Panacea, Inc.
14700 Firestone Blvd., Suite 118
La Mirada, CA 90638
Phone (714) 228-1286
Fax (714) 228-1248

Baseline Human Health Risk Assessment

• Final •

Brown & Bryant Superfund Site
Arvin, California

Prepared for:
U.S. Army Corps of Engineers
Los Angeles District
Los Angeles, California

Christopher Stoker
Senior Risk Assessor

Project No. C00-266.2 June 2004

Table of Contents

EXECUTIVE SUMMARY ..... **vi**

1.0 INTRODUCTION **1**

1.1 SCOPE 1

1.2 RISK ASSESSMENT METHODOLOGY 1

1.3 GUIDANCE DOCUMENTS 4

1.4 REPORT ORGANIZATION 4

2.0 CHEMICALS OF POTENTIAL CONCERN **6**

2.1 SITE OPERATIONAL HISTORY 6

2.2 SITE CHARACTERIZATION STUDIES 7

2.3 CHEMICALS OF POTENTIAL CONCERN 8

3.0 TOXICITY ASSESSMENT **9**

3.1 NONCARCINOGENIC CHEMICALS 9

3.2 CARCINOGENIC CHEMICALS 10

3.3 QUANTIFICATION OF DERMAL EXPOSURE RISKS 10

4.0 EXPOSURE ASSESSMENT **11**

4.1 CONCEPTUAL SITE MODEL 11

4.1.1 EXPOSURE SETTING 11

4.1.2 CONCEPTUAL SITE MODEL DEVELOPMENT 13

4.2 EXPOSURE POINT CONCENTRATIONS 19

4.2.1 STATISTICAL EVALUATION OF SITE DATA 19

4.2.2 GROUNDWATER FATE AND TRANSPORT 21

4.2.3 AIR TRANSPORT ANALYSES 22

4.3 EXPOSURE QUANTIFICATION 30

4.3.1 AIR EXPOSURES – INHALATION EXAMPLE CALCULATIONS 31

4.3.2 GROUNDWATER EXPOSURE – INGESTION EXAMPLE CALCULATIONS 32

4.3.3 GROUNDWATER EXPOSURE – DERMAL CONTACT EXAMPLE CALCULATIONS 33

4.3.4 SOIL EXPOSURES – INCIDENTAL INGESTION EXAMPLE CALCULATIONS 36

4.3.5 SOIL EXPOSURES – DERMAL CONTACT EXAMPLE CALCULATIONS 37

5.0 RISK CHARACTERIZATION 38

5.1 RISK CHARACTERIZATION METHODOLOGY 38

5.1.1 HEALTH EFFECTS INDICES FOR QUANTITATIVE RISK ASSESSMENT 38

5.1.2 METHODS FOR CHARACTERIZING HEALTH EFFECTS 39

5.2 HEALTH RISKS FOR THE SITE 40

6.0 UNCERTAINTIES 41

6.1 SOURCES OF UNCERTAINTY 41

6.2 UNCERTAINTIES IN SELECTION OF CHEMICALS OF POTENTIAL CONCERN 42

6.2.1 SPECIES OF SITE CHEMICALS 42

6.2.2 SAMPLING DESIGN 42

6.2.3 DATA QUALITY 42

6.2.4 DETECTION LIMITS 42

6.2.5 NATURAL ATTENUATION OF ORGANICS 42

6.3 UNCERTAINTIES IN EXPOSURE ASSESSMENT 43

6.3.1 SITE SETTING 43

6.3.2 RECEPTOR SELECTION 43

6.3.3 EXPOSURE PARAMETERS 43

6.3.4 USE OF THE 95-PERCENT UPPER CONFIDENCE LIMIT 43

6.3.5 ALGORITHMS FOR MODELS 44

6.3.6 INPUT PARAMETERS 44

6.4 UNCERTAINTIES IN TOXICITY ASSESSMENT 44

6.4.1 EXTRAPOLATION 45

6.4.2 ADDITIVE NONCARCINOGENIC EFFECTS 46

6.5 CONCLUSIONS REGARDING UNCERTAINTY 46

7.0 CONCLUSIONS 46

8.0 REFERENCES 47

TABLES

2-1 COPCS AND THE MEDIA OF THEIR PRESENCE (X) AT THE BROWN & BRYANT SUPERFUND SITE

3-1 COPC—NON-CARCINOGEN REFERENCE DOSE (RFD)

3-2 COPC—CANCER SLOPE FACTORS (CSFS)

4-1 95-PERCENT UCL CONCENTRATIONS OF SOIL COPCS

4-2 CURRENT ONSITE 95 PERCENT UCL CONCENTRATIONS OF COPCS IN A-ZONE GROUNDWATER

4-3 MODELED MAXIMUM 30-YEAR AVERAGE CONCENTRATIONS OF COPCS IN ZONES OF GROUNDWATER

4-4 SOIL COPC-SPECIFIC CONSTANTS

4-5 CALCULATED SOIL COPC-SPECIFIC VOLATILIZATION ATTENUATION FACTORS

4-6 CALCULATED ON-SITE COMMERCIAL INDUSTRIAL INDOOR AIR CONCENTRATIONS

4-7 CALCULATED OFF-SITE INDOOR AIR CONCENTRATIONS

4-8 MODELED OUTDOOR AIR CONCENTRATIONS

4-9 RME EXPOSURE SCENARIO RECEPTOR EXPOSURE PARAMETERS AND THEIR VALUES

4-10 CENTRAL TENDENCY EXPOSURE SCENARIO RECEPTOR EXPOSURE PARAMETERS AND THEIR VALUES

4-11 COPC-SPECIFIC CONSTANTS

4-12 CALCULATED COPC-SPECIFIC DOSE ABSORBED (DA) FROM DERMAL CONTACT WITH B-ZONE GROUNDWATER

4-13 DERMAL ABSORPTION FACTORS (ABS)

5-1 SUMMARY OF HEALTH RISK CURRENT SITE CONDITIONS REASONABLE MAXIMUM EXPOSURE SCENARIOS

5-2 SUMMARY OF HEALTH RISK CURRENT SITE CONDITIONS CENTRAL TENDENCY EXPOSURE SCENARIOS

5-3 SUMMARY OF HEALTH RISK FUTURE SITE CONDITIONS REASONABLE MAXIMUM EXPOSURE SCENARIOS

5-4 SUMMARY OF HEALTH RISK FUTURE SITE CONDITIONS CENTRAL TENDENCY EXPOSURE SCENARIOS

7-1 SUMMARY OF HEALTH RISK—CURRENT CONDITIONS

7-2 SUMMARY OF HEALTH RISK—FUTURE CONDITIONS

7-3 FENCE-LINE CONCENTRATIONS OF COPCs IN 30 YEARS

FIGURES

4-1 CONCEPTUAL EXPOSURE MODEL FOR PATHWAYS
CURRENT EXPOSURE SCENARIO

4-2 CONCEPTUAL EXPOSURE MODEL FOR PATHWAYS
FUTURE EXPOSURE SCENARIO

APPENDICES

A RISK ASSESSMENT DATA SET – STATISTICAL SUMMARIES

B AIR MODELING OUTPUT

C RECEPTOR COPC INTAKE AND RISK CALCULATION SHEETS

EXECUTIVE SUMMARY

This Baseline Risk Assessment (BLRA) was performed in connection with the former Brown & Bryant Superfund site in Arvin, California. This risk assessment concludes, using United States Environmental Protection Agency (EPA) and California Environmental Protection Agency (Cal/EPA) guidelines, that detected chemicals at the site, including metals and volatile organic compounds found in groundwater and soils, do not pose a significant hazard to on-site receptors under current site conditions. However, should volatile organic contaminants be allowed to migrate, off-site receptors may experience a significant increase in potential risk associated with indoor air exposures.

Greater than 90 percent of the total estimated risk for off-site receptors is likely to originate from the modeled indoor air exposures associated with calculated future groundwater concentrations of 1,2,3-trichloropropane, 1,2-dibromo-3-chloropropane, and 1,3-dichloropropane. The maximum 30-year average fence-line concentrations of these contaminants used in this risk assessment are 2.08-milligrams per liter (mg/L), 1.33 mg/L, and 10.1 mg/L, respectively. Using an acceptable risk goal of 10^{-6} and the reasonable maximum exposure scenario, it is projected that off-site groundwater concentrations should be prevented from exceeding 0.058 mg/L (1,2,3-trichloropropane), 0.066 mg/L (1,2-dibromo-3-chloropropane), and 0.17 mg/L (1,3-dichloropropane) in order to maintain health protection. It is important to note, however, that these numbers do not take into account additivity, which will need to be further evaluated during the feasibility analysis of potential remedial alternatives.

SITE CONDITIONS

The site is located at 600 South Derby Road, bordered on the east by irrigated agricultural fields, on the north and south by food packing and shipping facilities, and on the west by a residential area. Two schools (Gospel Tabernacle of Arvin and Stepping Stones Child Care Center) and a park (Bear Mountain Recreation and Park Center) are located within 0.5 mile of the site. The Morning Star Pre-School, located at 416 North Hill Street, is located within 1 mile of the site.

In operation from 1960 to 1989, Brown & Bryant, Inc., provided pesticide reformulation and custom applicator services to the surrounding agricultural community. This facility reformulated agricultural chemicals including pesticides, herbicides, fumigants, and fertilizers. Throughout facility operations there were numerous controlled and uncontrolled releases of chemicals onsite. The documented largest releases onsite occurred in the areas of a former waste pond, a wash-down sump, and a dinoseb storage tank.

CHEMICALS OF POTENTIAL CONCERN

Thirty-four chemicals present in soil and groundwater at the site were selected as chemicals of potential concern that are related to site operations and are likely to adversely impact the health of exposed human populations. This BLRA focuses on these chemicals.

POTENTIALLY EXPOSED POPULATIONS (RECEPTORS)

For the purpose of defining potential on-site receptor exposure scenarios (current and future), this report assumes a single land use for the site as a controlled commercial/industrial facility. Given this land use, one exposure scenario is examined that is associated with daily operations (the *commercial/industrial scenario*). The commercial/industrial land use is consistent with existing controls and surrounding land

use. Potential off-site receptor exposure scenarios include exposure associated with residential and commercial/industrial land use. Residential land use is often associated with the greatest potential exposure for off-site users. The residential exposure scenario has been developed in accordance with Cal/EPA and EPA risk assessment guidelines (EPA, 1989a, Cal/EPA, 1992).

The receptors were chosen to provide a broad range of potential exposures. If the risk associated with these receptors is acceptable, then other, lesser exposures, such as those for trespassers, are likely to also be acceptable. Receptor exposure parameters were based on the principles of reasonable maximum exposure as promulgated by Cal/EPA and EPA. A central tendency analysis was also conducted for the risk assessment.

PATHWAYS OF CONCERN

Direct and indirect exposure pathways were assessed for residual contamination in soils and groundwater. The exposure pathways of concern for the site are dermal contact with residual soil contaminants, incidental ingestion of soil, inhalation of volatiles from soils and groundwater, ingestion of groundwater, dermal contact with groundwater, and inhalation of particulates originating from soils. These are the primary pathways described by Cal/EPA and EPA.

EPA AND CAL/EPA GUIDANCE

The projected risks associated with the chemicals and pathways of concern were quantified using the procedures and methodologies established by EPA and Cal/EPA risk assessment guidance. The key assumptions reflect standard practice by EPA, the Department of Toxic Substances Control (DTSC), and the California agencies responsible for health risk assessment.

UNCERTAINTIES IN RISK ASSESSMENT

The purpose of a health risk assessment is to provide a conservative estimate of the potential for health effects from residual chemicals at a site. However, numerous assumptions and modeling efforts are made to try and predict future site conditions and potential receptor exposures. To account for these uncertainties, conservative estimates have been made in the risk assessment methodology, assumptions, and models. Thus, the methodology used throughout the risk assessment is likely to overestimate the true risk at the site.

Baseline Human Health Risk Assessment

Brown & Bryant Superfund Site, Arvin, California

1.0 INTRODUCTION

This Baseline Human Health Risk Assessment (BHHRA) has been prepared for the Brown & Bryant Superfund site in Arvin, California. The report provides an evaluation, in accordance with the Risk Assessment Guidance for Superfund (RAGS), of the potential threat to human health in the absence of any further remedial action at the Brown & Bryant site.

The report is intended to fulfill the requirements for a risk assessment in accordance with the National Contingency Plan (NCP). The NCP (Title 40 Code of Federal Regulations [CFR], Part 300) sets forth the manner in which Superfund remediation is to be planned and conducted. The NCP requires development of a risk assessment for sites listed on the National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation. Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). This BHHRA has also been prepared in accordance with California Environmental Protection Agency (Cal/EPA) guidance.

The NCP requires that remedial investigations (RIs) and feasibility studies (FSs) be performed for sites requiring remedial action. The RI defines the nature and extent of contamination, and obtains the data needed to perform the subsequent BHHRA and FS. The FS develops a number of alternative remedial actions and evaluates them to select an appropriate remedial action for the site. The BHHRA is designed to utilize data generated by the RI to evaluate potential public health risks posed by the site and to formulate goals used in selecting remedial actions in the FS.

1.1 SCOPE

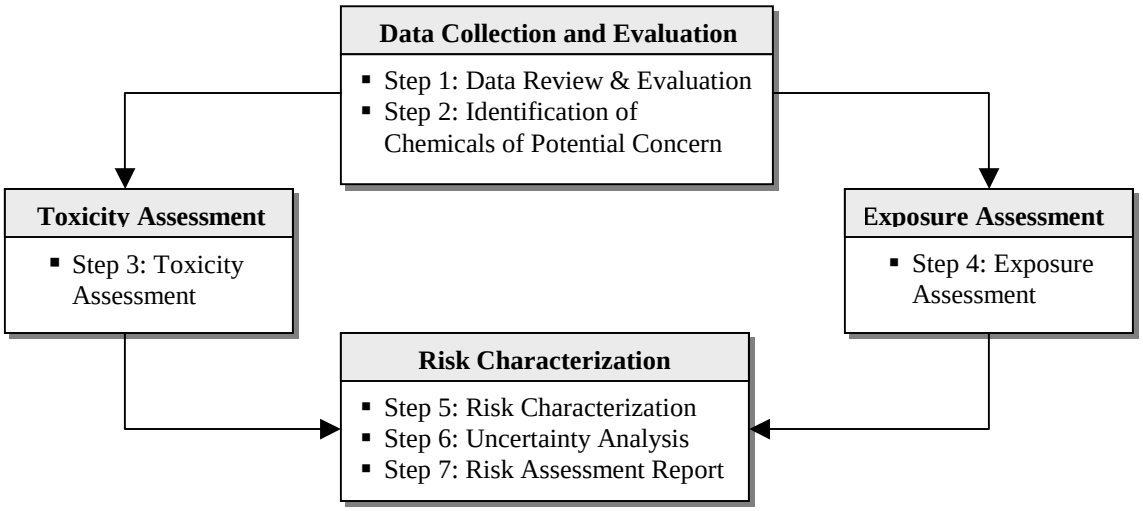
The specific scope of this BHHRA is to evaluate the potential health risks associated with existing and projected future conditions under the “no remedial action” alternative. Current and future exposure scenarios are developed assuming continued on-site commercial/industrial use. Surrounding land uses are assumed to remain a mix of residential and commercial/industrial land uses.

An upper-bound estimate of risk from this BHHRA is expected to enable the lead agencies to assess the magnitude of potential risks associated with chemicals present at the site and to design remedial strategies that eliminate unacceptable risks to human health (if any).

1.2 RISK ASSESSMENT METHODOLOGY

This BHHRA evaluates the potential health risks to human receptors associated with current and projected future site conditions. As shown in Figure 1-1, the BHHRA process consists of seven distinct steps.

FIGURE 1-1
BASELINE HUMAN HEALTH RISK ASSESSMENT PROCESS



Step 1: Data Review & Evaluation

Data review and data evaluation involves gathering and analyzing information related to site history, geology, hydrology, contaminant background concentrations, surrounding land uses, topography, and local meteorology. The data is then examined according to the data usability criteria established for risk assessment. This data forms the foundation of the risk assessment.

Step 2: Identification of Chemicals of Potential Concern

In this phase of the risk assessment, a list of chemicals of potential concern (COPCs) is selected. The chemicals on this list (see Table 2-1) are carried through the detailed risk assessment for the site. The rationale for the identification of COPCs and subsequent screening of chemicals is documented. Chemicals posing a risk that is clearly nominal are eliminated from further risk consideration.

Those COPCs for which regulatory-derived toxicity data exist (as published in the California Cancer Potency Factors Update, Integrated Risk Information System [IRIS], or Health Effects Assessment Summary Tables [HEAST]) are quantified in the risk analysis.

Step 3: Toxicity Assessment

For each identified COPC, an understanding of its potential toxicity to humans is essential. Toxicity information, which includes carcinogenic and non-carcinogenic effects, is obtained for many compounds through regulatory agencies and scientific literature.

Step 4: Exposure Assessment

Exposure assessment is conducted to estimate the magnitude, frequency, and duration of exposure to COPCs. Conceptual exposure scenarios are developed for the site to describe the potential exposures and provide a basis for quantifying those exposures. Each exposure scenario is used to:

- Analyze contaminant releases,
- Identify potential exposure pathways,
- Estimate exposure concentrations for pathways,
- Identify potentially exposed populations (known as "receptors"), and
- Estimate contaminant intakes for pathways.

In support of the exposure assessment, computer-aided fate and transport modeling may be used to identify media that are receiving or may receive site-related chemicals.

Step 5: Risk Characterization

In this step, the toxicity and exposure assessments are summarized and integrated to express quantitative and qualitative estimates of risk. The following steps are essential to risk characterization:

- Review outputs from toxicity and exposure assessments,
- Quantify risks from individual chemicals,
- Combine risks across exposure pathways,
- Assess and present uncertainty, and
- Consider site-specific human studies.

Risk characterization also serves as the bridge between risk assessment and risk management and is therefore a key step in (1) selection of a remedy, (2) remedial design, and (3) remedial action.

Step 6: Uncertainty Analysis

This part of the risk assessment discusses practical approaches to assessing uncertainty in Superfund site risk assessment. A qualitative discussion identifying the key source of uncertainty in the risk assessment, as prescribed by EPA (1989a), is provided assessing the level of uncertainty in the risk and hazard values.

Step 7: Risk Assessment Report

The final step in the risk assessment process is the development and presentation of findings in a report (i.e., this document). This step is useful in providing risk managers insight into the interpretation of the risk assessment results. The findings of the BHHRA are prepared as a stand-alone document and include

a complete description of assumptions, results, needs, uncertainties, and a recommended course of action for protection of human health. All scientific and engineering data and assumptions are supported by calculations, procedures, and references. A detailed summary of the risk assessment is included as a chapter in the accompanying RI.

1.3 GUIDANCE DOCUMENTS

The following major guidance documents and/or information sources have been used in the preparation of this risk assessment:

- *Risk Assessment Guidance for Superfund (RAGS): Volume I - Human Health Evaluation Manual Part A* (EPA, 1989a);
- *Supplemental Guidance for Human Health Multimedia Risk Assessment of Hazardous Waste Sites and Permitted Facilities* (Cal/EPA, 1992);
- *Risk Assessment Guidance for Superfund (RAGS): Volume I - Human Health Evaluation Manual Part C, Risk Evaluation of Remedial Alternatives* (EPA, 1991a);
- *Guidance for Data Usability in Risk Assessment* (EPA, 1992c);
- *Exposure Factors Handbook* (EPA, 1990a);
- *Dermal Exposure Assessment, Principles and Applications* (EPA, 1992a);
- *Technical Support Document for Describing Available California Cancer Potency Factors* (Cal/EPA, 2002);
- *Integrated Risk Information System* (IRIS) database (EPA, 2003);
- *Health Effects Assessment Summary Tables* (HEAST) (EPA, 1997b); and
- *Superfund Exposure Assessment Manual* (SEAM) (EPA, 1988c).

1.4 REPORT ORGANIZATION

This report is organized into the following sections:

- **Section 1. Introduction:** Presents scope, methodology, overview, and a list of guidance documents used in the preparation of this site-specific BHHRA.
- **Section 2. Chemicals of Potential Concern:** Lists the COPCs in soil and groundwater at the site. Past investigation and removal activities are discussed within the context of identifying the COPCs for the site.
- **Section 3. Toxicity Assessment:** Summarizes the toxicity information (for carcinogenic and non-carcinogenic effects) for each site COPC. The toxicity criteria used to characterize potential health risks are identified.

- **Section 4. Exposure Assessment.** Addresses the conceptual site model and exposure point concentrations, and characterizes the physical and chemical characteristics of the site, with an emphasis on current geological and hydrological conditions, COPCs, potential future surrounding land uses, and potentially exposed populations. Through the site's conceptual site model, possible exposure pathways are identified, and those pathways deemed significant to the identified receptors are selected for quantitative evaluation. The Exposure Assessment section presents calculations for exposure point concentrations (i.e., concentrations of chemicals in groundwater and air that may contact the potential receptors). The results of chemical fate and transport modeling for contaminants in groundwater and soil vapor are presented.

- **Section 5. Risk Characterization:** Presents the characterization of potential health risks to the exposed receptors. The risk characterization methodology is presented along with the health risk estimates for current and future conditions and associated exposure scenarios developed in Section 4.

- **Section 6. Uncertainties:** Discusses uncertainties associated with the estimated risk values. The potential magnitude and direction of bias that may be introduced by each identified factor to the estimated risk values are evaluated. The discussion includes identification of uncertainties related to COPC selection, exposure assessment, toxicity determination, fate and transport analysis, and risk characterization.

- **Section 7. Conclusions:** Presents a summary of findings and the conclusions regarding the risks associated with site chemicals under current and future conditions.

- **Section 8. References:** Presents the references used in the development of this report.

To assist the reader in understanding how the risk values were derived, risk calculation sheets and additional information are presented in appendices, as follows:

- **Appendix A: Risk Assessment Data Set—Statistical Summaries:** Contains the statistical summaries of data developed for the completion of the risk assessment. The complete set of data used in the risk assessment can be found in the accompanying RI report.

- **Appendix B: Air Modeling Output:** Portrays the air modeling conducted for the baseline risk assessment including indoor air model calculations, calculation of ambient air concentrations associated with residual volatile COPCs, and air dispersion modeling.

- **Appendix C: Receptor COPC Intake and Risk Calculation Sheets:** Includes a complete set of COPC intake and risk calculation sheets compiled by current and future exposure scenarios. Both carcinogenic and noncarcinogenic risk calculations are presented for each receptor via each significant exposure pathway.

2.0 CHEMICALS OF POTENTIAL CONCERN

Numerous studies have been completed at the Brown & Bryant Superfund Site to date. These studies have characterized the nature and extent of contamination associated with historical operations and current site conditions. The objective of this section is to provide a list of the COPCs identified through these studies. Section 2.1 provides a brief summary of historical operations at the site. A chronological synopsis of site characterization studies is provided in Section 2.2. Section 2.3 lists the COPCs in order to quantify risk for this baseline risk assessment. For a more complete discussion of site conditions and characterization efforts see the remedial investigation report.

2.1 SITE OPERATIONAL HISTORY

In operation from 1960 to 1989, Brown & Bryant, Inc., provided pesticide reformulation and custom applicator services to the surrounding agricultural community. The Arvin facility reformulated agricultural chemical including pesticides, herbicides, fumigants, and fertilizers. The primary material used in the reformulation process was dinoseb (2,4-dinotro-6-sec-butylphenol). Dinoseb can be used as a preemergent herbicide and/or insecticide (see Toxicity Profile - Appendix E of RI/FS [Panacea, 2004]). Additional matreriuals included 1,2-dichloropropane, 1,3-dichloropropane, 1,2-dibromo-3-chloropropane, 1,2,3-trichloropropane, and ethylene dibromide. These materials were used primarily as organic bases and carriers for the dinoseb. With the exception of dinoseb, all of these constituents are volatile.

Throughout facility operations there were numerous controlled and uncontrolled releases of chemicals onsite. The largest documented releases onsite occurred in the areas of a former waste pond, a wash-down sump, and a dinoseb storage tank (Panacea, 2002).

The waste pond, located in the southwest portion of the site, was originally excavated as an unlined earthen pond in 1960. The pond was used to collect run-off water from the yard and from two sumps (since excavated). The pond was also used to collect rinse water from rinsing tanks used for fumigants. Excess pond water and rainwater run-off also collected in a topographically low area to the east and south of the pond. In addition, ponded water from precipitation and irrigation from the east occasionally breached the berm in the southwest corner of the pond, and drained into the pond. The pond was double lined with a synthetic liner in November 1979. The liner and additional soil were excavated in 1987. Approximately 640 cubic yards of soil that showed visible signs of contamination were removed from the pond at that time. The depths of this excavation ranged from approximately 1.5 feet on the sides to 5 feet in the center (Panacea, 2002).

In 1960, an unlined earthen sump was constructed in the center of the site. The sump was used to collect wash water from a pad where equipment and tanks used for liquid fertilizers and fumigants were washed. Water from the sump was drained to the pond through an underground pipeline. In 1980, the unlined sump was replaced with two double-lined sumps (Panacea 2002).

Dinoseb was stored in a small tank storage area along the eastern fence, just north of the pond. In 1983, there was a significant dinoseb spill in this area. As a result, the soil and groundwater underlying this portion of the site has been reported to contain the highest concentrations of dinoseb. Is reported that EPA excavated the contaminated soil from this area in the mid-1990s (Panacea, 2002).

Currently vacant, on-site features include a warehouse, an open metal shed, and an aboveground storage tank. The asphalt cap acts as a Resource Conservation and Recovery Act (RCRA) cap in the site's

southern portion and a non-RCRA cap in the site's northern portion (Panacea, 2002). In 1981, the facility was licensed under RCRA as a hazardous waste transporter. In 1989, the site was listed on the National Priorities List (NPL). Subsequently, various emergency removal actions were initiated to minimize or eliminate immediate threats to human health and the environment (Panacea, 2002).

2.2 SITE CHARACTERIZATION STUDIES

Panacea was provided various historical site documents dated from 1987 through 1999 for review. These reports generally present the results of onsite soil and groundwater investigations, feasibility studies, and remedial action plans. A brief review of some of the more pertinent studies is provided in the following paragraphs.

The earliest document reviewed, prepared by Hargis & Associates (H&A) in June 1987, presents a work plan to assess the extent of soil and groundwater contamination from the release of onsite chemicals (H&A, 1987). The work plan summarizes the results of previous shallow soil sampling and groundwater testing (Wells AMW-1 through AMW-4) conducted in 1984 by H&A. Water and soil samples collected from these wells/borings were noted as having elevated concentrations of site-related contaminants. H&A implemented this work plan in 1987 and 1988. H&A's investigation included sampling vadose zone soils and installing six monitoring wells (AP-1 through AP-5, and AR-1) (H&A, 1988). Contaminants were detected in samples collected from each of the newly developed wells.

Shallow impacted soils (up to 12-foot depths) beneath the former onsite sumps and pond were excavated and documented in August 1987 by Canonie Environmental (Canonie Environmental, 1987). Soil samples collected from the base of the excavations were noted as containing elevated concentrations of site-related contaminants. Groundwater testing was not conducted during this remedial action.

The EPA commissioned an RI/FS study report in 1993 (EPA, 1993). The resultant report focused on the assessment of groundwater in the A-zone aquifer and the B-zone aquifer. Seven COPCs were identified for the site. An additional 49 organic compounds were detected in the A-zone, but were not included in the list of COPCs. The highest concentrations of COPCs were observed in a well near the former sump (AMW-2P), a well west of the sump (WA-6), and wells near the former pond (AMW-1P, EPAS, and EPAS-3). Distribution of the contaminants was consistent with the locations of the previously discussed source areas and followed a pattern consistent with groundwater flow in the A-zone. The compound 1,2-dichloropropane was found to be the most widely ranging contaminant in the A-zone (over 5.5 acres). This contaminant was also reported to be present in water samples collected from wells in the B-zone. For the definition of A-zone, B-zone and C-zone refer to the RI/FS document.

In February 1999, Ecology and Environment prepared a memorandum showing the results of groundwater sampling conducted in July 1998 and January 1999 (Ecology and Environment, 1999a,b). Analytical results indicated that relatively elevated concentrations of the COPCs continued to be present in the onsite and offsite wells. The distribution of four COPCs was provided with the July 1998 results (Ecology and Environment, 1999a). These COPCs were shown as underlying most of the site's central and southern portions, and extending offsite to the southwest, south, and southeast.

In June 1999, Morrison Knudson Corporation (MK) prepared a monitoring well completion report for Wells MW-1, MW-2, and MW-3 (MK, 1999). These three wells were installed to serve as observation wells during aquifer testing of the three adjacent extraction wells (EW-1, EW-2, and EW-3). The new monitoring wells were placed 8 to 15 feet from the extraction wells. The MK (1999) report generally presented well construction procedures and physical properties of soil collected.

In August 1999, MK presented the results of a series of aquifer tests that were performed on the newly installed extraction wells (EW-1, EW-2, and EW-3) and injection wells (IW-1 and IW-2) (MK, 1999). The objectives of the aquifer tests were to determine the sustainable yield at each of the five test locations and the efficiency, specific capacity, and hydraulic properties of the perched aquifer. Data collected were used to assess the viability of using the pump-and-treat method for remediating the perched aquifer. Test results indicated a relatively low yield for extraction and injection wells, suggesting only limited success with the pump-and-treat method.

Between July 2000 and May 2003, Panacea sampled 11 onsite wells and 13 offsite wells as part of a continuing groundwater assessment program. Sixteen of these wells are screened within the A-zone aquifer, seven are screened within the B-zone aquifer, and one is a city well screened within the C-zone aquifer (Panacea 2003a).

In October 2002, Panacea prepared a work plan for further groundwater assessment on and off the site (Panacea, 2002). The objective of this planned investigation was to install 10 additional groundwater monitoring wells to further define the extent of COPC contamination onsite and offsite. Five of the wells were installed within the A-zone, and five were installed within the B-zone.

In an effort to provide further clarification and interpretation of the previous studies, Panacea conducted an extensive fate and transport analysis (Panacea, 2003b). The purpose of this study was to assess and understand the fate and transport of COPCs in the vadose and saturated zones at the Brown & Bryant Superfund Site. The findings of the fate and transport analysis for the vadose and saturated zones are referenced throughout this risk assessment.

2.3 CHEMICALS OF POTENTIAL CONCERN

Throughout the course of site investigations, numerous groundwater and soil samples were collected. However, because these samples were designed to address specific site characterization issues, not all can be used in a health risk assessment. A detailed data evaluation process is required to determine the validity and usefulness of the sample results in a quantitative risk assessment (EPA, 1992b).

Once the data are determined to be valid and of sufficient quality to be used in a quantitative risk assessment, further data analysis is employed to identify the COPCs. The resultant COPCs are used throughout the remainder of the risk assessment process. COPCs are the chemicals that are potentially site related and whose data is of sufficient quality for use in quantitative risk assessment.

Due to the extensive amount of historical data and the number of non-detected analytes reported, a detailed data usability methodology was developed and submitted in Section 2.0 of the *Human Health Risk Assessment Workplan* (Panacea, 2003c). However, following the compiling of historical records and more recent investigation results, Panacea's Project Director decided that all detected chemicals should be used in the baseline risk assessment. Therefore, all detected analytes in soil and groundwater have been included as COPCs for this risk assessment. Table 2-1 lists 34 COPCs present in soil and groundwater at the site. Appendix A provides a statistical summary of these COPCs and their concentrations in each medium on the site. These concentrations are used in estimating the exposure intake doses discussed in Section 4. Uncertainties associated with the selection of COPCs are discussed in Section 6.2.

3.0 TOXICITY ASSESSMENT

The objective of this section is to provide a quantitative estimate of the exposure dose of non-carcinogenic and carcinogenic COPCs and the probability and/or severity of human effects for each of the 34 COPCs identified in the previous section. Section 3.1 describes how dose-response, or toxicity values, are developed by the EPA and used for noncarcinogenic COPCs. Section 3.2 presents a similar discussion of the toxicity values for potentially carcinogenic COPCs that are developed by Cal/EPA's Office of Environmental Health Hazard Assessment (OEHHA). The derivation of dermal toxicity factors is addressed in Section 3.3.

In accordance with Cal/EPA's suggested hierarchy of sources used to locate dose-response values (Cal/EPA, 1992), relevant carcinogenic and noncarcinogenic dose-response values were obtained from the following sources (in descending order of preference):

1. Cancer Potency Factor database (Cal/EPA, 2002)

2. Integrated Risk Information System (IRIS) database (EPA, 2003)

3. Health Effects Assessment Summary Tables (HEAST) for FY 1997 (EPA, 1997b)

Searches of the OEHHA and IRIS databases were conducted in March 2003. Toxicity profiles (EPA 1993) have been provided in Appendix E of RI/FS (Panacea, 2004).

3.1 NONCARCINOGENIC CHEMICALS

For the noncarcinogenic effects of specific chemicals (excluding lead), EPA assumes that a dose exists below which no adverse health effects will be seen (EPA, 1989a). It is believed that exposure to a chemical can be tolerated without adverse effects below this "threshold dose," and the body burden is not increased. Adverse effects become manifest only when physiologic protective mechanisms are overcome by exposure doses above the threshold. The reference dose (RfD), expressed in units of milligrams per kilogram-day (mg/kg-d), represents the daily intake of a chemical (averaged over a year) per kilogram of body weight that is below the threshold for that chemical. In essence, the RfD represents the receptor-specific threshold dose. In addition, EPA assumes that noncarcinogenic exposure doses are not cumulative from age group to age group over a lifetime of exposure (EPA, 1989a) and are limited to chemical-specific target organs. Thus, an RfD is specific to the chemical, route of exposure, duration (subchronic and chronic) over which the exposure occurs, and target organ.

These RfDs are used to estimate "hazard indices" for the chemicals (see Section 6). The inhalation and oral RfDs for the noncarcinogenic COPCs are presented in Table 3-1. The primary source for toxicological reference values is the IRIS database (EPA, 2003), which contains current health risk and regulatory information. Provisional RfDs are tabulated in HEAST (EPA, 1997b). Chronic RfDs are used to calculate the noncarcinogenic "hazard" (Cal/EPA, 1999) for exposures longer than 1 year in duration, while subchronic RfDs are used for shorter exposure periods. When an inhalation RfD is unavailable, the oral RfD is used (Cal/EPA, 1999).

3.2 CARCINOGENIC CHEMICALS

EPA's model of carcinogenesis assumes that the relationship between exposure to a carcinogen and cancer risk is linear over the entire dose range, except at very high doses (EPA, 1989a). This linearity assumes there is no threshold-of-exposure dose below which harmful effects will not occur. Because of this, carcinogenic effects are considered to be cumulative across age groups when considering lifetime exposures. The incremental lifetime cancer risk (ILCR) attributed to a carcinogen is calculated as a product of the daily intake (mg/kg-d) and the cancer slope factor (CSF). CSFs are upper-bound (95 percent upper confidence limit [UCL]) estimates of the increased cancer risk per unit dose specific to exposure route (inhalation, oral), in which risk is expressed as the probability that an individual will develop cancer within his or her lifetime as the result of exposure to a given level of a carcinogen. All cancers or tumors are considered, whether or not death results. This approach is inherently conservative because of the no-threshold assumption and the use of the 95 percent UCL of the estimated slope of dose versus cancer risk.

In addition to the CSF, the toxicity information considered in the assessment of potential carcinogenic risk includes a weight-of-evidence classification. EPA groups chemicals according to their potential for carcinogenic effects based on clinical evidence (EPA, 1989a) as follows:

- Group A Human carcinogen
- Group B Probable human carcinogen
- Group C Possible human carcinogen
- Group D Insufficient data to classify as a human carcinogen
- Group E Not a human carcinogen

The CSFs for the COPCs evaluated in this report are presented in Table 3-2. The primary source for these toxicological reference values is OEHHA’s Cancer Potency Factor Database (Cal/EPA, 2002), with IRIS (EPA, 2003) the secondary source. Provisional CSFs are tabulated in HEAST (EPA, 1997b).

3.3 QUANTIFICATION OF DERMAL EXPOSURE RISKS

Dermal RfDs and CSFs are traditionally derived from the corresponding oral values (EPA, 1989a). However, Cal/EPA recommends that dermal RfDs and CSFs should not be derived; instead, oral RfDs and CSFs should be conservatively used in place of derived dermal toxicity values (Cal/EPA, 1998a, 1998b).

The uncertainty ascribed to a toxicity value (RfD or CSF) is a function of the individual study from which it was derived, and the completeness of the supporting database. Uncertainties associated with the toxicity value are discussed in Section 6.4.

4.0 EXPOSURE ASSESSMENT

4.1 CONCEPTUAL SITE MODEL

The conceptual site model traces the site COPCs' flow from their sources through various release mechanisms, transport media, and exposure routes to potentially affected receptor populations. That provides the basis for a comprehensive evaluation of the risks to human health by identifying the routes and mechanisms by which receptors may be exposed to residual COPCs. The conceptual site model also facilitates the analysis and screening of exposure pathways likely to pose risks to human health. Of particular importance, the model identifies which exposure routes are potentially complete under the given land use scenarios. These complete pathways are evaluated in the quantitative risk assessment for each receptor.

Section 4.1.1 presents the site physical characteristics and describes the potential exposure scenarios under both current and future site conditions. Section 4.1.2 discusses a conceptual site model development that identifies the COPC sources, release mechanisms, potential receptor populations, and exposure pathways for the identified current and future exposure scenarios.

4.1.1 EXPOSURE SETTING

The specific attributes of the site's physical characteristics and land use influence the availability of COPCs to release mechanisms, exposure routes, and receptor populations.

4.1.1.1 Site Physical Characteristics

The physical characteristics of the site are described in the *Remedial Investigation Workplan* prepared by Panacea (2001). The following paragraphs summarize the published information as it relates to this risk assessment, with an emphasis on the COPC sources, release mechanisms, exposure media, and exposure pathways for the site. Highlights for area climate, meteorology, geological setting, soil types, hydrology, and local demographics are presented.

4.1.1.1.1 Climate and Meteorology

Meteorological data for the Brown & Bryant Superfund site or the City of Arvin were not readily available from the San Joaquin Valley Air Pollution Control District (SJV-APCD) during the preparation of this risk assessment. The nearest, readily available data set provided by SJV-APCD was for the City of Bakersfield. The Brown & Bryant Superfund site is located 18 miles southeast of Bakersfield. The Bakersfield data set shows an average annual temperature of 77.8 degrees Fahrenheit (°F), ranging from an average maximum of 98.6°F in July to an average minimum of 38.2°F in December. Prevailing winds are from the west and northwest. Wind speeds range from calm to greater than 10.8 meters/second (m/sec) (SJV-APCD, 2002). The Brown & Bryant Superfund site is located in an arid region of California; average annual precipitation for the period from 1937 to 2001 was 6.23 inches (WRCC, 2002).

4.1.1.1.2 Regional Geology and Hydrogeology

The following description of site geology and hydrogeology has been extracted from the Remedial Investigation Workplan Operable Unit No. 2 prepared by Panacea (2001):

Geology beneath the site is comprised of an alluvial deposit of alternating layers and mixtures of unconsolidated sands, silts, and clay. Soil underlying the site to a depth of 80 feet generally consists of silty fine sand to fine sandy silt. Clean, well-graded sand lenses and thin seams of silty clay occur locally within these soils. The soils are thinly interbedded, with textural changes occurring every few vertical inches. These textural changes are also believed to occur laterally.

The site geology has been divided into two zones: the A-zone and the B-zone. The A-zone includes unsaturated soil to 65 to 75 feet below ground surface (bgs) and includes the first water-bearing unit, the A-zone groundwater. The depth to the saturated zone (see groundwater depths listed in Section 2.5) varied between 65 and 85 feet bgs in recent groundwater depth measurements. The base of the A-zone is a thin sandy clay layer from 75 to 85 feet bgs. The clay layer and the A-zone groundwater occur beneath the entire site but disappear within 900 feet south of the site.

The B-zone includes unsaturated soil beneath the A-zone and the second-lowest water-bearing unit (B-zone groundwater) at 150 to 165 feet bgs. The B-zone extends to at least 250 feet bgs and ends at a clay layer known as the Corcoran Clay that confines the drinking water aquifer beneath it. Specific data regarding the alluvial soil types within the B-zone were not encountered in previous reports prepared for the site or the adjoining properties. It is our understanding that these materials are comprised of mixtures and layers of clay, silt, sand, and gravel. The thickness of this clay layer beneath the site is unknown.

Groundwater in the A-zone flows in a generally southerly direction, with some mounding of the water table observed extending south from the southwest corner of the site. The saturated thickness of the A-zone groundwater ranges from 0 to 10 feet. The groundwater velocity in the A-zone has been estimated at 53 feet/year. Slug test results suggest that a yield of less than 100 gallons per day can be expected for wells in the A-zone. Aquifer testing of three of the onsite extraction wells showed a groundwater yield of approximately ¼ gallon per minute (gpm)(MK, 1999). Note, however, that it is Panacea's opinion that the wells tested were located in a portion of the site that typically yields low water quantities. Wells south of the site, within the A-zone, have significantly greater yield.

The B-zone groundwater comprises a series of water-bearing units. All of the wells in the B-zone were installed in the water-bearing unit located at approximately 170 feet bgs. The direction of flow in this unit is to the south, and the gradient is very flat (0.0004). Permeabilities are much higher than for the A-zone groundwater. Past pump tests indicated that wells screened in the B-zone could be pumped at 7 gpm (MK, 1999) for an extended period.

4.1.1.2 Land Use and Associated Exposure Scenarios

The site is located at 600 South Derby Road, bordered on the east by irrigated agricultural fields, on the north and south by food packing and shipping facilities, and on the west by a residential area. Two schools (Gospel Tabernacle of Arvin and Stepping Stones Child Care Center) and a park (Bear Mountain Recreation and Park Center) are located within 0.5 mile of the site. The Morning Star Pre-School, located at 416 North Hill Street, is located within 1 mile of the site.

For the purpose of defining potential on-site receptor exposure scenarios (current and future), this report assumes a single land use for the site as a controlled commercial/industrial facility. Given this land use, one exposure scenario is examined that is associated with daily operations (the *commercial/industrial scenario*). The commercial/industrial land use is consistent with existing controls and surrounding land use.

Potential off-site receptor exposure scenarios include exposure associated with residential and commercial/industrial land use. Residential land use is often associated with the greatest potential exposure for off-site users. The residential exposure scenario has been developed in accordance with Cal/EPA and EPA risk assessment guidelines (Cal/EPA, 1992; EPA, 1989a).

Adjacent commercial/industrial land use is consistent with existing developments. While decisions concerning the exact long-term future use of the off-site parcels has not been made, reasonable and conservative assumptions concerning potential commercial/industrial uses were employed in the development of the exposure scenarios

The potential for a trespasser scenario was reviewed and determined, based on existing site controls and extensive hardscaping, that potential exposures under a hypothetical trespasser scenario are likely to be significantly lower than the exposure scenarios evaluated in this report.

4.1.1.3 Reasonable Maximum and Central Tendency Exposures

EPA (1989a) recommends the use of reasonable maximum exposure (RME), which is defined as the highest exposure that could reasonably occur at a site. It is a conservative estimate of exposure within the range of possible exposures. RMEs are estimated for individual pathways. If a population is exposed to more than one pathway, then the sum of the exposures across pathways also represents the RME (EPA, 1989a). Because of uncertainties associated with any exposure estimate, a central tendency (CT) exposure analyses or average will also be conducted to quantify the upper estimates of exposures for receptor populations.

Populations potentially affected by site COPCs include people of various ages and lifestyles who live or conduct business at or near the site. Instead of estimating health impacts to a specific individual, risk assessments focus on potential health effects to representative receptor groups. Each receptor group evaluated in this work plan has been chosen to represent upper-bound exposures associated with people that have similar lifestyles or perform similar daily activities. If the resultant risk to the receptor group is acceptable, then it is assumed that all other receptors with lesser exposures will also be acceptable.

4.1.2 CONCEPTUAL SITE MODEL DEVELOPMENT

Figures 4-1 and 4-2 present the conceptual site models developed to describe the exposure setting under current and future site conditions. Given these conditions, there are several potential exposure scenarios through which receptors may come into contact with COPCs at the site. For an exposure scenario to be deemed complete, four elements must be present:

- COPC source(s),
- Release mechanism(s),
- Transport medium and exposure pathway(s), and

- Receptor(s).

The following sections provide details on these elements.

4.1.2.1 COPC Sources

A discussion of COPC sources provides a starting point for the development of the exposure scenarios. The following sources have been identified at the site:

- Residual soil concentrations from 0 to 10 feet below ground surface (bgs),
- Residual soil concentrations from 10 feet to A-zone groundwater,
- Residual concentrations in A-zone groundwater, and
- Residual concentrations in B-zone groundwater.

These sources and the resultant conceptual site models (Figure 4-1 and 4-2) address the primary COPCs identified at the site (Panacea, 2002). These environmental media may also act as reservoirs for COPCs that slowly migrate to other environmental compartments and serve as secondary sources of human exposure.

4.1.2.2 Release Mechanisms

The COPCs released into transport media of soil, air, and groundwater from its sources can be divided conceptually into two categories: (1) immediate sources, such as soils, which are readily available for potential receptor exposures, and (2) secondary sources, such as groundwater, which is not readily available for receptor exposure and requires an intermediate release and transport mechanism before receptors can be exposed. The typical mechanisms for COPC release and transport for secondary sources are groundwater flow, leaching, volatilization, and dust and particulate emissions.

4.1.2.2.1 Groundwater Flow

Migration of a COPC via groundwater flow depends on the properties of the COPC, aquifer geology, and groundwater velocity. The solubility and organic carbon partition coefficient (K_{OC}) affect the transport of organic chemicals in groundwater. Organic chemicals tend to flow in the direction of the groundwater but at a slower rate. This is because organic chemicals moving with groundwater tend to partition themselves between the mobile water phase and the stationary soil particles that are in contact with the groundwater (i.e., the process of adsorption). The overall effect of this adsorption process is to retard the rate of COPC transport and thus increase the travel time for the bulk of the contaminant plume .

4.1.2.2.2 Leaching

COPCs can also be released to the groundwater from subsurface sources (e.g., surface and subsurface soil) as a result of leaching. Precipitation infiltrating the source media initiates the release of COPCs from the soil into the downward migrating water. As the infiltrating water moves toward the underlying groundwater, the COPCs are subjected to many of the same forces (gravitational potential, metric potential, temperature gradient). Transport time from source to groundwater is highly dependent upon additional conditions, including infiltration volume, surface structures, frequency of precipitation, depth from source to groundwater, and soil properties.

Chemical composition, molecular weight, solubility, and viscosity also influence COPC migration. In general, chemicals that are highly soluble in water are considered mobile in groundwater. Those with high water solubilities (greater than 1,000 parts per million [ppm]) and low K_{OC} values (less than 150) are considered very mobile in water. Those COPCs exhibiting low mobility, based on their solubility and K_{OC} values, would not be expected to move readily in groundwater or leach into groundwater.

4.1.2.2.3 Volatilization

Volatilization is the mass transfer of an organic chemical from a specific medium (e.g., soil or groundwater) to air. Vapor from volatile chemicals moves in the subsurface soil away from the source, toward the atmosphere. Environmental factors that affect volatilization include temperature, soil porosity, soil moisture content, soil organic carbon content, depth to contamination, and surface structures. The volatility of a chemical is a function of its vapor pressure, water solubility, and air diffusion coefficient. Among chemicals with similar vapor pressures, the more water-soluble the chemical, the less likely it is to become volatile. Generally, chemicals with high vapor pressures (greater than 10^{-3} millimeters mercury [mm Hg]) or high Henry's Law constants (greater than 10^{-5} atm-m^3/mol [atmosphere cubical meter per mol]) can be expected to volatilize readily from soil (Cal/EPA, 1994, 1999).

4.1.2.2.4 Dust/Soil Particulate Emissions

Dust/soil particulate emissions can result from wind, maintenance activites, and mechanical erosion. Common factors that influence emission rates are wind speed, moisture content, vegetative cover, soil composition, maintenance frequency and surface structures. Chemical and physical properties can also be used to estimate a chemical's potential to be emitted in dust. Chemicals with relatively high organic carbon partition coefficients (K_{OC} greater than 2,000), such as metals, are more likely to be associated with soil and thus more likely to be adsorbed onto dust or soil particulates (EPA, 1988c).

Each of the COPCs identified in Section 2 have been evaluated for the above-mentioned secondary release mechanisms. A COPC has been quantified for exposure only when one of the pertinent release mechanisms can be established. Figures 4-1 and 4-2 identify the potential release mechanisms at the site under current and future site conditions.

4.1.2.3 Potential Exposure Pathways

This section discusses the potential for the completeness of each exposure pathway for its inclusion or exclusion in the determination of risk. Figures 4-1 and 4-2 summarize the identified complete and incomplete pathways at the site and their relationships to the contamination sources under current and future site conditions.

4.1.2.3.1 Inhalation Exposure

Exposures via the inhalation route consist of COPCs transported by air eventually reaching a receptor that inhales airborne vapor, gases, and/or suspended particulates. The following inhalation routes were reviewed for inclusion in this risk assessment in accordance with Cal/EPA guidance (Cal/EPA, 1992):

- Inhalation of suspended particulates in outdoor air,
- Inhalation of suspended organic vapor in outdoor air,
- Inhalation of particulates migrating from outdoor to indoor air, and

- Inhalation of organic vapor that migrates to indoor air.

With the exception of long-term particulate-based exposures, all inhalation exposure pathways are further evaluated in this risk assessment. Particulate emissions have been limited to short-term emission intervals as a result of previously completed site capping and shallow source removal (Panacea, 2001).

4.1.2.3.2 Dermal Contact Exposure

This group of pathways encompasses all receptor activities that result in dermal contact with soil or groundwater containing COPCs. The following dermal contact exposure pathways were reviewed for inclusion in this risk assessment:

- Dermal contact with surface soils, and
- Dermal contact with groundwater via baths and showers.

Dermal exposure to groundwater is assessed for off-site residential receptors assuming uncontrolled plume migration in the future. Dermal contact with onsite soils has been limited to short-term exposure intervals as a result of previously completed site capping and shallow source removal (Panacea, 2001).

4.1.2.3.3 Ingestion Exposure

The following ingestion exposure routes were reviewed for inclusion in this risk assessment:

- Incidental ingestion of soil containing COPCs;
- Ingestion of groundwater containing COPCs;
- Ingestion of fruits, vegetables, and grains containing COPCs due to atmospheric exposure;
- Ingestion of meat, milk, and eggs containing COPCs due to atmospheric exposure of the livestock feed source;
- Ingestion of meat, milk, and eggs containing COPCs due to livestock inhalation;
- Ingestion of fruits, vegetables, and grains grown in soil containing COPCs;
- Ingestion of meat, milk, and eggs containing COPCs due to livestock consumption of feed grown in soil containing COPCs;
- Ingestion of meat, milk, and eggs containing COPCs due to incidental ingestion by livestock during feeding;
- Ingestion of fruits, vegetables, and grains containing COPCs due to irrigation with groundwater containing COPCs;
- Ingestion of meat, milk, and eggs containing COPCs due to livestock consumption of feed irrigated with groundwater containing COPCs; and

- Ingestion of meat, milk, and eggs containing COPCs due to livestock consumption of groundwater containing COPCs.

On-site land use is limited to commercial/industrial activities; on-site controls (capping) and deed and zoning restrictions will preclude on-site agricultural development. Existing on-site controls and shallow source removal preclude the loss of contaminated particulate materials that could be deposited on surrounding agricultural products. Thus, all agriculturally based exposure pathways are insignificant when compared to other potential exposure pathways. Ingestion of groundwater will be quantified in the risk assessment for future on- and off-site exposures. The incidental ingestion of soil associated with on-site receptor activity patterns will be limited to short-term exposure intervals due to on-site controls and previous shallow source removal. These same measures have mitigated the potential release of particulate for off-site exposures.

4.1.2.4 Potentially Exposed Populations

Populations of persons who work at or live near the site have the highest potential to be exposed to site-related COPCs. To provide overestimates of risk for planning and comparison purposes, the risk assessment will evaluate the potential health effects to five receptor populations under both current and future site conditions: the on-site maintenance worker, the on-site commercial/industrial worker, off-site residents (adult and child), and an off-site commercial/industrial worker. Receptors were chosen to ensure that the estimated risk values are protective of human health and that risks to the actual population do not exceed the estimated values. The development and selection of these receptors was based on the RME concept discussed in Section 4.1.1.3 and regulatory guidance (Cal/EPA, 1992).

Descriptions of the types, locations, and lifestyles of these receptors are provided below.

4.1.2.4.1 On-Site Maintenance Worker

This receptor represents the full-time employees of firms contracted to develop and maintain a commercial/industrial facility onsite. The maintenance worker is assumed to work on site 8 hours a day, 5 days a week, 250 days/year, for 1 year. Three significant exposure routes are applicable to this receptor under the maintenance scenario:

- Inhalation of volatilized surface soil COPCs and suspended particulate (outdoor air),
- Incidental ingestion of soil, and
- Dermal contact with soil.

Ingestion of groundwater drawn from the underlying aquifer is not applicable to this receptor because all on-site water will be provided by the local municipality or off-site sources. A more detailed summary of exposure pathways for this receptor can be found in Figures 4-1 and 4-2.

4.1.2.4.2 On-Site Commercial/Industrial Worker

This receptor represents the full-time employees of a commercial/industrial facility developed on the site and is assumed to work on site full time for many years (patrons or others visiting or conducting brief business at the site would have lesser exposures). Under current site conditions, two significant exposure routes are applicable to this receptor including the inhalation of vapors in ambient air and the inhalation

of vapors that migrate through floors to indoor air. Under both current and future exposure scenarios, emissions are estimated from surface soils, deep soils, and A-zone groundwater.

On-site water needs are assumed to be met by the local municipality from the nearest downgradient supply well from the site. The ingestion of contaminated groundwater drawn from the underlying aquifers is not applicable under current site conditions. However, it is assumed that groundwater contamination will reach this well in the future and therefore the ingestion of groundwater will also be assessed under the future exposure scenario. Due to assumed maintenance personnel, see Section 4.1.2.4.1, this receptor is not assumed to have frequent contact with contaminated soils. A more detailed summary of exposure pathways for this receptor can be found in Figures 4-1 and 4-2.

4.1.2.4.3 Off-Site Resident Adult

The potential for adjacent residential development is plausible and represents a potentially sensitive exposure condition. This receptor is assumed to reside adjacent to the site at the fenceline. Residential water needs are assumed to be supplied by a private well developed adjacent to the site at the location of projected maximum contaminant concentrations in the B-zone groundwater. The significant receptor exposure route identified under current site conditions is the inhalation of volatilized COPCs in ambient air originating from the adjacent site. Projected future routes include the inhalation of volatilized COPCs and the ingestion of and dermal contact with contaminated tap water (groundwater). A more detailed summary of exposure pathways for this receptor can be found in Figures 4-1 and 4-2.

4.1.2.4.4 Off-Site Resident Child

Young children (ages 1 through 6) living in the vicinity of the site form a population of concern because they may be more sensitive to a given exposure (i.e., noncarcinogenic exposure) than are adults. For this risk assessment, this receptor, like his/her parents, is assumed to reside adjacent to the site (fenceline). The significant receptor exposure route identified under current site conditions is the inhalation of volatilized COPCs in ambient air from the adjacent site. Projected future routes include the inhalation of volatilized COPCs and the ingestion of and dermal contact with contaminated tap water (groundwater). A more detailed summary of exposure pathways for this receptor can be found in Figures 4-1 and 4-2.

4.1.2.4.5 Off-Site Commercial/Industrial Worker

This receptor represents the full-time employees of the surrounding commercial/industrial facilities, as well as patrons or others who would be exposed while visiting for short durations of time at these businesses. The significant exposure route for this receptor under the current scenario is the inhalation of volatilized COPCs in ambient air from the adjacent site.

Water needs are supplied by the local municipality from the nearest downgradient supply well from the site. The ingestion of contaminated groundwater drawn from the underlying aquifers is not applicable under current site conditions. However, it is assumed that groundwater contamination will reach this well in the future and therefore the ingestion of groundwater will also be assessed under the future exposure scenario. A more detailed summary of exposure pathways for this receptor can be found in Figures 4-1 and 4-2.

4.2 EXPOSURE POINT CONCENTRATIONS

These COPC *exposure point concentrations* are assumed to be equal to the representative concentration in the medium (direct exposures such as dermal contact and incidental ingestion) or are predicted by transport modeling (indirect exposures). Fate and transport models provide a means of predicting future COPC concentrations at potential exposure locations. This section describes the methodologies used in the derivation of exposure point concentrations for direct and indirect exposures. To quantify these concentrations, statistically representative concentrations will be estimated for COPCs in impacted environmental media.

Section 4.2.1 discusses the statistical evaluation of site data and presents the resultant exposure point concentrations. An introduction to the groundwater fate and transport modeling previously completed for the site is presented in Section 4.2.2. The concentrations presented in Sections 4.2.1 and 4.2.2 are used in the detailed fate and transport analysis in Section 4.2.3 to estimate potential exposure point concentrations in ambient and indoor air.

4.2.1 STATISTICAL EVALUATION OF SITE DATA

Statistical methods are used to evaluate the analytical results from the site sampling to (1) characterize the statistical distribution of COPCs, (2) develop source-term concentrations for fate and transport modeling, and (3) establish exposure point concentrations for direct exposures for applicable receptors. The rationale used to develop this methodology and the statistical techniques are based on the following sources:

- *Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual, Part A* (EPA, 1989a),
- *Statistical Methods for Evaluating the Attainment of Cleanup Standards, Volume 1* (EPA, 1989b), and
- *Statistical Methods for Environmental Pollution Monitoring* (Gilbert, 1987).
- *Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities (Cal/EPA 1992)*

The specific scope of this risk assessment is to evaluate the potential health risks associated with existing site conditions and projected future groundwater conditions under the no action alternative. Additional discussions of historical off-site studies and or background characterization may be found in the remedial investigation report.

4.2.1.1 Statistical Analysis of Soil Data

For each COPC detected in soil, statistical summaries were developed, including the arithmetic mean, standard error of the arithmetic mean, minimum detected concentration, maximum detected concentration, variance, standard deviation, and 95 percent upper confidence limit (UCL) of the mean. First, however, the approach for assigning proxy values to COPC results reported as below detection limits had to be developed.

4.2.1.1.1 Treatment of COPC "Nondetects"

Every laboratory technique used to measure the concentration of chemicals has an associated limit of detection (LOD) and limit of quantification (LOQ). A chemical that is "nondetect" in a sample is either not present or is present in a concentration below the LOD. A chemical that is detected but in such low amounts that its concentration could not be accurately determined is below the LOQ.

For this risk assessment, when a COPC is detected in some samples, it is assumed to be present in samples in which it was not detected. The assignment of a proxy value equal to one-half the detection limit (if the chemical is normally distributed) to all nondetect samples reflects the assumption that the samples are equally likely to have any value up to the detection limit. Furthermore, when the sample values above the LOQ are lognormally distributed, it is reasonable to assume that values below the LOQ are also lognormally distributed, and the reported detection limit divided by the square root of 2 is assigned as a proxy to "nondetect" concentrations in samples (Cal/EPA, 1992; EPA, 1988a, 1988b).

4.2.1.1.2 Assessment of Data Distribution

Any assignment of proxy value for results reported as below the LOD depends on an assessment of the data distribution. The distribution must be evaluated before applying any statistical methods. This minimizes the effect of data biasing and subsequent underestimation of exposures. Distribution fit testing of the data using Crystal Ball™, a commercial software package, was used to assess chemical-specific distributions. In the majority of the cases, the findings were inconclusive; thus, concentrations were calculated assuming normal and lognormal distribution for COPCs as described in Appendix A.

4.2.1.1.3 Use of 95-Percent Upper Confidence Limit Concentrations

Due to the uncertainty associated with characterizing potentially heterogeneous media, the 95-percent UCL for either a normal or lognormal distribution is used to represent chemical concentrations (Cal/EPA, 1992; EPA, 1988a, 1988b, 1992d). Since the underlying data distribution could not be defined in the majority of the cases, the greater of the 95-percent UCL under normal or lognormal conditions, not exceeding the maximum detected value, was used in this risk assessment. When both 95-percent UCLs exceeded the maximum detected value, the maximum detected value was used. This approach is consistent with DTSC guidance (Cal/EPA, 1994; DTSC, 2002).

Table 4-1 presents the 95-percent UCL concentrations of COPCs in site soil. These concentrations are assumed to be representative of concentrations across the entire site. Appendix A presents statistical summaries for each of the site COPCs.

4.2.1.2 Statistical Analysis of Groundwater Data

Throughout the remedial investigation, contractors have routinely collected groundwater samples from across the site (Panacea, 2003a). Two water-bearing units, the A- and B-zones, have been consistently sampled. This BHHRA has used the 95-percent UCL of the average results from these samples in the derivation of current onsite exposure point concentrations. Due to the lack of complete exposure pathways to the B-zone groundwater under the current exposure scenario, exposure point concentrations have only been calculated for the A-zone. Table 4-2 summarizes the resultant exposure point concentrations for the A-zone. The groundwater sampling results are presented in Appendix B of the RI report.

4.2.2 GROUNDWATER FATE AND TRANSPORT

Panacea has assessed the fate and transport of selected COPCs identified in the unsaturated and saturated zones (Panacea, 2002). Specifically, a computer-aided fate and transport analysis has been completed to estimate future concentrations of the COPCs in groundwater at selected locations based on current concentrations in soil (Table 4-1) and groundwater (Table 4-2). The modeling effort was designed in a way that provides conservative yet reasonable and technically defensible concentration estimates.

The computer model T2VOC was used to assess the future impact to selected groundwater receptor points resulting from the predicted vertical migration of COPCs from the overlying unsaturated zone soils and subsequent migration through the saturated zone.[1]

Input parameters required to run T2VOC for the assessment of vertical transport include COPC-specific soil concentrations, COPC-specific chemical parameters (including the organic carbon-water portioning coefficient and Henry's Law constant), soil physical parameters (including moisture content, bulk density, porosity, and organic carbon content), and the groundwater recharge rate. Site-specific and literature data were used to assign values to these input parameters. T2VOC uses the COPC-specific soil concentrations and chemical parameters to partition COPC mass among the adsorbed (soil), aqueous phase, and vapor phase within the unsaturated zone. Mass in the mobile aqueous phase is transported vertically toward groundwater. Vapor-phase contaminants are transported towards the surface and underlying groundwater. The groundwater recharge rate is used to transport mass in the aqueous phase, while the vapor phase diffusion coefficient is used for the vapor phase. T2VOC calculates the total mass loading over time due to aqueous-phase and vapor-phase migration from the unsaturated zone into the groundwater. This mass loading term is internally used as input to the fate and transport analysis of the saturated zone.

T2VOC calculates groundwater elevations and flow based on user-specified hydraulic and lithologic boundaries, aquifer characteristics, and hydraulic stresses to the groundwater system (such as production wells). Therefore, the data required to run T2VOC for the assessment of the saturated zone includes hydraulic and lithologic boundaries as quantified through the use of site-specific and regional cross-sections, groundwater elevations, aquifer parameters (e.g., hydraulic conductivity and the storage coefficient as quantified through the use of site-specific and literature data), and production well information (e.g., screened intervals and pumping schedules).

T2VOC uses the calculated flow field to transport the COPCs through the saturated zone. The previously discussed loading from the unsaturated zone and COPCs already present in the saturated zone serve as input into the T2VOC model. The T2VOC output is presented as "x-y" graphs of concentrations versus time for each COPC at each predetermined point of compliance. Three separate points of compliance were identified in the groundwater fate and transport modeling for use in the risk assessment: A-Zone fence line, B-Zone fence line, and B-Zone City well (downgradient Arvin City production well). The

[1] T2VOC was developed with funding from the EPA and U.S. Department of Energy – Lawrence Berkeley National Laboratory. Quality control and quality assurance measures for the development and testing of the modeling code have been some of the most stringent in the industry. In 1994, Multimedia Environmental Technologies, Inc. (MET) received a letter of approval from the California Regional Water Quality Control Board for the use of this code for fate and transport analysis on the complicated San Gabriel Valley Superfund site. Throughout the model approval process on this project, the Regional Water Quality Control Board consulted EPA Region IX. For these reasons, T2VOC was identified as the preferred numerical code for groundwater fate and transport simulations at the Brown & Bryant Superfund Site (Panacea, 2002).

maximum 30-year average projected by the model at each predetermined compliance point has been used as the exposure point concentration for this risk assessment. These maximum 30-year averages are designed to be conservative yet reasonable based on projected groundwater fate and transport conditions and modeling assumptions. Table 4-3 summarizes these concentrations. These concentrations are used conservatively to assess the potential future risk to site receptors as described in the following sections. A complete copy of the fate and transport analysis completed by Panacea can be found in the accompanying Remedial Investigation report (Panacea, 2003b).

4.2.3 AIR TRANSPORT ANALYSES

An analysis of the transport of COPCs at the site through the air pathway was conducted to assess potential receptor exposure concentrations. This section describes the methodologies used in the air transport analysis.

This air transport analysis estimates the airborne COPC concentrations for two emissions cases. The first case is applicable to the short-term ambient (outside) air; soils are assumed to be uncovered (existing cap breached) during maintenance and construction activities. Source terms were limited to concentrations in surface soils (0 to 10 feet bgs) based on the theoretical potential for increased direct exposure to surface soils by potential maintenance workers.

The second emissions case estimates the long-term airborne COPC concentrations inside residential or commercial/industrial facilities and the outside ambient air. It is important to note that the indoor air intrusion model accounts for the attenuation effects of anticipated future site structures on volatile emissions. However, to be conservative, no attenuation of volatiles has been assumed for asphalt and vegetation outside of the building footprint. Due to the long-term nature of this emissions case, all potential soil sources and the A-zone groundwater are evaluated.

The air transport analysis follows guidelines developed by the EPA (1989a) and Cal/EPA (1990, 1992). The sources of air emissions and the COPCs released are identified based on site-specific information (see Section 4.1). In this analysis, site-specific data are used for chemical concentrations. Site-specific data regarding soil properties have also been used when available. When site-specific values were not available, conservative assumptions found in appropriate literature have been used. Regulatory default options and values are used in the source emission calculations and air models. The intent of assumptions used in this analysis is to make the results relevant to the site, yet conservative, so that the risk associated with this exposure pathway is not underestimated. This approach is consistent with EPA and Cal/EPA guidance (EPA, 1989a, Cal/EPA, 1992).

4.2.3.1 Short-Term Emission Case

Inhalation exposures for soil emissions are characterized as secondary, meaning exposures occur away from or in a different medium than the source. The COPC concentrations at the point of exposure are typically lower than the representative value determined for the source medium. Therefore, to quantify exposure through indirect exposures, the reduction in COPC concentrations associated with each transport mechanism from the source medium to the point of exposure must be characterized in terms of an attenuation factor (Cal/EPA, 1994, 1999).

Attenuation factors for the volatilization and particulate resuspension of COPCs are developed for use in the quantification of potential ambient air exposures associated with the site. These attenuation factors are used to correlate potential exposure point concentrations originating from limited surface areas

during construction activities. Site-specific data are used when available, with literature sources serving as a secondary source. The following sections present the methodology used in the development of these attenuation factors for each transport mechanism.

4.2.3.1.1 Volatilization Attenuation Factors

A volatilization emission model is used to calculate ambient air attenuation factors for COPCs that volatilize from soil. This is the same model used by EPA (1996b, 1998a) to develop preliminary remediation goals (PRGs). The volatilization model estimates the concentration of chemicals emitted from soils and dispersed throughout ambient air during transport from the source to the point of exposure. Estimating a volatilization attenuation factor for airborne concentrations of chemicals in the volatilized phase involves modeling both emissions and dispersion. The emission component follows the mathematical model developed by Farmer et al. (1980), while the dispersion component is the AREA-ST model, an updated version of the Industrial Source Complex Model 2 (ISC2) developed by the EPA Office of Air Quality Planning and Standards (EPA, 1996a).

The emission component incorporates several assumptions (EPA 1996a). This equation, based on Fick's First Law of steady-state diffusion, assumes that diffusion into the atmosphere occurs at a plane surface where concentrations remain constant. It ignores biodegradation, transport in water, and adsorption. Thus, diffusion of vapor through soil cover is the controlling factor.

The AREA-ST dispersion model is based on the Gaussian dispersion principle. Gaussian models assume that material that is continually released will be transported in a direction opposite to the wind direction, and time-averaged spreading of the pollutants will result in normal distribution if sampled in cross sections of the plume. AREA-ST is extremely useful as a practical modeling tool, but it relies on several fundamental assumptions that must be noted. Emission rates are assumed to be constant and continuous. No variations occur in wind speed, wind direction, or Pasquill stability class during transport from source to receptor. The values used in this baseline risk assessment are either site-specific or literature values designed to produce conservative results, thus ensuring that potential health impacts are not underestimated.

The volatilization attenuation factors for the site are calculated as follows:

$$VF = Q/C \times [(3.1416 \times Z \times T)^{1/2}/(2 \times D_{ei} \times P_a \times K_{as})] \times UC1 \qquad (4\text{-}1)$$

where:

VF = volatilization attenuation factor (cubic meters per kilogram [m^3/kg])

Q/C = dispersion component, emission flux per unit concentration [grams per square meter per second (g/m^2/sec)/kilograms per cubic meter (kg/m^3)], from Equation 4-2

Z = intermediate conversion factor (square centimeters per second [cm^2/sec]), from Equation 4-6

T = exposure interval; total exposure in seconds, as follows:

2.16×10^7 for the construction worker

D_{ei} = effective diffusivity of a COPC through a soil matrix (cm^2/sec), from Equation 4-4

P_a = air-filled porosity of the soil matrix, 0.13 (unitless) (DTSC, 2002)

K_{as} = soil-to-air partition coefficient (grams soil per cubic centimeter of air [g soil/cm^3 air]), from Equation 4-5

UC1 = unit conversion factor (0.0001 square meter per square centimeter [m^2/cm^2])

The dispersion coefficient, Q/C, is calculated using the following equation:

$$Q/C = \{exp[((0.1004 \times ln(A))-5.3466) + (2.92 \times sY)]\}^{-1} \quad (4\text{-}2)$$

where

A = assumed area of contiguous contamination, 484 m^2 (Cal/EPA, 1994, 1999)

sY = intermediate value for calculating Q/C, derived as follows:

$$0.02685 \times \{0.25 + [(ln(A)-11.0509)^2/26.3608]\} \quad (4\text{-}3)$$

The effective diffusivity of the COPC through the soil matrix, D_{ei}, was estimated by:

$$D_{ei} = D_i \times (P_a^{3.33}/P_t^2) \quad (4\text{-}4)$$

where

D_i = COPC-specific diffusivity of COPC in air (cm^2/sec), from Table 4-4

P_a = air-filled porosity of soil matrix, 0.13 (unitless) (DTSC, 2002)

P_t = total porosity of soil matrix, 0.43 (unitless) (DTSC, 2002)

The soil-to-air partition coefficient, K_{as}, is derived from the COPC-specific soil-water partition coefficient and Henry's Law constant:

$$K_{as} = H'/(R \times T \times K_d) \quad (4\text{-}5)$$

where

H′ = COPC-specific Henry's Law constant (atm-m^3/mol), from Table 4-4

R = ideal gas constant, 8.206 x 10^{-5} atm-m^3/mol/K (atmosphere-cubic meter/mol/Kelvin)

T = temperature (degrees Kelvin), 293°K

K_d = soil-to-water partitioning coefficient (cubic centimeter per gram [cm^3/g]), K_{oc}, from Table 4-4 multiplied by the fraction of organic carbon (f_{oc}), 0.002 (unitless) (Cal/EPA, 1994, 1999)

The intermediate conversion factor, Z, in the volatilization attenuation factor is calculated as:

$$Z = (D_{ei} \times P_a)/[P_a + (ps \times (1-P_a)/K_{as})] \qquad (4\text{-}6)$$

where

D_{ei} = effective diffusivity of a COPC through a soil matrix (cm^2/sec)

P_a = air-filled porosity of the soil matrix, 0.13 (unitless) (DTSC, 2002)

ps = true soil or particle density, 2.72 grams per cubic centimeter (g/cm^3) (DTSC, 2002)

K_{as} = soil-to-air partition coefficient (g soil/cm^3 air)

A summary of the calculated volatilization attenuation factors is presented in Table 4-5.

4.2.3.1.2 Particulate Re-suspension Attenuation Factors

Estimating airborne concentrations of COPCs in the particulate phase involves modeling both resuspension and dispersion. The resuspension component was designed by Cowherd et al (1985) as a rapid assessment procedure applicable to a typical hazardous waste site where the surface contamination provides relatively continuous and constant potential for emission over a period of time.

This component considers wind-borne emissions and does not consider dust emissions from traffic or other forms of mechanical disturbances. However, it is felt that the degree of accuracy attainable using this model is consistent with that generally expected to result from simplified quantitative estimation procedures (EPA, 1998a).

For this analysis, the Gaussian dispersion component applied to volatile emissions (Section 4.2.3.1.1) was also applied to particulate dispersion.

The particulate resuspension attenuation factor, PF, is calculated as follows:

$$PF = Q/C \times \{3600/[RPF \times (1-G) \times (U_m/U_t)^3 \times F_x]\} \qquad (4\text{-}7)$$

where

PF = particulate attenuation factor (m^3/kg)

Q/C = dispersion component, emission flux per unit concentration [$(g/m^2/sec)/(kg/m^3)$], from Equation 4-9, equal to 103.0

RPF = respirable fraction of particulate, 0.036 grams per square meter per hour ($g/m^2/h$)

G = fraction of vegetative cover, 0 (unitless) (Cal/EPA 1999)

U_m = wind speed, 4.50 m/sec (Cal/EPA, 1999)

U_t = equivalent threshold value of wind speed at 7 meters, 12.8 m/sec (Cal/EPA, 1999)

F_x = function describing U_t/U_m (unitless), equal to 0.0497 and derived as follows:

$$F_x = 0.18 \times [8X^3 + 12X] \times \exp[-(X^2)] \qquad (4\text{-}8)$$

where

$X = 0.886 \times (U_t/U_m)$

The dispersion coefficient, Q/C, is calculated using the following equation:

$$Q/C = \{\exp[((0.1004 \times \ln(A))-5.3466) + (2.92 \times sY)]\}^{-1} \qquad (4\text{-}9)$$

where

A = assumed area of contiguous contamination, 484 m^2 (Cal/EPA, 1999)

sY = intermediate value for calculating Q/C, derived as follows:

$$0.02685 \times \{0.25 + [(\ln(A)-11.0509)^2/26.3608]\} \qquad (4\text{-}10)$$

As shown in the previous equations, the calculated particulate attenuation factor is independent of the COPC and represents an estimated rate of re-suspension of soil. The calculated value used in this risk assessment is 4.77×10^9 m^3/kg soil. This is the identical particulate emission factor calculated by EPA Region IX for use in the Preliminary Remediation Goals (EPA, 1998a).

4.2.3.2 Long-Term Emission Case

The long-term emission case consists of three components: (1) indoor air modeling to account for COPCs that may migrate into onsite buildings, (2) emissions of volatile COPCs from onsite soil sources to outdoor ambient air, and (3) emissions of COPC volatiles from groundwater to outdoor ambient air.

4.2.3.2.1 Indoor Air Emission Case

All of the assumed exposure scenarios include buildings. A building may trap volatile emissions from underlying soil. The resultant indoor air concentrations may be higher than those in the ambient air.

Vapor intrusion models were reviewed to identify an appropriate model for estimating potential indoor air concentrations resulting from COPCs that may volatilize from soil/groundwater and enter future buildings. The models estimate the chemical concentration in soil gas, the subsequent movement of the vapor phase chemical upward to the atmosphere, and then the concentration of the chemical in indoor air. EPA and DTSC recommend the Johnson-Ettinger Model for Subsurface Vapor Intrusion into Buildings (Johnson and Ettinger, 1991). Copies of this model are provided and maintained by DTSC (2002), and the model has been incorporated into this risk assessment. The following paragraphs summarize several of the major points found in this reference.

The Johnson-Ettinger intrusion model incorporates several fundamental assumptions (Johnson and Ettinger, 1991). The model considers both diffusive flux and convection-driven flow. The chemical is assumed to be present as a non-diminishing, steady-state source even though, for most chemicals, biodegradation and other attenuation forces are expected to occur in subsurface media over time. This is therefore a conservative assumption. The system is assumed to be at equilibrium, and exposure to chemicals above equilibrium levels due to shutdown of the building ventilation system is assumed to be trivial in terms of exposure duration. It is assumed that flux occurs only through infiltration areas such as cracks in the building slab and that flux through the building slab itself is insignificant. Finally, all vapors originating directly below the foundation are assumed to enter the building. This too is a conservative assumption (Johnson and Ettinger, 1991).

The vapor intrusion model was proposed as a method of calculating chemical concentrations in indoor air based on specified chemical concentrations in soil gas (Johnson and Ettinger, 1991). Physical parameters such as moisture content, dry-soil density, porosity, and effective air permeability affect the rate at which the vapors from a volatile chemical migrate through the soils. The dominant mechanism, (diffusion or convection) of vapor migration is closely correlated with the depth to source and soil permeability (Johnson and Ettinger, 1991).

For the indoor air analysis, site-specific values were used for these parameters when available. Conservative default values were identified based on known site characteristics for parameters that were not measured directly. Regulatory guidance and literature sources were consulted regarding the building parameters (e.g., building dimensions, air exchange rates, and foundation characteristics). These building parameters are applied in the indoor air analysis.

The modeling of on-site vapor intrusion has included all soil sources and the underlying A-zone groundwater contamination. The maximum 30-year average fence line concentrations found in the A-zone groundwater were used for modeling off-site residential and commercial/industrial scenarios. B-zone contamination was found to be insignificant as a result of depth and markedly lower levels of contaminants. The detailed model outputs are presented in Appendix B. Tables 4-6 and 4-7 summarize the modeled indoor air concentrations.

4.2.3.2.2 Ambient Air Emissions

The latest release of the Industrial Source Complex – Short Term 3 (ISCST3) air dispersion model (EPA, 1996a) is used in this assessment to calculate maximum annual onsite and offsite COPC concentrations under both current and future exposure scenarios. This model is recommended in California's risk assessment guidance for air pathway analysis at hazardous waste sites (Cal/EPA, 1992). EPA developed the ISCST3 model to assess the air-quality impact of emissions from a wide variety of sources. The model incorporates a steady-state Gaussian plume equation that is applicable in flat and gently rolling terrain (applicable to conditions at this site) and can be used for single- or multiple-point area or volume

sources. ISCST3 can calculate short-term as well as annual average COPC concentrations at user-defined receptor locations. The required input to the model includes source locations, configurations and emissions, receptor locations and elevations, and hourly meteorological data (e.g., wind speed, wind direction, atmospheric stability, ambient temperature, and mixing height).

Emission Estimates

The primary release mechanism identified for COPC air emissions from soils and groundwater is volatilization. Methods for estimating organic COPC emission rates from various hazardous waste media are provided in guidance documents from Cal/EPA (1990) and EPA (1987a, 1987b, 1988c, 1989a). The methods described for estimating organic emissions from landfills without internal gas generation are applicable and appropriate to use to estimate organic emissions from the site in this assessment.

The landfill emission equation (without internal gas generation) is based on Fick's First Law of steady state diffusion and was developed by Farmer et al. (1980). The Farmer et al. model provides a worst-case estimate by assuming the soil is completely dry and the COPC concentration at the surface-soil/air interface is zero. These assumptions provide the largest soil vapor space for volatilization and the highest driving force for COPC flux from the soil. The Farmer et al. model was modified by Shen (1981) to enable calculation of the volatilization of specific components of complete waste mixtures. The final equations used in the analysis for calculating organic COPC emissions from the site (EPA, 1989a, 1989b, 1990a) are presented below.

COPC concentrations in soil gas are estimated using each site representative soil and underlying groundwater concentrations as follows:

$$\textit{Soil:} \quad C_{sg} = \frac{C_s H P_s}{\left[P_w + K_{oc} P_s + H P_a\right]} \qquad (4\text{-}11)$$

or

$$\textit{Groundwater:} \qquad C_{sg} = H C_w \qquad (4\text{-}12)$$

where

C_{sg} = concentration in soil gas (mg/L)

C_s = representative concentration in soil (mg/kg), from Table 4-1

Cw = representative concentration in groundwater (mg/L), from Table 4-2

H = Henry's law constant (unitless), from Table 4-4

P_s = soil bulk density, 1.5 g/cm^3 (Cal/EPA, 1999)

P_w = water-filled porosity, 0.3 (Cal/EPA, 1999)

K_S = K_{oc} (liters per kilogram [L/kg]), from Table 4-4 multiplied by foc, 0.002 (Cal/EPA, 1999)

P_a = air-filled porosity, 0.13(Cal/EPA, 1999)

The estimated soil gas concentrations are used to calculate the diffusive flux of the COPC from soils to the atmosphere:

$$F = (C_{sg} - C_o) \times D_{ei} \times UC1 / X \qquad (4\text{-}13)$$

where

F = flux (mg/cm^2-sec [milligrams per square centimeters-second])

C_{sg}= concentration in soil gas (mg/L), from Equations *4-11* and *4-12*

Co = existing soil gas concentration, 0 mg/L, assumed for soil source estimation purposes

D_{ei} = effective diffusivity of a COPC through soil matrix (cm^2/sec)

UC1 = unit conversion, 0.001 liter per cubic centimeter (L/cm^3)

X = effective depth of cover,
61 cm (surface soils 0 to 10 feet) 61cm = 2.0 feet
305 cm (subsurface soils 10 feet to A-zone)
1981 cm (A-zone groundwater)

The effective diffusivity, Dei, of the COPC through the media between the source and atmosphere is approximated as:

$$D_{ei} = D_i \times (Pa)^{3.33} / P_t^2 \qquad (4\text{-}14)$$

where

D_i = COPC-specific diffusivity of COPC in air (cm^2/sec), from Table 4-4

P_t = total soil porosity, 0.43 (unitless) (Cal/EPA, 1999)

P_a = air-filled soil porosity, 0.13 (unitless) (Cal/EPA, 1999)

To maximize the estimated flux of COPCs, it is conservatively assumed for each medium (0 to 10, 10 to Azone, and A-Zone) that the existing soil gas concentration in the overlying soil column is zero. Therefore, each source is estimated at its maximum flux rate.

Meteorological Data

ISCST3 requires as input meteorological data characterizing the transport and dispersion conditions of the study area. An electronic file of hourly readings summarizing the meteorological conditions for the years 1986 to 1990 was compiled. Meteorological data for the Brown & Bryant Superfund site or the City of Arvin was not available from the SJV-APCD during the preparation of this risk assessment. The nearest complete available data set provided by SJV-APCD was for the City of Bakersfield. The Brown & Bryant Superfund site is located 18 miles southeast of Bakersfield.

Receptors

An 80-element, rectangular grid was used for air-dispersion analysis. The grid covers the entire site and projected future off-site COPC plume. The grid-point interval of 25 meters is fine enough to show the maximum on- and off-site impact location for each COPC. The flagpole receptor option in the ISCST3 model is used in this assessment to place the grid points 1.5 meters above the ground—the approximate breathing height of a typical adult.

Air Dispersion Modeling Results

The ISCST3 results for the maximum onsite and offsite COPC concentrations in ambient air are summarized in Table 4-8. The modeling output files are provided in Appendix B. These results are used throughout the remainder of this risk assessment to estimate long-term volatile exposures to ambient air. It should also be noted that ambient air is introduced into all hypothetical buildings assessed in this risk assessment via ventilation systems. Thus, these values are used to estimate the concentration of COPCs introduced to the indoor air environment through this pathway.

4.3 EXPOSURE QUANTIFICATION

The conceptual site model described in Sections 4.1 quantified the magnitude, frequency, and duration of exposure for those populations and pathways selected for quantitative evaluation. The following sections give standard equations for estimating human intake doses and subsequent risk associated with the selected exposure pathways for the site COPCs. The equations, exposure parameters, and parameter values were taken from EPA's RAGS (EPA, 1989a, 1991b) and *Exposure Factors Handbook* (EPA, 1990a, 1997a). The exposure parameter values for each receptor under study are presented in Tables 4-9 and 4-10, below. Table 4-9 has been prepared in accordance with the reasonable maximum exposure, and Table 4-10 in accordance with central tendency exposure assumptions (Section 4.1.1.3).

Exposure intake doses were calculated for all receptors identified in Sections 4.1 and 4.2, and all results are presented in Appendix C.

In the following subsections, examples are presented to illustrate the calculation of exposure due to a concentration of a hypothetical contaminant through each of the previously identified applicable pathways. The example calculation methodologies apply to all receptors associated with the site exposure scenarios; however, appropriate exposure parameters for the other receptors could be substituted where applicable.

4.3.1 AIR EXPOSURES – INHALATION EXAMPLE CALCULATIONS

Equation 6-16 from RAGS (EPA, 1989a) was used to quantify intake dose from the inhalation pathway:

$$I_a = (C_a)(IR)(ET)(EF)(ED) / (BW)(AT) \quad (4\text{-}15)$$

where

I_a = intake dose from inhalation of a COPC in air (mg/kg-d [milligrams per kilogram-day])

C_a = concentration of COPC in air (milligrams per cubic meter [mg/m^3])

IR = inhalation rate (cubic meters per hour [m^3/h])

ET = exposure time (hours per day [h/d])

EF = exposure frequency (days per year [d/y])

ED = exposure duration (years [y])

BW = body weight (kilograms [kg])

AT = averaging time (d), ED x 365 d/y (noncarcinogens), 70 y x 365 d/y (carcinogens)

The COPC concentration in air, C_a, was calculated separately for the short-term (maintenance worker) and long-term (all other receptors) exposures, as follows:

Short-Term Exposures

$$C_a = (C_s)(1/VF + 1/PF) \quad (4\text{-}16)$$

C_s = concentration of COPC in surface soil, 0 to 10 feet bgs (mg/kg), Table 4-1

VF = receptor-specific volatilization attenuation factor (m^3/kg), Table 4-5

PF = particulate attenuation factor, 4.77 x 10^9 m^3/kg

Long-Term Exposures

$$C_a = C_i \text{ or } C_{ototal} \quad (4\text{-}17)$$

C_i = modeled indoor air concentration (mg/m^3), Table 4-6 or 4-7

C_{ototal} = outdoor volatiles from all sources (mg/m^3), from Table 4-7

Using the off-site resident adult as an example, intake (I_a) resulting from inhaling indoor air hypothetically containing 1 milligram of contaminant per cubic meter of air (C_a) is calculated as follows (see Table 4-9 for exposure parameters). The inhalation rate (IR) for an active adult is 0.86 cubic meter per hour. The total exposure time (ET) is 16 hours per day for exposures indoors. The exposure duration (ED) is 30 years, and the exposure frequency (EF) is 350 days per year. The body weight (BW) for an adult is 70 kilograms. The assessment of carcinogenic exposure is averaged over a 70-year lifetime (AT = 25,550 d), while for noncarcinogenic effects, exposure is averaged over the actual period of exposure (AT = ED x 365). Substituting these values into Equation 4-15 yields:

$$I_a = (1.0\ mg/m^3)(0.86\ m^3/h)(16\ h/d)(350\ d/y)(30\ y) / (70kg)(25{,}550\ d) \qquad (4\text{-}18)$$

or

$$I_a = 8.08 \times 10^{-2}\ mg/kg\text{-}d$$

Appropriate sections of Appendix C present the calculations for intake doses for all inhalation exposure pathways.

4.3.2 GROUNDWATER EXPOSURE – INGESTION EXAMPLE CALCULATIONS

Equation 6-11 from RAGS (EPA, 1989a) is used to quantify intake dose from the groundwater ingestion pathway:

$$Igi = (C_W)(IR)(EF)(ED) / (BW)(AT) \qquad (4\text{-}19)$$

where

Igi = intake dose from ingestion of groundwater for a COPC (mg/kg-d)

C_W = concentration of COPC in water (mg/L), Table 4-3

IR = ingestion rate (liter per day [L/d])

EF = exposure frequency (d/y)

ED = exposure duration (y)

BW = body weight (kg)

AT = averaging time (d), ED x 365 d/y (noncarcinogens), 70 y x 365 d/y (carcinogens)

Using the off-site resident adult's exposure to a hypothetical contaminant as an example, intake (I_{gi}) resulting from ingestion of groundwater hypothetically containing 1 milligram of contaminant per liter (CW) is calculated as follows (see Table 4-9 for exposure parameters). The reasonable maximum ingestion rate (IR) of groundwater is 2 liters per day. The exposure frequency (EF) is 350 days per year, and the exposure duration (ED) is 30 years. The body weight (BW) for an adult is 70 kilograms. For potential carcinogenic risk, the intake is averaged over a 70-year lifetime (AT = 25,550 d). For potential

noncarcinogenic hazards, the intake is averaged over the actual duration of exposure (AT = ED x 365 d). Substituting these values into Equation 4-19 yields:

$$I_{gi} = (1\ mg/L)(2\ L/d)(350\ d/y)(30\ y) / (70\ kg)(25{,}550\ d) \qquad (4\text{-}20)$$

or

$$I_{gi} = 1.17 \times 10^{-2}\ mg/kg\text{-}d$$

Appropriate sections of Appendix C have complete calculation sheets for all receptor exposures through the ingestion of groundwater.

4.3.3 GROUNDWATER EXPOSURE – DERMAL CONTACT EXAMPLE CALCULATIONS

Equation 6-12 from RAGS (EPA, 1989a) is used to quantify intake dose from dermal exposures to contaminated groundwater:

$$Igd = (DA)(SA)(EF)(ED) / (BW)(AT) \qquad (4\text{-}21)$$

where

I_{gd} = intake dose from dermal contact with groundwater for a COPC (mg/kg-d)

DA = dermal absorbed dose per exposure event (mg/cm^2-d [milligrams/square centimeters-day])

SA = body surface area in contact with groundwater (cm^2)

EF = exposure frequency (d/y)

ED = exposure duration (y)

BW = body weight (kg)

AT = averaging time (d)

The dose absorbed (DA) per event can be estimated using two different models: steady state and nonsteady state. The steady-state approach assumes that a fraction or percentage of the applied dose will be absorbed across the skin membrane. The nonsteady-state model assumes that for periods of short exposure, a flux value, normalized for concentration, can be developed to represent the rate at which the chemical will penetrate the skin. Currently, EPA recommends the use of the steady-state model for inorganic chemicals and the nonsteady-state model for organic chemicals (EPA 1992a). All COPCs identified in the B-zone groundwater are organics; therefore, the nonsteady-state model was used as described below.

The nonsteady-state model requires input parameters that are difficult to measure, such as the stratum corneum diffusion coefficient (Dsc), which must generally be estimated. The estimation of these chemical-specific parameters makes this a six-step process.

The first step is the calculation of the permeability coefficient, K_p, for the organic COPC:

$$\log K_p = -2.72 + 0.71 \times \log K_{ow} - 0.0061 \times MW \qquad (4\text{-}22)$$

where

K_p = permeability coefficient in water (cm/hr) K_{ow} = octanol/water partition coefficient (unitless), from Table 4-11

MW = molecular weight, from Table 4-11

Table 4-11 presents the resultant Kp values for each COPC. For highly lipophilic compounds, the viable epidermis also serves as a significant resistance to penetration into the skin. The effect of the viable epidermis on the cumulative mass entering the stratum corneum can be characterized by a parameter, β, which describes the relative contribution of the permeability coefficients of the chemical in the stratum corneum and viable epidermis. The relative contribution described by this parameter is used in later calculations. This dimensionless parameter is calculated in the second step as follows:

$$\beta = K_{ow}/10^4 \qquad (4\text{-}23)$$

In the third step, the stratum corneum diffusion coefficient, D_{sc}, must be estimated for the subject chemical using the following:

$$\log (D_{sc}/l_{sc}) = -2.72 - 0.0061 \times MW \qquad (4\text{-}24)$$

where

D_{sc} = stratum corneum diffusion coefficient (cm^2/hr)

l_{sc} = stratum corneum diffusion path length, 10^{-3} cm (EPA, 1992a, 1997a)

MW = molecular weight, from Table 4-11

The fourth step is the calculation of τ (hours), an interim factor used in the calculation of the time of exposure necessary to reach a steady state. τ is calculated using equation 5-14 from EPA (1992a, 1997a):

$$\tau = l_{sc}^2/6D_{sc} \qquad (4\text{-}25)$$

where

l_{sc} = stratum corneum diffusion path length, 10^{-3} cm (EPA, 1992a)

D_{sc} = stratum corneum diffusion coefficient (cm^2/hr)

At the fifth step, T is calculated. The time necessary to reach a steady-state exposure, T (hours), can be evaluated as function of β:

For $\beta \leq 0.1$

$$T = 2.4 \times \tau \qquad (4\text{-}26)$$

For $0.1 \leq \beta \leq 1.17$

$$T = (8.4 + 6\log\beta) \times \tau \qquad (4\text{-}27)$$

For $\beta \geq 1.17$

$$T = 6 \times (b - (b^2 - c^2)^{0.5}) \times \tau \qquad (4\text{-}28)$$

where b and c are calculated as follows:

$$b = 2/\pi \times (1 + \beta)^2 - c \qquad (4\text{-}29)$$

$$c = (1 + 3\beta)/3 \qquad (4\text{-}30)$$

The sixth step is to calculate DA_{event} (mg/cm^2-event) relative to T:

If ET < T, then

$$DA_{event} = C_{gw} \times 2 \times Kp \times CF \times (6 \times \tau \times ET/\pi)^{0.5} \qquad (4\text{-}31)$$

where

Cgw = concentration in tap water (mg/L), Table 4-3

Kp = permeability coeffieicent (cm/hr), EPA 1992a, 1997a

CF = volumetric conversion factor (L/cm^3), 1 x 10^{-3}

ET = exposure time (hours)

π = Pi (unitless)

If ET > T, then

$$DA_{event} = C_{gw} \times kp \times CF \{(ET/1+B) + 2\tau \times ((1+3\beta)/(1+\beta))\} \qquad (4\text{-}32)$$

where

Cgw = concentration in tap water (mg/L), Table 4-3

Kp = permeability coeffieicent (cm/hr), EPA 1992a, 1997a

CF = volumetric conversion factor (L/cm^3), 1 x 10^{-3}

ET = exposure time (hours)

B = Beta (unitless), Equation 4-23

Table 4-12 presents the calculated COPC-specific dose-absorbed values, per event, from dermal contact with B-zone groundwater. Dose-absorbed values were only calculated for those COPCs that were projected to reach future offsite B-zone groundwater users.

Using the off-site resident adult's exposure to a hypothetical contaminant as an example, intake (I_{gd}) resulting from dermal exposure with a dermal-absorbed dose of 1E-09 milligrams of a contaminant per square centimeter of exposed body surface area per event (DA) is calculated as follows (see Table 4-10 for exposure parameters). The body surface area (SA) for an adult while bathing is 23,000 square centimeters. The exposure frequency (EF) is 350 days per year, and the exposure duration (ED) is 30 years. The body weight (BW) for an adult is 70 kilograms. For potential carcinogenic effects, the intake is averaged over a 70-year lifetime (AT = 25,550 d). For potential noncarcinogenic hazards, the intake is averaged over the actual duration of exposure (AT = ED x 365 d). Substituting these values into Equation 4-21 yields:

$$I_{gd} = (1E\text{-}09\ mg/cm^2\text{-}d)(23000\ cm^2)(350\ d/y)(30\ y)\ /\ (70\ kg)(25{,}550\ d) \qquad (4\text{-}33)$$

or

$$I_{gd} = 1.35 \times 10^{-7}\ mg/kg\text{-}d$$

Appropriate sections of Appendix C have complete calculation sheets for exposure through dermal contact with groundwater.

4.3.4 SOIL EXPOSURES – INCIDENTAL INGESTION EXAMPLE CALCULATIONS

Equation 5-14 from RAGS (EPA, 1989a) is used to quantify intake from the ingestion pathway:

$$I_{si} = (C_s)(IR)(CF)(EF)(ED)\ /\ (BW)(AT) \qquad (4\text{-}34)$$

where

I_{si} = intake dose from incidental ingestion of soil for a COPC (mg/kg-d)

C_s = concentration of COPC in surface soil 0 to 10 feet bgs (mg/kg), Table 4-1

IR = ingestion rate (mg/d)

CF = conversion factor, 10^{-6} kg/mg

EF = exposure frequency (d/y)

ED = exposure duration (y)

BW = body weight (kg)

AT = averaging time (d), ED x 365d/y (noncarcinogens), 70y x 365d/y (carcinogens)

Using the on-site maintenance worker's exposure as an example, intake (I_{si}) resulting from ingestion of soil hypothetically containing 1milligram contaminant per kilogram soil (C_s) is calculated as follows (see Table 4-9 for exposure parameters). The reasonable maximum ingestion rate (IR) of soil for maintenance activities is 480 mg/d. The exposure frequency (EF) is 250 days per year, and the exposure duration (ED) is 1 year. The body weight (BW) for an adult is 70 kilograms. For potential carcinogenic effects, the intake is averaged over a 70-year lifetime (AT = 25,550 d). For potential noncarcinogenic hazards, the intake is averaged over the actual duration of exposure (AT = ED x 365 d). Substituting these values into Equation 4-19 yields:

$$I_{si} = (1\ mg/kg)(480\ mg/d)(10^{-6})(250\ d/y)(1\ y) / (70\ kg)(25{,}550\ d) \qquad (4\text{-}35)$$

or

$$I_{si} = 6.71 \times 10^{-8}\ mg/kg\text{-}d$$

Appropriate sections of Appendix C have complete calculation sheets for exposure through incidental ingestion of soil.

4.3.5 SOIL EXPOSURES – DERMAL CONTACT EXAMPLE CALCULATIONS

Equation 6-15 from RAGS (EPA, 1989a) is used to quantify intake from the dermal contact pathway:

$$I_{sd} = (C_s)(SA)(CF)(AF)(ABS)(EF)(ED) / (BW)(AT) \qquad (4\text{-}36)$$

where

I_{sd} = intake dose from dermal contact with soil (mg/kg-d)

C_s = concentration of a COPC in surface soil 0 to 10 feet bgs (mg/kg), Table 4-1

SA = skin surface area in contact with soils (cm^2/d)

CF = conversion factor, 10^{-6} kg/mg

AF = soil-to-skin adherence factor (mg/cm^2)

ABS = COPC-specific absorption factor (unitless), from Table 4-13

EF = exposure frequency (d/y)

ED = exposure duration (y)

BW = body weight (kg)

AT = averaging time (d), ED x 365d/y (noncarcinogens), 70y x 365d/y (carcinogens)

Continuing with the maintenance worker example, intake (I_{sd}) resulting from dermal contact with soil hypothetically containing 1 milligram contaminant per kilogram soil is calculated as follows (see Table 4-9 for exposure parameters). The adult skin surface area (SA) assumed exposed during construction activities is 5,800 square centimeters per day with a soil-to-skin adherence factor (AF) of 0.8 and a COPC-specific absorption factor (ABS) of 3.0 x 10^{-2} (Table 4-13 presents the absorption factors for each COPC evaluated in this report). The exposure frequency (EF) is 250 days per year, and the exposure duration (ED) is 1 year (construction schedule). The body weight for an adult is 70 kilograms. For potential carcinogenic risks, the intake is averaged over a 70-year lifetime (AT = 25,550 d). For potential noncarcinogenic effects, the intake is averaged over the actual duration of exposure (AT = ED x 365 d). Substituting these values into Equation 4-21 yields:

$$I_{sd} = (1\ mg/kg)(5800\ cm^2/d)(10^{-6})(0.8\ mg/cm^2)(3x10^{-2})(250\ d/y)(1\ y)/(70\ kg)(25{,}550\ d)$$

or (4-37)

$$I_{sd} = 1.94 \times 10^{-8}\ mg/kg\text{-}d$$

Appropriate sections of Appendix C present the complete calculation sheets for dermal contact exposures.

5.0 RISK CHARACTERIZATION

Risk characterization is the final step in the risk quantification process, combining the results of toxicity assessment (Section 3), exposure assessment (Section 4.1), and exposure point concentrations (Section 4.2). Risk characterization is the estimate of carcinogenic and noncarcinogenic effects from the exposure of COPCs over the applicable duration of exposure. In this report, potential carcinogenic risks resulting from exposure to site-related COPCs is presented as the incremental lifetime cancer risk (ILCR). The hazard of potential noncarcinogenic health effects is presented as the hazard index (HI).

Section 5.1 describes the methodology employed to characterize carcinogenic and noncarcinogenic risks. Section 5.2 presents the risks values estimated for the site exposure scenarios.

5.1 RISK CHARACTERIZATION METHODOLOGY

Potential health risks to humans following exposure to site-related COPCs were estimated using methods established by EPA and Cal/EPA. Key documents used as guidance for preparing this risk assessment are listed in Section 1 and are referenced throughout the following paragraphs.

5.1.1 HEALTH EFFECTS INDICES FOR QUANTITATIVE RISK ASSESSMENT

In health risk assessments, two different indices are calculated to evaluate potential health effects: the ILCR and the HI. The ILCR is an upper-bound estimate of the incremental cancer probability for individuals who may have been exposed to site-related, potentially carcinogenic COPCs. The ILCR is compared to a range of acceptable probabilities to determine whether the potential hazard poses an unacceptable health threat. The EPA currently uses an ILCR of 10^{-4} to 10^{-6} as the range of acceptable risk (EPA, 1990b, 1991a).

The potential health effects resulting from exposure to a noncarcinogenic, hazardous COPC are evaluated by comparing a receptor's exposure or intake dose to the reference dose (RfD) of that COPC (EPA, 1989a). The ratio of intake over the RfD is termed the hazard quotient (HQ). An RfD is the level at which no deleterious health effect is likely to occur to the exposed individual, where an exposure above the RfD (hazard quotient of greater than 1) puts the individual at risk of developing a chemical-specific health effect. Exposure to multiple chemicals can impose different stresses to different parts of the body or multiply the impact to one part of the body. As a conservative assessment of risk, HQs are summed into one Hazard Index (HI), assuming a multiplying effect (EPA, 1986). The HI is also compared to a threshold level of unity.

5.1.2 METHODS FOR CHARACTERIZING HEALTH EFFECTS

Risks from exposure to hazardous COPCs are calculated for carcinogenic and/or noncarcinogenic effects as appropriate. Some COPCs may pose both a noncarcinogenic hazard and a carcinogenic risk to receptors; risks from these COPCs are characterized for each type of health effect.

5.1.2.1 Carcinogenic Effects

The risk attributed to exposure to carcinogenic compounds is estimated as the probability of an individual developing cancer over a lifetime as a result of the exposure. At low doses (see Section 3.2), the risk of developing cancer (ILCR) is determined as follows (Cal/EPA, 1992, EPA, 1989a):

$$ILCR = (CDI)(CSF) \qquad (5\text{-}1)$$

An exposed receptor's risk is presented as the ILCR and is calculated by multiplying the chronic daily intake (CDI) value for carcinogenic effects by the cancer slope factor (CSF) of the carcinogenic COPC (presented in Section 3). If a receptor is exposed to several carcinogens through one pathway, the following equation is used to sum cancer risks:

$$ILCR_t = ILCR\ (COPC_1) + ILCR\ (COPC_2) + \ldots ILCR\ (COPC_n) \qquad (5\text{-}2)$$

where

$ILCR_t$ = total incremental lifetime risk of cancer incidence for a given pathway

$ILCR(COPC_n)$ = individual carcinogenic incremental lifetime risk

Similarly, if a receptor is exposed through multiple pathways, the total ILCR can be calculated by summing the pathway-specific risks (EPA, 1986).

5.1.2.2 Noncarcinogenic Effects

The noncarcinogenic hazard associated with a chemical exposure is expressed as the *hazard quotient* (HQ). The HQ is a ratio of the estimated chemical intake, based on the measured or calculated exposure concentration for a chemical (dose), divided by the appropriate oral or inhalation RfD. If the HQ exceeds 1, some harmful effect may occur or the threshold dose may be exceeded. If the HQ is equal to or less than 1, the exposure level is not likely to cause adverse effects. If exposure to multiple chemicals occurs, the potential for harmful effect is assessed by summing the HQs and is designated the *hazard index* (HI).

In keeping with EPA guidance (EPA, 1989a), all noncarcinogenic risk was considered additive for individual receptors regardless of target organ specificity. Since the noncarcinogenic COPCs typically are associated with various adverse effects on distinct target organs and systems, the assumption of additivity of effects may overstate the potential for harmful effects. On the other hand, the potential synergistic effects of two or more COPCs must also be recognized. That is, the combined effects of exposure to two or more COPCs may be worse than exposure to either COPC alone, because of interactions.

The HQ is used to characterize the potential health effects resulting from exposure to noncarcinogenic, hazardous COPCs. The HQ compares a receptor's exposure or intake level for a given COPC to the RfD of the COPC (EPA, 1989a). HQ is defined as:

$$HQ_i = CDI_i/RfD_i \qquad (5\text{-}3)$$

where

HQ_i = hazard quotient for $COPC_i$ (unitless)

CDI_i = chronic daily intake of $COPC_i$ (mg/kg-d)

RfD_i = reference dose of $COPC_i$ (mg/kg-d)

When using the above equation to estimate potential noncarcinogenic risk, both the intake and RfD must refer to exposures of equivalent duration (e.g., chronic, subchronic, or less than 2 weeks). In this risk assessment, residential and commercial/industrial activities were assessed using chronic RfD values. HIs were determined by assuming dose additivity for those COPCs acting by the same mechanism and inducing the same effects (EPA, 1986, 1989a). In the case of simultaneous exposure of a receptor to several COPCs, an HI was calculated as the sum of the HQs by:

$$HI_t = HQ(COPC_1) + HQ(COPC_2) + \ldots HQ(COPC_n) \qquad (5\text{-}4)$$

where

HI_t = total hazard index

$HQ(COPC_n)$ = individual non-carcinogenic COPC hazard

If the receptor is exposed through multiple pathways, the HI was calculated by first estimating the HQs for each COPCs in each exposure pathway and then summing the HQs to calculate a pathway-specific HI. Pathway HIs were then summed to produce a total HI specific to the receptor. By summing the HQs across pathways and COPCs, it is assumed that all COPCs exhibit similar toxic properties and that those from different pathways manifest the same toxic effects. This assumption is conservative and is addressed further in Section 6.

5.2 HEALTH RISKS FOR THE SITE

Tables 5-1 through 5-4 present the HI and ILCR results for each receptor studied under both current and future exposure scenarios. These tables present the risk from each pathway and also the total risk (in bold type) from all pathways. When a pathway is not complete (NC) then the risk is assumed zero. The

reasonable maximum exposure (RME) and central tendency exposure scenarios were used to quantify potential health impacts. If the RME values are within acceptable limits, then all other, lesser exposures related to the site are also within these limits (see Section 4.1). Tables 5-1 through 5-4 provide detailed calculations of health risks by receptor, COPC, and pathway for entries in Appendix C.

6.0 UNCERTAINTIES

The goal of a site health risk assessment is to provide estimates of risk indices that may help effective risk management. In this section, as recommended in EPA and Cal/EPA (EPA, 1989a, Cal/EPA 1992) guidance, the numeric risk index values are evaluated to identify the type and degree of uncertainty introduced in their assessment. Decision makers need to consider the uncertainties, limitations, and assumptions inherent in the numeric health risk assessment process to place RI and FS for the site.

For example, the ”de minimus,” or insignificant, cancer risk of 10^{-6} (or one in one million) may be calculated for an individual from exposure to a particular source of chemicals. However, if the uncertainty in this number is measured in orders of magnitude, then the real risk probability may in fact be higher than the risk from another contaminated source that has a calculated risk of 10^{-5} (or one in one hundred thousand) but a small degree of uncertainty. The risk assessment is an iterative process involving sequential evaluation of all site data. Once any type of uncertainty is introduced into the early stages of the process, it will propagate as calculations proceed. In its guidance for human health risk assessments, the EPA states that “it is more important to identify the key site-related variables and assumptions that contribute most to the uncertainty than to precisely quantify the degree of uncertainty in the health risk assessment” (EPA, 1989a).

The uncertainties inherent in this risk assessment are evaluated in this section. This evaluation is intended to provide a proper perspective of the overall quality of the predicted risk values.

6.1 SOURCES OF UNCERTAINTY

Health risk assessments generally carry two types of uncertainty—measurement and informational. Measurement uncertainty comes from the use of discrete samples to define overall site conditions and the variations in analytical results for COPCs. This uncertainty requires the use of 95-percent UCL concentration value to calculate an overestimate of risk from the exposure of a selected COPC.

Informational uncertainty arises when site-specific information regarding site parameters, such as slab thickness, air exchange rates, and building volumes are unavailable. When such values were not available and default values suggested by Cal/EPA were used in models to estimate indoor air vapor concentrations from COPCs in the soil, the resultant indoor air concentrations in air are likely to be overestimated.

In toxicity assessments, the impact of informational uncertainty is significant (e.g., uncertainties from the absence of information on the effects of human exposure to a chemical or on the biological mechanisms of action of a chemical) (EPA, 1992b, 1992d). In some instances, one can compensate for the overall impact of uncertainty by using the information available, coupled with reasonable assumptions, to place an upper limit on the uncertainty. This latter approach can be applied to such uncertainties as the interactions of chemical mixtures in the human body, the use of computer model default values for site conditions (such as the estimation of vapor concentrations from chemicals in soil), the accuracy with which the model itself represents actual environmental or biological processes, the manner in which the

exposure scenario is developed, and the high-to-low dose and interspecies extrapolations for dose-response relationships (which are the basis for the toxicity factors).

6.2 UNCERTAINTIES IN SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Specific uncertainties related to COPC determination are presented in the following subsections.

6.2.1 SPECIES OF SITE CHEMICALS

A major concern in any risk assessment is the reliability of COPC identification to ensure that all site chemicals have been identified. This is controlled in the design of the sampling and analysis plan, which details both the sampling and analytical protocols.

The proper identification of COPCs in this risk assessment has been confirmed by a review of the data collected to characterize soil and groundwater chemicals. Because the COPCs investigated in this risk assessment include all chemicals detected in site soils and groundwater, it is unlikely that aggregate risks presented by site contamination would be underestimated by exclusion of non-detected chemicals.

6.2.2 SAMPLING DESIGN

The sampling programs implemented by various contractors throughout the remedial investigation programs at the site do not follow a random sampling design. The programs purposely focused on the areas within and around suspected sources of chemicals. The bias introduced by selecting sampling locations in this manner (i.e., to specifically locate areas and chemicals of potential concern) and the uncertainty inherent in measured concentrations are likely to result in the overestimation of estimated risk values.

6.2.3 DATA QUALITY

In validating and determining data usability for the risk assessment, it became evident that all site data were obtained under the direction of Federal and State regulatory agencies. This oversight of the investigations has resulted in data of consistent quality, thereby reducing a significant source of uncertainty.

6.2.4 DETECTION LIMITS

A potential source of uncertainty related to the extent of contamination is the treatment of “non-detect” analytical results. A non-detect value was assigned a value as described in Section 4.2.1.1. The statistical distribution testing of many COPCs was inconclusive, thus the greatest of the normal or lognormal 95-percent UCL of the mean was used as the source representative concentration if these values did not exceed the maximum detected value.

6.2.5 NATURAL ATTENUATION OF ORGANICS

Natural attenuation, also known as passive bioremediation, intrinsic bioremediation, or intrinsic remediation, is a passive approach that depends upon natural processes to degrade and dissipate organic chemicals in soil and groundwater. Some of the processes involved in natural attenuation of organics include aerobic and anaerobic biodegradation, dispersion, volatilization, and adsorption. In general, for organics, biodegradation is the most important natural attenuation mechanism; it is the only natural process that results in an actual reduction of chemical mass. This risk assessment did not take into

account that these chemicals often degrade naturally in soil over time. Therefore, the concentration of vapors estimated in this risk assessment is likely to decrease significantly over time due to decreasing source concentrations, thereby overestimating the risk values.

6.3 UNCERTAINTIES IN EXPOSURE ASSESSMENT

The uncertainty associated with the exposure point concentrations estimated in this risk assessment depends on the quality of the selected input parameters as presented in the following subsections. This section addresses the uncertainty related to the quantification of exposure concentrations and COPC intakes with regard to these input parameters.

6.3.1 SITE SETTING

As presented in Section 4, many attributes of the site setting influence the outcome of exposure predictions. One of the key sources of uncertainty associated with predicting exposures at a site is the future disposition of the property itself. This report has assumed continued site control with limited commercial/industrial land use for the site. However, immediate redevelopment plans adjacent to the site were conservatively assumed to include residential and commercial/industrial development.

6.3.2 RECEPTOR SELECTION

The site land use, exposure scenarios (Section 4) and associated receptor-specific exposure parameters (Section 5) represent reasonable maximum exposure (RME) conditions. Therefore, the combination of these exposure assumptions addresses the health and safety of those who will live or work at adjacent properties or visit the site in the future (i.e., those with less exposure to the site than the populations evaluated).

6.3.3 EXPOSURE PARAMETERS

Each exposure parameter value selected for use in this risk assessment also has uncertainty associated with it. Many regulatory recommended exposure parameters for use in risk assessment are based on national surveys of physiological and lifestyle profiles. The attributes and activities studied in these surveys generally have a broad distribution. To account for this distribution, the RME exposure parameters used in this risk assessment generally represent the habits defined by the 90- to 95-percent UCLs for the entire population. The effect of the conservative nature of these parameters on the intake and risk modeling is a likely overestimation of predicted risk values. In this risk assessment the use of a central tendency analysis has been completed to provide the reader with a more likely or plausible estimate of potential risks associated with the site. The central tendency analysis traditionally incorporates the 50th percentile values for the studied population.

6.3.4 USE OF THE 95-PERCENT UPPER CONFIDENCE LIMIT

One key source of conservatism built in to this risk assessment is the use of the 95-percent UCL of each chemical concentration, rather than the average, in estimating COPC levels and exposure concentrations. Statistically, this means that 95 percent of the time, the actual mean concentration is less than the value used in the exposure assessment. Conversely, 5 percent of the time the actual mean concentration is greater than the value used in the exposure assessment.

Inherent in the use of a single, 95-percent UCL concentration to represent the source concentration of each chemical at the site is that the receptors or site users are assumed to be exposed to the 95-percent UCL concentration at all times and at all site locations. Realistically, it is likely that receptors will move around at the site and be exposed to concentrations lower than the 95-percent UCL.

In several cases even greater conservatism has been added by using the maximum detected value due to data set limitations (e.g., statistical distribution uncertainties). It is recognized that this level of conservatism again not likely to represent true exposure conditions, however current guidance by Cal?EPA is to use the maximum detected value when standard statistical methods can not be applied correctly (Cal/EPA 1992).

6.3.5 ALGORITHMS FOR MODELS

There is additional built-in conservatism in the models used to predict exposure concentrations; thus, these models tend to overestimate exposure point concentrations. Due to the complexity of the natural environment, regulators have used simplifying but conservative assumptions in developing the models. Each assumption carries with it a level of uncertainty. In addition, most model parameter values use maximized estimates of transport. Thus, the modeled concentrations are generally higher than the measured concentrations in the field.

6.3.6 INPUT PARAMETERS

In the modeling used in this assessment, because some site-specific data were unavailable, necessary assumptions were made using either regulatory default values or professional judgment based upon literature. All of these efforts are designed such that exposures are not underestimated. For instance, in the air dispersion-modeling component of the volatilization factor model, the receptor is assumed to be exposed to the maximum onsite concentrations for each COPC during the entire exposure period investigated although the location of these maximums are not collocated.

6.4 UNCERTAINTIES IN TOXICITY ASSESSMENT

Considerable uncertainty is associated with the qualitative (hazard assessment) and quantitative (dose-response) evaluations of the chemicals. The hazard assessment deals with characterizing the nature and strength of the evidence of causation, or the likelihood that a chemical that induces adverse effects in animals will induce adverse effects in humans. Dose-response assessment is the process of characterizing the relationship between the administered dose of an agent and the incidence and severity of adverse health effects in an exposed population.

Regulatory agencies use uncertainty factors (previously referred to as safety factors) in calculating dose-response values for chemicals so that potential health impacts to the exposed receptors will not be underestimated. In this report, the dose-response values (cancer slope factors and RfDs) of the COPCs arise out of the application of guidelines recommended by the agencies involved and professional organizations. The built-in uncertainty with the derivation of the dose-response values is carried through to the predicted risk values.

The EPA reviews all relevant human and animal studies for each chemical and selects the studies pertinent to the derivation of specific RfDs. Each study is evaluated to determine the no-observable-adverse-effect level (NOAEL) or, if data are inadequate for such a determination, the lowest-observable-adverse-effect level (LOAEL). The NOAEL corresponds to a dose (mg/kg-d) that can be administered

over a lifetime without inducing observable adverse effects. The LOAEL corresponds to the lowest daily dose (mg/kg-d) that can be administered over a lifetime that induces an observable adverse effect. The toxic effect characterized by the LOAEL is referred to as the "critical effect" (EPA, 2003). To derive an RfD, the NOAEL (or LOAEL) is divided by uncertainty factors to ensure protection of human health. Uncertainty factors are applied to account for (1) extrapolation of data from laboratory animals to humans (interspecies extrapolation), (2) variation in human sensitivity to the toxic effects of a chemical (intraspecies differences), (3) derivation of a chronic RfD based on a subchronic rather than a chronic study, and (4) derivation of an RfD from the LOAEL rather than the NOAEL. Each of these uncertainties usually results in a safety factor of 10 when the RfD is developed. Thus, the safety factor for an individual COPC could be as high as 10,000. In addition to these uncertainty factors, modifying factors between 0 and 10 may be applied to reflect additional qualitative considerations in evaluating the data (EPA, 1989a).

When determining the appropriate dose-response values, government agencies extrapolate experimental toxicity data to humans under specified conditions. These extrapolations involve many assumptions and have a certain amount of inherent uncertainty. In the absence of (or in addition to) reliable epidemiological data, experimental laboratory data are used for dose-response assessments. The inference that adverse effects found in animal bioassays conducted in the laboratory are indicative of likely human toxicity is fundamental to toxicological research and risk assessment. This premise has been extended from experimental biology and medicine into the experimental observation of carcinogenic effects.

Extrapolation from animals to humans is also inherent in the process of toxicity testing, as is route-to-route extrapolation. Both of these extrapolations are examples of the limitations of toxicity data. The associated uncertainty of these two issues is discussed in greater detail in the following subsections.

6.4.1 EXTRAPOLATION

Uncertainties related to toxicity assessment are inherent in the modeling of dose-response relationships for exposure to chemicals and in calculating numerical estimators used to predict health effects with a margin of safety. Examples of inherent uncertainties in numerical estimators include factors incorporated into RfD values and cancer slope factors to provide a margin of safety for use in human health assessments. Examples of uncertainties inherent to modeling of dose-response relationships, upon which RfD values and/or cancer slope factors were based, include the following:

- Extrapolation of findings in animal experiments to humans (uncertainties arising from surface-area-based dose conversion and interspecies extrapolation),
- Extrapolation of findings at high exposure levels to low exposure levels,
- Extrapolation of findings from acute exposures to chronic exposures or from occupational conditions to nonoccupational or environmental conditions, and
- Extrapolation of findings for oral toxicity values to dermal toxicity values.

The level of uncertainty for different chemicals varies because information for some chemicals and their associated health effects is comparatively scarce, while for others, more information is available from health effects studies.

6.4.2 ADDITIVE NONCARCINOGENIC EFFECTS

For noncarcinogenic chemicals, the use of the hazard index (HI) has introduced uncertainty and a measure of conservatism to the estimate of risk. The basis for using the HI is the assumption that the toxic effects of all noncarcinogenic chemicals are additive. Additive toxicity assumes that chemicals act in a concerted fashion to generate toxicity. It is clear, however, that noncarcinogenic chemicals do not all have identical toxic effects and mechanisms of action. For example, some chemicals act specifically on the liver, while others act on the lung. Hazard quotients (HQs) have not been calculated for each generalized toxic effect or mechanism of action as recommended in RAGS (EPA, 1989a). If the HI calculated in Section 5 was segregated according to target organ, the overall potential for noncarcinogenic effects would be diminished.

6.5 CONCLUSIONS REGARDING UNCERTAINTY

Although it is difficult to quantify the uncertainties associated with all the assumptions made in this risk assessment, the use of upper-bound assumptions is likely to contribute to a substantial overestimate of exposure and, hence, of risk. Language suggested by EPA (1989b) to explain the effect of using conservative assumptions in regulatory risk assessments is as follows:

> *"These values are upper-bound estimates of excess cancer risk potentially arising from lifetime exposure to the chemical in question. A number of assumptions have been made in the derivation of these values, many of which are likely to overestimate exposure and toxicity. The actual incidence of cancer is likely to be lower than these estimates and may be zero."*

7.0 CONCLUSIONS

This risk assessment has shown, in a conservative manner using U.S. Environmental Protection Agency (EPA) and California Environmental Protection Agency (Cal/EPA) guidance, that detected chemicals at the site, including metals and volatile organic compounds (VOCs) found in groundwater and soils, do not pose a significant hazard to receptors under current site conditions and land uses as determined by the conceptual site model. However, should contaminants be allowed to migrate, off-site receptors may experience a significant increase in potential risk associated with indoor air exposures.

In operation from 1960 to 1989, Brown & Bryant, Inc., provided pesticide reformulation and custom applicator services to the surrounding agricultural community. This facility reformulated agricultural chemicals including pesticides, herbicides, fumigants, and fertilizers. Throughout facility operations there were numerous controlled and uncontrolled releases of chemicals onsite. Currently vacant, on-site features include a warehouse, open metal shed, and an aboveground storage tank. An asphalt cap acts as a Resource Conservation and Recovery Act (RCRA) cap in the site's southern portion and a non-RCRA cap in the site's northern portion (Panacea, 2002). In 1981, the facility was licensed under RCRA as a hazardous waste transporter. In 1989, the site was listed on the National Priorities List (NPL). Subsequently, various emergency removal actions were initiated to minimize or eliminate immediate threats to human health and the environment (Panacea, 2002).

This risk assessment was developed to estimate the potential for risk to human health from the presence of detected residual chemicals at the site. The exposures and associated risks detailed in this assessment were developed using the reasonable maximum exposure approach promulgated by Cal/EPA and EPA.

The exposure assumptions were made in accordance with regulatory guidance (Cal/EPA, 1994, 1999; EPA 1989a).

In accordance with standard practices, this report has quantified risks under both current and future controlled conditions. Tables 7-1 and 7-2 summarize the potential health risks to future site users in terms of the noncarcinogenic hazard index (HI) and incremental lifetime cancer risk (ILCR) exposure scenarios.

Under the current exposure scenario, the carcinogenic risks (ILCR) for all receptors are below the 10-4 (1 in 10,000) to 10-6 (1 in 1,000,000), risk management goal stipulated by EPA (1990b), except the on-site commercial industrial worker, which exceeds the "de minimis" risk level of 1 in 1,000,000 typically applied by Cal/EPA (1992). The projected risks to this receptor are associated with potential indoor air exposures to contaminants originating from the underlying soils and groundwater.

This pathway becomes more prevalent in the future exposure scenario when the A-zone contaminants are projected to migrate offsite. The emissions from these projected offsite sources are responsible for all long-term receptors exceeding the de minimis risk and, in select cases, the EPA target range of 10-4 (1 in 10,000) to 10-6 (1 in 1,000,000). The only receptor shown to be below the de minimis level is the on-site maintenance worker.

A review of the risk calculations and the Johnson and Ettinger (1991) Indoor Air Model reveals that the majority of the total estimated risk for the offsite residents (the most sensitive receptors) originates from the modeled future groundwater concentrations of 1,2,3-trichloropropane, 1,2-dibromo-3-chloropropane, and 1,3-dichloropropane. The maximum 30-year average fence-line concentrations of these contaminants used in this risk assessment are shown in Table 7-3. Using an acceptable risk goal of 10^{-6} and the reasonable maximum exposure scenario, a backward calculation shows that the offsite groundwater concentrations should not exceed the concentrations of these chemicals shown in Table 7-3. This calculation assumes all the exposure pathways given in this report, and the projected concentration may be recommended to maintain health protection. It is important to note, however, that these numbers do not take into account additivity, which can be more accurately assessed during the feasibility analysis of potential remedial alternatives.

In conclusion, this risk assessment has shown, in a conservative manner using EPA and Cal/EPA guidance, which detected chemicals at the site, including metals and VOCs found in groundwater and soils, pose a significant hazard to potential receptors if not controlled.

8.0 REFERENCES

California Environmental Protection Agency (Cal/EPA) 1990, *Scientific and Technical Standards for Hazardous Waste Sites*, Book H (Draft), Department of Toxic Substances Control, Sacramento, CA.

_____, 1992, *Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities*, Department of Toxic Substances Control, Office of Science Advisor, Sacramento, CA.

_____, 1994, *Preliminary Endangerment Assessment Guidance Manual*, Department of Toxic Substances Control, Sacramento, CA.

_____, 1998a, *Memorandum from Y.Luthra, Human and Ecological Risk Division, to K.Baker, Geology Section, re. Surrogate Toxicity Values and Preliminary Remediation Goals (PRGs) for Boeing Parcel A Post-Demolition Risk Assessment*, Department of Toxic Substances Control, Feb. 10, 1998.

_____, 1998b, *Letter from K.Baker, Department of Toxic Substances Control, to S.M.Stavale, Boeing Realty Corp., re. Post-Demolition Risk Assessment, Boeing C-6 Facility, Parcel A, Los Angeles, CA* (ver. dated Feb. 12, 1998), Feb. 26, 1998.

_____, 1999, Reprint: *Preliminary Endangerment Assessment Guidance Manual*, Department of Toxic Substances Control, Sacramento, CA.

_____, 2002, *Technical Support Document for Describing Available Cancer Potency Factors*, Cal/EPA, Office of Environmental Health Hazard Assessment (OEHHA), March 2002.

Canonie Environmental, 1987, Phase I – *Investigation Report, Arvin and Shafter Facilities, Kern County, California*, dated November 1987.

Cowherd et al., 1985, *Rapid Assessment of Exposure to Particulate Emissions from Surface Contaminated Sites*, Pub. PB85-192219, Midwest Research Institute, Kansas City, MO.

Department of Toxic Substances Control (DTSC) 2002, *Memorandum of Review: Baseline Risk Assessment Work Plan Memorandum*, from Bryan Eya, Staff Toxiclogist, to Robert Romero, Project Manager, May 1, 2002.

Ecology and Environment, Inc., 1999a, *Memorandum presenting a Summary of January 1999 Groundwater Sampling, Brown & Byrant, Arvin, California*, dated February 25, 1999.

_____, 1999b, *Memorandum presenting a Summary of July 1998 Groundwater Sampling, Brown & Byrant, Arvin, California*, dated February 25, 1999.

Farmer, W.J., M.S. Yang, J. Letey, and W.E. Spencer, 1980, *Land Disposal of Hexachlorobenzene Wastes, Controlling Vapor Movement in Soil*, EPA-600/2-80-119, U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, OH.

Gilbert, R.O. 1987, *Statistical Methods for Environmental Pollution Monitoring*, Van Nostrand Reinhold, New York, NY.

Hargis & Associates, Inc. (H&A), 1987, *Remedial Investigation Work Plan, Brown & Bryant Facility, Arvin, California*, dated June 1987.

_____, 1988, *Interim Assessment Report, Brown & Bryant Facility Arvin, California*, dated July 27, 1988

Johnson, P.C., and R.A. Ettinger, 1991, *Heuristic Model for Predicting the Intrusion Rate of Contaminant Vapors into Buildings*, Environ. Sci. Technol. 25:1445-1452.

Morrison Knudson (MK), 1999, *Aquifer Test Report, Brown and Bryant Superfund Site*, U.S. Army Corps of Engineers, dated August 1999.

Panacea, Inc. 2001, *Remedial Investigation Workplan – Operable Unit 2, Brown & Bryant Superfund Site, Arvin*, California, July 2001.

_____, 2002, *Monitoring Well Installation Report* – Operable Unit 2, Brown & Bryant Superfund Site, Arvin, California, October 2002.

_____, 2003a, May 2003 Quarterly Groundwater Sapling and Analysis Report - *Brown & Bryant Superfund Site, Arvin, California*, March 2003

_____, 2003b, Preliminary Fate and Transport Modeling - *Brown & Bryant Superfund Site, Arvin, California*, March 2003

_____, 2003c, *Human Health Risk Assessment Workplan – Operable Unit 2, Brown & Bryant Superfund Site, Arvin, California*, February 2003.

_____, 2004, *Remedial Investigation/Feasibility Study for Remedial Alternatives – Operable Unit 2, Brown & Bryant Superfund Site, Arvin, California*, June 2004.

San Joaquin Valley Air Pollution Control District (SJV-APCD) 2002, *Bakersfield, California, Internet worldwide web site [http://www.valleyair.org/busind/pto/tox_Resources/toxics_ resources.htm]*.

Shen, T.T. 1981 *Estimating Hazardous Air Emissions from Disposal Sites, Pollution Engineering*, 13(8):31-34.

U.S. Environmental Protection Agency (EPA) 1986, *Guidelines for the Health Risk Assessment of Chemical Mixtures*, 51 Fed. Reg. 34014, Sept. 26.

_____, 1987a, *Hazardous Waste Treatment Storage and Disposal Facilities - TSDF Air Emissions Models Documentation*, Washington, D.C., EPA SWDK 88046-A, December 1987.

_____, 1987b, *Industrial Source Complex (ISC) Model User's Guide* - Second Edition (revised), EPA 450/4-88-002a, Office of Air Quality Planning and Standards, EPA, Research Triangle Park, NC.

_____, 1988a, *Laboratory Data Validation, Functional Guidelines for Evaluating Inorganic Analyses*, Hazardous Site Evaluation Div., Washington, D.C.

_____, 1988b, *Laboratory Data Validation, Functional Guidelines for Evaluating Organic Analyses*, Hazardous Site Evaluation Div., Washington, D.C.

_____, 1988c, *Superfund Exposure Assessment Manual (SEAM)*, EPA/540/1-88/001, OSWER Directive 9285, 5-1, Office of Remedial Response.

_____, 1989a, *Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual, Part A, Interim Final*, Office of Emergency and Remedial Response, EPA/540/1-89/002.

_____, 1989b, *Statistical Methods for Evaluating the Attainment of Cleanup Standards, Volume 1, Soils and Solid Media*, EPA/230/02-89/042, Office of Policy, Planning, and Evaluation, Statistical Policy Branch, PM-223, Washington, D.C.

_____, 1990a, *Exposure Factors Handbook*, Office of Health and Environmental Assessment, EPA/600/8-89/043, March 1990.

_____, 1990b, *National Oil and Hazardous Substances Pollution Contingency Plan*, Final Rule, Federal Register, Vol. 55, No. 46, Rules and Regulations, March 8, 1990.

_____, 1991a, *Risk Assessment Guidance for Superfund (RAGS), Vol. I, Human Health Evaluation Manual, Part C, Risk Evaluation of Remedial Alternatives, Interim Final*, Office of Emergency and Remedial Response, EPA 9285,7-01C.

_____, 1991b, *Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors, Interim Final*, OERR Directive 9285,6-03, Office of Emergency and Remedial Response, Washington, D.C.

_____, 1992a, *Dermal Exposure Assessment, Principles and Applications*, Office of Research and Development, EPA600/8-91/011B.

_____, 1992b, *Guidance on Risk Characterization for Risk Assessors and Risk Managers*, Memorandum, February 26, 1992.

_____, 1992c, *Guidance for Data Usability in Risk Assessment, Interim Final*, Office of Emergency and Remedial Response, EPA/540/G90/008.

_____, 1992d, *Supplemental Guidance to RAGS, Calculating the Concentration Term*, Office of Solid Waste and Emergency Response, Washington, D.C.

_____, 1993, *Remedial Investigation / Feasibility Study Report, Brown & Bryant Superfund Site, Arvin, California*, dated May 28, 1993.

_____, 1996a, *Industrial Source Complex (ISC) Model User's Guide*, 2nd Ed. (Rev.), EPA450/4-88-002a, Office of Air Quality Planning and Standards, Research Triangle Park, NC.

_____, 1996b, *Soil Screening Guidance, Technical Background Document*, EPA/540/R-95/128, Office of Emergency and Remedial Response, Washington, D.C., Pb96-963502.

_____, 1997a, *Exposure Factors Handbook, Office of Health and Environmental Assessment*, EPA/600/C-99/001, August 1997.

_____, 1997b, *Health Effects Assessment Summary Tables (HEAST)*, Annual Update FY 1997, incl. Nov. suppl., Office of Emergency Remedial Response, OERR9200,6303 (92-1), Washington, D.C.

_____, 1998a, Region 9 *Preliminary Remediation Goals (PRGs)*, Internet worldwide web site [www.epa.gov/region09/waste/superfund/prg/index.html].

_____, 2003, *Integrated Risk Information System (IRIS) database*, March 2003.

Western Regional Climate Center (WRCC) 2002, *Period of Record Monthly Climate Summary – Bakersfield WSO Airport, Internet worldwide web site [http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?cabake]*.

Tables

Project No. C00-266.2 June 2004

TABLE 2-1
COPCS AND THE MEDIA OF THEIR PRESENCE (X)
AT THE BROWN & BRYANT SUPERFUND SITE

COPC	Soil	GW	COPC	Soil	GW	COPC	Soil	GW
1. 1,1,2-trichloroethane		X	13. antimony	X		25. lead	X	
2. 1,1-dichloroethane		X	14. arsenic	X		26. mercury	X	
3. 1,1-dichloropropene		X	15. barium	X		27. methylene chloride		X
4. 1,2,3-trichloropropane	X	X	16. benzene		X	28. nickel	X	
5. 1,2,4-trimethylbenzene		X	17. benzyl chloride		X	29. selenium	X	
6. 1,2-dibromo-3-chloropropane	X	X	18. beryllium	X		30. tetrachloroethene		X
7. 1,2-dibromoethane	X	X	19. bromobenzene		X	31. thallium	X	
8. 1,2-dichloroethane		X	20. chlorobenzene		X	32. toluene		X
9. 1,2-dichloroethene-cis		X	21. chloroform	X	X	33. vanadium	X	
10. 1,2-dichloropropane	X	X	22. chromium	X		34. zinc	X	
11. 1,3-dichloropropane	X	X	23. cobalt	X				
12. 2,4-dinitro-6-sec-butylphenol	X	X	24. copper	X				

TABLE 3-1
COPC—NON-CARCINOGEN REFERENCE DOSE (RfD [mg/kg-d])

	Inhalation[a]		Oral[a]	
COPC	**Subchronic[b]**	**Chronic**	**Subchronic[b]**	**Chronic**
1. 1,1,2-trichloroethane	4.00E-02	4.00E-03	4.00E-02	4.00E-03
2. 1,1-dichloroethane	1.40E+00	1.43E-01	1.00E+00	1.00E-01
3. 1,1-dichloropropene	NA	NA	NA	NA
4. 1,2,3-trichloropropane	6.00E-02	6.00E-03	6.00E-02	6.00E-03
5. 1,2,4-trimethylbenzene	NA	1.71E-03	NA	5.00E-02
6. 1,2-dibromo-3-chloropropane	NA	5.71E-05	NA	NA
7. 1,2-dibromoethane	5.70E-04	5.71E-05	NA	NA
8. 1,2-dichloroethane	NA	NA	NA	NA
9. 1,2-dichloroethene-cis	1.00E-01	1.00E-02	1.00E-01	1.00E-02
10. 1,2-dichloropropane	3.70E-03	1.14E-03	NA	NA
11. 1,3-dichloropropane*	5.70E-03	5.71E-03	3.00E-02	3.00E-03
12. 2,4-dinitro-6-sec-butylphenol	1.00E-03	1.00E-03	1.00E-03	1.00E-03
13. antimony	1.10E-04	4.00E-04	2.00E-04	4.00E-04
14. arsenic	3.00E-04	3.00E-04	3.00E-04	3.00E-04
15. barium	1.40E-03	1.43E-04	7.00E-02	7.00E-02
16. benzene	NA	NA	NA	NA
17. benzyl chloride	NA	NA	NA	NA
18. beryllium	5.00E-03	5.71E-06	5.00E-03	2.00E-03
19. bromobenzene	NA	NA	NA	NA
20. chlorobenzene	2.00E-01	5.71E-03	2.00E-01	2.00E-02
21. chloroform	1.00E-02	1.00E-02	1.00E-02	1.00E-02
22. chromium	2.00E-02	2.86E-05	2.00E-02	3.00E-03
23. cobalt	NA	NA	NA	NA
24. copper	NA	NA	NA	NA
25. lead	NA	NA	NA	NA
26. mercury	3.00E-04	3.00E-04	3.00E-04	3.00E-04
27. methylene chloride	8.60E-01	8.57E-01	6.00E-02	6.00E-02
28. nickel	2.00E-02	2.00E-02	2.00E-02	2.00E-02
29. selenium	5.00E-03	5.00E-03	5.00E-03	5.00E-03
30. tetrachloroethene	1.00E-01	1.71E-01	1.00E-01	1.00E-02
31. thallium	NA	NA	NA	NA
32. toluene	2.60E-01	1.14E-01	2.00E+00	2.00E-01
33. vanadium	7.00E-03	7.00E-03	7.00E-03	7.00E-03
34. zinc	3.00E-01	3.00E-01	3.00E-01	3.00E-01

NOTES:
NA = not available
2.00E-01 = $2x10^{-1}$ = 0.2
mg/kg-d = milligrams per kilogram-day
*Because there is no toxicity factor for 1,3-dichloropropane, 1,3-dichloropropene toxicity values were used as a surrogate for 1,3-dichloropropane toxicity.

SOURCES:
[a] IRIS (EPA, 2003)
[b] HEAST (EPA, 1997b)

TABLE 3-2

COPC—CANCER SLOPE FACTORS [a] (CSFs [1/mg/kg-d])

COPC	Inhalation	Oral
1. 1,1,2-trichloroethane	5.70E-02	7.20E-02
2. 1,1-dichloroethane	5.70E-03	5.70E-03
3. 1,1-dichloropropene	NC	NC
4. 1,2,3-trichloropropane	7.00E+00	7.00E+00
5. 1,2,4-trimethylbenzene	NC	NC
6. 1,2-dibromo-3-chloropropane	7.00E+00	7.00E+00
7. 1,2-dibromoethane	2.50E-01	3.60E+00
8. 1,2-dichloroethane	7.20E-02	4.70E-02
9. 1,2-dichloroethene-cis	NC	NC
10. 1,2-dichloropropane	3.60E-02	6.30E-02
11. 1,3-dichloropropane*	5.50E-02	9.10E-02
12. 2,4-dinitro-6-sec-butylphenol	NC	NC
13. antimony	NC	NC
14. arsenic	1.20E+01 [b]	1.50E+01 [b]
15. barium	NC	NC
16. benzene	1.00E-01[b]	1.00E-01[b]
17. benzyl chloride	1.70E-01	1.70E-01
18. beryllium	8.40E+00	NC
19. bromobenzene	NC	NC
20. chlorobenzene	NC	NC
21. chloroform	1.90E-02	3.10E-02
22. chromium	5.10E+02 [b]	NC
23. cobalt	NC	NC
24. copper	NC	NC
25. lead	4.20E-02	8.50E-03
26. mercury	NC	NC
27. methylene chloride	3.50E-03	1.40E-02
28. nickel	9.10E-01	NC
29. selenium	NC	NC
30. tetrachloroethene	2.10E-02 [b]	5.40E-02 [b]
31. thallium	NC	NC
32. toluene	NC	NC
33. vanadium	NC	NC
34. zinc	NC	NC

NOTES:
NC = not established as a carcinogen by any government agency
2.00E-01 = $2x10^{-1}$ = 0.2
mg/kg-d = milligram per kilogram-day
*Because there is no toxicity factor for 1,3-dichloropropane, 1,3-dichloropropene toxicity values were used as a surrogate for 1,3-dichloropropane toxicity.

SOURCES:
[a] IRIS (EPA, 2003)
[b] California Cancer Potency Factors Update (Cal/EPA, 2002)

TABLE 4-1
95-PERCENT UCL CONCENTRATIONS OF SOIL COPCs

COPC	0-10 Feet bgs (mg/kg)	10 Feet bgs A-Zone (mg/kg)
1. 1,1,2-trichloroethane	ND	ND
2. 1,1-dichloroethane	ND	ND
3. 1,1-dichloropropene	ND	ND
4. 1,2,3-trichloropropane	1.00E-01	1.96E-01
5. 1,2,4-trimethylbenzene	ND	ND
6. 1,2-dibromo-3-chloropropane	9.10E-03	2.09E-02
7. 1,2-dibromoethane	6.00E-03	7.10E-03
8. 1,2-dichloroethane	ND	ND
9. 1,2-dichloroethene-cis	ND	ND
10. 1,2-dichloropropane	8.00E-02	2.48E-01
11. 1,3-dichloropropane	ND	1.40E-01
12. 2,4-dinitro-6-sec-butylphenol	1.05E-01	3.60E-02
13. antimony	NA	4.12E+00
14. arsenic	NA	1.52E+01
15. barium	NA	2.02E+02
16. benzene	ND	ND
17. benzyl chloride	ND	ND
18. beryllium	NA	6.95E-01
19. bromobenzene	ND	ND
20. chlorobenzene	ND	ND
21. chloroform	ND	1.24E-01
22. chromium	NA	1.90E+01
23. cobalt	NA	1.27E+01
24. copper	NA	7.64E+00
25. lead	NA	3.76E+00
26. mercury	NA	2.64E-01
27. methylene chloride	ND	ND
28. nickel	NA	8.28E+00
29. selenium	NA	2.79E+00
30. tetrachloroethene	ND	ND
31. thallium	NA	5.60E+00
32. toluene	ND	ND
33. vanadium	NA	5.06E+01
34. zinc	NA	6.34E+01

NOTES:

bgs = below ground surface
mg/kg = milligrams per kilogram
ND = not detected in media
NA = not analyzed
5.0E-03 = 5.00×10^{-3} = 0.005

TABLE 4-2
CURRENT ONSITE 95 PERCENT UCL CONCENTRATIONS OF COPCs
IN A-ZONE GROUNDWATER

COPC	A-Zone (mg/L)
1. 1,1,2-trichloroethane	9.26E-03
2. 1,1-dichloroethane	1.15E-02
3. 1,1-dichloropropene	4.16E-03
4. 1,2,3-trichloropropane	1.57E+00
5. 1,2,4-trimethylbenzene	2.20E+00
6. 1,2-dibromo-3-chloropropane	7.34E-01
7. 1,2-dibromoethane	1.07E-01
8. 1,2-dichloroethane	6.23E-02
9. 1,2-dichloroethene-cis	6.00E-03
10. 1,2-dichloropropane	2.32E+01
11. 1,3-dichloropropane	1.37E-01
12. 2,4-dinitro-6-sec-butylphenol	ND
13. antimony	NA
14. arsenic	NA
15. barium	NA
16. benzene	1.43E-02
17. benzyl chloride	6.40E-03
18. beryllium	NA
19. bromobenzene	3.19E-01
20. chlorobenzene	1.66E-02
21. chloroform	1.98E-01
22. chromium	NA
23. cobalt	NA
24. copper	NA
25. lead	NA
26. mercury	NA
27. methylene chloride	8.06E-02
28. nickel	NA
29. selenium	NA
30. tetrachloroethene	1.02E-03
31. thallium	NA
32. toluene	1.99E-01
33. vanadium	NA
34. zinc	NA

NOTES:

mg/L = milligrams per liter
ND = not detected in media
NA = not analyzed
5.00E-03 = 5.00×10^{-3} = 0.005

TABLE 4-3
MODELED MAXIMUM 30-YEAR AVERAGE
CONCENTRATIONS OF COPCs IN ZONES OF GROUNDWATER

COPC	A-Zone Fence Line (mg/L)	B-Zone Fence Line (mg/L)	B-Zone City Well (mg/L)
1. 1,1,2-trichloroethane	NC	NC	NC
2. 1,1-dichloroethane	NC	NC	NC
3. 1,1-dichloropropene	NC	NC	NC
4. 1,2,3-trichloropropane	2.08E+00	8.13E-02	4.90E-07
5. 1,2,4-trimethylbenzene	NC	NC	NC
6. 1,2-dibromo-3-chloropropane	1.33E+00	0.00E+00	4.59E-23
7. 1,2-dibromoethane	1.04E-03	0.00E+00	1.53E-23
8. 1,2-dichloroethane	NC	NC	NC
9. 1,2-dichloroethene-cis	NC	NC	NC
10. 1,2-dichloropropane	2.04E+01	6.23E-05	3.76E-07
11. 1,3-dichloropropane	1.01E-02	0.00E+00	5.84E-17
12. 2,4-dinitro-6-sec-butylphenol	2.78E+00	0.00E+00	1.53E-21
13. antimony	NC	NC	NC
14. arsenic	NC	NC	NC
15. barium	NC	NC	NC
16. benzene	NC	NC	NC
17. benzyl chloride	NC	NC	NC
18. beryllium	NC	NC	NC
19. bromobenzene	NC	NC	NC
20. chlorobenzene	NC	NC	NC
21. chloroform	2.16E-01	0.00E+00	1.10E-22
22. chromium	NC	NC	NC
23. cobalt	NC	NC	NC
24. copper	NC	NC	NC
25. lead	NC	NC	NC
26. mercury	NC	NC	NC
27. methylene chloride	NC	NC	NC
28. nickel	NC	NC	NC
29. selenium	NC	NC	NC
30. tetrachloroethene	NC	NC	NC
31. thallium	NC	NC	NC
32. toluene	NC	NC	NC
33. vanadium	NC	NC	NC
34. zinc	NC	NC	NC

NOTES:

mg/L = milligrams per liter

NC = not calculated; model simulations not completed based on review of concentration and migration potential

5.00E-03 = 5.00×10^{-3} = 0.005

TABLE 4-4
SOIL COPC-SPECIFIC CONSTANTS

COPC	Henry's Law Constant, H′ (atm-m3/mol)	Henry's Law Constant, H (unitless)	Organic Partitioning Coefficient, Koc (cm3/g)	Diffusivity Coefficient, D_i (cm^2/s)
1. 1,1,2-trichloroethane	9.09E-04	3.78E-02	5.60E+01	7.97E-02
2. 1,1-dichloroethane	5.87E-03	2.44E-01	3.00E+01	9.59E-02
3. 1,1-dichloropropene	1.80E-02	7.26E-01	1.56E+02	6.30E-02
4. 1,2,3-trichloropropane	3.44E-04	1.43E-02	6.31E+01	7.53E-02
5. 1,2,4-trimethylbenzene	6.16E-03	2.56E-01	2.71E+03	6.40E-02
6. 1,2-dibromo-3-chloropropane	3.11E-04	1.29E-02	9.80E+01	7.08E-02
7. 1,2-dibromoethane	1.31E-03	5.45E-02	4.40E+01	8.56E-02
8. 1,2-dichloroethane	1.10E-03	4.58E-02	1.65E+01	9.45E-02
9. 1,2-dichloroethene-cis	4.07E-03	1.67E-01	3.55E+01	7.36E-02
10. 1,2-dichloropropane	2.80E-03	1.15E-01	4.37E+01	7.82E-02
11. 1,3-dichloropropane	9.76E-04	4.06E-02	2.90E+02	8.50E-02
12. 2,4-dinitro-6-sec-butylphenol	NV	NV	NV	NV
13. antimony	NV	NV	NV	NV
14. arsenic	NV	NV	NV	NV
15. barium	NV	NV	NV	NV
16. benzene	5.56E-03	2.28E-01	5.89E+01	8.80E-02
17. benzyl chloride	5.48E-03	2.28E-01	1.39E+02	7.52E-02
18. beryllium	NV	NV	NV	NV
19. bromobenzene	2.08E-03	8.65E-02	2.68E+02	2.70E-02
20. chlorobenzene	3.71E-03	1.52E-01	2.19E+02	7.30E-02
21. chloroform	3.66E-03	1.50E-01	3.98E+01	1.04E-01
22. chromium	NV	NV	NV	NV
23. cobalt	NV	NV	NV	NV
24. copper	NV	NV	NV	NV
25. lead	NV	NV	NV	NV
26. mercury	NV	NV	NV	NV
27. methylene chloride	2.19E-03	8.98E-02	1.17E+01	1.01E-01
28. nickel	NV	NV	NV	NV
29. selenium	NV	NV	NV	NV
30. tetrachloroethene	1.84E-02	7.54E-01	1.55E+02	7.20E-02
31. thallium	NV	NV	NV	NV
32. toluene	6.63E-03	2.72E-01	1.82E+02	8.70E-02
33. vanadium	NV	NV	NV	NV
34. zinc	NV	NV	NV	NV

NOTES:

NV = not volatile
1.00E-01 = 1.00×10^{-1} = 0.1
atm-m^3/mol = atmosphere-cubic meter per mol
cm^3/g = cubic centimeters per gram
cm^2/s = square centimeters per second

SOURCE: EPA Soil Screening Guidance (EPA, 1996b)

TABLE 4-5
CALCULATED SOIL COPC-SPECIFIC
VOLATILIZATION ATTENUATION FACTORS (m^3/kg)

COPC	Maintenance Worker
1. 1,1,2-trichloroethane	ND
2. 1,1-dichloroethane	ND
3. 1,1-dichloropropene	ND
4. 1,2,3-trichloropropane	1.07E+04
5. 1,2,4-trimethylbenzene	ND
6. 1,2-dibromo-3-chloropropane	1.45E+04
7. 1,2-dibromoethane	4.22E+03
8. 1,2-dichloroethane	ND
9. 1,2-dichloroethene-cis	ND
10. 1,2-dichloropropane	2.98E+03
11. 1,3-dichloropropane	ND
12. 2,4-dinitro-6-sec-butylphenol	NV
13. antimony	ND
14. arsenic	ND
15. barium	ND
16. benzene	ND
17. benzyl chloride	ND
18. beryllium	ND
19. bromobenzene	ND
20. chlorobenzene	ND
21. chloroform	ND
22. chromium	ND
23. cobalt	ND
24. copper	ND
25. lead	ND
26. mercury	ND
27. methylene chloride	ND
28. nickel	ND
29. selenium	ND
30. tetrachloroethene	ND
31. thallium	ND
32. toluene	ND
33. vanadium	ND
34. zinc	ND

NOTES:
m^3/kg = cubic meters per kilogram
NV = not volatile
ND = not detected
1.00E-01 = 1.00×10^{-1} = 0.1

TABLE 4-6
CALCULATED ON-SITE COMMERCIAL/INDUSTRIAL
INDOOR AIR CONCENTRATIONS (mg/m^3)

COPC	Ci_s Surface Soils	Ci_{ss} Subsurface Soils	Ci_{gw} A-Zone Groundwater	Ci Total
1. 1,1,2-trichloroethane	ND	ND	3.90E-07	3.90E-07
2. 1,1-dichloroethane	ND	ND	3.00E-06	3.00E-06
3. 1,1-dichloropropene	ND	ND	2.62E-06	2.62E-06
4. 1,2,3-trichloropropane	2.72E-05	1.00E-05	2.24E-05	5.96E-05
5. 1,2,4-trimethylbenzene	ND	ND	4.27E-04	4.27E-04
6. 1,2-dibromo-3-chloropropane	1.80E-06	7.77E-07	9.21E-06	1.18E-05
7. 1,2-dibromoethane	8.00E-06	1.78E-06	6.66E-06	1.64E-05
8. 1,2-dichloroethane	ND	ND	3.90E-06	3.90E-06
9. 1,2-dichloroethene-cis	ND	ND	1.12E-06	1.12E-06
10. 1,2-dichloropropane	2.24E-04	1.29E-04	3.01E-03	3.36E-03
11. 1,3-dichloropropane	ND	3.14E-07	8.57E-05	8.57E-05
12. 2,4-dinitro-6-sec-butylphenol	NV	NV	NV	NV
13. antimony	NV	NV	NV	NV
14. arsenic	NV	NV	NV	NV
15. barium	NV	NV	NV	NV
16. benzene	ND	ND	4.20E-06	4.20E-06
17. benzyl chloride	ND	ND	1.36E-06	1.36E-06
18. beryllium	NV	NV	NV	NV
19. bromobenzene	ND	ND	9.05E-06	9.05E-06
20. chlorobenzene	ND	ND	2.48E-06	2.48E-06
21. chloroform	ND	1.20E-04	4.70E-05	1.67E-04
22. chromium	NV	NV	NV	NV
23. cobalt	NV	NV	NV	NV
24. copper	NV	NV	NV	NV
25. lead	NV	NV	NV	NV
26. mercury	NV	NV	NV	NV
27. methylene chloride	ND	ND	1.16E-05	1.16E-05
28. nickel	NV	NV	NV	NV
29. selenium	NV	NV	NV	NV
30. tetrachloroethene	ND	ND	7.47E-07	7.47E-07
31. thallium	NV	NV	NV	NV
32. toluene	ND	ND	6.52E-05	6.52E-05
33. vanadium	NV	NV	NV	NV
34. zinc	NV	NV	NV	NV

NOTES:
mg/m^3 = milligrams per cubic meter
Ci_s = concentration in indoor air from surface soils
Ciss = concentration in indoor air from subsurface soils
Ci_{gw} = concentration in indoor air from groundwater
ND = not detected in media
NV = not volatile
1.00E-04 = 1.00×10^{-4} = 0.0001

TABLE 4-7
CALCULATED OFF-SITE
INDOOR AIR CONCENTRATIONS (mg/m^3)

COPC[a]	Commercial/ Industrial	Residential
1. 1,1,2-trichloroethane	NC	NC
2. 1,1-dichloroethane	NC	NC
3. 1,1-dichloropropene	NC	NC
4. 1,2,3-trichloropropane	2.97E-05	6.59E-05
5. 1,2,4-trimethylbenzene	NC	NC
6. 1,2-dibromo-3-chloropropane	1.67E-05	3.71E-05
7. 1,2-dibromoethane	6.43E-08	1.43E-07
8. 1,2-dichloroethane	NC	NC
9. 1,2-dichloroethene-cis	NC	NC
10. 1,2-dichloropropane	2.65E-04	5.89E-04
11. 1,3-dichloropropane	6.35E-06	1.41E-02
12. 2,4-dinitro-6-sec-butylphenol	NC	NC
13. antimony	NV	NV
14. arsenic	NV	NV
15. barium	NV	NV
16. benzene	NC	NC
17. benzyl chloride	NC	NC
18. beryllium	NV	NV
19. bromobenzene	NC	NC
20. chlorobenzene	NC	NC
21. chloroform	5.13E-05	1.14E-04
22. chromium	NV	NV
23. cobalt	NV	NV
24. copper	NV	NV
25. lead	NV	NV
26. mercury	NV	NV
27. methylene chloride	NC	NC
28. nickel	NV	NV
29. selenium	NV	NV
30. tetrachloroethene	NC	NC
31. thallium	NV	NV
32. toluene	NC	NC
33. vanadium	NV	NV
34. zinc	NV	NV

NOTES:
mg/m^3 = milligrams per cubic meter
[a] Source limited to A-zone groundwater
NC = not calculated; modeling not completed for COPC based on review of concentration and migration potential
NV = not volatile
1.00E-04 = 1.00x10-4 = 0.0001

TABLE 4-8
MODELED OUTDOOR AIR CONCENTRATIONS (mg/m^3)

COPC	Onsite	Fence Line
1. 1,1,2-trichloroethane	5.16E-09	3.81E-09
2. 1,1-dichloroethane	4.97E-08	3.67E-08
3. 1,1-dichloropropene	3.50E-08	2.59E-08
4. 1,2,3-trichloropropane	3.28E-07	2.42E-07
5. 1,2,4-trimethylbenzene	6.69E-06	4.94E-06
6. 1,2-dibromo-3-chloropropane	1.25E-07	9.23E-08
7. 1,2-dibromoethane	9.73E-08	7.18E-08
8. 1,2-dichloroethane	4.99E-08	3.68E-08
9. 1,2-dichloroethene-cis	1.37E-08	1.01E-08
10. 1,2-dichloropropane	3.87E-05	2.86E-05
11. 1,3-dichloropropane	8.90E-08	6.57E-08
12. 2,4-dinitro-6-sec-butylphenol	NV	NV
13. antimony	NV	NV
14. arsenic	NV	NV
15. barium	NV	NV
16. benzene	3.37E-07	2.49E-07
17. benzyl chloride	2.04E-08	1.50E-08
18. beryllium	NV	NV
19. bromobenzene	1.38E-07	1.02E-07
20. chlorobenzene	3.41E-08	2.52E-08
21. chloroform	6.32E-07	4.67E-07
22. chromium	NV	NV
23. cobalt	NV	NV
24. copper	NV	NV
25. lead	NV	NV
26. mercury	NV	NV
27. methylene chloride	1.35E-07	1.00E-07
28. nickel	NV	NV
29. selenium	NV	NV
30. tetrachloroethene	1.03E-08	7.57E-09
31. thallium	NV	NV
32. toluene	8.75E-07	6.46E-07
33. vanadium	NV	NV
34. zinc	NV	NV

NOTES:
mg/m^3 = milligrams per cubic meter
ND = not detected
NV = not volatile
1.00E-04 = 1.00×10^{-4} = 0.0001

TABLE 4-9
RME EXPOSURE SCENARIO
RECEPTOR EXPOSURE PARAMETERS AND THEIR VALUES

Pathway	Parameter	Off-Site Adult	Off-Site Child	Maintenance Worker	Commercial/ Industrial Worker
Inhalation	IR - Inhalation Rate (m^3/h)	0.83[a]	0.6 [b]	2.5 [b]	0.83 [a]
	EF - Exposure Frequency (d/y)	350 [a]	350 [a]	250 [b]	250 [b]
	ED - Exposure Duration (y)	30 [a]	6 [a]	1 [c]	25 [b]
	ET - Exposure Time, Outdoors (h/d)	8 [c]	8 [c]	8 [c]	4 [c]
	ET - Exposure Time, Indoors (h/d)	16 [c]	16 [c]	0 [c]	4 [c]
	BW - Body Weight (kg)	70 [a]	15 [a]	70 [a]	70 [a]
	AT - Averaging Time, Carcinogen (d)	25,550 [a]	25,550 [a]	25,550 [a]	25,550 [a]
	AT - Averaging Time, Noncarcinogen (d)	10,950 [a]	2,190 [a]	365 [a]	9,125 [a]
Incidental Ingestion of Soil	IR - Ingestion Rate (mg/d)	NA	NA	480[b]	NA
	EF - Exposure Frequency (d/y)	NA	NA	250 [b]	NA
	ED - Exposure Duration (y)	NA	NA	1 [c]	NA
	BW - Body Weight (kg)	NA	NA	70 [a]	NA
	AT - Averaging Time, Carcinogen (d)	NA	NA	25,550 [a]	NA
	AT - Averaging Time, Noncarcinogen (d)	NA	NA	365 [a]	NA
	CF - Conversion Factor (kg/mg)	NA	NA	1.00E-06 [a]	NA
Ingestion of Water	IR - Ingestion Rate (L/d)	2 [a]	1 [a]	NA	1 [b]
	EF - Exposure Frequency Outdoors (d/y)	350 [a]	350 [a]	NA	250 [b]
	ED - Exposure Duration (y)	30 [a]	6 [a]	NA	25 [b]
	BW - Body Weight (kg)	70 [a]	15 [a]	NA	70 [a]
	AT - Averaging Time, Carcinogen (d)	25,550 [a]	25,550 [a]	NA	25,550 [a]
	AT - Averaging Time, Noncarcinogen (d)	10,950 [a]	2,190 [a]	NA	9,125 [a]
Dermal Contact with Soil	SA - Surface Area (cm^2/d)	NA	NA	5,800[c]	NA
	ABS - Absorption Coefficient	NA	NA	CSV	NA
	AF - Adherence Factor (mg/cm^2)	NA	NA	0.8 [c]	NA
	ED - Exposure Duration (y)	NA	NA	1 [c]	NA
	EF - Exposure Frequency Outdoors (d/y)	NA	NA	250 [b]	NA
	BW - Body Weight (kg)	NA	NA	70 [a]	NA
	AT - Averaging Time, Carcinogen (d)	NA	NA	25,550 [a]	NA
	AT - Averaging Time, Noncarcinogen (d)	NA	NA	365 [a]	NA
	CF - Conversion Factor (kg/mg)	NA	NA	1.00E-06 [a]	NA

TABLE 4-9 (Continued)
RME EXPOSURE SCENARIO
RECEPTOR EXPOSURE PARAMETERS AND THEIR VALUES

Pathway	Parameter	Off-Site Adult	Off-Site Child	Maintenance Worker	Commercial/ Industrial Worker
Dermal Contact with Water	SA - Surface Area (cm^2)	23,000 [b]	12,000 [b]	NA	NA
	ED - Exposure Duration (y)	30 [a]	6 [a]	NA	NA
	EF - Exposure Frequency Outdoors (d/y)	350 [a]	350 [a]	NA	NA
	BW - Body Weight (kg)	70 [a]	6 [a]	NA	NA
	AT - Averaging Time, Carcinogen (d)	25,550 [a]	25,550 [a]	NA	NA
	AT - Averaging Time, Noncarcinogen (d)	10,950 [a]	2,190 [a]	NA	NA
	DA – Dermal Absorbed Dose (mg/cm2-d)	CSV	CSV	NA	NA

NOTES:

CSV = chemical-specific value
NA = not applicable
m^3/h = cubic meters per hour
d/y = days per year
y = years
h/d = hours per day
kg = kilograms
d = days
cm^2 = square centimeters
L/d =

SOURCES:

[a]EPA (1991b)

[b]EPA (1990a, 1997a)

[c]Cal/EPA, 1992

TABLE 4-10
CENTRAL TENDENCY EXPOSURE SCENARIO
RECEPTOR EXPOSURE PARAMETERS AND THEIR VALUES

Pathway	Parameter	Off-Site Adult	Off-Site Child	Maintenance Worker	Commercial/ Industrial Worker
Inhalation	IR - Inhalation Rate (m^3/h)	0.625[b]	0.6 [b]	0.83[a]	0.83 [a]
	EF - Exposure Frequency (d/y)	350 [a]	350 [a]	250 [b]	250 [b]
	ED - Exposure Duration (y)	9 [b]	6 [a]	1 [c]	9 [b]
	ET - Exposure Time, Outdoors (h/d)	8 [c]	8 [c]	8 [c]	4 [c]
	ET - Exposure Time, Indoors (h/d)	16 [c]	16 [c]	0 [c]	4 [c]
	BW - Body Weight (kg)	70 [a]	15 [a]	70 [a]	70 [a]
	AT - Averaging Time, Carcinogen (d)	25,550 [a]	25,550 [a]	25,550 [a]	25,550 [a]
	AT - Averaging Time, Noncarcinogen (d)	3,285 [a]	2,190 [a]	365 [a]	3,285 [a]
Incidental Ingestion of Soil	IR - Ingestion Rate (mg/d)	NA	NA	50 [b]	NA
	EF - Exposure Frequency (d/y)	NA	NA	250 [b]	NA
	ED - Exposure Duration (y)	NA	NA	1[c]	NA
	BW - Body Weight (kg)	NA	NA	70 [a]	NA
	AT - Averaging Time, Carcinogen (d)	NA	NA	25,550 [a]	NA
	AT - Averaging Time, Noncarcinogen (d)	NA	NA	365 [a]	NA
	CF - Conversion Factor (kg/mg)	NA	NA	1.00E-06 [a]	NA
Ingestion of Water	IR - Ingestion Rate (L/d)	1.4 [b]	0.7 [b]	NA	0.7 [b]
	EF - Exposure Frequency Outdoors (d/y)	350 [a]	350 [a]	NA	250 [b]
	ED - Exposure Duration (y)	9 [b]	6 [a]	NA	9 [b]
	BW - Body Weight (kg)	70 [a]	15 [a]	NA	70 [a]
	AT - Averaging Time, Carcinogen (d)	25,550 [a]	25,550 [a]	NA	25,550 [a]
	AT - Averaging Time, Noncarcinogen (d)	3,285 [a]	2,190 [a]	NA	3,285 [a]
Dermal Contact with Soil	SA - Surface Area (cm^2/d)	NA	NA	3,120 [b]	NA
	ABS - Absorption Coefficient	NA	NA	CSV	NA
	AF - Adherence Factor (mg/cm^2)	NA	NA	0.8 [c]	NA
	ED - Exposure Duration (y)	NA	NA	1 [c]	NA
	EF - Exposure Frequency Outdoors (d/y)	NA	NA	250 [b]	NA
	BW - Body Weight (kg)	NA	NA	70 [a]	NA
	AT - Averaging Time, Carcinogen (d)	NA	NA	25,550 [a]	NA
	AT - Averaging Time, Noncarcinogen (d)	NA	NA	365 [a]	NA
	CF - Conversion Factor (kg/mg)	NA	NA	1.00E-06 [a]	NA

TABLE 4-10 (Continued)
CENTRAL TENDENCY EXPOSURE SCENARIO
RECEPTOR EXPOSURE PARAMETERS AND THEIR VALUES

Pathway	Parameter	Off-Site Adult	Off-Site Child	Maintenance Worker	Commercial/ Industrial Worker
Dermal Contact with Water	SA - Surface Area (cm^2)	19,400 [b]	9`310 [b]	NA	NA
	ED - Exposure Duration (y)	9 [b]	6 [a]	NA	NA
	EF - Exposure Frequency Outdoors (d/y)	350[a]	350 [a]	NA	NA
	BW - Body Weight (kg)	70 [a]	15 [a]	NA	NA
	AT - Averaging Time, Carcinogen (d)	25,550 [a]	25,550 [a]	NA	NA
	AT - Averaging Time, Noncarcinogen (d)	3285 [a]	2,190 [a]	NA	NA
	DA - Dermal Absorbed Dose (mg/cm2-d)	CSV	CSV	NA	NA

NOTES:

CSV = chemical-specific value
NA = not applicable
m^3/h = cubic meters per hour
d/y = days per year
y = years
h/d = hours per day
kg = kilograms
d = days
cm^2 = square centimeters
L/d =

SOURCES:

[a]EPA (1989a)

[b]EPA (1990a, 1997a)

[c]Cal/EPA (1992)

TABLE 4-11
COPC-SPECIFIC CONSTANTS

COPC	K_p (cm/hr)	Log K_{ow} (unitless)	MW (unitless)
1. 1,1,2-trichloroethane	8.35E-03	2.05E+00	1.33E+02
2. 1,1-dichloroethane	8.85E-03	1.79E+00	9.90E+01
3. 1,1-dichloropropene	5.48E-03	1.60E+00	1.10E+02
4. 1,2,3-trichloropropane	9.83E-03	2.27E+00	1.47E+02
5. 1,2,4-trimethylbenzene	1.70E-01	3.78E+00	1.20E+02
6. 1,2-dibromo-3-chloropropane	8.71E-03	2.96E+00	2.36E+02
7. 1,2-dibromoethane	3.35E-03	1.96E+00	1.87E+02
8. 1,2-dichloroethane	5.33E-03	1.48E+00	9.90E+01
9. 1,2-dichloroethene-cis	1.02E-02	1.86E+00	9.69E+01
10. 1,2-dichloropropane	1.02E-02	2.00E+00	1.13E+02
11. 1,3-dichloropropane	5.48E-03	1.60E+00	1.11E+02
12. 2,4-dinitro-6-sec-butylphenol	8.69E-03	2.76E+00	2.40E+02
13. antimony	NA	NA	1.22E+02
14. arsenic	NA	NA	7.50E+01
15. barium	NA	NA	1.37E+02
16. benzene	2.07E-02	2.13E+00	7.81E+01
17. benzyl chloride	1.37E-02	2.30E+00	1.27E+02
18. beryllium	NA	NA	9.01E+00
19. bromobenzene	2.79E-02	2.99E+00	1.57E+02
20. chlorobenzene	4.07E-02	2.84E+00	1.12E+02
21. chloroform	8.92E-03	1.97E+00	1.19E+02
22. chromium	NA	NA	5.20E+01
23. cobalt	NA	NA	5.90E+01
24. copper	NA	NA	6.35E+01
25. lead	NA	NA	2.07E+02
26. mercury	NA	NA	2.00E+02
27. methylene chloride	3.76E-02	1.30E+00	8.50E+01
28. nickel	NA	NA	5.87E+01
29. selenium	NA	NA	7.90E+01
30. tetrachloroethene	4.82E-02	3.40E+00	1.65E+02
31. thallium	NA	NA	2.04E+02
32. toluene	4.53E-02	2.73E+00	9.21E+01
33. vanadium	NA	NA	5.10E+01
34. zinc	NA	NA	6.53E+01

NOTES:
4.2E-06 = 4.2 x 10^{-6} = 0.0000042
NA = not applicable; Kp = permeability coefficient
Log Kow = Log transformed version of the Octanol/Water partition coefficient
MW= Molecular weight
SOURCE: EPA (1997a)

TABLE 4-12
CALCULATED COPC-SPECIFIC DOSE ABSORBED (DA)
FROM DERMAL CONTACT WITH B-ZONE GROUNDWATER

COPC	DA (mg/cm2-event)
1. 1,1,2-trichloroethane	NC
2. 1,1-dichloroethane	NC
3. 1,1-dichloropropene	NC
4. 1,2,3-trichloropropane	1.42E-09
5. 1,2,4-trimethylbenzene	NC
6. 1,2-dibromo-3-chloropropane	NC
7. 1,2-dibromoethane	NC
8. 1,2-dichloroethane	NC
9. 1,2-dichloroethene-cis	NC
10. 1,2-dichloropropane	8.94E-10
11. 1,3-dichloropropane	NC
12. 2,4-dinitro-6-sec-butylphenol	NC
13. antimony	NC
14. arsenic	NC
15. barium	NC
16. benzene	NC
17. benzyl chloride	NC
18. beryllium	NC
19. bromobenzene	NC
20. chlorobenzene	NC
21. chloroform	NC
22. chromium	NC
23. cobalt	NC
24. copper	NC
25. lead	NC
26. mercury	NC
27. methylene chloride	NC
28. nickel	NC
29. selenium	NC
30. tetrachloroethene	NC
31. thallium	NC
32. toluene	NC
33. vanadium	NC
34. zinc	NC

NOTES:
NC = not calculated; not projected to occur in down gradient city well

TABLE 4-13
DERMAL ABSORPTION FACTORS (ABS)

COPC	ABS (unitless)
1. 1,1,2-trichloroethane	1.00E-01
2. 1,1-dichloroethane	1.00E-01
3. 1,1-dichloropropene	9.00E-01
4. 1,2,3-trichloropropane	1.00E-01
5. 1,2,4-trimethylbenzene	1.00E-01
6. 1,2-dibromo-3-chloropropane	1.00E-01
7. 1,2-dibromoethane	1.00E-01
8. 1,2-dichloroethane	1.00E-01
9. 1,2-dichloroethene-cis	1.00E-01
10. 1,2-dichloropropane	1.00E-01
11. 1,3-dichloropropane	1.00E-01
12. 2,4-dinitro-6-sec-butylphenol	9.00E-01
13. antimony	1.00E-02
14. arsenic	3.00E-02
15. barium	1.00E-02
16. benzene	1.00E-01
17. benzyl chloride	1.00E-01
18. beryllium	1.00E-02
19. bromobenzene	9.00E-01
20. chlorobenzene	1.00E-01
21. chloroform	1.00E-01
22. chromium	1.00E-02
23. cobalt	1.00E-02
24. copper	1.00E-02
25. lead	1.00E-02
26. mercury	1.00E-02
27. methylene chloride	1.00E-01
28. nickel	1.00E-02
29. selenium	1.00E-02
30. tetrachloroethene	1.00E-01
31. thallium	1.00E-01
32. toluene	1.00E-01
33. vanadium	1.00E-01
34. zinc	1.00E-02

SOURCE: Cal/EPA, 1994

TABLE 5-1
SUMMARY OF HEALTH RISK
CURRENT SITE CONDITIONS
REASONABLE MAXIMUM EXPOSURE SCENARIOS

Receptors	Hazard Index (HI)	Incremental Lifetime Cancer Risk (ILCR)
On-Site Maintenance Worker	**5.9E-03**	**1.0E-07**
Incidental Ingestion of Soils	5.0E-04	5.3E-08
Dermal Contact with Soils	5.4E-03	5.1E-08
Inhalation Outdoor Air	1.4E-06	1.1E-10
On-Site Commercial/Industrial Worker	**1.2E-01**	**7.5E-06**
Inhalation Indoor Air (Vapor Intrusion)	1.2E-01	7.4E-06
Inhalation of Indoor Air (Ventilation System)	1.4E-03	5.4E-08
Inhalation of Outdoor Air	1.4E-03	5.4E-08
Ingestion of B-Zone Groundwater (City Well)	NC	NC
Off-Site Resident Adult	**8.4E-03**	**4.0E-07**
Inhalation Indoor Air (Vapor Intrusion)	NC	NC
Inhalation of Indoor Air (Ventilation System)	5.6E-03	2.7E-07
Inhalation Outdoor Air	2.8E-03	1.3E-07
Ingestion of B-Zone Groundwater (Fence Line)	NC	NC
Dermal Contact B-Zone Groundwater (Fence Line)	NC	NC
Off-Site Resident Child	**2.8E-02**	**2.7E-07**
Inhalation Indoor Air (Vapor Intrusion)	NC	NC
Inhalation of Indoor Air (Ventilation System)	1.9E-02	1.8E-07
Inhalation Outdoor Air	9.5E-03	9.0E-08
Ingestion of B-Zone Groundwater (Fence Line)	NC	NC
Dermal Contact B-Zone Groundwater (Fence Line)	NC	NC
Off-Site Commercial/Industrial Worker	**2.0E-03**	**8.0E-08**
Inhalation of Indoor Air (Vapor Intrusion)	NC	NC
Inhalation of Indoor Air (Ventilation System)	1.0E-03	4.0E-08
Inhalation Outdoors	1.0E-03	4.0E-08
Ingestion of B-Zone Groundwater (City Well)	NC	NC

NOTES:

NC = Pathway not complete under current site conditions (risk is zero)

4.2E-06 = 4.2×10^{-6} = 0.0000042

TABLE 5-2
SUMMARY OF HEALTH RISK
CURRENT SITE CONDITIONS
CENTRAL TENDENCY EXPOSURE SCENARIOS

Receptors	Hazard Index (HI)	Incremental Lifetime Cancer Risk (ILCR)
On-Site Maintenance Worker	**3.0E-03**	**3.3E-08**
Incidental Ingestion of Soils	5.2E-05	5.5E-09
Dermal Contact with Soils	2.9E-03	2.8E-08
Inhalation Outdoor Air	4.5E-07	3.6E-11
On-Site Commercial/Industrial Worker	**1.2E-01**	**2.7E-06**
Inhalation Indoor Air (Vapor Intrusion)	1.2E-01	2.6E-06
Inhalation of Indoor Air (Ventilation System)	1.4E-03	1.9E-08
Inhalation of Outdoor Air	1.4E-03	1.9E-08
Ingestion of B-Zone Groundwater (City Well)	NC	NC
Off-Site Resident Adult	**6.3E-03**	**9.1E-08**
Inhalation Indoor Air (Vapor Intrusion)	NC	NC
Inhalation of Indoor Air (Ventilation System)	4.2E-03	6.0E-08
Inhalation Outdoor Air	2.1E-03	3.0E-08
Ingestion of B-Zone Groundwater (Fence Line)	NC	NC
Dermal Contact B-Zone Groundwater (Fence Line)	NC	NC
Off-Site Resident Child	**2.8E-02**	**2.7E-07**
Inhalation Indoor Air (Vapor Intrusion)	NC	NC
Inhalation of Indoor Air (Ventilation System)	1.9E-02	1.8E-07
Inhalation Outdoor Air	9.5E-03	9.0E-08
Ingestion of B-Zone Groundwater (Fence Line)	NC	NC
Dermal Contact B-Zone Groundwater (Fence Line)	NC	NC
Off-Site Commercial/Industrial Worker	**2.0E-03**	**2.9E-08**
Inhalation of Indoor Air (Vapor Intrusion)	NC	NC
Inhalation of Indoor Air (Ventilation System)	1.0E-03	1.4E-08
Inhalation Outdoors	1.0E-03	1.4E-08
Ingestion of B-Zone Groundwater (City Well)	NC	NC

NOTES:

NC = Pathway not complete under current site conditions

4.2E-06 = 4.2×10^{-6} = 0.0000042

TABLE 5-3
SUMMARY OF HEALTH RISK
FUTURE SITE CONDITIONS
REASONABLE MAXIMUM EXPOSURE SCENARIOS

Receptors	Hazard Index (HI)	Incremental Lifetime Cancer Risk (ILCR)
On-Site Maintenance Worker	**5.9E-03**	**1.0E-07**
Incidental Ingestion of Soils	5.0E-04	5.3E-08
Dermal Contact with Soils	5.4E-03	5.1E-08
Inhalation Outdoor Air	1.4E-06	1.1E-10
On-Site Commercial/Industrial Worker	**1.2E-01**	**7.5E-06**
Inhalation Indoor Air (Vapor Intrusion)	1.2E-01	7.4E-06
Inhalation of Indoor Air (Ventilation System)	1.4E-03	5.4E-08
Inhalation of Outdoor Air	1.4E-03	5.4E-08
Ingestion of B-Zone Groundwater (City Well)	8.0E-07	1.2E-08
Off-Site Resident Adult	**6.7E-01**	**1.3E-04**
Inhalation Indoor Air (Vapor Intrusion)	6.7E-01	1.2E-04
Inhalation of Indoor Air (Ventilation System)	5.6E-03	2.7E-07
Inhalation Outdoor Air	2.8E-03	1.3E-07
Ingestion of B-Zone Groundwater (Fence Line)	3.7E-04	6.7E-06
Dermal Contact B-Zone Groundwater (Fence Line)	7.5E-05	1.4E-06
Off-Site Resident Child	**2.3E+00**	**8.4E-05**
Inhalation Indoor Air (Vapor Intrusion)	2.2E+00	8.0E-05
Inhalation of Indoor Air (Ventilation System)	1.9E-02	1.8E-07
Inhalation Outdoor Air	9.5E-03	9.0E-08
Ingestion of B-Zone Groundwater (Fence Line)	8.7E-04	3.1E-06
Dermal Contact B-Zone Groundwater (Fence Line)	1.8E-04	6.6E-07
Off-Site Commercial/Industrial Worker	**1.9E-02**	**4.0E-06**
Inhalation of Indoor Air (Vapor Intrusion)	1.7E-02	3.9E-06
Inhalation of Indoor Air (Ventilation System)	1.0E-03	4.0E-08
Inhalation Outdoors	1.0E-03	4.0E-08
Ingestion of B-Zone Groundwater (City Well)	8.0E-07	1.2E-08

NOTES:

4.2E-06 = 4.2×10^{-6} = 0.0000042

TABLE 5-4
SUMMARY OF HEALTH RISK
FUTURE SITE CONDITIONS
CENTRAL TENDENCY EXPOSURE SCENARIOS

Receptors	Hazard Index (HI)	Incremental Lifetime Cancer Risk (ILCR)
On-Site Maintenance Worker	**3.0E-03**	**3.3E-08**
Incidental Ingestion of Soils	5.2E-05	5.5E-09
Dermal Contact with Soils	2.9E-03	2.8E-08
Inhalation Outdoor Air	4.5E-07	3.6E-11
On-Site Commercial/Industrial Worker	**1.2E-01**	**2.7E-06**
Inhalation Indoor Air (Vapor Intrusion)	1.2E-01	2.6E-06
Inhalation of Indoor Air (Ventilation System)	1.4E-03	1.9E-08
Inhalation of Outdoor Air	1.4E-03	1.9E-08
Ingestion of B-Zone Groundwater (City Well)	5.6E-07	3.0E-09
Off-Site Resident Adult	**6.7E-01**	**3.7E-05**
Inhalation Indoor Air (Vapor Intrusion)	6.7E-01	3.6E-05
Inhalation of Indoor Air (Ventilation System)	5.6E-03	8.0E-08
Inhalation Outdoor Air	2.8E-03	4.0E-08
Ingestion of B-Zone Groundwater (Fence Line)	2.6E-04	1.4E-06
Dermal Contact B-Zone Groundwater (Fence Line)	6.3E-05	3.4E-07
Off-Site Resident Child	**2.3E+00**	**8.3E-05**
Inhalation Indoor Air (Vapor Intrusion)	2.3E+00	8.0E-05
Inhalation of Indoor Air (Ventilation System)	1.9E-02	1.8E-07
Inhalation Outdoor Air	9.5E-03	9.0E-08
Ingestion of B-Zone Groundwater (Fence Line)	6.1E-04	2.2E-06
Dermal Contact B-Zone Groundwater (Fence Line)	1.4E-04	5.1E-07
Off-Site Commercial/Industrial Worker	**1.9E-02**	**1.4E-06**
Inhalation of Indoor Air (Vapor Intrusion)	1.7E-02	1.4E-06
Inhalation of Indoor Air (Ventilation System)	1.0E-03	1.4E-08
Inhalation Outdoors	1.0E-03	1.4E-08
Ingestion of B-Zone Groundwater (City Well)	5.6E-07	3.0E-09

NOTES:

4.2E-06 = 4.2 x 10^{-6} = 0.0000042

TABLE 7-1
SUMMARY OF HEALTH RISK—CURRENT CONDITIONS

Scenarios	Hazard Index (HI)	Incremental Lifetime Cancer Risk (ILCR)
Reasonable Maximum Exposures		
On-Site Maintenance Worker	5.9E-03	1.0E-07
On-Site Commercial/Industrial Worker	1.2E-01	7.5E-06
Off-Site Resident Adult	8.4E-03	4.0E-07
Off-Site Resident Child	2.8E-02	2.7E-07
Off-Site Commercial Industrial Worker	2.0E-03	8.0E-08
Central Tendency Exposures		
On-Site Maintenance Worker	3.0E-03	3.3E-08
On-Site Commercial/Industrial Worker	1.2E-01	2.7E-06
Off-Site Resident Adult	8.4E-03	1.2E-07
Off-Site Resident Child	2.8E-02	2.7E-07
Off-Site Commercial Industrial Worker	2.0E-03	2.9E-08

NOTE:

4.2E-06 = 4.2×10^{-6} = 0.0000042

TABLE 7-2
SUMMARY OF HEALTH RISK—FUTURE CONDITIONS

Scenarios	Hazard Index (HI)	Incremental Lifetime Cancer Risk (ILCR)
Reasonable Maximum Exposures		
On-Site Maintenance Worker	5.9E-03	1.0E-07
On-Site Commercial/Industrial Worker	1.2E-01	7.5E-06
Off-Site Resident Adult	6.7E-01	1.3E-04
Off-Site Resident Child	2.3E+00	8.4E-05
Off-Site Commercial Industrial Worker	1.9E-02	4.0E-06
Central Tendency Exposures		
On-Site Maintenance Worker	3.0E-03	3.3E-08
On-Site Commercial/Industrial Worker	1.2E-01	2.7E-06
Off-Site Resident Adult	6.7E-01	3.7E-05
Off-Site Resident Child	2.3E+00	8.3E-05
Off-Site Commercial Industrial Worker	1.9E-02	1.4E-06

NOTES:

1.5E-06 = 1.5×10^{-6} = 0.0000015

TABLE 7-3
FENCE-LINE CONCENTRATIONS OF COPCs IN 30 YEARS (mg/L)

COPCs	Concentrations in 30 Years	Projected Concentrations for Risk Less than 10^{-6}
1,2,3-trichloropropane	2.08	0.058
1,2-dibromo-3-chloropropane	1.33	0.066
1,3-dichloropropane	10.1	0.17

NOTE:
mg/L = milligrams per liter

Figures

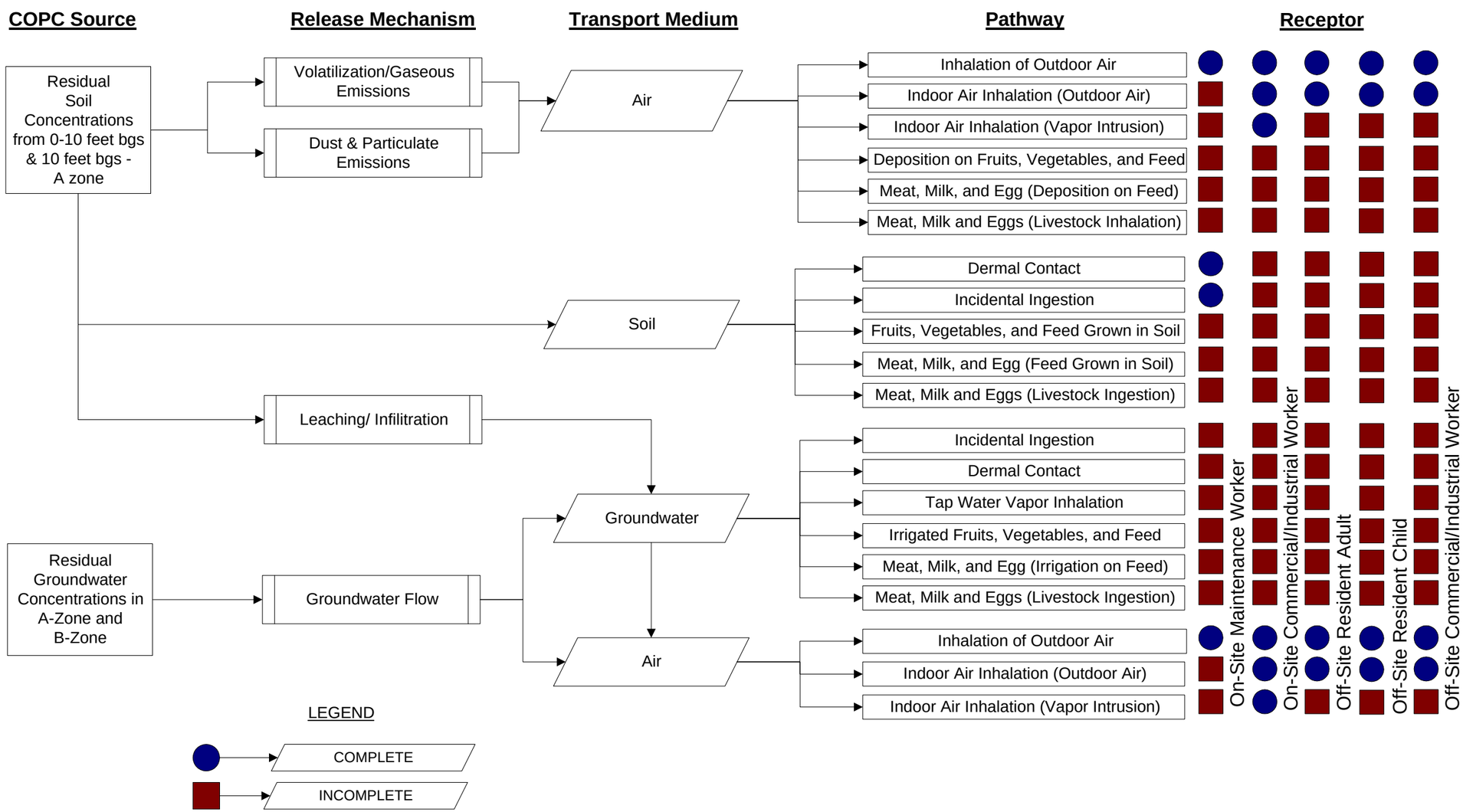


FIGURE 4-1
CONCEPTUAL EXPOSURE MODEL FOR PATHWAYS
CURRENT EXPOSURE SCENARIO

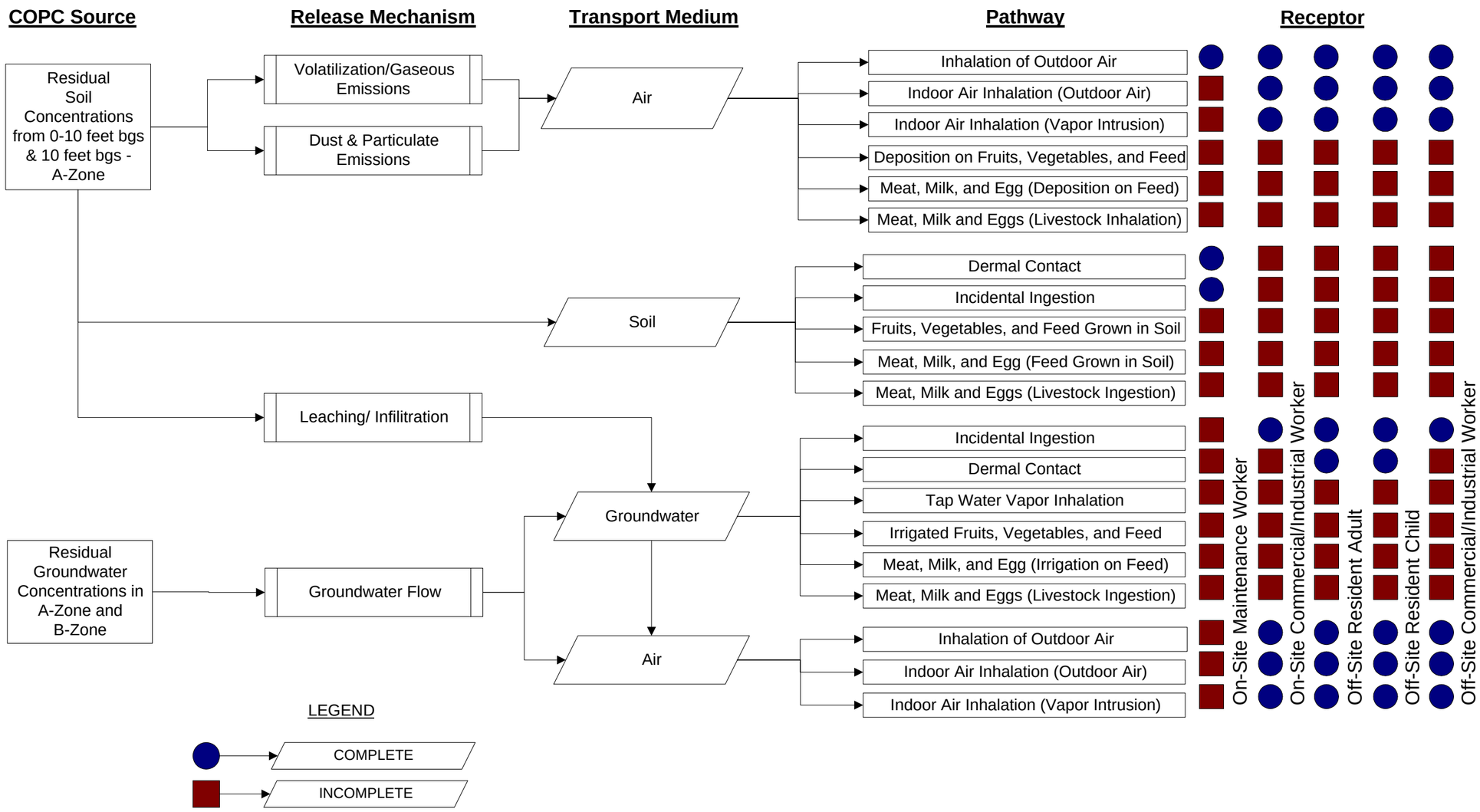


FIGURE 4-2
CONCEPTUAL EXPOSURE MODEL FOR PATHWAYS
FUTURE EXPOSURE SCENARIO

Appendix A

Risk Assessment Data Set – Statistical Summaries Field

Project No. C00-266.2 June 2004

Table A-1
Statistical Analysis of Soils Data (mg/kg)
Soils 0-10 Feet Below Ground Surface

	Statistics															
	Number of Samples	Number of Detects	Minimum Detected Concentration	Maximum Detected Concentration	Arithematic Mean Normal	Arithematic Mean Log Tranformed	Standard Error Normal	Standard Error Log Transformed	Variance Normal	Variance Log Transformed	Standard Deviation Normal	Standard Dev. Log Tranformed	95 UCL Normal	95 UCL Lognormal	Distribution Analysis Results *	Exposure Point Concentration
1,2,3-Trichloropropane	75	1	1.00E-01	1.00E-01	1.24E-01	-3.37E+00	4.01E-01	1.42E+00	2.58E-02	4.07E+00	1.61E-01	2.02E+00	1.55E-01	5.69E-01	Unknown	1.00E-01
1,2-Dibromo-3-chloropropane	75	2	1.00E-02	1.00E-02	6.50E-03	-4.85E+00	8.54E-02	6.14E-01	5.33E-05	1.42E-01	7.30E-03	3.77E-01	7.90E-03	9.10E-03	Unknown	9.10E-03
1,2-Dibromoethane	75	1	6.00E-03	6.00E-03	5.10E-03	-5.25E+00	8.76E-02	8.07E-01	5.93E-05	4.23E-01	7.70E-03	6.51E-01	6.60E-03	7.50E-03	Unknown	6.00E-03
1,2-Dichloropropane	75	1	8.00E-02	8.00E-02	1.25E-01	-2.55E+00	3.69E-01	1.15E+00	1.85E-02	1.75E+00	1.36E-01	1.32E+00	1.51E-01	2.72E-01	Unknown	8.00E-02
1,3-Dichloropropane	75	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Dinitro-6-sec-Butylphenol	77	3	2.00E-01	2.15E+00	5.81E-02	-3.43E+00	4.99E-01	8.47E-01	6.18E-02	5.15E-01	2.49E-01	7.17E-01	1.05E-01	4.92E-02	Unknown	1.05E-01
Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloroform	60	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

* - Distributions based on CrystalBall Data Fit Analysis

NA - Not analyzed in sample set ND - Not Detected

Exposure Point Concentration - distribution-specific UCL value that does not exceed the detected maximum; when distributiuon unknown, maximum UCL that does not exceed detected maximum

Table A-2
Statistical Analysis of Soils Data (mg/kg)
Soils 10 Feet Below Ground Surface to A-Zone Groundwater

	Statistics															
	Number of Samples	Number of Detects	Minimum Detected Concentration	Maximum Detected Concentration	Arithematic Mean Normal	Arithematic Mean Log Tranformed	Standard Error Normal	Standard Error Log Transformed	Variance Normal	Variance Log Transformed	Standard Deviation Normal	Standard Dev. Log Tranformed	95 UCL Normal	95 UCL Lognormal	Distribution Analysis Results *	Exposure Point Concentration
1,2,3-Trichloropropane	486	37	1.40E-03	7.10E-01	1.06E-01	-3.70E+00	4.12E-01	1.37E+00	2.87E-02	3.57E+00	1.69E-01	1.89E+00	1.18E-01	1.96E-01	Unknown	1.96E-01
1,2-Dibromo-3-chloropropane	482	27	1.00E-02	6.95E-01	1.62E-02	-4.71E+00	2.51E-01	8.62E-01	3.97E-03	5.52E-01	6.30E-02	7.43E-01	2.09E-02	1.28E-02	Unknown	2.09E-02
1,2-Dibromoethane	480	13	4.00E-03	6.60E-02	5.70E-03	-5.30E+00	1.00E-01	8.70E-01	1.00E-04	5.74E-01	1.00E-02	7.57E-01	6.50E-03	7.10E-03	Unknown	7.10E-03
1,2-Dichloropropane	487	47	1.30E-03	1.52E+01	1.84E-01	-2.69E+00	9.28E-01	1.16E+00	7.40E-01	1.78E+00	8.61E-01	1.34E+00	2.48E-01	1.94E-01	Unknown	2.48E-01
1,3-Dichloropropane	479	11	3.00E-02	2.12E+00	9.56E-02	-3.31E+00	4.09E-01	1.23E+00	2.79E-02	2.32E+00	1.67E-01	1.52E+00	1.08E-01	1.40E-01	Unknown	1.40E-01
2,4-Dinitro-6-sec-Butylphenol	416	8	3.00E-02	5.00E-02	3.68E-02	-3.55E+00	4.38E-01	7.60E-01	3.67E-02	3.34E-01	1.92E-01	5.78E-01	5.23E-02	3.60E-02	Unknown	3.60E-02
Antimony	4	4	3.07E+00	4.12E+00	3.59E+00	1.27E+00	6.80E-01	3.60E-01	2.12E-01	1.69E-02	4.60E-01	1.30E-01	4.13E+00	4.41E+00	Unknown	4.12E+00
Arsenic	26	26	1.18E+00	3.68E+01	1.06E+01	2.06E+00	3.01E+00	8.91E-01	8.19E+01	6.31E-01	9.05E+00	7.94E-01	1.36E+01	1.52E+01	Unknown	1.52E+01
Barium	27	27	6.03E+01	3.62E+02	1.67E+02	5.02E+00	8.50E+00	6.86E-01	5.21E+03	2.21E-01	7.22E+01	4.70E-01	1.91E+02	2.02E+02	Unknown	2.02E+02
Beryllium	8	8	5.40E-01	7.79E-01	6.43E-01	-4.47E-01	2.67E-01	3.30E-01	5.07E-03	1.19E-02	7.12E-02	1.09E-01	6.91E-01	6.95E-01	Unknown	6.95E-01
Chloroform	356	5	3.00E-03	1.60E-01	1.12E-01	-3.06E+00	3.72E-01	1.28E+00	1.92E-02	2.67E+00	1.39E-01	1.63E+00	1.24E-01	2.30E-01	Unknown	1.24E-01
Chromium	27	27	3.63E+00	2.96E+01	1.55E+01	2.64E+00	2.52E+00	6.95E-01	4.05E+01	2.33E-01	6.36E+00	4.83E-01	1.76E+01	1.90E+01	Unknown	1.90E+01
Cobalt	27	27	2.65E+00	1.97E+01	1.04E+01	2.25E+00	2.05E+00	6.84E-01	1.77E+01	2.19E-01	4.20E+00	4.68E-01	1.18E+01	1.27E+01	Unknown	1.27E+01
Copper	27	27	1.85E+00	1.57E+01	6.05E+00	1.66E+00	1.80E+00	7.44E-01	1.05E+01	3.07E-01	3.24E+00	5.54E-01	7.12E+00	7.64E+00	Unknown	7.64E+00
Lead	27	27	9.91E-01	8.16E+00	3.04E+00	9.80E-01	1.28E+00	7.31E-01	2.66E+00	2.85E-01	1.63E+00	5.34E-01	3.58E+00	3.76E+00	Unknown	3.76E+00
Mercury	7	7	1.20E-01	4.00E-01	1.80E-01	-1.80E+00	3.15E-01	6.45E-01	9.84E-03	1.73E-01	9.92E-02	4.16E-01	2.53E-01	2.64E-01	Unknown	2.64E-01
Nickel	27	27	2.23E+00	1.30E+01	7.01E+00	1.87E+00	1.65E+00	6.55E-01	7.35E+00	1.84E-01	2.71E+00	4.30E-01	7.90E+00	8.28E+00	Unknown	8.28E+00
Selenium	15	15	6.78E-01	4.29E+00	2.15E+00	6.76E-01	9.85E-01	6.72E-01	9.40E-01	2.04E-01	9.70E-01	4.52E-01	2.60E+00	2.79E+00	Unknown	2.79E+00
Thallium	12	12	2.22E+00	7.25E+00	4.49E+00	1.45E+00	1.25E+00	5.92E-01	2.41E+00	1.23E-01	1.55E+00	3.51E-01	5.29E+00	5.60E+00	Unknown	5.60E+00
Vanadium	27	27	1.31E+01	8.17E+01	4.17E+01	3.63E+00	4.26E+00	6.90E-01	3.29E+02	2.26E-01	1.81E+01	4.76E-01	4.77E+01	5.06E+01	Unknown	5.06E+01
Zinc	27	27	2.11E+01	8.36E+01	5.59E+01	3.97E+00	4.17E+00	5.86E-01	3.02E+02	1.18E-01	1.74E+01	3.44E-01	6.16E+01	6.34E+01	Unknown	6.34E+01

Notes:

* - Distributions based on CrystalBall Data Fit Analysis

NA - Not analyzed in sample set ND - Not Detected

Exposure Point Concentration - distribution-specific UCL value that does not exceed the detected maximum; when distributiuon unknown, maximum UCL that does not exceed detected maximum

Table A-3
Statistical Analysis of A-Zone Groundwater Data (mg/l)

	Number of Samples	Number of Detects	Minimum Detected Concentration	Maximum Detected Concentration	Arithematic Mean Normal	Standard Error Normal	Standard Deviation Normal	95 UCL Normal	Exposure Point Concentration
1,1,2-Trichloroethane	18	5	5.10E-03	1.10E-02	6.92E-03	1.56E-03	2.45E-03	9.26E-03	9.26E-03
1,1-Dichloroethane	57	9	5.90E-04	1.80E-02	8.75E-03	2.39E-03	5.72E-03	1.15E-02	1.15E-02
1,1-Dichloropropene	33	2	1.10E-04	6.90E-03	2.00E-03	1.62E-03	2.63E-03	4.16E-03	4.16E-03
1,2,3-Trichloropropane	277	224	1.30E-04	1.10E+01	1.35E+00	4.57E-02	2.09E+00	1.57E+00	1.57E+00
1,2,4-Trimethylbenzene	9	1	2.20E+00	2.20E+00	2.20E+00	0.00E+00	0.00E+00	NC	2.20E+00
1,2-Dinitro-3-chloropropane	264	180	6.20E-06	1.70E+01	5.20E-01	4.20E-02	1.83E+00	7.34E-01	7.34E-01
1,2-Dibromoethane	225	123	1.50E-05	1.56E+00	7.54E-02	1.52E-02	2.30E-01	1.07E-01	1.07E-01
1,2-Dichloroethane	57	23	3.00E-04	2.60E-01	4.23E-02	7.73E-03	5.98E-02	6.23E-02	6.23E-02
1,2-Dichloropropane	278	242	4.00E-04	1.60E+02	2.01E+01	1.72E-01	2.95E+01	2.32E+01	2.32E+01
1,3-Dichloropropane	246	98	2.00E-04	1.00E+00	1.07E-01	1.31E-02	1.72E-01	1.37E-01	1.37E-01
2,4-Dinitro-6-Sec-ButylPhenol	231	151	NV	NV	NV	NV	NV	NV	NV
Benzene	48	12	1.10E-04	4.70E-02	9.41E-03	3.27E-03	1.07E-02	1.43E-02	1.43E-02
Benzyl Chloride	9	1	6.40E-03	6.40E-03	6.40E-03	0.00E+00	0.00E+00	NC	6.40E-03
Bromobenzene	23	3	2.60E-02	2.08E-01	1.45E-01	1.02E-02	1.03E-01	3.20E-01	3.20E-01
Chlorobenzene	35	9	5.10E-03	3.80E-02	1.08E-02	3.16E-03	9.97E-03	1.66E-02	1.66E-03
Chloroform	268	123	1.10E-04	1.90E+00	1.60E-01	1.76E-02	3.11E-01	1.98E-01	1.98E-01
Cis-1,2-Dichloroethene	9	1	6.00E-03	6.00E-03	6.00E-03	0.00E+00	0.00E+00	NC	6.00E-03
Methylene Chloride	62	4	1.30E-04	2.40E-01	5.00E-02	8.05E-03	6.47E-02	8.06E-02	8.06E-02
Tetrachloroethene	37	5	1.30E-04	1.90E-03	7.17E-04	7.88E-04	6.21E-04	1.02E-03	1.02E-03
Toluene	83	21	1.10E-04	1.76E+00	9.70E-02	1.80E-02	3.25E-01	2.00E-01	2.00E-01

Notes:
NC- Not Calculated due to lack of sufficient data
NV - Not Volatile thus no exposure point concentration was required

Appendix B

Air Modeling Output

Project No. C00-266.2 June 2004

Appendix C

Receptor COPC Intake and Risk Calculation Sheets

Project No. C00-266.2 June 2004

Appendix I-C

Automated Data Review Criteria

Project No. C00-266.2 September 2005

Library Validation Criteria: Holding Times

Library Group ID : B&B1_03 All Methods

Sample Matrix : AQ

Analytical Method	Sampling To Extraction	Extraction To Analysis	Sampling To Analysis	Units	Rejection Point	Rejection Point Criteria
504.1			28	Days	2	GT
8151A	7	40		Days	2	GT
8260B			14	Days	2	GT

Legend

Rejection Point Criteria
LT : Less Than *GT : Greater Than*
LE : Less Than or Equal *GE : Greater Than or Equal*

Library Validation Criteria: Reporting and Detection Limits

Library Group ID : B&B04 All Methods

Sample Matrix : AQ

Analytical Method	Client Analyte ID	Analyte Name	Reporting Limit Criteria	Reporting Limit Type	Units
504.1	96-12-8	1,2-Dibromo-3-chloropropane	0.010	RDL	ug/l
	106-93-4	1,2-Dibromoethane	0.020	RDL	ug/l
8151A	88-85-7	Dinoseb	0.50	RDL	ug/l
8260B	630-20-6	1,1,1,2-Tetrachloroethane	1	PQL	ug/l
	71-55-6	1,1,1-Trichloroethane	1	PQL	ug/l
	79-34-5	1,1,2,2-Tetrachloroethane	1	PQL	ug/l
	79-00-5	1,1,2-Trichloroethane	1	PQL	ug/l
	75-34-3	1,1-Dichloroethane	1	PQL	ug/l
	75-35-4	1,1-Dichloroethene	1	PQL	ug/l
	563-58-6	1,1-Dichloropropene	1	PQL	ug/l
	87-61-6	1,2,3-Trichlorobenzene	1	PQL	ug/l
	96-18-4	1,2,3-Trichloropropane	1	RDL	ug/l
	120-82-1	1,2,4-Trichlorobenzene	1	PQL	ug/l
	95-63-6	1,2,4-Trimethylbenzene	1	PQL	ug/l
	96-12-8	1,2-Dibromo-3-chloropropane	1	RDL	ug/l
	106-93-4	1,2-Dibromoethane (EDB)	1	PQL	ug/l
	95-50-1	1,2-Dichlorobenzene	1	PQL	ug/l
	107-06-2	1,2-Dichloroethane	1	PQL	ug/l
	78-87-5	1,2-Dichloropropane	1	RDL	ug/l
	108-67-8	1,3,5-Trimethylbenzene	1	PQL	ug/l
	541-73-1	1,3-Dichlorobenzene	1	PQL	ug/l
	142-28-9	1,3-Dichloropropane	1	RDL	ug/l
	106-46-7	1,4-Dichlorobenzene	1	PQL	ug/l
	594-20-7	2,2-Dichloropropane	1	PQL	ug/l
	78-93-3	2-Butanone	10	PQL	ug/l
	110-75-8	2-Chloroethylvinyl ether	10	PQL	ug/l
	95-49-8	2-Chlorotoluene	1	PQL	ug/l
	591-78-6	2-Hexanone	10	PQL	ug/l
	106-43-4	4-Chlorotoluene	1	PQL	ug/l
	108-10-1	4-Methyl-2-pentanone	10	PQL	ug/l
	67-64-1	Acetone	10	PQL	ug/l
	71-43-2	Benzene	1	PQL	ug/l
	108-86-1	Bromobenzene	1	PQL	ug/l
	74-97-5	Bromochloromethane	1	PQL	ug/l
	75-27-4	Bromodichloromethane	1	PQL	ug/l
	75-25-2	Bromoform	1	PQL	ug/l
	74-83-9	Bromomethane	1	PQL	ug/l
	75-15-0	Carbon disulfide	10	PQL	ug/l
	56-23-5	Carbon tetrachloride	1	PQL	ug/l
	108-90-7	Chlorobenzene	1	PQL	ug/l
	75-00-3	Chloroethane	1	PQL	ug/l
	67-66-3	Chloroform	1	RDL	ug/l
	74-87-3	Chloromethane	1	PQL	ug/l
	156-59-2	cis-1,2-Dichloroethene	1	PQL	ug/l
	10061-01-5	cis-1,3-Dichloropropene	1	PQL	ug/l
	124-48-1	Dibromochloromethane	1	PQL	ug/l
	74-95-3	Dibromomethane	1	PQL	ug/l
	75-71-8	Dichlorodifluoromethane	1	PQL	ug/l
	100-41-4	Ethylbenzene	1	PQL	ug/l

Library Validation Criteria: Reporting and Detection Limits

Library Group ID : B&B04

All Methods

Sample Matrix : AQ

Analytical Method	Client Analyte ID	Analyte Name	Reporting Limit Criteria	Reporting Limit Type	Units
8260B	76-13-1	Freon 113	1	PQL	ug/l
	87-68-3	Hexachlorobutadiene	1	PQL	ug/l
	98-82-8	Isopropylbenzene	1	PQL	ug/l
	136777-61-2	m,p-Xylene	1	PQL	ug/l
	1634-04-4	Methyl tert-butyl ether	1	PQL	ug/l
	75-09-2	Methylene chloride	1	PQL	ug/l
	91-20-3	Naphthalene	1	PQL	ug/l
	104-51-8	n-Butylbenzene	1	PQL	ug/l
	103-65-1	n-Propylbenzene	1	PQL	ug/l
	95-47-6	o-Xylene	1	PQL	ug/l
	99-87-6	p-Isopropyltoluene	1	PQL	ug/l
	135-98-8	sec-Butylbenzene	1	PQL	ug/l
	100-42-5	Styrene	1	PQL	ug/l
	98-06-6	tert-Butylbenzene	1	PQL	ug/l
	127-18-4	Tetrachloroethene	1	PQL	ug/l
	108-88-3	Toluene	1	PQL	ug/l
	156-60-5	trans-1,2-Dichloroethene	1	PQL	ug/l
	10061-02-6	trans-1,3-Dichloropropene	1	PQL	ug/l
	79-01-6	Trichloroethene	1	PQL	ug/l
	75-69-4	Trichlorofluoromethane	1	PQL	ug/l
	108-05-4	Vinyl acetate	20	PQL	ug/l
	75-01-4	Vinyl chloride	1	PQL	ug/l

Library Validation Criteria: Method Blanks

Library Group ID : B&B1_03 All Methods
Sample Matrix : AQ

Analytical Method	Client Analyte ID	Analyte Name	5X or 10X Rule
504.1	96-12-8	1,2-Dibromo-3-chloropropane	5
	106-93-4	1,2-Dibromoethane	5
8151A	88-85-7	Dinoseb	5
8260B	630-20-6	1,1,1,2-Tetrachloroethane	5
	71-55-6	1,1,1-Trichloroethane	5
	79-34-5	1,1,2,2-Tetrachloroethane	5
	79-00-5	1,1,2-Trichloroethane	5
	75-34-3	1,1-Dichloroethane	5
	75-35-4	1,1-Dichloroethene	5
	563-58-6	1,1-Dichloropropene	5
	87-61-6	1,2,3-Trichlorobenzene	5
	96-18-4	1,2,3-Trichloropropane	5
	120-82-1	1,2,4-Trichlorobenzene	5
	95-63-6	1,2,4-Trimethylbenzene	5
	96-12-8	1,2-Dibromo-3-chloropropane	5
	106-93-4	1,2-Dibromoethane (EDB)	5
	95-50-1	1,2-Dichlorobenzene	5
	107-06-2	1,2-Dichloroethane	5
	78-87-5	1,2-Dichloropropane	5
	108-67-8	1,3,5-Trimethylbenzene	5
	541-73-1	1,3-Dichlorobenzene	5
	142-28-9	1,3-Dichloropropane	5
	106-46-7	1,4-Dichlorobenzene	5
	594-20-7	2,2-Dichloropropane	5
	78-93-3	2-Butanone	10
	110-75-8	2-Chloroethylvinyl ether	5
	95-49-8	2-Chlorotoluene	5
	591-78-6	2-Hexanone	5
	106-43-4	4-Chlorotoluene	5
	108-10-1	4-Methyl-2-pentanone	5
	67-64-1	Acetone	10
	71-43-2	Benzene	5
	108-86-1	Bromobenzene	5
	74-97-5	Bromochloromethane	5
	75-27-4	Bromodichloromethane	5
	75-25-2	Bromoform	5
	74-83-9	Bromomethane	5
	75-15-0	Carbon disulfide	5
	56-23-5	Carbon tetrachloride	5
	108-90-7	Chlorobenzene	5
	75-00-3	Chloroethane	5
	67-66-3	Chloroform	5
	74-87-3	Chloromethane	5

Library Validation Criteria: Method Blanks

Library Group ID : B&B1_03 All Methods
Sample Matrix : AQ

Analytical Method	Client Analyte ID	Analyte Name	5X or 10X Rule
8260B	156-59-2	cis-1,2-Dichloroethene	5
	10061-01-5	cis-1,3-Dichloropropene	5
	124-48-1	Dibromochloromethane	5
	74-95-3	Dibromomethane	5
	75-71-8	Dichlorodifluoromethane	5
	100-41-4	Ethylbenzene	5
	76-13-1	Freon 113	5
	87-68-3	Hexachlorobutadiene	5
	98-82-8	Isopropylbenzene	5
	136777-61-2	m,p-Xylene	5
	1634-04-4	Methyl tert-butyl ether	5
	75-09-2	Methylene chloride	5
	91-20-3	Naphthalene	5
	104-51-8	n-Butylbenzene	5
	103-65-1	n-Propylbenzene	5
	95-47-6	o-Xylene	5
	99-87-6	p-Isopropyltoluene	5
	135-98-8	sec-Butylbenzene	5
	100-42-5	Styrene	5
	98-06-6	tert-Butylbenzene	5
	127-18-4	Tetrachloroethene	5
	108-88-3	Toluene	10
	156-60-5	trans-1,2-Dichloroethene	5
	10061-02-6	trans-1,3-Dichloropropene	5
	79-01-6	Trichloroethene	5
	75-69-4	Trichlorofluoromethane	5
	108-05-4	Vinyl acetate	5
	75-01-4	Vinyl chloride	5

Library Validation Criteria: Laboratory Control Samples / Duplicates

Library Group ID : B&B1_03 All Methods

Sample Matrix : AQ

Analytical Method	Client Analyte ID	Analyte Name	Rejection Point	Rejection Point Criteria	Percent Recovery		RPD
					Lower Limit	Upper Limit	
504.1	96-12-8	1,2-Dibromo-3-chloropropane	10	LT	70	130	20
	106-93-4	1,2-Dibromoethane	10	LT	70	130	20
8151A	88-85-7	Dinoseb	10	LT	30	150	20
8260B	96-18-4	1,2,3-Trichloropropane	10	LT	65	135	35
	96-12-8	1,2-Dibromo-3-chloropropane	10	LT	65	135	35
	78-87-5	1,2-Dichloropropane	10	LT	65	135	35
	142-28-9	1,3-Dichloropropane	10	LT	65	135	35
	67-66-3	Chloroform	10	LT	65	135	35

Legend *Rejection Point Criteria*
LT : Less Than *GT : Greater Than*
LE : Less Than or Equal *GE : Greater Than or Equal*

Library Validation Criteria: Matrix Spike /Matrix Spike Duplicates

Library Group ID : B&B1_03 All Methods

Sample Matrix : AQ

Analytical Method	Client Analyte ID	Analyte Name	Rejection Point	Rejection Point Criteria	Percent Recovery Lower Limit	Percent Recovery Upper Limit	RPD
504.1	96-12-8	1,2-Dibromo-3-chloropropane	10	LT	65	135	20
	106-93-4	1,2-Dibromoethane	10	LT	65	135	20
8151A	88-85-7	Dinoseb	10	LT	30	150	20
8260B	96-18-4	1,2,3-Trichloropropane	10	LT	65	135	35
	96-12-8	1,2-Dibromo-3-chloropropane	10	LT	65	135	35
	78-87-5	1,2-Dichloropropane	10	LT	65	135	35
	142-28-9	1,3-Dichloropropane	10	LT	65	135	35
	67-66-3	Chloroform	10	LT	65	135	35

Legend

Rejection Point Criteria
LT : Less Than *GT : Greater Than*
LE : Less Than or Equal *GE : Greater Than or Equal*

Library Validation Critera: Laboratory and Field Duplicate Criteria

Library: **B&B1_03** All Methods

Matrix: **AQ**

Analytical Method	Client Analyte ID	Analyte Name	Lab Duplicate RPD	Field Duplicate RPD
504.1	96-12-8	1,2-Dibromo-3-chloropropane	20	50
	106-93-4	1,2-Dibromoethane	20	50
8151A	88-85-7	Dinoseb	20	50
8260B	630-20-6	1,1,1,2-Tetrachloroethane		
	71-55-6	1,1,1-Trichloroethane		
	79-34-5	1,1,2,2-Tetrachloroethane		
	79-00-5	1,1,2-Trichloroethane		
	75-34-3	1,1-Dichloroethane		
	75-35-4	1,1-Dichloroethene		
	563-58-6	1,1-Dichloropropene		
	87-61-6	1,2,3-Trichlorobenzene		
	96-18-4	1,2,3-Trichloropropane	35	50
	120-82-1	1,2,4-Trichlorobenzene		
	95-63-6	1,2,4-Trimethylbenzene		
	96-12-8	1,2-Dibromo-3-chloropropane	35	50
	106-93-4	1,2-Dibromoethane (EDB)		
	95-50-1	1,2-Dichlorobenzene		
	107-06-2	1,2-Dichloroethane	0	0
	78-87-5	1,2-Dichloropropane	35	50
	108-67-8	1,3,5-Trimethylbenzene		
	541-73-1	1,3-Dichlorobenzene		
	142-28-9	1,3-Dichloropropane	35	50
	106-46-7	1,4-Dichlorobenzene		
	594-20-7	2,2-Dichloropropane		
	78-93-3	2-Butanone		
	110-75-8	2-Chloroethylvinyl ether		
	95-49-8	2-Chlorotoluene		
	591-78-6	2-Hexanone		
	106-43-4	4-Chlorotoluene		
	108-10-1	4-Methyl-2-pentanone		
	67-64-1	Acetone		
	71-43-2	Benzene		
	108-86-1	Bromobenzene		
	74-97-5	Bromochloromethane		
	75-27-4	Bromodichloromethane		
	75-25-2	Bromoform		
	74-83-9	Bromomethane		
	75-15-0	Carbon disulfide		
	56-23-5	Carbon tetrachloride		
	108-90-7	Chlorobenzene		
	75-00-3	Chloroethane		
	67-66-3	Chloroform	35	50
	74-87-3	Chloromethane		
	156-59-2	cis-1,2-Dichloroethene		
	10061-01-5	cis-1,3-Dichloropropene		
	124-48-1	Dibromochloromethane		
	74-95-3	Dibromomethane		
	75-71-8	Dichlorodifluoromethane		
	100-41-4	Ethylbenzene		
	76-13-1	Freon 113		

Library Validation Critera: Laboratory and Field Duplicate Criteria

Library: **B&B1_03** All Methods

Matrix: **AQ**

Analytical Method	Client Analyte ID	Analyte Name	Lab Duplicate RPD	Field Duplicate RPD
8260B	87-68-3	Hexachlorobutadiene		
	98-82-8	Isopropylbenzene		
	136777-61-2	m,p-Xylene	0	0
	1634-04-4	Methyl tert-butyl ether	0	50
	75-09-2	Methylene chloride	0	0
	91-20-3	Naphthalene		
	104-51-8	n-Butylbenzene		
	103-65-1	n-Propylbenzene		
	95-47-6	o-Xylene		
	99-87-6	p-Isopropyltoluene		
	135-98-8	sec-Butylbenzene		
	100-42-5	Styrene		
	98-06-6	tert-Butylbenzene		
	127-18-4	Tetrachloroethene		
	108-88-3	Toluene		
	156-60-5	trans-1,2-Dichloroethene		
	10061-02-6	trans-1,3-Dichloropropene		
	79-01-6	Trichloroethene		
	75-69-4	Trichlorofluoromethane		
	108-05-4	Vinyl acetate		
	75-01-4	Vinyl chloride		

Library Acceptance Criteria: Surrogates

Library Group ID : B&B1_03

Sample Matrix : AQ

Analytical Method	Client Analyte ID	Analyte Name	Rejection Point	Rejection Point Criteria	Percent Recovery Lower Limit	Percent Recovery Upper Limit
504.1	109-64-8	1,3-Dibromopropane	10	LT	50	130
8151A	19719-28-9	2,4-DCAA	10	LT	30	150
8260B	17060-07-0	1,2-Dichloroethane-d4	10	LT	74	135
	460-00-4	4-Bromofluorobenzene	10	LT	86	119
	1868-53-7	Dibromofluoromethane	10	LT	84	122
	2037-26-5	Toluene-d8	10	LT	84	119

Legend

Rejection Point Criteria
LT : Less Than *GT : Greater Than*
LE : Less Than or Equal *GE : Greater Than or Equal*

Appendix I-D

Biological Constraints Analysis Report

Project No. C00-266.2 September 2005

Pacific Southwest Biological Services, Inc.

Post Office Box 985, National City, California 91951-0985 • **(619) 477-5333** • FAX (619) 477-5380

Ms. Mitra Fiuzat
Panacea, Inc.
14700 Firestone Boulevard, Suite 118
La Mirada CA 90638
Telephone: (714) 228-1286
Facsimile: (714) 228-1248

5 December 2002
PSBS #U173

Dear Ms. Fiuzat:

Re: Biological Constraints Analysis, Brown & Bryant Superfund Site
City of Arvin, Kern County, California

INTRODUCTION

Pacific Southwest Biological Services, Inc., (Pacific Southwest) has completed a biological constraints analysis of the approximately 5-acre Brown & Bryant Superfund site in the City of Arvin in south-central Kern County, California. This letter report summarizes the reconnaissance field survey and discusses potential sensitive species and other biological resource issues that may occur on the property.

LOCATION

The site is located at 600 South Derby Street on the east side of the City of Arvin. Arvin is a small community (population approximately 13,000) located in a highly productive area of extensive agriculture near the southern end of the San Joaquin Valley. The map location is in the southwest quarter of the northwest quarter, Section 25, Township 31 South, Range 29 East of the San Bernardino Base and Meridian, U. S. Geological Survey 7.5' Arvin, California quadrangle at UTM: 11-S: 334,220mE; 3,896,920mN (Figures 1 & 2). Access to the site from U. S. Interstate Highway 5 is east on Bear Mountain Boulevard (State Highway 223), then south on South Derby Street, which parallels the property on the west side.

METHODS

Prior to the field survey, a search was made of the California Department of Fish and Game's (CDFG) California Natural Diversity Data Base (CNDDB) for the 7.5' Arvin, California quadrangle for sensitive flora and fauna potentially occurring on the site (Appendix 1 & 2). Additionally, aerial photographs at scales of 1"=400' and 1"=180' were reviewed for local land use patterns (Figures 3 & 4). Also consulted electronically was the U. S. Geological Survey Mapping Information: Geographic Names Information System (GNIS) for regional information.

Pacific Southwest biologist Cornelius W. Bouscaren visited the site 26 November 2002 during the period 0750-0935 hours. During the visit the temperature range was 49-63°F, a light fog prevailed, and winds were calm becoming west 3 mph. The assessment was conducted on foot, walking the entire perimeter of the site to the extent possible. Particular attention was paid to potential presence of those species noted in the CNDDB. Binoculars (8.5x44) were used to assist in the detection and identification of wildlife. The site is completely enclosed by a chain link fence topped with barbed wire, preventing entrance to the site. However, the site was adequately assessed by walking the perimeter and using binoculars.

RESULTS

The site is on generally level land at an elevation of 433 feet above mean sea level. The property is the site of an abandoned agricultural chemical storage and distribution facility. Structures on the site include a chemical storage tank and distribution building. The site is fully surfaced with concrete, generally precluding the presence of vegetation, although a few Russian Thistle (*Salsola tragus*) subshrubs are growing around the building.

Surrounding land uses include an agricultural equipment storage and servicing facility, a light industrial facility, and residential housing to the west across South Derby Street, a light industrial facility immediately adjacent to the north, agricultural fields under active cultivation adjacent to the east, and agricultural product processing and packing facilities adjacent to the south. Abandoned railroad tracks occupy the area immediately adjacent to the west and southwest, between the site and South Derby Street, along with substantial areas of bare ground. Scattered weedy vegetation occurs here, consisting primarily of Russian Thistle but also including an assortment of non-native Brome grasses (*Bromus* ssp.), Red-stem Filaree (*Erodium cicutarium*), a common non-native forb, and Pineapple-weed (*Matricaria matricarioides*), a common pest of roadsides, gardens, and cropland. Trash of every description is abundant in this area. The same vegetative mix adheres in a narrow band to the chain link fence on the perimeter of the site.

Flora observed are limited to those few weedy species mentioned above. Fauna observed are limited to such common and widespread species as the American Crow (*Corvus brachyrhynchos*), White-crowned Sparrow (*Zonotrichia leucophrys*), House Finch (*Carpodacus mexicanus*), and House Sparrow (*Passer domesticus*).

No sensitive flora or fauna were observed on the site, or are expected to occur.

BIOLOGICAL RESOURCE EVALUATION

REGIONAL EVALUATION

The site lies in the City of Arvin, a small municipality surrounded on all sides by miles of rich agricultural lands that have been under active cultivation for many decades. The site is approximately six miles west of the lower slopes of the Tehachapi Mountains, where isolated patches of native vegetation, and native wildlife habitat, may persist despite the long history of

livestock grazing in these mountains. The site is approximately 20 miles northwest of Tehachapi Mountain Park, a 5,000-acre county park offering hiking, nature awareness, camping, and equestrian activity. This is the nearest dedicated open space. The site is approximately 29 miles southwest of the nearest segment of the Sequoia National Forest.

LOCAL ISSUES

For potential sensitive fauna and flora occurrence on the site refer to Appendix 1 & 2. None of these are expected to occur because of absence of suitable habitat coupled with severe disturbance at the site. The nearest occurrence of the Burrowing Owl (*Athene cunicularia*) was last reported to the CNDDB in 1990, at 2.8 miles east-southeast of Arvin in heavily-grazed grassland. The nearest occurrence of the Blunt-nosed Leopard Lizard (*Gambelia sila*) was reported in 1935, five miles east of Arvin. Information on the last reported occurrence of the San Joaquin Kit Fox (*Vulpes macrotis mutica*) is non-specific.

There are no known local wildlife/biological issues with any relevance to this site. There are no potential biological resource problem areas related to this site or within the region. Issues related to any mitigation of the chemical/superfund status of the site are not addressed here.

RECOMMENDATIONS

It is Pacific Southwest's understanding that there are no proposed plans to alter, demolish, or remove the existing structures on the site, or to further develop the property. In view of the absence of sensitive biological resources on the site or nearby, no recommendations are offered to interfere with this course of inaction.

Should you have any questions regarding this letter or the field survey, please do not hesitate to call me or Mr. Bouscaren at 619-477-5333.

Regards,

Cornelius W Bouscaren

for

R. Mitchel Beauchamp, M. Sc., President
Pacific Southwest Biological Services, Inc.

Appendix 1. Flora Reported from CNDDB Arvin, CA Quadrangle

SPECIES NAME	STATUS Federal/State/CNPS	HABITAT REQUIREMENTS	PROBABILITY OF OCCURRENCE
Eschscholzia lemmonii ssp. *kernensis* Tejon Poppy	FSC/None/1B (3-3-3)	Chenopod scrub, valley and foothill grassland. Endemic to Kern Co. Little information available on habitat, 160-1000 m.	Low. No habitat
Layia leucopappa Comanche Point Layia	FSC/None/1B (3-3-3)	Chenopod scrub, valley and foothill grassland. Endemic to Kern Co. Dry hills in white-gray clay soils, often with weedy grasses, 100-350 m.	Low. No habitat
Opuntia basilaris var. *treleasei* Bakersfield Cactus	FE/CE/1B (3-3-3)	Chenopod scrub, valley and foothill grassland, cismontane woodland. Endemic to Kern Co. Coarse or cobbly well-drained granitic sand on bluffs, low hills, and flats within grassland, 90-550 m.	Low. No habitat

Appendix 2. Fauna Reported from CNDDB Arvin, CA Quadrangle

SPECIES NAME	STATUS Federal/State/CDFG	HABITAT REQUIREMENTS	PROBABILITY OF OCCURRENCE
Blunt-nosed Leopard Lizard *Gambelia sila*	FE/CE/None	Resident of sparsely vegetated alkali and desert scrub habitats, in areas of low topographic relief. Seeks cover in mammal burrows, under shrubs or structures such as fence posts; does not excavate own burrow.	Low. No habitat
Burrowing Owl (*Athene [Speotyto] cunicularia*) (burrow sites)	FSC/None/None	Open dry annual or perennial grasslands, desrt and scrublands w/low growing vegetation, uses ground squirrel burrows for nesting	Low. No habitat
San Joaquin Kit Fox *Vulpes macrotis mutica*	FE/CT/None	Annual grasslands or grassy open stages of scrubland with scattered shrubby vegetation. Needs loose-textured sandy soils for burrowing, and suitable prey base.	Low. No habitat

DEFINITIONS OF SENSITIVITY RATINGS

California Native Plant Society (CNPS)

List Status

List 1A	Plants presumed extinct in California. CEQA consideration mandatory
List 1B	Plants rare, threatened, or endangered in California and elsewhere. CEQA consideration mandatory
List 2	Plants rare, threatened, or endangered in California, but more common elsewhere. CEQA consideration mandatory
List 3	Plants about which we need more information - a review list. CEQA consideration strongly recommended
List 4	Plants of limited distribution - a watch list. CEQA consideration strongly recommended

CNPS R-E-D Code

R (Rarity)

1	Rare, but found in sufficient numbers and distributed widely enough that the potential for extinction is low at this time
2	Distributed in a limited number of occurrences, occasionally more if each occurrence is small
3	Distributed in one to several highly restricted occurrences, or present in such small numbers that it is seldom reported

E (Endangerment)

1	Not endangered
2	Endangered in a portion of its range
3	Endangered throughout its range

D (Distribution)

1	More or less widespread outside California
2	Rare outside California
3	Endemic to California

State-Listed/Designated Plants and Animals

CE	State-listed, endangered
CT	State-listed, threatened
CR	State-listed, rare
CC	Candidate for State listing
CSC	California Special Concern Species (Department of Fish and Game)

Federally-Listed/Designated Plants and Animals

FE	Federally-listed, endangered
FT	Federally-listed, threatened
PE	Federally-proposed, endangered
PT	Federally-proposed, threatened
FC	Candidate for Federal listing
FSC	Federal Special Concern Species
C2*	Threat and/or distribution data are insufficient to support federal listing, but the plant is presumed extinct
C3c	Too widespread and/or not threatened

Multiple Species Conservation Program Covered Species List

yes	Covered
no	Not covered

Figure 1. Project Vicinity - Brown & Bryant Superfund Site ✪

N

Pacific Southwest Biological Services, Inc.

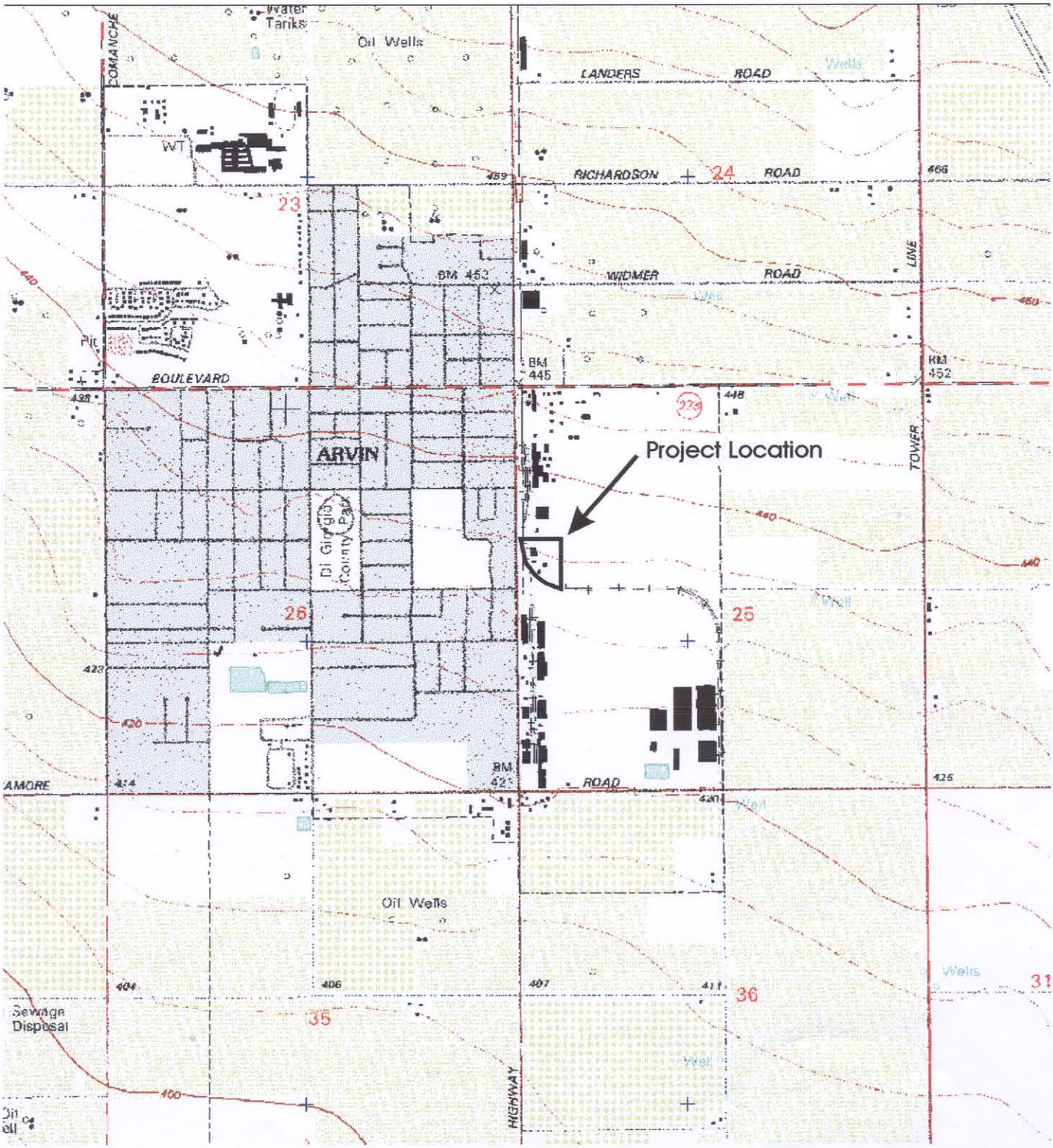


Figure 2. Project Location
USGS 7.5' Arvin, CA Quadrangle

N

1" = 2,000'

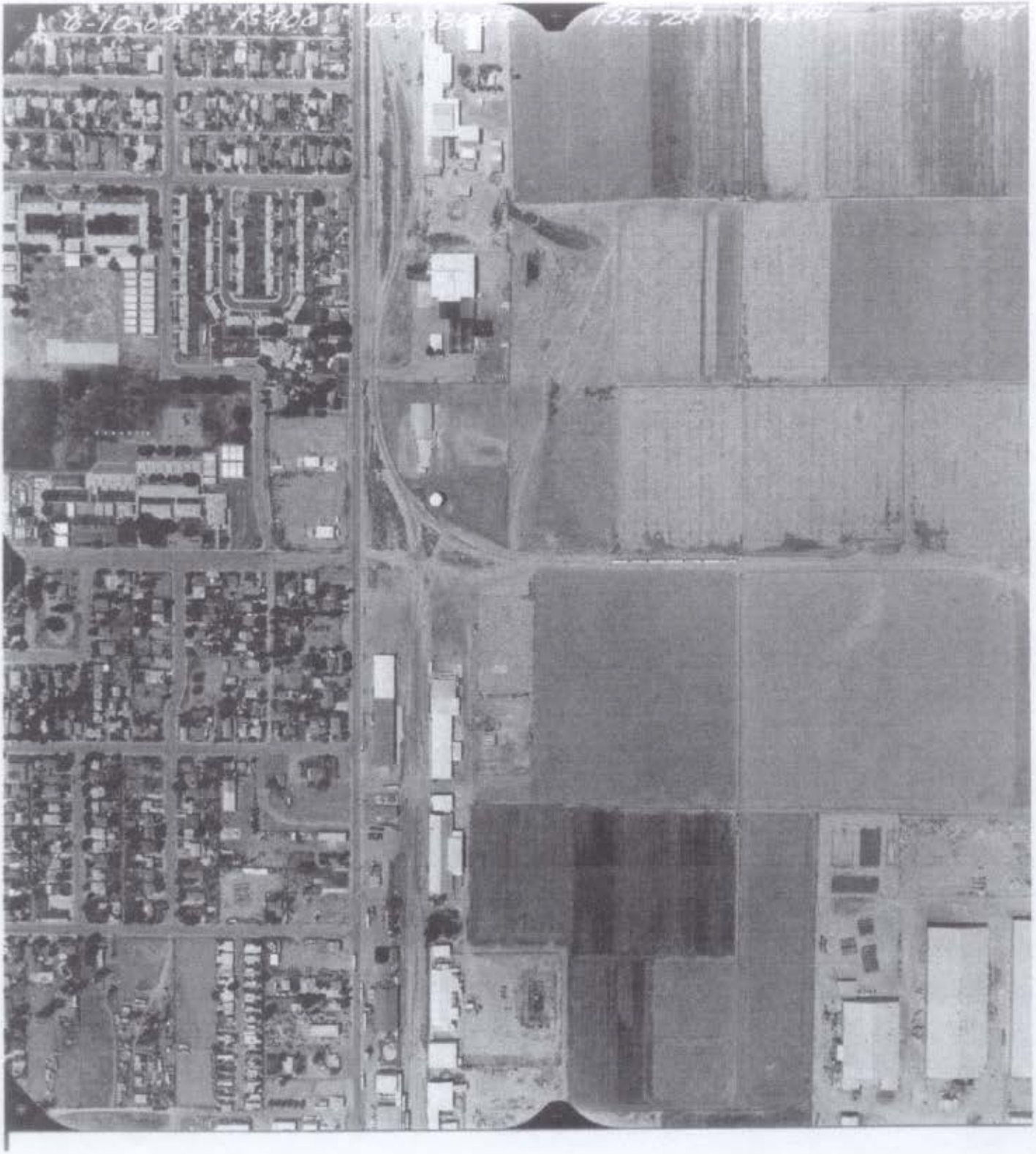


Figure 3. Brown & Bryant Superfund Site
Aerial Photo - 1"=400'

N

Figure 4. Brown & Bryant Superfund Site
Aerial Photo - 1"=180'

N

Appendix I-E

Toxicity Profiles

Project No. C00-266.2 September 2005

Toxicity Profiles

Toxicity profiles are available in the attached CD.