



BP Amoco Oil Corporation 295 SW 41= Street Bidg 13, Suite N Renton, WA 98055 425/251-0689 425/251-0736 FAX

May 12, 2000

Alameda County Health Care Services Agency Attention Ms. Eva Chu 1131 Harbor Bay Parkway, Room 250 Alameda, CA 94502-6577

RE:

Former BP Oil Site No. 11133

2220 98<sup>th</sup> Avenue (at Bancroft) Oakland, CA

Dear Ms. Chu:

This letter transmits the *Risk-Based Corrective Action (RBCA) Evaluation for BP Oil Facility No. 11133* prepared on behalf of BP by Newfields. The report concludes that remnant hydrocarbons associated with this site do not pose a risk to current and future onsite workers or off-site residents.

Based on the findings made in the enclosed report, I would appreciate a concurrence letter from the Alameda County Health Care Services Agency, noting no objections to the proposed redevelopment of this vacant property as a full-service car wash business.

Please give me a call at (425) 251-0689 if you have any questions or comments regarding this submittal.

Sincerely,

Scott Hooton

attachment

cc:

site file

David Camille - Tosco (w/attachment)

Emerging Star Enterprises, Attention Mr. Clifford Hoskins, 655 S. Fair Oaks

Avenue, B215, Sunnyvale, CA 94086 (w/5 copies)

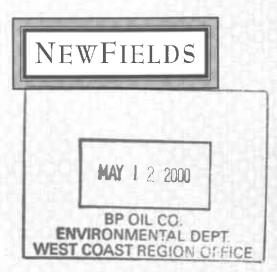
City of Oakland, Public Works Agency - Environmental Services, Attention Mr.

Mark Gomez, 250 Frank Ogawa Plaza, STE 5301, Oakland, CA 94612

(w/attachment)

PROTECTION

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# RISK-BASED CORRECTIVE ACTION (RCBA) EVALUATION FOR BP OIL FACILITY No. 11133

OAKLAND, CALIFORNIA

Prepared for

**BP OIL COMPANY** 

May 2000

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OAKLAND, CALIFORNIA

Prepared for

**BP Oil Company** 

May 12, 2000

Prepared by



NEWFIELDS, INC. 1550 HARBOR BLVD., SUITE 130 WEST SACRAMENTO, CALIFORNIA 95691

# RISK-BASED CORRECTIVE ACTION (RBCA) EVALUATION FOR BP OIL FACILITY NO. 11133

## OAKLAND, CALIFORNIA

The material and data in this report were prepared under the supervision and direction of the undersigned.

NEWFIELDS, INC.

Mark K. Jones

Senior Scientist

Mark A. Bowland Staff Scientist

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#### **ACRONYMS**

ADD Average Daily Dose

ASTM American Society for Testing and Materials

bgs below ground surface

BTEX Benzene, Toluene, Ethylbenzene, and Xylenes

CSF Cancer Slope Factor

DTSC California Department of Toxic Substances Control

EPA U.S. Environmental Protection Agency

HI Hazard Index

ILCR Incremental Lifetime Cancer Risk IRIS Integrated Risk Information System

LADD Lifetime Average Daily Dose

MADEP Massachusetts Department of Environmental Protection

NA Not Applicable

OEHHA California Office of Environmental Health Hazard Assessment

OSHA Occupational Safety and Health Administration

PAHs Polynuclear Aromatic Hydrocarbons

RBCA Risk-Based Corrective Action

RfD Reference Dose

SSTL Site-Specific Target Level TPH Total Petroleum Hydrocarbons

TPHCWG Total Petroleum Hydrocarbon Working Group

UCL Upper Confidence Limit UST Underground Storage Tank

#### **EXECUTIVE SUMMARY**

This report presents the results of a risk-based corrective action (RBCA) evaluation for the former BP Oil Facility No. 11133, which is a retail site, located at 2220 98<sup>th</sup> Avenue, Oakland, California (Figure 1). The site is currently a commercial property. Plans to build a commercial car wash on the property are underway. Because a commercial car wash is proposed to be constructed on the property and the site is not zoned for residential, it is considered unlikely that the site will become residential any time in the near future. Surrounding the site are residential areas.

The purpose of this report is to evaluate whether constituents of gasoline and diesel, namely benzene, toluene, ethylbenzene, and xylenes (BTEX), methyl-tert-butyl ether (MTBE), and total petroleum hydrocarbons (TPH) detected in soil and groundwater at the site present a potential health risk to current and future on-site workers, and off-site residents. RBCA uses risk assessment to tailor site-specific solutions. The evaluation follows the basic procedures outlined in the Oakland Risk-Based Corrective Action: Technical Background Document, the Oakland Urban Land Redevelopment Program: Guidance Document, and the ASTM Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites (E1739-95e1). The completed Oakland RBCA Eligibility Checklist for the site is presented in Table E-1.

The Oakland and ASTM RBCA processes consist of three steps or tiers. Using the Oakland RBCA process, the first two tiers are comparisons of site data to concentrations presented in Tier 1 and Tier 2 look-up tables. The Oakland RBCA Tier 1 and Tier 2 look-up values are based on conservative, generic exposure and modeling parameters, resulting in conservative risk-based screening levels. Where site conditions exceeded Oakland RBCA Tier 1 and Tier 2 levels, these conditions were further assessed under the Oakland RBCA Tier 3 analysis. The Tier 3 analysis replaces some of the conservative, generic assumptions of Tiers 1 and 2 with data that represent actual site conditions, thus more accurately reflecting existing and future risks.

Results of the Oakland RBCA Tier 3 evaluation indicate that remnant levels of petroleum hydrocarbons are below City of Oakland and U.S. EPA acceptable cancer risks and non-cancer levels. Therefore, soil and groundwater conditions at the site should not pose a risk to current and future on-site workers or off-site residents.

# Table E-1

#### Oakland RBCA Eligibility Checklist

The Oakland Tier 1 RBSLs and Tier 2 SSTLs are intended to address human health concerns at the majority of sites in Oakland where commonly-found contaminants are present. Complicated sites—especially those with continuing releases, ecological concerns or unusual subsurface conditions—will likely require a Tier 3 analysis. The following checklist is designed to assist you in determining your site's eligibility for the Oakland RBCA levels.

	CRITERIA	YES	NO
1.	Is there a continuing, <i>primary</i> source of a chemical of concern, such as a leaking container, tank or pipe? (This does <i>not</i> include residual sources.)		
2.	Is there any mobile or potentially-mobile free product? <sup>1</sup>		$\boxtimes$
3.	Are there more than five chemicals of concern at the site at a concentration greater than the lowest applicable Oakland RBCA level?		$\boxtimes$
4.	Are there any preferential vapor migration pathways—such as gravel channels or utility corridors—that are potential conduits for the migration, on-site or off-site, of a volatilized chemical of concern?		$\boxtimes$
5.	<ul> <li>Do both of the following conditions exist?</li> <li>(a) Groundwater is at depths less than 300 cm (10 feet)<sup>2</sup></li> <li>(b) Inhalation of volatilized chemicals of concern from groundwater in indoor or outdoor air is a pathway of concern but groundwater ingestion is not*</li> </ul>		$\boxtimes$
6.	Are there any existing on-site or off-site structures intended for future use where exposure to indoor air vapors from either soil or groundwater is of concern and one of the following three conditions is present? <sup>3</sup> (a) A slab-on-grade foundation that is less than 15 cm (6 inches) thick  (b) An enclosed, below-grade space (e.g., a basement) that has floors or walls		
	less than 15 cm (6 inches) thick (c) A crawl space that is not ventilated		$\boxtimes$
7.	Are there any immediate, acute health risks to humans associated with contamination at the site, including explosive levels of a chemical?		$\boxtimes$
8.	Are there any complete exposure pathways to nearby ecological receptors, such as endangered species, wildlife refuge areas, wetlands, surface water bodies or		
	other protected areas?		$\boxtimes$

If you answer "no" to all questions, your site is eligible for the Oakland RBCA levels. If you answer "yes" to any of the questions, your site is not eligible for the Oakland Tier 1 or Tier 2 RBCA levels at this time.

Oakland Urban Land Redevelopment Program

<sup>\*</sup>If groundwater ingestion is a pathway of concern, the associated Oakland RBCA levels will be more stringent than those for any groundwater-related inhalation scenario, rendering depth to groundwater irrelevant in the risk analysis. <sup>1</sup> Liquid hydrocarbon product accumulations have been documented in wells MW-1 and RW-1. Remedial activities have abated product in well MW-1. Liquid product recently observed in RW-1 was removed by bailing. Product in RW-1 appears to be an isolated occurrence associated with the former location of the UST system and not subject to rapid or easy subsurface movement.

<sup>&</sup>lt;sup>2</sup>Although depth to groundwater in some areas of the site is sometimes below 10 feet, the average depth to groundwater is greater than 10 feet.

Because building conditions for off-site structures is unknown, a conservative foundation thickness of one inch was

used in the Tier 3 analysis.

#### **RISK-BASED CORRECTIVE ACTION (RBCA) EVALUATION**

#### 1. INTRODUCTION

This report presents the results of a risk-based corrective action (RBCA) evaluation for the former BP Oil Facility No. 11133, which is a retail site at 2220 98<sup>th</sup> Avenue, Oakland, California (Figure 1). RBCA uses risk assessment to identify technically defensible and site-specific solutions, in place of generic, universally-applied cleanup standards. The RBCA process is guided by standards issued by the American Society for Testing and Materials (ASTM) in the Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites (E1739-95e1), and in Oakland, the Oakland Risk-Based Corrective Action: Technical Background Document (1999).

#### 1.1 Purpose of Report

The purpose of this report is to evaluate whether constituents of gasoline and diesel, namely benzene, toluene, ethylbenzene, and xylenes (BTEX) and total petroleum hydrocarbons (TPH) detected in soil and groundwater at the site present a potential health risk to current and future on-site workers, and off-site residents. Depth to groundwater is believed to range from 10 to 22 feet below ground surface (bgs) based on measurements from multiple wells on-site. Potential downward migration to groundwater from soil is also assessed in this evaluation.

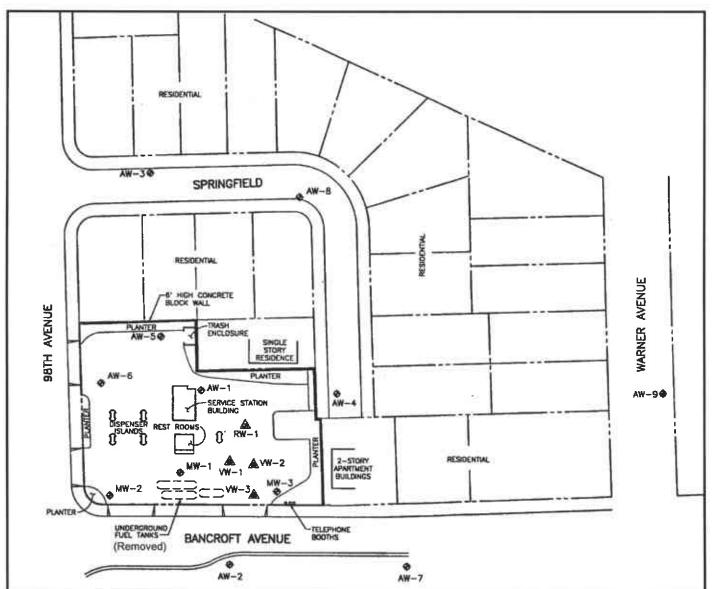
#### 1.2 Methodology

The evaluation follows the basic procedures outlined in the Oakland Risk-Based Corrective Action: Technical Background Document (1999), the Oakland Urban Land Redevelopment Program: Guidance Document (2000), the ASTM Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites (E1739-95e1; ASTM, 1999), and the U.S. Environmental Protection Agency's Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (EPA, 1989). Other guidance documents consulted include the California Department of Toxic Substances Control's Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities (DTSC, 1992).

#### 1.3 Organization

The report is composed of several sections that are outlined below. This section presents the methods used in this evaluation and background on the site. Section 2 presents the results of the Oakland RBCA Tier 1 and Tier 2 evaluations. Section 3 contains a summary of the statistical evaluation conducted for the site. Section 4 presents the focused Oakland RBCA Tier 3 evaluation conducted for the site. Specifically, this section includes a discussion of the ways that people could be exposed to chemicals

Figure 1. Site Plan



detected in soil and groundwater, the assumptions that are made about the extent to which people could be exposed, and the rates at which people could potentially intake the chemicals via the various exposure pathways. This section also presents a summary of the toxicity assessment component of the risk assessment, the risk characterization, and reviews the sources of uncertainty factored into the risk estimates. Section 5 summarizes the results, and Section 6 presents the references used to complete this evaluation.

#### 1.4 Site Background

Mobil operated the site prior to 1989, BP Oil operated the site from 1990 to 1994, and Tosco operated the site after 1994. The following site background summarizes information provided in the Gettler-Ryan *Underground Storage Tank and Product Piping Removal Report* (1999), EMCON *Baseline Assessment Report* (1994), Alton Geoscience Phase III-Supplemental Site Investigation Study (1991), and Alton Geoscience Supplemental Site Investigation Report (1990).

In 1987, three underground storage tanks (USTs) were removed from the site. Soil samples were collected from the soils beneath the tanks, and TPH were detected. In 1988, three monitoring wells were installed at the site (MW-1, MW-2, MW-3). Initial sampling from these wells indicated soil and groundwater at the site had been impacted with TPH. In 1990, additional soil borings were advanced at the site and additional monitoring wells and an extraction well were installed. Soil and groundwater samples were collected from these new locations. Soil types encountered at the site were silty alays, clayey silts, and clavey sands. Results of chemical analyses indicated that soils and groundwater on-site were impacted with BTEX and TPH as gasoline (TPH-G). Additional soil borings and conversion of these borings to wells was conducted again in 1991 by Alton. Additional TPH and BTEX compounds were detected in these soil and groundwater samples. Supplemental soil borings were collected by EMCON in 1994. One location had a detected diesel concentration of 3,900 parts per million from below a dispenser. Further UST removal activities were conducted in late 1998. Quarterly groundwater monitoring activities have occurred for many of the groundwater monitoring wells at the site since 1991.

The results of the investigations identified petroleum releases that account for the current petroleum products found in the soil. The site investigations have shown petroleum products on site to be limited to soils in the vicinity of the product lines, dispensers, and USTs.

#### 1.4.1 Geology

The site is located about 40 feet above mean sea level in Oakland California, in the Alameda Bay Plain Groundwater Basin. The underlying unit in the area is Undivided Quaternary deposits. Site investigations have revealed silty clays, clayey silts, and clayey sands beneath the site.

#### 1.4.2 Groundwater

Depth to groundwater beneath the site ranges from approximately 10 to greater than 20 feet bgs and varies among the wells installed at the site, with notable seasonal fluctuations. Hydraulic gradient is approximately 0.08 feet/feet across the site, with an overall southerly groundwater flow direction.

#### 1.5 Site Characterization Results

The data used in this evaluation were obtained from Alton Geoscience (1990a&b, 1991) Blaine Tech Services (1999), Alisto Engineering Group (1996, 1997), KEI Consulting Engineers (1990), Gettler-Ryan Inc (1999) and EMCON (1994). The soil sampling results and the results of the last four quarters of groundwater monitoring are presented in Appendix A.

This RBCA evaluation was performed for chemicals detected at the site. Statistical summaries of the soil analytical results were done for BTEX, methyl-tert-butyl ether (MTBE), and total petroleum hydrocarbons as gasoline (TPH-G) and diesel (TPH-D). The statistical analyses performed on the data are described in Section 3.

#### 2. RBCA TIER 1 AND TIER 2 EVALUATIONS

The Oakland and ASTM RBCA processes consist of three tiers. Using the Oakland RBCA process, the first two tiers are comparisons of site data to acceptable concentrations presented in Tier 1 and Tier 2 look-up tables. For the purposes of this analysis, Oakland RBCA Tier 1 and Tier 2 look-up values are based on conservative, generic exposure and modeling parameters, resulting in conservative risk-based screening levels considered appropriate for the site. For example, the vapor migration from soil into indoor air screening values used in the Oakland RBCA Tier 1 look-up table are based on a model by Johnson and Ettinger (1991). This model assumes that all chemical vapors below a building will enter a basement and become well-mixed once in the building. This model is widely used for screening purposes only due to its conservative assumptions.

The site is currently a commercial property. Plans to build a commercial car wash on the property are underway. Because a commercial car wash is being constructed on the property, it is considered unlikely that the site will become residential any time in the near future. The car wash site plan is presented on Figure 2. Surrounding the site are residential areas. The RBCA Tier 1 evaluation considered exposures to on-site commercial workers, construction workers, and off-site residents. To be conservative, indirect exposures to off-site residents were evaluated without adjusting on-site concentrations of chemicals to account for migration off-site. In other words, for off-site residents, it is assumed that the concentrations to which they may be exposed are the same as the concentrations to which they would be exposed if residential units were constructed directly on the site. This is a conservative assumption because the

Figure 2. -6-MOMICONCERTE BLOCK MALL Car Wash Site Plan TRASH ENCLOSURE SINGLE-STORY EESITE LL 1 2-STORY APARTMENT BUILDINGS FUNTER MW-3 UNDERGROUND FUEL TANKS --EDOTHS BANCROFT AVENUE

concentrations to which off-site residents might be exposed would be lower than these estimates. For construction workers, exposures from direct contact with soils and inhalation of vapors were assessed. For commercial workers and residents, inhalation of vapors was assessed. Because the site is planned for development into a car wash and will be paved, direct soil exposures were not assessed for commercial workers or off-site residents. The conceptual site model is presented on Figure 3.

Figure 3. Tier 1 and 2 RBCA Conceptual Site Model

	Primary		Potential Receptors				
Primary Source	Release Mechanism	Exposure Media	Exposure Route	Construction Workers	Commercial Workers	Residentia Receptor	
			Dermal Contact	1			
Soil		Soil	Ingestion	1			
	Volatilization	Indoor Air	Inhalation of Volatiles		✓	1	
	Volatilization	Outdoor Air	Inhalation of Volatiles	~			
round-water			Inhalation of Volatiles	<b>~</b>	~	~	

<sup>✓</sup> Potentially complete exposure pathway.

Unlike the ASTM approach, the Oakland RBCA Tier 2 evaluation is much like a Tier 1 evaluation, except that the lookup values are specific to one of three soil types specific to the Oakland area: Merritt sands, sandy silts, and clayey silts. For each of these soil types, RBCA Tier 2 lookup values were calculated (by the City of Oakland Environmental Services Division) by modifying the Tier 1 soil property input parameters to reflect the properties of each of the soil types used in Tier 2 (i.e., the soil properties for each of the three soil types are used to calculate new lookup values unique to each soil type).

#### Soil RBCA Tier 1 Evaluation

Based on the results of the Tier 1 soil evaluation, none of the constituent concentrations in soil at the site exceed the Oakland default Tier 1 look-up values except benzene for residents exposed to indoor air and TPH-G and TPH-D concentrations for all receptors because no Tier 1 values are available for TPH measurements. Because the maximum detected benzene and TPH concentrations exceeded the Tier 1 concentrations, a RBCA Tier 2 evaluation of each in soil was performed. The results of the RBCA Tier 1 evaluation for soil are presented in Table 1.

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#### **Groundwater RBCA Tier 1 Evaluation**

Based on the results of the Tier 1 groundwater evaluation, none of the constituent concentrations in groundwater at the site exceed the Oakland default Tier 1 look-up values except benzene for commercial workers and residents exposed to indoor air, and TPH-G concentrations for all receptors because no Tier 1 values are available for TPH measurements. Because the maximum detected benzene and TPH concentrations exceeded the Tier 1 concentrations, a RBCA Tier 2 evaluation of each in groundwater was performed. The results of the RBCA Tier 1 evaluation for groundwater are presented in Table 2.

#### **Soil RBCA Tier 2 Evaluation**

The soils beneath the site are predominantly silty clays, clayey silts and clayey sands. Based on these soil types, the Tier 2 values for sandy silts were used. Based on the results of the Tier 2 soil evaluation, residential exposure to benzene in indoor air was not evaluated further. Tier 2 look-up values for TPH-G and TPH-D were not available. Therefore, a RBCA Tier 3 evaluation of each in soil was performed for TPH-G and TPH-D. The results of the RBCA Tier 2 evaluation for soil are presented in Table 3.

#### **Groundwater RBCA Tier 2 Evaluation**

Based on the soil types beneath the site, the Tier 2 values for sandy silts were used. Based on the results of the Tier 2 groundwater evaluation, benzene in groundwater for commercial indoor air exposures was not evaluated further. However, maximum benzene concentrations for residential indoor air exposures exceeded Tier 2 lookup values. Because the maximum detected benzene and TPH concentrations exceeded the Tier 2 concentrations, a Tier 3 RBCA evaluation of each in groundwater was performed. The results of the Tier 2 evaluation for groundwater are presented in Table 4.

The remainder of this report presents the RBCA Tier 3 evaluation for the site. The results of the Tier 1 and 2 comparisons are presented in Tables 1 through 4. RBCA Tier 1 and 2 evaluations could not be performed for TPH because Tier 1 and 2 look-up values were not available for TPH. Therefore, the RBCA Tier 3 evaluation also includes TPH.

#### 3. STATISTICAL EVALUATION OF CHEMICAL DATA

For the purposes of conducting statistical analyses for each chemical, non-detects were included at one-half the detection limit (EPA, 1989). For example, if benzene was not found at a detection limit of 0.005 mg/kg, a concentration of 0.0025 was used as an assumed concentration of benzene at this location. For groundwater, the four most recent quarters of monitoring data for each chemical were compiled. For each constituent, only wells in which at least one sample had a positive detection in the last four quarters of analytical data were combined.

For each chemical and sampling location, the distribution of the data was determined using either the Shapiro-Wilk W Test for sample sizes less than 50, or the D'Agostino's Test for sample sizes greater than 50 (D-Test; Gilbert, 1987).

Three different types of distribution profiles are possible: normal distribution, lognormal distribution, and non-parametric (i.e., neither normal nor lognormal). Based on the distribution profile for each chemical, the 95 percent upper confidence limit (UCL) of the arithmetic mean was calculated. For data sets that did not fit normal or lognormal distributions, the 95 percent UCL was calculated as a normal distribution, resulting in a higher and more conservative UCL than using the non-parametric approach for these data sets. The non-parametric calculation of the 95 percent UCL tended to be lower than the estimation based on a normal distribution because of the large number of non-detect values. Therefore, using the normal distribution estimate is more conservative. That is, use of the normal distribution results in a higher estimate of exposure concentrations and consequently higher estimates of potential risks.

The purpose for using the 95 percent UCL instead of the average concentration is to account for "...the uncertainty associated with estimating the true average concentration at a site... The 95 percent UCL provides reasonable confidence that the true site average will not be underestimated" (EPA, 1992). The 95 percent UCL on the arithmetic mean was calculated following methods in EPA (1992) and Gilbert (1987). All of the chemical concentration distributions were non-parametric. For these non-parametrically distributed data, the following equation for a normal distribution was used:

$$UCL = \mu + \left(t \times \frac{s}{\sqrt{n}}\right)$$

where:

UCL = 95 percent upper confidence limit on the arithmetic mean

 $\mu$  = mean of the data

s = standard deviation of the data t = t-statistic (from Gilbert, 1987)

n = number of samples

For the lognormally distributed data, the following equation was used:

$$UCL = e^{(\mu + \theta.5s^2 + sH/\sqrt{n-1})}$$

where:

e = constant (base of the natural log, equal to 2.718)

 $\mu$  = mean of the transformed data

s = standard deviation of the transformed data

H = H-statistic (from Gilbert, 1987)

For the RBCA Tier 3 evaluation, estimates of exposure point concentrations for direct soil contacts (construction workers only) are based on soil data from zero to ten feet bgs (DTSC, 1992). For certain datasets the estimated 95 percent UCL may result in a concentration higher then the maximum detected concentration. Therefore, the 95 percent UCL or the maximum detected value (whichever is lower) was the concentration used as the exposure point concentration used to assess risk from direct exposures to soil (i.e., direct contact with surface soil, incidental soil ingestion). If modeling were used to evaluate the transfer of chemicals from groundwater to another media (e.g., air), average values were used as model inputs. The results of the statistical analyses for soil and groundwater are presented in Tables 5 and 6.

#### 4. RBCA TIER 3 EVALUATION

This evaluation follows a series of steps common to risk assessments. First, the ways in which people could be exposed to the chemicals are identified, and assumptions are made about the extent to which people could be exposed. Lastly, the estimated exposure rates are combined with chemical toxicity criteria to estimate the risks associated with the exposures. The differences between the RBCA Tier 3 evaluation and the RBCA Tier 2 evaluation are the use of the 95 percent UCLs as exposure point concentrations, quantification of TPH exposures and risks, use of site-specific soil parameters (see Section 4.1.5), and adjustment of the foundation thickness in the indoor air model to one inch to account for uncertainties associated with off-site residential structures.

#### 4.1 Exposure Assessment

The exposure assessment step in a risk assessment combines information about the chemical concentrations in site media with assumptions about how a potential receptor could contact the impacted media. The result is an estimation of the level of intake, or dose, of a chemical.

In this section, the ways in which human receptors could be exposed to chemicals in soil and groundwater, and the populations of receptors that could be exposed, are identified and discussed. The concentrations of chemicals detected in soil and groundwater at locations where receptors might be exposed are identified and this information, presented in tables, is summarized. Fate and transport modeling were used to estimate potential exposure of receptors at potential receptor locations away from the currently impacted areas. Potential receptors are identified and assumptions regarding the activities of potential receptors, such as the frequency with which a person could come into contact with chemicals in soil and air, are also discussed. Finally, the methods used to estimate daily doses at the points of potential human contact, using the exposure assumptions and the chemical concentrations, are reviewed.

#### 4.1.1 Tier 3 Conceptual Site Model

The conceptual site model is a tool used in risk assessment to describe relationships between chemicals and potentially exposed populations, thereby delineating the relationships between the suspected sources of chemicals identified at the property, the mechanisms by which the chemicals could be released and transported in the environment, and the means by which the receptors could come in contact with the chemicals. The potentially complete exposure pathways identified in the conceptual site model were carried through the risk evaluation. The conceptual site model for the Oakland site is presented on Figure 4.

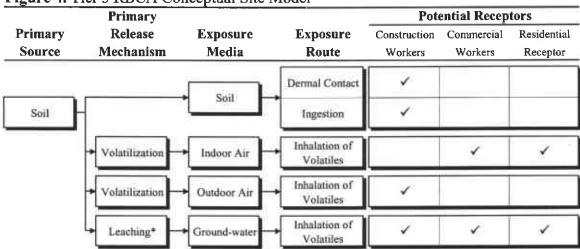


Figure 4. Tier 3 RBCA Conceptual Site Model

#### 4.1.2 Land Use

To determine which receptor populations might be at risk for chemical exposure at the property, it is necessary to determine the present and potential future land use at and around the property. The site is located in downtown Oakland, and is currently planned for redevelopment to a commercial carwash. Under these conditions, the exposure patterns associated with the site would include not only those associated with a commercial site, but might also include construction worker exposures. The site has thus been evaluated using construction and commercial land use assumptions for human exposure. Because some of the adjacent areas have residential development, the site has been evaluated using potential residential land use assumptions for human exposure associated with vapor transport pathways. The residential scenario is evaluated to ensure protection of current and potential future land uses for adjacent properties.

<sup>✓</sup> Potentially complete exposure pathway.

Evaluated using the RBCA equations.

#### 4.1.3 Potential Receptors

The identification of people who could potentially be exposed to chemicals at a site involves consideration of current and future land uses of a particular site. Because the site is located in a commercial area, and is currently planned for commercial use and future use of the site will also be commercial, the most likely receptor to be exposed to chemicals in soils are on-site commercial workers (e.g., convenience store workers, car wash workers) and construction workers. Because the chemicals in soil are not at the surface as well as lower exposure frequencies, this scenario would also be protective of the less intensely exposed individuals using the site (e.g., visitors to the site [patrons], landscape workers). In addition, the adjacent residential receptor was also evaluated for the site.

#### 4.1.4 Potential Exposure Pathways

An exposure pathway is a description of the ways in which a person could be exposed to chemicals and is defined by four elements: (1) a source and mechanism of chemical release to the environment; (2) an environmental transport medium (e.g., air) for the released chemical; (3) a point of potential contact with the contaminated medium (the exposure point); and (4) an exposure route (e.g., inhalation) at the contact point. In order for an exposure pathway to be considered complete, all four elements must be present. As presented in Figure 4, one potential exposure pathway exists for on-site commercial workers and off-site residents; inhalation of vapors volatilized from soil and groundwater. Direct contact with soil will not occur for residents or commercial workers because the site is currently paved and there are no plans for removal of the pavement. For on-site construction workers, inhalation of vapors volatilized from soil into ambient air, and direct contact with soils via incidental ingestion and dermal contact during construction activities are evaluated.

#### 4.1.5 Fate and Transport Modeling

Indirect exposure to chemicals in soil can occur when chemicals migrate from the original media (soil) to a new media (e.g., air) with which receptors could come into contact. Chemicals at a site can volatilize from impacted soil into indoor and outdoor ambient air. Predicting migration of chemicals at the site to indoor and ambient air from subsurface soil involved three models. Flux of chemicals from soil into air (as well as downward migration) is determined based on results of the use of the standard RBCA fate and transport equations presented in the Oakland and ASTM RBCA guidance documents.

In assessing the fate and transport of TPH-G and TPH-D, a "fractionation approach" was used, whereby the measurement of TPH is broken down into several indication fractions for the purposes of modeling exposure and toxicity assessment. Section 4.2.1 details this approach further.

As the soil parameters used in each of the equations are dependent upon the type of soils being assessed, it is important to identify the soil types present beneath the site. As described in Section 1.4, the primary soil types found beneath the site are silty clays, clayey silts, and sandy clays. Therefore, the soil parameters for the sandy silts and clayey silts, as identified in the Oakland RBCA guidance (1999) were used. The point value used for each parameter is the average of the parameter values for sandy silts and clayey silts. The predicted indoor and outdoor air concentrations are given in Tables 7 through 9.

In addition to modeling the infiltration of vapors from soil and groundwater through the vadose zone and into ambient and indoor air, RBCA equations were also used to evaluate whether the concentrations of BTEX, MTBE, and TPH might be expected to increase in groundwater beneath the site in the future as a result of vadose zone leaching. Results of the RBCA modeling predict that residual petroleum hydrocarbon concentrations in soils may reach groundwater beneath the site, but not in sufficient concentrations to increase the concentrations currently measured groundwater (see Table 10). The only exception to this is TPH-D, which has not yet been detected in groundwater. However, due to its limited extent in soils, and the current presence of asphalt and anticipated presence of asphalt over the site in the future, it is unlikely that sufficient infiltration by groundwater will occur to provide a means for TPH-D to reach groundwater. The following discussion provides further support for this conclusion.

The mobility of a liquid in the unsaturated zone depends upon a variety of factors, including (1) the kinematic viscosity, a physical parameter that represents the resistance of a fluid (e.g., diesel) to move through soil, affecting the rate of percolation; (2) the quantity of free product released, which will affect the depth of penetration into the soil; (3) the permeability of the soil, which affects both the rate of percolation and the plume geometry; and (4) the residual saturation level of free product in the soil, which is dependent on both the soil type and the product viscosity (Dragun, 1988). Heavier petroleum hydrocarbons with higher viscosity do not penetrate as readily into soil as do lighter hydrocarbons with lower viscosity.

Because of retention by soil, the extent of migration of a particular quantity of petroleum hydrocarbons in soil is limited. As a mass of hydrocarbons migrates in the unsaturated zone, a small amount of the total hydrocarbon mass will remain adsorbed to the soil. The hydrocarbons that are retained by soil particles are considered immobile. In addition, petroleum hydrocarbons are considered to be biodegradable. In the unsaturated zone, vapor-phase molecular diffusion can maintain an oxygen supply even at depths of tens of feet bgs. This oxygen supply facilitates biodegradation. Thus, it is likely that hydrocarbon levels in the subsurface will decrease over time, further reducing vertical migration.

#### 4.1.6 Quantification Of Exposure

The risks associated with exposure to chemicals depend not only on the concentrations of chemicals, but also on the extent to which receptors are exposed. For example, the risks associated with exposure to chemicals for one hour per day are less than those associated with exposure at the same concentrations for two hours per day. Because risks depend

upon both the concentration and the extent of the exposure, the assumptions regarding the extent of exposure are discussed in this section for each of the complete exposure pathways identified above. Table 11 presents each of the exposure parameters used in this Tier 3 evaluation. All values are EPA and ASTM referenced values as selected by the Oakland RBCA process. These values are scientifically defensible and are regularly used in risk assessment. Using more site-specific data would be part of a more sophisticated Tier 3 evaluation, and would require additional site characterization.

Chemicals are grouped into carcinogens and non-carcinogens and risk are assessed differently depending on which classification a chemical has. Benzene has both carcinogenic and non-carcinogenic effects. TPH-D and TPH-G are assessed as non-carcinogens only. The lifetime average daily dose (LADD) for carcinogens and average daily dose (ADD) for non-carcinogens are estimated based on the parameters identified in Table 11, the air and soil concentrations presented in Tables 5, 7, 8 and 9, and the following equations:

$$ADD \text{ or } LADD_{inhalation}(mg / kg - d) = \frac{C_{air} \times IR \times EF \times ED \times AF_{i}}{BW \times AT}$$

$$ADD \text{ or } LADD_{dermal}(mg / kg - d) = \frac{C_{soil} \times CF \times SA \times SAF \times EF \times ED \times AF_{d}}{BW \times AT}$$

$$ADD \text{ or } LADD_{ingestion}(mg / kg - d) = \frac{C_{soil} \times CF \times IR_{s} \times EF \times ED}{BW \times AT}$$

where:

 $C_{air}$  = chemical concentration in air (mg/m<sup>3</sup>)

 $C_{\text{soil}} = 95\% \text{ UCL chemical concentration in soil (mg/kg)}$ 

CF = conversion factor  $(1 \times 10^{-6} \text{ kg/mg})$ 

IR = inhalation rate; the amount of the transport medium contacted per unit time  $(m^3/day)$ 

 $IR_s$  = soil ingestion rate (mg/day)

EF = exposure frequency (days/year)

ED = exposure duration (years)

 $AF_i$  = inhalation absorption fraction (fraction)

AT = averaging time; the time over which the exposure is averaged (days)

BW = body weight (kilograms)

AF<sub>d</sub> = dermal absorption fraction (fraction) SA = skin surface area exposed (cm<sup>2</sup>/day) SAF = soil-skin adherence factor (mg/cm<sup>2</sup>)

For residential exposures, the exposure equation is calculated twice, once for adults, and once for children (using their respective exposure parameters) and the results are added together. The exposure parameter that differs between the calculation of an ADD and a

15 this acceptable

LADD is averaging time (AT). A lifetime, 70 year, AT is used for the LADD while an AT equal to exposure duration is used for the ADD. The resulting LADDs and ADDs are presented in Section 4.3 (Risk Characterization) and Tables 12 through 17.

#### 4.2 Toxicity Assessment

Toxicity values, when available, are published by EPA in the on-line Integrated Risk Information System ([IRIS]; EPA, 1999) and by the California Office of Environmental Health Hazard Assessment (OEHHA, 1994). Cancer slope factors (CSFs) are chemical-specific, experimentally derived potency values that are used to calculate the risk of cancer resulting from exposure to potentially carcinogenic chemicals. A higher value implies a more potent carcinogen. The CSF for benzene obtained from OEHHA is more than three times greater (more conservative) than that developed by the EPA. The benzene CSF derived by OEHHA was used in this assessment. Reference Doses (RfDs) are used to evaluate exposures against non-cancer endpoints. The non-TPH RfDs were obtained from IRIS (EPA, 1999). For adverse non-cancer health effects, EPA assumes that a dose threshold exists, below which adverse effects are not expected to occur. A chronic RfD of a chemical is an estimate of an average daily dose to humans that is likely to be without appreciable deleterious non-carcinogenic effects.

#### 4.2.1 Total Petroleum Hydrocarbons

Gasoline, diesel, motor oil and other petroleum products are complex mixtures of hydrocarbons. Once these products have been released into the environment, the composition of the mixture changes because the components have different physical and chemical properties (e.g., solubility in water, volatility, and soil adsorption coefficients). These properties dictate the behavior of each component in the environment. Consequently, a receptor will not be exposed to fresh product but to a mixture of the various chemical components of petroleum hydrocarbons as they have 'weathered,' or changed in composition, during migration in the environment.

The chemical composition has not been quantitatively identified in most petroleum-based complex mixtures, such as gasoline and diesel. Routine qualitative and quantitative analyses of either commercial products or samples of impacted soil or groundwater for the purpose of establishing the chemical breakdown of hydrocarbon mixtures are currently impractical, primarily because the low potential usefulness of such data does not justify the high cost of routine chemical analysis. In addition, specific toxicity criteria that are essential to risk assessment have been developed for only a handful of the constituent hydrocarbons. The reason is that most of these hydrocarbons have not been subjected to the battery of toxicity tests required for developing the criteria.

Because a consensus method for setting cleanup levels for complex hydrocarbon mixtures has not been established, a number of different approaches that are not health-based or site-specific have been recommended by regulatory agencies. Two such approaches are:

Remediate TPH to a concentration equivalent to the practical limit of quantification (PLQ). This approach is generally considered by most environmental professionals to lack scientific basis and be an inefficient use of resources.

Remediate TPH to pre-established cleanup levels. These levels vary among regulatory agencies, and typically range between 10 and 10,000 parts per million for soil. This approach is frequently criticized for being arbitrary and lacking scientific basis.

In an effort to move away from methods that are inefficient and lacking in scientific foundation, several approaches have been developed for the determination of more appropriate site-specific and health-based cleanup levels. Some of these approaches include:

Assess certain discrete compounds with established toxicity criteria. Typical examples of compounds included are benzene and the alkyl benzenes such as ethylbenzene, toluene, and total xylenes in gasoline, or polynuclear aromatic hydrocarbons (PAHs). The main rationale cited for this approach are: (a) these selected compounds are the predominate contributors to total risk; thus, the relative significance of other TPH constituents is low, (b) analytical procedures are well-established and affordable for individual the more toxic compounds, and (c) essential toxicity criteria have been established.

Assume the composition of residual TPH in soil is equivalent to fresh product. This approach has become feasible with the development by EPA of provisional toxicity criteria for several petroleum products, including gasoline, diesel, and jet fuels. This approach also assumes the presence of BTEX in the toxicity criteria, thus double counting the effects of BTEX, which are usually evaluated separately from TPH. In addition, petroleum products can change appreciably after release into soil due to the influence of differential rates of degradation and dispersion on individual compounds in the mixture (i.e., weathering). For example, the aromatic versus the aliphatic constituents in hydrocarbon mixtures are prone to faster rates of degradation and dispersion. Therefore, the assumption that a TPH fraction in soil is equivalent to fresh product is likely to greatly overestimate risk.

The fractionation approach. This approach accounts for the differential weathering of petroleum hydrocarbons and estimation of risks of mixtures for which toxicity data are not available. The approach consists of a) fractionation of fuel products into chemical families or fractions, b) selection of surrogate chemicals that are considered representative of each fraction, c) normalization of surrogate chemicals to represent all chemicals within a fraction, d) fate and transport modeling of the surrogate chemicals, and e) risk characterization of the surrogate chemicals.

In order to develop risk-based screening benchmark values for petroleum hydrocarbons in soil for the Oakland site, the fractionation approach developed by the Massachusetts Department of Environmental Protection (MaDEP) in which the total mass of petroleum hydrocarbons is separated into aromatic and aliphatic fractions, is used. For each quantifiable analytical fraction, a "reference" toxicity value is assigned to conservatively

represent the toxicity of that fraction. The utility of the MaDEP fractionation approach is its applicability to all forms of petroleum products, whether fresh or weathered. The environmental fractions identified using this approach are aliphatics (alkanes) and aromatics.

MaDEP recommended product-specific fractions and toxicity criteria for each fraction were used to develop the human health screening benchmark values. In the absence of site-specific fractionation analytical data, composition recommendations for TPH as gasoline (TPH-g) and TPH as diesel (TPH-d) from the MaDEP are used to determine the percent of each fraction present in the environment. The product-specific fractions, fraction composition for each petroleum product, and toxicity criteria for each fraction used in the Tier 3 evaluation are presented in Table 18.

#### 4.3 Risk Characterization

In the last step of a risk assessment, the estimated rate at which a person intakes a chemical is compared with information about the toxicity of that chemical to estimate the potential risks to human health posed by exposure to the chemical. This step is known as the risk characterization.

For carcinogens, risk is estimated as the incremental probability of an individual developing cancer over a lifetime as a result of a chemical exposure. Theoretical upper-bound incremental lifetime cancer risks are evaluated by multiplying the estimated average exposure rate (*i.e.*, LADD) by the chemical's CSF. The CSF converts estimated daily intakes averaged over a lifetime to the incremental risk of an individual developing cancer. Theoretical upper-bound incremental lifetime cancer risk estimates are compared to EPA's acceptable risk range of one in one million ( $10^{-6}$ ) to one in ten thousand ( $10^{-4}$ ). A risk level of  $10^{-5}$  is consistent with Oakland RBCA process for risk management decisions. A risk level of  $1 \times 10^{-5}$  represents a probability of one in one hundred thousand that an individual could develop cancer from exposure to the potential carcinogen under a defined set of exposure assumptions.

For non-carcinogenic health effects, a Hazard Index (HI) is used to evaluate exposure relative to a toxicity reference value. The HI is calculated by dividing the average exposure rate (ADD) by the chemical-specific RfD. An HI of 1.0 is typically used as an acceptable hazard level.

The pathway, location, and chemical or TPH fraction-specific HIs and theoretical upper-bound incremental lifetime cancer risks are presented in Tables 12 through 17. A summary of the HIs and risk estimates is presented in Table 19.

#### 4.4 Uncertainty Analysis

Risk estimates are values that have uncertainties associated with them. These uncertainties, which arise at every step of a risk assessment, are evaluated to provide an indication of the relative degree of uncertainty associated with a risk estimate. In this

section, a qualitative discussion of the uncertainties associated with the estimation of risks for the site is presented.

Risk assessments are not intended to estimate actual risks to a receptor associated with exposure to chemicals in the environment. Risk assessment is a means of estimating the probability that an adverse health effect (e.g., cancer, and impaired reproduction) will occur in a receptor. The multitude of conservative assumptions used in risk assessments guard against underestimation of risks.

Risk estimates are calculated by combining site data, assumptions about individual receptor's exposures to impacted media, and toxicity data. The uncertainties in this risk assessment can be grouped into three main categories that correspond to these steps:

- Uncertainties in environmental sampling and analysis
- Uncertainties in assumptions concerning exposure scenarios
- Uncertainties in toxicity data and dose-response extrapolations

It is possible to quantify the uncertainty in a risk assessment through the use of Monte Carlo simulations in the risk calculations. Risk assessments with quantitative uncertainty analyses are called "probabilistic evaluations." Instead of calculating risks using point estimates, which are often upper-bound values, for each parameter, as was done at the facility, a probability distribution function representing a range of data is used. A computer model performs the risk calculations up to 10,000 times, and each iteration incorporates a different combination of data from the various probability distribution functions. The result is a distribution of risks instead of a single value.

In general, theoretical upper-bound risks calculated in probabilistic risk assessments are lower and more realistic than those calculated in deterministic evaluations, and because the result is a distribution and not a point estimate, there is a greater level of certainty associated with the calculated risks. Regulatory agencies recognize the usefulness of a quantitative uncertainty analysis. However, the use of probabilistic methods is beyond the scope of this Oakland RBCA Tier 3 evaluation.

#### 4.4.1 Uncertainty in Site Characterization

Uncertainty can exist in characterizing the nature and extent of the petroleum impacts on soils at the site. In an effort to reduce this uncertainty, multiple samples were collected from the site. The number of sampling locations and events is large and spans several years; therefore, the sampling and analysis data should be sufficient to characterize the distribution of petroleum hydrocarbons and the associated potential risks.

#### 4.4.2 Soil Sampling Bias

The RBCA evaluation was based on data obtained during site characterization activities. Most data collected was focused on finding and delineating petroleum hydrocarbons in soil at the gasoline and diesel fueling systems. Sampling plans are designed to be efficient

in defining the vertical and horizontal extent of petroleum hydrocarbons in soil. Thus, more samples are collected from impacted areas than non-impacted areas. This adds additional conservative bias to the evaluation, given that the assumed exposure concentration actually only make up a portion of the site, while actual exposure patterns would cover the whole site.

#### 4.4.3 Uncertainty in the Exposure Assessment

Exposure assessment inputs used in this evaluation, and typically in risk assessments in general, attempt to incorporate reasonable maximum exposure assumptions to protect individuals likely to have the highest exposure. Therefore, while there is a great deal of variability and uncertainties in these exposure inputs because they are high-end assumptions, they would likely tend to overestimate rather than underestimate exposure to most individuals. In addition, no attempt was made to predict biodegradation or environmental decay of petroleum constituents. However, over the exposure durations used in the evaluation, some decrease in concentrations would be expected. A decrease in concentrations over time would lead to decreased risk. Therefore, the steady state assumption used in this evaluation would tend to overestimate risk.

In addition, there are Occupational Safety and Health Administration (OSHA) training requirements for workers engaged in construction activities at retail gasoline outlets. Proper adherence to OSHA requirements will enable a worker to take appropriate actions to mitigate potential chemical exposures.

Use of fate and transport models, in general, introduces some degree of uncertainty in any analysis In particular, environmental transport models were used in this evaluation to estimate partitioning of chemicals from soil. Uncertainties result both from any model's limited ability to predict complicated, constantly changing environmental conditions, as well as in the input parameters used to solve the models.

#### 4.4.4 Toxicological Data and Dose Response Extrapolations

The availability and quality of toxicological data is another source of uncertainty in the risk assessment. Uncertainties associated with animal and human studies may have influenced the toxicity criteria. Carcinogenic criteria are classified according to the amount of evidence available that suggests human carcinogenicity. EPA assigns each carcinogen a designation of A through E, dependent upon the strength of the scientific evidence for carcinogenicity.

Extrapolation of toxicological data from animal tests is one of the largest sources of uncertainty in a risk assessment. There may be important, but unidentified, differences in uptake, metabolism, and distribution of chemicals in the body between the test species and humans. For the most part, these uncertainties are addressed through use of conservative assumptions in establishing values for CSFs, which results in the likelihood that the risk is overstated. Even if studies of chemical effect in humans are available (e.g.,

for benzene), they generally are for workplace exposures far in excess of those expected in the environment. Uncertainties can be large because the activity patterns, exposure duration and frequency, individual susceptibility, and dose may not be the same in the study populations as in the individuals exposed to environmental concentrations. Because conservative methods are used in developing the toxicity criteria, the possibility of underestimating risks is low.

#### 5. SUMMARY

NewFields, Inc., has evaluated the potential risks to human health posed by BTEX, MTBE, and TPH in soil and groundwater at 3101 98<sup>th</sup> Avenue, Oakland, California. To ensure that human health is adequately protected, conservative concentrations, exposure parameters, and toxicity assumptions were used in estimating exposure potential and risks. Results of the RBCA Tier 1 and Tier 2 evaluations indicate that concentrations of toluene, ethylbenzene, xylenes, and MTBE in soil and groundwater should not pose a risk to construction workers, and that concentrations of benzene, toluene, ethylbenzene, xylenes, and MTBE should not pose a risk to commercial workers or off-site residents. Results of the RBCA Tier 2 evaluation indicate that levels of benzene in soil should not pose a risk to current and future on-site workers or residents.

Results of the RBCA Tier 3 evaluation indicate that levels of benzene in groundwater and TPH in soil and groundwater should not pose a risk to current and future on-site workers or off-site residents. The concentrations of chemicals to which individuals could potentially be exposed were based on available measured data and estimation of indoor air and outdoor air concentrations. This evaluation indicates that the theoretical upper-bound incremental lifetime cancer risk levels for benzene are below 10<sup>-5</sup>, and well within or below the EPA acceptable cancer risk range of 10<sup>-4</sup> to 10<sup>-6</sup>. The evaluation indicates that the HI levels are below the acceptable level of 1.0. Because these values are less than 1.0, adverse non-carcinogenic health effects are not likely to be associated with the site.

Results of the risk assessment also served as a basis for the development of site-specific target level (SSTLs). The SSTLs calculated for each receptor were compared to the concentrations measured at the site and presented in Tables 12 through 17. Construction, commercial, and residential scenarios were evaluated and soil 95 percent UCL concentrations and groundwater average plume concentrations at the site are below their respective SSTLs.

It is important to note, that although some specific sample locations may have detected concentrations greater than the SSTLs, it is inappropriate to compare individual sample results to the SSTLs. Rather, the 95 percent UCL concentrations should be used for determining whether conditions at the site pose a risk to workers. There are two reasons why it is more appropriate to use the 95 percent UCL versus a single sample result: (1) any risk-based cleanup levels developed for the site are derived using toxicity criteria that are based on lifetime average exposures; and (2) the 95 percent UCL concentration is more representative of the concentration that would be contacted at the site over time

(EPA, 1992). That is, a person would not expect to be exposed to soil at a single point on the site, rather they would be exposed to soil over an area of the site.

Chapter 2 of DTSC's supplemental guidance states, "Estimates of chemical concentrations in soil are to be derived using these principles for all state-lead sites..." (DTSC, 1992). Chapter 2 recommends calculating a 95 percent UCL for "an appropriate-sized area..." (DTSC, 1992). For a commercial site, this area of exposure may be very large and may in fact consist of the entire site. Risk assessors within both EPA and DTSC support and endorse this position. EPA and DTSC have consistently used this approach at other sites in California. There are numerous examples of sites where the 95 percent UCL was used to determine whether further action was warranted that were approved by DTSC. Scientists at DTSC's Office of Scientific Affairs should be contacted for supporting information regarding this issue.

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Table 1. Soil RBCA Tier 1 Analysis

Table 1. Son Reservited 1 Timely 515							
	T		Soil Co	ncentration (	(mg/kg) <sup>a</sup>		
			Ethyl-				
	Benzene	Toluene	benzene	Xylenes	MTBE	TPH-G	TPH-D
Minimum	0.01	0.01	0.003	0.01	0.10	1.00	3,900
Mean	0.08	0.04	0.025	0.14	0.5	3.0	
Maximum	1.0	0.71	0.520	3.0	4.0	33.0	3,900
Location of Maximum	RW-1@25°	RW-1@25 <sup>c</sup>	P3@2.5 <sup>d</sup>	P3@2.5 <sup>d</sup>	P3@3.5 <sup>d</sup>	RW-1@25°	TD-5-0.5 <sup>e</sup>
Soil Direct Contact-Construction							
Tier 1 level (Oakland-RBCA)	195.0	5,833	3,438	31,250	177	NA	NA
Proceed to Tier 2?	No	No	No	No	No	Yes	Yes
Soil to Outdoor Air-Construction				•			
Tier 1 level (Oakland-RBCA)	18.3	ŞAT ()	SAT	SAT	SAT	NA	NA
Proceed to Tier 2?	No	No	No	No	No	Yes	Yes
Soil to Enclosed Space Air-Workers							
Tier 1 level (Oakland-RBCA)	1.1	SAT \	SAT	SAT	SAT	NA	NA
Proceed to Tier 2?	No	No	No	No	No	Yes	Yes
Soil to Enclosed Space Air-Residents		-					
Tier 1 level (Oakland-RBCA)	0.069	SAT	$\setminus$ SAT	SAT	SAT	NA	NA
Proceed to Tier 2?	Yes	No	\ No	No	No	Yes	Yes

<sup>&</sup>lt;sup>a</sup>From soil sampling for the site.

SAT = soil saturation concentration



<sup>&</sup>lt;sup>b</sup>Construction benzene Tier 1 level was calculated using construction worker exposure parameters (480 mg/day ingestion, exposure duration of 1 year).

<sup>&</sup>lt;sup>c</sup>Alton Geoscience (1990b).

<sup>&</sup>lt;sup>d</sup>Gettler-Ryan Inc (1999).

<sup>&</sup>lt;sup>e</sup>EMCON (1994).

Table 2. Groundwater RBCA Tier 1 Analysis

	Groundwater Concentration (µg/L) <sup>a</sup>						
	Benzene	Toluene	Ethyl- benzene	Xylenes	мтве	TPH-G	TPH-D
Minimum	1	6.6	1.4	1.2	1.9	60	ND
Mean	4,328	10,094	1,604	6,025	978	34,868	ND
Maximum	26,000	46,000	5,100	30,000	3,000	260,000	ND
Location of Maximum	RW-1	RW-1	RW-1	RW-1	AW-5	RW-1	NA
GW to Outdoor Air-Construction Tier 1 level (Oakland) <sup>b</sup> Proceed to Tier 2	525,000 No	>Sol No	>Sol No	>Sol No	>Sol No	NA Yes	NA No
GW to Indoor Air-Commercial Tier 1 level (Oakland) Proceed to Tier 2	1,800 <b>Yes</b>	>Sol No	>Sol No	>Sol No	>Sol No	NA Yes	NA No
GW to Enclosed Space Air-Residential Tier 1 level (Oakland) Proceed to Tier 2	110 <b>Yes</b>	210,000 No	Sol	>Sol No	>1,000,000 No	NA Yes	NA No

<sup>&</sup>lt;sup>a</sup>From groundwater sampling for the site; the last 4 quarters where the constituent was analyzed (Blaine Tech Sevices, 1999)

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<sup>&</sup>lt;sup>b</sup>Construction benzene Tier 1 level was adjusted to reflect the difference between the construction worker exposure duration (1 year) versus the commercial worker exposure duration (assumed to be 25 years).

<sup>&</sup>gt; Sol = the acceptable concentration is greater than the constituent's solubility in water. The constituent's solubility was not exceeded by the maximum detected concentration

Table 3. Soil RBCA Tier 2 Analysis

	Conc	Concentration (mg/kg) <sup>a</sup>				
Minimum Mean Mean Mean Maximum Mean Mean Maximum Mean Mean Maximum Mean Mean Mean Mean Mean Mean Mean Mean	TPH-D					
Minimum	0.01	1.00	3,900			
Mean	0.08	3.0				
Maximum	1.00	33.0	3,900			
Location of Maximum	RW-1@25 <sup>d</sup>	RW-1@25 <sup>d</sup>	TD-5-0.5 <sup>e</sup>			
Soil Direct Contact-Construction						
Tier 2 level (Oakland-RBCA-Sandy Silts),c	NA	NA	NA			
Proceed to Tier 3	NA	Yes	Yes			
Soil to Outdoor Air-Construction						
Tier 2 level (Oakland-RBCA-Sandy Silts),c	NA	NA	NA			
Tier 2 level (Cal-EPA adjusted) <sup>d</sup>	NA					
Proceed to Tier 3	NA	Yes	Yes			
Soil to Enclosed Space Air-Workers						
Tier 2 level (Oakland-RBCA-Sandy Silts)	NA	NA	NA			
Proceed to Tier 3	NA	Yes	Yes			
Soil to Enclosed Space Air-Residents						
Tier 2 level (Oakland-RBCA-Sandy Silts)	1.1	NA	NA			
Proceed to Tier 3	No	Yes	Yes			

<sup>&</sup>lt;sup>a</sup>From soil sampling for the site.

SAT = soil saturation concentration

<sup>&</sup>lt;sup>b</sup>Construction benzene Tier 1 level was adjusted to reflect the difference between the construction worker exposure duration (1 year) versus the commercial worker exposure duration (assumed to be 25 years).

<sup>&</sup>lt;sup>c</sup>Sandy Silts Tier 2 values are used because they are considered the most appropriate based on the soil types beneath the site.

<sup>&</sup>lt;sup>d</sup>Alton Geoscience (1990b).

<sup>&</sup>lt;sup>e</sup>EMCON (1994).

Table 4. Groundwater RBCA Tier 2 Analysis

	Concentrat	ion (μg/L) <sup>a</sup>
	Benzene	TPH-G
Minimum	1	60
Mean	4,328	34,868
Maximum	26,000	260,000
Location of Maximum	RW-1	RW-1
GW to Outdoor Air-Construction		
Tier 2 level (Oakland-Sandy Silts),c	NA	NA
Tier 2 level (Cal-EPA adjusted) <sup>d</sup>	NA	
Proceed to Tier 3	NA	Yes
GW to Indoor Air-Commercial		
Tier 2 level (Oakland-Sandy Silts)	53,000	NA
Proceed to Tier 3	No	Yes
GW to Enclosed Space Air-Residential		
Tier 2 level (Oakland-Sandy Silts)	3,400	NA
Proceed to Tier 3	Yes	Yes

<sup>&</sup>lt;sup>a</sup>From groundwater sampling for the site; the last four quarters where the constituent was analyzed-see text.

bConstruction benzene Tier 2 level was adjusted to reflect the difference between the construction worker exposure duration (1 year) versus the commercial worker exposure duration (assumed to be 25 years).

<sup>&</sup>lt;sup>c</sup>Sandy Silts Tier 2 values are used because they are considered the most appropriate based on the soil types beneath the site.

 Table 5. Soil Statistical Analysis

		So	oil Concentr	<b>ation</b> (mg/k	g) <sup>a</sup>		
	Benzene	Toluene	Ethyl- benzene	Xylenes	МТВЕ	трн-с	TPH-D
Soil (all depths)							
Samples	58	58	58	58	16	58	2
Detections	29	19	19	22	5	11	1
Detection Frequency	50%	33%	33%	38%	31%	19%	50%
Minimum Detection	0.01	0.01	0.030	0.01	0.10	1.00	3,900
Mean	0.08	0.04	0.025	0.14	0.5	3.01	NA
Maximum Detection	1.0	0.71	0.520	3.0	4.0	33	3,900
Standard Deviation	0.22	0.124	0.078	0.515	1.067	5.72	NA
Distribution	Lognormal	NP	NP	NP	NP	NP	NA
95% UCL	0.16	0.07*	0.04*	0.26*	0.95*	3.51	3,900
Soil (0-10 feet)							
Samples	HEALTH HIS BLAND	and the second of the second		Heriotekinen ek	and the same	23	2
Detections	BEAR THAT	indanikan m	Philippin de barrio	And The second second		8	1
Detection Frequency					Ellu Aksitu (naksa) s	35%	50%
Minimum Detection			1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	re esse a transferation of the		1.20	3,900
Mean				e in the care of the care		3.5	NA
Maximum Detection				Distriction of the last of the		23.0	3,900
Standard Deviation	W- 1			e in outenier en en ditali		5.86	NA
Distribution	en e		MINE PROPERTY.		MONETAL LIGHT	NP	NA
95% UCL	Committee of the commit	Parameter - Constitution	Last all all has been all a Marketine	<b>POLICE</b> EL LINGUES	Tagair Cardinan (CAMACA)	5.66	3,900

<sup>\*</sup> Determined assuming the underlying distribution of the data is normal. See text.

NP = Non-parametric

NA= not applicable

<sup>&</sup>lt;sup>a</sup>Half the detection limit was used for non-detect values.

Table 6. Groundwater Statistical Analysis

	Groundwater Concentration (μg/L) <sup>a</sup>										
	Benzene	Toluene	Ethyl- benzene	Xylenes	MTBE	TPH-G	TPH-D				
Groundwater											
Minimum Detection	1.0	6.60	1.400	1.20	23.00	60	ND				
Mean-Detects	4,328	10,094	1,604	6,025	904.8	27,899	ND				
Maximum Detection	26,000	46,000	5,100	30,000	3500.0	260,000	ND				
Standard Deviation	7,932	18,248	1,662	9,835	940.21	63,003	ND				
Distribution	NP	NP	NP	NP	NP	NP	ND				
95% UCL	6,880*	18,091*	2,246*	9,288*	1,157*	44,804*	ND				

<sup>\*</sup> Determined assuming the underlying distribution of the data is normal

NP = Non-parametric

ND = not detected

<sup>&</sup>lt;sup>a</sup>Data used are the last four quarters of sampling where samples were collected. Only those wells which had at least one detection for the constituent were used. Half the detection limit was used for non-detect values.

 $\textbf{Table 7. } Vapor \ Diffusion \ Model \ - \ Subsurface \ Soil \ to \ Ambient \ and \ Indoor \ Air^a$ 

			TPH-	G: C5-C8 a	liphatics
				Indoor	Indoor
Parameter	Abbrev.	Units	Outdoor	Resident	Commercial
Henry's law constant	H	unitless	42.64	42.64	42.64
Volumetric air content in vadose zone soils <sup>b</sup>	$ heta_{ m as}$	cm <sup>3</sup> /cm <sup>3</sup>	0.13	0.13	0.13
Volumetric water content in vadose zone soils <sup>b</sup>	$ heta_{ m ws}$	cm <sup>3</sup> /cm <sup>3</sup>	0.35	0.35	0.35
Volumetric air content in crack <sup>b</sup>	$ heta_{ m acrack}$	cm <sup>3</sup> /cm <sup>3</sup>	0.26	0.26	0.26
Volumetric water content in crack <sup>b</sup>	$ heta_{ ext{wcrack}}$	cm <sup>3</sup> /cm <sup>3</sup>	0.12	0.12	0.12
Total soil porosity <sup>b</sup>	$ heta_{ extsf{T}}$	cm <sup>3</sup> /cm <sup>3</sup>	0.45	0.45	0.45
Diffusion coefficient in water <sup>b</sup>	$\mathbf{D}^{\mathrm{wat}}$	$cm^2/s$	1.0 E-5	1.0 E-5	1.0 E-5
Vapor phase diffusion coefficient in air <sup>b</sup>	$\mathbf{D}^{ ext{air}}$	cm <sup>2</sup> /s	0.100	0.100	0.100
Effective diffusion coefficient-soil <sup>c</sup>	$D_{s}^{eff}$	cm <sup>2</sup> /s	4.6 E-4	4.9 E-4	4.9 E-4
Effective diffusion coefficient-crack <sup>c</sup>	${ m D}^{ m eff}_{ m crack}$		5.2 E-3	5.2 E-3	5.2 E-3
Wind speed <sup>d</sup>	$U_{air}$	cm/s	322.0		
Mixing zone height <sup>b</sup>	$\delta_{\!\scriptscriptstyle{ m air}}$	cm	200		
Partition coefficient for organic carbon <sup>e</sup>	$k_{oc}$	cm <sup>3</sup> /g	1,778	1,778	1,778
Organic carbon content of soil <sup>b</sup>	$f_{ m oc}$		1.8%	1.8%	1.8%
Sorption coefficient <sup>f</sup>	$k_s$	cm³/g	31.12	31.12	31.12
Soil bulk density <sup>b</sup>	$ ho_{ m s}$	g/cm <sup>3</sup>	1.5	1.5	1.5
Depth to subsurface soil sources <sup>d</sup>	$L_{S}$	cm	237.7	237.74	237.7
Width of source area parallel to wind <sup>d</sup>	W	em	2,286		
Enclosed space air exchange rate <sup>b</sup>	ER	sec <sup>-1</sup>		5.6 E-4	1.4 E-3
Enclosed space volume/infiltration area ratio <sup>g</sup>	$L_{\rm B}$	cm		2.3 E+2	3.1 E+2
Enclosed space or wall thickness <sup>b</sup>	$L_{\rm crack}$	em		15	15
Areal fraction of cracks in foundations/walls <sup>b</sup>	η	cm <sup>2</sup> /cm <sup>2</sup>		0.001	0.001
Soil to ambient air volatilization factor <sup>b</sup>	VF	$(mg/m^3) / (mg/kg)$	8.4 E-5	3.0 E-4	9.1 E-5
Concentration in soil <sup>d</sup>	$C_s$	mg/kg	1.2	1.2	1.2
Ambient air concentrationi	$C_{air}$	mg/m <sup>3</sup>	1.0 E-4	3.7 E-4	1.1 E-4

Table 7. Vapor Diffusion Model - Subsurface Soil to Ambient and Indoor Aira

			TPH-G: C9-C18 aliphatics			TPH-C	G: C9-C22 a	romatics
				Indoor	Indoor		Indoor	Indoor
Parameter Parameter	Abbrev.	Units	Outdoor	Resident	Commercial	Outdoor	Resident	Commercial
Henry's law constant	H	unitless	250.51	250.51	250.51	0.17	0.17	0.17
Volumetric air content in vadose zone soils <sup>b</sup>	$ heta_{ m as}$	cm <sup>3</sup> /cm <sup>3</sup>	0.13	0.13	0.13	0.13	0.13	0.13
Volumetric water content in vadose zone soils <sup>b</sup>	$ heta_{ m ws}$	cm <sup>3</sup> /cm <sup>3</sup>	0.35	0.35	0.35	0.35	0.35	0.35
Volumetric air content in crack <sup>b</sup>	$ heta_{ m acrack}$	cm <sup>3</sup> /cm <sup>3</sup>	0.26	0.26	0.26	0.26	0.26	0.26
Volumetric water content in crack <sup>b</sup>	$ heta_{ ext{wcrack}}$	cm <sup>3</sup> /cm <sup>3</sup>	0.12	0.12	0.12	0.12	0.12	0.12
Total soil porosity <sup>b</sup>	$oldsymbol{ heta}_{\Gamma}$	cm <sup>3</sup> /cm <sup>3</sup>	0.45	0.45	0.45	0.45	0.45	0.45
Diffusion coefficient in water <sup>b</sup>	$\mathbf{D}^{\text{wat}}$	$cm^2/s$	1.0 E-5	1.0 E-5	1.0 E-5	1.0 E-5	1.0 E-5	1.0 E-5
Vapor phase diffusion coefficient in airb	$\mathbf{D}^{ ext{air}}$	$cm^2/s$	0.100	0.100	0.100	0.100	0.100	0.100
Effective diffusion coefficient-soil <sup>c</sup>	$D_{s}^{eff}$	cm <sup>2</sup> /s	4.6 E-4	4.9 E-4	4.9 E-4	4.6 E-4	4.9 E-4	4.9 E-4
Effective diffusion coefficient-crack <sup>e</sup>	${ m D}^{ m eff}_{ m crack}$		5.2 E-3	5.2 E-3	5.2 E-3	5.2 E-3	5.2 E-3	5.2 E-3
Wind speed <sup>d</sup>	$U_{air}$	cm/s	322.0			322.0		
Mixing zone height <sup>b</sup>	$\delta_{\!\scriptscriptstyle{ m air}}$	em	200			200		
Partition coefficient for organic carbon <sup>e</sup>	$k_{oc}$	cm³/g	341,455	341,455	341,455	4,217	4,217	4,217
Organic carbon content of soil <sup>b</sup>	$f_{ m oc}$		1.8%	1.8%	1.8%	1.8%	1.8%	1.8%
Sorption coefficient <sup>f</sup>	$k_s$	cm <sup>3</sup> /g	5975.46	5975.46	5975.46	73.80	73.80	73.80
Soil bulk density <sup>b</sup>	$ ho_{ extsf{s}}$	g/cm <sup>3</sup>	1.5	1.5	1.5	1.5	1.5	1.5
Depth to subsurface soil sources <sup>d</sup>	$L_s$	cm	237.7	237.74	237.7	237.7	237.74	237.7
Width of source area parallel to wind <sup>d</sup>	W	cm	2,286			2,286		
Enclosed space air exchange rate <sup>b</sup>	ER	sec <sup>-1</sup>		5.6 E-4	1,4 E-3		5.6 E-4	1,4 E-3
Enclosed space volume/infiltration area ratio <sup>g</sup>	$L_{B}$	cm		2.3 E+2	3.1 E+2		2.3 E+2	3.1 E+2
Enclosed space or wall thickness <sup>b</sup>	$L_{\rm crack}$	cm		15	15	<del></del>	15	15
Areal fraction of cracks in foundations/walls <sup>b</sup>	η	cm <sup>2</sup> /cm <sup>2</sup>		0.001	0.001		0.001	0.001
Soil to ambient air volatilization factor <sup>h</sup>	VF	$(mg/m^3) / (mg/kg)$	2.9 E-6	1.0 E-5	3.1 E-6	1.6 E-7	5.9 E <b>-</b> 7	1.8 E-7
Concentration in soil <sup>d</sup>	$C_s$	mg/kg	0.88	0.88	0.88	1.40	1.40	1.40
Ambient air concentration	$C_{air}$	mg/m <sup>3</sup>	2.5 E-6	9.1 E <b>-</b> 6	2.7 E-6	2.3 E-7	8.3 E-7	2.5 E-7

Table 7. Vapor Diffusion Model  $\,$  - Subsurface Soil to Ambient and Indoor  $\operatorname{Air}^{a}$ 

			TPH-D: C9-C18 aliphatics			TPH-D	: C9-C22 a	romatics
				Indoor	Indoor		Indoor	Indoor
Parameter	Abbrev.	Units	Outdoor	Resident	Commercial	Outdoor	Resident	Commercial
Henry's law constant	H	unitless	250.51	250.51	250.51	0.17	0.17	0.17
Volumetric air content in vadose zone soils <sup>b</sup>	$ heta_{ m as}$	$cm^3/cm^3$	0.13	0.13	0.13	0.13	0.13	0.13
Volumetric water content in vadose zone soils <sup>b</sup>	$ heta_{\!\scriptscriptstyle{\mathrm{ws}}}$	cm <sup>3</sup> /cm <sup>3</sup>	0.35	0.35	0.35	0.35	0.35	0.35
Volumetric air content in crack <sup>b</sup>	$ heta_{ m acrack}$	cm <sup>3</sup> /cm <sup>3</sup>	0.26	0.26	0.26	0.26	0.26	0.26
Volumetric water content in crack <sup>b</sup>	$ heta_{ ext{wcrack}}$	cm <sup>3</sup> /cm <sup>3</sup>	0.12	0.12	0.12	0.12	0.12	0.12
Total soil porosity <sup>b</sup>	$oldsymbol{ heta}_\Gamma$	$cm^3/cm^3$	0.45	0.45	0.45	0.45	0.45	0.45
Diffusion coefficient in water <sup>b</sup>	$\mathbf{D}^{wat}$	cm <sup>2</sup> /s	1.0 E-5	1.0 E-5	1.0 E-5	1.0 E-5	1.0 E-5	1.0 E-5
Vapor phase diffusion coefficient in air <sup>b</sup>	$\mathbf{D}^{air}$	$cm^2/s$	0.100	0.100	0.100	0.100	0.100	0.100
Effective diffusion coefficient-soil <sup>c</sup>	$\mathbf{D}^{eff}_{\ \ s}$	cm <sup>2</sup> /s	4.6 E-4	4.9 E-4	4.9 E-4	4.6 E-4	4.9 E-4	4.9 E-4
Effective diffusion coefficient-crack <sup>c</sup>	$\mathbf{D}^{\mathrm{eff}}_{}}$		5.2 E-3	5.2 E-3	5.2 E-3	5.2 E-3	5.2 E-3	5.2 E-3
Wind speed <sup>d</sup>	$ m U_{air}$	cm/s	322.0			322.0		
Mixing zone height <sup>b</sup>	$\delta_{\!\scriptscriptstyle{ m air}}$	cm	200			200		
Partition coefficient for organic carbon <sup>e</sup>	$\mathbf{k}_{\mathrm{oc}}$	cm³/g	341,455	341,455	341,455	4,217	4,217	4,217
Organic carbon content of soil <sup>b</sup>	$f_{ m oc}$		1.8%	1.8%	1.8%	1.8%	1.8%	1.8%
Sorption coefficient <sup>f</sup>	$k_s$	cm <sup>3</sup> /g	5975.46	5975.46	5975.46	73.80	73.80	73.80
Soil bulk density <sup>b</sup>	$ ho_{ extsf{s}}$	g/cm <sup>3</sup>	1.5	1.5	1.5	1.5	1.5	1.5
Depth to subsurface soil sources <sup>d</sup>	$L_{S}$	cm	15.2	15.2	15.2	15.2	15.2	15.2
Width of source area parallel to wind <sup>d</sup>	W	cm	305			305		
Enclosed space air exchange rate <sup>b</sup>	ER	sec <sup>-1</sup>		5.6 E-4	1.4 E-3		5.6 E-4	1.4 E-3
Enclosed space volume/infiltration area ratio <sup>g</sup>	$L_{B}$	cm		2.3 E+3	9.4 E+3		2.3 E+3	9.4 E+3
Enclosed space or wall thickness <sup>b</sup>	$L_{\rm crack}$	cm	W-10	15	15		15	15
Areal fraction of cracks in foundations/walls <sup>b</sup>	η	$cm^2/cm^2$		0.001	0.001		0.001	0.001
Soil to ambient air volatilization factor <sup>h</sup>	VF	$(mg/m^3) / (mg/kg)$	6.0 E-6	1.1 E-6	1.0 E- <b>7</b>	3.4 E-7	6.0 E-8	5.9 E-9
Concentration in soil <sup>d</sup>	$C_s$	mg/kg	2,535	2,535	2,535	1,365	1,365	1,365
Ambient air concentration	$C_{air}$	mg/m³	1.5 E-2	2.7 E-3	2.6 E-4	4.6 E-4	8.3 E-5	8.0 E-6

## Table 7. Vapor Diffusion Model - Subsurface Soil to Ambient and Indoor Air

$$^{c}D^{air} \times (\theta_{as}^{3.33}/\theta_{\Gamma}^{2}) + D^{wat} \times (1/H) \times (\theta_{ws}^{3.33}/\theta_{\Gamma}^{2}).$$

$$f_{oc} \times k_{oc}$$
.

<sup>8</sup> For TPH-G estimates, the default is used. For TPH-D, only one sample had detected TPH-D. Because of the limited a to be impacted by TPH-D, it is assumed that an area 10' by 10' is impacted with TPH-D. For commercial buildings, Bu Building Volume/(Building Area Over Plume). Building dimensions (W × L × H) =  $36' \times 86' \times 10'$ , where 100 ft<sup>2</sup> is the of the building which is assumed to extend over impacted soils. For residential area, the DTSC residential lot size of 1 is assumed, of which, 100 ft<sup>2</sup> is assumed to be the amount of the building (10%) over the TPH-D soils.

$$\label{eq:local_$$

<sup>-- =</sup> parameter not required for this model.

<sup>&</sup>lt;sup>a</sup>ASTM, 1995, Oakland RBCA (1999)

<sup>&</sup>lt;sup>b</sup>Oakland RBCA (1999) default value. The soils beneath the site are predominantly silty clay; therefore, soil parameters of the sandy silt and clayey silt parameters.

<sup>&</sup>lt;sup>d</sup>Based on site data.

<sup>&</sup>lt;sup>e</sup>Based on available scientific literature.

Table 8. Vapor Diffusion Model - Groundwater to Indoor Air<sup>a</sup>

			Benzene	TPH-G: C5	-C8 aliphatics
Parameter	Abbrev.	Units	Resident	Resident	Commercial
Henry's law constant	Н	unitless	0.22	42.64	42.64
Volumetric air content in vadose zone soils <sup>b</sup>	$ heta_{ m as}$	cm <sup>3</sup> /cm <sup>3</sup>	0.13	0.13	0.13
Volumetric air content in capillary fringe soils <sup>b</sup>	$ heta_{ ext{a,cap}}$	cm <sup>3</sup> /cm <sup>3</sup>	0.015	0.015	0.015
Volumetric water content in vadose zone soils <sup>b</sup>	$ heta_{ m ws}$	cm <sup>3</sup> /cm <sup>3</sup>	0.33	0.33	0.33
Volumetric water content in capillary fringe soils <sup>b</sup>	$\theta_{ m w,cap}$	cm <sup>3</sup> /cm <sup>3</sup>	0.44	0.44	0.44
Volumetric air content in foundation/wall cracks <sup>b</sup>	$\theta_{ m acrack}$	cm <sup>3</sup> /cm <sup>3</sup>	0.26	0.26	0.26
Volumetric water content in foundation/wall cracks <sup>b</sup>	$\theta_{wcrack}$	cm <sup>3</sup> /cm <sup>3</sup>	0.12	0.12	0.12
Effective diffusion coefficient through capillary fringe	$\mathbf{D}_{\mathrm{eff,cap}}$	$cm^2/s$	1.6 E-5	4.9 E-7	5.0 E-7
Effective diffusion coefficient in soil <sup>d</sup>	$\mathbf{D}_{eff.s}$	$cm^2/s$	4.6 E-4	4.9 E-4	4.9 E-4
Effective diffusion coefficient between groundwater and soil	$\mathbf{D}_{eff,ws}$	$cm^2/s$	7.0 E-5	2.5 E-6	2.5 E-6
Effective diffusion coefficient through cracks <sup>f</sup>	$\mathbf{D}_{ ext{eff,crack}}$	cm <sup>2</sup> /s	5.2 E-3	5.6 E-3	5.6 E-3
Thickness of capillary fringe <sup>b</sup>	$h_{cap}$	cm	106	106	106
Thickness of vadose zone <sup>g</sup>	h <sub>v</sub>	cm	427	427	427
Total soil porosity <sup>b</sup>	$\theta_{T}$	$cm^3/cm^3$	0.45	0.45	0.45
Diffusion coefficient in water <sup>b</sup>	$\mathbf{D}_{w}$	$cm^2/s$	1.1 E-5	1.0 E-5	1.1 E-5
Vapor phase diffusion coefficient in air <sup>b</sup>	$\mathbf{D}_{\mathrm{air}}$	$cm^2/s$	0.093	0.100	0.100
Soil bulk density <sup>b</sup>	$\rho_{s}$	g/cm <sup>3</sup>	1.5	1.5	1.5
Depth to groundwater <sup>g</sup>	$L_{GW}$	çm	533.4	533.4	533.4
Enclosed-space volume/infiltration ratio <sup>b</sup>	$L_{B}$	cm	229	229	305
Enclosed-space foundation or wall thickness <sup>b</sup>	$L_{ m crack}$	cm	1	1	1
Areal fraction of cracks in foundations/walls <sup>b</sup>	η	cm <sup>2</sup> /cm <sup>2</sup>	0.001	0.001	0.001
Enclosed space air exchange rate <sup>b</sup>	ER.	L/s	5.6 E-4	5.6 E-4	1.4 E-3
Groundwater to indoor air volatilization factor <sup>h</sup>	$ m VF_{es}$	$(mg/m^3)/$ $(mg/L)$	2.2 E-4	1.5 E-3	4.7 E-4
Concentration in groundwater <sup>g</sup>	$C_{\sf gw}$	mg/L)	1.1	2.4	9.8
Enclosed-space air concentration	C <sub>es</sub>	$mg/m^3$	2.3 E-4	3.6 E-3	4.5 E-3

Table 8. Vapor Diffusion Model - Groundwater to Indoor Air<sup>a</sup>

	<del></del>	<del></del>	TPH-G: C9-	C18 aliphatics	<b>TPH-G:</b> C9-	C22 aromatics
Parameter	Abbrev.	Units	Resident	Commercial	Resident	Commercial
Henry's law constant	Н	unitless	250.51	250.51	0.17	0.17
Volumetric air content in vadose zone soils <sup>b</sup>	$oldsymbol{ heta}_{ m as}$	cm <sup>3</sup> /cm <sup>3</sup>	0.13	0.13	0.13	0.13
Volumetric air content in capillary fringe soils <sup>b</sup>	$ heta_{ ext{a,cap}}$	cm <sup>3</sup> /cm <sup>3</sup>	0.015	0.015	0.015	0.015
Volumetric water content in vadose zone soils <sup>b</sup>	$ heta_{ m ws}$	cm <sup>3</sup> /cm <sup>3</sup>	0.33	0.33	0.33	0.33
Volumetric water content in capillary fringe soils <sup>b</sup>	$\theta_{\mathbf{w}, \mathrm{cap}}$	cm <sup>3</sup> /cm <sup>3</sup>	0.44	0.44	0.44	0.44
Volumetric air content in foundation/wall cracks <sup>b</sup>	$\theta_{ m acrack}$	cm <sup>3</sup> /cm <sup>3</sup>	0.26	0.26	0.26	0.26
Volumetric water content in foundation/wall cracks <sup>b</sup>	$\theta_{ m wcrack}$	$cm^3/cm^3$	0.12	0.12	0.12	0.12
Effective diffusion coefficient through capillary fringe <sup>c</sup>	$\mathbf{D}_{eff,cap}$	$cm^2/s$	4.3 E-7	4.3 E-7	1.8 E-5	2.0 E-5
Effective diffusion coefficient in soil <sup>d</sup>	$\mathrm{D}_{\mathrm{eff,s}}$	cm <sup>2</sup> /s	4.9 E-4	4.9 E-4	4.9 E-4	4.9 E-4
Effective diffusion coefficient between groundwater and soile	$D_{\rm eff,ws}$	$cm^2/s$	2.2 E-6	2.2 E-6	7.9 E-5	8.6 E-5
Effective diffusion coefficient through cracks <sup>f</sup>	$D_{eff,crack}$	$cm^2/s$	5.6 E-3	5.6 E-3	5.6 E-3	5.6 E-3
Thickness of capillary fringe <sup>b</sup>	h <sub>cap</sub>	cm	106	106	106	106
Thickness of vadose zone <sup>8</sup>	$h_{v}$	cm	427	427	427	427
Total soil porosity <sup>b</sup>	$\boldsymbol{\theta_{\mathrm{T}}}$	$cm^3/cm^3$	0.45	0.45	0.45	0.45
Diffusion coefficient in water <sup>b</sup>	$\mathbf{D_w}$	cm <sup>2</sup> /s	1.0 E-5	1.1 E-5	1.0 E-5	1.1 E-5
Vapor phase diffusion coefficient in air <sup>b</sup>	$\mathbf{D}_{air}$	cm <sup>2</sup> /s	0.100	0.100	0.100	0.100
Soil bulk density <sup>b</sup>	$ ho_{ m s}$	g/cm <sup>3</sup>	1.5	1.5	1.5	1.5
Depth to groundwater <sup>g</sup>	$L_{GW}$	cm	533.4	533.4	533.4	533.4
Enclosed-space volume/infiltration ratio <sup>b</sup>	$L_{\mathrm{B}}$	cm	229	305	229	305
Enclosed-space foundation or wall thickness <sup>b</sup>	$L_{crack}$	cm	1	1	1	1
Areal fraction of cracks in foundations/walls <sup>b</sup>	η	$cm^2/cm^2$	0.001	0.001	0.001	0.001
Enclosed space air exchange rate <sup>b</sup>	ER	L/s	5.6 E-4	1.4 E-3	5.6 E-4	1.4 E-3
Groundwater to indoor air volatilization factor <sup>h</sup>	$VF_{es}$	(mg/m <sup>3</sup> )/ (mg/L)	7.9 E-3	2.4 E-3	2.0 E-4	6.4 E-5
Concentration in groundwater <sup>g</sup>	$C_{gw}$	mg/L	1.7	7.0	2.7	11.2
Enclosed-space air concentration <sup>i</sup>	$C_{es}$	mg/m <sup>3</sup>	1.3 E-2	1.7 E-2	5.3 E-4	7.1 E-4

## Table 8. Vapor Diffusion Model - Groundwater to Indoor Air<sup>a</sup>

<sup>b</sup>Oakland RBCA (1999) default value. The soils beneath the site are predominantly silty clay; therefore, soil parameters are the average of the sandy silt and clayey silt parameters.

$${}^{c}D_{a} \times (\theta_{a,cap}^{-3.33}/\theta_{T}^{2}) + D_{w} \times (1/H) \times (\theta_{w,cap}^{-3.33}/\theta_{T}^{2})$$

$${}^{d}D_{a} \times (\theta_{as}^{-3.33}/\theta_{T}^{2}) + D_{w} \times (1/H) \times (\theta_{ws}^{-3.33}/\theta_{T}^{2})$$

$$^{d}D_{a} \times (\theta_{as}^{3.33}/\theta_{T}^{2}) + D_{w} \times (1/H) \times (\theta_{ws}^{3.33}/\theta_{T}^{2})$$

$$^{e}(h_{can} + h_{v})/[(h_{can}/D_{eff can}) + (h_{v}/D_{eff s})]$$

$$\begin{aligned} ^{e}(h_{cap}+h_{v})/[(h_{cap}/D_{eff,cap})+(h_{v}/D_{eff,s})] \\ ^{f}D_{a}\times(\theta_{a,crack}^{-3.33}/\theta_{T}^{-2})+D_{w}\times(1/H)\times(\theta_{w,crack}^{-3.33}/\theta_{T}^{-2}) \end{aligned}$$

<sup>g</sup>Based on site data. For resident exposures, only the wells with detected concentrations in 1999 are used (AW-2, AW-3, and AW-4)

$$^{h}1000~L/m^{3}\times H\times [D_{eff,ws}/(L_{GW}\times ER\times L_{B})]/[1+D_{eff,ws})/(L_{GW}\times ER\times L_{B}) + (D_{eff,s}\times L_{crack})/(L_{GW}\times D_{eff,crack}\times \eta)]$$

<sup>&</sup>lt;sup>a</sup>ASTM, 1995, Oakland RBCA (1999)

 $<sup>^{</sup>i}C_{gw} \times VF_{es}$ 

Table 9. Vapor Diffusion Model - Groundwater to Ambient Aira

				TPH-G	
			C5-C8	C9-C18	C9-C22
<u>Parameter</u>	Abbrev.	Units	aliphatics	aliphatics	aromatics
Henry's law constant	Н	unitless	42.64	250.51	0.17
Volumetric air content in vadose zone soils <sup>b</sup>	$oldsymbol{ heta_{as}}$	cm³/cm³	0.13	0.13	0.13
Volumetric air content in capillary fringe soils <sup>b</sup>	$\boldsymbol{\theta}_{\mathrm{a,cap}}$	cm <sup>3</sup> /cm <sup>3</sup>	0.015	0.015	0.015
Volumetric water content in vadose zone soils <sup>b</sup>	$ heta_{ m ws}$	cm <sup>3</sup> /cm <sup>3</sup>	0.33	0.33	0.33
Volumetric water content in capillary fringe soils <sup>b</sup>	$\theta_{\rm w,cap}$	cm <sup>3</sup> /cm <sup>3</sup>	0.44	0.44	0.44
Effective diffusion coefficient through capillary fringe <sup>c</sup>	$\mathrm{D}_{\mathrm{eff,cap}}$	$\mathrm{cm}^2/\mathrm{s}$	4.9 E-7	4.3 E-7	1.8 E-5
Effective diffusion coefficient in soil <sup>d</sup>	$\mathbf{D}_{eff,s}$	$\mathrm{cm}^2/\mathrm{s}$	4.9 E-4	4.9 E-4	4.9 E-4
Groundwater/soil effective diffusion coefficient <sup>e</sup>	$D_{eff,ws}$	$\mathrm{cm}^2/\mathrm{s}$	2.5 E-6	2.2 E-6	7.9 E-5
Thickness of capillary fringe <sup>b</sup>	$h_{cap}$	cm	106	106	106
Thickness of vadose zone f	$h_v$	cm	427	427	427
Total soil porosity <sup>b</sup>	$\boldsymbol{\theta}_{T}$	cm <sup>3</sup> /cm <sup>3</sup>	0.45	0.45	0.45
Diffusion coefficient in water <sup>b</sup>	$\mathbf{D_w}$	$cm^2/s$	1.0 E-5	1.0 E-5	1.0 E-5
Vapor phase diffusion coefficient in air <sup>b</sup>	$\mathbf{D}_{\mathrm{air}}$	$\mathrm{cm}^2/\mathrm{s}$	0.100	0.100	0.100
Wind speed above source parallel to groundwater flow <sup>b</sup>	$ m U_{air}$	cm/s	322	322	322
Ambient air mixing zone height <sup>b</sup>	$\delta_{ m air}$	cm	200	200	200
Width of source area parallel to groundwater flow <sup>f</sup>	W	cm	2,286	2,286	2,286
Soil bulk density <sup>b</sup>	$ ho_{ m s}$	g/cm <sup>3</sup>	1.5	1.5	1.5
Depth to groundwater <sup>f</sup>	$L_{GW}$	cm	533.4	533.4	533.4
Groundwater to ambient air volatilization factor <sup>g</sup>	$\mathrm{VF}_{\mathrm{am}}$	$(mg/m^3)/(mg/kg)$	7.0 E-6	3.6 E-5	9.2 E-7
Concentration in groundwater <sup>f</sup>	$C_{gw}$	mg/L	9.8	7.0	11.2
Ambient air concentration <sup>h</sup>	$C_{am}$	mg/m³	6.8 E-5	2.5 E-4	1.0 E-5

<sup>&</sup>lt;sup>a</sup>ASTM, 1995, Oakland RBCA (1999)

<sup>&</sup>lt;sup>b</sup>Oakland RBCA (1999) default value. The soils beneath the site are predominantly silty clay; therefore, soil parameters are the average of the sandy silt and clayey silt parameters.  ${}^{c}D_{a}\times(\theta_{a,cao}^{\phantom{a}3.33}/\theta_{T}^{\phantom{a}2}) + D_{w}\times(1/H)\times(\theta_{w,cao}^{\phantom{w}3.33}/\theta_{T}^{\phantom{a}2}) \\ {}^{d}D_{a}\times(\theta_{as}^{\phantom{a}3.33}/\theta_{T}^{\phantom{a}2}) + D_{w}\times(1/H)\times(\theta_{ws}^{\phantom{w}3.33}/\theta_{T}^{\phantom{a}2})$ 

 $<sup>^{</sup>e}(h_{can} + h_{v})/[(h_{can}/D_{eff,can}) + (h_{v}/D_{s,eff})]$ 

fBased on site data.

 $<sup>^{</sup>g}1000~L/m^{3}\times H/[1+(U_{air}~\times~\delta_{air}\times L_{GW})/(W~\times D_{eff,ws})]$ 

 $<sup>{}^</sup>h C_{ew} \times VF_{am}$ 

**Table 10.** Leaching Model - Soil to Groundwater<sup>a</sup>

					Ethyl-		
Parameter	Abbrev.	Units	Benzene	Toluene	benzene	Xylene	MTBE
Henry's law constant	H	unitless	0.22	0.22	0.22	0.22	0.22
Volumetric air content in vadose zone soils <sup>b</sup>	$ heta_{ m as}$	cm <sup>3</sup> /cm <sup>3</sup>	0.13	0.13	0.13	0.13	0.13
Volumetric water content in vadose zone soils <sup>b</sup>	$oldsymbol{ heta_{ m ws}}$	cm <sup>3</sup> /cm <sup>3</sup>	0.33	0.33	0.33	0.33	0.33
Groundwater darcy velocity <sup>b</sup>	$\mathrm{U}_{\mathrm{air}}$	cm/s	33.0	33.0	33.0	33.0	33.0
Groundwater mixing zone thickness <sup>b</sup>	$\delta_{ m gw}$	cm	1143	1143	1143	1143	1143
Partition coefficient for organic carbon <sup>b</sup>	$\mathbf{k}_{\mathrm{oc}}$	$cm^3/g$	83	83	83	83	83
Organic carbon content of soil <sup>b</sup>	$f_{ m oc}$		1.8%	1.8%	1.8%	1.8%	1.8%
Sorption coefficient <sup>d</sup>	$k_s$	cm <sup>3</sup> /g	1.45	1.45	1.45	1.45	1.45
Soil bulk density <sup>b</sup>	$ ho_{ extsf{s}}$	g/cm <sup>3</sup>	1.72	1.72	1.72	1.72	1.72
Infiltration rate <sup>b</sup>	I	cm/yr	4.5	4.5	4.5	4.5	4.5
Width of source area <sup>e</sup>	W	cm	2286.0	2286.0	2286.0	2286.0	2286.0
Soil to ambient air volatilization factor <sup>f</sup>	LF	(mg/L) / (mg/kg)	1.3 E-1				
Concentration in soil <sup>e</sup>	$C_s$	mg/kg	0.16	0.07	0.04	0.26	0.95
Predicted groundwater concentration <sup>g</sup>	$C_{gw}$	mg/L	0.021	0.009	0.006	0.033	0.122
Current average groundwater concentration <sup>e</sup>	$C_{gw}$	mg/L	4.33	10.09	1.60	6.03	0.90
Predicted concentration>current concentration?			NO	NO	NO.	NO	NO

<sup>\*</sup> This model assumes that the asphalt is removed from the site. If the asphalt remains it will acta as an effective barrier to infiltration. If infiltration is impeded, it is considered likely that there will no driving force for this COPC to move through the vadose zone, and if it does reach water it is unlikely to be in detectable amounts.

$$^{\rm f}\rho_{\rm s}/[\,\theta_{\rm as} + {\rm ks}\times\rho_{\rm S} + \theta_{\rm as}\times {\rm H}] \times (1 + ((U_{\rm gwr}\times \delta_{\rm gw}/({\rm I}\times {\rm W}))~{\rm cm}^3 + {\rm kg/l-g}.$$

<sup>&</sup>lt;sup>a</sup>ASTM, 1995, Oakland RBCA (1999)

<sup>&</sup>lt;sup>b</sup>Oakland RBCA (1999) default value. The soils beneath the site are predominantly silty clay; therefore, soil parameters are the average of the sandy silt and clayey silt parameters.

<sup>&</sup>lt;sup>c</sup>Based on available scientific literature.

 $<sup>^{</sup>d}f_{oc} \times \mathbf{k}_{oc}$ 

<sup>&</sup>lt;sup>c</sup>Based on site data.

 $<sup>{}^{</sup>g}C_{s} \times LF$ .

Table 10. Leaching Model - Soil to Groundwater<sup>a</sup>

		_		TPH-G		TPI	I-D
			C5-C8	C9-C18	Ç9-C22	C9-C18	C9-C22
Parameter Parameter	Abbrev.	Units	aliphatics	aliphatics	aromatics	aliphatics	aromatics
Henry's law constant	H	unitless	42.64	250.51	0.17	250.51	0.17
Volumetric air content in vadose zone soils <sup>b</sup>	$ heta_{ m as}$	cm <sup>3</sup> /cm <sup>3</sup>	0.13	0.13	0.13	0.13	0.13
Volumetric water content in vadose zone soils <sup>b</sup>	$ heta_{ m ws}$	cm <sup>3</sup> /cm <sup>3</sup>	0.33	0.33	0.33	0.33	0.33
Groundwater darcy velocity <sup>b</sup>	$U_{air}$	cm/s	33.0	33.0	33.0	33.0	33.0
Groundwater mixing zone thickness <sup>b</sup>	$\delta_{\!\!\scriptscriptstyle{\mathrm{gw}}}$	cm	1143	1143	1143	1143	1143
Partition coefficient for organic carbon <sup>b</sup>	$k_{oc}$	cm³/g	1,778	65000 341,455	4,217	341,455	4,217
Organic carbon content of soil <sup>b</sup>	$f_{ m oc}$		1.8%	1.8%	1.8%	1.8%	1.8%
Sorption coefficient <sup>d</sup>	$k_s$	cm <sup>3</sup> /g	31.12	5975.46	73.80	5975.46	73.80
Soil bulk density <sup>b</sup>	$ ho_{ extsf{s}}$	g/cm <sup>3</sup>	1.72	1.72	1.72	1.72	1.72
Infiltration rate <sup>b</sup>	I	cm/yr	4.5	4.5	4.5	4.5	4.5
Width of source area <sup>e</sup>	W	cm	2286.0	2286.0	2286.0	305	305
Soil to ambient air volatilization factor <sup>f</sup>	LF	(mg/L)/(mg/kg)	6.2 E-3	3.6 E-5	2.9 E-3	5.9 E-6	4.7 E-4
Concentration in soil <sup>e</sup>	$C_s$	mg/kg	1.23	0.88	(1.40>	2,535	(1,365 >
Predicted groundwater concentration <sup>g</sup>	$C_{gw}$	mg/L	0.008	0.00003	0.004	0.015	0.647
Current average groundwater concentration <sup>e</sup>	$C_{gw}$	mg/L	9.76	6.97	11.16	ND	ND
Predicted concentration>current concentration?			NO	NO	NO	YES*	YES*

<sup>\*</sup> This model assumes that the asphalt is removed from the site. If the asphalt remains it will act as an effective barrier to infiltration. If infiltration is impeded, it is considered likely that there will no driving force for this COPC to move through the vadose zone, and if it does reach water it is unlikely to be in detectable amounts.

$${}^{f}\rho_{s}/[\theta_{as}+ks\times\rho_{s}+\theta_{as}\times H]\times(1+((U_{gwr}\times\delta_{gw}/(I\times W))\text{ cm}^{3}-kg/l-g.$$

<sup>&</sup>lt;sup>a</sup>ASTM, 1995, Oakland RBCA (1999)

<sup>&</sup>lt;sup>b</sup>Oakland RBCA (1999) default value. The soils beneath the site are predominantly silty clay; therefore, soil parameters are the average of the sandy silt and clayey silt parameters.

<sup>&</sup>lt;sup>c</sup>Based on available scientific literature.

 $<sup>^{</sup>d}f_{oc} \times \mathbf{k}_{oc}$ .

<sup>&</sup>lt;sup>e</sup>Based on site data.

 $<sup>^{</sup>g}C_{s} \times LF$ .

 Table 11. Exposure Parameters

				Valu	ie <sup>a</sup>	
			Commercial	Construction	Resident	Resident
Parameter	Abbrev.	Units	Worker	Worker	Child	Adult
Dermal absorption factor	ABS		0.1	0.1	NA	NA
Averaging time for carcinogens	$AT_c$	days	25,550	25,550	25,550	25,550
Averaging time for non-carcinogens	$AT_{nc}$	days	9,125	365	2,190	8,760
Body weight	BW	kg	70	70	15	70
Exposure frequency	EF	d/yr	250	183	350	350
Exposure duration	ED	years	25	1	6	24
Skin surface area exposed to soil	SA	$cm^2$	5,000	5,000	NA	NA
Soil adherence factor	AF	mg/cm <sup>2</sup>	0.5	0.5	NA	NA
Soil ingestion rate	SI	mg/d	50	480	NA	NA
Exposure time to indoor air	$\mathrm{ET_{ia}}$	hr/d	9		24	24
Exposure time to outdoor air	$\mathrm{ET}_{\mathrm{oa}}$	hr/d		9		
Outdoor air inhalation rate	$IR_{am}$	$m^3/d$		20		
Indoor air inhalation rate	$IR_{es}$	$m^3/d$	20		10	15

<sup>&</sup>lt;sup>a</sup>Oakland RBCA (1999) unless otherwise noted.

Table 12. RBCA Tier 3 Evaluation for Soil - Residential

	Exposure	RfD <sup>a</sup>	CSF <sup>a</sup>		LADD		$ADD^{c}$	Hazard
Chemical	Pathway	(mg/kg-d)	(mg/kg-d) <sup>-1</sup>	Conc.b	(mg/kg-d)	ILCR <sup>d</sup>	(mg/kg-d)	Index <sup>d</sup>
Indoor Air								
TPH-G								
C5-C8 aliphatics	Inhalation	0.06		3.7 E-4	4.7 E-5		3.1 E-4	0.0052
C9-C18 aliphatics	Inhalation	0.6		9.1 E-6	1.1 E-6		7.7 E-6	0.00001
C9-C22 aromatics	Inhalation	0.03		8.3 E-7	1.0 E-7	w-v No	7.1 E-7	0.00002
TPH-D								
C9-C18 aliphatics	Inhalation	0.06		2.7 E-3	3.4 E-4		2.3 E-3	0.038
C9-C22 aromatics	Inhalation	0.057		8.3 E-5	1.0 E-5		7.0 E-5	0.0012
Total Risk/HI Acro	ss Pathways	e				<del></del>		0.044
Site-Specific Targe	t Level (SST	L, in mg/kg	) <sup>f</sup> -TPG-G					665
Site-Specific Targe	t Level (SST	L, in mg/kg	) <sup>f</sup> -TPG-D					>100,000
SSTL Exceeded?						_		NO
Target Risk						1 E-5		1.0

<sup>&</sup>lt;sup>a</sup>From OEHHA (1994).

<sup>&</sup>lt;sup>b</sup>For air, concentration is in mg/m<sup>3</sup>; for soil, concentration is in mg/kg.

<sup>&</sup>lt;sup>c</sup>Air: LADD/ADD =  $(C_{air} \times IR \times ED \times EF \times AF_i) / (AT \times BW)$ .

Soil-Ingestion: LADD/ADD =  $(C_{soil} \times CF \times IR_s \times ED \times EF) / (AT \times BW)$ .

Soil-Dermal Contact: LADD/ADD =  $(C_{soil} \times CF \times SA \times SAF \times ED \times EF \times AFd) / (AT \times BW)$ .

 $<sup>^{</sup>d}ILCR = LADD \times CSF$ ; HI = ADD × RfD.

<sup>&</sup>lt;sup>e</sup>Assumes either an indoor or outdoor occupational worker.

<sup>&</sup>lt;sup>f</sup>SSTL =  $(C_{soil} \times (1 \times 10^{-5})) / ILCR \text{ or } (C_{soil} \times 1.0) / HI.$ 

Table 13. RBCA Tier 3 Evaluation for Soil - Commercial Worker

	Exposure	RfD <sup>a</sup>	CSF <sup>a</sup>		LADD <sup>e</sup>		ADD <sup>e</sup>	Hazard
Chemical	Pathway	(mg/kg-d)	(mg/kg-d) <sup>-1</sup>	Conc.b	(mg/kg-d)	ILCR <sup>d</sup>	(mg/kg-d)	Index <sup>d</sup>
<u>Indoor Air</u>								
TPH-G								
C5-C8 aliphatics	Inhalation	0.06		1.1 E-4	2.9 E-6		8.2 E-6	0.00014
C9-C18 aliphatics	Inhalation	0.6		2.7 E-6	7.2 E-8		2.0 E-7	0.000003
C9-C22 aromatics	Inhalation	0.03		2.5 E-7	6.6 <b>E-9</b>		1.8 E-8	0.0000003
TPH-D								
C9-C18 aliphatics	Inhalation	0.06		2.6 E-4	6.8 E-6		1.9 E-5	0.0003
C9-C22 aromatics	Inhalation	0.057		8.0 E-6	2.1 E-7		5.9 E-7	0.00001
Total Risk/HI Acro	ss Pathways	e						0.0005
Site-Specific Targe	t Level (SS7	L, in mg/kg	y) <sup>f</sup> -TPG-G					25,022
Site-Specific Targe	t Level (SST	L, in mg/kg	g) <sup>f</sup> -TPG-D					>100,000
SSTL Exceeded?								NO
Target Risk						1 E-5		1.0

<sup>&</sup>lt;sup>a</sup>From OEHHA (1994).

Soil-Ingestion: LADD/ADD =  $(C_{soil} \times CF \times IR_s \times ED \times EF) / (AT \times BW)$ .

Soil-Dermal Contact: LADD/ADD =  $(C_{soil} \times CF \times SA \times SAF \times ED \times EF \times AFd) / (AT \times BW)$ .

<sup>&</sup>lt;sup>b</sup>For air, concentration is in mg/m<sup>3</sup>; for soil, concentration is in mg/kg.

<sup>&</sup>lt;sup>c</sup>Air: LADD/ADD =  $(C_{air} \times IR \times ED \times EF \times AF_i) / (AT \times BW)$ .

 $<sup>^{</sup>d}ILCR = LADD \times CSF$ ;  $HI = ADD \times RfD$ .

<sup>&</sup>lt;sup>e</sup>Assumes either an indoor or outdoor occupational worker.

<sup>&</sup>lt;sup>f</sup>SSTL =  $(C_{soil} \times (1 \times 10^{-5})) / ILCR \text{ or } (C_{soil} \times 1.0) / HI.$ 

Table 14. RBCA Tier 3 Evaluation for Soil - Construction Worker

	Exposure	RfD <sup>a</sup>	CSF <sup>a</sup>		LADD <sup>c</sup>		$ADD^{c}$	Hazard
Chemical	Pathway	(mg/kg-d)	(mg/kg-d) <sup>-1</sup>	Conc.b	(mg/kg-d)	ILCR <sup>d</sup>	(mg/kg-d)	Index <sup>d</sup>
Soil								
TPH-G				5.66				
C5-C8 aliphatics	Ingestion	0.06		1.98	9.7 E-8		6.8 E-6	0.0001
C9-C18 aliphatics	Ingestion	0.6		1.42	6.9 E-8		4.9 E-6	0.00001
C9-C22 aromatics	Ingestion	0.03		2.26	1.1 E-7		7.8 E-6	0.0003
TPH-D				3,900				
C9-C18 aliphatics	Ingestion	0.06		2,535	1.2 E-4		8.7 E-3	0.15
C9-C22 aromatics	Ingestion	0.03		1,365	6.7 E-5		4.7 E-3	0.16
TPH-G				5.66				
C5-C8 aliphatics	Dermal	0.06		1.98	5.1 E-8		3.5 E-6	0.0001
C9-C18 aliphatics	Dermal	0.6		1.42	3.6 E-8		2.5 E-6	0.000004
C9-C22 aromatics	Dermal	0.03		2.26	5.8 E-8		4.1 E-6	0.0001
TPH-D				3,900				
C9-C18 aliphatics	Dermal	0.06		2,535	6.5 E-5		4.5 E-3	0.076
C9-C22 aromatics	Dermal	0.03		1,365	3.5 E-5		2.4 E-3	0.081
Outdoor Air								
TPH-G								
C5-C8 aliphatics	Inhalation	0.06		1.0 E-4	7.9 E-8		5.5 E-6	0.0001
C9-C18 aliphatics	Inhalation	0.6		2.5 E-6	1.9 <b>E</b> -9		1.4 E-7	0.0000002
C9-C22 aromatics	Inhalation	0.03		2.3 E-7	1.7 E-10		1.2 E-8	0.0000004
TPH-D								
C9-C18 aliphatics	Inhalation	0.06		1.5 E-2	1.2 E-5		8.1 E-4	0.014
C9-C22 aromatics	Inhalation	0.057		4.6 E-4	3.5 E-7		2.5 E-5	0.0004
Total Risk/HI Acro	ss Pathways	2				·····		0.47
Site-Specific Target Level (SSTL, in mg/kg) <sup>f</sup> -TPG-G								8,421
Site-Specific Targe	t Level (SST	L, in mg/kg	) <sup>f</sup> -TPG-D				,	8,249
SSTL Exceeded?								NO
Target Risk		·				1 E-5		1.0

<sup>&</sup>lt;sup>a</sup>From OEHHA (1994).

<sup>&</sup>lt;sup>b</sup>For air, concentration is in mg/m<sup>3</sup>; for soil, concentration is in mg/kg.

<sup>&</sup>lt;sup>c</sup>Air: LADD/ADD =  $(C_{air} \times IR \times ED \times EF \times AF_i) / (AT \times BW)$ .

Soil-Ingestion: LADD/ADD =  $(C_{soil} \times CF \times IR_s \times ED \times EF) / (AT \times BW)$ .

Soil-Dermal Contact: LADD/ADD =  $(C_{soil} \times CF \times SA \times SAF \times ED \times EF \times AFd) / (AT \times BW)$ .

 $<sup>^{</sup>d}ILCR = LADD \times CSF$ ; HI = ADD × RfD.

<sup>&</sup>lt;sup>e</sup>Assumes either an indoor or outdoor occupational worker.

 $<sup>^{\</sup>rm f}$ SSTL = ( $C_{\rm soil} \times (1 \times 10^{-5})$ ) / ILCR or ( $C_{\rm soil} \times 1.0$ ) / HI.

Table 15. RBCA Tier 3 Evaluation for Groundwater - Residential

	Exposure	RfD <sup>a</sup>	CSF <sup>a</sup>		LADD <sup>c</sup>	•	ADD <sup>c</sup>	Hazard
Chemical	Pathway	(mg/kg-d)	(mg/kg-d) <sup>-1</sup>	Conc.b	(mg/kg-d)	ILCR <sup>d</sup>	(mg/kg-d)	Index <sup>d</sup>
Indoor Air								
Benzene	Inhalation	0.0017	0.1	2.3 E-4	2.9 E-5	3 E-6	2.0 E-4	0.117
ТРН-С								
C5-C8 aliphatics	Inhalation	0.06		3.6 E-3	4.5 E-4		3.1 E-3	0.051
C9-C18 aliphatics	Inhalation	0.6		1.3 E-2	1.7 E-3		1.1 E-2	0.019
C9-C22 aromatics	Inhalation	0.03		5.3 E-4	6.7 E-5		4.5 E-4	0.015
Total Risk/HI Acro	ss Pathways	2				3 E-6		0.20
Site-Specific Targe	t Level (SSI	(L, in mg/L)	f-Benzene			14.7		37
Site-Specific Targe	t Level (SS7	(L, in mg/L)	<sup>f</sup> -TPG-G					329
SSTL Exceeded?						NO		NO
Target Risk						1 E-5		1.0

<sup>&</sup>lt;sup>a</sup>From OEHHA (1994).

<sup>&</sup>lt;sup>b</sup>For air, concentration is in mg/m<sup>3</sup>.

<sup>&</sup>lt;sup>c</sup>Air: LADD/ADD =  $(C_{air} \times IR \times ED \times EF \times AF_i) / (AT \times BW)$ .

 $<sup>^{</sup>d}ILCR = LADD \times CSF$ ;  $HI = ADD \times RfD$ .

<sup>&</sup>lt;sup>e</sup>Assumes either an indoor or outdoor occupational worker.

 $<sup>^{</sup>f}SSTL = (C \times (1 \times 10^{-5})) / ILCR \text{ or } (C \times 1.0) / HI.$ 

Table 16. RBCA Tier 3 Evaluation for Groundwater - Commercial Worker

	Exposure	RfD <sup>a</sup>	CSF <sup>a</sup>		LADD		ADD <sup>c</sup>	Hazard
Chemical	Pathway	(mg/kg-d)	(mg/kg-d) <sup>-1</sup>	Conc.b	(mg/kg-d)	ILCR <sup>d</sup>	(mg/kg-d)	Index <sup>d</sup>
<u>Indoor Air</u> TPH-G								
C5-C8 aliphatics	Inhalation	0.06		4.5 E-3	1.2 E-4		3.3 E-4	0.0056
C9-C18 aliphatics	Inhalation	0.6		1.7 E-2	4.3 E-4		1.2 E-3	0.0020
C9-C22 aromatics	Inhalation	0.03		7.1 E-4	1.9 E-5		5.2 E-5	0.0017
Total Risk/HI Acro	ss Pathways	e						0.009
Site-Specific Targe	t Level (SST	L, in mg/L)	f-Benzene					
Site-Specific Targe	t Level (SST			2,991				
SSTL Exceeded?								
Target Risk						1 E-5		1.0

<sup>&</sup>lt;sup>a</sup>From OEHHA (1994).

<sup>&</sup>lt;sup>b</sup>For air, concentration is in mg/m<sup>3</sup>.

<sup>&</sup>lt;sup>e</sup>Air: LADD/ADD =  $(C_{air} \times IR \times ED \times EF \times AF_i) / (AT \times BW)$ .

 $<sup>^{</sup>d}ILCR = LADD \times CSF$ ;  $HI = ADD \times RfD$ .

<sup>&</sup>lt;sup>e</sup>Assumes either an indoor or outdoor occupational worker.

 $<sup>^{</sup>f}SSTL = (C \times (1 \times 10^{-5})) / ILCR \text{ or } (C \times 1.0) / HI.$ 

Table 17. RBCA Tier 3 Evaluation for Groundwater - Construction Worker

	Exposure	RfD <sup>a</sup>	CSF <sup>a</sup>		LADD <sup>c</sup>		<b>ADD</b> <sup>c</sup>	Hazard
Chemical	Pathway	(mg/kg-d)	(mg/kg-d) <sup>-1</sup>	Conc.b	(mg/kg-d)	ILCR <sup>d</sup>	(mg/kg-d)	Index <sup>d</sup>
Outdoor Air								
TPH-G								
C5-C8 aliphatics	Inhalation	0.06		6.8 E-5	5.2 E-8		3.6 E-6	0.00006
C9-C18 aliphatics	Inhalation	0.6		2.5 E-4	1.9 E-7		1.3 E-5	0.00002
C9-C22 aromatics	Inhalation	0.03		1.0 E-5	7.9 E-9		5.5 E-7	0.00002
Total Risk/HI Acro	ss Pathways	•						0.00010
Site-Specific Targe	t Level (SST				274,594			
SSTL Exceeded? —								
Target Risk 1 E-5								

<sup>&</sup>lt;sup>a</sup>From OEHHA (1994).

<sup>&</sup>lt;sup>b</sup>For air, concentration is in mg/m<sup>3</sup>.

<sup>&</sup>lt;sup>c</sup>Air: LADD/ADD =  $(C_{air} \times IR \times ED \times EF \times AF_i) / (AT \times BW)$ .

 $<sup>^{</sup>d}ILCR = LADD \times CSF$ ;  $HI = ADD \times RfD$ .

<sup>&</sup>lt;sup>e</sup>Assumes either an indoor or outdoor occupational worker.

 $<sup>^{</sup>f}SSTL = (C \times (1 \times 10^{-5})) / ILCR \text{ or } (C \times 1.0) / HI.$ 

Table 18. Product-Specific Fractions, Fraction Composition, and Toxicity Criteria<sup>a</sup>

Product	Fractions	Composition	Toxicity Criteria
Benzene		•	$CSF = 0.1 \text{ (mg/kg-d)}^{-1b}$
TPH as gasolin	e (TPH-g)		
	C5-C8 aliphatics	35%	RfD = 0.06  mg/kg-d (n-hexane)
	C9-C18 aliphatics	25%	RfD = 0.6  mg/kg-d (n-nonane)
	C9-C22 aromatics	40%	RfD = 0.03  mg/kg-d (pyrene)
TPH as diesel (	TPH-d)		
	C9-C18 aliphatics	65%	RfD = 0.6  mg/kg-d (n-nonane)
	C9-C22 aromatics	35%	RfD = 0.03  mg/kg-d oral (pyrene)
			$RfD = 0.057 \text{ mg/kg-d inhalation (pyrene)}^{c}$

<sup>&</sup>lt;sup>a</sup>From MaDEP, 1997.

<sup>&</sup>lt;sup>b</sup>From OEHHA, 1994.

<sup>&</sup>lt;sup>e</sup>From TPHCWG, 1996.

Table 19. RBCA Tier 3 Hazard/Risk Summary

	Construction	Commercial	
	Worker	Worker	Resident
<b>Hazard Index</b>			
Soil	0.47	0.00047	0.044
Groundwater	0.00010	0.009	0.20
Incremental Lifetin	ne Cancer Risk		
Soil			
Groundwater		<b>4 = 4</b>	3 E-6

## APPENDIX A DATA SUMMARY

 Table A-2. Groundwater Data Summary

	_	diawater E					Ethyl-		
Sample	Media	Date	Units	TPH-G	Benzene	Toluene	benzene	Xylenes	MTBE
MW-1	GW	1/21/1999	ppb	18,000	120	37	590	1,800	2,700
MW-1	GW	4/30/1999	ppb	17,000	240	89	1,100	1,900	1,600
MW-1	GW	7/9/1999	ppb	58,000	140	100	1,800	6,900	1,200
MW-1	GW	11/3/1999	ppb	20,000	62	42	620	2,100	630
MW-2	GW	1/21/1999	ppb	<50	<1	<1	<1	<1	1.9
MW-2	GW	4/30/1999	ppb	NA	NA	NA	NA	NA	NA
MW-2	GW	7/9/1999	ppb	NA	NA	NA	NA	NA	NA
MW-2	GW	11/3/1999	ppb	NA	NA	NA	NA	NA	NA
MW-2	GW	6/19/1998	ppb	< 50	< 0.5	<1	<1	<1	<10
MW-2	GW	4/10/1998	ppb	< 50	1	<1	<1	<1	23
MW-2	GW	1/21/1998	ppb	160	< 0.5	<1	<1	<1	100
MW-3	GW	4/9/1998	ppb	950	< 0.5	<1	<1	<1	890
MW-3	GW	6/19/1998	ppb	1,800	< 0.5	<1	<1	<1	1,900
MW-3	GW	1/21/1999	ppb	1,100	< 0.5	<1	<1	<1	1,200
MW-3	GW	4/30/1999	ppb	NA	NA	NA	NA	NA	NA
MW-3	GW	7/9/1999	ppb	470	< 0.5	<1	<1	<1	470
MW-3	GW	11/3/1999	ppb	NA	NA	NA	NA	NA	NA
AW-1	GW	11/30/1998	ppb	23,000	6,700	<25	3,100	130	820
AW-1	GW	1/21/1999	ppb	25,000	4,800	54	2,800	780	1,000
AW-1	GW	4/30/1999	ppb	21,000	5,300	67	2,800	750	1,500
AW-1	GW	7/9/1999	ppb	11,000	3,000	<10	760	180	1,300
AW-1	GW	11/3/1999	ppb	NA	NA	NA	NA	NA	NA
AW-2	GW	1/21/1998	ppb	160	13	<1	<1	<1	110
AW-2	GW	4/9/1998	ppb	NA	NA	NA	NA	NA	NA
AW-2	GW	4/10/1998	ppb	<50	< 0.5	<1	<1	<1	<10
AW-2	GW	6/19/1998	ppb	60	< 0.5	<1	<1	<1	<10
AW-2	GW	11/30/1998	ppb	NA	NA	NA	NA	NA	NA
AW-2	GW	1/21/1999	ppb	< 50	< 0.5	<1	<1	<1	<1
AW-2	GW	4/30/1999	ppb	NA.	NA	NA	NA	NA	NA
AW-2	GW	7/9/1999	ppb	NA	NA	NA	NA	NA	NA
AW-2	GW	11/3/1999	ppb	NA	NA	NA	NA	NA	NA
AW-3	GW	1/21/1998	ppb	150	< 0.5	<1	<1	1.2	110
AW-3	GW	4/9/1998	ppb	NA	NA	NA	NA	NA	NA
AW-3	GW	4/10/1998	ppb	<50	< 0.5	<1	1	2	<10
AW-3	GW	6/19/1998	ppb	< 50	< 0.5	<1	<1	<1	<10
AW-3	GW	11/30/1998	ppb	NA	NA	NA	NA	NA	NA
AW-3	GW	1/21/1999	ppb	<50	<1	<1	<1	<1	<1
AW-3	GW	4/30/1999	ppb	NA	NA	NA	NA	NA	NA
AW-3	GW	7/9/1999	ppb	NA	NA	NA	NA	NA	NA
AW-3	GW	11/3/1999	ppb	NA	NA	NA	NA	NA	NA
AW-4	GW	4/10/1998	ppb	890	< 0.5	<1	<1	<1	730
AW-4	GW	6/19/1998	ppb	60	< 0.5	<1	<1	<1	34
AW-4	GW	11/30/1998	ppb	NA	NA	NA	NA	NA	NA
AW-4	GW	1/21/1999	ppb	3,700	830	93	200	360	30
AW-4	GW	4/30/1999	ppb	NA	NA	NA	NA	NA	NA
AW-4	GW	7/9/1999	ppb	76,000	12,000	7	2,000	8,700	320
AW-4	GW	11/3/1999	ppb	NA	NA	NA	NA	NA	NA

Table A-2. Groundwater Data Summary

				-			Ethyl-		
Sample	Media	Date	Units	TPH-G	Benzene	Toluene	benzene	Xylenes	MTBE
AW-5	GW	4/10/1998	ppb	3,500	<0.5	<1	<1	<1	3,000
AW-5	GW	6/19/1998	ppb	3,300	< 0.5	<1	<1	<1	2,500
AW-5	GW	11/30/1998	ppb	NA	NA	NA	NA	NA	NA
AW-5	GW	1/21/1999	ppb	2,800	<1	<1	<1	<1	1,800
AW-5	GW	4/30/1999	ppb	NA	NA	NA	NA	NA	NA
AW-5	GW	7/9/1999	ppb	4,000	<1	<1	<1	<1	3,500
AW-5	GW	11/3/1999	ppb	NA	NA	NA	NA	NA	NA
AW-6	GW	1/21/1998	ppb	160	< 0.5	<1	<1	<1	110
AW-6	GW	4/9/1998	ppb	NA	NA	NA	NA	NA	NA
AW-6	GW	4/10/1998	ppb	370	<0.5	<1	<1	<1	300
AW-6	GW	6/19/1998	ppb	830	2	<1	<1	<1	690
AW-6	GW	11/30/1998	ppb	NA	NA	NA	NA	NA	NA
AW-6	GW	1/21/1999	ppb	2,300	<1	<1	<1	<1	1,900
AW-6	GW	4/30/1999	ppb	NA	NA	NA	NA	NA	NA
AW-6	GW	7/9/1999	ppb	NA	NA	NA	NA	NA	NA
AW-6	GW	11/3/1999	ppb	NA	NA	NA	NA	NA	NA
AW-7	GW	1998	ppb	<50	< 0.5	<1	<1	<1	<10
AW-7	GW	1999	ppb	NA	NA	NA	NA	NA	NA
AW-8	GW	1998	ppb	<50	< 0.5	<1	<1	<1	<10
AW-8	GW	1999	ppb	NA	NA	NA	NA	NA	NA
AW-9	GW	1998	ppb	<50	< 0.5	<1	<1	<1	<10
AW-9	GW	1999	ppb	NA	NA	NA	NA	NA	NA
RW-1	GW	4/10/1998	ppb	220,000	26,000	46,000	4,400	24,500	<2,500
RW-1	GW	6/19/1998	ppb	180,000	19,000	32,000	3,000	17,400	<2,500
RW-1	GW	11/30/1998	ppb	NA	NA	NA	NA	NA	NA
RW-1	GW	1/21/1999	ppb	260,000	24,000	46,000	5,100	30,000	1,700
RW-1	GW	7/9/1999	ppb	NA	NA	NA	NA	NA	NA
RW-1	GW	11/3/1999	ppb	160,000	19,000	37,000	3,800	25,000	1,500

NA = not analyzed

TPH-G = Total petroleum hydrocarbons as gasoline

TPH-D = Total petroleum hydrocarbons as diesel

MTBE = Methyl tertiary butyl ether

Table A-1. Soil Data Summary

		Sample								Ethyl-	· · ·	
Sample	Media	Depth	Date	Units	TPH-G	TPH-D	TPH-O	Benzene	Toluene	benzene	Xylenes	MTBE
TD-5-0.5	Soil	0.5	Dec-94	ppm	ND	3900	ND	ND	ND	ND	ND	NA
P3	Soil	2.5	Jul-90	ppm	9.4	NA	NA	0.029	0.096	0.52	3	NA
P1	Soil	3	Jul-90	ppm	<1	NA	NA	0.9	0.079	0.0066	0.034	NA
P1	Soil	3.5	Oct-98	ppm	<1	NA	NA	< 0.005	< 0.005	< 0.005	0.029	< 0.05
P2	Soil	3.5	Oct-98	ppm	<1	NA	NA	< 0.005	< 0.005	< 0.005	< 0.005	4
P3	Soil	3.5	Oct-98	ppm	<1	NA	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05
P4	Soil	3.5	Oct-98	ppm	<1	NA	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05
P5	Soil	3.5	Oct-98	ppm	<1	NA	NA	0.0085	0.047	0.0071	0.057	0.74
P6	Soil	3.5	Oct-98	ppm	<1	NA	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05
P7	Soil	3.5	Oct-98	ppm	1.2	NA	NA	0.067	0.09	< 0.005	0.042	2
P8	Soil	3.5	Oct-98	ppm	<1	NA	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05
P2	Soil	4.5	Jul-90	ppm	<1	NA	NA	< 0.005	0.047	0.011	0.037	NA
AW-1	Soil	5	Jun-90	ppm	<1	NA	NA	< 0.005	< 0.005	< 0.005	< 0.005	NA
RW-1	Soil	5	Jun-90	ppm	<1.0	NA	NA	< 0.005	< 0.005	< 0.005	< 0.005	NA
D1	Soil	7	Jul-90	ppm	12	NA	NA	0.053	0.39	0.16	0.96	NA
D2	Soil	7	Jul-90	ppm	3.3	NA	NA	0.029	0.48	0.044	0.22	NA
THP1-S-9.5-10.5	Soil	9.5	Oct-94	ppm	ND	ND	ND	0.92	ND	0.008	ND	NA
AW-1	Soil	10	Jun-90	ppm	<1	NA	NA	0.011	< 0.005	< 0.005	< 0.005	NA
RW-1	Soil	10	Jun-90	ppm	<1.0	NA	NA	0.006	< 0.005	< 0.005	< 0.005	NA
SW1	Soil	10	Jul-90	ppm	1.3	NA	NA	0.011	0.056	0.025	0.035	NA
SW2	Soil	10	Jul-90	ppm	23	NA	NA	0.015	0.1	0.23	0.18	NA
SW3	Soil	10	Jul-90	ppm	12	NA	NA	0.016	0.018	0.12	0.25	NA
SW4	Soil	10	Jul-90	ppm	3.8	NA	NA	0.016	0.02	0.05	0.064	NA
AW-4	Soil	11	Jun-90	ppm	<1.0	NA	NA	< 0.005	< 0.005	< 0.005	< 0.005	NA
SW1	Soil	12	Oct-98	ppm	<1	NA	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05
SW2	Soil	12	Oct-98	ppm	<1	NA	NA	< 0.005	< 0.005	< 0.005	< 0.005	0.43
SW3	Soil	12	Oct-98	ppm	<1	NA	NA	< 0.005	< 0.005	< 0.005	< 0.005	0.099
SW4	Soil	12	Oct-98	ppm	<1	NA	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05
THP-1-S-13-13.5	Soil	13	Oct-94	ppm	ND	ND	ND	0.024	ND	ND	ND	NA
AW-1	Soil	15	Jun-90	ppm	<1	NA	NA	0.007	< 0.005	< 0.005	< 0.005	NA
RW-1	Soil	15	Jun-90	ppm	<1.0	NA	NA	0.031	< 0.005	< 0.005	< 0.005	NA
AW-4	Soil	16	Jun-90	ppm	<1.0	NA	NA	0.17	0.01	0.024	0.045	NA
VEW-9	Soil	16.5	May-96	ppm	<0.1	NA	NA	< 0.001	< 0.002	< 0.002	< 0.002	<0.1

Table A-1. Soil Data Summary

		Sample								Ethyl-		
Sample	Media	Depth	Date	Units	TPH-G	TPH-D	TPH-O	Benzene	Toluene	benzene	Xylenes	MTBE
AW-1	Soil	20	Jun-90	ppm	1.2	NA	NA	0.47	< 0.005	< 0.005	< 0.005	NA
RW-1	Soil	20	Jun-90	ppm	<1.0	NA	NA	0.23	0.088	0.01	0.04	NA
AW-2	Soil	21	Jun-90	ppm	<1.0	NA	NA	< 0.005	< 0.005	< 0.005	< 0.005	NA
AW-3	Soil	21	Jun-90	ppm	<1.0	NA	NA	0.074	0.027	0.01	0.049	NA
AW-4	Soil	21	Jun-90	ppm	1	NA	NA	0.15	0.013	0.04	0.09	NA
AW-1	Soil	25	Jun-90	ppm	<1.0	NA	NA	0.013	< 0.005	< 0.005	< 0.005	NA
RW-1	Soil	25	Jun-90	ppm	33	NA	NA	1	0.71	< 0.005	2.3	NA
AW-2	Soil	26	Jun-90	ppm	<1.0	NA	NA	< 0.005	< 0.005	< 0.005	< 0.005	NA
AW-3	Soil	26	Jun-90	ppm	<1.0	NA	NA	0.083	0.01	0.04	0.018	NA
AW-1	Soil	30	Jun-90	ppm	<1.0	NA	NA	< 0.005	< 0.005	< 0.005	< 0.005	NA
SBA-5 (AW-5)	Soil	10.5-11	Apr-91	ppm	<1	NA	NA	0.016	< 0.003	< 0.003	< 0.003	NA
SBA-6 (AW-6)	Soil	10.5-11	Apr-91	ppm	<1	NA	NA	0.091	0.022	0.008	0.04	NA
SBA-7 (AW-7)	Soil	10.5-11	Apr-91	ppm	<1	NA	NA	< 0.003	< 0.003	< 0.003	< 0.003	NA
SBA-8 (AW-8)	Soil	10.5-11	Apr-91	ppm	<1	NA	NA	< 0.003	< 0.003	< 0.003	< 0.003	NA
AW-9	Soil	16.5-17	Dec-96	ppm	<0.1	NA	NA	< 0.001	< 0.002	< 0.002	< 0.002	< 0.1
AW-9	Soil	19-19.5	Dec-96	ppm	< 0.1	NA	ÑΑ	< 0.001	< 0.002	< 0.002	< 0.002	< 0.1
SBA-5 (AW-5)	Soil	20.5-21	Apr-91	ppm	<1	NA	NA	0.02	< 0.003	0.007	0.008	NA
SBA-6 (AW-6)	Soil	20.5-21	Apr-91	ppm	<1	NA	NA	< 0.003	< 0.003	< 0.003	< 0.003	NA
SBA-7 (AW-7)	Soil	20.5-21	Арт-91	ppm	<1	NA	NA	< 0.003	< 0.003	< 0.003	< 0.003	NA
SBA-8 (AW-8)	Soil	20.5-21	Apr-91	ppm	<1	NA	NA	< 0.003	< 0.003	< 0.003	< 0.003	NA
SBA-5 (AW-5)	Soil	25.5-26	Apr-91	ppm	<1	NA	NA	0.077	< 0.003	0.003	0.011	NA
SBA-6 (AW-6)	Soil	25.5-26	Apr-91	ppm	<1	NA	NA	0.005	0.01	< 0.003	0.0066	NA
SBA-7 (AW-7)	Soil	25.5-26	Apr-91	ppm	<1	NA	NA	< 0.003	< 0.003	< 0.003	< 0.003	NA
SBA-8 (AW-8)	Soil	25.5-26	Apr-91	ppm	<1	NA	NA	< 0.003	< 0.003	< 0.003	< 0.003	NA
VEW-9	Soil	comp	May-96	ppm	<0.1	NA	NA	< 0.001	< 0.002	< 0.002	< 0.002	< 0.1

NA = not analyzed

ND = not detected, no detection limit located

Comp = composite

TPH-G = Total petroleum hydrocarbons as gasoline

TPH-D = Total petroleum hydrocarbons as diesel

TPH-O = Total petroleum hydrocarbons as oil

MTBE = Methyl tertiary butyl ether

## Oakland RBCA Cover Sheet

Project Proponent: BP Oil Company Site Address: 2220 98th Avenue Alameda County Parcel Number(s):

Submitted by: BP Oil

	Chemicals of Conce	rn								
(1) Benzene (4)	Xylenes	(7)								
(2) Toluene (5)	MTBE	(8)								
(3) Ethylbenzene (6)		(9)								
Ex	osure Pathways of C	oncern								
Surficial Soil		Groundwater								
☐Ingestion/dermal contact/inhalation ☐Ingestion of groundwater										
Subsurface Soil  Subsurface Soil										
☐ Ingestion of groundwater impacts	d by leachate	Inhalation of outdoor air vapors								
☑Inhalation of indoor air vapors	•	Water Used for Recreation								
Inhalation of outdoor air vapors		☐Ingestion/dermal contact								
*										
	Land Use Scenario	0								
⊠Residential (Off-Si	te)	⊠Commercial/Industrial								
Method of Analysis										
⊠Tier l										
Tier 2 (specify soil type: Merrit	t sands 🛮 🖾 sandy sil	lts								
—		ther(s) (specify: )								
		, (-F)								
A	pplication of RBCA I	evels								
As evidence that no further action required	<del></del>									
As target cleanup levels for removal or tre		of concern								
Other (specify: acceptability for future co										
Zomer (speed). Receptabling for fattale ex										
	Containment Measu	YAS								
Cap (specify material: )										
Other(s) (specify:	∟ vapor	barrier (specify material: )								
Exposure pathways that will be affected:										
Exposure painways that will be affected.										
	¥ 414 41 1 200 1									
	Institutional Contro									
Permit tracking Deed restriction	_	ce Water well restriction								
Access control Other(s) (special	y: )									
		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1								
	Public Notification	1								
Specify all actions to be taken:										

Date submitted: May 12, 2000