

Explanation

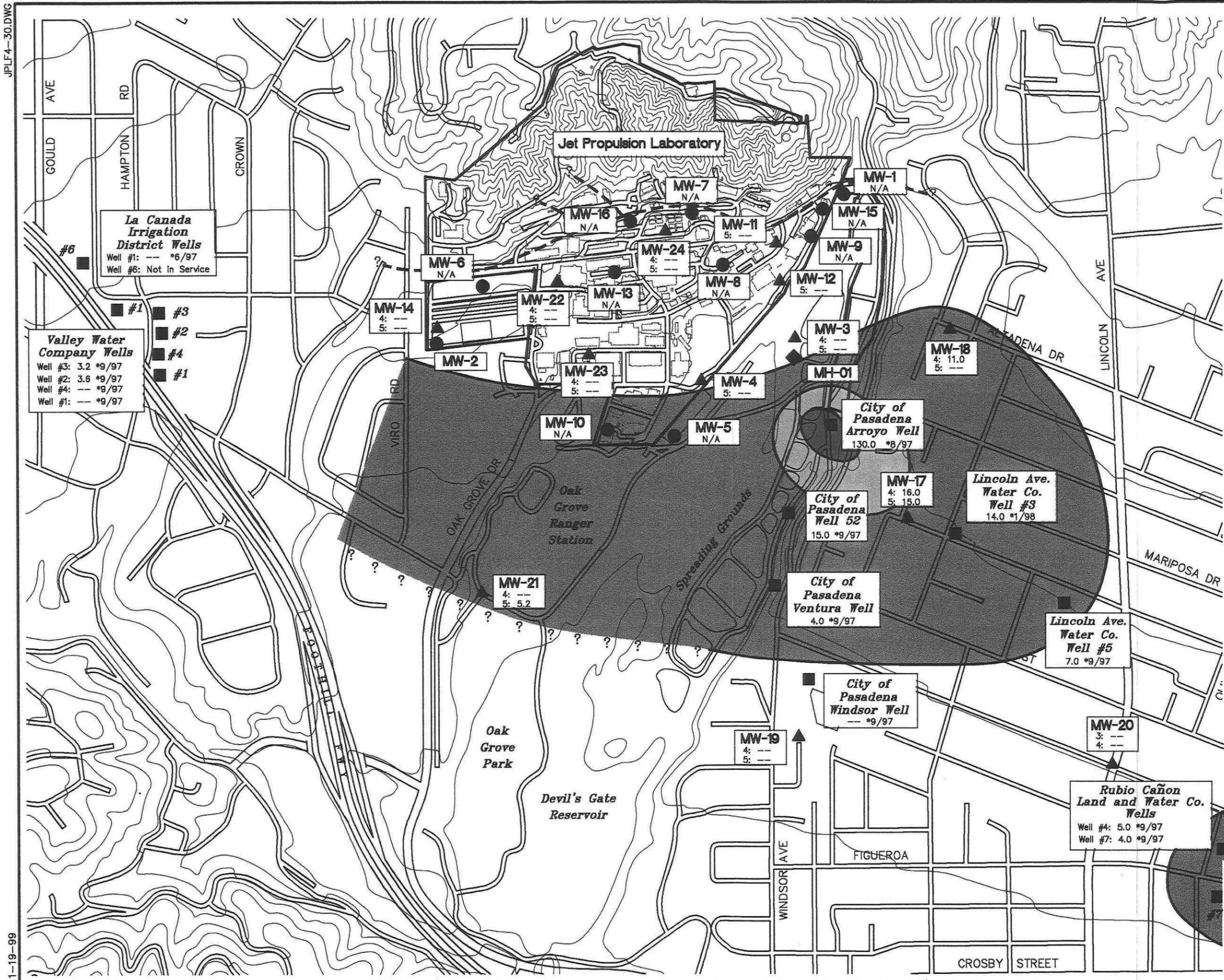
- JPL Shallow Monitoring Wells
- ▲ JPL Deep Multi-Port Monitoring Wells
- Municipal Production Wells
- ◆ City of Pasadena Monitoring Well
- 2: Screen Number for Wells in this Aquifer Layer
- Not Detected
- N/A Not Applicable (< 4.0 µg/L)
- *6/97 Date Represents Nearest Sampling Event with Respect to JPL Sampling Round.
- JPL Thrust Fault
- JPL Property Line
- Concentrations Between Detection Limit (4.0 µg/L) and IAL (18.0 µg/L)
- Concentrations 18.0 to 100.0 µg/L
- Concentrations 100.0 to 500.0 µg/L

Note: Distinctions between concentration (color) contours may become less clear in black and white photocopies. Refer to the original color figure for best resolution.

800 400 0 800
SCALE IN FEET

Source: USGS, 7.5 Minute Topographic Map Pasadena, CA 1966, Revised 1988, 1994.

FIGURE 4-30
**PERCHLORATE
AQUIFER LAYER 2**
January - February 1998
Jet Propulsion Laboratory
Pasadena, California
FOSTER WHEELER ENVIRONMENTAL
CORPORATION



Explanation

- JPL Shallow Monitoring Wells
- ▲ JPL Deep Multi-Port Monitoring Wells
- Municipal Production Wells
- ◆ City of Pasadena Monitoring Well
- 4: Screen Number for Wells in this Aquifer Layer
- Not Detected (< 4.0 µg/L)
- N/A Not Applicable
- *6/97 Date Represents Nearest Sampling Event with Respect to JPL Sampling Round.
- JPL Thrust Fault
- JPL Property Line
- Concentrations Between Detection Limit (4.0 µg/L) and IAL (18.0 µg/L)
- Concentrations 18.0 to 100.0 µg/L
- Concentrations 100.0 to 500.0 µg/L

Note: Distinctions between concentration (color) contours may become less clear in black and white photocopies. Refer to the original color figure for best resolution.

N

800 400 0 800

SCALE IN FEET

Source: USGS, 7.5 Minute Topographic Map Pasadena, CA 1988, Revised 1988, 1994.

La Canada Irrigation District Wells
 Well #1: --- *6/97
 Well #6: Not in Service

Valley Water Company Wells
 Well #3: 3.2 *9/97
 Well #2: 3.6 *9/97
 Well #4: --- *9/97
 Well #1: --- *9/97

#6
 #1
 #3
 #2
 #4
 #1

MW-6
 N/A

MW-22
 4: ---
 5: ---

MW-13
 N/A

MW-24
 4: ---
 5: ---

MW-8
 N/A

MW-12
 5: ---

MW-9
 N/A

MW-3
 4: ---
 5: ---

MW-18
 4: 11.0
 5: ---

MW-2
 N/A

MW-10
 N/A

MW-5
 N/A

City of Pasadena Arroyo Well
 130.0 *8/97

City of Pasadena Well 52
 15.0 *9/97

Lincoln Ave. Water Co. Well #3
 14.0 *1/98

City of Pasadena Ventura Well
 4.0 *9/97

Lincoln Ave. Water Co. Well #5
 7.0 *9/97

City of Pasadena Windsor Well
 --- *9/97

MW-19
 4: ---
 5: ---

MW-20
 3: ---
 4: ---

Rubio Cañon Land and Water Co. Wells
 Well #4: 5.0 *9/97
 Well #7: 4.0 *9/97

Las Flores Water Co. Well #2
 7.0 *9/97

FIGURE 4-31
PERCHLORATE
AQUIFER LAYER 3
 January - February 1998
 Jet Propulsion Laboratory
 Pasadena, California
 FOSTER WHEELER ENVIRONMENTAL CORPORATION

5.0 CONTAMINANT FATE AND TRANSPORT

The fate and transport characteristics of the primary constituents identified in the groundwater above drinking water standards during the RI (Section 4.0) are described in this section. These constituents include three VOCs [carbon tetrachloride (CCl_4), trichloroethene (TCE), and 1,2-dichloroethane (1,2-DCA)], and a non-volatile oxyanion, perchlorate (ClO_4^-), all of which have been detected at concentrations exceeding their respective regulatory limits. Both total chromium (Cr) and hexavalent chromium [Cr(VI)] have also been detected within the study area and are included in this discussion. Total Cr concentrations have exceeded state MCLs in a few cases, and MCLs for Cr(VI) presently do not exist. An additional VOC, tetrachloroethene (PCE) has not been detected above state or Federal MCLs in JPL monitoring wells during the RI, but has been included in this analysis.

The purpose of this section is to provide an understanding of the factors controlling the environmental fate and transport of contaminants in OU-1 and OU-3 (on-site and off-site groundwater, respectively) at JPL, and thereby determine the potential for further migration to be used in assessment of the potential risk of current and future exposure to these compounds in the groundwater. This section is organized into five parts as follows:

- Section 5.1 – potential contaminant sources and migration at JPL.
- Section 5.2 – physical and chemical characteristics of groundwater contaminants relevant to environmental fate and transport
- Section 5.3 – fate and transport processes most likely to be present at JPL based on site history, site physical characteristics, and the nature and extent of contamination.
- Section 5.4 – rationale, methodology and results of fate and transport modeling of CCl_4 , TCE and ClO_4^- in groundwater at JPL.
- Section 5.5 – general conclusions.

5.1 POTENTIAL SOURCES AND MIGRATION PATHWAYS

As summarized in Section 1.3, past research and development activities at JPL have led to apparent discharge of various liquid materials into seepage pits (or cesspools), which were associated with many buildings at JPL. The seepage pits were designed to allow liquid wastes to seep into the surrounding soil. Although this method of waste disposal was discontinued long ago (the 1950s), some of the seepage pits apparently received volatile organic compounds (VOCs) and other materials, which has resulted in varying degrees of soil and groundwater contamination. This has led to migration and redistribution of contaminants in on- and off-site groundwater due to complex local groundwater flow patterns. A summary of the potential migration pathways and fate and transport processes operating at JPL is provided in Figure 5-1.

As indicated by Figure 5-1, contaminants apparently discharged to the seepage pits at JPL entered the soil through infiltration and percolation. Data from the JPL soil RI (OU-2) confirm that over time, VOCs migrated downward into deeper portions of the vadose zone, and were detected in soil-vapor samples collected from depths extending to the water table in the north-central portion of JPL (see Section 4.3 for a brief summary of the results of the OU-2 RI, and refer to the OU-2 RI report [Foster Wheeler, 1999] for complete details). The downward migration of contaminants was most likely facilitated by infiltration events, which included transport of a soluble phase, as well as migration of VOCs in soil-gas. JPL soils consist predominantly of medium- to coarse-grained sand and gravel interbedded with some fine sand and silt (see Section 3.3), and percolation through these types of soils is generally considered to be rapid.

Data from the OU-1/OU-3 RI indicate that contaminants, consisting primarily of a few VOCs and perchlorate, have infiltrated to the groundwater. Further, contaminants dissolved in on-site groundwater have migrated off-site due primarily to advection and dispersion processes. A portion of dissolved contaminants may also remain adsorbed to aquifer solids, or volatilize to soil-gas (VOCs).

With regard to future migration of contaminants in groundwater, the data collected during the RI has led to several general conclusions. First, the City of Pasadena municipal production wells, which are located immediately down-gradient of JPL, are known to strongly influence groundwater flow patterns beneath JPL. This has apparently enhanced downward migration of contaminants into the deeper portions of the aquifer along the eastern edge of JPL (see Section 4.2.1), and inhibited further horizontal downgradient contaminant migration. Secondly, analysis of temporal trends in JPL plume wells has suggested that contaminant concentrations are stable or decreasing, and there is no evidence that plume boundaries are increasing. The RI data suggests that if the City of Pasadena and other nearby municipal production wells continue operating as they have, groundwater contaminants will continue to be drawn downward from JPL into the deeper portions of the aquifer and further horizontal downgradient migration will be inhibited.

5.2 CONTAMINANT CHARACTERISTICS AND BEHAVIOR

The primary contaminants identified in the JPL groundwater (Section 4.0) include select VOCs, total and hexavalent Cr, and ClO_4^- . Discussed in this section are the properties of each contaminant listed with respect to potential behavior in groundwater.

The chemical and physical properties of a compound or element (Table 5-1) can be used to predict its propensity to partition between environmental phases. For example, partitioning of a particular VOC between water, air, and soil can be estimated using the VOC's aqueous solubility value (water), Henry's Law constant (K_H) and vapor pressure (air), and its organic carbon partition coefficient (K_{OC}) [which can be estimated by measuring its octanol-water partition coefficient (K_{OW})] (soil). The aqueous solubility value gives the maximum amount (mass) of a

chemical that is soluble within a given volume of water. Compounds with solubility values less than 1 mg/L are generally considered insoluble in water, while compounds with values greater than 10,000 mg/L are considered highly soluble. The vapor pressure of a chemical is a measure of the chemical's tendency to volatilize. Vapor pressures greater than 1 millimeter of mercury (mm Hg) indicate volatility, whereas chemicals with vapor pressures ranging from 1 to 0.001 mm Hg are considered semi-volatile, and those with vapor pressures less than 0.001 mm Hg are considered nonvolatile. It is noted that the classification of volatility by vapor pressure does not necessarily correspond to the laboratory classification of compounds as either volatile or semi-volatile (base-neutral-acid extractable) target analyses. The specific Henry's Law constant for a given compound provides a measure of the tendency of that compound to volatilize from an aqueous solution. For volatile compounds, higher values of Henry's Law constants are associated with an increased volatilization from water. Chemicals that are readily volatilized from groundwater or surface water have constants exceeding 10^{-3} atmosphere-cubic meters/mole ($\text{atm}\cdot\text{m}^3/\text{mol}$), whereas compounds with low volatility have constants less than 10^{-7} $\text{atm}\cdot\text{m}^3/\text{mol}$.

The single most important characteristic for estimating adsorption of an organic contaminant by a soil is the soil's organic carbon (C) content. The K_{OW} defines the propensity of a compound to partition into octanol in an octanol/water system. Since octanol is considered to represent the sorptive properties of soil organic matter, the K_{OW} can provide an estimate of the tendency for a chemical to sorb to soil organic matter. The greater the value of K_{OW} , [generally expressed as $\text{Log}(K_{OW})$], the greater the tendency for adsorption. Compounds with $\text{Log}(K_{OW})$ values generally greater than 3, are preferentially sorbed into the soil phase in soil/water systems. Compounds with $\text{Log}(K_{OW})$ values less than 1 are considered to weakly partition into the soil phase, and values between 1 to 3 denote moderate affinity for the soil phase. Of course, actual partitioning of VOCs into the soil phase will be highly dependent on the organic carbon content of the soil. The following discussions describe relevant environmental characteristics of CCl_4 , TCE, PCE, 1,2-DCA, Cr, and ClO_4^- .

5.2.1 Volatile Organic Compounds

Relevant physical and chemical properties of CCl_4 , TCE, PCE, and 1,2-DCA are listed in Table 5-1. With reference to Table 5-1 and the above discussion (Section 5.2), these compounds can be classified as volatile, moderately soluble in water, and moderately adsorbing to soil organic carbon. Their high vapor pressures and moderate to high Henry's Law constants suggest that volatilization of these compounds from solution can readily occur. Moderate $\text{Log}(K_{OW})$ values indicate that partitioning of these compounds into soil organic carbon would likely have an impact on contaminant retardation if soil organic matter were present. In aquifers where organic carbon is not prevalent and coarser-grained materials (such as sands and gravels) are encountered, retardation will be diminished and the migration of contaminants will occur more readily.

With regard to degradation, VOCs in groundwater are typically not subject to hydrolytic reactions, however, halogenated VOCs can be degraded biologically via several mechanisms under both aerobic and anaerobic conditions as follows:

Oxidation

Oxidation of organic compounds by bacteria is the means by which heterotrophic organisms acquire energy for growth. This process occurs under aerobic conditions, with oxygen serving as the terminal electron acceptor, as well as anaerobically, with oxyanions such as nitrate (or various metals or organic compounds) serving as alternate terminal electron acceptors. Oxidation of PCE and TCE as energy sources is generally not believed to occur, but the lesser chlorinated compounds are subject to aerobic bacterial oxidation reactions.

Co-metabolism

This is a process whereby organisms fortuitously degrade a non-growth substrate while growing on a structurally similar substrate. There is no energy derived from the co-metabolized compound, and no known benefit to the organism. The process is believed to occur as a result of enzymes with loose substrate specificity. The best documented example of this process is the fortuitous degradation of TCE by methane-oxidizing organisms (while growing on methane) under aerobic conditions.

Reductive dechlorination

Bacteria (and other organisms) generate energy needed to carry out their metabolic functions through a process known as respiration. This process involves the transfer of electrons from an electron donor (energy source) to a terminal electron acceptor. Typical energy sources can include organic compounds such as natural soil organic matter, or fuel hydrocarbons. In aerobic environments, oxygen is the preferred electron acceptor, but in anaerobic environments, other compounds (including VOCs such as TCE and PCE) can serve as terminal electron acceptors.

Reductive dechlorination is a process whereby a chlorinated organic compound takes the place of oxygen as the terminal electron acceptor during anaerobic respiration (not as a source of organic carbon). In this process, chlorine (Cl) atoms are removed from the parent compound (thus destroying it) and less chlorinated metabolites and the chloride ion (Cl⁻) are formed. In general, reductive dechlorination proceeds sequentially, for example: from PCE, yielding TCE, then dichloroethene, etc. Depending on environmental conditions, PCE and TCE degradation may yield a variety of dichloroethene isomers, as well as several dichloroethanes.

5.2.2 Chromium

Chromium is a transition metal having the atomic number 24 and an atomic weight of 52. It is found in nature in two oxidation states: the trivalent state, Cr(III), and the hexavalent state, Cr(VI). The trivalent form is most common, occurring in a variety of forms, including several

primary and secondary minerals, and various oxides and hydroxides such as chromium hydroxide [Cr(OH)₃].

When released to the environment by weathering, Cr(III) is readily adsorbed by clay-sized particles, organic matter, and oxyhydroxides of iron (Fe) and manganese (Mn). Under normal environmental conditions (pH 5 to 9), Cr(III) is highly insoluble, forming oxide and hydroxide precipitates. At a pH of less than 5, Cr(III) is stable as the chromic ion, and at an alkaline pH, it forms a soluble complex, Cr(OH)₄⁻_(aq). Cr(III) is also known to form soluble complexes with various organic compounds. Consequently, Cr(III) is generally only mobile under very acidic or very alkaline conditions, or in the presence of suitable organic compounds at high enough concentrations. Cr(III) may be naturally oxidized to the hexavalent form by dissolved oxygen, but the reaction is very slow, even under highly oxidizing conditions. Oxidation of Cr(III) has also been shown to occur in soils in the presence of Mn(IV).

While Cr(VI) occurs in nature, it is unstable relative to the trivalent form unless conditions are highly oxidizing, or unless it occurs as a constituent of primary igneous minerals. When released to the environment, hexavalent chromium occurs as an oxyanion over the entire pH range, under oxidizing conditions. As a result, it is very soluble in water and highly mobile. Hexavalent chromium is readily reduced to the trivalent form by several mechanisms including bacterial reduction (in the presence of a suitable organic carbon source), or a biotic reduction by ferrous iron or hydrogen sulfide. The abundance of iron in most soil may provide a natural source for the conversion of Cr(VI) to Cr(III). Adsorption of Cr(VI) in soil/water systems is not well documented, but may be most significant in low pH conditions when the surface charge of clays and oxyhydroxides tends to be more positive (Moore and Ramamoorthy, 1984; Losi, et al., 1994).

5.2.3 Perchlorate

Perchlorate (ClO₄⁻) is a chloro-oxyanion containing Cl in its most oxidized form [Cl(VII)]. When combined with monovalent alkali metal ions (Na⁺ or K⁺) or ammonium (NH₄⁺), it occurs as a salt in the solid phase. These salts are very soluble in water, and while ClO₄⁻ is a powerful oxidizing agent when heated, at room temperature (characteristic of groundwater), aqueous solutions of ClO₄⁻ are not notable oxidizers and are extremely stable (Greenwood and Earnshaw, 1985).

Because it has only recently been identified as an environmental contaminant, very little data are available regarding behavior of ClO₄⁻ in environmental matrices. However because it is very soluble in water, is stable at common groundwater temperatures, and is negatively charged, it can be considered mobile in typical soil/water systems.

5.3 CONTAMINANT MIGRATION AT JPL

Based on site conditions, and contaminant types and distribution, it appears that only a limited number of the fate and transport mechanisms illustrated in Figure 5-1 are considered significant enough to cause further migration and redistribution of contaminants in JPL groundwater.

Groundwater flow is the principal contaminant fate and transport mechanism at JPL, which has led to the migration of VOCs, and ClO_4^- from upgradient sources to downgradient locations. Infiltration from precipitation events may have led to the on-site groundwater contamination, with natural and induced groundwater flow leading to off-site contaminant migration. However, the RI data suggest that contamination migration beyond the City of Pasadena municipal production wells is minimal (see Section 4.0), and therefore, operation of these production wells appears to be, and to have been, an effective barrier to extensive downgradient plume migration.

Migration of Cr by advective flow in groundwater is possible. However, significant off-site migration of Cr is not indicated by the RI data (see Section 4.2). In light of the relative insolubility and immobility of Cr(III), as well as potential natural attenuative mechanisms that affect Cr(VI) (which have not been confirmed at JPL), advection is probably not a significant transport mechanism for Cr at JPL.

The following sections present a summary of the likely contaminant transport processes at JPL, and how these processes may have affected contaminant distribution. A general discussion of on-site and off-site groundwater is presented below.

5.3.1 Volatile Organic Compounds

VOCs found in JPL groundwater were apparently originally released to soil via seepage pits, where they infiltrated into the soil, and eventually migrated to groundwater. Moderate $\text{Log}(K_{ow})$ values for the VOCs present in the groundwater suggest a generally moderate affinity for soil organic carbon. The aquifer material underlying the JPL site and surrounding area is composed predominantly of poorly graded medium- to coarse-grained sands and gravels with interbedded silt-rich zones likely deposited in relatively high energy alluvial fan and stream channel type environments. The relatively high energy depositional environment of these poorly graded sands would tend to preclude the deposition of significant amounts of organic carbon. Therefore, it is likely that retardation factors for VOC migration would be low in the JPL aquifer. However, retardation may occur due to contaminant adsorption to the finer-grained aquifer materials such as the interbedded silt-rich intervals.

Solubilized VOCs in groundwater can potentially volatilize into the unsaturated zone. The moderate to high Henry's Law constants for the VOCs detected in JPL groundwater suggest that volatilization from groundwater and soil may be an important process. However, VOCs at the groundwater/vadose zone interface at JPL occur only at a relatively small area on-site before downward vertical migration into the groundwater becomes significant (see Section 4.0). VOCs volatilizing from the groundwater into the soil is not an issue with off-site groundwater due to the depth of contamination in the groundwater and the relatively low VOC concentrations.

With regard to bio-processes, 1,2-DCA was not commonly used as a solvent, and its presence in conjunction with TCE in the JPL groundwater may be indicative of biodegradation. Since low dissolved oxygen levels are common under saturated conditions, reductive dechlorination is a

likely mechanism. The small amount of 1,2-DCA present, and the absence of more reduced metabolites probably indicates that a suitable energy source (such as carbon) is limiting.

5.3.2 Chromium

In the absence of extremes in pH and appreciable amounts of organic carbon, Cr(III) is largely insoluble in groundwater and, therefore, is relatively immobile due to physical interactions with fine-grained minerals in the aquifer matrix that can retard its movement relative to groundwater flow. Adsorption and precipitation reactions may also limit transport of Cr(III) in groundwater. Cr(VI) is considered more mobile, but can undergo biotic and/or abiotic reduction to the trivalent form in the presence of common soil constituents such as organic matter or ferrous iron.

Total and hexavalent Cr have only been consistently detected in a few on-site JPL monitoring wells, and have rarely been detected in off-site monitoring wells (see Section 4.2). These detections have been at very low levels. Concentrations have decreased or remained relatively constant over the RI period, and no direct evidence of significant Cr migration was found. It is possible that natural attenuation mechanisms may be operating in the JPL aquifer, however, these mechanisms have not been confirmed at JPL.

5.3.3 Perchlorate

Perchlorate (ClO_4^-) has been detected in JPL monitoring wells at the north-central part of the site (primarily MW-7 and MW-16). Data regarding chemical properties of ClO_4^- suggest that it is stable and mobile in soil/water systems. This is supported by available data from the JPL RI, which shows that off-site migration has occurred. However, because actual environmental behavior of ClO_4^- is not well documented, and also because of an apparent other source of ClO_4^- (see Section 4.3), the fate and transport parameters are difficult to define. However, the available RI data suggests that, as with the VOCs, migration of ClO_4^- appears largely constrained by the pumping of the City of Pasadena municipal production wells (Section 4.0).

5.4 GROUNDWATER FATE AND TRANSPORT MODELING

With the considerable data collected during the OU-1/OU-3 RI, the fate and transport of constituents of concern are generally well known. Data have shown that VOC plume sizes generally appear not to be increasing over time, and that VOC and Cr concentrations in JPL monitoring wells are generally stable (data for ClO_4^- has not been collected long enough to establish reliable trends). This is largely attributed to pumping by the City of Pasadena municipal production wells, which strongly affects groundwater flow patterns around JPL (Section 3.4.3), and inhibits downgradient contaminant migration. Furthermore, because natural groundwater gradients (with no municipal wells pumping) to the east and southeast are relatively small, it is believed that pumping by the City of Pasadena production wells has accelerated off-site contaminant migration into the vicinity of the production wells. Over the RI period, the City of Pasadena production wells were estimated to have operated for approximately 90% of the time (Figure 3-19). Based on the RI data, it is reasonable to assume that if the City of Pasadena

production wells continue operating as they have historically, contaminant concentrations in the vicinity of these wells will most likely remain relatively constant, and downgradient contaminant migration beyond these wells will be inhibited. However, if in the future the City of Pasadena and other nearby production wells are shut down for an extended period of time (several years for example), the effects on further downgradient contaminant migration are unknown.

To investigate this scenario, the transport of CCl_4 , TCE, and ClO_4^- in groundwater at JPL under conditions where the City of Pasadena and other nearby production wells were not operating for an extended period of time (50 years) was simulated using the analytical contaminant transport model SOLUTE (Version 4.04). SOLUTE provides estimates of conservative solute transport in saturated groundwater systems and is featured in EPA's "Compilation of Ground-Water Models" (EPA, 1993a). The following sections discuss the model and results of the modeling exercise.

5.4.1 Methodology

Model Features

For modeling the transport of contaminants, SOLUTE permits the user to choose among one-, two-, or three-dimensional algorithms for the saturated zone, and can simulate one-dimensional groundwater flow and contaminant transport for constituents introduced into the system either instantaneously or continuously (Beljin and van der Heijde, 1997).

The following general assumptions are built into the model regarding aquifer conditions and contaminants:

- Aquifer material is uniformly porous.
- Aquifer material is homogeneous with respect to the transport parameters.
- Flow is uniform where there is a constant flux in direction and magnitude away from the source.
- Density and viscosity of fluid are constant in time, and independent of contaminant concentration.
- Mass exchange does not occur between the porous media within the plume and the surrounding area.

Approach

Complex groundwater flow patterns due to variable pumping of the City of Pasadena (and other) municipal production wells near the JPL site (Figures 3-20 to 3-32), present considerable problems with regard to modeling contaminant transport in groundwater beneath the site and surrounding area. However, with the extensive amount of RI data collected over the last 5 years, the fate and transport of the constituents of concern are generally well known. Concentrations of constituents of concern are generally stable. Therefore, fate and transport modeling for this report can be considered a scoping level assessment focused on a scenario where CCl_4 , TCE and ClO_4^-

could migrate further downgradient, beyond their currently known limits of extent, with natural groundwater gradients typical during periods when the City of Pasadena and other municipal pumping wells are not operating. RI data suggests that when nearby municipal wells are pumping, downgradient contaminant migration is inhibited. The source location for this scenario of contaminant migration modeling was chosen as MW-17, Aquifer Layer 2, because CCl_4 , TCE and ClO_4^- have consistently been detected there above drinking water standards (for references to monitoring well locations, see Figure 2-1). If the City of Pasadena and other production wells were to be shut down for an extended period of time, contaminant migration from MW-17, Aquifer Layer 2, would be of potential concern. The contaminant path from MW-17 to MW-20 was selected for the model simulations because MW-20 is downgradient from MW-17 under natural flow conditions and there are no known physical constraints between these two points, and, therefore, it will provide an appropriate estimate of off-site migration.

This scenario of groundwater flow and potential contaminant migration at JPL was modeled using the one-dimensional contaminant transport model SOLUTE. One-dimensional models provide very conservative solute-transport results. The three-dimensional groundwater flow model developed for the JPL aquifer (see Section 1.3.3.19) was constructed to predict physical aquifer characteristics only, such as flow directions and gradients, to be used evaluating a variety of potential pump and treat remedial scenarios, and was not prepared to simulate contaminant transport. The JPL three-dimensional groundwater flow model will be an important tool for the OU-1/OU-3 Feasibility Study.

Although CCl_4 and TCE levels are generally stable or slightly decreasing in JPL monitoring wells located within the plumes (ClO_4^- concentration trends are not yet reliably known) the model simulations assumed continuous releases for all three contaminants for 20 years. Twenty years was chosen making the very conservative assumption that it would take 20 years to effectively see positive results from soil and potential on-site groundwater remedial activities.

One modeling run was carried out for each of the three constituents of concern listed above. In these runs, source concentrations and several input parameters were based on site information or, when site information was not available, on literature values, which were considered to be more conservative than actual site conditions. The conditions selected for the model are summarized on Table 5-2. All input parameters are discussed further below.

5.4.2 Input Parameters and Assumptions

The model is based on calculating contaminant migration as a function of physical parameters such as groundwater velocity and dispersivity, as well as chemical factors controlling migration, such as contaminant retardation and degradation. SOLUTE requires the user to provide input parameters into a menu-driven system, which includes three sections: hydrogeologic information, contaminant point source information, and dimensional components. A summary of the hydrogeologic and contaminant source input parameters is provided in Table 5-2. For parameters listed in Table 5-2, measured or known values are given where site-specific data were available,

and in the absence of such data, conservative assumptions were made based on general site information, or literature or default values (Beljin and van der Heijde, 1997).

The groundwater velocity used (0.15 ft/day) is based on the estimated porosity used (20 percent), an observed groundwater gradient in Aquifer Layer 2 when the City of Pasadena and other production wells were not operating (Figure 3-24), and the average hydraulic conductivity values estimated from aquifer tests conducted on Layer 2 well screens (Table 3-4). The groundwater gradient was not varied during the modeling runs reflecting constant groundwater recharge. Porosity relates the amount of void space per total volume of material, and was very conservatively estimated at 20% based on site-specific soil-type information. The retardation factor is an estimate of the amount of retardation for a migrating constituent due to parameters such as adsorption and tortuosity. Even though constituent retardation will occur to some extent, an unrealistically conservative retardation factor of 1.0, which represents a case where there is no retardation, was used. Longitudinal dispersivity is the spreading of a solute in the direction of groundwater flow and is measured as a function of the composition and heterogeneity of aquifer materials. Dispersion accounts for a decrease in the concentration of a contaminant at the end of a contaminant plume downgradient from a source where some water molecules and solute particles travel faster than the average groundwater flow velocity. Longitudinal dispersivity was estimated at 500 feet, based on published values for areas with similar lithologies (Beljin and van der Heijde, 1997).

As mentioned above, for all model simulations one contaminant source was used (MW-17, Aquifer Layer 2), and the initial aquifer concentration (the concentration at MW-20) was assumed to be 0 $\mu\text{g/l}$ (none of the constituents were detected in Aquifer Layer 2 at MW-20 during the RI). The duration of the release of each contaminant (solute pulse) was assumed to be 20 years. This estimate is conservative, since as mentioned, remediation activities are expected to have an impact (reducing concentrations) over the next 20 years. The "aquifer half-life", which describes the propensity of a compound to degrade or decay, was assumed to be 0 for all runs (a conservative estimate). Thus, contaminant degradation was not a factor in the simulations. This is the most conservative assumption regarding decay and degradation.

Dimensional components are required for the model to calculate the time necessary for constituent concentrations to reach a specified level at a specified distance along the flow path (plume migration distance). The plume migration distance was equal to the length of the flow path from the contaminant source point (MW-17) to the point of interest located downgradient (MW-20). This covered a distance of approximately 3,000-ft. The actual model runs consisted of calculating the potential time it would take for the constituents released at MW-17 to reach their respective regulatory limits (0.5, 5.0, and 18 $\mu\text{g/l}$, respectively, for CCl_4 , TCE and ClO_4^-) in MW-20.

5.4.3 Modeling Results

Initial contaminant concentrations and results of the model runs for CCl_4 , TCE, and ClO_4^- are summarized in Table 5-3. The simulations have predicted that with an initial CCl_4 concentration of 6.6 $\mu\text{g/l}$ (maximum detected in MW-17), under the defined conditions (no pumping), and with general input parameters based on very conservative assumptions, the MCL for CCl_4 would be exceeded in 22 years in MW-20. With TCE, at an initial concentration of 23 $\mu\text{g/l}$ (maximum detected in MW-17), and under very conservative input assumptions, levels in MW-20 would increase to the MCL (5.0 mg/l) in 31 years. With regard to ClO_4^- , at an initial concentration of 55 $\mu\text{g/l}$ (maximum detected in MW-17), and with very conservative input parameter assumptions, the IAL (18 $\mu\text{g/l}$) would be exceeded in MW-20 in 40 years.

As emphasized, conservative input parameters were assumed for the modeling such that the results would reflect a conservative scenario. In reality, porosity values will vary from 20-30%, and retardation of contaminant migration due to dispersion and adsorption to fine-grained aquifer materials and naturally occurring organic matter will occur to some extent. In addition, there is currently no basis to assume that the City of Pasadena and other nearby municipal wells will be continuously shut down for such extended periods of time. Furthermore, RI data suggest that contaminant concentrations are generally stable or slightly decreasing (Section 4.0), and therefore a continuous release at maximum levels detected in MW-17 during the RI for a period of 20 years is an overestimate.

5.5 GENERAL CONCLUSIONS

Data from the RI (Section 4.0) show that CCl_4 , TCE and ClO_4^- have migrated into the vicinity of the nearby City of Pasadena municipal production wells at concentrations exceeding regulatory limits. The RI data also suggest that contaminant migration beyond the City of Pasadena production wells has been minimal, and for CCl_4 and TCE, plume sizes are generally stable or slightly decreasing (ClO_4^- data has not been collected long enough to establish meaningful trends). Based on this data, the pumping of the City of Pasadena production wells appears to be an effective barrier to extensive downgradient contaminant migration. The data also show that Cr has consistently been detected at low levels on-site only, and has occasionally been detected off-site. There is no evidence suggesting significant Cr migration is occurring, and, although it has not been confirmed at JPL, it is likely that natural attenuation mechanisms are operating in the JPL aquifer.

The contaminant transport simulations predicted that with an initial CCl_4 concentration of 6.6 $\mu\text{g/l}$ in MW-17 (with conservative input assumptions), under the defined conditions, it would take 22 years for CCl_4 concentrations to reach the MCL (0.5 $\mu\text{g/l}$) in MW-20. For TCE at an initial concentration of 23 $\mu\text{g/l}$ (with conservative input assumptions), levels in MW-20 would potentially reach the MCL (5.0 $\mu\text{g/l}$) in 31 years. At an initial ClO_4^- concentration of 55 $\mu\text{g/l}$ (with conservative input assumptions), 40 years would be required for concentrations to reach the IAL (18 $\mu\text{g/l}$) in MW-20.

Results of the model runs indicate that even under conservative assumptions, it will take a very long time for these constituents to migrate downgradient of the City of Pasadena wells at significant concentrations. There is a very low probability this will happen, however, since it is very unlikely nearby municipal production wells will stop pumping for the extended periods of time required for significant migration to occur.

TABLE 5-1

CHEMICAL AND PHYSICAL PROPERTIES FOR PRIMARY CONSTITUENTS OF CONCERN IN GROUNDWATER AT THE JET PROPULSION LABORATORY

Group	Analyte	CAS Number	Empirical Formula	Molecular Weight (g/mol)	Physical State (at 25 degrees C)	Density (g/ml)	Aqueous Solubility (mg/l)	Vapor Pressure (mm Hg)	Henry's Law Constant (atm-m ³ /mol)	Octanol-Water Partition Coefficient (Log[K _{ow}])
VOCs	Carbon Tetrachloride	56-23-5	CCl ₄	153.82	Liquid	1.594	800	113	0.0293	2.73
	1,2-Dichloroethane	107-06-2	C ₂ H ₄ Cl ₂	98.96	Liquid	1.235	8,500	79	9.77x10 ⁻⁴	1.48
	Tetrachloroethene	127-18-4	C ₂ Cl ₄	165.8	Liquid	1.63	150	19	0.0685	2.53
	Trichloroethene	79-01-6	C ₂ HCl ₃	131.39	Liquid	1.46	1,100	77	0.0117	2.53
Metals	Chromium ¹	7440-47-3	Cr	51.996	Solid	7.2	Insoluble	NA	NA	NA
Anions	Perchlorate	NA	ClO ₄ ⁻	99.5	Solid ²	2.02 ²	Soluble	NA	NA	NA

NA: Not available.

1: Properties are presented for metallic chromium. Values are not available for the hexavalent state of chromium.

2: Properties are presented for sodium perchlorate. Values are not available for perchlorate as an anion.

References for chemical and physical properties include the following: (Micromedex, 1997), (ATSDR, 1997), (Burkhard and Kuehl, 1986), and (Howard, 1990).

TABLE 5-2
INPUT PARAMETERS FOR FATE AND TRANSPORT
MODELING (SOLUTE VERSION 4.04)
JET PROPULSION LABORATORY

Parameter	Site-Specific Data Available?	Known/Measured/ Assumed Value ^a
<u>Hydrogeologic Information</u>		
Groundwater velocity (ft/d)	Yes	0.15
Porosity (%)	No	20
Hydraulic gradient (ft/ft)	Yes	0.005
Longitudinal dispersivity (ft)	No	500
Retardation factor	No	1.0
Hydraulic Conductivity (ft/d)	Yes	6.0
<u>Contaminant Point Source Information</u>		
Number of contaminant sources	Yes	1 (MW-17)
Initial aquifer concentration (µg/l)	Yes	0
Contaminant source concentration ^b	Yes	CCl ₄ : 6.6 µg/L TCE: 23 µg/L ClO ₄ ⁻ : 55 µg/L
Duration of solute pulse (yrs)	No	20
Aquifer half-life (yrs)	No	0

a: Where site specific data was not available, assumptions were made based on conservative literature values (see text – Sections 5.4.1, 5.4.2).

b: Highest concentration of analyte detected in MW-17 during RI.

TABLE 5-3
RESULTS OF FATE AND TRANSPORT MODELING
JET PROPULSION LABORATORY

Analyte	MCL/IAL	Initial Concentration at MW-17	Time at Which Analyte Concentration is Predicted to Exceed MCL/IAL at MW-20
CCl ₄	0.5 µg/l	6.6 µg/l ^a	22 years
TCE	5.0 µg/l	23 µg/l ^a	31 years
ClO ₄ ⁻	18 µg/l	55 µg/l ^a	40 years

a: Highest concentration of analyte detected in MW-17 during RI; input assumptions considered to be very conservative.

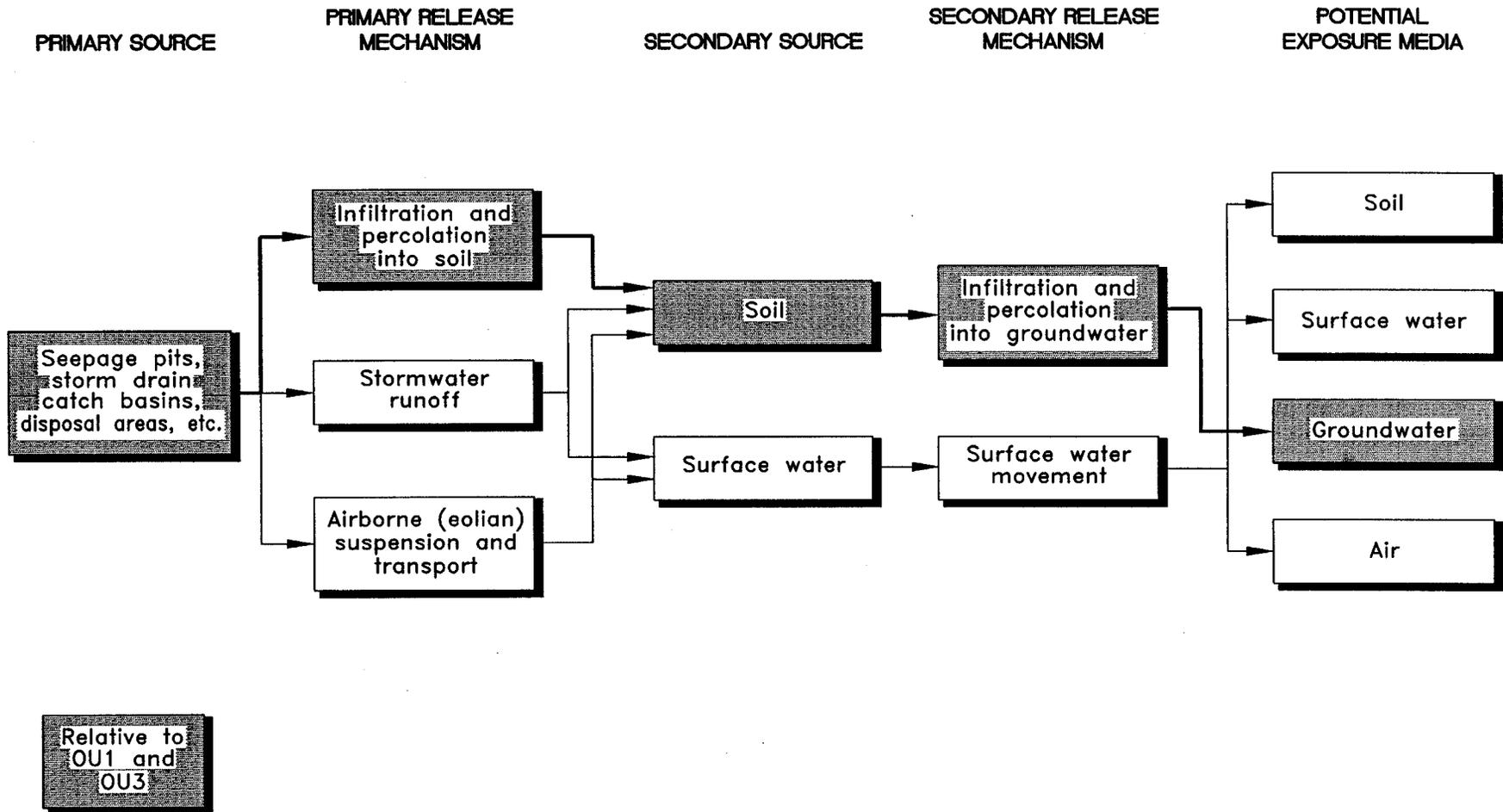


FIGURE 5-1

SITE CONCEPTUAL MODEL FOR FATE AND TRANSPORT OF CONTAMINANTS

Jet Propulsion Laboratory
Pasadena, California



FOSTER WHEELER ENVIRONMENTAL CORPORATION

6.0 SUMMARY OF RISK ASSESSMENT

This section presents the baseline human health risk assessment and summarizes a preliminary, or scoping, assessment of ecological risk for JPL groundwater. The risk assessment describes potential health risks to humans that may result from exposures to untreated JPL groundwater under current and hypothetical future land-use scenarios. The scoping ecological risk assessment addresses possible risks to plants and animals exposed to untreated JPL groundwater.

6.1 BASELINE HUMAN HEALTH RISK ASSESSMENT

For the baseline human health risk assessment, the concentrations of chemicals in groundwater were used to calculate an estimated risk to people who live on or near the JPL site. Risks to both existing and hypothetical future populations were examined. The following guidance documents were used in the human health risk assessment: *Risk Assessment Guidance for Superfund (RAGS): Volume I—Human Health Evaluation Manual, Part A* (EPA, 1989); *Risk Assessment Guidance for Superfund (RAGS): Volume I—Human Health Evaluation Manual (Part B) (Development of Risk-Based Preliminary Remediation Goals)* (EPA, 1991b); *Risk Assessment Guidance for Superfund (RAGS): Volume I—Human Health Evaluation Manual (Part D) Standardized Planning, Reporting, and Review of Superfund Risk Assessments, Interim Guidance* (EPA, 1998a); *Region IX Preliminary Remediation Goals (PRGs)* (EPA, 1999); *Dermal Exposure Assessment: Principles and Applications* (EPA, 1992d); *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance Dermal Risk Assessment Interim Guidance* (EPA, 1998b); *Exposure Factors Handbook* (EPA, 1995a); and *California Department of Toxic Substances Control (DTSC) Preliminary Endangerment Assessment Guidance Manual* (DTSC, 1994).

A new requirement of the EPA RAGS Part D guidance is that standard tables must be used to present the information used in the risk assessment so that the data can be easily entered into EPA's CERCLIS database. Appendix I contains the entire set of standard tables for this risk assessment, along with a list of tables and a brief description of the contents of each table series. Twenty-three JPL monitoring wells and 14 nearby municipal water production wells were evaluated individually in this risk assessment, which generated over 300 tables using the RAGS Part D format. Because of the significant number of tables produced, summary tables have been created and placed at the end of this section in order to assist the readers' understanding of the large volume of material. Some of the tables presented in the report are duplicates of the tables in Appendix I and are noted in the text.

A site characterization summary, which includes site description, history and physical characteristics of the site, is presented in Sections 1.0 and 3.0 of this report. As mentioned above, data from 23 JPL monitoring wells and 14 municipal water production wells were evaluated in the risk assessment. Of the 23 JPL monitoring wells, 18 of the wells were installed for OU-1. Three of these wells (MW-1, MW-6 and MW-14) are considered upgradient monitoring wells.

Five JPL monitoring wells were installed for OU-3 (MW-17, -18, -19, -20, -21). Of these, MW-21 is considered an upgradient monitoring well. Fourteen nearby municipal water production wells were evaluated including the upgradient Valley Water Company Wells Nos. 1, 2, 3, 4 and the La Canada Irrigation District Well No. 1 located west of the site. The remaining nine production wells are located southeast of the site.

6.1.1 Site Specific Objectives

The primary objectives of the human health baseline risk assessment include the following:

- Identify potential ways in which humans may be exposed to untreated groundwater (exposure pathways).
- Identify the chemicals that may be of concern for human health based on the laboratory analytical results presented in the RI report.
- Characterize potential noncancer and cancer risks from exposure to untreated groundwater under current and hypothetical future land uses.
- Identify on- and off-site areas potentially posing risk to human health.

6.1.2 Organization of the Risk Assessment Sections

The JPL human health risk assessment has been organized to illustrate how the data were evaluated, present the risk assessment methods used, and summarize the findings and conclusions. The information is presented in the following sections:

- Section 6.1.3 Selection of Chemicals of Potential Concern (COPCs)
- Section 6.1.4 Exposure Assessment
- Section 6.1.5 Toxicity Assessment
- Section 6.1.6 Risk Characterization
- Section 6.1.7 Uncertainty Analysis
- Section 6.1.8 Summary

6.1.3 Selection of Chemicals of Potential Concern (COPCs)

During the RI, numerous groundwater sampling events were completed at and adjacent to JPL (see Section 4.0). During the course of groundwater sampling, the list of chemicals tested for was occasionally modified based on results from previous sampling events, on new information, and on discussions with state and federal regulators. Groundwater samples from JPL monitoring wells have been analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), Title 26 metals, strontium, hexavalent chromium, aluminum, cyanide, total petroleum hydrocarbons, gross alpha/gross beta, perchlorate, and tributyltin. A summary of the RI sampling events is provided in Table 4-1.

Of primary importance to a quantitative risk assessment is the identification of chemicals of potential concern (COPCs), or those site-related chemicals that may be associated with adverse effects on human health. Of the chemicals positively detected at the JPL site, only a few are

considered COPCs. This risk assessment used a two step screening process to select the final COPCs, which were then used in the quantitative risk assessment. In agreement with the EPA Region IX and DTSC risk personnel, the two step screening process was used to: (1) evaluate and screen all of the chemical data that was collected at the site during the RI period for COPCs (1994–1998); and (2) perform the quantitative risk evaluation on those chemical constituents that could potentially cause risk using concentrations detected during the last year of the RI (1997–1998). During the two step screening process, the maximum concentrations of each chemical detected were compared to EPA Preliminary Remediation Goals (PRGs) and to California DTSC Preliminary Endangerment Assessment (PEA) values. This process helped to quickly evaluate a large body of data and focused the risk assessment on the chemicals that may potentially contribute to risk.

EPA Region IX PRG and California PEA values are chemical concentrations that correspond to fixed levels of risk (i.e., either a one-in-one million [1×10^{-6}] cancer risk or a noncarcinogenic hazard quotient of 1.0) in soil, air, and water. The EPA Region IX PRG and California PEA values are derived by combining current toxicity values (EPA or State of California) with standard exposure factors to estimate contaminant concentrations in environmental media (e.g. groundwater). The EPA Region IX PRG table has each chemical's PRG published in a look-up table format, whereas the California PEA values must be calculated following DTSC guidance. The PRG and PEA values for each agency differ slightly based on differences in cancer slope factors and exposure parameters used in the equations. Appendix J presents the EPA Region IX and California PEA values and indicates the most conservative value between the two that was used in the COPC screening process. Appendix J also presents the equations, input parameters, variables, and toxicity values that were used in the calculation of the California PEA values.

Chemical constituents that are considered trace essential nutrients were not evaluated in the COPC screening or the quantitative risk assessment in accordance with EPA guidance (EPA, 1989). Essential nutrients are chemicals that are (1) naturally occurring trace essential human nutrients (i.e., calcium, magnesium, potassium and sodium); (2) present at low concentrations; and (3) toxic to humans only at very high doses. Also, chemicals that were characterized as tentatively identified compounds (TICs) by the laboratory were not used in the risk assessment as approved by EPA and DTSC risk personnel. TIC data are not sufficiently accurate because the laboratory instruments used to analyze the groundwater are not calibrated for TICs. The TIC information is further discussed below in the Results of the Screening Analysis.

In the first step of the COPC screening process, all RI data (1994–1998) were used and the maximum detected concentration of each analyte was selected from this dataset. The maximum contaminant detections were compared to the most conservative (i.e., lowest) PRG or PEA value for that constituent. Chemicals with maximum concentrations greater than the PRG/PEA value were carried through to the second step of the COPC screening process. The second screening step used the maximum detected concentration from the most recent year of RI data (1997–1998). The 1997–1998 analytical data is considered most representative of the current and future conditions that may occur at the JPL site. (The complete 1994–1998 data set was used in the first

step of the screening process because some chemicals were not tested for during the last year of RI sampling.) . The maximum concentration of each analyte was again compared to the lowest PRG/PEA value. Analytes that exceeded the PRG or PEA value were selected as final COPCs and were used in the quantitative evaluation of risk.

Results of the Screening Analysis

Table 6-1 and Appendix I Table I-2 present the chemicals detected in groundwater during the years 1994–1998 and summary statistics for each analyte. The maximum detected values were compared to California PEA or EPA PRG values. Twenty-four chemicals were chosen as “preliminary COPCs” based on the results of the first step of the screening process and are listed in Table 6-2 and Appendix I Table I-3.

The results of the second step of the screening process are also summarized in Table 6-2. The 12 chemicals chosen as final COPCs after the second step of the screening process and used in the quantitative risk evaluation are as follows:

- Inorganics - Arsenic, hexavalent chromium, lead, nitrate and perchlorate.
- Organics - 1,1-dichloroethene, 1,2-dichloroethane, bromodichloromethane, carbon tetrachloride, chloroform, tetrachloroethene, and trichloroethene.

Analytes not sampled in 1997-1998

Of the analytes selected as “preliminary COPCs” using the 1994–1998 data, nine chemicals did not have data available for the 1997-1998 sampling events. These analytes included fluoride and eight polycyclic aromatic hydrocarbons (PAHs): (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, indeno (1,2,3-c,d)pyrene, phenanthrene and benzo(g,h,i) perylene). The eight PAH compounds were only detected once in MW-12, Screen 2 (which equates to being detected only once in 135 samplings). The PAHs were not detected in an associated duplicate groundwater sample collected at the same time and in samples collected during two subsequent sampling events completed to try to verify the anomalous results. The PAH results most likely are the result of laboratory contamination, and were not sampled for again pursuant to regulatory agency approval.

Fluoride Analysis

Fluoride analyses were conducted for on-site JPL monitoring wells from 1990 through 1994 and for off-site wells in 1995. Fluoride is naturally occurring and was consistently detected at very low levels in all wells (see Tables 4-12 and 4-13, Section 4.0). Evaluation of fluoride data indicates that only one well (MW-3, Screen 5) consistently had concentrations that exceeded both the PEA value of 0.939 mg/L (California) and the PRG value of 2.2 mg/L (EPA). None of the samples exceeded the federal maximum contaminant level (MCL) value of 4.0 mg/L. Fluoride was not evaluated further in the risk assessment for the following reasons: (1) the slightly elevated detections of fluoride in only the bottom screen of one multi-port well (MW-3, Screen 5) is probably naturally occurring; (2) there is no evidence of historical use of fluoride

on-site; (3) fluoride is not a known carcinogen; and (4) fluoride has only a cosmetic effect in children, its risk is not based on toxic or adverse effects (EPA, 1999).

TIC data

Table 6-3 presents the 11 analytes identified as TICs during the COPC screening. The concentrations reported for these compounds are based on qualitative chemical analysis and are considered estimated concentrations only. Review of the TIC results indicate they were rarely detected in very few samples. For the TIC compounds with toxicological information, the comparison of the maximum detected concentrations to their respective PEA/PRG values indicated that all of the detected values were below the benchmark value. TIC compounds without toxicological information were not evaluated further because of the limited number of detections and the qualitative nature of the results, pursuant to regulatory agency approval.

6.1.4 Exposure Assessment

The objective of the exposure assessment is to estimate the type and magnitude of human exposure to contaminants by characterizing the exposure setting, determining potentially exposed populations, identifying exposure pathways, and estimating the concentration of chemicals in the water or air a person may drink or breathe (exposure point concentrations). Factors which contribute to complete exposure pathways, from source to human receptors, include the nature of the source of chemical contaminants, how the chemicals are transported and what happens to them during transport (their fate), and the types of potential exposure points. Exposure to chemicals is quantified by calculating exposure point concentrations and estimating the amount of chemical uptake by a person at the exposure points.

6.1.4.1 Exposure Setting and Site Conceptual Model

The exposure setting includes the physical environment of the site, including the land and water uses associated with the current and potential future uses of the site and the environmental media (e.g., groundwater) in the immediate vicinity that have been potentially affected by site activities.

JPL is covered by buildings, trailers, and pavement over the majority of the useable land surface. Access to the JPL site is restricted and controlled through a security system that includes fencing, security personnel, and controlled entry. JPL does not, and cannot, pump water for domestic or non-domestic use from the aquifer due to basin adjudication/water right issues. JPL is also not expected to have groundwater rights under any future use scenarios. The municipal production wells located near JPL do, however, produce water from the aquifer. The data on water quality from the production wells evaluated in this assessment are from untreated groundwater and are not representative of water quality that is supplied to area users. Water suppliers are required to conduct routine water quality analyses to ensure that stringent drinking water standards are met. Water treatment systems and "blending" (mixing with other well water or imported water) are used as needed to meet strict drinking water standards (ATSDR, 1998). It is important to note that water samples from the production wells were obtained by the water companies or other

representatives, therefore, the sampling and analytical methods used are not necessarily the same as those used for the JPL site.

Potentially Complete Exposure Pathways

Exposure pathway analysis involves the systematic examination of the potential contaminant sources, the ways in which contaminants may move (transport) from source to receptor, and the potentially exposed populations. After examining these factors, the appropriate combinations of them are evaluated quantitatively in the risk assessment. The combinations that are considered for risk evaluation are typically those that represent complete current or future pathways (based on reasonable assumptions about future land use). The potential JPL exposure pathways are presented in the site conceptual model for risk assessment on Figure 6-1.

Under current conditions, on-site workers and off-site residential adults and children do not have access to untreated groundwater. Groundwater produced from nearby water production wells meet strict state and federal water quality standards prior to distribution to consumers. Under future use scenarios, the JPL facility operations and basin water right adjudication issues are not expected to change.

However, for this risk assessment, based on direction from EPA Region IX and the California DTSC risk assessors, a conservative hypothetical current and future residential use scenario was evaluated in which on-site human residents could be exposed to untreated groundwater. For this risk assessment, it is assumed that current and future uses of the site will be identical (residential) and, therefore, hypothetical exposure to untreated groundwater will be referred to as the "current/future" use scenario.

It is important to repeat that because groundwater is located in a deep aquifer, and water purveyors treat impacted groundwater before use, there is no complete pathway for residential exposure to untreated JPL groundwater. The exposure to untreated groundwater evaluated in this risk assessment represents a conservative hypothetical scenario and is not reflective of current or likely future site scenarios.

Hypothetically, the exposure mechanisms to untreated groundwater for humans are presented in Appendix I Table I-1 and include the following:

- Ingestion (drinking), dermal (skin) contact, and inhalation of vapors from domestic drinking water sources.

Pathways Selected for Quantitative Evaluation

The approach of this risk assessment was to select human populations that were conservative representatives of the several populations that could potentially be exposed to untreated groundwater under the hypothetical current/future use scenario. The following populations were selected to model risk to human receptors:

- The time-, or age-adjusted adult, (child/adult) resident was chosen as the most conservative model for people that would live on or near the site under a current/future use scenario. The age-adjusted adult is used to evaluate risks from continuous exposure to carcinogenic compounds over a 30-year period. This term is called a time-weighted, or time-adjusted, value because the calculations are based on a projected 30-year exposure to the chemicals. Of these 30 years, the first 6 years are based on a child's parameters and the next 24 years of life are based on adult parameters. This conservative method accounts for differences in body weights, surface areas of the skin, and intake rates (by breathing, drinking, and contact with skin) of children versus adults, which is important in determining conservative overall exposure estimates. For this model, exposure for 350 days/year for 30 years was assumed (EPA, 1991b).
- The child resident (6 years) was chosen to model exposure under the current/future residential exposure scenario for noncarcinogenic risks. The child is the most conservative receptor to model risk for noncarcinogenic risks because even though children may drink less water than an adult, the amount they ingest is greater than an adults when body weight is taken into account.

6.1.4.2 Exposure Point Concentrations

For this evaluation, exposure point concentrations (EPCs) were determined for each individual JPL monitoring well and nearby production well for each of the COPCs using the most recent year of RI groundwater data (1997) and data from the California Department of Health Services database for the same period for the nearby municipal production wells per agreement with EPA Region IX and DTSC risk assessors. The EPC for each JPL multi-port monitoring well was calculated by combining the data for all depths and screen intervals. The EPC was calculated following the guidance presented in EPA's Supplemental Guidance to RAGS: Calculating the Concentration Term (EPA, 1992c). For Superfund assessments, the concentration term (EPC) in the intake equation is an estimate of the concentration for a contaminant based on a set of site sampling results. Because of the uncertainty associated with estimating the true average concentration in a well, the more conservative 95 percent upper confidence limit (UCL) of the arithmetic mean was used. The 95 percent UCL provides reasonable confidence that the true site average will not be underestimated. If the 95 percent UCL exceeded the maximum detected value in a well, then the maximum detected value was used. The equation to calculate the 95 percent UCL is as follows:

$$UCL = e^{\left(\bar{x} + 0.5s^2 + sH/\sqrt{n-1}\right)}$$

Where:

- UCL = upper confidence limit
- e = constant (base of the natural log, equal to 2.718)
- \bar{x} = mean of the log-transformed data
- s = standard deviation of the log-transformed data
- s^2 = variance
- H = H-statistic (e.g., from table published in Gilbert 1987)
- n = number of samples

Table 6-4 lists the exposure point concentrations used in the calculations of the chronic daily intake of untreated groundwater for the child/adult and child receptors. The EPC values that were based on maximum detected concentrations are denoted by an “m” flag in the table.

6.1.4.3 Estimation of Chemical Intakes

To calculate contaminant intakes (and corresponding risks), the following factors must be estimated:

- Chemical concentration (EPC) to which an individual is potentially exposed.
- Amount of chemical uptake by the body via ingestion, dermal absorption, and/or inhalation.
- Frequency and duration of potential exposures.

These factors are incorporated into a term referred to as the chronic daily intake (CDI), which represents an estimated average daily amount of chemical (dose) received via direct contact (groundwater ingestion and dermal contact) and/or inhalation pathways. CDIs are expressed in units of milligrams of chemical per kilogram of body weight per day (mg/kg-day) and are calculated using the exposure pathway-specific equations summarized in Table 6-5. The EPCs used in these equations are listed in Table 6-4. The risks associated with exposure to COPCs depend not only on the concentrations and toxicity of COPCs but also on the extent to which human receptors are potentially exposed. Table 6-6 (Appendix I Table I-79) presents the exposure parameters used in this assessment for each receptor and CDI equation. The exposure assumptions were obtained from the PEA manual (DTSC, 1994) and EPA guidance documents (EPA, 1989; 1991b; 1996b). Averaging time for carcinogenic chemicals is based on 30 years of continuous exposure averaged over a 70-year lifetime. Averaging time for noncarcinogenic chemicals is based on the 6-year exposure duration for a child. The CDI for carcinogenic chemicals incorporates intakes by adults and children and the CDI for noncarcinogenic chemicals addresses intake by children only. Appendix I Tables I-4 through I-40 present the CDI concentration calculation for each well.

6.1.5 Toxicity Assessment

For risk assessment purposes, COPCs were evaluated under two categories of chemical toxicity: carcinogenic and noncarcinogenic effects. As defined below, this distinction is made under the assumption that these two groups of chemical effects act on a human body differently. Tables 6-7 through 6-10 list the toxicity values developed for noncarcinogenic and carcinogenic COPCs. These values were combined with the CDIs defined in Section 6.1.4 to calculate risks using the methods described below in Section 6.1.6, Risk Characterization.

The toxicity databases used to obtain information for the COPCs were as follows, in order of preference: EPA's Integrated Risk Information System (IRIS) (EPA, 1999), California Office of Environmental Health Hazard Assessment (CAOEHHA, 1994), EPA Region IX PRG tables (EPA, 1999) and EPA National Center for Environmental Assessment (NCEA) Regional Support provisional values from the Superfund Health Risk Technical Support Center (as listed in the Region IX PRG tables, (EPA, 1999). The CAOEHHA document was used as the primary source

for cancer slope factor values. The carcinogenic and noncarcinogenic effects, including the cancer slope factor (SF) and reference dose values (RfD) for all chemicals chosen as COPCs are presented in Tables 6-7 through Table 6-10. Cancer slope factors and reference dose values are defined and discussed below.

For noncarcinogenic chemicals that lacked an oral or inhalation RfD in IRIS, the EPA Region IX PRG table was used to obtain extrapolated values (i.e., extrapolation from oral to inhalation RfDs and from inhalation to oral RfD values). Total chromium concentrations were not evaluated in this risk assessment because hexavalent chromium concentrations were analyzed by the laboratory; therefore, risks from hexavalent chromium, and not total chromium, concentrations were evaluated as agreed with EPA Region IX and DTSC risk assessors. Toxicity information in the California or EPA toxicity databases was not available for 1,2,3-trichlorobenzene, gross alpha, and gross beta. Toxicity data was available for 1,2,4-trichlorobenzene, which was used for 1,2,3-trichlorobenzene. Detections of gross alpha (range 2.0–11.8 picocuries/liter [pCi/L]) and gross beta (3.0–6.0 pCi/L) were both less than the state regulatory levels of 15 pCi/L and 50 pCi/L, respectively. Thus, adverse effects are not expected from these analytes. Toxicity information was also not available for several of the TIC compounds, including 2-methyl-1-propene; 2-methylpropane; acetic acid; sulfur dioxide; 2,4-bis(1,1-dimethylethyl)phenol; and N-butyl-benzene sulfonamide. These chemicals were excluded from further evaluation due to their rare detections, qualitative chemical analysis, and lack of toxicity information.

6.1.5.1 Toxicity Information For Potential Carcinogenic Effects

As described in EPA guidance (EPA, 1989), a small number of molecular changes can cause changes in a single cell or a small number of cells that can lead to the formation of tumors. Cancer slope factors, used in the calculation of risk, are developed under the assumption that exposure to a carcinogen causes some finite increase in the probability of causing cancer; that is, there is no threshold level of exposure required to cause the disease. Evaluation of carcinogenic effects is a two-step process involving weight-of-evidence determination and calculation of slope factors. These steps are described below.

Weight-of-evidence classifications are assigned to account for the likelihood that a chemical is a human carcinogen. With the use of this system, chemicals are classified as either Group A, Group B1, Group B2, Group C, Group D, or Group E. Group A chemicals (human carcinogens) are chemical agents for which there is sufficient evidence to support a causal association between human exposures and cancer. Group B1 and B2 chemicals (probable human carcinogens) are agents for which there is limited (B1) or inadequate (B2) evidence of cancer causing properties (carcinogenicity) from human studies, but for which there is sufficient evidence of carcinogenicity from animal studies. Group C chemicals (possible human carcinogens) are agents for which there is limited evidence of carcinogenicity in animals and no human data. Group D chemicals, which are not classified as human carcinogens, are agents for which data are inadequate to evaluate either animal or human carcinogenicity. Group E chemicals (evidence of noncarcinogenicity in humans) are agents for which there is evidence of no carcinogenicity in human or animal studies. In this risk assessment, chemicals with weight-of-evidence

classifications A, B, and C are considered carcinogens. Chemicals with unknown carcinogenicity (Class D) are treated as noncarcinogens.

Based on the weight-of-evidence determinations described above, EPA calculates a slope factor that quantitatively defines the relationship between dose and response. This factor is expressed in units of $(\text{mg}/\text{kg}\text{-day}^{-1})$. Slope factors are derived from studying the occurrence of disease in people (epidemiological studies) or, in many cases, in animals (chronic animal bioassays). The animal studies are usually conducted using relatively high doses to detect possible adverse effects. Because humans are expected to be exposed to lower doses than those used in animal studies, animal data are adjusted by using mathematical models and applying an interspecies scaling factor to derive a comparable low-dose slope factor for humans. The use of these slope factors typically results in an upper-bound estimate of the probability of an individual developing cancer as a result of exposure to a given level of a potential carcinogen. While the actual risks are not likely to be higher than the risks estimated using these slope factors, they could be considerably lower. The chemical-specific slope factors are presented in Tables 6-9 and 6-10 (and in the Appendix I risk calculation tables).

The State of California has derived their own slope factors (cancer potency factors) for many chemicals, which may differ slightly from the values in the EPA IRIS database. One difference between the State of California and EPA databases is that California considers hexavalent chromium a carcinogen via oral exposure while EPA does not. Also, EPA has withdrawn weight-of-evidence carcinogenicity classifications and carcinogenic toxicity criteria from IRIS for both tetrachloroethene (PCE) and trichloroethene (TCE). Both compounds have caused cancer in laboratory animals, but the relevance of these findings to humans has been under debate for several years. EPA's National Center for Environmental Assessment (NCEA) has established an inhalation SF for PCE of $2.0\text{E-}03$ $(\text{mg}/\text{kg}\text{-day}^{-1})$ that is 10.5 times smaller than the CAOEHHA value of $2.1\text{E-}02$. The oral SF for PCE established by the two agencies are similar. The toxicity information from the California database was used as the primary source for slope factors for all COPCs. For chemicals without State of California values, the slope factor was obtained from IRIS or other EPA databases.

6.1.5.2 Toxicity Information for Potential Noncarcinogenic Effects

For chemicals that have noncarcinogenic effects, humans are assumed to have the ability to accommodate some level of chemical exposure without toxic effects. It is assumed that a range of exposures from just above zero to some finite threshold value can be tolerated by humans without appreciable risk of an adverse effect (EPA, 1989).

Health criteria for chemicals exhibiting noncarcinogenic effects are generally developed using reference doses (RfDs). The RfD, expressed in units of $\text{mg}/\text{kg}/\text{day}$, is an estimate of the daily dose that a human (including sensitive subpopulations) can sustain that is not likely to present an unacceptable risk during a lifetime (EPA, 1989). RfDs are generally developed by the EPA RfD Work Group. Alternative sources include Health Effects Assessments (HEAs) and Office of Drinking Water criteria documents that support health-based drinking water standards. These

values are usually derived from animal studies and, in some cases, from human studies involving occupational exposures. These experimental or epidemiological data are then adjusted using a range of uncertainty factors. The RfDs thereby provide a benchmark to which chemical intakes may be compared. Tables 6-7 and 6-8 list the RfDs developed for noncarcinogenic effects for the COPCs for oral and dermal routes of exposure and RfDs developed for inhalation exposure routes, when applicable.

6.1.5.3 Toxicity Factors Used To Evaluate Dermal Route Exposures

In accordance with EPA Region IV guidance (EPA, 1995b); EPA Dermal Exposure Assessment Principles and Applications (EPA, 1992b); and RAGS (EPA, 1989); the reference doses and oral slope factors listed in Tables 6-7 and 6-9 were adjusted to derive dermal RfDs and slope factors based on a conversion from an orally administered dose to a dose absorbed through the skin. The calculated dermal (CDI) dose is actually an absorbed dose, and is not the amount of chemical that comes in contact with the skin (i.e., intake). This is because the skin is not infinitely or instantly permeable to chemicals; permeability constants are used to represent how a chemical moves across the skin and into the bloodstream. Since dermal RfD and SF values are not available, the oral RfD and SF values, which are based on an administered dose, are modified to reflect the relative differences in the fraction of a dermal dose (versus an oral dose) that reaches the systemic circulation in the human body. Chemical-specific data to adjust for the differences in dermal absorption rates for different chemicals have not been issued by EPA headquarters, EPA Region IX or the State of California. In the absence of chemical-specific data to adjust for dermal absorption efficiencies, EPA Region IV recommends the following default values: 80 percent for volatile organic chemicals, 50 percent for semi-volatile organic chemicals, and 20 percent for inorganic chemicals. The slope factors are divided by the default value and the RfDs are multiplied by the default factor. This adjustment was applied to the slope factors and RfDs and is presented in the dermal exposure risk spreadsheets in Appendix I. By agreement with the Region IX risk assessors, the COPCs that were evaluated for dermal exposure were the non-volatile compounds.

6.1.6 Risk Characterization

This section presents the results of the quantitative risk assessment conducted for exposure to untreated JPL groundwater. Sections 6.1.6.1 and 6.1.6.2 describe the mathematical methods used in the pathway-specific cancer risk (carcinogenic) and hazard index (noncarcinogenic) calculations. Section 6.1.6.3 presents the results of the risk assessment.

6.1.6.1 Calculation Methodology for Carcinogenic Endpoints

Excess lifetime cancer risks associated with exposures to known or potentially carcinogenic COPCs were calculated by multiplying the slope factor by the estimated average lifetime dose, or CDI. Excess cancer risks are risks in excess of the normal expectancy that a person in a given population will develop cancer and represent the upperbound probability that an individual exposed to a given level of chemical over a lifetime will develop cancer as a result of those exposures. A 10^{-6} upperbound excess lifetime cancer risk, for example, is an increase of 1 in 1

million in the probability that an exposed individual would develop cancer. By convention, the values are rounded to two significant figures. Table 6-5 lists the pathway-specific equations to calculate the CDI value.

In equation form, risk is defined as follows:

$$\text{Risk} = (\text{SF}) * (\text{CDI})$$

where:

- Risk = A unitless probability that an individual will develop cancer attributable to the assumed exposure scenario
- SF = Slope factor, expressed in (mg/kg/day)
- CDI = Chronic daily intake averaged over 70 years (mg/kg/day)

6.1.6.2 Calculation Methodology for Noncarcinogenic Endpoints

Risk estimates for noncarcinogenic chemicals are generally developed using RfDs. These criteria are estimates of the daily chemical exposures that present no risk of adverse effects to an individual over a specified time of exposure, or exposure duration. Table 6-5 lists the pathway-specific equations used to calculate the CDI value. The ratio of the CDI to the RfD is called the Hazard Quotient (HQ). In the absence of any information on the specific chemical mixture in question, the mixture is assessed by means of a hazard index (HI). The HI is defined as the sum of the ratios of the CDI to the RfD for each noncarcinogenic chemical, as in the following equation:

$$\text{HI} = \text{CDI}_1 / \text{RfD}_1 + \text{CDI}_2 / \text{RfD}_2 + \dots \text{CDI}_i / \text{RfD}_i$$

where:

- CDI_i = Chronic daily intake for the i^{th} chemical in mg/kg/day
- RfD_i = Chronic reference dose for the i^{th} chemical in mg/kg/day

Any single chemical with an exposure level greater than the reference level would cause the HI to exceed 1.0, indicating potential health risks of concern. For exposures to more than one chemical, the HI can exceed the 1.0 target criterion even if no single chemical in the mixture exceeds its corresponding RfD. However, the assumption of additivity reflected in the HI equation is most properly applied to chemicals that induce the same effect by the same mechanism. Consequently, applying this equation to a mixture of compounds that are not expected to induce the same type of effects could overestimate the potential for adverse health effects. For this reason, a target organ HI value is calculated which is the sum of the HI values for chemicals that affect a particular organ (i.e., the liver or thyroid gland).

Health risks from exposure to inorganic lead in groundwater were assessed based on State of California DTSC guidance (DTSC, 1996) by agreement with DTSC and EPA Region IX risk

assessors. The human health effects of lead are assessed based on calculation of blood lead concentrations rather than on an external dose, therefore the traditional reference dose approach to toxic chemicals does not apply to lead. Site-specific blood lead concentrations were estimated following the California guidance and were compared to the blood lead concentration of concern (10 µg/dl) for protection of human health.

The methodology used to estimate the site-specific blood lead concentrations is presented in Appendix K. The model calculates a blood-lead level based on a combined exposure from dietary intake, drinking water, soil and dust ingestion, and inhalation exposure. One of the input parameters required for the model is a site-specific soil lead concentration. Samples for background concentrations of lead at the JPL site were collected at depths greater than 15 feet below the ground surface. Because of the depth, this soil data was not considered representative of lead concentrations that humans would typically be exposed to at the ground surface. Therefore, a regional lead background level of 23.9 mg/kg soil (University of California, 1996) was used as the default value. Blood lead concentrations were estimated for each well in which the analyte was detected and are presented in Table 6-11.

6.1.6.3 Risk Assessment Results

This section quantifies risks for the two representative receptors (child/adult and child) potentially exposed to untreated groundwater from JPL monitoring wells and nearby municipal water production wells. The cancer and noncancer risk values calculated for the two receptors represent very conservative estimates because there is no current or foreseeable future exposure pathway to untreated groundwater from the aquifer. The context within which to evaluate the relative risk from each of the pathways has been established by EPA for the federal Superfund program under the National Contingency Plan (EPA, 1989). For carcinogens, the EPA acceptable risk range is a 10^{-6} to 10^{-4} incremental cancer risk (1 in 1,000,000 to 1 in 10,000 increase in chance of getting cancer); risks below 10^{-6} are generally considered negligible. For noncarcinogens, where the HQ (individual chemical and pathway) and HI values (sum of all chemicals and pathways) exceed 1.0, it is assumed exposures may present a health hazard. As the HQ and HI values increase above 1.0, the level of uncertainty decreases. Thus, given all of the uncertainties in risk assessment (toxicity values, exposure assumptions, chemical data, etc., see Section 6.1.7), an HI of 1,000 suggests that you are more likely to reach a dose that exceeds the reference dose, than is indicated by an HI of 1.1. As the HI increases, there is a greater likelihood that the reference dose will be exceeded.

For each representative receptor, the cancer risk and HQ value for each analyte and exposure pathway (ingestion, inhalation, and dermal) was summed to produce total cancer risk and total noncancer risk (HI) values for each well. Tables 6-12 through 6-48 present the well by well chemical specific cancer risk and noncancer HQ and HI values for each analyte and total risk values. Table 6-49 presents a summary of the total cancer risks and noncancer HI values by well. Table 6-50 presents the chemicals that are the major contributors to overall risk for samples from wells with cancer risks greater than 10^{-6} and or HI values greater than 1.0. In general, individual

chemicals with cancer risks greater than 10^{-6} or HI values greater than 0.5 were included in the table as major contributors.

The non-cancer (Section 6.1.6.3.1) and cancer risk assessment results (Section 6.1.6.3.2) are presented separately below. For both the noncancer and cancer risk assessment results, the results are divided into three sections: OU-1 well results, OU-3 well results, and nearby production well results. The evaluation of lead detections in groundwater are discussed in Section 6.1.6.3.3.

6.1.6.3.1 Results for Non-carcinogenic Risks

OU-1 Monitoring Wells

The distribution of non-carcinogenic risks (HI) was divided into ranges for discussion purposes. HI values represent the summed risk values for all chemicals and pathways combined. The number of OU-1 wells in each HI range was as follows:

HI < 1.0	5 wells
HI of 1.0–2.0	4 wells
HI of 2.0–10	5 wells
HI > 10	4 wells

Table 6-49 presents the HI values for each well. For monitoring wells associated with samples having HI values of 1.0–2.0 (MW-6, -14, -22, and -23), perchlorate and nitrate accounted for the majority of chemical risk, and no individual chemical produced an HI value that exceeded 1.0.

Five wells had slightly elevated HI values (range 2.0–10) and four wells had samples with HI values greater than 10. In samples from all of these wells, perchlorate and/or carbon tetrachloride were the major contributors to noncancer risks, based on the percent contribution to the overall HI value. For the four wells with samples that had relatively significantly elevated HI values, perchlorate and carbon tetrachloride accounted for greater than 90 percent of the total HI. The HI values and major chemicals contributing to risk at these wells were as follows:

HI 2.0–10

- MW-3 HI=2.1; arsenic and perchlorate
- MW-4 HI=8.5; carbon tetrachloride and perchlorate
- MW-8 HI=6.3; carbon tetrachloride and perchlorate
- MW-10 HI=3.2; perchlorate and nitrate
- MW-12 HI=8.9; carbon tetrachloride and perchlorate

HI > 10

- MW-7 HI=190; carbon tetrachloride and perchlorate
- MW-13 HI=47; carbon tetrachloride and perchlorate
- MW-16 HI=220; carbon tetrachloride and perchlorate
- MW-24 HI=65; carbon tetrachloride and perchlorate

To refine the HI approach, the HI value can be evaluated based on the affected target organ. Because of the assumption of additivity in the HI equation, applying the HI equation to a mixture of compounds with different target organs and effects may overestimate the potential for adverse health effects. Perchlorate has adverse effects on the thyroid gland, while 1,1-dichloroethene, carbon tetrachloride, chloroform, and PCE affect the liver. Evaluation of the total organ HI values by well indicate that the following wells have samples with total organ HI values that exceed the benchmark of 1.0:

Total Organ HI Value (for wells with total HI = 2.0–10)

- MW-4 HI: liver = 2.6 and thyroid =4.9
- MW-8 HI: liver = 2.1 and thyroid =3.7
- MW-10 HI: thyroid = 2.1
- MW-12 HI: liver = 7.9

Total Organ HI Value (for wells with total HI > 10)

- MW-7 HI: liver =98 and thyroid = 93
- MW-13 HI: liver =11 and thyroid = 33
- MW-16 HI: liver =61 and thyroid = 160
- MW-24 HI: liver =20 and thyroid = 43

OU-3 Monitoring Wells

The HI values for all chemicals combined and the major chemical contributors to noncancer risk for the OU-3 monitoring wells were as follows:

- MW-17 HI = 7.6; carbon tetrachloride, perchlorate, and TCE
- MW-18 HI = 2.9; arsenic, carbon tetrachloride, and perchlorate
- MW-19 HI < 1.0
- MW-20 HI = 1.7; arsenic, nitrate, and perchlorate
- MW-21 HI = 2.4; perchlorate, nitrate, and TCE

The OU-3 monitoring wells with target organ HI values greater than 1.0 are as follows:

- MW-17 HI: liver = 1.3 and thyroid = 4.7
- MW-18 HI: liver = 1.1

Figure 6-2 presents the distribution of HI values for the OU-1 and OU-3 JPL monitoring wells.

Production Well Risks

Data was obtained from 14 municipal water production wells located in the immediate vicinity of the JPL site. Of these wells, 9 are located downgradient of the site and 5 are located upgradient. The risk numbers were calculated for untreated groundwater and are not representative of water delivered by purveyors to residential areas and businesses.

The number of nearby municipal production wells with samples in each HI range was as follows:

HI < 1.0	6 wells
HI 1.0–2.0	5 wells
HI 2.0–10	2 wells (both wells <4.0)
HI >10	1 well

For wells with samples having total HI values greater than 1.0, the HI values and chemicals that were major contributors to the noncarcinogenic risk were as follows:

- Valley Well No. 1 HI = 1.5; arsenic and perchlorate
- Valley Well No. 2 HI = 1.1; arsenic and perchlorate
- Valley Well No. 4 HI = 1.3; arsenic and perchlorate
- Las Flores Well No. 2 HI = 1.3; arsenic and perchlorate
- Pasadena Well No. 52 HI = 3.1; carbon tetrachloride and perchlorate
- Pasadena Arroyo Well HI = 20; carbon tetrachloride and perchlorate
- Lincoln Avenue Well No. 3 HI = 3.5; carbon tetrachloride, perchlorate, and TCE
- Lincoln Avenue Well No. 5 HI = 1.7; perchlorate and TCE

Only the wells having samples with HI values greater than 3.0 (Pasadena Well No. 52, Pasadena Arroyo Well, and Lincoln Avenue Well No. 3), had individual chemical HI values that exceeded 1.0. These wells also had samples with target organ HI values greater than 1.0 as follows:

- Pasadena Well No. 52 HI: thyroid = 1.9
- Pasadena Arroyo Well HI: liver = 3.0 and thyroid = 17
- Lincoln Avenue Well No. 3 HI: thyroid = 1.8

6.1.6.3.2 Results for Carcinogenic Risks

OU-1 Monitoring Wells

The carcinogenic risks by well were initially evaluated by dividing the results into ranges based on the magnitude of total cancer risk (10^{-6} , 10^{-5} , 10^{-4} , and 10^{-3}). The cancer risk values for each well represent the total risk for all chemicals and pathways combined. The number of OU-1 wells associated with samples in each cancer risk range were as follows:

- 10^{-6} 4 wells
- 10^{-5} 4 wells
- 10^{-4} 4 wells
- 10^{-3} 2 wells

Four wells (MW-1, -5, -9 and -13) had no samples with carcinogenic compounds detected. The total cancer risk for the other OU-1 wells and the major chemicals (major chemicals are

chemicals with cancer risk $> 1 \times 10^{-6}$ [or $1E-06$] for all pathways) contributing to the cancer risk are listed below:

10^{-6}

- MW-6 Cancer Risk = $4.0E-06$; PCE
- MW-14 Cancer Risk = $3.1E-06$; chloroform and PCE
- MW-22 Cancer Risk = $3.2E-06$; PCE
- MW-23 Cancer Risk = $5.3E-06$; chloroform, PCE, and TCE

10^{-5}

- MW-4 Cancer Risk = $7.7E-05$; 1,1-dichloroethene, 1,2-dichloroethane, carbon tetrachloride, chloroform, and TCE
- MW-8 Cancer Risk = $5.5E-05$; carbon tetrachloride, chloroform, and TCE
- MW-10 Cancer Risk = $1.3E-05$; chloroform, PCE, and TCE
- MW-11 Cancer Risk = $1.1E-05$; carbon tetrachloride, and chloroform

10^{-4}

- MW-3 Cancer Risk = $1.1E-04$; arsenic, bromodichloromethane, carbon tetrachloride and chloroform
- MW-12 Cancer Risk = $1.6E-04$; carbon tetrachloride and chloroform
- MW-13 Cancer Risk = $5.5E-04$; 1,1-dichloroethene, 1,2-dichloroethane, carbon tetrachloride, chloroform, hexavalent chromium and TCE
- MW-24 Cancer Risk = $5.2E-04$; 1,2-dichloroethane, arsenic, carbon tetrachloride, chloroform and TCE.

10^{-3}

- MW-7 Cancer Risk = $2.2E-03$; 1,1-dichloroethene, 1,2-dichloroethane, carbon tetrachloride, chloroform, hexavalent chromium, PCE, and TCE
- MW-16 Cancer Risk = $1.4E-03$; 1,1-dichloroethene, 1,2-dichloroethane, chloroform, carbon tetrachloride, hexavalent chromium, PCE, and TCE

OU-3 Monitoring Wells

All of the OU-3 JPL monitoring wells had samples with total cancer risks in the 10^{-5} range, with the exception of MW-18, which had a total cancer risk of 10^{-4} . The total cancer risk values and chemicals that contributed to the majority of the risk (risk $> 1.0E-06$) are presented below:

- MW-17 Cancer Risk = $8.5E-05$; bromodichloromethane, carbon tetrachloride, chloroform, hexavalent chromium, PCE and TCE
- MW-18 Cancer Risk = $1.2E-04$; arsenic, bromodichloromethane, carbon tetrachloride, chloroform, hexavalent chromium, PCE, and TCE
- MW-19 Cancer Risk = $1.0E-05$; bromodichloromethane, chloroform, and PCE
- MW-20 Cancer Risk = $7.3E-05$; arsenic, bromodichloromethane, and chloroform
- MW-21 Cancer Risk = $1.9E-05$; chloroform, PCE, and TCE

Figure 6-3 presents the distribution of cancer risk values for the OU-1 and OU-3 JPL monitoring wells.

Production Wells

For the 14 nearby municipal production wells, the distribution of total cancer risk values (by magnitude) were as follows:

- 10^{-6} range 3 wells
- 10^{-5} range 8 wells
- 10^{-4} range 1 well

Two wells had no carcinogenic compounds detected in their samples (Rubio Cañon Wells Nos. 4 and 7). The total carcinogenic risks and the chemicals that were the major contributors to risk for the other municipal production wells were as follows:

10^{-6}

- La Canada Well No.1 Cancer Risk = 1.4E-06, PCE
- Pasadena Ventura Well Cancer Risk = 2.7E-06; PCE, and TCE
- Pasadena Windsor Well Cancer Risk = 3.6E-06; PCE, and TCE

10^{-5}

- Lincoln Ave. Well No.3 Cancer Risk = 3.3E-05; carbon tetrachloride, PCE, and TCE
- Lincoln Ave. Well No.5 Cancer Risk = 1.4E-05; PCE and TCE
- Pasadena Arroyo Well Cancer Risk = 6.8E-05 carbon tetrachloride, TCE, and PCE
- Pasadena Well No. 52 Cancer Risk = 2.2E-05; carbon tetrachloride and TCE
- Valley Well No. 2 Cancer Risk = 6.7E-05; arsenic and PCE
- Valley Well No. 3 Cancer Risk = 3.6E-05; arsenic and PCE
- Valley Well No. 4 Cancer Risk = 9.8E-05; arsenic, PCE and TCE
- Las Flores Well No. 2 Cancer Risk = 6.5E-05; arsenic and PCE

10^{-4}

- Valley Well No. 1 Cancer Risk = 1.3E-04; arsenic, PCE and TCE

The production well with the highest total cancer risk value is located upgradient of the site (Valley Water Company Well No. 1). The risk values were calculated for untreated groundwater and are not representative of water delivered by water purveyors for consumption.

Total Risk Isopleth Maps

Figures 6-4 and 6-5 present the distribution of total hypothetical noncancer and cancer risk values from exposure to untreated groundwater by well, respectively. These maps allow the presentation of spatial trends in the risk data. It should be kept in mind that the risk estimates are very conservative and are not representative of actual exposures because there is no complete

exposure route to untreated groundwater. Figure 6-4 shows a general decrease in the noncancer risk values from west to east across the study area. The primary area of concern for noncancer risks extends from on-site monitoring wells MW-16 and MW-7 southeast towards the City of Pasadena Arroyo well. Figure 6-4 also indicates that the wells with target organ HI values greater than 1.0 are present in the same general area.

Figure 6-5 presents the distribution of hypothetical total cancer risk values from exposure to untreated groundwater across the study area. Overall, the majority of the total cancer risk values fall within the EPA range of acceptable cancer risk of 10^{-6} to 10^{-4} . The main area of concern again falls within the area that extends from on-site wells MW-16 and MW-7 towards the general area of the Pasadena Arroyo well including MW-18 and MW-3. For nearby municipal production wells, all total cancer risk values for hypothetical exposure to untreated groundwater are within the EPA's acceptable risk range, with the exception of Valley Water Company Well No. 1.

6.1.6.3.3 Evaluation of Lead Detections

As mentioned in Section 6.1.6.2 (Risk Calculation Methodology), health risks from exposure to inorganic lead in groundwater were evaluated using State of California DTSC guidance (DTSC, 1996). The State of California model estimates blood-lead concentrations in adults and children based on a multi-pathway (water, diet, soil, dust and air) exposure. Appendix K presents the methodology and spreadsheets that were used in the calculation of the blood-lead levels for potential receptors. Table 6-11 presents the lead concentrations detected in JPL monitoring wells. Lead detects were not reported in any nearby production wells. Appendix K Tables K-1 through K-10 presents the values used in the calculation of the blood-lead levels that were estimated for the potential receptors for the 50th, 90th, 95th, 98th and 99th percentile values. The 99th percentile blood-lead concentration for the child was used in the comparison to the blood-lead level of concern (10 µg/dl). Table 6-11 presents the blood-lead concentrations that were estimated for each exposure point. All estimated blood-lead levels were below the benchmark level (10 µg/dl).

6.1.7 Uncertainty Analysis

Assessing risk is an inexact science but remains an essential tool used to characterize and quantitatively evaluate potential health effects resulting from exposure to chemicals. In this section, a qualitative discussion of the uncertainties associated with the estimation of risks for the site is presented.

Risk assessments are not intended to estimate actual risks to a receptor associated with exposure to contaminants in the environment. In fact, estimating actual risks is impossible because of the variability in the exposed or potentially exposed populations. Therefore, the risk assessment is a means of estimating the probability that an adverse health effect will occur in a receptor. The multitude of conservative assumptions used in risk assessment evaluations guard against underestimation of risks.

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

- Uncertainties in sampling and analysis of environmental media, such as soil and groundwater.
- Uncertainties in assumptions concerning exposure scenarios.
- Uncertainties in toxicity data and dose-response extrapolations.
- Combinations of sources of uncertainty.

Environmental Sampling and Analysis

Risk estimates developed for JPL are based on the RI sampling results conducted at the site. Errors in laboratory analysis procedures are not common, but possible, and impacts from these sorts of errors on risk estimates are likely to be low. Environmental sampling can potentially be a source of uncertainty in risk evaluation. However, the number of sampling locations and number of sampling events for the JPL site is large, and with the use of laboratory audits, QA/QC protocols, and data validation, the uncertainty is reduced significantly. Therefore, the JPL sampling and analysis data is considered to be more than satisfactory to characterize potential risks.

Exposure Assessment

In this report, the exposure assessment is based on a number of assumptions with varying degrees of uncertainty (EPA, 1992e). Uncertainties can arise from the types of exposures examined, the points of potential human exposure, the concentrations of chemicals at the points of human exposure, and the intake assumptions. These factors and the ways in which they contribute to the risk estimation are discussed below.

Points of Human Exposure

In this assessment, the assumption was made that people could come into contact with untreated groundwater at every JPL monitoring well and nearby municipal production well. It was also assumed that individuals would be exposed to a constant COPC concentration (95 percent UCL or maximum detected value) in each well for the duration of exposure. The exposure pathway does not consider that fluctuations in groundwater chemical concentrations, both spatially or temporally, will occur over time. These are very conservative assumptions as exposure to untreated water from JPL monitoring wells and nearby production wells cannot occur under any realistic exposure scenario now or in the future.

Intake Assumptions Used

The risks calculated depend largely on the assumptions used to calculate the rate of COPC intake. For this assessment, the Reasonable Maximum Exposure (RME) parameters

recommended by DTSC and EPA guidance were used. The uncertainties associated with the parameters used in this risk assessment are described below.

Absorption Factors

The amount of COPCs in groundwater the body may absorb may be different from the amount inhaled or ingested. Absorption associated with inhalation may be very high initially, especially for volatile organic compounds (VOCs), and then drop significantly once steady-state (stabilization) between the air and blood is reached. The values for the original absorption and the steady-state absorption are not known for most compounds; therefore, inhalation absorption factors were conservatively assumed to be 100 percent of oral. Similarly, the levels of absorption of contaminants following ingestion were not known and were conservatively assumed to be 100 percent of laboratory tests. Laboratory tests with VOCs often administer the dose in a way that increases absorption compared to a chemical in drinking water.

Exposure Frequency and Exposure Duration

Standard default values developed by EPA (EPA, 1991b), are used for RME frequency and exposure duration for residents. A resident is assumed to remain in his house 24 hours a day for 350 days per year for 30 years (carcinogens) or 6 years (noncarcinogens), as explained in Section 6.1.4.1. The 350-day exposure assumes two weeks of vacation away from home. These upper bound estimates are conservative values, and it is unlikely they will underestimate risk.

Body Weight

The average body weight for adults of 70 kg (154 pounds) and for children of 15 kg (33 pounds) were used (EPA, 1991b). If people weigh more than these estimated values, their intake per unit of body weight is expected to decrease, and their risks could be overestimated. Likewise, if people weigh less than these assumed body weights, their intake per unit of body weight is expected to increase, and their risks could be underestimated.

Uncertainties in Animal and Human Studies

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

Typically, animals are administered high doses (e.g., maximum tolerated dose) of a chemical in a standard diet or in air. Humans may be exposed to much lower doses in a highly variable diet, which may affect the toxicity of the chemical. In these studies, animals, usually laboratory rodents, are exposed daily to the chemical agent for various periods of time up to 2 years (their approximate lifespan). Humans have an average 70-year lifetime and may be exposed either intermittently or regularly for an exposure period ranging from months to a full lifetime. Because

of these differences, it is not surprising that extrapolation error is a large source of uncertainty in a risk assessment.

Non-Carcinogenic Toxicity Criteria

In the establishment of the non-carcinogenic criteria, conservative multipliers, known as uncertainty factors, are used. Many of the chronic non-carcinogenic toxicity criteria that were located in either IRIS or NCEA had uncertainty factors of 1,000. This means that the dose corresponding to the toxicological outcome (e.g., LOAEL) was divided by, or decreased by a factor of, 1,000. The purpose of the uncertainty factors is to account for the extrapolation of toxicity data from animals to humans and to ensure the protection of sensitive individuals.

Currently, there is much debate about the provisional RfD value for perchlorate and the actual risks from the chemical. A provisional RfD for perchlorate was developed based on an acute study in which single doses of potassium perchlorate caused the release of iodide from the thyroid gland of patients with Graves' disease. It was difficult to establish a dose-response for the effects on thyroid function from daily or repeated exposures in normal humans from the data on patients with Graves' disease because of a variety of confounding factors, including that the disease itself has effects; that often only a single exposure, rather than repeated exposures, was tested; that only one or two doses were employed; and that often the only effect monitored was iodide release from the thyroid or control of the hyperthyroid state. Currently laboratory animal toxicity studies are being conducted with perchlorate that will provide input into a potential revision of the provisional RfD.

Carcinogenic Toxicity Criteria

The availability and quality of toxicological data is another source of uncertainty in a risk assessment. Uncertainties associated with animal and human studies can influence the criteria. Carcinogenic criteria are classified according to the amount of evidence available that suggests human carcinogenicity. Each carcinogen is given a weight of evidence designation of A through E dependent on the strength of the evidence.

EPA assumes that there is no threshold for carcinogenic substances. That is, exposure to even one molecule of a carcinogen is sufficient to cause cancer. This is a conservative assumption because the body has several mechanisms to protect against cancer. This is especially true for carcinogens such as PCE and TCE. These carcinogens do not attack the DNA. Rather, their carcinogenic action is via a secondary, or tertiary, mechanism. For these compounds, a threshold dose does actually exist. If an individual were exposed to levels that would not exceed the threshold dose, it would be unlikely that the individual would get cancer. Therefore, by assuming that all potential human carcinogens do not have a threshold dose, considerable uncertainty and conservatism are incorporated into cancer risk assessments.

Uncertainty due to extrapolation of toxicological data for potential carcinogens tested in animals to humans is more prominent for potentially carcinogenic chemicals than non-carcinogenic ones.

EPA uses the Linearized Multi-Stage Model (LMS) to extrapolate the toxicological data. The LMS assumes that there is no threshold for carcinogenic substances; that is, exposure to even one molecule of a carcinogen is sufficient to cause cancer. As previously noted, this is a conservative assumption because the body has several mechanisms to protect against cancer.

The use of the LMS model to extrapolate is a well-recognized source of significant uncertainty in the development of carcinogenic toxicity criteria and, subsequently, theoretical carcinogenic risk estimates. Animal studies cannot determine what happens at low levels of exposure, however, which are generally typical of human exposure levels.

At low levels of exposure, the probability of cancer cannot be measured, but must be extrapolated from higher dosages. To do this, animals are typically exposed to carcinogens at levels that are orders of magnitude greater than those likely to be encountered by humans in the environment. It would be difficult, if not impossible, to perform animal experiments with a large enough number of animals to directly estimate the level of risk at the low exposure levels typically encountered by humans. Thus, to estimate the risk to humans exposed at low levels, dose-response data derived from animals given high dosages are extrapolated downward using mathematical models such as the LMS, which assumes that there is no threshold of response. The dose-response curve generated by the model is known as the maximum likelihood estimate. The slope of the 95 percent lower confidence interval (i.e., upper bound limit) curve, which is a function of the variability in the input animal data, is taken as the slope factor. The slope factors are then used directly in cancer risk assessment.

The federal government, including EPA itself, has acknowledged the limitations of the high-to-low dose extrapolation models, particularly the LMS (EPA, 1991c). In fact, this aspect of cancer risk assessment has been criticized by many scientists (including regulatory scientists) in recent years. In the process of re-evaluating the 1986 cancer risk assessment guidelines, EPA released proposed new draft cancer guidance (EPA, 1996b). This guidance proposes profound changes to the way in which carcinogenicity data is approached and used in the establishment of cancer criteria for use in risk assessment.

Several other factors inherent in the LMS result in overestimated carcinogenic potency including: (1) any exaggerations in the extrapolation that can be produced by some high dose responses (if they occur) are generally neglected, (2) upper confidence limits on the actual response observed in the animal study are used rather than the actual response, which can greatly overestimate risk, and (3) threshold carcinogens are modeled in the same manner as non-threshold chemicals.

The following excerpts are from the Regulatory Program of the United States Government, April 1990 - March 1991, Executive Office of the President (EPA, 1991c):

None of (the) purported advantages of the LMS approach has a sound statistical basis. It is a fundamental axiom of statistics that unbiased estimates are generally preferred to biased ones. Using the upper confidence limit instead of the unbiased estimate exaggerates underlying specification errors instead of eliminating them.

“Instability” is overcome, but at the cost of greater errors in specification. The problem with the LMS is that it generates biases that intensify with the degree to which the multistage model mis-specifies the true dose-response relationship.

The LMS cannot be justified as a method of scientific risk assessment. The “yardstick” defense implicitly asserts that scientific advancements in risk assessment methodology should take a back seat to the preservation of an outdated and misguided statistical procedure.

The habitual reliance upon either the multistage model or its LMS descendant cannot be supported by sound scientific principles.

Even if studies of chemical effect in humans are available, they generally are for workplace exposures far in excess of those expected in the environment. Uncertainties can be large because the activity patterns, exposure duration and frequency, individual susceptibility, and dose may not be the same in the study populations as in the individuals exposed to environmental concentrations. Another source of uncertainty arises from differences in regulatory agencies development of toxicity benchmark values. The State of California has developed its own cancer potency factors and considers hexavalent chromium a carcinogen via the oral route, whereas EPA does not consider this chemical an oral carcinogen. But, because conservative methods are used in developing the RfDs and SFs, the possibility of underestimating risks is low.

Combinations of Sources of Uncertainty

Uncertainties from different sources are compounded in the risk assessment. For example, if a person’s daily intake rate for a chemical is compared to an RfD to determine potential health risks, the conservatism and uncertainties in the concentration measurements, exposure assumptions, and toxicity will all be expressed in the result. Therefore, by combining all upper-bound numbers, the conservatism and uncertainty are compounded, and the resulting risk estimate is above the 90th or 95th percentile, perhaps even greater than the 99th percentile.

6.1.8 Summary

The two representative receptors chosen to model risk from hypothetical exposure to untreated groundwater at the JPL site were the residential adult and child. Noncancer and cancer risks were calculated based on a 6-year exposure for the child and a 30-year age-adjusted exposure averaged over 70 years for the adult. Exposure to untreated groundwater contamination was evaluated for ingestion, inhalation and dermal contact at each JPL monitoring well and nearby municipal production well. It was assumed that the receptors were exposed to the maximum detected or 95 percent UCL contaminant concentration, in each well for 350 days per year. The exposure scenario is a hypothetical situation that does not reflect realistic current or future land-use scenarios because there are no direct exposure pathways for humans to untreated groundwater in the study area. The receptors and scenarios modeled in this risk assessment represent a

conservative RME exposure scenario that is designed to determine where areas of risk may occur.

Non-cancer Risks

The evaluation of noncancer risks for the child receptor show that with the exception of four on-site monitoring wells (MW-7, -13, -16 and -24), all of the JPL monitoring wells produced HI values less than 10. Of the 23 JPL monitoring wells, the HI values were distributed as follows:

- HI < 1.0 6 wells
- HI = 1.0-2.0 5 wells
- HI = 2.0-10 8 wells
- HI > 10 4 wells

Analysis of the HI values based on target organ effects, indicates that 10 monitoring wells (MW-4, -7, -8, -10, -13, -16, -17, -18, -21 and -24) produced HI values that exceeded the benchmark value of 1.0 (Table 6-51). In these wells, carbon tetrachloride and perchlorate were consistently the predominant chemicals producing risk. Table 6-51 presents the chemicals by well that produced individual HI values greater than 1.0 and were the major contributors to the overall risk value.

Off-site monitoring wells MW-18 and MW-21 produced target organ HI values that only slightly exceeded the benchmark of 1.0 for liver and thyroid effects, respectively. MW-17 produced a liver HI value of 1.3 and a thyroid HI value of 4.7.

For nearby municipal production wells, the range of HI values was as follows:

- HI < 1.0 6 wells
- HI = 1.0-2.0 5 wells
- HI = 2.0-4.0 2 wells
- HI =>4.0 1 well

In the wells with HI values greater than 1.0, the major chemicals contributing to risk were arsenic and perchlorate (Valley Water Wells No. 1, 2, and 4); carbon tetrachloride and perchlorate (Pasadena Well 52 and Pasadena Arroyo Well); carbon tetrachloride, perchlorate and TCE (Lincoln Avenue well No. 3) and perchlorate and TCE (Lincoln Avenue Well No. 5). In three wells, the total organ HI value exceeded 1.0 as follows: Pasadena Well 52 (thyroid HI=1.9); Pasadena Arroyo (thyroid HI=17 and liver HI=3.1) and Lincoln Avenue Well No. 3 (thyroid HI=1.8). Table 6-52 presents the chemicals by well with individual HI values greater than 1.0.

Cancer Risks

Evaluation of cancer risks for JPL monitoring wells shows that greater than half of the wells had cancer risk values fall within EPA's range for acceptable levels of risk of 10^{-6} to 10^{-4} (1 in 1,000,000 to 1 in 10,000 increase in chance of getting cancer). Four wells had no cancer risks

because no carcinogenic chemicals were detected. Seven wells had cancer risk values greater than 10^{-4} , of which two wells (MW-7 and MW-16) had cancer risks greater than 10^{-3} .

The five wells with cancer risks values in the 10^{-4} range were as follows:

- MW-3 1.1E-04
- MW-12 1.6E-04
- MW-13 5.5E-04
- MW-18 1.2E-04
- MW-24 5.2E-04

Figure 6-6 presents a graphical distribution of the major contributors to the cancer risk values by well. Table 6-51 (JPL monitoring wells) and 6-52 (production wells) presents the major chemical contributors to cancer risk in wells with total cancer risks that exceeded 10^{-6} . The individual chemicals were considered major contributors, if their individual chemical total cancer risk were greater than 10^{-6} . For chemicals that were major contributors, Tables 6-53 and 6-54 present the percent contribution of each chemical to the total cancer risk estimate. These tables present the chemicals that are the predominant contributor to risk in each well.

Two wells, MW-3 and MW-18 slightly exceeded the EPA acceptable risk range ($>10^{-4}$) and the constituent contributing to the majority of the risk was arsenic. During the RI, arsenic was only consistently detected in the lowermost screen of MW-3 and randomly detected in a few other wells at very low levels (range 0.005–0.01 mg/L), all below the MCL value of 0.05 mg/L. The detection frequency of arsenic for the 1997-1998 RI data used for the risk assessment was 6 detections out of 278 samples (2%). Arsenic is a naturally occurring metal and the arsenic detections probably reflect natural concentrations of the analyte (see Section 4.0) and do not represent a human health concern. The EPA's risk management policy for arsenic suggests that arsenic-related cancer risks of up to $1.0E-03$ can be accepted because the cancer caused by the exposure is associated with a low mortality rate (as cited in EPA, 1996b).

Three other JPL monitoring wells had total cancer risks greater than 10^{-4} (MW-12, MW-13 and MW-24), and a variety of chemicals contributed to the total cancer risk value. For MW-12, Table 6-51 indicates that both carbon tetrachloride and chloroform produced individual cancer risks greater than 10^{-6} . Of these two chemicals, the carbon tetrachloride accounted for 99.9% of the total risk (Table 6-53) and the chloroform accounted for less than 1 percent of the total. The predominant chemical contributors in wells with cancer risks greater than 10^{-4} were as follows: MW-12 (carbon tetrachloride); MW-13 (carbon tetrachloride and hexavalent chromium) and MW-24 (carbon tetrachloride).

The two JPL wells with the highest total cancer risk were MW-7 (risk = $2.2E-03$) and MW-16 (risk = $1.4E-03$). In these wells carbon tetrachloride accounted for 91 percent and 86 percent, respectively, of the total risk value. These two wells also have the highest noncancer risk values (HI values of 193 and 222, respectively).

For the OU-3 JPL monitoring wells, four out of five wells had cancer risk values in the 10^{-5} range (1.0E-05 to 8.5E-05) and one well (MW-18) had a cancer risk value of 1.2E-04. All of these wells, with one exception (MW-18) have cancer risk values that fall within the EPA range for acceptable cancer risks of 10^{-6} to 10^{-4} . The cancer risk in MW-18 is primarily due to concentrations of arsenic, which account for 46 percent of the total risk. As discussed above, the detections of arsenic likely reflect natural background variability.

All of the cancer risk values for hypothetical exposure to untreated groundwater from nearby production wells were within EPA's range for acceptable cancer risks, with the exception of Valley Well No. 1 (cancer risk =1.3E-04). Tables 6-52 and 6-54 indicate that concentrations of arsenic and PCE are the primary contributors to the total hypothetical cancer risk in Valley Well No.1, which is located approximately ½ mile upgradient of JPL. The Valley Well No. 1 is outside the known influence of JPL impacted groundwater due to the lack of PCE at the JPL site and appears to be impacted from commercial activities not associated with JPL. Arsenic and PCE also account for the majority of the hypothetical cancer risk values for exposure to untreated groundwater in Valley Wells Nos. 2, 3, and 4.

6.2 SCOPING ASSESSMENT OF ECOLOGICAL RISK

An initial scoping assessment of ecological risks was completed at JPL (Foster Wheeler, 1996g) to determine if a quantitative ecological assessment of the potential risks to biota (plants and animals) associated with contamination found at the site was required. The scoping assessment qualitatively evaluated potential ecological receptors, constituents of concern, and potentially complete exposure pathways for soil, soil vapor and groundwater contamination. An evaluation of ecological risk is required because ecological receptors are frequently more sensitive to contaminant-induced effects than humans, and may be exposed to different levels of contaminants than would be expected for humans. This section summarizes the scoping ecological assessment as it related to the groundwater beneath and downgradient of JPL.

The scoping assessment used a habitat approach as the basis for identifying potentially complete pathways between areas of contamination and specific plant and animal species that occupy or potentially occupy the site. Potentially affected habitats within or adjacent to the JPL site were found to include: urban landscape, chaparral, riparian, wetlands, southern oak woodland, and desert wash. A wide variety of plant and animal (invertebrates, amphibians, reptiles, birds, and mammals) species were catalogued during field surveys by Foster Wheeler personnel and from reported observations from JPL personnel. In addition, lists of threatened or endangered species that could occur in the JPL area were compiled. From the list of plant and animal inhabitants, representative receptors for the various trophic (food chain) levels were identified for each identified habitat to allow for the evaluation of the interactions within the ecosystem that might be important in the identification of exposure pathways for potential receptors. The constituents of concern evaluated for groundwater included the metals and VOCs that had been detected in groundwater during the RI (Foster Wheeler, 1996g).

The chaparral and southern oak woodland habitats are found only in the San Gabriel Mountains to the north of the JPL site. Because no contamination was known or suspected within the chaparral and southern oak woodland habitats, no potential exposure pathways were identified for these habitats. The riparian, desert wash and wetland habitats occur off-site only, and contaminated groundwater typically underlies these habitats at depths of approximately 100 ft or more. For this reason, there are no plausible groundwater exposure pathways to plants and animals within the riparian, desert wash, and wetland habitats. The urban landscape habitat is the predominant on-site JPL habitat. As with the off-site habitats, contamination of groundwater is found at depths between approximately 100 to 250 feet and therefore no groundwater exposure pathways to plants and animals are plausible within the on-site JPL urban landscape habitat.

It was therefore concluded that since there were no complete exposure pathways from groundwater to site biota, that no further characterization of ecological risks to plants and animals due to JPL groundwater contamination was warranted.

TABLE 6-1
RESULTS OF STEP 1 OF COPC SELECTION PROCESS
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
Jet Propulsion Laboratory—Summary of Data for Monitoring Wells (1994-1998)

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Monitoring Wells (1994-1998)—Tap Water

CAS Number	Chemical	(1)		(1)		Units	Location of Maximum Concentration	Detection Frequency	Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
		Minimum Concentration	Minimum Qualifier	Maximum Concentration	Maximum Qualifier									
71-55-6	1,1,1-Trichloroethane	1.2	--	1.2	--	ug/L	MW-10	1/533	0.5	1.2	N/A	480	No	BSL
79-34-5	1,1,2,2-Tetrachloroethane	0.6	--	0.6	--	ug/L	MW-21-2	1/533	0.5	0.6	N/A	0.055	Yes	ASL
75-34-3	1,1-Dichloroethane	0.6	--	3.9	--	ug/L	MW-14-1	30/533	0.5	3.9	N/A	5.8	No	BSL
75-35-4	1,1-Dichloroethene	0.5	--	4.7	--	ug/L	MW-16	39/533	0.5	4.7	N/A	0.046	Yes	ASL
87-61-6	1,2,3-Trichlorobenzene (5)	0.5	--	0.8	--	ug/L	MW-14-2	4/533	0.5	0.8	N/A	120	No	BSL
107-06-2	1,2-Dichloroethane	0.6	--	8.9	--	ug/L	MW-13	35/533	0.5	8.9	N/A	0.12	Yes	ASL
7429-90-5	Aluminum	0.05	--	1.1	--	mg/L	MW-12-1	42/151	0.05	1.1	N/A	16	No	BSL
7440-38-2	Arsenic	0.005	--	0.014	--	mg/L	MW-03-5	12/529	0.005	0.014	N/A	0.000040	Yes	ASL
7440-39-3	Barium	0.021	--	0.15	--	mg/L	MW-21-3	125/129	0.02	0.15	N/A	1.1	No	BSL
56-55-3	Benzo(a)anthracene	12	--	12	--	ug/L	MW-12-2	1/135	0.05	12	N/A	0.020	Yes	ASL
50-32-8	Benzo(a)pyrene	16	--	16	--	ug/L	MW-12-2	1/135	0.02	16	N/A	0.0015	Yes	ASL
205-99-2	Benzo(b)fluoranthene	28	--	28	--	ug/L	MW-12-2	1/135	0.02	28	N/A	0.016	Yes	ASL
191-24-2	Benzo(g,h,i)perylene	10	--	10	--	ug/L	MW-12-2	1/131	0.05	10	N/A	N/A	Yes	NTX
207-08-9	Benzo(k)fluoranthene	11	--	11	--	ug/L	MW-12-2	1/131	0.02	11	N/A	0.016	Yes	ASL
75-27-4	Bromodichloromethane	0.5	--	1.9	--	ug/L	MW-18-2	27/533	0.5	1.9	N/A	0.18	Yes	ASL
7440-70-2	Calcium	3.8	--	180	--	mg/L	MW-23-1	508/508	1	180	N/A	N/A	No	NUT
56-23-5	Carbon Tetrachloride	0.5	--	310	--	ug/L	MW-07	130/533	0.5	310	N/A	0.17	Yes	ASL
67-66-3	Chloroform	0.5	--	58	--	ug/L	MW-16	257/533	0.5	58	N/A	0.16	Yes	ASL
74-87-3	Chloromethane	0.8	--	0.8	--	ug/L	MW-12-4	1/533	0.5	0.8	N/A	1.5	No	BSL
n/a	Chromium	0.01	--	0.24	--	mg/L	MW-06	58/506	0.01	0.24	N/A	N/A	No	NTX
218-01-9	Chrysene	21	--	21	--	ug/L	MW-12-2	1/131	0.02	21	N/A	0.20	Yes	ASL
7440-50-8	Copper	0.012	--	0.044	--	mg/L	MW-18-4	5/129	0.01	0.044	N/A	0.58	No	BSL
57-12-5	Cyanide	0.006	--	0.006	--	mg/L	MW-11-1	2/129	0.005	0.006	N/A	0.31	No	BSL
84-74-2	Di-n-butylphthalate	10	--	16	--	ug/L	MW-11-1	9/131	10	16	N/A	1500	No	BSL
75-09-2	Dichloromethane	0.7	--	2.1	--	ug/L	MW-03-5	4/533	0.5	2.1	N/A	3.8	No	BSL
100-41-4	Ethylbenzene	0.5	--	0.5	--	ug/L	MW-03-5	1/533	0.5	0.5	N/A	1300	No	BSL
206-44-0	Fluoranthene	39	--	39	--	ug/L	MW-12-2	1/130	5	39	N/A	460	No	BSL
16984-48-8	Fluoride	0.15	--	3.67	--	mg/L	MW-03-5	129/129	0.1	3.67	N/A	0.94	Yes	ASL
75-69-4	Fluorotrichloromethane	0.8	--	1.8	--	ug/L	MW-13	5/533	0.5	1.8	N/A	1300	No	BSL
7440-47-3	Hexavalent Chromium	0.006	--	0.047	--	mg/L	MW-13	30/507	0.005	0.047	N/A	0.00016	Yes	ASL
193-39-5	Indeno(1,2,3-c,d)pyrene	10	--	10	--	ug/L	MW-12-2	1/130	0.05	10	N/A	0.011	Yes	ASL
7439-89-6	Iron	0.055	--	7.2	--	mg/L	MW-19-2	429/508	0.1	7.2	N/A	4.7	Yes	ASL
7439-92-1	Lead	0.0012	--	0.028	--	mg/L	MW-14-5	35/527	0.002	0.028	N/A	0.0040	Yes	ASL

**TABLE 6-1
RESULTS OF STEP 1 OF COPC SELECTION PROCESS
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
Jet Propulsion Laboratory—Summary of Data for Monitoring Wells (1994-1998)**

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Monitoring Wells (1994-1998)—Tap Water

CAS Number	Chemical	(1)		(1)		Units	Location of Maximum Concentration	Detection Frequency	Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
		Minimum Concentration	Minimum Qualifier	Maximum Concentration	Maximum Qualifier									
7439-95-4	Magnesium	1.0	--	58	--	mg/L	MW-14-2	503/508	0.1	58	N/A	N/A	No	NUT
7439-97-6	Mercury	0.0002	--	0.0002	--	mg/L	MW-21-2	3/130	0.0002	0.0002	N/A	0.0047	No	BSL
1634-04-4	Methyl tert-butyl ether	0.7	--	7.1	--	ug/L	MW-11-1	2/243	0.5	7.1	N/A	20	No	BSL
7439-89-7	Molybdenum	0.025	--	0.025	--	mg/L	MW-20-4	1/129	0.02	0.025	N/A	0.078	No	BSL
91-20-3	Naphthalene	0.7	--	1.9	--	ug/L	MW-03-2	2/526	0.5	1.9	N/A	0.017	Yes	ASL
7440-02-0	Nickel	0.01	--	0.044	--	mg/L	MW-18-4	14/129	0.01	0.044	N/A	0.31	No	BSL
14797-55-8	Nitrate	0.1	--	20	--	mg/L	MW-14-1	445/508	0.1	20	N/A	10	Yes	ASL
7601-90-3	Perchlorate	4.1	--	1230	--	ug/L	MW-16	76/214	4	1230	N/A	7.8	Yes	ASL
85-01-8	Phenanthrene	29	--	29	--	ug/L	MW-12-2	1/129	5	29	N/A	N/A	Yes	NTX
7440-09-7	Potassium	1.0	--	9.7	--	mg/L	MW-01	507/508	1	9.7	N/A	N/A	No	NUT
129-00-0	Pyrene	33	--	33	--	ug/L	MW-12-2	1/129	5	33	N/A	180	No	BSL
7440-23-5	Sodium	2.5	--	120	--	mg/L	MW-20-4	508/508	1	120	N/A	N/A	No	NUT
7440-24-6	Strontium	0.076	--	1.3	--	mg/L	MW-21-2	129/129	0.01	1.3	N/A	9.4	No	BSL
127-18-4	Tetrachloroethene	0.5	--	4.5	--	ug/L	MW-21-5	143/533	0.5	4.5	N/A	0.87	Yes	ASL
108-88-3	Toluene	0.6	--	1.2	--	ug/L	MW-01	6/533	0.5	1.2	N/A	720	No	BSL
688-73-3	Tributyltin	2	--	5	--	ng/l	MW-12-1	3/19	2	5.0	N/A	4700	No	BSL
79-01-6	Trichloroethene	0.5	--	73	--	ug/L	MW-13	143/533	0.5	73	N/A	1.6	Yes	ASL
76-13-1	Trichlorotrifluoroethane	0.5	--	8.8	--	ug/L	MW-07	37/533	0.5	8.8	N/A	59000	No	BSL
7440-66-6	Zinc	0.02	--	0.065	--	mg/L	MW-18-5	57/129	0.02	0.065	N/A	4.7	No	BSL
156-59-2	cis-1,2-Dichloroethene	0.6	--	0.6	--	ug/L	MW-21-5	1/533	0.5	0.6	N/A	61	No	BSL
n/a	m,p-Xylenes	1.3	--	1.3	--	ug/L	MW-01	1/533	0.5	1.3	N/A	1400	No	BSL

- (1) Minimum/maximum detected concentration
- (2) Applicable background information was not available.
- (3) Screening toxicity value derived in accordance with State of California Department of Toxic Substances Control Preliminary *Endangerment Assessment Guidance Manual* (DTSC 1994) and EPA *Region 9 PRG Table* (EPA 1999)
- (4) Rationale Codes Selection Reason: Above Screening Levels (ASL)
- Deletion Reason: Below Screening Level (BSL)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
- (5) Toxicity information not available for 1,2,3-trichlorobenzene. Toxicity information from 1,2,4-trichlorobenzene used as a surrogate.

Definitions:

CAS = Chemical Abstract Service
COPC = chemical of potential concern
DTSC = Department of Toxic Substances Control
EPA = U.S. Environmental Protection Agency
mg/L = milligrams per liter
MW = monitoring well
N/A = Not applicable
PRG = Preliminary Remedial Goal
ug/L = micrograms per liter

**TABLE 6-2
RESULTS OF STEP 2 OF COPC SELECTION PROCESS
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
Jet Propulsion Laboratory—Summary of Data for Monitoring Wells (1997-1998)**

Scenario Timeframe: Current/Future

Medium: Groundwater

Exposure Medium: Groundwater

Exposure Point: Monitoring Wells (1997-1998)—Tap Water

CAS Number	Chemical	(1)		(1)		Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background (2) Value	Screening (3) Toxicity Value	COPC Flag	Rationale (4) for Contaminant Deletion or Selection
		Minimum Concentration	Minimum Qualifier	Maximum Concentration	Maximum Qualifier									
79-34-5	1,1,2,2-Tetrachloroethane	N/D	--	N/D	--	ug/L	N/D	0/278	0.5	N/D	N/A	0.055	No	ND
75-35-4	1,1-Dichloroethene	0.50	--	2.6	--	ug/L	MW-16	18/278	0.5	2.6	N/A	0.046	Yes	ASL
107-06-2	1,2-Dichloroethane	0.8	--	2.1	--	ug/L	MW-16	15/278	0.5	2.1	N/A	0.12	Yes	ASL
7440-38-2	Arsenic	0.005	--	0.01	--	mg/L	MW-03-5	6/278	0.005	0.01	N/A	0.00004	Yes	ASL
56-55-3	Benzo(a)anthracene	N/A	--	N/A	--	N/A	N/A	N/A	0.05	N/A	N/A	0.020	No	NA
50-32-8	Benzo(a)pyrene	N/A	--	N/A	--	N/A	N/A	N/A	0.02	N/A	N/A	0.0015	No	NA
205-99-2	Benzo(b)fluoranthene	N/A	--	N/A	--	N/A	N/A	N/A	0.02	N/A	N/A	0.0155	No	NA
191-24-2	Benzo(g,h,i)perylene	N/A	--	N/A	--	N/A	N/A	N/A	0.05	N/A	N/A	N/A	No	NA
207-08-9	Benzo(k)fluoranthene	N/A	--	N/A	--	N/A	N/A	N/A	0.02	N/A	N/A	0.0155	No	NA
75-27-4	Bromodichloromethane	0.5	--	0.9	--	ug/L	MW-17-3	12/278	0.5	0.9	N/A	0.18	Yes	ASL
56-23-5	Carbon Tetrachloride	0.6	--	150	--	ug/L	MW-07	67/278	0.5	150	N/A	0.17	Yes	ASL
67-66-3	Chloroform	0.5	--	43	--	ug/L	MW-13	126/278	0.5	43	N/A	0.16	Yes	ASL
218-01-9	Chrysene	N/A	--	N/A	--	N/A	N/A	N/A	0.02	N/A	N/A	0.20	No	NA
16984-48-8	Fluoride	N/A	--	N/A	--	N/A	N/A	N/A	0.1	N/A	N/A	0.94	No	NA
7440-47-3	Hexavalent Chromium	0.006	--	0.045	--	mg/L	MW-13	13/279	0.005	0.045	N/A	0.00016	Yes	ASL
193-39-5	Indeno(1,2,3-c,d)pyrene	N/A	--	N/A	--	N/A	N/A	N/A	0.05	N/A	N/A	0.011	No	NA
7439-89-6	Iron	0.055	--	4.4	--	mg/L	MW-23-3	214/263	0.1	4.4	N/A	4.69	No	BSL
7439-92-1	Lead	0.0012	--	0.028	--	mg/L	MW-14-5	18/278	0.002	0.028	N/A	0.004	Yes	ASL
91-20-3	Naphthalene	N/D	--	N/D	--	ug/L	N/D	0/278	0.5	N/D	N/A	0.0173	No	ND
14797-55-8	Nitrate	0.1	--	19	--	mg/L	MW-14-1	233/263	0.1	19	N/A	10	Yes	ASL
7601-90-3	Perchlorate	4.1	--	1230	--	ug/L	MW-16	76/214	4.0	1230	N/A	7.82	Yes	ASL
85-01-8	Phenanthrene	N/A	--	N/A	--	N/A	N/A	N/A	5.0	N/A	N/A	N/A	No	NA
127-18-4	Tetrachloroethene	0.5	--	4.4	--	ug/L	MW-21-4	71/278	0.5	4.4	N/A	0.87	Yes	ASL
79-01-6	Trichloroethene	0.5	--	29	--	ug/L	MW-21-1	74/278	0.5	29	N/A	1.6	Yes	ASL

(1) Minimum/maximum detected concentration

(2) Applicable background information was not available.

(3) Screening toxicity value derived in accordance with State of California Department of Toxic Substances Control Preliminary Endangerment Assessment Guidance Manual (DTSC 1994) and EPA Region 9 PRG Table (EPA 1999)

(4) Rationale Codes Selection Reason: Above Screening Levels (ASL)

Deletion Reason: Below Screening Level (BSL)

Not Detected (ND)

Not Analyzed (NA) in 1997-1998 sampling—See discussion in text

Definitions:

CAS = Chemical Abstract Service

COPC = chemical of potential concern

DTSC = Department of Toxic Substances Control

EPA = U.S. Environmental Protection Agency

mg/L = milligrams per liter

MW = monitoring well

N/A = Not analyzed in the 1997-1998 sampling events

N/D = Not detected

PRG = Preliminary Remedial Goal

ug/L = micrograms per liter

TABLE 6-3
 OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
 TIC Information 1994-1998 Jet Propulsion Laboratory - All Wells

Scenario Timeframe: Current/Future
 Medium: Groundwater
 Exposure Medium: Groundwater
 Exposure Point: Monitoring Wells (1994-1998) - Tap Water*

CAS Number	Chemical	Minimum Concentration ⁽¹⁾	Minimum Qualifier	Maximum Concentration ⁽¹⁾	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening ⁽²⁾	Background Value ⁽³⁾	Screening Toxicity Value	COPC Flag	Rationale for Contaminant Deletion or Selection ⁽⁴⁾
96-76-4	2,4-bis(1,1-Dimethylethyl)phenol	32	t	32	t	ug/L	MW-11-5	1/1		32	N/A	N/A	No	NTX
115-11-7	2-Methyl-1-propene	1.5	t	1.5	t	ug/L	MW-11-4	1/1		1.5	N/A	N/A	No	NTX
75-28-5	2-Methylpropane	1.6	t	1.6	t	ug/L	MW-04-2	1/1		1.6	N/A	N/A	No	NTX
85-60-9	4,4'-butylidenebis[2-(1,1-dimethylphenol)]	9.2	t	9.2	t	ug/L	MW-17-2	1/1		9.2	N/A	N/A	No	NTX
64-19-7	Acetic acid	2.0	t	5.1	t	ug/L	MW-19-1	2/2		5.1	N/A	N/A	No	NTX
67-67-1	Acetone	1.1	t	5.5	t	ug/L	MW-18-3	40/40		5.5	N/A	610	No	BSL
75-15-0	Carbon Disulfide	0.5	t	44	t	ug/L	MW-11-5	20/20		44	N/A	1000	No	BSL
100-41-4	Ethylbenzene (5)	9.1	t	9.3	t	ug/L	MW-21-4	2/2		9.3	N/A	1300	No	BSL
110-54-3	Hexane	1.0	t	7.4	t	ug/L	MW-04-5	2/2		7.4	N/A	350	No	BSL
3622-84-2	N-Butyl-benzenesulfonamide	8.9	t	8.9	t	ug/L	MW-03-5	1/1		8.9	N/A	N/A	No	NTX
7446-09-5	Sulfur dioxide	2.7	t	2.7	t	ug/L	MW-03-5	1/1		2.7	N/A	N/A	No	NTX

(1) Minimum/maximum detected concentration.

(2) Maximum value of the detected concentrations was used as screening value

(3) Background information was not available.

(4) Rationale Codes Selection Reason: N/A

Deletion Reason: Below Screening Level (BSL)
 No Toxicity Information (NTX)

(5) Concentration based on semi-volatile compound methodology for ethylbenzene

Definitions:

CAS = Chemical Abstract Service

COPC = Chemical of potential concern

MW = Monitoring Well

N/A = Not applicable

t = Tentatively identified compound

ug/L = micrograms per liter

*Off-site wells include MW-17, MW-18, MW-19, MW-20, and MW-21.

TABLE 6-4

**SUMMARY OF EXPOSURE POINT CONCENTRATIONS FOR
CHEMICALS OF POTENTIAL CONCERN FOR WELLS AT THE JET PROPULSION LABORATORY**

Chemical of Potential Concern	Units*	Exposure Point Concentrations (a)									
		MW-01	MW-03	MW-04	MW-05	MW-06	MW-07	MW-08	MW-09	MW-10	MW-11
1,1-Dichloroethene	µg/L	--	--	0.39	--	--	2.1 (m)	--	--	--	--
1,2-Dichloroethane	µg/L	--	--	0.33	--	--	0.89	--	--	--	--
Arsenic	mg/L	--	0.0041	--	--	--	--	--	--	--	--
Bromodichloromethane	µg/L	--	0.3	--	--	--	--	--	--	--	--
Carbon Tetrachloride	µg/L	--	0.49	3.7	--	--	150 (m)	3.2 (m)	--	--	0.69
Chloroform	µg/L	--	1.3	3.2	--	--	13 (m)	1.3 (m)	--	1.4 (m)	0.85
Hexavalent Chromium	mg/L	--	--	--	--	--	0.01 (m)	--	--	--	--
Lead	mg/L	--	0.0015	--	--	--	--	0.0023 (m)	--	--	0.0017
Nitrate	mg/L	1.5 (m)	1.1	8.2	2.4 (m)	11 (m)	6.5 (m)	3.7 (m)	5.5 (m)	18 (m)	0.63
Perchlorate	µg/L	--	6.4	38	4.2 (m)	5.5 (m)	720 (m)	29 (m)	--	16 (m)	--
Tetrachloroethene	µg/L	--	0.29	0.29	--	2.0 (m)	3.7 (m)	--	--	2.2 (m)	--
Trichloroethene	µg/L	--	0.32	10	--	--	27 (m)	4.5 (m)	--	5.2 (m)	--

TABLE 6-4

**SUMMARY OF EXPOSURE POINT CONCENTRATIONS FOR
CHEMICALS OF POTENTIAL CONCERN FOR WELLS AT THE JET PROPULSION LABORATORY**

Chemical of Potential Concern	Units*	Exposure Point Concentrations (a)								
		MW-12	MW-13	MW-14	MW-15	MW-16	MW-17	MW-18	MW-19	MW-20
1,1-Dichloroethene	µg/L	--	0.96	--	--	2.6 (m)	--	--	--	--
1,2-Dichloroethane	µg/L	--	1.1 (m)	--	--	2.1 (m)	--	--	--	--
Arsenic	mg/L	--	--	--	--	--	--	0.0028	--	0.0029
Bromodichloromethane	µg/L	--	--	--	--	--	0.44	0.41	0.28	0.28
Carbon Tetrachloride	µg/L	12	16	--	--	91 (m)	1.6	1.3	--	--
Chloroform	µg/L	2.0	11 (m)	0.46	--	43 (m)	7.6	6.6 (m)	1.2	2.2
Hexavalent Chromium	mg/L	--	0.041	--	--	0.007 (m)	0.0033	0.003	--	--
Lead	mg/L	0.0012	0.0016	0.0032	--	--	0.0012	--	0.0012	0.0013
Nitrate	mg/L	1.5	9.6 (m)	19 (m)	4.4 (m)	18 (m)	2.3 (m)	3.8	11 (m)	15 (m)
Perchlorate	µg/L	7.0	255	3.6	--	1230 (m)	36.3	6.8	2.7	3.2
Tetrachloroethene	µg/L	--	0.4	0.79	--	1.3 (m)	0.57	1.5	1.8	--
Trichloroethene	µg/L	0.28	29 (m)	0.46	--	25 (m)	23 (m)	1.7	0.46	--

TABLE 6-4

**SUMMARY OF EXPOSURE POINT CONCENTRATIONS FOR
CHEMICALS OF POTENTIAL CONCERN FOR WELLS AT THE JET PROPULSION LABORATORY**

Chemical of Potential Concern	Units*	Exposure Point Concentrations (a)								
		MW-21	MW-22	MW-23	MW-24	LCW #1	LFW #2	LAW #3	LAW #5	PAW
1,1-Dichloroethene	µg/L	--	--	--	--	--	--	--	--	--
1,2-Dichloroethane	µg/L	--	--	--	0.39	--	--	--	--	--
Arsenic	mg/L	--	--	--	0.0034	--	2.4 (m)	--	--	--
Bromodichloromethane	µg/L	--	--	--	--	--	--	--	--	--
Carbon Tetrachloride	µg/L	--	--	--	30 (m)	--	--	1.1	--	4.7 (m)
Chloroform	µg/L	0.68	--	0.52	15 (m)	--	--	--	--	--
Hexavalent Chromium	mg/L	--	--	--	--	--	--	--	--	--
Lead	mg/L	0.0016	--	--	--	--	--	--	--	--
Nitrate	mg/L	17 (m)	11 (m)	15 (m)	3.4	--	--	--	--	--
Perchlorate	µg/L	8.1	5.0	5.6	330 (m)	--	6.1	14	7.0 (m)	130 (m)
Tetrachloroethene	µg/L	3.7	1.4	0.65	0.32	0.6 (m)	4.8 (m)	1.1 (m)	0.7 (m)	0.89
Trichloroethene	µg/L	9.0	--	2.9	15 (m)	--	--	16 (m)	13 (m)	3.4

TABLE 6-4

**SUMMARY OF EXPOSURE POINT CONCENTRATIONS FOR
CHEMICALS OF POTENTIAL CONCERN FOR WELLS AT THE JET PROPULSION LABORATORY**

Chemical of Potential Concern	Units*	Exposure Point Concentrations (a)								
		PVW	PW-52	PWW	RCW #4	RCW #7	VW #1	VW #2	VW #3	VW #4
1,1-Dichloroethene	µg/L	--	--	--	--	--	--	--	--	--
1,2-Dichloroethane	µg/L	--	--	--	--	--	--	--	--	--
Arsenic	mg/L	--	--	--	--	--	1.9 (m)	2.0 (m)	1.5 (m)	1.9 (m)
Bromodichloromethane	µg/L	--	--	--	--	--	--	--	--	--
Carbon Tetrachloride	µg/L	--	1.3 (m)	--	--	--	--	--	--	--
Chloroform	µg/L	--	--	--	--	--	--	--	--	--
Hexavalent Chromium	mg/L	--	--	--	--	--	--	--	--	--
Lead	mg/L	--	--	--	--	--	--	--	--	--
Nitrate	mg/L	--	--	--	--	--	--	--	--	--
Perchlorate	µg/L	4.9	15 (m)	--	5.5	3.2	3.9	4.0 (m)	4.4 (m)	3.9
Tetrachloroethene	µg/L	0.7 (m)	--	1.1 (m)	--	--	38 (m)	9.1 (m)	1.1 (m)	23 (m)
Trichloroethene	µg/L	1.1	5.2	1.2 (m)	--	--	3.5 (m)	1.0 (m)	--	2.6 (m)

Notes:

-- = Not detected

mg/L = milligrams per liter

(m) = maximum detection used as the exposure point concentration

LAW = Lincoln Avenue Well

LCW = La Canada Well

LFW = Las Flores Well

µg/L = micrograms per liter

MW = monitoring well

PAW = Pasadena Arroyo Well

PVW = Pasadena Ventura Well

PW-52 = Pasadena Well 52

PWW = Pasadena Windsor Well

RCW = Rubio Cañon Well

UCL = upper confidence limit

VW = Valley Well

(a) = All exposure point concentrations are the 95% UCL of log-transformed data, unless otherwise noted.

* = Organic chemical units are µg/L and inorganic chemical units are mg/L.

TABLE 6-5
CARCINOGENIC AND NONCARCINOGENIC INTAKE EQUATIONS FOR
GROUNDWATER AT THE JET PROPULSION LABORATORY

Carcinogenic Intake Equations ^(a)

Ingestion

$$\text{Intake} = \left(\frac{CW \cdot IRW_A \cdot EF \cdot ED_A \cdot CF1}{BW_A \cdot AT_C \cdot CF2} \right) + \left(\frac{CW \cdot IRW_C \cdot EF \cdot ED_C \cdot CF1}{BW_C \cdot AT_C \cdot CF2} \right)$$

Dermal

$$\text{Intake} = \left(\frac{CW \cdot SA_A \cdot PC \cdot ET_A \cdot EF_A \cdot ED_A \cdot CF1 \cdot CF3}{BW_A \cdot AT_C \cdot CF2} \right) + \left(\frac{CW \cdot SA_C \cdot PC \cdot ET_C \cdot EF_C \cdot ED_C \cdot CF1 \cdot CF3}{BW_C \cdot AT_C \cdot CF2} \right)$$

Inhalation

$$\text{Intake} = \left(\frac{CW \cdot VF \cdot IH_A \cdot ED_A \cdot EF_A \cdot CF1}{BW_A \cdot AT_C \cdot CF2} \right) + \left(\frac{CW \cdot VF \cdot IH_C \cdot ED_C \cdot EF_C \cdot CF1}{BW_C \cdot AT_C \cdot CF2} \right)$$

Noncarcinogenic Intake Equations ^(a)

Ingestion

$$\text{Intake} = \frac{CW \cdot IRW_C \cdot EF \cdot ED_C \cdot CF1}{BW_C \cdot AT_N \cdot CF2}$$

Dermal

$$\text{Intake} = \frac{CW \cdot SA_C \cdot PC \cdot ET_C \cdot EF_C \cdot ED_C \cdot CF1 \cdot CF3}{BW_C \cdot AT_N \cdot CF2}$$

Inhalation

$$\text{Intake} = \frac{CW \cdot VF \cdot IH_C \cdot ED_C \cdot EF_C \cdot CF1}{BW_C \cdot AT_N \cdot CF2}$$

(a) Refer to Table 6-6 for definition of parameters.

**TABLE 6-6
VALUES USED FOR DAILY INTAKE CALCULATIONS
Jet Propulsion Laboratory—Operable Units 1 and 3**

Scenario Timeframe: Current/Future

Medium: Groundwater

Exposure Medium: Tap Water

Exposure Point: Sitewide

Receptor Population: Resident

Receptor Age: Child/Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	Intake Equation/Model Name
Ingestion	CW	Chemical Concentration in Water	ug/L	See Table 3	See Table 6-3	Chronic Daily Intake (CDI) for carcinogens (mg/kg-day) = (CW x IRW-A x EF x ED-A x CF1 x 1/BW-A x 1/AT-C x 1/CF2) + (CW x IRW-C x EF x ED-C x CF1 x 1/BW-C x 1/AT-C x 1/CF2)
	IRW-A	Ingestion Rate of Water for Adults	liters/day	2	EPA, 1991	
	IRW-C	Ingestion Rate of Water for Children	liters/day	1	EPA, 1991	CDI for non-carcinogens (mg/kg-day) = (CW x IRW-C x EF x ED-C x CF1 x 1/BW-C x 1/AT-N x 1/CF2)
	EF	Exposure Frequency	days/year	350	EPA, 1991	
	ED-A	Exposure Duration for Adults	years	24	EPA, 1991	
	ED-C	Exposure Duration for Children	years	6	EPA, 1991	
	CF1	Conversion Factor 1	mg/ug	1.00E-03	N/A	
	CF2	Conversion Factor 2	days/year	365	N/A	
	BW-A	Body Weight for Adults	kg	70	EPA, 1991	
	BW-C	Body Weight for Children	kg	15	EPA, 1991	
	AT-C	Averaging Time (Cancer)	years	70	EPA, 1989	EPA, 1989
	AT-N	Averaging Time (Non-cancer)	years	6	EPA, 1989	
Dermal	CW	Chemical Concentration in Water	ug/L	See Table 3	See Table 6-3	CDI for carcinogens (mg/kg-day) = (CW x SA-A x PC x ET-A x EF-A x ED-A x CF1 x CF3 x 1/BW-A x 1/AT-C x 1/CF2) + (CW x SA-C x PC x ET-C x EF-C x ED-C x CF1 x CF3 x 1/BW-C x 1/AT-C x 1/CF2)
	CF1	Conversion Factor 1	mg/ug	1.00E-03	N/A	
	CF2	Conversion Factor 2	days/year	365	N/A	DTSC, 1994
	CF3	Volumetric Conversion Factor for Water	L/cm3	1.00E-03	N/A	
	PC	Permeability Constant	cm/hr	chemical-specific	EPA, 1992	EPA, 1992
	ET-A	Exposure Time for Adults	hr/day	0.25	EPA, 1992	
	ET-C	Exposure Time for Children	hr/day	0.25	EPA, 1997	EPA, 1997
	SA-A	Skin Surface Area Available for Contact for Adults	cm2	18,000	EPA, 1997	
	SA-C	Skin Surface Area Available for Contact for Children	cm2	6,600	EPA, 1997	CDI for non-carcinogens (mg/kg-day) = (CW x SA-C x PC x ET-C x EF-C x ED-C x CF1 x CF3 1/BW-C x 1/AT-N x 1/CF2)
	EF-A	Exposure Frequency for Adults	days/year	350	EPA, 1991	
	EF-C	Exposure Frequency for Children	days/year	350	EPA, 1991	EPA, 1991
	ED-A	Exposure Duration for Adults	years	24	EPA, 1991	
	ED-C	Exposure Duration for Children	years	6	EPA, 1991	EPA, 1991
	BW-A	Body Weight for Adults	kg	70	EPA, 1991	
	BW-C	Body Weight for Children	kg	15	EPA, 1991	EPA, 1989
	AT-C	Averaging Time (Cancer)	years	70	EPA, 1989	
	AT-N	Averaging Time (Non-cancer)	years	6	EPA, 1989	
Inhalation	CA	Chemical Concentration in Air	ug/L	See Table 3	See Table 6-3	CDI for carcinogens (mg/kg-day) = (CW x VF x IH-A x ED-A x EF-A x CF1 x 1/BW-A x 1/AT-C x 1/CF2) + (CW x VF x IH-C x ED-C x EF-C x CF1 x 1/BW-C x 1/AT-C x 1/CF2)
	CF1	Conversion Factor 1	mg/ug	1.0E-03	N/A	
	CF2	Conversion Factor 2	days/year	365	N/A	EPA, 1991, DTSC, 1992
	IH-A	Inhalation Rate for Adults	m3/day	20	EPA, 1989, DTSC, 1992	
	IH-C	Inhalation Rate for Children	m3/day	10	EPA, 1991	CDI for non-carcinogens (mg/kg-day) = (CW x VF x IH-C x ED-C x EF-C x CF1 x 1/BW-C x 1/AT-N x 1/CF2)
	EF-A	Exposure Frequency for Adults	days/year	350	EPA, 1991	
	EF-C	Exposure Frequency for Children	days/year	350	EPA, 1991	EPA, 1991
	ED-A	Exposure Duration for Adults	years	24	EPA, 1991	

**TABLE 6-6
VALUES USED FOR DAILY INTAKE CALCULATIONS
Jet Propulsion Laboratory—Operable Units 1 and 3**

Scenario Timeframe: Current/Future

Medium: Groundwater

Exposure Medium: Tap Water

Exposure Point: Sitewide

Receptor Population: Resident

Receptor Age: Child/Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	Intake Equation/Model Name
	ED-C	Exposure Duration for Children	years	6	EPA, 1991	
	BW-A	Body Weight for Adults	kg	70	EPA, 1991	
	BW-C	Body Weight for Children	kg	15	EPA, 1991	
	AT-C	Averaging Time (Cancer)	years	70	EPA, 1989	
	AT-N	Averaging Time (Non-cancer)	years	6	EPA, 1989	
	VF	Volatilization Factor	L/m3	0.5	EPA, 1996	

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Definitions:

cm/hr = centimeters per hour

cm² = centimeters squared

days/year = days per year

DTSC = Department of Toxic Substances Control

hr/day = hours per day

kg = kilogram

L/cm³ = liters per cubic centimeter

liters/day = liters per day

m³/day = cubic meter per day

mg/ug = milligrams per microgram

N/A = Not applicable

RME = reasonable maximum exposure

ug/L = micrograms per liter

TABLE 6-7
NONCANCER TOXICITY DATA—ORAL/DERMAL
Jet Propulsion Laboratory—Operable Units 1 and 3

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal RfD (2)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (MM/DD/YY)
1,1-Dichloroethene	Chronic	0.009	mg/kg/day	0.8	0.0072	mg/kg/day	Liver	1000/1	IRIS	2/16/99
1,2-Dichloroethane (3)	Chronic	0.0029	mg/kg/day	0.8	0.0023	mg/kg/day	N/A (4)	N/A (4)	Region 9 PRG	3/99 (5)
Arsenic	Chronic	0.0003	mg/kg/day	0.2	0.00006	mg/kg/day	Skin	3/1	IRIS	2/16/99
Bromodichloromethane	Chronic	0.02	mg/kg/day	0.8	0.016	mg/kg/day	Kidney	1000/1	IRIS	2/16/99
Carbon Tetrachloride	Chronic	0.0007	mg/kg/day	0.8	0.00056	mg/kg/day	Liver	1000/1	IRIS	2/16/99
Chloroform	Chronic	0.01	mg/kg/day	0.8	0.008	mg/kg/day	Liver	1000/1	IRIS	2/16/99
Hexavalent Chromium	Chronic	0.005	mg/kg/day	0.2	0.001	mg/kg/day	No effects	500/1	IRIS	2/16/99
Lead	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate	Chronic	1.6	mg/kg/day	0.2	0.32	mg/kg/day	Red blood cells	1/1	IRIS	2/16/99
Perchlorate	Chronic	0.0005	mg/kg/day	0.2	0.0001	mg/kg/day	Thyroid	N/A (4)	NCEA	3/99 (5)
Tetrachloroethene	Chronic	0.01	mg/kg/day	0.8	0.008	mg/kg/day	Liver	1000/1	IRIS	2/16/99
Trichloroethene (6)	Chronic	0.006	mg/kg/day	0.8	0.0048	mg/kg/day	N/A (4)	N/A (4)	Region 9 PRG	3/99 (5)

(1) Oral to dermal adjustment factor obtained from EPA, 1995. *Supplemental Guidance to RAGS—*

Region 4 Bulletins. Office of Health Assessment. November, 1995

(2) Adjusted dermal RfD = oral RfD x oral to dermal adjustment factor

(3) RfD value is based on route-to-route extrapolation.

(4) Value obtained from EPA Region 9 PRG Summary Table (EPA, 1999). Target organ and uncertainty/modifying factors are not provided.

(5) EPA Region 9 PRG Summary Table expires May 1999

(6) Cited in EPA Region 9 PRG Summary Table (EPA, 1999) as withdrawn.

Definitions:

EPA = U.S. Environmental Protection Agency

IRIS = Integrated Risk Information System

mg/kg/day = milligrams per kilogram per day

MM/DD/YY = month/day/year

N/A = Not applicable

NCEA = National Center for Environmental Assessment

PRG = preliminary remediation goal

RfD = reference dose

TABLE 6-8
NONCANCER TOXICITY DATA—INHALATION
Jet Propulsion Laboratory—Operable Units 1 and 3

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RFC	Units	Adjusted Inhalation RfD (1)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RFC:RfD: Target Organ	Dates (MM/DD/YY)
1,1-Dichloroethene (2)	chronic	0.03	mg/m3	0.009	mg/kg/day	N/A (3)	N/A (3)	Region 9 PRG	3/99 (4)
1,2-Dichloroethane (5)	chronic	0.01	mg/m3	0.0029	mg/kg/day	N/A (3)	N/A (3)	Region 9 PRG	3/99 (4)
Arsenic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bromodichloromethane (2)	chronic	0.07	mg/m3	0.02	mg/kg/day	N/A (3)	N/A (3)	Region 9 PRG	3/99 (4)
Carbon Tetrachloride (5)	chronic	0.002	mg/m3	0.00057	mg/kg/day	N/A (3)	N/A (3)	Region 9 PRG	3/99 (4)
Chloroform (2)	chronic	0.04	mg/m3	0.01	mg/kg/day	N/A (3)	N/A (3)	Region 9 PRG	3/99 (4)
Hexavalent Chromium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lead	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Perchlorate	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tetrachloroethene	chronic	0.4	mg/m3	0.11	mg/kg/day	N/A (3)	N/A (3)	NCEA	3/99 (4)
Trichloroethene (2)	chronic	0.02	mg/m3	0.006	mg/kg/day	N/A (3)	N/A (3)	Region 9 PRG	3/99 (4)

(1) Adjusted Inhalation RfD = RfC x (20 m3/day) / (70 kg)

(2) RfD based on route-to-route extrapolation.

(3) Value obtained from EPA Region 9 PRG Summary Table (EPA, 1999). Target organ and uncertainty/modifying factors are not provided.

(4) EPA Region 9 PRG Summary Table expires May 1999

(6) Cited in EPA Region IX PRG Summary Table (EPA, 1999) as withdrawn.

Definitions:

EPA = U.S. Environmental Protection Agency

kg= kilograms

m3/day = cubic meters per day

mg/kg/day = milligrams per kilogram per day

mg/m3 = milligrams per cubic meter

MM/DD/YY = month/day/year

N/A = Not applicable

NCEA = EPA's National Center for Environmental Assessment

PRG = preliminary remediation goal

RfC = reference concentration

RfD = reference dose

TABLE 6-9
CANCER TOXICITY DATA—ORAL/DERMAL
Jet Propulsion Laboratory—Operable Units 1 and 3

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor	Adjusted Dermal Cancer Slope Factor (1)	Units	Weight of Evidence/ Cancer Guideline Description (2)	Source	Date (MM/DD/YY)
1,1-Dichloroethene	0.6	0.8	0.75	(mg/kg/day)-1	C	IRIS	2/17/99
1,2-Dichloroethane	0.07	0.8	0.088	(mg/kg/day)-1	B2	CAOEHHA	11/98
Arsenic	1.5	0.2	7.5	(mg/kg/day)-1	A	CAOEHHA	11/98
Bromodichloromethane	0.13	0.8	0.16	(mg/kg/day)-1	B2	CAOEHHA	11/98
Carbon Tetrachloride	0.15	0.8	0.19	(mg/kg/day)-1	B2	CAOEHHA	11/98
Chloroform	0.031	0.8	0.039	(mg/kg/day)-1	B2	CAOEHHA	11/98
Hexavalent Chromium	0.42	0.2	2.1	(mg/kg/day)-1	A	CAOEHHA	11/98
Lead	N/A	N/A	N/A	N/A	B2	N/A	N/A
Nitrate	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Perchlorate	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tetrachloroethene	0.051	0.8	0.064	(mg/kg/day)-1	N/A	CAOEHHA	11/98
Trichloroethene	0.015	0.8	0.019	(mg/kg/day)-1	N/A	CAOEHHA	11/98

(1) Adjusted dermal cancer slope factor = oral cancer slope factor/oral to dermal adjustment factor. Obtained from EPA. 1995. *Supplemental Guidance to RAGS—Region 4 Bulletins*. Office of Health Assessment. November, 1995

(2) EPA Weight of Evidence Classification:

A - Human carcinogen

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans

C - Possible human carcinogen

Definitions:

CAOEHHA = California Office of Environmental Health
Hazard Assessment

EPA = U.S. Environmental Protection Agency

IRIS = Integrated Risk Information System

mg/kg/day = milligrams per kilogram per day

MM/DD/YY = month/day/year

N/A = Not applicable

TABLE 6-10
CANCER TOXICITY DATA—INHALATION
Jet Propulsion Laboratory—Operable Units 1 and 3

Chemical of Potential Concern	Unit Risk	Units	Adjustment (1)	Inhalation Cancer Slope Factor	Units	Weight of Evidence/ Cancer Guideline Description (2)	Source	Date (MM/DD/YY)
1,1-Dichloroethene	5.0E-05	ug/m3	3,500	0.18	(mg/kg/day)-1	C	IRIS	2/17/99
1,2-Dichloroethane	2.2E-05	ug/m3	3,500	0.07	(mg/kg/day)-1	B2	CAOEHHA	11/98
Arsenic	3.3E-03	ug/m3	3,500	12.0	(mg/kg/day)-1	A	CAOEHHA	11/98
Bromodichloromethane	3.7E-05	ug/m3	3,500	0.13	(mg/kg/day)-1	B2	CAOEHHA	11/98
Carbon Tetrachloride	4.2E-05	ug/m3	3,500	0.15	(mg/kg/day)-1	B2	CAOEHHA	11/98
Chloroform	5.3E-06	ug/m3	3,500	0.019	(mg/kg/day)-1	B2	CAOEHHA	11/98
Hexavalent Chromium	1.5E-01	ug/m3	3,500	510	(mg/kg/day)-1	A	CAOEHHA	11/98
Lead	N/A	N/A	N/A	N/A	N/A	B2	N/A	N/A
Nitrate	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Perchlorate	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tetrachloroethene	5.9E-06	ug/m3	3,500	0.021	(mg/kg/day)-1	N/A	CAOEHHA	11/98
Trichloroethene	2.0E-06	ug/m3	3,500	0.01	(mg/kg/day)-1	N/A	CAOEHHA	11/98

(1) Adjustment factor applied to unit risk to calculate inhalation slope factor =
 $(70 \text{ kg}) \times (1/20 \text{ m}^3/\text{day}) \times (1000 \text{ ug}/\text{mg})$

(2) EPA Weight of Evidence Classification:

A - Human carcinogen

B2 - Probable human carcinogen - indicates sufficient evidence in animals and
inadequate or no evidence in humans

C - Possible human carcinogen

Definitions:

$1.0\text{E}-02 = 1.0 \times 10^{-2} = 0.010$

CAOEHHA = California Office of Environmental Health
Hazard Assessment

EPA = U.S. Environmental Protection Agency

IRIS = Integrated Risk Information System

kg = kilograms

m³/day = cubic meters per day

mg/kg/day = milligrams per kilogram per day

MM/DD/YY = month/day/year

N/A = Not applicable

ug/m³ = micrograms per cubic meter

ug/mg = micrograms per milligram

**TABLE 6-11
SUMMARY OF LEAD DATA (1997-1998)
COMPARISON OF MODELED BLOOD LEAD CONCENTRATIONS TO SCREENING TOXICITY VALUE
Jet Propulsion Laboratory**

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: All Wells (1997-1998) — Tap Water

CAS Number	Chemical	(1)		(1)		Units	Location of Maximum Concentration	Detection Frequency	Detection Limit	Concentration Used for Screening	Background Value (3)	Screening Toxicity Value (4)	COPC Flag	Rationale for Contaminant Deletion or Selection
		Minimum Concentration	Minimum Qualifier	Maximum Concentration	Maximum Qualifier									
7439-92-1	Lead	0.0076	--	0.0076	--	mg/L	MW-03	1/20	0.002	5.9	N/A	10	--	--
7439-92-1	Lead	0.0023	--	0.0023	--	mg/L	MW-08	1/4	0.002	6.0	N/A	10	--	--
7439-92-1	Lead	0.0024	--	0.0093	--	mg/L	MW-11	2/20	0.002	6.0	N/A	10	--	--
7439-92-1	Lead	0.0032	--	0.0032	--	mg/L	MW-12	1/22	0.002	5.9	N/A	10	--	--
7439-92-1	Lead	0.0028	--	0.0028	--	mg/L	MW-13	1/8	0.002	5.9	N/A	10	--	--
7439-92-1	Lead	0.0024	--	0.028	--	mg/L	MW-14	5/20	0.002	6.2	N/A	10	--	--
7439-92-1	Lead	0.0025	--	0.0025	--	mg/L	MW-17	1/20	0.002	5.9	N/A	10	--	--
7439-92-1	Lead	0.0025	--	0.0025	--	mg/L	MW-19	1/19	0.002	5.9	N/A	10	--	--
7439-92-1	Lead	0.0012	--	0.0038	--	mg/L	MW-20	2/19	0.002	5.9	N/A	10	--	--
7439-92-1	Lead	0.003	--	0.0035	--	mg/L	MW-21	3/19	0.002	5.9	N/A	10	--	--

- (1) Minimum/maximum detected concentration
- (2) Values are 99th percentile child blood lead concentrations estimated using State of California guidance (DTSC, 1996) and are expressed in micrograms of lead per deciliter of blood (ug/dl). Exposure point concentrations used to estimate blood lead concentrations are presented in Appendix H along with model and input parameters.
- (3) Background information was not available.
- (4) Blood lead concentration of concern in children and adults is 10 ug/dl (DTSC, 1996).

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
CAS = Chemical Abstract Service
COPC = chemical of potential concern
DTSC = Department of Toxic Substance Control
mg/L = milligrams per liter
MW = monitoring well
N/A = Not applicable
ug/dl = micrograms of lead per deciliter of blood

**TABLE 6-12
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 01**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Monitoring Well 01--	Nitrate	N/A	--	--	N/A	Nitrate	Red blood cells	0.060	--	0.00049	0.060
		Tap Water	(Total)	--	--	--	--	(Total)		0.060	--	0.00049	0.060
	Air	Monitoring Well 01--	--	--	--	--	--	--	--	--	--	--	--
Water Vapor		(Total)	--	--	--	--	(Total)		--	--	--	--	
Total Risk Across Groundwater				--				Total Hazard Index Across All Media and All Exposure Routes					0.060
Total Risk Across Air				--				Total Liver HI =					--
Total Risk Across All Media and All Exposure Routes				--				Total Red blood cell HI =					0.060

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-13
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 03**

Scenario Timeframe: Current/Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Monitoring Well 03— Tap Water	Arsenic	9.1E-05	--	9.3E-07	9.2E-05	Arsenic	Skin	0.87	--	0.0072	0.88
			Bromodichloromethane	5.8E-07	--	--	5.8E-07	Bromodichloromethane	Kidney	0.00096	--	--	0.00096
			Carbon Tetrachloride	1.1E-06	--	--	1.1E-06	Carbon Tetrachloride	Liver	0.045	--	--	0.045
			Chloroform	6.0E-07	--	--	6.0E-07	Chloroform	Liver	0.0083	--	--	0.0083
			Lead	N/A	--	N/A	N/A	Lead	N/A	N/A	--	N/A	N/A
			Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.044	--	0.00036	0.044
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.82	--	0.0068	0.83
			Tetrachloroethene	2.2E-07	--	--	2.2E-07	Tetrachloroethene	Liver	0.0019	--	--	0.0019
			Trichloroethene	7.1E-08	--	--	7.1E-08	Trichloroethene	N/A	0.0034	--	--	0.0034
			(Total)	9.4E-05	--	9.3E-07	9.5E-05	(Total)		1.8	--	0.014	1.8
	Air	Monitoring Well 03— Water Vapor	Bromodichloromethane	--	2.9E-06	--	2.9E-06	Bromodichloromethane	Kidney	--	0.0048	--	0.0048
			Carbon Tetrachloride	--	5.5E-06	--	5.5E-06	Carbon Tetrachloride	Liver	--	0.27	--	0.27
			Chloroform	--	1.8E-06	--	1.8E-06	Chloroform	Liver	--	0.042	--	0.042
			Tetrachloroethene	--	4.5E-07	--	4.5E-07	Tetrachloroethene	Liver	--	0.00084	--	0.00084
			Trichloroethene	--	2.4E-07	--	2.4E-07	Trichloroethene	N/A	--	0.017	--	0.017
			(Total)	--	1.1E-05	--	1.1E-05	(Total)		--	0.34	--	0.34
			Total Risk Across Groundwater				9.5E-05	Total Hazard Index Across All Media and All Exposure Routes				2.1	
			Total Risk Across Air				1.1E-05						
			Total Risk Across All Media and All Exposure Routes				1.1E-04						

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

Total Skin HI =	0.88
Total Kidney HI =	0.0058
Total Liver HI =	0.37
Total Red blood cell HI =	0.044
Total Thyroid HI =	0.83

**TABLE 6-14
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 04**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient					
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total	
Groundwater	Groundwater	Monitoring Well 04— Tap Water	1,1-Dichloroethene	3.5E-06	--	--	3.5E-06	1,1-Dichloroethene	Liver	0.0028	--	--	0.0028	
			1,2-Dichloroethane	3.4E-07	--	--	3.4E-07	1,2-Dichloroethane	N/A	0.0073	--	--	0.0073	
			Carbon Tetrachloride	8.3E-06	--	--	8.3E-06	Carbon Tetrachloride	Liver	0.34	--	--	0.34	
			Chloroform	1.5E-06	--	--	1.5E-06	Chloroform	Liver	0.020	--	--	0.020	
			Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.33	N/A	--	0.0027	0.33
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	4.9	--	--	0.040	4.9
			Tetrachloroethene	2.2E-07	--	--	2.2E-07	Tetrachloroethene	Liver	0.0019	--	--	--	0.0019
			Trichloroethene	2.2E-06	--	--	2.2E-06	Trichloroethene	N/A	0.11	--	--	--	0.11
	(Total)	1.6E-05	--	N/A	1.6E-05	(Total)		5.7	--	--	0.043	5.7		
	Air	Monitoring Well 04— Water Vapor	1,1-Dichloroethene	--	5.2E-06	--	5.2E-06	1,1-Dichloroethene	Liver	--	0.014	--	--	0.014
			1,2-Dichloroethane	--	1.7E-06	--	1.7E-06	1,2-Dichloroethane	N/A	--	0.036	--	--	0.036
			Carbon Tetrachloride	--	4.1E-05	--	4.1E-05	Carbon Tetrachloride	Liver	--	2.1	--	--	2.1
			Chloroform	--	4.5E-06	--	4.5E-06	Chloroform	Liver	--	0.10	--	--	0.10
			Tetrachloroethene	--	4.5E-07	--	4.5E-07	Tetrachloroethene	Liver	--	0.00084	--	--	0.00084
Trichloroethene			--	7.4E-06	--	7.4E-06	Trichloroethene	N/A	--	0.53	--	--	0.53	
(Total)	--	6.1E-05	--	6.1E-05	(Total)		--	2.8	--	--	2.8			
Total Risk Across Groundwater							1.6E-05	Total Hazard Index Across All Media and All Exposure Routes					8.5	
Total Risk Across Air							6.1E-05							
Total Risk Across All Media and All Exposure Routes							7.7E-05							

Total Liver HI =	2.6
Total Red blood cell HI =	0.33
Total Thyroid HI =	4.9

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-15
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 05**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Monitoring Well 05— Tap Water	Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.096	--	0.0008	0.097
			Perchlorate	N/A	--	N/A	N/A		Thyroid	0.54	--	0.0044	0.54
			(Total)	N/A	--	N/A	N/A		(Total)	0.63	--	0.0052	0.64
	Air	Monitoring Well 05— Water Vapor	--	--	--	--	--	--	--	--	--	--	
			(Total)	--	--	--	--	(Total)	--	--	--	--	
Total Risk Across Groundwater							N/A	Total Hazard Index Across All Media and All Exposure Routes					0.64
Total Risk Across Air							--						
Total Risk Across All Media and All Exposure Routes							N/A						

Definitions: COPC = chemical of potential concern
 -- = Not evaluated for this pathway
 HI = hazard index
 N/A = Not applicable

Total Red blood cell HI = 0.097
 Total Thyroid HI = 0.54

**TABLE 6-16
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 06**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Monitoring Well 06— Tap Water	Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.44	--	0.0036	0.44
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.70	--	0.0058	0.71
		Tetrachloroethene	1.5E-06	--	--	1.5E-06	Tetrachloroethene	Liver	0.013	--	--	0.013	
		(Total)	1.5E-06	--	N/A	1.5E-06	(Total)		1.2	--	0.0094	1.2	
	Air	Monitoring Well 06—	Tetrachloroethene	--	3.1E-06	--	3.1E-06	Tetrachloroethene	Liver	--	0.0058	--	0.0058
			(Total)	--	3.1E-06	--	3.1E-06	(Total)		--	0.0058	--	0.0058
Total Risk Across Groundwater							1.5E-06	Total Hazard Index Across All Media and All Exposure Routes					1.2
Total Risk Across Air							3.1E-06						
Total Risk Across All Media and All Exposure Routes							4.6E-06						

Total Liver HI =	0.019
Total Red blood cell HI =	0.44
Total Thyroid HI =	0.71

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-17
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 07**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Monitoring Well 07— Tap Water	1,1-Dichloroethene	1.9E-05	--	--	1.9E-05	1,1-Dichloroethene	Liver	0.015	--	--	0.015
			1,2-Dichloroethane	9.3E-07	--	--	9.3E-07	1,2-Dichloroethane	N/A	0.020	--	--	0.020
			Carbon Tetrachloride	3.3E-04	--	--	3.3E-04	Carbon Tetrachloride	Liver	14	--	--	14
			Chloroform	6.0E-06	--	--	6.0E-06	Chloroform	Liver	0.083	--	--	0.083
			Hexavalent Chromium	6.2E-05	--	1.3E-06	6.4E-05	Hexavalent Chromium	No effects	0.13	--	0.0021	0.13
			Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.26	--	0.0021	0.26
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	92	--	0.76	93
	Tetrachloroethene	2.8E-06	--	--	2.8E-06	Tetrachloroethene	Liver	0.024	--	--	0.024		
	Trichloroethene	6.0E-06	--	--	6.0E-06	Trichloroethene	N/A	0.29	--	--	0.29		
	(Total)	4.3E-04	--	1.3E-06	4.3E-04	(Total)		110	--	0.76	110		
	Air	Monitoring Well 07— Water Vapor	1,1-Dichloroethene	--	2.8E-05	--	2.8E-05	1,1-Dichloroethene	Liver	--	0.075	--	0.075
			1,2-Dichloroethane	--	4.6E-06	--	4.6E-06	1,2-Dichloroethane	N/A	--	0.098	--	0.098
			Carbon Tetrachloride	--	1.7E-03	--	1.7E-03	Carbon Tetrachloride	Liver	--	84	--	84
			Chloroform	--	1.8E-05	--	1.8E-05	Chloroform	Liver	--	0.42	--	0.42
Tetrachloroethene			--	5.8E-06	--	5.8E-06	Tetrachloroethene	Liver	--	0.011	--	0.011	
Trichloroethene			--	2.0E-05	--	2.0E-05	Trichloroethene	N/A	--	1.4	--	1.4	
(Total)			--	1.8E-03	--	1.8E-03	(Total)		--	86	--	86	
Total Risk Across Groundwater				4.3E-04				Total Hazard Index Across All Media and All Exposure Routes					200
Total Risk Across Air				1.8E-03									
Total Risk Across All Media and All Exposure Routes				2.2E-03									

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

Total No effects HI =	0.13
Total Liver HI =	98
Total Red blood cell HI =	0.26
Total Thyroid HI =	93

**TABLE 6-18
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 08**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Monitoring Well 08— Tap Water	Carbon Tetrachloride	7.1E-06	--	--	7.1E-06	Carbon Tetrachloride	Liver	0.29	--	--	0.29
			Chloroform	6.0E-07	--	--	6.0E-07	Chloroform	Liver	0.0083	--	--	0.0083
			Lead	N/A	--	N/A	N/A	Lead	N/A	N/A	--	N/A	N/A
			Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.15	--	0.0012	0.15
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	3.7	--	0.031	3.7
			Trichloroethene	1.0E-06	--	--	1.0E-06	Trichloroethene	N/A	0.048	--	--	0.048
	(Total)	8.7E-06	--	N/A	8.7E-06	(Total)		4.2	--	0.032	4.2		
	Air	Monitoring Well 08— Water Vapor	Carbon Tetrachloride	--	3.6E-05	--	3.6E-05	Carbon Tetrachloride	Liver	--	1.8	--	1.8
			Chloroform	--	1.8E-06	--	1.8E-06	Chloroform	Liver	--	0.042	--	0.042
			Trichloroethene	--	3.3E-06	--	3.3E-06	Trichloroethene	N/A	--	0.24	--	0.24
(Total)			--	4.1E-05	--	4.1E-05	(Total)		--	2.1	--	2.1	
Total Risk Across Groundwater							8.7E-06	Total Hazard Index Across All Media and All Exposure Routes					6.3
Total Risk Across Air							4.1E-05						
Total Risk Across All Media and All Exposure Routes							5.0E-05						

Total Liver HI =	2.1
Total Red blood cell HI =	0.15
Total Thyroid HI =	3.7

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-19
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 09**

Scenario Timeframe: Current/Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient						
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total		
Groundwater	Groundwater	Monitoring Well 09—Tap Water	Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.22	--	0.0018	0.22		
		(Total)	N/A	--	N/A	N/A	(Total)			0.22	--	0.0018	0.22		
	Air	Monitoring Well 09—Water Vapor	--	--	--	--	--	--	--	--	--	--	--		
		(Total)	(Total)	--	--	--	--	(Total)	(Total)	--	--	--	--		
Total Risk Across Groundwater							N/A	Total Hazard Index Across All Media and All Exposure Routes							0.22
Total Risk Across Air							--								
Total Risk Across All Media and All Exposure Routes							N/A	Total Red blood cell HI =							0.22

Definitions:
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-20
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 10**

Scenario Timeframe: Current/Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Monitoring Well 10— Tap Water	Chloroform	6.5E-07	--	--	6.5E-07	Chloroform	Liver	0.0089	--	--	0.0089
			Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.72	--	0.0059	0.73
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	2.0	--	0.017	2.1
			Tetrachloroethene	1.7E-06	--	--	1.7E-06	Tetrachloroethene	Liver	0.014	--	--	0.014
			Trichloroethene	1.2E-06	--	--	1.2E-06	Trichloroethene	N/A	0.055	--	--	0.055
	(Total)	3.5E-06	--	N/A	3.5E-06	(Total)		2.8	--	0.023	2.9		
	Air	Monitoring Well 10— Water Vapor	Chloroform	--	2.0E-06	--	2.0E-06	Chloroform	Liver	--	0.045	--	0.045
			Tetrachloroethene	--	3.4E-06	--	3.4E-06	Tetrachloroethene	Liver	--	0.0064	--	0.0064
			Trichloroethene	--	3.9E-06	--	3.9E-06	Trichloroethene	N/A	--	0.28	--	0.28
			(Total)	--	9.3E-06	--	9.3E-06	(Total)		--	0.33	--	0.33
Total Risk Across Groundwater							3.5E-06	Total Hazard Index Across All Media and All Exposure Routes					3.2
Total Risk Across Air							9.3E-06						
Total Risk Across All Media and All Exposure Routes							1.3E-05						

Total Liver HI =	0.074
Total Red blood cell HI =	0.73
Total Thyroid HI =	2.1

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-21
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 11**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient					
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total	
Groundwater	Groundwater	Monitoring Well 11— Tap Water	Carbon Tetrachloride	1.5E-06	--	--	1.5E-06	Carbon Tetrachloride	Liver	0.063	--	--	0.063	
			Chloroform	3.9E-07	--	--	3.9E-07	Chloroform	Liver	0.0054	--	--	0.0054	
			Lead	N/A	--	N/A	N/A	Lead	N/A	N/A	--	N/A	N/A	
			Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.025	--	0.00021	0.025	
		(Total)		1.9E-06	--	N/A	1.9E-06	(Total)		0.094	--	0.00021	0.094	
	Air	Monitoring Well 11— Water Vapor	Carbon Tetrachloride	--	7.7E-06	--	7.7E-06	Carbon Tetrachloride	Liver	--	0.39	--	0.39	
			Chloroform	--	1.2E-06	--	1.2E-06	Chloroform	Liver	--	0.027	--	0.027	
				(Total)		--	8.9E-06	--	8.9E-06	(Total)		--	0.41	--
Total Risk Across Groundwater							1.9E-06	Total Hazard Index Across All Media and All Exposure Routes					0.51	
Total Risk Across Air							8.9E-06							
Total Risk Across All Media and All Exposure Routes							1.1E-05							
								Total Liver HI =					0.48	
								Total Red blood cell HI =					0.025	

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-22
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 12**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient						
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total		
Groundwater	Groundwater	Monitoring Well 12— Tap Water	Carbon Tetrachloride	2.7E-05	--	--	2.7E-05	Carbon Tetrachloride	Liver	1.1	--	--	1.1		
			Chloroform	9.2E-07	--	--	9.2E-07	Chloroform	Liver	0.013	--	--	0.013		
			Lead	N/A	--	N/A	N/A	Lead	N/A	N/A	--	N/A	N/A		
			Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.060	--	0.00049	0.060		
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.89	--	0.0074	0.90		
			Trichloroethene	6.2E-08	--	--	6.2E-08	Trichloroethene	N/A	0.003	--	--	0.003		
	(Total)	2.8E-05	--	N/A	2.8E-05	(Total)		2.1	--	0.0079	2.1				
	Air	Monitoring Well 12— Water Vapor	Carbon Tetrachloride	--	1.3E-04	--	1.3E-04	Carbon Tetrachloride	Liver	--	6.7	--	6.7		
			Chloroform	--	2.8E-06	--	2.8E-06	Chloroform	Liver	--	0.064	--	0.064		
			Trichloroethene	--	2.1E-07	--	2.1E-07	Trichloroethene	N/A	--	0.015	--	0.015		
			(Total)	--	1.4E-04	--	1.4E-04	(Total)		--	6.8	--	6.8		
			Total Risk Across Groundwater				2.8E-05				Total Hazard Index Across All Media and All Exposure Routes				
Total Risk Across Air				1.4E-04				Total Liver HI =					7.9		
Total Risk Across All Media and All Exposure Routes				1.6E-04				Total Red blood cell HI =					0.060		
								Total Thyroid HI =					0.90		

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-23
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 13**

Scenario Timeframe: Current/Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Monitoring Well 13— Tap Water	1,1-Dichloroethene	8.6E-06	--	--	8.6E-06	1,1-Dichloroethene	Liver	0.0068	--	--	0.0068
			1,2-Dichloroethane	1.1E-06	--	--	1.1E-06	1,2-Dichloroethane	N/A	0.024	--	--	0.024
			Carbon Tetrachloride	3.6E-05	--	--	3.6E-05	Carbon Tetrachloride	Liver	1.5	--	--	1.5
			Chloroform	5.1E-06	--	--	5.1E-06	Chloroform	Liver	0.070	--	--	0.070
			Hexavalent Chromium	2.6E-04	--	5.2E-06	2.6E-04	Hexavalent Chromium	No effects	0.52	--	0.0086	0.53
			Lead	N/A	--	N/A	N/A	Lead	N/A	N/A	--	N/A	N/A
			Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.38	N/A	0.0032	0.39
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	33	--	0.27	33
			Tetrachloroethene	3.0E-07	--	--	3.0E-07	Tetrachloroethene	Liver	0.0026	--	--	0.0026
			Trichloroethene	6.5E-06	--	--	6.5E-06	Trichloroethene	N/A	0.31	--	--	0.31
	(Total)	3.1E-04	--	5.2E-06	3.2E-04	(Total)		35	--	0.28	36		
	Air	Monitoring Well 13— Water Vapor	1,1-Dichloroethene	--	1.3E-05	--	1.3E-05	1,1-Dichloroethene	Liver	--	0.034	--	0.034
			1,2-Dichloroethane	--	5.7E-06	--	5.7E-06	1,2-Dichloroethane	N/A	--	0.12	--	0.12
			Carbon Tetrachloride	--	1.8E-04	--	1.8E-04	Carbon Tetrachloride	Liver	--	9.0	--	9.0
			Chloroform	--	1.6E-05	--	1.6E-05	Chloroform	Liver	--	0.35	--	0.35
			Tetrachloroethene	--	6.2E-07	--	6.2E-07	Tetrachloroethene	Liver	--	0.0012	--	0.0012
			Trichloroethene	--	2.2E-05	--	2.2E-05	Trichloroethene	N/A	--	1.5	--	1.5
			(Total)	--	2.3E-04	--	2.3E-04	(Total)		--	11	--	11
			Total Risk Across Groundwater				3.2E-04	Total Hazard Index Across All Media and All Exposure Routes				47	
Total Risk Across Air				2.3E-04									
Total Risk Across All Media and All Exposure Routes				5.5E-04									

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

Total No effects HI =	0.53
Total Liver HI =	11
Total Red blood cell HI =	0.39
Total Thyroid HI =	33

**TABLE 6-24
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 14**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Monitoring Well 14— Tap Water	Chloroform	2.1E-07	--	--	2.1E-07	Chloroform	Liver	0.0029	--	--	0.0029
			Lead	N/A	--	N/A	N/A	Lead	N/A	N/A	--	N/A	N/A
			Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.76	--	0.0063	0.77
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.46	--	0.0038	0.46
			Tetrachloroethene	6.0E-07	--	--	6.0E-07	Tetrachloroethene	Liver	0.0051	--	--	0.0051
			Trichloroethene	1.0E-07	--	--	1.0E-07	Trichloroethene	N/A	0.0049	--	--	0.0049
	(Total)	9.1E-07	--	N/A	9.1E-07	(Total)		1.2	--	0.010	1.2		
	Air	Monitoring Well 14— Water Vapor	Chloroform	--	6.5E-07	--	6.5E-07	Chloroform	Liver	--	0.015	--	0.015
			Tetrachloroethene	--	1.2E-06	--	1.2E-06	Tetrachloroethene	Liver	--	0.0023	--	0.0023
			Trichloroethene	--	3.4E-07	--	3.4E-07	Trichloroethene	N/A	--	0.025	--	0.025
(Total)			--	2.2E-06	--	2.2E-06	(Total)		--	0.042	--	0.042	
Total Risk Across Groundwater							9.1E-07	Total Hazard Index Across All Media and All Exposure Routes					1.3
Total Risk Across Air							2.2E-06						
Total Risk Across All Media and All Exposure Routes							3.1E-06						

Total Liver HI =	0.025
Total Red blood cell HI =	0.77
Total Thyroid HI =	0.46

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-25
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 15**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Monitoring Well 15-- Tap Water	Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.18	--	0.0015	0.18
		(Total)	N/A	--	N/A	(Total)	0.18			--	0.0015	0.18	
	Air	Monitoring Well 15-- Water Vapor	--	--	--	--	--	--	--	--	--	--	--
			(Total)	--	--	--	--	(Total)	--	--	--	--	--
Total Risk Across Groundwater				N/A				Total Hazard Index Across All Media and All Exposure Routes					0.18
Total Risk Across Air				--									
Total Risk Across All Media and All Exposure Routes				N/A				Total Red blood cell HI =					0.18

Definitions: COPC = chemical of potential concern
 -- = Not evaluated for this pathway
 HI = hazard index
 N/A = Not applicable

**TABLE 6-26
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 16**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Monitoring Well 16— Tap Water	1,1-Dichloroethene	2.3E-05	--	--	2.3E-05	1,1-Dichloroethene	Liver	0.018	--	--	0.018
			1,2-Dichloroethane	2.2E-06	--	--	2.2E-06	1,2-Dichloroethane	N/A	0.046	--	--	0.046
			Carbon Tetrachloride	2.0E-04	--	--	2.0E-04	Carbon Tetrachloride	Liver	8.3	--	--	8.3
			Chloroform	2.0E-05	--	--	2.0E-05	Chloroform	Liver	0.27	--	--	0.27
			Hexavalent Chromium	4.4E-05	--	8.9E-07	4.5E-05	Hexavalent Chromium	No effects	0.089	--	0.0015	0.091
			Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.72	--	0.0059	0.73
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	160	--	1.3	160
	Tetrachloroethene	9.9E-07	--	--	9.9E-07	Tetrachloroethene	Liver	0.0083	--	--	0.0083		
	Trichloroethene	5.6E-06	--	--	5.6E-06	Trichloroethene	N/A	0.27	--	--	0.27		
	(Total)	3.0E-04	--	8.9E-07	3.0E-04	(Total)		170	--	1.3	170		
	Air	Monitoring Well 16— Water Vapor	1,1-Dichloroethene	--	3.5E-05	--	3.5E-05	1,1-Dichloroethene	Liver	--	0.092	--	0.092
			1,2-Dichloroethane	--	1.1E-05	--	1.1E-05	1,2-Dichloroethane	N/A	--	0.23	--	0.23
			Carbon Tetrachloride	--	1.0E-03	--	1.0E-03	Carbon Tetrachloride	Liver	--	51	--	51
			Chloroform	--	6.1E-05	--	6.1E-05	Chloroform	Liver	--	1.4	--	1.4
Tetrachloroethene			--	2.0E-06	--	2.0E-06	Tetrachloroethene	Liver	--	0.0038	--	0.0038	
Trichloroethene			--	1.9E-05	--	1.9E-05	Trichloroethene	N/A	--	1.3	--	1.3	
(Total)			--	1.1E-03	--	1.1E-03	(Total)		--	54	--	54	
Total Risk Across Groundwater							3.0E-04	Total Hazard Index Across All Media and All Exposure Routes					220
Total Risk Across Air							1.1E-03						
Total Risk Across All Media and All Exposure Routes							1.4E-03						
								Total No effects HI =	0.091				
								Total Liver HI =	61				
								Total Red blood cell HI =	0.73				
								Total Thyroid HI =	160				

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-27
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 17**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Monitoring Well 17— Tap Water	Bromodichloromethane	8.5E-07	--	--	8.5E-07	Bromodichloromethane	Kidney	0.0014	--	--	0.0014
			Carbon Tetrachloride	3.6E-06	--	--	3.6E-06	Carbon Tetrachloride	Liver	0.15	--	--	0.15
			Chloroform	3.5E-06	--	--	3.5E-06	Chloroform	Liver	0.049	--	--	0.049
			Hexavalent Chromium	2.1E-05	--	4.2E-07	2.1E-05	Hexavalent Chromium	No effects	0.042	--	0.00070	0.043
			Lead	N/A	--	N/A	N/A	Lead	N/A	N/A	--	N/A	N/A
			Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.092	--	0.00076	0.093
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	4.6	--	0.038	4.7
			Tetrachloroethene	4.3E-07	--	--	4.3E-07	Tetrachloroethene	Liver	0.0036	--	--	0.0036
			Trichloroethene	5.1E-06	--	--	5.1E-06	Trichloroethene	N/A	0.25	--	--	0.25
	(Total)	3.4E-05	--	4.2E-07	3.5E-05	(Total)		5.2	--	0.040	5.3		
	Air	Monitoring Well 17— Water Vapor	Bromodichloromethane	--	4.3E-06	--	4.3E-06	Bromodichloromethane	Kidney	--	0.0070	--	0.0070
			Carbon Tetrachloride	--	1.8E-05	--	1.8E-05	Carbon Tetrachloride	Liver	--	0.90	--	0.90
			Chloroform	--	1.1E-05	--	1.1E-05	Chloroform	Liver	--	0.24	--	0.24
			Tetrachloroethene	--	8.9E-07	--	8.9E-07	Tetrachloroethene	Liver	--	0.0017	--	0.0017
			Trichloroethene	--	1.7E-05	--	1.7E-05	Trichloroethene	N/A	--	1.2	--	1.2
			(Total)	--	5.1E-05	--	5.1E-05	(Total)		--	2.4	--	2.4
			Total Risk Across Groundwater				3.5E-05	Total Hazard Index Across All Media and All Exposure Routes				7.6	
			Total Risk Across Air				5.1E-05						
Total Risk Across All Media and All Exposure Routes				8.5E-05									

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

Total Kidney HI =	0.0084
Total No effects HI =	0.043
Total Liver HI =	1.3
Total Red blood cell HI =	0.093
Total Thyroid HI =	4.7

**TABLE 6-28
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 18**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Monitoring Well 18— Tap Water	Arsenic	6.2E-05	--	6.3E-07	6.3E-05	Arsenic	Skin	0.60	--	0.0049	0.60
			Bromodichloromethane	7.9E-07	--	--	7.9E-07	Bromodichloromethane	Kidney	0.0013	--	--	0.0013
			Carbon Tetrachloride	2.9E-06	--	--	2.9E-06	Carbon Tetrachloride	Liver	0.12	--	--	0.12
			Chloroform	3.0E-06	--	--	3.0E-06	Chloroform	Liver	0.042	--	--	0.042
			Hexavalent Chromium	1.9E-05	--	3.8E-07	1.9E-05	Hexavalent Chromium	No effects	0.038	--	0.00063	0.039
			Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.15	--	0.0013	0.15
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.87	--	0.0072	0.88
			Tetrachloroethene	1.1E-06	--	--	1.1E-06	Tetrachloroethene	Liver	0.0096	--	--	0.0096
			Trichloroethene	3.8E-07	--	--	3.8E-07	Trichloroethene	N/A	0.018	--	--	0.018
	(Total)	8.9E-05	--	1.0E-06	9.0E-05	(Total)		1.8	--	0.014	1.9		
	Air	Monitoring Well 18— Water Vapor	Bromodichloromethane	--	4.0E-06	--	4.0E-06	Bromodichloromethane	Kidney	--	0.0066	--	0.0066
			Carbon Tetrachloride	--	1.5E-05	--	1.5E-05	Carbon Tetrachloride	Liver	--	0.73	--	0.73
			Chloroform	--	9.3E-06	--	9.3E-06	Chloroform	Liver	--	0.21	--	0.21
			Tetrachloroethene	--	2.3E-06	--	2.3E-06	Tetrachloroethene	Liver	--	0.0044	--	0.0044
Trichloroethene			--	1.3E-06	--	1.3E-06	Trichloroethene	N/A	--	0.091	--	0.091	
(Total)	--	3.1E-05	--	3.1E-05	(Total)		--	1.0	--	1.0			
Total Risk Across Groundwater						9.0E-05	Total Hazard Index Across All Media and All Exposure Routes						2.9
Total Risk Across Air						3.1E-05							
Total Risk Across All Media and All Exposure Routes						1.2E-04							

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

Total Skin HI =	0.60
Total Kidney HI =	0.0079
Total No effects HI =	0.039
Total Liver HI =	1.1
Total Red blood cell HI =	0.15
Total Thyroid HI =	0.88

**TABLE 6-29
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 19**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient						
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total		
Groundwater	Groundwater	Monitoring Well 19— Tap Water	Bromodichloromethane	5.4E-07	--	--	5.4E-07	Bromodichloromethane	Kidney	0.00089	--	--	0.00089		
			Chloroform	5.5E-07	--	--	5.5E-07	Chloroform	Liver	0.0077	--	--	0.0077		
			Lead	N/A	--	N/A	N/A	Lead	N/A	N/A	--	N/A	N/A		
			Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.44	--	0.0036	0.44		
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.35	--	0.0028	0.35		
			Tetrachloroethene	1.4E-06	--	--	1.4E-06	Tetrachloroethene	Liver	0.012	--	--	0.012		
			Trichloroethene	1.0E-07	--	--	1.0E-07	Trichloroethene	N/A	0.0049	--	--	0.0049		
	(Total)	2.6E-06	--	N/A	2.6E-06	(Total)		0.81	--	0.0065	0.82				
	Air	Monitoring Well 19— Water Vapor	Bromodichloromethane	--	2.7E-06	--	2.7E-06	Bromodichloromethane	Kidney	--	0.0045	--	0.0045		
			Chloroform	--	1.7E-06	--	1.7E-06	Chloroform	Liver	--	0.038	--	0.038		
			Tetrachloroethene	--	2.8E-06	--	2.8E-06	Tetrachloroethene	Liver	--	0.0052	--	0.0052		
			Trichloroethene	--	3.4E-07	--	3.4E-07	Trichloroethene	N/A	--	0.025	--	0.025		
			(Total)	--	7.6E-06	--	7.6E-06	(Total)		--	0.073	--	0.073		
			Total Risk Across Groundwater				2.6E-06				Total Hazard Index Across All Media and All Exposure Routes				
Total Risk Across Air				7.6E-06											
Total Risk Across All Media and All Exposure Routes				1.0E-05											

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

Total Kidney HI =	0.0054
Total Liver HI =	0.063
Total Red blood cell HI =	0.44
Total Thyroid HI =	0.35

**TABLE 6-30
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 20**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Monitoring Well 20— Tap Water	Arsenic	6.5E-05	--	6.6E-07	6.5E-05	Arsenic	Skin	0.62	--	0.0051	0.62
			Bromodichloromethane	5.4E-07	--	--	5.4E-07	Bromodichloromethane	Kidney	0.00089	--	--	0.00089
			Chloroform	1.0E-06	--	--	1.0E-06	Chloroform	Liver	0.014	--	--	0.014
			Lead	N/A	--	N/A	N/A	Lead	N/A	N/A	--	N/A	N/A
			Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.60	--	0.0049	0.60
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.41	--	0.0034	0.41
	(Total)	6.6E-05	--	6.6E-07	6.7E-05	(Total)		1.6	--	0.013	1.7		
	Air	Monitoring Well 20— Water Vapor	Bromodichloromethane	--	2.7E-06	--	2.7E-06	Bromodichloromethane	Kidney	--	0.0045	--	0.0045
			Chloroform	--	3.1E-06	--	3.1E-06	Chloroform	Liver	--	0.070	--	0.070
			(Total)	--	5.8E-06	--	5.8E-06	(Total)		--	0.075	--	0.075
Total Risk Across Groundwater				6.7E-05	Total Hazard Index Across All Media and All Exposure Routes				1.7				
Total Risk Across Air				5.8E-06	Total Skin HI =				0.62				
Total Risk Across All Media and All Exposure Routes				7.3E-05	Total Kidney HI =				0.0054				
					Total Liver HI =				0.084				
					Total Red blood cell HI =				0.60				
					Total Thyroid HI =				0.41				

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

Total Skin HI =	0.62
Total Kidney HI =	0.0054
Total Liver HI =	0.084
Total Red blood cell HI =	0.60
Total Thyroid HI =	0.41

**TABLE 6-31
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 21**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient					
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total	
Groundwater	Groundwater	Monitoring Well 21— Tap Water	Chloroform	3.1E-07	--	--	3.1E-07	Chloroform	Liver	0.0043	--	--	0.0043	
			Lead	N/A	--	N/A	N/A	Lead	N/A	N/A	--	N/A	N/A	
			Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.68	--	0.0056	0.68	
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	1.0	--	0.0085	1.0	
			Tetrachloroethene	2.8E-06	--	--	2.8E-06	Tetrachloroethene	Liver	0.024	--	--	0.024	
			Trichloroethene	2.0E-06	--	--	2.0E-06	Trichloroethene	N/A	0.096	--	--	0.096	
		(Total)		5.1E-06	--	N/A	5.1E-06	(Total)		1.8	--	0.014	1.9	
		Air	Monitoring Well 21— Water Vapor	Chloroform	--	9.6E-07	--	9.6E-07	Chloroform	Liver	--	0.022	--	0.022
	Tetrachloroethene			--	5.8E-06	--	5.8E-06	Tetrachloroethene	Liver	--	0.011	--	0.011	
	Trichloroethene			--	6.7E-06	--	6.7E-06	Trichloroethene	N/A	--	0.48	--	0.48	
	(Total)				--	1.3E-05	--	1.3E-05	(Total)		--	0.51	--	0.51
	Total Risk Across Groundwater						5.1E-06	Total Hazard Index Across All Media and All Exposure Routes					2.4	
	Total Risk Across Air						1.3E-05							
	Total Risk Across All Media and All Exposure Routes						1.9E-05							

Total Liver HI =	0.060
Total Red blood cell HI =	0.68
Total Thyroid HI =	1.0

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-32
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 22**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Monitoring Well 22— Tap Water	Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.44	--	0.0036	0.44
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.64	--	0.0053	0.64
			Tetrachloroethene	1.1E-06	--	--	1.1E-06	Tetrachloroethene	Liver	0.0089	--	--	0.0089
		(Total)	1.1E-06	--	N/A	1.1E-06	(Total)		1.1	--	0.0089	1.1	
	Air	Monitoring Well 22— Water Vapor	Tetrachloroethene	--	2.2E-06	--	2.2E-06	Tetrachloroethene	Liver	--	0.0041	--	0.0041
			(Total)	--	2.2E-06	--	2.2E-06	(Total)		--	0.0041	--	0.0041
Total Risk Across Groundwater							1.1E-06	Total Hazard Index Across All Media and All Exposure Routes					1.1
Total Risk Across Air							2.2E-06						
Total Risk Across All Media and All Exposure Routes							3.2E-06						
								Total Liver HI =	0.013				
								Total Red blood cell HI =	0.44				
								Total Thyroid HI =	0.64				

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-33
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 23**

Scenario Timeframe: Current/Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient					
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total	
Groundwater	Groundwater	Monitoring Well 23— Tap Water	Chloroform	2.4E-07	--	--	2.4E-07	Chloroform	Liver	0.0033	--	--	0.0033	
			Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.60	--	0.0049	0.60	
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.72	--	0.0059	0.72	
			Tetrachloroethene	4.9E-07	--	--	4.9E-07	Tetrachloroethene	Liver	0.0042	--	--	0.0042	
			Trichloroethene	6.5E-07	--	--	6.5E-07	Trichloroethene	N/A	0.031	--	--	0.031	
		(Total)		1.4E-06	--	N/A	1.4E-06	(Total)		1.4	--	0.011	1.4	
		Air	Monitoring Well 23— Water Vapor	Chloroform	--	7.3E-07	--	7.3E-07	Chloroform	Liver	--	0.017	--	0.017
	Tetrachloroethene			--	1.0E-06	--	1.0E-06	Tetrachloroethene	Liver	--	0.0019	--	0.0019	
	Trichloroethene			--	2.2E-06	--	2.2E-06	Trichloroethene	N/A	--	0.15	--	0.15	
				(Total)		--	3.9E-06	--	3.9E-06	(Total)		--	0.17	--
			Total Risk Across Groundwater				1.4E-06		Total Hazard Index Across All Media and All Exposure Routes					1.5
			Total Risk Across Air				3.9E-06							
			Total Risk Across All Media and All Exposure Routes				5.3E-06							

Total Liver HI =	0.026
Total Red blood cell HI =	0.60
Total Thyroid HI =	0.72

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-34
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Monitoring Well 24**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Monitoring Well 24— Tap Water	1,2-Dichloroethane	4.1E-07	--	--	4.1E-07	1,2-Dichloroethane	N/A	0.0086	--	--	0.0086
			Arsenic	7.6E-05	--	7.7E-07	7.7E-05	Arsenic	Skin	0.72	--	0.006	0.73
			Carbon Tetrachloride	6.7E-05	--	--	6.7E-05	Carbon Tetrachloride	Liver	2.7	--	--	2.7
			Chloroform	6.9E-06	--	--	6.9E-06	Chloroform	Liver	0.096	--	--	0.096
			Nitrate	N/A	--	N/A	N/A	Nitrate	Red blood cells	0.14	--	0.0011	0.14
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	42	--	0.35	43
			Tetrachloroethene	2.4E-07	--	--	2.4E-07	Tetrachloroethene	Liver	0.0020	--	--	0.0020
	Trichloroethene	3.3E-06	--	--	3.3E-06	Trichloroethene	N/A	0.16	--	--	0.16		
	(Total)	1.5E-04	--	7.7E-07	1.5E-04	(Total)		46	--	0.36	46		
	Air	Monitoring Well 24— Water Vapor	1,2-Dichloroethane	--	2.0E-06	--	2.0E-06	1,2-Dichloroethane	N/A	--	0.043	--	0.043
			Carbon Tetrachloride	--	3.3E-04	--	3.3E-04	Carbon Tetrachloride	Liver	--	17	--	17
			Chloroform	--	2.1E-05	--	2.1E-05	Chloroform	Liver	--	0.48	--	0.48
			Tetrachloroethene	--	5.0E-07	--	5.0E-07	Tetrachloroethene	Liver	--	0.00093	--	0.00093
			Trichloroethene	--	1.1E-05	--	1.1E-05	Trichloroethene	N/A	--	0.80	--	0.80
(Total)			--	3.7E-04	--	3.7E-04	(Total)		--	18	--	18	
(Total)							(Total)						
Total Risk Across Groundwater							1.5E-04	Total Hazard Index Across All Media and All Exposure Routes					65
Total Risk Across Air							3.7E-04						
Total Risk Across All Media and All Exposure Routes							5.2E-04						
								Total Skin HI =					0.73
								Total Liver HI =					20
								Total Red blood cell HI =					0.14
								Total Thyroid HI =					43

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

Total Skin HI =	0.73
Total Liver HI =	20
Total Red blood cell HI =	0.14
Total Thyroid HI =	43

**TABLE 6-35
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—La Canada Well #1**

Scenario Timeframe: Current/Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	La Canada Well #1— Tap Water	Tetrachloroethene	4.6E-07	--	--	4.6E-07	Tetrachloroethene	Liver	0.0038	--	--	0.0038
			(Total)	4.6E-07	--	--	4.6E-07	(Total)		0.0038	--	--	0.0038
	Air	La Canada Well #1— Water Vapor	Tetrachloroethene	--	9.4E-07	--	9.4E-07	Tetrachloroethene	Liver	--	0.0017	--	0.0017
			(Total)	--	9.4E-07	--	9.4E-07	(Total)		--	0.0017	--	0.0017
Total Risk Across Groundwater							4.6E-07	Total Hazard Index Across All Media and All Exposure Routes					0.0056
Total Risk Across Air							9.4E-07						
Total Risk Across All Media and All Exposure Routes							1.4E-06						
								Total Liver HI =					0.0056

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index

**TABLE 6-36
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Las Flores Well #2**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Las Flores Well #2— Tap Water	Arsenic	5.4E-05	--	5.4E-07	5.4E-05	Arsenic	Skin	0.51	--	0.0042	0.52
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.78	--	0.0064	0.79
			Tetrachloroethene	3.6E-06	--	--	3.6E-06	Tetrachloroethene	Liver	0.031	--	--	0.031
	(Total)	5.7E-05	--	5.4E-07	5.8E-05	(Total)		1.3	--	0.011	1.3		
	Air	Las Flores Well #2— Water Vapor	Tetrachloroethene	--	7.5E-06	--	7.5E-06	Tetrachloroethene	Liver	--	0.014	--	0.014
			(Total)	--	7.5E-06	--	7.5E-06	(Total)		--	0.014	--	0.014
Total Risk Across Groundwater							5.8E-05	Total Hazard Index Across All Media and All Exposure Routes					1.3
Total Risk Across Air							7.5E-06						
Total Risk Across All Media and All Exposure Routes							6.5E-05						

Total Skin HI =	0.52
Total Liver HI =	0.045
Total Thyroid HI =	0.79

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-37
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Lincoln Ave. Well #3**

Scenario Timeframe: Current/Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Lincoln Ave. Well #3— Tap Water	Carbon Tetrachloride	2.5E-06	--	--	2.5E-06	Carbon Tetrachloride	Liver	0.10	--	--	0.10
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	1.8	--	0.015	1.8
			Tetrachloroethene	8.3E-07	--	--	8.3E-07	Tetrachloroethene	Liver	0.0070	--	--	0.0070
			Trichloroethene	3.5E-06	--	--	3.5E-06	Trichloroethene	N/A	0.17	--	--	0.17
		(Total)		6.8E-06	--	N/A	6.8E-06	(Total)		2.1	--	0.015	2.1
	Air	Lincoln Ave. Well #3— Water Vapor	Carbon Tetrachloride	--	1.2E-05	--	1.2E-05	Carbon Tetrachloride	Liver	--	0.62	--	0.62
			Tetrachloroethene	--	1.7E-06	--	1.7E-06	Tetrachloroethene	Liver	--	0.0032	--	0.0032
			Trichloroethene	--	1.2E-05	--	1.2E-05	Trichloroethene	N/A	--	0.85	--	0.85
(Total)			--	2.6E-05	--	2.6E-05	(Total)		--	1.5	--	1.5	
Total Risk Across Groundwater							6.8E-06	Total Hazard Index Across All Media and All Exposure Routes					3.5
Total Risk Across Air							2.6E-05	Total Liver HI =					0.73
Total Risk Across All Media and All Exposure Routes							3.3E-05	Total Thyroid HI =					1.8

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-38
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Lincoln Ave. Well #5**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Lincoln Ave. Well #5— Tap Water	Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.89	--	0.0074	0.90
			Tetrachloroethene	5.3E-07	--	--	5.3E-07	Tetrachloroethene	Liver	0.0045	--	--	0.0045
			Trichloroethene	2.9E-06	--	--	2.9E-06	Trichloroethene	N/A	0.14	--	--	0.14
		(Total)	3.4E-06	--	N/A	3.4E-06	(Total)		1.0	--	0.0074	1.0	
	Air	Lincoln Ave. Well #5— Water Vapor	Tetrachloroethene	--	1.1E-06	--	1.1E-06	Tetrachloroethene	Liver	--	0.0020	--	0.0020
			Trichloroethene	--	9.7E-06	--	9.7E-06	Trichloroethene	N/A	--	0.69	--	0.69
(Total)			--	1.1E-05	--	1.1E-05	(Total)		--	0.69	--	0.69	
Total Risk Across Groundwater							3.4E-06	Total Hazard Index Across All Media and All Exposure Routes					1.7
Total Risk Across Air							1.1E-05						
Total Risk Across All Media and All Exposure Routes							1.4E-05						
								Total Liver HI =	0.0065				
								Total Thyroid HI =	0.90				

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-39
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Pasadena Arroyo Well**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Pasadena Arroyo Well— Tap Water	Carbon Tetrachloride	1.0E-05	--	--	1.0E-05	Carbon Tetrachloride	Liver	0.43	--	--	0.43
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	17	--	0.14	17
			Tetrachloroethene	6.8E-07	--	--	6.8E-07	Tetrachloroethene	Liver	0.0057	--	--	0.0057
			Trichloroethene	7.6E-07	--	--	7.6E-07	Trichloroethene	N/A	0.036	--	--	0.036
		(Total)		1.2E-05	--	N/A	1.2E-05	(Total)		17	--	0.14	17
	Air	Pasadena Arroyo Well— Water Vapor	Carbon Tetrachloride	--	5.2E-05	--	5.2E-05	Carbon Tetrachloride	Liver	--	2.6	--	2.6
			Tetrachloroethene	--	1.4E-06	--	1.4E-06	Tetrachloroethene	Liver	--	0.0026	--	0.0026
			Trichloroethene	--	2.5E-06	--	2.5E-06	Trichloroethene	N/A	--	0.18	--	0.18
(Total)			--	5.6E-05	--	5.6E-05	(Total)	--	--	2.8	--	2.8	
Total Risk Across Groundwater							1.2E-05	Total Hazard Index Across All Media and All Exposure Routes					20
Total Risk Across Air							5.6E-05						
Total Risk Across All Media and All Exposure Routes							6.8E-05						
								Total Liver HI =					3.1
								Total Thyroid HI =					17

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-40
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Pasadena Ventura Well**

Scenario Timeframe: Current/Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Pasadena Ventura Well—Tap Water	Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.63	--	0.0052	0.63
			Tetrachloroethene	5.3E-07	--	--	5.3E-07	Tetrachloroethene	Liver	0.0045	--	--	0.0045
			Trichloroethene	2.5E-07	--	--	2.5E-07	Trichloroethene	N/A	0.012	--	--	0.012
	(Total)	7.8E-07	--	N/A	7.8E-07	(Total)		0.64	--	0.0052	0.65		
Air	Air	Pasadena Ventura Well—Water Vapor	Tetrachloroethene	--	1.1E-06	--	1.1E-06	Tetrachloroethene	Liver	--	0.0020	--	0.0020
			Trichloroethene	--	8.2E-07	--	8.2E-07	Trichloroethene	N/A	--	0.059	--	0.059
			(Total)	--	1.9E-06	--	1.9E-06	(Total)		--	0.061	--	0.061
	Total Risk Across Groundwater							7.8E-07	Total Hazard Index Across All Media and All Exposure Routes				
Total Risk Across Air							1.9E-06						
Total Risk Across All Media and All Exposure Routes							2.7E-06						
								Total Liver HI =					0.0065
								Total Thyroid HI =					0.63

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-41
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Pasadena Well 52**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Pasadena Well 52— Tap Water	Carbon Tetrachloride	2.9E-06	--	--	2.9E-06	Carbon Tetrachloride	Liver	0.12	--	--	0.12
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	1.9	--	0.016	1.9
			Trichloroethene	1.2E-06	--	--	1.2E-06	Trichloroethene	N/A	0.055	--	--	0.055
		(Total)	4.1E-06	--	N/A	4.1E-06	(Total)		2.1	--	0.016	2.1	
	Air	Pasadena Well 52— Water Vapor	Carbon Tetrachloride	--	1.5E-05	--	1.5E-05	Carbon Tetrachloride	Liver	--	0.73	--	0.73
			Trichloroethene	--	3.9E-06	--	3.9E-06	Trichloroethene	N/A	--	0.28	--	0.28
(Total)			--	1.8E-05	--	1.8E-05	(Total)		--	1.0	--	1.0	
Total Risk Across Groundwater							4.1E-06	Total Hazard Index Across All Media and All Exposure Routes					3.1
Total Risk Across Air							1.8E-05						
Total Risk Across All Media and All Exposure Routes							2.2E-05						
								Total Liver HI =					0.85
								Total Thyroid HI =					1.9

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-42
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Pasadena Windsor Well**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Pasadena Windsor Well—Tap Water	Tetrachloroethene	8.3E-07	--	--	8.3E-07	Tetrachloroethene	Liver	0.0070	--	--	0.0070
			Trichloroethene	2.7E-07	--	--	2.7E-07	Trichloroethene	N/A	0.013	--	--	0.013
			(Total)	1.1E-06	--	--	1.1E-06	(Total)		0.020	--	--	0.020
	Air	Pasadena Windsor Well—Water Vapor	Tetrachloroethene	--	1.7E-06	--	1.7E-06	Tetrachloroethene	Liver	--	0.0032	--	0.0032
			Trichloroethene	--	8.9E-07	--	8.9E-07	Trichloroethene	N/A	--	0.064	--	0.064
			(Total)	--	2.6E-06	--	2.6E-06	(Total)		--	0.067	--	0.067
Total Risk Across Groundwater							1.1E-06	Total Hazard Index Across All Media and All Exposure Routes					0.087
Total Risk Across Air							2.6E-06						
Total Risk Across All Media and All Exposure Routes							3.7E-06						
								Total Liver HI =					0.010

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-43
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory -- Rubio Cañon #4**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Rubio Cañon #4— Tap Water	Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.70	--	0.0058	0.71
			(Total)	N/A	--	N/A	N/A	(Total)		0.70	--	0.0058	0.71
	Air	Rubio Cañon #4— Water Vapor	--	--	--	--	--	--	--	--	--	--	--
			(Total)	--	--	--	--	(Total)		--	--	--	--
Total Risk Across Groundwater							N/A	Total Hazard Index Across All Media and All Exposure Routes					0.71
Total Risk Across Air							--						
Total Risk Across All Media and All Exposure Routes							N/A	Total Thyroid HI =					0.71

Definitions: COPC = chemical of potential concern
 -- = Not evaluated for this pathway
 HI = hazard index
 N/A = Not applicable

**TABLE 6-44
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Rubio Cañon Well #7**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Rubio Cañon Well #7— Tap Water	Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.41	--	0.0034	0.41
			(Total)	N/A	--	N/A	N/A	(Total)		0.41	--	0.0034	0.41
	Air	Rubio Cañon Well #7— Water Vapor	--	--	--	--	--	--	--	--	--	--	--
			(Total)	--	--	--	--	(Total)		--	--	--	--
Total Risk Across Groundwater							N/A	Total Hazard Index Across All Media and All Exposure Routes					0.41
Total Risk Across Air							--						
Total Risk Across All Media and All Exposure Routes							N/A	Total Thyroid HI =					0.41

Definitions: COPC = chemical of potential concern
 -- = Not evaluated for this pathway
 HI = hazard index
 N/A = Not applicable

**TABLE 6-45
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Valley Well #1**

Scenario Timeframe: Current/Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Valley Well #1— Tap Water	Arsenic	4.2E-05	--	4.3E-07	4.3E-05	Arsenic	Skin	0.40	--	0.0033	0.41
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.50	--	0.0041	0.50
			Tetrachloroethene	2.9E-05	--	--	2.9E-05	Tetrachloroethene	Liver	0.24	--	--	0.24
			Trichloroethene	7.8E-07	--	--	7.8E-07	Trichloroethene	N/A	0.037	--	--	0.037
		(Total)		7.2E-05	--	4.3E-07	7.2E-05	(Total)		1.2	--	0.0075	1.2
	Air	Valley Well #1— Water Vapor	Tetrachloroethene	--	5.9E-05	--	5.9E-05	Tetrachloroethene	Liver	--	0.11	--	0.11
			Trichloroethene	--	2.6E-06	--	2.6E-06	Trichloroethene	N/A	--	0.19	--	0.19
				(Total)	--	6.2E-05	--	6.2E-05	(Total)		--	0.30	--
Total Risk Across Groundwater							7.2E-05	Total Hazard Index Across All Media and All Exposure Routes					1.5
Total Risk Across Air							6.2E-05						
Total Risk Across All Media and All Exposure Routes							1.3E-04						
								Total Skin HI =					0.41
								Total Liver HI =					0.35
								Total Thyroid HI =					0.50

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-46
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Valley Well #2**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Valley Well #2— Tap Water	Arsenic	4.5E-05	--	4.5E-07	4.5E-05	Arsenic	Skin	0.43	--	0.0035	0.43
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.51	--	0.0042	0.52
			Tetrachloroethene	6.9E-06	--	--	6.9E-06	Tetrachloroethene	Liver	0.058	--	--	0.058
			Trichloroethene	2.2E-07	--	--	2.2E-07	Trichloroethene	N/A	0.011	--	--	0.011
		(Total)		5.2E-05	--	4.5E-07	5.2E-05	(Total)		1.0	--	0.0077	1.0
	Air	Valley Well #2— Water Vapor	Tetrachloroethene	--	1.4E-05	--	1.4E-05	Tetrachloroethene	Liver	--	0.026	--	0.026
			Trichloroethene	--	7.4E-07	--	7.4E-07	Trichloroethene	N/A	--	0.053	--	0.053
				(Total)	--	1.5E-05	--	1.5E-05	(Total)		--	0.080	--
			Total Risk Across Groundwater				5.2E-05		Total Hazard Index Across All Media and All Exposure Routes				1.1
					1.5E-05								
					6.7E-05								

Total Skin HI =	0.43
Total Liver HI =	0.085
Total Thyroid HI =	0.52

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-47
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Valley Well #3**

Scenario Timeframe: Current/Future Receptor Population: Resident Receptor Age: Child/Adult
--

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Valley Well #3— Tap Water	Arsenic	3.3E-05	--	3.4E-07	3.4E-05	Arsenic	Skin	0.32	--	0.0026	0.32
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.56	--	0.0046	0.57
			Tetrachloroethene	8.3E-07	--	--	8.3E-07	Tetrachloroethene	Liver	0.0070	--	--	0.0070
	(Total)	3.4E-05	--	3.4E-07	3.5E-05	(Total)		0.89	--	0.0073	0.90		
	Air	Valley Well #3— Water Vapor	Tetrachloroethene	--	1.7E-06	--	1.7E-06	Tetrachloroethene	Liver	--	0.0032	--	0.0032
			(Total)	--	1.7E-06	--	1.7E-06	(Total)		--	0.0032	--	0.0032
Total Risk Across Groundwater							3.5E-05	Total Hazard Index Across All Media and All Exposure Routes					0.90
Total Risk Across Air							1.7E-06						
Total Risk Across All Media and All Exposure Routes							3.6E-05						

Total Skin HI =	0.32
Total Liver HI =	0.010
Total Thyroid HI =	0.57

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

**TABLE 6-48
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Jet Propulsion Laboratory—Valley Well #4**

Scenario Timeframe: Current/Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Valley Well #4— Tap Water	Arsenic	4.2E-05	--	4.3E-07	4.3E-05	Arsenic	Skin	0.40	--	0.0033	0.41
			Perchlorate	N/A	--	N/A	N/A	Perchlorate	Thyroid	0.50	--	0.0041	0.50
			Tetrachloroethene	1.7E-05	--	--	1.7E-05	Tetrachloroethene	Liver	0.14	--	--	0.14
			Trichloroethene	5.8E-07	--	--	5.8E-07	Trichloroethene	N/A	0.028	--	--	0.028
		(Total)	6.0E-05	--	4.3E-07	6.1E-05	(Total)		1.1	--	0.0075	1.1	
		Valley Well #4— Water Vapor	Tetrachloroethene	--	3.5E-05	--	3.5E-05	Tetrachloroethene	Liver	--	0.066	--	0.066
	Trichloroethene		--	1.9E-06	--	1.9E-06	Trichloroethene	N/A	--	0.14	--	0.14	
			(Total)	--	3.7E-05	--	3.7E-05	(Total)		--	0.20	--	0.20
Total Risk Across Groundwater						6.1E-05	Total Hazard Index Across All Media and All Exposure Routes						1.3
Total Risk Across Air						3.7E-05							
Total Risk Across All Media and All Exposure Routes						9.8E-05							
							Total Skin HI =						0.41
							Total Liver HI =						0.21
							Total Thyroid HI =						0.50

Definitions: 1.0E-02 = 1.0 x 10⁻² = 0.010
 -- = Not evaluated for this pathway
 COPC = chemical of potential concern
 HI = hazard index
 N/A = Not applicable

TABLE 6-49
SUMMARY OF CARCINOGENIC AND NONCARCINOGENIC
RISK RESULTS BY WELL AT THE JET PROPULSION LABORATORY

Well	Noncarcinogenic Risk			Carcinogenic Risk		
	Ingestion/ Dermal	Inhalation	Total	Ingestion/ Dermal	Inhalation	Total
MW-01	0.06	0.00049	0.060	--	--	--
MW-03	1.8	0.34	2.1	9.5E-05	1.1E-05	1.1E-04
MW-04	5.7	2.8	8.5	1.6E-05	6.1E-05	7.7E-05
MW-05	0.64	--	0.64	--	--	--
MW-06	1.2	0.0058	1.2	1.5E-06	3.1E-06	4.6E-06
MW-07	110	86	200	4.3E-04	1.8E-03	2.2E-03
MW-08	4.2	2.1	6.3	8.7E-06	4.1E-05	5.0E-05
MW-09	0.22	--	0.22	--	--	--
MW-10	2.9	0.33	3.2	3.5E-06	9.3E-06	1.3E-05
MW-11	0.094	0.41	0.51	1.9E-06	8.9E-06	1.1E-05
MW-12	2.1	6.8	8.9	2.8E-05	1.4E-04	1.6E-04
MW-13	36	11	47	3.2E-04	2.3E-04	5.5E-04
MW-14	1.2	0.042	1.3	9.1E-07	2.2E-06	3.1E-06
MW-15	0.18	--	0.18	--	--	--
MW-16	170	54	220	3.0E-04	1.1E-03	1.4E-03
MW-17	5.3	2.4	7.6	3.5E-05	5.1E-05	8.5E-05
MW-18	1.9	1.0	2.9	9.0E-05	3.1E-05	1.2E-04
MW-19	0.82	0.073	0.89	2.6E-06	7.6E-06	1.0E-05
MW-20	1.7	0.075	1.7	6.7E-05	5.8E-06	7.3E-05
MW-21	1.9	0.51	2.4	5.1E-06	1.3E-05	1.9E-05
MW-22	1.1	0.0041	1.1	1.1E-06	2.2E-06	3.2E-06
MW-23	1.4	0.17	1.5	1.4E-06	3.9E-06	5.3E-06
MW-24	46	18	65	1.5E-04	3.7E-04	5.2E-04
LCW #1	0.0038	0.0017	0.0056	4.6E-07	9.4E-07	1.4E-06
LFW #2	1.3	0.014	1.3	5.8E-05	7.5E-06	6.5E-05

TABLE 6-49

**SUMMARY OF CARCINOGENIC AND NONCARCINOGENIC
RISK RESULTS BY WELL AT THE JET PROPULSION LABORATORY**

Well	Noncarcinogenic Risk			Carcinogenic Risk		
	Ingestion/ Dermal	Inhalation	Total	Ingestion/ Dermal	Inhalation	Total
LAW #3	2.1	1.5	3.5	6.8E-06	2.6E-05	3.3E-05
LAW #5	1.0	0.69	1.7	3.4E-06	1.1E-05	1.4E-05
PAW	17	2.8	20	1.2E-05	5.6E-05	6.8E-05
PVW	0.65	0.061	0.71	7.8E-07	1.9E-06	2.7E-06
PW-52	2.1	1.0	3.1	4.1E-06	1.8E-05	2.2E-05
PWW	0.020	0.067	0.087	1.1E-06	2.6E-06	3.7E-06
RCW #4	0.71	--	0.71	--	--	--
RCW #7	0.41	--	0.41	--	--	--
VW #1	1.2	0.30	1.5	7.2E-05	6.2E-05	1.3E-04
VW #2	1.0	0.080	1.1	5.2E-05	1.5E-05	6.7E-05
VW #3	0.90	0.0032	0.90	3.5E-05	1.7E-06	3.6E-05
VW #4	1.1	0.20	1.3	6.1E-05	3.7E-05	9.8E-05

Notes:1.0E-02 = 1×10^{-2} = 0.010

LAW = Lincoln Avenue Well

LCW = La Canada Well

LFW = Las Flores Well

MW = monitoring well

PAW = Pasadena Arroyo Well

PVW = Pasadena Ventura Well

PW = Pasadena Well

PWW = Pasadena Windsor Well

RCW = Rubio Cañon Well

VW = Valley Well

TABLE 6-50
CHEMICALS THAT ARE THE MAJOR CONTRIBUTORS^(A) TO RISK FOR
WELLS WITH CANCER RISK GREATER THAN 10⁻⁶ AND/OR HAZARD INDEX VALUES GREATER THAN 1.0

Chemical	MW-01		MW-03		MW-04		MW-05	
	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic
1,1-Dichloroethene					8.7E-06			
1,2-Dichloroethane					2.0E-06			
Arsenic			9.2E-05	0.90				
Bromodichloromethane			3.5E-06					
Carbon Tetrachloride			6.6E-06	0.30	4.9E-05	2.4		
Chloroform			2.4E-06		6.0E-06			
Hexavalent Chromium								
Nitrate						0.30		
Perchlorate				0.80		4.9		
Tetrachloroethene								
Trichloroethene					9.6E-06	0.60		
Total Risk*	--	0.070	1.1E-04	2.1	7.7E-05	8.5	--	0.60
Total Liver HI				0.40		2.6		
Total Skin HI				0.90				
Total Thyroid HI				0.80		4.9		
Total RBC HI								

**Table 6-50 Chemicals That Are The Major
Contributors To Risk for Wells with Cancer Risk $>10^{-6}$ and/or HI >1.0**

Chemical	MW-06		MW-07		MW-08		MW-09	
	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic
1,1-Dichloroethene			4.7E-05					
1,2-Dichloroethane			5.5E-06					
Arsenic								
Bromodichloromethane								
Carbon Tetrachloride			2.0E-03	98	4.3E-05	2.1		
Chloroform			2.4E-05	0.50	2.4E-06			
Hexavalent Chromium			6.2E-05					
Nitrate		0.40						
Perchlorate		0.70		93		3.7		
Tetrachloroethene	4.6E-06		8.6E-06					
Trichloroethene			2.6E-05	1.7	4.3E-06			
Total Risk*	4.6E-06	1.2	2.2E-03	193	5.0E-05	6.3	--	0.20
Total Liver HI				98		2.1		
Total Skin HI								
Total Thyroid HI		0.70		93		3.7		
Total RBC HI		0.40						

**Table 6-50 Chemicals That Are The Major
Contributors To Risk for Wells with Cancer Risk $>10^{-6}$ and/or HI >1.0**

Chemical	MW-10		MW-11		MW-12		MW-13	
	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic
1,1-Dichloroethene							2.2E-05	
1,2-Dichloroethane							6.8E-06	
Arsenic								
Bromodichloromethane								
Carbon Tetrachloride			9.2E-06		1.6E-04	7.8	2.2E-04	11
Chloroform	2.6E-06		1.6E-06		3.7E-06		2.1E-05	
Hexavalent Chromium							2.6E-04	0.50
Nitrate		0.70						
Perchlorate		2.1				0.90		33
Tetrachloroethene	5.1E-06							
Trichloroethene	5.1E-06	0.30					2.8E-05	1.8
Total Risk*	1.3E-05	3.2	1.1E-05	0.50	1.6E-04	8.9	5.5E-04	47
Total Liver HI						7.9		11
Total Skin HI								
Total Thyroid HI		2.1				0.9		33
Total RBC HI		0.70						

**Table 6-50 Chemicals That Are The Major
Contributors To Risk for wells With Cancer Risk $>10^{-6}$ and/or HI >1.0**

Chemical	MW-14		MW-15		MW-16		MW-17	
	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic
1,1-Dichloroethene					5.8E-05			
1,2-Dichloroethane					1.3E-05			
Arsenic								
Bromodichloromethane							5.2E-06	
Carbon Tetrachloride					1.2E-03	59	2.2E-05	1.1
Chloroform	8.6E-07				8.1E-05	1.7	1.5E-05	
Hexavalent Chromium					4.5 E-05		2.1E-05	
Nitrate		0.80				0.73		
Perchlorate		0.50				160		4.7
Tetrachloroethene	1.8E-06				3.0E-06		1.3E-06	
Trichloroethene					2.5E-05	1.6	2.2E-05	1.5
Total Risk*	3.1E-06	1.3	--	0.20	1.4E-03	220	8.5E-05	7.6
Total Liver HI						61		1.3
Total Skin HI								
Total Thyroid HI		0.50				160		4.7
Total RBC HI		0.80						

**Table 6-50 Chemicals That Are The Major
Contributors To Risk for Wells with Cancer Risk $>10^{-6}$ and/or HI >1.0**

Chemical	MW-18		MW-19		MW-20		MW-21	
	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic
1,1-Dichloroethene								
1,2-Dichloroethane								
Arsenic	6.3E-05	0.60			6.5E-05	0.60		
Bromodichloromethane	4.8E-06		3.2E-06		3.2E-06			
Carbon Tetrachloride	1.8E-05	0.80						
Chloroform	1.2E-05		2.3E-06		4.1E-06		1.3E-06	
Hexavalent Chromium	1.9E-05							
Nitrate						0.60		0.70
Perchlorate		0.90				0.40		1.0
Tetrachloroethene	3.4E-06		4.2E-06				8.6E-06	
Trichloroethene	1.7E-05						8.7E-06	0.50
Total Risk*	1.2E-04	2.9	1.0E-05	0.90	7.3E-05	1.7	1.9E-05	2.4
Total Liver HI		1.1						
Total Skin HI		0.60				0.60		
Total Thyroid HI		0.90				0.40		1.0
Total RBC HI						0.60		0.70

**Table 6-50 Chemicals That Are The Major
Contributors To Risk for Wells with Cancer Risk >10⁻⁶ and/or HI >1.0**

Chemical	MW-22		MW-23		MW-24	
	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic
1,1-Dichloroethene						
1,2-Dichloroethane					2.4E-06	
Arsenic					7.7E-05	0.70
Bromodichloromethane						
Carbon Tetrachloride					4.0E-04	20
Chloroform			9.7E-07		2.8E-05	
Hexavalent Chromium						
Nitrate		0.40		0.60		
Perchlorate		0.60		0.70		43
Tetrachloroethene	3.2E-06		1.5E-06			
Trichloroethene			2.7E-06		1.4E-05	0.90
Total Risk*	3.2E-06	1.1	5.3E-06	1.5	5.2E-04	65
Total Liver HI						20
Total Skin HI						0.70
Total Thyroid HI		0.60		0.70		43
Total RBC HI		0.40		0.60		

Table 6-50 Chemicals That Are The Major Contributors To Risk for Wells with Cancer Risk $>10^{-6}$ and/or HI >1.0

Chemical	Lincoln Avenue Well No. 3		Lincoln Avenue Well No. 5	
	Carcinogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic
1,1-Dichloroethene				
1,2-Dichloroethane				
Arsenic				
Bromodichloromethane				
Carbon Tetrachloride	1.5E-05	0.70		
Chloroform				
Hexavalent Chromium				
Nitrate				
Perchlorate		1.8		0.90
Tetrachloroethene	2.5E-06		1.6E-06	
Trichloroethene	1.5E-05	1.0	1.3E-05	0.80
Total Risk*	3.3E-05	3.5	1.4E-05	1.7
Total Liver HI		0.70		
Total Skin HI				
Total Thyroid HI		1.8		0.90
Total RBC HI				

**Table 6-50 Chemicals That Are The Major
Contributors To Risk for Wells with Cancer Risk $>10^{-6}$ and/or HI >1.0**

Notes:

- (a) Major contributors are those chemicals with individual cancer risk values greater than $1.0E-6$ and HIs greater than 0.5.
- (b) Total risk is for all chemical detections and pathways, of which the major contributors are a subset; therefore, the sum of the major contributors does not necessary equal the total value.

$1.0E-02 = 1.0 \times 10^{-2} = 0.010$

HI = hazard index

MW = monitoring well

No. = number

RBC = red blood cell

-- = no carcinogens detected

TABLE 6-51

**MONITORING WELLS WITH CHEMICAL SPECIFIC CANCER RISKS GREATER
THAN 10^{-6} OR HAZARD INDEX VALUES GREATER THAN 1.0 (FOR ALL EXPOSURE PATHWAYS COMBINED)**

Chemical of Concern	Monitoring Well																								Total Wells (N/C)
	01	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
1,1-Dichloroethene			C			C						C			C										0/4
1,2-Dichloroethane			C			C						C			C								C		0/5
Arsenic		C															C		C				C		0/4
Bromodichloromethane		C														C	C	C	C						0/5
Carbon Tetrachloride		C	N,C			N,C	N,C			C	N,C	N,C			N,C	N,C	C						N,C		8/11
Chloroform		C	C			C	C		C	C	C	C	C		N,C	C	C	C	C	C			C		1/16
Hexavalent Chromium						C						C			C	C	C								0/5
Nitrate																									0/0
Perchlorate			N			N	N		N			N			N	N					N			N	9/0
Tetrachloroethene					C	C			C				C		C	C	C	C		C	C	C			0/11
Trichloroethene			C			N,C	C		C			N,C			N,C	N,C	C			C		C	C		4/11
Wells with Target Organ HI values >1.0			Y			Y	Y		Y			Y			Y	Y	Y			Y			Y		

Notes:C = Carcinogenic risk ($> 1.0 \times 10^{-6}$)

N = Noncarcinogenic risk (HI > 1.0)

HI = Hazard Index

TABLE 6-52

**PRODUCTION WELLS WITH CHEMICAL SPECIFIC CANCER RISKS GREATER
THAN 10^{-6} OR HAZARD INDEX VALUES GREATER THAN 1.0 (FOR ALL EXPOSURE PATHWAYS COMBINED)**

Chemical of Concern	Production Well														Total Wells (N/C)
	Valley #1	Valley #2	Valley #3	Valley #4	La Canada #1	Las Flores	Pasadena Arroyo	Pasadena Windsor	Pasadena 52	Lincoln Ave #3	Lincoln Ave #5	Rubio Canon #4	Rubio Canon #7	Pasadena Ventura	
1,1-Dichloroethene															0/0
1,2-Dichloroethane															0/0
Arsenic	C	C	C	C		C									0/5
Bromodichloromethane															0/0
Carbon Tetrachloride							N,C		C	C					1/3
Chloroform															0/0
Hexavalent Chromium															0/0
Nitrate															0/0
Perchlorate							N		N	N					3/0
Tetrachloroethene	C	C	C	C	C	C	C	C		C	C			C	0/11
Trichloroethene	C			C			C	C	C	N,C	C			C	1/8
Wells with Target Organ HI values >1.0							Y		Y	Y					

Notes:C = Carcinogenic risk ($> 1.0 \times 10^{-6}$)

N = Noncarcinogenic risk (HI > 1.0)

HI = Hazard Index

**TABLE 6-53
PERCENT CONTRIBUTION OF CHEMICALS TO OVERALL RISK
IN JPL MONITORING WELLS WITH CANCER RISKS GREATER THAN 10⁻⁶**

Chemical of Concern*	Monitoring Well																							
	01	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
1,1-Dichloroethene			11			2					4			4										
1,2-Dichloroethane			2			<1					1			<1									<1	
Arsenic		84														46		89					15	
Bromodichloromethane		3													6	3	32	4						
Carbon Tetrachloride		6	63			91	86			84	100	39			86	25	13						77	
Chloroform		2	7			1	5		20	14	<1	4	27		6	17	8	23	6	7		18	5	
Hexavalent Chromium						3						47			3	24	14							
Nitrate																								
Perchlorate																								
Tetrachloroethene					100	<1			39				58		<1	1	2	42		45	100	28		
Trichloroethene			12			1	9		39		5			2	25	12				46		51	2	

Notes:

* Chemicals were included if their individual cancer risk values were greater than 1.0E-06
 Bold numbers indicate that the chemical contributes greater than 20% to the overall risk value

**TABLE 6-54
PERCENT CONTRIBUTION OF CHEMICALS TO OVERALL RISK IN
JPL PRODUCTION WELLS WITH CANCER RISKS GREATER THAN 10⁻⁶**

Chemical of Concern*	Production Well													
	Valley #1	Valley #2	Valley #3	Valley #4	La Canada #1	Las Flores	Pasadena Arroyo	Pasadena Windsor	Pasadena 52	Lincoln Ave #3	Lincoln Ave #5	Rubio Canon #4	Rubio Canon #7	Pasadena Ventura
1,1-Dichloroethene														
1,2-Dichloroethane														
Arsenic	31	67	94	43		83								
Bromodichloromethane														
Carbon Tetrachloride							91		78	45				
Chloroform														
Hexavalent Chromium														
Nitrate														
Perchlorate														
Tetrachloroethene	65	31	6	53	100	16	3	66		7	10			59
Trichloroethene	3	1		2			5	33	22	45	90			40

Notes:

* Chemicals were included if their individual cancer risk values were greater than 1.0E-06

Bold numbers indicate that the chemical contributes greater than 20% to the overall risk value

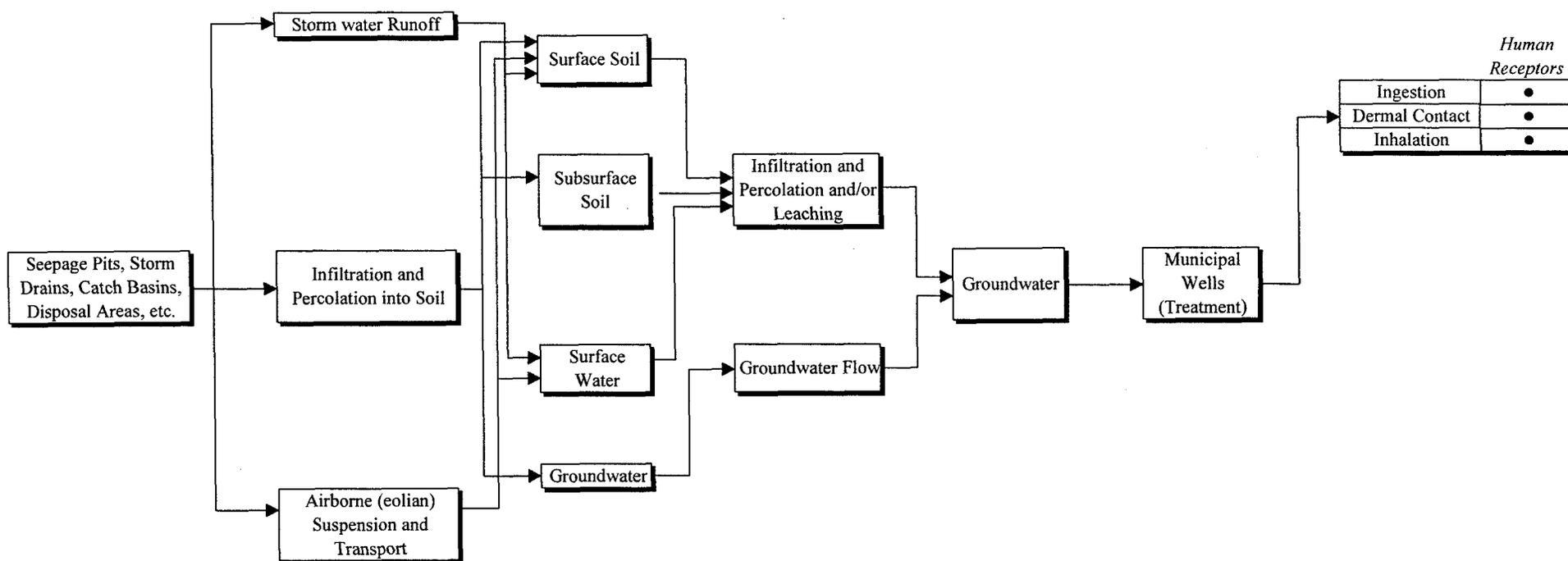
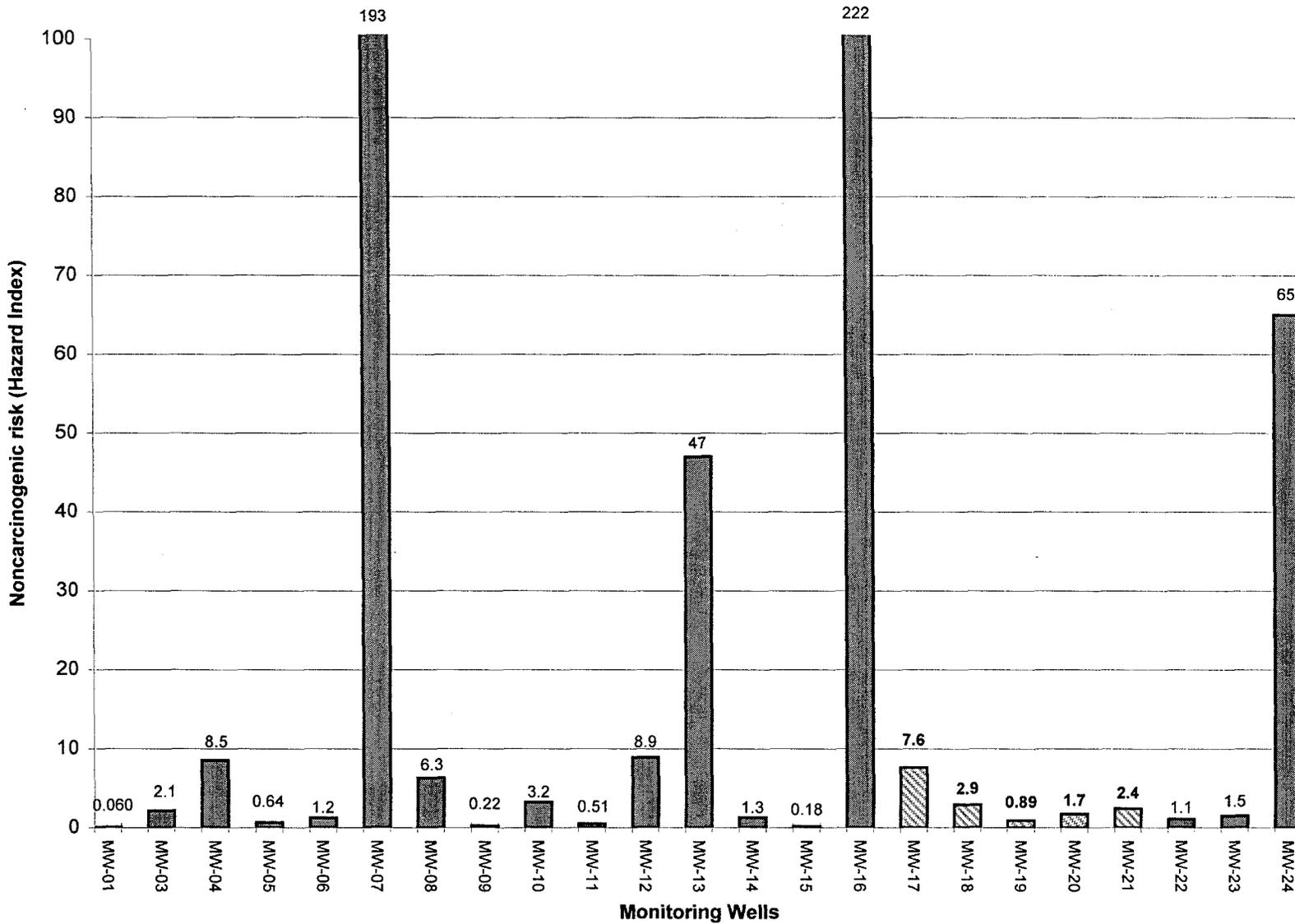


FIGURE 6-1. SITE CONCEPTUAL MODEL FOR THE HUMAN HEALTH RISK ASSESSMENT FOR OPERABLE UNITS 1 AND 3 AT THE JET PROPULSION LABORATORY



On-site wells have solid shading
 Off-site wells are shaded diagonally

FIGURE 6-2 NONCARCINOGENIC RISK VALUES FOR THE JET PROPULSION LABORATORY MONITORING WELLS

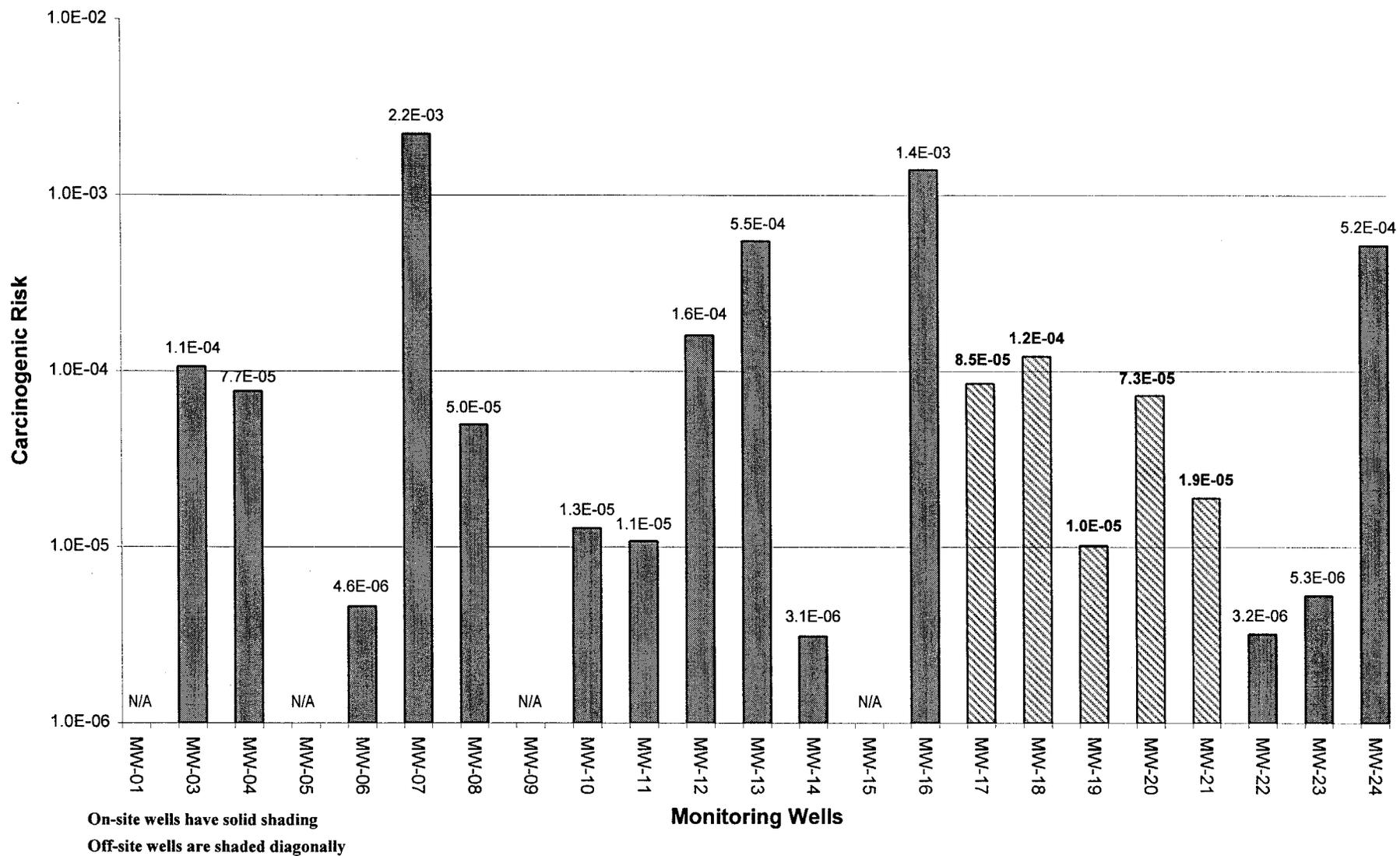


FIGURE 6-3. CARCINOGENIC RISK VALUES FOR THE JET PROPULSION LABORATORY MONITORING WELLS