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21 March 2000

Lawrence Seto  
Alameda County Health Agency  
Division of Environmental Protection  
1131 Harbor Bay Parkway, 2nd Floor  
Alameda, California 94502

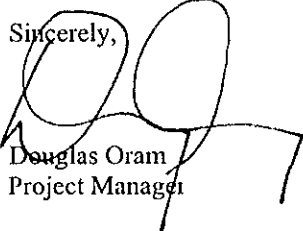
RE: Nestle USA Inc. Facility, 1310 14<sup>th</sup> Street, Oakland, California

Dear Mr. Seto:

Attached for your review is a Draft Risk-Based Corrective Action Analysis for the above-referenced site. The risk analysis was done based on data from historical environmental investigations, recent analysis of soil vapor samples, and current groundwater monitoring. Please provide comments regarding the risk analysis to ETIC's office by 31 April 2000 if possible. Comments can be provided in writing or by e-mail ([doram@eticeng.com](mailto:doram@eticeng.com)).

If you have any immediate questions regarding this project, please contact Binayak Acharya at 818-549-5948 or me at the number listed below.

Sincerely,



Douglas Oram  
Project Manager

cc: Betty Graham, California Regional Water Quality Control Board, San Francisco Bay Region  
Roger Brewer, California Regional Water Quality Control Board, San Francisco Bay Region  
Binayak Acharya, Nestle USA



## MEMORANDUM

Risk-Based Corrective Action Analysis  
Nestle USA, Inc. Facility  
1310 14<sup>th</sup> Street  
Oakland, CA

March 17, 2000

*Prepared for:*

ETIC Engineering, Inc.

*Prepared by:*

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March 17, 2000

**DRAFT**

**MEMORANDUM**

**To:** Doug Oram, Ph.D.  
ETIC Engineering, Inc.

**From:** Mehrdad M. Javaherian, Ph.D., P.Hg., P.E., DABT *MJ*  
Javaherian Consulting, Inc.

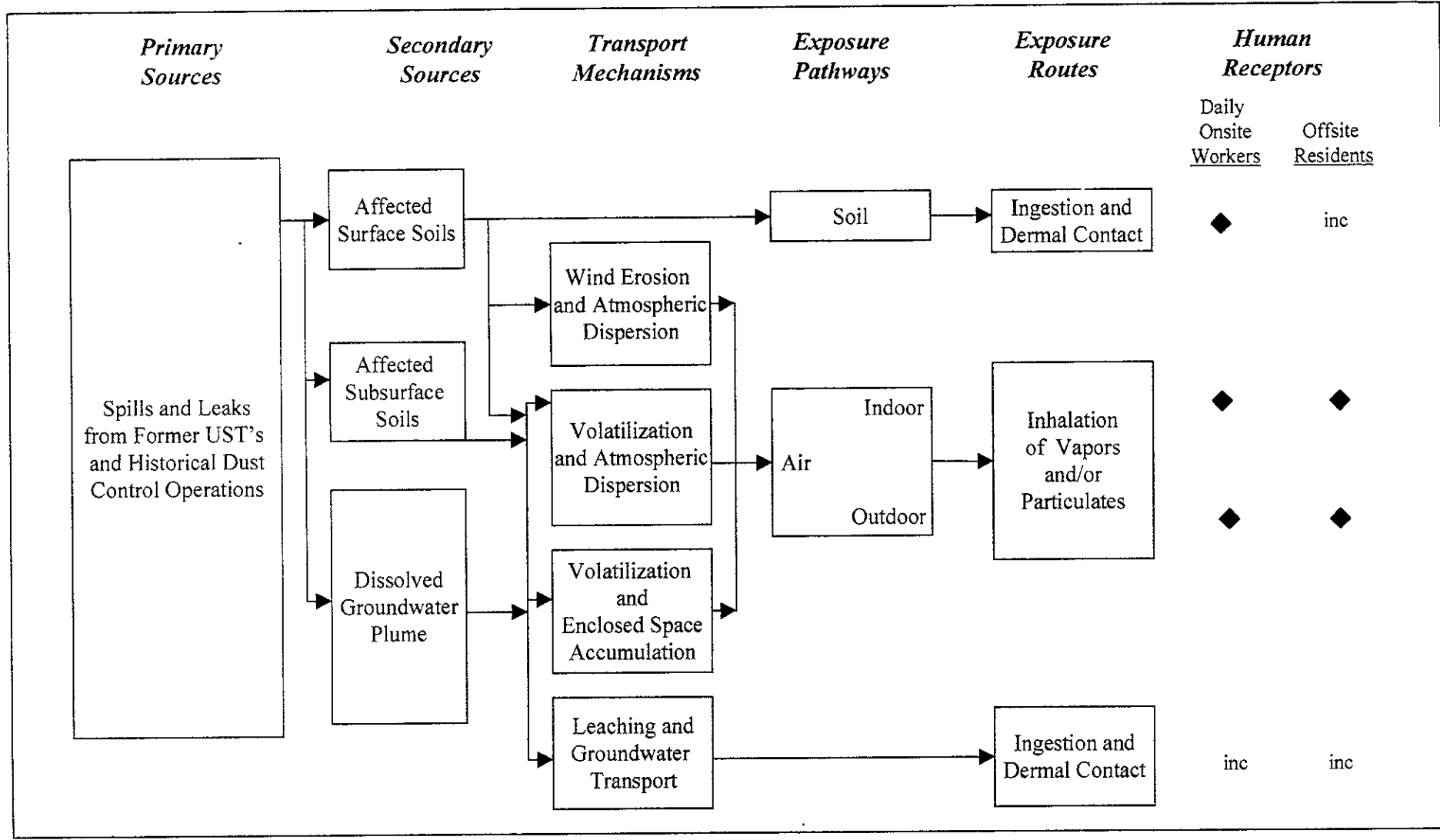
**Re:** Risk-Based Corrective Action Analysis  
Nestle USA, Inc. Facility  
1310 14<sup>th</sup> Street, Oakland, CA

This memorandum documents a risk-based corrective action (RBCA)-analysis and associated conceptual site model (CSM) for the above referenced site, focusing on protection of human health at and in the vicinity of the site. This analysis was based on RBCA guidelines outlined by the American Society for Testing and Materials (ASTM, 1995 and 1998), the USEPA (1991), and the California Environmental Protection Agency Department of Toxic Substance Control ([DTSC], 1994). This RBCA analysis is based on available historical data collected at the site, including the 4<sup>th</sup> Quarter 1999 groundwater monitoring event and recently collected soil matrix and soil gas data (ETIC Engineering, Inc. [ETIC], 1999). Moreover, this RBCA analysis focuses on continued commercial/industrial land use, with the purpose of determining potential health risks to future site occupants in the absence of continued remediation.

**CONCEPTUAL SITE MODEL**

As the initial step in evaluation of health risks resulting from potential exposure to contaminants at the site, a conceptual site model (CSM) of chemical occurrence, fate, transport, and potential exposure was developed. Specifically, the CSM documents sources of chemicals, affected media and transport mechanisms, and potential exposure pathways and receptors. Development of the CSM was based on available information characterizing land use and hydrogeologic conditions, together with soil gas, soil matrix, and groundwater quality data summarized by ETIC (1999). Figure 1 is a graphical representation of the CSM, which is comprised of the components summarized below.

**Sources of Chemicals:** Historical site investigations have identified the subsurface presence of chemicals consistent with those used at the site. Occurrence of chemicals in soil and groundwater underlying the site is likely due to historical spills and releases associated with former underground storage tanks (USTs), dust control operations, which utilized used oil.. No primary sources in the form of on-going leaks and/or spills are known to exist at the site, with USTs and associated piping and dispensers removed in 1988 and 1989 (ETIC, 1999). The presence of residual non-aqueous phase liquids (NAPLs) and impacted soils and



◆ Complete pathway  
 inc Incomplete pathway

**Conceptual Site Model**  
 Nestle Oakland Facility  
 Oakland, CA

Figure No. 1  
 Date: March 2000

groundwater serve as potential secondary sources of chemicals. To address secondary sources, remedial efforts at the site have included soil excavation, NAPL skimming, soil vapor extraction, and multi-phase extraction activities. Details of remedial actions are summarized by ETIC (1999).

**Affected Media and Transport Mechanisms:** Review of historical investigation results indicates the presence of chemicals in surface soils (< 4 ft below ground surface [bgs]), subsurface soils (>4 ft bgs), and groundwater. Impacted groundwater is a result of dissolution and leaching of chemicals through soils and NAPL migration to the water table. Due to the volatile nature of various chemicals released at the site, soil vapor underlying the site has also been impacted. Offsite migration of chemicals in groundwater appears limited to the immediate vicinity of the site. This is due in part to the limited groundwater velocity (0.5 ft/day) estimated at the site.

**Land and Groundwater Use:** Historical land use at the site has been limited to industrial use. Plans for future property transfer and land use involve continued industrial/commercial use (ETIC, 2000). While much of the area surrounding the site is characterized by industrial land use, a residential facility is located approximately 100 feet hydraulically downgradient of the site.

Review of available data indicates that no water supply wells are present at or within a one mile radius of the site (ETIC, 1999 and 2000). Given the fine-grained sediments, limited saturated thickness, and low permeability of the sediments underlying the site, development of potable water supplies at and in the vicinity of the site is highly unlikely. Furthermore, potential water supply development would likely be limited to deeper water-bearing units, as opposed to the shallow unit impacted by past site operations.

**Potential Exposure Pathways and Receptors:** Potential exposure pathways and receptors (exposure scenarios) were evaluated based on the previously defined sources of chemicals, affected media, transport mechanisms, and land use at and in the vicinity of the site. This analysis accounted for the four principal elements of an exposure pathway:

- 1) a source and mechanism of chemical release;
- 2) one or more retention or transport media (e.g., soil, groundwater, and/or air);
- 3) a point of potential contact with the contaminated medium (referred to as the exposure point); and
- 4) an exposure route at the point of contact (e.g., inhalation, ingestion, or dermal contact).

Analysis of exposure pathways links sources, locations, and types of environmental releases with population locations and activity patterns, in order to establish significant and complete exposure pathways. Based on available data, analysis of exposure pathways for human receptors at and in the vicinity of the site is summarized below.

Because of the current presence of a paved surface throughout the site, direct exposure of site occupants to surface soils (<4 ft bgs) and associated contaminants is not likely. Future site development plans (industrial/commercial use) indicate the presence of a paved surface throughout much of the site, with some unpaved areas (ETIC, 2000). Accordingly, future site occupants may potentially be exposed to chemicals in surface soils within unpaved areas. Direct exposure to soils may occur via ingestion, inhalation, and dermal contact.

Based on the presence of volatile organic compounds (VOCs) in soil and groundwater underlying the site, daily onsite industrial/commercial workers may be subject to inhalation of contaminated vapor emissions to ambient and/or indoor air. Exposure of offsite downwind receptors to vapor emissions from the site is assumed negligible, since the magnitude of risk-based target levels associated with the inhalation route of exposure will be governed by the larger intake associated with onsite receptors.

Based on the depth to the water table of the shallow aquifer (approximately 7 feet below ground surface) and absence of potential drinking water sources at and in the vicinity of the site, direct exposure to groundwater at on- and offsite locations is assumed incomplete. Chemical concentrations in groundwater have historically remained at low levels in downgradient monitoring wells immediately adjacent to the site (ETIC, 1999). As a result, indirect exposure (inhalation of volatiles from groundwater) of nearby residents to chemicals in offsite groundwater is considered insignificant. Nevertheless, this pathway was assumed complete and conservatively evaluated based on potential volatilization to ambient and indoor air.

Future construction work at the site may also result in exposure of construction workers to chemicals in soil and groundwater. However, this risk will be addressed through risk management practices and appropriate health and safety measures implemented prior to construction, ensuring protection of future construction workers.

To summarize, the following exposure scenarios corresponding to relevant human receptors were assumed complete in this RBCA analysis:

- Ingestion, inhalation, and dermal contact with surface soils (on-site industrial/commercial worker);
- inhalation of volatile emissions from subsurface soils and groundwater to indoor air (on-site industrial/commercial worker);
- inhalation of volatile emissions from subsurface soils and groundwater to ambient air (on-site industrial/commercial worker);
- inhalation of volatile emissions from groundwater to indoor air (off-site residents); and
- inhalation of volatile emissions from groundwater to ambient air (off-site residents).

## **RISK-BASED CORRECTIVE ACTION ANALYSIS**

Making use of available site characterization data, a RBCA analysis based on ASTM (1995 and 1998) USEPA (1991), and DTSC (1994) guidelines was performed. The RBCA process is the integration of site assessment, remedial action selection, and monitoring with USEPA-recommended risk and exposure assessment practices. This creates a process by which corrective action decisions are made in a consistent manner that is protective of human health and the environment.

### **Tier I RBCA Input Data**

Consistent with the Tiered approach adopted by the ASTM RBCA guidelines, the initial attempt at evaluating the risk associated with potential exposure to chemicals emanating from the site was based on a Tier I evaluation. As outlined in ASTM (1995 and 1998), the Tier I evaluation involves comparison of the site-specific chemical source concentrations to highly conservative, generic Risk-Based Screening Levels (RBSLs) based on simplified chemical transport and exposure equations. These algorithms are supplemented by generalized site conditions conservatively represented by default data adopted by ASTM (1995 and 1998). All Tier I input data are included as Appendix I. Chemical-specific toxicity data are included as Appendix II.

In performing the Tier I analysis, the above mentioned input data were further supplemented by source concentrations for each chemical of potential concern (COPC) corresponding to the previously defined exposure scenarios. Consistent with ASTM (1995) guidelines, evaluation of risks associated with petroleum hydrocarbons in this RBCA analysis focused on individual chemical constituents such as benzene, toluene, ethylbenzene, and xylenes (BTEX). The risk associated with hydrocarbon fuel mixtures (i.e. TPH-g and TPH-d) was not quantified; however, by evaluating the risk associated with the most toxic and mobile hydrocarbons (e.g. BTEX), potential health impacts associated with exposure to hydrocarbon mixtures was indirectly evaluated. In fact, the conservative approach for quantifying risks associated with hydrocarbon mixtures, as outlined by Massachusetts Department of Environmental Protection ([MDEP] 1994), makes use of indicator and/or surrogates such as BTEX for evaluation of the risk associated with TPH-g and TPH-d; hence, findings with respect to individual hydrocarbon constituents may be conservatively used as representative of hydrocarbon fuel mixtures.

For each exposure scenario, COPCs and media-specific source concentrations were identified based on available soil matrix, soil vapor, and groundwater quality data. The rationale behind selection of COPCs and associated source concentrations for each exposure scenario is summarized below.

***Inhalation, Ingestion, and Dermal Contact with Soils-Onsite Commercial/Industrial Receptor:*** For evaluation of direct exposure to chemicals in onsite soils, all chemicals detected in surface soils (<4 ft bgs) were included as COPCs (see Table 1). Selection of COPC source concentrations involved a detailed review of on-going remediation efforts and historical soil and groundwater quality data. While the presence of NAPLs has contributed to the historical levels of chemicals in soil and groundwater, on-going NAPL remediation and past remedial activities (soil excavation, soil vapor extraction) have resulted in removal and/or stabilization of chemical levels in the subsurface (ETIC, 1999). As a conservative measure, selection of COPC soil source concentrations focused on historical maximum chemical levels detected in soil (see Table 1). Specifically, maximum chemical concentrations in soil samples collected from <4 feet bgs were used to represent soil quality in surface soils.

**Table 1. Chemicals of Potential Concern and Source Concentrations  
Direct Exposure to Surface Soils  
Onsite Commercial/Industrial Receptor**

COPC	COPC Source Concentration* (mg/kg)
1,2-Dichloroethane (1,2-DCA)	2.50E-03
Ethylbenzene	2.70E-03
Toluene	2.00E-03
Xylenes	2.70E-03

\* Concentrations represent historical maximum values in shallow (<4 ft bgs) soil samples

***Ambient and Indoor Air Inhalation of Volatiles from Soils and Groundwater-Onsite Commercial/Industrial Receptors:*** For evaluation of indirect exposure to chemicals in soils and groundwater, recently collected shallow (3 ft bgs) soil vapor quality data within the footprint of contaminated soils and groundwater plumes were used as representative of COPC source concentrations. Soil vapor concentrations at 3 feet bgs correspond to vapor contribution from all potential subsurface sources, including residual NAPLs, soils, and groundwater. Hence, risk estimates using soil vapor quality data represent total pathway risks to indoor and outdoor receptors from combined soil and groundwater

sources. Use of soil vapor data in risk assessments is acknowledged by the USEPA (1989), DTSC (1994, 1999), GSI (1995 and 1997), and the California Regional Water Quality Control Board San Francisco Bay Region (RWQCB, 1999).

As a result of using soil vapor quality data, chemicals detected in shallow soil vapor samples were included as COPCs (see Table 2), with their maximum detected concentrations used as representative of source levels in vapor phase. This list of COPCs represents a larger number of chemicals than those encountered in soil matrix and groundwater beneath the site. Due to the absence of data characterizing chemical toxicity and physical/chemical properties, eight chemicals (Cyclohexane, Ethanol, 4-Ethyltoluene, Freon 11, Freon 12, Freon 113, Heptane, and 2-Propanol) detected in soil vapor samples were excluded as COPCs; however, detection of most of these chemicals was limited in frequency and magnitude (ETIC, 1999). The limited subsurface presence of these chemicals is corroborated by their absence at above detection limits in soil matrix and groundwater samples across the site.

**Table 2. Chemicals of Potential Concern and Source Concentrations  
Volatilization to Ambient and Indoor Air Pathways  
Onsite Commercial/Industrial Receptor**

COPC	COPC Source Concentration* (ppbv)
Benzene	9,900
Toluene	240
Ethylbenzene	68
Total Xylenes	610
Methyl t-butyl ether	2.9
Acetone	260
1,3-Butadiene	61
2-Butanone	24
Carbon Disulfide	18
Chloroform	3.9
Chloromethane	3.7
1,2-Dichlorobenzene	480
1,4-Dichlorobenzene	76
1,4-Dioxane	22
Hexane	18,000
4-Methyl-2-pentanone	15
Methylene chloride	340
Styrene	3
Tetrachloroethene	160
Tetrahydrofuran	58
1,1,1-Trichloroethane	21
1,3,5-Trimethylbenzene	740
1,2,4-Trimethylbenzene	580

\* Concentrations represent historical maximum values in shallow (3 ft bgs) soil vapor samples



**Ambient and Indoor Air Inhalation of Volatiles from Groundwater-Offsite Residential Receptors:** For evaluation of potential indirect exposure to chemicals in groundwater at the nearest (100 ft downgradient) residential property, chemicals detected in offsite monitoring wells MW-28 and MW-29 (ETIC 1999) were included as COPCs. As a conservative measure, historical maximum COPC concentrations detected in these wells (see Table 3) were used as representative of source concentrations. As a result, chemical attenuation along the path of groundwater transport between monitored locations and the downgradient residence was conservatively ignored.

**Table 3. Chemicals of Potential Concern and Source Concentrations  
Volatilization-to-Ambient- and Indoor Air Pathways Offsite Residential Receptor**

COPC	COPC Source Concentration* (mg/l)
Benzene	1.80E-02
1,1 DCA	5.20E-02
1,2 DCA	1.70E-01
cis-1,2 DCE	2.30E-03
Ethylbenzene	2.20E-03
MTBE	5.60E-02
Toluene	2.00E-02
TCE	1.90E-03
Xylenes	1.30E-02

\* Concentrations represent historical maximum values in offsite monitoring wells MW-28 and MW-29

### Tier I RBCA Results

COPCs, media-specific concentrations, and ASTM (1995) default input data were incorporated into the highly conservative ASTM (1995) exposure algorithms, yielding Tier I RBSLs corresponding to target risk and hazard levels of  $1 \times 10^{-6}$  and 1.0, respectively. Tier I output data, including sample calculations using soil vapor data, are included as Appendix III and are summarized below.

Table 4 depicts a comparison of highly conservative Tier I RBSLs with COPC source concentrations for direct exposure of daily site occupants to chemicals in surface (<4 ft bgs) soils. As indicated in Table 4, source concentrations for all COPCs are protective of the highly conservative Tier I RBSLs for direct exposure to surface soils.

**Table 4. Tier I Results Direct Exposure to Surface Soils  
Onsite Commercial/Industrial Receptor**

COPC	COPC Source Concentration (mg/kg)	Tier I RBSLs * (mg/kg)
1,2 DCA	2.50E-03	1
Ethylbenzene	2.70E-03	>RES
Toluene	2.00E-03	>RES
xylenes	2.70E-03	>RES

\*: RBSL corresponds to target risk and hazard levels of  $1 \times 10^{-6}$  and 1.0, respectively  
>RES: indicates RBSL is greater than constituent residual saturation in soil

Table 5 depicts a comparison of the highly conservative Tier I RBSLs with COPC source concentrations for indirect exposure (via inhalation of ambient air) of daily onsite receptors to vapor emissions from subsurface sources.

**Table 5. Tier I Results  
Volatilization to Ambient Air Pathway  
Onsite Commercial/Industrial Receptor**

COPC	COPC Source Concentration (ppbv)	Tier I RBSLs* (ppbv)	Carcinogenic Risk	Non-Carcinogenic Hazard
Benzene	9.9E+03	1.7E+04	5.90E-07	9.80E-03
Toluene	240	6.2E+07	-	3.90E-06
Ethylbenzene	68	1.5E+08	-	4.40E-07
Total Xylenes	610	1.1E+08	-	5.50E-06
Methyl t-butyl ether	2.9	5.6E+08	-	5.20E-09
Acetone	260	5.8E+07	-	4.50E-06
1,3-Butadiene	61	7.1E+03	8.60E-09	-
2-Butanone	24	2.0E+08	-	1.20E-07
Carbon Disulfide	18	1.1E+08	-	1.60E-07
Chloroform	3.9	1.2E+04	3.20E-10	1.30E-04
Chloromethane	3.7	2.3E+04	1.60E-10	6.50E-08
1,2-Dichlorobenzene	480	2.4E+07	-	2.00E-05
1,4-Dichlorobenzene	76	5.4E+04	1.40E-09	5.90E-06
1,4-Dioxane	22	2.3E+06	3.50E-12	-
Hexane	1.8E+04	1.4E+07	-	1.30E-03
4-Methyl-2-pentanone	15	1.4E+07	-	1.10E-06
Methylene chloride	340	8.7E+05	3.90E-10	7.80E-07
Styrene	3	1.7E+08	-	1.80E-08
Tetrachloroethene	160	5.0E+05	3.20E-10	4.00E-06
Tetrahydrofuran	58	2.5E+05	2.30E-10	1.10E-06
1,1,1-Trichloroethane	21	1.2E+08	-	1.80E-07
1,3,5-Trimethylbenzene	740	2.5E+08	-	3.00E-06
1,2,4-Trimethylbenzene	580	1.4E+09	-	4.10E-07
<b>Total Pathway Risk/Hazard:</b>		-	<b>6.01E-07</b>	<b>1.13E-02</b>

\*: RBSL corresponds to target risk and hazard levels of  $1 \times 10^{-6}$  and 1.0, respectively

As previously indicated, this analysis made use of maximum detected soil vapor concentrations as representative of vapor contribution from all potential subsurface sources (i.e. residual NAPL, soil, and groundwater). Hence, RBSLs represent soil vapor concentrations at 3 ft bgs (see Appendix III), corresponding to target risk/hazard levels of  $1 \times 10^{-6}$  and 1.0, respectively.

Due to the quantity of COPCs detected in soil vapor, individual and total pathway risks/hazards were also quantified (see Table 5) to represent potential cumulative impacts. As indicated in Table 5, soil vapor concentrations for all COPCs are protective of the highly conservative Tier I RBSLs. In addition, total pathway (i.e. cumulative) risk/hazard estimates remain protective of the target risk/hazard of  $1 \times 10^{-6}$  and 1.0, respectively.

Table 6 provides a comparison between the highly conservative Tier I RBSLs and COPC source concentrations for indoor air inhalation of vapors associated with daily onsite receptors.

**Table 6. Tier I Results  
Volatilization to Indoor Air Pathway  
Onsite Commercial/Industrial Receptor**

COPC	COPC Source Concentration* (ppbv)	Tier I RBSLs* (ppbv)	Carcinogenic Risk	Non-Carcinogenic Hazard
<b>Benzene</b>	<b>9,900</b>	<b>660</b>	<b>1.50E-05</b>	<b>2.40E-01</b>
Toluene	240	2.4E+06	-	9.80E-05
Ethylbenzene	68	6.2E+06	-	1.10E-05
Total Xylenes	610	4.4E+06	-	1.40E-04
Methyl t-butyl ether	2.9	2.2E+07	-	1.30E-07
Acetone	260	2.4E+06	-	1.10E-04
1,3-Butadiene	61	2.9E+02	2.10E-07	-
2-Butanone	24	8.3E+06	-	2.90E-06
Carbon Disulfide	18	4.4E+06	-	4.10E-06
Chloroform	3.9	4.9E+02	7.90E-09	3.20E-03
Chloromethane	3.7	1.2E+04	3.10E-10	1.60E-06
1,2-Dichlorobenzene	480	9.4E+05	-	5.10E-04
1,4-Dichlorobenzene	76	2.2E+03	3.50E-08	1.50E-04
1,4-Dioxane	22	9.3E+04	8.80E-11	-
Hexane	1.8E+04	5.6E+05	-	3.20E-02
4-Methyl-2-pentanone	15	5.4E+05	-	2.80E-05
Methylene chloride	340	3.5E+04	9.80E-09	1.90E-05
Styrene	3	6.7E+06	-	4.50E-07
Tetrachloroethene	160	2.0E+04	8.00E-09	1.00E-04
Tetrahydrofuran	58	1.0E+04	5.70E-09	2.70E-05
1,1,1-Trichloroethane	21	4.6E+06	-	4.60E-06
1,3,5-Trimethylbenzene	740	1.0E+07	-	7.40E-05
1,2,4-Trimethylbenzene	580	5.8E+07	-	1.00E-05
<b>Total Pathway Risk/Hazard:</b>		<b>-</b>	<b>1.53E-05</b>	<b>2.76E-01</b>

\*: RBSL corresponds to target risk and hazard levels of  $1 \times 10^{-6}$  and 1.0, respectively  
 Bolded parameters indicate exceedance of RBSLs.

As indicated in Table 6, with the exception of the benzene volatilization- to-indoor air pathway, shallow soil vapor concentrations for all COPCs are protective of the highly conservative Tier I RBSLs for both indoor and ambient air exposure. For the more stringent indoor air pathway, the carcinogenic risk and noncarcinogenic hazard for benzene approximate  $1.5 \times 10^{-5}$  and 0.24, respectively. The carcinogenic risk associated with benzene represents 98 percent of the total pathway risk, while the noncarcinogenic hazard for benzene represents 87 percent of the total pathway hazard. It should be noted that the total pathway risk, representing the cumulative risk from all COPCs in soil vapor, is within the target range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$  defined by the USEPA (1989). Nevertheless, benzene volatilization to onsite indoor air was further evaluated in the Tier II analysis.

Table 7 depicts a comparison between highly conservative Tier I RBSLs and COPC concentrations for the groundwater volatilization-to-indoor air and outdoor air pathways for offsite residential receptors. As indicated, with the exception of benzene and 1,2-DCA volatilization-to-indoor air, all COPCs are protective of the highly conservative RBSLs for both indoor and ambient air exposure pathways.

**Table 7. Tier I Results  
Volatilization to Indoor and Ambient Air  
Offsite Residential Receptor**

COPC	COPC Source Concentration (mg/l)	Tier I RBSLs* (mg/l) Groundwater Volatilization to Indoor Air	Tier I RBSLs* (mg/l) Groundwater Volatilization to Ambient Air
<b>Benzene</b>	<b>1.80E-02</b>	<b>7E-03</b>	<b>3.2</b>
1,1 DCA	5.20E-02	21	>SOL
<b>1,2 DCA</b>	<b>1.70E-01</b>	<b>2.20E-02</b>	<b>7.5</b>
cis-1,2 DCE	2.30E-03	>SOL	>SOL
Ethylbenzene	2.20E-03	77	>SOL
MTBE	5.60E-02	1.40E+03	>SOL
Toluene	2.00E-02	33	>SOL
TCE	1.90E-03	4.60E-02	13
Xylenes	1.30E-02	>SOL	>SOL

\*: RBSL corresponds to target risk and hazard levels of  $1 \times 10^{-6}$  and 1.0, respectively

>SOL: indicates RBSL is greater than constituent solubility in water

Bolded parameters indicate exceedance of RBSLs.

Based on the Tier I results, the following exposure scenarios were further evaluated in the Tier II analysis:

- Benzene volatilization to indoor from subsurface sources (Onsite commercial/industrial receptor); and
- Benzene and 1,2-DCA volatilization to indoor air from groundwater (Offsite residential receptor).

#### Tier II RBCA Input Data

Consistent with the ASTM guidelines, a Tier II analysis was performed on exposure scenarios and COPCs exceeding the highly conservative Tier I RBSLs. Specifically, site-specific target levels (SSTLs) were calculated accounting for site-specific conditions, chemical attenuation between source and receptor locations, and relevant target risk levels.

As part of the Tier II analysis, the highly conservative vapor transport and exposure algorithms used in the Tier I analysis were maintained. The sole deviation from the Tier I analysis involved changes to select input data characterizing site conditions. These data, as summarized in Table 8, correspond to values adopted for the Oakland Urban Land Redevelopment Program Tier I Risk-Based Screening Levels (Spence and Gomez, 1997 and 1999), and accordingly maintain significant conservatism. All other input data were maintained from the Tier I analysis (see Appendix I).

**Table 8. Tier II Input Data**

Parameter	Value	Reference
Depth to groundwater	7 ft	Site specific value
Capillary fringe thickness	2 ft	Default value for mixed sediments (Spence and Gomez, 1997 and 1999)
Vadose zone thickness	5 ft	Back-calculated from capillary fringe thickness and depth to groundwater
Soil porosity	0.4	Default value for mixed sediments (Spence and Gomez, 1997 and 1999)
Vadose zone water content	0.25	Default value for mixed sediments (Spence and Gomez, 1997 and 1999)
Vadose zone air content	0.15	Default value for mixed sediments (Spence and Gomez, 1997 and 1999)
Capillary fringe water content	0.38	Default value for mixed sediments (Spence and Gomez, 1997 and 1999)
Capillary fringe air content	0.02	Default value for mixed sediments (Spence and Gomez, 1997 and 1999)
Foundation crack fraction	0.001	Default value (Spence and Gomez, 1997 and 1999)

**Tier II RBCA Results**

Tier II output data are included as Appendix IV, with results summarized in Table 9. As indicated in Table 9, Tier II COPC source concentrations are protective of SSTLs for both on- and offsite receptors.

**Table 9. Tier II RBCA Results**

Exposure Scenario	COPC	COPC Source Concentration	Tier II SSTL
Volatilization to Indoor Air-Onsite Commercial/Industrial Receptor	Benzene	9,900 ppbv	44,800 ppbv
Volatilization to Indoor Air-Offsite Residential Receptor	Benzene	0.018 mg/l	0.272 mg/l
Volatilization to Indoor Air-Offsite Residential Receptor	1,2-DCA	0.170 mg/l	0.98 mg/l

**Uncertainty Analysis**

The assumptions, procedures, and parameters used in this RBCA analysis are subject to various degrees of uncertainty. To this end, conservative assumptions are incorporated into the RBCA process to ensure protection of human health, as documented herein. Specifically, uncertainty and conservatism associated with sample collection and analysis, fate and transport calculations, representation of site conditions, standard exposure factors, toxicological endpoints, and interpretation of target risk levels are documented below.

**Sample Collection and Analysis:** Environmental sampling and analysis error can stem from improper sample collection and handling procedures, inadequate sample numbers, laboratory analysis errors, and the heterogeneity of the subsurface environment. The use of standard techniques such as the collection of duplicates, and the use of trip and method blanks can be used to reduce the likelihood of errors. Errors in data analyses can occur from the simplest tabulation and typographical errors to complex interpretational errors. Matrix interference due to the presence of high concentrations often raise the detection limits of other chemicals in the analytical procedure and introduce uncertainty in the method of data analyses.

The sampling effort implemented at the Nestle site was specifically designed to identify areas that were suspected to have elevated chemical concentrations. This sampling bias resulted in a data base that focused on the worst-case areas of the site. This focused approach resulted in assumptions related to representation of COPC concentrations that make this RBCA analysis conservative in nature. These conditions will result in a significant overestimation of risk and excessively low RBSLs and SSTLs.

**ASTM RBCA Fate and Transport Algorithms:** The ASTM guidelines and the GSI RBCA Spreadsheet System used in this analysis employ a series of simplified fate and transport models for predicting COPC concentrations at points of exposure. The simplified analytic nature of these models, particularly those used to simulate volatilization and transport of vapor emissions to ambient and indoor air, often result in grossly over-estimated COPC exposure point concentrations (Sanders and Stern, 1994; GSI, 1995 and 1997; AEHS, 1997; Javaherian, 1994 and 1997); in turn, these result in over-estimation of health risks and lower RBSLs and SSTLs. In fact, GSI (1995 and 1997) warns against delineation of cleanup levels based on the use of its formulation for vapor intrusion to indoor air. Examples of physical and chemical processes ignored by the simplified GSI vapor transport models include:

- loss mechanisms- absence of loss mechanisms such as biodegradation and adsorption results in over-estimation of vapor and contaminant flux to ambient and indoor air;
- depleting contaminant source- use of a non-depleting, constant source results in an unlimited supply of contaminated vapor and an over-estimation of vapor and contaminant flux to ambient and indoor air over time; and
- water movement- absence of water movement through subsurface soils results in an over-estimation of air-filled porosity and vapor and contaminant flux to ambient and indoor air.

**Representation of Site Conditions:** As part of the Tier I analysis, the ASTM RBCA process promotes the use of conservative default values for various parameters representing site conditions. This RBCA analysis consistently incorporated conservative assumptions for selection of input parameters, while attempting to maintain a reasonable, site-specific evaluation. Examples of conservative assumptions used to formulate input parameters include:

- On- and offsite buildings will directly overlie locations of historical maximum soil matrix, soil vapor, and groundwater concentrations;
- Cracks may exist in foundations of both onsite and offsite buildings; and
- The paved surface at the site has a negligible impact on vapor emissions to ambient air.
- Historical maximum chemical concentrations in surface soil, soil vapor, and groundwater are representative of current and future source concentrations;
- No chemical attenuation occurs in groundwater between the site and the location of the nearest offsite residential facility;

Use of these conservative assumptions results in an over-estimation of health risks and lower RBSLs and SSTLs.

**Standard Exposure Factors:** Standard exposure scenarios evaluated in this RBCA analysis incorporate the most likely site-specific exposure pathways and represent the greatest potential for exposure to contaminants at the site. Conservative assumptions consistent with state and federal guidelines were used to conceptualize the exposure scenarios. These methods and procedures contribute to an overall overestimation of potential exposure.

Numerous conservative exposure assumptions serve as the basis for exposure parameters adopted by ASTM (1995). Duration, frequency, and other input parameters were selected to represent the maximally exposed individual and are not an accurate portrayal of time spent at a place of business or residence. The quantitative effect of these uncertainties may be significant in overestimating overall potential health risk.

The exposure parameters used to develop the onsite indoor worker exposure scenarios at the site are conservative estimates of the true exposures. Although indoor workers are present at the site, the assumed duration of exposure is likely to be much greater than the true duration. For instance, an indoor onsite worker is assumed to be indoors 8-hours per day, 250-days per year, for 25 years. In reality, based on Department of Labor statistics regarding average job tenure nationwide, this type of worker would be expected to remain in his/her job less than 10 years.

Further, the hypothetical worker is assumed to be exposed to chemical emissions that were conservatively estimated from maximum reported soil and groundwater concentrations (e.g. Tier I analysis). Therefore, assuming exposure to air concentrations of COPCs based on maximum concentrations and using the conservative exposure parameters provided, the onsite indoor worker scenario significantly overestimates the true risk/hazard associated with site-related COPC emissions; this results in underestimation (i.e. lower) of RBSLs.

Likewise, the onsite outdoor worker is assumed to have the same exposure frequency and duration as the indoor worker. In reality, based on weather conditions alone, a worker will not be outdoors 250-days per year. For the same reasons documented above, a worker would not be expected to remain in his/her job for a 25-year duration. Consequently, the outdoor worker scenario also overestimates the true risk/hazard, while underestimating action levels associated with site-related COPC emissions.

**Toxicological Endpoints:** Several aspects of the toxicological data employed in the ASTM RBCA process contain a high degree of uncertainty that affect estimation of risk and delineation of SSTLs. These uncertainties arise in two primary areas: First, slope factors used in this assessment correspond to the 95% upper confidence limit (UCL) on the low-dose portion of the chemical's dose-response curve, as extrapolated from high-dose human or animal response data using the EPA linearized multistage model (LMS). This assumption means actual risks are likely to be lower than the risk estimates calculated in this assessment.

Second, results of animal studies are often used to predict the potential human health effects of a chemical. Extrapolation of toxicological data from animal tests is one of the largest sources of uncertainty in the human health risk evaluation process. There may be important, but unidentified differences in uptake, metabolism, distribution, and elimination of chemicals between a test species and humans. Animal studies are usually conducted under high-dose conditions, whereas humans are rarely exposed to such high doses. The dose level itself may be responsible for the observed carcinogenic effects. Also, animal lifetimes tend to be less than two years, while assumed human life expectancy is 70 years.

**Interpretation of Target Risk Levels:** The excess lifetime cancer risk used to evaluate carcinogenic compounds is often misunderstood. For example, a risk level of one-in-one million ( $1 \times 10^{-6}$ ) associated with exposure to a particular chemical is often misconstrued as an expectation that one out of one million people exposed to the chemical will be stricken with cancer. In actuality the carcinogenic risk is not an actual risk, but rather a mathematical risk based on conservative scientific assumptions used in the risk assessment process. The Food and Drug Administration (FDA) uses this conservative estimate to ensure that the risk is not understated.

Uncertainties from the various sources discussed above are additive; hence, the overall effect of using conservative assumptions in each step of the risk assessment process results in significant overestimation of potential risks/hazards, and an underestimation of action levels. Accordingly, comparison of COPC concentrations with applicable RBSLs must be viewed with an understanding of the uncertainty and conservatism involved, and how these effect risk estimations. Because of the high degree of conservatism associated with the RBCA process, findings of insignificant risk (high RBSLs) may reflect conditions close to reality; however, findings of measurable risk (low RBSLs) may reflect conditions that result from the conservative nature of the evaluation.

## CONCLUSIONS

Based on the historical levels of chemicals in soil matrix, soil vapor, and groundwater at on- and offsite locations, together with results of this RBCA analysis, the following conclusions are formulated for the site:

- The conservatively estimated risk/hazard levels associated with direct exposure of daily site (commercial/industrial) occupants to observed levels of chemicals in surface soils are protective of USEPA-defined target risk/hazard levels;
- The conservatively estimated risk/hazard levels associated with onsite (commercial/industrial) indoor and ambient air inhalation of volatiles detected in shallow soil vapor samples are protective of USEPA-defined target risk/hazard levels;
- The conservatively estimated risk/hazard associated with offsite (residential) indoor and ambient air inhalation of volatiles detected in groundwater at offsite locations are protective of USEPA-defined target risk/hazard levels;
- Appropriate risk management practices and health and safety measures should be implemented prior to initiation of construction activities at the site.



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# Appendix I

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## Tier I RBCA Input Data

# RBCA TIER 1 Input Data

## Table I.1

Site Name: NESTLE OAKLAND FACILITY Job Identification:  
Site Location: Oakland, CA

Date Completed: 3/17/99  
Completed By: Mehrdad M. Javaherian, Ph.D., P.Hg., P.E.

Software: GSI RBCA Spreadsheet  
Version: 1.0.1

NOTE: values which differ from Tier 1 default values are shown in bold italics and underlined.

Exposure Parameter	Definition (Units)	Residential			Commercial/Industrial		Surface Parameters		Residential	Commercial		
		Adult	(1-6yrs)	(1-16 yrs)	Chronic	Constrctn	Definition (Units)	Value				
ATc	Averaging time for carcinogens (yr)	70					A	Contaminated soil area (cm <sup>2</sup> )	2.2E+06	1.0E+06		
ATn	Averaging time for non-carcinogens (yr)	30	6	16	25	1	W	Length of affect. soil parallel to wind (cm)	1.5E+03	1.0E+03		
BW	Body Weight (kg)	70	15	35	70		W.gw	Length of affect. soil parallel to groundwater (cm)	1.5E+03			
ED	Exposure Duration (yr)	30	6	16	25	1	Uair	Ambient air velocity in mixing zone (cm/s)	2.3E+02			
t	Averaging time for vapor flux (yr)	30			25	1	delta	Air mixing zone height (cm)	2.0E+02			
EF	Exposure Frequency (days/yr)	350			250	250	Lss	Thickness of affected surface soils (cm)	1.0E+02			
EF.Derm	Exposure Frequency for dermal exposure	350			250		Pe	Particulate areal emission rate (g/cm <sup>2</sup> /s)	6.9E-14			
IRgw	Ingestion Rate of Water (L/day)	2			1		<b>Groundwater Definition (Units)</b>					
IRs	Ingestion Rate of Soil (mg/day)	100	200		50	480	delta.gw	Groundwater mixing zone depth (cm)	2.0E+02			
IRadj	Adjusted soil ing. rate (mg-yr/kg-d)	1.1E+02			9.4E+01		l	Groundwater infiltration rate (cm/yr)	3.0E+01			
IRa.in	Inhalation rate indoor (m <sup>3</sup> /day)	15			20		Ugw	Groundwater Darcy velocity (cm/yr)	2.5E+03			
IRa.out	Inhalation rate outdoor (m <sup>3</sup> /day)	20			20	20	Ugw.tr	Groundwater seepage velocity (cm/yr)	6.6E+03			
SA	Skin surface area (dermal) (cm <sup>2</sup> )	5.8E+03		2.0E+03	5.8E+03	5.8E+03	Ks	Saturated hydraulic conductivity (cm/s)				
SAadj	Adjusted dermal area (cm <sup>2</sup> -yr/kg)	2.1E+03			1.7E+03		grad	Groundwater gradient (cm/cm)				
M	Soil to Skin adherence factor	1					Sw	Width of groundwater source zone (cm)				
AAFs	Age adjustment on soil ingestion	FALSE			FALSE		Sd	Depth of groundwater source zone (cm)				
AAFd	Age adjustment on skin surface area	FALSE			FALSE		phi.eff	Effective porosity in water-bearing unit	3.8E-01			
tox	Use EPA tox data for air (or PEL based)?	TRUE					foc.sat	Fraction organic carbon in water-bearing unit	1.0E-03			
gwMCL?	Use MCL as exposure limit in groundwater?	FALSE					BIO?	Is bioattenuation considered?	FALSE			
							BC	Biodegradation Capacity (mg/L)				
<b>Matrix of Exposed Persons to Complete Exposure Pathways</b>		<b>Residential</b>			<b>Commercial/Industrial</b>		<b>Soil</b>		<b>Definition (Units)</b>		<b>Value</b>	
<b>Outdoor Air Pathways:</b>					<b>Chronic</b>	<b>Constrctn</b>	hc	Capillary zone thickness (cm)	5.0E+00			
SS.v	Volatiles and Particulates from Surface Soils	FALSE			TRUE	FALSE	hv	Vadose zone thickness (cm)	3.0E+02			
S.v	Volatilization from Subsurface Soils	FALSE			TRUE		rho	Soil density (g/cm <sup>3</sup> )	1.7			
GW.v	Volatilization from Groundwater	FALSE			TRUE		foc	Fraction of organic carbon in vadose zone	0.01			
<b>Indoor Air Pathways:</b>							phi	Soil porosity in vadose zone	0.38			
S.b	Vapors from Subsurface Soils	FALSE			TRUE		Lgw	Depth to groundwater (cm)	3.0E+02			
GW.b	Vapors from Groundwater	FALSE			TRUE		Ls	Depth to top of affected subsurface soil (cm)	1.0E+02			
<b>Soil Pathways:</b>							Lsubs	Thickness of affected subsurface soils (cm)	2.0E+02			
SS.d	Direct Ingestion and Dermal Contact	FALSE			TRUE	FALSE	pH	Soil/groundwater pH	6.5			
<b>Groundwater Pathways:</b>									<b>capillary</b>	<b>vadose</b>	<b>foundation</b>	
GW.i	Groundwater Ingestion	FALSE			FALSE		phi.w	Volumetric water content	0.342	0.12	0.12	
S.l	Leaching to Groundwater from all Soils	FALSE			FALSE		phi.a	Volumetric air content	0.038	0.26	0.26	
<b>Matrix of Receptor Distance and Location On- or Off-Site</b>		<b>Residential</b>			<b>Commercial/Industrial</b>		<b>Building</b>		<b>Definition (Units)</b>		<b>Residential</b>	<b>Commercial</b>
GW	Groundwater receptor (cm)						Lb	Building volume/area ratio (cm)	2.0E+02	3.0E+02		
S	Inhalation receptor (cm)		TRUE			TRUE	ER	Building air exchange rate (s <sup>-1</sup> )	1.4E-04	2.3E-04		
			TRUE			TRUE	Lcrk	Foundation crack thickness (cm)	1.5E+01			
							eta	Foundation crack fraction	0.01			
<b>Matrix of Target Risks</b>		<b>Individual</b>	<b>Cumulative</b>				<b>Transport Parameters</b>		<b>Definition (Units)</b>		<b>Residential</b>	<b>Commercial</b>
TRab	Target Risk (class A&B carcinogens)	1.0E-06					<b>Groundwater</b>					
TRc	Target Risk (class C carcinogens)	1.0E-05					ax	Longitudinal dispersivity (cm)				
THQ	Target Hazard Quotient	1.0E+00					ay	Transverse dispersivity (cm)				
Opt	Calculation Option (1, 2, or 3)	1					az	Vertical dispersivity (cm)				
Tier	RBCA Tier	1					<b>Vapor</b>					
							dcy	Transverse dispersion coefficient (cm)				
							dcz	Vertical dispersion coefficient (cm)				

**Table I.2. RBCA Tier I Input/Output Data  
Outdoor Air Inhalation of Benzene from Soil Vapor-Onsite Commercial/Industrial Receptor**

Soil Specific Parameters			
ASTM Default	$\rho_a$	1.7	Soil Bulk Density (g/cm <sup>3</sup> ) of (kg/L)
ASTM Default	$\theta_{as}$	0.26	Air Content of Soil (v/v)
ASTM Default	$\theta_{ws}$	0.12	Water Content of Soil (v/v)
ASTM Default	$\theta_t$	0.38	Total Soil Porosity (v/v)
Site-Specific	d	91	Depth to location of vapor sample (cm) – 3 ft depth
Diffusivity Parameters			
ASTM Default	H	0.22	Henry's Constant (dimensionless)
ASTM Default	$D^{air}$	9.30E-02	Air Diffusion Coefficient (cm <sup>2</sup> /s)
ASTM Default	$D^{wat}$	1.10E-05	Water Diffusion Coefficient (cm <sup>2</sup> /s)
Calculated	$D_s^{eff}$	0.0073	Effective Diffusion Coefficient through Soil (cm <sup>2</sup> /s)
Prediction of Flux from Soil Vapor Concentration			
Site Specific	$C_v$	9,900	Maximum Benzene Concentration in Soil Vapor (ppbv)
Unit Conv	$C_v$	32	Maximum Benzene Concentration in Soil Vapor (µg/L)
Calculated	F	2.6E-06	Maximum Diffusive Vapor Flux Predicted from Benzene Concentration in Soil Vapor (µg/cm <sup>2</sup> -sec)
Outdoor Air Concentration			
ASTM Default	s	200	Outdoor Mixing Height (cm)
ASTM Default	$U_{air,outdoor}$	225	Outdoor Wind Velocity (cm/sec)
ASTM Default	W	1500	Width of Outdoor Source Area Parallel to Wind Direction (cm)
Calculated	$C_{outdoor}$	8.5E-08	Outdoor Air Concentration (µg/cm <sup>3</sup> )
Dose			
ASTM Default	$IR_{air,Outdoor}$	20	Daily Outdoor Inhalation Rate (m <sup>3</sup> /day)
ASTM Default	EF	250	Exposure Frequency (days/year)
ASTM Default	ED	25	Exposure Duration (years)
Calculated	Dose	11	Dose (mg)
Risk			
CAL EPA	$SF_1$	0.1	California Cancer Slope Factor for Benzene(kg-day/mg)
ASTM Default	BW	70	Body Weight (kg)
ASTM Default	$AT_c$	70	Averaging Time for Carcinogens (years)
Calculated	Risk	5.9E-07	Risk (positive/population)
Calculated	RBSL	17,000	Tier 1 Risk-Based Screening Level (ppbv) for TRL = 1E-06

Formulas
$D_{soil}^{eff} = D^{air} \frac{\theta_{as}^{3.33}}{\theta_T} + D^{wat} \frac{1}{H} \frac{\theta_{ws}^{3.33}}{\theta_T}$
$F = D_{soil}^{eff} \frac{C_v}{d}$
$C_{outdoor} = \frac{F \times W}{U_{air-outdoor} \times s}$
$Dose = C_{outdoor} \times IR_{air-outdoor} \times EF \times ED$
$Risk = \frac{Dose \times SF}{BW \times AT}$

Notes:

ASTM = American Standard for Testing and Materials, 1995 Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites, E 1739-95.

Calculations: Effective diffusivity, diffusive vapor flux, enclosed space air concentrations, dose, and risk calculations from ASTM 95 guidance formulas presented above.

level

**Table I.3. RBCA Tier I Input/Output Data  
Indoor Air Inhalation of Benzene from Soil Vapor-Onsite Commercial/Industrial Receptor**

Soil/Building Parameters		
ASTM Default	$\rho_a$	1.7 Soil Bulk Density (g/cm <sup>3</sup> ) of (kg/L)
ASTM Default	$\theta_{as}$	0.26 Air Content of Soil (v/v)
ASTM Default	$\theta_{ws}$	0.12 Water Content of Soil (v/v)
ASTM Default	$\theta_{ac}$	0.26 Air Content of Crack (v/v)
ASTM Default	$\theta_{wc}$	0.12 Water Content of Crack (v/v)
ASTM Default	$\theta_t$	0.38 Total Porosity-Soil and Crack (v/v)
Site-specific	L <sub>soil</sub>	91 Depth to Location of Vapor Sample (cm) – 3.0 ft depth
ASTM Default	L <sub>crack</sub>	15 Foundation Crack Thickness (cm)
ASTM Default	$\eta$	0.01 Foundation Crack Fraction (dimensionless)
Diffusivity Parameters		
ASTM Default	H	0.22 Henry's Constant (dimensionless)
ASTM Default	D <sup>air</sup>	9.30E-02 Air Diffusion Coefficient (cm <sup>2</sup> /s)
ASTM Default	D <sup>wat</sup>	1.10E-05 Water Diffusion Coefficient (cm <sup>2</sup> /s)
Calculated	D <sup>eff</sup> <sub>soil</sub>	0.0073 Effective Diffusion Coefficient through Soil (cm <sup>2</sup> /s)
Calculated	D <sup>eff</sup> <sub>crack</sub>	0.0073 Effective Diffusion Coefficient through Foundation Cracks (cm <sup>2</sup> /s)
Prediction of Flux from Soil Vapor Concentration		
Site Specific	C <sub>source</sub> = C <sub>v</sub>	9,900 Maximum Benzene Concentration in Soil Vapor (ppbv)
Unit Conv	C <sub>source</sub> = C <sub>v</sub>	32 Maximum Benzene Concentration in Soil Vapor (µg/L)
Calculated	F	1.5E-07 Diffusive Vapor Flux Predicted from Benzene Concentration in Soil Vapor (µg/cm <sup>2</sup> -sec)
Indoor Air Concentration		
ASTM Default	L <sub>b</sub>	300 Enclosed Space Volume/Infiltration Area Ratio (cm)
ASTM Default	ER <sub>air-indoor</sub>	0.00023 Enclosed Space Air Exchange Rate (sec <sup>-1</sup> )
Calculated	C <sub>indoor</sub>	2.1E-06 Enclosed Space Air Concentration (µg/cm <sup>3</sup> )
Dose		
ASTM Default	IR <sub>air-indoor</sub>	20 Daily Indoor Inhalation Rate (m <sup>3</sup> /day)
ASTM Default	EF	250 Exposure Frequency-Adult (days/year)
ASTM Default	ED	25 Exposure Duration (years)
Calculated	Dose	260 Dose (mg)
Risk		
DTSC	SF <sub>i</sub>	0.1 Inhalation California Cancer Slope Factor for Benzene (kg-day/mg)
ASTM Default	BW	70 Body Weight (kg)
ASTM Default	AT	70 Averaging Time for Carcinogens (years)
Calculated	Risk	1.5E-05 Risk (positive/population)
Calculated	RBSL	660.0 Tier I Risk-Based Screening Level (ppbv) for TRL = 1E-06

Formulas	
$D_{soil}^{eff} = D^{air} \frac{\theta_{as}^{SS}}{\theta_T} + D^{wat} \frac{1}{H} \frac{\theta_{ws}^{SS}}{\theta_T}$	
$D_{crack}^{eff} = D^{air} \frac{\theta_{ac}^{SS}}{\theta_T} + D^{wat} \frac{1}{H} \frac{\theta_{wc}^{SS}}{\theta_T}$	
$D_v^{eff} = \frac{L_{soil} + L_{crack}}{\frac{L_{crack}}{D_{crack}^{eff} \eta} + \frac{L_{soil}}{D_{soil}^{eff}}}$	
$F = D_v^{eff} \frac{\Delta C_v}{\Delta \chi}$	
$= \frac{C_{source} \frac{D_{soil}^{eff}}{L_{soil}}}{1 + \frac{D_{soil}^{eff}}{L_{soil}} \frac{L_{crack}}{D_{crack}^{eff} \eta}}$	
$C_{indoor} = \frac{F}{ER_{air-indoor} \times L_b}$	
$Dose = C_{indoor} \times IR_{air-indoor} \times EF \times ED$	
$Risk = \frac{Dose \times SF}{BW \times AT}$	

Notes:

ASTM = American Standard for Testing and Materials, 1995. Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites, E 1739-95.

Calculations. Effective diffusivity, diffusive vapor flux, enclosed space air concentrations, dose, and risk calculations from ASTM 95 guidance formulas presented above.

## Appendix II

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### Chemical Toxicity Data

**Table II.1**  
**Chemical Toxicity Data**

COPC	INHALATION		ORAL	
	RfD	CSF	RfD	CSF
Benzene	1.70E-03	1.00E-01	NA	NA
Toluene	1.10E-01	NA	2.00E-01	NA
Ethylbenzene	2.90E-01	NA	1.00E-01	NA
Total Xylenes	2.00E-01	NA	2.00E+00	NA
Methyl t-butyl ether	8.57E-01	NA	NA	NA
Acetone	1.00E-01	NA	NA	NA
1,3-Butadine	NA	1.80E+00	NA	NA
2-Butanone	2.86E-01	NA	NA	NA
Carbon Disulfide	2.00E-01	NA	NA	NA
Chloroform	NA	8.10E-02	NA	NA
Chloromethane	8.60E-05	6.30E-03	NA	NA
1,2-Dichloroethane	NA	NA	3.00E-02	9.10E-02
1,2-Dichlorobenzene	5.70E-02	NA	NA	NA
1,4-Dichlorobenzene	3.00E-02	2.20E-02	NA	NA
1,4-Dioxane	NA	1.10E-02	NA	NA
Hexane	5.71E-02	NA	NA	NA
4-Methyl-2-pentanone	2.29E-02	NA	NA	NA
Methylene chloride	8.57E-01	1.64E-03	NA	NA
Styrene	2.86E-01	NA	NA	NA
Tetrachloroethene	1.10E-01	2.00E-03	NA	NA
Tetrahydrofuran	8.60E-02	6.80E-03	NA	NA
1,1,1-Trichloroethane	2.86E-01	NA	NA	NA
1,3,5-Trimethylbenzene	1.70E-03	NA	NA	NA
1,2,4-Trimethylbenzene	1.70E-03	NA	NA	NA

NA = Not Applicable

COPC = Chemical of Potential Concern

RfD = Reference Dose (mg/kg-day)

CSF = Cancer Slope Factor 1/(mg/kg-day)

Source: IRIS (USEPA 2000), HEAST (USEPA, 1997), DTSC (1994), USEPA Region IX PRGs (2000)



## Appendix III

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### Tier I RBCA Output Data

**RBCA TIER 1 OUTPUT DATA-ONSITE COMMERCIAL/INDUSTRIAL RECEPTORS**

Tier 1 Worksheet 6.1

Site Name: NESTLE OAKLAND FACILITY

Completed By: JCI

Site Location: Oakland CA

Date Completed: 3/17/1999

1 OF 1

**SURFACE SOIL RBSL VALUES  
( < 3.3 FT BGS)**

Target Risk (Class A & B) 1.0E-6

MCL exposure limit?

Calculation Option 1

Target Risk (Class C) 1.0E-5

PEL exposure limit?

Target Hazard Quotient 1.0E+0

**RBSL Results For Complete Exposure Pathways ("x" if Complete)**

CONSTITUENTS OF CONCERN		Representative Concentration (mg/kg)	Soil Leaching to Groundwater			X Ingestion, Inhalation and Dermal Contact		Construction Worker	Applicable RBSL (mg/kg)	RBSL Exceeded ?	Required CRF
CAS No.	Name		Residential: (on-site)	Commercial: (on-site)	Regulatory(MCL) (on-site)	Residential: (on-site)	Commercial (on-site)	Commercial (on-site)	(mg/kg)	* If yes	Only if "yes" left
107-06-2	D.chloroethane, 1,2-	2.5E-3	NA	NA	NA	NA	1.0E+0	NA	1.0E+0	<input type="checkbox"/>	<1
100-41-4	Ethylbenzene	2.7E-3	NA	NA	NA	NA	>Res	NA	>Res	<input type="checkbox"/>	<1
108-88-3	Toluene	2.0E-3	NA	NA	NA	NA	>Res	NA	>Res	<input type="checkbox"/>	<1
1330-20-7	Xylene (mixed isomers)	2.7E-3	NA	NA	NA	NA	>Res	NA	>Res	<input type="checkbox"/>	<1

>Res indicates risk-based target concentration greater than constituent residual saturation value

**RBGA TIER I OUTPUT DATA-OFFSITE RESIDENTIAL RECEPTORS**

Tier 1 Worksheet 6.3

Site Name: NESTLE OAKLAND FACILITY

Completed By: JCI

Site Location: Oakland, CA

Date Completed: 3/17/1999

1 OF 1

**GROUNDWATER RBSL VALUES**

Target Risk (Class A & B) 1.0E-6

MCL exposure limit?

Calculation Option 1

Target Risk (Class C) 1.0E-5

PEL exposure limit?

Target Hazard Quotient 1.0E+0

**RBSL Results For Complete Exposure Pathways ("x" If Complete)**

CONSTITUENTS OF CONCERN		Representative Concentration (mg/L)	Groundwater Ingestion			Groundwater Volatilization to Indoor Air		Groundwater Volatilization to Outdoor Air		Applicable RBSL (mg/L)	RBSL Exceeded ?	Required CRF
			Residential: (on-site)	Commercial: (on-site)	Regulatory(MCL): (on-site)	Residential: (offsite)	Commercial: (on-site)	Residential: (offsite)	Commercial: (on-site)			
71-43-2	Benzene	1.8E-2	NA	NA	NA	6.9E-3	NA	3.1E+0	NA	6.9E-3	■	-
75-34-3	Dichloroethane, 1,1-	5.2E-2	NA	NA	NA	2.1E+1	NA	>Sol	NA	2.1E+1	□	<1
107-06-2	Dichloroethane, 1,2-	1.7E-1	NA	NA	NA	2.2E-2	NA	7.5E+0	NA	2.2E-2	■	8.0E+00
156-59-2	Dichloroethene, cis-1,2-	2.3E-3	NA	NA	NA	>Sol	NA	>Sol	NA	>Sol	□	<1
100-41-4	Ethylbenzene	2.2E-3	NA	NA	NA	7.7E+1	NA	>Sol	NA	7.7E+1	□	<1
1634-04-4	Methyl t-Butyl Ether	5.6E-2	NA	NA	NA	1.4E+3	NA	>Sol	NA	1.4E+3	□	<1
108-88-3	Toluene	2.0E-2	NA	NA	NA	3.3E+1	NA	>Sol	NA	3.3E+1	□	<1
79-01-6	Trichloroethene	1.9E-3	NA	NA	NA	4.6E-2	NA	1.3E+1	NA	4.6E-2	□	<1
1330-20-7	Xylene (mixed isomers)	1.3E-2	NA	NA	NA	>Sol	NA	>Sol	NA	>Sol	□	<1

>Sol indicates risk-based target concentration greater than constituent solubility

**Tier I RBCA Output Data**  
**Tier I Risk and RBSL Sample Calculation**  
**Indoor Air Inhalation of Benzene from Soil Vapor-Onsite Commercial/Industrial Receptor**

Soil/Building Parameters			
ASTM Default	$\rho_a$	1.7	Soil Bulk Density (g/cm <sup>3</sup> ) of (kg/L)
ASTM Default	$\theta_{as}$	0.26	Air Content of Soil (v/v)
ASTM Default	$\theta_{ws}$	0.12	Water Content of Soil (v/v)
ASTM Default	$\theta_{ac}$	0.26	Air Content of Crack (v/v)
ASTM Default	$\theta_{wc}$	0.12	Water Content of Crack (v/v)
ASTM Default	$\theta_t$	0.38	Total Porosity-Soil and Crack (v/v)
Site-specific	Lsoil	91	Depth to Location of Vapor Sample (cm) – 3.0 ft depth
ASTM Default	Lcrack	15	Foundation Crack Thickness (cm)
ASTM Default	$\eta$	0.01	Foundation Crack Fraction (dimensionless)
Diffusivity Parameters			
ASTM Default	H	0.22	Henry's Constant (dimensionless)
ASTM Default	$D^{air}$	9.30E-02	Air Diffusion Coefficient (cm <sup>2</sup> /s)
ASTM Default	$D^{wat}$	1.10E-05	Water Diffusion Coefficient (cm <sup>2</sup> /s)
Calculated	$D^{eff}_{soil}$	0.0073	Effective Diffusion Coefficient through Soil (cm <sup>2</sup> /s)
Calculated	$D^{eff}_{crack}$	0.0073	Effective Diffusion Coefficient through Foundation Cracks (cm <sup>2</sup> /s)
Prediction of Flux from Soil Vapor Concentration			
Site Specific	$C_{source} = C_v$	9,900	Maximum Benzene Concentration in Soil Vapor (ppbv)
Unit Conv	$C_{source} = C_v$	32	Maximum Benzene Concentration in Soil Vapor (µg/L)
Calculated	F	1.5E-07	Diffusive Vapor Flux Predicted from Benzene Concentration in Soil Vapor (µg/cm <sup>2</sup> -sec)
Indoor Air Concentration			
ASTM Default	Lb	300	Enclosed Space Volume/Infiltration Area Ratio (cm)
ASTM Default	ER <sub>air/indoor</sub>	0.00023	Enclosed Space Air Exchange Rate (sec <sup>-1</sup> )
Calculated	$C_{indoor}$	2.1E-06	Enclosed Space Air Concentration (µg/cm <sup>3</sup> )
Dose			
ASTM Default	IR <sub>air/indoor</sub>	20	Daily Indoor Inhalation Rate (m <sup>3</sup> /day)
ASTM Default	EF	250	Exposure Frequency-Adult (days/year)
ASTM Default	ED	25	Exposure Duration (years)
Calculated	Dose	260	Dose (mg)
Risk			
DTSC	SF <sub>i</sub>	0.1	Inhalation California Cancer Slope Factor for Benzene (kg-day/mg)
ASTM Default	BW	70	Body Weight (kg)
ASTM Default	AT	70	Averaging Time for Carcinogens (years)
Calculated	Risk	1.5E-05	Risk (positive/population)
Calculated	RBSL	660.0	Tier I Risk-Based Screening Level (ppbv) for TRL = 1E-06

Formulas	
$D_{soil}^{eff} = D^{air} \frac{\theta_{as}^{5.55}}{\theta_T^{5.55}} + D^{wat} \frac{1}{H} \frac{\theta_{ws}^{5.55}}{\theta_T^{5.55}}$	
$D_{crack}^{eff} = D^{air} \frac{\theta_{ac}^{5.55}}{\theta_T^{5.55}} + D^{wat} \frac{1}{H} \frac{\theta_{wc}^{5.55}}{\theta_T^{5.55}}$	
$D_v^{eff} = \frac{L_{soil} + L_{crack}}{\frac{D_{crack}^{eff} \eta}{L_{crack}} + \frac{D_{soil}^{eff}}{L_{soil}}}$	
$F = D_v^{eff} \frac{\Delta C_v}{\Delta \chi}$	
$= \frac{C_{source} \frac{D_{soil}^{eff}}{L_{soil}}}{1 + \frac{D_{soil}^{eff}}{L_{soil}} \frac{L_{crack}}{D_{crack}^{eff} \eta}}$	
$C_{indoor} = \frac{F}{ER_{air/indoor} \times L_b}$	
$Dose = C_{indoor} \times IR_{air/indoor} \times EF \times ED$	
$Risk = \frac{Dose \times SF}{BW \times AT}$	

Notes:

ASTM = American Standard for Testing and Materials, 1995. Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites, E 1739-95

Calculations: Effective diffusivity, diffusive vapor flux, enclosed space air concentrations, dose, and risk calculations from ASTM 95 guidance formulas presented above.

**Tier I RBCA Output Data**  
**Tier I Risk and RBSL Sample Calculation**  
**Outdoor Air Inhalation of Benzene from Soil Vapor-Onsite Commercial/Industrial Receptor**

Soil Specific Parameters			
ASTM Default	$\rho_s$	1.7	Soil Bulk Density (g/cm <sup>3</sup> ) of (kg/L)
ASTM Default	$\theta_{as}$	0.26	Air Content of Soil (v/v)
ASTM Default	$\theta_{ws}$	0.12	Water Content of Soil (v/v)
ASTM Default	$\theta_t$	0.38	Total Soil Porosity (v/v)
Site-Specific	d	91	Depth to location of vapor sample (cm) – 3 ft depth
Diffusivity Parameters			
ASTM Default	H	0.22	Henry's Constant (dimensionless)
ASTM Default	$D^{air}$	9.30E-02	Air Diffusion Coefficient (cm <sup>2</sup> /s)
ASTM Default	$D^{wat}$	1.10E-05	Water Diffusion Coefficient (cm <sup>2</sup> /s)
Calculated	$D_s^{eff}$	0.0073	Effective Diffusion Coefficient through Soil (cm <sup>2</sup> /s)
Prediction of Flux from Soil Vapor Concentration			
Site Specific	$C_v$	9,900	Maximum Benzene Concentration in Soil Vapor (ppbv)
Unit Conv	$C_v$	32	Maximum Benzene Concentration in Soil Vapor (µg/L)
Calculated	F	2.6E-06	Maximum Diffusive Vapor Flux Predicted from Benzene Concentration in Soil Vapor (µg/cm <sup>2</sup> -sec)
Outdoor Air Concentration			
ASTM Default	s	200	Outdoor Mixing Height (cm)
ASTM Default	$U_{air-outdoor}$	225	Outdoor Wind Velocity (cm/sec)
ASTM Default	W	1500	Width of Outdoor Source Area Parallel to Wind Direction (cm)
Calculated	$C_{outdoor}$	8.5E-08	Outdoor Air Concentration (µg/cm <sup>3</sup> )
Dose			
ASTM Default	$IR_{air-outdoor}$	20	Daily Outdoor Inhalation Rate (m <sup>3</sup> /day)
ASTM Default	EF	250	Exposure Frequency (days/year)
ASTM Default	ED	25	Exposure Duration (years)
Calculated	Dose	11	Dose (mg)
Risk			
CAL EPA	$SF_1$	0.1	California Cancer Slope Factor for Benzene(kg-day/mg)
ASTM Default	BW	70	Body Weight (kg)
ASTM Default	$AT_c$	70	Averaging Time for Carcinogens (years)
Calculated	Risk	5.9E-07	Risk (positive/population)
Calculated	RBSL	17,000	Tier 1 Risk-Based Screening Level (ppbv) for TRL = 1E-06

Formulas
$D_{soil}^{eff} = D^{air} \frac{\theta_{as}^{3.33}}{\theta_t^2} + D^{wat} \frac{1}{H} \frac{\theta_{ws}^{3.33}}{\theta_t^2}$
$F = D_{soil}^{eff} \cdot C_v$
$C_{outdoor} = \frac{F \times W}{U_{air-outdoor} \times s}$
$Dose = C_{outdoor} \times IR_{air-outdoor} \times EF \times ED$
$Risk = \frac{Dose \times SF}{BW \times AT}$

Notes:

ASTM = American Standard for Testing and Materials, 1995. Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites, E 1739-95

Calculations: Effective diffusivity, diffusive vapor flux, enclosed space air concentrations, dose, and risk calculations from ASTM 95 guidance formulas presented above level.

## Appendix IV

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### Tier II RBCA Output Data

**RBCA TIER II OUTPUT DATA-OFFSITE RESIDENTIAL RECEPTORS**

Tier 2 Worksheet 9.3

Site Name: NESTLE OAKLAND FACILITY

Completed By: JCI

Site Location: Oakland, CA

Date Completed: 3/17/1999

1 OF 1

**GROUNDWATER SSTL VALUES**

Target Risk (Class A & B) 1.0E-6

MCL exposure limit?

Calculation Option: 2

Target Risk (Class C) 1.0E-5

PEL exposure limit?

Target Hazard Quotient 1.0E+0

**SSTL Results For Complete Exposure Pathways ("x" if Complete)**

CONSTITUENTS OF CONCERN		Representative Concentration (mg/L)	Groundwater Ingestion			Groundwater Volatilization to Indoor Air		Groundwater Volatilization to Outdoor Air		Applicable SSTL (mg/L)	SSTL Exceeded ? *■* If yes	Required CRF
CAS No.	Name		Residential: (on-site)	Commercial: (on-site)	Regulatory(MCL) (on-site)	Residential (offsite)	Commercial: (on-site)	Residential (on-site)	Commercial: (on-site)			
71-43-2	Benzene	1.8E-2	NA	NA	NA	2.7E-1	NA	NA	NA	2.7E-1	<input type="checkbox"/>	<1
107-06-2	Dichloroethane, 1,2-	1.7E-1	NA	NA	NA	9.8E-1	NA	NA	NA	9.8E-1	<input type="checkbox"/>	<1

>Sol indicates risk-based target concentration greater than constituent solubility

**RBCA Tier II Input/Output Data  
Tier 2 Risk and SSTL Calculation  
Indoor Air Inhalation of Benzene from Soil Vapor-Onsite Commercial/Industrial Receptor**

Soil/Building Parameters		
ASTM Default	$\rho_a$	1.7 Soil Bulk Density (g/cm <sup>3</sup> ) of (kg/L)
Oakland ULR	$\theta_{as}$	0.15 Air Content of Soil (v/v)
Oakland ULR	$\theta_{ws}$	0.25 Water Content of Soil (v/v)
Oakland ULR	$\theta_{ac}$	0.15 Air Content of Crack (v/v)
Oakland ULR	$\theta_{wc}$	0.25 Water Content of Crack (v/v)
Oakland ULR	$\theta_t$	0.40 Total Porosity-Soil and Crack (v/v)
Site-specific	L <sub>soil</sub>	91 Depth to Location of Vapor Sample (cm) – 3.0 ft depth
ASTM Default	L <sub>crack</sub>	15 Foundation Crack Thickness (cm)
Oakland ULR	$\eta$	0.001 Foundation Crack Fraction (dimensionless)
Diffusivity Parameters		
ASTM Default	H	0.22 Henry's Constant (dimensionless)
ASTM Default	D <sup>air</sup>	9.30E-02 Air Diffusion Coefficient (cm <sup>2</sup> /s)
ASTM Default	D <sup>wat</sup>	1.10E-05 Water Diffusion Coefficient (cm <sup>2</sup> /s)
Calculated	D <sup>eff</sup> <sub>soil</sub>	0.0011 Effective Diffusion Coefficient through Soil (cm <sup>2</sup> /s)
Calculated	D <sup>eff</sup> <sub>crack</sub>	0.0011 Effective Diffusion Coefficient through Foundation Cracks (cm <sup>2</sup> /s)
Prediction of Flux from Soil Vapor Concentration		
Site Specific	C <sub>source</sub> = C <sub>v</sub>	9,900 Maximum Benzene Concentration in Soil Vapor (ppbv)
Unit Conv	C <sub>source</sub> = C <sub>v</sub>	32 Maximum Benzene Concentration in Soil Vapor (µg/L)
Calculated	F	2.2E-09 Diffusive Vapor Flux Predicted from Benzene Concentration in Soil Vapor (µg/cm <sup>2</sup> -sec)
Indoor Air Concentration		
ASTM Default	L <sub>b</sub>	300 Enclosed Space Volume/Infiltration Area Ratio (cm)
ASTM Default	ER <sub>air-indoor</sub>	0.00023 Enclosed Space Air Exchange Rate (sec <sup>-1</sup> )
Calculated	C <sub>indoor</sub>	3.2E-08 Enclosed Space Air Concentration (µg/cm <sup>3</sup> )
Dose		
ASTM Default	IR <sub>air-indoor</sub>	20 Daily Indoor Inhalation Rate (m <sup>3</sup> /day)
ASTM Default	EF	250 Exposure Frequency-Adult (days/year)
ASTM Default	ED	25 Exposure Duration (years)
Calculated	Dose	260 Dose (mg)
Risk		
DTSC	SF <sub>1</sub>	0.1 Inhalation California Cancer Slope Factor for Benzene (kg-day/mg)
ASTM Default	BW	70 Body Weight (kg)
ASTM Default	AT	70 Averaging Time for Carcinogens (years)
Calculated	Risk	2.3E-07 Risk (positive/population)
Calculated	SSTL	44,800 Tier II Site-Specific Target Level (ppbv) for TRL = 1E-06

Formulas	
$D_{soil}^{eff} = D^{air} \frac{\theta_{as}^{5.55}}{\theta_T^{5.55}} + D^{wat} \frac{1}{H} \frac{\theta_{ws}^{5.55}}{\theta_T^{5.55}}$	
$D_{crack}^{eff} = D^{air} \frac{\theta_{ac}^{5.55}}{\theta_T^{5.55}} + D^{wat} \frac{1}{H} \frac{\theta_{wc}^{5.55}}{\theta_T^{5.55}}$	
$D_c^{eff} = \frac{L_{soil} + L_{crack}}{\frac{D_{crack}^{eff} \eta}{D_{soil}^{eff}}}$	
$F = D_c^{eff} \frac{\Delta C_v}{\Delta X}$	
$= \frac{C_{source} \frac{D_{soil}^{eff}}{L_{soil}}}{1 + \frac{D_{soil}^{eff}}{L_{soil}} \frac{L_{crack}}{D_{crack}^{eff} \eta}}$	
$C_{indoor} = \frac{F}{ER_{air-indoor} \times L_b}$	
$Dose = C_{indoor} \times IR_{air-indoor} \times EF \times ED$	
$Risk = \frac{Dose \times SF}{BW \times AT}$	

Notes:

ASTM = American Standard for Testing and Materials, 1995. Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites, E 1739-95.

ULR = Tier I Risk-Based Screening Levels, Oakland Urban Land Redevelopment Program (Spence and Gomez, 1997 and 1999).

Calculations: Effective diffusivity, diffusive vapor flux, enclosed space air concentrations, dose, and risk calculations from ASTM 95 guidance formulas presented above.