6920 Koll Center Parkway
Suite 216
Pleasanton, CA 94566
925.426.2600
Fax 925.426.0106

Clayton GROUP SERVICES

6070

- Does not evaluate TPH
- Expects natural biodegrad even though it hasn't been shown

February 16, 2001

Mr. Barney Chan
Hazardous Materials Specialists
Alameda County Health Care Services
1131 Harbor Bay Parkway, Suite 250
Alameda, California 94502-6577

Clayton Project No.70-97066.00

Subject: Risk Assessment and Feasibility Study for the property at 630 29th Avenue in Oakland, California

Dear Mr. Chan:

Clayton has prepared the accompanying report, which presents a risk assessment (RA), and a feasibility study (FS) for property at 630 29th Avenue in Oakland, California. Clayton performed a risk analysis to evaluate potential human health and environmental effects and determine site specific cleanup goals. The FS incorporates the RBCA results for the determination of appropriate corrective actions for the site.

If you have any comments or questions regarding the RA/FS please contact me at (925) 426-2665.

Sincerely,

Warren B. Chamberlain, R.G., C.HG., P.E.
Project Manager
Environmental Services

Jon A. Rosso, P.E.
Director

WBC/wbc
cc: Donna Proffitt
Marlin Zechman
Rita Repko
Thomas Downing

grab gw

B-7 ~6000 umhos/cm
B-8 ~13,000 " "

MW-3 ~ 10,000 " "

2/2/98

Clayton GROUP SERVICES

Risk Assessment and Feasibility Study
for the
Former Lemoine Sausage Facility
630 29th Avenue
Oakland, California

Clayton Project No. 70-97066.00

February 16, 2001

6070

CONTENTS

CONTENTS

Tables

Figures

Appendices

1. INTRODUCTION

Clayton Group Services, Inc., (Clayton) has prepared a risk assessment (RA) and a feasibility study (FS) for the former Lemoine Sausage Facility located at 630 29th Avenue in Oakland, California (Figure 1). The RA/FS has been prepared pursuant a request from the Alameda County Health Care Services (ACHCS) in the letter dated June 21, 1999. The RA was performed as a preliminary step to determine site specific cleanup goals based on present and future use. The FS presents an evaluation of different remediation technologies that may be effective in achieving site cleanup to regulatory satisfaction and within the bounds of practical applicability and economic constraints.

The following outline has been used to present this report:

- Site Description and History.
- Site Conceptual Model.
- Risk Analysis.
- Evaluation of Potential Remedial Methods.
- Conclusion and Recommendations

2. SITE DESCRIPTION AND HISTORY

A single 1,000-gallon gasoline underground storage tank (UST) and associated plumbing/piping were formerly located beneath the sidewalk of 7th Street and adjacent (east) of the subject property building (Figure 2). The associated fuel dispenser was located in a "cubby hole" near the building's roll-up door. The UST and associated piping were removed on November 21, 1996 and confirmation soil samples were collected. A petroleum hydrocarbon sheen was noted on top of groundwater and petroleum hydrocarbons were detected in the confirmation soil samples collected at the time of the UST removal.

In addition to the three quarterly groundwater monitoring reports issued since the Second Quarter of 2000, site characterization efforts have been documented in the following Clayton prepared reports:

- *"Underground Storage Tank Closure Report"*, dated September 24, 1997.
- *"Air Sampling for Benzene at 630 29th Avenue, Oakland California"*, dated March 1998.
- *"Limited Subsurface Investigation, Former Lemoine Sausage Facility, 630 29th Avenue, Oakland, California"*, dated April 1998.
- *"Limited Groundwater Investigation, Former Lemoine Sausage Facility, 630 29th Avenue, Oakland, California"* dated March 1999
- *"Additional Field Investigation, and Groundwater Monitoring, for the Former Lemoine Sausage Facility, 630 29th Avenue"*, dated November 11, 2000.

3. SITE CONCEPTUAL MODEL

In developing a risk assessment and feasibility study, a clear understanding of the nature of the site (that is, geologic setting, hydrogeology, and distribution of contamination) is required. A site conceptual model (SCM) is presented and is founded on site information gathered during field investigations and laboratory analytical data.

3.1. SITE GEOLOGY

Soil cores recovered from site investigation work, show the site to be underlain by predominantly fined grained silty clay soils that contain occasional sand and gravel lenses. A silty soil type exists beneath the building footprint and extends from grade (street level) to approximately three feet below grade. The silty clay is underlain by a moist, clayey sandy silt layer that varies in thickness from two to six feet. Green staining was noted in soils in this interval from approximately 3 to 6 feet below ground surface (bgs), but no free hydrocarbon product was observed in soil cores.

A stiff, moist silty clay was encountered below the clayey sandy silt layer and extended to the termination depth within most boreholes. The deepest boreholes extend to approximately 20 feet below grade. In borehole MW-7, a silty sandy gravel was encountered at a depth of approximately 18.5 feet bgs.

Soil borings MW-1, B-9, and B-10 were installed within the backfill trench of a sanitary sewer pipeline. Each boring was terminated at 9 feet bgs, the depth at which the concrete sanitary sewer pipe was encountered. The fill below the surface asphalt and base material consisted of a sandy clay with gravel to approximately 8 feet bgs. An approximately one-foot layer of saturated sand occurs from 8 to 9 feet bgs and covers the concrete sanitary sewer pipe.

3.2. HYDROGEOLOGY

Four rounds of groundwater sampling and water table measurements have been performed at the site. The first encountered groundwater beneath the site appears to occur under unconfined conditions. The depth to groundwater has been measured to vary from approximately 3.5 feet to approximately 8.5 feet bgs in most wells.

The initial (February 1999) groundwater measurements were obtained from temporary well points set within exploration boreholes, and the groundwater gradient was determined to be 0.09 feet/foot (ft/ft) towards the north-northeast. However, groundwater measurements from monitoring wells collected during the Second, Third and Fourth Quarter 2000 monitoring events, indicate that the groundwater gradient beneath the site has an average magnitude of 0.02 ft/ft towards the west. The water table elevation contour map with the groundwater gradient and flow direction indicated as measured in December 2000 is presented as Figure 3. The groundwater data indicates that groundwater most commonly flow towards the west (to Alameda Island canal). However, the subject property may be influenced by water level changes in the sanitary sewer trenches or the nearby Alameda Island canal.

From field observations during the installation of soil borings and from monitoring well purge measurements, it appears that soil beneath the site is predominantly fine grained in nature and of low permeability. For example, while attempting to collect grab groundwater samples from borings B-7, B-8, and MW-2, no appreciable quantity of groundwater had collected in the temporary well points when left open overnight. Also, many of the monitoring wells can be bailed dry upon removal of approximately two to three well casing volumes of groundwater. During the installation of many boreholes, soil conditions were observed to be moist or saturated, however, monitoring well purge results would suggest that much of the subsurface water appears to be irreducible and bound to soil particles due to capillary forces.

3.3. EXTENT OF CONTAMINATION

To-date, eight (8) groundwater monitoring wells and nine (9) soil borings have been installed at the subject property to determine the extent of hydrocarbon impacts to the subsurface.

3.3.1. Soil

The thickness of unsaturated vadose zone soil is limited due to the shallow depth to water measured below the site. A capillary fringe appears to exist from the water table to approximately one-foot bgs. Through the unsaturated soil zone (from approximately 3 ft to 8 ft bgs), a hydrocarbon "smear zone" has developed at the soil/groundwater interface due to fluctuating groundwater levels. **The highest concentrations of TPHG and BTEX in soil were collected from soil samples from approximately 6 feet bgs, that is, from within the smear zone.** Historical soil analytical data are presented in Table 2.

3.3.2. Groundwater

The present network of groundwater monitoring wells provides adequate coverage to discern groundwater flow and hydrocarbon plume conditions beneath the subject property. Recent groundwater monitoring indicated that groundwater flows west from the subject property towards the Alameda Island canal. The hydrocarbon plume appears stable in size and configuration with the highest concentration of hydrocarbons being detected beneath the central portion of the building in the vicinity of monitoring wells MW-2 and MW-3.

The extent of groundwater impacted by petroleum hydrocarbons covers much of the site and extends offsite. The **hydrocarbon plume appears to have two areas of high dissolved hydrocarbon concentrations; one area of high concentrations is located west of the former UST in the vicinity of monitoring wells MW-2, MW-3, and MW-5, and other located east of the former UST in the vicinity of monitoring well MW-1.** TPHG and BTEX are observed in offsite monitoring well locations MW-1, MW-6, and MW-7.

Monitoring well MW-6 appears to be located near the eastern upgradient edge of the hydrocarbon plume. Trace and non-detect concentrations of TPHG and BTEX have been detected in the downgradient well MW-7. Monitoring well MW-7 appears to be located near the northern downgradient edge of the hydrocarbon plume.

The distribution of TPHG and benzene in groundwater beneath the site are shown in Figures 4a and 4b, respectively. These isoconcentration maps show the distribution of TPHG and benzene in groundwater gathered during the Fourth Quarter 2000 groundwater monitoring event. The TPHG and benzene isoconcentration maps show that the elevated concentrations within the hydrocarbon plume occur beneath the central portion of the onsite building and near the former UST. The location of the center of the "building" plume relative to the known source area (the former UST) indicates that over time groundwater flow and contaminant transport has been predominantly to the west. The TPHG and benzene isoconcentration maps produced from the three quarterly monitoring events performed to-date, indicate that the plume geometry is relatively stable. The slight differences in hydrocarbon concentrations and shape of plume geometry can be attributed to concentration/dilution effects associated with fluctuating groundwater levels at the site.

Chlorinated volatile organic compounds (VOCs); Trichloroethene (TCE), cis- and trans-1,2-Dichloroethene (1,2-DCE), and Vinyl Chloride (VC) were detected in monitoring well MW-8. The greater concentration of 1,2-DCE than TCE in the groundwater samples would indicate that the VOCs have undergone significant degradation. Due to the limited onsite distribution of the chlorinated VOCs (with the exception of 1,2-DCA), the source for these compounds is most probably related to an off-site source area.

need to show this

Historical groundwater analytical data from grab groundwater samples and from monitoring well sampling are presented in Table 3 and Table 4, respectively.

3.4. BIO-ASSESSMENT OF GROUNDWATER

Clayton collected additional groundwater samples during quarterly monitoring events to assess site conditions for bacterial activity. A summary of the bio-assessment data collected during monitoring events is presented in Table 5.

Water quality parameters Hydrogen Ion Index (pH), Temperature and Oxidation-Reduction Potential (ORP) are within the normal range for "non-toxic" groundwater. The Dissolved Oxygen (DO) values for the plume are less than 2 mg/kg, indicating anaerobic (oxygen deficient) conditions. The upgradient sampling point MW-7, was the exception with the DO measured at 3.1 mg/kg.

To test for the presence of anaerobic bacteria, the Heterotrophic Plate Count (HPC) analysis were performed on select samples. The HPC is a test that stimulates bacterial growth on an agar solution containing nutrients. The General HPC test indicated that heterotrophic bacteria are present within groundwater and responsive to growth factors (optimum temperature and food sources). A Selective HPC was performed where a 100 parts per million (ppm) of gasoline fuel is added to the culture as the carbon source. For the Selective HPC test, the results show that groundwater from MW-1 (located within the onsite hydrocarbon plume) had a greater percentage of responsive bacterial growth than the bacteria from groundwater samples collected from the peripheral wells, MW-6, MW-7 and MW-8. The Selective HPC data would indicate that a hydrocarbon-selective bacteria exist within the plume, and that bacterially driven natural attenuation processes are occurring, albeit at a less than optimum rate.

Bio-nutrient nitrogen (as nitrate, nitrite, and ammonia) and phosphorus (as phosphate) compounds where detected within groundwater beneath the site, but were sporadic in distribution and below levels necessary to foster optimum microbial activity. Nitrogen compounds were only detected in monitoring well MW-7 (nitrate at approximately 20 mg/L), and given the well is location near a sanitary sewer pipeline, the source of nitrogen compounds is most probably leakage from the sanitary sewer system.

Orthophosphate was detected in monitoring wells at MW-3 at 1 mg/L and trace levels in MW-1

The bio-assessment data for the site indicates that groundwater beneath the site contains heterotrophic bacteria that are capable of degrading organic compounds. The dissolved oxygen readings indicate that groundwater is anaerobic (oxygen-poor) and lacking essential (nitrogen and phosphate) inorganic nutrients. Increasing the concentrations of oxygen, nitrogen, and phosphate compounds within groundwater may potentially increase bacteriological activity.

4. SITE-SPECIFIC RISK ASSESSMENT

No regulatory mandated site cleanup goals for soil and groundwater have been set. Clayton is proposing that site cleanup goals be determined using risk analysis as a guide and that cleanup levels be set such that no adverse human health or environmental conditions occur. From a human health perspective the area of principle concern would be worker exposure within the present onsite building and offsite utility trenches. Environmental risk can be evaluated by identifying potential downstream receptor locations. To evaluate potential human health and environmental risk related to the site, Clayton has prepared the following a risk assessment in accordance with acceptable risk assessment methods or has collected and analyzed media samples to compare with regulatory exposure threshold limits.

4.1. SITE RISK ASSESSMENT

The following risk assessment has been performed in accordance with the California Code of Regulations Title 22 Division 21 (Title 22), methods outlined in the American Society for Testing and Materials (ASTM-E1735) Standard Guide for Risk Based Corrective Action (RBCA) Applied at Petroleum Release Sites (ASTM, 1995), and the Oakland Urban Land Redevelopment Program (OULRP): Guidance Document (COPWA, 2000).

In preparing the OULRP guidance document, the City of Oakland gathered and validated technical data for the performance of a RBCA within the City of Oakland. The document "*Oakland Risk-Based Corrective Action: Technical Background Document*", (ORBCA) prepared by Spence and Gomez and updated January 1, 2000 presents the technical support to the OULRP guidance document and contains data that is specific to the City of Oakland environ. The ORBCA presents data that has received extensive review by multiple public and private parties, including federal, state, and local regulatory agencies. As such, where site-specific data is not available, the Oakland-specific data presented in the ORBCA are used as a source of regulatory acceptable default parameters for this current RBCA. The ORBCA technical background document is presented as Appendix E.

For this current risk assessment the carcinogenic risk was set at a cumulative risk of 1 in 100,000 and the hazard quotient for non-carcinogenic risk was set at 1. The justification for these risk levels is presented in the ORBCA document (see Appendix E, Section B.4 Target Risk Levels).

4.1.1. RBCA ANALYSIS

The RBCA process is a three tiered method where potential risk is estimated based on a set of governing mathematical equations. Tiers 1, 2, and 3 are equally protective of human health and the environment, based on applicable target risks and exposure criteria. However, with each tier upgrade, the degree of uncertainty and conservatism involved in the cleanup standard calculation is reduced based upon a more detailed characterization of actual site conditions (GSI, 1995). The tiered RBCA analysis is briefly described below:

Tier 1: risk is calculated using default parameters to describe the site. The only site specific input at this level of evaluation are the concentrations of the site specific chemical of concerns. If chemical specific risk is not exceeded in the Tier 1 evaluation then no further action is required. If target risk is exceeded, then a Tier 2 evaluation can be performed.

Tier 2: risk is calculated using the same set of mathematical formulae as the Tier 1 analysis, however, default parameters are replaced by site-specific data collected during site characterization field investigations. If chemical specific risk is not exceed in the Tier 2 evaluation then no further action is required. If target risk is exceeded, then a Tier 3 evaluation can be performed.

Tier 3: risk is calculated using site-specific data usually collected as part of field investigations and complex mathematical models. The mathematical models usually require evaluation by computer processing, and can account for time and spatial variations not implicit in the Tiers 1 and 2 analysis. If chemical specific risk is not exceed in the Tier 3 evaluation then no further action is required. If target risk is exceeded, then site remediation of the chemicals of concern is needed.

The risk assessment presented in this report is at the Tier II level and follows the guidelines presented in the ASTM E-1739 document, as follows:

1. Identification of Chemicals of Concern
2. Identification of Primary Source
3. Identification of Secondary Sources
4. Identify Transport Mechanisms
5. Identification of Chemical Exposure Pathways to Potential Receptors
6. Receptor Characterization and Survey
7. Risk Evaluation
8. Decision Analysis – Remedial Action Options

An essential part of the RBCA process is to recognize the potential fate and transport of released chemicals through all possible media (soil, water, and air). An exposure pathway flowchart, has been prepared for the site to assist in recognizing potential chemical exposure and transportation pathways, and is presented as Figure 5. The following discussion presents the site-specific details for the valid elements of the exposure pathway flowchart (Figure 5).

4.1.2. Chemicals of Concern

The United States Environmental Protection Agency (EPA) and State of California regulate individual chemicals and not formulation of chemicals, such as gasoline. Therefore, hydrocarbon constituent compounds benzene, toluene, ethylbenzene and xylenes (BTEX), and the fuel additive 1,2-Dichloroethane (1,2-DCA) are the known chemicals of concern (COCs) associated with the site. In addition, analytical results from the June and December 2000 groundwater sampling events showed the presence of VOCs; TCE, cis- and trans-1,2-DCE, and VC in groundwater, however, these compounds are not included in the RBCA due to their limited distribution.

4.1.3. Identification of Primary Source

The source of hydrocarbon related compounds (BTEX and 1,2-DCA) to the environment are historic releases from the former gasoline UST system. Removal of the UST and residual contents has removed the primary source of hydrocarbons from the site. The source of chlorinated VOCs (except 1,2-DCA) has not been determined, but the localized detection of VOCs (except 1,2-DCA) to the southern portion of the building (in the vicinity of monitoring well MW-8) suggests an offsite source.

4.1.4. Identification of Secondary Sources

Secondary sources at the site include surficial soil (less than 3 feet bgs), unsaturated subsurface soil, and groundwater. Results from site characterization reveal that within surficial soil low concentrations of BTEX were only present in one soil sample (B-5), see Table 2. For unsaturated (or smear zone) soil, three of the five sample locations contained low concentrations of BTEX compounds, see Table 2. However, the hydrocarbons detected within the subsurface soil were collected at depths below the known shallowest groundwater levels. Thus, due to the trace concentration levels and sporadic distribution, both capillary fringe and vadose soils are not considered a primary or secondary source of COCs to the environment.

Dissolved hydrocarbons in groundwater represent the only valid secondary source of COCs at the site. Groundwater monitoring reveals that a BTEX plume is concentrated beneath the central portion of the onsite building in the vicinity of monitoring wells MW-2 and MW-3. A plume width of 30 feet was chosen, based on the benzene isoconcentration maps from the June and September 2000 groundwater monitoring events. During these monitoring events, the contour representing benzene concentrations at 10 milligrams per liter (mg/L) or greater was approximately 30 feet. Benzene was not detected above 10 mg/L during the December 2000 monitoring event. The thickness of the hydrocarbon impacted water bearing zone was taken to be 10 feet.

4.1.5. Transport Mechanisms

Based on the evaluation of secondary sources, COCs may move through the environment through two possible transport mechanisms, as follows:

1. Advective and dispersive movement of COCs within groundwater, and
2. Volatilization of COCs dissolved in groundwater to ambient (indoor and outdoor) air.

The site's de minimus secondary soil source areas are protected from infiltration by concrete pavement and asphalt, therefore ~~both~~ potential leaching from soil to groundwater is not considered a valid pathway. Similarly, direct exposure to surficial soil and groundwater is restricted due to building and pavement structures.

4.1.6. Evaluation of Exposure Pathways to Potential Receptors

The identified pathways include:

- The volatilization of COCs (in particular, benzene) from groundwater to indoor or outdoor air. This chemical fate pathway was demonstrated not to posed exposure beyond regulatory levels based on the results of indoor and outdoor air testing performed by Clayton and documented in the report, "*Air Sampling for Benzene at 630 29th Avenue, Oakland California*", dated March 1998.
- Dissolved Groundwater – three possible receptors are recognized for impacted groundwater.
  - Ingestion of groundwater as drinking water
  - Downgradient surface water receptors (the Alameda Island canal)
  - Downgradient subsurface water receptors (utility trenches)
  - onsite utility workers ?

4.1.7. Receptor Survey

A receptor is considered any person or environment that may come into prolonged contact with chemicals released from the site. Apart from the obvious site workers that may become exposed to COCs, other possible receptors include offsite construction workers performing utility maintenance, downgradient domestic water wells, or aquatic surface water bodies that receive contaminated groundwater. To determine possible offsite receptors, Clayton gathered information with regard to groundwater supply wells and utility trenches in the immediate vicinity of the site.

Clayton requested a well search from the Alameda County Public Works Agency (ACPWA) for all wells within a 2,000-foot radius of the site. The ACPWA well survey documents indicate that no domestic drinking water wells exist within a ½ -mile radius downgradient of the site. Based on the ACPWA survey data, the risk exposure due to groundwater consumption within 2,000 feet downgradient of the site does not exist. The ACPWA well survey data is presented as Appendix A.

Clayton contacted nine utility and telecommunication companies listed by Underground Services Alert (USA) as having underground equipment in the vicinity of the site. Of the many types of utilities present, only the storm drain and sanitary sewer systems are likely viable conduits to disperse COCs. The location of storm drain and sanitary sewer lines within the immediate vicinity of the site are shown on the City of Oakland supplied utility map of the neighborhood (Appendix B). The nearest storm water pipe is located along 29th Avenue; storm water flows from the northeast to the southwest through this section of storm water drains. Monitoring well MW-7 tests groundwater that moves offsite towards the storm water drains, and groundwater samples from the December

2000 monitoring event contained TPHG as non-detect and benzene was detected at 0.0016 mg/L. Significant impact to the storm drain utility trench does not seem likely.

Similarly the nearest sanitary sewer is located upgradient and north of the site within East 7th Street, and a sewer line parallels the storm drain along 29th Avenue. Again, the groundwater in the vicinity of the sewer line along 29th Avenue is monitored by monitoring well MW-7, with the latest analytical results stated above. Groundwater that may impact the sewer line along East 7th street is monitored by MW-1 and MW-6. For the December 2000 analytical results for MW-6; TPHG was detected at 0.32 mg/L and benzene was non detect. The analytical results from monitoring events indicate that monitoring wells MW-6 and MW-7 are situated at the perimeter edge of the hydrocarbon plume.

The RBCA was run with one offsite point of exposure (POE) at approximately 330 feet or 1/16-mile. This scenario was tested to discern possible risk to a utility worker whom may be required to perform maintenance within a utility trench. The 330 feet POE approximates a 1-neighborhood block radius from the site.

Immediately downgradient of the site (¼-mile) is the Alameda Island canal, groundwater may enter the canal through natural pathways or via leakage from utility trenches. The main risk to human health is the ingestion of fish that live within the canal. The Alameda Island canal was incorporated into the RBCA analysis as a surface water receptor located approximately ¼-mile from the site, the exposure pathway was considered to be ingestion of fish, the recreational use pathway (e.g., swimming) was not considered viable pathways due to the canal's use as an active marine thoroughfare.

4.1.8. Risk Evaluation

The risk assessment was performed using RBCA Tool Kit for Chemical Releases Version 1.2 software developed by Groundwater Services Inc. (GSI, 1999). A tier II RBCA was performed. Site-specific data were used where available, Oakland-specific data (Spence and Gomez, 2000) were used as default data where site-specific data were not available.

A summary of the RBCA input parameters is presented as Figure 6, and a summary of results from the RBCA for all valid pathways is presented as Figure 7. A complete set of the RBCA input parameters and the output results are presented in Appendix C.

First the RBCA indicates that for Ethylbenzene, Toluene and mixed Xylenes, no adverse health effects exist. The cumulative hazard quotient for all valid pathways was less than 1 for these compounds.

The RBCA suggested that indoor air quality for benzene exceed the individual COC risk of 1 in 1,000,000, but not the cumulative risk of 1 in 100,000. As previously mentioned, field testing of indoor air quality within the subject building demonstrated that actual benzene concentrations are well below the regulatory exposure levels.

The analysis does indicate that ingestion of onsite groundwater could pose a cumulative health risk of 1 in 555 due to the (modeled) concentrations of benzene and 1,2-DCA. The cumulative risk for the site-model is 180 times in excess of the cumulative health risk goal of 1 in 100,000. For the groundwater ingestion pathway, the individual risk for benzene was 1 in 560, while for 1,2-DCA the individual risk was 1 in 1,900. Also the hazard quotient for the ingestion of benzene was 54. The RBCA indicates that carcinogenic (above the 1 in 100,000) and non-carcinogenic risk (hazard quotient greater that 1) health risk may exist at the site through the exposure pathway of consumption of groundwater. The health risk exists due to the presence of benzene and 1,2-DCA in groundwater.

However, the RBCA modeling shows that health risk at the offsite utility trench (330 feet away) POE diminished to allowable limits as the concentration of contaminants in groundwater decreases offsite, due to natural attenuation processes. Similarly, no significant environmental risk exists at the Alameda Island canal POE.

Groundwater beneath the site is non-potable, (by —?) and as such, no significant health risk issues should be associated with the site. Finally, in obtaining the level of health risk associated with the site the maximum measured concentration of COCs were used, as such this risk assessment has attempted to model the worse case scenario.

4.1.9. Decision Analysis – Select Appropriate Remedial Action

The risk analysis suggests that no potential offsite receptors will be impacted by COCs at levels that exceed their respective risk based limits. The RBCA analysis does indicate that health concerns may be encountered through the ingestion of groundwater from the site. Primarily, the present concentration of benzene within groundwater exceeds the cumulative 1 in 100,000 by a factor of 180. Thereby reducing the modeled benzene concentration of 16 mg/L by a factor of 180 would set an acceptable risk for benzene at [redacted].

The development of onsite groundwater as a potable drinking water source is highly unlikely for the following reasons:

- Site is located less than 300 feet from a known sanitary sewer system.
- Brackish nature of the groundwater, specific conductance (SC) measurements of groundwater range from approximately 1,000 to 1,800 micromhos per centimeter (µmhos/cm). For potable water, the State of California recommends and that SC not exceed 900 µmhos/cm and sets an upper limit of 1,600 µmhos/cm. (in MW, higher SC observed in grab GW)
- The ability to produce cost effective quantities of water from the fine grained soils that underlie the site is doubtful. That is, any water production wells screen through the impacted soil beneath the site would not be capable of producing water at a rate of 5 gallon per minute over a prolonged period of time.

Based on the points presented above, that groundwater beneath the site is non potable, then the RBCA indicates that no action is necessary to protect human health and the environment. if nat. attenuation is observed & gw conc < RWQCB guideline for TPH.

5. POTENTIAL REMEDIAL ALTERNATIVES

As requested by the ACHCS, Clayton explored the feasibility of possible remedial technologies that may be implemented to remediate the site. The objectives of the FS are to identify the portion of the site that requires remediation, and evaluate remedial alternatives that are technically and economically appropriate for the site. Remedial alternatives are evaluated on three criteria: Effectiveness, Technical Implementability, and Cost. Potential remedial alternatives are formulated for consideration based on site-specific conditions and their recognized applicability and success on similar projects, elsewhere. Existing site conditions will have a significant impact on technology selection.

5.1. TREATABILITY OF CONTAMINANTS

The chemicals of concern within hydrocarbon plume are known to be volatile and biodegradable. Therefore, application of field tested and proven remedial technologies will be largely dependent on site conditions and economics. Site conditions important to remedial design and implementation are:

- shallow groundwater,
- low permeability soils, and
- structural controls (that is, building foundation and walls, and pavements).

5.2. DESCRIPTION OF REMEDIAL ALTERNATIVES

Smear zone /capillary fringe soil and groundwater remediation alternatives to be evaluated for the site are described below. These alternatives were selected for consideration based on a number of factors:

- their recognized applicability on similar projects,
- potential for straight-forward implementation,
- availability of treatment equipment,
- minimal site structural requirements,
- anticipated acceptance by ACHCS, and
- limited long-term operation and maintenance so as not to encumber the site's present operations.

In grading potential remedial technologies: effectiveness, implementation and cost are important factors. Effectiveness is a rating of the remedial technology's ability to reach cleanup goals within a desired time frame. However, the ability to predict actual clean-up time to risk based target levels is not possible at this time. Implementation is a rating of the degree of difficulty required to construct and maintain the remedial technology. Cost is a financial estimate for the design, implementation, future maintenance, and shutdown of the remedial technology. As it is not possible to predict actual clean-up times, the cost estimates presented in this study are for system design, construction, system start –up, one-year of operation and maintenance, one-year of quarterly monitoring and for final system shut-down costs.

The rating for remedial effectiveness has been judge as follows:

- Excellent – option has 90% or better chance of achieving clean-up success.
- Good – option has 60 to 89% chance of achieving clean-up success.
- Fair – option has 40 to 59% chance of achieving clean-up success.

- Poor – option has 0 to 39% chance of achieving clean-up success.

The rating for ability to implement has been judge as follows:

- Excellent – easy to implement, regulatory permitting straight forward.
- Good – can be implement without special design considerations and/or obtain regulatory permits.
- Fair – can be implement with minor special design considerations and/or regulatory permits require significant design effort and testing.
- Poor – difficult to implement and/or difficult to permit.

A cost estimate summary for each remediation technology is presented in Appendix D. Table 6 presents a rating summary of effectiveness (to achieve desire cleanup goals), implementation (ability to construct and operate remedial technology) and cost for each remedial technology considered in the following discussion.

5.2.1. No Action - Monitoring Only

The preceding risk assessment indicated that based on highest measured levels of contamination at the subject property, that provided no groundwater from the impacted zone is not used as a potable water source, then no remedial action is required to protect human health and the environment. Groundwater monitoring would be performed on a quarterly basis to confirm the stability of groundwater flow conditions and plume geometry. This option is easy to implement, and remediation occurs due to natural attenuation processes. (Slow) no evidence of this occurring

5.2.2. Soil Treatment Methods

Onsite remediation of the soil will best be accomplished when coupled with treatment of hydrocarbon impacted groundwater. Therefore, the remedial alternatives considered in this FS for soils are addressed in the following groundwater treatment section.

5.2.3. Groundwater Remediation Methods

The following text provides a brief description of proven groundwater remedial technologies. These options are considered in the FS for their overall technical applicability:

Option 1 - Enhanced Insitu Bioremediation (EIB):- to stimulate bacterial activity and increase the biomass within the hydrocarbon plume, non-toxic inorganic chemicals (bio-nutrients) are added to the groundwater that release oxygen, nitrogen and phosphate. At sites where stagnant hydrocarbon plumes are present one or more of the essential bio-nutrient elements is commonly depleted, and natural attenuation of the hydrocarbon plume due to microbial activity ceases. By determining site's "bio-needs" the missing elements can be injected into the hydrocarbon plume to boost bioactivity. The supply of bio-nutrients is assessed prior to and during remediation. During the course of remediation, if nutrient concentrations are found to be inadequate, then further nutrient addition is performed.

An advantage of the EIB approach is that only minor structural effort is needed. That is, only limited concrete cutting for borehole injection points is necessary and no plumbing/piping or aboveground treatment facility construction is required. The effectiveness of EIB can be measured by off-gas analysis (carbon dioxide concentration) by soil vapor sampling and dissolved oxygen measurements in groundwater. These data are compared against predicted first-order biological reaction kinetics to assess overall cleanup effectiveness.

Option 2 - Air Sparging-Vapor Recovery (ASVR):-This approach uses compressed air injected into the saturated zone. The air bubbles disperse and travel upward through the saturated zone and remove volatile hydrocarbon compounds (VHCs) from the groundwater through chemical partitioning (stripping). Stripping involves the mass transfer of VHCs from the aqueous phase to the vapor (air) phase. Air laden with VOCs is collected by a soil venting system under negative pressure. Where groundwater TPHG concentrations are high, sparge vapors may exceed the lower explosive limit (LEL) for some of the volatile compounds. Air flows for sparging are generally high.

The difficulty in implementing this technology is extremely shallow groundwater conditions, low permeability soils and potential hazard of collecting explosive levels sparge vapors within utility conduits and beneath the building. In addition, available space to construct a treatment plant and other structural limits restrict this option.

Option 3 - Pump and Treat:- Groundwater extraction and treatment through activated carbon filters is a proven technology for the removal of hydrocarbon impacted groundwater. However, due to low permeability soil at the site, construction costs, and the relatively high number of groundwater extraction wells required to capture the plume, this technology is not considered time or cost effective for this site.

Option 4 - Dual Phase Extraction:- Dual phase extraction (DPE) is a proven technology that combines soil venting with groundwater extraction. A perforated pipe (suction pipe) would be placed in specially constructed airtight DPE wells finishing approximately 3 to 10 feet below the groundwater surface. A vacuum, typically 10 to 15 inches of mercury ("Hg) is then applied to the tube.

Suction lifts water and soil vapor simultaneously through the suction pipes into a piping network to a treatment plant. Using this technique, groundwater extraction rates and soil venting effectiveness are greatly enhanced due to the drawdown effect of groundwater pumping and the uplift of the water table from the soil venting vapor suction. These opposing forces within the same well screen enhance dewatering and vapor stripping in the vicinity of the well.

General Requirements: For options 3 and 4, extracted groundwater would be treated and discharged to local storm drain system if capacity is available under authority of a National Pollutant Discharge Elimination System (NPDES) permit or to a publicly owned treatment works (POTW). Typical groundwater extraction treatment equipment would include downhole pumps and motor controls, water level switches, holding tanks, particulate filters, and activated carbon filters. Significant pavement trenching would also be required to plumb the systems together.

For options 2 and 4, typical soil vapor extraction equipment would include compressed air and vacuum blowers, water/vapor separator, water transfer pump, and process controls to allow for safe unattended operation. Extracted soil vapors would be treated using a thermal or catalytic oxidizer or activated carbon filters. Both groundwater extraction and soil vapor extraction systems are best implemented in a trial and enhancement approach whereby the progress of site remediation is assessed periodically and system enhancements made.

An estimate of the time to completion for any of the above alternatives to achieve the RBCA target levels (that is, to reduce benzene to 0.089 mg/L within groundwater) can not be made at this time without first performing a pilot study for each remedial technology.

5.3. GROUNDWATER TREATMENT RECOMMENDATION

5.3.1. Selected Remedial Option

The RBCA analysis supports the no further action option, however, if a remedial is required, then Enhanced Insitu Bioremediation (Option 1) is a potentially suitable remedial technology for this site. The bio-assessment data indicates that present DO and bio-nutrient concentrations beneath the site are below optimum levels to promote microbial growth. Therefore increasing the DO concentrations at the site should increase bacterial activity and biomass, and thereby increase the rate of hydrocarbon degradation. DO can be readily added to the subsurface using readily available non-toxic chemicals and placed using conventional trenching, drilling and injection methods.

The chemicals that release DO have a limited period of activity (usually 6 to 9 months) and due to DO consumption by bacteria, two to three applications of DO may be needed to maintain subsurface DO concentrations and increase subsurface biomass to its maximum possible levels. The time between DO applications should be dictated by field measurements of DO and hydrocarbons in monitoring wells.

5.3.2. Reasons for discounting other options

Options 2, 3, and 4 although practical, are not considered feasible, due to the low permeability soil beneath the site. When fine grained, low permeability materials similar to site soil conditions are placed under physical stress by pumping or vacuum extraction, preferential fluid pathways are commonly observed, resulting in a limited volume of the subsurface being affected by the remedial actions. The subsurface volume not under the influence of the imposed remedial stress will release bound contaminants by the very slow chemical diffusion process.

However, the biggest impediment to these options is the ability to obtain space to construct a treat system that would not adversely impact the daily business activities of the current occupant. Furthermore, these options will require costly structural effort for trenching, and construction of a treatment plant.

6. CONCLUSION AND RECOMMMENDATIONS

This RA/FS report has summarized past site characterization efforts and results. A site conceptual model was developed from investigation data to assist in the performance of a risk assessment and design of remedial alternatives. The site conceptual model shows that hydrocarbon related compounds impact groundwater, while hydrocarbon compound impacts to soil are de minimus. Hydrocarbon compounds, and in particular benzene, impacts to groundwater are the main area of concern at the subject site.

Clayton performed an ASTM standard Tier II RBCA using site specific and Oakland-specific input parameters. The RBCA showed that site contamination did not pose unacceptable risk to potential downgradient and offsite receptors, whether the pathway be through direct ingestion of groundwater or inhalation of vapors that might emanate from the hydrocarbon groundwater plume. The RBCA did indicate that unacceptable risk might occur if source area (onsite) groundwater is ingested. However, as water quality beneath the site is brackish, future development of the groundwater as a potable water supply is doubtful. Therefore, the risk assessment supports a no further action groundwater monitoring only, as a valid remedial alternative.

not true!

A requested by the ACHCS a feasibility study of potential remedial technologies was performed. Although, all the alternatives presented are technology feasible, the low permeability soil conditions that exist beneath the site and the ability to obtain space for the construction of a treatment plant and other structural controls limit the applicability of groundwater pumping or soil vapor extraction technologies. Site characterization data indicated that natural attenuation through microbial action of the hydrocarbon compounds is being retarded due to insufficient oxygen and supply of bacterial nutrients. Should a remedial effort be required, then a potentially suitable remedial option is enhanced insitu bioremediation.

To achieve cleanup via the EIB option several applications of ORC and nutrients may be required, and remedial success would be judge through groundwater monitoring. The FS has judged that the EIB approach has a good chance of being capable to cleanup hydrocarbons to the RBCA levels. However, the time frame to achieve cleanup to the benzene risk assessment value of 0.089 mg/L is not readily estimated and may be a substantial amount of time. The degree of success of implementing an alternative remediation technology (either options 2, 3, or 4) is judged as poor, due to structural controls and low permeability soils beneath the site.

thus, it not a reasonable cleanup value

Given the inherent difficulty of implementing a common field proven remedial effort at the site. Clayton recommends that the no action option be implemented and that a minimum of four continuous quarterly monitoring events be performed to demonstrate groundwater flow and plume stability be initiated. Upon the demonstration of plume stability, Clayton recommends that site closure be granted and deed restriction placed on the property that restricts the development of groundwater.

NO! I wouldn't concur w/ this

Table 1

Historic Groundwater Table Elevation Data
Former Lemoine Sausage Facility
Oakland, California

Well Identification	Date Measured	Top of Casing Elevation (ft,msl)	Depth to Water (feet)	Groundwater Elevation (ft,msl)
MW-1	12/19/00	16.69	5.50	11.19
	9/22/00		6.30	10.39
	6/15/00		4.82	11.87
	2/8/99		3.60	13.09
MW-2	12/19/00	20.79	11.38	9.41
	9/22/00		11.49	9.30
	6/15/00		10.46	10.33
	2/8/99		14.20	6.59
MW-3	12/19/00	21.10	9.72	11.38
	9/22/00		15.30	5.80
	6/15/00		10.56	10.54
	2/8/99		7.45	13.65
MW-4	12/19/00	17.78	6.40	11.38
	9/22/00		6.90	10.88
	6/15/00		6.30	11.48
	2/8/99		4.13	13.65
MW-5	12/19/00	21.12	9.99	11.13
	9/22/00		9.99	11.13
	6/15/00		10.36	10.76
	2/8/99		7.62	13.50
MW-6	12/19/00	16.60	5.93	10.67
	9/22/00		6.54	10.06
	6/15/00		5.47	11.13
MW-7	12/19/00	15.47	7.20	8.27
	9/22/00		7.51	7.96
	6/15/00		6.40	9.07
MW-8	12/19/00	17.58	7.71	9.87
	9/22/00		8.33	9.25
	6/15/00		7.14	10.44

Notes:

1. All top of casing elevations referenced to mean sea level (msl) and measured with reference to the benchmark located at Peterson Street and East 7th Street.
2. NM = Not Measured.

Table 2

Summary of Historical Soil Analytical Data
Former Lemoine Sausage Facility
Oakland, California

Sample Location	Sample Depth (feet)	Date Sampled	TPHG	MTBE	Benzene	Ethyl benzene	Toluene	Total Xylenes
B-1	**2.5**	8/29/97	<0.3	NA	<0.005	<0.005	<0.005	<0.005
B-1	**5.5**	8/29/97	30	NA	<0.03	<0.03	<0.03	<0.04
B-2	**2.5**	8/29/97	<0.3	NA	<0.005	<0.005	<0.005	<0.005
B-2	**6**	8/29/97	660	NA	<0.5	6	<0.5	10
B-3	**2.5**	8/29/97	27	NA	<0.1	<0.3	<0.1	<0.1
B-3	**5**	8/29/97	170	NA	<0.1	<0.1	<0.1	<0.1
B-4	**2.5**	8/29/97	<0.3	NA	<0.005	<0.005	<0.005	<0.005
B-4	**6**	8/29/97	25	NA	<0.1	<0.1	<0.2	<0.1
B-4	**9.5**	8/29/97	0.3	NA	<0.005	<0.005	<0.005	0.008
B-5	**2.5**	9/2/97	1.6	NA	0.009	0.012	0.005	0.045
B-5	**6**	9/2/97	<0.3	NA	<0.005	<0.005	<0.005	0.005

Notes:
1. All results in milligrams per kilogram (mg/kg).
2. NA = Not Analyzed.

Table 3

Summary of Grab Groundwater Analytical Data
Former Lemoine Sausage Facility
Oakland, California

Sample Location	Date Sampled	TPHG	MTBE	Benzene	Ethyl benzene	Toluene	Total Xylenes	1,2-DCA
B-1	8/29/97	34,000	NA	430	2,400	54	4,649	NA
B-2	9/3/99	5,100	NA	2,800	43	120	140	NA
B-3	9/10/97	51,000	<5	14,000	290	5,900	7,100	410
B-4	9/3/97	100	NA	<0.4	<0.3	<0.3	<0.4	NA
B-5	9/10/97	78,000	<5	16,000	1,100	22,000	6,000	910
B-7	2/8/99	63,000	NA	5,900	2,700	4,100	9,600	160
B-8	2/8/99	140	NA	5.4	2.6	3.2	4.6	2.9
B-9	1/28/99	51,000	NA	240	640	5,600	3,150	<0.3
B-10	1/28/99	210	NA	1.4	1.9	16.0	100.8	<0.3

Notes:

1. All results in micrograms per liter (μg/L).
2. NA = Not Analyzed.
3. 1,2-DCA = 1,2-dichloroethane.
4. TPHG = Total Petroleum Hydrocarbons as Gasoline.
5. MTBE = methyl tert-butyl ether.

Table 4

Summary of Monitoring Well Groundwater Analytical Results
Former Lemoine Sausage Facility
Oakland, California

Sample Location	Date Sampled	TPHG	MTBE	Benzene	Ethyl benzene	Toluene	Total Xylenes	1,2-DCA	TCE	cis-1,2 DCE	trans-1,2-DCE	VC
MW-1	12/19/00	25,000	NA	3,200	480	1,900	3,300	<2.5	<2.5	<2.5	<2.5	<2.5
	9/22/00	25,000	<500	3,100	470	1,800	3,600	NA	NA	NA	NA	NA
	6/15/00	29,000	NA	3,900	1,900	<100	4,200	<5.0	<5.0	<5.0	<5.0	<5.0
	2/8/99	48,000	NA	3,900	970	6,300	4,300	<30	NA	NA	NA	NA
MW-2	12/19/00	43,000	NA	9,800	810	4,000	2,430	21	<13	<13	<13	<13
	9/22/00	24,000	<500	10,000	370	2,700	1,200	NA	NA	NA	NA	NA
	6/29/00	31,000	NA	11,000	4,400	930	250	25	<5.0	<5.0	<5.0	<5.0
	2/8/99	41,000	NA	11,000	650	4,900	1,720	60	NA	NA	NA	NA
MW-3	12/19/00	50,000	NA	1,200	510	1,600	1,810	350	<8.3	<8.3	<8.3	<8.3
	9/22/00	83,000	<1,000	16,000	1,300	20,000	7,000	NA	NA	NA	NA	NA
	6/29/00	39,000	NA	7,800	8,000	630	3,400	600	<5.0	<5.0	<5.0	<5.0
	2/8/99	35,000	NA	1,200	1,400	3,400	4,900	<30	NA	NA	NA	NA
MW-4	12/19/00	2,200	NA	200	100	2.9	81.4	<0.5	<0.5	<0.5	<0.5	<0.5
	9/22/00	12,000	<500	2,800	1,100	82	1,300	NA	NA	NA	NA	NA
	6/15/00	2,300	NA	230	10	<5	94	0.88	<0.5	2.1	<0.5	<0.5
	2/8/99	15,000	NA	670	780	90	940	<30	NA	NA	NA	NA
MW-5	12/19/00	21,000	NA	3,200	1,100	1,100	1,300	15	<4.2	<4.2	<4.2	<4.2
	9/27/00	16,000	<500	4,300	420	3,100	1,600	NA	NA	NA	NA	NA
	6/29/00	3,900	NA	1,500	330	28	260	36	<0.5	<0.5	<0.5	<0.5
	2/8/99	4,900	NA	780	230	440	370	<0.5	<0.5	<0.5	<0.5	<0.5
MW-6	12/19/00	320	NA	<0.5	<0.5	<0.5	<0.5	<0.5*	<0.5	<0.5	<0.5	<0.5
	9/22/00	71	<5	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA	NA
	6/15/00	1,100	NA	3.8	2.1	2.2	4.8	0.78	<0.5	<0.5	<0.5	<0.5

Table 4

Summary of Monitoring Well Groundwater Analytical Results
Former Lemoine Sausage Facility
Oakland, California

Sample Location	Date Sampled	TPHG	MTBE	Benzene	Ethyl benzene	Toluene	Total Xylenes	1,2-DCA	TCE	cis-1,2 DCE	trans-1,2-DCE	VC
MW-7	12/19/00	<50	NA	1.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	9/22/00	<50	<5	2	<0.5	<0.5	<0.5	NA	NA	NA	NA	NA
	6/15/00	1,000	NA	250	<10	<10	16	<0.5	<0.5	<0.5	<0.5	<0.5
MW-8	12/19/00	2,700	NA	410	4.8	<2.5	<2.5	9.1	**130**	**1,000**	**67**	**48**
	9/22/00	1,800	<25	340	<2.5	<2.5	<2.5	NA	NA	NA	NA	NA
	6/15/00	5,400	NA	150	8.9	<5	8.7	<13	210	1,100	73	25

Notes:
1. All results in micrograms per liter (μg/L).
2. NA = Not Analyzed.
3. 1,2-DCA = 1,2-dichloroethane.
4. TPHG = Total Petroleum Hydrocarbons as Gasoline.
5. MTBE = methyl tert-butyl ether.
6. TCE = Trichlororethene.
7. DCE = Dichlororethene.
8. VC= Vinyl Chloride.

* 1,1-DCA detected at 1.1 μg/L.

Table 5

Summary of Bio-Assessment Groundwater Analytical Data
Former Lemoine Sausage Facility
Oakland, California

Sample Location	Date Sampled	pH	ORP (mV)	Temperature (°C)	DO (mg/L)	Nitrate (NO_3^-)	Nitrite (NO_2^-)	Orthophosphate (PO_4^-)	HPC General	HPC Selective
MW-1	12/19/00	7.1	23	15.9	1.7	<0.05	<0.05	<0.2	NA	NA
	9/22/00	NA	NA	NA	NA	<0.05	<0.05	0.13J	NA	NA
	6/15/00	6.9	9	24.2	0.8	NA	NA	NA	2.1	0.5
MW-2	12/19/00	7.1	7	17.3	NA	<0.5	<0.5	<2.0	NA	NA
MW-3	9/22/00	NA	NA	NA	NA	<0.25	<0.25	1.00	NA	NA
MW-4	12/19/00	7.3	22	16.3	NA	<0.05	<0.05	<0.2	NA	NA
MW-6	6/15/00	7.0	-16	24.3	1.4	NA	NA	NA	3.5	0.3
MW-7	12/19/00	7.1	NA	18.6	0.6	23.00	<0.5	<0.2	NA	NA
	9/22/00	NA	NA	NA	NA	21.00	0.09	<0.2	NA	NA
	6/15/00	6.8	7	22.1	3.1	NA	NA	NA	3.8	0.3
MW-8	6/15/00	6.8	9	17.7	0.5	NA	NA	NA	3.6	0.4

Notes:
1. Inorganic chemical results in milligrams per liter (mg/L).
2. ORP = Oxygen Reduction Potential; field measurements in millivolts (mV).
3. DO = Dissolved Oxygen; field measurements in milligrams per liter (mg/L).
4. Temperature, field measurement in degrees Celsius (°C).
5. HPC = Heterotrophic Plate Count; results presents as colony forming units (CFU X 10^5).
6. NA = Not Analyzed.

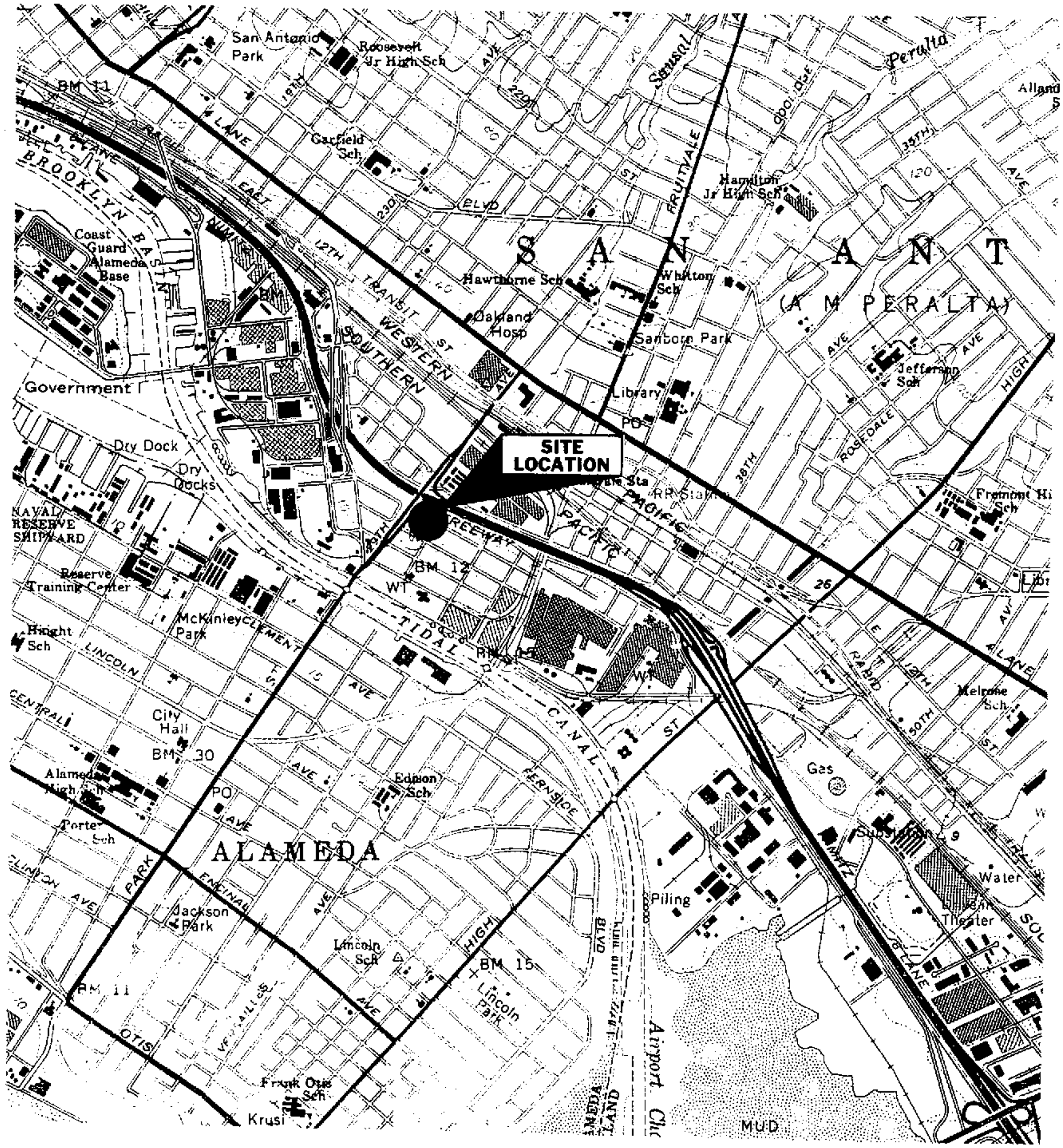
Table 6

RATING OF REMEDIAL TECHNOLOGIES
Former Lemoine Sausage Factory
630 29th Avenue, Oakland, California

REMEDIAL ALTERNATIVE	CRITERIA		
	Effectiveness	Implementation	Estimated Cost
No Action Quarterly Monitoring only	Poor	Excellent	$38,000 ← 1yr only
Enhanced Insitu Bioremediation	Good	Good	$166,681
Air Sparge - Vapor Collection	Poor	Poor	$316,615
Groundwater Pump and Treat	Poor	Poor	$265,578
Dual Phase Extraction	Fair	Poor	$402,316

Definition of Terms:
Effectiveness: ability of remedial technology to achieve RBCA-targetted clean-up goals.
Excellent: 90% or better chance of success.
Good: 60-89% chance of success.
Fair: 40-59% chance of success.
Poor: 0-39% chance of success.

Implementability: ability to permit, construct and maintain remedial technology.
Excellent: easy to implement, regulatory permitting straight forward.
Good: can be implemented without special design considerations (structural controls), and regulatory permits require do not require additional design or testing.
Fair: can be implemented with minor special design considerations and /or regulatory permits require significant design effort and testing.
Poor: difficult to implement and/or permit.



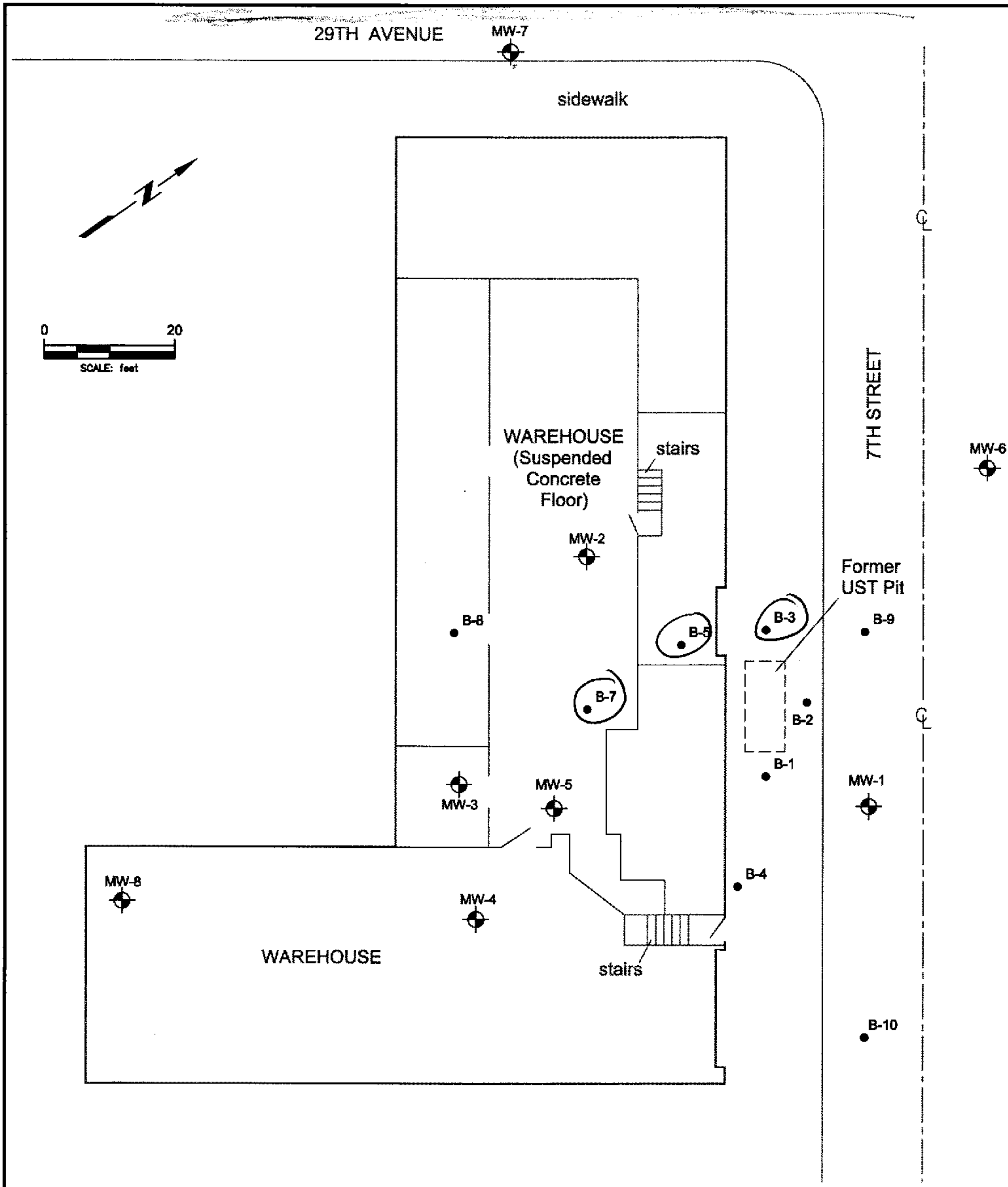
N

0 2,000

SCALE: FEET

Source: U.S.G.S. OAKLAND EAST, CALIF., 7.5 Minute Quadrangle, 1959, (photorevised 1980).

SITE LOCATION FORMER LEMOINE SAUSAGE FACTORY 630 29th AVENUE OAKLAND, CALIFORNIA Clayton Project No. 70-97066.00.002	Figure **1** 12/31/96 TOPOFIG1.CDR	**Clayton** ENVIRONMENTAL CONSULTANTS



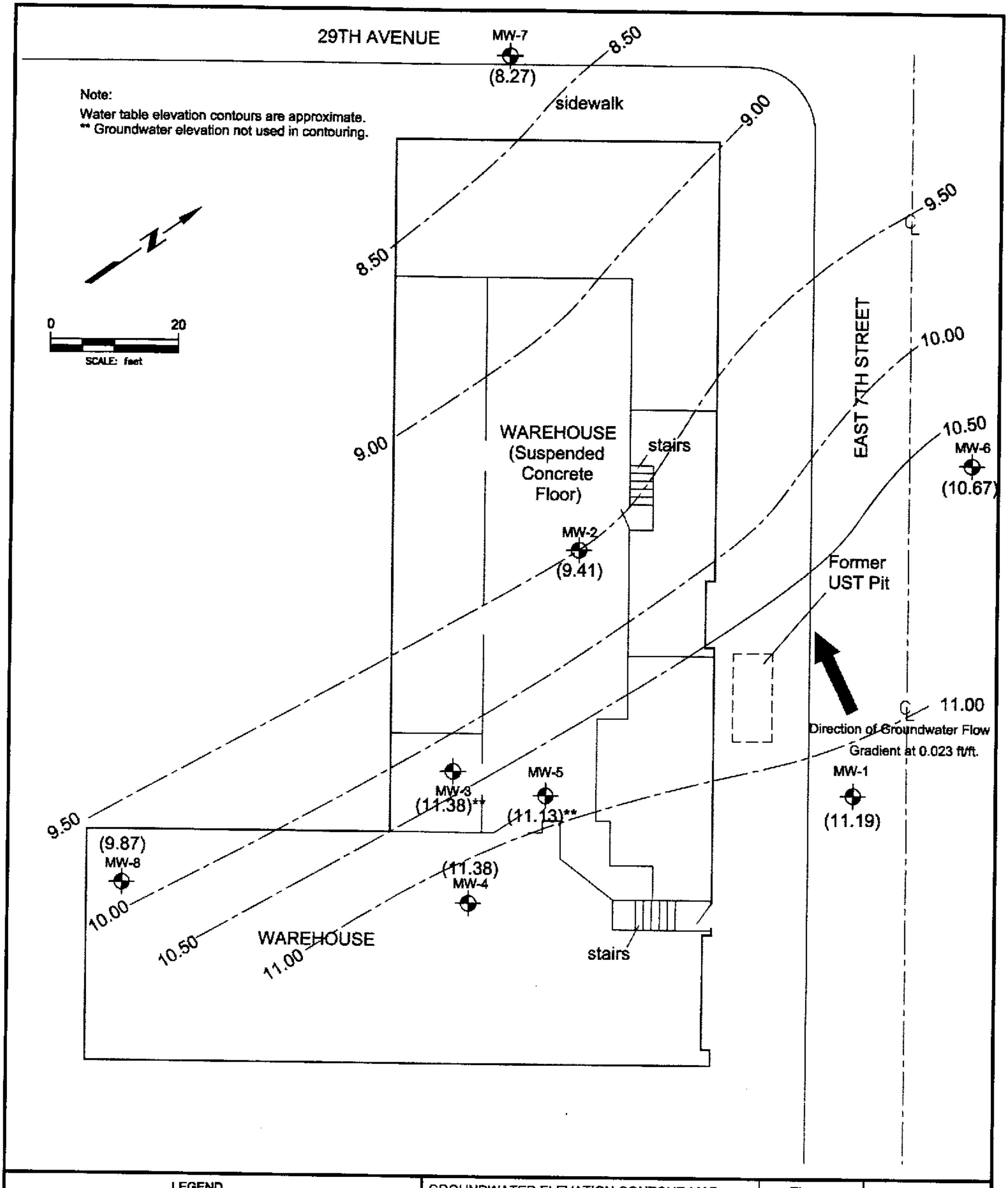
LEGEND	
MW-1 ⊕	Monitoring Well Location
B-1 ●	Soil Boring/Temporary Monitoring Well Location

SITE PLAN SHOWING MONITORING WELL AND SOIL BORING LOCATIONS

FORMER LEMOINE SAUSAGE FACTORY
630 29TH AVENUE
OAKLAND, CALIFORNIA
Clayton Project No. 70-97066.00

Figure
2
9/19/00
SITEFSRD.DWG

Clayton
ENVIRONMENTAL CONSULTANTS



LEGEND

MW-1 Monitoring Well Location

(11.19) Groundwater Elevation in Feet above Mean Sea Level

10.50 Groundwater Surface Contour and Elevation

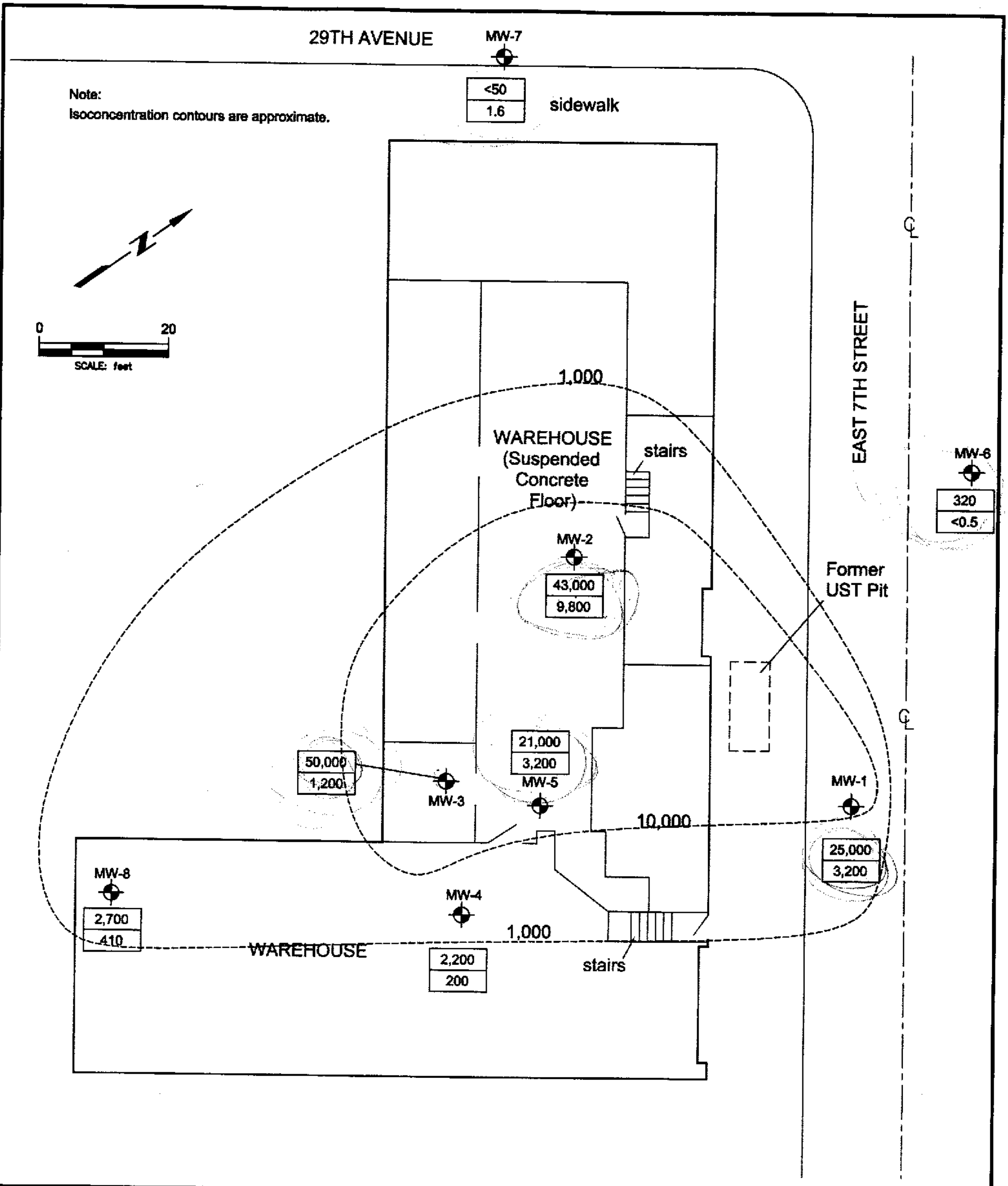
GROUNDWATER ELEVATION CONTOUR MAP
(DECEMBER 19, 2000)

FORMER LEMOINE SAUSAGE FACTORY
630 29TH AVENUE
OAKLAND, CALIFORNIA
Clayton Project No. 70-97066.00

Figure
3

1/08/01
Q4TH_00.DWG

Clayton
ENVIRONMENTAL CONSULTANTS



LEGEND

MW-1 Monitoring Well Location

25,000 — TPH-G Concentration (micrograms per liter)

3,200 — Benzene Concentration (micrograms per liter)

1,000 — Isoconcentration Contour (micrograms per liter)

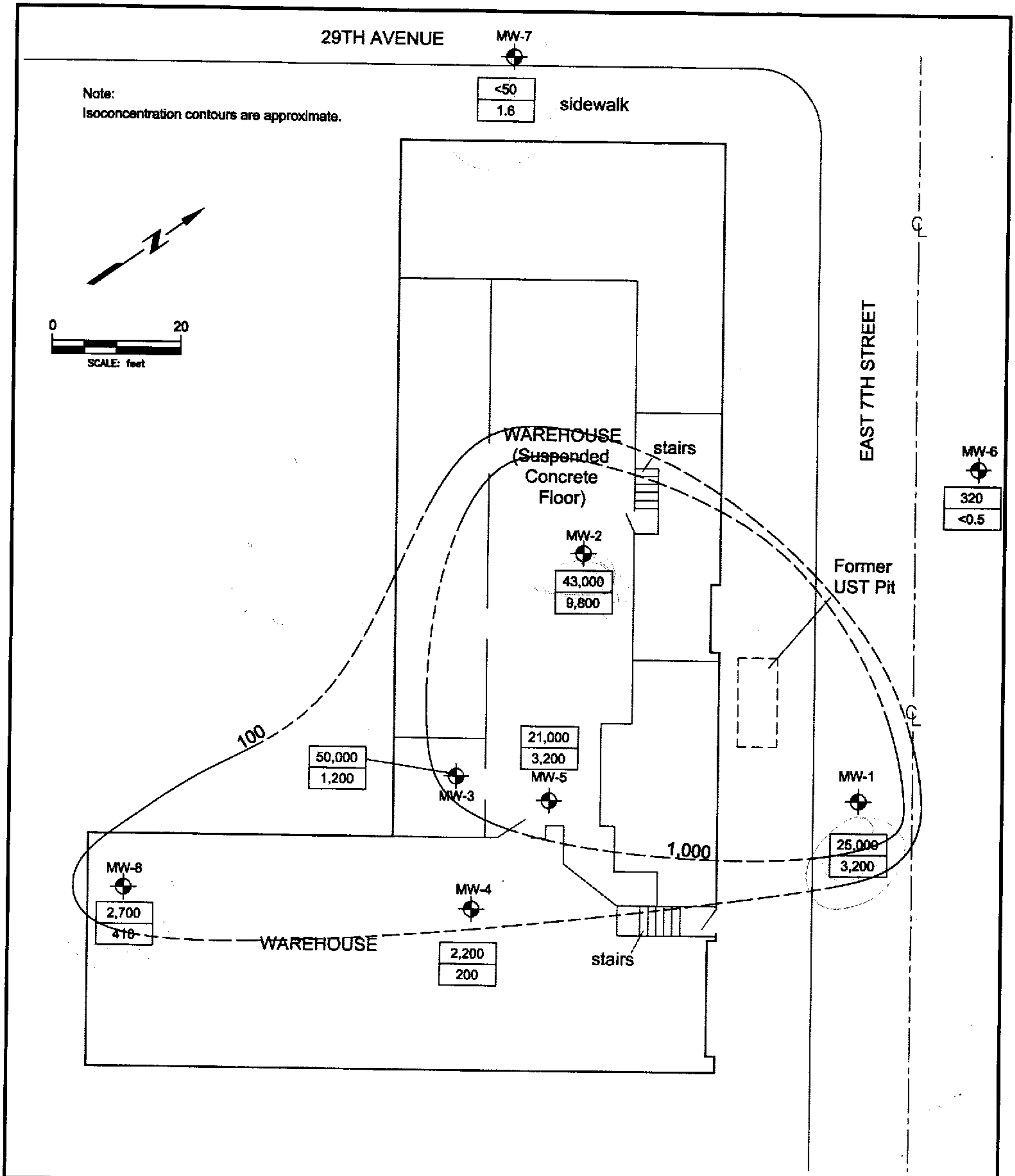
TPH-G
CONCENTRATIONS IN GROUNDWATER
DECEMBER 2000

FORMER LEMOINE SAUSAGE FACTORY
630 29TH AVENUE
OAKLAND, CALIFORNIA
Clayton Project No. 70-97066.00

Figure
4a

1/08/01
Q4TH_00.DWG

Clayton
ENVIRONMENTAL CONSULTANTS



LEGEND

MW-1 Monitoring Well Location

25,000 TPH-G Concentration (micrograms per liter)

3,200 Benzene Concentration (micrograms per liter)

1,000 Isoconcentration Contour (micrograms per liter)

BENZENE CONCENTRATIONS IN GROUNDWATER DECEMBER 2000

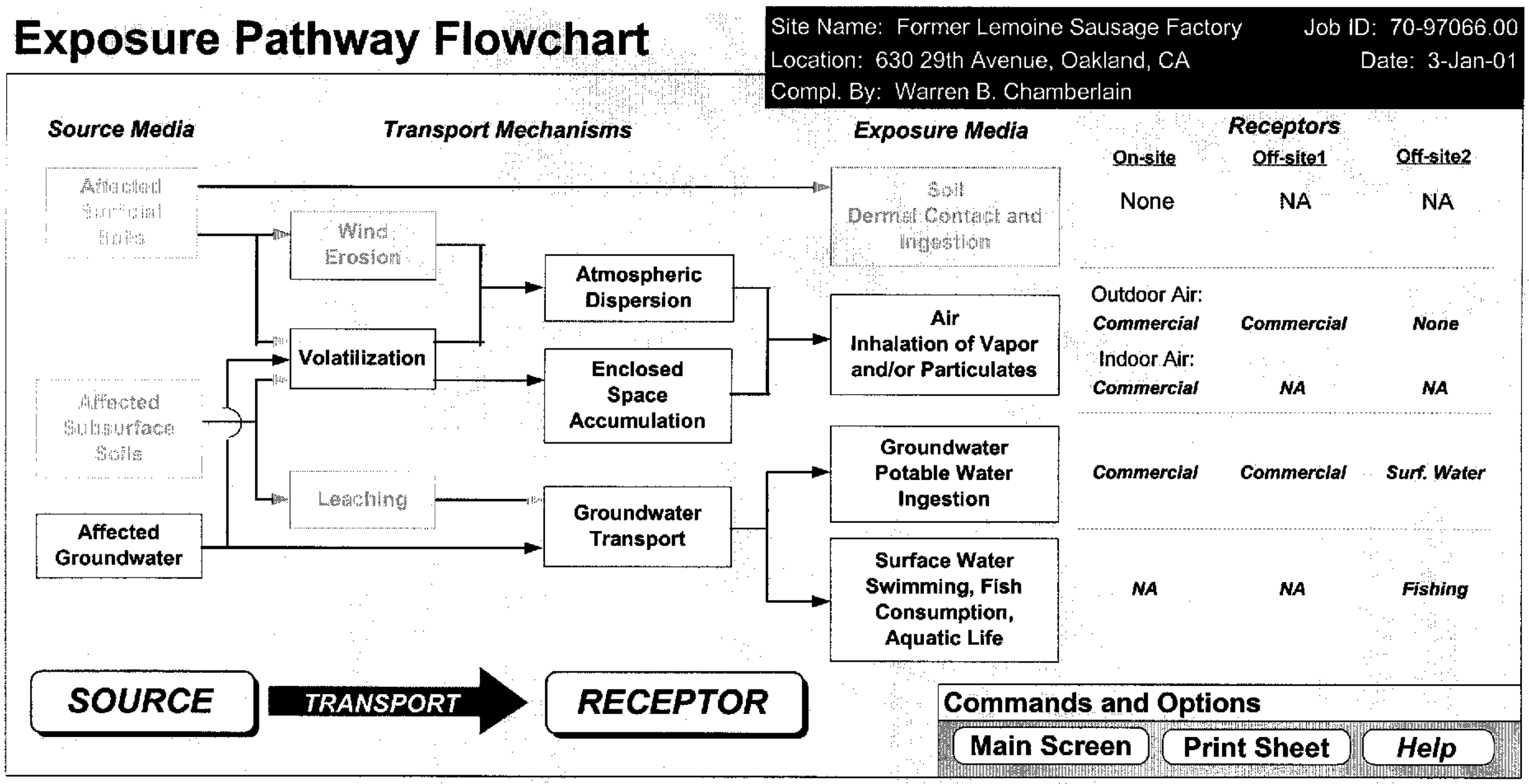
FORMER LEMOINE SAUSAGE FACTORY
630 29TH AVENUE
OAKLAND, CALIFORNIA
Clayton Project No. 70-97066.00

Figure **4b**

1/08/01
Q4TH_00.DWG

Clayton ENVIRONMENTAL CONSULTANTS

Figure 5



Input file SF1_3_01

Figure 6

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: Former Lemoine Sausage Factory | Completed By: Warren B. Chamberlain | Job ID: 70-97066.00
Site Location: 630 29th Avenue, Oakland, CA | Date Completed: 3-Jan-01 | 1 OF 1

Exposure Parameters		Residential			Commercial/Industrial	
		Adult	(1-6yrs)	(1-16 yrs)	Chronic	Construc.
AT_c	Averaging time for carcinogens (yr)	70				
AT_n	Averaging time for non-carcinogens (yr)	30			25	1
BW	Body weight (kg)	70	15	35	70	
ED	Exposure duration (yr)	30	6	16	25	1
τ	Averaging time for vapor flux (yr)	30			25	1
EF	Exposure frequency (days/yr)	350			250	180
EF_D	Exposure frequency for dermal exposure	350			250	
IR_w	Ingestion rate of water (L/day)	2			1	
IR_s	Ingestion rate of soil (mg/day)	100	200		50	100
SA	Skin surface area (dermal) (cm^2)	5800		2023	5800	5800
M	Soil to skin adherence factor	1				
ET_{swim}	Swimming exposure time (hr/event)	3				
EV_{swim}	Swimming event frequency (events/yr)	12	12	12		
IR_{swim}	Water ingestion while swimming (L/hr)	0.05	0.5			
SA_{swim}	Skin surface area for swimming (cm^2)	23000		8100		
IR_{fish}	Ingestion rate of fish (kg/yr)	0.025				
FI_{fish}	Contaminated fish fraction (unitless)	1				

Complete Exposure Pathways and Receptors	On-site	Off-site 1	Off-site 2
Groundwater:			
Groundwater Ingestion	Commercial	Commercial	Surf. Water
Soil Leaching to Groundwater Ingestion	None	None	None
Applicable Surface Water Exposure Routes:			
Swimming			No
Fish Consumption			Yes
Aquatic Life Protection			No
Soil:			
Direct Ingestion and Dermal Contact	None		
Outdoor Air:			
Particulates from Surface Soils	None	None	None
Volatilization from Soils	None	None	None
Volatilization from Groundwater	Commercial	Commercial	None
Indoor Air:			
Volatilization from Subsurface Soils	None	NA	NA
Volatilization from Groundwater	Commercial	NA	NA

Receptor Distance from Source Media	On-site	Off-site 1	Off-site 2	(Units)
Groundwater receptor	0	330	1300	(ft)
Soil leaching to groundwater receptor	NA	NA	NA	(ft)
Outdoor air inhalation receptor	0	330	NA	(ft)

Target Health Risk Values		Individual	Cumulative
TR_{ab}	Target Risk (class A&B carcinogens)	1.0E-6	1.0E-5
TR_c	Target Risk (class C carcinogens)	1.0E-5	
THQ	Target Hazard Quotient (non-carcinogenic risk)	1.0E+0	1.0E+0

Modeling Options	
RBCA tier	Tier 2
Outdoor air volatilization model	Surface & subsurface models
Indoor air volatilization model	Johnson & Ettinger model
Soil leaching model	NA
Use soil attenuation model (SAM) for leachate?	NA
Air dilution factor	User-specified ADF
Groundwater dilution-attenuation factor	Domenico model w/ biodeg.

W/O

NOTE: NA = Not applicable

Surface Parameters		General	Construction	(Units)
A	Source zone area	0.0E+0	NA	(ft^2)
W	Length of source-zone area parallel to wind	0.0E+0	NA	(ft)
W_{gw}	Length of source-zone area parallel to GW flow	NA		(ft)
U_{air}	Ambient air velocity in mixing zone	1.1E+1		(ft/s)
δ_{air}	Air mixing zone height	6.0E+0		(ft)
P_e	Areal particulate emission rate	NA		(g/cm^2/s)
L_{ss}	Thickness of affected surface soils	NA		(ft)

Surface Soil Column Parameters		Value			(Units)
h_{cap}	Capillary zone thickness	3.0E+0			(ft)
h_v	Vadose zone thickness	3.0E+0			(ft)
ρ_s	Soil bulk density	1.3E+0			(g/cm^3)
f_{oc}	Fraction organic carbon	2.0E-2			(-)
θ_T	Soil total porosity	5.0E-1			(-)
K_{vs}	Vertical hydraulic conductivity	3.0E+0			(m/yr)
k_v	Vapor permeability	1.0E-14			(ft^2)
L_{gw}	Depth to groundwater	6.0E+0			(ft)
L_s	Depth to top of affected soils	NA			(ft)
L_{base}	Depth to base of affected soils	NA			(ft)
L_{subs}	Thickness of affected soils	NA			(ft)
pH	Soil/groundwater pH	7.0E+0			(-)
		capillary	vadose	foundation	
θ_w	Volumetric water content	0.49	0.4	0.12	(-)
θ_a	Volumetric air content	0.01	0.1	0.26	(-)

Building Parameters		Residential	Commercial	(Units)
L_b	Building volume/area ratio	NA	1.90E+1	(ft)
A_b	Foundation area	NA	9.50E+3	(cm^2)
X_{crk}	Foundation perimeter	NA	5.00E+2	(ft)
ER	Building air exchange rate	NA	2.30E-4	(1/s)
L_{crk}	Foundation thickness	NA	4.92E-1	(ft)
Z_{crk}	Depth to bottom of foundation slab	NA	4.92E-1	(ft)
η	Foundation crack fraction	NA	1.00E-3	(-)
dP	Indoor/outdoor differential pressure	NA	0.00E+0	(g/cm/s^2)
Q_s	Convective air flow through slab	NA	0.00E+0	(ft^3/s)

Groundwater Parameters		Value	(Units)
δ_{gw}	Groundwater mixing zone depth	NA	(ft)
I_f	Net groundwater infiltration rate	NA	(cm/yr)
U_{gw}	Groundwater Darcy velocity	6.0E-2	(m/yr)
V_{gw}	Groundwater seepage velocity	1.2E-1	(m/yr)
K_s	Saturated hydraulic conductivity	NA	(m/yr)
i	Groundwater gradient	NA	(-)
S_w	Width of groundwater source zone	3.0E+1	(ft)
S_d	Depth of groundwater source zone	1.0E+1	(ft)
θ_{eff}	Effective porosity in water-bearing unit	NA	(-)
f_{oc-sat}	Fraction organic carbon in water-bearing unit	2.0E-2	(-)
pH_{sat}	Groundwater pH	7.0E+0	(-)
	Biodegradation considered?	1st Order	

Transport Parameters		Off-site 1	Off-site 2	Off-site 1	Off-site 2	(Units)
Lateral Groundwater Transport		Groundwater Ingestion		Soil Leaching to GW		
α_x	Longitudinal dispersivity	3.3E+1	1.3E+2	NA	NA	(ft)
α_y	Transverse dispersivity	1.1E+1	4.3E+1	NA	NA	(ft)
α_z	Vertical dispersivity	1.7E+0	6.5E+0	NA	NA	(ft)
Lateral Outdoor Air Transport		Soil to Outdoor Air Inhal.		GW to Outdoor Air Inhal.		
σ_y	Transverse dispersion coefficient	NA	NA	NA	NA	(ft)
σ_z	Vertical dispersion coefficient	NA	NA	NA	NA	(ft)
ADF	Air dispersion factor	NA	NA	1.0E+0	NA	(-)

Surface Water Parameters		Off-site 2	(Units)
Q_{sw}	Surface water flowrate	0.03	(ft^3/s)
W_{pl}	Width of GW plume at SW discharge	100	(ft)
δ_{pl}	Thickness of GW plume at SW discharge	10	(ft)
DF_{sw}	Groundwater-to-surface water dilution factor	4.8E+3	(-)

Figure 7

RBCA SITE ASSESSMENT	Baseline Risk Summary-All Pathways

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain
Date Completed: 3-Jan-01

TIER 2 BASELINE RISK SUMMARY TABLE

	BASELINE CARCINOGENIC RISK					BASELINE TOXIC EFFECTS				
	Individual COC Risk		Cumulative COC Risk		Risk	Hazard Quotient		Hazard Index		Toxicity
EXPOSURE PATHWAY	Maximum Value	Target Risk	Total Value	Target Risk	Limit(s) Exceeded?	Maximum Value	Applicable Limit	Total Value	Applicable Limit	Limit(s) Exceeded?
OUTDOOR AIR EXPOSURE PATHWAYS										
Complete:	1.8E-8	1.0E-6	2.0E-8	1.0E-5	☐	1.0E-3	1.0E+0	1.1E-3	1.0E+0	☐
INDOOR AIR EXPOSURE PATHWAYS										
Complete:	6.6E-6	1.0E-6	7.0E-6	1.0E-5	■	3.8E-1	1.0E+0	3.9E-1	1.0E+0	☐
SOIL EXPOSURE PATHWAYS										
Complete:	NA	NA	NA	NA	☐	NA	NA	NA	NA	☐
GROUNDWATER EXPOSURE PATHWAYS										
Complete:	1.6E-3	1.0E-6	1.8E-3	1.0E-5	■	5.2E+1	1.0E+0	5.4E+1	1.0E+0	■
SURFACE WATER EXPOSURE PATHWAYS										
Complete:	5.1E-110	1.0E-6	5.2E-110	1.0E-5	☐	1.4E-105	1.0E+0	1.5E-105	1.0E+0	☐

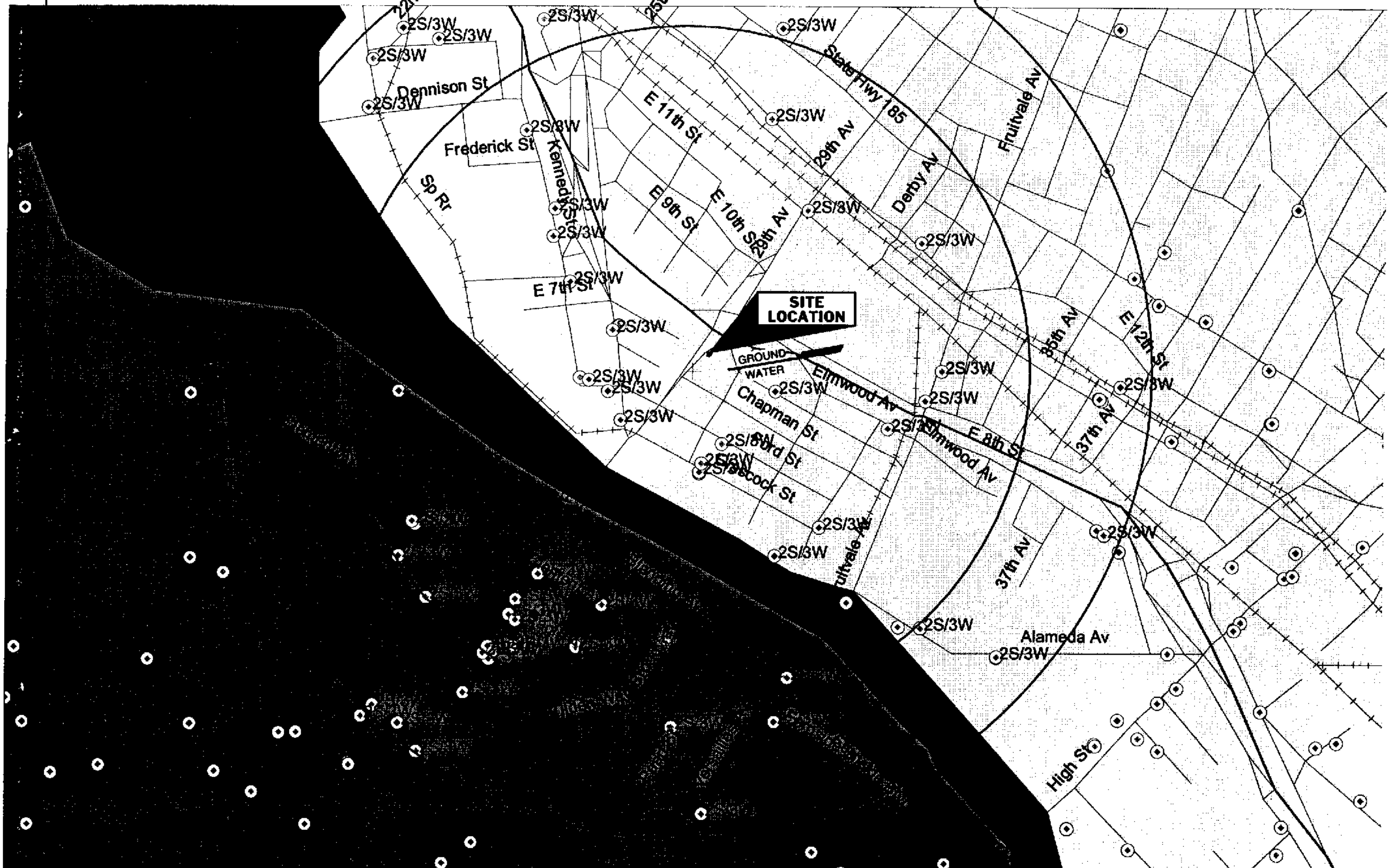
CRITICAL EXPOSURE PATHWAY (Maximum Values From Complete Pathways)										
	1.6E-3	***1.0E-6***	***1.8E-3***	***1.0E-5***	■	***5.2E+1***	***1.0E+0***	***5.4E+1***	***1.0E+0***	■
	Groundwater		***Groundwater***			***Groundwater***		***Groundwater***		

APPENDIX A

RECEPTOR SURVEY RESULTS – ACPWA WELL SURVEY

→ Alameda Canal

½-mile radius



↳ Alameda Canal

Page 1

WELL SURVEY - ½ MILE RADIUS
630 29th AVENUE, OAKLAND

Water Wells located downgradient of the Former Lemoine Sausage Factory site at 630 29th Avenue in Oakland, California

Site	Well Identification Township/Range	Section	Well Use	Water Use
E 7th St. & 29th Av.	2S/3W	7G	Monitoring well	Non-potable
333 23rd Av.	2S/3W	7F 1	Monitoring well	Non-potable
333 23rd Av.	2S/3W	7F 2	Monitoring well	Non-potable
333 23rd Av.	2S/3W	7F 3	Monitoring well	Non-potable
333 23rd Av.	2S/3W	7F 4	Monitoring well	Non-potable
333 23rd Av.	2S/3W	7F 5	Monitoring well	Non-potable
333 23rd Av.	2S/3W	7F 6	Monitoring well	Non-potable
333 23rd Av.	2S/3W	7F 7	Monitoring well	Non-potable
333 23rd Av.	2S/3W	7F 8	Monitoring well	Non-potable
333 23rd Av.	2S/3W	7F 9	Monitoring well	Non-potable
333 23rd Av.	2S/3W	7F 10	Monitoring well	Non-potable
333 23rd Av.	2S/3W	7F 11	Monitoring well	Non-potable
333 23rd Av.	2S/3W	7F 12	Monitoring well	Non-potable
333 23rd Av.	2S/3W	7F 13	Monitoring well	Non-potable
333 23rd Av.	2S/3W	7F 25	Monitoring well	Non-potable
527 23rd Av.	2S/3W	7F 22	Monitoring well	Non-potable
527 23rd Av.	2S/3W	7F 23	Monitoring well	Non-potable
527 23rd Av.	2S/3W	7F 24	Monitoring well	Non-potable
534 23rd Av.	2S/3W	7F 20	Monitoring well	Non-potable
534 23rd Av.	2S/3W	7F 21	Monitoring well	Non-potable
Crn of Kennedy & 23rd	2S/3W	7F 14	Recreation well	Non-potable
401 Kennedy St.	2S/3W	7F 15	Monitoring well	Non-potable
401 Kennedy St.	2S/3W	7F 16	Monitoring well	Non-potable
401 Kennedy St.	2S/3W	7F 17	Monitoring well	Non-potable
401 Kennedy St.	2S/3W	7F 18	Monitoring well	Non-potable
646 Kennedy St.	2S/3W	7F 19	Monitoring well	Non-potable
646 Kennedy St.	2S/3W	7C 6	Monitoring well	Non-potable
646 Kennedy St.	2S/3W	7C 7	Monitoring well	Non-potable
2900 Glascock St.	2S/3W	7G 1	Irrigation well	Non-potable
2901 Glascock St.	2S/3W	7G 2	Monitoring well	Non-potable
2901 Glascock St.	2S/3W	7G 3	Monitoring well	Non-potable
2901 Glascock St.	2S/3W	7G 4	Monitoring well	Non-potable
2901 Glascock St.	2S/3W	7G 5	Monitoring well	Non-potable
2901 Glascock St.	2S/3W	7G 6	Monitoring well	Non-potable
2901 Glascock St.	2S/3W	7G 7	Monitoring well	Non-potable
2901 Glascock St.	2S/3W	7G 9	Monitoring well	Non-potable
2901 Glascock St.	2S/3W	7G 8	Monitoring well	Non-potable
2915 Ford St.	2S/3W	7K 4	Monitoring well	Non-potable
2915 Ford St.	2S/3W	7K 5	Monitoring well	Non-potable

APPENDIX B

RECEPTOR SURVEY RESULTS – UTILITY SURVEY

Results of Utility Trench Survey in the Vicinity of the Former Lemoine Sausage Factory, 630 29th Avenue in Oakland, California

Clayton contacted Underground Service Alert (USA) to obtain a list of companies that may have underground utilities in the vicinity of the site. USA identified nine (9) organizations that have utilities in the vicinity of the site. Of particular interest to this survey, is the location of underground utility trenches located downgradient of the site, the downgradient groundwater flow direction is west-southwest of the site.

Clayton contacted each USA-listed company to determine if they have services near the site. Clayton allowed one-month for utility companies to reply to our request for information. The list of utility companies and the results of Clayton's research are presented below.

East Bay Municipal Utility District (EBMUD)

- Has maps of water and sewer lines through the east bay area
- Contact Number: 510-835-3000-*main contact*
- Contacted on 12/4/00, a map was faxed to Clayton the same day.

City Of Oakland

- Has maps of sanitary sewer and storm drain lines throughout the city of Oakland
- Contact Number: 510-238-4777-*main contact*
- Contacted on 12/4/00, maps were reviewed at 250 Frank Ogawa Plaza in Oakland on 12/20/00. Copies of the relevant maps were requested and sent to Clayton on 12/22/00.

County of Alameda

- Has for maps showing the county's storm sewer lines
- Contact Numbers: 510-208-9528 Public works department
  510-670-5560 Allen in public works-*main contact*
- Contacted on 12/4/00, relevant maps were copied on 12/15/00 at 399 Elmhurst Street Room 240 Hayward, California.

Pacific Gas & Electric

- Clayton is looking for maps showing their natural gas and electrical lines in the vicinity of the site
- Contact Numbers: 1-800-743-5000 Information
  510-437-2233 Engineering
  510-437-2110 Thomas Robinson
  510-437-2113 Zamete Ting-*main contact*
  510-437-2144 FAX number
- Contacted on 12/4/00, Clayton sent two FAX letters to Zamete on 12/4, one requesting utility maps, the other explaining why we wanted the maps. No response was received. Follow up phone call and message left with Zamete Ting on 12/19/00, and copies of their maps were sent to Clayton on 12/28/00.

Qwest Communications

- Clayton is looking for maps of their telecommunication lines in the vicinity of the site
- Contact Numbers: 1-800-524-7258 Information, transferred to Summer-*main contact*
  303-992-1729 FAX number
- Contacted on 12/4/00, Clayton sent in a FAX requesting utility maps on 12/4, No return response was received.

Pacific Bell

- Clayton is looking for maps of their communication lines in the vicinity of the site.
- Contact Numbers: 415-542-9000 Information
  1-800-701-8988 Engineering
  925-901-8520 Karen Bulls-*main contact*
- Contacted on 12/4/00, Clayton left a message with Karen Bulls on 12/4/00, no return response was received.

MCI/WorldCom

- Clayton is looking for maps of their telecommunication lines in the vicinity of the site.
- Contact Numbers: 1-888-624-9266 Information
  510-635-3981-engineering
- No contact was made with their engineering department on 12/4/00, the whole phone system was automated and no personal calls can go through without a legitimate business reason. However, on a request to USA for drilling at the site on 5/20/00, MCI/WorldCom replied to Clayton with a FAX stating that the site of the former sausage factory was clear of any of their lines. The following number was listed on the FAX to "answer any further questions" 1-800-840-0338.

TCI/AT&T

- Clayton is looking for maps of their communication lines in the vicinity of the site
- Contact Numbers: 1-510-261-6800 Information
  408-918-3200 Technical repair department-*main contact*
- Contacted on 12/4/00, Clayton left a message with the technical repair department on 12/4. No return call was received.

Level 3 Communications

- Clayton is looking for maps of their communication lines in the vicinity of the site
- Contact Numbers: No phone number was found during Clayton's 12/4/00 investigation.
- However, on a request to USA for drilling at the site on 5/20/00, Level 3 replied to Clayton with a FAX stating that the site was clear of any of their lines.

Summary of Finding

Two large utility trenches are located in the immediate vicinity of the site, the storm drain and sanitary sewer trenches. The accompanying map shows the location of these trenches with respect to the site and groundwater flow direction. From previous investigations performed at the site, the telecommunication lines were placed along the northern edge of 7th Street on the opposite side of the sanitary sewer trench than the site.

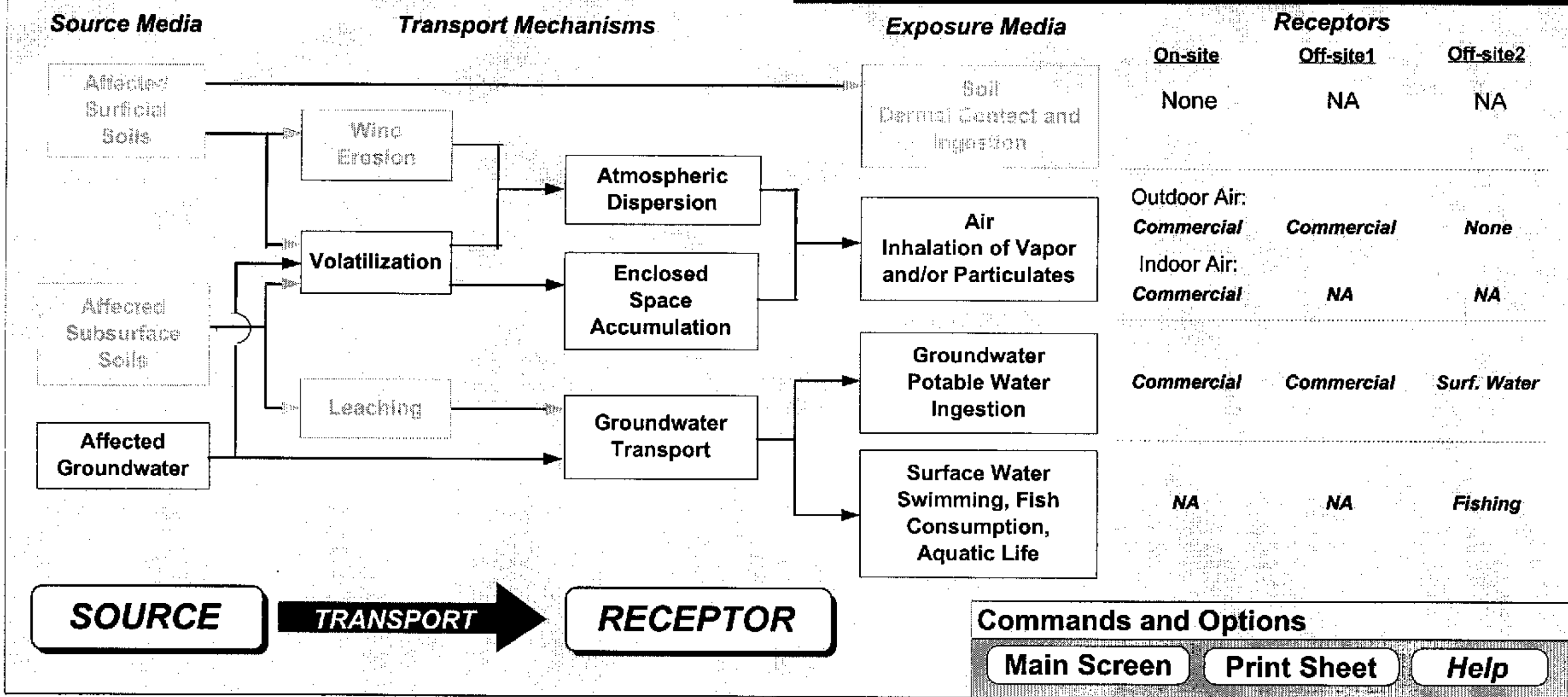
Clayton Group Services

APPENDIX C

TIER II RBCA ANALYSIS

Exposure Pathway Flowchart

Site Name: Former Lemoine Sausage Factory — Job ID: 70-97066.00
Location: 630 29th Avenue, Oakland, CA — Date: 3-Jan-01
Compl. By: Warren B. Chamberlain



CHEMICAL DATA FOR SELECTED COCs

Physical Property Data

Constituent	CAS Number	type	Molecular Weight (g/mole) MW	ref	Diffusion Coefficients in air (cm2/s) Dair	ref	Diffusion Coefficients in water (cm2/s) Dwat	ref	log (Koc) or log(Kd) (@ 20 - 25 C) log(L/kg)	partition	ref	Henry's Law Constant (@ 20 - 25 C) (atm-m3) mol	Henry's Law Constant (@ 20 - 25 C) (unitless)	ref	Vapor Pressure (@ 20 - 25 C) (mm Hg)	ref	Solubility (@ 20 - 25 C) (mg/L)	ref	acid pKa	base pKb	ref
Dichloroethane, 1,2-	107-06-2	C	99	4	1.04E-01	4	9.90E-06	4	1.76	Koc	4	1.20E-03	4.95E-02	4	8.00E+01	4	8.69E+03	5	-	-	-
Benzene*	71-43-2	A	78.1	PS	8.80E-02	PS	9.80E-06	PS	1.77	Koc	PS	5.55E-03	2.29E-01	PS	9.52E+01	PS	1.75E+03	PS	-	-	-
Ethylbenzene	100-41-4	A	106.2	PS	7.50E-02	PS	7.80E-06	PS	2.56	Koc	PS	7.88E-03	3.25E-01	PS	1.00E+01	PS	1.69E+02	PS	-	-	-
Toluene	108-88-3	A	92.4	5	8.50E-02	A	9.40E-06	A	2.13	Koc	A	6.30E-03	2.60E-01	A	3.00E+01	4	5.15E+02	29	-	-	-
Xylene (mixed isomers)	1330-20-7	A	106.2	5	7.20E-02	A	8.50E-06	A	2.38	Koc	A	7.03E-03	2.90E-01	A	7.00E+00	4	1.98E+02	5	-	-	-

* = Chemical with user-specified data

Site Name: Former Lemoine Sausage Factory

Site Location: 630 29th Avenue, Oakland, CA

Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01

Job ID: 70-97066.00

CHEMICAL DATA FOR SELECTED COCs

Toxicity Data

	Reference Dose (mg/kg/day)				Reference Conc. (mg/m3)		Slope Factors 1/(mg/kg/day)				Unit Risk Factor 1/(µg/m3)			
Constituent	Oral RfD_oral	ref	(mg/kg/day) Dermal RfD_dermal	ref	Inhalation RfC_inhal	ref	Oral SF_oral	ref	1/(mg/kg/day) Dermal SF_dermal	ref	Inhalation URF_inhal	ref	EPA Weight of Evidence	Is Constituent Carcinogenic ?
Dichloroethane, 1,2-	-	-	-	-	1.00E-02	R	9.10E-02	R	9.10E-02	TX	2.60E-05	R	B2	TRUE
Benzene*	3.00E-03	R	-	-	5.95E-03	R	1.00E-01	0	1.00E-01	0	8.29E-06	PS	A	TRUE
Ethylbenzene	1.00E-01	PS	9.70E-02	TX	1.00E+00	PS	-	-	-	-	-	-	D	FALSE
Toluene	2.00E-01	A,R	1.60E-01	TX	4.00E-01	A,R	-	-	-	-	-	-	D	FALSE
Xylene (mixed isomers)	2.00E+00	A,R	1.84E+00	TX	7.00E+00	A	-	-	-	-	-	-	D	FALSE

* = Chemical with user-specified

Site Name: Former Lemoine Sau

Site Location: 630 29th Aveni

Miscellaneous Chemical Data

Constituent	Maximum Contaminant Level MCL (mg/L)	ref	Time-Weighted Average Workplace Criteria TWA (mg/m3)	ref	Aquatic Life Prot. Criteria AQL (mg/L)	ref	Bioconcentration Factor (L-wat/kg-fish)
Dichloroethane, 1,2-	5.00E-03	52 FR 25690 (08 Jul 87)	4.00E+00	NIOSH	-	-	2
Benzene*	5.00E-03	52 FR 25690	3.25E+00	-	-	-	12.6
Ethylbenzene	7.00E-01	56 FR 3526 (30 Jan 91)	4.35E+02	PS	-	-	1
Toluene	1.00E+00	56 FR 3526 (30 Jan 91)	1.47E+02	ACGIH	-	-	70
Xylene (mixed isomers)	1.00E+01	56 FR 3526 (30 Jan 91)	4.34E+02	ACGIH	-	-	1

* = Chemical with user-specified

Site Name: Former Lemoine Sau

Site Location: 630 29th Aveni

CHEMICAL DATA FOR SELECTED COCs

Miscellaneous Chemical Data

Constituent	Dermal Relative Absorp. Factor (unitless)	Water Dermal Permeability Data: Dermal Permeability Coeff. (cm/hr)	Lag time for Dermal Exposure (hr)	Critical Exposure Time (hr)	Relative Contr of Derm Perm Coeff (unitless)	Water/Skin Derm Adsorp Factor (cm/event)	ref	Detection Limits: Groundwater (mg/L)	ref	Soil (mg/kg)	ref	Half Life (First-Order Decay) (days): Saturated	Unsaturated	ref
Dichloroethane, 1,2-	0.5	0.0053	0.35	0.84	0.003	2.0E-2	D	0.0005	S	0.005	S	360	360	H
Benzene*	0.5	0.021	0.26	0.63	0.013	7.3E-2	D	0.002	S	0.005	S	720	720	H
Ethylbenzene	0.5	0.074	0.39	1.3	0.14	2.7E-1	D	0.002	S	0.005	S	228	228	H
Toluene	0.5	0.045	0.32	0.77	0.054	1.6E-1	D	0.002	S	0.005	S	28	28	H
Xylene (mixed isomers)	0.5	0.08	0.39	1.4	0.16	2.9E-1	D	0.005	S	0.005	S	360	360	H

* = Chemical with user-specified

Site Name: Former Lemoine Sa

Site Location: 630 29th Aven

RBCA SITE ASSESSMENT

Input Parameter Summary

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain
Date Completed: 3-Jan-01
Job ID: 70-97066.00

Exposure Parameters		Residential Adult	Residential (1-6yrs)	Residential (1-16 yrs)	Commercial/Industrial Chronic	Commercial/Industrial Construc.
AT_c	Averaging time for carcinogens (yr)	70				
AT_n	Averaging time for non-carcinogens (yr)	30			25	1
BW	Body weight (kg)	70	15	35	70	
ED	Exposure duration (yr)	30	6	16	25	1
τ	Averaging time for vapor flux (yr)	30			25	1
EF	Exposure frequency (days/yr)	350			250	180
EF_D	Exposure frequency for dermal exposure	350			250	
IR_w	Ingestion rate of water (L/day)	2			1	
IR_s	Ingestion rate of soil (mg/day)	100	200		50	100
SA	Skin surface area (dermal) (cm^2)	5800		2023	5800	5800
M	Soil to skin adherence factor	1				
ET_{swim}	Swimming exposure time (hr/event)	3				
EV_{swim}	Swimming event frequency (events/yr)	12	12	12		
IR_{swim}	Water ingestion while swimming (L/hr)	0.05	0.5			
SA_{swim}	Skin surface area for swimming (cm^2)	23000		8100		
IR_{fish}	Ingestion rate of fish (kg/yr)	0.025				
Fl_{fish}	Contaminated fish fraction (unitless)	1				

Complete Exposure Pathways and Receptors	On-site	Off-site 1	Off-site 2
Groundwater:			
Groundwater Ingestion	Commercial	Commercial	Surf. Water
Soil Leaching to Groundwater Ingestion	None	None	None
Applicable Surface Water Exposure Routes:			
Swimming			No
Fish Consumption			Yes
Aquatic Life Protection			No
Soil:			
Direct Ingestion and Dermal Contact	None		
Outdoor Air:			
Particulates from Surface Soils	None	None	None
Volatilization from Soils	None	None	None
Volatilization from Groundwater	Commercial	Commercial	None
Indoor Air:			
Volatilization from Subsurface Soils	None	NA	NA
Volatilization from Groundwater	Commercial	NA	NA

Receptor Distance from Source Media	On-site	Off-site 1	Off-site 2	(Units)
Groundwater receptor	0	330	1300	(ft)
Soil leaching to groundwater receptor	NA	NA	NA	(ft)
Outdoor air inhalation receptor	0	330	NA	(ft)

Target Health Risk Values		Individual	Cumulative
TR_{ab}	Target Risk (class A&B carcinogens)	1.0E-6	1.0E-5
TR_c	Target Risk (class C carcinogens)	1.0E-5	
THQ	Target Hazard Quotient (non-carcinogenic risk)	1.0E+0	1.0E+0

Modeling Options	
RBCA tier	Tier 2
Outdoor air volatilization model	Surface & subsurface models
Indoor air volatilization model	Johnson & Ettinger model
Soil leaching model	NA
Use soil attenuation model (SAM) for leachate?	NA
Air dilution factor	User-specified ADF
Groundwater dilution-attenuation factor	Domenico model w/ biodeg.

NOTE: NA = Not applicable

Surface Parameters		General	Construction	(Units)
A	Source zone area	0.0E+0	NA	(ft^2)
W	Length of source-zone area parallel to wind	0.0E+0	NA	(ft)
W_{gw}	Length of source-zone area parallel to GW flow	NA		(ft)
U_{air}	Ambient air velocity in mixing zone	1.1E+1		(ft/s)
δ_{air}	Air mixing zone height	6.0E+0		(ft)
P_e	Areal particulate emission rate	NA		(g/cm^2/s)
L_{ss}	Thickness of affected surface soils	NA		(ft)

Surface Soil Column Parameters		Value			(Units)
h_{cap}	Capillary zone thickness	3.0E+0			(ft)
h_v	Vadose zone thickness	3.0E+0			(ft)
ρ_s	Soil bulk density	1.3E+0			(g/cm^3)
f_{oc}	Fraction organic carbon	2.0E-2			(-)
θ_T	Soil total porosity	5.0E-1			(-)
K_{vs}	Vertical hydraulic conductivity	3.0E+0			(m/yr)
k_v	Vapor permeability	1.0E-14			(ft^2)
L_{gw}	Depth to groundwater	6.0E+0			(ft)
L_s	Depth to top of affected soils	NA			(ft)
L_{base}	Depth to base of affected soils	NA			(ft)
L_{subs}	Thickness of affected soils	NA			(ft)
pH	Soil/groundwater pH	7.0E+0			(-)
		capillary	vadose	foundation	
θ_w	Volumetric water content	0.49	0.4	0.12	(-)
θ_a	Volumetric air content	0.01	0.1	0.26	(-)

Building Parameters		Residential	Commercial	(Units)
L_b	Building volume/area ratio	NA	1.90E+1	(ft)
A_b	Foundation area	NA	9.50E+3	(cm^2)
X_{crk}	Foundation perimeter	NA	5.00E+2	(ft)
ER	Building air exchange rate	NA	2.30E-4	(1/s)
L_{crk}	Foundation thickness	NA	4.92E-1	(ft)
Z_{crk}	Depth to bottom of foundation slab	NA	4.92E-1	(ft)
η	Foundation crack fraction	NA	1.00E-3	(-)
dP	Indoor/outdoor differential pressure	NA	0.00E+0	(g/cm/s^2)
Q_s	Convective air flow through slab	NA	0.00E+0	(ft^3/s)

Groundwater Parameters		Value	(Units)
δ_{gw}	Groundwater mixing zone depth	NA	(ft)
I_f	Net groundwater infiltration rate	NA	(cm/yr)
U_{gw}	Groundwater Darcy velocity	6.0E-2	(m/yr)
V_{gw}	Groundwater seepage velocity	1.2E-1	(m/yr)
K_s	Saturated hydraulic conductivity	NA	(m/yr)
i	Groundwater gradient	NA	(-)
S_w	Width of groundwater source zone	3.0E+1	(ft)
S_d	Depth of groundwater source zone	1.0E+1	(ft)
θ_{eff}	Effective porosity in water-bearing unit	NA	(-)
f_{oc-sat}	Fraction organic carbon in water-bearing unit	2.0E-2	(-)
pH_{sat}	Groundwater pH	7.0E+0	(-)
	Biodegradation considered?	1st Order	

Transport Parameters		Off-site 1	Off-site 2	Off-site 1	Off-site 2	(Units)
Lateral Groundwater Transport		Groundwater Ingestion		Soil Leaching to GW		
α_x	Longitudinal dispersivity	3.3E+1	1.3E+2	NA	NA	(ft)
α_y	Transverse dispersivity	1.1E+1	4.3E+1	NA	NA	(ft)
α_z	Vertical dispersivity	1.7E+0	6.5E+0	NA	NA	(ft)
Lateral Outdoor Air Transport		Soil to Outdoor Air Inhal.		GW to Outdoor Air Inhal.		
σ_y	Transverse dispersion coefficient	NA	NA	NA	NA	(ft)
σ_z	Vertical dispersion coefficient	NA	NA	NA	NA	(ft)
ADF	Air dispersion factor	NA	NA	1.0E+0	NA	(-)

Surface Water Parameters		Off-site 2	(Units)
Q_{sw}	Surface water flowrate	0.03	(ft^3/s)
W_{pl}	Width of GW plume at SW discharge	100	(ft)
δ_{pl}	Thickness of GW plume at SW discharge	10	(ft)
DF_{sw}	Groundwater-to-surface water dilution factor	4.8E+3	(-)

RBCA SITE ASSESSMENT | **Tier 2 Domenico Groundwater Modeling Summary**

Site Name: Former Lemoine Sausa Site Location: 630 29th Avenue, Oakland, CA Completed By: Warren B. Chamberlain Date Completed: 3-Jan-01

DOMENICO GROUNDWATER MODELING SUMMARY

OFF-SITE GROUNDWATER EXPOSURE PATHWAYS ☐ **(CHECKED IF PATHWAY IS ACTIVE)**

SOILS : LEACHING TO GROUNDWATER INGESTION

Exposure Concentration

Constituents of Concern	1) Source Medium	2) Steady-state Exposure Concentration Groundwater: POE Conc. (mg/L)		3) POE Concentration Limit Groundwater: POE Conc. (mg/L)		4) Time to Reach POE Conc. Limit Conc. limit reached? ("■" if yes) ; Time (yr)	
	Soil Conc. (mg/kg)	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None
Dichloroethane, 1,2-						NA	NA
Benzene*						NA	NA
Ethylbenzene						NA	NA
Toluene						NA	NA
Xylene (mixed isomers)						NA	NA

NOTE: POE = Point of exposure

RBCA SITE ASSESSMENT | **Tier 2 Domenico Groundwater Modeling Summary**

Site Name: Former Lemoine Sausa Site Location: 630 29th Avenue, Oakland, C/ Completed By: Warren B. Chamberlain Date Completed: 3-Jan-01

DOMENICO GROUNDWATER MODELING SUMMARY

OFF-SITE GROUNDWATER EXPOSURE PATHWAYS ■ **(CHECKED IF PATHWAY IS ACTIVE)**

GROUNDWATER: INGESTION

Exposure Concentration

Constituents of Concern	1) Source Medium	2) Steady-state Exposure Concentration Groundwater: POE Conc. (mg/L)		3) POE Concentration Limit Groundwater: POE Conc. (mg/L)		4) Time to Reach POE Conc. Limit Conc reaches limit? ("■" If yes) ; Time (yr)	
	Groundwater Conc. (mg/L)	Off-site 1 (330 ft) Commercial	Off-site 2 (1300 ft) Surf. Water	Off-site 1 (330 ft) Commercial	Off-site 2 (1300 ft) Surf. Water	Off-site 1 (330 ft) Commercial	Off-site 2 (1300 ft) Surf. Water
Dichloroethane, 1,2-	6.0E-1	4.7E-75	2.6E-108	3.1E-3	6.3E+4	□ NA	□ NA
Benzene*	1.6E+1	3.1E-52	6.9E-107	2.9E-3	9.1E+3	□ NA	□ NA
Ethylbenzene	8.0E+0	8.0E-100	3.5E-107	1.0E+1	4.9E+8	□ NA	□ NA
Toluene	2.0E+1	2.0E-99	8.7E-107	2.0E+1	1.4E+7	□ NA	□ NA
Xylene (mixed isomers)	7.0E+0	7.0E-100	3.0E-107	2.0E+2	9.8E+9	□ NA	□ NA

NOTE: POE = Point of exposure

16 ppm max in Boring

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

OUTDOOR AIR EXPOSURE PATHWAYS ☐ **(CHECKED IF PATHWAY IS ACTIVE)**

SURFACE SOILS (0 - 0 ft):

VAPOR AND DUST INHALATION

Constituents of Concern	1) Source Medium	2) NAF Value (m^3/kg) Receptor				3) Exposure Medium Outdoor Air: POE Conc. (mg/m^3) (1) / (2)			
	Soil Conc. (mg/kg)	On-site (0 ft) None	On-site (0 ft) Construction Worker	Off-site 1 (330 ft) None	Off-site 2 (0 ft) None	On-site (0 ft) None	On-site (0 ft) Construction Worker	Off-site 1 (330 ft) None	Off-site 2 (0 ft) None
Dichloroethane, 1,2-									
Benzene*									
Ethylbenzene									
Toluene									
Xylene (mixed isomers)									

NOTE: NAF = Natural attenuation factor POE = Point of exposure

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

OUTDOOR AIR EXPOSURE PATHWAYS

SURFACE SOILS (0 - 0 ft):

VAPOR AND DUST INHALATION (cont'd)

	4) Exposure Multiplier (EFxED)/(ATx365) (unitless)				5) Average Inhalation Exposure Concentration (mg/m^3) (3) X (4)			
	On-site (0 ft)		Off-site 1 (330 ft)	Off-site 2 (0 ft)	On-site (0 ft)		Off-site 1 (330 ft)	Off-site 2 (0 ft)
Constituents of Concern	None	Construction Worker	None	None	None	Construction Worker	None	None
Dichloroethane, 1,2-								
Benzene*								
Ethylbenzene								
Toluene								
Xylene (mixed isomers)								

* = Chemical with user-specified data

NOTE: AT = Averaging time (days) EF = Exposure frequency (days/yr) ED = Exposure duration (yr)

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

OUTDOOR AIR EXPOSURE PATHWAYS ☐ **(CHECKED IF PATHWAY IS ACTIVE)**

SUBSURFACE SOILS (3.3 - 0 ft):

VAPOR INHALATION

Constituents of Concern	1) Source Medium	2) NAF Value (m^3/kg) Receptor			3) Exposure Medium Outdoor Air: POE Conc. (mg/m^3) (1) / (2)		
	Soil Conc. (mg/kg)	On-site (0 ft) None	Off-site 1 (330 ft) None	Off-site 2 (0 ft) None	On-site (0 ft) None	Off-site 1 (330 ft) None	Off-site 2 (0 ft) None
Dichloroethane, 1,2-							
Benzene*							
Ethylbenzene							
Toluene							
Xylene (mixed isomers)							

NOTE: NAF = Natural attenuation factor POE = Point of exposure

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

OUTDOOR AIR EXPOSURE PATHWAYS

SUBSURFACE SOILS (3.3 - 0 ft):

VAPOR INHALATION (cont'd)

	4) Exposure Multiplier (EFxED)/(ATx365) (unitless)			5) Average Inhalation Exposure Concentration (mg/m^3) (3) X (4)		
Constituents of Concern	On-site (0 ft) None	Off-site 1 (330 ft) None	Off-site 2 (0 ft) None	On-site (0 ft) None	Off-site 1 (330 ft) None	Off-site 2 (0 ft) None
Dichloroethane, 1,2-						
Benzene*						
Ethylbenzene						
Toluene						
Xylene (mixed isomers)						

NOTE: AT = Averaging time (days) EF = Exposure frequency (days/yr) ED = Exposure duration (yr)

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

OUTDOOR AIR EXPOSURE PATHWAYS ■ **(CHECKED IF PATHWAY IS ACTIVE)**

GROUNDWATER: VAPOR INHALATION

Exposure Concentration

Constituents of Concern	1) Source Medium	2) NAF Value (m^3/L) Receptor			3) Exposure Medium Outdoor Air: POE Conc. (mg/m^3) (1) / (2)		
	Groundwater Conc. (mg/L)	On-site (0 ft) Commercial	Off-site 1 (330 ft) Commercial	Off-site 2 (0 ft) None	On-site (0 ft) Commercial	Off-site 1 (330 ft) Commercial	Off-site 2 (0 ft) None
Dichloroethane, 1,2-	6.0E-1	2.1E+6	2.1E+6		2.8E-7	2.8E-7	
Benzene*	1.6E+1	1.8E+6	1.8E+6		9.1E-6	9.1E-6	
Ethylbenzene	8.0E+0	2.1E+6	2.1E+6		3.7E-6	3.7E-6	
Toluene	2.0E+1	1.8E+6	1.8E+6		1.1E-5	1.1E-5	
Xylene (mixed isomers)	7.0E+0	2.0E+6	2.0E+6		3.5E-6	3.5E-6	

NOTE: NAF = Natural attenuation factor POE = Point of exposure

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

OUTDOOR AIR EXPOSURE PATHWAYS

GROUNDWATER: VAPOR INHALATION (cont'd)

Constituents of Concern	4) Exposure Multiplier (EFxED)/(ATx365) (unitless)			5) Average Inhalation Exposure Concentration (mg/m^3) (3) X (4)		
	On-site (0 ft) Commercial	Off-site 1 (330 ft) Commercial	Off-site 2 (0 ft) None	On-site (0 ft) Commercial	Off-site 1 (330 ft) Commercial	Off-site 2 (0 ft) None
Dichloroethane, 1,2-	2.4E-1	2.4E-1		7.0E-8	7.0E-8	
Benzene*	2.4E-1	2.4E-1		2.2E-6	2.2E-6	
Ethylbenzene	6.8E-1	6.8E-1		2.6E-6	2.6E-6	
Toluene	6.8E-1	6.8E-1		7.6E-6	7.6E-6	
Xylene (mixed isomers)	6.8E-1	6.8E-1		2.4E-6	2.4E-6	

NOTE: AT = Averaging time (days) EF = Exposure frequency (days/yr) ED = Exposure duration (yr)

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

OUTDOOR AIR EXPOSURE PATHWAYS

TOTAL PATHWAY EXPOSURE (mg/m^3)

(Sum average expsosure concentrations from soil and groundwater routes.)

	On-site (0 ft)		Off-site 1 (330 ft)	Off-site 2 (0 ft)
Constituents of Concern	Commercial	Construction Worker	Commercial	None
Dichloroethane, 1,2-	7.0E-8		7.0E-8	
Benzene*	2.2E-6		2.2E-6	
Ethylbenzene	2.6E-6		2.6E-6	
Toluene	7.6E-6		7.6E-6	
Xylene (mixed isomers)	2.4E-6		2.4E-6	

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA Tool Kit for Chemical Releases, Version 1.2

RBCA SITE ASSESSMENT

TIER 2 PATHWAY RISK CALCULATION

OUTDOOR AIR EXPOSURE PATHWAYS ■ **(CHECKED IF PATHWAYS ARE ACTIVE)**

CARCINOGENIC RISK

Constituents of Concern	(1) EPA Carcinogenic Classification	(2) Total Carcinogenic Exposure (mg/m^3) On-site (0 ft) Commercial	(2) On-site (0 ft) Construction Worker	(2) Off-site 1 (330 ft) Commercial	(2) Off-site 2 (0 ft) None	(3) Inhalation Unit Risk Factor (µg/m^3)^-1	(4) Individual COC Risk (2) x (3) x 1000 On-site (0 ft) Commercial	(4) On-site (0 ft) Construction Worker	(4) Off-site 1 (330 ft) Commercial	(4) Off-site 2 (0 ft) None
Dichloroethane, 1,2-	B2	7.0E-8		7.0E-8		2.6E-5	1.8E-9		1.8E-9	
Benzene*	A	2.2E-6		2.2E-6		8.3E-6	1.8E-8		1.8E-8	
Ethylbenzene	D									
Toluene	D									
Xylene (mixed isomers)	D									
						Total Pathway Carcinogenic Risk =	**2.0E-8**		**2.0E-8**	

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA

Completed By: Warren B. Chamberlain
Date Completed: 3-Jan-01

Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 PATHWAY RISK CALCULATION

OUTDOOR AIR EXPOSURE PATHWAYS ■ **(CHECKED IF PATHWAYS ARE ACTIVE)**

TOXIC EFFECTS

Constituents of Concern	(5) Total Toxicant Exposure (mg/m^3) On-site (0 ft) Commercial	On-site (0 ft) Construction Worker	Off-site 1 (330 ft) Commercial	Off-site 2 (0 ft) None	(6) Inhalation Reference Conc. (mg/m^3)	(7) Individual COC Hazard Quotient (5) / (6) On-site (0 ft) Commercial	On-site (0 ft) Construction Worker	Off-site 1 (330 ft) Commercial	Off-site 2 (0 ft) None
Dichloroethane, 1,2-	1.9E-7		1.9E-7		1.0E-2	1.9E-5		1.9E-5	
Benzene*	6.2E-6		6.2E-6		6.0E-3	1.0E-3		1.0E-3	
Ethylbenzene	2.6E-6		2.6E-6		1.0E+0	2.6E-6		2.6E-6	
Toluene	7.6E-6		7.6E-6		4.0E-1	1.9E-5		1.9E-5	
Xylene (mixed isomers)	2.4E-6		2.4E-6		7.0E+0	3.4E-7		3.4E-7	
Total Pathway Hazard Index =						**1.1E-3**		**1.1E-3**	

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA

Completed By: Warren B. Chamberlain
Date Completed: 3-Jan-01

Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 PATHWAY RISK CALCULATION

GROUNDWATER EXPOSURE PATHWAYS ■ **(CHECKED IF PATHWAYS ARE ACTIVE)**

CARCINOGENIC RISK

Constituents of Concern	(1) EPA Carcinogenic Classification	(2) Maximum Carcinogenic Intake Rate (mg/kg/day)			(3) Oral Slope Factor (mg/kg-day)^-1	(4) Individual COC Risk (2) x (3)		
		On-site (0 ft) Commercial	Off-site 1 Commercial	Off-site 2 Surf. Water		On-site (0 ft) Commercial	Off-site 1 Commercial	Off-site 2 Surf. Water
Dichloroethane, 1,2-	B2	2.1E-3	1.7E-77		9.1E-2	1.9E-4	1.5E-78	
Benzene*	A	5.6E-2	1.1E-54		1.0E-1	5.6E-3	1.1E-55	
Ethylbenzene	D							
Toluene	D							
Xylene (mixed isomers)	D							

	On-site (0 ft) Commercial	Off-site 1 Commercial	Off-site 2 Surf. Water
Total Pathway Carcinogenic Risk =	**5.8E-3**	**1.1E-55**	

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 PATHWAY RISK CALCULATION

GROUNDWATER EXPOSURE PATHWAYS ■ **(CHECKED IF PATHWAYS ARE ACTIVE)**

TOXIC EFFECTS

Constituents of Concern	(5) Maximum Toxicant Intake Rate (mg/kg/day)			(6) Oral Reference Dose (mg/kg/day)	(7) Individual COC Hazard Quotient (5) / (6)		
	On-site (0 ft) Commercial	Off-site 1 Commercial	Off-site 2 Surf. Water		On-site (0 ft) Commercial	Off-site 1 Commercial	Off-site 2 Surf. Water
Dichloroethane, 1,2-							
Benzene*	1.6E-1	3.1E-54		3.0E-3	5.2E+1	1.0E-51	
Ethylbenzene	7.8E-2	7.8E-102		1.0E-1	7.8E-1	7.8E-101	
Toluene	2.0E-1	2.0E-101		2.0E-1	9.8E-1	9.8E-101	
Xylene (mixed isomers)	6.8E-2	6.9E-102		2.0E+0	3.4E-2	3.4E-102	
Total Pathway Hazard Index =					**5.4E+1**	**1.0E-5[illegible]**	

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

SURFACE WATER EXPOSURE PATHWAYS ☐ **(CHECKED IF PATHWAY IS ACTIVE)**

SOILS : LEACHING TO GROUNDWATER/ DISCHARGE TO SURFACE WATER / DERMAL CONTACT & INGESTION VIA SWIMMING

Constituents of Concern	1) Source Medium Soil Conc. (mg/kg)	2) NAF Value (L/kg) Receptor Off-site 2 (0 ft) None	3) Exposure Medium Surface Water: POE Conc. (mg/L) (1)/(2) Off-site 2 (0 ft) None
Dichloroethane, 1,2-			
Benzene*			
Ethylbenzene			
Toluene			
Xylene (mixed isomers)			

NOTE: NAF = Natural attenuation factor POE = Point of exposure

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

SURFACE WATER EXPOSURE PATHWAYS

SOILS : LEACHING TO GROUNDWATER/ DISCHARGE TO SURFACE WATER / DERMAL CONTACT & INGESTION VIA SWIMMING (cont'd)

	4) Exposure Multiplier [(IRxET+SAxZ)xEVxED]/(BWxAT) (L/kg/day)	5) Average Daily Intake Rate (mg/kg/day) (3) x (4)
Constituents of Concern	Off-site 2 (0 ft) None	Off-site 2 (0 ft) None
Dichloroethane, 1,2-		
Benzene*		
Ethylbenzene		
Toluene		
Xylene (mixed isomers)		

AT = Averaging time (days)	ED = Exposure duration (yr)	EV = Event frequency (yr^-1)	SA = Skin exposure area (cm^2/day)
BW = Body weight (kg)	ET = Exposure time (hr)	IR = Ingestion rate (L/hr)	Z = Water/skin dermal adsorp. factor (cm)

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain
Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

INDOOR AIR EXPOSURE PATHWAYS ☐ (CHECKED IF PATHWAY IS ACTIVE)

SOILS : VAPOR

INTRUSION INTO ON-SITE BUILDINGS	1) Source Medium	2) NAF Value (m^3/kg) Receptor	3) Exposure Medium Indoor Air: POE Conc. (mg/m^3) (1) / (2)	4) Exposure Multiplier (EFxED)/(ATx365) (unitless)	5) Average Inhalation Exposure Concentration (mg/m^3) (3) X (4)
Constituents of Concern	Soil Conc. (mg/kg)	None	None	None	None
Dichloroethane, 1,2-					
Benzene*					
Ethylbenzene					
Toluene					
Xylene (mixed isomers)					

* = Chemical with user-specified data

NOTE: AT = Averaging time (days) EF = Exposure frequency (days/yr) ED = Exposure duration (yr) NAF = Natural attenuation factor POE = Point of exposure

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

INDOOR AIR EXPOSURE PATHWAYS ■ (CHECKED IF PATHWAY IS ACTIVE)

GROUNDWATER: VAPOR INTRUSION INTO ON-SITE BUILDINGS	Exposure Concentration				
	1) Source Medium	2) NAF Value (m^3/L) Receptor	3) Exposure Medium Indoor Air: POE Conc. (mg/m^3) (1) / (2)	4) Exposure Multiplier (EFxED)/(ATx365) (unitless)	5) Average Inhalation Exposure Concentration (mg/m^3) (3) X (4)
Constituents of Concern	Groundwater Conc. (mg/L)	Commercial	Commercial	Commercial	Commercial
Dichloroethane, 1,2-	6.0E-1	9.3E+3	6.4E-5	2.4E-1	1.6E-5
Benzene*	1.6E+1	4.9E+3	3.3E-3	2.4E-1	8.0E-4
Ethylbenzene	8.0E+0	5.5E+3	1.5E-3	6.8E-1	1.0E-3
Toluene	2.0E+1	4.9E+3	4.1E-3	6.8E-1	2.8E-3
Xylene (mixed isomers)	7.0E+0	5.4E+3	1.3E-3	6.8E-1	9.0E-4

NOTE: AT = Averaging time (days) EF = Exposure frequency (days/yr) ED = Exposure duration (yr) NAF = Natural attenuation factor POE = Point of exposure

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

INDOOR AIR EXPOSURE PATHWAYS

Constituents of Concern	TOTAL PATHWAY EXPOSURE (mg/m^3) *(Sum average expsosure concentrations from soil and groundwater routes.)* Commercial
Dichloroethane, 1,2-	1.6E-5
Benzene*	8.0E-4
Ethylbenzene	1.0E-3
Toluene	2.8E-3
Xylene (mixed isomers)	9.0E-4

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain
Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 PATHWAY RISK CALCULATION

INDOOR AIR EXPOSURE PATHWAYS ■ **(CHECKED IF PATHWAYS ARE ACTIVE)**

CARCINOGENIC RISK

Constituents of Concern	(1) EPA Carcinogenic Classification	(2) Total Carcinogenic Exposure (mg/m^3) Commercial	(3) Inhalation Unit Risk Factor (µg/m^3)^-1	(4) Individual COC Risk (2) x (3) x 1000 Commercial
Dichloroethane, 1,2-	B2	1.6E-5	2.6E-5	4.1E-7
Benzene*	A	8.0E-4	8.3E-6	6.6E-6
Ethylbenzene	D			
Toluene	D			
Xylene (mixed isomers)	D			

Total Pathway Carcinogenic Risk = **7.0E-6**

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 PATHWAY RISK CALCULATION

INDOOR AIR EXPOSURE PATHWAYS ■ **(CHECKED IF PATHWAYS ARE ACTIVE)**

	TOXIC EFFECTS		
Constituents of Concern	(5) Total Toxicant Exposure (mg/m^3) Commercial	(6) Inhalation Reference Concentration (mg/m^3)	(7) Individual COC Hazard Quotient (5) / (6) Commercial
Dichloroethane, 1,2-	4.4E-5	1.0E-2	4.4E-3
Benzene*	2.2E-3	6.0E-3	3.8E-1
Ethylbenzene	1.0E-3	1.0E+0	1.0E-3
Toluene	2.8E-3	4.0E-1	7.0E-3
Xylene (mixed isomers)	9.0E-4	7.0E+0	1.3E-4

Total Pathway Hazard Index = **3.9E-1**

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

GROUNDWATER EXPOSURE PATHWAYS ☐ **(CHECKED IF PATHWAY IS ACTIVE)**

SOILS : LEACHING TO GROUNDWATER INGESTION

	1) Source Medium	2) NAF Value (L/kg) Receptor			3) Exposure Medium Groundwater: POE Conc. (mg/L) (1)/(2)		
Constituents of Concern	Soil Conc. (mg/kg)	On-site (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None	On-site (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None
Dichloroethane, 1,2-							
Benzene*							
Ethylbenzene							
Toluene							
Xylene (mixed isomers)							

* = Chemical with user-specified data

NOTE: NAF = Natural attenuation factor POE = Point of exposure

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

GROUNDWATER EXPOSURE PATHWAYS

SOILS : LEACHING TO GROUNDWATER INGESTION (cont'd)

Constituents of Concern	4) Exposure Multiplier (IRxEFxED)/(BWxAT) (L/kg-day)			5) Average Daily Intake Rate (mg/kg/day) (3) x (4)		
	On-site (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None	On-site (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None
Dichloroethane, 1,2-						
Benzene*						
Ethylbenzene						
Toluene						
Xylene (mixed isomers)						

* = Chemical with user-specified data

NOTE: AT = Averaging time (days); BW = Body weight (kg); ED = Exposure duration (yr); EF = Exposure frequency (days/yr); IR = Ingestion rate (mg/day)

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain
Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

GROUNDWATER EXPOSURE PATHWAYS ■ **(CHECKED IF PATHWAY IS ACTIVE)**

GROUNDWATER: INGESTION

	1) Source Medium	2) NAF Value (unitless) Receptor			3) Exposure Medium Groundwater: POE Conc. (mg/L) (1)/(2)		
Constituents of Concern	Groundwater Conc. (mg/L)	On-site (0 ft) Commercial	Off-site 1 (330 ft) Commercial	Off-site 2 (1300 ft) Surf. Water	On-site (0 ft) Commercial	Off-site 1 (330 ft) Commercial	Off-site 2 (1300 ft) Surf. Water
Dichloroethane, 1,2-	6.0E-1	1.0E+0	1.3E+74		6.0E-1	4.7E-75	
Benzene*	1.6E+1	1.0E+0	5.1E+52		1.6E+1	3.1E-52	
Ethylbenzene	8.0E+0	1.0E+0	1.0E+100		8.0E+0	8.0E-100	
Toluene	2.0E+1	1.0E+0	1.0E+100		2.0E+1	2.0E-99	
Xylene (mixed isomers)	7.0E+0	1.0E+0	1.0E+100		7.0E+0	7.0E-100	

NOTE: NAF = Natural attenuation factor POE = Point of exposure

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

GROUNDWATER EXPOSURE PATHWAYS

GROUNDWATER INGESTION (cont'd)

	4) Exposure Multiplier (IRxEFxED)/(BWxAT) (L/kg/day)			5) Average Daily Intake Rate (mg/kg/day) (3) x (4)		
Constituents of Concern	On-site (0 ft) Commercial	Off-site 1 (330 ft) Commercial	Off-site 2 (1300 ft) Surf. Water	On-site (0 ft) Commercial	Off-site 1 (330 ft) Commercial	Off-site 2 (1300 ft) Surf. Water
Dichloroethane, 1,2-	3.5E-3	3.5E-3		2.1E-3	1.7E-77	
Benzene*	3.5E-3	3.5E-3		5.6E-2	1.1E-54	
Ethylbenzene	9.8E-3	9.8E-3		7.8E-2	7.8E-102	
Toluene	9.8E-3	9.8E-3		2.0E-1	2.0E-101	
Xylene (mixed isomers)	9.8E-3	9.8E-3		6.8E-2	6.9E-102	

* = Chemical with user-specified data

NOTE: AT = Averaging time (days) ED = Exposure duration (yr) IR = Ingestion rate (mg/day)
BW = Body weight (kg) EF = Exposure frequency (days/yr)

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain
Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

GROUNDWATER EXPOSURE PATHWAYS

	MAXIMUM PATHWAY INTAKE (mg/kg/day) *(Maximum intake of active pathways soil leaching & groundwater routes.)*		
Constituents of Concern	On-site (0 ft) Commercial	Off-site 1 Commercial	Off-site 2 Surf. Water
Dichloroethane, 1,2-	2.1E-3	1.7E-77	
Benzene*	5.6E-2	1.1E-54	
Ethylbenzene	7.8E-2	7.8E-102	
Toluene	2.0E-1	2.0E-101	
Xylene (mixed isomers)	6.8E-2	6.9E-102	

* = Chemical with user-specified data

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

SURFACE WATER EXPOSURE PATHWAYS ☐ **(CHECKED IF PATHWAY IS ACTIVE)**

SOILS : LEACHING TO GROUNDWATER/ DISCHARGE TO SURFACE WATER/ FISH CONSUMPTION	**Exposure Concentration**		
	1) Source Medium	2) NAF Value (L/kg) Receptor	3) Exposure Medium Surface Water: POE Conc. (mg/L) (1)/(2)
Constituents of Concern	Soil Conc. (mg/kg)	Off-site 2 (0 ft) None	Off-site 2 (0 ft) None
Dichloroethane, 1,2-			
Benzene*			
Ethylbenzene			
Toluene			
Xylene (mixed isomers)			

NOTE: NAF = Natural attenuation factor POE = Point of exposure

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

SURFACE WATER EXPOSURE PATHWAYS

SOILS : LEACHING TO GROUNDWATER/ DISCHARGE TO SURFACE WATER/ FISH CONSUMPTION (cont'd) Constituents of Concern	4) Exposure Multiplier (IRxFIxBCFxED)/(BWxAT) (L/kg/day) Off-site 2 (0 ft) None	5) Average Daily Intake Rate (mg/kg/day) (3) x (4) Off-site 2 (0 ft) None
Dichloroethane, 1,2-		
Benzene*		
Ethylbenzene		
Toluene		
Xylene (mixed isomers)		

AT = Averaging time (days)	BDF = Bioconc. Factor (-)	FI = Affected fish fraction (-)
BW = Body weight (kg)	ED = Exposure duration (yr)	IR = Ingestion rate (kg/yr)

Site Name: Former Lemoine Sausage Factory Completed By: Warren B. Chamberlain Job ID: 70-97066.00
Site Location: 630 29th Avenue, Oakland, CA Date Completed: 3-Jan-01

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

SURFACE WATER EXPOSURE PATHWAYS ☐ **(CHECKED IF PATHWAY IS ACTIVE)**

GROUNDWATER: DISCHARGE TO SURFACE WATER / DERMAL CONTACT & INGESTION VIA SWIMMING

Constituents of Concern	1) Source Medium Groundwater Conc. (mg/L)	2) NAF Value (unitless) Receptor Off-site 2 (1300 ft) None	3) Exposure Medium Surface Water: POE Conc. (mg/L) (1)/(2) Off-site 2 (1300 ft) None
Dichloroethane, 1,2-	6.0E-1		
Benzene*	1.6E+1		
Ethylbenzene	8.0E+0		
Toluene	2.0E+1		
Xylene (mixed isomers)	7.0E+0		

NOTE: NAF = Natural attenuation factor POE = Point of exposure

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

SURFACE WATER EXPOSURE PATHWAYS

GROUNDWATER: DISCHARGE TO SURFACE WATER / DERMAL CONTACT & INGESTION VIA SWIMMING (cont'd)

Constituents of Concern	4) Exposure Multiplier [(IRxET+SAxZ)xEVxED]/(BWxAT) (L/kg/day)	5) Average Daily Intake Rate (mg/kg/day) (3) x (4)
	Off-site 2 (1300 ft) None	Off-site 2 (1300 ft) None
Dichloroethane, 1,2-		
Benzene*		
Ethylbenzene		
Toluene		
Xylene (mixed isomers)		

AT = Averaging time (days)	ED = Exposure duration (yr)	EV = Event frequency (yr^-1)	SA = Skin exposure area (cm^2/day)
BW = Body weight (kg)	ET = Exposure time (hr)	IR = Ingestion rate (L/hr)	Z = Water/skin dermal adsorp. factor (cm)

Site Name: Former Lemoine Sausage Factory   Completed By: Warren B. Chamberlain   Job ID: 70-97066.00
Site Location: 630 29th Avenue, Oakland, CA   Date Completed: 3-Jan-01

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

SURFACE WATER EXPOSURE PATHWAYS ■ **(CHECKED IF PATHWAY IS ACTIVE)**

GROUNDWATER: DISCHARGE TO SURFACE WATER / FISH CONSUMPTION

	1) Source Medium	2) NAF Value (unitless) Receptor	3) Exposure Medium Surface Water: POE Conc. (mg/L) (1)/(2)
Constituents of Concern	Groundwater Conc. (mg/L)	Off-site 2 (1300 ft) None	Off-site 2 (1300 ft) None
Dichloroethane, 1,2-	6.0E-1	4.8E+103	1.2E-104
Benzene*	1.6E+1	4.8E+103	3.3E-103
Ethylbenzene	8.0E+0	4.8E+103	1.7E-103
Toluene	2.0E+1	4.8E+103	4.2E-103
Xylene (mixed isomers)	7.0E+0	4.8E+103	1.5E-103

NOTE: NAF = Natural attenuation factor POE = Point of exposure

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 EXPOSURE CONCENTRATION AND INTAKE CALCULATION

SURFACE WATER EXPOSURE PATHWAYS

GROUNDWATER: DISCHARGE TO SURFACE WATER / FISH CONSUMPTION (cont'd)	4) Exposure Multiplier (IRxFIxBCFxED)/(BWxAT) (L/kg/day)	5) Average Daily Intake Rate (mg/kg/day) (3) x (4)	MAXIMUM PATHWAY INTAKE (mg/kg/day) *(Maximum Intake of active pathways soil leaching & groundwater routes.)*
Constituents of Concern	Off-site 2 (1300 ft) None	Off-site 2 (1300 ft) None	Off-site 2 None
Dichloroethane, 1,2-	8.4E-7	1.0E-110	1.0E-110
Benzene*	5.3E-6	1.8E-108	1.8E-108
Ethylbenzene	9.8E-7	1.6E-109	1.6E-109
Toluene	6.8E-5	2.9E-107	2.9E-107
Xylene (mixed isomers)	9.8E-7	1.4E-109	1.4E-109

AT = Averaging time (days)	BDF = Bioconcentration factor (-)	FI = Affected fish fraction (-)
BW = Body weight (kg)	ED = Exposure duration (yr)	IR = Ingestion rate (kg/yr)

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA

Completed By: Warren B. Chamberlair Job ID: 70-97066.00
Date Completed: 3-Jan-01

RBCA SITE ASSESSMENT

TIER 2 PATHWAY RISK CALCULATION

SURFACE WATER EXPOSURE PATHWAYS ■ **(CHECKED IF PATHWAYS ARE ACTIVE)**

CARCINOGENIC RISK

Constituents of Concern	(1) EPA Carcinogenic Classification	(2) Maximum Carcinogenic Intake Rate (mg/kg/day) (a) via Ingestion	(b) via Dermal Contact	(3) Slope Factor (mg/kg/day)^-1 (a) Oral	(b) Dermal	(4) Individual COC Risk (2a)x(3a) + (2b)x(3b)
		Off-site 2 None				Off-site 2 None
Dichloroethane, 1,2-	B2	1.0E-110		9.1E-2	9.1E-2	9.5E-112
Benzene*	A	1.8E-108		1.0E-1	1.0E-1	1.8E-109
Ethylbenzene	D					
Toluene	D					
Xylene (mixed isomers)	D					

* No dermal slope factor available--oral slope factor used.

Total Pathway Carcinogenic Risk = **1.8E-109**

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

TIER 2 PATHWAY RISK CALCULATION

SURFACE WATER EXPOSURE PATHWAYS ■ **(CHECKED IF PATHWAYS ARE ACTIVE)**

TOXIC EFFECTS

Constituents of Concern	(5) Maximum Toxicant Intake Rate (mg/kg/day) (a) via Ingestion	(b) via Dermal Contact	(6) Reference Dose (mg/kg/day) (a) Oral	(b) Dermal	(7) Individual COC Hazard Quotient (5a)/(6a) + (5b)/(6b)
	Off-site 2 None				Off-site 2 None
Dichloroethane, 1,2-					
Benzene*	4.1E-108		3.0E-3	3.0E-3*	**1.4E-105**
Ethylbenzene	1.6E-109		1.0E-1	9.7E-2	**1.6E-108**
Toluene	2.9E-107		2.0E-1	1.6E-1	1.4E-106
Xylene (mixed isomers)	1.4E-109		2.0E+0	1.8E+0	7.1E-110

* No dermal reference dose available--oral reference dose used.

Total Pathway Hazard Index = **1.5E-105**

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain

Date Completed: 3-Jan-01
Job ID: 70-97066.00

RBCA SITE ASSESSMENT

Baseline Risk Summary-All Pathways

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA

Completed By: Warren B. Chamberlain
Date Completed: 3-Jan-01

TIER 2 BASELINE RISK SUMMARY TABLE

	BASELINE CARCINOGENIC RISK					BASELINE TOXIC EFFECTS				
	Individual COC Risk		Cumulative COC Risk		Risk	Hazard Quotient		Hazard Index		Toxicity
EXPOSURE PATHWAY	Maximum Value	Target Risk	Total Value	Target Risk	Limit(s) Exceeded?	Maximum Value	Applicable Limit	Total Value	Applicable Limit	Limit(s) Exceeded?
OUTDOOR AIR EXPOSURE PATHWAYS										
Complete:	1.8E-8	1.0E-6	2.0E-8	1.0E-5	☐	1.0E-3	1.0E+0	1.1E-3	1.0E+0	☐
INDOOR AIR EXPOSURE PATHWAYS										
Complete:	6.6E-6	1.0E-6	7.0E-6	1.0E-5	■	3.8E-1	1.0E+0	3.9E-1	1.0E+0	☐
SOIL EXPOSURE PATHWAYS										
Complete:	NA	NA	NA	NA	☐	NA	NA	NA	NA	☐
GROUNDWATER EXPOSURE PATHWAYS										
Complete:	5.6E-3	1.0E-6	5.8E-3	1.0E-5	■	5.2E+1	1.0E+0	5.4E+1	1.0E+0	■
SURFACE WATER EXPOSURE PATHWAYS										
Complete:	1.8E-109	1.0E-6	1.8E-109	1.0E-5	☐	1.4E-105	1.0E+0	1.5E-105	1.0E+0	☐

CRITICAL EXPOSURE PATHWAY (Maximum Values From Complete Pathways)										
	5.6E-3	***1.0E-6***	***5.8E-3***	***1.0E-5***	■	***5.2E+1***	***1.0E+0***	***5.4E+1***	***1.0E+0***	■
	Groundwater		***Groundwater***			***Groundwater***		***Groundwater***		

RBCA SITE ASSESSMENT | **Chemical-Specific Tier 2 Cleanup Summary**

Site Name: Former Lemoine Sausage Factory — Completed By: Warren B. Chamberlain — Job ID: 70-97066.00

Site Location: 630 29th Avenue, Oakland, CA — Date Completed: 3-Jan-01 — *1 of 6*

Constituent: Dichloroethane, 1,2- CAS No.: 107-06-2

Site-Specific Target Level (SSTL) Concentrations

		On-site	Off-site1	Off-site2
Groundwater Ingestion				
	Receptor Type / Distance (ft)	Commercial / 0	Commercial / 330	Surf. Water / 1300
$SSTL_{gw}$ (mg/L)	THQ = 1e+0	NC	NC	NC
	TR = 1e-6	3.1E-3	>8.7E+3	NC
Soil Leaching to Groundwater Ingestion				
	Receptor Type / Distance (ft)	None	None	None
$SSTL_s$ (mg/kg)	THQ = 1e+0	NA	NA	NA
	TR = 1e-6	NA	NA	NA
Surface Soil Ingestion and Dermal Contact				
	Receptor Type / Distance (ft)	None	No Off-site Receptors	
$SSTL_{ss}$ (mg/kg)	THQ = 1e+0	NA		
	TR = 1e-6	NA		
Outdoor Air Inhalation				
	Receptor Type / Distance (ft)	Commercial / 0	Commercial / 330	None
$RBEL_{air}$ (μg/m³)	THQ = 1e+0	1.5E+1	1.5E-2	NA
	TR = 1e-6	1.6E-1	1.6E-4	NA
Soil Volatilization/Particulates to Outdoor Air Inhalation				
	Receptor Type / Distance (ft)	None	None	None
$SSTL_s$ (mg/kg)	THQ = 1e+0	NA	NA	NA
	TR = 1e-6	NA	NA	NA
Groundwater Volatilization to Outdoor Air Inhalation				
	Receptor Type / Distance (ft)	Commercial / 0	Commercial / 330	None
$SSTL_{gw}$ (mg/L)	THQ = 1e+0	>8.7E+3	>8.7E+3	NA
	TR = 1e-6	3.3E+2	3.3E+2	NA
Indoor Air Inhalation				
	Receptor Type / Distance (ft)	Commercial / 0	No Off-site Receptors	
$RBEL_{air}$ (μg/m³)	THQ = 1e+0	1.5E+1		
	TR = 1e-6	1.6E-1		
Soil Volatilization to Indoor Air Inhalation				
	Receptor Type / Distance (ft)	None	No Off-site Receptors	
$SSTL_s$ (mg/kg)	THQ = 1e+0	NA		
	TR = 1e-6	NA		
Groundwater Volatilization to Indoor Air Inhalation				
	Receptor Type / Distance (ft)	Commercial / 0	No Off-site Receptors	
$SSTL_{gw}$ (mg/L)	THQ = 1e+0	1.4E+2		
	TR = 1e-6	1.5E+0		

	Units	Residential	Commercial	Construction
Cross-Media Transfer Factors				
VF_{ss}	(kg-soil/L-air)	NA	NA	NA
VF_{samb}	(kg-soil/L-air)	NA	NA	NA
VF_{wamb}	(L-wat/L-air)	NA	4.7E-7	NA
VF_{sesp}	(kg-soil/L-air)	NA	NA	NA
VF_{wesp}	(L-wat/L-air)	NA	1.1E-4	NA
LF	(kg-soil/L-wat)	NA		NA

	Units	On-Site	Off-Site1	Off-Site2
Lateral Transport Factors				
DAFgw	(-)	1.0E+0	1.3E+74	1.0E+100
DAFs/gw	(-)	NA	NA	NA

Chemical Parameters

	Units	Value	Reference
Physical Properties			
MW	(g/mol)	9.9E+1	4
Sol	(mg/L)	8.7E+3	5
P_{vap}	(mmHg)	8.0E+1	4
H_{atm}	(atm-m³/mol)	1.2E-3	4
pK_a	(log[mol/mol])	-	-
pK_b	(log[mol/mol])	-	-
$\log(K_{oc})$	(log[L/kg])	1.8E+0	4
D_{air}	(cm²/sec)	1.0E-1	4
D_{wat}	(cm²/sec)	9.9E-6	4
Toxicity Data			
Wt of Evd.		B2	
SF_o	(1/[mg/kg/day])	9.1E-2	R
SF_d	(1/[mg/kg/day])	9.1E-2	TX
URF_i	(1/[μg/m³])	2.6E-5	R
RfD_o	(mg/kg/day)	-	-
RfD_d	(mg/kg/day)	-	-
RfC_i	(mg/m³)	1.0E-2	R
Dermal Exposure Parameters			
RAF_d	(mg/mg)	5.0E-1	D
K_p	(cm/hr)	5.3E-3	
tau_d	(hr/event)	3.5E-1	
t_{crit}	(hr)	8.4E-1	
B	(-)	3.0E-3	
Regulatory Standards			
MCL	(mg/L)	5.0E-3	*
TWA	(mg/m³)	4.0E+0	NIOSH
AQL	(mg/L)	-	-
Miscellaneous Parameters			
ADL_{gw}	(mg/L)	5.0E-4	S
ADL_s	(mg/kg)	5.0E-3	S
$t_{1/2,sat}$	(d)	3.6E+2	H
$t_{1/2,unsat}$	(d)	3.6E+2	H

* MCL ref = 52 FR 25690 (08 Jul 87)

	Units	Value
Derived Parameters		
H	(L-wat/L-air)	4.9E-2
K_{sw}	(L-wat/kg-soil)	6.9E-1
C_{sat}	(mg/kg-soil)	1.3E+4
$C_{sat,vap}$	(μg/m³-air)	4.3E+5
$D_{eff,s}$	(cm²/sec)	2.3E-4
$D_{eff,crk}$	(cm²/sec)	8.1E-3
$D_{eff,cap}$	(cm²/sec)	7.4E-5
$D_{eff,ws}$	(cm²/sec)	1.1E-4
R_{sat}	(-)	5.0E+0
R_{unsat}	(-)	4.8E+0
Z	(cm/event)	2.0E-2

Notes: 1) NA = Not applicable; NC = Not calculated.

2) Definitions and references presented on page 6 of 6.

RBCA SITE ASSESSMENT | **Chemical-Specific Tier 2 Cleanup Summary**

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain
Date Completed: 3-Jan-01
Job ID: 70-97066.00

Constituent: Benzene* **CAS No.: 71-43-2**

Site-Specific Target Level (SSTL) Concentrations

		On-site	Off-site1	Off-site2
Groundwater Ingestion				
Receptor Type / Distance (ft)		Commercial / 0	Commercial / 330	Surf. Water / 1300
$SSTL_{gw}$ (mg/L)	THQ = 1e+0	3.1E-1	>1.8E+3	NC
	TR = 1e-6	2.9E-3	>1.8E+3	NC
Soil Leaching to Groundwater Ingestion				
Receptor Type / Distance (ft)		None	None	None
$SSTL_s$ (mg/kg)	THQ = 1e+0	NA	NA	NA
	TR = 1e-6	NA	NA	NA
Surface Soil Ingestion and Dermal Contact				
Receptor Type / Distance (ft)		None	No Off-site Receptors	
$SSTL_{ss}$ (mg/kg)	THQ = 1e+0	NA		
	TR = 1e-6	NA		
Outdoor Air Inhalation				
Receptor Type / Distance (ft)		Commercial / 0	Commercial / 330	None
$RBEL_{air}$ (μg/m³)	THQ = 1e+0	8.7E+0	8.7E-3	NA
	TR = 1e-6	4.9E-1	4.9E-4	NA
Soil Volatilization/Particulates to Outdoor Air Inhalation				
Receptor Type / Distance (ft)		None	None	None
$SSTL_s$ (mg/kg)	THQ = 1e+0	NA	NA	NA
	TR = 1e-6	NA	NA	NA
Groundwater Volatilization to Outdoor Air Inhalation				
Receptor Type / Distance (ft)		Commercial / 0	Commercial / 330	None
$SSTL_{gw}$ (mg/L)	THQ = 1e+0	>1.8E+3	>1.8E+3	NA
	TR = 1e-6	8.7E+2	8.7E+2	NA
Indoor Air Inhalation				
Receptor Type / Distance (ft)		Commercial / 0	No Off-site Receptors	
$RBEL_{air}$ (μg/m³)	THQ = 1e+0	8.7E+0		
	TR = 1e-6	4.9E-1		
Soil Volatilization to Indoor Air Inhalation				
Receptor Type / Distance (ft)		None	No Off-site Receptors	
$SSTL_s$ (mg/kg)	THQ = 1e+0	NA		
	TR = 1e-6	NA		
Groundwater Volatilization to Indoor Air Inhalation				
Receptor Type / Distance (ft)		Commercial / 0	No Off-site Receptors	
$SSTL_{gw}$ (mg/L)	THQ = 1e+0	4.3E+1		
	TR = 1e-6	2.4E+0		

	Units	Residential	Commercial	Construction
Cross-Media Transfer Factors				
VF_{ss}	(kg-soil/L-air)	NA	NA	NA
VF_{samb}	(kg-soil/L-air)	NA	NA	NA
VF_{wamb}	(L-wat/L-air)	NA	5.7E-7	NA
VF_{sesp}	(kg-soil/L-air)	NA	NA	NA
VF_{wesp}	(L-wat/L-air)	NA	2.0E-4	NA
LF	(kg-soil/L-wat)	NA		NA

	Units	On-Site	Off-Site1	Off-Site2
Lateral Transport Factors				
DAFgw	(-)	1.0E+0	5.1E+52	1.0E+100
DAFs/gw	(-)	NA	NA	NA

Chemical Parameters

	Units	Value	Reference
Physical Properties			
MW	(g/mol)	7.8E+1	PS
Sol	(mg/L)	1.8E+3	PS
P_{vap}	(mmHg)	9.5E+1	PS
H_{atm}	(atm-m³/mol)	5.6E-3	PS
pK_a	(log[mol/mol])	-	-
pK_b	(log[mol/mol])	-	-
$\log(K_{oc})$	(log[L/kg])	1.8E+0	PS
D_{air}	(cm²/sec)	8.8E-2	PS
D_{wat}	(cm²/sec)	9.8E-6	PS
Toxicity Data			
Wt of Evd.		A	
SF_o	(1/[mg/kg/day])	1.0E-1	0
SF_d	(1/[mg/kg/day])	1.0E-1	0
URF_i	(1/[μg/m³])	8.3E-6	PS
RfD_o	(mg/kg/day)	3.0E-3	R
RfD_d	(mg/kg/day)	-	-
RfC_i	(mg/m³)	6.0E-3	R
Dermal Exposure Parameters			
RAF_d	(mg/mg)	5.0E-1	D
K_p	(cm/hr)	2.1E-2	
tau_d	(hr/event)	2.6E-1	
t_{crit}	(hr)	6.3E-1	
B	(-)	1.3E-2	
Regulatory Standards			
MCL	(mg/L)	5.0E-3	*
TWA	(mg/m³)	3.3E+0	-
AQL	(mg/L)	-	-
Miscellaneous Parameters			
ADL_{gw}	(mg/L)	2.0E-3	S
ADL_s	(mg/kg)	5.0E-3	S
$t_{1/2,sat}$	(d)	7.2E+2	H
$t_{1/2,unsat}$	(d)	7.2E+2	H

* MCL ref = 52 FR 25690

	Units	Value
Derived Parameters		
H	(L-wat/L-air)	2.3E-1
K_{sw}	(L-wat/kg-soil)	6.7E-1
C_{sat}	(mg/kg-soil)	2.6E+3
$C_{sat,vap}$	(μg/m³-air)	4.0E+5
$D_{eff,s}$	(cm²/sec)	1.7E-4
$D_{eff,crk}$	(cm²/sec)	6.9E-3
$D_{eff,cap}$	(cm²/sec)	1.6E-5
$D_{eff,ws}$	(cm²/sec)	2.9E-5
R_{sat}	(-)	5.1E+0
R_{unsat}	(-)	4.9E+0
Z	(cm/event)	7.3E-2

Notes: 1) NA = Not applicable; NC = Not calculated.
2) Definitions and references presented on page 6 of 6.

RBCA SITE ASSESSMENT

Chemical-Specific Tier 2 Cleanup Summary

Site Name: Former Lemoine Sausage Factory | Completed By: Warren B. Chamberlain | Job ID: 70-97066.00
Site Location: 630 29th Avenue, Oakland, CA | Date Completed: 3-Jan-01 | *3 of 6*

Constituent: Ethylbenzene **CAS No.: 100-41-4**

Site-Specific Target Level (SSTL) Concentrations

		On-site	Off-site1	Off-site2
Groundwater Ingestion				
Receptor Type / Distance (ft)		Commercial / 0	Commercial / 330	Surf. Water / 1300
$SSTL_{gw}$	THQ = 1e+0	1.0E+1	NC	NC
(mg/L)	TR = 1e-6	NC	NC	NC
Soil Leaching to Groundwater Ingestion				
Receptor Type / Distance (ft)		None	None	None
$SSTL_s$	THQ = 1e+0	NA	NA	NA
(mg/kg)	TR = 1e-6	NA	NA	NA
Surface Soil Ingestion and Dermal Contact				
Receptor Type / Distance (ft)		None	No Off-site Receptors	
$SSTL_{ss}$	THQ = 1e+0	NA		
(mg/kg)	TR = 1e-6	NA		
Outdoor Air Inhalation				
Receptor Type / Distance (ft)		Commercial / 0	Commercial / 330	None
$RBEL_{air}$	THQ = 1e+0	1.5E+3	1.5E+0	NA
(µg/m³)	TR = 1e-6	NC	NC	NA
Soil Volatilization/Particulates to Outdoor Air Inhalation				
Receptor Type / Distance (ft)		None	None	None
$SSTL_s$	THQ = 1e+0	NA	NA	NA
(mg/kg)	TR = 1e-6	NA	NA	NA
Groundwater Volatilization to Outdoor Air Inhalation				
Receptor Type / Distance (ft)		Commercial / 0	Commercial / 330	None
$SSTL_{gw}$	THQ = 1e+0	>1.7E+2	>1.7E+2	NA
(mg/L)	TR = 1e-6	NC	NC	NA
Indoor Air Inhalation				
Receptor Type / Distance (ft)		Commercial / 0	No Off-site Receptors	
$RBEL_{air}$	THQ = 1e+0	1.5E+3		
(µg/m³)	TR = 1e-6	NC		
Soil Volatilization to Indoor Air Inhalation				
Receptor Type / Distance (ft)		None	No Off-site Receptors	
$SSTL_s$	THQ = 1e+0	NA		
(mg/kg)	TR = 1e-6	NA		
Groundwater Volatilization to Indoor Air Inhalation				
Receptor Type / Distance (ft)		Commercial / 0	No Off-site Receptors	
$SSTL_{gw}$	THQ = 1e+0	>1.7E+2		
(mg/L)	TR = 1e-6	NC		

	Units	Residential	Commercial	Construction
Cross-Media Transfer Factors				
VF_{ss}	(kg-soil/L-air)	NA	NA	NA
VF_{samb}	(kg-soil/L-air)	NA	NA	NA
VF_{wamb}	(L-wat/L-air)	NA	4.7E-7	NA
VF_{sesp}	(kg-soil/L-air)	NA	NA	NA
VF_{wesp}	(L-wat/L-air)	NA	1.8E-4	NA
LF	(kg-soil/L-wat)	NA		NA

	Units	On-Site	Off-Site1	Off-Site2
Lateral Transport Factors				
DAFgw	(-)	1.0E+0	1.0E+100	1.0E+100
DAFs/gw	(-)	NA	NA	NA

Chemical Parameters

	Units	Value	Reference
Physical Properties			
MW	(g/mol)	1.1E+2	PS
Sol	(mg/L)	1.7E+2	PS
P_{vap}	(mmHg)	1.0E+1	PS
H_{atm}	(atm-m³/mol)	7.9E-3	PS
pK_a	(log[mol/mol])	-	-
pK_b	(log[mol/mol])	-	-
$\log(K_{oc})$	(log[L/kg])	2.6E+0	PS
D_{air}	(cm²/sec)	7.5E-2	PS
D_{wat}	(cm²/sec)	7.8E-6	PS
Toxicity Data			
Wt of Evd.		D	
SF_o	(1/[mg/kg/day])	-	-
SF_d	(1/[mg/kg/day])	-	-
URF_i	(1/[µg/m³])	-	-
RfD_o	(mg/kg/day)	1.0E-1	PS
RfD_d	(mg/kg/day)	9.7E-2	TX
RfC_i	(mg/m³)	1.0E+0	PS
Dermal Exposure Parameters			
RAF_d	(mg/mg)	5.0E-1	D
K_p	(cm/hr)	7.4E-2	
tau_d	(hr/event)	3.9E-1	
t_{crit}	(hr)	1.3E+0	
B	(-)	1.4E-1	
Regulatory Standards			
MCL	(mg/L)	7.0E-1	*
TWA	(mg/m³)	4.4E+2	PS
AQL	(mg/L)	-	-
Miscellaneous Parameters			
ADL_{gw}	(mg/L)	2.0E-3	S
ADL_s	(mg/kg)	5.0E-3	S
$t_{1/2,sat}$	(d)	2.3E+2	H
$t_{1/2,unsat}$	(d)	2.3E+2	H

* MCL ref = 56 FR 3526 (30 Jan 91)

	Units	Value
Derived Parameters		
H	(L-wat/L-air)	3.2E-1
K_{sw}	(L-wat/kg-soil)	1.3E-1
C_{sat}	(mg/kg-soil)	1.3E+3
$C_{sat,vap}$	(µg/m³-air)	5.8E+4
$D_{eff,s}$	(cm²/sec)	1.4E-4
$D_{eff,crk}$	(cm²/sec)	5.9E-3
$D_{eff,cap}$	(cm²/sec)	9.0E-6
$D_{eff,ws}$	(cm²/sec)	1.7E-5
R_{sat}	(-)	2.6E+1
R_{unsat}	(-)	2.5E+1
Z	(cm/event)	2.7E-1

Notes: 1) NA = Not applicable; NC = Not calculated.
2) Definitions and references presented on page 6 of 6.

RBCA SITE ASSESSMENT

Chemical-Specific Tier 2 Cleanup Summary

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA
Completed By: Warren B. Chamberlain
Date Completed: 3-Jan-01
Job ID: 70-97066.00

Constituent: Toluene **CAS No.: 108-88-3**

Site-Specific Target Level (SSTL) Concentrations

		On-site	Off-site1	Off-site2
Groundwater Ingestion				
	Receptor Type / Distance (ft)	Commercial / 0	Commercial / 330	Surf. Water / 1300
$SSTL_{gw}$ (mg/L)	THQ = 1e+0	2.0E+1	NC	NC
	TR = 1e-6	NC	NC	NC
Soil Leaching to Groundwater Ingestion				
	Receptor Type / Distance (ft)	None	None	None
$SSTL_s$ (mg/kg)	THQ = 1e+0	NA	NA	NA
	TR = 1e-6	NA	NA	NA
Surface Soil Ingestion and Dermal Contact				
	Receptor Type / Distance (ft)	None	No Off-site Receptors	
$SSTL_{ss}$ (mg/kg)	THQ = 1e+0	NA		
	TR = 1e-6	NA		
Outdoor Air Inhalation				
	Receptor Type / Distance (ft)	Commercial / 0	Commercial / 330	None
$RBEL_{air}$ (μg/m³)	THQ = 1e+0	5.8E+2	5.8E-1	NA
	TR = 1e-6	NC	NC	NA
Soil Volatilization/Particulates to Outdoor Air Inhalation				
	Receptor Type / Distance (ft)	None	None	None
$SSTL_s$ (mg/kg)	THQ = 1e+0	NA	NA	NA
	TR = 1e-6	NA	NA	NA
Groundwater Volatilization to Outdoor Air Inhalation				
	Receptor Type / Distance (ft)	Commercial / 0	Commercial / 330	None
$SSTL_{gw}$ (mg/L)	THQ = 1e+0	>5.2E+2	>5.2E+2	NA
	TR = 1e-6	NC	NC	NA
Indoor Air Inhalation				
	Receptor Type / Distance (ft)	Commercial / 0	No Off-site Receptors	
$RBEL_{air}$ (μg/m³)	THQ = 1e+0	5.8E+2		
	TR = 1e-6	NC		
Soil Volatilization to Indoor Air Inhalation				
	Receptor Type / Distance (ft)	None	No Off-site Receptors	
$SSTL_s$ (mg/kg)	THQ = 1e+0	NA		
	TR = 1e-6	NA		
Groundwater Volatilization to Indoor Air Inhalation				
	Receptor Type / Distance (ft)	Commercial / 0	No Off-site Receptors	
$SSTL_{gw}$ (mg/L)	THQ = 1e+0	>5.2E+2		
	TR = 1e-6	NC		

	Units	Residential	Commercial	Construction
Cross-Media Transfer Factors				
VF_{ss}	(kg-soil/L-air)	NA	NA	NA
VF_{samb}	(kg-soil/L-air)	NA	NA	NA
VF_{wamb}	(L-wat/L-air)	NA	5.5E-7	NA
VF_{sesp}	(kg-soil/L-air)	NA	NA	NA
VF_{wesp}	(L-wat/L-air)	NA	2.0E-4	NA
LF	(kg-soil/L-wat)	NA		NA

	Units	On-Site	Off-Site1	Off-Site2
Lateral Transport Factors				
DAFgw	(-)	1.0E+0	1.0E+100	1.0E+100
DAFs/gw	(-)	NA	NA	NA

Chemical Parameters

	Units	Value	Reference
Physical Properties			
MW	(g/mol)	9.2E+1	5
Sol	(mg/L)	5.2E+2	29
P_{vap}	(mmHg)	3.0E+1	4
H_{atm}	(atm-m³/mol)	6.3E-3	A
pK_a	(log[mol/mol])	-	-
pK_b	(log[mol/mol])	-	-
$\log(K_{oc})$	(log[L/kg])	2.1E+0	A
D_{air}	(cm²/sec)	8.5E-2	A
D_{wat}	(cm²/sec)	9.4E-6	A
Toxicity Data			
Wt of Evd.		D	
SF_o	(1/[mg/kg/day])	-	-
SF_d	(1/[mg/kg/day])	-	-
URF_i	(1/[μg/m³])	-	-
RfD_o	(mg/kg/day)	2.0E-1	A,R
RfD_d	(mg/kg/day)	1.6E-1	TX
RfC_i	(mg/m³)	4.0E-1	A,R
Dermal Exposure Parameters			
RAF_d	(mg/mg)	5.0E-1	D
K_p	(cm/hr)	4.5E-2	
tau_d	(hr/event)	3.2E-1	
t_{crit}	(hr)	7.7E-1	
B	(-)	5.4E-2	
Regulatory Standards			
MCL	(mg/L)	1.0E+0	*
TWA	(mg/m³)	1.5E+2	ACGIH
AQL	(mg/L)	-	-
Miscellaneous Parameters			
ADL_{gw}	(mg/L)	2.0E-3	S
ADL_s	(mg/kg)	5.0E-3	S
$t_{1/2,sat}$	(d)	2.8E+1	H
$t_{1/2,unsat}$	(d)	2.8E+1	H

* MCL ref = 56 FR 3526 (30 Jan 91)

	Units	Value
Derived Parameters		
H	(L-wat/L-air)	2.6E-1
K_{sw}	(L-wat/kg-soil)	3.3E-1
C_{sat}	(mg/kg-soil)	1.6E+3
$C_{sat,vap}$	(μg/m³-air)	1.5E+5
$D_{eff,s}$	(cm²/sec)	1.7E-4
$D_{eff,crk}$	(cm²/sec)	6.6E-3
$D_{eff,cap}$	(cm²/sec)	1.4E-5
$D_{eff,ws}$	(cm²/sec)	2.5E-5
R_{sat}	(-)	1.0E+1
R_{unsat}	(-)	1.0E+1
Z	(cm/event)	1.6E-1

Notes: 1) NA = Not applicable; NC = Not calculated.

2) Definitions and references presented on page 6 of 6.

RBCA SITE ASSESSMENT | **Chemical-Specific Tier 2 Cleanup Summary**

Site Name: Former Lemoine Sausage Factory — Completed By: Warren B. Chamberlain — Job ID: 70-97066.00

Site Location: 630 29th Avenue, Oakland, CA — Date Completed: 3-Jan-01 —

Constituent: Xylene (mixed isomers)   CAS No.: 1330-20-7

Site-Specific Target Level (SSTL) Concentrations

		On-site	Off-site1	Off-site2
Groundwater Ingestion				
Receptor Type / Distance (ft)		Commercial / 0	Commercial / 330	Surf. Water / 1300
$SSTL_{gw}$ (mg/L)	THQ = 1e+0	>2.0E+2	NC	NC
	TR = 1e-6	NC	NC	NC
Soil Leaching to Groundwater Ingestion				
Receptor Type / Distance (ft)		None	None	None
$SSTL_s$ (mg/kg)	THQ = 1e+0	NA	NA	NA
	TR = 1e-6	NA	NA	NA
Surface Soil Ingestion and Dermal Contact				
Receptor Type / Distance (ft)		None	No Off-site Receptors	
$SSTL_{ss}$ (mg/kg)	THQ = 1e+0	NA		
	TR = 1e-6	NA		
Outdoor Air Inhalation				
Receptor Type / Distance (ft)		Commercial / 0	Commercial / 330	None
$RBEL_{air}$ (µg/m^3)	THQ = 1e+0	1.0E+4	1.0E+1	NA
	TR = 1e-6	NC	NC	NA
Soil Volatilization/Particulates to Outdoor Air Inhalation				
Receptor Type / Distance (ft)		None	None	None
$SSTL_s$ (mg/kg)	THQ = 1e+0	NA	NA	NA
	TR = 1e-6	NA	NA	NA
Groundwater Volatilization to Outdoor Air Inhalation				
Receptor Type / Distance (ft)		Commercial / 0	Commercial / 330	None
$SSTL_{gw}$ (mg/L)	THQ = 1e+0	>2.0E+2	>2.0E+2	NA
	TR = 1e-6	NC	NC	NA
Indoor Air Inhalation				
Receptor Type / Distance (ft)		Commercial / 0	No Off-site Receptors	
$RBEL_{air}$ (µg/m^3)	THQ = 1e+0	1.0E+4		
	TR = 1e-6	NC		
Soil Volatilization to Indoor Air Inhalation				
Receptor Type / Distance (ft)		None	No Off-site Receptors	
$SSTL_s$ (mg/kg)	THQ = 1e+0	NA		
	TR = 1e-6	NA		
Groundwater Volatilization to Indoor Air Inhalation				
Receptor Type / Distance (ft)		Commercial / 0	No Off-site Receptors	
$SSTL_{gw}$ (mg/L)	THQ = 1e+0	>2.0E+2		
	TR = 1e-6	NC		

	Units	Residential	Commercial	Construction
Cross-Media Transfer Factors				
VF_{ss}	(kg-soil/L-air)	NA	NA	NA
VF_{samb}	(kg-soil/L-air)	NA	NA	NA
VF_{wamb}	(L-wat/L-air)	NA	5.0E-7	NA
VF_{sesp}	(kg-soil/L-air)	NA	NA	NA
VF_{wesp}	(L-wat/L-air)	NA	1.9E-4	NA
LF	(kg-soil/L-wat)	NA		NA

	Units	On-Site	Off-Site1	Off-Site2
Lateral Transport Factors				
DAFgw	(-)	1.0E+0	1.0E+100	1.0E+100
DAFs/gw	(-)	NA	NA	NA

Chemical Parameters

	Units	Value	Reference
Physical Properties			
MW	(g/mol)	1.1E+2	5
Sol	(mg/L)	2.0E+2	5
P_{vap}	(mmHg)	7.0E+0	4
H_{atm}	(atm-m^3/mol)	7.0E-3	A
pK_a	(log[mol/mol])	-	-
pK_b	(log[mol/mol])	-	-
$log(K_{oc})$	(log[L/kg])	2.4E+0	A
D_{air}	(cm^2/sec)	7.2E-2	A
D_{wat}	(cm^2/sec)	8.5E-6	A
Toxicity Data			
Wt of Evd.		D	
SF_o	(1/[mg/kg/day])	-	-
SF_d	(1/[mg/kg/day])	-	-
URF_i	(1/[µg/m^3])	-	-
RfD_o	(mg/kg/day)	2.0E+0	A,R
RfD_d	(mg/kg/day)	1.8E+0	TX
RfC_i	(mg/m^3)	7.0E+0	A
Dermal Exposure Parameters			
RAF_d	(mg/mg)	5.0E-1	D
K_p	(cm/hr)	8.0E-2	
tau_d	(hr/event)	3.9E-1	
t_{crit}	(hr)	1.4E+0	
B	(-)	1.6E-1	
Regulatory Standards			
MCL	(mg/L)	1.0E+1	*
TWA	(mg/m^3)	4.3E+2	ACGIH
AQL	(mg/L)	-	-
Miscellaneous Parameters			
ADL_{gw}	(mg/L)	5.0E-3	S
ADL_s	(mg/kg)	5.0E-3	S
$t_{1/2,sat}$	(d)	3.6E+2	H
$t_{1/2,unsat}$	(d)	3.6E+2	H

* MCL ref = 56 FR 3526 (30 Jan 91)

	Units	Value
Derived Parameters		
H	(L-wat/L-air)	2.9E-1
K_{sw}	(L-wat/kg-soil)	2.0E-1
C_{sat}	(mg/kg-soil)	1.0E+3
$C_{sat,vap}$	(µg/m^3-air)	4.0E+4
$D_{eff,s}$	(cm^2/sec)	1.4E-4
$D_{eff,crk}$	(cm^2/sec)	5.6E-3
$D_{eff,cap}$	(cm^2/sec)	1.1E-5
$D_{eff,ws}$	(cm^2/sec)	2.0E-5
R_{sat}	(-)	1.8E+1
R_{unsat}	(-)	1.7E+1
Z	(cm/event)	2.9E-1

Notes: 1) NA = Not applicable; NC = Not calculated.

2) Definitions and references presented on page 6 of 6.

RBCA SITE ASSESSMENT | **Chemical-Specific Tier 2 Cleanup Summary**

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA

Completed By: Warren B. Chamberlain
Date Completed: 3-Jan-01

Definitions

Site-Specific Target Level Concentrations	
SSTLgw	Site-specific target level for groundwater (mg/L)
SSTLs	Site-specific target level for soil (mg/kg)
RBELair	Risk-based exposure limit for air (µg/m3)
THQ	Target hazard quotient
TR	Target risk

Cross-Media Transfer Factors	
VF_{ss}	Volatilization factor, surface soil to outdoor air (kg-soil/L-air)
VF_{samb}	Volatilization factor, subsurface soil to outdoor air (kg-soil/L-air)
VF_{wamb}	Volatilization factor, groundwater to outdoor air (L-wat/L-air)
VF_{sesp}	Volatilization factor, subsurface soil to indoor air (kg-soil/L-air)
VF_{wesp}	Volatilization factor, groundwater to indoor air (L-wat/L-air)
LF	Leaching factor, soil to groundwater (kg-soil/L-wat)

Cross-Media Transfer Factors	
DAF_{gw}	Dilution-attenuation factor, groundwater (-)
$DAF_{s/gw}$	Dilution-attenuation factor, soil leaching to groundwater (-)

Physical Properties	
MW	Molecular weight (g/mol)
Sol	Aqueous solubility limit (mg/L)
P_{vap}	Vapor pressure (mmHg)
H_{atm}	Henry's Law constant (atm-m^3/mol)
pK_a	Acid ionization constant (log[mol/mol])
pK_b	Base ionization constant (log[mol/mol])
K_{oc}	Organic carbon/Water partition coeffiecient (L/kg)
K_d	Soil/Water distribution coeffient (L/kg)
D_{air}	Molecular diffusion coeffient in air (cm^2/sec)
D_{wat}	Molecular diffusion coeffient in water (cm^2/sec)

Toxicity Data	
Wt of Evd.	Weight of evidence
SF_o	Oral slope factor for carcinogens (1/[mg/kg/day])
SF_d	Dermal slope factor for carcinogens (1/[mg/kg/day])
URF_i	Inhalation unit risk facor for carcinogens (1/[µg/m^3])
RfD_o	Oral reference dose (mg/kg/day)
RfD_d	Dermal reference dose (mg/kg/day)
RfC_i	Inhalation reference concentration (mg/m^3)

Dermal Exposure Parameters	
RAF_d	Dermal relative absorption factor (mg/mg)
K_p	Dermal permeability coeff. (cm/hr)
tau_d	Lag time for dermal exposure (hr/event)
t_{crit}	Critical exposure time (hr)
B	Relative contribution of permeability coeff. (-)

Regulatory Standards	
MCL	Maximum contaminant level for drinking water protection (mg/L)
TWA	Time-weighted average workplace air criterion (mg/m^3)
AQL	Aquatic life protection criterion (mg/L)

Miscellaneous Parameters	
ADL_{gw}	Analytical detection limit in groundwater (mg/L)
ADL_s	Analytical detection limit in soil (mg/kg)
$t_{1/2,sat}$	Half life, saturated zone (d)
$t_{1/2,unsat}$	Half life, unsaturated zone (d)

Derived Parameters	
H	Dimensionless Henry's Law contant (L-wat/L-air)
K_{sw}	Soil to pore-water partitioning factor (L-wat/kg-soil)
C_{sat}	Saturated residual conc. in vadose zone soils (mg/kg-soil)
$C_{sat,vap}$	Saturated concentration in vapors (mg/m3-air)
$D_{eff,s}$	Effective diffusion coeff. in vadose zone soils (cm^2/sec)
$D_{eff,crk}$	Effective diffusion coeff. in foundation cracks (cm^2/sec)
$D_{eff,cap}$	Effective diffusion coeff. in capillary zone (cm^2/sec)
$D_{eff,ws}$	Effective diffusion coeff., water table to ground surface (cm^2/sec)
R_{sat}	Retardation factor, saturated zone (-)
R_{unsat}	Retardation factor, unsaturated zone (-)
Z	Water to skin dermal absorption factor (cm/event)

Chemical Parameter References

PS	Standard Provisional Guide for Risk-Based Corrective Action, ASTM PS 104-98.
A	Emergency Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites,
D	USEPA, Dermal Exposure Assessment: Principles and Applications, ORD, EPA/600/8-91/011B.
H	Howard, Handbook of Environmental Degradation Rates, Lewis Publishers, Chelsea, MI, 1989
R	EPA Region III Risk Based Concentration Table, EPA Region 3, March 7, 1995.
S	USEPA, Test Methods for Evaluating Solid Waste, SW-846, Third Edition, OSWER, November 1986.
T	TPH Criteria Working Group, 1996.
TX	TNRCC Risk-Based Corrective Action for Leaking Storage Tank Sites, January 1994.
3	based on Kow from (2) and DiToro, D. M., 1985:"A Particle Interaction Model of Reversible Organic Chemical Sorption", Chemosphere, 14(10), 1505-1538. log(Koc) = 0.00028 + 0.983 log(Kow)
4	USEPA, 1989: Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF) - USEPA, OAQPS, Air Emission Models, (EPA-450/3-87-026).
5	Verschueren, Karel, 1983: Handbook of Environmental data on organic Chemicals, Second Ed., (Van nostrand Reinhold Company Inc., New York), ISBN: 0-442-28802-6.
6	Calculated diffusivity using the method of Fuller, Schettler, and Giddings from (9).
7	Calculated diffusivity using the method of Hayduk and Laudie and the reference from (9).
8	Calculated using Kenaga ang Goring Kow/solubility regression equation reference (9) and Kow data from (2), log(S, mg/l) = -0.922 log(Kow) + 4.184
9	Handbook of Chemical Property Estimation Methods, 1982, W.J. Lyman, (McGraw-Hill, New York), ISBN -0-07-039175-0.
10	Calculated from (Pv/Patm)/(solubility/mol wt).
11	Back calculated from solubility, Note (8) and (3).
12	Aldrich Chemical Calalog, 1991.
13	Calculated using Modified Watson Correlation from (9) and normal boiling point.
14	USEPA, 1979: Water Related Environmental Fate of 129 Priority Pollutants, Vol.1, USEPA, OWQPS,(EPA-4404-79-029a).
15	The Agrochemicals Handbook, (The Royal Society of Chemistry, The University, Nottingham, England), ISBN 0-85186-406-6.
16	Vapor pressure specified at elevated temperature, adjustments to 25C using methods presented by (9).
17	Wauchope, R. D., T. M. Butler, A. G. Hornsby, P. W. M. Augustijn-Beckers, and J.P. Burt, 1992: "The SCS/ARS/CES Pesticide Properties Database for Environmental Decision Making", Reviews of Environmental Contamination and Toxicology, vol 123, 1-155.
18	Farm Chemicals Handbook 91, C. Sine, ed., (Meister Publishing Company, Willoughby, Ohio).
19	Structure and Nomenclature Search System, (Version 7.00/7.03) December, 1992.
20	From Syracuse Research Corporation Calculated Value from pcchem-pcgems, 1988, ref no. 255435 in Enirofate database, Accession no. 105543.
23	NIOSH, 1990: Pocket Guide to Chemical Hazards, (U. S. Dept. of Health & Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health).
24	Buchter, B. et al., 1989: Correlation of Greundlich Kd and N retention Parameters with Soils and Elements, Soil Science, 148, 370-379.
25	USEPA, 1993: Air/Superfund National Technical Guidance Study series: Estimation of Air Impacts for Thermal Desorption Units Used at Superfund Sites, US Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA-451/R-93-005,
26	NTIS Accession No. PB93-215630, April 1993.
27	Based on salt solubilities in Table 3-120, R. H. Perry and D. W. Green, " Perry's Chemical Engineering Handbook" Sixth Edition, (McGraw-Hill, New York), 1973.
28	Based on salt solubilities in Table of Physical Constants for Inorganic Compounds, Weast, R. C., CRC Handbook of Chemistry and Physics, 67th edition, (CRC Press, Inc., Boca Raton), 1987.
29	Montgomery and Welkom, "Groundwater Chemicals Desk Reference", Lewis Publishers, Chelsea, MI, 1990.
30	USEPA, 1996: Soil Screening Guidance: Technical Background Doc., (EPA/540/R-95/128)
31	TNRCC Risk Reduction Rule Implementation, July 23, 1998. (update to Reference "TX")
32	USEPA, Method 8270C, Revision 3, "Semivolatile Organic Compounds by GC/MS", December 1996.
33	40 CFR 131.36, July 1, 1997
34	40 CFR 141.23, July 1, 1997
35	USEPA, Manual for the Certification of Laboratories Analyzing Drinking Water, EPA 815-B-97-001, March 1997
36	Calculated using Chiou et al. equation reported in (9); S (µmol/L) from (15).
37	Calculated using Chiou et al. equation reported in (9); S (µmol/L) from (23).
38	Calculated using Chiou et al. equation reported in (9); S (µmol/L) from (4).

RBCA SITE ASSESSMENT

Site Name: Former Lemoine Sausage Factory | Completed By: Warren B. Chamberlain | Job ID: 70-97066.00

Site Location: 630 29th Avenue, Oakland, CA | Date Completed: 3-Jan-01

GROUNDWATER SSTL VALUES

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

Target Risk (Class C) 1.0E-5

Target Hazard Quotient 1.0E+0

Groundwater DAF Option: Domenico - First Order (One-directional vert. dispersion)

SSTL Results For Complete Exposure Pathways ("X" if Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	X Groundwater Ingestion / Discharge to Surface Water			X GW Vol. to Indoor Air	X Groundwater Volatilization to Outdoor Air			Applicable SSTL	SSTL Exceeded ?	Required CRF
			On-site (0 ft)	Off-site 1 (330 ft)	Off-site 2 (1300 ft)	On-site (0 ft)	On-site (0 ft)	Off-site 1 (330 ft)	Off-site 2 (0 ft)			Only if "yes" left
CAS No.	**Name**	(mg/L)	Commercial	Commercial	Surf. Water	Commercial	Commercial	Commercial	None	(mg/L)	"■" if yes	
107-06-2	Dichloroethane, 1,2-	6.0E-1	3.1E-3	>8.7E+3	>8.7E+3	1.5E+0	3.3E+2	3.3E+2	NA	3.1E-3	■	1.9E+2
71-43-2	Benzene*	1.6E+1	2.9E-3	>1.8E+3	>1.8E+3	2.4E+0	8.7E+2	8.7E+2	NA	2.9E-3	■	5.6E+3
100-41-4	Ethylbenzene	8.0E+0	1.0E+1	>1.7E+2	>1.7E+2	>1.7E+2	>1.7E+2	>1.7E+2	NA	1.0E+1	□	<1
108-88-3	Toluene	2.0E+1	2.0E+1	>5.2E+2	>5.2E+2	>5.2E+2	>5.2E+2	>5.2E+2	NA	2.0E+1	□	<1
1330-20-7	Xylene (mixed isomers)	7.0E+0	>2.0E+2	>2.0E+2	>2.0E+2	>2.0E+2	>2.0E+2	>2.0E+2	NA	>2.0E+2	□	NA

* = Chemical with user-specified data

">" indicates risk-based target concentration greater than constituent solubility value. NA = Not applicable. NC = Not calculated.

RBCA SITE ASSESSMENT | **Cumulative Risk Worksheet**

Site Name: Former Lemoine Sausage Factory | Completed By: Warren B. Chamberlain | Job ID: 70-97066.00

Site Location: 630 29th Avenue, Oakland, CA | Date Completed: 3-Jan-01 |

CUMULATIVE RISK WORKSHEET

CONSTITUENTS OF CONCERN

CAS No.	Name	Representative Concentration: Soil (mg/kg)	Representative Concentration: Groundwater (mg/L)	Proposed CRF: Soil	Proposed CRF: GW	Resultant Target Concentration: Soil (mg/kg)	Resultant Target Concentration: Groundwater (mg/L)
107-06-2	Dichloroethane, 1,2-		6.0E-1		1.9E+2		3.1E-3
71-43-2	Benzene*		1.6E+1		5.6E+3		2.9E-3
100-41-4	Ethylbenzene		8.0E+0		<1		8.0E+0
108-88-3	Toluene		2.0E+1		<1		2.0E+1
1330-20-7	Xylene (mixed isomers)		7.0E+0		NA		7.0E+0

Cumulative Values:

RBCA SITE ASSESSMENT | **Cumulative Risk Worksheet**

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA

Completed By: Warren B. Chamberlain
Date Completed: 3-Jan-01

Job ID: 70-97066.00

CUMULATIVE RISK WORKSHEET

Cumulative Target Risk: 1.0E-5   Target Hazard Index: 1.0E+0

ON-SITE RECEPTORS

CONSTITUENTS OF CONCERN		Outdoor Air Exposure: Commercial		Indoor Air Exposure: Commercial		Soil Exposure: None		Groundwater Exposure: Commercial	
		Target Risk: 1.0E-6 / 1.0E-5	Target HQ: 1.0E+0	Target Risk: 1.0E-6 / 1.0E-5	Target HQ: 1.0E+0	Target Risk: 1.0E-6 / 1.0E-5	Target HQ: 1.0E+0	Target Risk: 1.0E-6 / 1.0E-5	Target HQ: 1.0E+0
CAS No.	**Name**	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient
107-06-2	Dichloroethane, 1,2-	9.5E-12	1.0E-7	2.1E-9	2.3E-5			#VALUE!	
71-43-2	Benzene*	3.3E-12	1.9E-7	1.2E-9	6.7E-5			#VALUE!	#VALUE!
100-41-4	Ethylbenzene		2.6E-6		1.0E-3				#VALUE!
108-88-3	Toluene		1.9E-5		7.0E-3				#VALUE!
1330-20-7	Xylene (mixed isomers)		3.4E-7		1.3E-4				#VALUE!
	Cumulative Values:	**1.3E-11**	**2.2E-5**	**3.3E-9**	**8.2E-3**	**0.0E+0**	**0.0E+0**	**#VALUE!**	**#VALUE!**

■ indicates risk level exceeding target risk

RBCA SITE ASSESSMENT | **Cumulative Risk Worksheet**

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA

Site Name: Former Lemoine Sausage Factory
Site Location: 630 29th Avenue, Oakland, CA

Completed By: Warren B. Chamberlain
Date Completed: 3-Jan-01

Job ID: 70-97066.00

CUMULATIVE RISK WORKSHEET

Cumulative Target Risk: 1.0E-5 Target Hazard Index: 1.0E+0

Groundwater DAF Option: Domenico - First Order

OFF-SITE RECEPTORS

CONSTITUENTS OF CONCERN		Outdoor Air Exposure:				Groundwater Exposure:			
		Commercial (330 ft)		None		Commercial (330 ft)		Surface Water (1300 ft)	
		Target Risk: 1.0E-6 / 1.0E-5	Target HQ: 1.0E+0	Target Risk: 1.0E-6 / 1.0E-5	Target HQ: 1.0E+0	Target Risk: 1.0E-6 / 1.0E-5	Target HQ: 1.0E+0	Target Risk: 1.0E-6 / 1.0E-5	Target HQ: 1.0E+0
CAS No.	**Name**	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient
107-06-2	Dichloroethane, 1,2-	9.5E-12	1.0E-7			7.9E-81		5.0E-114	
71-43-2	Benzene*	3.3E-12	1.9E-7			2.0E-59	1.8E-55	3.1E-113	2.4E-109
100-41-4	Ethylbenzene		2.6E-6				7.8E-101		1.6E-108
108-88-3	Toluene		1.9E-5				9.8E-101		1.4E-106
1330-20-7	Xylene (mixed isomers)		3.4E-7				3.4E-102		7.1E-110
	Cumulative Values:	**1.3E-11**	**2.2E-5**	**0.0E+0**	**0.0E+0**	**2.0E-59**	**1.8E-55**	**3.6E-113**	**1.4E-106**

■ indicates risk level exceeding target risk

Clayton
GROUP SERVICES

APPENDIX D

COST ESTIMATES FOR ALTERNATIVE REMEDIAL METHODS

COST ESTIMATE BREAKDOWN
NO ACTION _ MONITORING ONLY
Former Lemoine Sausage Factory
630 29th Avenue,Oakland, California

Assumes closure after 4 more qtrs

Task	Supplier	Quantity	Unit Cost	Units	Total Cost
QUARTERLY MONITORING, REPORTING AND CLOSURE COSTS					
Quarterly Monitoring (4 quarters)					
Staff Professional	Clayton	40	$75	hrs.	$3,000
Sampling Equipment and Supplies	Vendor	4	$750	LS	$3,000
Analytical - GW (8 wells: 8010 & 8015/8020)	Vendor	64	$75	LS	$4,800
GW Quarterly Reports	Clayton	4	$3,500	LS	$14,000
					$24,800
Site Closure					
Closure Report	Clayton	1	$2,000	LS	$2,000
Agency Consultation	Clayton	8	$150	LS	$1,200
					$3,200
Groundwater Monitoring Well Abandonment					
Well Destruction	Sub	1	$5,000	LS	$5,000
Disposal Cost	Ven/Sub	1	$5,000	LS	$5,000
					$10,000
				Task Cos	**$38,000**

TOTAL ESTIMATED COST (No Contingency) **$38,000**

COST ESTIMATE SUMMARY
ENHANCED INSITU BIOREMEDIATION
Former Lemoine Sausage Factory
630 29th Avenue, Oakland, California

TASK		Estimated Cost
Preconstruction		
Design Plans, Bid Documents		$5,000
Work Plan		$6,760
Permitting (RWQCB, Bldg.Dept, Utility Dist.)		$3,500
	Subtotal	**$15,260**
Costruction		
ORC Injection (3X)		$86,100
System Installation		$0
Trenching, Utility Connection and Security		$0
System Start-up		$0
Construction Oversight		$0
	Subtotal	**$86,100**
System Operation and Maintenance		
Labor & Utilities		$0
Maintenace Equipment and Carbon		$0
	Subtotal	**$0**
Reporting		
Quarterly Monitoring		$32,380
Closure Report and Agency Consultation		$3,200
Well Abandonment		$8,000
	Subtotal	**$43,580**

Not necessarily the only oxygenating agent

Estimated Cost: ORC	**$144,940**
Total Estimated Cost with Contingency at 15%	**$166,681**

COST ESTIMATE SUMMARY
PUMP & TREAT GROUNDWATER EXTRACTION SYSTEM
Former Lemoine Sausage Factory
630 29th Avenue, Oakland, California

TASK		Estimated Cost
Preconstruction		
Design Plans, Bid Documents		$17,720
Work Plan		$6,760
Permitting (RWQCB, Bldg.Dept, Utility Dist.)		$4,500
	Subtotal	**$28,980**
Costruction		
Pump and Treat System- Plant		$29,600
System Installation		$16,500
Trenching, Utility Connection and Security		$29,520
System Start-up		$16,100
Construction Oversight		$8,000
	Subtotal	**$99,720**
System Operation and Maintenance		
Labor & Utilities		$34,838
Maintenace Equipment and Carbon		$6,600
	Subtotal	**$41,438**
Reporting		
Quarterly Monitoring		$32,600
Closure Report and Agency Consultation		$3,200
P&T System and Well Abandonment		$25,000
	Subtotal	**$60,800**

Estimated Cost: Pump & Treat Groundwater Extraction System	**$230,938**
Total Estimated Cost with Contingency at 15%	**$265,578**

COST ESTIMATE SUMMARY
AIR SPARGE_SOIL VAPOR COLLECTION
Former Lemoine Sausage Factory
630 29th Avenue, Oakland, California

TASK		Estimated Cost
Preconstruction		
Design Plans, Bid Documents		$17,720
Work Plan		$6,760
Permitting (RWQCB, Bldg.Dept, Utility Dist.)		$3,500
	Subtotal	**$27,980**
Costruction		
Air Sparge_Soil Vapor Extraction System- Plant		$65,000
System Installation		$20,500
Trenching, Utility Connection and Security		$28,000
System Start-up		$11,300
Construction Oversight		$8,000
	Subtotal	**$132,800**
System Operation and Maintenance		
Labor & Utilities		$33,638
Maintenace Equipment and Carbon		$20,100
	Subtotal	**$53,738**
Reporting		
Quarterly Monitoring		$32,600
Closure Report and Agency Consultation		$3,200
AS_SVE System and Well Abandonment		$25,000
	Subtotal	**$60,800**

Estimated Cost: Air Sparging_Soil Vapor Extraction System	**$275,318**
Total Estimated Cost with Contingency at 15%	**$316,615**

COST ESTIMATE SUMMARY
DUAL PHASE EXTRACTION SYSTEM
Former Lemoine Sausage Factory
630 29th Avenue, Oakland, California

TASK		Estimated Cost
Preconstruction		
Design Plans, Bid Documents		$17,720
Work Plan		$6,760
Permitting (RWQCB, Bldg.Dept, Utility Dist.)		$6,000
	Subtotal	**$30,480**
Costruction		
DPE system- Plant		$78,700
System Installation		$25,500
Trenching, Utility Connection and Security		$26,520
System Start-up		$11,300
Construction Oversight		$8,000
	Subtotal	**$150,020**
System Operation and Maintenance		
Labor & Utilities		$87,840
Maintenace Equipment and Carbon		$20,100
	Subtotal	**$107,940**
Reporting		
Quarterly Monitoring		$33,200
Closure Report and Agency Consultation		$3,200
DPE System and Well Abandonment		$25,000
	Subtotal	**$61,400**

Estimated Cost: Dual Phase Extraction System	**$349,840**
Total Estimated Cost with Contingency at 15%	**$402,316**

APPENDIX E

ORBCA TECHNICAL BACKGROUND DOCUMENT

OAKLAND RISK-BASED CORRECTIVE ACTION: TECHNICAL BACKGROUND DOCUMENT

Prepared by:

Lynn R. Spence
Spence Environmental Engineering

Mark M. Gomez
City of Oakland
Environmental Services Division

May 17, 1999

Updated: January 1, 2000

CONTENTS

LIST OF TABLES

FOREWORD

Oakland Risk-Based Corrective Action: Technical Background Document establishes the technical basis for the Oakland risk-based corrective action (RBCA) approach.

The Oakland RBCA approach is the result of extensive work by the Urban Land Redevelopment (ULR) Program Technical Advisory Committee, consisting of representatives from the Alameda County Department of Environmental Health, the Department of Toxic Substances Control, the San Francisco Bay Regional Water Quality Control Board, the United States Environmental Protection Agency (U.S. EPA), Spence Environmental Engineering, volunteer environmental consultants, and the City of Oakland. The environmental consulting firms that volunteered their time and assisted with peer review included: Cambria Environmental Technology; Chaney, Walton & McCall; Environ; Geomatrix Consultants; ICF Kaiser; Levine-Fricke-Recon; SECOR International; SOMA Environmental Engineering; Subsurface Consultants; Weiss Associates; and Woodward-Clyde. The ULR Program was developed through a grant from the U.S. EPA, Region 9, Office of Underground Storage Tanks.

Please forward any comments or suggestions for improving this document to:

Mark Gomez
City of Oakland
Environmental Services Division
250 Frank H. Ogawa Plaza, Suite 5301
Oakland, CA 94612

Phone: (510) 238-7314
FAX: (510) 238-7286
e-mail: mmgomez@oaklandnet.com

1.0 INTRODUCTION

The City of Oakland risk-based corrective action (RBCA) approach is based on the guidelines prescribed in *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (ASTM 1995). ASTM (1995) integrates risk and exposure assessment practices with site assessment activities and remedial measures to ensure that the selected corrective action is protective of human health and the environment. The U.S. EPA has endorsed the ASTM (1995) approach and several state regulatory agencies across the nation have adopted it. The approach is being applied at a wide variety of sites, not just those with petroleum releases.

ASTM (1995) prescribes a three-tiered decision-making process for evaluating sites with potential environmental issues. In Tier 1, sites are characterized through information collected from historical records, a visual inspection, and minimal site investigation. Contaminant sources, impacted human and environmental receptors, and potential contaminant transport pathways are identified. Site concentrations are compared with Tier 1 risk-based screening levels (RBSLs) for all applicable exposure pathways. Site concentrations above Tier 1 RBSLs must be addressed through corrective actions or further analysis under Tiers 2 or 3.

In Tier 2, additional site characterization constituting a minimal incremental effort is undertaken to establish site-specific target levels (SSTLs). Tier 2 SSTLs are generally less stringent than Tier 1 RBSLs, but are still based on conservative assumptions. Site concentrations are compared with Tier 2 SSTLs for all applicable exposure pathways. Site concentrations above Tier 2 SSTLs must be addressed through corrective actions or further analysis under Tier 3.

Tier 3 represents a substantial incremental effort relative to Tiers 1 and 2. The analysis is more complex and may include highly-detailed site assessment, probabilistic evaluations, and sophisticated chemical fate and transport models. Tier 3 SSTLs are established and, if the selected target levels are exceeded and corrective action is necessary, a corrective action plan must be developed and implemented (ASTM 1995).

The Oakland RBCA approach forms the centerpiece of the City of Oakland Urban Land Redevelopment Program, which provides the following:

- Oakland-specific Tier 1 RBSLs
- Oakland-specific Tier 2 SSTLs based on Oakland's geology
- Guidance for conducting a cost-efficient Tier 3 analysis (City of Oakland 2000)

Section 2 explains the methodology behind the Oakland RBCA approach. Section 3 describes the input parameters used in the Oakland RBCA equations.

Appendix A presents the equations used to calculate the Oakland RBCA levels. Appendix B provides the justification for all the input parameter values selected. Appendix C contains a sensitivity analysis describing the relationship of each input parameter to the calculated RBCA levels. Appendix D presents spreadsheet validation results for the Oakland RBCA look-up tables that are found in *Oakland Urban Land Redevelopment Program: Guidance Document* (City of Oakland 2000).

2.0 METHODOLOGY

The Oakland RBCA approach is based on the methodology recommended by ASTM (1995) and is supported by other standard risk assessment literature (U.S. EPA 1989a, 1996).

The Oakland RBCA look-up tables contain Tier 1 RBSLs and Tier 2 SSTLs for commonly-found chemicals of concern. The Tier 1 RBSLs and Tier 2 SSTLs are presented for both a residential and a commercial/industrial land use scenario for each of eight exposure pathways. The Tier 1 RBSLs may be applied at all sites in Oakland; the Tier 2 SSTLs may only be applied at sites where one or more of the three predominant Oakland soil types (Merritt Sands, sandy silts and/or clayey silts) prevails. Different SSTLs are presented for each of these soil types. In order to qualify for either the Tier 1 or Tier 2 Oakland RBCA levels, a site must first pass a set of eligibility criteria developed to ensure that site conditions do not violate any of the basic assumptions incorporated in the Oakland RBCA approach (City of Oakland 2000).

The Oakland RBCA look-up tables are created using an Excel spreadsheet. The Oakland RBCA spreadsheet may be downloaded off of the internet at no cost at **www.oaklandpw.com**.

Section 2.1 discusses how human health risks are typically calculated. This lays the groundwork for "back-calculating" RBCA levels. **Section 2.2** presents the methodology used to compute the Oakland RBCA levels in each of the media considered.

2.1 Calculating Human Health Risk

Risk Assessment Guidance for Superfund (U.S. EPA 1989a) details the processes used to estimate human health risk from various contaminated media. The human health risk assessment calculation is sometimes called the "forward calculation". The inputs required for this forward calculation are: chemical concentration, chemical toxicity, and exposure levels (e.g., two liters of water ingested per day). A risk assessment is conducted for an individual site and the calculated risk level is compared with a selected, "acceptable" risk level. If the acceptable risk is exceeded, the site may require corrective action.

Risk assessments analyze chemicals in two ways: as "carcinogens" and as "hazards" (or "non-carcinogens"). Carcinogens are chemicals that have been shown to cause cancer or are suspected to cause cancer. For carcinogens, the calculation of risk assumes that there is no "safe dose" (i.e., an exposure of any magnitude has some effect over a lifetime). The risk from these chemicals is presented as an "individual excess lifetime cancer risk" (IELCR) and represents the likelihood of developing "excess" cancer (i.e., additional cancer beyond the populations average) due to the estimated exposure to the chemical. The IELCR is expressed as a probability. The toxicity values for carcinogens are known as slope factors. The higher the slope factor is, the more risk a chemical poses at a given dose.

Hazards are chemicals that neither have been shown to cause cancer nor are suspected to cause cancer, but that may cause other health problems, such as liver toxicity, neurotoxicity, or respiratory malfunction. For hazards, the calculation of risk assumes that there is a safe dose (or "reference dose") below which no adverse health effects occur. Exposure is not considered cumulative as in the carcinogenic risk calculation.

The measure used to determine the potential for non-carcinogenic adverse health effects is called a hazard quotient. A hazard quotient is the ratio of the estimated exposure level to the reference dose. A hazard quotient below one indicates that no adverse health effects are expected.

Hazard quotients are not probabilities. Chemicals with low reference doses are more toxic than ones with higher reference doses.

Some chemicals are both a carcinogen and a hazard. These chemicals have both a slope factor and a reference dose.

2.2 Calculating Risk-Based Corrective Action Levels

The Oakland RBCA approach calculates RBSLs and SSTLs by manipulating the human health risk assessment equations to solve for an acceptable concentration. Instead of calculating the risk (either IELCR or hazard quotient), a target risk level is plugged into the equations along with the exposure parameter values and chemical properties data. This method of calculating RBCA levels is sometimes called the "back-calculation".

The methodology used to calculate the Oakland Tier 1 and Tier 2 RBCA levels is identical to that recommended by ASTM (1995), with the following exceptions:

- For carcinogenic health effects, residential exposure assumes a combined child/adult receptor (six years as a child and 24 years as an adult). This approach is more conservative (i.e., generates lower acceptable concentrations) than assuming the entire exposure is as an adult, as does ASTM (1995).
- For non-carcinogenic health effects, the residential receptor is always assumed to be a child. This approach is more conservative than assuming that the residential receptor is always an adult, as does ASTM (1995).
- A "water used for recreation" medium is included, with the RBCA equations based on the same principles that guided the development of the ASTM (1995) equations for exposure pathways in the other media. This medium is not addressed by ASTM (1995).
- ASTM (1995) default values are replaced with Oakland-specific values when appropriate.

The following subsections describe the exposure pathways considered for calculating RBCA levels in each of five media: surficial soil, subsurface soil, groundwater, air, and water used for recreation.

2.2.1 Surficial Soil

Surficial soil is defined as the top one meter of soil. Different RBCA levels are calculated for this shallow soil than for the rest of the unsaturated soil layer because it is assumed that direct receptor contact with surficial soil is possible. The potential exposure scenarios considered for chemicals in surficial soil are:

- ingestion of soil
- dermal contact with soil
- inhalation of vapors in outdoor air
- inhalation of particulates in outdoor air

The RBCA levels for surficial soil assume that all four of the potential exposure scenarios occur simultaneously; that is, the four doses are added together to obtain an overall dose from surficial soil, from which the RBCA level is then calculated.

Ingestion and dermal contact are direct pathways: the receptor is contacting the contaminant in the source area (i.e., in the surficial soil).

Inhalation of vapors and inhalation of particulates are indirect pathways: the receptor is contacting the contaminant outside of the source area (i.e., not in the surficial soil). For the inhalation scenarios, two volatilization factors are employed to account for the chemical moving from soil to outdoor air: in one case as a vapor; in the other as a particulate. A concentration in soil is then calculated below which air quality in the breathing zone is not impacted at a level that poses unacceptable risk.

2.2.2 Subsurface Soil

Subsurface soil is defined as vadose zone soil that is deeper than one meter below ground surface. Three different RBCA levels are calculated for subsurface soil, one for each of the following exposure scenarios:

- inhalation of vapors in indoor air
- inhalation of vapors in outdoor air
- ingestion of groundwater

These are indirect pathways. Volatilization and leaching factors from subsurface soil are employed to calculate the RBCA levels.

2.2.3 Groundwater

Three different RBCA levels are calculated for groundwater, one for each of the following exposure scenarios:

- ingestion of groundwater
- inhalation of vapors in indoor air
- inhalation of vapors in outdoor air

Ingestion of groundwater is a direct pathway. The inhalation of vapors scenarios are indirect pathways. Volatilization factors from groundwater are employed to calculate RBCA levels for each.

2.2.4 Air

Two different RBCA levels are calculated for air, one for each of the following exposure scenarios:

- inhalation of indoor air
- inhalation of outdoor air

These are direct pathways. (Note: RBCA levels for air are not presented in the Oakland RBCA tables. They are, however, used as inputs to back-calculate soil and groundwater concentrations protective of inhalation of indoor and outdoor air.)

2.2.5 Water Used for Recreation

The Oakland RBCA tables also contain RBSLs and SSTLs for water used for recreation. These RBCA levels apply to scenarios such as exposure to water in nearby creeks and exposure to groundwater or surface water used to fill swimming pools. This recreational-use scenario is not addressed by ASTM (1995).

The RBCA levels calculated for water used for recreation assume that the following two potential exposure scenarios occur simultaneously:

- ingestion of the water
- dermal contact with the water

These are direct pathways. They are based on a hypothetical swimming scenario in which the exposed individual's entire body is submerged.

3.0 INPUT PARAMETERS

The input parameters that comprise the Oakland RBCA equations fall into five categories:

(1) soil-specific transport parameters
(2) non-soil-specific transport parameters
(3) receptor-specific parameters
(4) target risk levels
(5) chemical-specific parameters

The following subsections describe the individual input parameters that pertain to each of these categories. (For a detailed justification and analysis of the values selected for all input parameters, please refer to Appendix B.)

3.1 Soil-Specific Transport Parameters

The soil-specific transport parameter values selected for Oakland RBCA Tier 1 reflect conservative assumptions about the geology that may be found at any site in Oakland. The soil-specific transport parameter values selected for Oakland RBCA Tier 2 reflect the characteristics of the three predominant soil types found in Oakland. These soil types are: Merritt sands, sandy silts and clayey silts.

Merritt sands are mostly located in the flatlands area to the west of Lake Merritt. They are a fine-grained, silty sand with lenses of sandy clay and clay (Radbruch 1957). Merritt sands have a low moisture content and high permeability.

Sandy silts are found throughout Oakland. They are made up of unconsolidated, moderately-sorted sand, silt, and clay sediments, with both fine-grained and course-grained materials. Sandy silts have a medium moisture content and moderate permeability.

Clayey silts are primarily found along the Bay and estuary, and in land fills from those areas. They may contain organic materials, peaty layers and small lenses of sand. Clayey silts have a high moisture content and low permeability.

Table 1 provides a description of the soil-specific transport parameters.

Table 1. Description of Oakland RBCA Soil-Specific Transport Parameters

Input Parameter	Description
Capillary fringe thickness	Height of the zone just above the water table, where water is drawn upward by capillary attraction.
Capillary fringe air content	Fraction of the capillary fringe that is air: expressed as volume of air divided by total volume of soil.
Capillary fringe water content	Fraction of the capillary fringe that is water: expressed as volume of water divided by total volume of soil.
Fraction organic carbon in soil (F_{oc}*)[a]	Measure of the effect of organic carbon, clay and electromagnetic molecular forces on sorption of chemicals to soil.
Groundwater Darcy velocity	Measure of amount of groundwater flowing through the saturated zone (hydraulic conductivity X hydraulic gradient).
Groundwater mixing zone thickness	Depth to which contaminants entering groundwater from the unsaturated zone mix with the flow of groundwater.
Infiltration rate through the vadose zone	Amount of water (and, hence, contaminant) that travels through the vadose zone and reaches groundwater.
Soil bulk density	Weight of the soil per volume ([real density]—[total porosity][real density]).
Soil to skin adherence factor	Amount of soil that will stick to skin upon contact.
Total soil porosity	Pore spaces divided by total volume of soil.
Vadose zone air content	Fraction of the unsaturated zone that is air: expressed as volume of air divided by total volume of soil.
Vadose zone water content	Fraction of the unsaturated zone that is water: expressed as volume of water divided by total volume of soil.
Vadose zone thickness	Distance from the soil surface to the water table, excluding the capillary fringe.

[a]In the Oakland RBCA approach, this input parameter was modified to take into consideration that factors other than organic carbon also cause chemicals to sorb to soil (Spence and Gomez 1999).

3.2 Non-Soil-Specific Transport Parameters

The Oakland RBCA equations employ several transport parameters that do not vary by soil type. Table 2 provides a description of these.

Table 2. Description of Oakland RBCA Non-Soil-Specific Transport Parameters

Input Parameter	Description
Areal fraction of cracks in building foundation	Fraction of foundation or basement walls comprised of cracks (including expansion or drainage joint). It is the area of the cracks over the total area of the foundation walls.
Foundation air content	Fraction of air in cracks in the foundation or basement walls.
Foundation water content	Fraction of water in cracks in the foundation or basement walls.
Foundation thickness	Thickness of the building foundation (if any).
Lower depth of surficial soil zone	Maximum depth of soil with which an individual may come in direct contact.
Depth to subsurface soil sources	Distance from the foundation to the contamination in subsurface soil.
Depth to groundwater	Depth to the water table from the ground surface, including the capillary fringe.
Width of source area parallel to wind or groundwater flow direction	Distance from one side of the soil source to the other in the predominant direction of groundwater flow. The width of the source is used to estimate the size of the mixing zones in groundwater and outdoor air.
Outdoor air mixing zone height	Height of the imaginary "breathing box" used to estimate the size of the mixing zone in the air.
Particulate emission rate	Rate at which dust particles $\leq$10 um in diameter become airborne and enter the breathing zone.
Wind speed above ground surface in outdoor air mixing zone	Average annual wind speed at the site in question.

3.3 Receptor-Specific Parameters

Receptor-specific parameters are those input parameters whose values vary by receptor (child, adult or worker) and land use scenario (residential or commercial/industrial). Table 3 provides a description of the receptor-specific parameters.

Table 3. Description of Oakland RBCA Receptor-Specific Parameters

Input Parameter	Description
Averaging time for carcinogenic effects	Number of years over which exposure to a carcinogen is statistically normalized.
Averaging time for non-carcinogenic effects	Same as the exposure duration (see below).
Averaging time for vapor flux	Length of time over which a chemical is assumed to volatilize from surficial soil.
Body weight	Average body weight of the receptor (child or adult).
Building air volume/floor area	The height of the ceiling.
Exposure duration	Number of years over which a person may be exposed to a chemical of concern.
Exposure frequency	Days per year a person may be exposed to a chemical.
Exposure frequency to water used for recreation	Days per year that a person might come in recreational contact with contaminated water.
Exposure time to indoor air	Hours per day a person is inside an impacted building.
Exposure time to outdoor air	Hours per day a person is outside at an impacted site.
Exposure time to water used for recreation	Average amount of time spent in contact with water used for recreation during each exposure.
Groundwater ingestion rate	Amount of groundwater that is extracted from a domestic well and ingested each day.
Indoor air exchange rate	Amount of indoor air replaced by outdoor air each day.
Indoor inhalation rate	Average volume of indoor air breathed per hour.
Ingestion rate of water used for recreation	Amount of water used for recreation that is inadvertently ingested (e.g., while swimming).
Outdoor inhalation rate	Average volume of outdoor air breathed per hour.
Skin surface area exposed to soil	Surface area of skin that may come in contact with surficial soil and absorb it soil through the skin.
Skin surface area exposed to water used for recreation	Surface area of skin that may come in contact with water used for recreation.
Soil ingestion rate	Amount of soil ingested per day. For adults, this may be from yard work; for children, from eating dirt.

3.4 Target Risk Levels

The Oakland RBCA equations employ two types of target risk levels: an individual excess lifetime cancer risk (IELCR) for carcinogenic health effects and a hazard quotient for non-carcinogenic health effects. If a chemical has both a slope factor and a reference dose, both target risk levels are used and two RBCA levels are generated for each exposure pathway.

For carcinogenic health effects, the target risk level represents a subjective risk level that is considered "acceptable". For example, an IELCR of 1×10^{-6} means that, for each individual exposed to a given chemical of concern at the levels assumed in the model, there is a one-in-one-million chance of excess cancer over a lifetime. For non-carcinogenic health effects, if the estimated dose is less than the reference dose, it is assumed that no adverse health effects occur. The hazard quotient is not based on a lifetime of exposure, as is the case with carcinogens; rather, it is based on a shorter term, chronic exposure.

Table 4 provides a description of the target risk levels.

Table 4. Description of Oakland RBCA Target Risk Levels

Input Parameter	Description
Individual Excess Lifetime Cancer Risk (IELCR)	Likelihood of a single person experiencing excess cancer from exposure to a chemical over a lifetime.
Hazard Quotient	Ratio of the estimated dose to the reference dose.

3.5 Chemical-Specific Parameters

The Oakland RBCA equations employ chemical-specific parameters to account for differences in the type and level of risk chemicals can pose. Table 5 provides a description of these.

Table 5. Description of Oakland RBCA Chemical-Specific Parameters

Input parameter	Description
Slope factor (oral, inhalation and dermal)	Estimate of the probability of a carcinogenic response per unit intake of a chemical over a lifetime.
Reference dose (oral, inhalation and dermal)	Toxicity value for evaluating non-carcinogenic health effects resulting from exposure to a chemical.
Absorption adjustment factors	Used to calculate the absorption of chemicals into the body, from dermal contact, oral intake or inhalation.
Skin permeability coefficient	Used to calculate movement of the chemical in water across the skin and into the bloodstream.
Maximum Contaminant Level (MCL)	The maximum concentration of a chemical that is allowed in drinking water by the State of California.
Solubility	Amount of the chemical that can dissolve in a fixed amount of water.
Henry's Law constant	Equilibrium ratio of the partial pressure of a chemical in air to the concentration in water.
Organic carbon partition coefficient (K_{oc})	Describes the affinity of the chemical for adsorbing to organic carbon in the soil.
Partition coefficient for inorganics (K_s)	Used only for metals to calculate their partitioning onto soil.
Diffusion coefficient in air	Measure of the amount of diffusion of a vapor-phase chemical in air.
Diffusion coefficient in water	Measure of the amount of diffusion of a chemical that is dissolved in water.

This appendix presents the equations used to calculate the Oakland Tier 1 RBSLs and Tier 2 SSTLs for each of the five media considered: surficial soil, subsurface soil, groundwater, air, and water used for recreation.

Please note the following:

- Different equations are used to calculate RBCA levels for carcinogenic and non-carcinogenic health effects.
- For carcinogenic health effects under the residential land use scenario, the equations assume an additive child/adult receptor; that is, the receptor is assumed to be a young child for six years of the 30-year exposure duration and an adult for the remaining 24 years. For non-carcinogenic health effects under the residential land use scenario, the equations assume that the receptor is always a child.
- ✓ For both carcinogenic and non-carcinogenic health effects under the commercial/industrial land use scenario, the equations assume that the receptor is always an adult.
- For the subsurface soil medium, if the calculated RBCA level exceeds the saturated soil concentration (C_{sat}), the target risk cannot be exceeded for any concentration and "SAT" is entered in the appropriate Tier 1 or Tier 2 table.
- For the groundwater and water used for recreation media, if the calculated RBCA level exceeds the solubility of the chemical in water, the target risk cannot be exceeded for any concentration and ">SOL" is entered in the appropriate Tier 1 or Tier 2 look-up table.
- If the RBCA level exceeds the California MCL for ingestion of groundwater, then (1) the MCL is entered in the Tier 1 and Tier 2 look-up tables in the exposure pathway "groundwater: ingestion"; and (2) the MCL is used as an input in the equation to calculate the RBCA level for the exposure pathway "subsurface soil: ingestion of groundwater impacted by leachate".
- RBCA levels for air are not presented in the Oakland RBCA Tier 1 and Tier 2 look-up tables. They are used only as inputs to back-calculate soil and groundwater concentrations protective of inhalation of indoor and outdoor air.

Section A.1 defines the input parameter symbols used in the Oakland RBCA equations. **Section A.2** presents the equations used to calculate the Oakland RBCA levels for carcinogenic health effects. **Section A.3** presents the equations used to calculate the Oakland RBCA levels for non-carcinogenic health effects. **Section A.4** presents the equations for the volatilization factors, leaching factors, effective diffusion coefficients and saturated soil concentrations that are used in the Oakland RBCA calculations.

A.1 INPUT PARAMETER SYMBOLS

Table A-1 defines the input parameter symbols used in the Oakland RBCA equations.

Table A-1. Oakland RBCA Input Parameter Symbols

Parameter	Definition	Unit
AT_{carc}	averaging time for carcinogens	years
AT_{haz}	averaging time for non-carcinogens	years
$BW_{c,a,i}$	body weight (child, adult, worker)	kg
C_{sat}	saturated soil concentration	mg/kg
d	lower depth of surficial soil zone	cm
D^{air}	diffusion coefficient in air	cm^2/s
D^{water}	diffusion coefficient in water	cm^2/s
$ED_{c,a,i}$	exposure duration (child, adult, worker)	years
$EF_{c,a,i}$	exposure frequency (child, adult, worker)	d/year
$EF(sw)_{c,a}$	exposure frequency to water used for recreation (child, adult)	d/yr
ER	indoor air exchange rate	s^{-1}
$ET(ind)_{c,a,i}$	exposure time to indoor air (child, adult, worker)	hr/d
$ET(out)_{c,a,i}$	exposure time to outdoor air (child, adult, worker)	hr/d
$ET(sw)_{c,a}$	exposure time to water used for recreation (child, adult)	hr/d
f_{oc}	fraction organic carbon in soil	g OC/g soil
H	Henry's Law constant	(cm^3 H_2O)/ (cm^3 air)
h_{cap}	capillary fringe thickness	cm
h_v	vadose zone thickness	cm
I	infiltration rate through the vadose zone	cm/yr
$ING(gw)$	groundwater ingestion rate	l/d
$ING(soil)_{c,a,i}$	soil ingestion rate (child, adult, worker)	mg/d
$ING(sw)_{c,a}$	ingestion rate of water used for recreation (child, adult)	l/hr
$INH(ind\ air)_{c,a,i}$	indoor inhalation rate (child, adult, worker)	m^3/d
$INH(out\ air)_{c,a,i}$	outdoor inhalation rate (child, adult, worker)	m^3/d
k_{oc}	organic carbon partition coefficient	(cm^3 H_2O)/ (g OC)
k_s	partition coefficient for inorganics	(cm^3 H_2O)/ (g soil)
LF	leaching factor	(mg/l)/ (mg/kg)
M	soil to skin adherence factor	mg/cm^2
MCL	maximum contaminant level	mg/l
L_B	building air volume/floor area	cm
L_{crack}	foundation thickness	cm
L_{gw}	depth to groundwater	cm
L_s	depth to subsurface soil sources	cm
P_e	particulate emission rate	$g/cm^2/s$
PC	skin permeability coefficient in water	cm/hr
RAF_d	dermal relative absorption factor	mg/mg
RAF_o	oral relative absorption factor	mg/mg

Table A-1—*Continued.*

RfD_{inh}	inhalation chronic reference dose	mg/kg/d
RfD_o	oral chronic reference dose	mg/kg/d
S	pure chemical solubility in water	mg/L
SF_{inh}	inhalation slope factor	1/(mg/kg/d)
SF_o	oral slope factor	1/(mg/kg/d)
$SSA(soil)_{c,a,i}$	skin surface area exposed to soil (child, adult, worker)	cm^2
$SSA(total)_{c,a}$	skin surface area exposed to water for recreation (child, adult)	cm^2
THQ	hazard quotient	unitless
TR	individual excess lifetime cancer risk	unitless
U_{air}	wind speed above ground surface in outdoor air mixing zone	cm/s
U_{gw}	groundwater Darcy velocity	cm/yr
VF_p	volatilization factor: surficial soils to outdoor air (particulates)	$(mg/m^3)/(mg/kg)$
VF_{ss}	volatilization factor: surficial soils to outdoor air (vapors)	$(mg/m^3)/(mg/kg)$
VF_{samb}	volatilization factor: subsurface soils to outdoor air	$(mg/m^3)/(mg/kg)$
VF_{sesp}	volatilization factor: subsurface soils to indoor air	$(mg/m^3)/(mg/kg)$
VF_{wesp}	volatilization factor: groundwater to indoor air	$(mg/m^3)/(mg/l)$
VF_{wamb}	volatilization factor: groundwater to outdoor air	$(mg/m^3)/(mg/l)$
W	width of source area parallel to wind or groundwater flow direction	cm
δ_{air}	outdoor air mixing zone height	cm
δ_{gw}	groundwater mixing zone thickness	cm
η	areal fraction of cracks in building foundation	$(cm^2$ cracks$)/(cm^2$ area$)$
θ_{acap}	capillary fringe air content	$(cm^3$ air$)/(cm^3$ soil$)$
θ_{acrack}	foundation cracks air content	$(cm^3$ air$)/(cm^3$ soil$)$
θ_{as}	vadose zone air content	$(cm^3$ air$)/(cm^3$ soil$)$
θ_T	total soil porosity	$(cm^3$ voids$)/(cm^3$ soil$)$
θ_{wcap}	capillary fringe water content	$(cm^3$ water$)/(cm^3$ soil$)$
θ_{wcrack}	foundation cracks water content	$(cm^3$ water$)/(cm^3$ soil$)$
θ_{ws}	vadose zone water content	$(cm^3\ H_2O)/(cm^3$ soil$)$
ρ_s	soil bulk density	g/cm^3
τ	averaging time for vapor flux	s

A.2 RBCA EQUATIONS FOR CARCINOGENIC HEALTH EFFECTS

Equations A-1 through A-11 are the equations used to calculate the Oakland RBCA levels for carcinogenic health effects.

Equation A-1. RBCA Level for Surficial Soil—
Ingestion Of Soil, Dermal Contact With Soil, Inhalation Of Vapors and Particulates in Outdoor Air
[mg/kg]

(A-1.1) Residential

$$RBSL_{surf\,soil} = \frac{TR}{\left[\begin{array}{l}\dfrac{EF_c \times ED_c}{BW_c \times AT_{carc} \times 365\frac{d}{yr}}\left[\left(SF_o \times 10^{-6}\dfrac{kg}{mg} \times \left(ING(soil)_c \times RAF_o + SSA(soil)_c \times M \times RAF_d\right)\right) + \left(SF_{inh} \times INH(out\ air)_c \times \left(\dfrac{ET(out)_c}{24}\right) \times \left(VF_{ss} + VF_p\right)\right)\right] \\ + \dfrac{EF_a \times ED_a}{BW_a \times AT_{carc} \times 365\frac{d}{yr}}\left[\left(SF_o \times 10^{-6}\dfrac{kg}{mg} \times \left(ING(soil)_a \times RAF_o + SSA(soil)_a \times M \times RAF_d\right)\right) + \left(SF_{inh} \times INH(out\ air)_a \times \left(\dfrac{ET(out)_a}{24}\right) \times \left(VF_{ss} + VF_p\right)\right)\right]\end{array}\right]}$$

(A-1.2) Commercial/Industrial

$$RBSL_{surf\,soil} = \frac{TR \times BW_i \times AT_{carc} \times 365\frac{d}{yr}}{EF_i \times ED_i\left[\left(SF_o \times 10^{-6}\dfrac{kg}{mg} \times \left(ING(soil)_i \times RAF_o + SSA(soil)_i \times M \times RAF_d\right)\right) + \left(SF_{inh} \times INH(out\ air)_i \times \left(\dfrac{ET(out)_i}{24}\right) \times \left(VF_{ss} + VF_p\right)\right)\right]}$$

Equation A-2. RBCA Level for Subsurface Soil—
Inhalation of Indoor Air Vapors
[mg/kg]

Residential and Commercial/Industrial

$$RBSL_{sub\ soil} = \frac{RBSL_{ind\ air}}{VF_{sesp}} \times 10^{-3}\frac{mg}{\mu g}$$

Equation A-3. RBCA Level for Subsurface Soil—
Inhalation of Outdoor Air Vapors
[mg/kg]

Residential and Commercial/Industrial

$$RBSL_{sub\ soil} = \frac{RBSL_{out\ air}}{VF_{samb}} \times 10^{-3} \frac{mg}{\mu g}$$

Equation A-4. RBCA Level for Subsurface Soil—
Ingestion of Groundwater Impacted by Leachate
[mg/kg]

Residential and Commercial/Industrial

$$RBSL_{sub\ soil} = \frac{RBSL_{gw}}{LF_{sw}}$$

Equation A-5. RBCA Level for Groundwater—
Ingestion of Groundwater*
[mg/l]

Residential and Commercial/Industrial

$$\mathrm{RBSL_{gw}} = \mathrm{MCL}$$

*if no MCL exists, refer to equation A-6

Equation A-6. RBCA Level for Groundwater—
Ingestion of Groundwater*
[mg/l]

(A-6.1) Residential

$$RBSL_{GW} = \frac{TR}{\left[\frac{ED_c \times EF_c \times ING(gw)_c \times SF_o}{BW_c \times AT_{carc}} + \frac{ED_a \times EF_a \times ING(gw)_a \times SF_o}{BW_a \times AT_{carc}}\right]} \times 365 \frac{d}{yr}$$

(A-6.2) Commercial/Industrial

$$RBSL_{gw} = \frac{TR \times BW_i \times AT_{carc}}{SF_o \times ING(gw)_i \times EF_i \times ED_i} \times 365 \frac{d}{yr}$$

*only employed if no MCL exists for the chemical

Equation A-7. RBCA Level for Groundwater—
Inhalation of Indoor Air Vapors
[mg/l]

Residential and Commercial/Industrial

$$RBSL_{gw} = \frac{RBSL_{ind\ air}}{VF_{wesp}} \times 10^{-3} \frac{mg}{\mu g}$$

Equation A-8. RBCA Level for Groundwater—
Inhalation of Outdoor Air Vapors
[mg/l]

Residential and Commercial/Industrial

$$RBSL_{gw} = \frac{RBSL_{out\ air}}{VF_{wamb}} \times 10^{-3} \frac{mg}{\mu g}$$

Equation A-9. RBCA Level for Air—Inhalation of Indoor Air Vapors [mg/m³]

(A-9.1) Residential

$$RBSL_{ind\ air} = \frac{TR}{\left[\frac{ED_c \times EF_c \times INH(ind\ air)_c \times \left(\frac{ET(ind)_c}{24}\right) \times SF_{inh}}{BW_c \times AT_{carc}} + \frac{ED_a \times EF_a \times INH(ind\ air)_a \times \left(\frac{ET(ind)_a}{24}\right) \times SF_{inh}}{BW_a \times AT_{carc}}\right]} \times 365\frac{d}{yr} \times 10^3 \frac{\mu g}{mg}$$

(A-9.2) Commercial/Industrial

$$RBSL_{ind\ air} = \frac{TR \times AT_{carc} \times BW_i}{SF_i \times EF_i \times ED_i \times INH(ind\ air)_i \times \left(\frac{ET(ind)_i}{24}\right)} \times 365\frac{d}{yr} \times 10^3 \frac{\mu g}{mg}$$

Equation A-10. RBCA Level for Air—Inhalation of Outdoor Air Vapors [mg/m³]

(A-10.1) Residential

$$RBSL_{out\ air} = \frac{TR}{\left[\frac{ED_c \times EF_c \times INH(out\ air)_c \times \left(\frac{ET(out)_c}{24}\right) \times SF_{inh}}{BW_c \times AT_{carc}} + \frac{ED_a \times EF_a \times INH(out\ air)_a \times \left(\frac{ET(out)_a}{24}\right) \times SF_{inh}}{BW_a \times AT_{carc}}\right]} \times 365\frac{d}{yr} \times 10^3 \frac{\mu g}{mg}$$

(A-10.2) Commercial/Industrial

$$RBSL_{out\ air} = \frac{TR \times AT_{carc} \times BW_i}{SF_i \times EF_i \times ED_i \times INH(out\ air)_i \times \left(\frac{ET(out)_i}{24}\right)} \times 365\frac{d}{yr} \times 10^3 \frac{\mu g}{mg}$$

Equation A-11. RBCA Level for Water Used for Recreation—
Ingestion and Dermal Contact
[mg/l]

*Residential**

$$RBSL_{sw} = \frac{TR}{\left[\frac{EF(sw)_c \times ED_c \times SF_o}{BW_c \times AT_{carc} \times 365\frac{d}{yr}}\left(ING(sw)_c + SSA(total)_c \times \frac{PC}{10^3\,cm^3/l}\right) + \frac{EF(sw)_a \times ED_a \times SF_o}{BW_a \times AT_{carc} \times 365\frac{d}{yr}}\left(ING(sw)_a + SSA(total)_a \times \frac{PC}{10^3\,cm^3/l}\right)\right]}$$

*Commercial/industrial scenario not considered for this medium

A.3 RBCA EQUATIONS FOR NON-CARCINOGENIC HEALTH EFFECTS

Equations A-12 through A-22 are the equations used to calculate the Oakland RBCA levels for non-carcinogenic health effects.

Equation A-12. RBCA Level for Surficial Soil—
Ingestion of Soil, Dermal Contact with Soil, Inhalation of Vapors and Particulates in Outdoor Air
[mg/kg]

(A-12.1) Residential

$$RBSL_{surf\ soil} = \frac{THQ \times BW_c \times AT_{haz} \times 365\frac{d}{yr}}{EF_c \times ED_c\left[\frac{\left(10^{-6}\frac{kg}{mg} \times \left(ING(soil)_c \times RAF_o + SSA(soil)_c \times M \times RAF_d\right)\right)}{RfD_o} + \frac{\left(INH(out\ air)_c \times \left(\frac{ET(out)_c}{24}\right) \times \left(VF_{ss} + VF_p\right)\right)}{RfD_{inh}}\right]}$$

(A-12.2) Commercial/Industrial

$$RBSL_{surf\ soil} = \frac{THQ \times BW_i \times AT_{haz} \times 365\frac{d}{yr}}{EF_i \times ED_i\left[\frac{\left(10^{-6}\frac{kg}{mg} \times \left(ING(soil)_i \times RAF_o + SSA(soil)_i \times M \times RAF_d\right)\right)}{RfD_o} + \frac{\left(INH(out\ air)_i \times \left(\frac{ET(out)_i}{24}\right) \times \left(VF_{ss} + VF_p\right)\right)}{RfD_{inh}}\right]}$$

Equation A-13. RBCA Level for Subsurface Soil—
Inhalation of Indoor Air Vapors
[mg/kg]

Residential and Commercial/Industrial

$$RBSL_{sub\ soil} = \frac{RBSL_{ind\ air}}{VF_{sesp}} \times 10^{-3} \frac{mg}{\mu g}$$

Equation A-14. RBCA Level for Subsurface Soil—
Inhalation of Outdoor Air Vapors
[mg/kg]

Residential and Commercial/Industrial

$$RBSL_{sub\ soil} = \frac{RBSL_{out\ air}}{VF_{samb}} \times 10^{-3} \frac{mg}{\mu g}$$

Equation A-15. RBCA Level for Subsurface Soil—
Ingestion of Groundwater Impacted by Leachate
[mg/kg]

Residential and Commercial/Industrial

$$RBSL_{sub\ soil} = \frac{RBSL_{gw}}{LF_{sw}}$$

Equation A-16. RBCA Level for Groundwater—
Ingestion of Groundwater*
[mg/l]

Residential and Commercial/Industrial

$$RBSL_{gw} = MCL$$

*if no MCL exists, refer to equation A-17

Equation A-17. RBCA Level for Groundwater—
Ingestion of Groundwater*
[mg/l]

(A-17.1) Residential

$$RBSL_{gw} = \frac{THQ \times AT_{haz} \times BW_c \times RfD_o}{EF_c \times ED_c \times ING(gw)_c} \times 365 \frac{d}{yr}$$

(A-17.2) Commercial/Industrial

$$RBSL_{gw} = \frac{THQ \times AT_{haz} \times BW_i \times RfD_o}{EF_i \times ED_i \times ING(gw)_i} \times 365 \frac{d}{yr}$$

*only employed if no MCL exists for the chemical

Equation A-18. RBCA Level for Groundwater—
Inhalation of Indoor Air Vapors
[mg/l]

Residential and Commercial/Industrial

$$RBSL_{gw} = \frac{RBSL_{ind\ air}}{VF_{wesp}} \times 10^{-3} \frac{mg}{\mu g}$$

Equation A-19. RBCA Level for Groundwater—
Inhalation of Outdoor Air Vapors
[mg/l]

Residential and Commercial/Industrial

$$RBSL_{gw} = \frac{RBSL_{out\ air}}{VF_{wamb}} \times 10^{-3} \frac{mg}{\mu g}$$

Equation A-20. RBCA Level for Air—
Inhalation of Indoor Air Vapors
[mg/m³]

(A-20.1) Residential

$$\mathrm{RBSL}_{\mathrm{ind\ air}} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{haz}} \times \mathrm{BW}_{\mathrm{c}} \times \mathrm{RfD}_{\mathrm{inh}}}{\mathrm{EF}_{\mathrm{c}} \times \mathrm{ED}_{\mathrm{c}} \times \mathrm{INH(ind\ air)}_{\mathrm{c}} \times \left(\frac{\mathrm{ET(ind)}_{\mathrm{c}}}{24}\right)} \times 365 \frac{\mathrm{d}}{\mathrm{yr}} \times 10^{3} \frac{\mu\mathrm{g}}{\mathrm{mg}}$$

(A-20.2) Commercial/Industrial

$$\mathrm{RBSL}_{\mathrm{ind\ air}} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{haz}} \times \mathrm{BW}_{\mathrm{i}} \times \mathrm{RfD}_{\mathrm{inh}}}{\mathrm{EF}_{\mathrm{i}} \times \mathrm{ED}_{\mathrm{i}} \times \mathrm{INH(ind\ air)}_{\mathrm{i}} \times \left(\frac{\mathrm{ET(ind)}_{\mathrm{i}}}{24}\right)} \times 365 \frac{\mathrm{d}}{\mathrm{yr}} \times 10^{3} \frac{\mu\mathrm{g}}{\mathrm{mg}}$$

Equation A-21. RBCA Level for Air—
Inhalation of Outdoor Air Vapors
[mg/m³]

(A-21.1) Residential

$$\mathrm{RBSL}_{\mathrm{out\ air}} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{haz}} \times \mathrm{BW}_{\mathrm{c}} \times \mathrm{RfD}_{\mathrm{inh}}}{\mathrm{EF}_{\mathrm{c}} \times \mathrm{ED}_{\mathrm{c}} \times \mathrm{INH(out\ air)}_{\mathrm{c}} \times \left(\frac{\mathrm{ET(out)}_{\mathrm{c}}}{24}\right)} \times 365 \frac{\mathrm{d}}{\mathrm{yr}} \times 10^{3} \frac{\mu\mathrm{g}}{\mathrm{mg}}$$

(A-21.2) Commercial/Industrial

$$RBSL_{out\ air} = \frac{THQ \times AT_{haz} \times BW_i \times RfD_{inh}}{EF_i \times ED_i \times INH(out\ air)_i \times \left(\frac{ET(out)_i}{24}\right)} \times 365\frac{d}{yr} \times 10^3 \frac{\mu g}{mg}$$

Equation A-22. RBCA Level for Water Used for Recreation—
Ingestion and Dermal Contact
[mg/l]

*Residential**

$$RBSL_{sw} = \frac{THQ \times RfD_o \times BW_c \times AT_{haz} \times 365\frac{d}{yr}}{EF(sw)_c \times ED_c \times ET(sw)_c \times \left(ING(sw)_c + SSA(total)_c \times PC \times 10^{-3}\frac{l}{cm^3}\right)}$$

*Commercial/industrial scenario not considered for this medium

A.4 EQUATIONS FOR VOLATILIZATION FACTORS, LEACHING FACTORS, EFFECTIVE DIFFUSION COEFFICIENTS AND SATURATED SOIL CONCENTRATIONS

Equations A-23 through A-34 are the equations used to calculate the volatilization factors, leaching factors, effective diffusion coefficients and saturated soil concentrations that are employed in the Oakland RBCA equations.

Equation A-23. Volatilization factor from surficial soils to outdoor air (vapors)
[(mg/m^{3}air)/(mg/kg soil)]

$$VF_{ss} = \frac{2W\rho_s}{U_{air}\delta_{air}}\sqrt{\frac{D_s^{eff}H}{\pi(\theta_{ws} + k_s\rho_s + H\theta_{as})\tau}} \times 10^3 \frac{cm^3 kg}{m^3 g}$$

or:

$$VF_{ss} = \frac{W\rho_s d}{U_{air}\delta_{air}\tau} \times 10^3 \frac{cm^3 kg}{m^3 g}; \quad \text{whichever is less}$$

Equation A-24. Volatilization factor from surficial soils to outdoor air (particulates) [(mg/m³air)/(mg/kg soil)]

$$VF_p = \frac{P_e W}{U_{air}\delta_{air}} \times 10^3 \frac{cm^3 kg}{m^3 g}$$

Equation A-25. Volatilization factor from subsurface soils to outdoor air [(mg/m³air)/(mg/kg soil)]

$$VF_{samb} = \frac{H\rho_s}{\left[\theta_{ws} + k_s\rho_s + H\theta_{as}\right]\left(1 + \frac{U_{air}\delta_{air}L_s}{D_s^{eff}W}\right)} x10^3 \frac{cm^3 kg}{m^3 g}$$

Equation A-26. Volatilization factor from subsurface soils to indoor air [(mg/m³air)/(mg/kg soil)]

$$VF_{sesp} = \frac{\frac{H\rho_s}{\left[\theta_{ws} + k_s\rho_s + H\theta_{as}\right]}\left[\frac{D_s^{eff} / L_s}{ER \cdot L_B}\right]}{1 + \left[\frac{D_s^{eff} / L_s}{ER \cdot L_B}\right] + \left[\frac{D_s^{eff} / L_s}{(D^{eff}{}_{crack} / L_{crack})\eta}\right]} x10^3 \frac{cm^3 kg}{m^3 g}$$

Equation A-27. Volatilization factor from groundwater to indoor air
[(mg/m³air)/(mg/l H_2O)]

$$VF_{wesp} = \frac{H\left[\dfrac{D_{ws}^{eff}/L_{gw}}{ER\ L_B}\right]}{1+\left[\dfrac{D_{ws}^{eff}/L_{gw}}{ER\ L_B}\right]+\left[\dfrac{D_{ws}^{eff}/L_{gw}}{(D_{crack}^{eff}/L_{crack})\eta}\right]} \times 10^3 \frac{l}{m^3}$$

Equation A-28. Volatilization factor from groundwater to outdoor air
[(mg/m³air)/(mg/l H_2O)]

$$VF_{wamb} = \frac{H}{1+\left[\dfrac{U_{air}\delta_{air}L_{gw}}{WD_{ws}^{eff}}\right]} \times 10^3 \frac{l}{m^3}$$

Equation A-29. Leaching factor from subsurface soil to groundwater
[(mg/l H_2O)/(mg/kg soil)]

$$LF_{sw} = \frac{\rho_s}{\left[\theta_{ws} + k_s\rho_s + H\theta_{as}\right]\left(1+\dfrac{U_{gw}\delta_{gw}}{IW}\right)} x \frac{cm^3 kg}{l\ g}$$

Equation A-30. Effective diffusion coefficient in soil based on vapor-phase concentration
[cm²/s]

$$D_s^{eff} = D^{air}\frac{\theta_{as}^{3.33}}{\theta_T^2} + D^{water}\left(\frac{1}{H}\right)\frac{\theta_{ws}^{3.33}}{\theta_T^2}$$

Equation A-31. Effective diffusion coefficient through foundation cracks
[cm²/s]

$$D_{crack}^{eff} = D^{air}\frac{\theta_{acrack}^{3.33}}{\theta_T^2} + D^{water}\left(\frac{1}{H}\right)\frac{\theta_{wcrack}^{3.33}}{\theta_T^2}$$

Equation A-32. Effective diffusion coefficient through capillary fringe
[cm²/s]

$$D_{cap}^{eff} = D^{air}\frac{\theta_{acap}^{3.33}}{\theta_T^2} + D^{water}\left(\frac{1}{H}\right)\frac{\theta_{wcap}^{3.33}}{\theta_T^2}$$

Equation A-33. Effective diffusion coefficient between groundwater and soil surface
(depth-weighted average)
[cm²/s]

$$D_{ws}^{eff} = \frac{(h_{cap} + h_v)}{\left[\frac{h_{cap}}{D_{cap}^{eff}} + \frac{h_v}{D_s^{eff}}\right]}$$

Equation A-34. Soil concentration at which dissolved pore-water and vapor phases become
saturated
[(mg/kg soil)]

$$C_{sat} = \frac{S}{\rho_s}\left[\theta_{ws} + k_s\rho_s + H\theta_{as}\right]\ x\frac{l\ g}{cm^3 kg}$$

JUSTIFICATION FOR INPUT PARAMETER VALUES

This appendix presents a detailed justification for the input parameter values selected for the Oakland Tier 1 and Tier 2 RBCA calculations. The organization mirrors section 3.0 of the body. The various input parameters are discussed in the following order:

(1) **soil-specific transport parameters**
(2) **non-soil-specific transport parameters**
(3) **receptor-specific parameters**
(4) **target risk levels**
(5) **chemical-specific parameters**

Comparisons to the ASTM (1995) default values, used to calculate the example look-up tables contained therein, are made throughout this appendix. Please note that, although these values are helpful for comparison purposes, ASTM (1995) intended them to be only reasonable examples from a range of potential values and explicitly states that they "should not be viewed… as proposed remediation 'standards'".

The following list indexes the input parameters discussed in this appendix alphabetically by the section in which they may be found:

Index of Input Parameters

Index of Input Parameters—*Continued*

B.1 SOIL-SPECIFIC TRANSPORT PARAMETERS

This section discusses the transport parameters whose input values vary by soil type. Table B-1 presents the Oakland RBCA values and indicates which of these diverge from the ASTM (1995) defaults.

Table B-1. Oakland RBCA Soil-Specific Transport Parameter Values

Oakland RBCA	Tier 1	Tier 2		
Input Parameter	All Soils	Merritt Sands	Sandy Silts	Clayey Silts
Capillary fringe air content (cm^3/cm^3)	0.038	0.025*	0.02*	0.01*
Capillary fringe water content (cm^3/cm^3)	0.342	0.33*	0.38*	0.49*
Capillary fringe thickness (cm)	5	10.1*	60.1*	152*
F_{oc} in soil (g/g)	0.01	0.01	0.015*	0.02*
Groundwater Darcy velocity (cm/yr)	6*	600*	60*	6*
Groundwater mixing zone thickness (cm)	1,524*	305*	762*	1,524*
Infiltration rate of water through the vadose zone (cm/yr)	3.0*	9.0*	6.0*	3.0*
Soil bulk density (g/cm^3)	1.7	1.72*	1.59*	1.33*
Soil to skin adherence factor (mg/cm^2)	0.5	0.2*	0.5*	1.0*
Total soil porosity (cm^3/cm^3)	0.38	0.35*	0.4*	0.5*
Vadose zone air content (cm^3/cm^3)	0.26	0.2*	0.15*	0.1*
Vadose zone water content (cm^3/cm^3)	0.12	0.15*	0.25*	0.4*
Vadose zone thickness (cm)	295.0	289.9*	239.9*	148*

*Oakland-specific value

The following subsections discuss in detail the selection of, and justification for, each of the soil-specific transport parameter values.

B.1.1 Capillary Fringe Parameters: Air Content, Water Content and Thickness

The capillary fringe is defined as the region above the water table that is completely saturated (Freeze and Cherry 1979; Knox et al. 1993). Table B-2 compares the Oakland Tier 1 and Tier 2 values for *capillary fringe air content, capillary fringe water content* and *capillary fringe thickness* with the ASTM (1995) defaults.

Table B-2. Comparison of Oakland RBCA Capillary Fringe Thickness, Water Content and Air Content Values with ASTM (1995) Defaults

	Oakland RBCA				ASTM
	Tier 1	Tier 2			Default
Input Parameter	All Soils	Merritt Sands	Sandy Silts	Clayey Silts	All Soils
Capillary fringe air content (cm^3/cm^3)	0.038[a]	0.025[b]	0.020[b]	0.010[b]	0.038
Capillary fringe water content (cm^3/cm^3)	0.342[a]	0.330[b]	0.380[b]	0.475[b]	0.342
Capillary fringe thickness (cm)	5[a]	10.1[b]	60.1[b]	152[b]	5

Source:
[a]ASTM (1995)
[b]selected by Technical Advisory Committee (1996b)

The Oakland Tier 1 values agree with the ASTM (1995) defaults.

The Oakland Tier 2 values deviate from the ASTM (1995) defaults. These values represent an average of values recommended by environmental experts with Oakland field experience (Technical Advisory Committee 1996b). The finer the soil particles, the less air and more water is assumed to be present in the capillary fringe. The capillary fringe is also assumed to be thicker in finer-grained soils. These assumptions are supported by standard literature on the subject. Table B-3 compares the capillary rise values reported by Guymon (1994) with the Oakland Tier 2 values for *capillary fringe thickness*.

Table B-3. Comparison of Standard Capillary Rise Values with Oakland Tier 2 *Capillary Fringe Thickness* Values

Guymon (1994)			Oakland Tier 2
Unconsolidated Material	Grain size (mm)	Capillary Rise* (cm)	Capillary Rise (cm)
Medium sand	0.50 - 0.20	24.6	
Fine sand	0.20 - 0.10	42.8	10.1[a]
Silt (sample #1)	0.10 - 0.05	105.5	60.1[b]; 152.0[c]
Silt (sample #2)	0.05 - 0.02	200.0[d]	

*capillary rise measured after 72 days; all samples were approximately 41% porous
[a]input parameter value for Merritt sands
[b]input parameter value for sandy silts
[c]input parameter value for clayey silts
[d]still rising after 72 days

The Oakland RBCA values are conservative because they assume that there is some air trapped in the capillary fringe, which makes it more permeable to chemicals volatilizing from the groundwater.

B.1.2 Fraction Organic Carbon in Soil

Fraction organic carbon in soil is included as an input parameter in the both the ASTM (1995) and Oakland RBCA models because it has a major impact on the ability of chemicals to sorb to soil. The Oakland RBCA value for this input parameter takes into account the fact that mineral surfaces, such as clay, and electromagnetic molecular forces also cause chemicals to sorb, even if no organic carbon is present (Lyman et al. 1992; Knox et al. 1993). Table B-4 compares the Oakland Tier 1 and Tier 2 values for *fraction organic carbon in soil* with the ASTM (1995) default.

Table B-4. Comparison of Oakland RBCA *Fraction Organic Carbon in Soil* Values with ASTM (1995) Default (g/g)

Oakland RBCA				ASTM
Tier 1	Tier 2			Default
All Soils	Merritt Sands	Sandy Silts	Clayey Silts	All Soils
0.010[a]	0.010[a]	0.015[a]	0.020[a]	0.010

Source:
[a]Spence and Gomez (1999)

The Oakland Tier 1 value agrees with the ASTM (1995) default.

The Oakland Tier 2 values deviate from the ASTM (1995) default for the sandy silts and clayey silts soil types. These deviations reflect the results of the Oakland soils characterization study (Spence and Gomez 1999). The soils characterization study was performed to more accurately predict sorption of organic chemicals to soil by taking into account factors other than organic carbon.

Sorption of chemicals to organic carbon is the only process considered in the ASTM (1995) equations to account for retardation. The equations assume that the mathematical product of fraction organic carbon (F_{oc}) and the organic carbon partition coefficient (K_{oc}) equals the distribution coefficient (K_s). Although F_{oc} is known to be an important contributor to sorption, it is only a partial predictor of the total sorption that occurs. To address this shortcoming, the soils characterization study measured the partitioning (or sorption) of dissolved-phase benzene onto the three Oakland soil types. Once the actual partitioning was measured for benzene, a soil-specific parameter ("F_{oc}*") was calculated for each of the three soil types. The F_{oc}* value is used to predict the variability in the level of sorption, from one soil type to another, for all organic chemicals. The Oakland RBCA approach still accounts for chemicals sorbing differently from one another by employing chemical-specific K_{oc} values in the equations.

B.1.3 Groundwater Darcy Velocity

Groundwater Darcy velocity, a measure of water flux, is the mathematical product of hydraulic conductivity and hydraulic gradient. Since Darcy velocity is difficult to measure independently, values for hydraulic conductivity and hydraulic gradient were selected and the Darcy velocity was then calculated. Table B-5 compares the Oakland Tier 1 and Tier 2 values for *groundwater Darcy velocity* with the ASTM (1995) default.

Table B-5. Comparison of Oakland RBCA *Groundwater Darcy Velocity* Values with ASTM (1995) Default (cm/yr)

Oakland RBCA				ASTM
Tier 1	Tier 2			Default
All Soils	Merritt Sands	Sandy Silts	Clayey Silts	All Soils
6[a,c]	600[b]	60[b]	6[b]	2500

Source:
[a]selected by Technical Advisory Committee (1998)
[b]selected by Technical Advisory Committee (1996b)
[c]*Infiltration rate through the vadose zone*, *groundwater Darcy velocity* and *groundwater mixing zone thickness* all affect the "ingestion of groundwater impacted by leachate" pathway only and the values for these input parameters were selected as a group. The Tier 1 values selected mirror those for clayey silts, which is the soil type with the most conservative combination of values for these input parameters.

Both the Oakland Tier 1 and Tier 2 values deviate from the ASTM default.

The hydraulic gradient used to calculate Darcy velocity (0.002 cm/cm) is on the low end of Oakland gradients and therefore conservative (Woodward-Clyde 1992). The values selected for hydraulic conductivity are supported by standard text values. Table B-6 compares hydraulic conductivity values reported by Freeze and Cherry (1979) with the Oakland RBCA values.

Table B-6. Comparison of Standard Hydraulic Conductivity Values with Oakland RBCA Values

Freeze and Cherry (1979, Table 2.2)			Oakland RBCA
Soil Type	Hydraulic Conductivity (cm/s)	Hydraulic Conductivity (cm/yr, extrapolated)	Hydraulic Conductivity[1] (cm/yr)
Silty sand	1E-5 to 9E-2	30 to 3E+6	3E+5[a]
Silt, loess	1E-7 to 2E-3	3 to 6E+4	3E+4[b]
Glacial till	1E-10 to 1E-4	3E+3 to 3.2E+3	3E+3[c]

[1]values rounded to one significant figure
[a]input parameter value for Merritt sands
[b]input parameter value for sandy silts
[c]input parameter value for clayey silts

The Oakland RBCA values for groundwater Darcy velocity are all significantly more conservative than the ASTM (1995) default, because a lower Darcy velocity results in less dilution of chemicals leaching to groundwater.

B.1.4 Groundwater Mixing Zone Thickness
The thickness of the mixing zone in groundwater is used to calculate the chemical concentration in groundwater at the down-gradient edge of the soil source. Table B-7 compares the Oakland Tier 1 and Tier 2 values for *groundwater mixing zone thickness* with the ASTM (1995) default.

Table B-7. Comparison of Oakland RBCA *Groundwater Mixing Zone Thickness* Values with ASTM (1995) Default
(cm)

Oakland RBCA				ASTM
Tier 1	Tier 2			Default
All Soils	Merritt Sands	Sandy Silts	Clayey Silts	All Soils
1,524[a,b]	305[a]	762[a]	1,524[a]	200

Source:
[a]selected by Technical Advisory Committee (1998)
[b]*Infiltration rate through the vadose zone, groundwater Darcy velocity* and *groundwater mixing zone thickness* all affect the "ingestion of groundwater impacted by leachate" pathway only and the values for these input parameters were selected as a group. The Tier 1 values selected mirror those for clayey silts, which is the soil type with the most conservative combination of values for these input parameters.

Both the Oakland Tier 1 and Tier 2 values deviate from the ASTM default.

The input value for *groundwater mixing zone thickness* is used to estimate the concentration of a chemical in groundwater extracted from a well. Varying hydraulic conductivity in the three different soil types is assumed to influence the well screen length required to extract the same amount of groundwater. The lower the hydraulic conductivity is, the longer the well screen length that is required.

The Oakland RBCA approach is conservative. All water pulled from the well is assumed to be fully mixed over the depth of the mixing zone. In reality, when a well is pumped, it also draws water from below the well screen, where the chemical concentration is likely lower.

B.1.5 Infiltration Rate of Water through the Vadose Zone
The infiltration rate is the amount of water that travels through the vadose zone and reaches groundwater. Table B-8 compares the Oakland Tier 1 and Tier 2 values for *infiltration rate of water through the vadose zone* with the ASTM (1995) default.

Table B-8. Comparison of Oakland RBCA *Infiltration Rate* Values with ASTM (1995) Default
(cm/yr)

Oakland RBCA				ASTM
Tier 1	Tier 2			Default
All Soils	Merritt Sands	Sandy Silts	Clayey Silts	All Soils
3.0[a,d]	9.0[b]	6.0[c]	3.0[a]	30

Source:
[a]Technical Advisory Committee (1998); equal to 5 percent of average Oakland rainfall
[b]Technical Advisory Committee (1998); equal to 15 percent of average Oakland rainfall
[c]Technical Advisory Committee (1998); equal to 10 percent of average Oakland rainfall
[d]*Infiltration rate through the vadose zone*, *groundwater Darcy velocity* and *groundwater mixing zone thickness* all affect the "ingestion of groundwater impacted by leachate" pathway only and the values for these input parameters were selected as a group. The Tier 1 values selected mirror those for clayey silts, which is the soil type with the most conservative combination of values for these input parameters.

Both the Oakland Tier 1 and Tier 2 values deviate from the ASTM (1995) default.

The Oakland RBCA values assume that infiltration rate is influenced by soil grain size and permeability. Standard literature indicates that the Oakland RBCA values are conservative. Table B-9 compares the range of recharge rate values reported by Walton (1988) for areas geologically similar to Oakland with the Oakland RBCA infiltration rate values.

Table B-9. Comparison of Standard Recharge Rates with Oakland RBCA *Infiltration Rate* Values
(in/yr)

Walton (1988) (Originally based on Heath 1982)		Oakland RBCA
Region	Recharge Rate	Infiltration Rate
Western Mountain Ranges	0.100 - 2	
Alluvial Basins	0.001 - 1	3.6[a]; 2.4[b]; 1.2[c]

[a]input parameter value for Merritt sands
[b]input parameter value for sandy silts
[c]input parameter value for clayey silts

B.1.6 Soil Bulk Density

Soil bulk density accounts for pore spaces and therefore differs from rock density. The following equation is used to calculate soil bulk density:

$$\text{soil bulk density} = (1 - \text{total porosity})\ (2.65\ \text{g/cm}^3)$$

Table B-10 compares the Oakland Tier 1 and Tier 2 values for *soil bulk density* with the ASTM (1995) default.

Table B-10. Comparison of Oakland RBCA *Soil Bulk Density* Values with ASTM (1995) Default
(g soil/cm^3 soil)

Oakland RBCA				ASTM
Tier 1	Tier 2			Default
All Soils	Merritt Sands	Sandy Silts	Clayey Silts	All Soils
1.7[a]	1.72[b]	1.59[b]	1.33[b]	1.7

Source:
[a]ASTM (1995)
[b]based on total soil porosity values selected by Technical Advisory Committee (1996b)

The Oakland Tier 1 value agrees with the ASTM (1995) default.

The Oakland Tier 2 values deviate from the ASTM (1995) default. These values were calculated using the total soil porosity values selected by the Technical Advisory Committee (1996b) and discussed in section B.1.8.

B.1.7 Soil to Skin Adherence Factor

The soil to skin adherence factor determines the amount of soil that will stick to an individual's skin upon contact. Table B-11 compares the Oakland Tier 1 and Tier 2 values for *soil to skin adherence factor* with the ASTM (1995) default.

Table B-11. Comparison of Oakland RBCA *Soil to Skin Adherence Factor* Values with ASTM (1995) Default
(mg soil/cm^2 soil)

Oakland RBCA				ASTM
Tier 1	Tier 2			Default
All Soils	Merritt Sands	Sandy Silts	Clayey Silts	All Soils
0.5[a]	0.2[b]	0.5[b]	1.0[b]	0.5

Source:
[a]ASTM (1995)
[b]U.S. EPA (1992)

The Oakland Tier 1 value agrees with the ASTM (1995) default.

The Oakland Tier 2 values deviate from the ASTM (1995) default, except for sandy silts. These values are conservative and are based on studies reported by U.S. EPA (1992) that showed soil adherence to skin to be a function of grain size. Based on these studies, U.S. EPA (1992) concluded that "0.2 [mg/cm^2] may be the best value to represent an average overall exposed skin and 1 [mg/cm^2]may be a reasonable upper value."

B.1.8 Vadose Zone Air Content, Vadose Zone Water Content and Total Soil Porosity
Vadose zone air content, vadose zone water content and *total soil porosity* are interrelated and are discussed here as a group. Total soil porosity is the sum of air content and water content. Total soil porosity is used in the RBCA calculations because it is not the effective soil porosity but the total soil porosity that is operative in diffusion processes. Table B-12 compares the Oakland Tier 1 and Tier 2 values for *total soil porosity, vadose zone water content* and *vadose zone air content* with the ASTM (1995) defaults.

Table B-12. Comparison of Oakland RBCA *Total Soil Porosity, Vadose Zone Water Content* and *Vadose Zone Air Content* Values with ASTM (1995) Defaults (cm^3/cm^3)

	Oakland RBCA				ASTM
	Tier 1	Tier 2			Default
Input Parameter	All Soils	Merritt Sands	Sandy Silts	Clayey Silts	All Soils
Total soil porosity	0.38[b]	0.35[a]	0.40[a]	0.5[a]	0.38
Vadose zone water content	0.12[b]	0.15[a]	0.25[a]	0.4[a]	0.12
Vadose zone air content	0.26[b]	0.20[a]	0.15[a]	0.1[a]	0.26

Source:
[a]selected by Technical Advisory Committee (1996b)
[b]ASTM (1995)

The Oakland Tier 1 values agree with the ASTM (1995) defaults.

The Oakland Tier 2 values deviate from the ASTM (1995) defaults. These values represent an average of values recommended by environmental experts with Oakland field experience (Technical Advisory Committee 1996b). The Tier 2 input parameter values selected for each soil type reflect the following considerations:

(1) The total soil porosity value should be reflective of the vadose zone in between the source and the building or the source and the ground surface. If there are any lower permeability (i.e., higher water content) lenses, they will be the limiting layer for diffusion and the air content and water content values should account for their presence.
(2) Total soil porosity in sand is diminished if the sand is "dirty" or not well-sorted because the larger pore spaces fill up with small particles.
(3) Total soil porosity in clays increases as the clay particle sizes decrease, resulting in a greater percent volumetric water content, and an absolute volumetric air content that is the same as or lower than that found in clays with larger particle sizes.
(4) Soils may be wetter in the winter and drier in the summer; therefore, the input parameter values should reflect an annual average.
(5) *Total soil porosity* is not the critical parameter, per se; rather, the model is driven by the values selected for *vadose zone air content* and *vadose zone water content.*

The Oakland Tier 2 *total soil porosity* values are supported by standard groundwater and soils texts. Table B-13 compares the ranges of total soil porosity values reported by Freeze and Cherry (1979) with the Oakland Tier 2 values.

Table B-13. Comparison of Standard Total Porosity Value Ranges for Various Soil Types with Oakland Tier 2 Values (cm^3_{voids}/cm^3_{soil})

Freeze and Cherry (1979)		Oakland Tier 2
Unconsolidated Deposits	Total Soil Porosity (Range)	Total Soil Porosity
Sand	0.25 - 0.50	0.35[a]
Silt	0.35 - 0.50	0.40[b]
Clay	0.40 - 0.70	0.50[c]

[a]input parameter value for Merritt sands
[b]input parameter value for sandy silts
[c]input parameter value for clayey silts

Texts do not typically report standard values for air content and water content in the vadose zone. Heath (1989) defines specific yield as the amount of water in storage in the vadose zone that drains under the influence of gravity, and specific retention as the amount of water that is retained in the pore spaces under the influence of gravity. Specific yield may be considered a conservative air content value and specific retention a conservative water content value. Table B-14 compares the Heath (1989) values for specific yield and retention with the Oakland Tier 2 values for *vadose zone air content* and *vadose zone water content*, respectively.

Table B-14. Comparison of Standard Specific Retention and Specific Yield Values with Oakland Tier 2 *Vadose Zone Air Content* and *Vadose Zone Water Content* Values (cm^3/cm^3)

Heath (1989)			Oakland Tier 2	
Material	Specific Yield	Specific Retention	Air Content	Water Content
Sand	0.22	0.03	0.20[a]	0.15[a]
Soil	0.40	0.15	0.15[b]	0.25[b]
Clay	0.02	0.48	0.10[c]	0.40[c]

[a]input parameter value for Merritt sands
[b]input parameter value for sandy silts
[c]input parameter value for clayey silts

The Oakland RBCA Tier 2 values for *vadose zone air content* and *vadose zone water content* take into consideration that clays hold more water and sands less. The Oakland RBCA values are conservative because the vadose zone air content is assumed to be on the high end of potential values, which renders the vadose zone more permeable to chemicals volatilizing from the soil and groundwater.

B.1.9 Vadose Zone Thickness

The thickness of the vadose zone is determined by the depth to groundwater and the thickness of the capillary fringe. Table B-15 compares the Oakland Tier 1 and Tier 2 values for *vadose zone thickness* with the ASTM (1995) default.

Table B-15. Comparison of Oakland RBCA *Vadose Zone Thickness* Values with ASTM (1995) Default (cm)

Oakland RBCA				ASTM
Tier 1	Tier 2			Default
All Soils	Merritt Sands	Sandy Silts	Clayey Silts	All Soils
295.0[a]	289.9[b]	239.9[b]	148.0[b]	295.0

Source:
[a]ASTM (1995)
[b]calculated from values for *capillary fringe thickness* and *depth to groundwater* selected by Technical Advisory Committee (1996b)

For a discussion of how the values for *capillary fringe thickness* and *depth to groundwater* were selected, and a comparison with standard literature values, refer to sections B.1.1 and B.2.5, respectively.

B.2 NON-SOIL-SPECIFIC TRANSPORT PARAMETERS

This section discusses the transport parameters whose input values do not vary by soil type. Table B-16 presents the Oakland RBCA values and indicates which of these diverge from the ASTM (1995) defaults.

Table B-16. Oakland RBCA Non-soil-specific Transport Parameter Values

Input Parameter	Value
Areal fraction of cracks in building foundation (cm^2/cm^2)	0.001*
Foundation cracks air content (cm^3/cm^3)	0.26
Foundation cracks water content (cm^3/cm^3)	0.12
Foundation thickness (cm)	15
Lower depth of surficial soil zone (cm)	100
Depth of subsurface soil sources (cm)	100
Depth to groundwater (cm)	300
Width of source area parallel to wind or groundwater flow direction (cm)	1500
Outdoor air mixing zone height (cm)	200
Particulate emission rate ($g/cm^2/s$)	1.38E-11*
Wind speed above ground surface in outdoor air mixing zone (cm/s)	322*

*Oakland-specific value

The following subsections discuss in detail the selection of, and justification for, each of the non-soil-specific transport parameter values.

B.2.1 Areal Fraction of Cracks in Building Foundation

Cracks in the foundation or basement walls can allow greater concentrations of a volatilized chemical to infiltrate a building. The Oakland RBCA value for *areal fraction of cracks in building foundation* deviates from the ASTM (1995) default (see Table B-17).

Table B-17. Comparison of Oakland RBCA *Areal Fraction of Cracks in Building Foundation* Value with ASTM (1995) Default (cm^2/cm^2)

Oakland RBCA	ASTM Default
0.001[a,b]	0.01

Source:
[a]Technical Advisory Committee (1997)
[b] American Society of Heating, Refrigerating, and Air Conditioning Engineering (1981)

The Oakland RBCA value was selected by the Technical Advisory Committee (1997) and is considered a typical assumption for buildings with slab floors. The value is supported by California data, collected by Carlos et al. and presented by the American Society of Heating, Refrigerating, and Air Conditioning Engineering (ASHRAE 1981).

B.2.2 Foundation Cracks Air Content and Water Content

Foundation cracks air content and *foundation cracks water content* are interrelated and discussed here together. The more air present in foundation or basement wall cracks, the more easily a volatilized chemical can infiltrate a building. The Oakland RBCA values for *foundation cracks air content* and *foundation cracks water content* agree with the ASTM (1995) default (see Table B-18).

Table B-18. Comparison of Oakland RBCA *Foundation Cracks Air Content* and *Foundation Cracks Water Content* Values with ASTM (1995) Defaults (cm)

Input Parameter	Oakland RBCA	ASTM Default
Foundation cracks air content	0.26[a]	0.26
Foundation cracks water content	0.12[a]	0.12

Source:
[a]ASTM (1995)

If one assumes that foundation cracks typically become filled with dirt over time, the Oakland RBCA values reflect conservative assumptions about the air content in that dirt.

B.2.3 Foundation Thickness
The thickness of a building foundation can effect the indoor air concentration of a chemical volatilizing from the soil or groundwater. The Oakland RBCA value for *foundation thickness* agrees with the ASTM (1995) default (see Table B-19).

Table B-19. Comparison of Oakland RBCA *Foundation Thickness* Value with ASTM (1995) Default
(cm)

Oakland RBCA	ASTM Default
15[a]	15

Source:
[a]California Building Code (1998)

The input parameter value for foundation thickness reflects the minimum construction standard for building foundations. The California Building Code (1998) requires a foundation thickness of six inches, or approximately 15 cm, for one-story buildings. The Oakland RBCA value is conservative under many scenarios because the California Building Code (1998) requires an eight-inch foundation for two-story buildings and a ten-inch foundation for buildings of three stories or more.

B.2.4 Source Geometry Parameters
Source geometry parameters serve to define the lateral and vertical extent of contamination. The Oakland RBCA values for *lower depth of surficial soil zone, depth to subsurface soil sources, depth to groundwater*, and *width of source area parallel to wind or groundwater flow direction* agree with the ASTM (1995) defaults (see Table B-20).

Table B-20. Comparison of Oakland RBCA Source Geometry Parameter Values and ASTM (1995) Defaults
(cm)

Input Parameter	Oakland RBCA	ASTM Default
Lower depth of surficial soil zone	100[a]	100
Depth to subsurface soil sources	100[a]	100
Depth to groundwater	300[a]	300
Width of source area parallel to wind or groundwater flow direction	1500[a]	1500

Source:
[a]ASTM (1995); Technical Advisory Committee (1996b)

The value for *lower depth of surficial soil zone* simply delineates the vertical extent of the surficial soil medium for the purpose of defining the exposure pathway of concern.

The depth and width of the source area will obviously vary from site to site. The Oakland RBCA approach is conservative because it assumes a moderate to large source area close to the ground surface.

Note that groundwater in Oakland is typically encountered at anywhere from 10 to 30 feet (Gomez 1999). The selected value of ten feet is therefore conservative. If actual site depth to groundwater is less than ten feet and inhalation of chemicals volatilizing from groundwater is the primary exposure pathway of concern, then the site in question is not eligible for application of the Oakland RBCA levels (City of Oakland 2000).

B.2.5 Outdoor Air Mixing Zone Height

The height of the outdoor air mixing zone defines the area from which a person draws air to breathe. The Oakland RBCA value for *outdoor air mixing zone height* agrees with the ASTM (1995) default (see Table B-21).

Table B-21. Comparison of Oakland RBCA *Outdoor Air Mixing Zone Height* Value with ASTM (1995) Default (cm)

Oakland RBCA	ASTM Default
200[a]	200

Source:
[a]ASTM (1995)

The Oakland RBCA value reflects the breathing area of an average person.

B.2.6 Particulate Emission Rate

The particulate emission rate is used to calculate a high-end estimate of the amount of breathable dust particles (<10 microns) originating from exposed soil that are present in outdoor air. Dust particles are assumed to come from the top few centimeters of the soil surface. The Oakland RBCA value for *particulate emission rate* deviates from the ASTM (1995) default (see Table B-22).

Table B-22. Comparison of Oakland RBCA *Particulate Emission Rate* Value with ASTM (1995) Default ($g/cm^2/s$)

Oakland RBCA	ASTM Default
1.38E-11[a]	6.9E-14

[a]based on Soil Screening Guidance (U.S. EPA 1995)

The particulate emission rate for the Oakland RBCA approach is based on *Soil Screening Guidance* (U.S. EPA 1995). Both the Oakland RBCA and ASTM (1995) particulate emission rates are derived from the Cowherd unlimited erosion potential model (U.S. EPA 1985);

however, different input values are used to calculate the rate. U.S. EPA (1995) inputs are very conservative and produce a higher particulate emission rate than the ASTM (1995) default.

B.2.7 Wind Speed above Ground Surface in Outdoor Air Mixing Zone

Wind speed can effect the concentration of a chemical of concern in the outdoor air through dispersion. The Oakland RBCA value for *wind speed above ground surface in outdoor air mixing zone* deviates from the ASTM (1995) default (see Table B-23).

Table B-23. Comparison of Oakland RBCA *Wind Speed* Value with ASTM (1995) Default (cm/s)

Oakland RBCA	ASTM Default
322[a]	225

Source:

[a]extrapolated from wind rose data provided by the Bay Area Air Quality Management District (BAAQMD 1996)

Average annual wind speeds for different areas of Oakland were extrapolated from wind rose data, and the lowest of these wind speeds was selected as the Oakland RBCA input parameter value (see Table B-24).

Table B-24. Location-specific Wind Speeds in Oakland (cm/s)

West Oakland (Sewage Treatment Plant)	East Oakland (Oakland International Airport)	Oakland-Berkeley Hills (Vollmer Peak)
322[a,d]	418[b]	640[c]

[a]measured from 4/1/92 through 3/31/93

[b]measured from 1/1/60 through 12/31/64

[c]measured from 1/1/90 through 12/4/90

[d]selected as the average annual wind speed for Oakland

The lower the wind speed is, the lower are the RBCA levels for the outdoor air exposure pathways. The selected wind speed value of 322 cm/s is conservative because it is the lowest of the average annual wind speeds measured in Oakland.

B.3 RECEPTOR-SPECIFIC PARAMETERS

This section discusses the input parameters whose values vary by receptor and land use scenario. The three potential receptors in the Oakland RBCA approach are: child residential, adult residential and adult commercial/industrial (i.e., worker). As described in section 2.2 of the body, the Oakland RBCA residential land use exposure scenario assumes a combined child/adult receptor for carcinogenic health effects and a child receptor for non-carcinogenic effects.

Table B-25 presents the Oakland RBCA values for the receptor-specific parameters and indicates which of these diverge from the ASTM (1995) defaults.

Table B-25. Oakland RBCA Receptor-Specific Input Parameter Values and Sources

Input Parameter	Residential		Commercial/ Industrial
	Child	Adult	Worker
Averaging time for carcinogenic effects (yr)	70*	70	70
Averaging time for non-carcinogenic effects (yr)	6*	24*	25
Averaging time for vapor flux (s)	9.46E+08[a]	9.46E+08[a]	7.88E+08
Body weight (kg)	15*	70	70
Building air volume/floor area (cm^3/cm^2)	229*	229*	305*
Exposure duration (yr)	6*	24	25
Exposure frequency (d/yr)	350*	350	250
Exposure frequency to water used for recreation (d/yr)	120*	120*	NA
Exposure time to indoor air (hr/d)	24*	24*	9*
Exposure time to outdoor air (hr/d)	16*	16*	9*
Exposure time to water used for recreation (hr/d)	2*	1*	NA
Groundwater ingestion rate (liters/d)	1*	2	1
Indoor air exchange rate (s^{-1})	5.60E-04*	5.60E-04*	1.40E-03*
Indoor inhalation rate (m^3/d)	10*	15	20
Ingestion rate while playing in water used for recreation (liters/hr)	0.05*	0.05*	NA
Outdoor inhalation rate (m^3/d)	10*	20*	20
Skin surface area exposed to soil (cm^2)	2000*	5000*	5000*
Skin surface area exposed to water used for recreation (cm^2)	8000*	20,000*	NA
Soil ingestion rate (mg/d)	200*	100	50

*Oakland-specific value

Note: NA indicates that the input parameter is not applicable to the commercial/industrial land use scenario

The following subsections discuss in detail the selection of, and justification for, each of the receptor-specific parameter values.

B.3.1 Averaging Time for Carcinogenic Effects

The averaging time for carcinogenic effects is the length of time used to statistically normalize the intake of a carcinogen. Table B-26 compares the Oakland RBCA values for *averaging time for carcinogenic effects* with the ASTM (1995) defaults.

Table B-26. Comparison of Oakland RBCA Values for *Averaging Time for Carcinogenic Effects* with ASTM (1995) Defaults

(yrs)

Land Use Scenario	Oakland RBCA	ASTM Default
Residential	Child: 70[a]; Adult: 70[a]	70
Commercial/Industrial	70[a]	70

Source:
[a]U.S. EPA (1996)

The Oakland RBCA value for *averaging time for carcinogenic effects* agrees with the ASTM (1995) default for both the residential and commercial/industrial land use scenarios. This value is based on an average life expectancy of approximately 70 years. This is standard throughout risk assessment literature and U.S. EPA toxicity data are based on it.

The Oakland RBCA approach assumes that the chemical concentration remains constant over the entire exposure duration (30 years for residential; 25 years for commercial/industrial). For volatile and soluble chemicals, this is a very conservative assumption since the concentration will actually decrease over time.

B.3.2 Averaging Time for Non-carcinogenic Effects

The averaging time for non-carcinogenic effects is set equal to the exposure duration because non-carcinogenic effects are not considered cumulative; instead, a daily intake level is determined. Table B-27 compares the Oakland RBCA values for *averaging time for non-carcinogenic effects* with the ASTM (1995) defaults.

Table B-27. Comparison of Oakland RBCA Residential Scenario Values for *Averaging Time for Non-carcinogenic Effects* with ASTM (1995) Defaults
(yrs)

Land Use Scenario	Oakland RBCA	ASTM Default
Residential	Child: 6[a]; Adult: 24[a]	30
Commercial/Industrial	25[a]	25

Source:
[a]U.S. EPA (1996)

The Oakland RBCA value for *averaging time for non-carcinogenic effects* agrees with the ASTM (1995) default for both the residential and commercial/industrial land use scenarios. Note, however, that this input parameter cancels out of the equation along with *exposure duration* since non-carcinogenic effects are calculated based on a daily intake and not cumulative exposure. Therefore, what is relevant is the conservative assumption that the receptor is always a young child.

B.3.3 Averaging Time for Vapor Flux

Averaging time for vapor flux is the length of time over which a chemical is assumed to volatilize from surficial soil. Table B-28 compares the Oakland RBCA values for *averaging time for vapor flux* with the ASTM (1995) defaults.

Table B-28. Comparison of Oakland RBCA Values for *Averaging Time for Vapor Flux* with ASTM (1995) Defaults
(s)

Land Use Scenario	Oakland RBCA	ASTM Default
Residential	9.46E+08[a]	9.46E+08
Commercial/Industrial	7.88E+08[a]	7.88E+08

Source:
[a]ASTM (1995)

The Oakland RBCA value for *averaging time for vapor flux* agrees with the ASTM (1995) default for both the residential and commercial/industrial land use scenarios.

The Oakland RBCA values are set equal to the input value for *exposure duration*, in seconds. For a discussion of how the values for exposure duration were selected and a comparison with research data, refer to **section 3.6.**

B.3.4 Body Weight

Body weight is assumed to influence the effect of a given concentration of a chemical on an exposed individual. Table B-29 compares the Oakland RBCA values for *body weight* with the ASTM (1995) defaults.

Table B-29. Comparison of Oakland RBCA Values for *Body Weight* with ASTM (1995) Defaults
(yrs)

Land Use Scenario	Oakland RBCA	ASTM Default
Residential	Child: 15[a]; Adult: 70[a]	70
Commercial/Industrial	70[a]	70

Source:
[a]U.S. EPA (1996)

The Oakland RBCA value for *body weight* deviates from the ASTM (1995) default for the residential land use scenario because the potential for a child receptor is taken into account in the Oakland RBCA calculations. The Oakland RBCA value for children is 15 kg, based on U.S. EPA (1996) data. For children between the ages of 0 and 6, this value falls slightly below the mean (U.S. EPA 1989a). The Oakland RBCA value is therefore moderately conservative.

The Oakland RBCA value for *body weight* agrees with the ASTM (1995) default for the commercial/industrial land use scenario. The Oakland RBCA value for adults for both the residential and commercial/industrial land use scenarios is 70 kg. This value is based on both ASTM (1995) and U.S. EPA (1996) data and approximates a mean value for individuals between the ages of 6 and 75 years (U.S. EPA 1989b).

B.3.5 Building Air Volume/Floor Area

The building air volume divided by the floor area is the height of the ceiling. Larger rooms allow for a greater reduction in the concentration of a volatilized chemical in the air. Table B-30 compares the Oakland RBCA values for *building air volume/floor area* with the ASTM (1995) defaults.

Table B-30. Comparison of Oakland RBCA Values for *Building Air Volume/Floor Area* with ASTM (1995) Defaults (cm^3/cm^2)

Land Use Scenario	Oakland RBCA	ASTM Default
Residential	Child: 229[a]; Adult: 229[a]	200
Commercial/Industrial	305[b]	300

Source:
[a]California Building Code (1998)
[b]based on U.S. EPA (1997) delineation of "typical" ceiling heights

The Oakland RBCA values for *building air volume/floor area* deviate from the ASTM (1995) defaults for both the residential and commercial/industrial land use scenarios.

The Oakland RBCA value for the residential land use scenario is based on the minimum California Building Code (1998) requirement of seven feet, six inches for residential structures. The Oakland RBCA value for the commercial/industrial land use scenario assumes an average ceiling height of 10 feet. This value reflects the average of the values defined by U.S. EPA (1997) as "typical" for residential (eight feet) and commercial (12 feet), and was selected to account for commercial enterprises operating on the ground floor of older, mixed-use structures.

B.3.6 Exposure Duration

The exposure duration is the number of years over which an individual is assumed to be exposed to a chemical of concern. Table B-31 compares the Oakland RBCA values for *exposure duration* with the ASTM (1995) defaults.

Table B-31. Comparison of Oakland RBCA Values for *Exposure Duration* with ASTM (1995) Default
(yrs)

Land Use Scenario	Oakland RBCA	ASTM Default
Residential	Child: 6[a]; Adult: 24[a]	30
Commercial/Industrial	25[a]	25

Source:
[a]U.S. EPA (1996)

The Oakland RBCA values for *exposure duration* agree with the ASTM (1995) default for both the residential and commercial/industrial land use scenarios. (Under the residential land use scenario, the child and adult *exposure duration* values are added together.) Research data indicate that both values are conservative. Table B-32 compares the Oakland RBCA values for residential land use exposure duration with U.S. EPA data on homeowners living continually in the same house.

Table B-32. Comparison of Oakland RBCA Values for Residential Land Use Scenario *Exposure Duration* with U.S. EPA Data on Homeowners Living Continually in the Same House
(yrs)

Oakland RBCA	U.S. EPA 1989b (50th percentile)	U.S. EPA 1989b (90th percentile)
30	9	30

The Oakland RBCA value for the residential land use scenario is 30 years: 24 as an adult and 6 as a child. The U.S. EPA (1989b) values are based on an analysis of 1983 Bureau of Census data. They indicate that the Oakland RBCA values are very conservative. Still, other population mobility studies indicate that the U.S. EPA (1989b) findings probably underestimate the conservatism of the Oakland RBCA value for three reasons. First, Oakland is an urban area and the U.S. EPA (1989b) analysis includes rural areas where population mobility tends to be lower. Second, many Oakland residents are not homeowners and studies have shown that the average residence time of an apartment dweller ranges from 18 to 24 months (U.S. EPA 1989b). Third, individuals living in the Western United States tend to be more mobile than those living in other areas of the country. Israeli and Nelson (1992) take these factors into account in their analysis (see Table B-33).

Table B-33. Comparison of Oakland RBCA Value for Residential Land Use Scenario Exposure Duration with Israeli and Nelson (1992) Data on Time Spent in One Residence (yrs)

Oakland RBCA	Israeli and Nelson (1992)		
All Oakland Households	All U.S. Households (95th percentile)	Western U.S. Households (95th percentile)	All Urban U.S. Households (95th percentile)
30.0	23.1	17.1	21.7

The Oakland RBCA value for the commercial/industrial land use scenario is 25 years. Again, labor mobility studies indicate that this value is conservative. Table B-34 compares the Oakland RBCA value for the commercial/industrial land use scenario with Bureau of Labor Statistics (1988) data on time spent at a specific job.

Table B-34. Comparison of Oakland RBCA Values for Commercial/Industrial Land Use Scenario Exposure Duration with Bureau of Labor Statistics Data on Time Spent at a Specific Job (yrs)

Oakland RBCA	Bureau of Labor Statistics (50th percentile)	Bureau of Labor Statistics (95th percentile)
25	4	25

B.3.7 Exposure Frequency

The exposure frequency is the number of days per year that an individual is assumed to be exposed to a chemical of concern. Table B-35 compares the Oakland RBCA values for *exposure frequency* with the ASTM (1995) defaults.

Table B-35. Comparison of Oakland RBCA Values for *Exposure Frequency* with ASTM (1995) Defaults (d/yr)

Land Use Scenario	Oakland RBCA	ASTM Default
Residential	Child: 350[a]; Adult: 350[a]	350
Commercial/Industrial	250[a]	250

Source:
[a]U.S. EPA (1996)

The Oakland RBCA value for *exposure frequency* agrees with the ASTM (1995) default for both the residential and commercial/industrial land use scenarios.

The Oakland RBCA value for the residential land use scenario, for both adult and child, is 350 days/year. This value is based on a two-week vacation scenario. It is conservative because it assumes that the individual is at home all 24 hours each day and does not take into consideration activities away from home, such as weekend trips, work and errands.

The Oakland RBCA value for the commercial/industrial land use scenario is 250 days/year. This value is based on a five-day work week for fifty weeks of the year. It is conservative because it does not take into account additional holidays and sick days that typically account for anywhere from 10 to 20 fewer work days per year.

B.3.8 Exposure Frequency to Water Used for Recreation

Exposure frequency to water used for recreation is a measure of the number of days per year that an individual is exposed to a chemical of concern through contact with groundwater or surface water. The Oakland RBCA value of 120 days/year is based on a hypothetical, swimming scenario in which water pulled from an extraction well or nearby surface water body is used to fill a pool. It assumes that the exposed individual swims in the contaminated water every day of the swim season, which is assumed to last four months.

ASTM (1995) does not consider this exposure scenario.

B.3.9 Exposure Time to Indoor Air

Exposure time to indoor air is determined by the number of hours per day that an individual is inside a building impacted by contaminated air. ASTM (1995) does not include this input parameter in its RBCA model, effectively assuming 24 hours of exposure per day for both the residential and commercial/industrial land use scenarios. For the residential land use scenario, the Oakland RBCA value is also 24 hours. This is a maximally conservative value that assumes the exposed individual is house-ridden for family obligations or health reasons.

For the commercial/industrial land use scenario, the Oakland RBCA value is 9 hours. This is based on an eight-hour work day with a one-hour lunch taken inside and on-site.

B.3.10 Exposure Time to Outdoor Air

Exposure time to outdoor air is determined by the number of hours per day that an individual is outside at a site with contaminated ambient air. ASTM (1995) does not include this input parameter in its RBCA model, effectively assuming 24 hours of exposure per day for both the residential and commercial/industrial land use scenarios. For the residential land use scenario, the Oakland RBCA value is 16 hours. This is a conservative value that assumes the exposed individual is on-site but outside of the home (e.g., in the yard or garden) the whole day except for eight hours of sleep.

For the commercial/industrial land use scenario, the Oakland RBCA value is 9 hours. This is based on an outdoor, eight-hour work day with a one-hour lunch taken outside and on-site.

B.3.11 Exposure Time to Water Used for Recreation

Exposure time to water used for recreation is a measure of the duration of each exposure to contaminated water used for recreation. The Oakland RBCA values are based on a hypothetical, swimming scenario in which water pulled from an extraction well or nearby surface water body is used to fill a pool. The Oakland RBCA value for an adult assumes one hour of swimming per day; the Oakland RBCA value for a child assumes two hours of swimming per day (Technical Advisory Committee 1997).

ASTM (1995) does not consider this exposure scenario.

B.3.12 Groundwater Ingestion Rate
The groundwater ingestion rate is the amount of impacted groundwater that is ingested by an individual each day. Table B-36 compares the Oakland RBCA values for *groundwater ingestion rate* with the ASTM (1995) defaults.

Table B-36. Comparison of Oakland RBCA *Groundwater Ingestion Rate* Values with ASTM (1995) Defaults
(L/d)

Land Use Scenario	Oakland RBCA	ASTM Default
Residential	Child: 1[a]; Adult: 2[a]	2
Commercial/Industrial	1[b]	1

Source:
[a]U.S. EPA (1996)
[b]ASTM (1995)

The Oakland RBCA value for *groundwater ingestion rate* deviates from the ASTM (1995) default for the residential land use scenario because the potential for a child receptor is taken into account in the Oakland RBCA model. The Oakland RBCA value for a child under the residential land use scenario is 1 liter/day. This value is based on U.S. EPA (1989b; 1996) data. The Oakland RBCA value for an adult under the residential land use scenario is 2 liters/day. This value is based on both ASTM (1995) and U.S. EPA (1996) data.

Tap water consumption studies indicate that these values are very conservative. Cantor et al. (1987) calculate the mean tap water consumption to be 1.4 liters per day. The same study calculates the 99.99th percentile to be 2.0 liters per day (U.S. EPA 1989b).

The Oakland RBCA value for *groundwater ingestion rate* agrees with the ASTM (1995) default for the commercial/industrial land use scenario.

B.3.13 Indoor Air Exchange Rate
The indoor air exchange rate determines how much fresh air is exchanged with indoor air in buildings. Table B-37 compares the Oakland RBCA values for *indoor air exchange rate* with the ASTM (1995) defaults.

Table B-37. Comparison of Oakland RBCA *Indoor Air Exchange Rate* Values with ASTM Default (ACH*)

Land Use Scenario	Oakland RBCA	ASTM Default
Residential	2.0[a]	0.5
Commercial/Industrial	5.0[b]	0.83

*Air changes per hour (1 ACH = 0.00028 building volume exchanges/second)
Source:
[a]Sherman (1997)
[b]Hydeman (1996)

The Oakland RBCA values for *indoor air exchange rate* deviate from the ASTM (1995) defaults for both the residential and commercial/industrial land use scenarios.

The ASTM (1995) defaults are 0.00014 building volumes/second for the residential land use scenario and 0.00023 building volumes/second for the commercial/industrial land use scenario. These rates translate to 0.5 and 0.83 air changes per hour (ACH), respectively.

Because of Oakland's extremely temperate climate, the Oakland RBCA indoor air exchange rates are set higher than the ASTM (1995) defaults. For a residential land use scenario in California, a value of 2.0 ACH is considered reasonable (Sherman 1997). For a commercial/industrial land use scenario, a value of 5.0 ACH is employed because, when the outside temperature is between 60° F and 70° F, it is most efficient to use 100 percent fresh air for building ventilation (Hydeman 1996). Oakland temperatures are between 60° F and 70° F during the day for about six months of the year (National Climactic Data Center 1982).

B.3.14 Indoor Inhalation Rate

The indoor inhalation rate is the average volume of indoor air breathed per hour. Table B-38 compares the Oakland RBCA values for *indoor inhalation rate* with the ASTM (1995) defaults.

Table B-38. Comparison of Oakland RBCA Values for *Indoor Inhalation Rate* with ASTM (1995) Defaults (m^3/d)

Land Use Scenario	Oakland RBCA	ASTM Default
Residential	Child: 10[a]; Adult: 15[a]	15
Commercial/Industrial	20[a]	20

Source:
[a]U.S. EPA (1996; 1997)

The Oakland RBCA values for *indoor inhalation rate* deviates from the ASTM (1995) default for the residential land use scenario because the potential for a child receptor is taken into account in the Oakland RBCA model. The Oakland RBCA values are based on *Exposure Factors Handbook* (U.S. EPA 1997). They represent average inhalation rates that are supported by several field studies discussed in detail in U.S. EPA (1997).

B.3.15 Ingestion Rate of Water Used for Recreation

The ingestion rate while in water used for recreation is based on a hypothetical, swimming scenario. The U.S. EPA (1989b) recommends assuming an incidental ingestion rate while swimming of 50 ml/hr. U.S. EPA (1989b) advises that workers are not expected to be exposed via this pathway.

ASTM (1995) does not consider this exposure scenario.

B.3.16 Outdoor Inhalation Rate

The outdoor inhalation rate is the average volume of outdoor air breathed per hour. Table B-39 compares the Oakland RBCA values for *outdoor inhalation rate* with the ASTM (1995) defaults.

Table B-39. Comparison of Oakland RBCA Values for *Outdoor Inhalation Rate* with ASTM (1995) Defaults
(m^3/d)

Land Use Scenario	Oakland RBCA	ASTM Default
Residential	Child: 10[a]; Adult: 15[a]	15
Commercial/Industrial	20[a]	20

Source:
[a]U.S. EPA (1996)

The Oakland RBCA value for *outdoor inhalation rate* deviates from the ASTM (1995) default for the residential land use scenario because the potential for a child receptor is taken into account. The Oakland RBCA values are based on the *Region 9 PRGs* (U.S. EPA 1996) and the *Exposure Factors Handbook* (U.S. EPA 1997). They represent average inhalation rates that are supported by several field studies discussed in detail in U.S. EPA (1997).

B.3.17 Skin Surface Area Exposed to Soil

The skin surface area exposed to soil is used to estimate how much soil may come in contact with the skin and be absorbed through the skin. Table B-40 compares the Oakland RBCA values for *skin surface area exposed to soil* with the ASTM (1995) defaults.

Table B-40. Comparison of Oakland RBCA Values for *Skin Surface Area Exposed to Soil* with ASTM (1995) Defaults
(cm^2/d)

Land Use Scenario	Oakland RBCA	ASTM Default
Residential	Child: 2000[a]; Adult: 5000[a]	3160
Commercial/Industrial	5000[a]	3160

Source:
[a]U.S. EPA (1996)

The Oakland RBCA values for *skin surface area exposed to soil* deviate from the ASTM (1995) defaults for both the residential and commercial/industrial land use scenarios.

The Oakland RBCA values are conservative. U.S. EPA (1989b) reports that a "typical case" scenario for adults (i.e., exposed individual wears long-sleeve shirt, pants and shoes; exposed areas are head and hands) is 2000 cm^3 and a "worst case" scenario for adults (i.e., exposed individual wears short-sleeve shirt, shorts and shoes; exposed areas are head, hands, forearms and lower legs) is 5000 cm^3.

U.S. EPA (1997) provides a breakdown of skin surface area by body part for both adults and children.

B.3.18 Skin Surface Area Exposed to Water Used for Recreation

Skin surface area exposed to water used for recreation is the surface area of skin that comes in contact with contaminated water during recreational activity. Table B-41 compares the Oakland RBCA values for *skin surface area exposed to water used for recreation* with U.S. EPA (1989b) data on total skin surface area.

Table B-41. Comparison of Oakland RBCA Values for *Skin Surface Area Exposed to Water Used for Recreation* with U.S. EPA (1989b) Data on Total Skin Surface Area (cm^2)

Receptor	Oakland RBCA*	U.S. EPA (1989b) (50^{th} percentile)	U.S. EPA (1989b) (95th percentile)
Male Adult	20,000[a]	19,400	22,000
Female Adult	20,000[a]	16,900	19,800
Male Child	8,000[a]	7,280	8,420
Female Child	8,000[a]	7,110	8,790

*no distinction is made in the Oakland RBCA model between male and female receptors

Source:

[a]U.S. EPA (1996)

The Oakland RBCA values are conservative. They are based on a hypothetical, swimming scenario in which the exposed individual's entire body is submerged.

ASTM (1995) does not consider this exposure scenario.

B.3.19 Soil Ingestion Rate

Soil ingestion rate is a measure of the amount of surficial soil intentionally or inadvertently ingested each day. For adults, soil ingestion typically results from oral or nasal contact with dirt on the hands or face. For children, soil ingestion may also result from actually eating dirt. Table B-42 compares the Oakland RBCA values for *soil ingestion rate* with the ASTM (1995) defaults.

Table B-42. Comparison of Oakland RBCA Values for *Soil Ingestion Rate* with ASTM (1995) Defaults
(mg/d)

Land Use Scenario	Oakland RBCA	ASTM Default
Residential	Child: 200[a]; Adult: 100[a]	100
Commercial/Industrial	50[a]	50

Source:
[a]U.S. EPA (1996)

The Oakland RBCA value deviates from the ASTM (1995) default for the residential land use scenario because the potential for a child receptor is taken into account. The Oakland RBCA value for the commercial/industrial scenario agrees with the ASTM (1995) default.

The Oakland RBCA values are based on U.S. EPA (1996) recommendations and are very conservative. Various studies have attempted to estimate typical soil ingestion rates by measuring traces of soil elements found in the urine and fecal matter of study participants. Results have varied depending on the trace element measured.

Table B-43 compares the Oakland RBCA values with values calculated by the American Industrial Health Council (AIHC 1994) from data reported by Calabrese and Stanek (1991).

Table B-43. Comparison of Oakland RBCA Values for *Soil Ingestion Rate* with AIHC (1994) Data
(mg/d)

Receptor	Oakland RBCA	AIHC*
Child	200	0.1 - 10
Adult	100	16

*extrapolated from Calabrese and Stanek (1991)

B.4 TARGET RISK LEVELS

This section discusses the Oakland RBCA target risk levels for carcinogenic and non-carcinogenic health effects. Table B-44 presents the Oakland RBCA values and indicates which of these diverge from the ASTM (1995) defaults.

Table B-44. Oakland RBCA Target Risk Levels

Input Parameter	Tier 1	Tier 2
Individual Excess Lifetime Cancer Risk (IELCR)	10^{-6}*	10^{-5}
Hazard Quotient	1	1

*Oakland-specific value

The following subsections discuss in detail the selection of, and justification for, each of the target risk levels.

B.4.1 Individual Excess Lifetime Cancer Risk

The Oakland Tier 1 IELCR agrees with the ASTM (1995) default.

The Oakland Tier 2 IELCR deviates from the ASTM (1995) default but falls within the range of target risks recommended by ASTM (1995). There is considerable and diverse support for the use of a 1×10^{-5} IELCR target level:

- Local representatives of the agencies charged with enforcing environmental regulations in Oakland agreed unanimously to 10^{-5} at a meeting of the ULR Program Technical Advisory Committee (1996a).

- The ULR Program Community Review Panel has approved 10^{-5}. The Panel is made up of Oakland residents representing a cross-section of the Oakland community. The Panel includes individuals from: African American Development Association, GEI Consultants, People United for a Better Oakland, Northern California Minority Business Opportunity Committee, Sierra Club, Urban Habitat and Uribe & Associates Environmental Consulting Services. Their additional experience has included participation with: Alameda Naval Air Station Restoration Advisory Board, Chevron USA Refinery Community Advisory Panel, City of Oakland Planning Commission, Community Assistance Panel for Verdese Carter Park, Regional Brownfields Working Group, Oakland Army Base Restoration Advisory Board, Oakland Sharing the Vision, Oakland General Plan Congress and United Parents Against Lead. The Panel met twelve times between September 1996 and August 1997 to review the ULR Program. In its report, *Consensus Recommendations for Implementing the Oakland Urban Land Redevelopment Program*, the Panel recommends that:

  > **[a] cancer risk level not to exceed 10^{-5} should be employed to calculate cleanup levels, provided that the following conditions are met: (1) the chemicals of concern at the site in question are well-known and well-characterized; (2) the conservatism of the assumptions that are proposed for use in the ULR cleanup calculations (such as those for exposure duration, soil ingestion and drinking water consumption) are maintained, thereby effectively reducing the risk further; (3) whenever possible, engineering controls (such as vapor barriers or asphalt caps) are considered to eliminate exposure through certain pathways; and (4) a comprehensive and effective plan for protecting the public from any remaining concentrations of contaminants is prepared, implemented and enforced (ULR Program Community Review Panel 1997).**

- State Proposition 65 enforcement is based on 10^{-5}. The Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) requires the Governor of California to publish annually a list of chemicals known to the State to cause cancer or reproductive toxicity. All persons who operate a business that might expose individuals to a listed chemical must give a clear and reasonable warning to such individuals, unless there is "no significant risk" posed by the carcinogen(s) in question. The State has defined "no significant risk" as less than one excess case of cancer per 100,000 individuals (i.e., a 10^{-5} risk level).

- Several states across the nation are using a 10^{-5} target risk level in their RBCA screening level calculations, including: Alabama, Iowa, Michigan, Ohio, South Dakota, Texas and Utah.

- ASTM (1995) recommends 10^{-5}. The ASTM *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* states:

  Actuarial data and risk estimates of common human activities, regulatory precedents, and the relationship between the magnitude and variance of background and incremental risk estimates all provide compelling support for the adoption of the de minimis risk level of 1 x 10^{-5} for regulatory purposes (ASTM 1995).

- US EPA closes sites at 10^{-5}. 10^{-5} falls in the middle of the target risk level range used by US EPA on Superfund sites (10^{-4} to 10^{-6}). In addition, the US EPA has selected a single risk level of 10^{-5} in the *Hazardous Waste Management System Toxicity Characteristics Revisions* (1995). In their justification, the US EPA cited the following rationale:

  The chosen risk level of 10^{-5} is at the midpoint of the reference risk range for carcinogens (10^{-4} to 10^{-6}) generally used to evaluate CERCLA actions. Furthermore, by setting the risk level at 10^{-5} for TC carcinogens, EPA believes that this is the highest risk level that is likely to be experienced, and most if not all risks will be below this level due to the generally conservative nature of the exposure scenario and the underlying health criteria. For these reasons, the Agency regards a 10^{-5} risk level for Group A, B, and C carcinogens as adequate to delineate, under the Toxicity Characteristics, wastes that clearly pose a hazard when mismanaged.

Like the EPA model, the Oakland RBCA approach for carcinogenic health effects embodies several conservative assumptions, such that the actual risk experienced by an exposed individual is likely to be considerably less than the target level.

B.4.2 Hazard Quotient

For non-carcinogenic health effects, the Oakland RBCA approach applies a target hazard quotient of 1, based on the precedent set in the Risk Assessment Guidance for Superfund (RAGS) (U.S. EPA 1989a).

The RAGS approach estimates the likelihood of non-carcinogenic health effects (e.g., temporary respiratory difficulties or liver toxicity) by use of the threshold/hazard quotient method. Unlike the method used for carcinogenic risk estimation, non-cancer toxicity risk is not based on a probability of occurrence. Rather, the likelihood of an adverse health effect is estimated by establishing a threshold of exposure below which even the most sensitive members of a population will not suffer adverse health effects. (The Oakland RBCA approach assumes that the receptor is always a young child.) This threshold, or "safe" level of exposure, is established experimentally by research on laboratory animals or humans participating in epidemiological investigations. If the hazard quotient ratio is less than one (i.e., if the estimated exposure to the chemical of concern is below the safe threshold for that chemical), then it is assumed that no adverse health effects occur.

The Oakland RBCA approach for non-carcinogenic health effects embodies several conservative assumptions (e.g., that the residential receptor is always a young child), such that the actual risk experienced by an exposed individual is likely to be considerably less than the target level.

B.5 CHEMICAL-SPECIFIC PARAMETERS

Table B-45 presents the chemical-specific parameter values used in the Oakland RBCA calculations (see next page).

Table B-45. Oakland RBCA Chemical Properties

Parameter	Units	Acenaph-thene	Acenaph-thylene	Acetone	Anthra-cene	Arsenic	Barium	Benz(a)-anthracene	Benzene
CAS Number	-	83-32-9	208-96-8	67-64-1	120-12-7	7440-38-2	7440-39-3	56-55-3	71-43-2
Toxicity Data									
Slope Factor Oral	1/(mg/kg-d)	ND	ND	ND	ND	1.50E+00	ND	1.20E+00	1.00E-01
Slope Factor Inhalation	1/(mg/kg-d)	ND	ND	ND	ND	1.20E+01	ND	3.90E+00	1.00E-01
RfD Oral	mg/kg-d	6.00E-02	6.00E-02	1.00E-01	3.00E-01	3.00E-04	7.00E-02	ND	1.70E-03
RfD Inhalation	mg/kg-d	6.00E-02	6.00E-02	1.00E-01	3.00E-01	ND	1.40E-04	ND	1.70E-03
Absorption Adjustment Factor: Oral-Soil	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Oral-Water	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Dermal-Soil	-	1.00E-01	1.00E-01	1.00E-01	1.00E-01	3.00E-02	1.00E-02	1.00E-01	1.00E-01
Absorption Adjustment Factor: Dermal-Wat	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Inhalation	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Skin Permeability Coefficient	cm/hr	1.50E-01	9.60E-02	5.69E-04	2.20E-01	1.00E-03	1.00E-03	8.10E-01	2.10E-02
Maximum Contaminant Levels (MCLs)	mg/L	ND	ND	ND	ND	5.00E-02	1.00E+00	ND	1.00E-03
Fate and Transport Parameters									
Solubility	mg/L	4.24E+00	3.93E+00	1.00E+06	4.34E-02	ND	ND	9.40E-03	1.75E+03
Henry's Law Constant (no NDs)	-	6.36E-03	4.67E-03	1.59E-03	2.67E-03	0.00E+00	0.00E+00	1.37E-04	2.28E-01
Koc (for organics, ND for inorganics)	ml/g	7.08E+03	4.79E+03	5.75E-01	2.95E+04	ND	ND	3.98E+05	5.89E+01
Kd (partition coefficient for inorganics)	ml/g	ND	ND	ND	ND	2.90E+01	4.10E+01	ND	ND
Diffusion Coeff. in Air	cm^2/s	4.21E-02	5.40E-02	1.24E-01	3.24E-02	ND	ND	5.10E-02	8.80E-02
Diffusion Coefficient in Water	cm^2/s	7.69E-06	6.60E-06	1.14E-05	7.74E-06	ND	ND	9.00E-06	9.80E-06

Table B-45. Oakland RBCA Chemical Properties

Parameter	Units	Benzo(a)-pyrene	Benzo(b)-fluoranthene	Benzo(g,h,I)-perylene	Benzo(k)-fluoranthene	Beryllium	Bis(2-ethylhexyl) phthalate	Butyl benzyl phthalate
CAS Number	-	50-32-8	205-99-2	191-24-2	207-08-9	7440-41-7	117-81-7	85-68-7
Toxicity Data								
Slope Factor Oral	1/(mg/kg-d)	1.20E+01	1.20E+00	ND	1.20E+00	ND	8.40E-03	ND
Slope Factor Inhalation	1/(mg/kg-d)	3.90E+00	3.90E-01	ND	3.90E-01	7.00E+00	8.40E-03	ND
RfD Oral	mg/kg-d	ND	ND	4.00E-03	ND	5.00E-03	2.00E-02	2.00E-01
RfD Inhalation	mg/kg-d	ND	ND	4.00E-03	ND	ND	2.20E-02	ND
Absorption Adjustment Factor: Oral-Soil	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Oral-Water	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Dermal-Soil	-	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-02	1.00E-01	1.00E-01
Absorption Adjustment Factor: Dermal-Wat	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Inhalation	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Skin Permeability Coefficient	cm/hr	1.20E+00	1.20E+00	1.66E+00	1.10E+00	1.00E-03	3.30E-02	7.40E-02
Maximum Contaminant Levels (MCLs)	mg/L	2.00E-04	ND	ND	ND	4.00E-03	ND	ND
Fate and Transport Parameters								
Solubility	mg/L	1.62E-03	1.50E-03	2.60E-04	8.00E-04	ND	3.40E-01	2.69E+00
Henry's Law Constant (no NDs)	-	4.63E-05	4.55E-03	1.09E-05	3.40E-05	0.00E+00	4.18E-06	5.17E-05
Koc (for organics, ND for inorganics)	ml/g	1.02E+06	1.23E+06	7.76E+06	1.23E+06	ND	1.51E+07	5.75E+04
Kd (partition coefficient for inorganics)	ml/g	ND	ND	ND	ND	7.90E+02	ND	ND
Diffusion Coeff. in Air	cm^2/s	4.30E-02	2.26E-02	4.10E-02	2.26E-02	ND	3.51E-02	3.90E-02
Diffusion Coefficient in Water	cm^2/s	9.00E-06	5.56E-06	4.90E-06	5.56E-06	ND	3.66E-06	7.03E-06

Table B-45. Oakland RBCA Chemical Properties

Parameter	Units	Cadmium	Carbon Disulfide	Carbon Tetrachloride	Chloro-benzene	Chloroform	Chromium (III)	Chromium (VI)	Chrysene
CAS Number	-	7440-43-9	75-15-0	56-23-5	108-90-7	67-66-3	7440-47-2	7440-47-3	218-01-9
Toxicity Data									
Slope Factor Oral	1/(mg/kg-d)	ND	ND	1.50E-01	ND	3.10E-02	ND	4.20E-01	1.20E-01
Slope Factor Inhalation	1/(mg/kg-d)	1.50E+01	ND	1.50E-01	ND	1.90E-02	ND	5.10E+02	3.90E-02
RfD Oral	mg/kg-d	5.00E-04	1.00E-01	7.00E-04	2.00E-02	1.00E-02	1.00E+00	5.00E-03	ND
RfD Inhalation	mg/kg-d	5.00E-04	2.90E-03	5.71E-04	5.70E-03	1.00E-02	1.00E+00	ND	ND
Absorption Adjustment Factor: Oral-Soil	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Oral-Water	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Dermal-Soil	-	1.00E-02	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-02	1.00E-02	1.00E-01
Absorption Adjustment Factor: Dermal-Wat	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Inhalation	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Skin Permeability Coefficient	cm/hr	1.00E-03	2.40E-02	2.20E-02	4.10E-02	8.90E-03	1.30E-03	1.30E-03	8.10E-01
Maximum Contaminant Levels (MCLs)	mg/L	5.00E-03	ND	5.00E-04	7.00E-02	1.00E-01	ND	5.00E-02	ND
Fate and Transport Parameters									
Solubility	mg/L	ND	1.19E+03	7.93E+02	4.72E+02	7.92E+03	ND	ND	1.60E-03
Henry's Law Constant (no NDs)	-	0.00E+00	5.92E-01	1.25E+00	1.52E-01	1.50E-01	0.00E+00	0.00E+00	3.88E-03
Koc (for organics, ND for inorganics)	ml/g	ND	4.57E+01	1.74E+02	2.19E+01	3.98E+01	ND	ND	3.98E+05
Kd (partition coefficient for inorganics)	ml/g	7.50E+01	ND	ND	ND	ND	1.80E+06	1.90E+01	ND
Diffusion Coeff. in Air	cm^2/s	ND	1.04E-01	7.80E-02	7.30E-01	1.04E-01	ND	ND	2.48E-02
Diffusion Coefficient in Water	cm^2/s	ND	1.00E-05	8.80E-06	8.70E-06	1.00E-05	ND	ND	6.21E-06

Table B-45. Oakland RBCA Chemical Properties

Parameter	Units	Copper	Cresol(-m)	Cresol(-o)	Cresol(-p)	Cyanide	Dibenz(a,h) anthracene	Dichloro ethane (1,1-)	Dichloro ethane (1,2-) (EDC)
CAS Number	-	7440-50-8	108-39-4	95-48-7	106-44-5	57-12-5	53-70-3	75-34-3	107-06-2
Toxicity Data									
Slope Factor Oral	1/(mg/kg-d)	ND	ND	ND	ND	ND	4.10E+00	5.70E-03	7.00E-02
Slope Factor Inhalation	1/(mg/kg-d)	ND	ND	ND	ND	ND	4.10E+00	5.70E-03	7.00E-02
RfD Oral	mg/kg-d	3.70E-02	5.00E-02	5.00E-02	5.00E-03	4.00E-02	ND	1.00E-01	2.90E-03
RfD Inhalation	mg/kg-d	ND	5.00E-02	5.00E-02	5.00E-03	ND	ND	1.40E-01	2.90E-03
Absorption Adjustment Factor: Oral-Soil	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Oral-Water	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Dermal-Soil	-	1.00E-02	1.00E-01	1.00E-01	1.00E-01	1.00E-02	1.00E-01	1.00E-01	1.00E-01
Absorption Adjustment Factor: Dermal-Wat	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Inhalation	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Skin Permeability Coefficient	cm/hr	1.00E-03	1.50E-02	1.60E-02	1.80E-02	1.00E-02	2.70E+00	8.90E-03	5.30E-03
Maximum Contaminant Levels (MCLs)	mg/L	1.30E+00	ND	ND	ND	2.00E-01	ND	5.00E-03	5.00E-04
Fate and Transport Parameters									
Solubility	mg/L	ND	2.27E+04	2.60E+04	3.53E+04	ND	2.49E-03	5.06E+03	8.52E+03
Henry's Law Constant (no NDs)	-	0.00E+00	3.55E-05	4.92E-05	4.10E-05	0.00E+00	6.03E-07	2.30E-01	4.01E-02
Koc (for organics, ND for inorganics)	ml/g	ND	8.71E+01	9.12E+01	8.13E+01	ND	3.80E+06	3.16E+01	1.74E+01
Kd (partition coefficient for inorganics)	ml/g	0.00E+00	ND	ND	ND	9.90E+00	ND	ND	ND
Diffusion Coeff. in Air	cm^2/s	ND	7.40E-02	7.40E-02	7.40E-02	ND	2.02E-02	7.42E-02	1.04E-01
Diffusion Coefficient in Water	cm^2/s	ND	1.00E-05	8.30E-06	1.00E-05	ND	5.18E-06	1.05E-05	9.90E-06

Table B-45. Oakland RBCA Chemical Properties

Parameter	Units	Dichloro ethylene (1,1-)	Dichloro ethylene (cis 1,2-)	Dichloro ethene (trans 1,2)	Dimethyl-benza(a) anthracene (7,12)	Dimethyl phenol (2,4)	di-n-Butyl-phthalate	di-n-octyl phthalate
CAS Number	-	75-34-4	156-59-2	156-60-5	57-97-6	105-67-9	84-74-2	117-84-0
Toxicity Data								
Slope Factor Oral	1/(mg/kg-d)	6.00E-01	ND	ND	ND	ND	ND	ND
Slope Factor Inhalation	1/(mg/kg-d)	1.80E-01	ND	ND	ND	ND	ND	ND
RfD Oral	mg/kg-d	9.00E-03	1.00E-02	2.00E-02	3.00E-02	2.00E-02	1.00E-01	2.00E-02
RfD Inhalation	mg/kg-d	9.00E-03	1.00E-02	2.00E-02	ND	2.00E-02	1.00E-01	2.00E-02
Absorption Adjustment Factor: Oral-Soil	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Oral-Water	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Dermal-Soil	-	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
Absorption Adjustment Factor: Dermal-Wat	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Inhalation	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Skin Permeability Coefficient	cm/hr	1.60E-02	1.00E-02	1.00E-02	1.20E+00	1.50E-02	3.30E-02	2.70E+01
Maximum Contaminant Levels (MCLs)	mg/L	6.00E-03	6.00E-03	1.00E-02	ND	ND	ND	ND
Fate and Transport Parameters								
Solubility	mg/L	2.25E+03	3.50E+03	6.30E+03	6.10E-02	7.87E+03	1.12E+01	2.90E-01
Henry's Law Constant (no NDs)	-	1.07E+00	1.67E-01	3.85E-01	1.28E-06	8.20E-05	3.85E-08	7.50E-09
Koc (for organics, ND for inorganics)	ml/g	5.89E+01	3.55E+01	5.25E+01	4.80E+05	2.09E+02	8.32E+07	1.10E+05
Kd (partition coefficient for inorganics)	ml/g	ND	ND	ND	ND	ND	ND	ND
Diffusion Coeff. in Air	cm^2/s	9.00E-02	7.36E-02	7.07E-02	4.60E-02	5.84E-02	1.51E-02	3.70E-02
Diffusion Coefficient in Water	cm^2/s	1.04E-05	1.13E-05	1.19E-05	5.00E-06	8.69E-06	3.58E-06	4.00E-05

Table B-45. Oakland RBCA Chemical Properties

Parameter	Units	Dinitro toluene (2,4)	Dioxane (1,4)	Ethyl-benzene	Ethylene Dibromide	Fluoran-thene	Fluorene	Indeno-(1,2,3-CD) pyrene
CAS Number	-	121-14-2	123-91-1	100-41-4	106-93-4	206-44-0	86-73-7	193-39-5
Toxicity Data								
Slope Factor Oral	1/(mg/kg-d)	3.10E-01	2.70E-02	ND	3.60E+00	ND	ND	1.20E+00
Slope Factor Inhalation	1/(mg/kg-d)	3.10E-01	2.70E-02	ND	2.50E-01	ND	ND	3.90E-01
RfD Oral	mg/kg-d	ND	ND	1.00E-01	5.70E-05	4.00E-02	4.00E-02	ND
RfD Inhalation	mg/kg-d	ND	ND	2.90E-01	5.70E-05	4.00E-02	4.00E-02	ND
Absorption Adjustment Factor: Oral-Soil	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Oral-Water	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Dermal-Soil	-	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
Absorption Adjustment Factor: Dermal-Wat	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Inhalation	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Skin Permeability Coefficient	cm/hr	3.80E-03	3.60E-04	7.40E-02	3.30E-03	3.60E-01	3.60E-01	1.90E+00
Maximum Contaminant Levels (MCLs)	mg/L	ND	ND	7.00E-01	5.00E-05	ND	ND	ND
Fate and Transport Parameters								
Solubility	mg/L	2.70E+02	1.10E-02	1.69E+02	4.30E+03	2.06E-01	1.98E+00	2.20E-05
Henry's Law Constant (no NDs)	-	3.80E-06	1.10E-02	3.23E-01	2.89E-02	6.60E-04	2.61E-03	6.56E-05
Koc (for organics, ND for inorganics)	ml/g	9.55E+01	1.70E+01	3.63E+02	4.37E+01	1.07E+05	1.38E+04	3.47E+06
Kd (partition coefficient for inorganics)	ml/g	ND	ND	ND	ND	ND	ND	ND
Diffusion Coeff. in Air	cm^2/s	2.03E-01	2.30E-01	7.50E-02	5.00E-02	3.02E-02	3.63E-02	1.90E-02
Diffusion Coefficient in Water	cm^2/s	7.06E-06	1.00E-05	7.80E-06	9.60E-06	6.35E-06	7.88E-06	5.66E-06

Table B-45. Oakland RBCA Chemical Properties

Parameter	Units	Mercury	Methanol	Methyl ethyl ketone	Methylene Chloride	Methyl-napthalene (2-)	MTBE	Naphthalene
CAS Number	-	7439-97-6	67-56-1	78-93-3	75-09-2	91-57-6	1634-04-4	91-20-3
Toxicity Data								
Slope Factor Oral	1/(mg/kg-d)	ND	ND	ND	1.40E-02	ND	ND	ND
Slope Factor Inhalation	1/(mg/kg-d)	ND	ND	ND	3.50E-03	ND	ND	ND
RfD Oral	mg/kg-d	1.00E-04	5.00E-01	6.00E-01	6.00E-02	4.00E-02	5.00E-03	4.00E-02
RfD Inhalation	mg/kg-d	8.57E-05	5.00E-01	2.90E-01	8.60E-01	4.00E-02	8.57E-01	4.00E-02
Absorption Adjustment Factor: Oral-Soil	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Oral-Water	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Dermal-Soil	-	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
Absorption Adjustment Factor: Dermal-Wat	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Inhalation	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Skin Permeability Coefficient	cm/hr	1.67E-03	3.50E-04	5.00E-03	4.50E-03	1.80E-01	3.08E-03	6.90E-02
Maximum Contaminant Levels (MCLs)	mg/L	2.00E-03	ND	ND	5.00E-03	ND	1.30E-02	2.00E-02
Fate and Transport Parameters								
Solubility	mg/L	ND	1.00E+06	2.12E+05	1.30E+04	2.46E+01	4.80E+04	3.10E+01
Henry's Law Constant (no NDs)	-	4.67E-01	1.87E-04	2.33E-03	8.98E-02	2.12E-02	2.04E-02	1.98E-02
Koc (for organics, ND for inorganics)	ml/g	ND	0.00E+00	4.50E+00	1.17E+01	8.50E+03	1.20E+01	2.00E+03
Kd (partition coefficient for inorganics)	ml/g	5.20E+01	ND	ND	ND	ND	ND	ND
Diffusion Coeff. in Air	cm^2/s	3.07E-02	1.55E-01	8.08E-02	1.01E-01	5.80E-02	7.10E-02	5.90E-02
Diffusion Coefficient in Water	cm^2/s	6.30E-06	1.64E-05	9.80E-06	1.17E-05	7.37E-06	9.04E-06	7.50E-06

Table B-45. Oakland RBCA Chemical Properties

Parameter	Units	Nickel	Nitro benzene	PCBs	Phenan-threne	Phenol	Pyrene	Pyridine	Selenium
CAS Number	-	7440-02-0	98-95-3	1336-36-3	85-01-8	108-95-2	129-00-0	110-86-1	7782-49-2
Toxicity Data									
Slope Factor Oral	1/(mg/kg-d)	ND	5.00E-04	7.70E+00	ND	ND	ND	1.00E-03	ND
Slope Factor Inhalation	1/(mg/kg-d)	9.10E-01	5.70E-04	7.70E+00	ND	ND	ND	1.00E-03	ND
RfD Oral	mg/kg-d	2.00E-02	ND	2.00E-05	3.00E-01	6.00E-01	3.00E-02	ND	5.00E-03
RfD Inhalation	mg/kg-d	ND	ND	2.00E-05	3.00E-01	6.00E-01	3.00E-02	ND	ND
Absorption Adjustment Factor: Oral-Soil	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Oral-Water	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Dermal-Soil	-	1.00E-02	1.00E-01	6.00E-02	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-02
Absorption Adjustment Factor: Dermal-Wat	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Inhalation	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Skin Permeability Coefficient	cm/hr	1.00E-03	7.00E-03	1.30E+00	2.70E-01	5.50E-03	3.24E-01	1.80E-03	1.00E-03
Maximum Contaminant Levels (MCLs)	mg/L	1.00E-01	ND	5.00E-04	ND	ND	ND	ND	5.00E-02
Fate and Transport Parameters									
Solubility	mg/L	1.73E+05	2.09E+03	4.20E-01	1.29E+00	8.28E+04	1.35E-01	1.00E+06	ND
Henry's Law Constant (no NDs)	-	0.00E+00	9.84E-04	1.11E-02	1.60E-03	1.63E-05	4.51E-04	4.51E-04	0.00E+00
Koc (for organics, ND for inorganics)	ml/g	ND	6.46E+01	3.09E+05	2.29E+04	2.88E+01	1.05E+05	5.38E+01	ND
Kd (partition coefficient for inorganics)	ml/g	6.50E+01	ND	ND	ND	ND	ND	ND	5.00E+00
Diffusion Coeff. in Air	cm^2/s	ND	7.60E-02	1.04E-01	5.17E-02	8.20E-02	2.72E-02	9.10E-02	ND
Diffusion Coefficient in Water	cm^2/s	ND	8.60E-05	1.00E-05	5.90E-06	9.10E-06	7.24E-06	7.60E-06	ND

Table B-45. Oakland RBCA Chemical Properties

Parameter	Units	Silver	Stryene	Tetrachloro ethane (1,1,2,2 -)	Tetrachloro-ethylene (PCE)	Tetraethyl Lead	Toluene	Trichloro ethane (1,1,1-)
CAS Number	-	7440-22-4	100-42-5	79-34-5	127-18-4	78-00-2	108-88-3	71-55-6
Toxicity Data								
Slope Factor Oral	1/(mg/kg-d)	ND	ND	2.70E-01	5.10E-02	ND	ND	ND
Slope Factor Inhalation	1/(mg/kg-d)	ND	ND	2.70E-01	2.10E-02	ND	ND	ND
RfD Oral	mg/kg-d	5.00E-03	2.00E-01	2.60E-02	1.00E-02	1.00E-07	2.00E-01	3.50E-02
RfD Inhalation	mg/kg-d	ND	2.86E-01	2.60E-02	1.00E-02	ND	1.14E-01	2.90E-01
Absorption Adjustment Factor: Oral-Soil	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Oral-Water	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Dermal-Soil	-	1.00E-02	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
Absorption Adjustment Factor: Dermal-Wat	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Inhalation	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Skin Permeability Coefficient	cm/hr	6.00E-04	5.50E-02	9.00E-03	4.80E-02	3.60E-02	4.50E-02	1.70E-02
Maximum Contaminant Levels (MCLs)	mg/L	1.00E-01	1.00E-01	1.00E-03	5.00E-03	1.50E-02	1.50E-01	2.00E-01
Fate and Transport Parameters								
Solubility	mg/L	ND	3.10E+02	2.97E+03	2.00E+02	2.10E-01	5.26E+02	1.33E+03
Henry's Law Constant (no NDs)	-	0.00E+00	1.13E-01	1.41E-02	7.54E-01	2.33E+01	2.72E-01	7.05E-01
Koc (for organics, ND for inorganics)	ml/g	ND	7.76E+02	9.33E+01	1.55E+02	4.90E+03	1.82E+02	1.10E+02
Kd (partition coefficient for inorganics)	ml/g	8.30E+00	ND	ND	ND	ND	ND	ND
Diffusion Coeff. in Air	cm^2/s	ND	7.10E-02	7.10E-02	7.20E-02	5.70E-02	8.70E-02	7.80E-02
Diffusion Coefficient in Water	cm^2/s	ND	8.00E-06	7.90E-06	8.20E-06	6.40E-06	8.60E-06	8.80E-06

Table B-45. Oakland RBCA Chemical Properties

Parameter	Units	Trichloro ethane (1,1,2-)	Trichloro-ethylene (TCE)	Vanadiu m	Vinyl Chloride	Xylenes	Zinc
CAS Number	-	79-00-5	79-01-6	7440-62-2	75-01-4	1330-20-7	7440-66-6
Toxicity Data							
Slope Factor Oral	1/(mg/kg-d)	7.20E-02	1.50E-02	ND	2.70E-01	ND	ND
Slope Factor Inhalation	1/(mg/kg-d)	7.20E-02	1.00E-02	ND	2.70E-01	ND	ND
RfD Oral	mg/kg-d	4.00E-03	6.00E-03	7.00E-03	ND	2.00E+00	3.00E-01
RfD Inhalation	mg/kg-d	4.00E-03	6.00E-03	ND	ND	2.00E-01	ND
Absorption Adjustment Factor: Oral-Soil	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Oral-Water	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Dermal-Soil	-	1.00E-01	1.00E-01	1.00E-02	1.00E-01	1.00E-01	1.00E-02
Absorption Adjustment Factor: Dermal-Wat	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Absorption Adjustment Factor: Inhalation	-	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Skin Permeability Coefficient	cm/hr	8.40E-03	2.30E-01	1.00E-03	7.30E-03	8.00E-02	6.00E-04
Maximum Contaminant Levels (MCLs)	mg/L	5.00E-03	5.00E-03	ND	5.00E-04	1.75E+00	ND
Fate and Transport Parameters							
Solubility	mg/L	4.42E+03	1.10E+03	ND	2.67E+03	1.98E+02	ND
Henry's Law Constant (no NDs)	-	3.74E-02	4.22E-01	0.00E+00	1.11E+00	2.90E-01	0.00E+00
Koc (for organics, ND for inorganics)	ml/g	5.01E+01	1.66E+02	ND	1.86E+01	2.40E+02	ND
Kd (partition coefficient for inorganics)	ml/g	ND	ND	1.00E+03	ND	ND	6.20E+01
Diffusion Coeff. in Air	cm^2/s	7.80E-02	7.90E-02	ND	1.06E-01	7.20E-02	ND
Diffusion Coefficient in Water	cm^2/s	8.80E-06	9.10E-06	ND	1.23E-05	8.50E-06	ND

The following subsections present the source(s) for each of the chemical-specific parameter values.

B.5.1 Slope Factors
For oral and inhalation slope factors, data from the following sources are used (in order of preference):

1. *California Cancer Potency Factors* (California Environmental Protection Agency 1994)
2. *Region 9 Preliminary Remediation Goals* (U.S. EPA 1996)

For all chemicals, the dermal slope factor is assumed to be equal to the oral slope factor.

B.5.2 Reference Doses
For oral and inhalation reference doses, data from the *Region 9 PRGs* (U.S. EPA 1996) are used. The dermal reference dose is assumed to be equal to the oral reference dose.

B.5.3 Absorption Adjustment Factors
For absorption adjustment factors for dermal contact with soil, data from the *Region 9 PRGs* (U.S. EPA 1996) are used. The absorption adjustment factor for dermal contact with soil is 0.1 for all organics, with the exception of arsenic (0.03) and PCBs (0.06), and 0.01 for all inorganics.

All other absorption adjustment factors are set equal to 1.

B.5.4 Skin Permeability Coefficients
For skin permeability coefficients, data from *Dermal Exposure Assessment: Principles and Applications* (U.S. EPA 1992) are used.

B.5.5 Maximum Contaminant Levels
For MCLs, the California Department of Health Services (1999) values are used.

B.5.6 Solubility
For solubility, data from the following sources are used (in order of preference):

1. *Soil Screening Guidance* (U.S. EPA 1996)
2. *Handbook of Physical Properties of Organic Chemicals* (Howard and Meylan 1997)

B.5.7 Henry's Law Constant
For Henry's Law Constant, data from the following sources are used (in order of preference):

1. *Soil Screening Guidance* (U.S. EPA 1996)
2. *Handbook of Physical Properties of Organic Chemicals* (Howard and Meylan 1997)
3. *Handbook of Fate and Exposure Data for Organic Chemicals (Volumes 1 - 3)* (Howard 1989)

B.5.8 Organic Carbon Partition Coefficient
For the organic carbon partition coefficient, K_{oc}, data from the following sources are used (in order of preference):

1. *Soil Screening Guidance* (U.S. EPA 1996)
2. *Handbook of Fate and Exposure Data for Organic Chemicals (Volumes 1 - 3)* (Howard 1989)

B.5.9 Partition Coefficient for Inorganics
For inorganic chemicals, although the K_{oc} is set equal to zero, sorption is still accounted for by employing the partition coefficient, K_s (also commonly written as K_d). Data for K_s are from *Soil Screening Guidance* (U.S. EPA 1996) and are based on a pH value of 6.8. For chemicals not listed therein, the K_s is assumed to be zero (i.e., no sorption occurs).

B.5.10 Diffusion Coefficients
For diffusion coefficients in air and water, data from the following sources are used (in order of preference):

1. *Soil Screening Guidance* (U.S. EPA 1996)
2. *Hazardous Waste Treatment, Storage and Disposal Facilities (TSDF) –Air Emission Models* (U.S. EPA 1987)

This appendix presents a sensitivity analysis for all the input parameters employed in the Oakland RBCA equations. The tables contained herein identify:

(1) the exposure pathway(s) that each input parameter affects
(2) the mathematical relationship between the input parameter value and the RBCA level

For purposes of this discussion, a "parallel" relationship means that the higher or lower the input parameter value, the higher or lower the resultant RBCA level. An "inverse" relationship means that the higher the input parameter value, the lower the resultant RBCA level, and vice versa.

C.1 SOIL-SPECIFIC TRANSPORT PARAMETERS

Table C-1 presents the exposure pathways affected by each of the Oakland RBCA soil-specific transport parameters and their mathematical relationship to the calculated RBCA level.

Table C-1. Sensitivity Analysis of Soil-Specific Transport Parameters

Input Parameter	Affected Pathways	Relationship
Capillary fringe air content	▸ Groundwater: inhalation of indoor and outdoor air	Inverse
Capillary fringe water content	▸ Groundwater: inhalation of indoor and outdoor air	Parallel
Capillary fringe thickness	▸ Groundwater: inhalation of indoor and outdoor air	Parallel
Fraction organic carbon in soil (F_{oc})*	▸ Surficial soil and subsurface soil: all ▸ Groundwater: inhalation of indoor and outdoor air	Parallel
Groundwater Darcy velocity	▸ Subsurface soil: ingestion of groundwater impacted by leachate	Parallel
Groundwater mixing zone thickness	▸ Subsurface soil: ingestion of groundwater impacted by leachate	Parallel
Infiltration rate through the vadose zone	▸ Subsurface soil: ingestion of groundwater impacted by leachate	Inverse
Soil bulk density	▸ Surficial and subsurface soil: all	Inverse
Soil to skin adherence factor	▸ Surficial soil	Inverse
Total soil porosity	▸ Surficial soil and subsurface soil: all	NA[a]
Vadose zone air content	▸ Surficial soil ▸ Subsurface soil and groundwater: inhalation of indoor and outdoor air	Inverse
Vadose zone water content	▸ Surficial soil ▸ Subsurface soil and groundwater: inhalation of indoor and outdoor air	Parallel
Vadose zone thickness	▸ Groundwater: inhalation of indoor and outdoor air	Parallel

[a]Not applicable: total soil porosity does not affect the RBCA levels—air and water content do.

C.2 NON-SOIL-SPECIFIC TRANSPORT PARAMETERS

Table C-2 presents the exposure pathways affected by each of the Oakland RBCA non-soil-specific transport parameters and their mathematical relationship to the calculated RBCA level.

Table C-2. Sensitivity Analysis of Non-Soil-Specific Transport Parameters

Input Parameter	Affected Pathways	Relationship
Areal fraction of cracks in building foundation	‣ Subsurface soil and groundwater: inhalation of indoor air	Inverse
Foundation cracks air content	‣ Subsurface soil and groundwater: inhalation of indoor air	Inverse
Foundation cracks water content	‣ Subsurface soil and groundwater: inhalation of indoor air	Parallel
Foundation thickness	‣ Subsurface soil and groundwater: inhalation of indoor air	Parallel
Lower depth of surficial soil zone	‣ Surficial soil	Inverse[a]
Depth to subsurface soil sources	‣ Subsurface soil: inhalation of indoor air	Parallel
Depth to groundwater	‣ Surficial soil ‣ Subsurface soil and groundwater: inhalation of indoor and outdoor air	Parallel
Width of source area parallel to wind or groundwater flow direction	‣ Surficial soil, subsurface soil and groundwater: all pathways	Inverse
Outdoor air mixing zone height	‣ Subsurface soil and groundwater: inhalation of outdoor air	Parallel
Particulate emission rate	‣ Surficial soil	Inverse
Wind speed above ground surface in outdoor air mixing zone	‣ Subsurface soil and groundwater: inhalation of outdoor air	Parallel

[a]Affects RBCA level only for highly-volatile chemicals

C.3 RECEPTOR-SPECIFIC PARAMETERS

Table C-3 presents the exposure pathways affected by each of the Oakland RBCA receptor-specific parameters and their mathematical relationship to the calculated RBCA level.

Table C-3. Sensitivity Analysis of Receptor-Specific Parameters

Input Parameter	Affected Pathways	Relationship
Averaging time for carcinogenic effects	‣ All pathways	Inverse[a]
Averaging time for non-carcinogenic effects	‣ All pathways	NA[b]
Averaging time for vapor flux	‣ Surficial soil	Parallel
Body weight	‣ All pathways	Parallel
Building air volume/floor area	‣ Subsurface soil and groundwater: inhalation of indoor air	Parallel
Exposure duration	‣ All pathways	Inverse[c]
Exposure frequency	‣ All pathways	Inverse
Exposure frequency to water used for recreation	‣ Water used for recreation	Inverse
Exposure time to indoor air	‣ Subsurface soil and groundwater: inhalation of indoor air	Inverse
Exposure time to outdoor air	‣ Surficial soil ‣ Subsurface soil and groundwater: inhalation of outdoor air	Inverse
Exposure time to water used for recreation	‣ Water used for recreation	Inverse
Groundwater ingestion rate	‣ Groundwater: ingestion	Inverse
Indoor air exchange rate	‣ Subsurface soil and groundwater: inhalation of indoor air	Parallel
Indoor inhalation rate	‣ Subsurface soil and groundwater: inhalation of indoor air	Inverse
Ingestion rate of water used for recreation	‣ Water used for recreation	Inverse
Outdoor inhalation rate	‣ Surficial soil ‣ Subsurface soil and groundwater: inhalation of outdoor air	Inverse
Skin surface area exposed to soil	‣ Surficial soil	Inverse
Skin surface area exposed to water used for recreation	‣ Water used for recreation	Inverse
Soil ingestion rate	‣ Surficial soil	Inverse

[a]The input value for *averaging time for carcinogenic effects* is effectively fixed since all toxicity data is based on 70 years.
[b]Not applicable; *averaging time for non-carcinogenic effects* cancels out with *exposure duration.*
[c]Applies only to RBCA levels for carcinogens; for non-carcinogens, the input value for *exposure duration* cancels out with the input value for *averaging time for non-carcinogenic effects*.

C.4 TARGET RISK LEVELS

Table C-4 presents the exposure pathways affected by each of the Oakland RBCA target risk levels parameters and their mathematical relationship to the calculated RBCA level.

Table C-4. Sensitivity Analysis of Target Risk Levels

Input Parameter	Affected Pathways	Relationship
Individual Excess Lifetime Cancer Risk (IELCR)	‣ All	Parallel
Hazard Quotient	‣ All	Parallel

C.5 CHEMICAL-SPECIFIC PARAMETERS

Table C-5 presents the exposure pathways affected by each of the Oakland RBCA chemical-specific parameters and their mathematical relationship to the calculated RBCA level.

Table C-5. Sensitivity Analysis of Chemical-Specific Parameters

Input parameter	Affected Pathways	Relationship
Slope factors	‣ All	Inverse
Reference doses	‣ All	Parallel
Absorption adjustment factors	‣ Surficial soil[a]	Inverse
Skin permeability coefficient	‣ Water used for recreation	Inverse
Maximum Contaminant Level (MCL)	‣ Subsurface soil: ingestion of groundwater impacted by leachate ‣ Groundwater: ingestion	Parallel[b]
Solubility	‣ Subsurface soil, groundwater and water used for recreation: all	NA[c]
Henry's Law constant	‣ Surficial soil ‣ Subsurface soil and groundwater: inhalation of indoor and outdoor air	Inverse
Organic carbon partition coefficient (K_{oc})	‣ Surficial and subsurface soil: all	Parallel
Partition coefficient for inorganics (K_s)	‣ Surficial and subsurface soil: all	Parallel
Diffusion coefficient in air	‣ Surficial soil ‣ Subsurface soil and groundwater: inhalation of indoor and outdoor air	Inverse
Diffusion coefficient in water	‣ Surficial soil ‣ Subsurface soil and groundwater: inhalation of indoor and outdoor air	Inverse

[a]Dermal contact with soil is the only absorption adjustment factor for which the Oakland RBCA approach employs chemical-specific values; all others are set equal to one.
[b]Risk-based calculations are replaced with MCLs when MCLs are more stringent.
[c]Not applicable; solubility is employed to check if the RBCA level is above the saturation limit.

This appendix compares the output of the Oakland RBCA *Excel* spreadsheet (see **Table D-1**) with the ASTM (1995) example Tier 1 table (see **Table D-2**) to verify that the algorithms for the Oakland RBCA model are entered correctly in the spreadsheet.

The default input parameter values from ASTM (1995) were employed in the Oakland RBCA spreadsheet. The output compares favorably with the ASTM (1995) example Tier 1 RBSLs, with the following exceptions:

(1) The RBSL calculated for Xylenes for surficial soil under the residential land use scenario (1.45E+05 mg/kg) does not match the value presented in the ASTM (1995) example Tier 1 table (1.45E+06 mg/kg). We believe that the ASTM (1995) value is a typo because (a) it is exactly one order of magnitude different from the value calculated by the Oakland RBCA spreadsheet, and (b) it is higher than the ASTM (1995) value presented for the same pathway under the commercial/industrial land use scenario.
(2) The RBSLs presented for benzo(a)pyrene for ingestion of groundwater impacted by leachate, using maximum contaminant levels (MCLs), do not match the ASTM (1995) value of 9.42E+00 mg/kg. This is because, although the Oakland RBCA spreadsheet also calculates a value of 9.42E+00, this value is recognized by the spreadsheet to be above the saturated soil concentration and "SAT" is entered. Because the Oakland RBCA spreadsheet results match the ASTM (1995) values for all other chemicals for this exposure pathway, we believe that the ASTM (1995) spreadsheet failed to recognize that the saturated soil concentration had been exceeded.

Please note that we were unable to perform a spreadsheet validation study for the "water used for recreation" exposure pathway since it is unique to the Oakland RBCA approach and is not considered by ASTM (1995).

Table D-1. Oakland RBCA Spreadsheet Validation Results

Medium	Exposure Pathway	Land Use	Type of Risk	Benzene	Benzo(a)-pyrene	Ethyl-benzene	Naphthalene	Toluene	Xylenes
Surficial Soil [mg/kg]	Ingestion/ Dermal/ Inhalation	Residential	Carcinogenic	5.82E+00	1.30E-01				
			Hazard			7.84E+03	9.77E+02	1.33E+04	1.45E+05
		Commercial/ Industrial	Carcinogenic	1.00E+01	3.04E-01				
			Hazard			1.15E+04	1.50E+03	1.87E+04	2.08E+05
Subsurface Soil [mg/kg]	Inhalation of Outdoor Air Vapors	Residential	Carcinogenic	2.73E-01	SAT				
			Hazard			SAT	SAT	SAT	SAT
		Commercial/ Industrial	Carcinogenic	4.59E-01	SAT				
			Hazard			SAT	SAT	SAT	SAT
	Inhalation of Indoor Air Vapors	Residential	Carcinogenic	5.38E-03	SAT				
			Hazard			4.29E+02	4.07E+01	2.08E+01	SAT
		Commercial/ Industrial	Carcinogenic	1.69E-02	SAT				
			Hazard			1.12E+03	1.06E+02	5.45E+01	SAT
	Ingestion of Groundwater Impacted by Leachate	Residential	Carcinogenic	2.93E-02	SAT	1.10E+02		1.77E+01	3.05E+02
			Hazard	2.93E-02	SAT	1.10E+02	2.29E+01	1.77E+01	3.05E+02
		Commercial/ Industrial	Carcinogenic	2.93E-02	SAT	1.10E+02		1.77E+01	3.05E+02
			Hazard	2.93E-02	SAT	1.10E+02	6.43E+01	1.77E+01	3.05E+02
Groundwater [mg/l]	Ingestion of Groundwater	Residential	Carcinogenic	5.00E-03	2.00E-04	7.00E-01		1.00E+00	1.00E+01
			Hazard	5.00E-03	2.00E-04	7.00E-01	1.46E-01	1.00E+00	1.00E+01
		Commercial/ Industrial	Carcinogenic	5.00E-03	2.00E-04	7.00E-01		1.00E+00	1.00E+01
			Hazard	5.00E-03	2.00E-04	7.00E-01	4.09E-01	1.00E+00	1.00E+01
	Inhalation of Indoor Air Vapors	Residential	Carcinogenic	2.40E-02	>Sol				
			Hazard			7.78E+01	4.70E+00	3.24E+01	>Sol
		Commercial/ Industrial	Carcinogenic	7.52E-02	>Sol				
			Hazard			>Sol	1.23E+01	8.48E+01	>Sol
	Inhalation of Outdoor Air Vapors	Residential	Carcinogenic	1.10E+01	>Sol				
			Hazard			>Sol	>Sol	>Sol	>Sol
		Commercial/ Industrial	Carcinogenic	1.85E+01	>Sol				
			Hazard			>Sol	>Sol	>Sol	>Sol

Table D-2. ASTM (1995) Example Tier 1 Table

E 1739

TABLE X2.1 Example Tier 1 Risk-Based Screening Level (RBSL) Look-up Table[A]

NOTE—This table is presented here only as an example set of Tier 1 RBSLs. It is not a list of proposed standards. The user should review all assumptions prior to using any values. Appendix X2 describes the basis of these values.

Exposure Pathway	Receptor Scenario	Target Level	Benzene	Ethylbenzene	Toluene	Xylenes (Mixed)	Napthalenes	Benzo (a)pyrene
Air								
Indoor air screening levels for inhalation exposure, μ/m^3	residential	cancer risk = 1E-06	3.92E-01					1.86E-03
		cancer risk = 1E-04	3.92E+01					1.86E-01
		chronic HQ = 1		1.39E+03	5.56E+02	9.73E+03	1.95E+01	
	commercial/ industrial	cancer risk = 1E-06	4.93E-01					2.35E-03
		cancer risk = 1E-04	4.93E+01					2.35E-01
		chronic HQ = 1		1.46E+03	5.84E+02	1.02E+04	2.04E+01	
Outdoor air screening levels for inhalation exposure, $\mu g/m^3$	residential	cancer risk = 1E-06	2.94E-01					1.40E-03
		cancer risk = 1E-04	2.94E+01					1.40E-01
		chronic HQ = 1		1.04E+03	4.17E+02	7.30E+03	1.46E+01	
	commercial/ industrial	cancer risk = 1E-06	4.93E-01					2.36E-03
		cancer risk = 1E-04	4.93E+01					2.36E-01
		chronic HQ = 1		1.46E+03	5.84E+02	1.02E+04	2.04E+01	
OSHA TWA PEL, $\mu g/m^3$			3.20E+03	4.35E+05	7.53E+05	4.35E+06	5.00E+04	2.00E+02[A]
Mean odor detection threshold, $\mu g/m^3$ [B]			1.95E+05		6.00E+03	8.70E+04	2.00E+02	
National indoor background concentration range, $\mu g/m^3$ [C]			3.25E+00 to 2.15E+01	2.20E+00 to 9.70E+00	9.60E-01 to 2.91E+01	4.85E+00 to 4.76E+01		
Soil								
Soil volatilization to outdoor air, mg/kg	residential	cancer risk = 1E-06	2.72E-01					RES[D]
		cancer risk = 1E-04	2.73E+01					RES
		chronic HQ = 1		RES	RES	RES	RES	
	commercial industrial	cancer risk = 1E-06	4.57E-01					RES
		cancer risk = 1E-04	4.57E+01					RES
		chronic HQ = 1		RES	RES	RES	RES	
Soil-vapor intrusion from soil to buildings, mg/kg	residential	cancer risk = 1E-06	5.37E-03					RES
		cancer risk = 1E-04	5.37E-01					RES
		chronic HQ = 1		4.27E+02	2.06E+01	RES	4.07E+01	
	commercial/ industrial	cancer risk = 1E-06	1.69E-02					RES
		cancer risk = 1E-04	1.69E+00					RES
		chronic HQ = 1		1.10E+03	5.45E+01	RES	1.07E+02	
Surficial soil (0 to 3 ft) (0 to 0.9 m) ingestion/ dermal/ inhalation, mg/kg	residential	cancer risk = 1E-06	5.82E+00					1.30E-01
		cancer risk = 1E-04	5.82E+02					1.30E+01
		chronic HQ = 1		7.83E+03	1.33E+04	1.45E+05	9.77E+02	
	commercial/ industrial	cancer risk = 1E-06	1.00E+01					3.04E-01
		cancer risk = 1E-04	1.00E+03					3.04E+01
		chronic HQ = 1		1.15E+04	1.87E+04	2.08E+05	1.50E+03	
Soil-leachate to protect ground water ingestion target level, mg/kg		MCLs	2.93E-02	1.10E+02	1.77E+01	3.05E+02	N/A	9.42E+00
	residential	cancer risk = 1E-06	1.72E-02					5.50E-01
		cancer risk = 1E-04	1.72E+00					RES
		chronic HQ = 1		5.75E+02	1.29E+02	RES	2.29E+01	
	commercial/ industrial	cancer risk = 1E-06	5.78E-02					1.85E+00
		cancer risk = 1E-04	5.78E+00					RES
		chronic HQ = 1		1.61E+03	3.61E+02	RES	6.42E+01	
Ground Water								
Ground water volatilization to outdoor air, mg/L	residential	cancer risk = 1E-06	1.10E+01					>S[E]
		cancer risk = 1E-04	1.10E+03					>S
		chronic HQ = 1		>S	>S	>S	>S	
	commercial/ industrial	cancer risk = 1E-06	1.84E+01					>S
		cancer risk = 1E-04	>S					>S
		chronic HQ = 1		>S	>S	>S	>S	
Ground water ingestion, mg/L		MCLs	5.00E-03	7.00E-01	1.00E+00	1.00E+01	N/A	2.00E-04
	residential	cancer risk = 1E-06	2.94E-03					1.17E-05
		cancer risk = 1E-04	2.94E-01					1.17E-03
		chronic HQ = 1		3.65E+00	7.30E+00	7.30E+01	1.46E-01	
	commercial/ industrial	cancer risk = 1E-06	9.87E-03					3.92E-05
		cancer risk = 1E-04	9.87E-01					>S
		chronic HQ = 1		1.02E+01	2.04E+01	>S	4.09E-01	
Ground water—vapor intrusion from ground water to buildings, mg/L	residential	cancer risk = 1E-06	2.38E-02					>S
		cancer risk = 1E-04	2.38E+00					>S
		chronic HQ = 1		7.75E+01	3.28E+01	>S	4.74E+00	
	commercial/ industrial	cancer risk = 1E-06	7.39E-02					>S
		cancer risk = 1E-04	7.39E+00					>S
		chronic HQ = 1		>S	6.50E+01	>S	1.23E+01	

[A] As benzene soluble coal tar pitch volatiles.
[B] See Ref (22).
[C] See Refs (23–25).
[D] RES—Selected risk level is not exceeded for pure compound present at any concentration.
[E] >S—Selected risk level is not exceeded for all possible dissolved levels (≤ pure component solubility).

REFERENCES

American Industrial Health Council. 1994. *Exposure Factors Sourcebook.* (Available from Update Coordinator, American Industrial Health Council, Suite 760, 2001 Pennsylvania Avenue, NW, Washington, DC 20006-1807.)

American Society for Testing and Materials. 1995. *Standard Guide to Risk-Based Corrective Action Applied at Petroleum Release Sites.* ASTM E1739-95.

American Society of Heating, Refrigerating, and Air Conditioning Engineering. 1981. *ASHRAE Handbook: 1981 Fundamentals.*

Bay Area Air Quality Management District. 1997. Oakland wind rose data. *Facsimile to Mark Gomez*, December 11.

Bureau of Labor Statistics. 1988. *Labor Force Statistics Derived from the Current Population Survey, 1948-1987.* Washington, D.C.: U.S. Department of Labor.

Calabrese, E.J. and E.J. Stanek, III. 1991. "A guide to interpreting soil ingestion studies II: qualitative and quantitative evidence of soil ingestion". *Regulatory Toxicology and Pharmacology (13:278-292).*

California Building Code. 1998. Sacramento, CA: California Building Standards Commission.

California Department of Health. 1999. Maximum Contaminant Levels.

California Environmental Protection Agency. 1994. *California Cancer Potency Factors.* Office of Environmental Health Hazard Assessment, Department of Pesticide Regulation (DPR) and Department of Toxic Substances Control.

City of Oakland. 2000. *Oakland Urban Land Redevelopment Program: Guidance Document.* Public Works Agency, Environmental Services Division.

Community Review Panel, Oakland Urban Land Redevelopment Program. 1997. *Consensus Recommendations for Implementing the Oakland Urban Land Redevelopment Program.* (Available from the City of Oakland Environmental Services Division.)

Freeze, R.A. and Cherry, J.A. 1979. *Groundwater.* New Jersey: Prentice-Hall, Inc.

Gomez, M.M. 1999. Review of Phase II environmental site assessments available in City of Oakland Environmental Services Division library.

Guymon, G. L. 1994. *Unsaturated Zone Hydrology.* New Jersey: Prentice-Hall, Inc.

Heath, R.C. 1982. "Classification of Ground-water Systems of the United States". *Ground Water.* Vol. 20: 4.

__________. 1989. *Basic Ground-Water Hydrology.* Third Edition. United States Government Printing Office for the USGS. (Available from U.S. Geological Survey Federal Center, Box 25425 Denver, CO 80225.)

Hiatt, Gerry. 199?.

Howard, P. H. 1989. *Handbook of Fate and Exposure Data for Organic Chemicals.* Volumes I, II, and III. Michigan: Lewis Publishers.

__________ and W.M. Meylan. 1997. *Handbook of Physical Properties of Organic Chemicals.* Boca Raton, FL: CRC Press.

Hydeman, M. PG&E Energy Center – San Francisco. 1996. Telephone conversation with Lynn Spence, December.

Knox, R.C., Sabatini, D.A., and Canter, L.W. 1993. *Subsurface Transport and Fate Processes.* Michigan: Lewis Publishers.

Lyman, W.J., Reidy, P.J., and Levy, B. 1992. *Mobility and Degradation of Organic Contaminants in Subsurface Environments.* Prepared for the U.S. EPA. Michigan: C. K. Smoley, Inc.

National Climactic Data Center. 1982. *Daily Normals of Temperature, Heating and Cooling Degree Days and Precipitation 1951-80.* Washington: United States Department of Commerce.

Radbruch, D. 1957. *Areal and Engineering Geology of the Oakland West Quadrangle, California.* United States Geological Survey.

Sherman, M. Lawrence Berkeley Laboratories. 1997. *E-mail message to Lynn Spence*, January 3.

Spence, L.R. and M.M. Gomez. 1999. *Oakland Benzene Partitioning Study: Synopsis.* Available from the City of Oakland Environmental Services Division.

State of California. *Safe Drinking Water and Toxic Enforcement Act (California State Proposition 65).* 1986.

Technical Advisory Committee, Oakland Urban Land Redevelopment Program. 1996a. *Meeting*, February 13.

__________. 1996b. *Meeting*, May 31.

__________. 1997. *Meeting*, February 11.

U.S. Environmental Protection Agency. 1987. *Hazardous Waste Treatment, Storage and Disposal Facilities (TSDF) – Air Emission Models.* EPA Office of Air and Radiation. EPA-540/3-87-026.

__________. 1989a. *Risk Assessment Guidance for Superfund.* Vol. I. Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response. EPA/540/1-89/002.

__________. 1989b. *Exposure Factors Handbook*. Office of Health and Environmental Assessment. EPA/600/8-89/043.

__________. 1992. *Dermal Exposure Assessment: Principles and Applications*. Interim Report. Office of Research and Development. EPA/600/8-91/011B.

__________. 1995. *Hazardous Waste Management System Toxicity Characteristics Revisions*. Washington, D.C.: US EPA. 55 FR 11798-11863.

__________. 1996. *Soil Screening Guidance: Technical Background Document*. Office of Solid Waste and Emergency Response. EPA/540/R-95/128.

__________. 1997. *Exposure Factors Handbook*. Office of Research and Development. EPA/600/P-95/002Fc.

Walton, W.C. 1988. *Practical Aspects of Groundwater Modeling—Third Edition*. Reprint: originally published by National Water Well Association.

Woodward-Clyde. 1992. *Limited Phase II Environmental Site Assessment: "Taldan Property" Block, Oakland, California*.