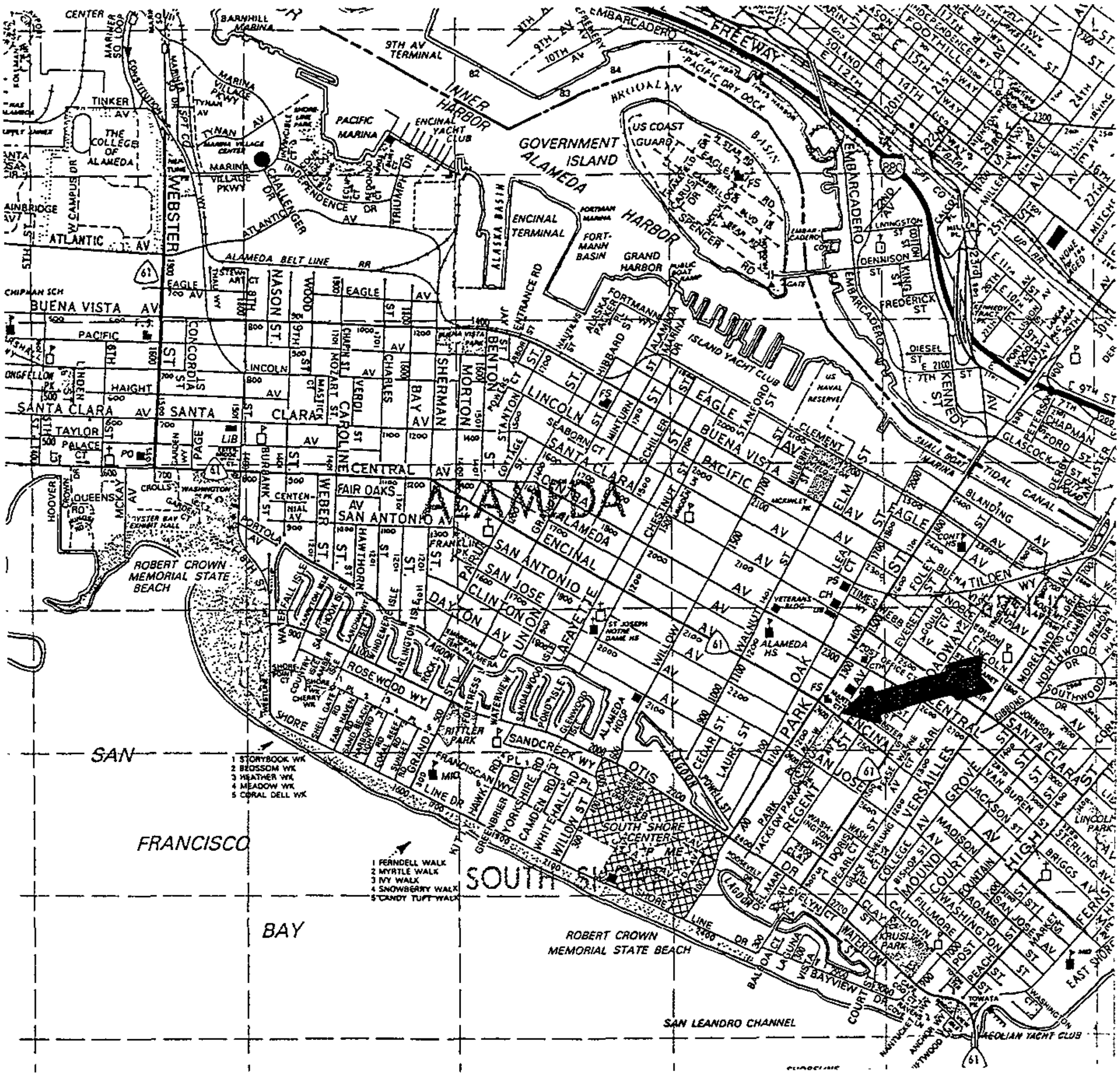


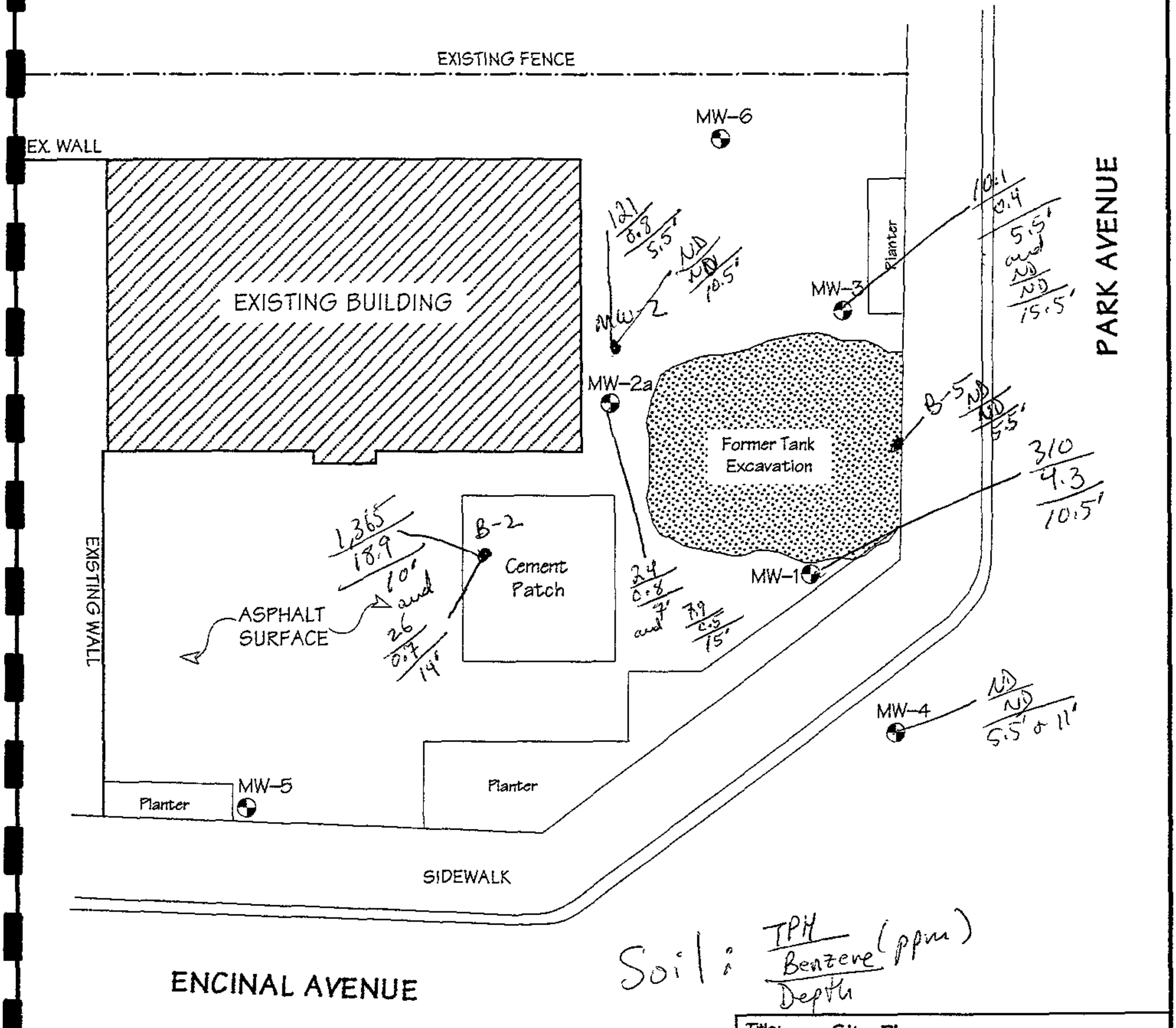
SOURCE: THOMAS BROTHERS GUIDE, 1990 *ed.*

Title: **Location Map**
2425 Encinal Avenue
Alameda, California

Figure Number: 1.0
Scale: 1" = 1/4 mi
Drawn By: JYC
Date: 3/19/96
Project Number: 6039-5

ACC Environmental Consultants
7977 Capwell Drive, Suite 100
Oakland, California 94621
(510) 638-8400 Fax: (510) 638-8404

N
W E
S



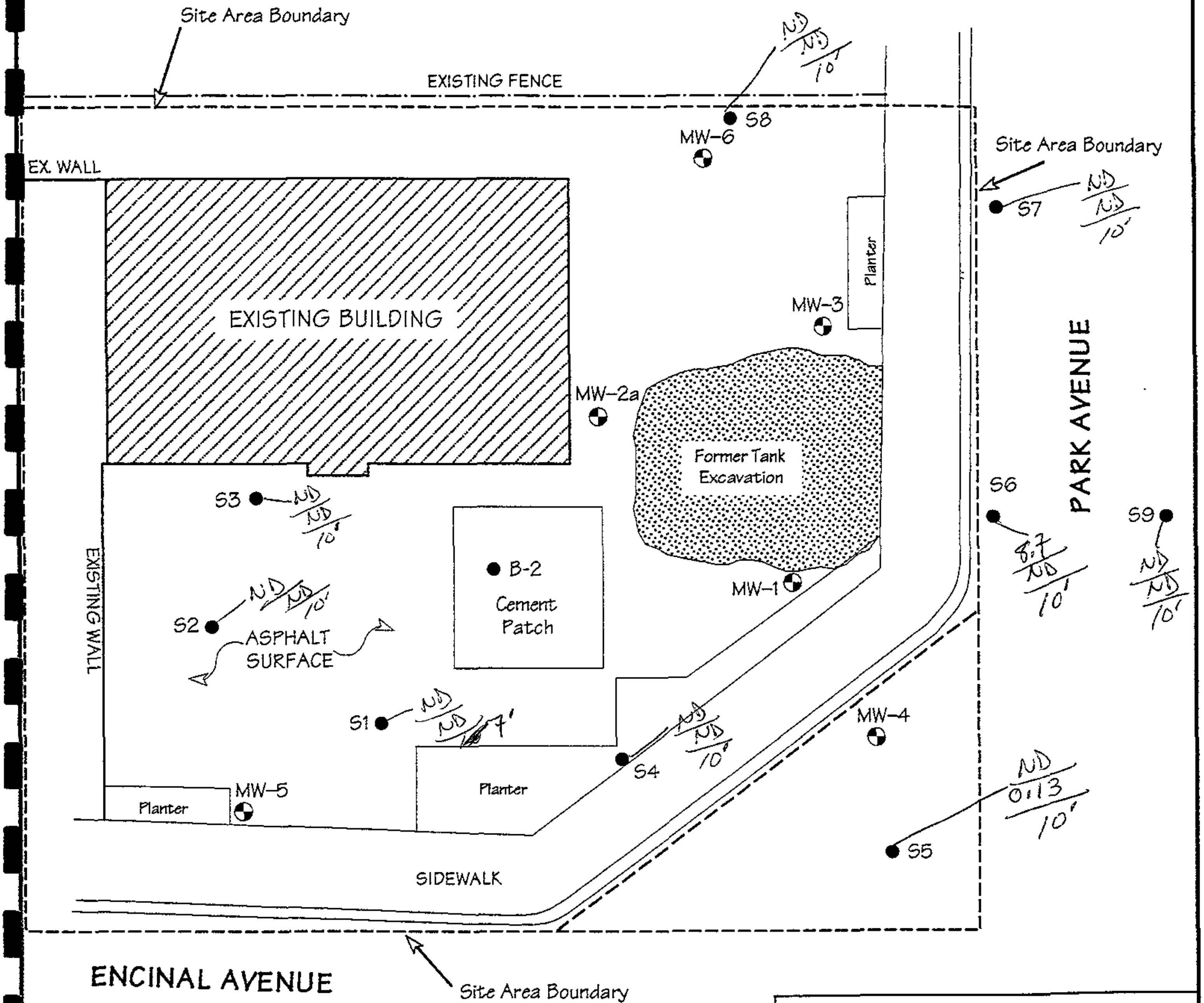
Legend

MW-5 ◐ - *Groundwater Monitoring Well Location*

Title: Site Plan
2425 Encinal Ave
Alameda, California

Figure Number: 2	Scale: 1" = 20"
Drawn By: JVC	Date: 11/18/96
Project Number: 6039-2.5	N E S W

ACC Environmental Consultants
7977 Capwell Drive, Suite 100
Oakland, CA 94621
(510) 638-8400 Fax: (510) 638-8404



Soil: $\frac{\text{TPHg (ppm)}}{\frac{\text{Benzene}}{\text{Depth}}}$

Title: **Boring Locations**
2425 Encinal Ave
Alameda, California

Figure Number: 3
Scale: 1" = 20'
Drawn By: JVC/DRD
Date: 12/31/96
Project Number: 6039-2.5

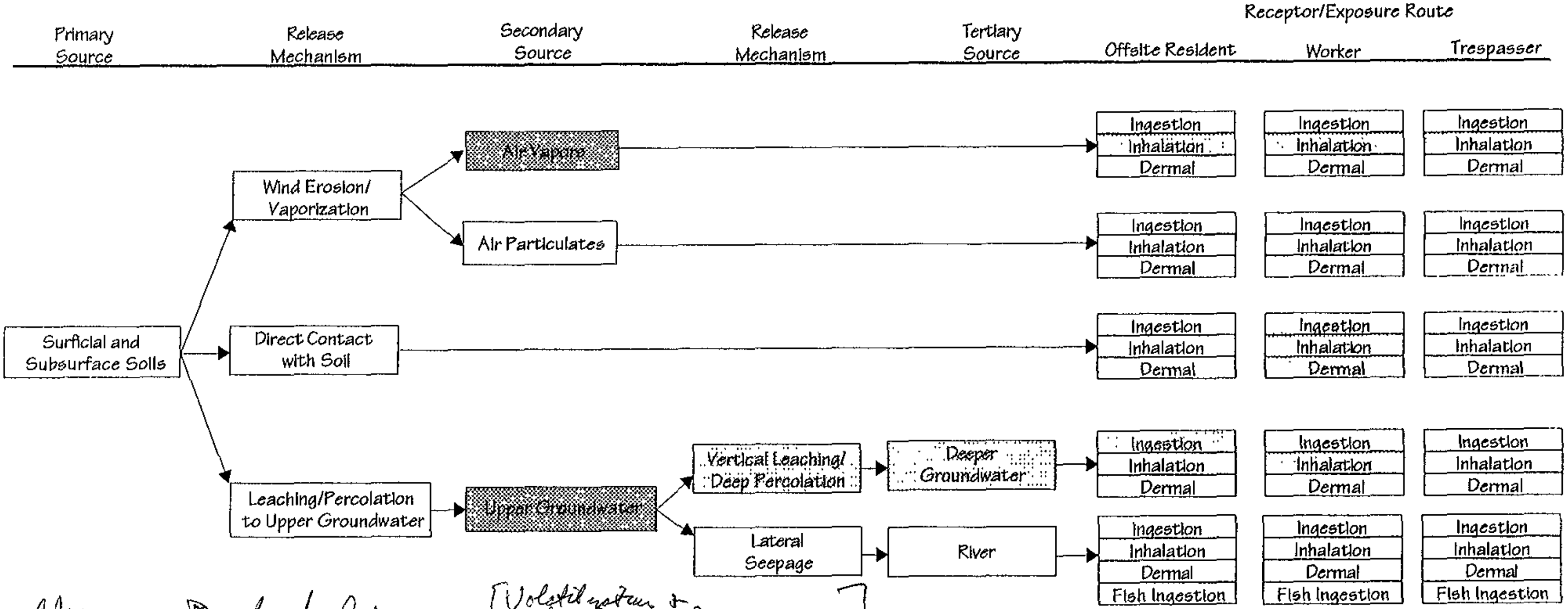
ACC Environmental Consultants
7977 Capwell Drive, Suite 100
Oakland, CA 94621
(510) 638-8400 Fax: (510) 638-8404

N E S W

Legend

- MW-5 ⊕ - Groundwater Monitoring Well
- S1 ● - Soil Boring Location

SITE CONCEPTUAL MODEL FOR CURRENT CONDITIONS



Also, Dissolved G.W. Plume → [Volatilization & Atmospheric Dispersion] [Volatilization & Enclosed-Space Accumulation] Inhalation ⇒ residence & commercial ~~(maybe construction workers)~~

[Leaching + g.w. Transport]

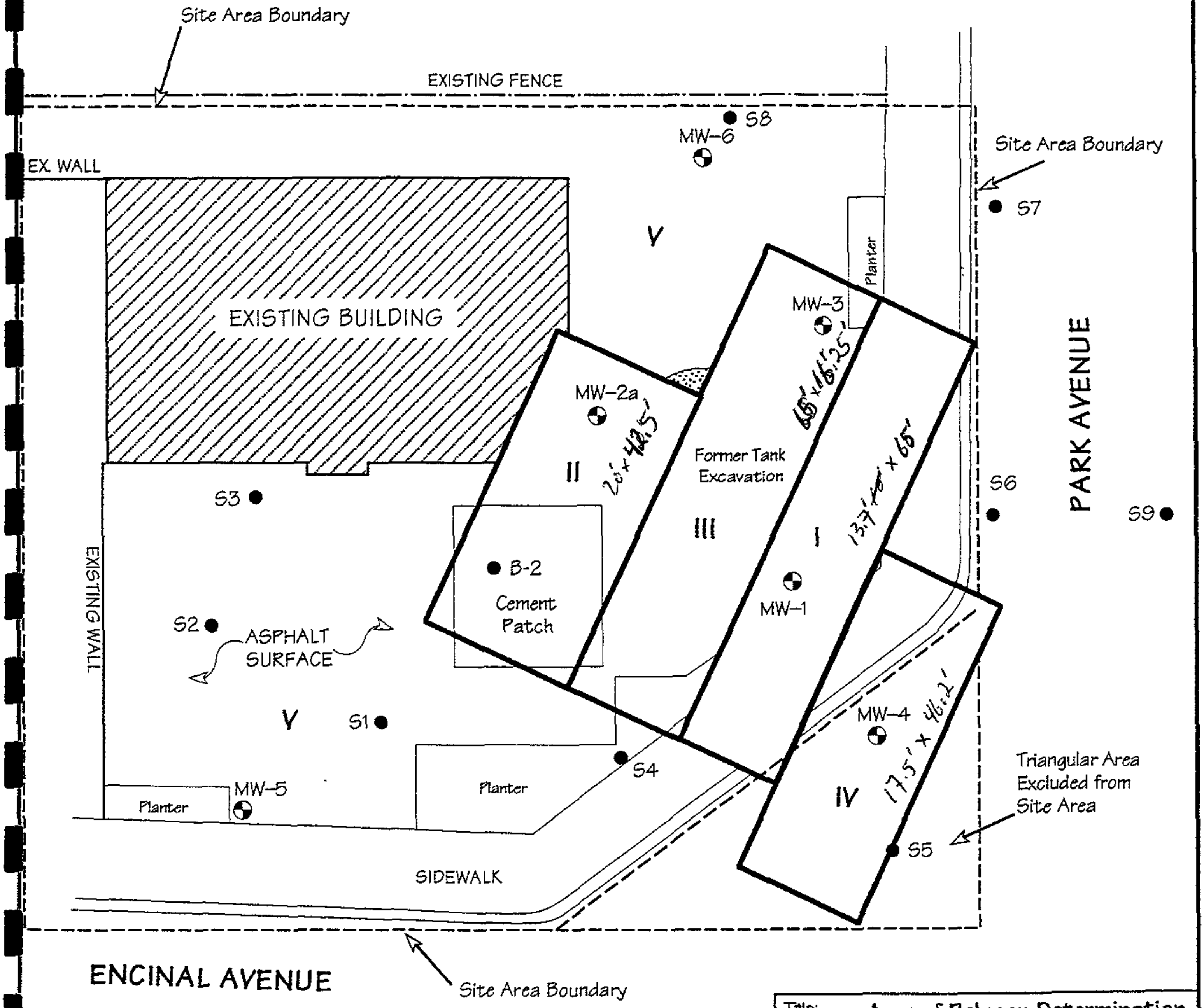
▨ Air Vapors — denotes exposure media

Inhalation (stippled) — denotes potentially complete pathways

Inhalation — denotes incomplete pathways

Title	Site Conceptual Model 2425 Encinal Avenue Alameda, California
Figure 4	Project Number: 6039-2.5
Prepared By: MCR	Date: 12/31/96

ACC Environmental Consultants
7977 Capwell Drive, Suite 100
Oakland, California 94621
(510) 638-8400 Fax: (510) 638-8404



Legend

MW-5 ⊕ - Groundwater Monitoring Well

II - Polygon Designation

☐ - Polygon Boundary

S1 ● - Soil Sampling Location

Title: Area of Polygon Determination 2425 Encinal Ave Alameda, California	
Figure Number: 5	Scale: 1" = 20'
Drawn By: JVC/DRD	Date: 12/31/96
Project Number: 6039-2.5	

ACC Environmental Consultants
7977 Capwell Drive, Suite 100
Oakland, CA 94621
(510) 638-8400 Fax: (510) 638-8404

N E S W

Correct ✓

TABLE 2-1
SUMMARY OF SOIL SAMPLE ANALYTICAL RESULTS
Alameda Cellars
2425 Encinal Avenue, Alameda, California

Sample Number-Depth (Well ID)	Date Sampled	TPHg (mg/kg)	Benzene (mg/kg)	Toluene (mg/kg)	Ethyl-benzene (mg/kg)	Total Xylenes (mg/kg)
B1-10.5' (MW-1)	12/23/92	314	4.3	3.8	6.8	11.6
B1-16' (MW-1)	12/23/92	<0.05	<0.0005	<0.0005	<0.0005	<0.0005
B2-10'	12/23/92	1,365	18.9	37.0	28.4	56.0
B2-14'	12/23/92	26	0.7	0.5	1.2	2.3
B3-5.5' (MW-2)	12/23/92	121	0.8	0.7	4.6	10.2
B3-10.5' (MW-2)	12/23/92	<0.05	<0.0005	<0.0005	<0.0005	<0.0005
B4-5.5' (MW-3)	12/23/92	10.1	0.4	0.4	0.5	0.8
B4-15.5' (MW-3)	12/23/92	<0.05	<0.0005	<0.0005	<0.0005	<0.0005
B5-5'	12/23/92	<0.05	<0.0005	<0.0005	<0.0005	<0.0005
MW2a-7'	01/06/93	24	0.8	0.6	0.6	1.1
MW2a-15'	01/06/93	7.9	0.5	0.4	0.2	0.5
S1-7'	05/12/93	<1.0	<0.005	<0.005	<0.005	<0.005
S2-10'	05/12/93	<1.0	<0.005	<0.005	<0.005	<0.005
S3-10'	05/12/93	<1.0	<0.005	<0.005	<0.005	<0.005
S4-10'	05/12/93	<1.0	<0.005	<0.005	<0.005	<0.005
S5-10'	05/12/93	<1.0	0.130	<0.005	<0.005	<0.005
S6-10'	05/12/93	8.7	~~0.130~~ ND	<0.005	0.020	0.024
S7-10'	05/12/93	<1.0	<0.005	<0.005	<0.005	<0.005
S8-10'	05/12/93	<1.0	<0.005	<0.005	<0.005	<0.005
S9-10'	05/12/93	<1.0	<0.005	<0.005	<0.005	<0.005
MW4-5.5'	12/10/93	<0.05	<0.0005	<0.0005	<0.0005	<0.0005
MW4-11'	12/10/93	<0.05	<0.0005	<0.0005	<0.0005	<0.0005
MW5-6'	12/10/93	<0.05	<0.0005	<0.0005	<0.0005	<0.0005
MW5-11'	12/10/93	<0.05	<0.0005	<0.0005	<0.0005	<0.0005
MW6-6'	12/14/93	<0.05	<0.0005	<0.0005	<0.0005	<0.0005
MW6-10.5'	12/14/93	<0.05	<0.0005	<0.0005	<0.0005	<0.0005

All results in mg/kg = parts per million (ppm)
<Not detected above laboratory reporting limit

TABLE 2-2
SUMMARY OF GROUNDWATER SAMPLE ANALYTICAL RESULTS

Alameda Cellars
2425 Encinal Avenue, Alameda, California

Well ID	Date Sampled	TPHg (µg/L)	Benzene (µg/L)	Toluene (µg/L)	Ethyl-benzene (µg/L)	Total Xylenes (µg/L)
MW-1	01/09/93	5,360	1,560.0	1,026.6	641.0	2,706.2
	04/12/93	12,000	750.0	100.0	500.0	1,400.0
	07/13/93	720	119.6	32.7	70.8	262.0
	10/12/93	8,400	420.0	39.0	280.0	880.0
	12/20/93	5,200	270.0	58.0	170.0	590.0
	03/18/94	18,000	570.0	180.0	270.0	1,500.0
	04/08/94	NT	NT	NT	NT	NT
	06/22/94	4,800	160.0	56.0	130.0	310.0
	12/07/94	9,100	530.0	200.0	350.0	1,300.0
	03/16/95	230	15.0	4.5	9.4	38.0
	06/23/95	2,700	170.0	19.0	40.0	180.0
	09/14/95	1,700	160.0	12.0	69.0	100.0
	12/18/95	2,900	190.0	57.0	130.0	380.0
	03/19/96	14,000	910	280	400	2,100
	06/27/96	5,300	320	81	280	710
	10/14/96	4,000	58	4.2	40	25
MW-2a	01/09/93	5,680	801.6	598.6	840.2	2,196.1
	04/12/93	12,000	460.0	110.0	240.0	1,600.0
	07/13/93	550	145.2	47.5	126.8	127.4
	10/12/93	2,000	280.0	17.0	100.0	120.0
	12/20/93	3,300	450.0	40.0	200.0	350.0
	03/18/94	7,900	370.0	53.0	190.0	530.0
	04/08/94	NT	NT	NT	NT	NT
	06/22/94	3,800	420.0	37.0	140.0	290.0
	12/07/94	6,800	640.0	100.0	370.0	950.0
	03/16/95	6,500	590.0	96.0	360.0	1,000.0
	06/23/95	4,300	170.0	58.0	33.0	810.0
	09/14/95	1,700	270.0	17.0	76.0	160.0
	12/18/95	3,900	410.0	52.0	290.0	610.0
	03/19/96	9,000	470	70	540	1,400
	06/27/96	9,900	350	33	230	580

← where is the 10/14/96 data

10/14/96 Not sampled because well could not be opened

Well ID	Date Sampled	TPHg (μg/L)	Benzene (μg/L)	Toluene (μg/L)	Ethyl-benzene (μg/L)	Total Xylenes (μg/L)
MW-3	01/09/93	<50	<0.5	<0.5	<0.5	<0.5
	04/12/93	1,500	95.0	30.0	46.0	85.0
	07/13/93	540	18.3	106.2	75.7	128.0
	10/12/93	3,500	290.0	230.0	210.0	460.0
	12/20/93	690	31.0	10.0	31.0	25.0
	03/18/94	450	9.6	11.0	5.5	23.0
	04/08/94	NT	NT	NT	NT	NT
	06/22/94	2,500	150.0	130.0	81.0	280.0
	12/07/94	420	16.0	8.3	26.0	37.0
	03/16/95	490	19.0	2.7	24.0	46.0
	06/23/95	860	41.0	5.4	32.0	110.0
	09/14/95	720	43.0	3.7	50.0	86.0
	12/18/95	860	27.0	10.0	38.0	53.0
	03/19/96	570	28	2.2	21	30
	06/27/96	910	54	4.9	53	79
	10/14/96	610	48	3.6	31	37
MW-4	12/20/93	580	2.3	<0.5	1.4	1.1
	03/18/94	2,100	11.0	1.5	2.3	6.0
	04/08/04	NT	NT	NT	NT	NT
	06/22/94	1,600	39.0	7.5	13.0	16.0
	12/07/94	2,100	82.0	9.6	4.7	14.0
	03/16/95	3,400	140.0	12.0	45.0	29.0
	06/23/95	1,800	140.0	13.0	13.0	28.0
	09/14/95	3,900	250.0	6.1	3.8	11.0
	12/18/95	2,400	94.0	14.0	11.0	29.0
	03/19/96	1,300	68.0	8.2	25.0	21.0
	06/27/96	2,100	96.0	11.0	18.0	20.0
	10/14/96	2,800	130	8.4	3.4	5,6

Well ID	Date Sampled	TPHg (µg/L)	Benzene (µg/L)	Toluene (µg/L)	Ethyl-benzene (µg/L)	Total Xylenes (µg/L)
MW-5	12/20/93	<50	<0.5	<0.5	<0.5	<0.5
	03/18/94	<50	<0.5	<0.5	<0.5	<0.5
	04/08/94	NT	NT	NT	NT	NT
	06/22/94	<50	<0.5	<0.5	<0.5	<0.5
	12/07/94	<50	<0.5	<0.5	<0.5	<0.5
	03/16/95	<50	<0.5	<0.5	<0.5	<0.5
	06/12/95	<50	<0.5	<0.5	<0.5	<0.5
	09/14/95	<50	<0.5	<0.5	<0.5	<0.5
	12/18/95	<50	<0.5	<0.5	<0.5	<0.5
	03/19/96	<50	<0.5	<0.5	<0.5	<0.5
	06/27/96	<50	<0.5	<0.5	<0.5	<0.5
MW-6	12/20/93	<50	<0.5	<0.5	<0.5	<0.5
	03/13/94	NT	NT	NT	NT	NT
	04/08/94	<50	<0.5	<0.5	<0.5	<0.5
	06/22/94	<50	<0.5	<0.5	<0.5	<0.5
	12/13/94	<50	<0.5	<0.5	<0.5	<0.5
	03/16/95	<50	<0.5	<0.5	<0.5	<0.5
	06/23/95	<50	<0.5	<0.5	<0.5	<0.5
	09/14/95	<50	<0.5	<0.5	<0.5	<0.5
	03/19/96	<50	<0.5	<0.5	<0.5	<0.5
	06/27/96	<50	<0.5	<0.5	<0.5	<0.5

Notes: µg/L = micrograms per liter (approximately equivalent to ppb)
NT = Not tested

TABLE 3-1
THIESSEN POLYGON METHOD FOR SOIL
Alameda Cellars
2425 Encinal Avenue, Alameda, California

1 ft² = 0.093 m²

Polygonal Element	Location of Corresponding Concentration *Boring/Well No..	Mean Soil Concentration C (mg/kg)	Area of the Element A (m^2)	A * C (m^2 - mg/kg)	Area Weighted Average Concentration (mg/kg)
I	MW-1, S7	~~2.35~~ 4.3	111.2 83.1	261.3	
II	MW-2a, B-2	9.85 ✓	81.9 79	806.7	
III	MW-3, S4	0.2 ✓	100.7 98	20.1	
IV	MW-4, S5, S6	0.04 .07	71.1 75	2.8	
V	MW-5, MW-6, S1, S2, S3, S8	0	708.4	0	
TOTALS			1,073.3	1,090.9	
Area-Weighted Average Concentration = (Σ A * C)/A_{Total}					1.02

* Benzene concentrations from boring S9 were evaluated to be too far from the subject property and were not used in the Polygon calculation for the site.

Should these samples be included for areas?

TABLE 3-2
THIESSEN POLYGON METHOD FOR GROUNDWATER
Alameda Cellars
2425 Encinal Avenue, Alameda, California

Polygonal Element	Location of Corresponding Concentration Well No..	Mean Benzene Concentration in Water - C (µg/L)	Area of the Element A (m^2)	A * C (m^2 - µg/L)	Area-Weighted Average Concentration µg/L
I	MW-1	395 ✓	111.2 83	43,924	
II	MW-2a	375 ✓	81.9 79	30,713	
III	MW-3	38 ✓	100.7 98	3,827	
IV	MW-4	127 ✓	71.1 75	9,030	
V	MW-5 and MW-6	0	708.4	0	
TOTALS			1,073.3	87,494	
Area-Weighted Average Concentration = (Σ A * C)/A_{Total}					81.5

mean benzene conc. does not include the 10/96 sample results.

Table 3-3
Benzene Concentrations in Soil Versus Tier 1 RBSLs

Route of Exposure	Subsurface Soil (mg/kg)					
	Maximum Detected Concentration	Area Weighted Average Concentration	ASTM RBCA Tier 1 RBSL	USEPA Soil Screening Levels (SSLs)	Average Concentration Exceeds RBSL?	Average Concentration Exceeds SSL?[1]
Indoor Inhalation Of Vapor	18.9 mg/kg 1.89E+01	1.02 mg/kg 1.02E+00	1.09E-01 ?	N/A	YES	N/A
Outdoor Inhalation Of Vapor	18.9 mg/kg 1.89E+01	1.02 mg/kg 1.02E+00	4.57E+00 ?	2.5E+01	no	no
Ingestion Of Soil	18.9 mg/kg 1.89E+01	1.02 mg/kg 1.02E+00	5.78E-01 ?	2.2E+02	YES	no

[1] USEPA. March 1994. *Technical Background Document for Draft Soil Screening Level Guidance.*

wrong values

check

Table 3-4
Benzene Concentrations in Groundwater Versus Tier 1 RBSLs

Route of Exposure	Groundwater (mg/kg)			
	Maximum Detected Concentration	Area Weighted Average Concentration	ASTM RBCA Tier 1 RBSL	Average Concentration Exceeds RBSL?
Indoor Inhalation Of Vapor	470 µg/L ✓ 4.7E+00 mg/L	81.5 µg/L 8.15E-02	7.39E-01	no
Outdoor Inhalation Of Vapor	470 µg/L 4.7E+00 mg/L	81.5 µg/L 8.15E-02	1.84E+2	no
Ingestion Of Groundwater	470 µg/L 4.7E+00 mg/L	81.5 µg/L 8.15E-02	9.87E-02	no

wrong values

Table 4-1
Effective Diffusion Coefficient in Soil Based on Vapor-Phase Concentration
Alameda Cellars
2425 Encinal Avenue, Alameda, California

$$D_s^{eff}\left(cm^2/s\right)=\left[D_{air}\times\left(\frac{\theta_{as}^{3.33}}{\theta_T^2}\right)\right]+\left[\frac{D_{wat}}{H}\times\left(\frac{\theta_{ws}^{3.33}}{\theta_T^2}\right)\right]$$ ✓

Parameter	Value
D_{air}	0.093 cm^2/s ✓
θ_{as}	0.26 cm^3-air/cm^3-soil ✓
θ_T	0.38 cm^3/cm^3-soil ✓
D_{wat}	1.1E-05 cm^2/s ✓
H	0.22 cm^3 H_2O/cm^3-air ✓
θ_{ws}	0.12 cm^3 H_2O/cm^3-soil ✓

All from
Tier 1 parameters

Therefore, D_s^{eff} = 7.26E-03 cm^2/s

Table 4-2
Effective Diffusion Coefficient Through Foundation
Alameda Cellars
2425 Encinal Avenue, Alameda, California

$$D_{crack}^{eff}\left(cm^2/s\right)=\left[D_{air}\times\left(\frac{\theta_{acrack}^{3.33}}{\theta_T^2}\right)\right]+\left[\frac{D_{wat}}{H}\times\left(\frac{\theta_{wcrack}^{3.33}}{\theta_T^2}\right)\right]$$ ✓

Parameter	Value
D_{air}	0.093 cm^2/s ✓
θ_{acrack}	0.26 cm^3-air/cm^3-soil ✓
θ_T	0.38 cm^3/cm^3-soil ✓
D_{wat}	1.1E-05 cm^2/s ✓
H	0.22 cm^3 H_2O/cm^3-air ✓
θ_{wcrack}	0.12 cm^3 H_2O/cm^3-soil ✓

Therefore, D_{cracks}^{eff} = 7.26E-03 cm^2/s

Table 4-3
Effective Diffusion Coefficient Through Capillary Fringe
Alameda Cellars
2425 Encinal Avenue, Alameda, California

$$D^{eff}_{cap}\left(cm^2/s\right)=\left[D_{air}\times\left(\frac{\theta^{3.33}_{acap}}{\theta^2_T}\right)\right]+\left[\frac{D_{wat}}{H}\times\left(\frac{\theta^{3.33}_{wcap}}{\theta^2_T}\right)\right]$$ ✓

Parameter	Value
D_{air}	0.093 cm^2/s ✓
θ_{acap}	0.38 cm^3-air/cm^3-soil ✓
θ_T	0.38 cm^3/cm^3-soil ✓
D_{wat}	1.1E-05 cm^2/s ✓
H	0.22 cm^3 H_2O/cm^3-air ✓
θ_{wcap}	0.342 cm^3 H_2O/cm^3-soil ✓

Therefore, D^{eff}_{cap} = 2.17E-05 cm^2/s 0,0267?

Table 4-4
Effective Diffusion Coefficient between Groundwater and Subsurface Soil
Alameda Cellars
2425 Encinal Avenue, Alameda, California

$$D^{eff}_{ws}\left(cm^2/s\right)=\left(h_{cap}+h_v\right)\times\left[\left(\frac{h_{cap}}{D^{eff}_{cap}}\right)+\left(\frac{h_v}{D^{eff}_s}\right)\right]^{-1}$$ ✓

Parameter	Value
h_{cap}	5 cm ✓
h_v	100 cm ✓
D^{eff}_{cap}	2.7E-05 cm^2/s ?
D^{eff}_s	7.26-03 cm^2/s

Therefore, D^{eff}_{ws} = 4.3E-04 cm^2/s

Table 4-5
Volatilization Factor: Groundwater to Enclosed Space Air

Alameda Cellars
2425 Encinal Avenue, Alameda, California

$$VF_{wesp}\left[\frac{(mg/m^3-air)}{mg/L-H_2O}\right]=\frac{H\times\left[\frac{D_{ws}^{eff}/L_{GW}}{ER\times L_B}\right]}{1+\left[\frac{D_{ws}^{eff}/L_{GW}}{ER\times L_B}\right]+\left[\frac{D_{ws}^{eff}/L_{GW}}{\left(D_{cracks}^{eff}/L_{crack}\right)n}\right]}\times 10^3\frac{L}{m^3}$$

Parameter	Value
H	0.22 cm^3 H_2O/cm^3-air
D_{ws}^{eff}	4.3E-04 cm^2/s
L_{GW}	105 cm
ER	2.3E-04 s^{-1}
L_B	300 cm
D_{cracks}^{eff}	7.26E-03 cm^2/s
L_{crack}	1.5E+01 cm
n	1.0E-02 cm^2-cracks/cm^2 -tota

Therefore, VF_{wesp} = 7.2E-02 (mg/m^3-air)/(mg/L-H_2O)]

Table 4-6
Volatilization Factor: Groundwater to Ambient Air

Alameda Cellars
2425 Encinal Avenue, Alameda, California

$$VF_{wamb}\left[\frac{(mg/m^3-air)}{mg/L-H_2O}\right]=\frac{H}{1+\left[\frac{U_{air}\times\delta_{air}\times L_{GW}}{W\times D_{ws}^{eff}}\right]}\times 10^3\frac{L}{m^3}$$

Parameter	Value
H	0.22 cm^3 H_2O/cm^3-air
U_{air}	225 cm
δ_{air}	200 cm
L_{GW}	105 cm
W	1,500 cm
D_{ws}^{eff}	4.3E-04 cm^2/s

Therefore, VF_{wamb} = 3.0E-04 (mg/m^3-air)/(mg/L-H_2O)

Table 4-7
Volatilization Factor: Soil to Enclosed Space Air

Alameda Cellars
2425 Encinal Avenue, Alameda, California

$$VF_{sesp}\left[\frac{mg/m^3-air}{mg/kg-soil}\right]=\frac{\dfrac{H_{\rho_s}}{\left[\theta_{ws}+k_s\rho_s+H\theta_{as}\right]}\left[\dfrac{D_s^{eff}/L_s}{ERL_B}\right]}{1+\left[\dfrac{D_s^{eff}/L_s}{ERL_B}\right]+\left[\dfrac{D_s^{eff}/L_s}{\left(D_{crack}^{eff}/L_{crack}\right)\eta}\right]}\times 10^3\,\frac{cm^3-kg}{m^3-g}$$

Parameter	Value
H	0.22 cm^3 H_2O/cm^3-air
ρ_s	1.7 g/cm^3
θ_{ws}	0.12g/cm^3
k_s	cm^3-H_20/g -soil
θ_{as}	0.26 cm^3-air/cm^3
D_s^{eff}	7.26-03 cm^2/s
ER	2.3E-04 s^{-1}
L_s	100 cm
L_B	300 cm
D_{cracks}^{eff}	7.26E-03 cm^2/s
L_{crack}	1.5E+01 cm
n	1.0E-02 cm^2-cracks/cm^2 -total area

Therefore, VF_{sesp} = 3.3E-04 (mg/m^3-air)/(mg/kg-soil)

Table 4-8
Volatilization Factor: Soil to Ambient Air
Alameda Cellars
2425 Encinal Avenue, Alameda, California

$$VF_{samb}\left[\frac{(mg/m^3-air)}{mg/kg-soil}\right]=\frac{H\rho_s}{[\theta_{ws}+k_s\rho_s+H\theta_{as}]\left(1+\frac{U_{air}\delta_{air}L_s}{D_s^{eff}W}\right)}\times 10^3\,\frac{cm^3-kg}{m^3-g}$$

Parameter	Value
H	0.22 cm^3 H_2O/cm^3-air
θ_{ws}	0.12 cm^3-air/cm^3-soil
k_s	0.38 cm^3 H_2O/g-soil
θ_{as}	0.26 cm^3-air/cm^3-soil
U_{air}	225 cm
δ_{air}	200 cm
L_s	100 cm
W	1,500 cm
D_s^{eff}	7.26E-03 cm^2/s

Therefore, VF_{samb} = 1.1E-02 (mg/m^3-air)/(mg/kg-soil)

Table 4-9
Exposure Point Concentrations for Groundwater COPCs
Alameda Cellars
2425 Encinal Avenue, Alameda, California

Chemical	Direct Groundwater Contact (mg/L)	Vf_{wesp} (mg/m^3-air)/(mg/L-H_2O)	Enclosed Air Concentration (mg/m^3) [1]	Vf_{wamb} (mg/m^3-air)/(mg/L-H_2O)	Ambient Air Concentration (mg/m^3) [2]
Benzene	8.15E-02	7.02E-02	5.72E-03	3.0E-04	2.4E-05

[1] Enclosed space air concentration calculated by multiplying groundwater concentration by appropriate volatilization factor (VF_{wesp}).

[2] Ambient air concentration calculated by multiplying groundwater concentration by appropriate volatilization factor (VF_{wamb}).

Table 4-10
Exposure Point Concentrations for Soil COPCs
Alameda Cellars
2425 Encinal Avenue, Alameda, California

Chemical	Direct Soil Contact (mg/kg)	VF_{sesp} (mg/m^3-air)/(mg/kg-soil)	Enclosed Air Concentration (mg/m^3) [1]	VF_{samb} (mg/m^3-air)/(mg/kg-soil)	Ambient Air Concentration (mg/m^3) [2]
Benzene	1.02E00	3.3E-04	3.4E-04	1.1E-02	1.1E-02

[1] Enclosed space air concentration calculated by multiplying groundwater concentration by appropriate volatilization factor (VF_{sesp}).

[2] Ambient air concentration calculated by multiplying groundwater concentration by appropriate volatilization factor (VF_{samb}).

Table 4-11
Chemical Intake Exposure Assumptions Onsite Commercial Worker - Groundwater Inhalation of Indoor Air
Alameda Cellars
2425 Encinal Avenue, Alameda, California

$$Intake(mg/kg-day) = \frac{C_A \times IR \times ET \times EF \times ED}{BW \times AT}$$

Parameter			Onsite Commercial Worker Value
CA	=	Chemical concentration in air (mg/m^3)	5.7E-03 (see Table 4-9)
IR	=	Inhalation rate (m^3/hour)	0.83
ET	=	Exposure time (hour/day)	8
EF	=	Exposure frequency (days/year)	250
ED	=	Exposure duration (years)	25
BW	=	Body weight (kg)	70
AT	=	Averaging time (days)	25,550

Therefore, Intake for the onsite commercial worker = 1.3E-04 mg/kg-day

Table 4-12
Chemical Intake Exposure Assumptions Onsite Construction Worker - Groundwater Inhalation of Outdoor Air
Alameda Cellars
2425 Encinal Avenue, Alameda, California

$$Intake(mg/kg-day) = \frac{C_A \times IR \times ET \times EF \times ED}{BW \times AT}$$

Parameter			Onsite Construction Worker Value
CA	=	Chemical concentration in air (mg/m^3)	2.4E-05 (see Table 4-9)
IR	=	Inhalation rate (m^3/hour)	0.83
ET	=	Exposure time (hour/day)	8
EF	=	Exposure frequency (days/year)	12
ED	=	Exposure duration (years)	1
BW	=	Body weight (kg)	70
AT	=	Averaging time (days)	25,550

Therefore, Intake for the onsite construction worker = 1.1E-09 mg/kg-day

Table 5-1
Toxicity Values for Benzene
Alameda Cellars
2425 Encinal Avenue, Alameda, California

Chemical	Carcinogenic Weight of Evidence	Inhalation Slope Factor (SF) $(mg/kg\text{-}day)^{-1}$	
		Value	Source
Benzene	A	2.9E-02 ✓	ASTM/USEPA

Table 6-1
Excess Cancer Risk Summary for Onsite Commercial Worker - Groundwater
Alameda Cellars
2425 Encinal Avenue, Alameda, California

$$R = SF \times LDCI$$

Parameter			Onsite, Indoor Commercial Worker Value
R	=	Excess lifetime cancer risk (probability)	3.7E-06
SF	=	Slope factor $(mg/kg/day)^{-1}$ for benzene from linearized model	2.9E0-2 (see Table 5-1)
LDCI	=	Lifetime daily chemical intake (mg/kg/day)	1.3E-04 (see Table 4-2)

Therefore, the excess lifetime cancer risk for the onsite, indoor commercial worker = 3.7E-06

Table 6-2
Excess Cancer Risk Summary for Onsite Construction Worker - Groundwater
Alameda Cellars
2425 Encinal Avenue, Alameda, California

$$R = SF \times LDCI$$

Parameter			Onsite Construction Worker Value
R	=	Excess lifetime cancer risk (probability)	3.2E-11
SF	=	Slope factor $(mg/kg/day)^{-1}$ from linearized model	2.9E0-2 (see Table 5-1)
LDCI	=	Lifetime daily chemical intake (mg/kg/day)	1.1E-09 (see Table 4-2)

Therefore, the excess lifetime cancer risk for the onsite, outdoor construction worker = 3.2E-11

Table 6-3
Excess Cancer Risk Summary for Onsite Commercial Worker - Soil
Alameda Cellars
2425 Encinal Avenue, Alameda, California

R = SF x LDCI

Parameter			Onsite, Indoor Commercial Worker Value
R	=	Excess lifetime cancer risk (probability)	2.3E-07
SF	=	Slope factor $(mg/kg/day)^{-1}$ for benzene from linearized model	2.9E0-2 (see Table 5-1)
LDCI	=	Lifetime daily chemical intake (mg/kg/day)	7.9E-06 (see Table 4-2)

Therefore, the excess lifetime cancer risk for the onsite, indoor commercial worker = 2.3E-07

Table 6-4
Excess Cancer Risk Summary for Onsite Construction Worker - Soil
Alameda Cellars
2425 Encinal Avenue, Alameda, California

R = SF x LDCI

Parameter			Onsite Construction Worker Value
R	=	Excess lifetime cancer risk (probability)	1.4E-08
SF	=	Slope factor $(mg/kg/day)^{-1}$ from linearized model	2.9E0-2 (see Table 5-1)
LDCI	=	Lifetime daily chemical intake (mg/kg/day)	4.9E-07 (see Table 4-2)

Therefore, the excess lifetime cancer risk for the onsite, outdoor construction worker = 1.4E-08

Table 6-5
Total Excess Cancer Risk Summary for Onsite Commercial Worker
Alameda Cellars
2425 Encinal Avenue, Alameda, California

Worker/Pathway	Excess Lifetime Cancer Risk
Onsite Commercial Worker/groundwater	3.7E-06
Onsite Commercial Worker/soil	2.3E-07
Total	3.9E-06

Table 6-6
Total Excess Cancer Risk Summary for Onsite Construction Worker
Alameda Cellars
2425 Encinal Avenue, Alameda, California

Worker/Pathway	Excess Lifetime Cancer Risk
Onsite Construction Worker/groundwater	3.2E-11
Onsite Construction Worker/soil	1.4E-08
Total	1.4E-08

ASTM PARAMETER DEFINITIONS

ASTM Parameter Definitions

Parameter	Definition, Units	Commercial/Industrial Value
d	lower depth of surficial soil zone, cm	100 cm
D^{air}	diffusion coefficient in air for benzene, cm^2/s	0.093 cm^2/s
D^{wat}	diffusion coefficient in water for benzene, cm^2/s	1.1E-05 cm^2/s
ER	enclosed-space air exchange rate, L/s	0.00023 s^{-1}
f_{oc}	fraction of organic carbon in soil, g-C/g-soil	0.01
H	henry's law constant (cm3-H_2O/cm^3-air)	0.22 L-H_2O/L-air
h_{cap}	thickness of capillary fringe	5 cm
h_v	thickness of vadose zone	100 cm (site specific)
I	infiltration rate of water through soil, cm/years	30 cm/year
k_{oc}	carbon-water sorption coefficient, cm^3-H_2O/g-C	38 L/kg
k_s	soil-water sorption coefficient, cm^3-H_2O/g-soil	0.38
L_B	enclosed-space volume/infiltration area ratio, cm	300 cm
L_{crack}	enclosed-space foundation or wall thickness, cm	15 cm
L_{GW}	depth to groundwater = $h_{cap} + h_v$, cm	105 cm (site specific)
L_s	depth to surface soils, cm	100 cm
S	pure component solubility in water, mg/l-H_2O	1750 mg/l-H_2O
SF	slope factor for benzene, kg-day/mg	0.029 kg-day/mg
U_{air}	wind speed above ground surface in ambient mixing zone	225 cm/s
U_{gw}	groundwater Darcy velocity, cm/year	2,500 cm/year
W	width of source area parallel to wind or groundwater flow direction	1,500 cm
δ_{air}	ambient air mixing zone height, cm	200 cm
δ_{gw}	groundwater mixing zone thickness, cm	200 cm
η	areal fraction of cracks in foundation/walls, cm^2-cracks/cm^2-total area	0.01 cm^2-cracks/cm^2-total area
θ_{acap}	volumetric air content in capillary fringe soils, cm^3-air/cm^3-soil	0.038 cm^3-air/cm^3-soil
θ_{acrack}	volumetric air content in foundation/wall cracks, cm^3-air/cm^3 total volume	0.26 cm^3-air/cm^3 total volume
θ_{as}	volumetric air content in vadose zone soils, cm3-air/cm^3-soil	0.26 cm^3-air/cm^3-soil
θ_T	total soil porosity, cm^3/cm^3-soil	0.38 cm^3/cm^3-soil
θ_{wcap}	volumetric water content in capillary fringe soils, cm^3-H_2O/cm^3-soil	0.342 cm^3-H_2O/cm^3-soil
θ_{wcrack}	volumetric water content in foundation/wall cracks, cm^3-H_2O/cm^3 total volume	0.12 cm^3-H_2O/cm^3 total volume
θ_{ws}	volumetric water content in vadose zone soils, cm^3-H_2O/cm^3-soil	0.12 cm^3-H_2O/cm^3-soil
ρ_s	soil bulk density, g-soil/cm^3-soil	1.7 g-soil/cm^3-soil